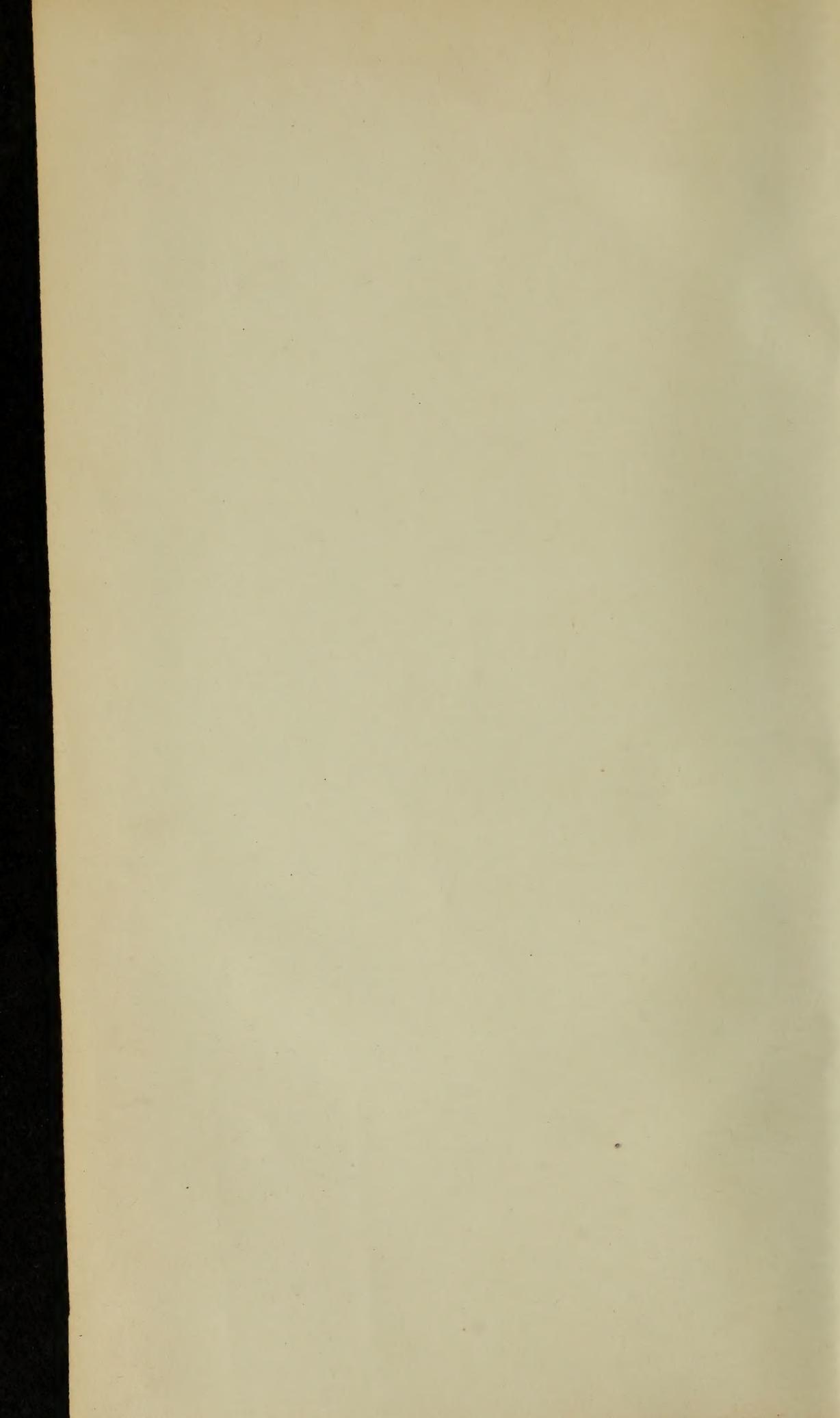


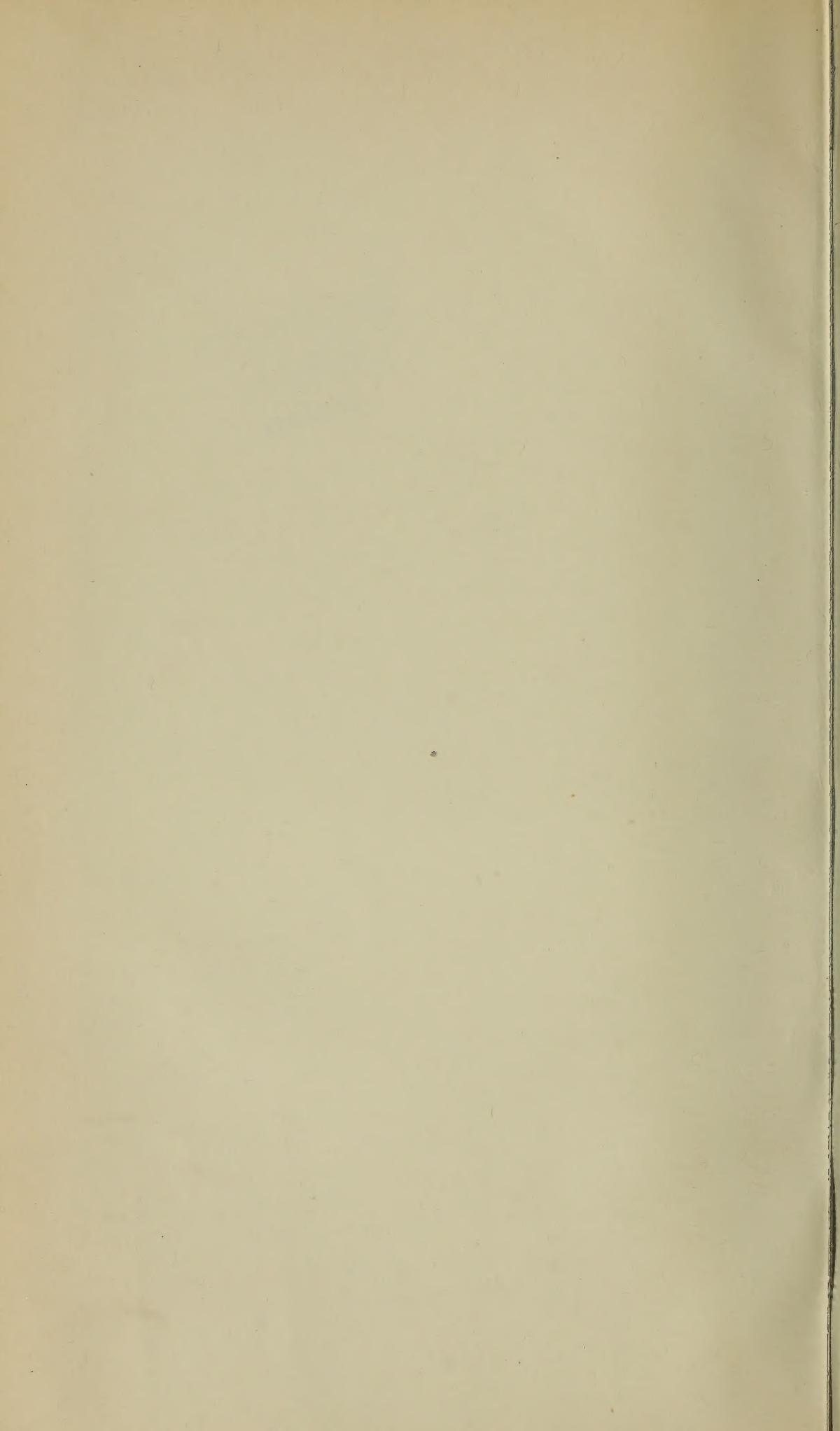
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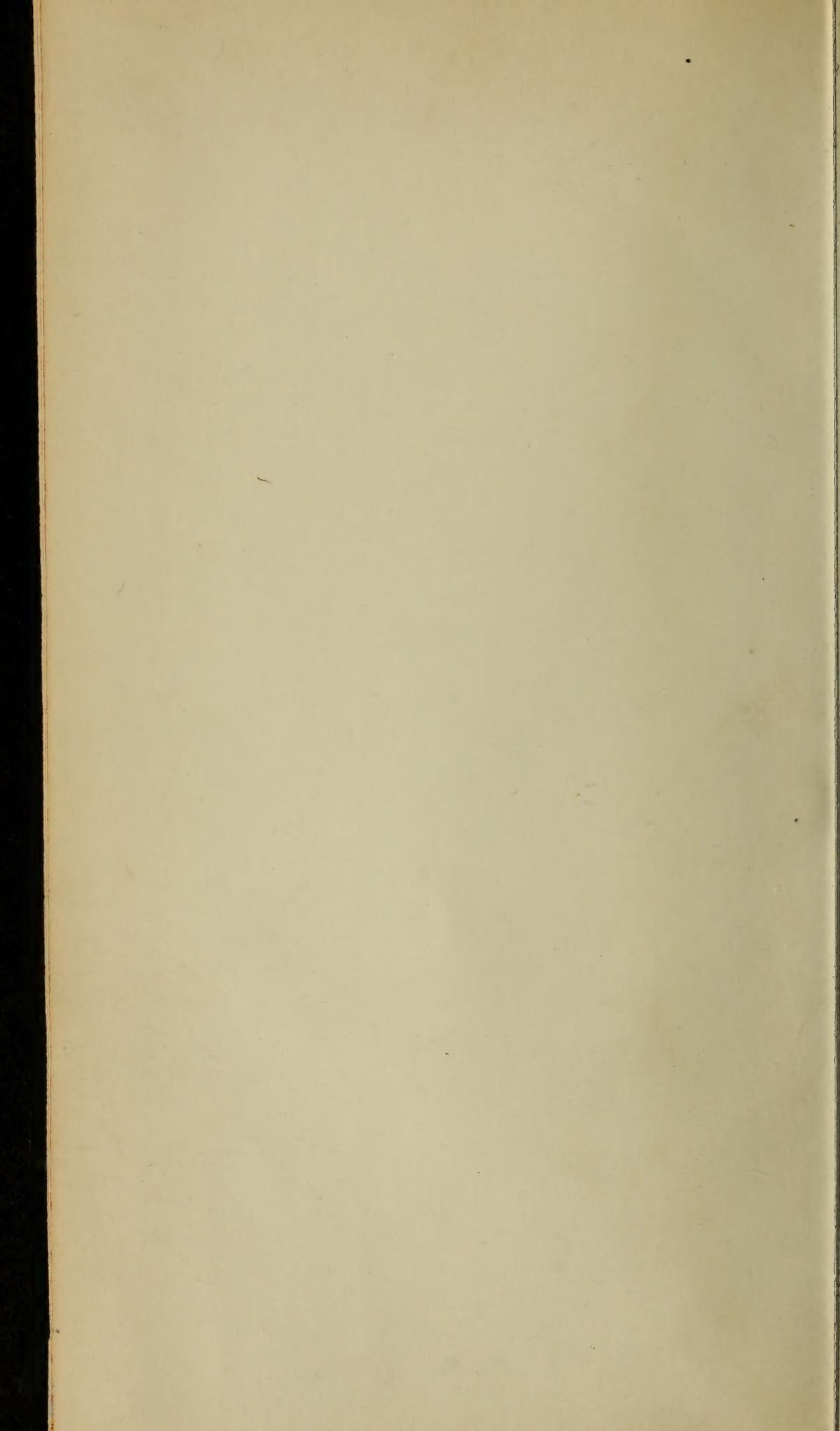


INVERTEBRAT.

ZOOLOGY

Crustacea







CLARENCE LUTHER HERRICK

(1858-1904)

686393

Smithsonian

MISCELLANEOUS ZOOLOGICAL PAPERS 14

(exclusive of papers on Mammals, Reptiles, Neurology and Geology. Biography and complete bibliography are given in Jour. Comparative Neurology and Psychology, Vol. 14, No. 6, November, 1904, and in Bull. Scientific Laboratories Denison University, Vol. 13, pp. 1-33, January, 1905).

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3. 1879. Microscopic Entomostraca. Geol. Nat. Hist. Survey Minnesota, 7th Ann. Report for 1878, Appendix B, pp. 81-123, pls. 1-21.
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14. 1885. The Evening Grosbeak - Hesperiphona vespertina, Bonap. Bull. Denison Univ. Lab., Vol. 1, pp. 5-15, pl. 1, and Frontspiece.
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16. 1885. Mud-inhabiting Crustacea. Bull. Denison Univ. Lab., Vol. 1, pp. 37-42, pl. 9.
17. 1885. Notes on American Rotifers. Bull. Denison Univ. Lab., Vol. 1, pp. 43-62, pls. 2-4, 10.
1887. Contributions to the fauna of the Gulf of Mexico and the South. List of the fresh-water and marine Crustacea of Alabama, with descriptions of the new species and synoptical keys for identification. Mem. Denison Sci. Assoc., Vol. 1, No. 1, 56 pp., 3 pls. ~~Filed~~ Filed separately. Inc. Mar. Surv. Library

18. 1895. Microcrustacea from New Mexico.
Zool. Anz., Vol. 18, pp. 40-47,
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[Photostatic copy].
1895. Synopsis of the Entomostraca of
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Survey Minnesota, Zool. Ser. 2,
525 pp., pls. 1-81. [With C. H.
Turner]. Bound separately.

Catalogue of the Geological and Mineralogical Specimen of the Museum, to December 31, 1876.—Continued.

Serial No.	OBTAINED.		Name.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
	When.	Whence.					
626	Dec. 1876	S. F. Peckham.....	"Gothite." (Haematite mostly).....	1	Michigan Mine, Marquette, Mich.	Huronian....	
627	"	"	Phosphrytic iron, containing Titanium.....	1	Cumberland Hill, R. I.....		
628	"	"	Phyllite.....	1	Cranston, R. I.....		
629	"	"	Ripidolite.....	1	Cumberland Hill, R. I.....		
630	"	"	Chalcopyrite.....	1	"		
631	"	"	Orthite (allanite) small, dark crystals.				
			Scapolite (Wernerite) white, main portion. Spheue (Titanite) greenish massive.....	1	Bolton, Mass.....		
632	Dec. 1874	"	Slab of slate with impressions of plants.....	1	Portsmouth Mine.....	Carb.....	
638	?	?	Plumbago.....	Many	Rhode Island I.		
634	Nov. 1876	Centennial Exposition.	Native sulphur.....	1	Ticonderoga, N. Y..... Kilauea, Sandwich Islands.....		

X.
ORNITHOLOGICAL NOTES.

By C. L. Herrick.

MINNEAPOLIS, Dec., 1876.

Prof. Winchell :

The work represented by the following list of birds was, of course, much impeded by the difficulties incident to the season during which it was prosecuted; for not only are there comparatively few birds, and those of the commonest species to be found during the heated term, but those actually collected are often unfit, on account of the summer moult, for preservation or study.

Yet though the field work was over before the fall migration was fairly commenced, a few facts of some interest were noticed.

From observations made during the summer it would seem that the Brotherly-Love Vireo (*Vireo philadelphicus*) is not as rare as until recently supposed, and, indeed, it may be found to be quite as common in this locality as the *Vireo gilvus*. The vireos collected were shot without discrimination, yet two were quite typical specimens of *philadelphicus*.

The results obtained from the study of the few shrikes as yet collected at Minneapolis are so unexpected and withal so contradictory, that the following remarks are given with some hesitancy, especially as they are at variance with what has been written upon these birds by others who have collected in this State.

The Great Northern Shrike, or *Collurio borealis*, is as yet only noted as occurring during Spring and Fall. I have never heard of the nest in this vicinity. I am led to believe that the bird is somewhat rare, even during the migrations, for in the Spring it is very conspicuous from the habit it has of perching on a high tree and uttering at intervals its peculiar metallic cry on its arrival in any

5th Ann. Rept. for the year 1876.

publ. 1877.

locality; and thus the comparatively small number of specimens collected is more significant.

The smaller shrikes, so abundant here, or many of them, seem to partake of the characteristics of both varieties, viz: *ludovicianus* and *excubitoroides*. The three in the museum seem to me to nearly accord with the descriptions of *ludovicianus*. They all, together with two in my own collection, have the two inner tail feathers black to the bases; but another, which also possesses several other resemblances to *excubitoroides*, has evident white patches on all the tail quills. Again a number of these birds in the possession of Mr. T. S. Roberts agree in disagreeing with every description of either variety.

I draw from these facts the inference that the variety *ludovicianus* predominates over the other, but that the types are mingled and blended so as to baffle any accurate identification.

The nesting of these birds may be easily observed in many parts of the suburbs, but the nests are often mistaken for those of the more northern Butcher Bird.

Perhaps the Red-bellied Nuthatch may be less rare during migration than supposed, if searched for in suitable localities.

The bird-fauna of the State has received one addition in the tern *Sterna caspia* (*Thalassus* c. Boie.) This is the largest of the terns, and is a very beautiful and striking bird. The only specimen as yet identified from this State, as far as I am aware, was secured at Long Lake by Will Secombe, of Minneapolis, by whom it was presented to the museum.

The English House-Sparrow was simultaneously observed by Mr. Roberts and myself during the early part of the winter about the streets of the city, and I learn from that observer that they have survived our severe weather as yet.

The fact that birds are often infested by intestinal worms particularly the Tape Worm, (*Tænia*) has attracted so much notice of late that I mention the collection of a variety of these parasites from the solitary Tattler; also a quasi-parasitic colony of crustaceans found upon a goose. I received from Mr. Roberts several specimens of crustaceans collected from Hutchins' goose, found deeply imbedded in the feathers near the skin. These proved to be miniature Sand Fleas (fresh water.) Of course it is hardly to be supposed that this was more than an accident. I cannot account for this except by supposing it to be the result of the proclivity of these fleas (so often noticed) to wedge themselves in the thick masses of leaves upon the Bladder-wort and other water plants.

A V E S .

Note. A star (*) signifies male. A dagger (†) denotes the female.

TURDIDÆ.

1. Harpochynchus rufas. Cab. Brown Thrush. Minneapolis, Aug. 20th, 1876. (69.)
2. Mimus carolinensis. Cab. Cat Bird.* Minneapolis, May 14th, 1875. (26.)

SITTIDÆ.

3. Sitta carolinensis. Gm. White-Bellied Nuthatch * Minneapolis, Aug. 12th, 1876. (64.)
4. Sitta carolinensis, Gm. White-Bellied Nuthatch. Minneapolis, July 24th, 1876. (65.)
5. Sitta canadensis, L. Red-Bellied Nuthatch. Minneapolis, Aug. 16th, 1876. (66.) *Not common.*

SYLVICOLIDÆ.

6. Mniotilla varia. Vieill. Black and White Creeper.* Minneapolis, Aug. 16th, 1876. (10.)
7. Mniotilla varia. Vieill. Black and White Creeper. Minneapolis, Aug. 18th, 1876. (77.)
8. Dendroœea æstiva. Bd. Golden Warbler. Minneapolis, May 7th, 1875. (6.)
9. Dendroœea æstiva. Bd. Golden Warbler.* Minneapolis, Aug. 16th, 1876. (7.)
10. Dendroœea æstiva. Bd. Golden Warbler.* Minneapolis, Aug. 14th, 1876. (8.)
11. Dendroœea coronata. Gray. Yellow-Rumped Warbler.† Minneapolis, May 15th, 1875. (9.)
12. Mniotilla varia. Vieill. Black and White Creeper. Minneapolis, Aug. 18th, 1876. (76.)

13. *Seiurus aurocapillus*. Sw. Golden-Crowned Thrush.* Minneapolis, Aug. 20th, 1876. (79.)
14. *Seiurus aurocapillus*. Sw. Golden-Crowned Thrush. Minneapolis, May 15th, 1875. (4.)
15. *Seiurus noveboracensis*. Nutt. Water Thrush. Lake Minnetonka, Aug. 14th, 1876. (5.)
16. *Setophaga ruticilla*. Sw. Red Start.* Minneapolis, Aug. 20th, 1876. (80.)
17. *Setophaga ruticilla*. Sw. Red Start.* Minneapolis, Aug. 20th, 1876. (81.)
18. *Setophaga ruticilla*. Sw. Red Start. Minneapolis, Aug. 15th. (15.)

TANAGRIDÆ.

19. *Pyrrhuloxia rubra*. Vieill. Scarlet Tanager.* Minneapolis, July 19th, 1876. (28.)

HIRUNDINIDÆ.

20. *Cotyle riparia*. Boie. Bank Swallow.* Minneapolis, Aug. 14th, 1876. (47.)

AMPELIDÆ.

21. *Ampelis cedrorum*. Bd. Cedar Bird.* Minneapolis, July, 1876. (25.)

VIREODINÆ.

22. *Vireo olivacea*. L. Red-eyed Vireo.* Minneapolis, July 19th, 1876. (11.)
23. *Vireo philadelphica*. Cassin. Philadelphia Vireo. Minneapolis, Aug. 1876. (14.)
24. *Vireo philadelphica*. Cassin. Philadelphia Vireo. Minneapolis, Aug. 20th, 1876. (78.)
25. *Vireo gilva*. Cass. Warbling Vireo.* Minneapolis, July 11th, 1876. (12.)
26. *Vireo flavifrons*. Bd. Yellow-throated Vireo.* Minneapolis, Aug. 16th, 1876. (13.)

LANIDÆ.

27. *Collurio ludivicianus*. Bd. Loggerhead Shrike.* Minneapolis, Aug., 1876. (7.)
28. *Collurio ludivicianus*. Bd. Loggerhead Shrike.† Minneapolis, July 20th, 1876. (2.)
29. *Collurio ludivicianus*. Bd. Loggerhead Shrike. Minneapolis, 1875. (3.)

FRINGILLIDÆ.

30. *Chrysomitris tristis*. Bon. Yellow Bird.† Minneapolis, Nov. 26th, 1875. (31.)
31. *Chrysomitris tristis*. Bon. Yellow Bird.* Champlin, Minn., June 18th, 1875. (30.)
32. *Plectrophanes nivalis*. Meyer. Snow Bunting.* Minneapolis, Nov. 30th, 1876. (88.)
33. *Plectrophanes nivalis*. Meyer. Snow Bunting.† Minneapolis, Nov. 30th, 1876. (89.)
34. *Poœcetes gramineus*. Bd. Grass Finch. Minneapolis, Aug. 16th, 1876. (35.)
35. *Poœcetes gramineus*. Bd. Grass Finch. Minneapolis, Aug. 1876. (36.)
36. *Spizella socialis*. Bon. Chipping Sparrow.* Minneapolis, Aug. 14th, 1876. (32.)
37. *Spizella monticolor*. Bd. Tree Sparrow.* Minneapolis, Oct. 9th, 1876. (84.)
38. *Spizella pallida*. Bon. Clay-Colored Bunting.* Minneapolis, Aug., 1876. (33.)
39. *Spizella pallida*. Bon. Clay-Colored Bunting.† Minneapolis, May 7th, 1875. (34.)
40. *Chondestes grammaca*. Bon. Lark Finch. Minneapolis, 1875. (38.)
41. *Melospiza melodia*. Bd. Song Sparrow.* Minneapolis, Aug. 12th, 1876. (37.)
42. *Goniaphea ludiviciiana*. Bowdich. Rose-Breasted Grosbeak.* Minneapolis, June, 1875. (27.)
43. *Coniaphea ludiviciiana*. Bow. Rose-Breasted Grosbeak. Minneapolis, Aug. 18th, 1876. (75.)
44. *Cyanospiza cyanea*. Bd. Indigo Bird.* Minneapolis, July, 1876. (29.)
45. *Pipilo crythrophthalmus*. Vieill. Chewink.* Minneapolis, Aug. 3d, 1876. (39.)
46. *Junco hyemalis*. Sd. Snow Bird.* Minneapolis, Oct. 9th, 1876. (83.)

IETERIDÆ.

47. *Dolichonyx oryzivorus*. Sw. Bobolink.* Minneapolis, July 20th, 1876. (42.)
48. *Agelæus phœnicus*. V. Red-Winged Black Bird.* Minneapolis, Aug. 4th, 1876. (41.)
49. *Sturnella magna*. Sw. Meadow Lark.* Minneapolis, July 18th, 1876. (40.)
50. *Ieterus baltimore*. Daudin. Baltimore Oriole.* Minneapolis, May 22d, 1875. (21.)
51. *Ieterus spurius*. Bon. Orchard Oriole.* Minneapolis, 1875. (22.)
52. *Ieterus spurius*. Bon. Orchard Oriole.* Minneapolis, 1875. *Juv. specimine*. (23.)

53. *Icterus spurius*. Bon. Orchard Oriole.† Minneapolis, July, 1876. (24.)

CORVIDÆ.

54. *Corvus corax*. L. Raven.* (*Mounted.*) Minneapolis, Oct., 1876. (85.)
Not common.
Presented by N. Herrick, Esq.
55. *Cyanurus cristatus*. Sw. Blue Jay. Minneapolis, July 20th, 1876.
 (45.)

TYRANNIDÆ.

56. *Tyrannus carolinensis*. Bd. King Bird.* Minneapolis, May 14th, 1875.
 (20.)
57. *Contonops virens*. Cab. Wood Pewee.* Minneapolis, Aug. 11th, 1876.
 (16.)
58. *C. virens*. Cab. Wood Pewee.* Minneapolis, Aug. 15th, 1876. (17.)
59. *C. virens*. Cab. Wood Pewee.† Minneapolis, Aug. 15th, 1876. (18.)
60. *C. virens*. Cab. Wood Pewee. Minneapolis, July, 1876. (19.)

CAPRIMULGIDÆ.

61. *Chordeiles virginianus*. Bon. Night Hawk.* Minneapolis, Aug. 16th,
 1876. (44.)

CYPSELIDÆ.

62. *Cotyle pelasgio*. Bd. Chimney Swift.* Minneapolis, July 10th, 1876.
 (43.)

ALCEDINIDÆ.

63. *Cryle alcyon*. Boie. Belted Kingfisher. Minneapolis, Aug. 1st, 1876.
 (46.)

PICIDÆ.

64. *Picus pubescens*. L. Downy Woodpecker.* Minneapolis, July, 1876.
 (60.)
65. *Picus pubescens*. L. Downy Woodpecker.* Minneapolis, Aug. 16th,
 1876. (61.)
66. *Picus pubescens*. L. Downy Woodpecker.* Minneapolis, Aug. 20th,
 1876. (73.)
67. *Melanerpes erythrocephalus*. Sw. Red-headed Woodpecker. July 23d,
 1876. (62.)
68. *Melanerpes erythrocephalus*. Sw. Red-headed Woodpecker.* Minne-
 apolis, Aug. 28th. (71.)
69. *Colaptes auratus*. Sw. Golden-winged Woodpecker. Minneapolis,
 April 29th, 1875. (63.)

70. *Colaptes auratus*. Su. Golden-winged Woodpecker.* Minneapolis, Aug. 28th, 1876. (72.)

STRIGIDÆ.

71. *Bubo virginianus*. Wilk. Great-horned Owl.* Minneapolis, Nov., 1876. (86.) *From Collection of C. L. Herrick.*

FALCONIDÆ.

72. *Falco sparverius*. L. Sparrow Hawk. Minneapolis, Aug. 2, 1876. (67.)
 73. *Falco sparverius*. L. Sparrow Hawk. Minneapolis, Aug. 13th, 1875. (68.)
 74. *Buteo borealis*. Vieill. Red-tailed Hawk.* Jav. Minneapolis, July, 1876. (82.) (*Mounted.*)

COLUMBIDÆ.

75. *Ectopistes migratorius*. Sw. Wild Pigeon. Minneapolis, July 11th, 1876. (58.)
 76. *Ectopistes migratorius*. S. Wild Pigeon. Minneapolis, July 11th, 1876. (59.)

TETRAONIDÆ.

77. *Bonasa umbellus*. Stephens. Ruffed Grouse. Minneapolis, July, 1876. (48.)

CHARADRIDÆ.

78. *Ægialitis vociferus*. Cass. Killdeer Plover.† Minneapolis, July 22d, 1876. (57.)

SCOLOPACIDÆ.

79. *Totanus solitarius*. Wilson. Solitary Tattler.* Minneapolis, Aug. 17th, 1876. (55.)
 80. *Totanus solitarius*. Wils. Solitary Tattler.* Minneapolis, Aug. 12th, 1876. (56.)
 81. *Totanus solitarius*. Wils. Solitary Tattler. Minneapolis, Aug. 20th, 1876. (74.)
 82. *Tringoides macularius*. Gray. Spotted Sandpiper. Minneapolis, Aug. 4th, 1876. (53.)
 83. *Tringoides macularius*. Gray. Spotted Sandpiper.* Minneapolis, July 14th, 1876. (54.)
 84. *Actiturus bartramius*. Bon. Upland Plover. Minneapolis, Aug. 6th, 1875. (52.)

ARDEIDÆ.

85. *Botaurus mugitans*. Coues. Bittern. Minneapolis, 1875. (49.)

RALLIDÆ.

86. *Porzana carolina*. V. Carolina Rail.† Minneapolis, Aug. 20th, 1876. (70.)

LARIDÆ.

87. *Sterna caspia*. Pall. Caspian Tern. Long Lake, Nov., 1876. (87.)

Rare.

Collected and presented by Will. Secombe.

88. *Hydrochelidon lariformis*. Coues. Black Tern. Minneapolis, July 19th, 1876. (50.)
89. *Hydrochelidon lariformis*. Coues. Black Tern, *young*. Minneapolis, July 19th, 1876. (51.)

ANATIDÆ.

90. *Bucephala clangula*. Wils. Golden-Eye. Garrot. Minneapolis, Jan. 17th, 1877.

Just as this proof is going to press, I have the pleasure of announcing that I had the good fortune to secure for the collection two specimens of Leconte's Sparrow, *coturniculus lecontei*, thus adding this to the very few localities of its occurrence. A more extended notice will doubtless be given hereafter.

XI.

A NEW CYCLOPS.

By C. L. Herrick.

Cyclops quadricornis has often been used as an object for study by those desirous of becoming familiar with the process of development in crustacea. For this it is eminently fitted both on account of its very distinct changes and its abundance in every pond and pool.

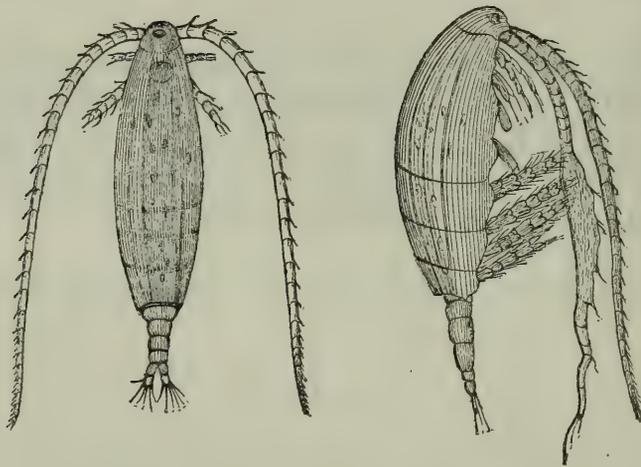


Fig. 1.

There is another member of the same genus which has not, apparently, been described, and I have therefore provisionally named it *C. longicornis* from the very long primary antennæ.

The appearance of an ordinary individual (*Fig. 1.*) is not very widely different from the ordinary species. But the first glance of the female with the spherical sac of ova under the abdomen makes the creature seem quite distinct.

The general appearance and its movements while swimming briskly about cause it to look like a magnified cladocera, the long

spreading antennæ increasing the similarity. The glass at once dispels the illusion however.

The eggs are larger in proportion than those of *quadricornis* and are loosely aggregated beneath the abdomen. The cephalothorax is very large and carries the usual complement of motory appendages. The first antennæ are long—exceeding the body. The second pair are specialized enough to be called antennæ, and the claws are, according to my observation, small though they were indistinctly seen.

The abdomen is in proportion smaller than in *quadricornis*, and the tail similar to that of a young of that species. Of internal structure little was made out, but the red glands are as prominent as in the other. A curious case of malformation of antennæ is shown in the figure. The color is transparent white, except the tips of the antennæ and the last segments of the abdomen.

The process of cephalization is well illustrated by the cyclops, though not as aptly as in the larger crustaceans, the Sand Fleas.

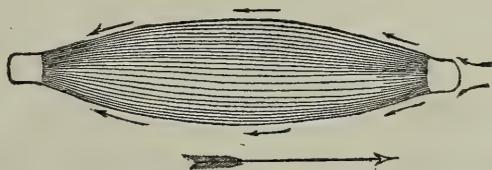


Fig. 2.

A recent observation of a number of diatoms dipped from the bottom of the deeper portion of Lake Calhoun, seems to prove that one species is clothed with cilia throughout, and not simply at the ends as usually described. While watching the motions of a Navicula-like plant propelling itself slowly along it was seen to collide with a large mass of vegetable matter, and while thus brought to a stand-still the infinitesimal particles floating near it were seen to traverse its whole length, the diatom and particles beyond reach of its influence remaining motionless in the meantime. This specimen was of sufficient length to preclude the possibility of the cilia at the ends having any influence upon the particles.

Other Collections.

Besides the Moose mentioned in the report of last year, the following mounted mammals are on exhibition:

Antilocapra Americana. Ord. Pronghorn Antelope. 2 male and 2 female.
Custer Expedition to the Black Hills. 1874.

Corvus Canadensis. Exl. American Elk. Custer Expedition to the Black Hills. 1874.

Badger. Custer Expedition to the Black Hills. 1874.

Ursus horribilis. Ord. Grizzly Bear, female. Custer Expedition to the Black Hills. 1874.

Corvus leucurus. Doug. White-Tailed Deer; 1 male, 2 females. Cus. Ex. Blk. Hills. 1874.

Rangifer Caribou. And. and Bach. Woodland Caribou (unmounted.)
Presented Dec., 1875, by Nathan Butler.

Sciurus hudsonius. Pall. Red Squirrel. Three specimens.

Tamias striatus. Bd. Chipmunk.

Spermophilus tridecemlineatus. Mitch. Striped Gopher.

Hesperomys michiganensis. Wag. Michigan Mouse.

Procyon lotor. Ston. Common Raccoon.

Reptiles.

Pana catesbiana. Shaw. Bull Frog.

Amblystoma tigrinum. Bd. (Immature.) Common Salamander.

Eutaenia radix. Bd. & Gir. Garter snake.

Skeletons Mounted.

Podilymbus podiceps. Lawr. Pied-billed Grebe.

Botaurus mugitans. Bart. Bittern.

1879

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APPENDIX B.

MICROSCOPIC ENTOMOSTRACA,

BY C. L. HERRICK, *Laboratory Assistant.*

NEW HAVEN, JANUARY 8, 1879.

Prof. N. H. Winchell:

DEAR SIR: I have examined the chapter by Mr. Herrick, which you placed in my hands, and think it a valuable contribution to science. It will make a very appropriate addition, it appears to me, to the Minnesota State Report, because of its illustrating with well-drawn figures and good descriptions the life of the fresh water of the State. The species are among the most interesting of the minuter animals of the waters, and have a wide distribution over the globe.

Yours truly,

JAMES D. DANA.

MINNEAPOLIS, MINN., JANUARY 14, 1879.

Gen. H. H. Sibley, President of the Board of Regents:

I herewith communicate to the Regents an illustrated memoir on the microscopic crustaceans of fresh waters of Minnesota, as a contribution on the Natural History of the State, in accordance with law. This valuable paper, by Mr. C. L. Herrick, my laboratory assistant, has cost the Survey nothing more than the use of its rooms and apparatus, and has been submitted to the approval of Prof. J. D. Dana of New Haven, who indorses it as a valuable contribution to science, and recommends its publication.

Very respectfully,

N. H. WINCHELL.

PREFACE.

It is with the hope that the following paper may be of service to some who, like myself, were interested in the many and varied forms found in every stagnant pool as well as in the lakes and ponds of our country, but who were unable to find any connected account of them, that it is offered to such, as a contribution toward a better understanding of a little known order of the natural kingdoms.

The lakes within a radius of ten miles of Minneapolis have furnished all the material examined, and the supply is not exhausted by any means. It is only hoped to so outline the extent and limits of this division of animal life that it will be less difficult to place the forms found from time to time, in approximately their true position.

With very few exceptions, as far as has been ascertained, no one has devoted any attention to the fresh water *Entomostraca* of America, and it is necessary for some one to act as a pioneer, to learn whether any of the forms described in Europe appear here, and to discover, if possible, if there be a general similarity between these widely separated faunæ. This has been the ambition of the present writer; and if only an intelligent attention be directed to this field, he will feel abundantly repaid for the attempt.

The works consulted were Dana's "Report of the Crustaceans collected during the Wilkes Exploring Expedition to the Pacific Ocean", Dr. W. Baird's "British Entomostraca," "Report of U. S. Fish Commission," papers in "Hayden's Survey of the Territories", and papers in the American Naturalist and other periodicals. Many thanks are due to Prof. N. H. Winchell, director of the State Geological Survey, for assistance and advice in many ways; to President W. W. Folwell, and Dr. P. L. Hatch, for assistance and intelligent sympathy, and to fellow members of the "Naturalist's Club."

That there will be found mistakes in the work is to be expected, but it is hoped that the information will be reliable in the main.

It is not without hesitation that, as a novice in scientific investigation, names are suggested for the new species found, but the purpose of this paper will be best served by defining as well as possible these forms, and submitting them to the test of further study; and if in the future more experience and greater research can be brought to bear upon this domain, these preliminary notes will perhaps not be without their value. The drawings were all made by the writer, in most cases from life, though some details have been introduced from the works consulted, and the plate of *Phyllopoda* was collected from the government reports and elsewhere. Clearness in outline and detail rather than beauty in execution was the desideratum.

C. L. HERRICK.

INTRODUCTION.

ENTOMOSTRACA.

The name was derived from two Greek words meaning insect and shell, by Otho F. Muller, and applied by him in his "*Entomostraca*" (1785) to the animals which had hitherto been all comprised in Jinnæus' genus *Monoculus*, named from the supposition that they all possessed but one eye. The name "*Branchipodes*" was also proposed, and would have been appropriate enough, but Muller supposed that the branchial appendages which suggested the name, were wanting in *Cythere*, etc. Muller, aside from naming the group, was the first to arrange these animals in anything like a systematic classification, and collected a great deal of interesting information. Since his time several authors have written upon these interesting animals in Europe, but with a few exceptions no systematic work on Entomostraca has appeared in English.

Dr. W. Baird published in 1850 a superb work on the Entomostraca of Great Britain, which is still the best thing in the English language. But since this work was published, many additions have been made to our knowledge. In Prof. J. D. Dana's magnificent work on the Crustacea found in the "Wilkes Exploring Expedition", many new species are described, and a revised classification for the whole order is proposed. In this work every known genus was characterized. Since then additions of new species have been published by various authors, and are scattered through the reports of various societies. Moreover, recent studies in Embryology have thrown new light on the classification of all the lower animals, and many changes are necessary, but it is not possible at this stage of the study to attempt a

SYSTEMATIC ARRANGEMENT

of this order. We shall follow quite closely Dana's system as being most complete.

The following changes, which will not affect essentially the nomenclature used must be indicated as the necessary result of modern research:

1. The *Merostomata*, or King Crab group, which contains the modern genus *Limulus* (Horseshoe Crab) and the ancient *Eurypteridæ*, etc., which was considered by Dana a sub-order of Entomostraca has by recent writers been regarded as a distinct order intermediate between the *Trilobita* (which Dana included with the sub-classes *Chorestopoda* and *Entromostraca* in the class *Edriophthalmia* or *Tetradecapoda*) and the *Entomostraca*.

Trilobita now stands at the foot of the sub-kingdom, its inferiority in rank being assumed from the inferiority in point of time.

The *Cormostomata* (including *Pacilopoda* or *Epizoa*) has been united with *Copepoda* (*Cyclopacea*) thus doing away with the sub-orders in Entomostraca.

The *Pectostraca* (including *Phizocephala* and cirripeda (barnacles) have been assigned a place among the Entomostraca from facts learned regarding their development. These crustaceans have been tossed from one division to another till they ought, it would seem, to find a permanent resting place. First considered mollusks, they have now taken their position among the lower crustaceans. These creatures, which are at maturity firmly cemented to foreign bodies, and are inclosed in a hard shell-like test have, in their earlier stages, forms resembling the "Nauplis" stage of *Cylops* (see plate III,) and also a stage resembling the mature *Cypris*.

It is now known that, as Huxley expresses it, "the barnacle is a crustacean fixed by its head and kicking its food into its mouth." The attachment of the head finds a parallel in the genus *Sida* (see beyond), which contains animals that can attach themselves at will to bodies by a sucker-like disk on the head, corresponding to the pedicle of the barnacles. As the barnacles and epizoa have not been observed no further mention will be made of them in this connection.

The following table from Huxley's Anatomy of Invertebrates will perhaps be useful for reference.

(Articulates or)

ARTHROPODA.

I.

Without manducatory appendages (*Gnathites*)

Trilobata. Tardigrada (?) Pentastomida(?)

II.

With pediform gnathites.

Merostomata. Arachnida. Peripatidea.

III.

With maxilliform gnathites.

Entomostraca.	Myriapoda.
Malacostraca.	Insecta.
<hr style="width: 50%; margin: 0 auto;"/>	
Water-breathers.	Air-breathers.

For the most part.

The extent of the *Entomostraca* has been outlined above, and the *Malacostraca* includes the remainder of the crustaceans, viz: those included by Dana under *Podophthalmia* and the order *Choristopoda* of *Edriophthalmia*, thus embracing crabs, shrimps and all the higher crustaceans, whose body consists (almost always) of twenty segments (somnites) of which six constitute the head, and bear, respectively, the eyes, superior antennæ, inferior antennæ, mandibles, and two pair of maxillæ. Of the remaining somnites eight pertain to the thorax, and carry the foot jaws and walking limbs, while six are abdominal and bear swimming limbs. These higher forms do not go through the Nauplius stage in their development, as do the *Entomostraca*.

GENERA CHARACTERS OF ENTOMOSTRACA.

The Crustaceans of this order are quite various in form, habits and internal structure. They possess specialized jaws, but there are never more than three pairs of qualities, while in the higher orders there are often six.

The somnites of the abdomen (that portion of the body posterior to the genital aperture) are devoid of appendages. Though the study of these animals is very fascinating and instructive the task is a difficult one, both on account of the minute size of most of them and the great difficulty of ascertaining with what organs of the higher forms some of the novel instruments seen are homologous. The curious misapprehensions and inaccuracies into which authors have fallen still further complicates the matter.

The descriptions of these organs, and their functions, must be taken up under the divisions of the order and treated separately. The process of reproduction is particularly interesting in this group, for we have numerous instances of agamogenesis and the *Pectostraca* are hermaphrodites peculiarly modified. Alternate generation will be spoken of more particularly under the *Daphnioidea*. The species described have all been collected and compared with descriptions of previous authors, the new species, it is hoped, will be found sufficiently well defined in connection with the figures given to permit of a ready identification.

The following table of the families of the order will be useful for reference, while the characters upon which they are founded, and synonyms, will be found in their appropriate places.

TABULAR VIEW OF ENTOMOSTRACA.

ORDER ENTOMOSTRACA.

LEGION I. LOPHYROPODA.

TRIBE I. CYCLOPOIDEA (here used as equal to *Copepoda* with the *Pæcilopoda* among the *Cormostomata* (or *Epizoa*.)

- Family 1. Calanidæ.
- Family 2. Cyclopidæ.
- Family 3. Corycaidæ.
- Epizoa?

TRIBE II. DAPHNIOIDÆ. (Cladocera.)

- Family 1. Penilidæ.
- Family 2. Daphnidæ.
- Family 3. Bosminidæ.
- Family 4. Polyphemidæ.

TRIBE III. CYPRIDÆ.

- Family 1. Cypridæ.
 - Sub-family a.* Cyprinæ. (Cypridæ Bd.)
 - Sub-family b.* Cythrinæ. (Cythridæ Bd.)
- Family 2. Halocypridæ.
 - Sub-family a.* Cypridinæ. (Cypridinæ Bd.)
 - Sub-family b.* Halocyprinæ.

LEGION II. PHYLLOPODA.

TRIBE I. ARTEMIOIDEA.

- Family 1. Artemiadæ. (Branchipodidæ.)
 Family 2. Nebalioidæ.

TRIBE II. APODIDÆ.

- Family 1. Apodidæ.

TRIBE III. LIMNADIOIDÆ.

- Family 1. Limnadidæ.

Note—Other genera have been added to those given by Dana, and changes made. The family Estheriadæ seems, however, to be equivalent to Limnadidæ.

LEGION I. LOPHYROPODA.

- Bibliography*.—Lophyropa, *Latreille*, Cuv. Regne An., 1677;
 Lophyropoda (in part), *Leach*, Dict. Sci. Nat., XIV., 554.
 ————— *Gray*, Cat. Brit. Crust. Brit. Mus., 1850,
 100.
 ————— *Baird* Brit. Entomost., 138.
 Cranchiopodes franges (in part), *Lamarck*, Hist. Ans. Vert.

Characters.—Feet normal and not greatly multiplied in number.

TRIBE I. CYCLOPOIDEA.

- Bibliography*.—Carcinoida (in part), *Latreille*.
 Copepodes, *Edwards*, Crust., iii., 411.
 Copepoda, *Baird*, Trans. Berw. Club, ii., 1875.
 ————— *Baird*, Brit. Entomost., 182.
 Cophyropoda, *Burmeister*, Organiz. of Trilobites.
 Copepodita, *Gray*, Cat. Brit. Crust. Brit. Mus., 1850.
 Crustacea copepoda (Cyclopacea), *Dana*, Proc. Ardes. Acad. Sci.
 and Art., 1847.
 Cyclopoidea, *Dana*, Rep. Wilkes' Exp. Ex., p. 1020.

Characters.—Body elongate, straight, never incurved. Cephalothorax and abdomen with few joints. Feet and jaws 16 to 18. The 6–10 posterior thoracic feet are double, foliaceous, with the last often prehensile.

This is a very extensive and widely distributed division, and there is a greater unity of plan seen in the structure of the animals comprised in it than in other divisions of similar importance. These creatures are distributed over the world, in both fresh and salt water, and the numbers may doubtless be reckoned by thousands, but little attention has been devoted to the subject, and our knowledge is quite meagre.

The Cyclopoidea are considered the highest group in the order, approaching the Macroural Crustaceans. The body is not covered by a carapace, as in the following tribes, and the abdomen is extended in the same line as the body, and not incurved as in Daphnioidea, etc. The abdomen is terminated by two stylets which bear several setæ. If the Epizoa are to be admitted into this tribe, certain modifications would be necessary, which we need not discuss.

The cephalothorax is composed of from four to seven segments. In those species having four segments, the first bears the first and second antennæ, mandibles, maxillæ, maxillipods, first feet and one pair of natatorial feet, while the following three carry the remaining pairs of natatores.

Eyes of the three kinds: 1. A pair of simple internal eyes with spherical lenses, which are the ordinary kind. These are usually united near the front in a single very small spot, though they are sometimes remote.

2. A pair in an elevation on the under side of the head between the antennæ. The pigment is often like a piece of solid indigo.

3. A pair of simple eyes consisting of an internal prolate lens situated at the extremity of a vermiform mass of pigment and of a large oblate, lens-shaped cornea. This kind of eye is found in the Corycæidæ.

Antennæ. The antennæ are of two pairs, of which the superior are organs of locomotion, and usually are long and powerful. In the males of many species one or both are modified to form a joint by which the female is held during coition. These modifications are often of generic importance.

The secondary antennæ are subjected to greater changes and serve various functions. Sometimes they are simple; in other species they have two rami. They are often prehensile, and when simple the setæ at the end are movable so that they assist the animal to creep on surfaces.

The mouth is situated in the posterior aspect of a low prominence beneath the head.

The mandibles are variously modified.

The maxillæ are one to four jointed organs.

The maxillipeds are always simple, or if divided the branch is rudimentary.

Anterior pair of legs (or *second maxillipeds*). These organs vary greatly in form, and afford means of generic classification, and will be described under their appropriate heads.

Natatory feet. These are similar to those of other Entomostraca, bearing setæ for locomotion. There are four pairs, and sometimes a prehensile or abortive pair following.

The heart is situated in the posterior part of the thorax, and the circulation may be watched as the blood globules circulate between the tissues; particularly in some transparent species of Calanidæ these may be well traced in the thorax.

Nervous system. A large ganglion exists over the mouth, and surrounds the cesophagus.

This tribe includes three families, as given by Dana, but the Epizoa must probably be included also. The family *Corycæidæ* is oceanic, and no members have been found in our locality.

FAMILY I. *Calanidæ.*

Bibliography.—Dana, Wilkes' Explor. Ex., p. 1039.

Characters.—Eyes often of two kinds, the upper pair being simple and minute, with their pigments either separate or collected into one. In

some species there is another pair beneath, with joined pigments. Mandibles and maxillæ elongate, carrying a palpus, which is furnished with setæ. Ova sac one. First pair of antennæ long, unappendaged; the right or neither having a geniculating joint. Feet of the first pair never sub-prehensile at the end.

The Calanidæ are divided into three sub-families, only one of which has been found to be represented in our locality, however, the classification will be indicated.

SUB-FAMILY 1. CALANINÆ.—Abdomen of moderate length, inferior pair of eyes wanting. Right superior antennæ of male without a geniculating joint. Secondary antennæ setigerous at the end.

Genus 1. *Calanus*, *Leach*, *Dana*.

Genus 2. *Rhincalanus*, *Dana*.

Genus 3. *Cetochilus*, *Goodsir*.

Genus 4. *Euchæta*, *Philippi*.

Genus 5. *Undina*, *Dana*.

SUB-FAMILY 2. OITHONINÆ.—Abdomen linear produced, scarcely shorter than the cephalothorax. Inferior eyes wanting. Maxille digitate on the interior margin. Superior antennæ long, few-jointed; right male antenna not geniculate nor movable in an angle.

SUB-FAMILY 3. PONTELLINÆ.—Abdomen of moderate length. Eyes sometimes of two kinds. Antennæ long and, in all the genera but *Acartia*, having a geniculating joint. Second antennæ setæ-bearing at the end. Posterior feet of the male thick; the right prehensile.

Genus 1. *Diaptomus*, *Westwood*.

Genus 2. *Hemicalanus*, *Dana*.

Genus 3. *Candace*, *Dana*.

Genus 4. *Acartia*, *Dana*.

Genus 5. *Pontella*, (*Pontia*, *Edwards*).

Genus 6. *Catopia*, *Dana*.

Genus *Diaptomus*, Westwood.

Bibliography.—*Monoculus*, *Linnaeus*, *Fabricius Jurine*, etc.

Cyclops, *Muller*, *Desmarest*, *Manuel*, etc.

Diaptomus, *J. O. Westwood*, *Partington's Cycl. Nat. Hist., Entomologist's Text-book*, 1838.

———— *W. Baird*, *Brit. Entomost.*, p. 219.

———— *J. D. Dana*, *Rep. Wilkes' Expl. Ex.*, p. 1045.

Cyclopsina, *M. Edwards*, 1840.

———— *Philippi*, 1843.

———— *Baird*, *Zoologist*, i. 56: *Trans. Berw. Clarb.*

———— *Dana*, *Proc. Amer. Acad. Art and Sci.*

Omethina, *Templeton*, *Trans. Ent. Soc.*, ii., 118, 1838.

Broteas, *Loren*, *Kongl. ret. Akad. Handl.*, 1845, p. 436.

Characters.—The smaller ramus of the secondary antennæ six to seven jointed. Maxillipeds scarcely less, often larger than the first pair of feet. Posterior pair of feet in the male thick, the right prehensile, those of the female long and different from the preceding pairs. Ova sac one.

Of the two species here described, one is certainly a member of this genus, while the other is in many respects more like Dana's genus *Hemicalanus*, which differs from *Diaptomus* in not having the posterior feet of the female large and stout and the shorter branch of the secondary antennæ without the numerous joints. The species of *Hemicalanus* are also oceanic, and none were seen to have ova sacs. Both our species have single ova sacs, while one is not evidently furnished with the plurality of articulations to second antennæ. Not having given a full account of the family, it may be well to incorporate a more general with the technical description. These animals are usually small, seldom reaching one-fourth of an inch, but commonly appearing as mere specks in the water. The body is canoe-shaped, and divided into two portions. The main portion, or cephalothorax, is usually much the longest. The antennæ are the organs of locomotion, being used as oars in the same manner as the "water-boatman," etc., use the feet. The posterior pair of feet vary with the sexes, as described above, the four following pairs are swimming organs, while the anterior pair are modified and turned forward.

The cephalothorax is more often seven jointed in *Pontellinæ* than in the *Calaninæ* but this is not a constant character.

Diaptomus longicornis*, Herrick.

This species is very near to *D. castor* and may, indeed, be a variety of that species, it differs, however, in shape and color from figures of that species, and the maxillæ, and antennæ differ considerably. Cephalothorax rather long, narrowly oval, six-jointed; superior antennæ, rather long but they are not curved as represented in Dr. Baird's figures of *D. castor*. The male right antenna has a geniculating joint at the thirteenth segment which is armed with a considerable curved spine; the joints following are more or less enlarged and sometimes coalesce, forming in extreme cases a monstrosity as represented in Geol. and Nat. Hist. Rep. for 1876. The secondary antennæ are two branched, the outer ramus being three-jointed and armed at the extremity with three curved spines, forming a sort of hand, the middle segment also bears a number of setæ on the inner margin, the minor ramus is six or seven-jointed, though it appears three-jointed at first, the middle segment being sub-divided. The head is produced into a beak in front but it is much smaller than in the following.

The maxillepedes (or first pair of feet) are of three portions, the latter two bearing setæ which are directed towards the head, the final division is composed of about six small joints each bearing a tuft of the setæ. The remaining pairs of feet are alike, each having two setiferous rami. In the female the fifth pair of feet are prehensile and stout, those of the male are unlike, the right being long and the other rudimentary.

This species is very brilliantly colored, the tips of the antennæ and last segments of the abdomen are a fine bluish purple, while the body is variegated with red, yellow and purple. The mass of eggs is also a beautiful red. Only one locality is known to contain the creature, though it may be abundant in the more marshy pools. In the Rep. of the Geol. Surv. of Minn. for 1878 it was mentioned and a figure given, but erroneously called cyclops. (See plate I.)

*See *D. sanguineus*, *Forbes* in Ill. State Mus. Rep. 1876. The description differs, apparently, in several respects, notably as to color, but the species is certainly closely allied.

Diaptomus pallidus, Herrick.

A more abundant form than the above, though less striking in appearance, is the creature for which this name is suggested. The cephalothorax is more elongate and has but five segments. The antennæ are much longer, considerably exceeding the body in some specimens. The joints of the antennæ following the geniculating joint are not united or modified, neither is there an appendage to the segment immediately preceding. The whole body is slender and graceful, resembling *Hemicalanus* but the fifth pair of feet is not obsolescent. The secondary antennæ were not noticed to have the multiplied intermediate joints in the minor ramus, but such may be the case.

This animal abounds in the larger lakes, and seems to prefer pure water, while the other is found in more stagnant water. These creatures are not found infested by bell animalcules and desmids as is the cyclops, probably from their rapid motions and the nature of their haunts.

D. pallidus may be at once distinguished from *longicornis* by its lacking the brilliant coloring of the other, it being quite colorless, and by its smaller size.

D. longicornis is 65-1000 inch in length, while the species in question rarely exceeds 40-1000 inch. The eye in this species is also less conspicuous. (See plate II.)

FAMILY II. **Cyclopidae**.

Bibliography.—Dana, Rep. Wilkes' Exp. Ex., Vol. XIV. Part 2, p. 1039.

Characters.—Eyes small, simple, usually with united pigments. Mandibles with a small or obsolete palpus and few setæ. Ova sacs one or two. Primary antennæ, often appendaged. Both or neither of the male antennæ geniculate. Feet of the first pair more or less prehensile at the end.

The prehensile character of the first pair of legs is chosen by Dana as the chief characteristic of the family; these organs sometimes being perfectly prehensile, with a perfect monodactyle hand, which never occurs in Calanidæ. These animals often possess appendages to the first and second segments of the abdomen, as see plate of *Canthocamptus*.

The cephalothorax has little variation in structure, having either four or five segments. The anterior antennæ are more often much shorter than the body, and if either of them is modified in the male, both of them have a geniculating point. The abdomen is five or six jointed, and may or not be abruptly smaller than the cephalothorax, which fact forms a basis for generic distinction.

The genus *Cyclops* possesses two ova sacs, while the remaining genera, so far as known, have but one. This leads to the division of the family into the two leading sub-families. The third sub-family is founded by Dana upon some sapphirina-like species of doubtful affinities, described by H. D. S. Goodsir.

Sub-family 1 Cyclopina, Dana.

Characters.—Ova sacs two.

Genus 1. *Cyclops*, Muller.

? Genus 2. *Cyclopina*, Claus*

*There are a considerable number of genera of the following sub-families, etc., mentioned in Claus' "Zoologie", which are, for the most part, not described. Since I have not been able to consult the works in which they are defined, and since he seems not to recognize many of those described by Dana, and to disregard his classification, the deciphering of their relation and situation will not be attempted here.

- ? Genus 3. Psammathi, *Philippi*, Archiv. fur Naturgeschichte.
 ? Genus 4. Idomene, *Philippi*, " " "
 ? Genus 5. Euryte, *Philippi*, " " "

GENUS 1. Cyclops.

Bibliography.—(See Cyclops quadricornis.)

Characters.—Cephalothorax four-jointed. Anterior antennæ of the female not appendaged; of the male both geniculate. Appendage at the base of abdomen small. Body sub-cylindrical. Feet of the first pair didactyle.

The various species of this genus are found in inland waters the world over, being essentially fresh water animals, in a few cases only inhabiting water a little brackish. They are among the most abundant of all the individuals of the order, every standing pool abounding in them; they are also extremely variable both in different stages of the same animal, in the different sexes and in different localities.

The young stages of Cyclops have been named as distinct species, in so far that the same animal has been honored with three or four different titles between birth and maturity. In our own locality many forms have been found, and it is quite likely that careful study would enable us to distinguish several species and numerous varieties, but such is the extreme variability of the one known to exist here, that it is not now possible to draw a dividing line between the varying forms, so that all that is attempted is to give a general view of the species, and leave further definition for more minute investigation.

Cyclops quadricornis, Muller.

- Bibliography.*—*Monoculus quadricornis*, *Linnaeus*, *Gmelin*, *Scopoli*, *Fabricius*, *Jurine*, *Sulzer*, *Donovan*, *Blumenbach*, *Manuel*, *Barbut*, *Shaw*.
Monoculus apus, *Poda*.
 Le Monocle à querie fourchue. *Geoffroy*.
 Le Monocle à quatre cornes. *De Geer*.
Cyclops quadricornis, *Muller*, Zool. Dan. Prod., 2416, 1776.
 ———— *Ramdhor*, *Latreille*, *Box*, *Lamarck*, *Baird*, *Leach*, *Koch*.
 ———— *Baird*, Brit. Entomost, p. 198.
Cyclops Geoffroyi, *Lamouelle*, British Insects, 81.
Cyclops vulgaris, *Desmarest*, *M. Edwards*, *Leach*.
 ———— *Baird*, Trans. Berw. Club, i., 97, (young).
 ———— *Garner*, Nat. Hist., Staffordshire.
Pediculus aquaticus, *Baker*, Empl. for Micros., 383.
Satyr, *Baker*.
Nauplius saltatorius, *Muller*, Zool. Prod., No. 2378.
 Four-horned Cyclops, *Prichard*, Microscop. Cab.
Cyclops quadricornis of most recent writers.

The full grown female is often of considerable size, attaining the length of .09 in. or more. The male is smaller, and there is every possible gradation between the above and small forms scarcely perceptible to the unassisted eye.

The cephalothorax is usually regularly oval, but varies from short oval to oblong, it is composed of four segments, of which the anterior one is largest,

equaling or exceeding the remaining three. The superior antennæ vary in length and form. Their shape is that of a letter s. In the male both antennæ possess the hinge, or geniculating joint, which serves as a hand for retaining the female during copulation. The antennæ are about twenty-six jointed, and furnished with numerous setæ. The secondary antennæ are four-jointed, and have six setæ at the end, serving as organs of prehension.

The mandibles are ovoid bodies, terminating in short teeth, and carrying a sort of palpus of two filaments.

The maxillipeds are somewhat similar but are furnished with two toothed processes.

The first pair of feet are organs of prehension, having two rami, of which the smaller, a three-jointed organ, springs from the base of the outer or main branch.

The basal joint of the outer ramus besides bearing the other has two projections on the inner side, the second joint is hook-shaped, as is the final and smallest segment which springs from it. The four following pairs of feet are composed of two rami, each consisting of three setæ-bearing joints, as see plate of Cyclops. There is also a pair of appendages at the base of the first segment of the abdomen. The abdomen is six-jointed, the final joint somewhat bifid, each side terminating in a caudal stylet between which is located the anus.

These stylets give rise to two small setæ on the outer margin and four at the extremity. The inner pair of filaments are usually much the longest, and are also different from the others in having a joint near the base which gives greater freedom to their motions. The setæ are usually barbed backward, and in old individuals are most beautifully pectinate. In cases where the moulting has been arrested these and the other hairs attain a curiously long growth, as illustrated in the plate, and the barblets become filiform appendages.

The digestive canal begins near the front of the thorax and can be traced to the anus. The ovaries are two, and are easily seen in the body, and communicate with external ova sacs. After the eggs are extruded from the ovary into the pouches they are not dependent on the mother, but will come to maturity if separated from her. These eggs vary in number, old individuals laying upwards of forty. It is calculated that in one year a single female would have become the progenitor of 4,442,189,120 young so that the abundance in which they occur, notwithstanding the ravages of the Hydræ, and other enemies, is not strange. A single copulation fertilizes the female for life, as in the case of the Aphides. The eggs, as they are hatched, descend from the ovary covered by a transparent pellicle in which they remain from two to ten days. The growth of the young is illustrated in the plate, the operation occupying about twenty or thirty days. The cyclops moults a number to times during its life, and in as the power of replacing lost parts, they are also very tenacious of life, often reviving after being frozen for a long time in the mud and water, which form their hiding places.

The cyclops is probably both carnivorous and a vegetable feeder.

Plate III. represents the usual form, the figures showing the different stages are copied from Dr. Baird's Entomotraca. *Plate IV.* gives one of the varieties collected here which may be worthy of a specific name; the greatly exaggerated caudal filaments and general hairiness is, however, only an age-modification, the color of this variety is dark, while the eggs in the sacs are pellucid. Another variety is oblong in shape and lighter in color, while the egg sacs are opaque. Still other varieties are smaller, and vary from bright red to green in color, having the egg sacs diverging from the abdomen. There seem to be intermediate forms and it is best to await further study before separating these varieties. (See Plates III. and IV.)

SUB-FAMILY 2. HARPACTICINÆ.

Characters.—External ovary only one.

* Cephalothorax 4-jointed.

Genus 1. *Canthocamptus*, *Westwood*.

Genus 2. *Harpacticus*, *Edwards*.

Genus 3. *Westwoodia*, *Dana*.

Genus 4. *Alteutha*, *Baird*.

Genus 5. *Metis*, *Philippi*.

Genus 6. *Clytemnestra*, *Dana*.

Genus 7. *Setella*, *Dana*.

** Cephalothorax 5-jointed.

Genus 8. *Laophon*, *Philippi*.

Genus 9. *Oncea*, *Philippi*.

Genus 10. *Ænippe*, *Philippi*.

Genus 11. *Idya*, *Philippi*.

Genus 1. Canthocamptus.

Bibliography.—*Monoculus*, *Linnaeus*, *Fabricius*, *Jurine*, etc.

Cyclops, *Muller*, *Ramdohr*, *Latreille*, etc.

Cyclopsina (part), *M. Edwards*.

Canthocamptus, *Westwood*, *Partington's Cyclop. Nat. Hist. art.*

Cyclops; *Entomologist's text-book*, 115.

Canthocarpus, *Baird*, *Trans. Berw. Nat. Club*.

Harpacticus (part) *Dana*, *Proc. Amer. Acad. Arts and Sci.*, 1847.

Nauphilius, *Philippi*, *Ann. Mag. Nat. Hist.*, 1840; *Wieg.*

Archer, 1843.

Characters.—Body scarcely flattened, generally linear or narrow. Feet of the first pair (second jaw feet of Baird) more often small; those of the second pair with two rami, rami three jointed. Antennæ of the female with an appendage at the end of the fourth joint, those of the male both with a geniculating joint. Appendix to base of the abdomen small. Generally no sudden transition from the segments of the thorax to those of the abdomen.

Canthocamptus minutus. Bd.

Bibliography.—*Cyclops minutus*, *Muller*, *Zool. Dan. Prod.*, No. 2409, 1776; *Entomostraca*, 101, t. 17, f. 1-7.

————— *Ramdohr*, *Beyt. zur Naturg.*, 10-13, t. 3, f. 1-9.

————— *Latreille*, *Hist. Nat. Crust.*, IV. 266.

————— *Bosv.* *Mém. Hist. Nat. Crust.*, ii. 257.

————— *Lamarck*, *Hist. Aus. Vert.*, V. 189.

————— *Baird*, *Trans. Berw. Nat. Club*, i. 97, 62, f. 1, 19, 20, etc.

Monoculus. *Gmelin*, *Linn. Sgot. Nat. Edit.* 13th, i. 2997, No. 11.

————— *Fabricius*, *Ent. Syst.*, ii. 499, No. 45.

————— *Manuel*, *Encyc. mith.*, vii., 719, t. 267.

Monoculus staphylinus, *Jurine*, *Hist. Nat. Monoc.*, 74-84.

Cyclops ——— *Desmarest*, *Cons. Gen. Crust.* 363, t. 53.

————— *Baird*, *Trans. Berw. Nat. Club*, i. 97.

Small Cyclops or Vaulter, *Prichard*, Mec. Cab., t. 9, f. 7.

Anyone satyra and Baecha, *Muller*, Entomost., 42 t. 2 (young).

Der Satyr, *Kohlers*.

————— *Prichard*.

Cyclopsina staphylinus, *M. Edwards*, Hist. Nat. Crust., iii. 428.

Canthocarpus ——— *Baird*, Trans Bew. Club, ii., 154.

Nauphilius minutus, *Philippi*, Weigm. and Erichs, Ar. 1843, 69.

Doris minuta, *Koch*, Deutsch, Crust., li. XXXV. t. 3, 1841.

Variety *occidentalis*. Herrick.*

Description, etc.—This variety, which is the only member of the sub-family yet distinguished in our locality, is so closely related to the type of the species as described by Dr. Baird that it is with much hesitation that it was finally concluded to separate it. The description given will apply to both, with such exceptions as will be pointed out.

Body rather long with no obvious distinction between the segments of thorax and abdomen, composed of ten segments, which taper toward the tail. Cephalothorax acute in front, resembling that of species of *Calanus* (in which respect it differs from Dr. Baird's figures of the European species) forming a sort of beak below. Viewed from the side the shape is triangular. The primary antennæ are shorter than in Cyclops, and those of the males more altered than is usually the case in that genus. In the male they consist of seven joints, the fourth of which is much enlarged.

The antennæ of the female possess eight or nine joints, and have a small projecting appendage from the extremity of the fourth segment. The secondary antennæ are simple with two or three joints.

The eye is bright red and contrasts finely with the pale yellow of the body. The mandibles are similar to those of the cyclops. The maxillipeds are divided at the end into four divisions at the extremity of which spring three or four setæ.

The first pair of feet (or second foot-jaws of Baird) are small, three-jointed organs. The final joint is hook-like, and directed forward for the purpose of arresting food particles and carrying them to the mouth.

The second pair of feet are large and modified in form, differing from the natatorial feet, (they form the basis of classification in this whole sub-family). Each is composed of two three-jointed rami, of which the outer one has the joints nearly equal with three setæ. At the apex of the final one, the inner ramus has the upper joint long, almost equalling the outer ramus. The second joint is shorter and with the final one, which carries at the extremity three long setæ, is serrated on the anterior margin. This ramus is directed forward also. The three following pairs have the rami unequal but both with three joints.

The sexual openings are at the base of the sixth segment. In copulation the males seize the caudal stylets with the geniculating joint of the primary antennæ and are bourn about rapidly by the female.

In most of the females seen there was a organ attached to the vulva, it consists of a long flexible stalk terminated by a cylindrical or club-shaped mass, which may be dark brown, red or pellucid.

*S. A. Forbes describes a species in Report Ill. Mus. Nat. Hist., the characters of which I have not been able to compare with our specimens, but it seems distinct.

It was conjectured by M. Siebold that these were similar to the seminal tubes discovered by him upon *Diaptomus*. The act of copulation in *Diaptomus*, as described by him, is so strange and improbable that it is hard to accept without some hesitation. He says that "the male does not accomplish a true coition but attaches to the female, during copulation, a tube containing spermatic liquor. This tube contains, beside the zoosperms, two substances of which one swells by the influence of water, and chases out the whole contents of the tube. The other substance coagulates, leaving in the middle of the mass a canal by which the zoosperms arrive at the vulva."

In the case of the *Canthrocampa*, however, the appendage is apparently of a different nature, being corneous and harder than the rest of the animal, moreover in no case have more than one of these been observed on the same female. Jurine, however, says that this body is never seen till after she has several times laid eggs. Dr. Baird adds that he has never seen more than one on the same female, and that no mature female is met without it, even though the ova are attached. My own observations accord with the above, but I am unable to add any suggestion as to the use of these organs.

The females are larger and usually darker in color than the male.

Habitat.—Shallow lakes and pools; everywhere abundant.

This species will repay well patient study, and from its abundance is easily found. This western variety is distinguished from the eastern type by the shape of the head, the greater brevity of the caudal stylets, the shape of the ova sac, the greater size of the fourth joint of the male antennæ, and other minor differences, which no great stress is laid upon, however; and these variations may be due to inaccuracies of the drawings of Baird's book. (See plate V.)

Sub-family 3. *Steropinae*, Dana.

Characters.—Form somewhat like *Sapphirina*, but the eyes minute, and generally situated in a prominence in the front. Superior antennæ short. Feet of the first pair monodactyl as in *Corycæidæ*. Caudal stylets short, sub-cylindrical.

Genus 1. *Zaus*, *Goodsir*.

Genus 2. *Sterope*, *Goodsir*.

No member of the family was met with.

FAMILY III. CORYCÆIDÆ.

The species are all oceanic. A species of *Sapphirina* is figured in the Rep. of Fish and Fisheries for 1871 and 1872.

TRIBE II. DAPHNIOIDEA. Dana.

Bibliography.—*Daphnioidea*, Dana, Rep. Wilkes' Expl. Ex., p. 1262.

Cladocera, Baird, Brit. Entomost. p. 62, 1850.

————— *Burmeister*, But. zur Naberg. Der Rankenfass.

Daphnides, Straus. Mem. Mus. d'Hist. Nat.

Daphnoides on Cladocères, M. Edwards, Hist. Nat. Brust., iii. 372.

————— Lucas, Exp. Sc. de l'Algine.

Characters.—This tribe which corresponds with the order *Cladocera* of Baird and some recent authors, is characterised as having the whole

body, exclusive of the head, (which is covered with a separate and similar plate) included in a large carapace, which is open below and behind, permitting the protrusion of the posterior portion of the abdomen, and allowing currents of water to pass within, both for respiratory purposes and to carry to the mouth particles of food.

The carapace is composed of three parts, in one species at least, and it would seem that this is the typical structure. The middle plate (in *Daphnia vetula*) lies over the dorsal region; the other two spring from it, flanking it on either side, and forming the bulk of the shield. We would suggest the probable similarity of the central shield to the caudal shield of other crustaceans, and the possibility that the now larger portions ought really to be considered as accessory simply.

The Daphnoidea possess from four to six pairs of foliaceous appendages, or branchial feet which do not assist in locomotion. The eye is apparently single and is a very prominent organ in all the members of the tribe, it is large and furnished with numerous lenses.

The superior antennæ are small, often obsolete, and except in *Bosmina* only one or two-jointed. The inferior antennæ are large, being the true organs of locomotion, and several-jointed.

The abdomen is incurved, mobile, furcate at the extremity and bears two prominences on the dorsal angle which are the origin of setæ.

The carapace is often beautifully reticulated and sometimes there are more than one sort or series of these markings. The Daphnoidea are distinguished from Cyproidea by the presence of posterior foliaceous legs, which is considered by Dana as of greater importance than the more obvious peculiarity—the exclusion of the head from the carapace.

Prof. Dana has united the genera of Dr. Baird's *Daphniadæ*, *Polyphemidæ* and *Lynceidæ* in this tribe, and this seems appropriate, since there cannot certainly be as wide a gap between *Daphnia* and *Lynceus* as between the curious *Bosmina* and *Daphnia*, yet the latter two were united in one family and *Lynceus* separated as totally distinct. The chief peculiarities which lead to the separation of *Lynceidæ* were first, the fact that they possessed in front of the eye a "black spot" of unknown use, and second, that the head was produced in front to form a more or less prominent beak.

But it has since been ascertained that the black spot is a common feature among the species of the whole tribe and, according to modern authors, is in some way connected with the base of the superior antennæ and serves, probably, as an organ of hearing.

The characters of the head seem to have been misunderstood. In all the species of the Daphnoidea which I have examined, the head seems to be covered with a curved plate or carapace, within which is the insertion of the organs of the head. Now a little change of position under the microscope serves to give to the anterior portion of this covering an acute or obtuse appearance, depending on which side of the carapace is in the focus of the instrument. As the shape of the beak is used as a generic character in this sub-division it seems quite probable that the matter will need further revision. The fact that the intestine is or is not convoluted was shown by Dana to be of no generic importance.

The characteristics of the tribe may be best seen as illustrated in the subdivisions.

FAMILY 1. PENILIDÆ. Dana.

Bibliography.—Penilidæ, *Dana*. Pro. Amer. Acad. Sci., ii., 47, 1849.

Sidina, *Baird*, Brit. Entomost., 106.

Sididæ, *Gray*, Cat. Brit. Crust. Brit. Mus., 93, 1850.

Characters.—Foliaceous feet twelve, narrow. Anterior antennæ obsolescent.

Genus 1. *Sida*, *Straus*. Posterior antennæ with the longer ramus three-articulate, shorter, two-articulate. Head not beaked below.

Genus 2. *Daphnella*, *Baird*. Both rami of posterior antennæ two-jointed. Anterior antennæ borne by the middle of the under aspect of the head.

Genus 3. *Penilia*, *Dana*. Both rami of the posterior antennæ two-jointed. Head short, produced below. Primary antennæ borne on the extremity. Species marine.

? Genus 4. *Latona*, *Strauss*. Posterior antennæ having three one-articulate rami.

Only one species of this family has been met with, which is here described.

*Genus 1.****Sida*, (*Straus*.)**

Bibliography.—*Sida*, *Straus*, Minn. Mus. Hist. Nat., v.

——— *M. Edwards*,

——— *Baird*.

——— *Dana*.

Daphnia, *Muller*.

——— *Latreille*, etc.

Monoculus, *De Geer*.

——— *Jurine*, etc.

Generic Characters.—Superior antennæ of moderate size. Longer rami of inferior antennæ with three articulations, shorter rami with two. Inferior antennæ very large and powerful.

***Sida crystallina*, *Muller*.**

Bibliography.—*Daphne crystallina*, *Muller*, Zool. Dan. Prod., No. 2,405, 1,776.

Daphnia crystallina, *Muller*, Entomost., 96, t. 14, f. 1-4.

————— *Latreille*, Hist. Nat. Crust. IV., 230.

————— *Rosc*, Minn. d'Hist. Nat. Crust. II., 231.

Sida crystallina, *Straus*, Minn. Mus. Hist. Nat., V.

Sida crystallina, *M. Edwards*, Hist. Nat. Crust., III., 383.

Monoculus crystallina, *Gmelin*, Linn. Lyst. Nat., edit. 13th, I. 3,000, No. 29.

————— *Manuel*, Enc. Mith., VII. 724, t. 265, f. 15-18.

————— *Fabricius*, Ent. Syst., II. 493.

Monoculus elongatus, *De Geer*, Mem. Servis Hist. Ins., VII. 470, t. 29, f. 1-4, 1,778.

Description, etc.—General shape that of an elongate rectangular prism, or sub-cylindrical. Carapace elongate oval, truncate before and behind, very transparent, being obviously reticulated only near the anterior portion.

Head large, obtuse in both vertical and horizontal aspect, furnished with a projecting disc or plate on the posterior part of upper surface. Eye round and rather large, red, with many corneæ.

Superior antennæ are quite observable, being rather long and armed with four bristles on the extremity.

Inferior antennæ very large. The basal joint is cylindrical, very large and fleshy, and wrinkled so as to appear many jointed. The two rami are unequal and rather short. The outer ramus has three articulations. The first is short and furnished with a minute spine. The second is longer and has three strong-jointed setæ on the inner margin, and a spine near its articulation with the third, which is of nearly the same length, and has four setæ on the inner margin, three at the end and a small spine at the upper outer angle.

The inner ramus has two unequal joints, the lower of which is much the longer, and is furnished with a spine and a seta, while the second has four large-jointed setæ at the extremity.

The labrum and mandible are similar to those of *Daphnia*.

The feet are of six pairs, which are described as follows:

The first pair consists of a main stalk of two joints, of which the first has four setæ, and the terminal (or "hand") joint seven. The first joint also has two branchial plates, of which the upper and smaller possesses nine or ten short setæ and one jointed and plumose filament, while the lower or main plate has about thirty plumose setæ. The second, third, fourth and fifth pairs are quite similar, but the stout setæ on the outer margin of the first joint are replaced by a triangular plate and the branchial filaments are shorter. The sixth pair has three articulations, each furnished with straight, stout spines, and is curved. The abdomen has at its extremity two strong, curved claws, which have each three spines on the basal half, and are dentate for the remainder of their length; it also has two tubercles at the angle behind each of which bears a long seta. Between the claws and these knobs are two rows of spines.

The ovary contains in full grown females, about twenty young, which resemble their parent from birth.

The organ on the top of the head is used as a sort of sucker, by which the animal adheres to water plants.

Their motion is rapid and steady. The circulation of the blood can be seen through the transparent walls of the body and head, as in the front part of the head, where the minute, colorless corpuscles are easily seen coursing from above. There appears to be a dorsal vessel just above the intestine in which these globules can be seen as they pass from behind forwards to near the juncture of the carapace with the glabella of the head, where is an enlargement forming the heart, the pulsations of which are uniform with the motions of the branchial feet. The motion of the feet, besides the aeration of the blood, propels (as in others of this family) a strong current of water between the bases of the limbs toward the mouth, bringing to it the particles on which it feeds and which it has no other means of capturing.

This interesting creature is quite rarely seen, whether from its reclusive habits or actual scarcity I do not know, but it deserves the attention of students, as presenting, both on account of its size and transparency and its somewhat anomalous structure, one of the best opportunities of investigating these little known forms.

Habitat.—"Grassy Lake," a pond tributary during high water to Lake Calhoun, near Minneapolis; also Diamond Lake. The animal seems to be found in lakes not completely isolated, and does not prefer so muddy a situation as most of the Daphnioidea.

The structure of this animal was compared minutely with the description given by Dr. Baird of *S. Crystallina*, and is beyond doubt identical. *Plates VI and VII.*

FAMILY II. DAPHNIDÆ.

Bibliography.—Daphnidæ, *Dana*, Rep. Wilkes' Expl. Exp., p. 1265.

————— *Dana*, Proc. Amer. Acad. Sci., ii., 1849.

Daphnita, *Gray*, Cat. Brit. Crust. Brit. Mus., 88.

Daphniadæ, (part), *Baird*, Brit. Entomos. 62.

Characters.—Foliaceous feet ten. Anterior antennæ one or two-jointed.

1. *Head large.*

Genus 1. *Daphnia*, *Muller*, (including *Ceriodaphnia* of *Dana*, which differ in the shape of the reticulations of the shell.)

Genus 2. *Moina*, *Baird*.

Genus 3. *Macrothrix*, *Baird* (including *Acanthocerus* of *Schodler*.)

2. *Head short.*

Genus 4. *Lynceus*, *Muller* (including *Eurycercus*, *Chydorus*, *Pera-cantha*, *Pleuroxis*, *Acroperus*, *Campotercus* and *Alona* of different authors, until some valid generic characters are announced.)

Genus *Daphnia*, *Muller*.

Bibliography.—*Daphnia*, *Muller*, Zool. Dan. Prod.

————— *Muller*, Entomost.

————— *Straus*, *Desmarest*, *Latreille*, etc.

Monoculus, *Linnaeus*, *Poda*, *Blumenbach*, *De Geer*, etc.

The Daphniæ are among our most abundant and most interesting Entomostraca, occurring in stagnant water everywhere, they are very prolific and voracious. This genus is confined strictly to fresh water.

The general characters will be gathered from the description of the tribe and of the species. The superior antennæ are usually rudimentary and hidden, but vary with the sexes. The most prominent organs are the inferior antennæ, which are large and powerful. They consist at the base of a single large, fleshy joint which has all possible play upon its attachments. This joint supports two branches of nearly equal length, but the outer is usually four-jointed, while the inner has but three articulations. Each of the last three is furnished with a long seta which is jointed at the middle, and usually pectinate, forming a fine swimming organ. The eye is a large, conspicuous organ near the front and is so furnished with muscles that it has a semi-rotation. This organ occupies a prominence on the underside of the head, which projects backward supporting the minute antennæ and the black spot before noticed. *Baird* says that the eye was mistaken by one author for the *stomach*. The chief ganglion of the nervous system lies near and communicates with the eye. The mouth lies at the back of the prominence described, and is armed with a labrum, a pair of mandibles and a pair of jaws. For particulars of structure see plate IX.

The digestive system is the most conspicuous part of the creature when filled. It is then often of a brilliant green color, extending along the whole dorsal region. The œsophagus is short, opening into the stomach just behind the brain ganglion. From this point the stomach curves upward and extends thence through the whole length of the animal. The contractile vessicle above the stomach is quite an obvious feature, but Gruithuisen says there are two hearts, one venous, the other arterial, but this is probably not established, though the existence of a dorsal vessel above the stomach is probable from analogy and observed appearances.

The legs, which are of five pairs, vary considerably, but the same plan is preserved. At the base of each is a branchial plate furnished with fine branchial filaments corresponding to gills, while the remaining portions of the leg serve to create currents of water toward the mouth. The result is a vigorous current between the legs under the body, which transports the food particles to the maxillæ. The ovaries are along the sides of the abdomen, and the ova are normally hatched within the shell of the parent above the abdomen.

These creatures have been supposed hermaphroditic, from the extreme scarcity of the males, but they are in this respect like the Aphides, being parthenogenetic. Besides the ova which are hatched within the shell of the living parent, another method is seen. The outside of the carapace grows opaque, and finally two spots appear within which are the eggs. When the moult takes place, the carapace with its burden is left in the water until a favorable time, when the eggs hatch. This obviously is a protection against the cold of winter, for the ephippium, as the carapace thus loaded is called, is thick and horny. The ephippia may be observed in winter, floating about in the water, often in abundance. (See plate IX.)

Daphnia Pulex.

- Bibliography.*—*Monoculus pulex*, *Linncæus*, *Sys. Nat.* 10 Ed., i., 635, No. 4, 1758.
 ———— *Gmelin*, *Syst. Nat.* 13th Edit., i., 2999, No. 4.
 ———— *Poda*, *Ins. Mus. Græcus*, 124.
 ———— *Muller*, *Faun. Insect*, *Fredrichsdalens*, 95.
 ———— *Blumenbach*, *Handbuch der Naturg.*, 399.
 ———— *Manuel*, *Enc. nieth.*, VII., 722, No. 15, t. 265, f. 1-4.
 ———— *Fabricius*, *Entoml. Syst.*, ii., 497.
 ———— *Leach*, *Encyc. Brit. art. Entoml.*
 ———— *Jurine*, *Hist. des Monoc.*, 85.
 ———— *Cuvier*, *Tab. Element.*, 455.
Daphne pulex, *Muller*, *Zool. Dan. Prod.*, 199, No. 2400, 1776.
Daphnia pulex, *Latreille*, *Gen. Crust. et Ins.*; *Hist. Nat. gen. et part.*, des *Crust*; *Règne Anim.* Cuv.
 ———— *Lamarck*, *Hist. Nat. des An. s. Vert.* Edit. 2, V., 181, No. 1.
 ———— *Lamouelle*, *British Insects*, 81.
 ———— *Straus*, *Mem. der Mus. d'Hist. Nat.*, v. t. 29.
 ———— *Demarest*, *Consid. gén. sur les Crust.*, 372, t. 54.
 ———— *Baird*, *Ann. Nat. Hist.*, i., 254.
 ———— *M. Edwards*, *Hist. Nat. des Crust.*
 ———— *Guerin*, *Iconograph. Crust.*, t. 33.
Daphnia pulex, *O. Fabricius* *Faun. Groenland.*, 263.
 ———— *Leach* *Edm. Encyc.*, vii. art. *Crustaceol.*

Daphnia pennata, *Muller*, *Entomost.*, t. 12, f. 4-7.

————— *Bosc*, *Man. d'Hist. Nat. des Crust.*, ii., 280.

————— *Schrank*, *Faun. Boic.*, iii., 264.

Monoculus pulex arborescens, *Linn.* *Syst. Nat.* 4th Edit., 96.

Pulex arborescens, *Swammerdam*, *Hist. Nat. Ins. Gen.*, 76, t. 1,
f. o. b. c. *Biblia Naturæ*, 86, t. 31, f. 1-3.

————— *Goeze* *Naturfoscher*, pt. 7.

• *Monoculus pulex ramosus*, *De Geer*, *Mém. pour servir à l'Hist. Ins.*, vii., 442.

Daphnia ramosa, *Koch*, *Deutsch. Crust.*, h. XXXV., t. 18.

Daphnia media, *Koch*, *Deutsch. Crust.*, h. XXXVII. t. 1.

Daphnia ehippiata, *Koch*, *Deutsch. Crust.*, h. XXXV t. 16.

Puckron branchu, *Trembley*.

Water-flea with branching horns, *Baker*, *Empl. for Micros.*

Pou aquatique, *Joblot*, *Observ. d'Hist. Nat.*

Le Perroquet d'can, *Geoffroy*, *Hist. abrég. Ins.*

Vermes minimi rubri, *Merrett*, *Pmax Res. Nat. Brit.*

Ammaletti aquatici, *Redi*, *Asservaz^oni. Opere.*

Monoculus, *Bradley*, *Phil. Occ. of Works of Nature.*

Le Puceron verdatre, *Ledermuller*.

Var. 1. *Daphnia longispina*, *Muller*.

————— *Latreille*.

————— *Bosc*.

————— *Ramdohr*.

————— *Lamarck*.

————— *Straus*.

————— *Demarest*.

————— *M. Edwards*.

————— *Koch*.

Monoculus longispinus, *Fabricius*.

————— *Manuel*.

————— *De Geer*.

————— *Schœffer*.

Var. 2. *Daphnia magna*, *Straus*.

————— *Demarest*.

————— *M. Edwards*.

Description.—Carapax oval or sub-quadrangular, transparent, more or less reticulated on all or part of the surface. Head large, more or less beaked. Superior antennæ very small. Inferior antennæ strong and long. The superior antennæ have five small setæ at the apex, while the inferior pair are armed with the usual complement of setæ, which in this species are finely plumose.

The color of this animal, which is our commonest and one of the largest species, is dependent upon the food taken into the stomach, which extends through nearly the whole length of the body in all the species. When feeding upon clean vegetation the intestinal canal is of a brilliant green hue, while at other times it is dark or brownish. In England they are often of a bright red color throughout, but I have never met with such here.

The carapax is terminated posteriorly by a serrated spine, which is variously situated, and varies also with the age of the animal. In one variety the spine is situated at the upper posterior angle while in others it springs from the centre of the posterior aspect. In the young the spine is long, almost equaling sometimes

the carapax in length, but at each successive moulting the spine is found to be shorter. The upper part of the body has four projections, one of which is longer than the others and serves evidently to keep the ova in position.

Dr. Baird says that "the male is much smaller than the female", which is the case in nearly all the species, "and the superior antennæ are much larger and spring from under the beak instead of from the beak itself. The inferior extremities of the valves are more densely serrated than in the female."

The males are always fewer than the females. The motions of this creature are quick, spasmodic leaps through the water, and it often presents a beautiful appearance.

Daphnia Vetula.

Bibliography.—*Daphne vetula*, Muller, Zool. Dan. Prod., No. 2399.

Daphnia vetulo, Straus, Mém Mus. Hist. Nat., V., t. 29, f. 25-6.

————— Baird, Ann. Mag. Nat. Hist., i., 255, t. 9, f. 13.

Daphnia sima, Muller, Entomost., 91, t. 12, f. 11-12, 1785.

————— Latreille.

————— Bosc.

————— Ramdohr.

————— Gruithuisen.

————— Desmarest.

————— Lamarck.

————— M. Edwards.

————— Koch.

Monoculus sima, Givélus.

————— Manuel.

————— Jurine.

Monoculus lævis, Fabricius.

Monoculus expinosus, De Geer.

Monoculus conchacus, Donovan.

Ungeschwauzter-zackiger, Wasserfloh, Schæffer.

Monoculus nasutus (?) Jurine.

Monoculus pulex, Sulger.

Daphnia congener, Koch.

Daphnia expinosa, Koch.

Description.—In size like *Daphnia pulex*, some forms of which it resembles. Carapax in the male quadrangular with the sides nearly parallel, the posterior prominence being near the dorsal part of the shell. In the female, however, the prominence is near the middle of the posterior side, while the carapax is widest near that extremity. The spine usually present in the larger Daphnidæ is obsolete, but there is a series of small spines or teeth on the upper posterior margin. The lower edge is strongly ciliated. The carapax is strongly lined transversely. These striæ arise from the one or two rows of hexagonal cells which border the lower margin, and anastomose occasionally, giving in some cases a reticulated appearance to the shell. The head is very small proportionately, rounded in front, and rather strongly beaked below.

The superior antennæ are quite evident. Inferior antennæ large. The first joint is fleshy and stout, margined at the extremity with spines and sending out three branches, of which the two large swimming organs are as in *pulex*, having the plumose setæ, etc. At the base and between these is a third, consisting of a conical point with a broadened base ending in a spinous appendage. The scuta

of the head seems wider and less arched than in other species. Jaws long and ending in a circle of fine teeth. Feet as in *pulex*.

Seen from above the carapax of the body is found to consist of three pieces. The first, which might be termed the scutella, is a small shield adjoining the head, and the two principal pieces or valves of the shell may be considered as appendages of the scutella. These pieces may be compared to the *tergum* and *pleuron* of trilobites.

The structure of the beak and its relation to the head is more clearly seen than in most of the *Daphniæ*. The head shield as seen from below is transversely sub-oval. Directly in front and very near the anterior margin of the skull is an eye, filling a circular elevation reaching the anterior margin, and sending off posteriorly a ridge or straight partition which divides the lower aspect of the head into two basin-like cavities. This ridge terminates in the beak which carries the superior antennæ and the black spot which Huxley calls an ocular pigment, but by other authors is thought to be attached to the auditory apparatus, and is termed by Dana the "otoliths", following Schoder in so considering it. (See *Plates X. and XI.*)

Daphnia Mucronata.

Bibliography.—*Daphne mucronata*, Muller, Zool. Dan. Prod., No. 2404, 1776.

Daphnia mucronata, Muller, Entomst., 94.

————— *Desmarest*, Cons. gèn. Crust. 374.

————— *Latreille*, Hist. Nat. Crust., IV., 229.

————— *Bosc*, Man. d'Hist. Nat. Crust., ii., 281.

————— *M. Edwards*, Hist. Nat. Crust. iii., 382.

————— *Baird*, Trans. Berw. Nat. club, ii, 148.

————— *Monoculus mucronatus*, *Gmelin*, Linn. Syst. Nat., edit. 14th, i., 3,000, No. 28.

————— *Manuel*, Enc. Mith., t. 265, f. 19.

————— *Jurine*, Hist. Nat. Monoc. 137, t. 14, f. 1, 2.

Monoculus bispinosus, *De Geer*, Mem. Servir. Hist. Ins., VII., 463, 1778.

————— *Fabricius*, Ent. Syst., iii., 493.

Daphnia bispinosa, *Koch*, Deutsch. Crust., h. VIII., t. 1.

Description.—General shape, as seen from above, oval. Lower margin of the carapax straight, terminated posteriorly by a curved spine. Head triangular, obtuse in front. Eye large. Superior antennæ small. Inferior antennæ long. Lower part of the carapax ciliated. Color dark. Dr. Baird says that the form of the head varies in this species, being sometimes rounded and at others terminated by a sharp, somewhat curved point directed upwards.

I have not observed in any of the many specimens seen a sharply pointed head; and though this point casts some doubt on the identification, every other point in his description seems to agree very well with our species, which I find no warrant for separating from *D. mucronata* var. *obtuse rostrata*.

Habitat.—Sandy Lake (East Minneapolis), Clark's Lake, Grassy Lake, etc. (See *Plnte XII.*)

Daphnia (Ceriodaphnia, Dana) Reticulata.

Bibliography.—*Monoculus reticulatus*, *Jurine*, Hist. Nat. Monoc., 139, t. 14, f. 3, 4.

Daphnia reticulata, *Desmarest*, Cons. gén Crust., 374.

M. Edwards, Hist. Nat. Crust., iii., 381.

————— *Baird*, Trans. Berws. Nat. Club. ii., 148.

Daphnia ventricosa (?) *Koch*, Deutsch. Crust., h. XXXV., t. 21.

Daphnia quadrangula, *Muller*, Ent., 90, t. 13. f. 4.

————— *Latreille*, Nat. Hist. Const. IV., 227.

Monoculus quadrangula, *Gmelin*, Linn. Syst. Nat., 2999, No. 24.

Monoculus quadrangularis, *Manuel*, Enc. Mith., VII., 723, No. 15.

Monoculus quadrangulus, *Fabricius*, Ent. Syst., ii., 492.

Note.—I was not able to fully satisfy myself that this is certainly identical with the species described by Baird but there are no good reasons for believing it a distinct species. It is round enough for *D. rotunda*. There is an evident spine on the posterior angle of the shell, though it sometimes is almost obsolete.

The reticulations are hexagonal (?). The color in the specimens examined is greenish, and moreover the superior antennæ agree better with *reticulata* than *rotunda*. The size is small.

Description.—Small (.02 in. or over). Carapace oval and comparatively very broad, covered with hexagonal markings. Head small as compared with the body, and more nearly at right angles with it than in most of the *Daphniæ*. There is also a slight depression a little in front of the juncture with the body. Superior antennæ rather larger than in most *Daphniæ*, and somewhat movable. Inferior antennæ quite large. Beak none. Feet as in the larger species.

This species is very active on account of the length of the antennæ, which have shorter spines (not plumose) than *D. pulex*. It presents a robust appearance in swimming either on its back or face, since it is much broader in proportion than most other species.

Habitat.—Lake Amelia, Grassy Lake, etc. Not very abundant but widely distributed.

Baird says of this species: "The ephippium differs considerably from that of *pulex*. It is more rounded, white at the centre, with a large round ampulla, containing only one ovum. When the animal has the ephippium on, it possesses a square appearance, and is the *D. quadrangula* of Muller."

This is one of the commonest species in many of our lakes, while in others it is replaced by the *pulex*, for as yet I have not seen them both in the same locality.

Habitat.—Grassy Lake, Lake Amelia, etc.

(See Plate VII.)

***Daphnia spinosa*, Herrick.**

Description.—General shape of the *Daphnia pulex*; carapace armed at the upper posterior margin with a rather long, serrated spine. The first of feet are long, bristled at the extremity as in young specimens of *D. pulex*. The anterior antennæ are larger than in *pulex* and two-jointed and setæ-bearing at the end. Posterior antennæ exactly as in *pulex*. The eye is nearer the antennæ than in other species, but the most striking peculiarity is the pointed spine formed by the front of the head, which is very marked. Carapace not obviously reticulated, transparent.

Habitat.—Found in Lake Calhoun, but not in large numbers. It seems to inhabit the deeper waters.

(See Plate XIII., p. 1.)

GENUS **Macrothrix**.

(Sig.—long hair.)

- Bibliography*.—*Macrothrix*, Baird, Ann. Mag. Nat. Hist., XI, 87, 1843, and XVII, 412; Trans. Berw. Nat. Hist. club, ii, 149.
Daphnia, M. Edwards, Hist. Nat. Crust., iii, 384.
 ———— Muller (?) Entomost.
Lynceus, Desmarest, Cons. Gen. Et. Part. Crust., 376.
Monoculus, Jurnine, Hist. Monoc. Generc.
Acanthocercas, Schulder Ericks, 1846.
Macrothrix, Dana, Wilkes' Explos. Exp. Report.

Characters.—Head, beneath, either subacute or rather obtuse, anterior antennæ rather long, pendulous from the beak, eye accompanied by a rather large black spot at the base of the antennæ; seta from first joint of anterior branch of inferior antennæ much longer than the others.

Macrothrix agills, Herrick.

Description.—Head shield (as seen from above) very nearly square; body carapace pear shaped; eye smaller than in *Daphnia* and accompanied with a rather large black spot similar to the obvious spot in *Lynceus*, but even larger. Superior antennæ very long in comparison with other members of the family. Inferior antennæ rather large, armed with large setæ, of which the spine from the end of the first joint is extremely elongate and plumose, nearly as long as the body. This joint also has a small spine on the opposite or upper side of the ramus.

The spine from the second joint is larger than in *Daphnia*. The final joint bears a small spine also in addition to the three setæ. (In the drawing both of the rami have the elongate seta. This may be a mistake in the observation, which was made in some haste.)

The jaws, feet, and posterior segments of the body, are similar, as far as observed, to like organs in *Daphnia*.

The lower and posterior part of the margin of the carapace bears a number of long stout spines directed backward. The posterior body filaments, instead of being simple or only plumose, are divided at the extremity into four small bristles, forming a tassel or brush at the end.

The intestine is not convoluted but is more abruptly curved and depressed near the head than in *Daphnia*, thus approaching *Lynceus*.

The motions of this interesting animal are lively and impetuous, it being assisted by the long filaments of the antennæ, which, with the body spines and strong teeth of the shell, give to it a spider like aspect.

This species differs materially from any described by Baird, or any other author with which I am familiar, but even if the elongate filaments should prove to be common to both rami of the antennæ, it must fall in this genus.

Habitat.—Only observed in Rocky Lake, a small pool near East Minneapolis.

Plate XIV.

GENUS **Lynceus**, Muller.

This genus was rejected by Dr. Baird who founded upon its remains a number of genera, most of which were rejected in turn by Prof. Dana, who recognized the following:

Lynceus, *Eurycercus* and *Alona*.

Lynceus=*Eurycercus* of Dr. Baird.

Eurycercus=*Chydorus*, *Percantha* and *Pleuroxus*.

Alona=*Alona*, *Acroperus* and *Camptocercus*.

In the genus *Alona*, he says, the beak diverges from the body at a large angle (60° to 90°) with the shell adjoining, while in *Lynceus* it is usually curved parallel to it.

But, as Dana himself admits, the distinctions are of doubtful importance, and it would seem preferable to retain Muller's old genus instituted for all of these forms than to further complicate the matter until a large amount of material shall be gathered and compared. The species observed will, therefore, be briefly described and the probable place in the rejected genera indicated.

***Lynceus macrourus*. Muller.**

Bibliography.—*Lynceus macrourus*, Muller, Dan. Prod., 2397.

————— *Latreille*, Hist. Nat. Crust., 207.

————— *M. Edwards*, Hist. Nat. Crust., iii. 388.

Monoculus macrourus, Genelin, Syst. Nat., 3008, No. 65.

Monoculus macrourus, Manuel, Enc. Mith., vii, 733, No. 68.

————— *Fabricius*, Ent. Syst., ii, 499.

Camptocercus macrourus, Baird, Ann. and Mag. Nat. Hist. ii;
Trans. Berw. Nat. Club. ii, 150; British Entomost. p. 128.

Description.—Carapace pear-shaped, transparent, finely lined longitudinally, sinuated on the lower margin, which is ciliated for most of its length. Head rather small, with a short, blunt beak projecting straight downwards. Superior antennæ rather large, situated about half way from the extremity of the beak to the body. Inferior antennæ long, with long setæ at the extremity, eyes small, first pair of feet large, abdomen very long and slender, serrated with well marked teeth on the posterior edge and terminating in the usual pair of claws. The extreme length and narrowness of the abdomen formed the basis of the genus *camptocercus* of Dr. Baird, this species being the only one described under it. The intestine is convoluted, and there is an opening near the juncture of the last segment of the abdomen with the rest of the body from which a long vessel begins and extends above the stomach, as at (a) Fig. 1, Plate XV. This species is quite abundant.

***Lynceus quadrangularis*, Muller.**

Bibliography.—*Lynceus quadrangularis*, Muller, Zool. Dan. Prod., No. 2393,
1876.

————— *Latreille*, Hist. Crust., 208.

————— *Baird*, Trans. Berw. Club.

————— *M. Edwards*, Hist. Crust., iii., 388.

————— *Kock*, Deutsch. Crust. L. XXXVI.

Monoculus quadrangulus, Gmelin, Maduel.

Monoculus quadrangularis, Fabricius.

Monoculus striatus (?) Jurine.

Alona quadrangularis, Baird, Ann. and Mag. Nat. Hist., ii. 92
Trans. Berw. Club, ii. 151;
Entomostraca, p. 131.

Description.—Carapace ovate quadrangular, but somewhat variable, being in some specimens quite abruptly rounded on the posterior margin, while in others it is almost truncate; shell of a yellowish or brown color, heavily marked and ciliated below. Beak blunt, varying in position in different individuals. Abdomen flat, sinuated at the extremity and bearing long claws. Anterior antennæ of moderate size. Eye rather large. Larger antennæ rather long.

Total length between .03 and .04 in. This species is also quite abundant, and if I am right in referring it to the *L. quadrangularis* of Muller, is quite variable. Drawings made from individuals collected at different localities on comparison show minute differences of form and markings. The intestine is strongly convoluted in this species, but the dark color of the shell usually interferes with observations of the organs within.

Plate XV. fig. 2.

Lynceus sphæricus, Muller. (?)

Bibliography.—*Lynceus sphæricus*, Muller.

—————Latreille.

—————Lamarck.

—————Desmarest.

—————Baird.

—————M. Edwards.

—————Prichard.

—————Koch.

Monoculus sphæricus, Gmelin.

—————Manuel.

—————Fabricius.

—————Jurine.

Monoculus infusorius, Schrank.

—————Eichorn.

Chydorus Mulleri, Leach.

Chydorus sphæricus, Baird, Ann. and Mag. Nat. Hist. ii. 89, t. 2;
Brit. Entomst. p. 126.

Description.—Baird's description of this species is applicable to any one of several almost equally, and the only recourse seems to be a reliance on the figure he gives with which our species seems to correspond quite well.

The shell is round and nearly blunt behind, the antennæ are quite small, so that the animal rolls slowly along like a corpulent sailor on land. Not enough attention has been devoted to this and the following species of the genus. Length, .03 in. Plate XIII, fig. 2.

Lynceus sp.?

See *L. (Pleurus) trigonellus*, *P. uncinatus* etc. cf Baird.

The animal figured in Plate XII, Fig. 3, evidently belongs to the genus *Pleuraxus* of Baird. In examining several specimens the turned up beak was found in several cases while in others it was seen as represented at (3a) of the same plate. Dr. Baird separated two species on the ground of this variation, but it does not seem to be a specific character. The length is .03 in. in the species seen, and except that the shell is longer in proportion, agrees pretty well with *L. trigonellus*, Muller.

Lynceus sp.?

Another member of the genus differing from any description met with is shown in plate XVI. It is the smallest form seen, not exceeding .02 in. The feet are proportionally large, as is the eye, while the antennæ are quite small.

FAMILY **Bosminidæ.**

This family has been removed, by Prof. Dana, (justly it would seem to us) from *Dahpniidæ*. The general appearance is unique, and the characteristics of the superior antennæ places the only member in the single genus composing this family at quite a distance from *Daphnia* and its allies.

Characteristics.—Foliceous feet, ten in number; anterior antennæ elongate and many-articulate.

GENUS **Bosmina.**

Bibliography.—*Daphnia*, *M. Edwards*.

————— *Desmarest*.

————— *Baird*.

Monoculus, *Jurine*.

Lynceus, *Muller*.

————— *Latreille*.

Bosmina, *Baird*, Trans. Berw. Nat. Club, 1845; Ann. Mag.

Nat. Hist. VI., 412.

NOTE. (Name)—“Bosmina,” a daughter of Fingal.

Generic characters.—Superior antennæ long, curved, cylindrical, consisting of many small articulations, and projecting from the extremity of the beak; inferior antennæ small as compared with size of the body.

Bosmina longirostris.

Bibliography.—*Lynceus longirostris*, *Muller*, Zool. Dan. Prod., No. 2394; Entomost., 76.

————— *Latreille*, Hist. Nat. Crust. IV., 206.

————— *Fabricius*, Ent. Syst., ii., 499.

Monoculus cornutus, *Jurine*, Hist. Nat. Monoc.

Daphnia cornuta, *Desmarest*, Cons. Gen. Crust.

————— *Baird*, Ann. Mag. Nat. Hist. ii., 257.

————— *M. Edward*, Hist. Nat. Crust., iii., 382.

Bosmina cornuta, *Baird*, Trans. Berw. Nat. Club.

Eunica longirostris, *Koch*, Deutsch Crust., h: XXXV. t. 23.

Description.—General form varying from nearly square to an irregular pear shape (the large portion anterior); carapace terminated on the lower posterior margin by short, curved spines. Head of moderate size, eye large, superior antennæ long, projecting from the beak, consisting of many articulations, the seventh joints furnished with setæ. Inferior antennæ small. Ova few.

The length of this animal is less than .02 in., which makes it a difficult matter to clearly discover the structure of the organs.

The superior antennæ are nearly immovable, and being closely in juxtaposition, give the appearance of a long, jointed beak or trunk. In fact, the first idea

suggested by this bizarre creature is a peculiar burlesque on the elephant. It requires favorable light and a high power to study the nature of the antennæ. The feet are apparently wider than in *Daphnia*. Under a favorable light, the carapace is seen to be reticulated with hexagonal cells (at least near the edge) and is covered, in some specimens at least, by exceedingly minute tubercles. The motion is steady, progressive, and not saltatory, as in many *Daphniæ*, which is due (as in *Lynceæ*) to the shortness of the antennæ. The species from which this description is drawn may be distinct from the *longirostris* of Baird, but on comparing both alcoholic specimens and drawings made from living specimens, no differences of importance were detected. The reticulated and tuberculated nature of the shell may be a local variation, or may have easily escaped his notice. The form of the shell demonstrably varies, and so probably does the number of apparent joints to the superior antennæ. The species was found in only one locality, having been dipped with a bottle from the bottom through the ice. but the time of collection is lost. Later, careful search was made during autumn, but no specimens rewarded the pains. The markings, and jointing of the antennæ would make good tests for microscopes of moderate power, for such as are interested in this subject.

Habitat.—Johnson's lake, Minneapolis.

(See Plate XVII.)

TRIBE III. CYPROIDEA. Dana.

Characters.—Dana gives the following: "The Cyproidea differ from all other crustacea except the *Lernæoids* [and *Rotatoria*] in the absence of the pairs of appendages belonging to all the normal cephalothoracic segments posterior to the eighth, that is, to the six posterior of these segments. The last two of these six pairs are obsolete in all the *Lophropoda*; and in the *Cyclopoidea* and *Daphnioinea* the first four of them are natatory and foliaceous, together with also another pair, next anterior in most species. The pairs of appendages present in the Cyproidea posterior to the mandibles, in number four pairs, are divided variously between mouth and legs." This tribe embraces two families, only one of which is represented in our locality, and aside from the general characters of the oceanic family we must confine ourselves to the other.

FAMILY I. Cypridæ. Dana.

Characters.—Antennæ of the second pair subterete, three to five-jointed. Mandibles two-branched, the main branch or body, denticulate at the extremity, the minor branch, or palpus several-jointed, palpus remote from the apex of the mandible; eyes with their pigments united, minute, with spherical lenses. Feet either two or if more, slender and pediform.

SUB-FAMILY 1. CYPRINÆ. Dana.

Bibliography.—Cypris, Muller and others.

Cyproides (in part) *M. Edwards*, Hist. Nat. Crust.

Cypridæ (in part) *Baird*, Trans. Berw. Club. ii, 153.

Cypridæ, Baird, Brit. Entomost., p. 130.

Characters.—Feet, two pairs; anterior slender and pediform, posterior weak; Abdomen elongate, bearing two clawed appendages.

The cyprinæ, in common with all the members of this tribe are enclosed in a brittle, mussel-like shell which hides from view, in general, all of body and members, except the extremities of the two pairs of antennæ and a pair of feet. They vary in size from an animal of sufficient size to be easily watched with the naked eye, and resembling a small *Unio* in shape and color, to creatures so minute that it is with the greatest difficulty that the valves of the shell are removed without destroying the parts within completely. This peculiarity of these animals renders them among the most difficult in all this order to study. The shell is usually opaque, and sometime beautifully colored and fringed. When, however, the soft parts within are separated from the crustaceous envelope the beauty and peculiarity of the structure well repays the student. The shell is composed of two valves, which are only united for a short part of the dorsal margin, and which are held together by muscles which are under the control of the animal. These valves are symmetrical with each other in general and are covered by a sort of varnish, which seems to repel the water so that when the creature takes air within the valves of the shell, and hence floats upon the surface it is impossible to cover it with water to prevent the glitter from the surface, while the air within prevents, by its refraction, a view of the interior in such as are transparent. On removing the shell the body is seen to consist of two parts, of which the anterior, or cephalothorax, is considerably the larger and is furnished with organs as follows: first, the eye, situated on the upper portion of the anterior aspect, which, according to Baird, has no crystallines. By Dana, however, two lenses are described; second, the superior antennæ, which are in general seven-jointed, and setigerous. These organs are always kept in vigorous motion when the animal swims. The setæ are sometimes plumose; third, the inferior antennæ. These are more like feet than antennæ and are five-jointed, and in one genus abundantly covered with (sometimes plumose) setæ. In all they are furnished with strong claws at the extremity; fourth, mandibles, which are composed of two parts, the main portion consisting of a triangular plate terminating below in a curved neck, bearing at the end a number of teeth. From the base of the neck arises a second portion, which is three or four-jointed and setigerous. From the end of the first joint of this palpus springs a small plate (branchial?) which has several fine filaments; fifth, first pair of maxillæ. These organs consist of a basal portion and the proper maxillæ which are of two rami, each ramus being furnished with setæ. There is also an attached branchial plate extending within the shell directed upwards and backwards; sixth, maxillipeds. These organs vary in Cypris. As figured by both Dana and Baird, they are of two rami, or have a "maxillary process," but in the species of *Candona* here figured they seemed to resemble the maxillipeds of the *Cyclopoidea*; seventh, first pair of feet. These are five-jointed and terminate in a strong hooked-claw which is directed forward, opposing the second pair of antennæ.

The second portion of the body or abdomen has but two sets of appendages, which are the second pair of legs and the caudal stylets. The second pair of legs are slender and four-jointed, and are directed backward along the abdomen. The caudal appendages are long and terminate in two claws. The anus opens between them. Of the other organs little or nothing is known. Baird was in doubt whether they were hermaphrodites or one copulation sufficed to render the mother and her offspring fertile for life, as in *Daphnia*. I have, however,

observed copulation in *Cypris*, and the peculiar organs represented in the plate of *Cypris* seem to be restricted to the male, so that it is certain that the sexes are distinct.

These minute creatures moult frequently, casting off in the process the minutest hairs as well as the shell.

This sub-family contains two genera, both of which are represented by a few abundant species within our limits.

GENUS 1. *Cypris*, Muller.

Characters.—Antennæ of the second pair furnished at the end with a bundle of long hairs, by means of which the animal swims freely in the water. The structure is that of the sub-family.

It is very difficult to characterize the species, and it will be necessary to rely chiefly on the figures, since there is little variation in internal structure between the species.

Cypris vidua, Muller. (?)

Bibliography.—*Cypris vidua*, Muller, Zool. Dan. Prod. No. 2384.

—————Latreille, Hist. Nat. Crust., IV. 245.

—————Bosc, Man. d'Hist. Nat. Crust.

—————Desmarest, 385, t. 55, p. 4.

—————Baird, Trans. Berw. Club, ii. 152.

—————M. Edwards, Hsst. Nat. Crust., iii. 399.

Monoculus viduus, Gmelin, Linn. Syst. Nat., 3002, No. 42.

—————Manuel, Enc. Méth., vii., 726, No. 36.

—————Jurine, Hist. Nat. Monoc., 175.

—————Rees, Cyclopedia, art. Monoc.

Monoculus viduatus, Fabricius, Ent. Syst., ii. 496.

(I here give Dr. Baird's description verbatim for comparison with the figure.)

Description.—"Shell of oval form, a little sinuated on the under margin, and beset all round with dense, fine, short hairs. The color is dull white, and the valves are distinctly marked with three black, somewhat waved fasciæ running transversely across the shell at equal distances, the most anterior of the three being smallest. Posterior margin rather narrower than anterior."

This species, if it be the one figured beyond, is the most abundant of this family here, inhabiting all the pools and lakes. It is quite small, appearing as a small speck, either floating on the surface or swimming rapidly about, with a sort of running motion, reminding one of the haste of an excitable man, in its seeming uncertainty and briskness. In figure 1, the shell is represented as transparent, to indicate the position of the organs. The size and shape of the dark bands upon the shell vary in different individuals.

(See Plate No. XVII. fig. 1.)

Cypria neglecta, Herrick.

This species is apparently different from any other which I have seen described. The size is very small, little exceeding .01 in. in length. The shape is, as seen from the side, a very perfect oval, not sinuate below, but narrower posteriorly

than in front. The lower edge of the shell is rather straight, while the upper narrows behind, to form the more acute apex. The color is dull white, without markings of any kind. The shell is more gibbous than any of the other species seen, and is quite glabrous.

The antennæ and feet are not protruded as far as in *vidua*. This species is also abundant.

Plate No. XVII. fig. 2.

GENUS *Candona*, Baird.

Baird's Brit. Entomost., p. 151.

Characters.—Distinguished from *Cypris* by the absence of the tuft of long hairs on the secondary antennæ, and the consequent creeping method of locomotion, and, perhaps, by a difference in the form of the maxillipeds.

Candona ornata. Herrick.

Resembles in size *C. lucens* of Baird, and is of somewhat the same shape. The lower posterior margin is acute, the lower margin is sinuated and the whole margin is beset with hairs. The edge of the shell is also bordered by a series of markings; the antennæ of the second pair are totally without setæ as far as observed; the shell is white and opaque with pearly lustre. This species is not very gibbous. (See Plate No. XX., Fig. 1.)

Candona (?) *elongata*. Herrick.

Shell reniform, very elongate, white, glabrous; the umbones of the valves are about two-thirds the distance from the anterior to the posterior dorsal margin; the portion of the shell anterior to the prominence thus formed is narrower than the posterior. It is questionable whether this be a member of the genus *Candona* or in reality a *Cypris*. The animal is quite large and the structure was more clearly made out than in the above. The same pair of bodies seen in the male *Cypris vidua* was found in this animal, the form of the maxillipeds, moreover, was found to differ from that given under the genus *Cypris* by Dana. It is to be hoped that some one may be able to devote a little patient study to this group and clear up the habits and structure as well as the history.

SUB-FAMILY II. CYTHERINÆ.

Cytheridæ, Baird, Brit. Entomostraca, 162.

Characters.—Feet six, all slender, alike and pediform.

Genus 1. *Cythere*, Muller.

Shell thin and light, tail short.

Genus 2. *Cythercis*, T. R. Jones.

Shell corrugate or tuberculate, animal unknown.

FAMILY II. HALOCYPRIDÆ.

This family includes two sub-families and three genera of oceanic species differing in almost all the organs from the above.

SUB-ORDER PHYLLOPODA. (sig. Leaf-footed.)

Bibliography.—Phyllopoda, *Latreille*, Hist. Nat. Crust., IV., 130, 1802.

—————*Leach*, Dict. Sc. Nat. XIV., art. Entomost.

—————*M. Edwards*, Hist. Nat. Crust., iii., 351.

—————*Desmarest*, Consid. Gen. Crust., 357.

—————*J. E. Gray*, Synops. Brit. Mus., 1842.

—————*Burmeister*, Organiz. of Trilobites, 34.

—————*Lucas*, Explor. Sc. de l'Algerie, Crust., 81.

Phyllopa, *Latreille*, Cuv. Règne Anim., IV., 171.

Branchiopodes Lamellipedes and Branchiopodes, *Geans* (in part),

Lamarck, Hist. An. S. Vert., V.

Characters.—Number of abnormal feet greatly multiplied.

TRIBE I. ARTEMIOIDEA.

Family 1.—Artemiodæ (Branchipodidæ.)

Family 1.—Nebaliadæ.

TRIBE II. APODOIDEA.

Family 1.—Apodidæ.

TRIBE III. LIMNADIOIDEA.

Family 1.—Limnioidæ (Estheridæ. ?)

ARTEMIOIDEA.

Bibliography.—Branchipiens, *Edwards*.

Branchiopoda, *Leach*.

Branchipodidæ, *Baird*.

Characters.—Cephalothorax many-jointed, either covered by the carapace or not. Appendages of the cephalothorax many, foliaceous and branchiform. Eyes peduncled.

Artemioidea includes *Chirocephalus*, (*Branchipus*) *Eulimene*, *Artemia*, *Branchinecta*, *Eubranchipus*, *Streptocephalus*, *Nebalia*, etc. These agree in having peduncled eyes, divided posterior thoracic legs and a straight abdomen terminated by spines or plates. This tribe is quite naturally divided into the two families of which *Nebalia* constitutes the one, while the remaining genera fall quite readily into the other.

FAMILY Artemiadæ.

Bibliography.—Branchipoda, *Leach*

Branchipiens, *Edwards*.

Branchipidæ, *Burmeister*.

Branchipusidæ, *Baird*, 1845.

Branchipodidæ, *Baird*, later.

—————Most modern authors.

Characters.—Cephalothorax many-articulate as far as the head, but nowhere covering the body. Feet foliaceous and numerous.

Dana subdivides this family, forming of the genus *Eulimene*, which has twenty-two branchial feet, the sub-family *Eulimenineæ*, leaving *Chirocephalus*, *Artemia*, etc., as the

SUB-FAMILY CHIROCEPHALINÆ.

Characters—Body slender, abdomen long and many jointed, antennæ of the second pair in the female very short and broad, while those of the male are prehensile.

GENUS *Chirocephalus*. (Sig. hand-headed.)

Bibliography.—*Chirocephalus*, *Prevost*, Jour. de Rhys., lvii., 37, 1803.

————— *Thompson*.

Branchipus, *M. Edwards*.

————— *Fischer*.

————— *Latreille*.

————— *Desmarest*.

————— *Guerin*.

————— *Lamarck*, etc.

Ino, *Schrank*, 1803.

————— *Oken*.

Cancer, *Shaw*.

Some member of this sub-family was found, during the autumn months, in a pool by the road-side but no accurate drawings were made and attempts to re-discover it have failed, so it remains uncertain what species it was. A figure is given of *Chirocephalus diaphanus* and the following description, mostly from Dr. Baird's work, will serve both for a better understanding of the genus and for comparison, when other specimens are obtained.

The head consists of two segments, the posterior of which is more slender than the anterior, and is usually called the "neck."

The antennæ are very important in the whole group, as furnishing basis for classification. The superior antennæ are alike in male and female, and are filiform, straight, many-jointed, and very flexible. At the extremity are a number of small setæ. The joints of these antennæ are with difficulty seen. The length equals the head. The inferior pair of antennæ are curious organs, from which the genus derives its name, and have been mistaken for mandibles and various other entirely different organs.

They are essentially prehensile organs, and consist chiefly of two large appendages, which occupy the forepart of the head, and are curved downward toward the thorax. They are articulated about the middle of their length; the first joint being large and fleshy and having a short, movable, conical appendage on its external edge; the second being curved, cylindrical, somewhat flattened at its extremity, and bearing a strongly toothed process at the base.

Arising from the base of the first joint of each of these appendages is another set of organs, called by Shaw "the trunk." These each consist of a long, flat, curved, very flexible body, composed of many short joints the edges of which are acute, giving a toothed appearance to this organ. From the outer edges of these arise four long and flexible appendages, which are toothed near the end, and also a triangular plate which is folded like a fan when not in use. (This is removed in figure b of plate 1, but shown at d.) These organs are generally carried rolled under the head, somewhat in the manner of the proboscis of a butterfly, being only visible externally as a protuberance.

These prehensile organs are used in retaining the female during copulation. In the female they are much more simple, being simply two flexible, horn-like bodies, carrying none of the appendages which pertain to the male.

The eyes are large, convex and compound, and are situated on rather large peduncles, which are movable; the mouth consisting of a labrum, a pair of mandibles and two pairs of jaws.

The thorax consists of eleven segments, each bearing a pair of branchial feet, which are large and foliaceous, and consist of three joints. The first is the largest, and has on its lower edge a semicircular branchial plate, which is furnished with about forty plumose hairs; the second joint of the feet bears on its inner side three projections, each of which sends off long hairs; the third joint is long, bearing plumose setæ.

The abdomen is composed of nine segments, which are devoid of appendages, except the two terminal plates, which are beset on their edges with plumose setæ. In the female there is an external oviferous pouch.

The dorsal vessel or heart, commences near the head, and traverses the whole length of the body. When fully grown it is upwards of an inch in length, slender, of a cylindrical form, and nearly transparent. The male has a reddish tinge throughout. The tail is of a beautiful red; the basal joint of the prehensile antennæ a bluish green tipped at the end with red. The back of the female is bluish, and the ovary brown.

These are beautiful animals, and may be seen in fine weather balancing themselves, near the surface of the pools they inhabit, by means of their branchial feet; but when disturbed they strike the water from right to left, and dart away like a fish, to conceal themselves among the weeds at the bottom of the pond.

GENUS *Branchinecta*.

Characters.—Form rather slender, with the medium appendages longest, so as to somewhat resemble *Artemia* in outline, but larger; male with rather slender, rounded, two-jointed claspers. Egg-pouch much elongated.

GENUS *Eubranchipus*. (Verrill.)

Characters.—Body robust; made with large head and very stout claspers; first joint of claspers much swollen, capable of retracting basal portion of the second joint into their cavity; second joint stout at the base, in the typical species with a large tooth on the inside, the outer portion tapering, rather obtuse. Front of head between the claspers bears two thin, flat tapering appendages. Caudal appendages long. Egg-pouch short and thick.

GENUS *Streptocephalus*. (Baird.)

Characters.—Male claspers long, three-jointed, tortuous; terminal point subdivided more or less into two branches, or bearing slender appendages. Male organs long and slender. Egg-pouch elongate or conical.

GENUS *Artemia*.

Bibliography.—*Artemia*, Leach, Dist. Sc. Nat., XIV.
Artemisus, Lamarck, Hist. An. S. Vert. (2d edit.)
Artemis, Thompson, Zool. Res., 104.

Characters.—Clasping organs three-jointed; egg-pouch short, broad; living in more or less saline waters.

The members of this genus, which will be often referred to, are peculiarly interesting from the way in which they show the great and sudden changes that a change in the invironment, is competent to effect in animal forms.

Three species are known in the United States, one of which is found in the eastern states, another in Utah, and still another in California, viz: *gracilis*, *monica*, and *fertilis*.

SUB-FAMILY EULEMENINÆ.

Characters.—Abdomen almost obsolete; both pairs of antennæ filiform.

GENUS *Eulimene*. (*Latreille*.)

FAMILY NEBALIDÆ.

Characters.—Antennæ large and ramiform; eyes peduncled; feet twelve pairs; carapax large, enclosing head, thorax and part of the abdomen, as in a bivalve shell.

GENUS *Nebalia*.

Bibliography.—*Nebalia*, *Leach*, *Thompson*, *Desmarest*, *Latreille*, *M. Edwards*, *Bosc*, *Lamarck*, etc., etc.

Cancer, *O. Fabricius*, *Herbst*..

Monoculus, *Montagu*.

Myses, *Olivier*.

Being the only genus in the family, the above characters also characterize the genus.

TRIBE II. APHODOIDEA.

Bibliography.—*Apusiens* (in part), *Edwards*.

Apodidæ, *Burmeister*.

—————*Baird*.

Characters.—Body straight; cephalothorax covered by a scuteliform shell; posterior appendages of the thorax lamelliform; abdomen many-jointed; eyes sessile.

FAMILY *Apodidæ*.

Bibliography.—*Apus*, *M. Edwards*, *Hist. Nat. Crust.*, iii., 356.

Phyllopoda, *Leach*, *Edin. Encyclop.* VII., art. *Crustaceology*.

Apodidæ, *Burmeister*, organization of *Trilobites*, 34.

Characters.—Of large size, with a rounded carapace partially covering the base of the abdomen, which is elongate and ends in two many-jointed, caudal filaments; about sixty pairs of swimming feet; antennæ rudimentary; first maxillipeds antenniform.

GENUS *Apus*. (Sig. without feet.)

Bibliography.—*Apus*, (see above for family.)
Monoculus, *Linnaeus*, *Fabricius*.
Binoculus, *Geoffroy*, *Leach*.
Limulus, *Muller*, *Lamarck*.
Trilopes, *Schrank*.

Characters.—Antenniform maxillipeds long; telson squarish.

GENUS *Lepidurus*.

Characters.—Body much shorter than in *Apus*. First maxillipeds shorter, and a long, spatulate, keeled telson projecting beyond the insertion of the caudal filaments.

Query—Should not this be reunited with *Apus*?

TRIBE III. LIMNADIOIDEA.

Bibliography.—*Apusieus* (in part), *Edwards*

Characters.—Body covered completely by a carapace which includes abdomen and head; eyes sessile, like *Cyproidea* in appearance.

FAMILY LIMNADÆ.

Characters.—Body compressed, with ten to twenty-seven feet, inclosed in a bivalve shell.

GENUS *Limnetis*.

Characters.—Shell small, round globose, without lines of growth or umbones; feet-bearing segments ten to twelve.

GENUS *Limnadella*.

(Uncertain. The species upon which it was founded are not now known.)

GENUS *Estheria*.

Shell oval, more or less globose, *Cyclas*-like with numerous lines of growth, amber-colored; animal without a "*haftorgan*"; second antennæ, with from eleven to seventeen joints to the flagella; from twenty-five to twenty-seven segments behind the head; feet twenty-four to twenty-eight; anterior feet in the males with clumsy hooks.

GENUS *Limnadia*.

Shell large, with four or five lines of growth, sub-triangular or broadly ovate; animal with a knob-like projection ("*haftorgan*") above the eyes; second antennæ with nine or ten joints to the flagella; feet eighteen to twenty-six; body much smaller than in *Estheria*.

GENUS *Cyzicus*.

(Am not familiar with any description of the generic characters.)

Remarks on the Sub-Order.—The species of this sub-order are scattered rather sparingly over the world, and many of them are dependent on peculiar circumstances for their perfect development, as in the case of *Artemia* (or Brine Shrimp) which is found in the waters of salt lakes and in the brine tubs of salt manufactories.

Of the family *Artemiadae* several species occur throughout the United States. No *Chirocephalus* has been found west of the Rocky Mountains. *Artemia* occurs in many places, as, one in Great Salt Lake, one in Mono Lake, California, and one in the eastern U. S. The genus *Branchinectas* which has a representative in Greenland and in Labrador, has also a species in Colorado, 12,800 feet above the sea. I am not informed that any species of *Nebalia* occurs in North America.

The tribe *Limnadioidea* is without a known representative east of the Mississippi and north of San Domingo. But in Greenland and the arctic regions, *Lepidurus glacialis* is found. West of the Mississippi and east of the Rocky Mountrins are three species of *Apus*, and there has been another found on the Pacific, at Cape St. Lucas. Geologically, the genus is found in European rocks in the Triassic, and our own rocks will probably furnish species.

In the *Phyllopoda* the abdomen and thorax are merged together, and in all but the family *Artemiadae*, there is a large carapace covering most of the body. In the *Limnadiidae* this shell is large and double, and resembles the small *Cyclos* shells of fresh water, and are often collected by Conchologists as such. The eggs are round or polygonal, and are dense and tough-shelled. The eggs are carried in an ova-sack similar to that of *Cyclops*, or in the *Limnadiadae*. They are borne under the shell, as in *Daphnia*, etc. The young, as in other *Entomostraca*, hatch from the egg in the "Nauplius stage" described more particularly under *Cyclops*. The difference between the sexes is usually sharply defined. The process of reproduction is very interesting in many species of this sub-order. The normal method of reproduction is perhaps less common than what is known as parthenogenesis, or virgin reproduction. The eggs are produced by a simple budding process from the ovary, without fertilization by the male. The proportion of males to females is very small. In some localities the males are entirely absent. In *Artemia* the amount of saline matter in water seems to vary the comparative number of males. This affords a curious parallel with the sexual changes in the pupa of the honey bee. The saltiness of the water not only affects the young, the form of the parent also varies. Schmankiewitsch found near Odessa, Russia, a species of *Artemia*, and by studying it discovered that it changed its form to correspond with the greater or less saltiness of the water. Toward the end of the summer, when the rain and cold weather set in, the *Artemia* increases in size, and the July generation has many differences from the later ones. He then attempted to verify his observations by artificial breeding. He increased the concentration in one case and lowered it in the other, and found that after a series of generations the two sets of animals varied between themselves, and also both differed from those of the pond from which they came. He also learned that males were only produced in water of medium strength.

In the genus *Apus* similar parthenogenetic broods are produced. Siebold's experiments, which have been made with great care and minuteness, have established this fact beyond doubt.

There is great need of further investigation in this subject, and we are glad to learn that it is about to receive attention from so competent hands as Dr. Packard's.

The systematic position of the sub-order is still a matter of doubt, and it is not yet possible to make any positive classification of the divisions of the *Entomostraca*.

(See Plates XVIII. and XIX.)

ADDENDA.

Since these pages were written the Bulletins of the Illinois Museum of Nat. Hist. have come under my notice, which, aside from other interesting matter, contain descriptions of many new species of crustacea inhabiting the water of that state. Fine descriptions are given of the following species of Entomostraca, to which the student is referred, viz:

Eubbranchipus serratus, Forbes.

Canthocamptus Illinoisensis, Forbes.

Diaptomus Sanguineus, Forbes.

Eubbranchipus Bundyi, Forbes.

In Bulletin No. 2, Prof. Forbes describes or mentions the following:

Eurycercus lamillatus, Mull.?

Bosmina, sp.?

Ceriodaphnia angulata, Say.

Daphnia pulex, L.?

Daphnia galeata, Sars.

Later study shows that there is yet much to be done in simply verifying the species which occur here, not to mention the ever remaining opportunity for more minute study of the structure of known forms, for aside from the whole genus *Cyclops*, which has not yet been attempted, and contains numerous species, new species are constantly being met with, among which are those described beyond.

FAMILY PENILIDÆ.

Genus *Daphnella*. Baird.

Bibliography.—*Daphnella*, Baird, Brit. Entomost., 809.

————— *Dana*, Wilkes' Exp. Crust., page 1267.

Another member of this interesting family has been found since the text was sent to press.

The genus *Daphnella* is characterized by Dana as follows: Posterior antennæ with both rami two-jointed, the shorter ramus often imperfectly three-jointed: Head oblong, not produced beneath, bearing the anterior antennæ near the middle. *Daphnella* differs from *Sida*, which it greatly resembles, even in

minute structure, in the number of joints of the antennæ and from *Penilia*, in having the first joint of the longer ramus shorter than the second.

The branch which is three-jointed in *Sida* is not the one which has the short terminal joint.

Daphnella Winchelli. Herrick.

This species closely resembles *D. Wingii*, Baird, but I have no hesitation in pronouncing it distinct. Length .03 in. Head rather short. Carapace pear-shaped, transparent. Superior antennæ short, but appearing on either side the head when the animal is swimming, they appear to have three setæ at the extremity. Inferior antennæ very long, as long as body. The shorter ramus has four setæ on the terminal joint and one on the first, while the other ramus carries eight on the terminal joint besides one that is much shorter than the others, and the first joint has four.

The tail has long diverging stylets, and seems not to have the minute teeth of the *D. Wingii*. The posterior portion of the front of the shell-margin is ciliated or spined. The back of the head seems to have the same appendage described in *Sida*. Ova two. This species was found in Minnetonka creek and is named in honor of Prof. Winchell.

FAMILY POLYPHEMIDÆ.

Genus Polyphemus. Muller.

Bibliography.—Polyphemus, Muller, Cuvier, Latreille, Strous, etc.

————— Baird, Brit, Entomost. p. 111.

————— Dana, Wilkes' Exp. p. 1266.

Characters—Body incurved toward the head except the posterior portion of the abdomen, which projects backward and is very slender, bearing two long spines at the extremity. Head distinct. Rami of posterior antennæ three, and four-jointed.

Polyphemus occidentalis. Herrick.

Length .25 in. Body excessively incurved, as is the head. Eye large, filling the head. Superior antennæ apparently obsolete. Inferior antennæ small. Jaws two or three-jointed, three-toothed at the apex. Feet, four pairs, first pair long, apparently four-jointed and three-clawed at the end, basal portion ciliated on the posterior margin. Fourth pair of feet nearly rudimentary. The abdomen is very long. Found in "Mud Lake," south of Minneapolis.

Eurycercus lamellatus. Muller?

Several specimens belonging to Baird's genus *Eurycercus* were found, and as far as can be determined they are not specifically distinct from *E. lamellatus*, though they are less in size and have a few minor points of difference.

I append his description, omitting the bibliography:

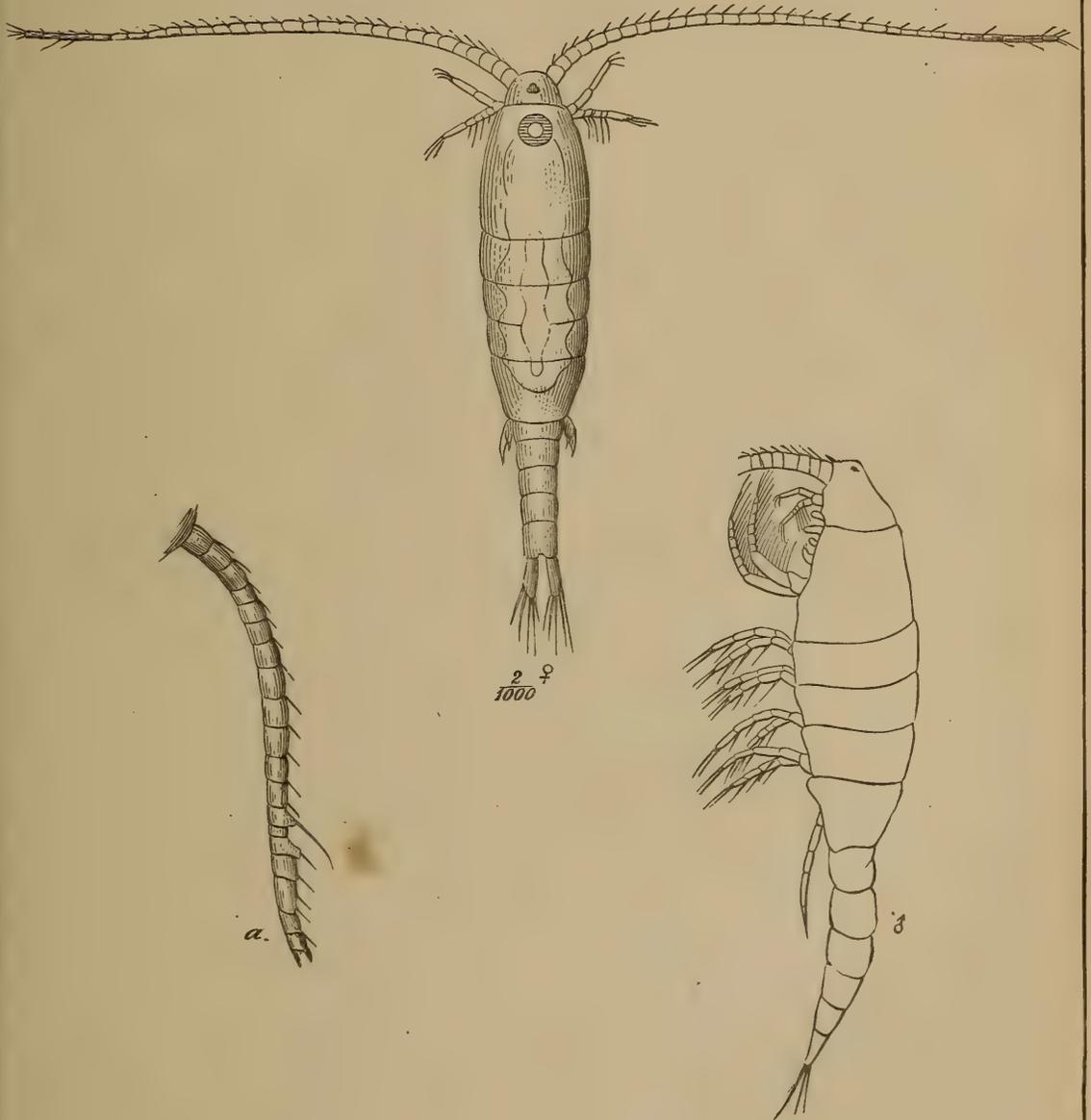
"Shell of an olive color; rather square-shaped, ciliated on anterior margin; ventricose in centre, and arched on posterior edge. Beak rather blunt and short, superior antennæ stout, somewhat conical, slightly curved and terminating in

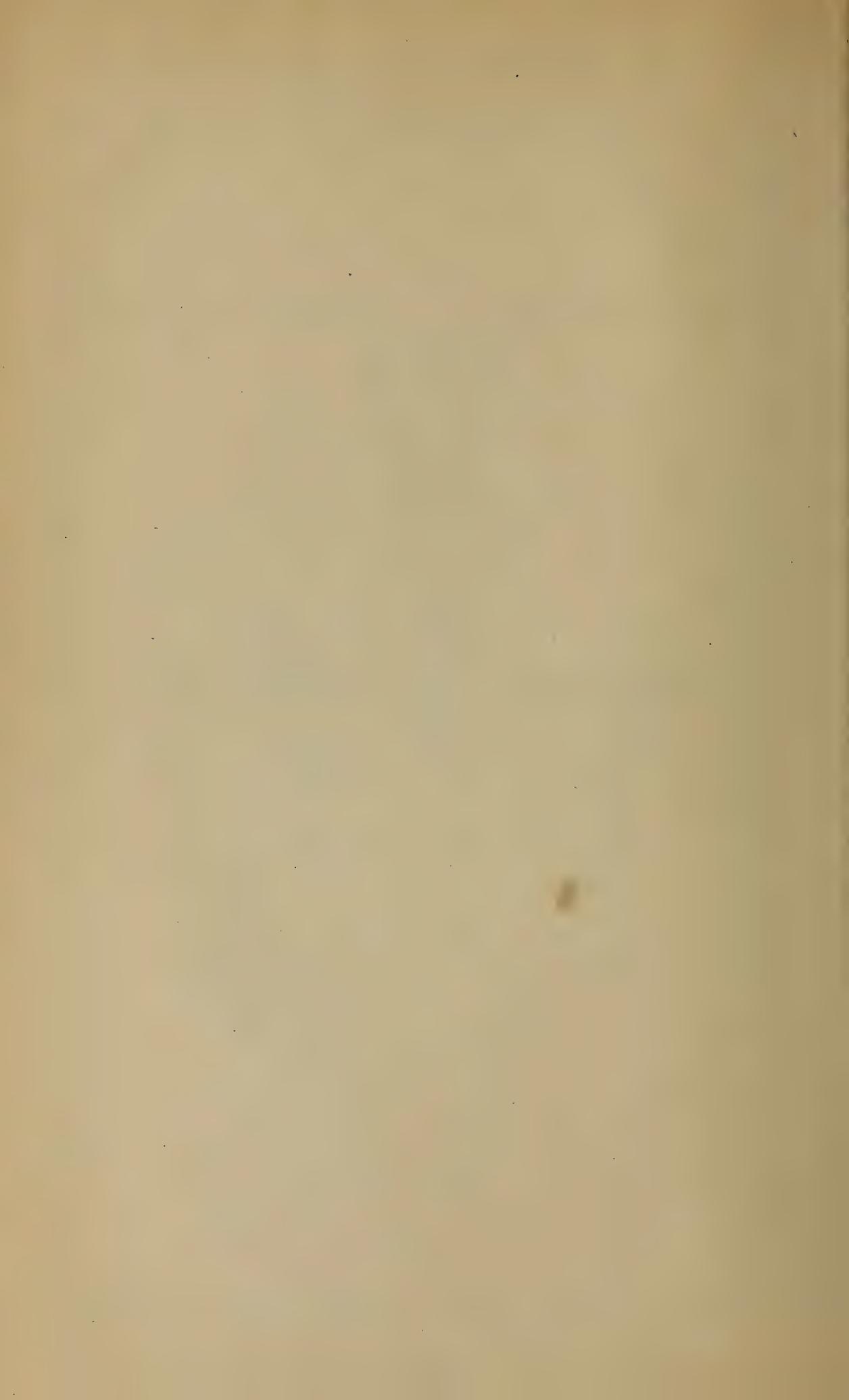
six spines, each of which gives out a fine seta. Inferior antennæ short compared with the size of the insect. Anterior branch has five long filaments, three from the terminal, and one from each of the other joints. The posterior branch has short spines on the two basal joints. Eye large. Abdomen very wide and densely ciliated. This is the largest member of the family, its motion is a succession of bounds. This animal is heavy and slothful compared to other species.

PLATE I.

Diaptomus longicornis, Herrick.—Back view of the female and side view of the male. *a*, basal portion of male antennæ showing geniculating joint.

MICROSCOPIC ENTOMOSTRACA.





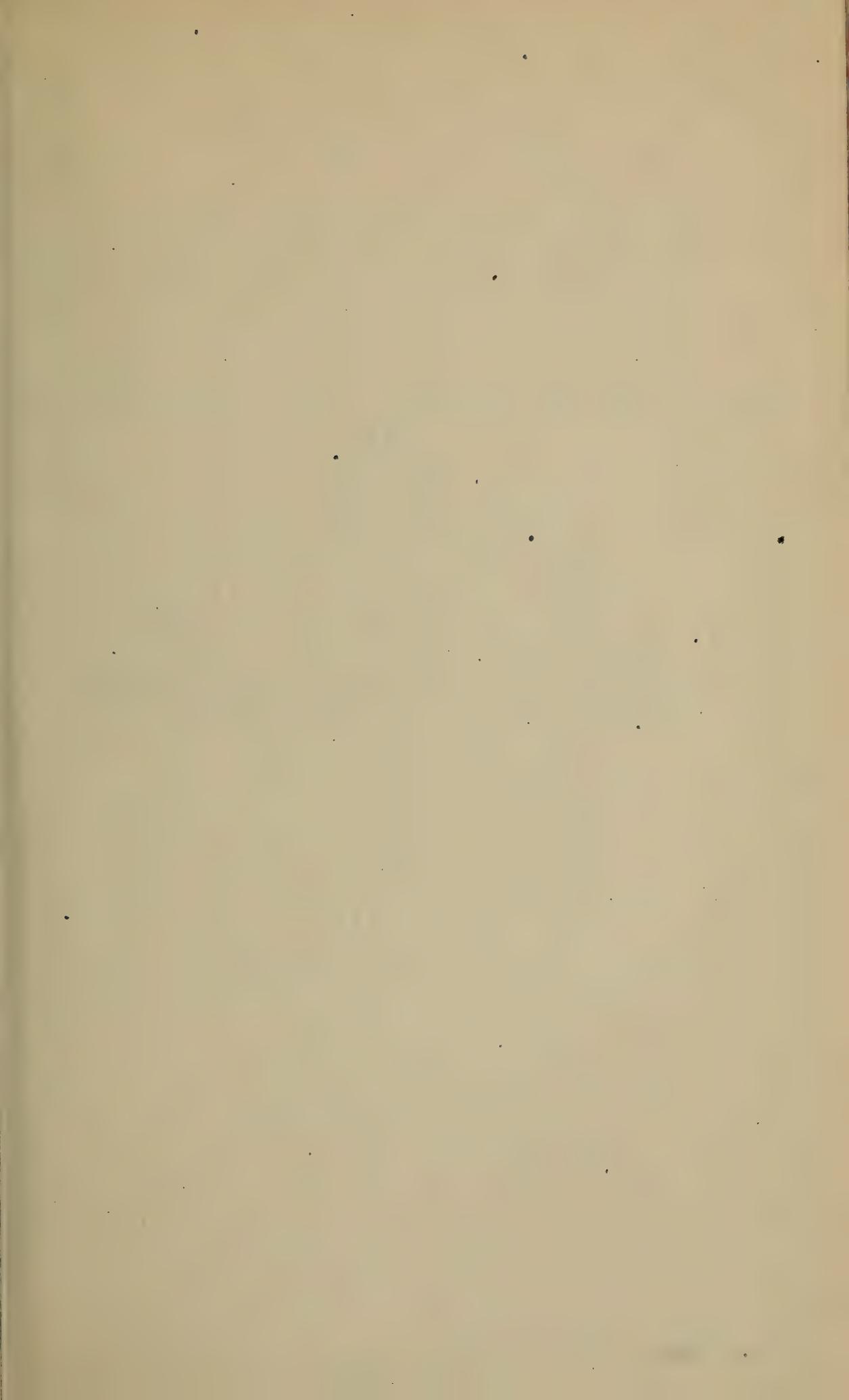
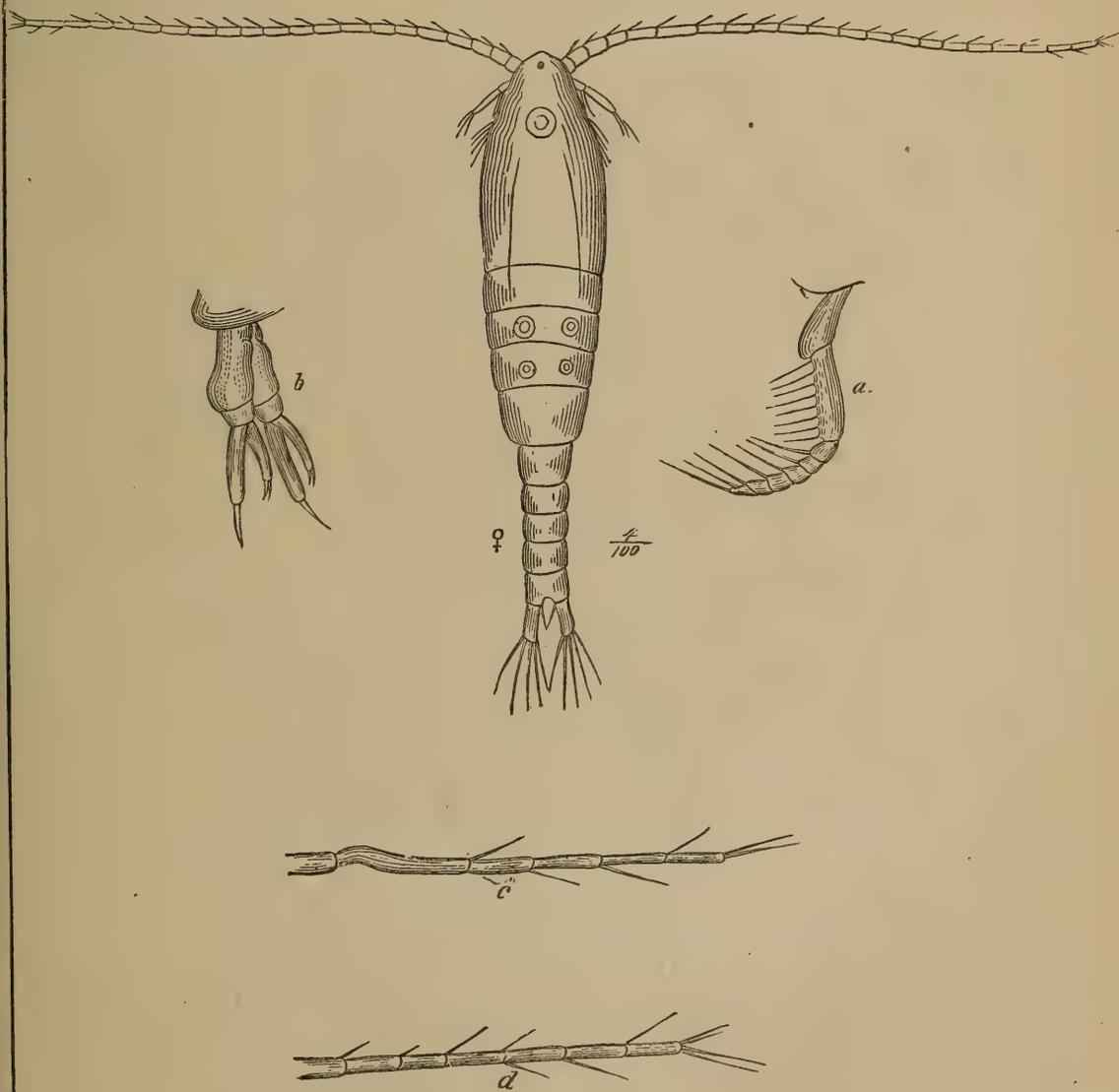


PLATE II.

Diaptomus pallidus, Herrick.—Back view of female. (In this plate the antennæ are represented far too short.) *a*, maxilliped. *b*, fifth pair of feet. *c*, extremity of male antennæ. *d*, extremity of female antennæ.

MICROSCOPIC ENTOMOSTRACA.



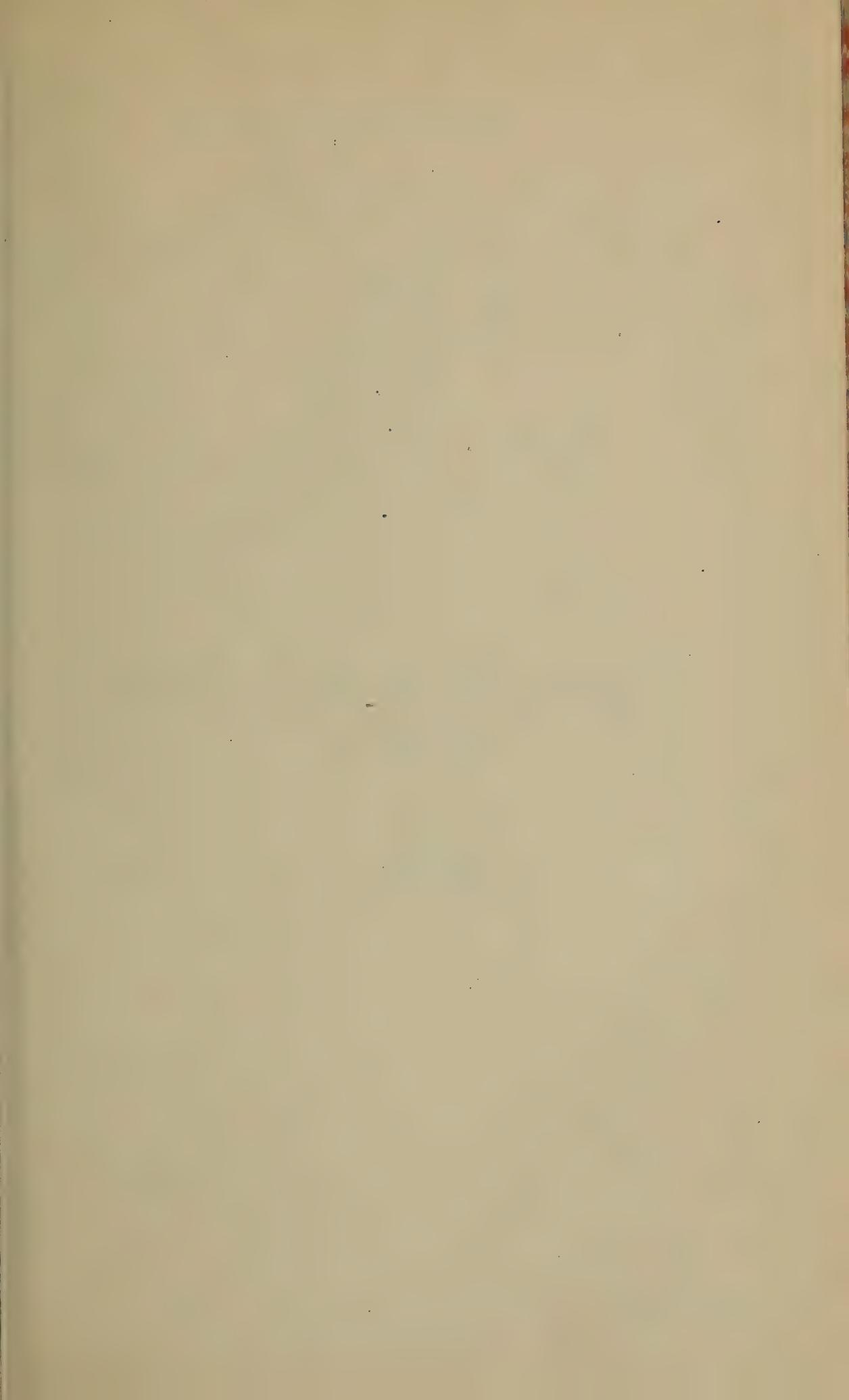
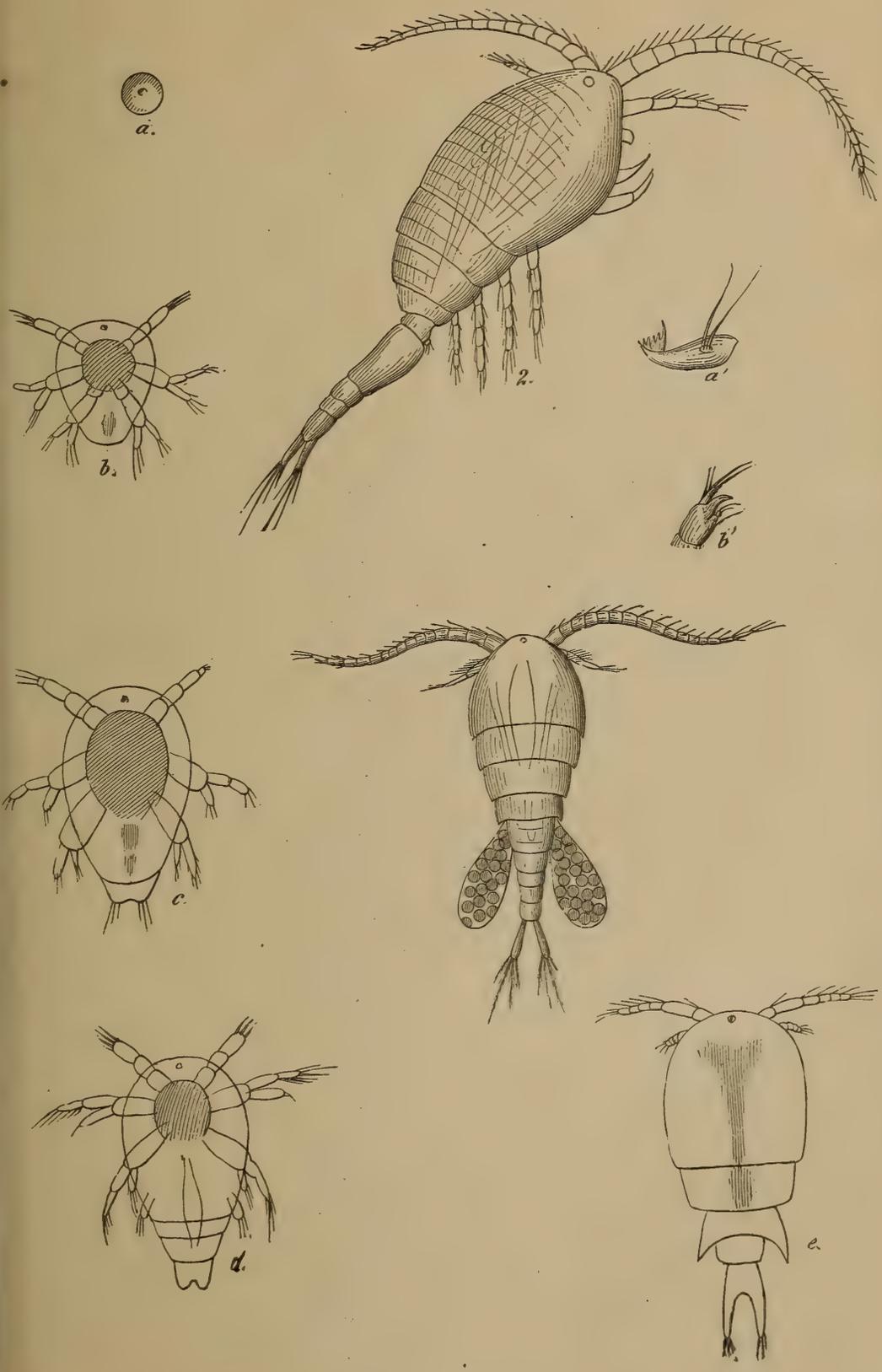


PLATE III.

Cyclops quadricornis, Linn.—1, mature female with egg sacks containing ova. *a*, egg. *b*, young just born. *c*, young eight days old. *d*, young fifteen days old. *e*, young seventeen days old. *a'*, mandible. *b'*, first pair of foot jaws. 2, side view of mature cyclops.

MICROSCOPIC ENTOMOSTRACA.



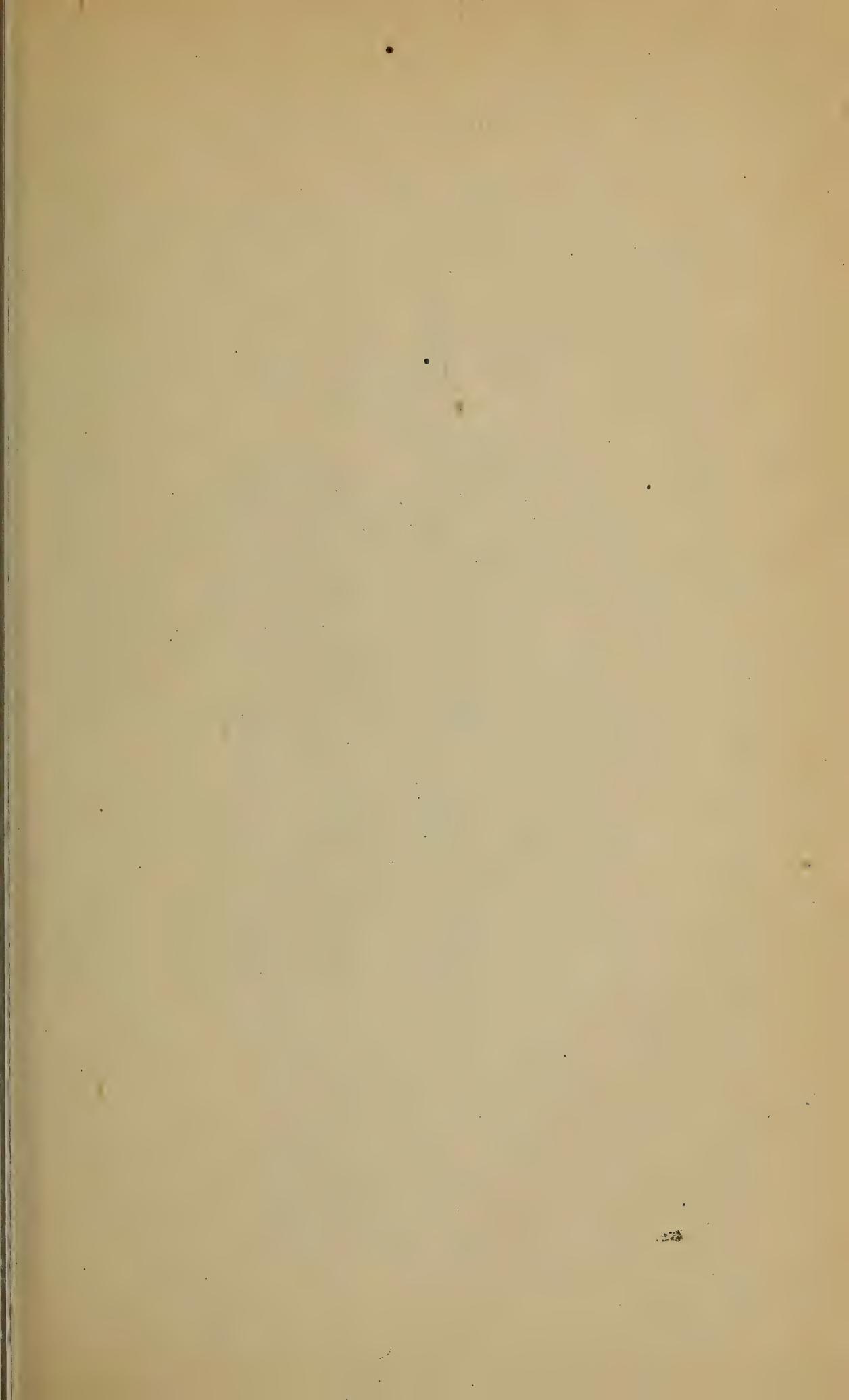
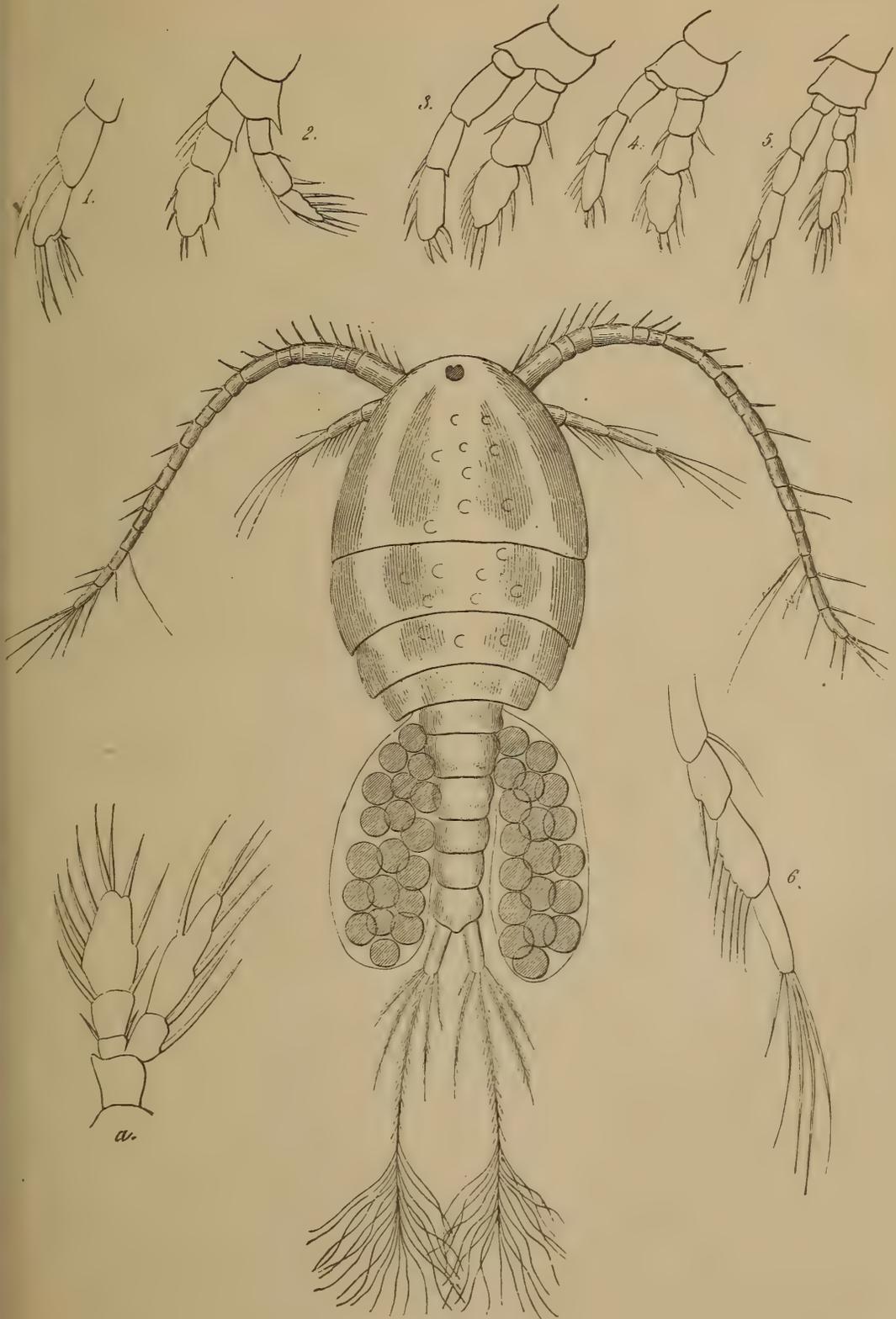


PLATE IV.

Cyclops quadricornis, Var?—*a*, last pair of feet 1, 2, 3, 4, 5, feet. 6, inferior antennæ.

MICROSCOPIC ENTOMOSTRACA.



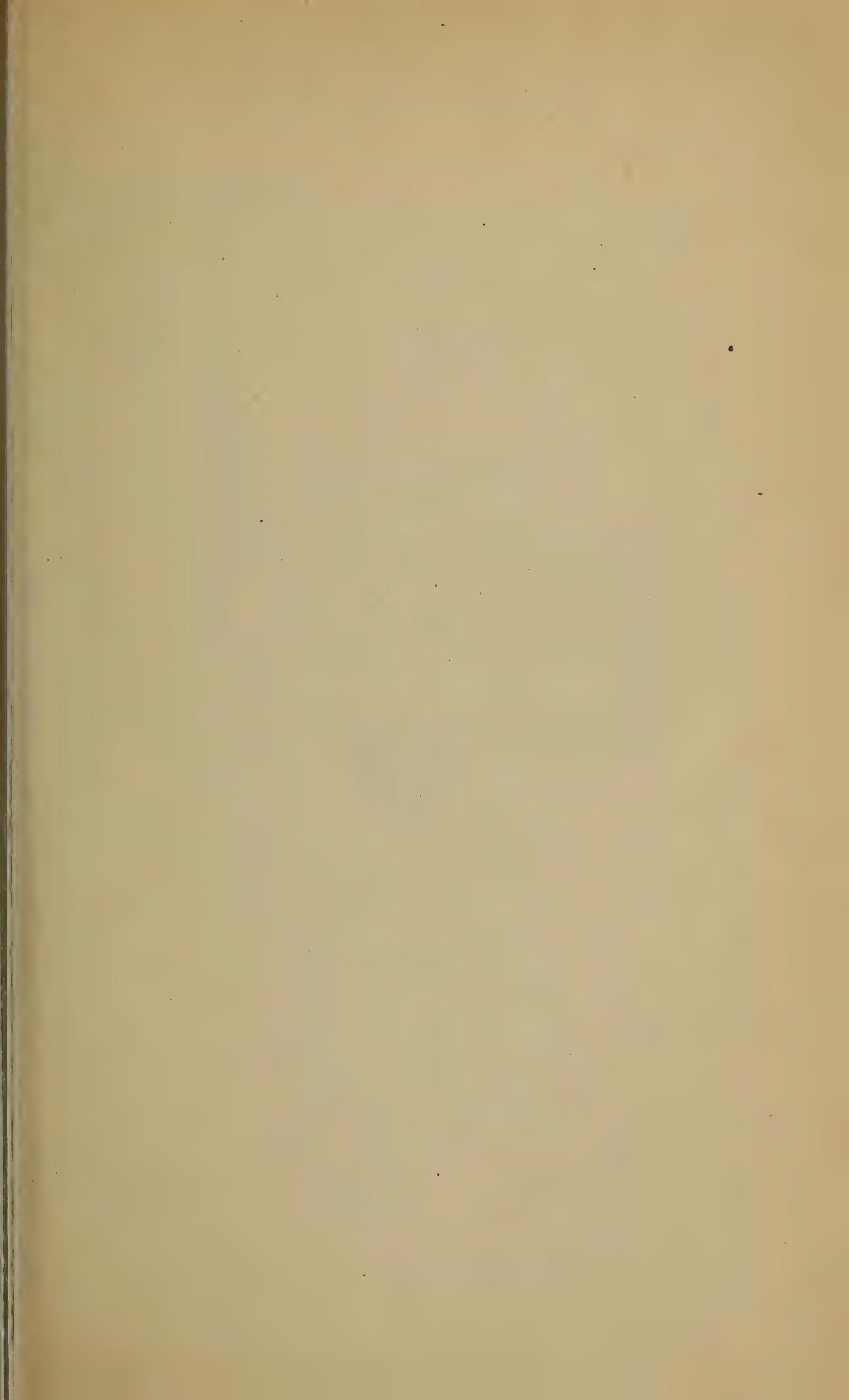
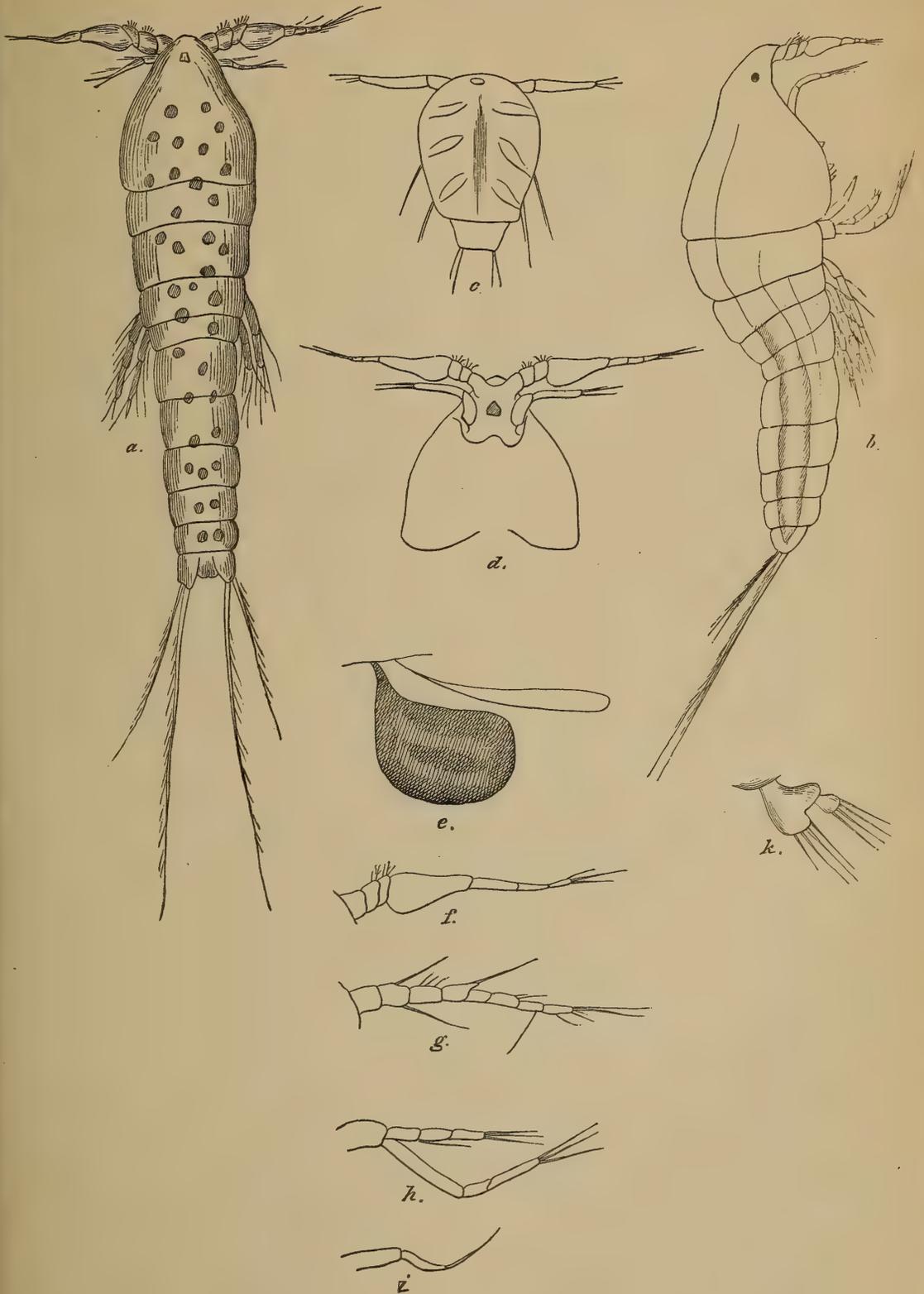


PLATE V.

- a*, *Canthocamptus minutus*, var. *occidentalis*, Herrick, male.
b, do., side view.
c, young, or Nauplius.
d, underview of head of male.
e. external ovary and appendage of female.
f, antenna of male.
g, antennæ of female.
i, foot of first pair.
k, appendage to abdomen of female. (Fifth pair of feet.)
h, foot of second pair.

MICROSCOPIC ENTOMOSTRACA.



O.L. HERRICK Del.

Plate V.

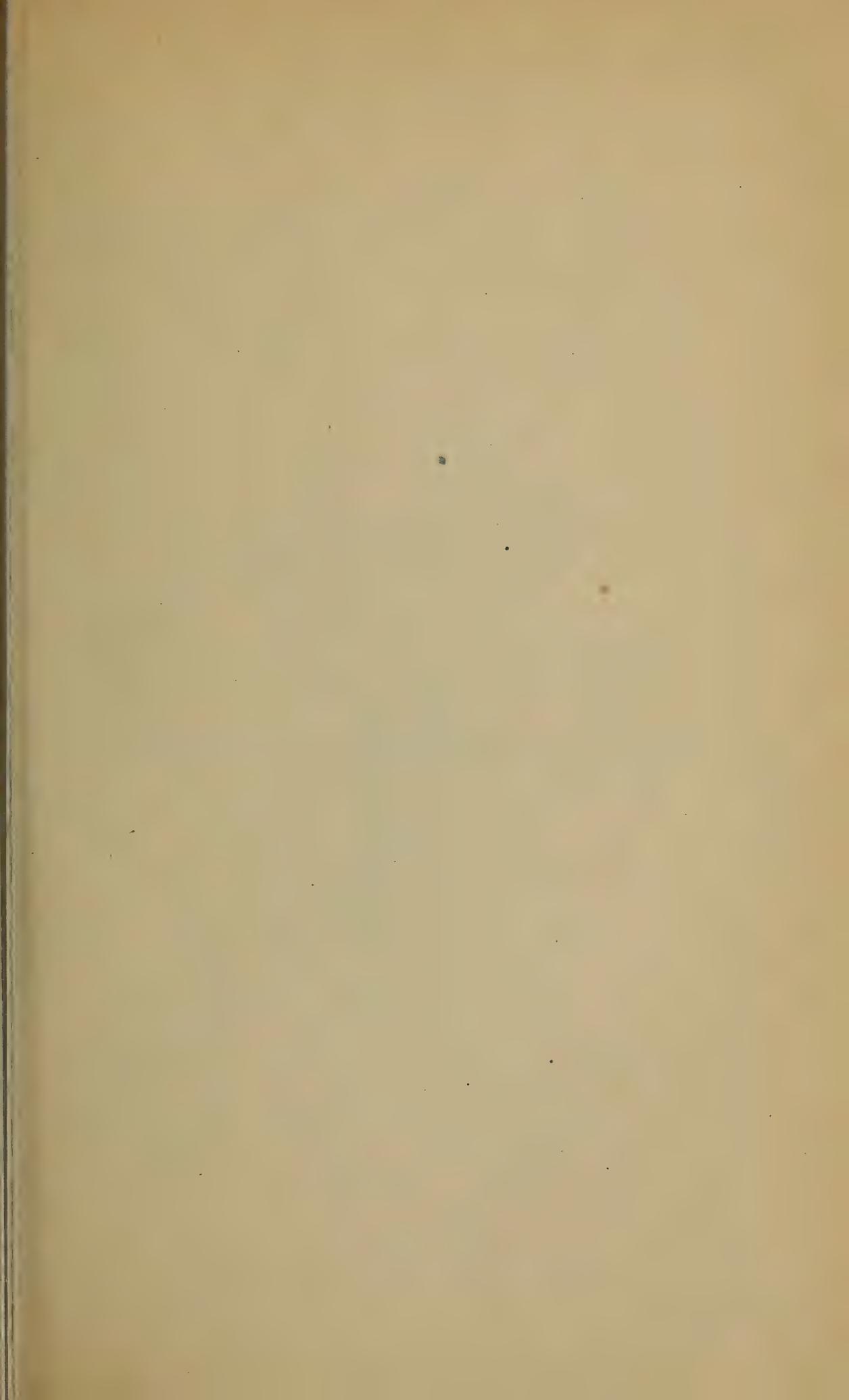
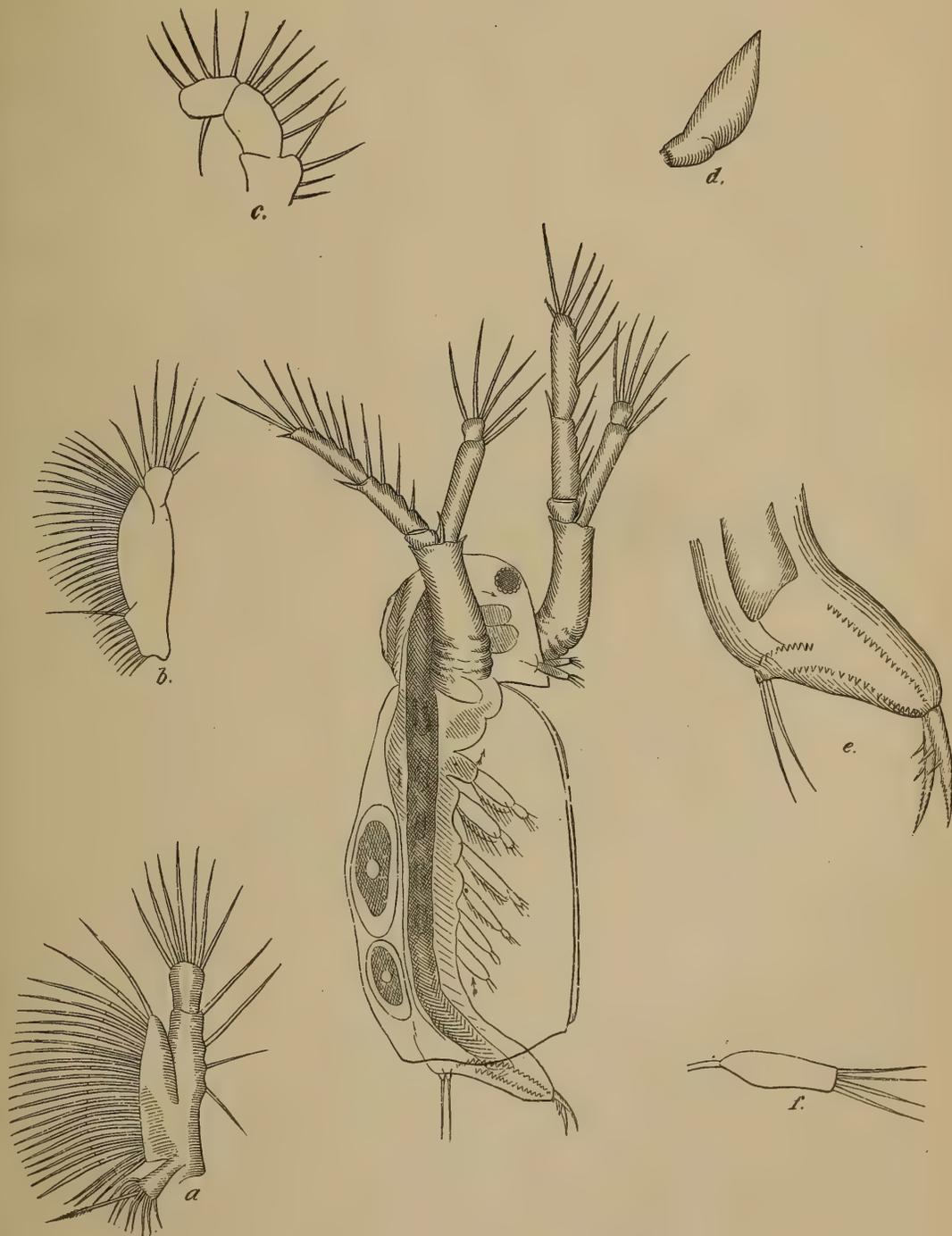


PLATE VI.

Sida crystallina, Straus. *a, b, c*, feet of first, second and last pairs. *d*, jaw.
e, extremity of abdomen. *f*, superior antennæ.

MICROSCOPIC ENTOMOSTRACA.



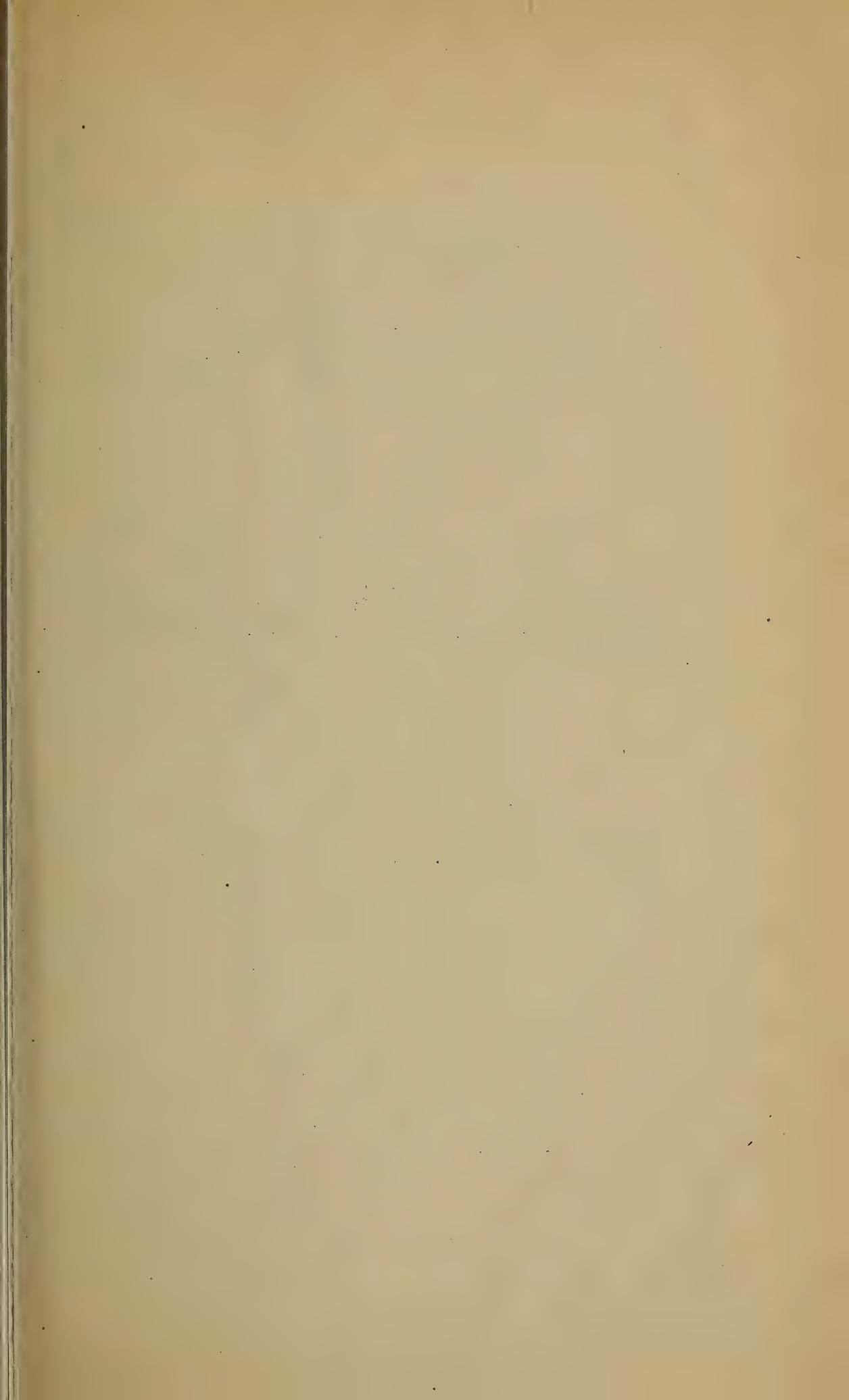
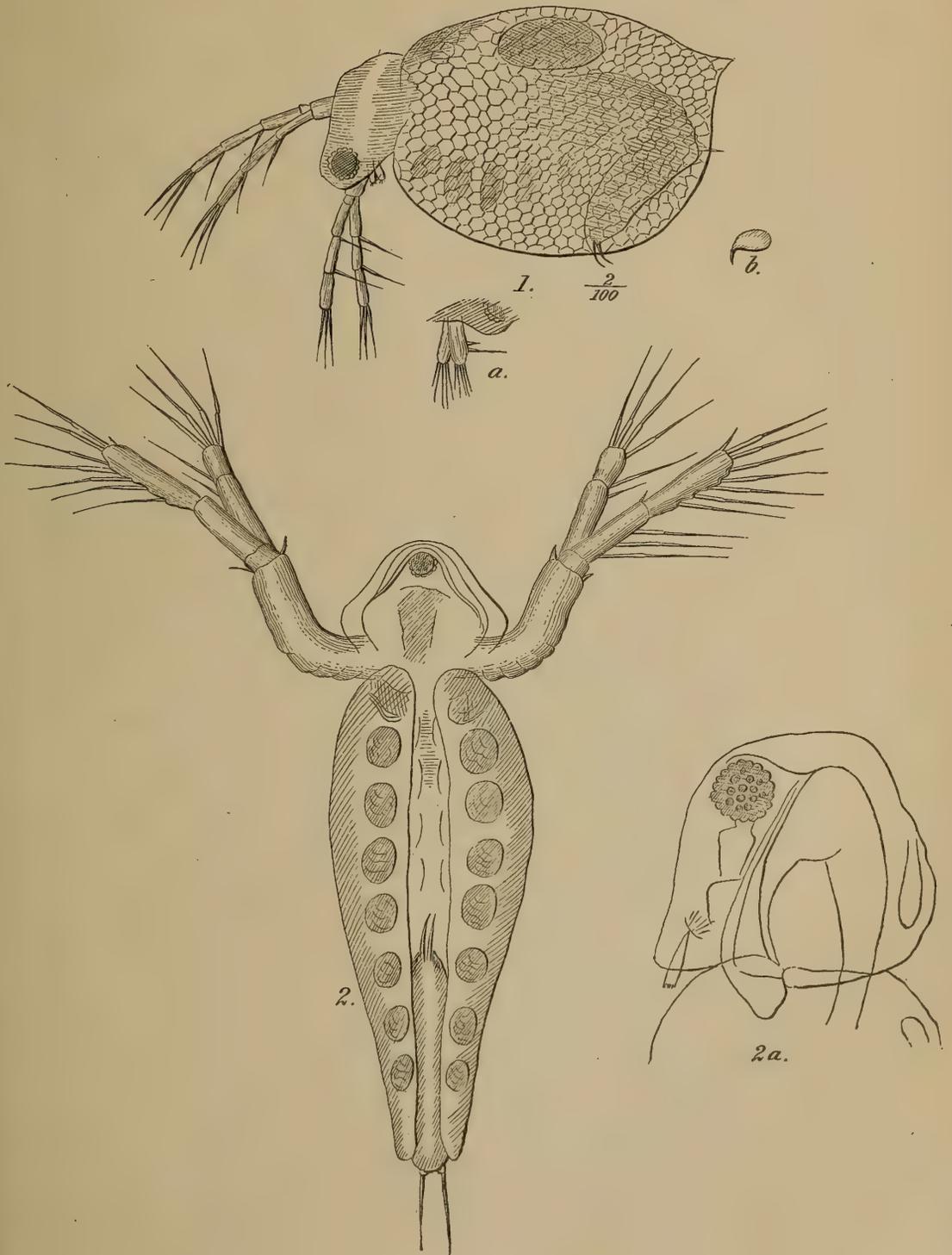


PLATE VII.

1. *Daphnia reticulata*. *a*, superior antennæ, *b*, heart.
2. *Sida crystallina*. *a*, head.

MICROSCOPIC ENTOMOSTRACA.



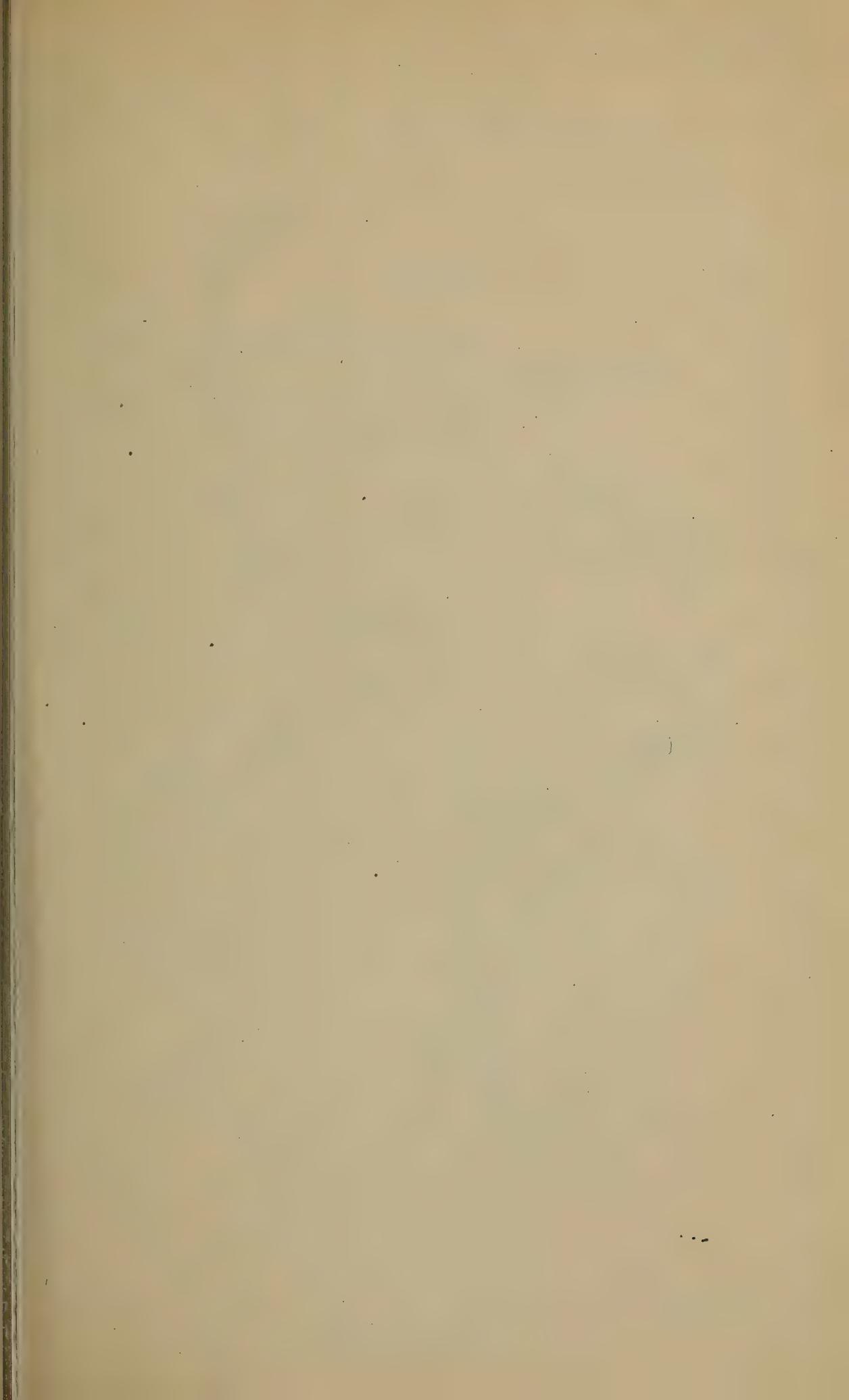


PLATE VIII.

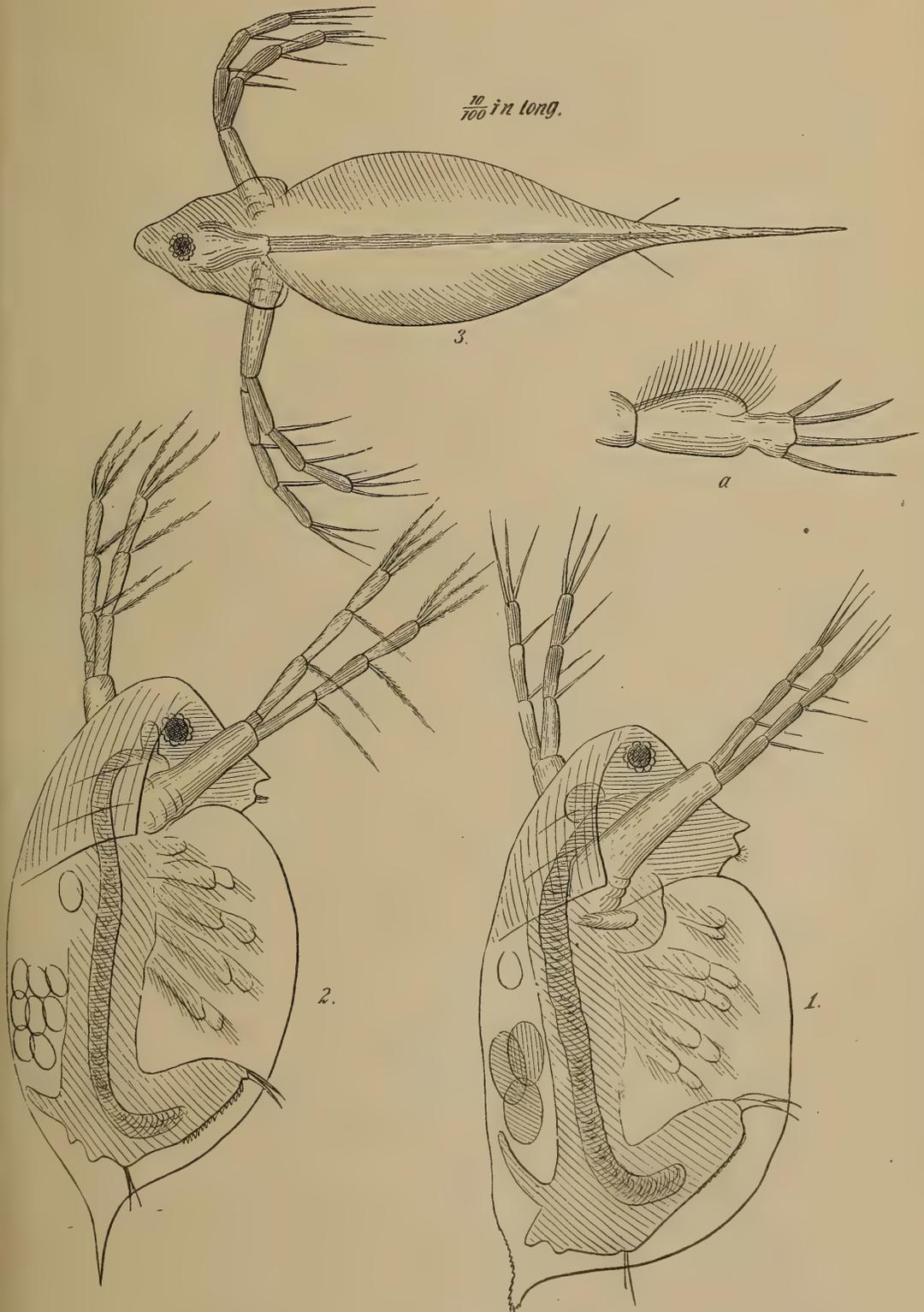
1. *Daphnia pulex*, var. 1.

2. ——— ——— var. 2.

3. ——— ——— var. 3.

(a) foot.

MICROSCOPIC ENTOMOSTRACA.



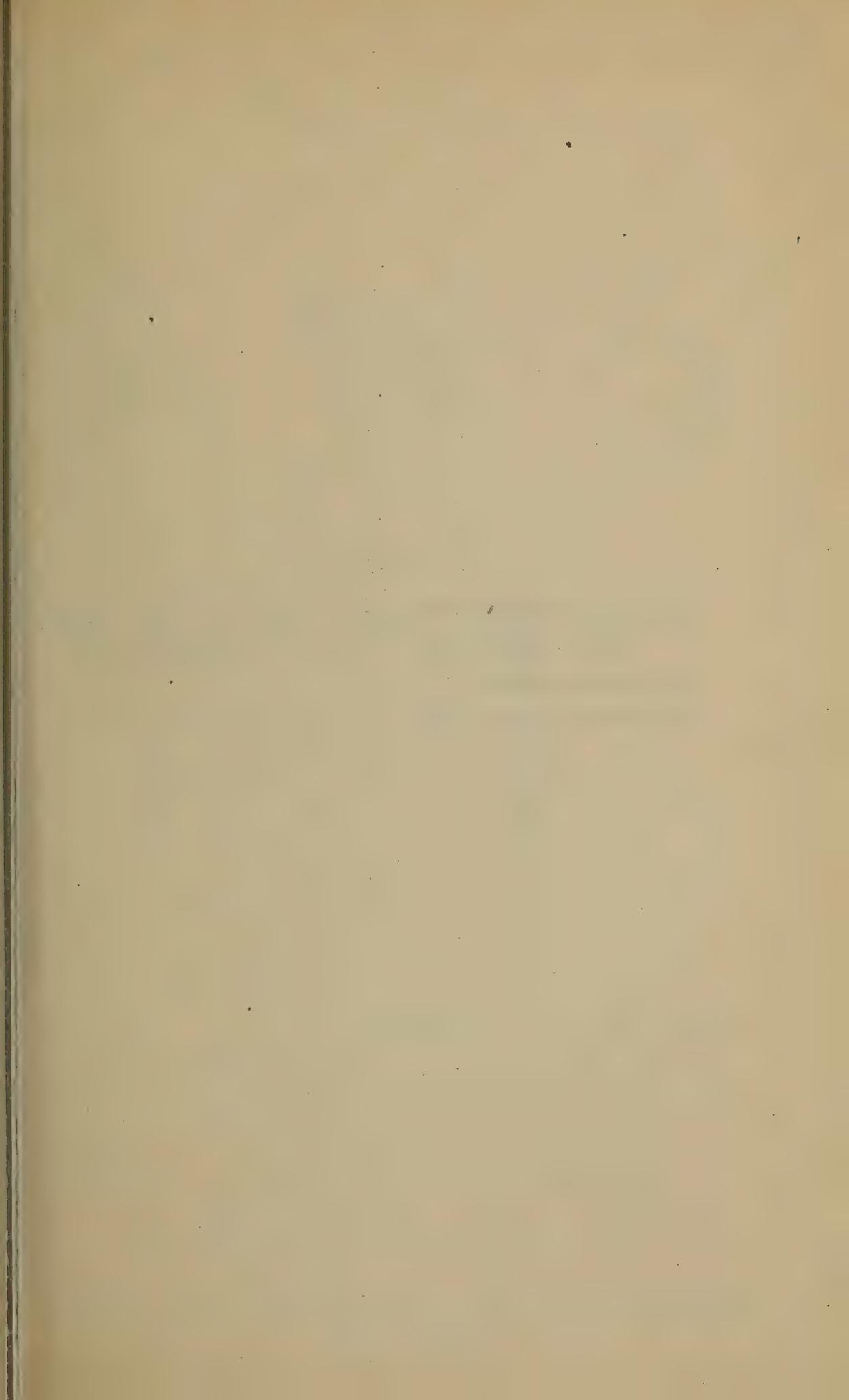


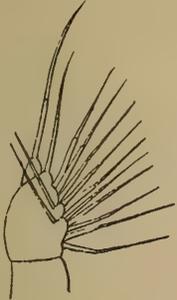
PLATE IX.

Fig. 1. Head of *Daphnia Schæfferi* showing alimentary apparatus etc., antennæ removed. *a*, heart. *b*, stomach. *c*, cœcum. *d*, superior antennæ. *e*, eye. *f*, labrum. *g*, jaw. *A, B, C, D, E*, one of each pair of feet.

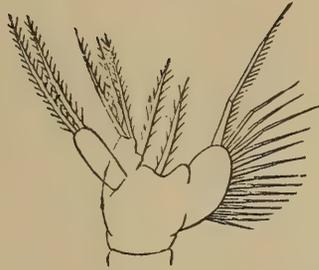
Fig. 2. Superior antennæ.

Fig. 3. Posterior portion of body.

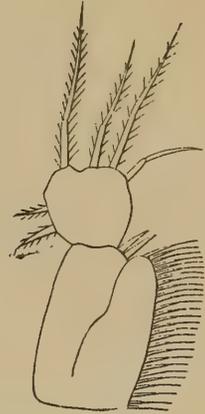
MICROSCOPIC ENTOMOSTRACA.



A.



B.



C.

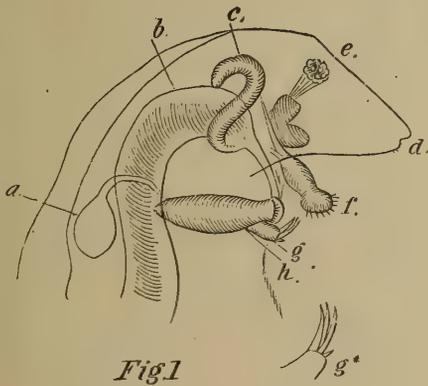
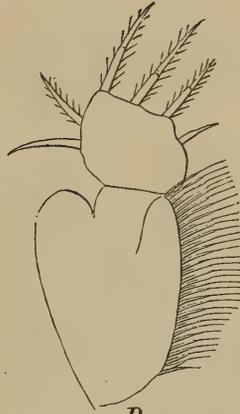


Fig1



D.



E.

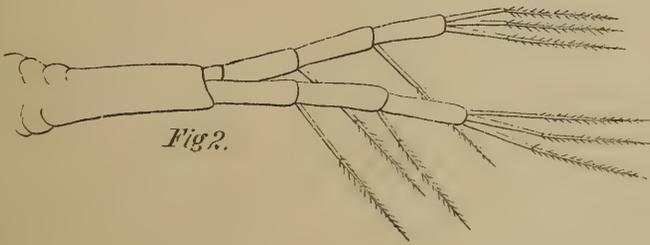


Fig2.

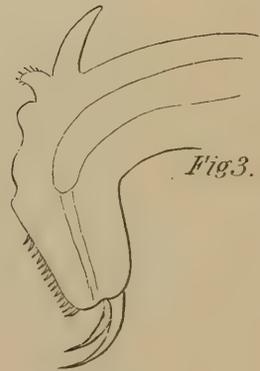


Fig3.

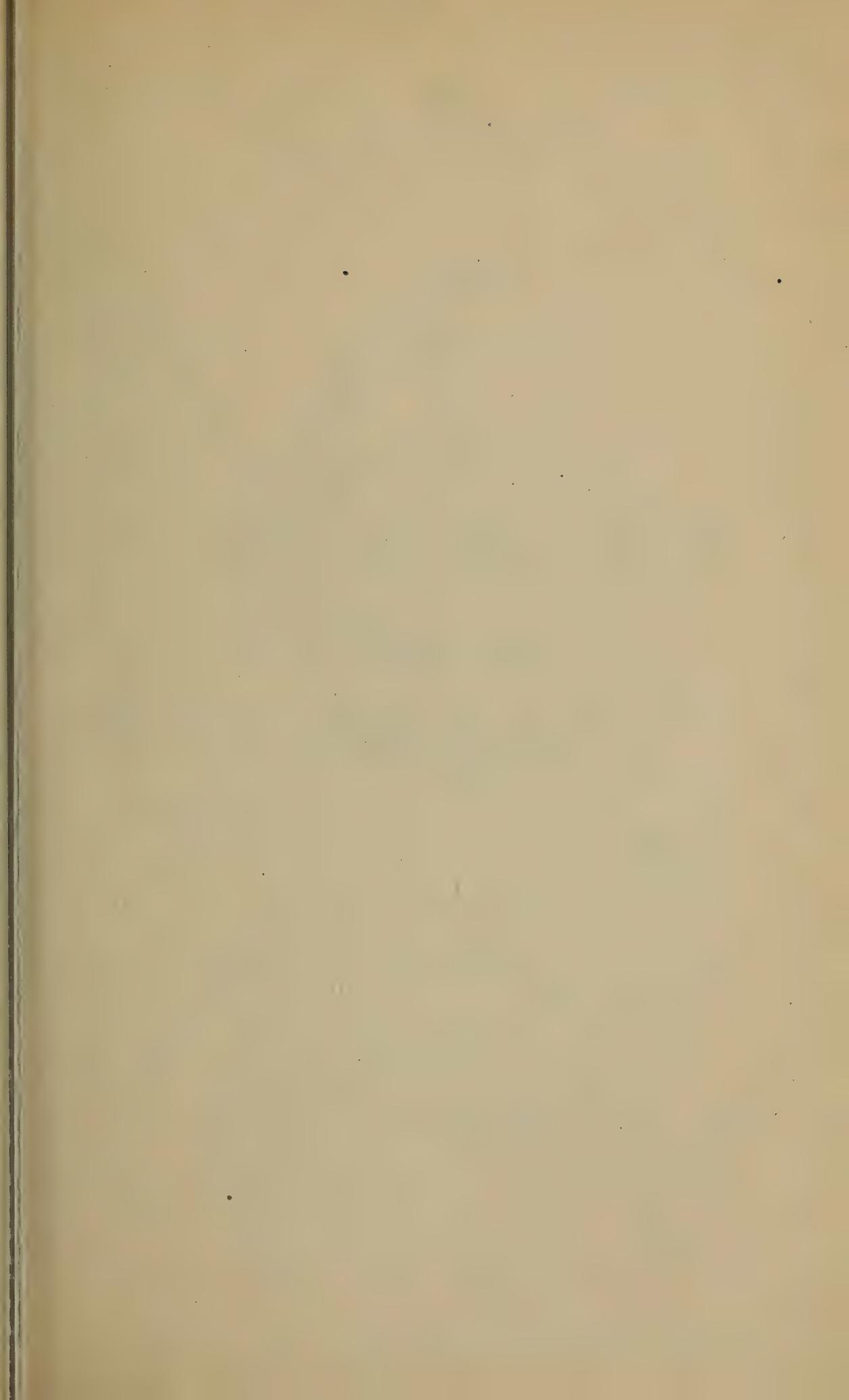
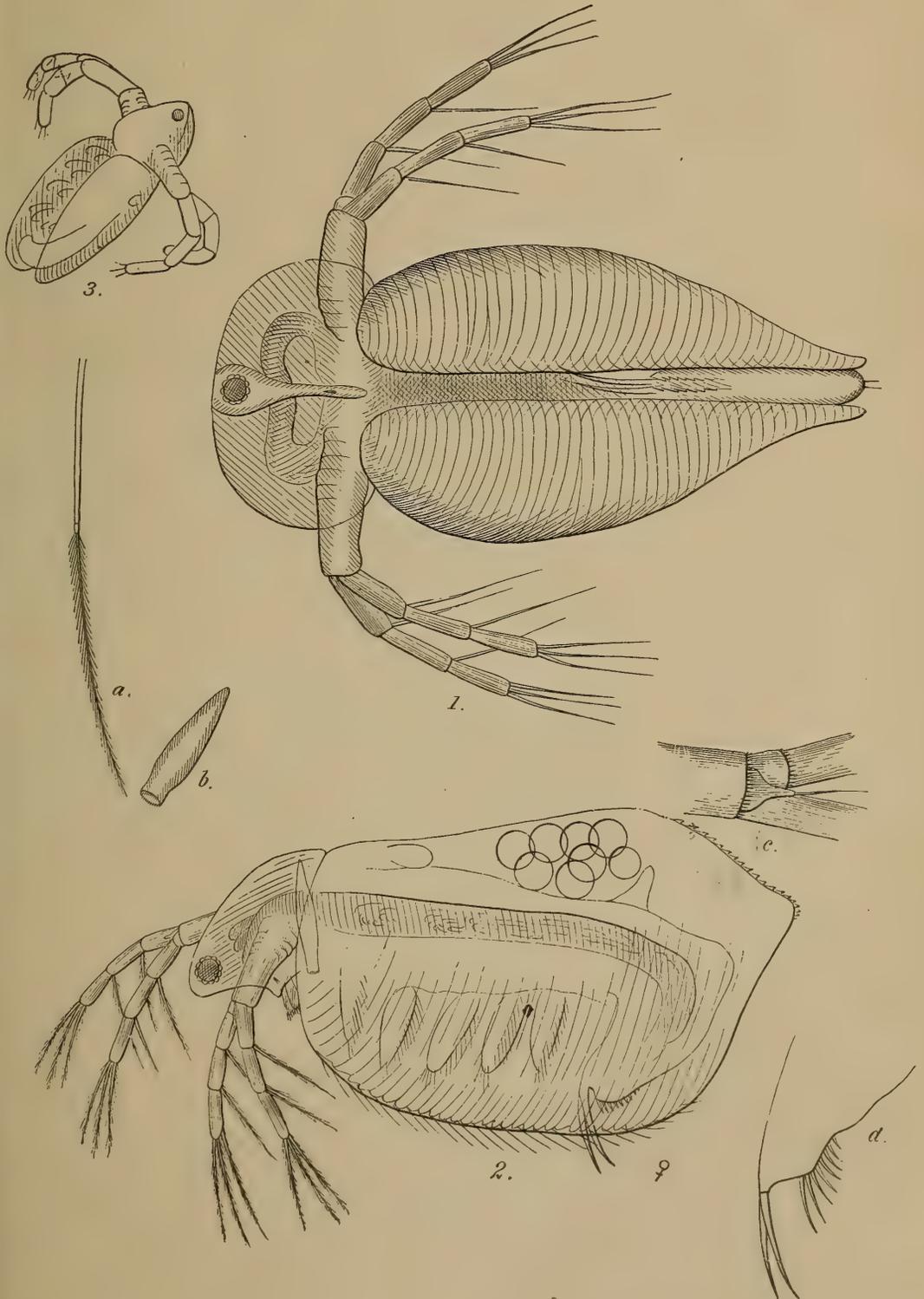
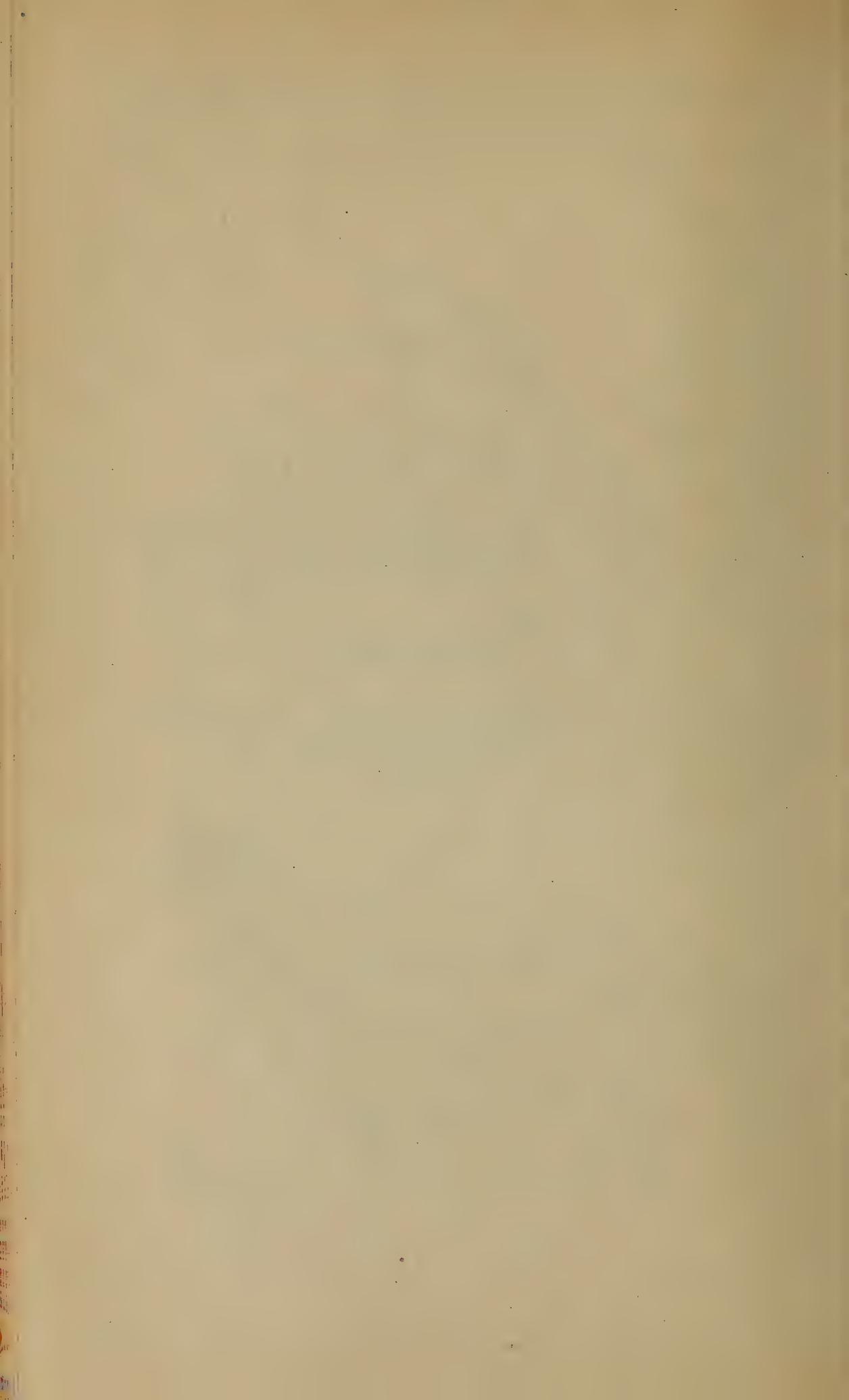


PLATE X.

Daphnia vetula.—1, under view. 2, side view. 3, young extracted from egg.
a, one of the setæ from the antennæ. *b*, jaw. *c*, base of the two rami
of the superior antennæ. *d*, end of abdomen.

MICROSCOPIC ENTOMOSTRACA.





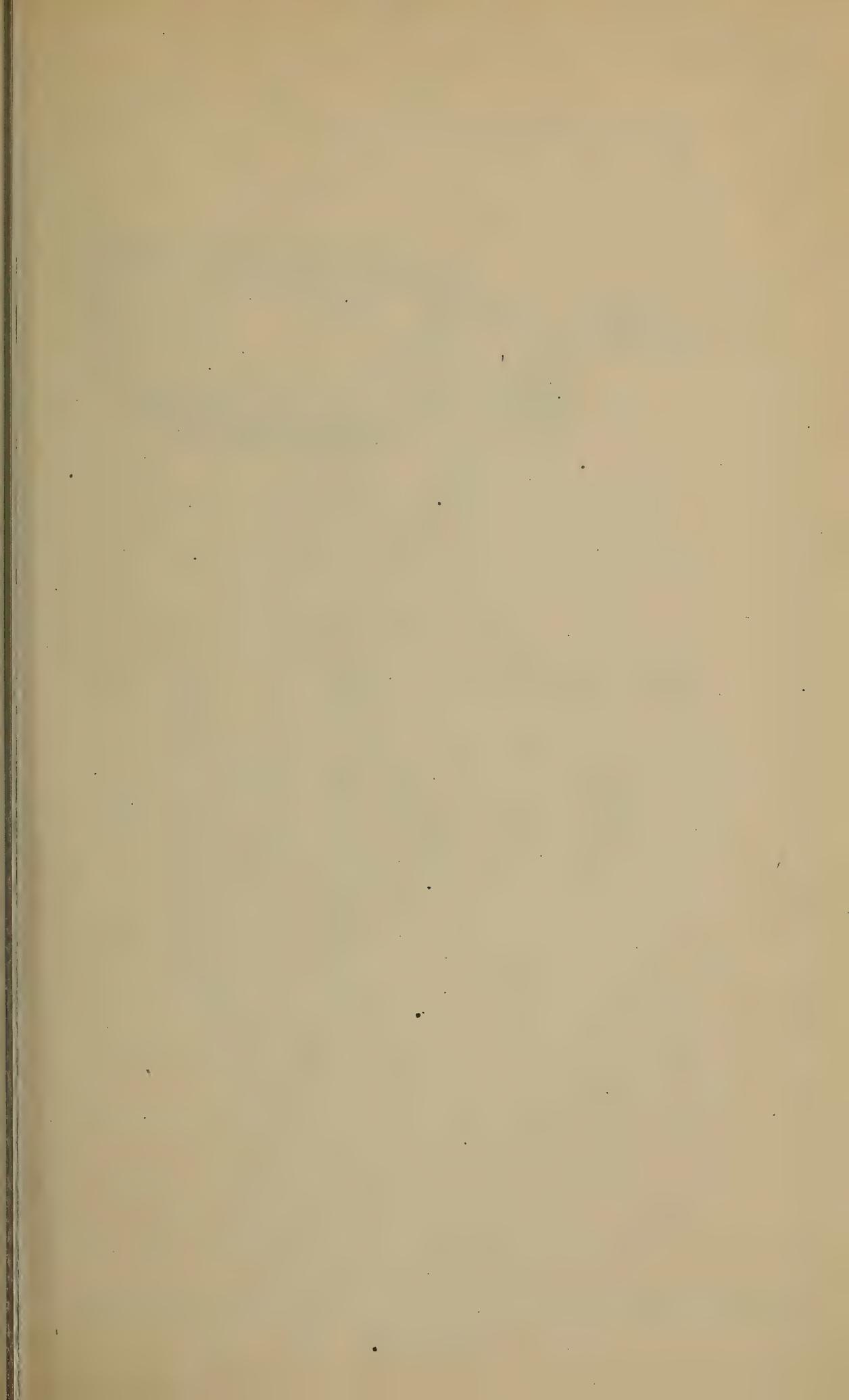


PLATE XI.

Daphnia vetula, male and female. *a*, jaws.

MICROSCOPIC ENTOMOSTRACA.

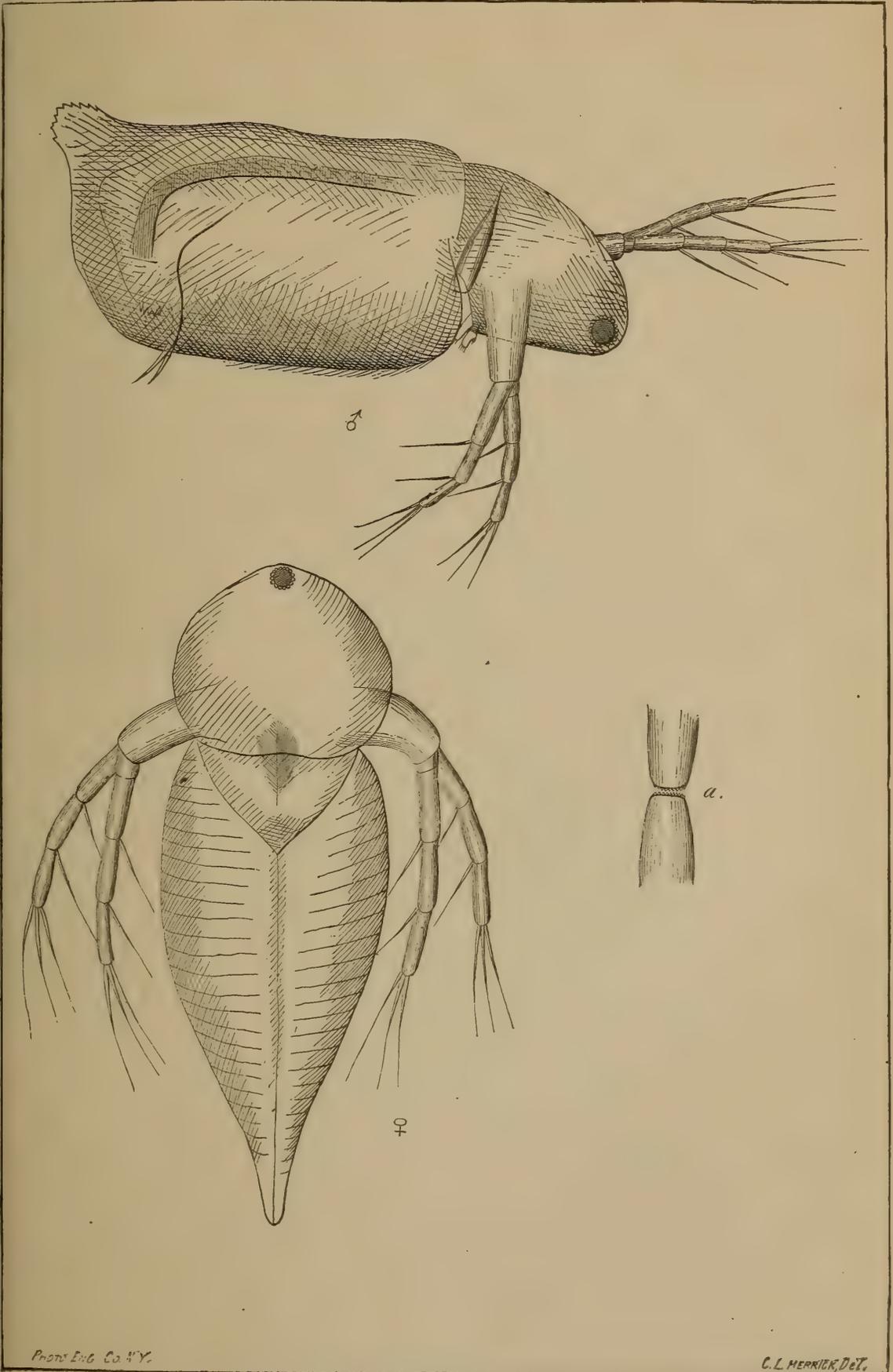


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C. L. HERRICK, DeT.

Plate XI.

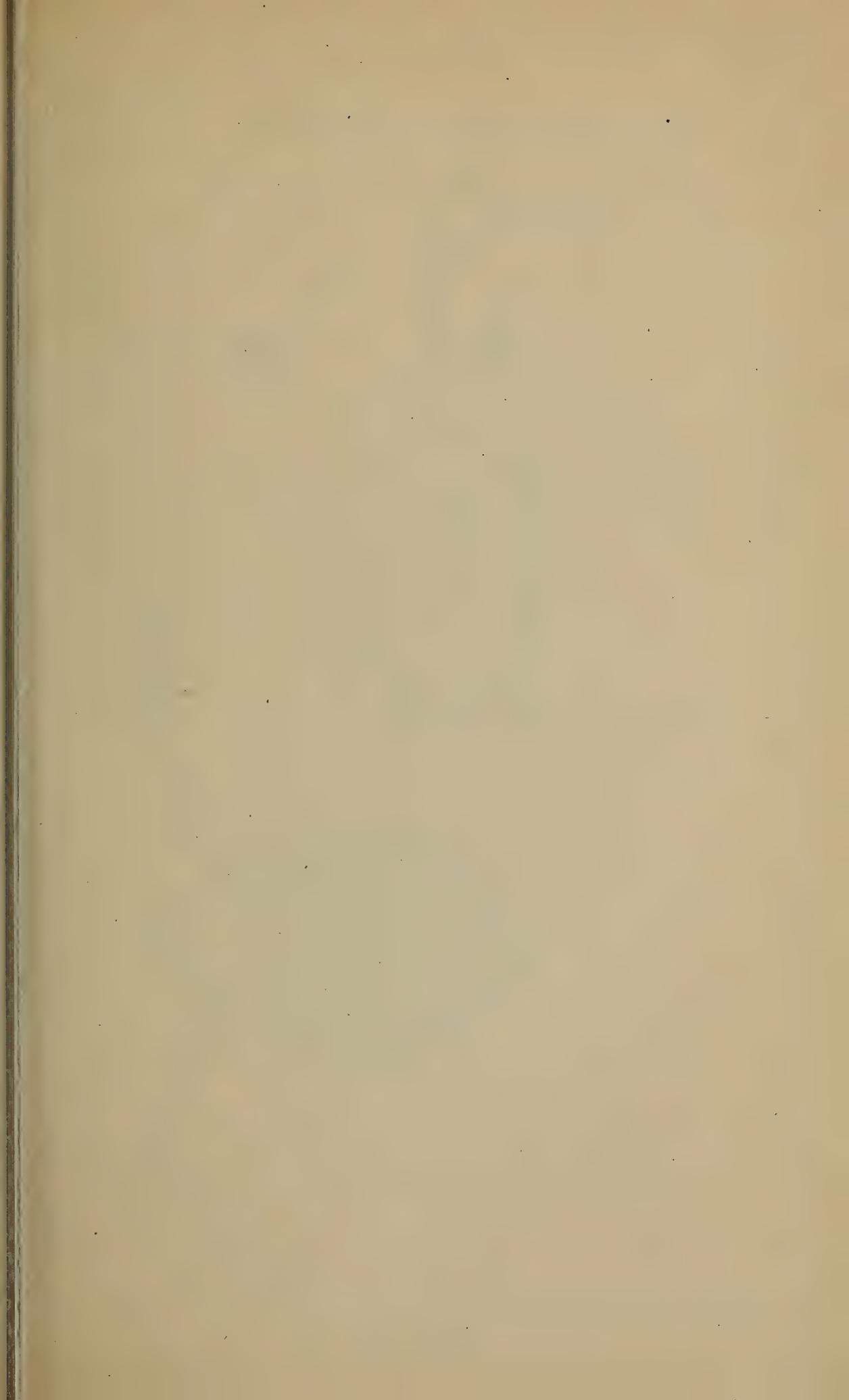


PLATE XII.

Daphnia mucronata. a, head and eye.

MICROSCOPIC ENTOMOSTRACA.

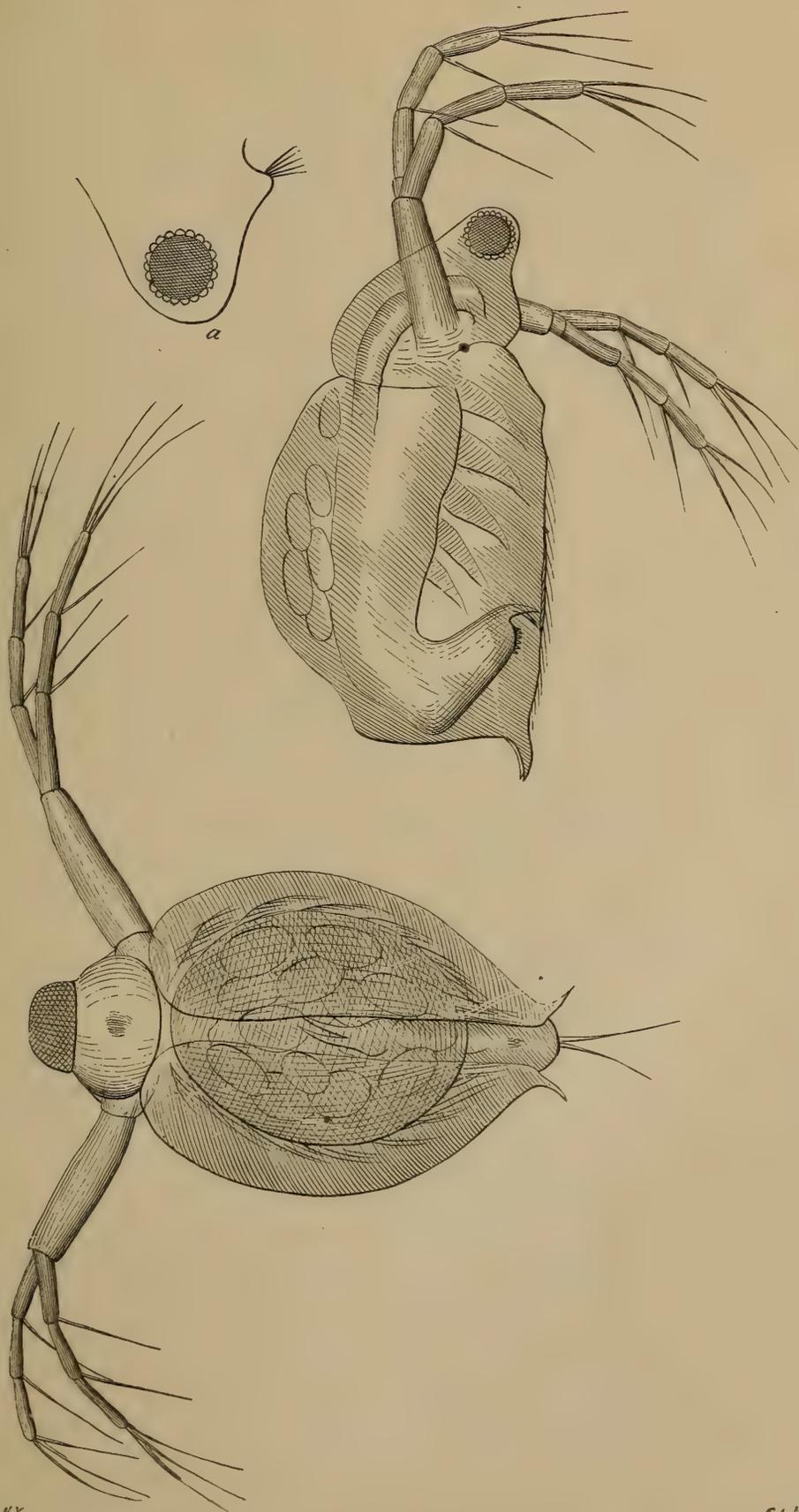
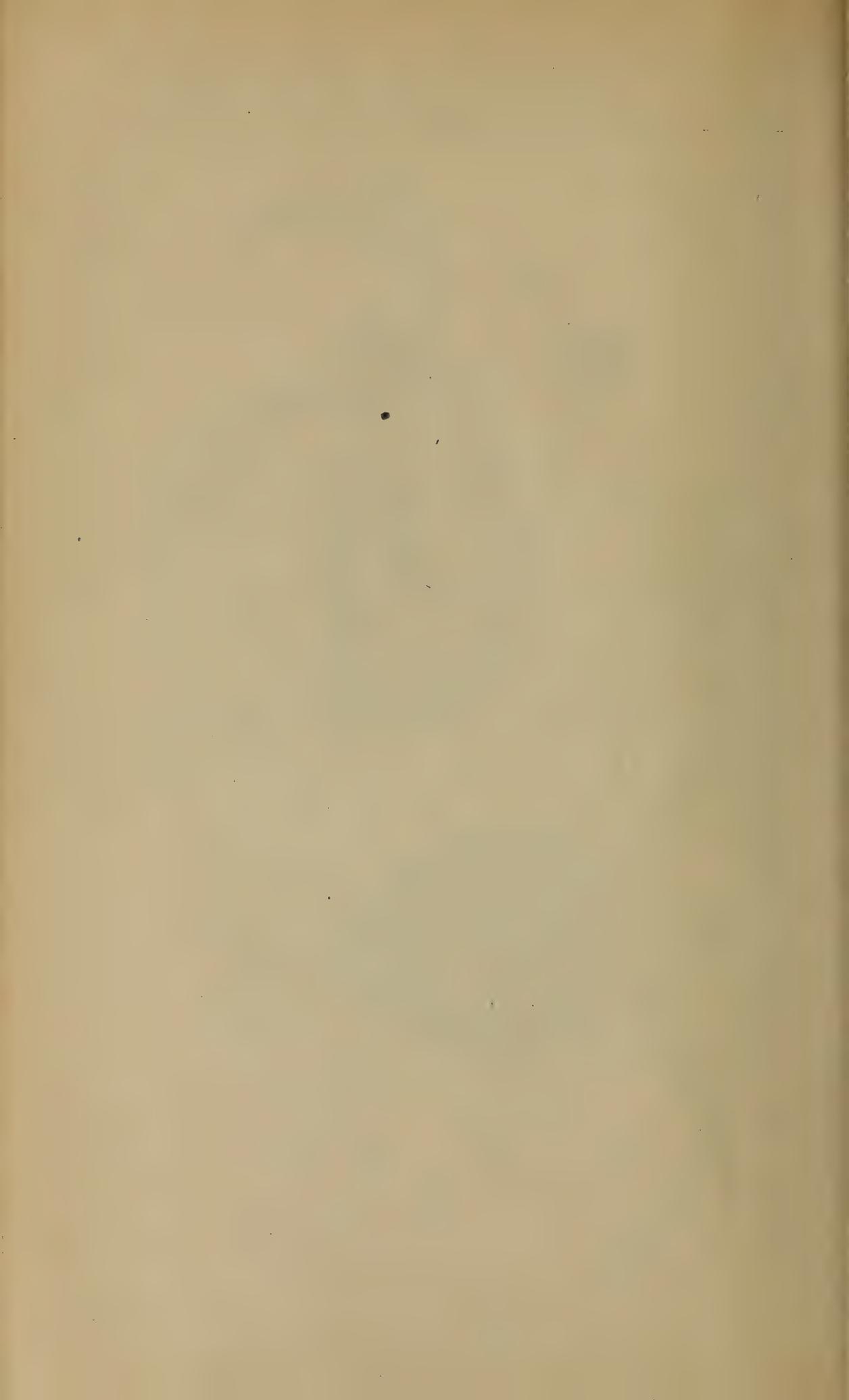


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C. L. HERRICK DEL.



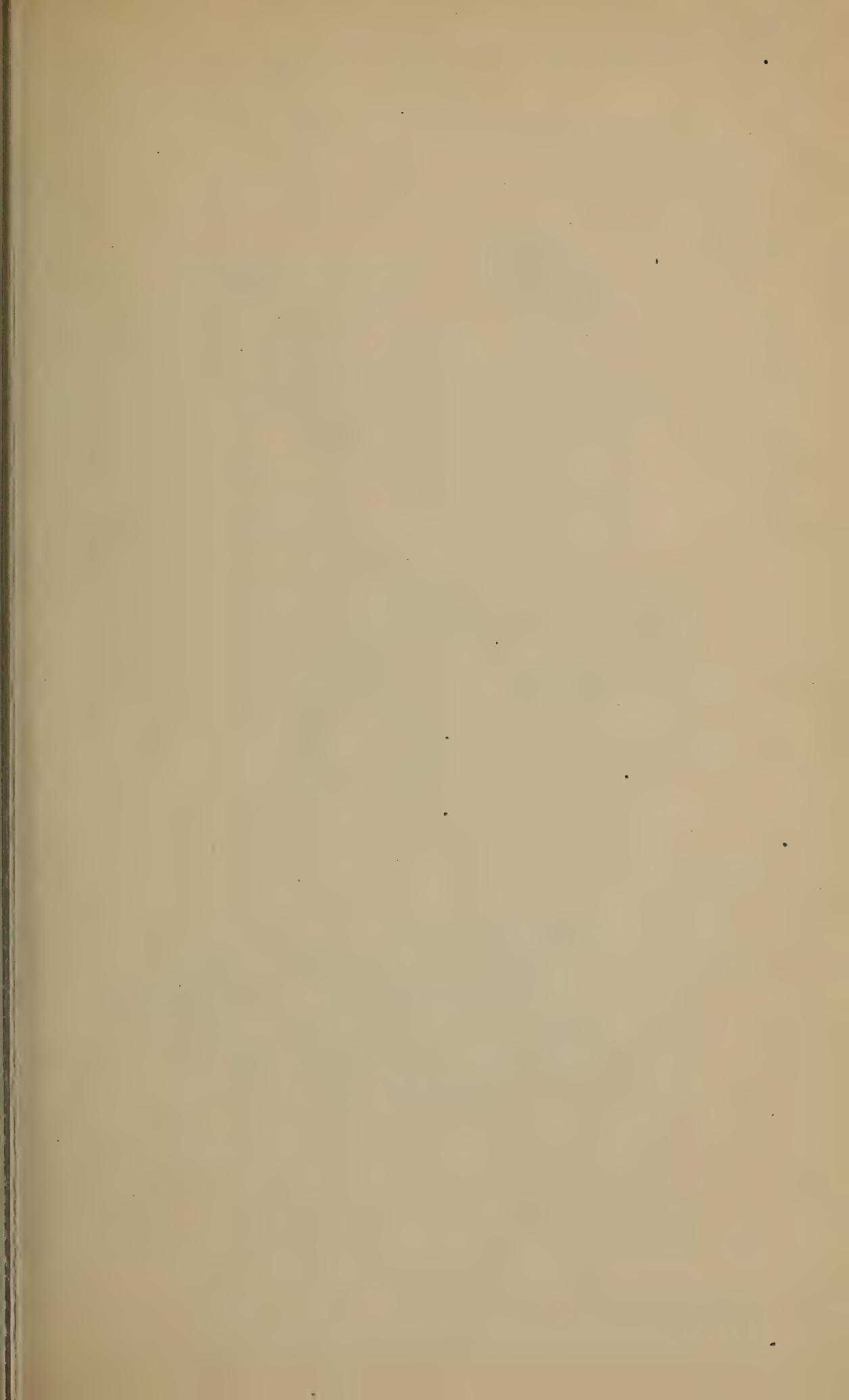
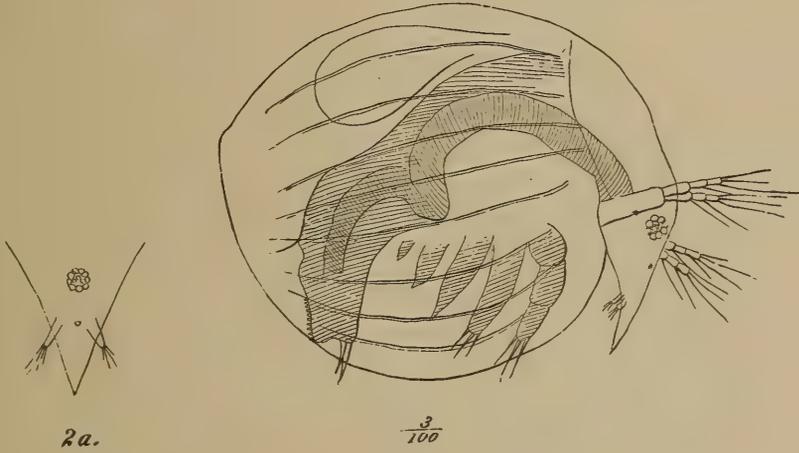
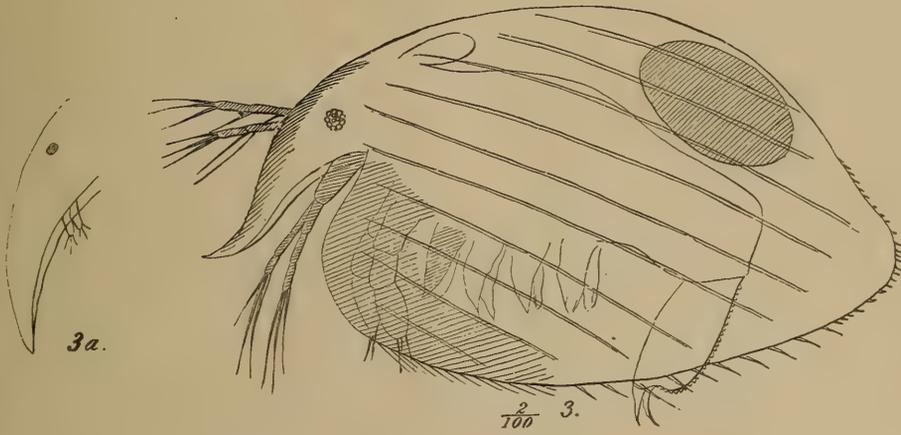
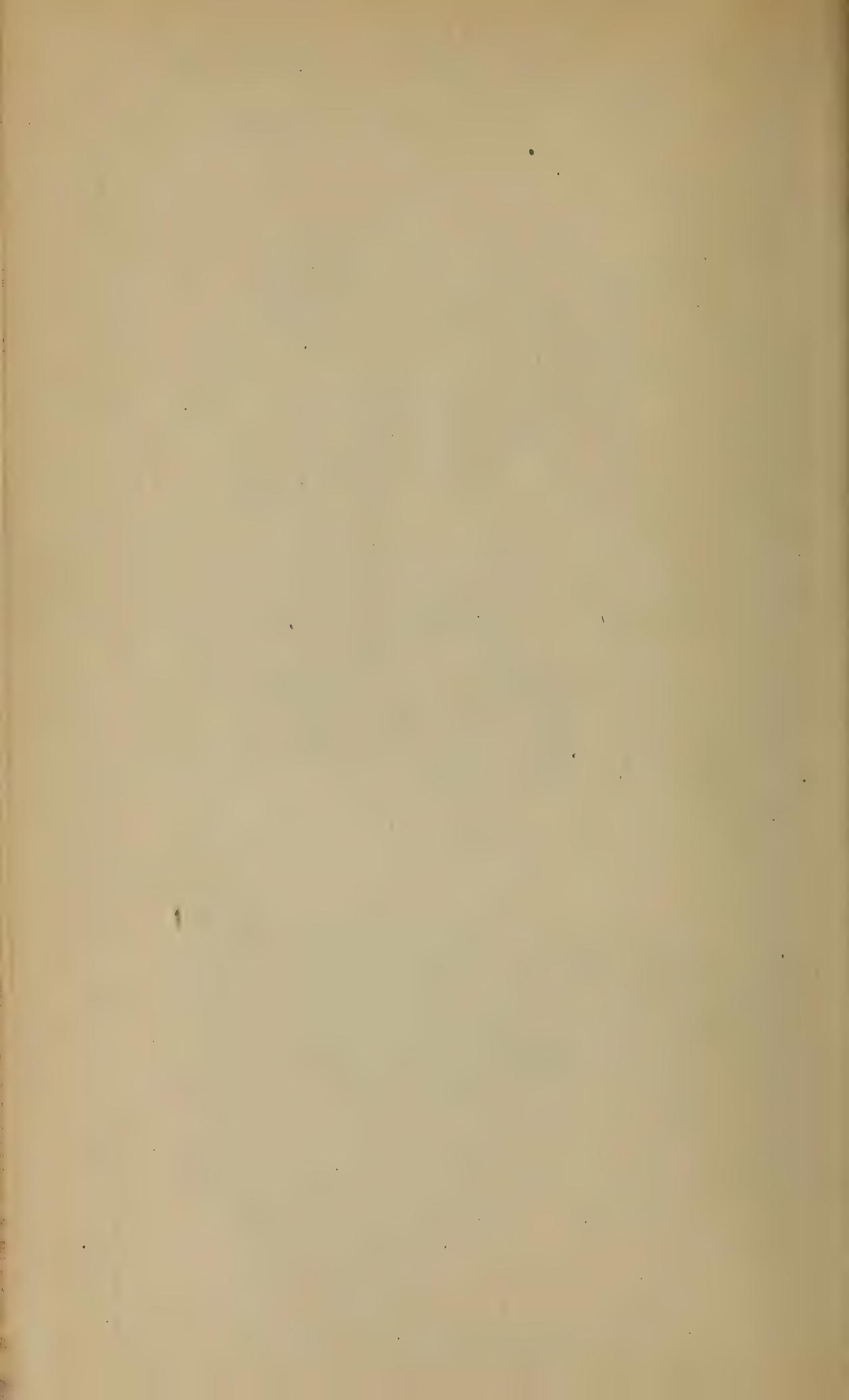


PLATE XIII.

- 1, *Daphnia spinosa*, Herrick.
- 2, *Lynceus* sp. ?
- 3, *Lynceus sphaericus*.

MICROSCOPIC ENTOMOSTRACA.





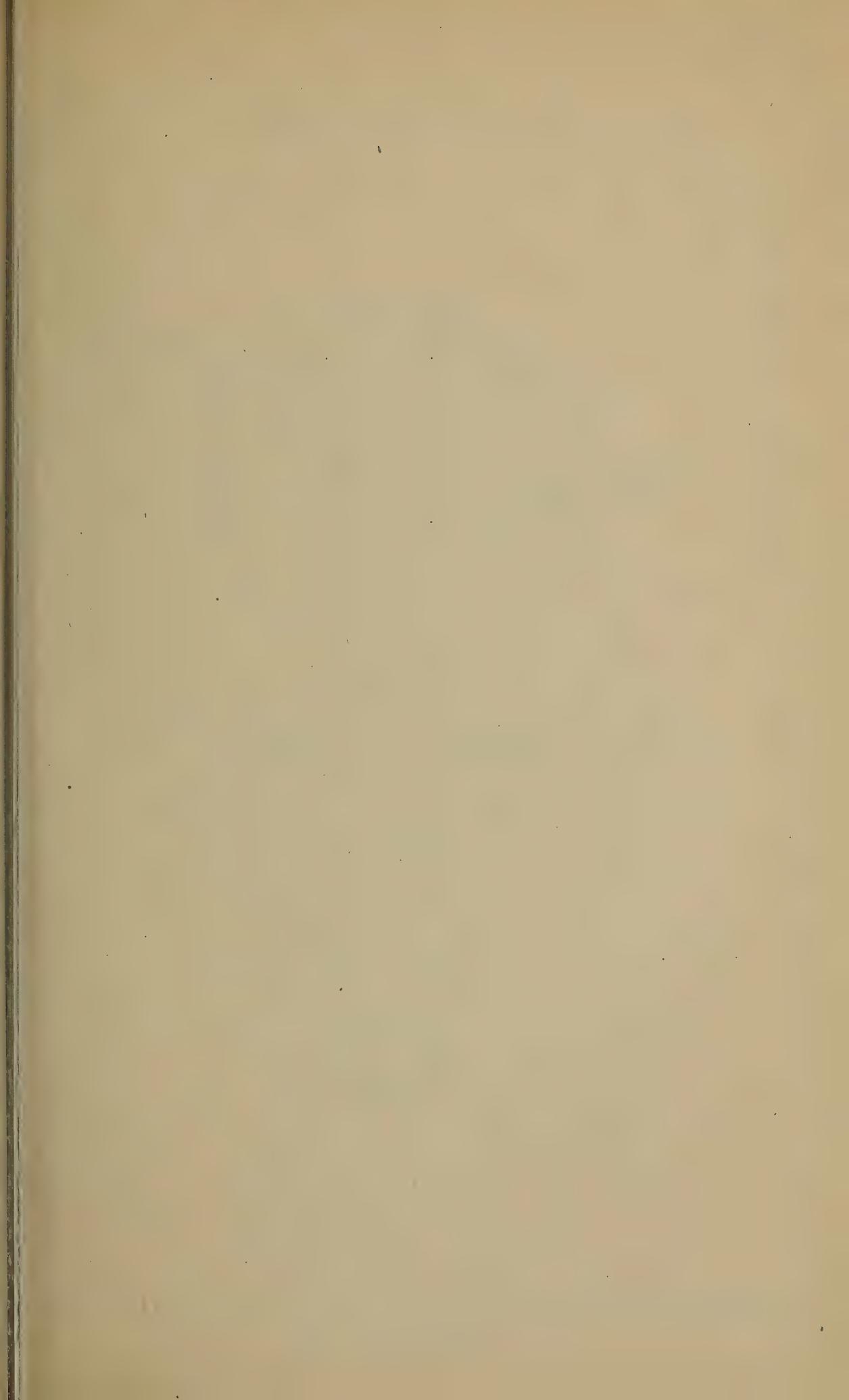
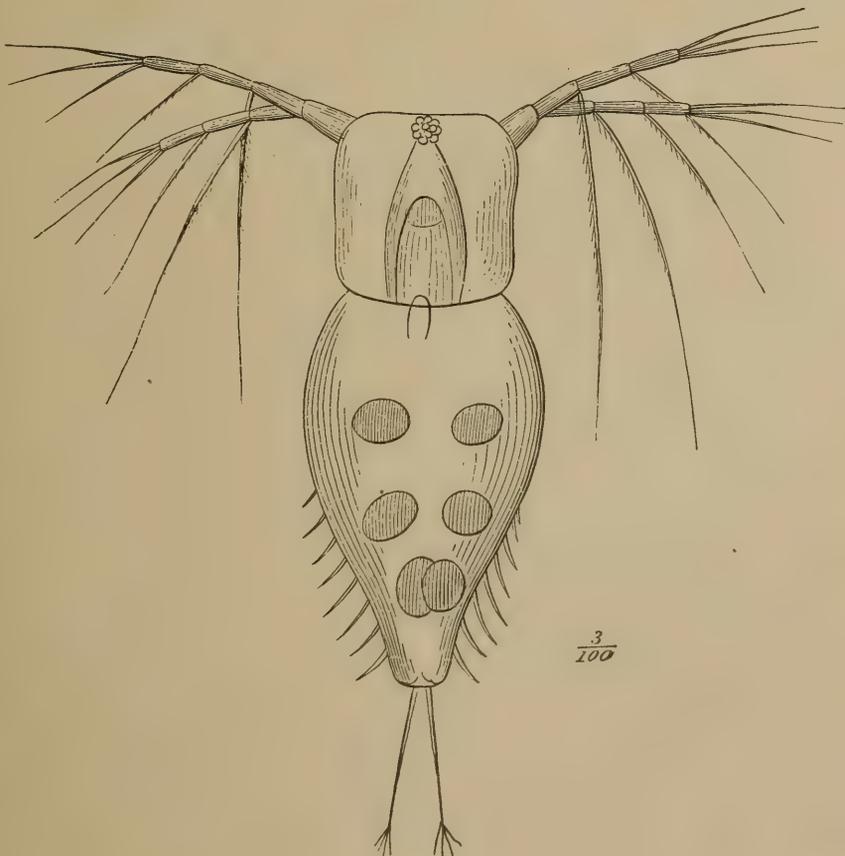
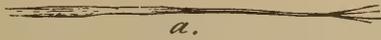


PLATE XIV.

Macrothrix agilis, Herrick. Two views. *a*, tail spine.

MICROSCOPIC ENTOMOSTRACA.



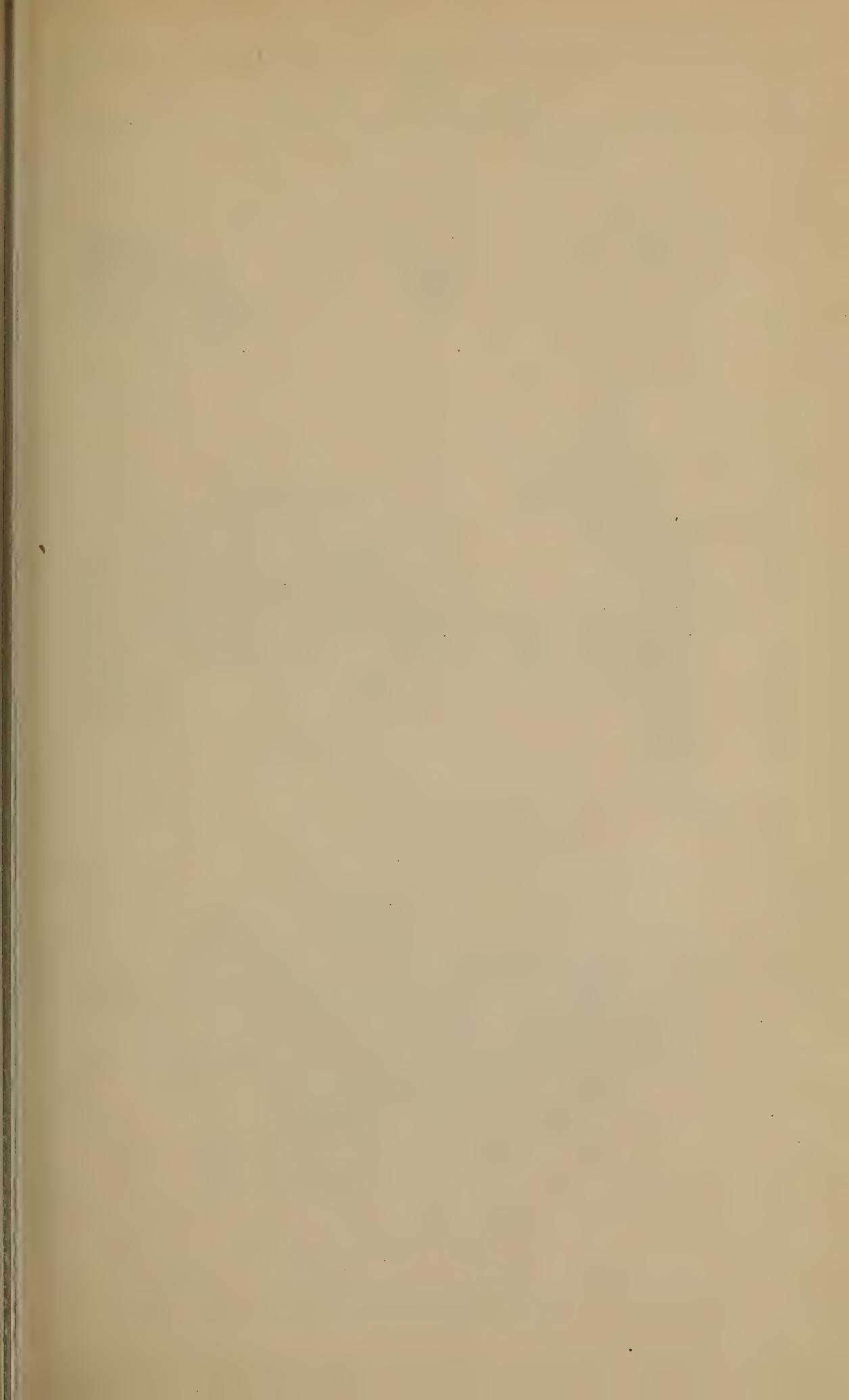


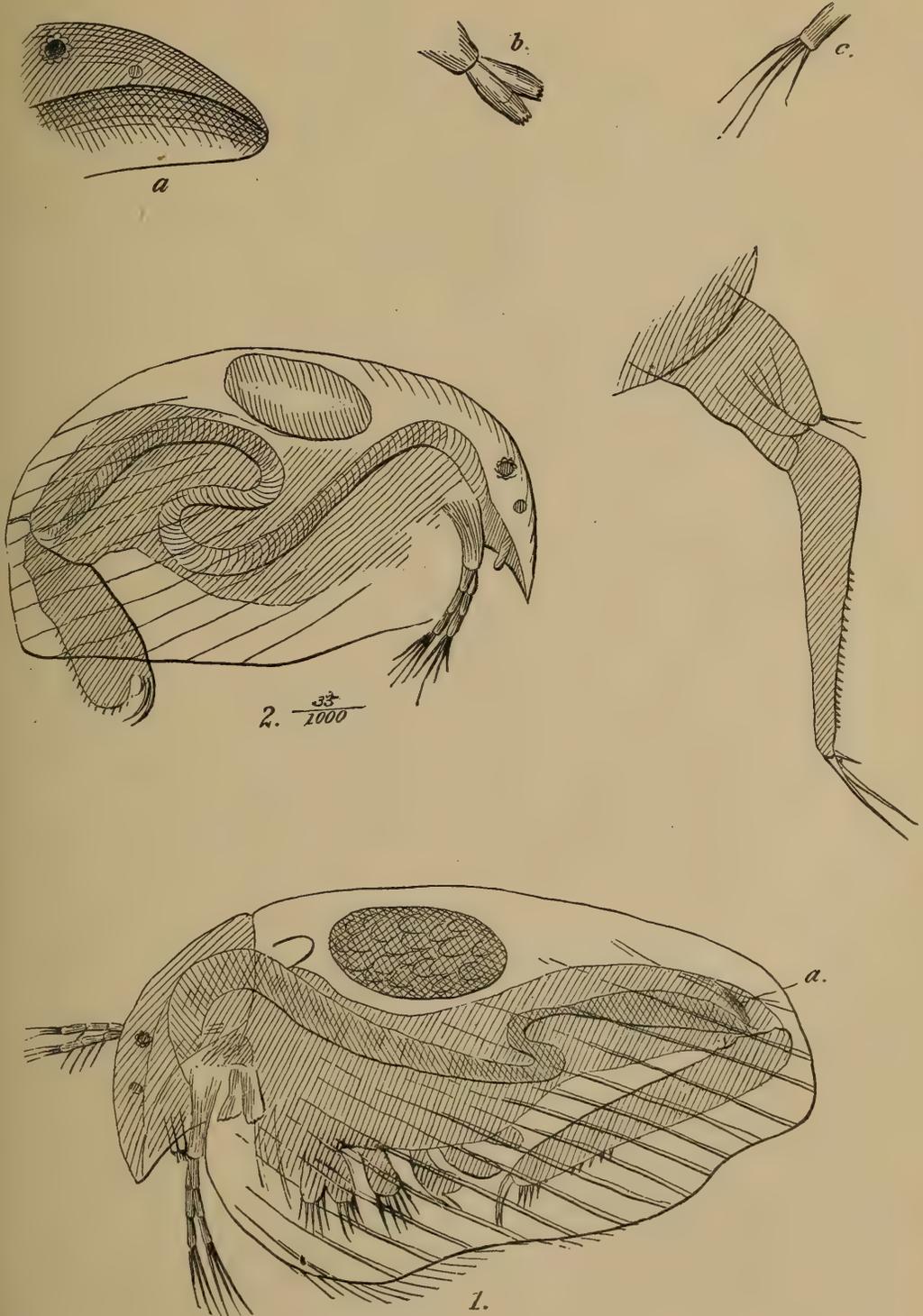
PLATE XV.

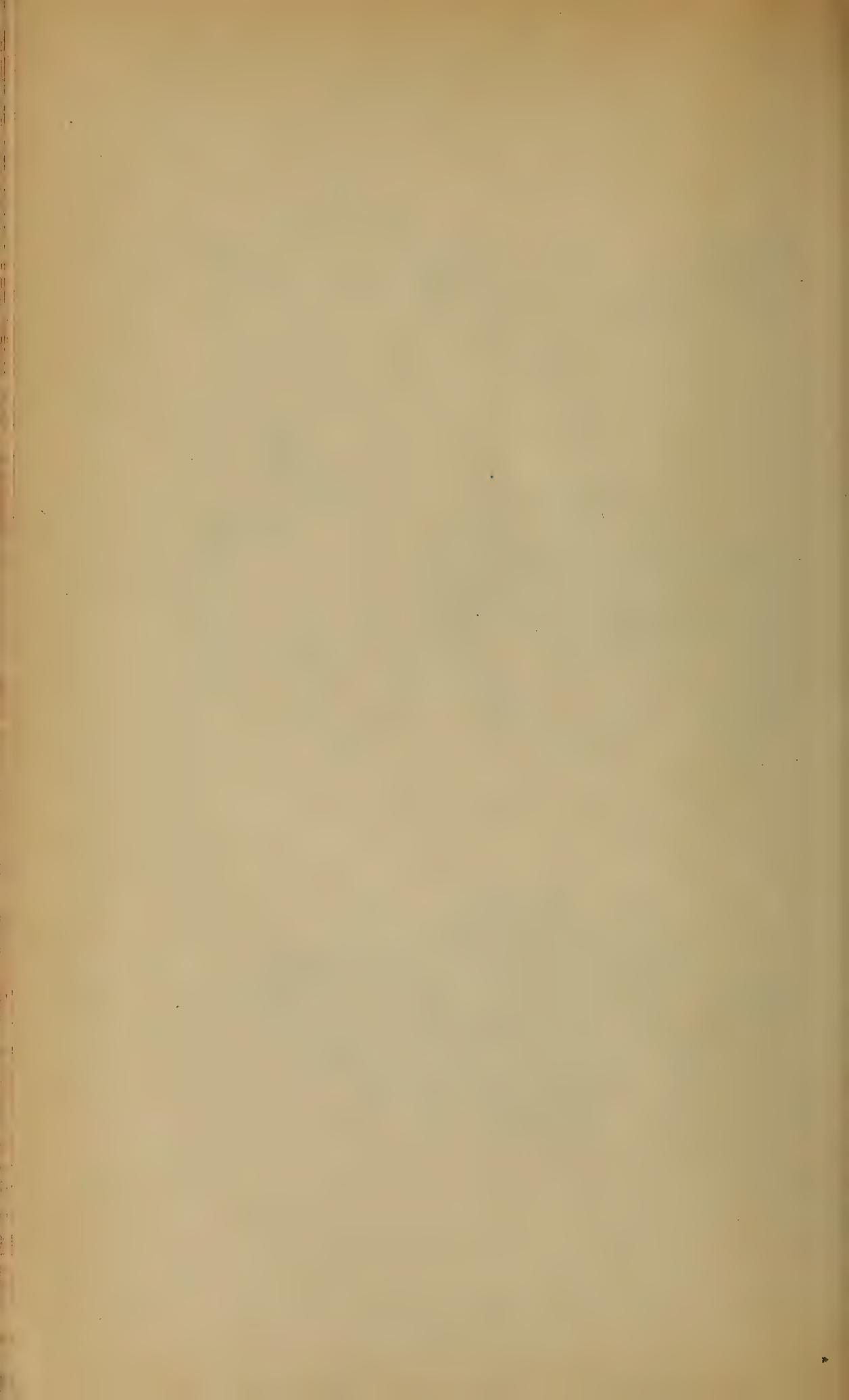
1, *Lynceus macrourus*, Muller. *a*, abdomen.

2, *Lynceus quadrangularis*, Muller.

a, beak. *b*, jaws. *c*, end of antennæ.

MICROSCOPIC ENTOMOSTRACA.





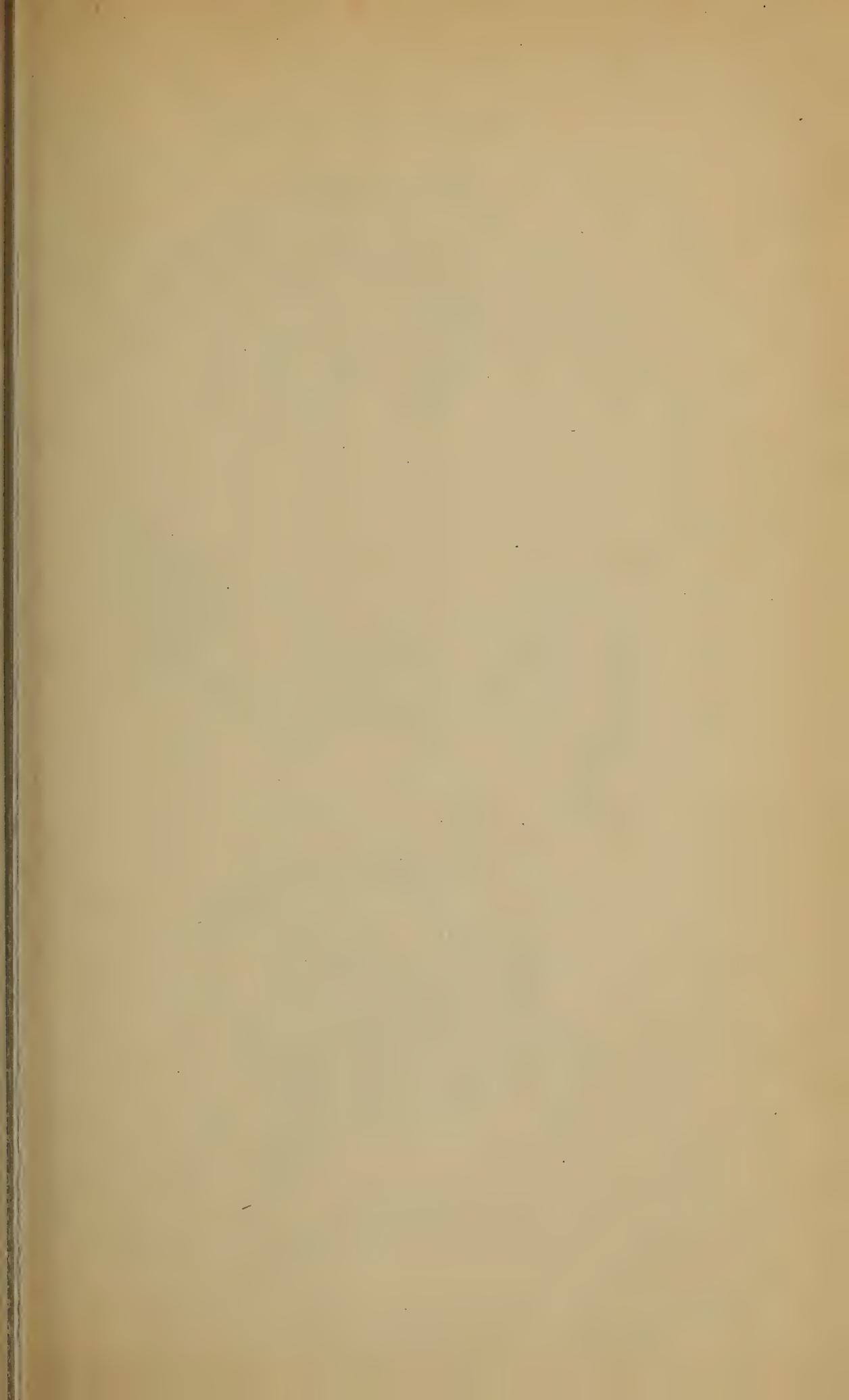
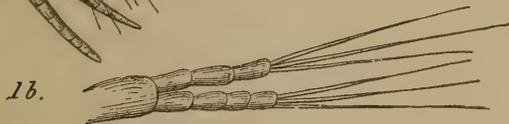
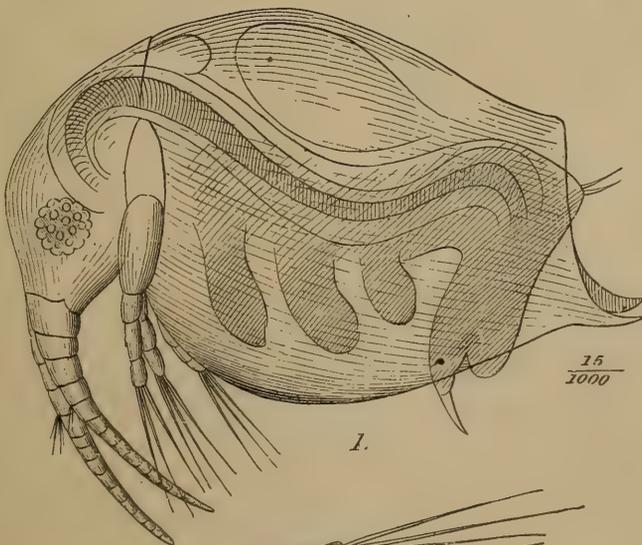
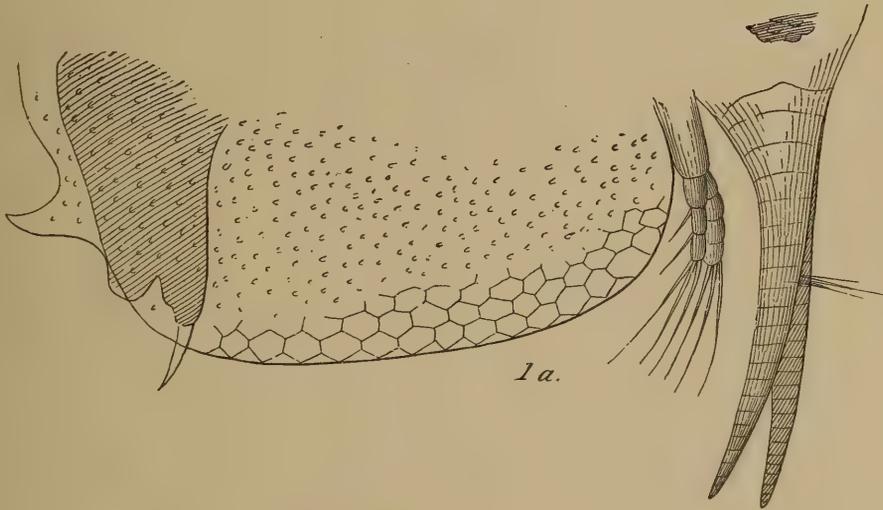
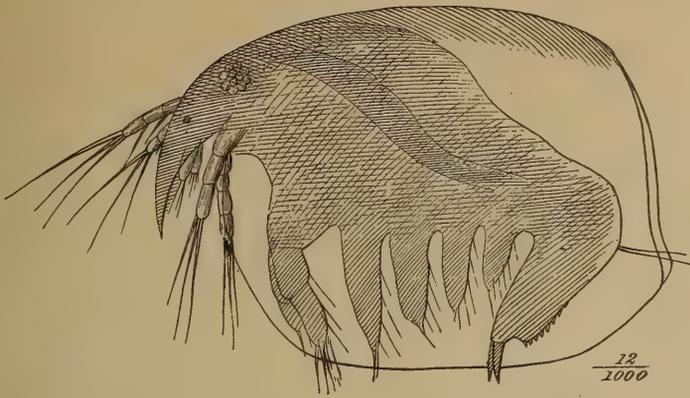


PLATE XVI.

- 1, *Bosmina longirostris*. a, portion of shell, superior antennae.
- 2, *Lynceus* sp. ?

MICROSCOPIC ENTOMOSTRACA.



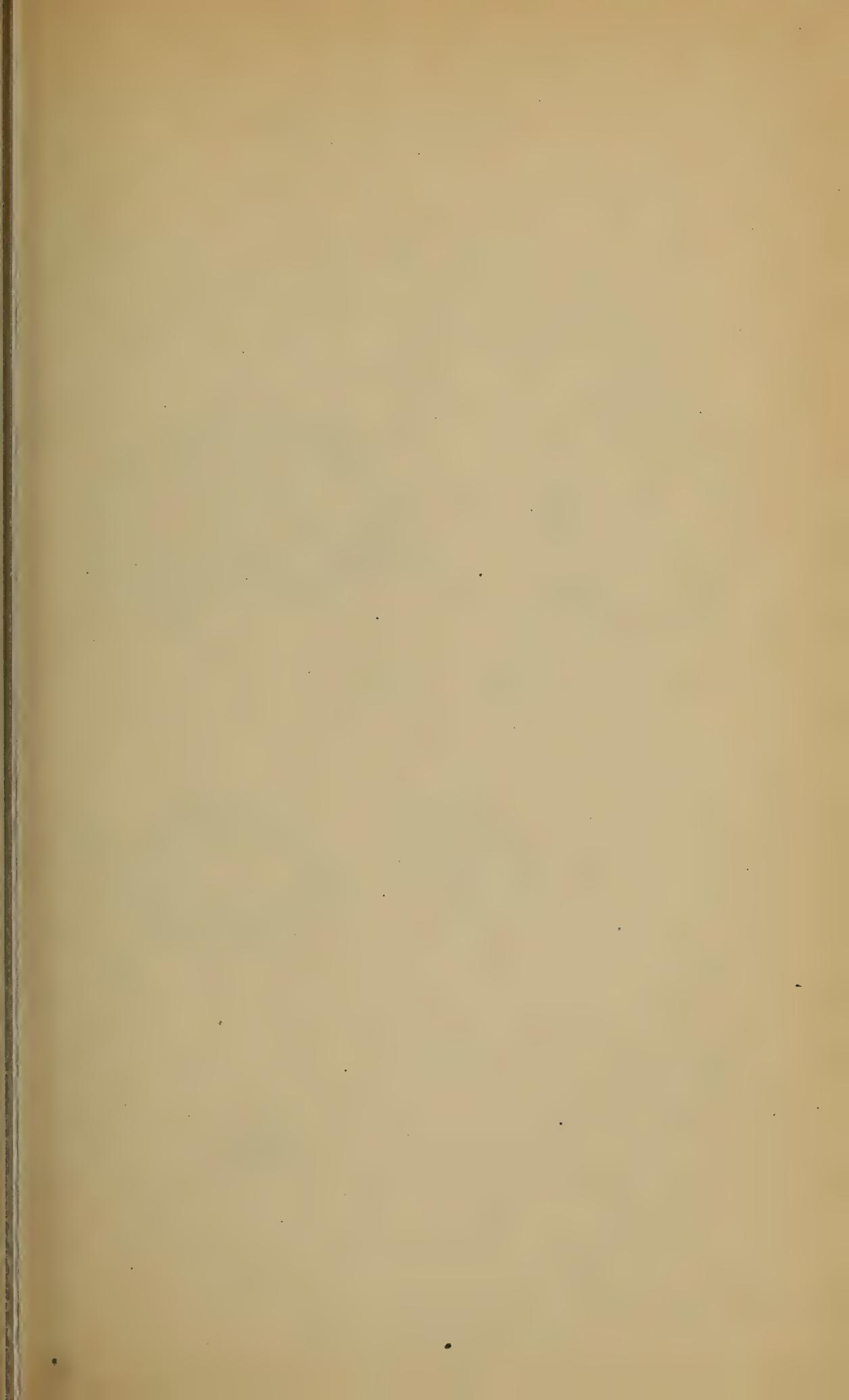


PLATE XVII.

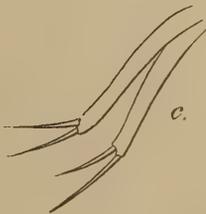
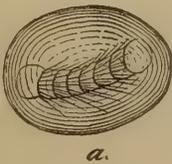
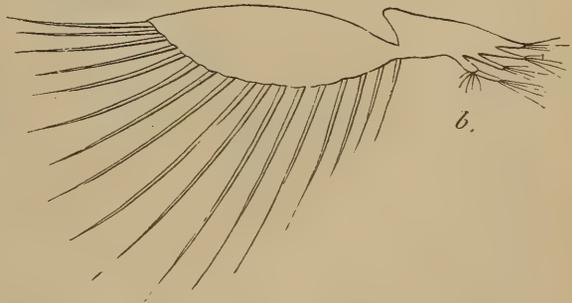
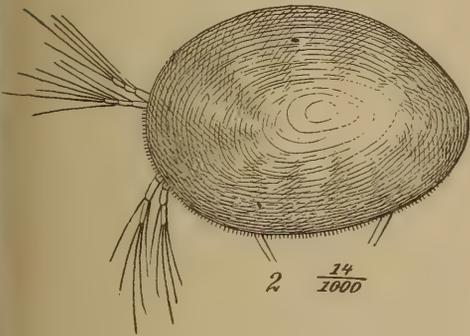
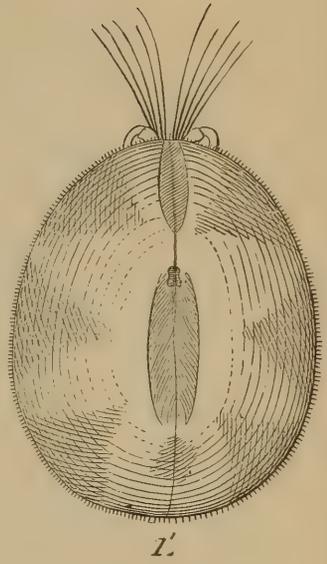
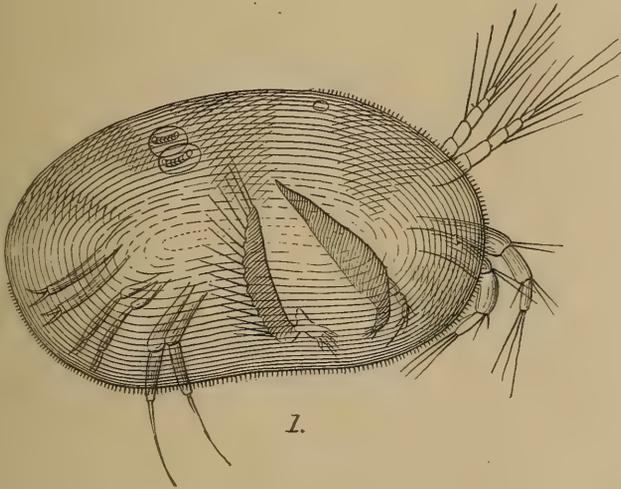
1. *Cypris vidua*, Muller.

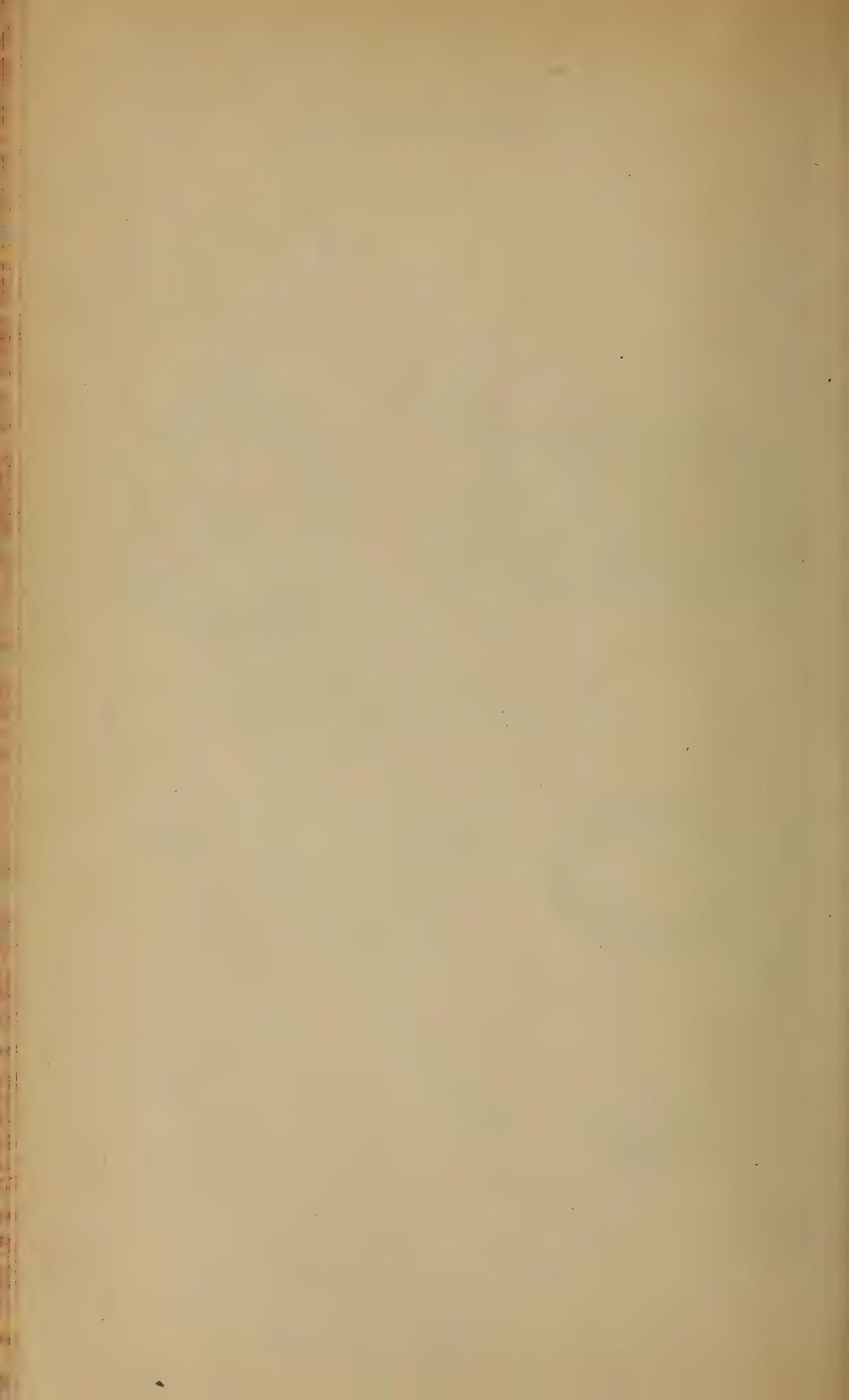
1'. ——— top view.

2. *Cypris neglecta*, Herrick.

a, testicle. *b*, maxilla. *c*, caudal stylets. *d*, inferior antennæ.

MICROSCOPIC ENTOMOSTRACA.





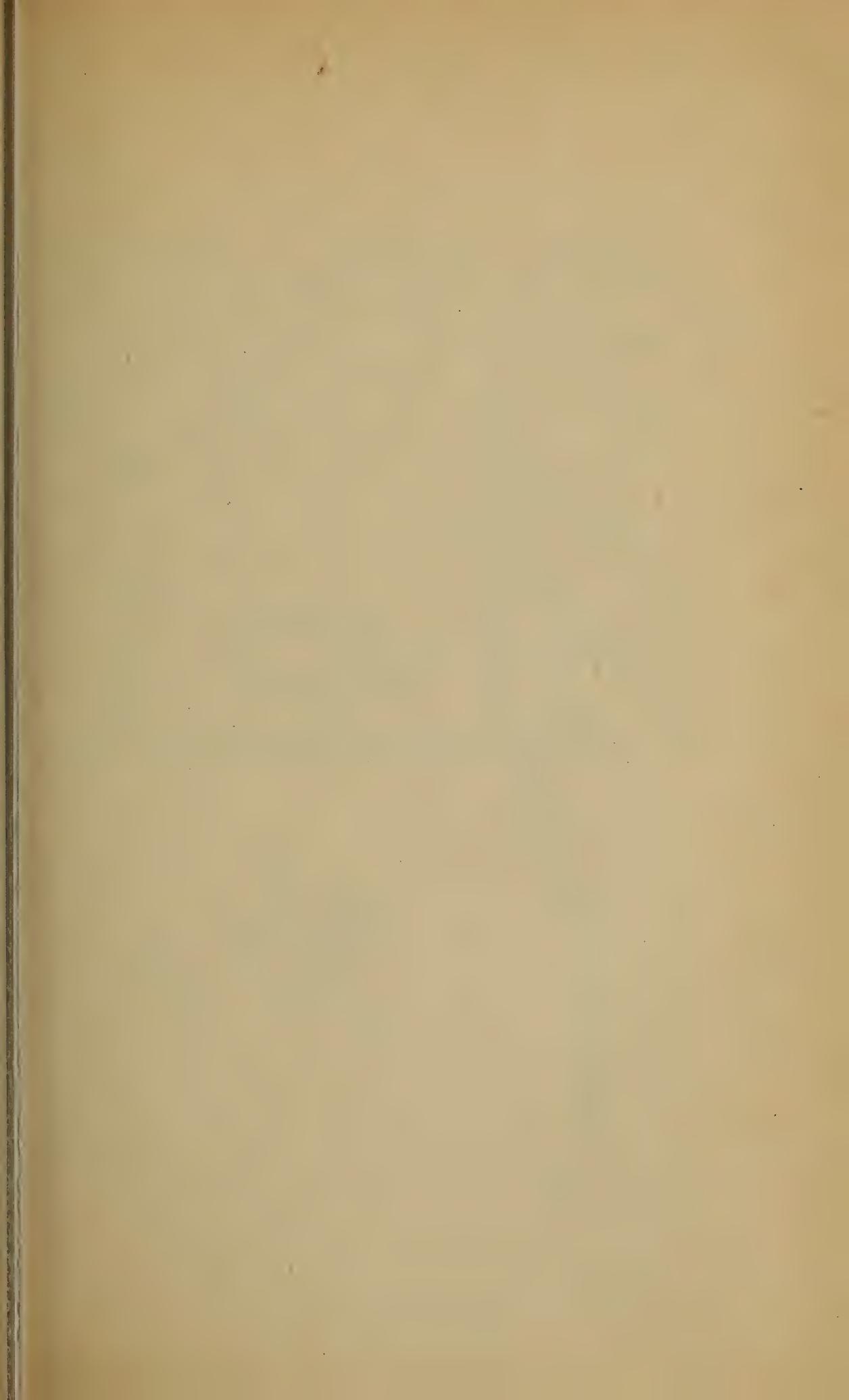
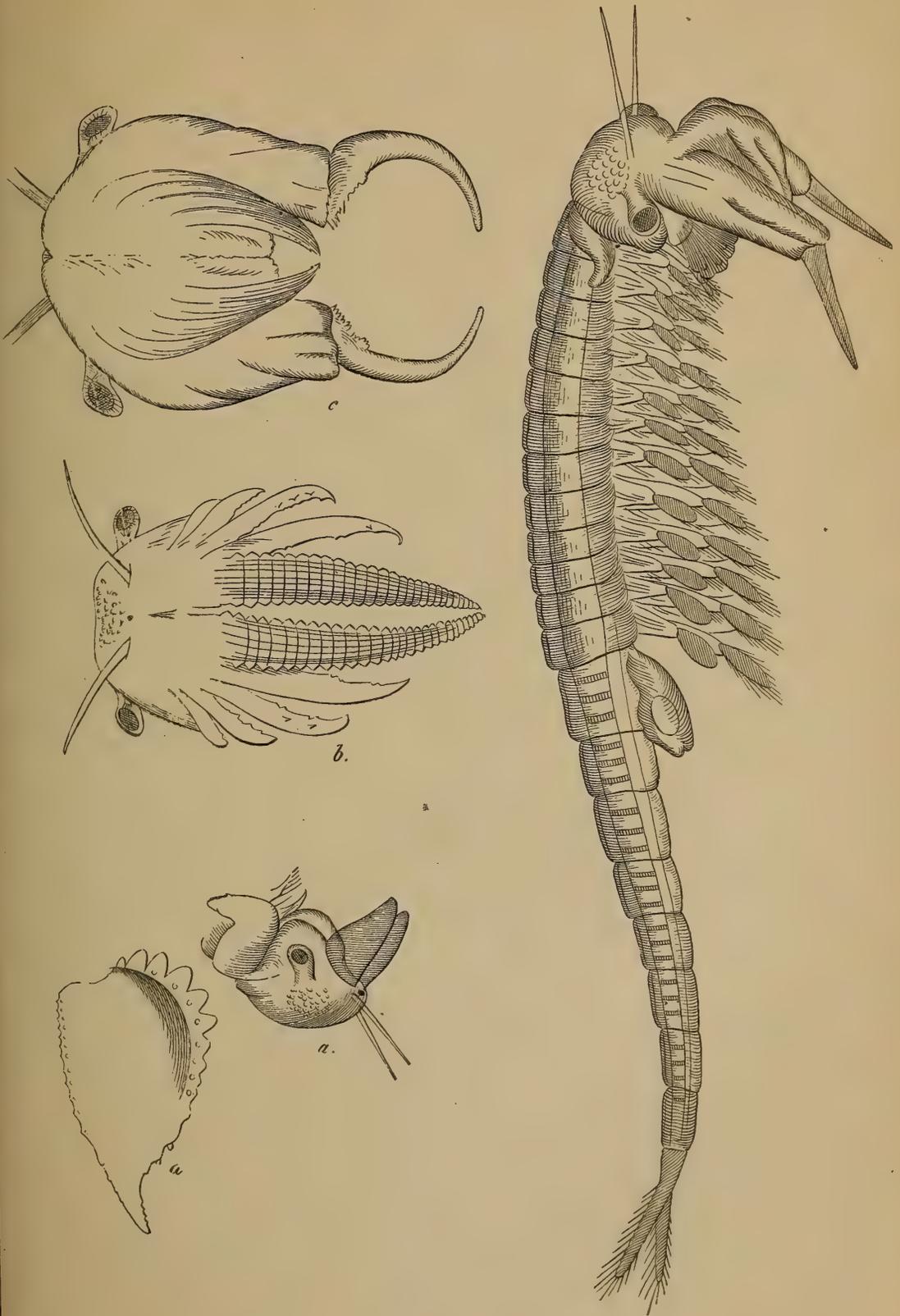
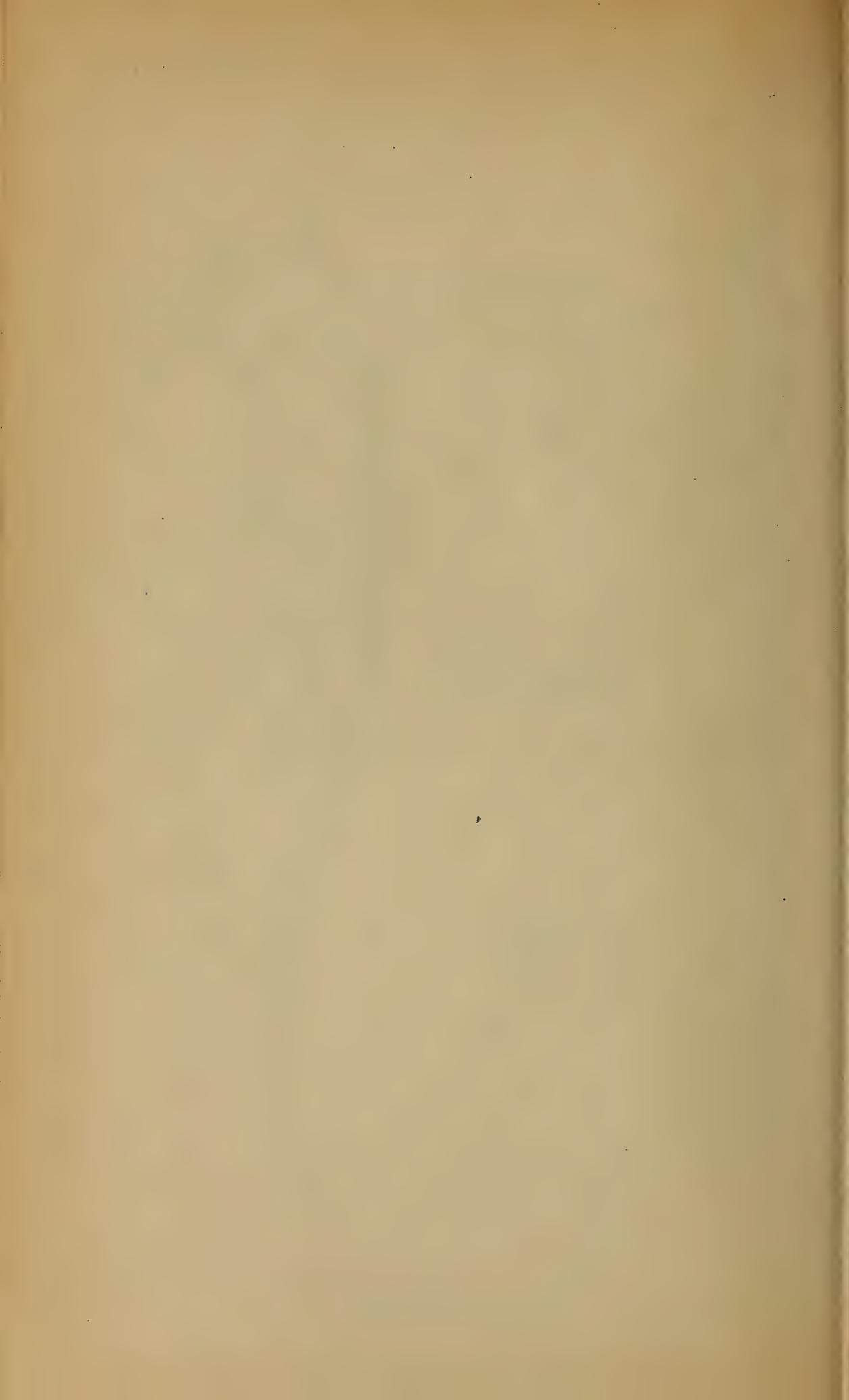


PLATE XVIII.

Chirocephalus diaphanus. *a*, head of female. *b*, head of male with claspers removed. *c*, head of male. *d*, appendage of claspers.

MICROSCOPIC ENTOMOSTRACA.





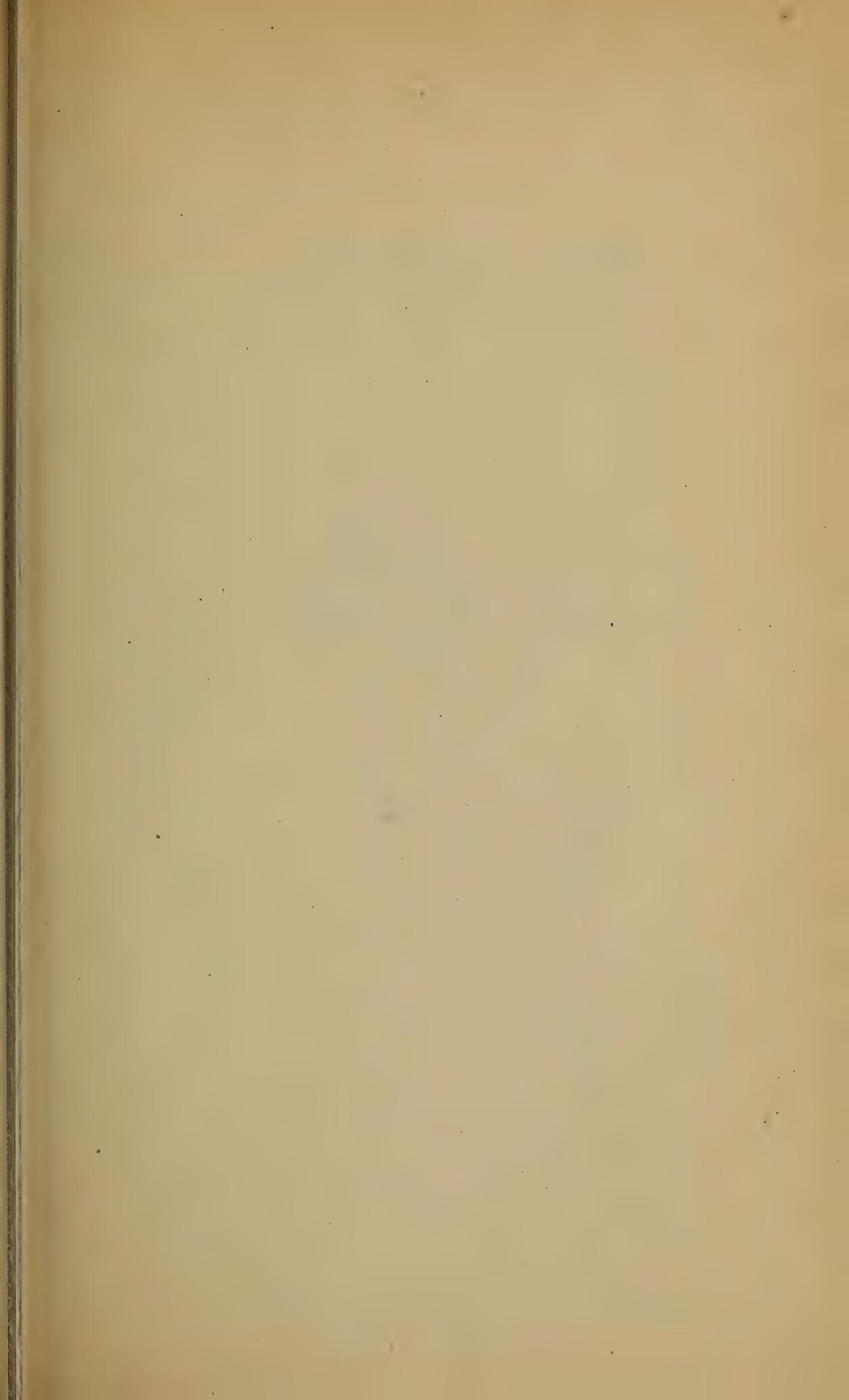
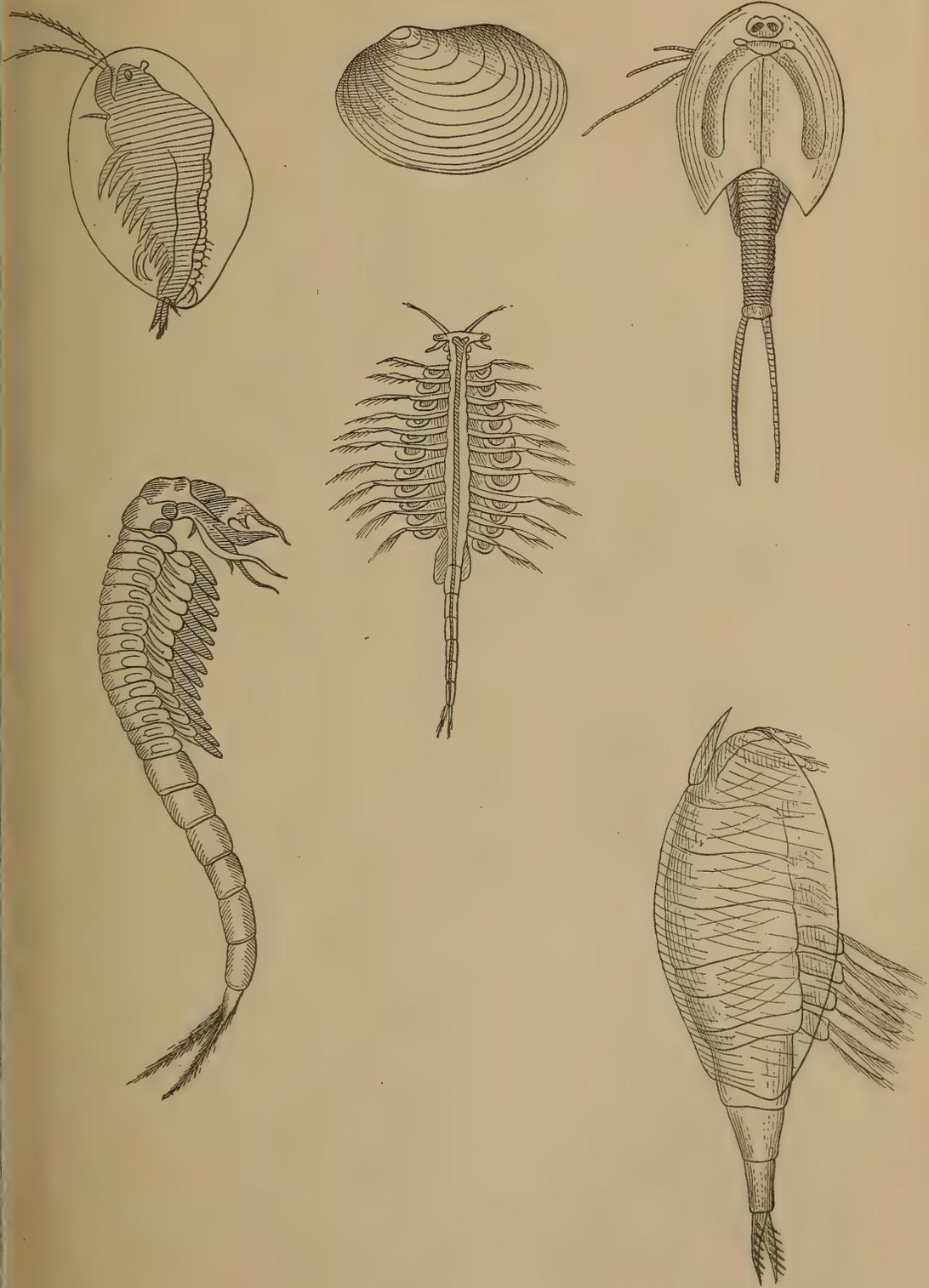


PLATE XIX.

Nebalia, Streptocephalus, Artemia, Apus, Estheria and Limnetes.

MICROSCOPIC ENTOMOSTRACA.



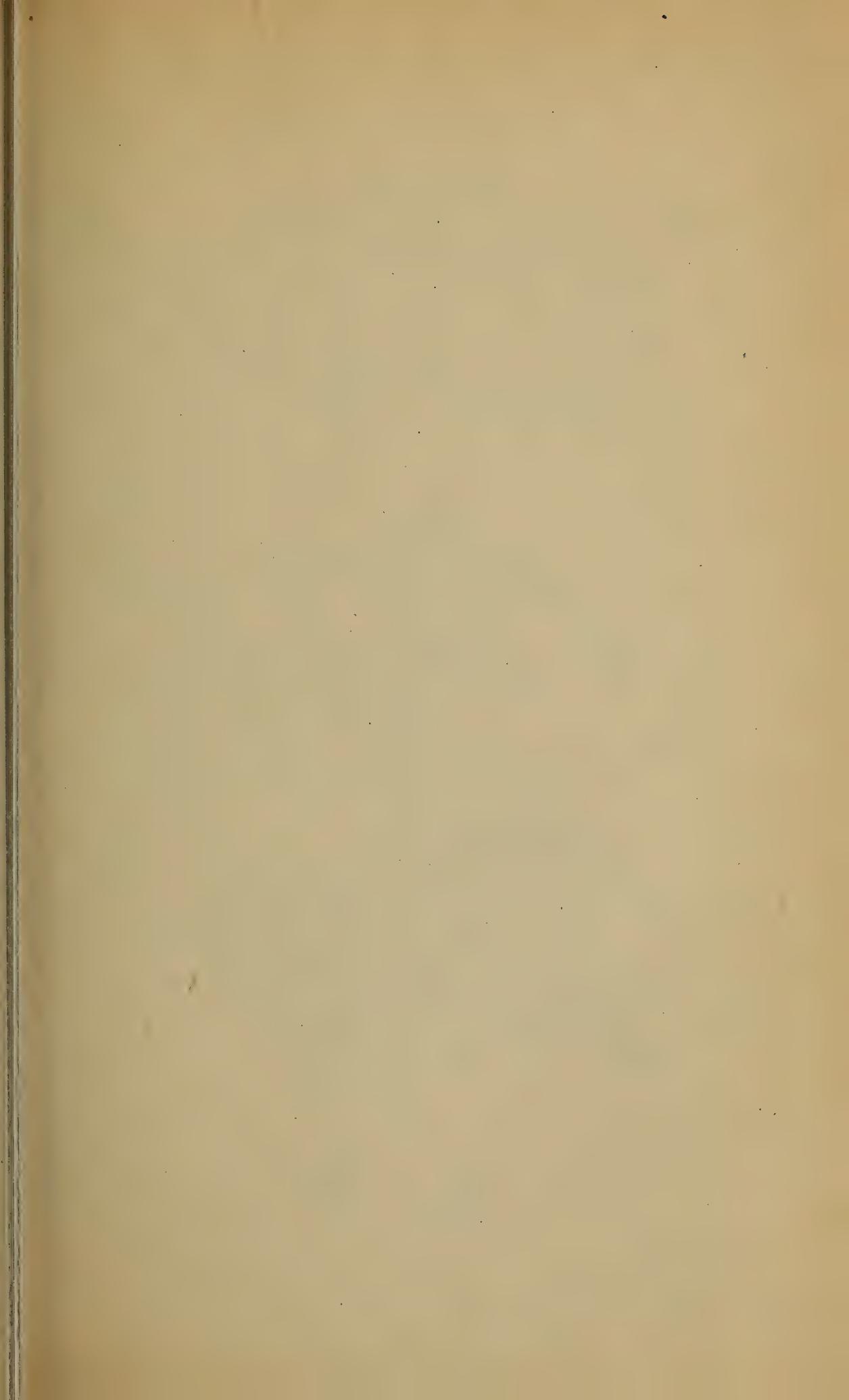
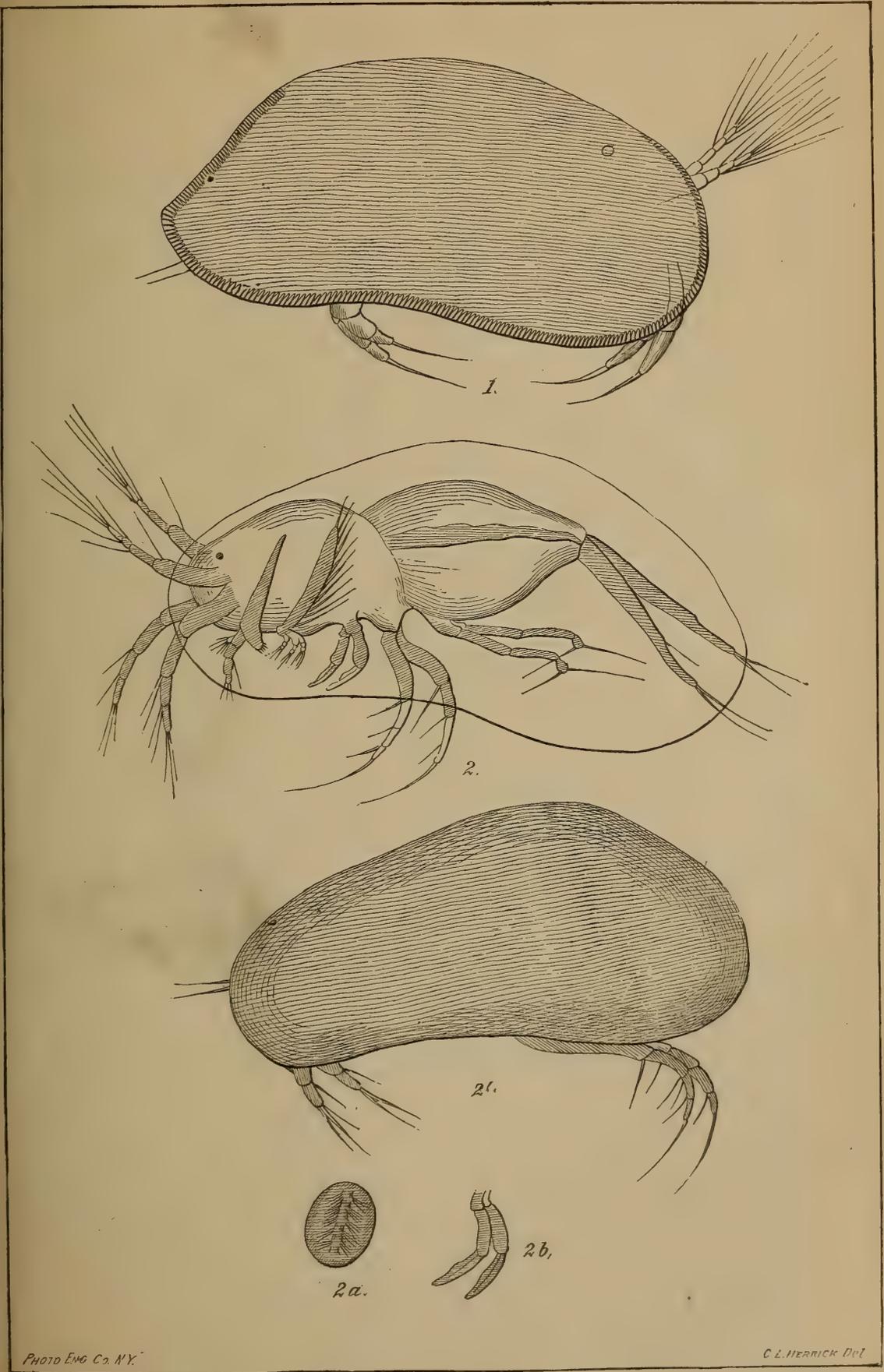
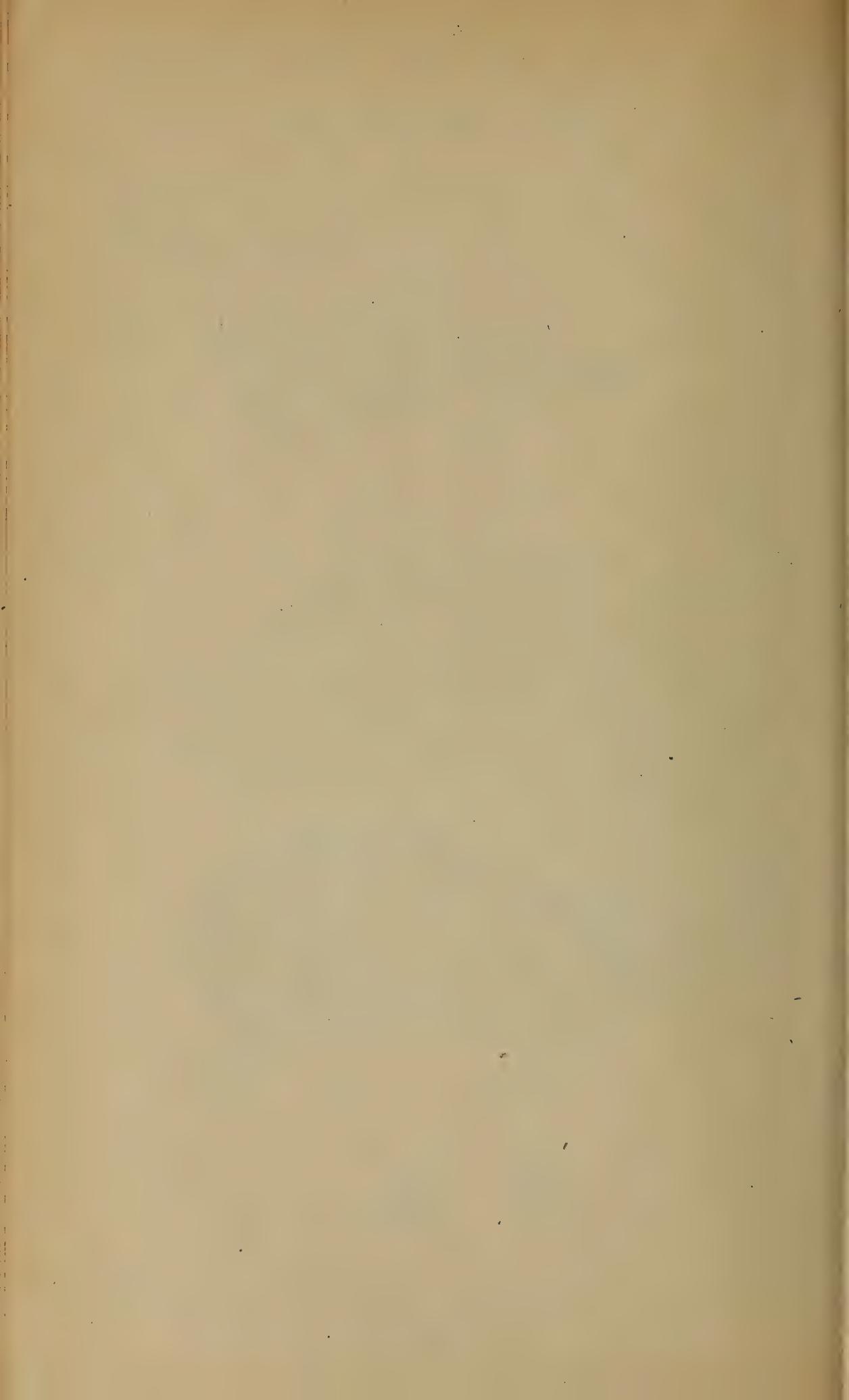


PLATE XX.

1. *Candona ornata*. 2. *Candona elongata*. 2a, testicle? 2b, maxillipeds.

MICROSCOPIC ENTOMOSTRACA.





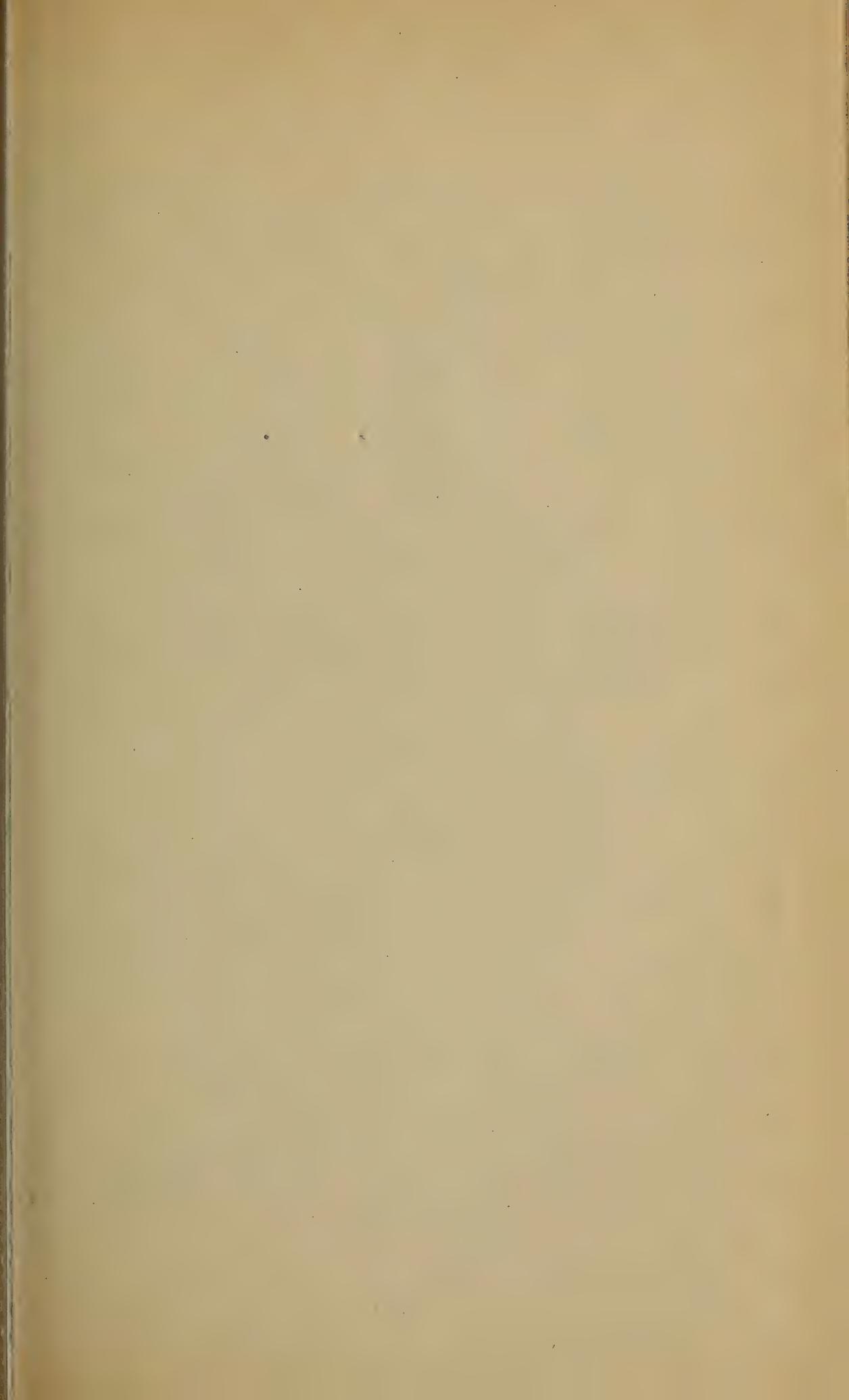
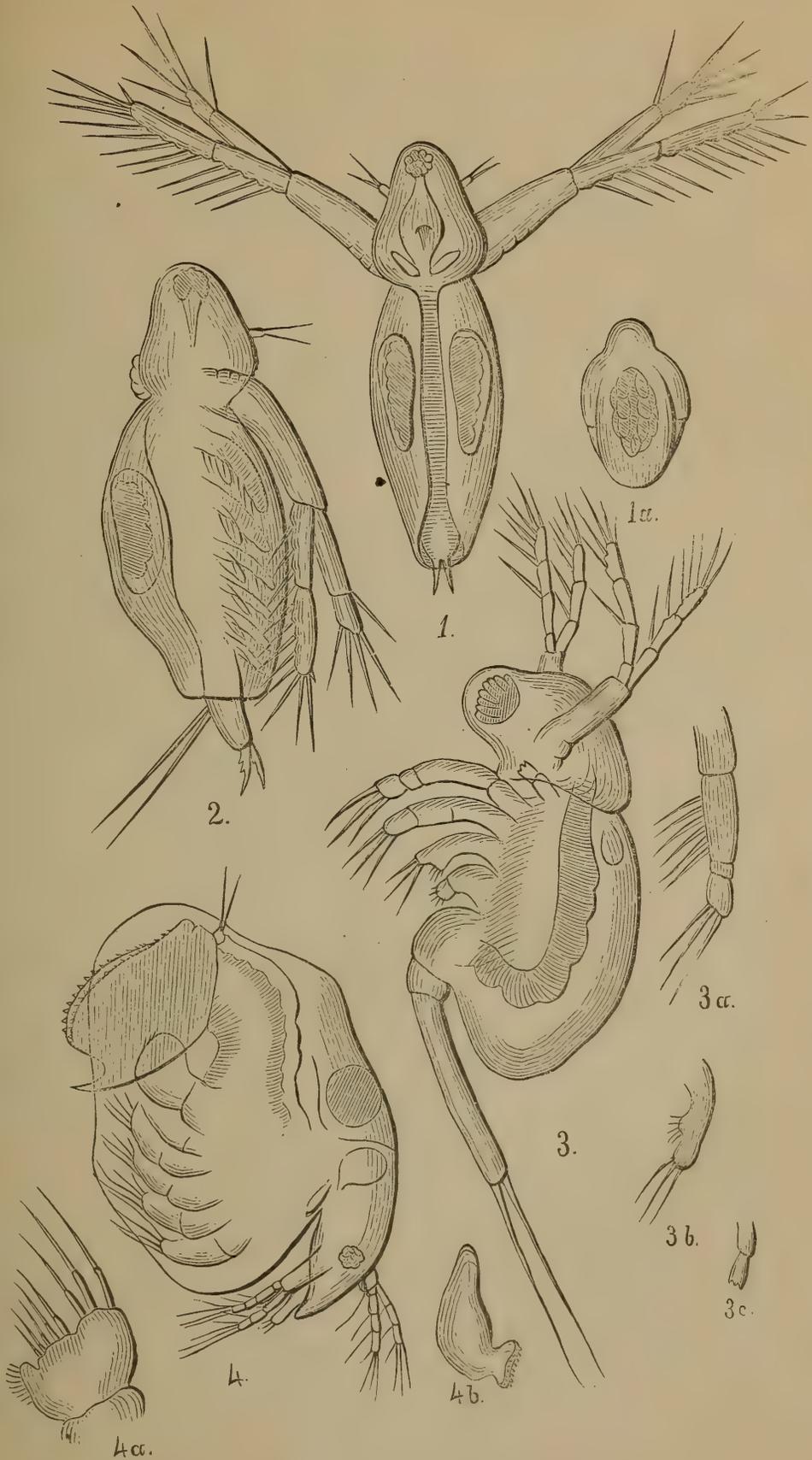
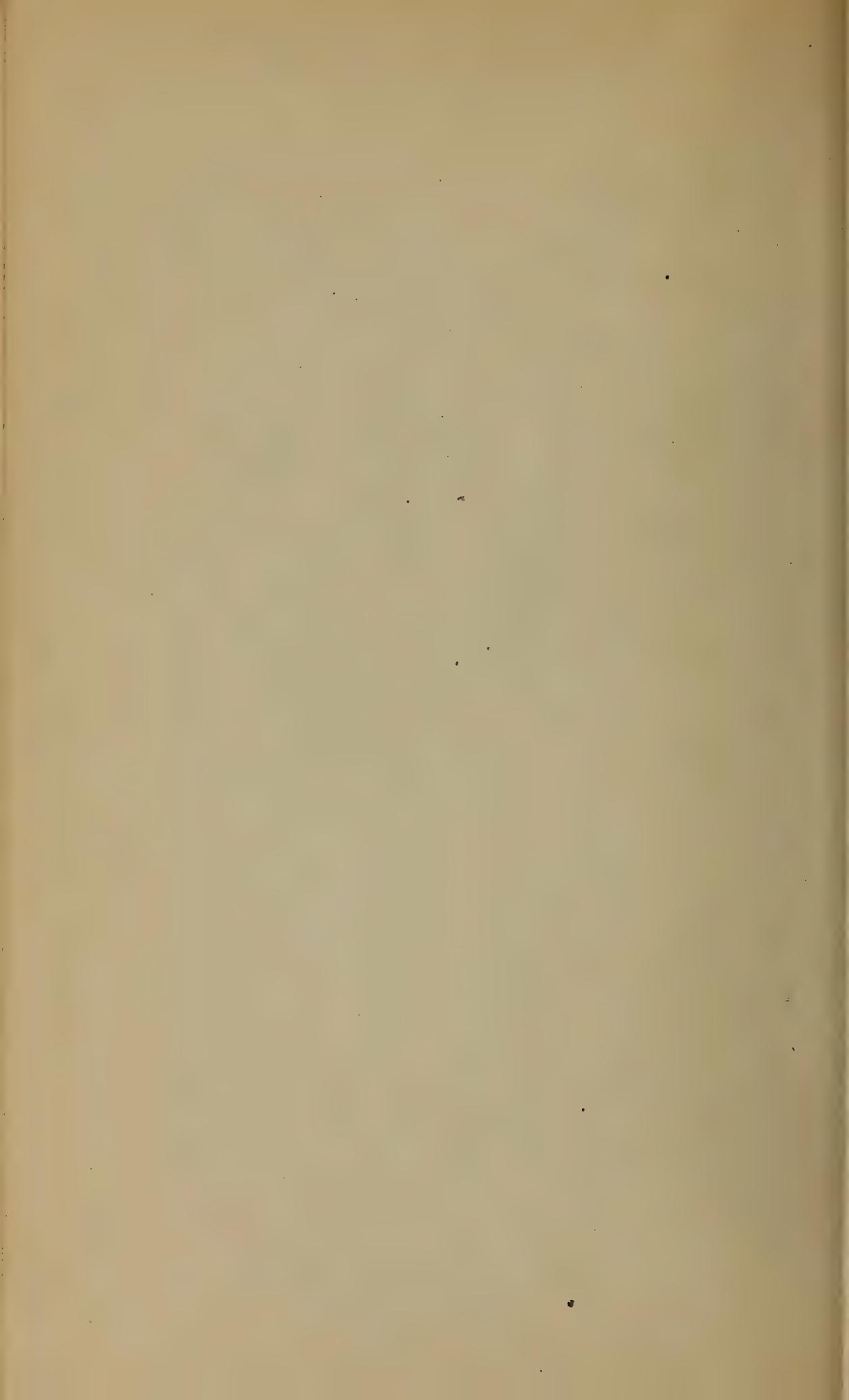


PLATE XXI.

1. *Daphnella Winchelli*. 1a Embryo. 2. Side view of same.
3. *Polyphemus occidentalis*. 3a, 1st pair of feet. 3b, 3d pair. c. jaw.
4. *Eurycercus lemellatus?* 4a. foot. 4b. jaw.





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ERRATA.

- The last line on page 13 should be transferred to be the sixth line on page 14.
- On page 19, line 23, for *non-discovery* read *discovery*.
- On page 119, 7th line from the bottom, for *neared* read *nearer*.
- On page 24, last line, insert *they*.
- At various places in the catalogue of specimens for *Linomite* read *Limonite*.

the ascogonium is filled up by the loose tissue of the inner ramifications.

The ascogonium is divided by repeated partition into a number of asci, each of which in our species contains eight spores. According to the observations of several botanists, these spores are not developed before the next spring, so that the parasite is preserved through the winter by means of the peridia. In most species of *Erysiphe* these peridia are provided with hyaline appendages, some of which are of wonderful regularity and elegance of form, when seen under the microscope.

—:o:—

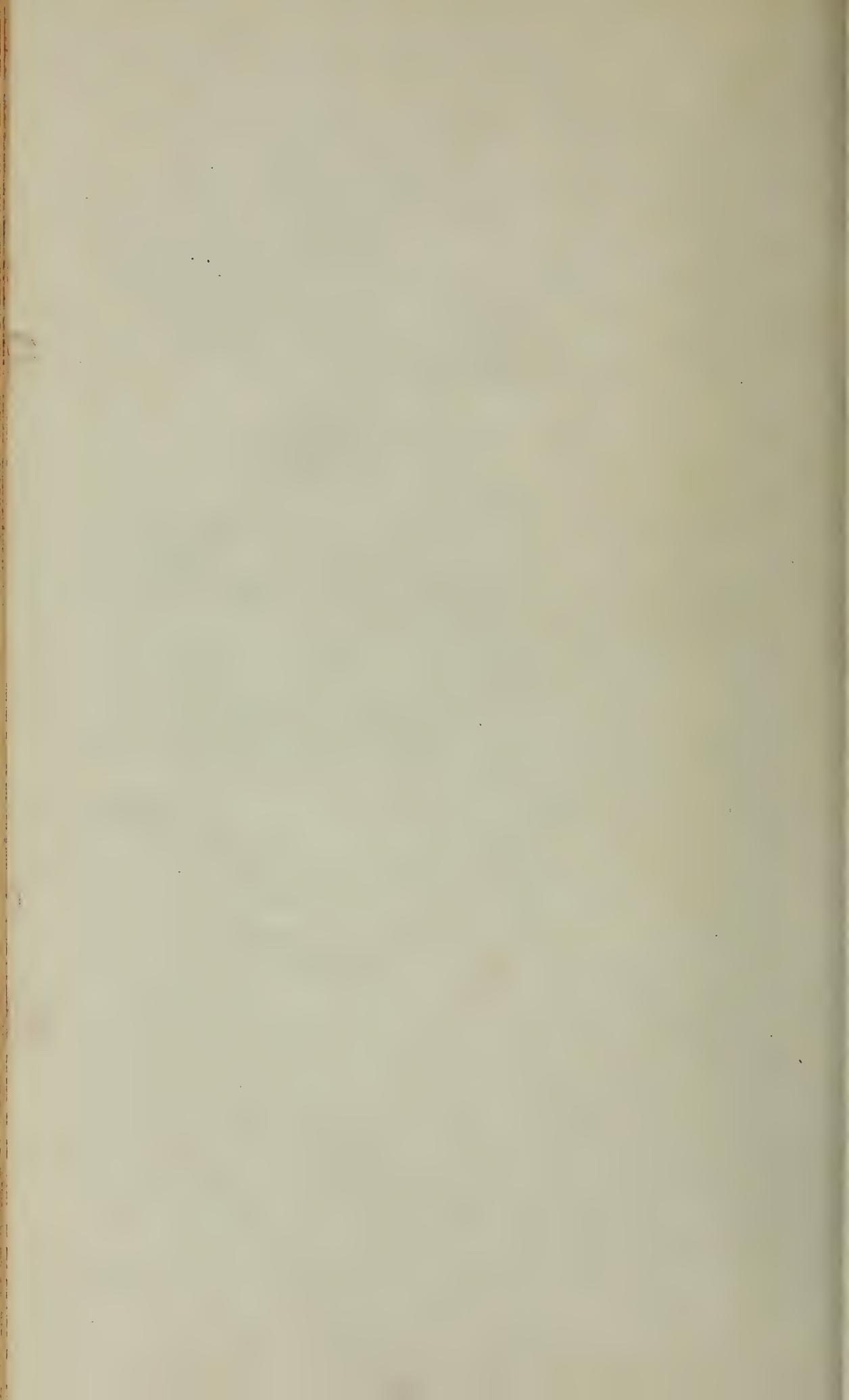
FRESH-WATER ENTOMOSTRACA.

BY C. L. HERRICK.

THE collector of fresh-water specimens is constantly meeting unexpected forms, especially among the smaller organisms, and of these no order of animals furnishes a wider variety or more curious adaptations than the fresh-water Crustaceans embraced in the old group *Entomostraca*, which is by many authors at the present day subdivided into several orders of Crustacea, the name being retained for a single order. To the microscopist particularly they are available as a never-failing field for study, since a cup of water from almost any source will contain abundant material for a day's work.

The Entomostraca have specialized jaws, but the gnathites never exceed three pairs. The segments of the abdomen are devoid of appendages. The name was derived from two words, meaning insect and shell, by Otho F. Müller, and applied by him in his "Entomostraca" (1785) to the animals which had hitherto been all comprised in Linnæus' genus *Monoculus*, named from the supposition that they possess but one eye. This order has, generally speaking, been much neglected, and in America particularly it seems to have escaped attention. The members of this order are never large, and many are so small as to be with the greatest difficulty detected by the unassisted eye, yet from their great variety, wide range and immense number they assume a position of considerable importance in the animal kingdom.

Recent investigations instituted by Mr. S. A. Forbes, of the Illinois State Laboratory of Natural History, have emphasized the fact that the lowly animals play important parts in the economy of nature, he having found that these Crustaceans enter



largely into the diet of fish, even of the larger varieties. The larger portion of the Entomostraca, numerically at least, are vegetable feeders and live on the minute particles of matter floating in the water, which otherwise would tend to render our waters impure. The snails wipe clean the stones and water-plants, and the scavenger fishes remove the carrion, but it remains for minuter forms to search carefully each drop and remove the particles, microscopic even to the thousand eyes of the dragon-fly larva. Thus the *Sida* (Plate III) in swimming uses the branchial feet within the shell-valves, not only in taking the necessary air from the water, but, by creating a counter current between the bases of the feet, particles of food are constantly brought within reach of the jaws. In common with low forms of animals in general, the processes of reproduction are often curiously anomalous. Congress of the sexes is in many cases unnecessary for many generations, and some forms, especially the *Artemia*, or "brine shrimp," seem unusually susceptible to changes in their environment. Males are often produced only in certain seasons of the year or under certain climatic conditions.

In the *Daphnia* the females produce young by simple budding from the ovary, but in the winter the ovum is enclosed between the valves of the carapace, which is removed at each molt, and it is thus enabled to resist the severity of the cold season. Speaking of the molt it is interesting to note that every hair, even to the finest filament, throws off a sheath, so that the cast-off integument is a perfect copy of the animal from which it came. In the higher forms the eggs are carried during the later stages of embryonic existence in double or single sacs extending beneath or on either side of the abdomen. In the *Daphnia* and other forms enclosed in a carapace the animal is oviparous, and the young can be seen within the shell in a cavity above the abdomen for some time before they are sent out to paddle their own crystal canoe. They may be removed from the parent without inconvenience. In the larger sub-division, the *Lophyropoda*, the chief organs of locomotion are one or both pairs of antennæ, though natatorial feet are never wanting. The antennæ also serve as prehensile organs in the *Cyclopoidea*, while the feet throughout the whole legion have branchial filaments.

Every one who has used the microscope has met with some of these animals, and we will mention a few forms. If water, taken from the clear surface of a lake on a sunny day, be carefully ob-

served, often a delicate, transparent animal may be seen darting about in the vessel like a flash of light, or if the lake be shallow and abounds in water plants the related form represented in Plate 1 may be seen. As it springs from side to side of the jar it seems a living jewel, for the antennæ and abdomen are tipped with varying purple, and the body glows yellow and scarlet, and if the bright-red egg-mass be present it is a conspicuous object. Place it under the microscope with a low power and we can see the long flexible antennæ, and if it is a male the thickened basal joints can be seen terminating in a spine at the thirteenth, where the geniculating joint is situated. The antennules on either side of the head segment, which is distinct from the thorax in this species, and the stylets on the last joint of the abdomen, with their setæ, are noted—when the antennules begin to rotate like the paddles of a steamer, and bending the abdomen and immediately launching a powerful “kick” with the caudal setæ spread out, at the same time that the antennæ beat the water like oars in the hands of an expert, the animal springs out of sight. One instinctively looks for the fellow some yards away, but remembering that the whole animal is little over .06 of an inch long, we again adjust the slide and bring him into view.

More abundant than the *Diatomus* and better known, is the *Cyclops*. Plate 11 represents a large species in which the hairs are greatly elongated, especially on the caudal setæ, the longest pair of which resemble feather dusters. The *Cyclops* has received more than its share of names, owing to the great difference between different stages of its existence. If we place a female *Cyclops* in a vial, in a few days little specks will be seen swimming about in the water, and the eggs will have disappeared. These specks prove to be the young of *Cyclops*, but so little like the parent that it requires much faith to believe they will ever assume its likeness. Instead of five pairs of feet there are but three, and as we watch the growth of the animal, these prove to be elementary antennæ and jaws, while the true feet bud out of segments not yet formed. Almost every pool furnishes another example of the *Cyclopoidea* in the *Canthocamptus* which resembles the *Cyclops* greatly, and goes through the same transformations. The body tapers gradually with no marked distinction between thorax and abdomen; the egg-sac too is under the abdomen, and has in connection with it a colorless tube.

Perhaps the next animal to attract our attention will be a crea-

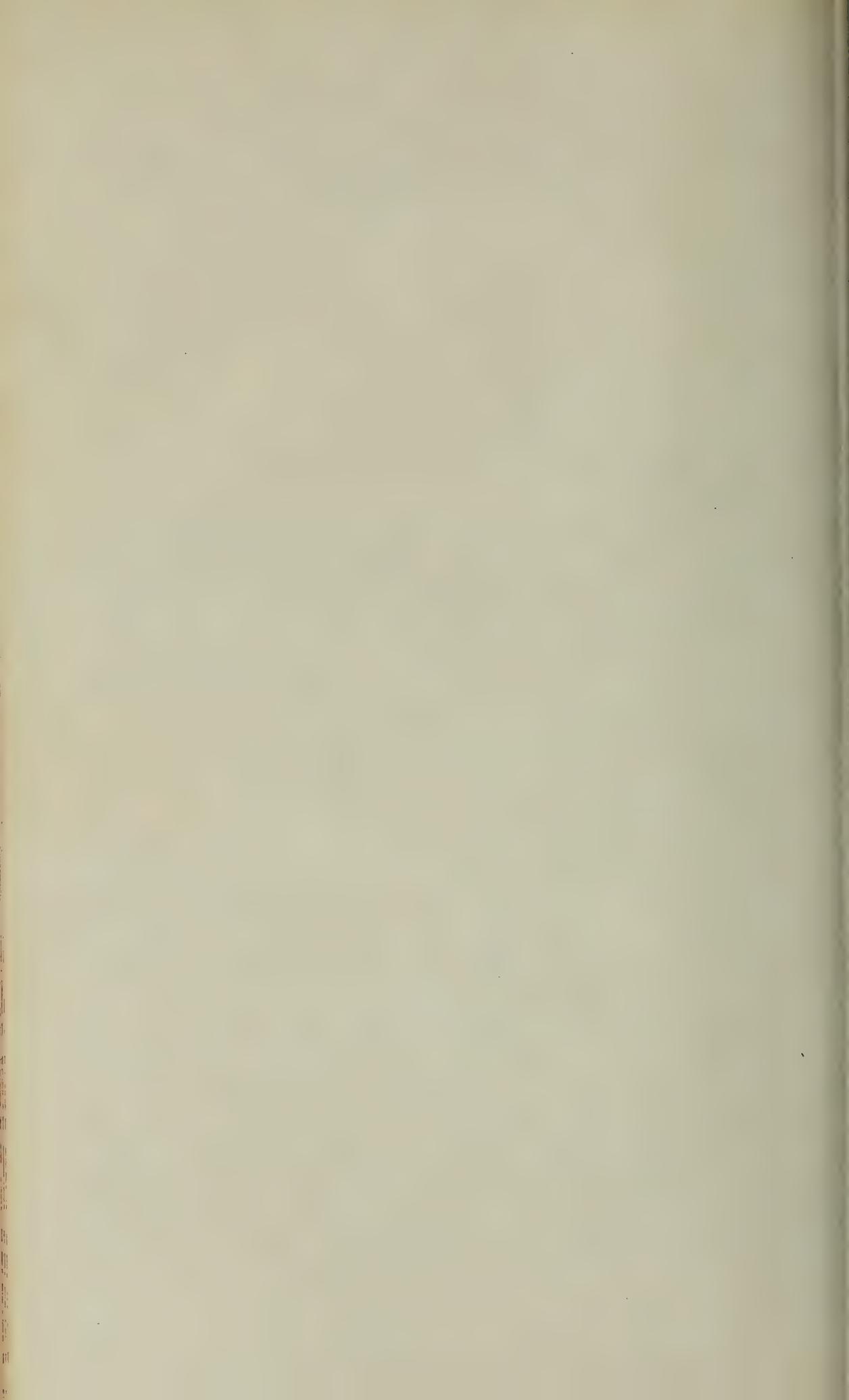
ture clothed in defensive armor of crystal, with an ovoid helmet on the head, from beneath which protrude the secondary antennæ, which in this family are always the larger, and the chief organs of locomotion. On the back is a small shield-like plate from which are suspended the two plates enclosing the body. Under the scuta of the back the heart can be seen pulsating regularly, while just below it is the intestinal canal, usually green from the vegetable matter contained therein. The jaws are suspended from the upper part of the head and meet below, where their toothed, grinding edges are placed in opposition, so that all the food must necessarily pass between them to be comminuted. The existence of a median dorsal plate in *Daphnia* seems to have been overlooked, it will be readily found however in this species (*D. retula*) by placing a specimen on a slide and allowing it to dry and then tilting it up.

The genus *Daphnia* is quite well represented in our waters, both in variety of species and abundance of specimens. The section of the genus separated by Dana and called *Ceriodaphnia* includes those members which have a cellularly reticulated shell, but this character does not seem constant in the closely allied smaller forms which it evidently ought to include, if indeed the same species may not embrace forms with both reticulate and non-reticulate shells.

One of the most interesting of all *Daphnia*-like species is *Sida*, Plate III. A species of *Sida* and also a new species of the allied genus *Daphnella* occurs in Minnesota waters. The body of *Sida* is highly transparent, rendering the study of the inner parts less difficult than in most of these animals. The movement of blood corpuscles in the head and the currents caused by the branchial feet (indicated by arrows in the drawing) can be readily traced.

The curious *Polyphemus* also is represented, an animal in which the body is much curved upon itself, and the last joint of the abdomen is greatly elongated and bears two long flagella. The single staring eye, occupying the whole of the head, is the most conspicuous organ, while the apparently undeveloped branchial feet at first suggest the young of some other species.

But the most curious of all these minute, shelled forms, is the single species of *Bosmina* (Plate IV), which constitutes the family *Bosminidæ* of Dana. The idea at once suggested is a strange burlesque on the elephant, though the animal is not by any means of elephantine proportions, being not two hundredths of an inch



in length. The superior antennæ, usually very small or nearly obsolete in the Daphnoidæ, are the longer, but they agree with those of other members of the tribe in having little motion or play. These many-jointed appendages constitute the trunk of our elephant, lying as they do in so close juxtaposition as to seem a single organ. The shell of *Bosmina* is tuberculate and partly, at least, reticulated with hexagonal cells.

A group of smaller animals than any of the above is the old family *Lynceidæ* which is now included in the Daphnidæ. Many genera have been formed, but only one or two are founded on reliable generic characters. *Euryceus* contains an animal nearly as large as *Daphnia*, but the remaining animals are small and they all agree in moving by a steady progressive motion rather than by successive bounds, which peculiarity is due to the shortness of the antennæ. The head is sharper in front and a little black spot beneath the eye, which is common to all Daphnidæ becomes in *Lynceus* and its allies as conspicuous as the eye itself. This spot is of unknown use but seems connected with the base of the antennæ.

There are representatives of two genera of the family *Cypridæ* to be found in every pool. These animals are enclosed in a shell which covers not only the body but the head also, so that the animal can withdraw entirely from view and close his shell about him like the mussel, which the shell much resembles in shape. The *Cypris* scurries about with an uncertain running motion, reminding one of the haste of an excited man, while the *Candona* loves the bottom. The inability to swim freely is due in *Candona* to the absence of the many setæ on the antennæ (the principal motary organs), which broaden these paddles in *Cypris*. In this sketch only a very few forms have been glanced at, and the legion *Phyllopora* containing *Branchipus* and the "brine shrimp," has not been noticed, but objects enough to employ many a leisure day have been seen, any one of which might well repay weeks of study.

DESCRIPTION OF PLATES.¹

PLATE I.—*Diaptomus longicornis* Herrick, back view of female and side view of male; *a*, basal portion of male antennæ showing enlarged segments preceding geniculating joint.

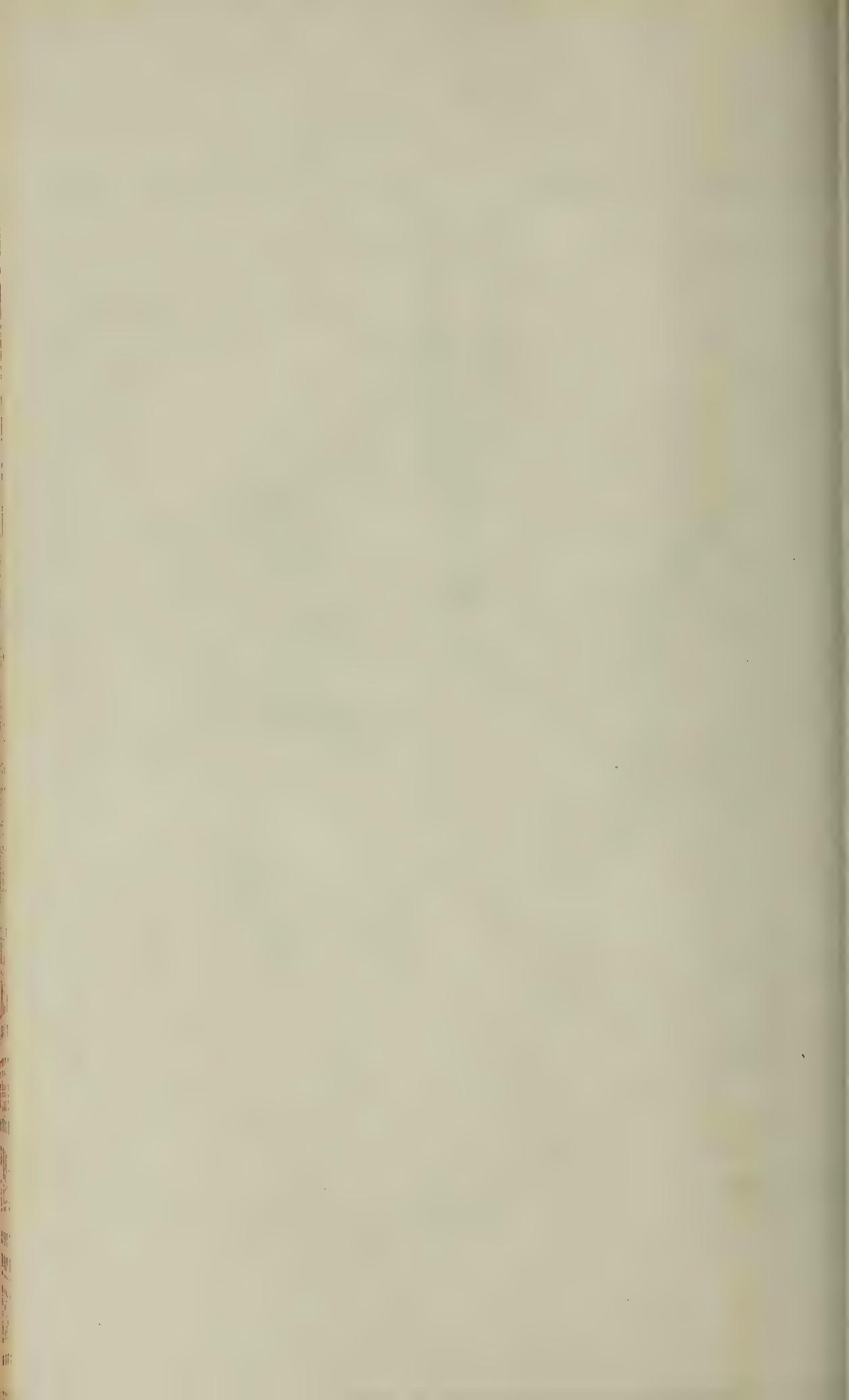
PLATE II.—*Cyclops* sp. ? *a*, last pair of feet; 1, 2, 3, 4, 5, feet of *Cyclops quadricornis*; 6, inferior antennæ.

PLATE III.—*Sida crystallina* Straus. *a*, *b*, *c*, feet of first, second and last pairs; *d*, jaw; *e*, extremity of abdomen; *f*, superior antennæ.

PLATE IV.—1, *Bosmina longirostris*; *a*, portion of shell with superior antennæ; *b*, anterior antenna; 2, *Lynceus* sp. ?

¹ Used through the kindness of Prof. N. H. Winchell, Director of Minnesota Geological Survey.





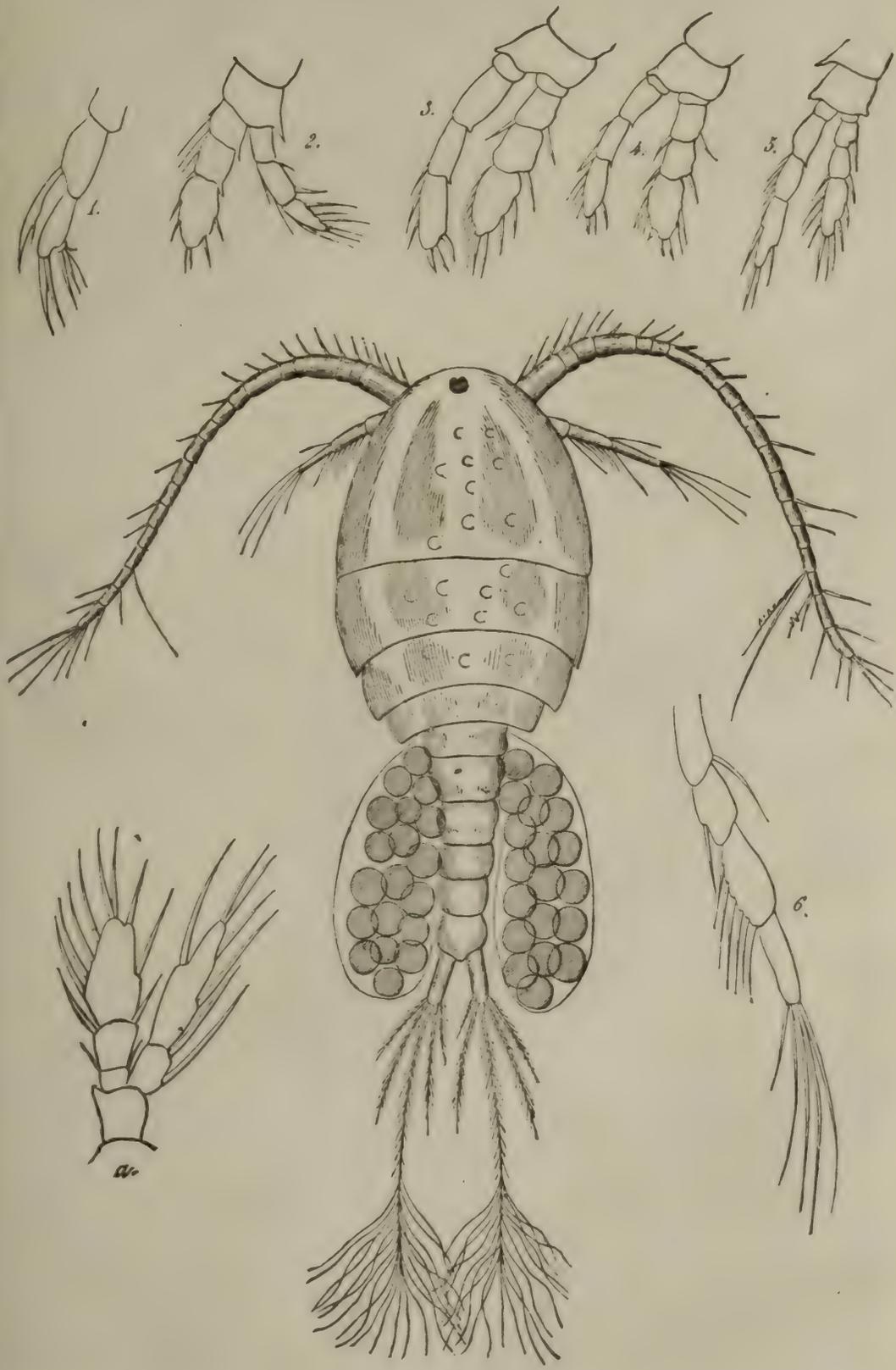
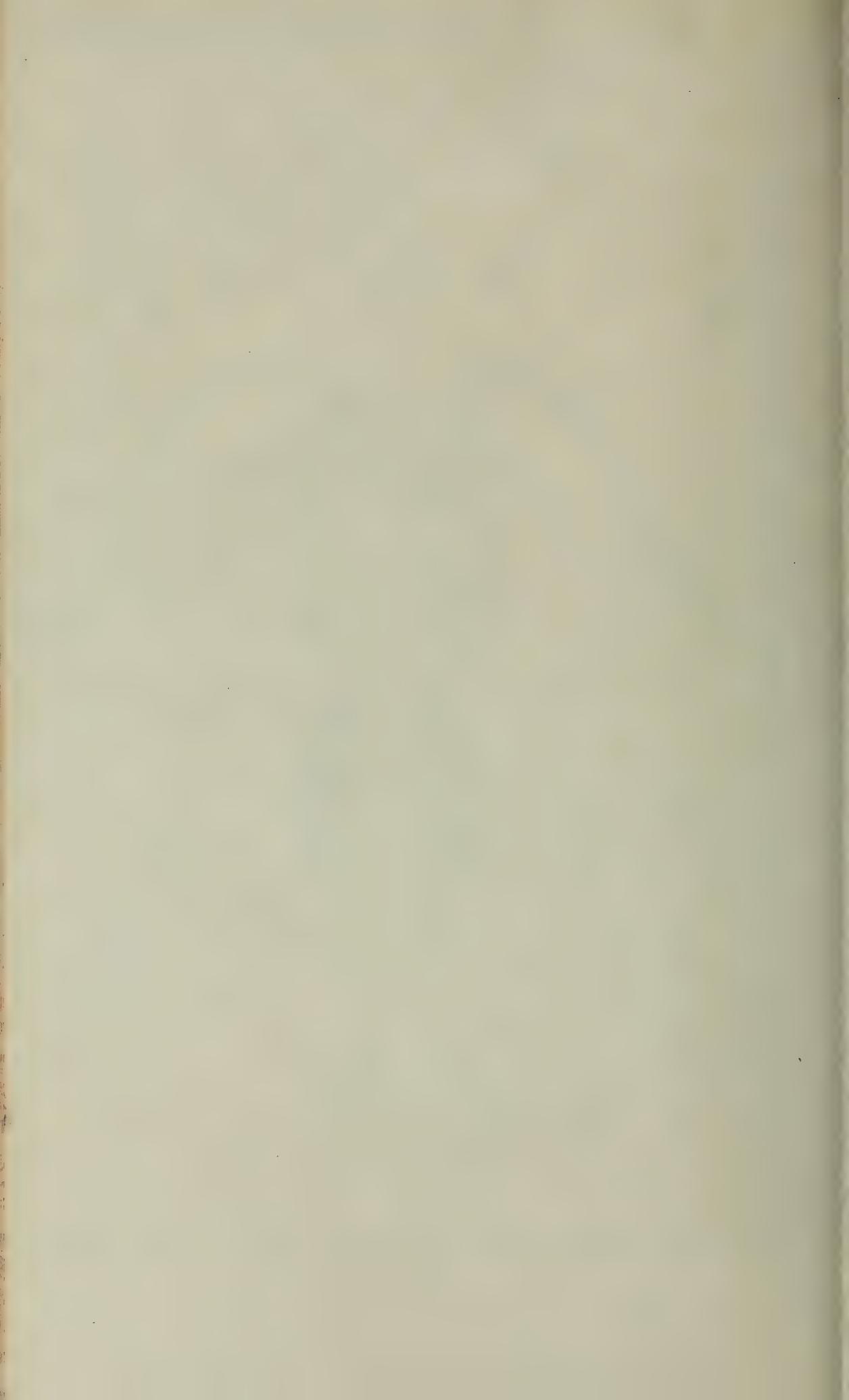
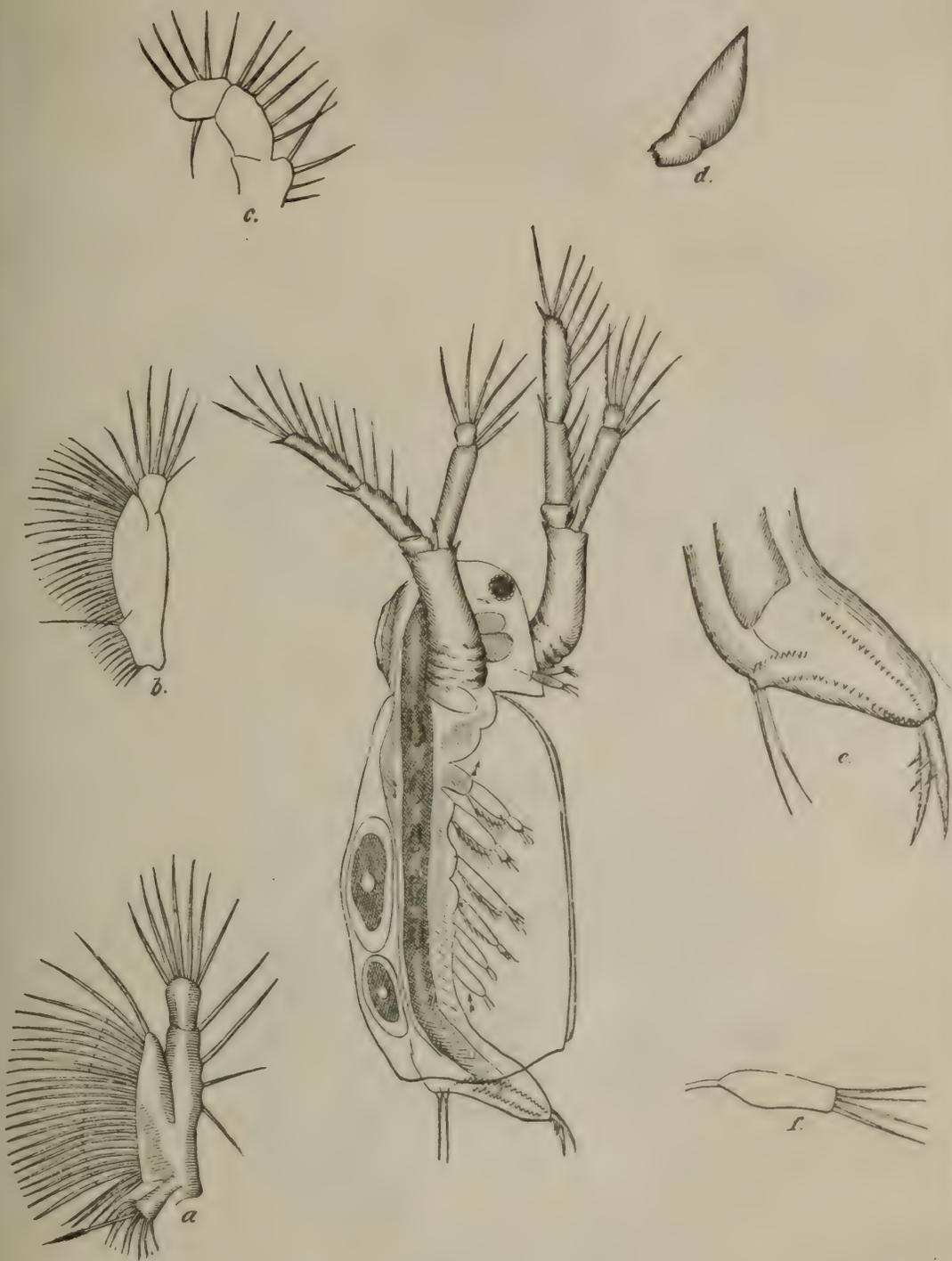


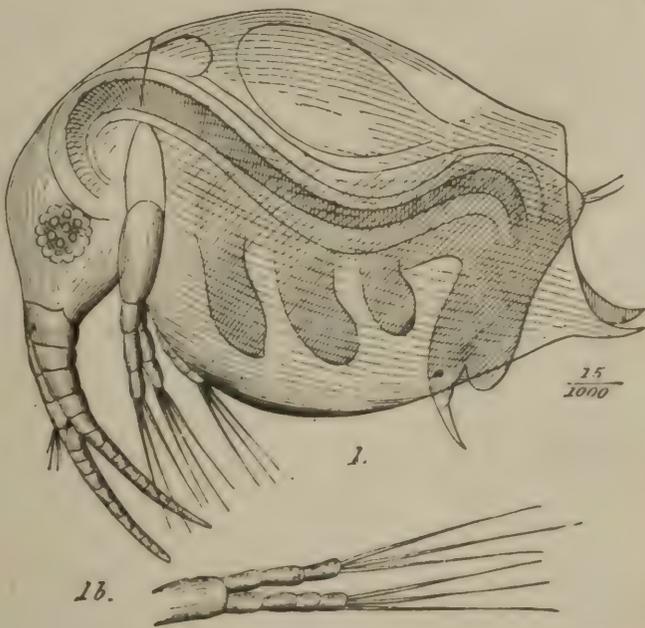
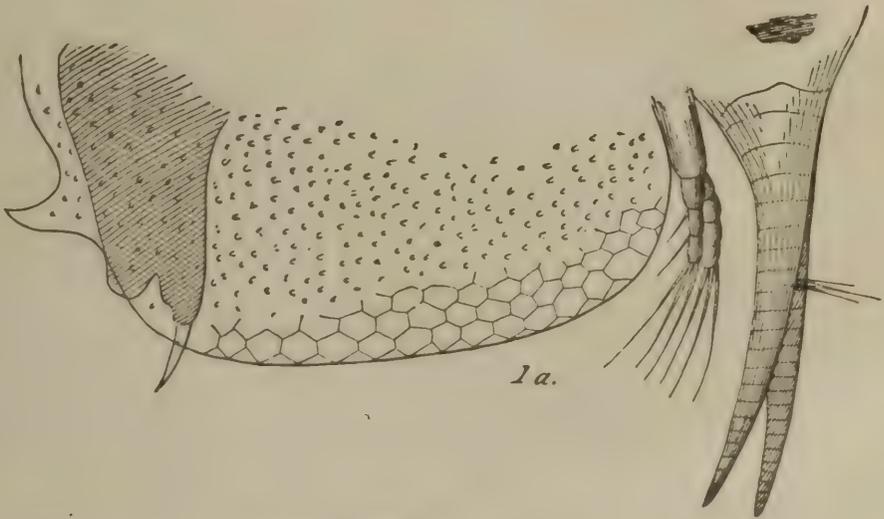
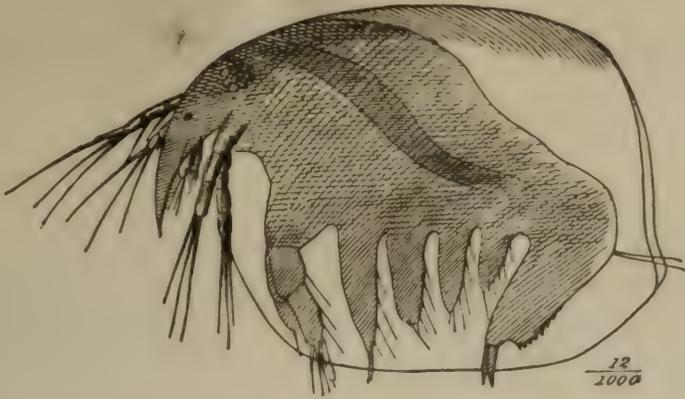
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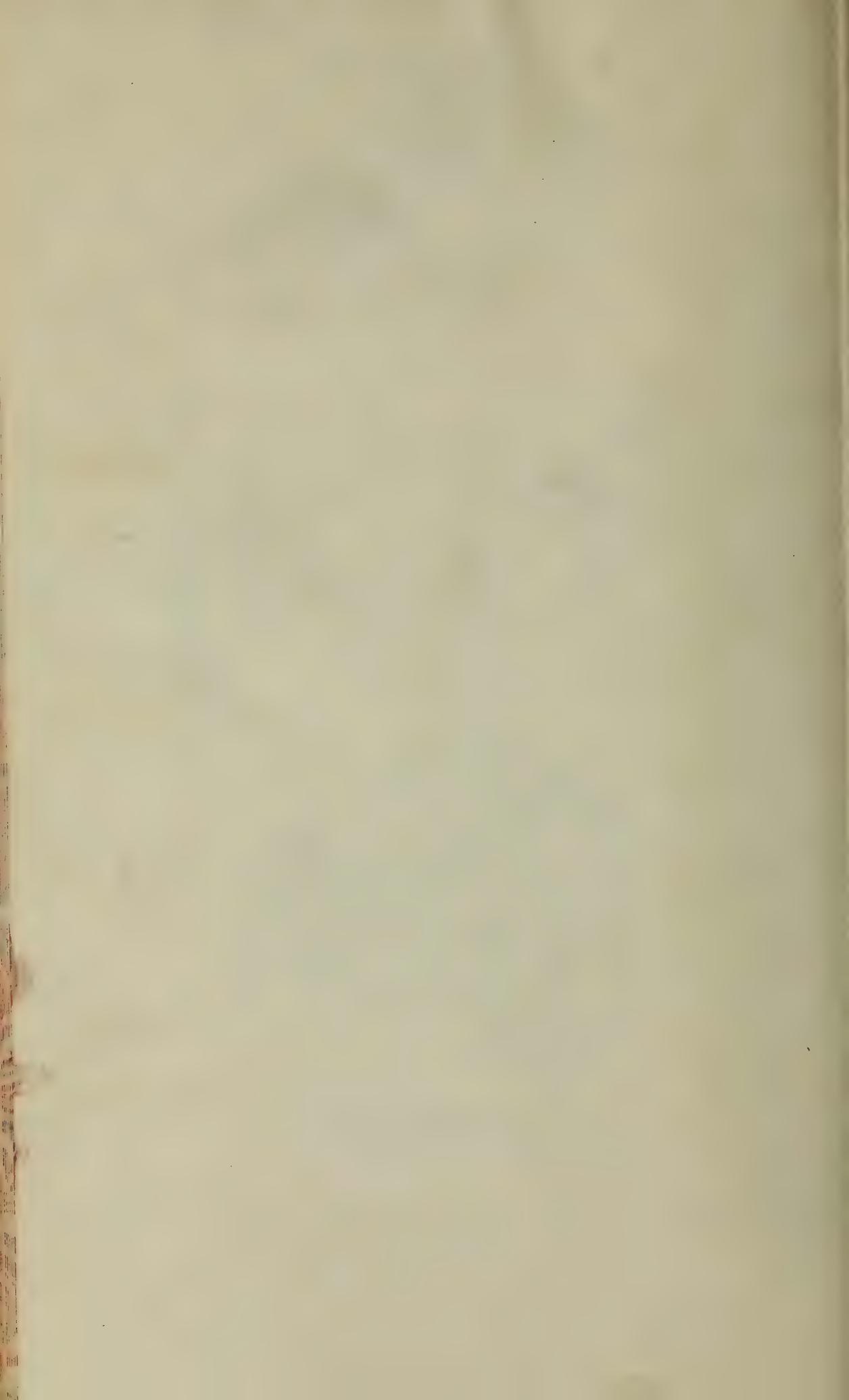
C. L. MERRICK, Des.

PLATE II.









Papers on the Crustacea of the Fresh Waters of Minnesota.

BY C. L. HERRICK.

- I. *Cyclopidae of Minnesota with notes on other Copepoda.*
- II. *Notes on some Minnesota Cladocera.*
- III. *On Notodromas and Cambarus.*

[Extracted from the Tenth Annual Report of the Geological and Natural History Survey of Minnesota—1882.]

[NOTE.—The author feels it but justice to himself to state that part of the material here presented has been in its present form for some time. The work was begun in 1879.]

I. CYCLOPIDÆ OF MINNESOTA, *with notes on other Copepods.*

CALANIDÆ.

It seems that recent authors have sufficient ground for uniting the families *Calanidæ* and *Pontellidæ* under the single name; the value of these terms as subfamily names even may be questioned.

The family is represented in our limits by two genera and by three, or doubtfully more species.

The fifth pair of feet furnishes, by its modifications, the best criteria for distinguishing genera and species.

Genus DIAPTOMUS, Westwood.

Body elongated, compressed; head distinct from the thorax, anterior antennæ 25-jointed, those of the male geniculate on the right side; posterior antennæ and mouth parts as in *Calanus*; inner branches of all the swimming feet three-jointed except the first, which is two-jointed; fifth foot consisting of two unequal branches, prehensile; abdomen of male with five-joints, of female three-jointed.

DIAPTOMUS CASTOR.

(Plate I, figs. 1-7, Plate II, figs. 1-2, 16.)

Bibliography.

Monoculus castor, *Jurine*.

Cyclops castor, *Desmarest*, *Baird*, Mag. Zool. and Bot.

Cyclops cæruleus, *Muller*, *Latreille*, *Bosc*.

Monoculus cæruleus, *Fabricius*, *Manuel*, *Gmelin*.

Cyclops lacinulatus, *Muller*, *Ramdohr*, *Latreille*, *Bosc*, *Baird*, Trans.

Beow. club.

Monoculus lacinulatus, *Manuel*, *Gmelin*.

Cyclops rubens, *Muller*, *Latreille*, *Bosc*, *Baird*.

Diaptomus castor, *Westwood*, *Baird*, *Baker*.

Cyclopsina castor, *M. Edwards*, *Baird*, *Claus*.

Glaucea rubens, *Koch*, Deutschlands Crust.

Glaucea cærulea, *Koch*, " "

Diaptomus castor, *Baird*, Brit. Entom.

Claus, Die Freilebenden Copepoden.

Lilljeborg, De Crust, ex ord. trib.

Lubbock, Trans. Linn. Soc.

westwoodii, *Lubbock*, " " "

castor, *Fric*. Die Krustenthierc Böhmens.

castor, *Brady*, Brit. Copepoda.

The above bibliography is complete only up to a comparatively recent date; many notices may be found in recent literature.

The species which, after careful study, has been considered identical with the European *D. castor* is that described previously as *D. longicornis* with the remark that it might prove too near *D. castor*. *D. sanguineus*, Forbes, seems to be the same thing nearly. If the amount of variability admitted by Brady to prevail is allowable I see no reason for separating this species. It is very variable as to size and coloration, and even in the configuration of some of the parts, as antennæ, etc., a certain amount of latitude is to be given; (See plates of Claus, Zur Anatomie und Entwicklungs-geschichte der Copepoden Arch. f. Naturg. XXIV Jahrg., B I.) $\frac{14}{100}$ - $\frac{8}{100}$; cm. in length. The following points are variable:—length of caudal stylets, structure and thickness of male geniculating antenna, size of claw of fifth male foot and spinous armature of feet. How far such variations may extend and how much they are dependent on peculiarities of habitat, etc., farther study must demonstrate. Some interesting facts meanwhile are suggestive. A second and gigantic form which may be known as

Diaptomus giganteus.

(Plate II, figs. 3-11-15.)

with the reservation that it is doubtfully of more than varietal value, was found under such circumstances as to suggest that it might be only a curiously magnified condition of *D. castor*. It is known to occur only in a small marshy pool of about two square rods extent and which annually dries up nearly completely. A few yards away is a second pool of a somewhat greater size and which less frequently dries up in summer. These two pools within the memory of the writer were united, but in the gradual dessication which has been observed in all Minnesota, they have been isolated. The former pool in June was found to contain *mature* males and females of the *D. giganteus only*, few other copepods being present, while the other pool contained *all stages* of the common *D. castor*. There are no neighboring waters, the nearest being half a mile, and that (L. of Isles) has only *D. castor*.

The smaller pool soon completely dried up so that this form was, for the time, exterminated. The conclusion seems almost resistless that the stagnation incident to evaporation produced circumstances favorable to the development of this enlarged form. At any rate it is an interesting fact in local distribution.

This variety is $\frac{3}{10}$ cm. long or more, and is much the largest fresh

water copepod known to me; it is a deep red in color and very compactly framed. Although so much larger than *D. castor*, it is almost impossible to find any structural differences. The male fifth foot differs somewhat, but mainly in the enlargement of one part at the expense of the others. The thorns on the feet are strongly pectinate and the larger ones bear short spines instead of bristles.

Diaptomus armatus, sp. n.

(See accompanying cut.)

A second form is imperfectly known, but presents some clearly marked distinctions which may have specific value.

Length about as *D. castor*; body slender; antennæ reaching base of abdomen only; female differing otherwise but little from *D. castor* (?); male considerably smaller; caudal stylets narrow; antennæ peculiar, shorter than the body; thickened portion of the geniculate antenna short; two last joints very short; one preceding the second long, bearing a hook at end; fifth foot with a very long claw to longer ramus (nearly as long as the ramus itself) with a tooth on the inner margin near the base, not perfectly arcuate, reaching, when extended, to end of caudal setæ.

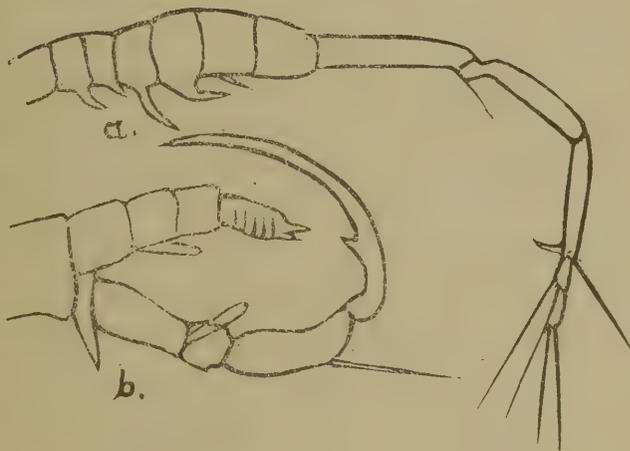


Fig. 1.

Diaptomus armatus.

a. part of male antenna. b. fifth foot of male.

Genus POTOMOICHETOR,* Gen. nov.

Cephalothorax six-jointed as in *Diaptomus*, but with the distal segment more evident; abdomen, in the male, five-jointed, in the female

*River inhabitant.

four-jointed; antennæ *twenty-four* jointed, the right geniculated as in *Centropages* (= *Ichthyophorbia*); first pair of feet with the rami *both three-jointed*, like the following; feet of the fifth pair, in the female, like the preceding, but with a spine of the joint preceding the terminal one enlarged and divaricated somewhat as in *Centropages*; in the male, the right with a two-jointed outer ramus, the terminal joint of which is spined and bears near its base a blunt expression of its inner margin; outer ramus of left foot three-jointed, armed with unequal spines; inner branches smaller, similar, three-jointed; the terminal joint bearing curved spines; ovary and testes as in *Diaptomus*, with which the mouth parts agree in the main; eyes medium, confluent; no lower or secondary eye-spots.

POTOMOICHETOR FUCOSUS, sp. nov.

(Plate II, Figs. 12-14. Plate III, Figs. 1-8, 13-14.)

Rather slender, and in size, as well as general appearance, resembling the smaller forms of *Diaptomus castor*; antennæ rather stout, reaching but little beyond the feet, appendaged as in *D. castor*, in the male strongly geniculated, but somewhat variously so; the six joints preceding the terminal four are thickened; those preceding the joint or hinge are arcuate on the distal margins; the secondary antennæ are about as in *Diaptomus*; mandibular palp two-branched; the outer three-jointed, the inner two-jointed; the terminal joint of the shorter branch bearing seven setæ, of the other four, the proximal joint of the former with three stout spines; the maxillæ nearly like *Diaptomus*; the processes have respectively the following numbers of setæ: the basal plate eight, the small process at base of posterior branchial appendage one, the appendage itself twelve, terminal portion three groups, first containing nine, the second three and the third four or five, the upper of the anterior processes two and the lower three; fifth feet nearly like the others in size; the right in the male having the outer branch but two-jointed by the coalescence of the two outer to form an arcuate and deformed appendage armed at the end with three stout equal spines; corresponding branch of left foot three-jointed; the terminal joint bearing three unequal spines, each of the preceding but one; inner branches similar, three-jointed; terminal joint being short and armed with three short lanceolate setæ and three longer ones, two of which are curved so as to be slightly prehensile; fifth foot of female with both rami three-jointed; inner ramus much smaller; antepenult

segment of the outer ramus extending into a large lanceolate process; ovisacs long-ellipsoidal reaching to nearly the end of caudal setæ.

This species prefers running water or estuaries of streams. Crow river, Meeker county, and a brook between Minneapolis and St. Paul.

NOTE ON CANTHOCAMPUS.

Claus says (*Freilebenden Copepoden*, p. 121) that he could not find the coiled "shell gland" in *Canthocampus*, though it is described by Leydig. I have found it in a European species, (*C. minutus?*) and think it constant. *Canthocampus* also has a singular area of nervous hairs upon the forehead, and in the same situation, pits which seem rudimentary eye-spots and sometimes appear to be pigmented. The pentagonal area mentioned is bounded by a raised line.

CYCLOPIDÆ

Contains five genera, viz.: *Thorellia*, *Cyclops*, *Oithona*, *Lophophorus* and *Cyclopina*; passing, by the genera *Misophria* and *Pseudocyclops*, into the *Calanidæ* or marine copepods. The affinities of these little studied genera need further study, as they are very interesting, the question being still open in how far the cyclopoid forms are altered by adaptation to saline habitat, if such an adaptation takes place at all.

The following is Brady's definition:

Cephalothorax ovate and usually much more robust than the abdomen; anterior antennæ seldom longer than the cephalothorax, those of the male alike on both sides and modified for the purpose of clasping; posterior antennæ branched (i. e. palpus wanting); palps of mandibles and maxillæ usually well-developed; foot-jaws mostly less developed than in *Calanidæ*; first four pairs of feet as in *Calanidæ*, fifth pair rudimentary, alike in both sexes, and usually one-jointed; ovisacs two.

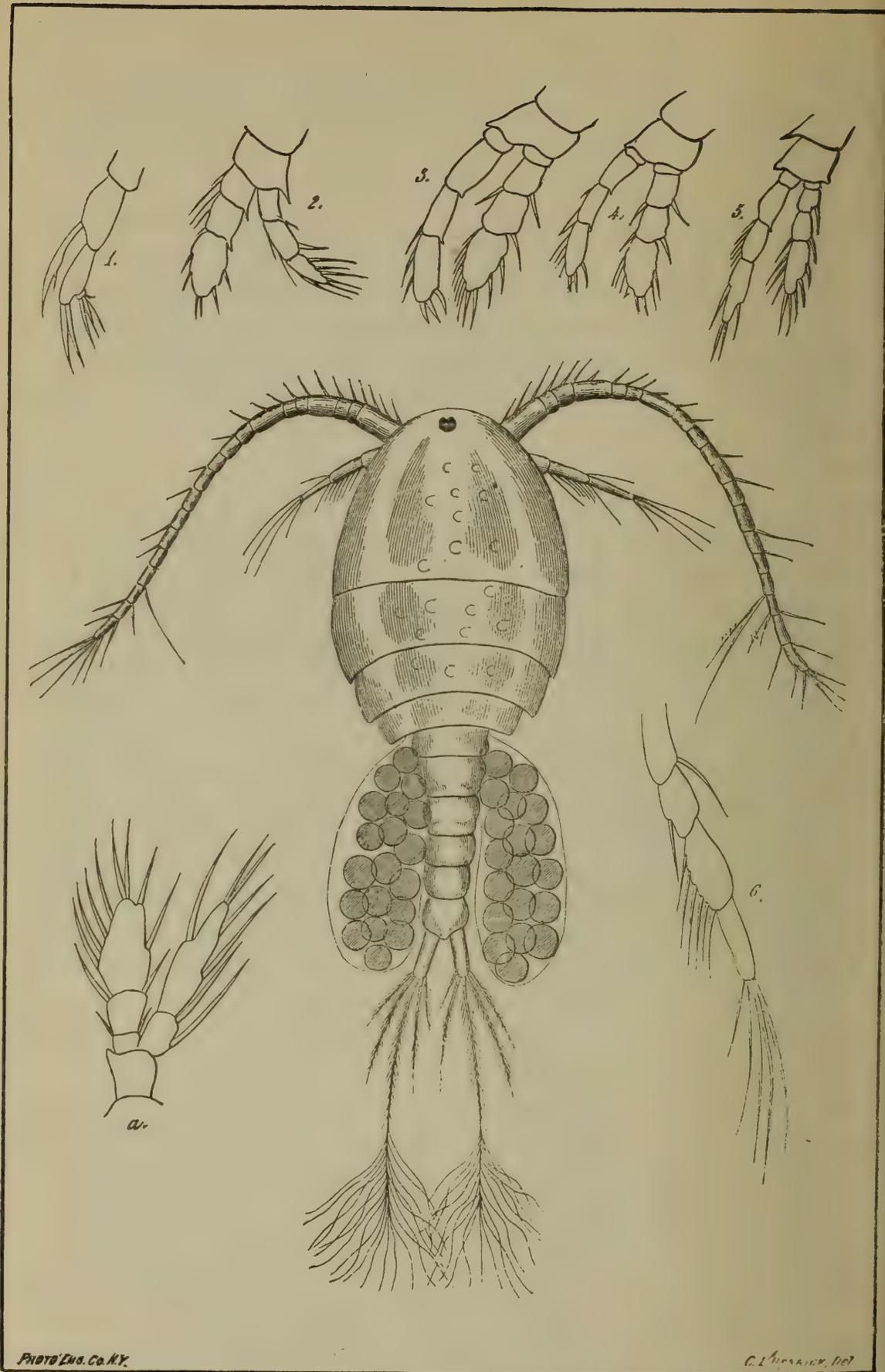


Fig. 2.

A Cyclops with abnormally pectinated caudal setæ.

Genus CYCLOPS.

Brady well says of this genus: "As regards discrimination of species it is, perhaps, the most difficult and puzzling of all the Copepoda." He also states that "the only safe rule in this state of things is to accept no specimens as types which do not show amongst them ova-bearing females." It is necessary, however, to limit the matter more closely, as will be shown farther on, for not only do immature females become fruitful even while the antennæ are yet incompletely developed, but the species are subject to a sort of dimorphism which it is interesting to parallelize with that in the males of *Cambarus*. The species are all fresh-water, so far as it is at present known, though it may be that salt-water forms exist under other names.

The characters of the family with some limitations apply to the genus.

The following species are probably but few of those which occur even in Minnesota, but they are so clearly defined, for the most part, as to be unmistakable and their description it is hoped will form a foundation upon which to lay later study.—Observations extend over a term of about four years.

Species with seventeen-jointed Antennæ.

CYCLOPS TENUICORNIS, Claus.

Bibliography.

Plate VI, figs. 1-11, 20. Plate V, fig. 14.

Cyclops tenuicornis, Claus, Das Genus Cyclops.

Die Frei-lebenden Copepoden.

Sars, Oversigt af de Indenlandske.

Ferskvands Copepoder.

Uljanin, Reise in Turkestan.

Brady, British Copepoda.

Cyclops signatus, Koch, Deutschlands Crust.

*G. O. Sars. Uljanin. Brady.

Cyclops coronatus, Claus. Fric.

We feel confident that the two forms distinguished by Claus as *C. coronatus*, (= *signatus*) and *C. tenuicornis* should be united, as the only distinction which is at all reliable, is the knife-like serrated ridge on the last joint of the antennæ. The last joints are frequently longer in *tenuicornis* form, as are the stylets in *coronatus*, but this varies. In the

The caudal setæ are naked for about a third of their length. These distinctions seem constant.

Section with twelve-jointed Antennæ.

CYCLOPS SERRULATUS, Fischer.

(Plate V, figs. 1-5, Plate VII, fig. 10.)

Bibliography.

- Cyclops serrulatus, *Fischer* Bulletin de la Soc. Imp. etc. Moscou.
Lilljeborg, De crust ex ord. trib.
Claus, Das genus Cyclops.
Sars, Oversigt Ferskvands Copepoder.
 Frei-lebenden Copepoden.
Fric, Die Krusten thiere Böhmens.
Uljanin, Reise in Turkestan.
Brady, British Copepoda.
 ? Cyclops minutus, *Claus*, loc. cit. (= young.)
 ? Cyclops macrurus, *Sars*, loc. cit.
 ? Cyclops spinulosus, *Claus*, loc. cit.

Typical Form.

Cephalothorax oval, compact; abdomen slender and short, suddenly enlarged previous to its union with the thorax; antennæ slender, reaching nearly, but not quite to the last thoracic segment; the last three joints are attenuated and furnish the most evident character of the species; formula — $\bar{\bar{}}$ — $\bar{\bar{}}$ — $\bar{\bar{}}$ — $\bar{\bar{}}$ — $\bar{\bar{}}$ — $\bar{\bar{}}$ — — —; during life the antennæ tend to assume the form of a rude Z, the proximal four joints forming the base; antennules small, reaching about to the sixth joint of antennæ; jaws small with large teeth; the single segment of the fifth foot with three equal spines; egg sacs oval, as long as the abdomen; eggs few, dark; caudal stylets very long and slender, spined along the outer margin; lateral setæ small and approximated to the upper one; outer terminal seta short, spine-like, in life set nearly at right angles to the others, spined or beaded on one margin and bristled on the other; the next seta is as long as the abdomen, being somewhat exceeded by the following one; inner seta insignificant; upper seta very small; length less than $\frac{1}{10}$ cm.

A larger form occurs with an elongated body and abdomen and with extremely attenuated antennæ and caudal stylets, but it is not a va-

above by a spined plate of the last thoracic segment; length about $\frac{11}{100}$ cm. excluding setæ:

This species appears not to be very abundant, or at least from its small size it is not often encountered. A few particulars distinguish these western forms from the description given by Brady, among them being the spinous armature of the stylets, the bristles on the penultimate segment of the abdomen, pectinate bristles of the fifth feet, and the greater length of the abdomen, yet I see no reason for separating them. I have not seen the male and can not be sure that there is no further development, but the fact that the feet in this form are three-jointed, and its peculiar characters, clearly distinguish the species from any other known to me.

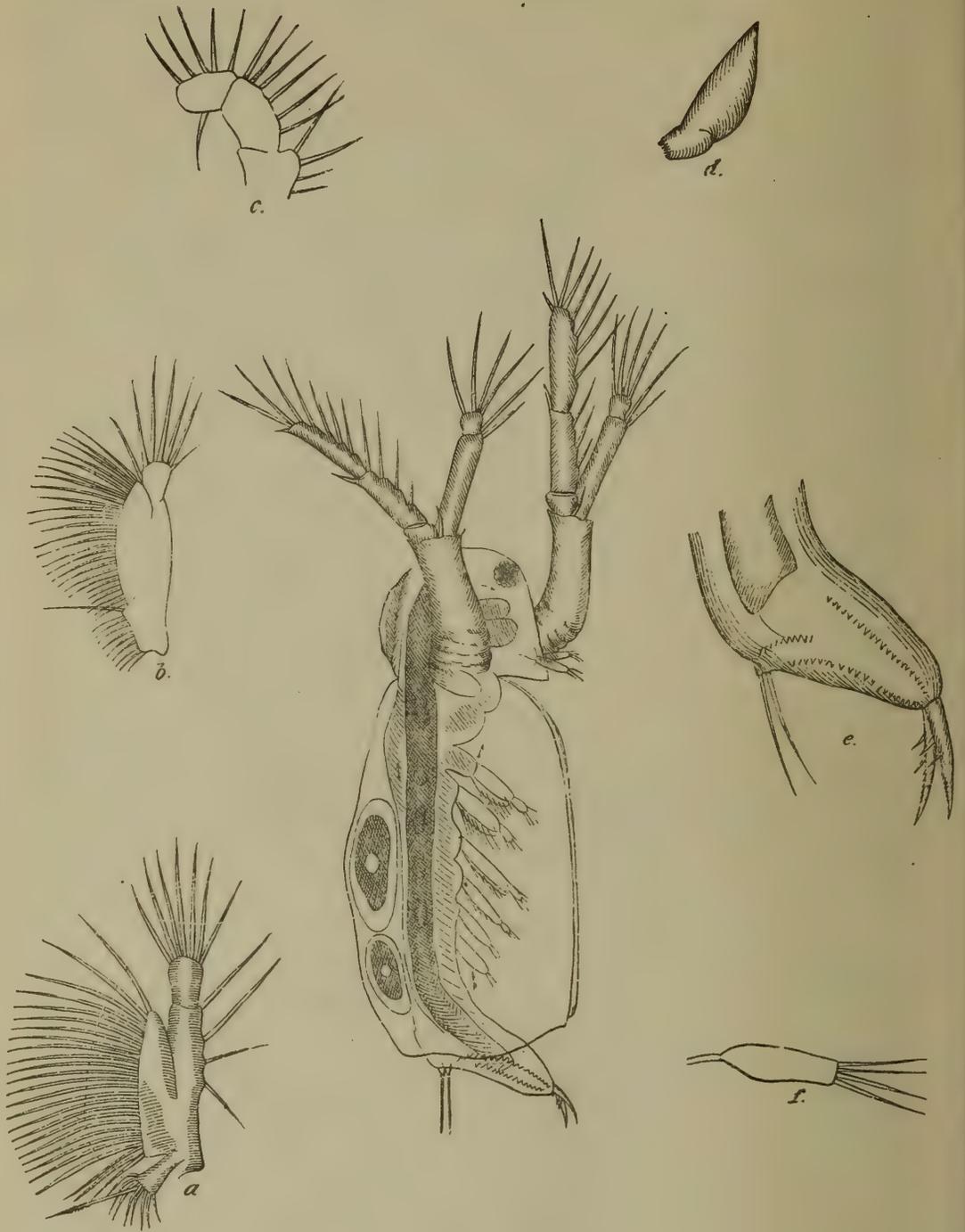


Fig. 3, *Sida crystallina*.

II. NOTES ON SOME MINNESOTA CLADOCERA.

Tribe I CTENOPODA.

SIDIDÆ.

Antennæ of second pair with unequal rami, superior larger; last joints compressed and setose; intestine simple.

Of this family two species are certainly identified in America, both of which are abundant in certain favorable locations at the proper seasons. No species of the *Holopedidæ* are known to occur here.

Genus SIDA Straus.

Superior ramus of second antennæ three-jointed; posterior margin of post-abdomen with numerous spines (20-30.)

SIDA CRYSTALLINA, Müller.

(Fig. 3.)

Bibliography.

Daphne crystallina, Müller.

Daphnia crystallina, Latreille. Bosc.

Sida crystallina, Straus, Mèm. Mus. Hist. Nat.

Sida crystallina, M. Edwards, Hist. Nat. Crust.

Monoculus crystallinus, Gmelin. Manuel. Fabricius.

Monoculus elongatus De Geer, Mèm. servir Hist. Ins.

Sida crystallina, Lievin, Branch. d. Danziger Geg.

Baird, Brit. Entom.

Lilljeborg, De crust. ex ord. trib.

Fischer.

Schödler, Die Branch. d. Umg. v Berlin.

Neue. Beitr.

Leydig, Naturg. d. Daph.

Sars, Norges Ferskv—Krebsdyr.

elongata Sars " " "

Sida crystallina, P. E. Müller, Danmark's Cladocera.

Kurz, Dodekas Neuer Cladoceren.

Birge, Notes on Cladocera.

Herrick, Microsc. Entom.

Lutz, Untersuch, ü. d. Cladoceren d. Umg. v. Bern.

1878.

Weismann.

I note this cosmopolitan species, of which a nearly complete bibliography is given above, simply to mention that I have recently found for the first time specimens of *Sida* reaching the size mentioned by P. E. Müller ($\frac{3}{100}$ cm.)

In smaller pools, when present our *Sida* is much (often $\frac{1}{2}$) smaller, and only in L. Minnetonka does the species attain its ultimate development.

GENUS DAPHNELLA.

Superior ramus of second antennæ apparently 2-jointed, narrow; post-abdomen destitute of spines.

DAPHNELLA BRACHYURA Lievin.

(Plate VII, 11-16)

Bibliography.

Sida brachyura, Lievin Branch. d. Danziger Geg.

Daphnella wingii, Baird, Brit. Entom.

Sida brachyura, Lilljeborg, De crust. ex ord. trib.

Diaphanosoma brandtianum, Fischer, Ergänzig, Berichtig.

Daphnella brandtiana, Sars, Norges Ferskv.—Krebsdyr.

Daphnella br. hyura, P. E. Müller, Danmark's Cladocera.

Daphnella brachyura, Lutz, Untersuchung ü. die Cladoceren d. Umg. v. Bern.

Sida brachyura, Pavesi, Nuova serie di ricerche della fauna pelagica nei laghi italiani, (L. Trasimens.)

(Compare also *D. expinosa*, Birge, Notes on Cladocera p. 3.)

The species of *Daphnella* found about Minneapolis, occasionally abundant, seems not to differ in any important character from European types of *D. brachyura* although I formerly regarded it as distinct (*D. winchelli*.)

Head less than one-half the body (about $\frac{27}{1000}$ cm. while body is $\frac{6}{1000}$ cm. long); eye about $\frac{1}{4}$ head; antennæ when reflexed extend a little beyond $\frac{2}{3}$ the length of body. Male $\frac{7}{100}$ cm. long; antennæ reflexed reaching base of shell; anterior antennæ extremely long; copulating organs reaching nearly to end of claws. Having carefully compared our specimens with the description and figures given by Birge for his *D. expinosa*, the evidence seems to indicate not only that they are identical but both are really *D. brachyura*. The distinctive characters of *D. expinosa* are a greater indentation between head and body, absence of caudal teeth, greater length of male appendages, and the opening of the vasa deferentia in the "instep" of these appendages.

The absence of teeth upon the post-abdomen is of even generic importance according to Sars, who gives it in his synopsis of genera as typical for *Daphnella*. In our specimens the claws are at least pectinate if not serrate, while the appendages of the male reach generally nearly to the middle of the claws. The relative length of these appendages and the antennæ of male is variable.

Tribe II, ANOMOPODA.

DAPHNIDÆ.

Rami of antennæ 3 and 4-jointed; feet of five pairs; intestine with anterior cœca not convolute.

Genus MOINA, Baird.

A transition between *Sidida* and *Daphnida* is made through this genus.

Head separated from the body by a depression; macula nigra absent; antennæ of female large, movable, of male very long, curved; first foot of male with strong hook; valves short, truncate behind.

MOINA BRACHIATA.

We believe with P. E. Müller that this and *M. rectirostris* are identical. The most complete discussion of the merits of the three species (the above and *M. paradoxa*) is found in Weismann's paper, *Ueber einige neue oder unvollkommen gekannte Daphniden*, Grüber and Weismann, 1877, which see for bibliography and elaborate, not to say labored, distinctions. This species is not common, but when found (in muddy pools in late summer) frequently appears in great numbers. For embryology see *Grobben*, *Entwicklungsgeschichte der Moina rectirostris*.

Genus DAPHNIA.

This genus as limited by Müller is well distinguished from the remaining genera of the family--*Simocephalus*, *Scapholeberis*, *Ceriodaphnia* and *Moina*.

As remarked by Birge, this is not the typical representative of the

group but is a very divergent member of it, worthy, probably, of forming a distinct section or sub-family. The most remarkable feature is one which appears in a comparatively early embryonic period and, in some cases, nearly disappears in later life. This is the development of a long spine from the dorsal, posterior end of the shell. This is the real diagnostic test and has not yet been incorporated into the definition of the genus. The occurrence of a crista is more variable apparently, but may be of some importance.

The following is suggested as a revision of the diagnosis:

Shell more or less oval or sub-quadrate and reticulate; head rounded anteriorly, but sometimes with a crest, prolonged below into a beak which is truncate posteriorly and bears the antennæ near the apex; upper dorsal corner of shell in young of both sexes and mature males prolonged into a long spine; the macula nigra is present but not always pigmented; the post-abdomen spined behind; opening of rectum at the end.

The female with two age-forms (heterogenetic and dimorphic); the second form frequently scarcely spined; antennæ small, not movable, furnished with sense-hairs; ephippium with two ova, separable from remainder of shell along the latero-median suture; the brood-cavity closed by more than two unequal processes of the abdomen.

Male with long movable (almost two-jointed) antennæ furnished with prehensile stylus; first foot bearing a curved claw; swimming antennæ very long; vas deferens opening at the end of post-abdomen. Embryo with second antennæ palpate; a curved appendage to shell which becomes the spine of adult.

DAPHNIA PULEX.

This species is mentioned here simply to remark concerning *D. pulex*, var *denticulata* of Birge, (Notes on Cladocera, p. 11, plate I, fig. 11,) that the European as well as all the American specimens of *D. pulex*, have a fine series of spines on the claws of the post-abdomen. A glance at Tafel XII, fig. 39, of the Zeitschrift für Wiss. Zool. Bd. XXXIII, with Weismann's plate of the end of the abdomen of this species, is sufficient evidence of this fact, though as the animal is a male and quite young, the spines are less evident; moreover the number of caudal teeth is known to be variable with age. Some other peculiarity must be found to give this varietal distinction validity.

DAPHNIA sp?

(Plate X, figs. 15-16).

From a cold marsh a gathering in June, 1882, contained several females like that represented by fig. 16. They were far from being abundant, however, and the pool contained no other *Daphnia* showing that it was unfavorable to the growth of these animals.

These females differ from *D. pulex* chiefly in their small size, ($\frac{14}{100}$ cm.) being the smallest *Daphnia* seen with an evidently mature appearance. The caudal spine is sickle-shaped; post-abdomen as in *pulex*; antennæ short; the animal beautifully clear and varigated by the brilliant contents of ovary, eggs and intestine. I hesitate to regard it as a distinct species.

Figure 15 represents a single specimen of *Daphnia* found with the above which was somewhat injured during its moult. This resembles *D. apicata*, Kurz, and *D. pellucida*, Müller, and is perhaps the male of the species represented by fig. 16. Our knowledge of the variations induced by environment is yet too meager to draw up definitions of species with certainty from a single gathering, but these forms are peculiarly interesting.

See also the accompanying figure, (fig. 4,). These forms merit closer study.

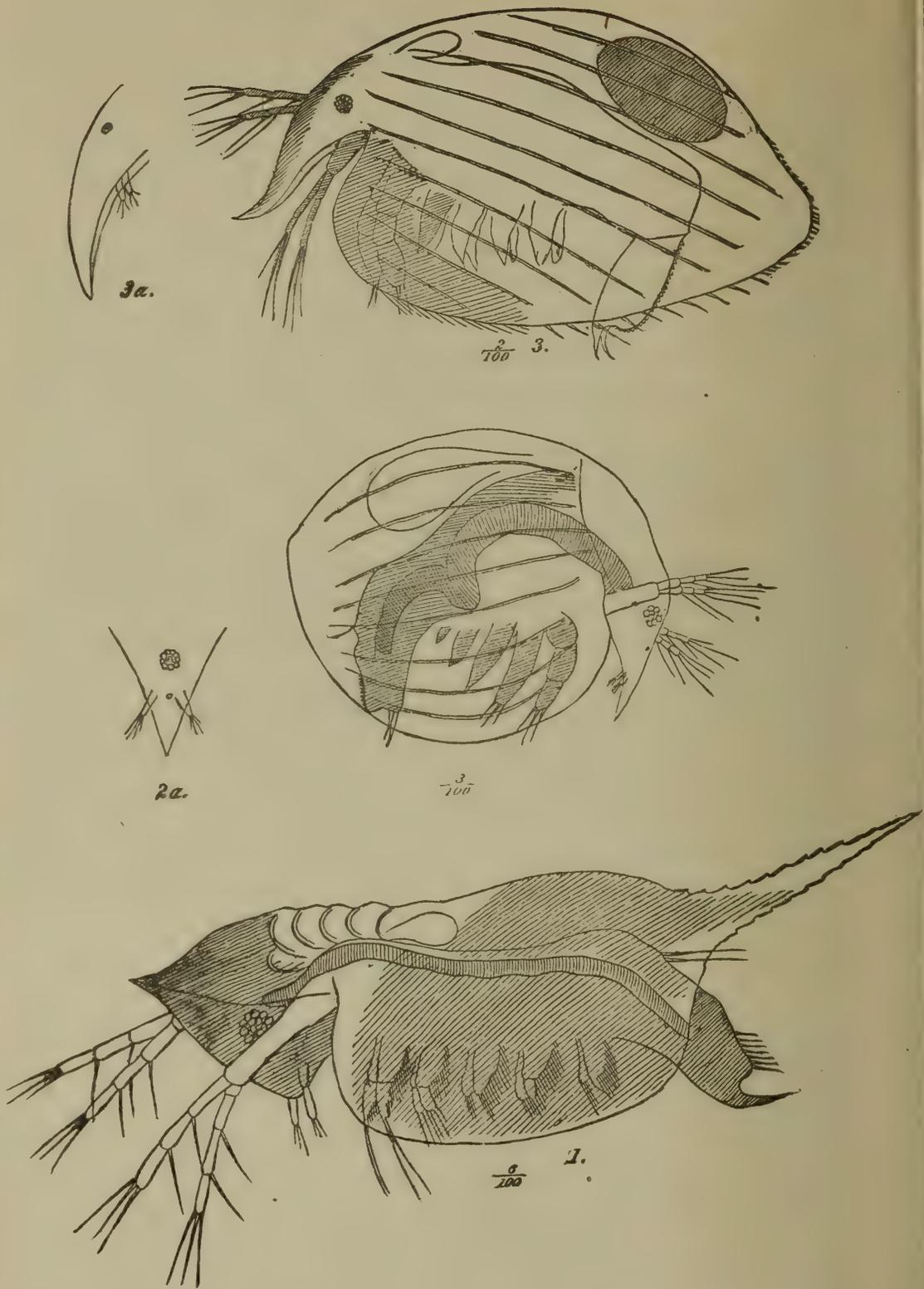


Fig. 4. *Daphnia longispina* (numbered 1) etc.

SCAPHOLEBERIS, Schödler.

In a former paper *S. mucronata* was reported from this locality with the remark that only the unhorned variety seems to occur here. A rather diligent search has failed to find var. *fronte cornuto*, though our waters have been carefully searched at intervals for several years and at different seasons. Birge quotes only this variety. However, the species is not common and the other form may yet be discovered. See Fig. 5.

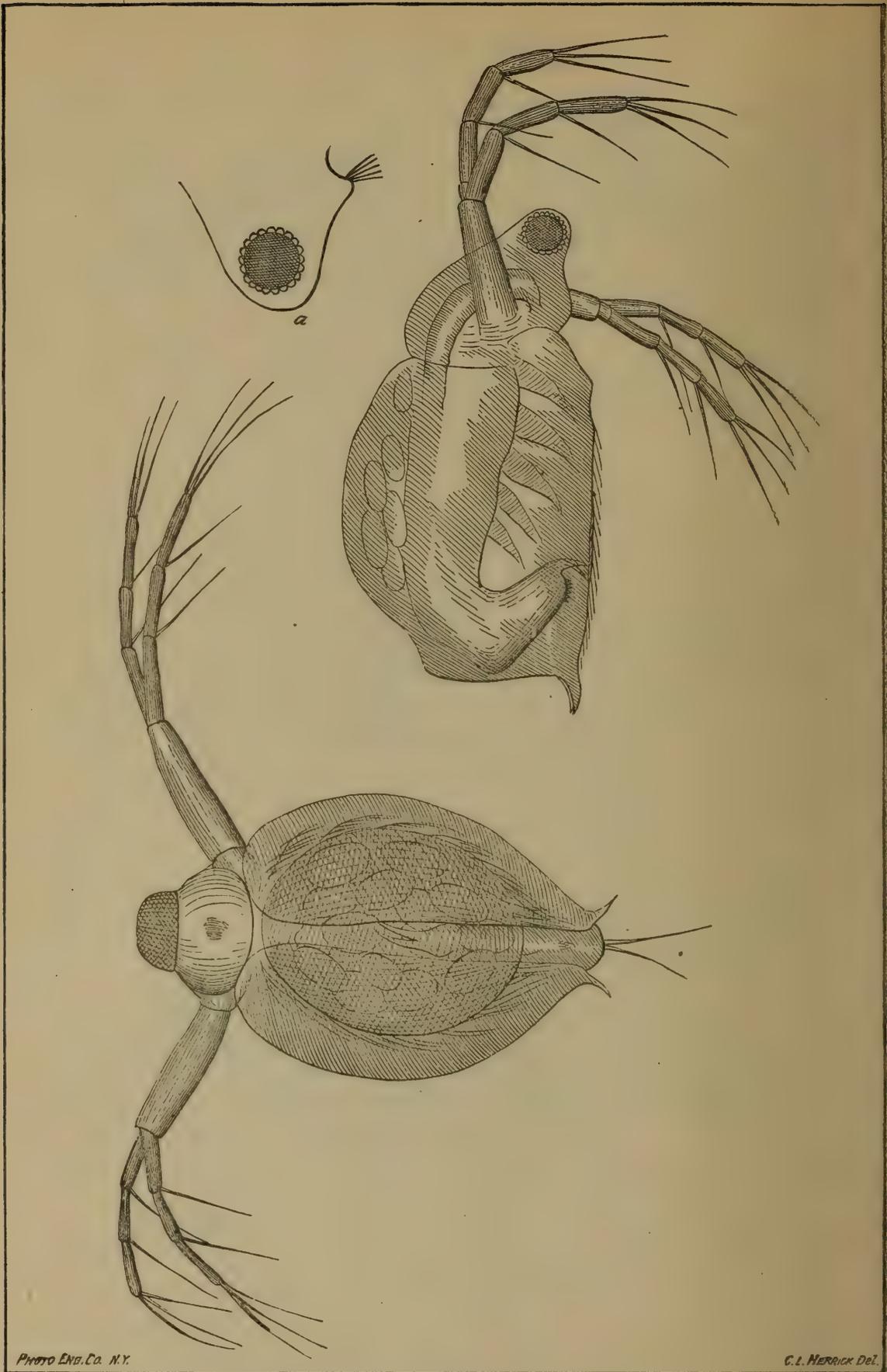


PHOTO ENG. CO. N.Y.

C. L. MERRICK DEL.

Fig. 5. *Scapholeberis mucronata*.

A second variety or species has been found which differs somewhat from typical *mucronata*, but does not appear to be *nasuta* of Birge. Is not the latter a variety simply?

SCAPHOLEBERIS ARMATA var. ? nov.

Length $\frac{7}{100}$ - $\frac{8}{100}$ cm.; much as *S. mucronata* in form; but the spines are greatly elongated in old as well as young individuals; and in individuals having winter as well as summer eggs, though the winter form seems to have longer spines which are nearly equal in some cases to the height. Antennæ are short and transparent. The head is separated from the body by a marked depression; but is curved forward so that the beak lies generally between the valves. The antennules are of medium size. Nowhere reticulate (?) nor tuberculate. The shell is marked by impressed lines, especially anteriorly and below. The lower margin is straight and beaded anteriorly, but toward the base of the *mucro* are several long bristles which stop abruptly and are followed by a few very weak hairs. The post-abdomen has three teeth at the base of the claws, which are smooth.

This variety is much like *S. nasuta* of Birge, perhaps, but differs perceptibly in several points. Most conspicuous are the greatly elongated spines and the short antennæ. This variety is about as large as *mucronata* but less than *nasuta*.

BOSMINIDÆ.

Genus BOSMINA.

First antennæ many-jointed; intestine straight. Sole genus of the family, and one which Kurz characterizes as "one of the most difficult of the genera of Cladocera."

There are three species known in the United States, two of which are found from the Eastern States to the Mississippi and westward, and are identical with European forms. The third may not prove distinct.

BOSMINA LONGIROSTRIS.

(Plate X, fig. 2.)

Differs from the following in having the terminal claws not toothed, and from *B. striata* in the shorter antennæ and reticulate shell.

BOSMINA CORNUTA.

(Plate IX, figs. 3-5.)

$\frac{3.5}{0.00}$ cm. long; shell reticulate with hexagonal meshes; antennæ curved backward and outward at the tip; claws with several teeth near the base. In embryonic specimens the antennæ are straight.

BOSMINA STRIATA, sp. n.

(Plate IX, fig. 1).

$\frac{2.5}{1.000}$ cm. long; shell marked with anastomosing longitudinal striæ; antennæ very long; frontal seta about midway between eye and the sense-hairs of the antennæ: posterior inferior angle of shell spined as in the previous species.

The species resembles *B. maritima* greatly. The members of this genus have been little studied owing to their small size and comparative rarity, and it is even possible that some of the species will prove invalid.

All three of the above species were found in one gathering from Lake Minnetonka. Only one other locality (for *B. longirostris*) is known to me in this State.

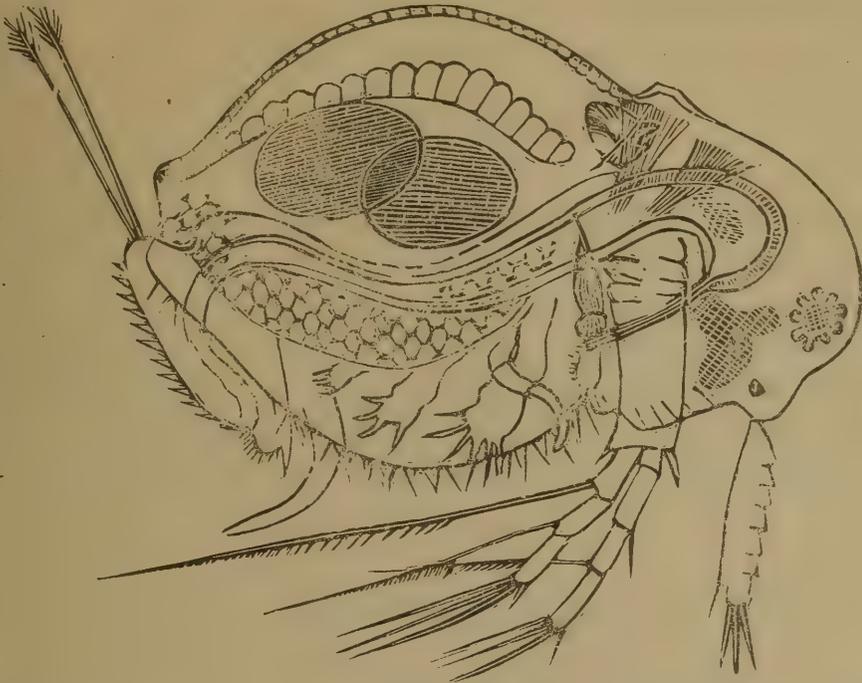
LYNCODAPHNIDÆ.

Genus MACROTHRIX.

Aside from *M. roseus* and *M. tenuicornis* (to which, perhaps, *M. agilis* of a previous report may be referred) a single species of macrothroid crustacean was collected at Lake Minnetonka, which is very remarkable. The specimen was apparently somewhat injured in moulting, and it is not possible to tell how much of its peculiar shape may be due to this fact, but some of its characters are sufficient evidence that it constitutes at least a new species.

It resembles in outline *Simocephalus vetulus*; the antennæ are very narrow and curved in a lateral as well as posterior direction; the second or swimming-antennæ are long as in other members of the genus; *macula nigra* present but small; eye small; post-abdomen short, triangular; claws pectinate; a dorsal sucking-disc is present;

length $\frac{10}{100}$ cm. For this species the name *MACROTHRIX PAUPER* is provisionally offered. (Plate VIII, fig. 1.)



(FIG. 6.)

MACROTHRIX TENUICORNIS, Kurz.

(FIG. 6.)

The description given by Kurz is very full and agrees very well. The peculiar arrangement of the movable spines at the margin of the valves is characteristic. I have observed that *this species forms an ephippium*. Müller says distinctly of the series of genera including *Macrothrix*, *Drepanothrix*, *Lathonura*, *Bosmina*, *Acantholebris* and *Iliocryptus*, "*Testae abjectæ corporis, nullo ephippio, ova hiberna obtegunt.*"

Bosmina is little related to the *Lyncodaphnidæ* and, however it may be with regard to other species, in *M. tenuicornis* an evident ephippium is formed in much the same way as in *Ceriodaphnia*. In *Daphnia* this egg-cover is produced by an alteration of part of the inner layer of the shell which becomes turgid and secretes a thick coating. The ephippium simply extends over the brood-cavity, being marked off from the rest of the shell by the median suture of the valves. In other *Daphnidæ* and in *Macrothrix* nearly the whole of the valves are thus modified. The shell of *M. tenuicornis* is normally smooth, but in the ephippial female, that portion of the inner layer of the shell

bordering the egg-cavity and a little beyond, is composed of large and very deep cells; the space between the outer and inner layers is much greater than in *Daphnia*.

Genus LATHONURA.

Although no species of this genus has been found in Minnesota, it is to be expected that it will eventually be discovered that the cosmopolite *L. rectirostris*, Müll. occurs in our limits. It occurs in Mass. according to Birge. The figures (Plate VIII, figs. 11-12) were drawn from specimens found in Leipzig, Saxony, illustrating a tendency, especially common in the *Lyncodaphindæ*, to abnormal growth of the spinous appendages—in this case the anal setæ.

Genus ILIOCRYPTUS.

A genus represented by a single European species. Our form may differ somewhat in some respects from the generic diagnosis, but certainly belongs here. There are no anterior cœca (as indeed there are probably not in the European *I. sordidus* though so stated by Müller,) and no permanent cœcum or dilation of the intestine before the rectum. The marginal spines are straight, long and movable without branches.

ILIOCRYPTUS SPINIFER sp. nov.

(Plate VIII, figs. 2-6.)

Short; depth nearly equaling length of body excluding head; rounded behind; free edges of valves beset with slender ciliate spines which are not branched; antennæ exactly as those of *I. sordidus*, as is the post-abdomen, save that the anus seems to be situated higher; ova three or more.

This species occurs in Silver lake, east of Minneapolis. It swims quite well, while of the European species it is said this is not the case. It does, however, frequently load itself with filth so as to be too heavy to swim freely.

LYNCODAPHNIA, Gen. n.

(Plate IX, figs. 1-3.)

Form much as is species of *Alonella*, etc., truncate behind; superior antennæ like *Macrothrix*, attached movably to the end of a blunt prominence beneath the head; second or swimming antennæ slender; four-jointed ramus with three long setæ at the end of terminal joint where is also a stout spine; joint following the basal joint also with a spine above; middle joint unarmed (?); three-jointed ramus as in *Macrothrix*; the basal segment armed with a much elongated seta; eye relatively small; pigment fleck present; intestine twice-convoluted, expanded in front of colon, opening in the "heel" of the post-abdomen; post-abdomen slender, sub-triangular, margined behind with a double series of spines; terminal claws large, straightish and furnished with a long and short spine near the base, also very minutely feathered behind; shell marked alone by the so-called "stuzbalkein;" lower margin with movable spines.

Few more interesting forms have been noticed than this, since it combines the characters which have hitherto been considered as very clearly forming the boundaries of distinct families.

Kurz says, (*Dodekas neuer Cladoceren nebst einer kurzen Uebersicht der Cladocerenfauna Böhmens*, p. 30:) "Keine Cladocerenfamilie bildet eine so streng in sich abgegrenztes natürliches ganze, wie eben die Lynceiden," and this even after recognizing the relationship of *Macrothrix* and *Lathonura* to the Lynceids by placing them in the sub-family *Lyncodaphniæ*. The form for which I propose the name *Lyncodaphnia* is quite as much like such forms as *Alona* and related Lynceids, as any species of the *Lyncodaphniæ*, while at the same time the characters of antennæ and head are almost identical with *Macrothrix*. This furnishes but another example of the fact that possibility of distinguishing families and genera lies alone in the meagerness of our knowledge.

LYNCODAPHNIA MACROTHROIDES, sp. n.

Form sub-rectangular, greatly elongated; length $\frac{1}{100}$ cm., height $\frac{5}{100}$ cm. or less; first antennæ long and slightly curved, bordered behind by about ten spines and terminating in two unequal sword-shaped spines and several sense-hairs, about $\frac{1}{1000}$ cm. long; swimming antennæ very slender as in *Macrothrix*, $\frac{6}{100}$ cm. long; head not marked off by a depression from the body, small and extending below into a blunt elevation for attachment of antennæ; labrum rather large; eye

small; macula nigra conspicuous but not large; anterior feet strongly armed with curved spines. The intestine anteriorly is furnished with cœca, is twice convoluted, broadened before entering the rectum and opens a little distance beyond the oval seta in the heel of the post-abdomen; post-abdomen rather slender, toothed behind with a double series of about twelve prominences, becoming distally sharp, strong teeth; terminal claws curved at the end only, pectinate and bearing two unequal but large processes near the base; eggs much like those of *Macrothrix*.

Occurs in Lake Minnetonka, Hennepin Co., Minnesota, rare.

LYNCEIDÆ.

But few of this large family, furnishing the majority of the Cladocera fauna of any locality and at any time of year, have been carefully studied here. The following are mentioned as of particular interest:

SUB-FAMILY EURYCERCINÆ.

The single species *Eurycercus lamellatus* which constitutes this subfamily has been mentioned and figured in a previous paper. It is quite abundant and constant.

Eurycercus is connected with the true Lynceids by the following genus which has quite as many affinities with *Eurycercus* as any Lynceid. Schödler seems to be the only writer who has laid sufficient stress upon this similarity, though it may not be best to unite the two forms as he did.

Genus LEYDIGIA, Kurz.

LEYDIGIA QUADRANGULARIS, Leydig.

(Plate VIII, 7-8.)

The Minnesota species is referred to *L. quadrangularis* under the belief that there is no specific distinction between that species and *L. acanthoceroides*, Fischer.

Our form does not agree in every particular with the very minute

description of Kurz and does agree very well with what is said of *L. acanthocercoides*. However, Kurz says of the latter species, "Diese Art ist von der vorangehenden (*L. acanthocercoides*) im weiblichen Geschlecht schwierig zu unterscheiden," and immediately adds that the male is unknown to him. In P. E. Müller's time both males were unknown. Müller says of *acanthocercoides*, "ungues caudales inermes," of *quadrangularis*, "ungues caudales dente minuto." Kurz on the other hand says of the former, "der Basaldorn ist kurz," of the latter "die Endklauen haben keinen Basaldorn."

Our species has no spine on the claws, and has a small spine on an eminence on the dorsal part of the abdomen, as well as two ciliated prominences between it and the oval setæ; length $\frac{9}{10}$ cm.; color red.

Silver Lake, east of Minneapolis.

CAMPTOCERCUS MACROURUS.

(Plate X, fig. 9.)

This large species occurs rather sparingly at Lake Minnetonka. It is probably widely distributed in America as well as Europe. It is known in Cambridge, Mass. and Madison, Wis. (Birge).

CAMPTOCERCUS ROTUNDUS, sp. nov.

(Plate VIII, figs. 9-10.)

Short, quadrangular, dorsally nearly uniformly arched; antennæ of first pair long, curved outward, with long terminal bristles; abdomen long, nearly uniform in width; teeth of post-abdomen few, inconspicuous; terminal claw nearly straight; basal spine large; the claw also has a series of spines beginning a little beyond the middle and shortening proximally; length $\frac{7}{10}$ cm. This resembles *C. rectirostris*, Schödler, a little in outline of body but the head is like *C. macrourus*, except that there is a slight beak directed anteriorly (not shown in the figure); the post-abdomen is much as in *C. macrourus*, but is less heavily spined. In size it is somewhat less than *C. lilljeborgii*, and the shortest species known to me.

ACROPERUS sp?

(Plate X, fig. 10.)

Resembles *Camptocercus macrourus* greatly. Are these two genera really distinct?

PLEUROXIS PROCURVUS, Birge.

(Plate X, fig. 6)

Very characteristic. Found in Shady Oak lake, and elsewhere abundant.

PLEUROXIS UNIDENS, Birge.

A species which agrees best with this is quite abundant. It is, however, always of a deep brownish color, and the beak is long and curved inward; it may be distinct.

A third form of *Pleuroxis*, probably *P. denticulatus*, Birge, is abundant also.

GRAPTOLEBRIS INERMIS, Birge.

(Plate X, figs. 8, 11-12.)

Resembles *Alona testudinaria* very closely; the antennæ are peculiar; each joint has a median circlet of fine bristles; the upper ramus is terminated by two long setæ, one shorter seta and a stout spine; the joint preceding the terminal one has a stout seta. The description given by Birge is otherwise complete. Lake Minnetonka.

CREPIDOCERCUS SETIGER, Birge.

This is exceedingly rare, and by reason of its small size, difficult to distinguish. It has been encountered but once in Minnesota. This species is easily recognized when found, and though our specimens differ a little from the figure given by Birge, they are doubtless the same.

ALONA OBLONGA, P. E. Müller.

The specimens examined differ somewhat from Müller's description. The caudal claw is pectinate; the spine at its base is large and covered with a tuft of hairs; the teeth of post-abdomen are large, emarginate and hairy; otherwise the agreement is very close; length .07 cm. Found in Grass Lake, Richfield.

TRIBE III ONYCHPODA.

POLYPHEMIDÆ.

POLYPHEMUS PEDICULUS.

(Plate IX, figs. 4-6.)

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- Polyphemus kochii, " " " "
- Polyphemus oculus, " " " "
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I have collected from various sources what I could of the extensive bibliography of this, the sole species of the genus. One of the most characteristic and pleasing figures given is that of Weismann in his article on the "Schmuckfarben der Daphnoiden," though we believe that author in the wrong in the deductions made. Our specimens rarely approach the brilliancy of the plate, and there seems to be a more legitimate way of explaining these secondary colors than by sexual selection. This species is never abundant, nor is it very rare; found in Lake Minnetonka, and the larger lakes with their outlets.

III On *Notadromas* and *Cambarus*.

CYPRIDÆ.

This group is one of the most difficult and perhaps least studied. A number of species some of which, perhaps most, are new, occur in Minnesota, and among them is a *Cypris* which exceeds any described form in size. I only mention one genus which is cosmopolitan.

NOTADROMAS, Lilljeborg.

Carapace differing in male and female; eyes two; antennæ similar to those of *Cypris*, the superior having seven and the inferior six joints; setæ of inferior antennæ reaching beyond the apex of the terminal claws; second pair of jaws without a branched appendage, in the male pediform; abdominal rami rather long.

NOTADROMAS MONACHUS, Müller.

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Brady, British Ostracoda.

Females of this widely distributed species were collected near Minneapolis, presenting in as far as could be seen no material points of distinction from English types.

DECAPODA.

But two species of *Cambarus*, *C. virilis*. Hagen, and *C. signifer*, occur in Hennepin county, except, perhaps, in the Mississippi. The following localities for the former species are known in the State: Mississippi river, Minnehaha creek, Bassett's creek, Cedar lake, Lake Minnetonka, Lake Independence, Lake Superior.

It is possible to recognize three age-forms in the males of this species.

A. The immature male (II Form, Hagen). Reaching two to three inches in length, this stage has the chelæ proportionally smaller, and the spinous armature less developed: the first abdominal foot is simply bifid at the end.

B. (Form I of Hagen,) usually over two and one-half inches long; chelæ larger; branches of abdominal foot distinct; inner branch grooved but lance-linear.

C. Very large (four inches); inner branch of abdominal foot spatulate at end; the two rows of tubercles on the inner margin of the "hand" with six or seven in a row instead of five.

Male of Form II, A stage, $2\frac{1}{2}$ in. long, Chela. 7 in., thumb .49 in.

" " I, B stage, $2\frac{1}{2}$ in. long, " 1 in., " .6 in.

" " I, C stage, 4 in. long, " 1.8 in., " 1.1 in.

" " II, A stage, 3 in. long, " 1.2 in., " .75 in.

It will be seen from the above that size does not govern the transition from the first to the second form entirely. This differs either in different localities or at different seasons of the year. A large gathering from Cedar lake showed no specimens of the form I, while a similar gathering at Lake Independence contained but one of the form II. A male from Minnehaha creek had rudiments of a third tooth on the carpus of the left claw, thus indicating an approach to Hagen's Var. A..

CAMBARUS SIGNIFER sp. nov.

(FIG. 7.)

A slender, graceful species of rather marked colors, belonging to the section having a hook on the third pair of legs but not on the fourth. The rostrum is not carinated nor toothed at the apex; acumen moderate, lateral borders curved, moderately excavated. Cephalothorax arched and not depressed above, densely punctate; areola linear; chelae slender, straight; thumb deeply excavated on the inner margin for the proximal one-third: opposite finger with an impressed groove on the inner but not on the outer margin.

Male, I Form. Color reddish-(crimson) brown, not obviously figured; tail lighter; fin chestnut, marked with gray; chelæ bright crimson below there are green markings on the body and legs, and some yellow below.

The hands are rather narrow and straight, while the "thumb" is deeply excavated for one-third its length, and the notch thus formed is armed with three or four teeth; the finger opposite has a tooth half way from the apex, and others near the base; the angle at base of thumb is densely hairy. The penultimate and previous joint of second foot bears a very dense and thick tuft of hairs on the inner margin which is particularly noticeable in living specimens. The antennæ are short about as long as the thorax when reflexed.

The first pair of abdominal feet resemble those of *C. virilis* somewhat, but are stouter and less divided. They are more strongly curved than in *C. propinquus*.

The laminae of antennæ are much as in *C. troglodytes* but wider at the base.

The second form has the two branches of the abdominal foot united almost to the end. The young males have the chelæ greenish-blue and mottled, while the coloration of the body is like the females.

The females have shorter chelæ, and broader abdomen marked with chestnut bars on each segment above.

A male 3.3 in. long was still in form II, while another 3.2 in. long was in the form I. Found by hundreds in a shallow pool known as Grass Lake, in Richfield, Hen. Co.

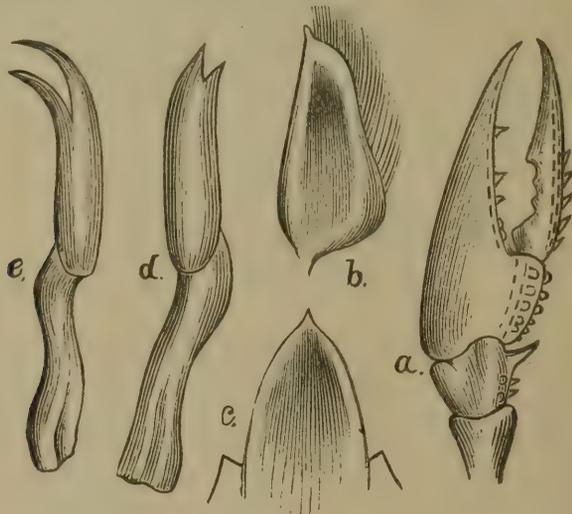


Fig. 7.

Cambarus signifer.

a chela. b lamina of antenna. c rostrum. d abdominal foot of form II. e abdominal foot of form I.

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PLATE I.

Diaptomus castor.

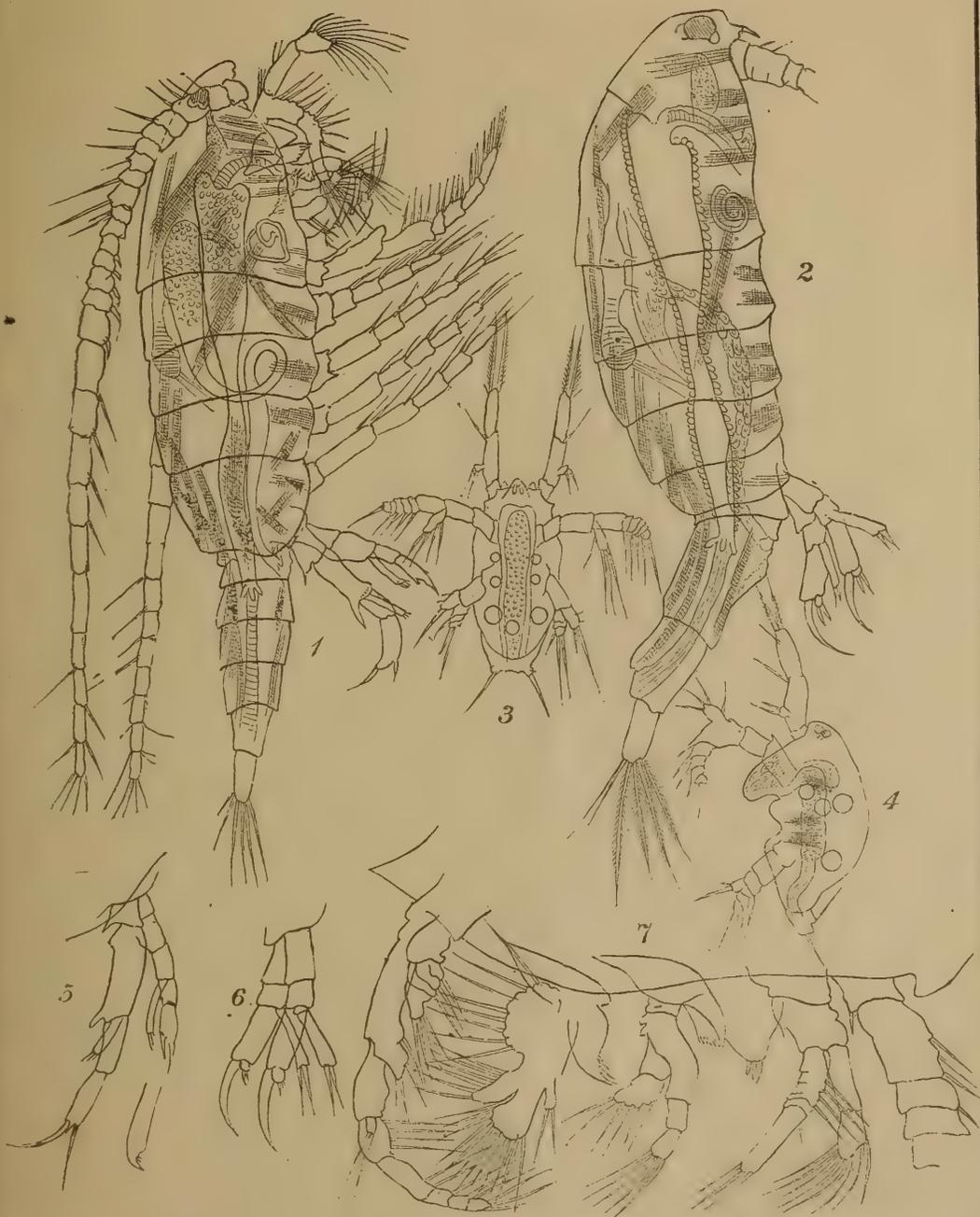
1. Male, antennæ not yet fully developed, showing shell, gland, heart, reproductive, alimentary and muscular systems.
2. Female, antennæ and appendages removed except fifth feet.
- 3 and 4. Nauplius stage.
5. Male foot of fifth pair, (a) "thumb" of larger branch.
6. Female foot₂ of fifth pair.
7. Mouth parts etc.

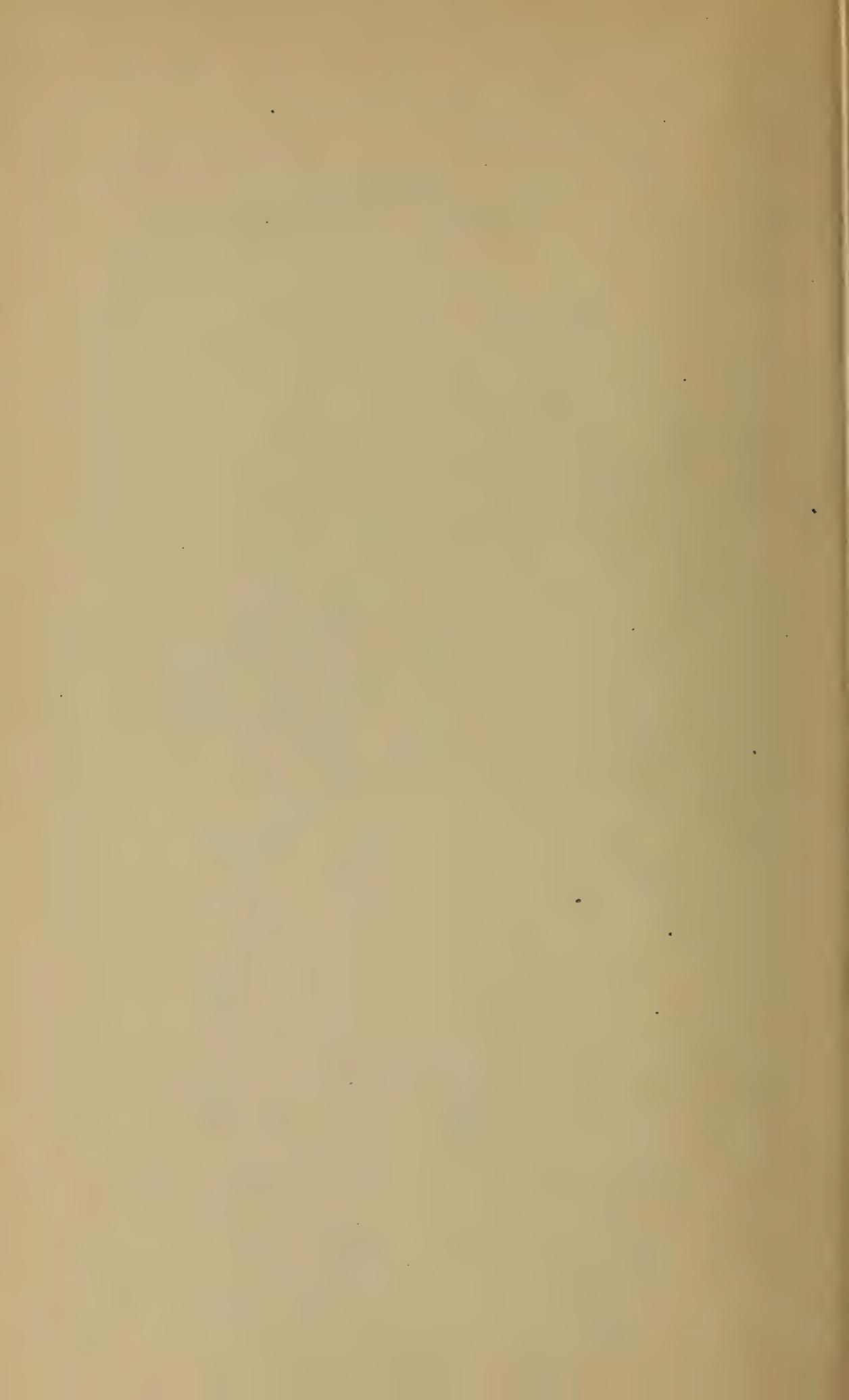
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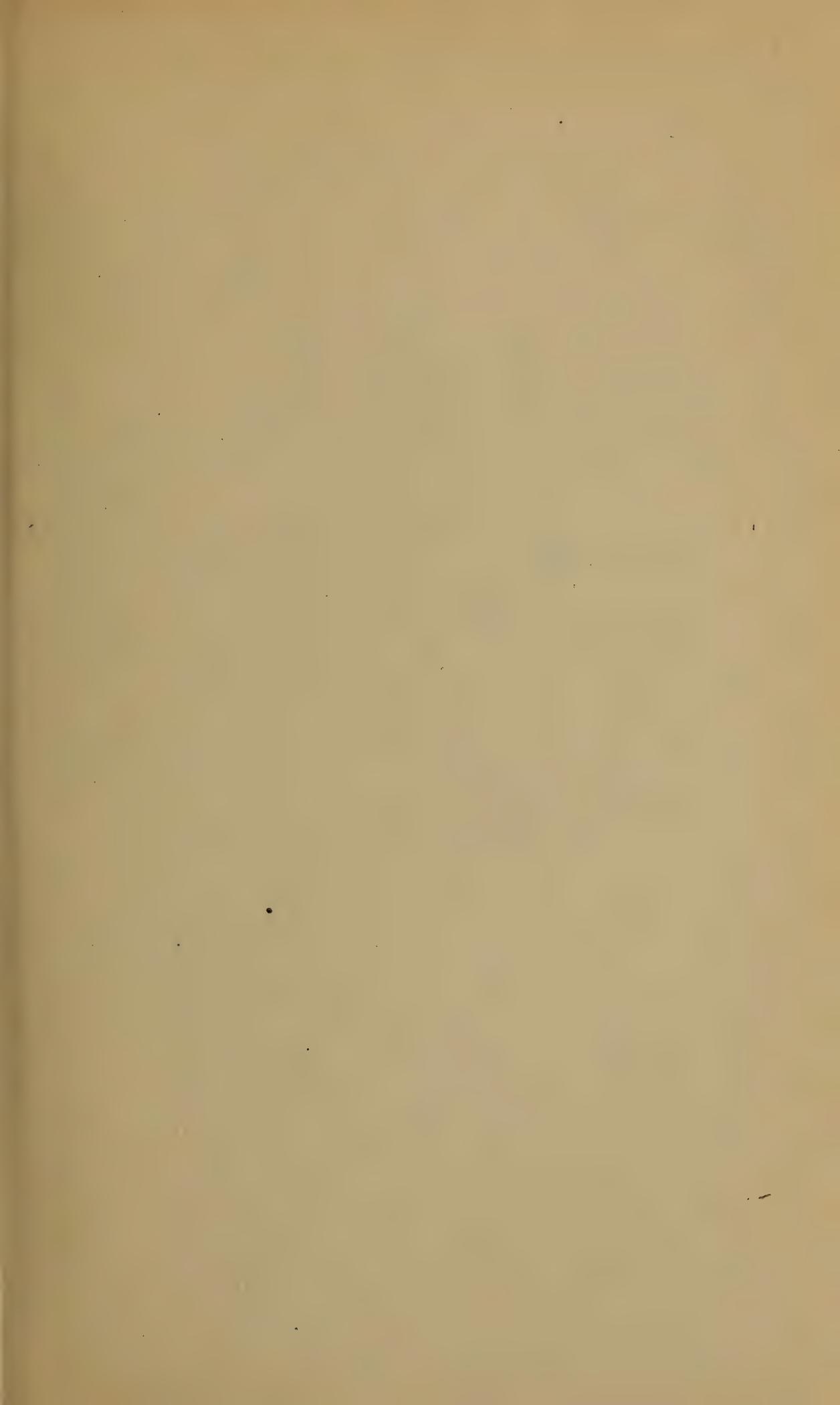
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PLATE I.

Geol. & Nat. Hist. Sur. Minn.





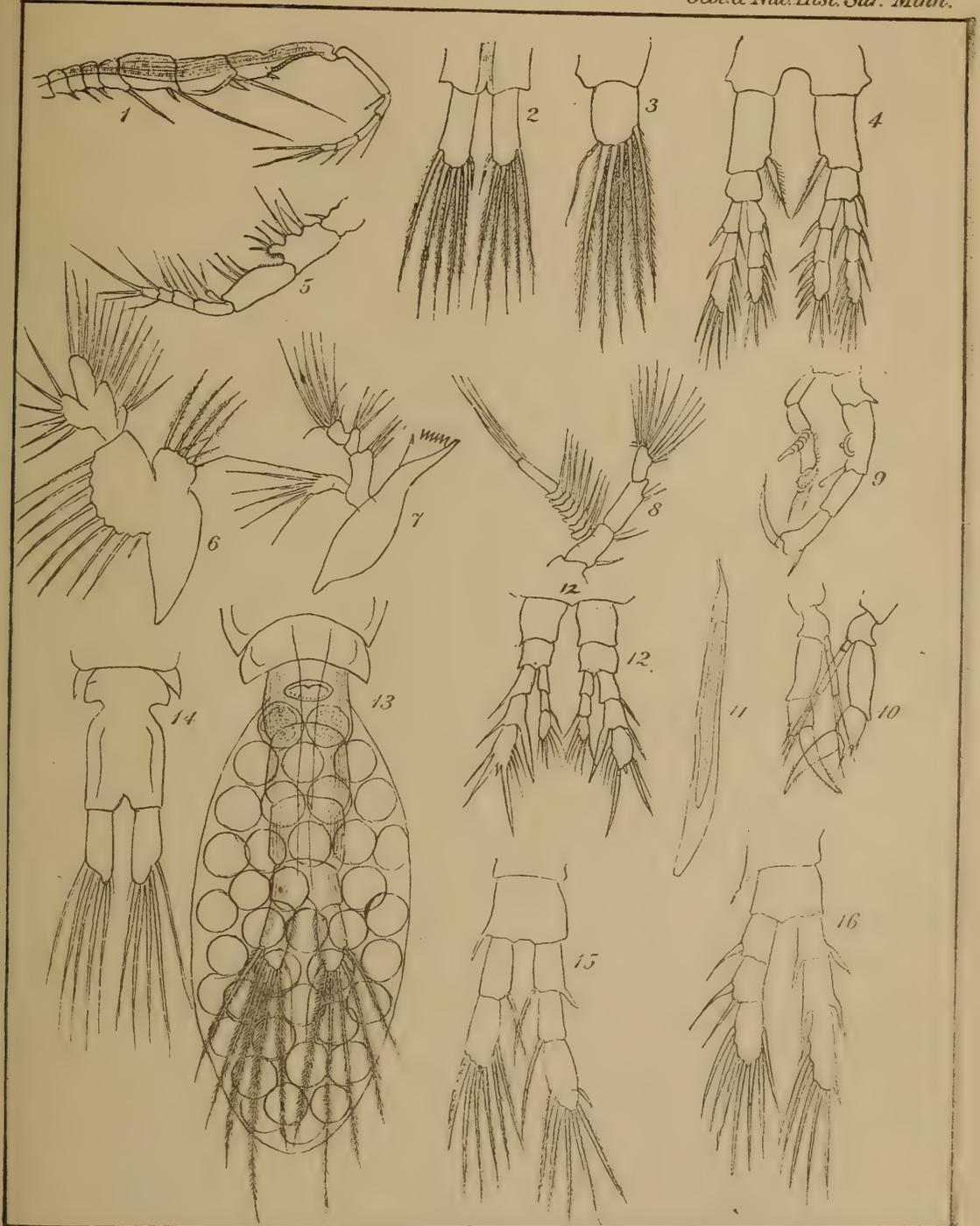


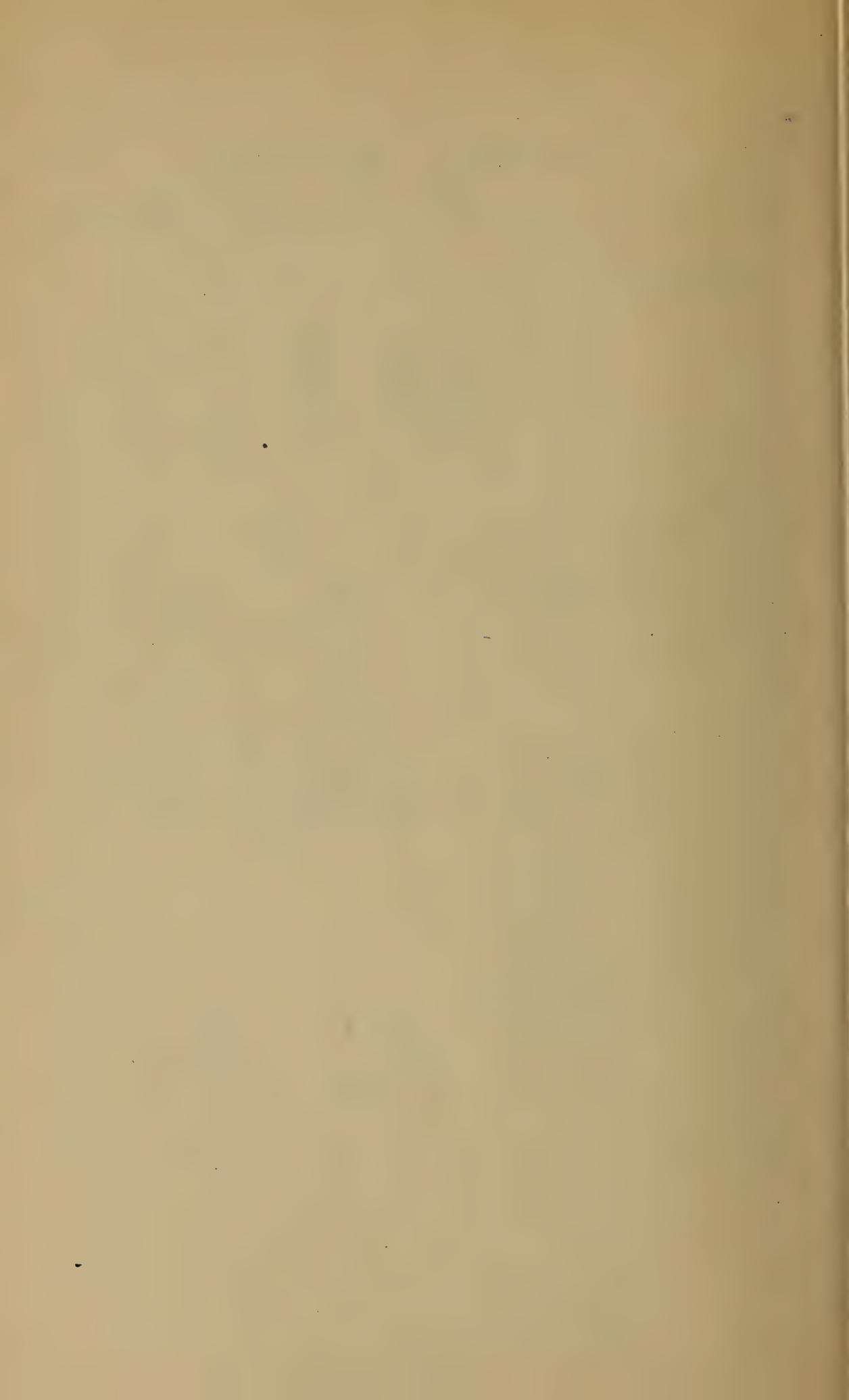
MINNESOTA CRUSTACEA.

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PLATE II.

Geol. & Nat. Hist. Sur. Minn.





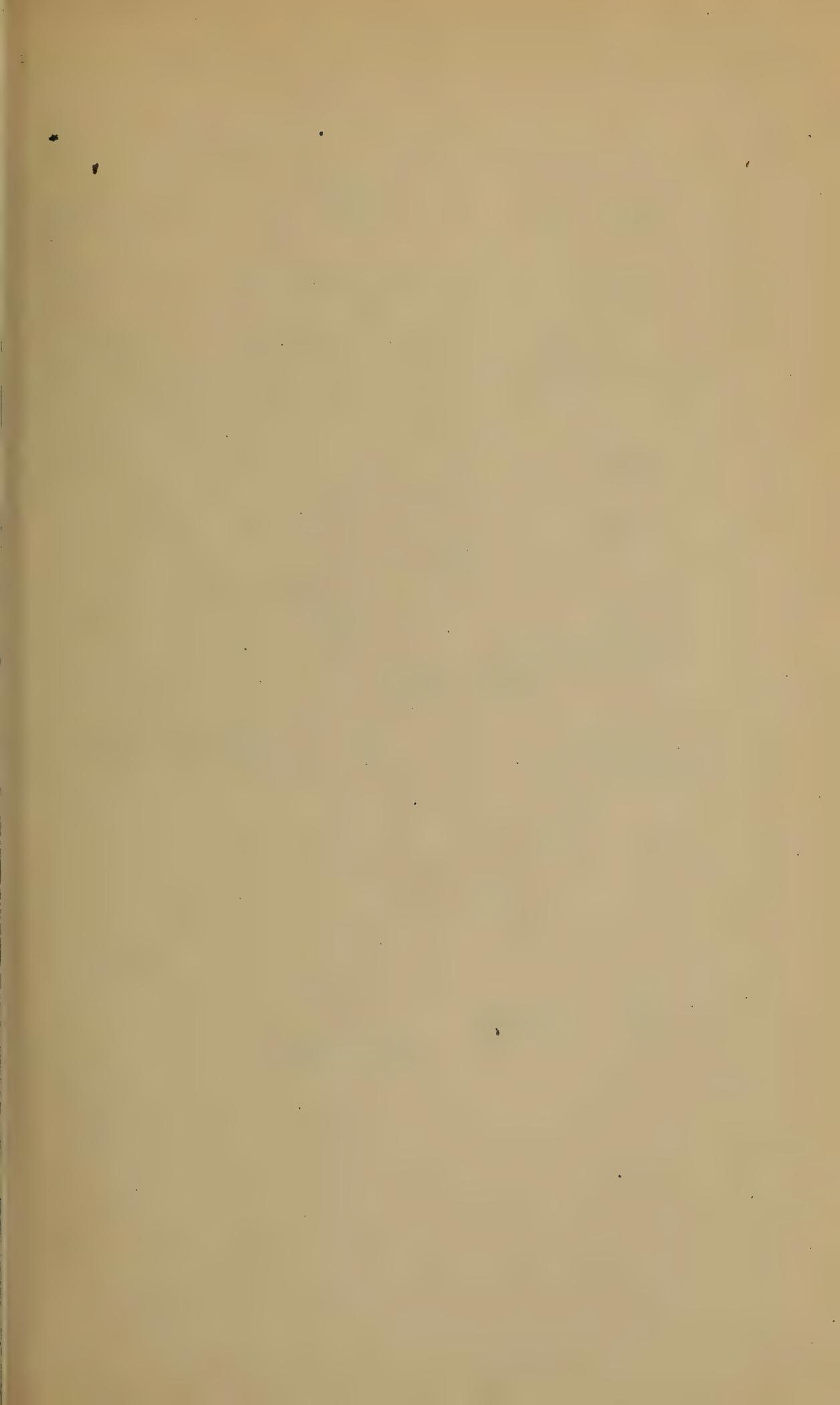


PLATE III.

Potamoichetor fucosus.

- | | |
|-----------------------------|------------------------|
| 1. Male. | 5. Palp of mandible. |
| 2. Anteanule. | 6. End of abdomen. |
| 3. Maxilliped. | 7. Feet of first pair. |
| 4. Male fifth pair of feet. | 8. Eye. |

Cyclops ater.

- | | |
|-----------------|--|
| 9. Female | 12. Antenna. |
| 10. Abdomen. | 13. Maxilla of <i>Potamoichetor fucosus.</i> |
| 11. Maxilliped. | 14. Mandible of " " |

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PLATE III.

Geol. & Nat. Hist. Sur. Minn.

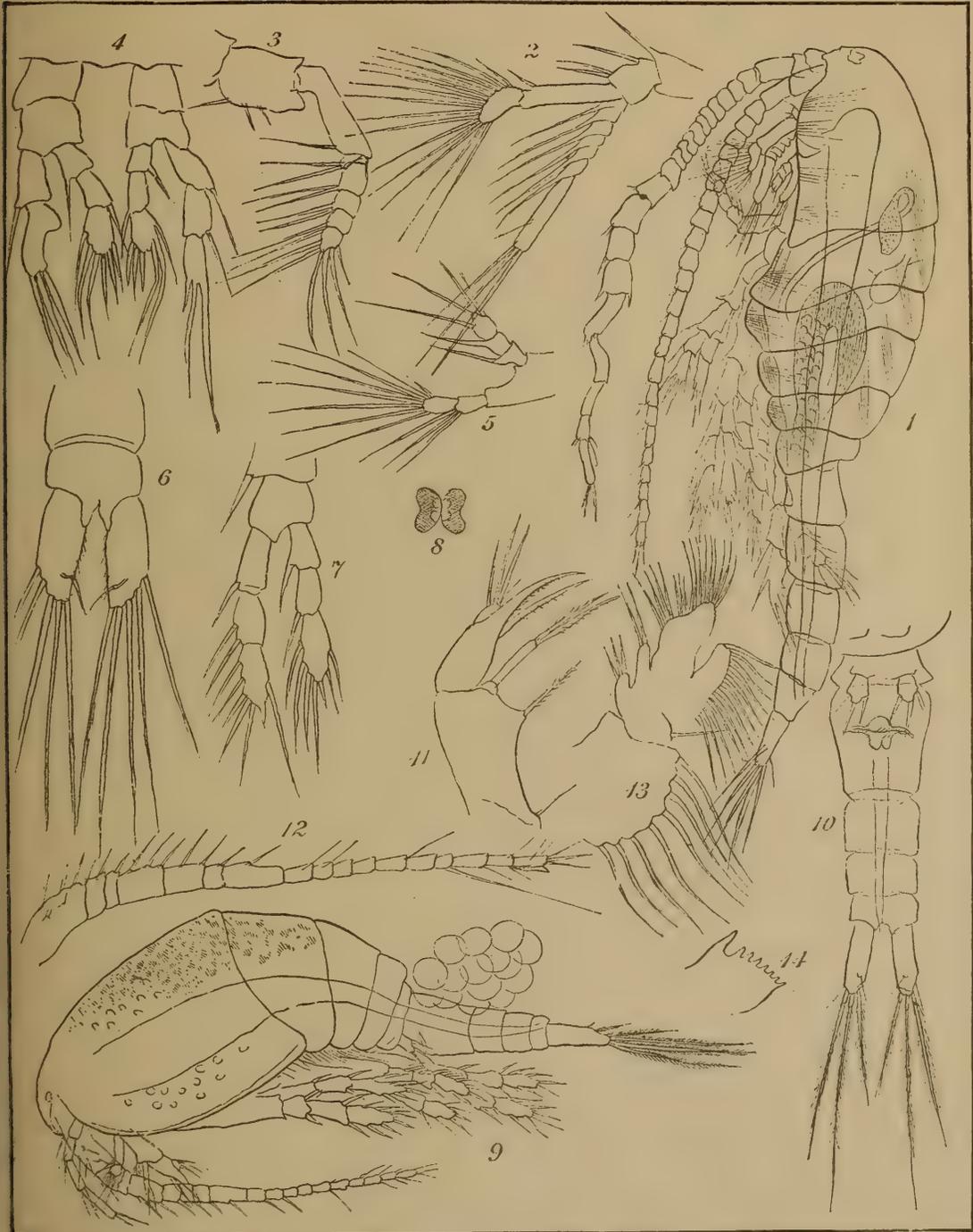


PLATE IV.

Cyclops ingens.

- | | |
|--|------------------------------|
| 1. First segment of abdomen of female. | 5. Stylets of mature female. |
| 2. Antenna. | 6. " young male. |
| 3. Fifth foot. | 7. Maxilliped. |
| 4. Antenna of young male. | 8. Mandible. |
| 9. <i>Cyclops crassicornis</i> , Female. | |
| 10. Antenna. | 13. Second antenna. |
| 11. Terminal portion of abdomen. | 14. Nauplius form. |
| 12. Female fifth foot. | |

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PLATE IV.

Geol. & Nat. Hist. Sur. Minn.

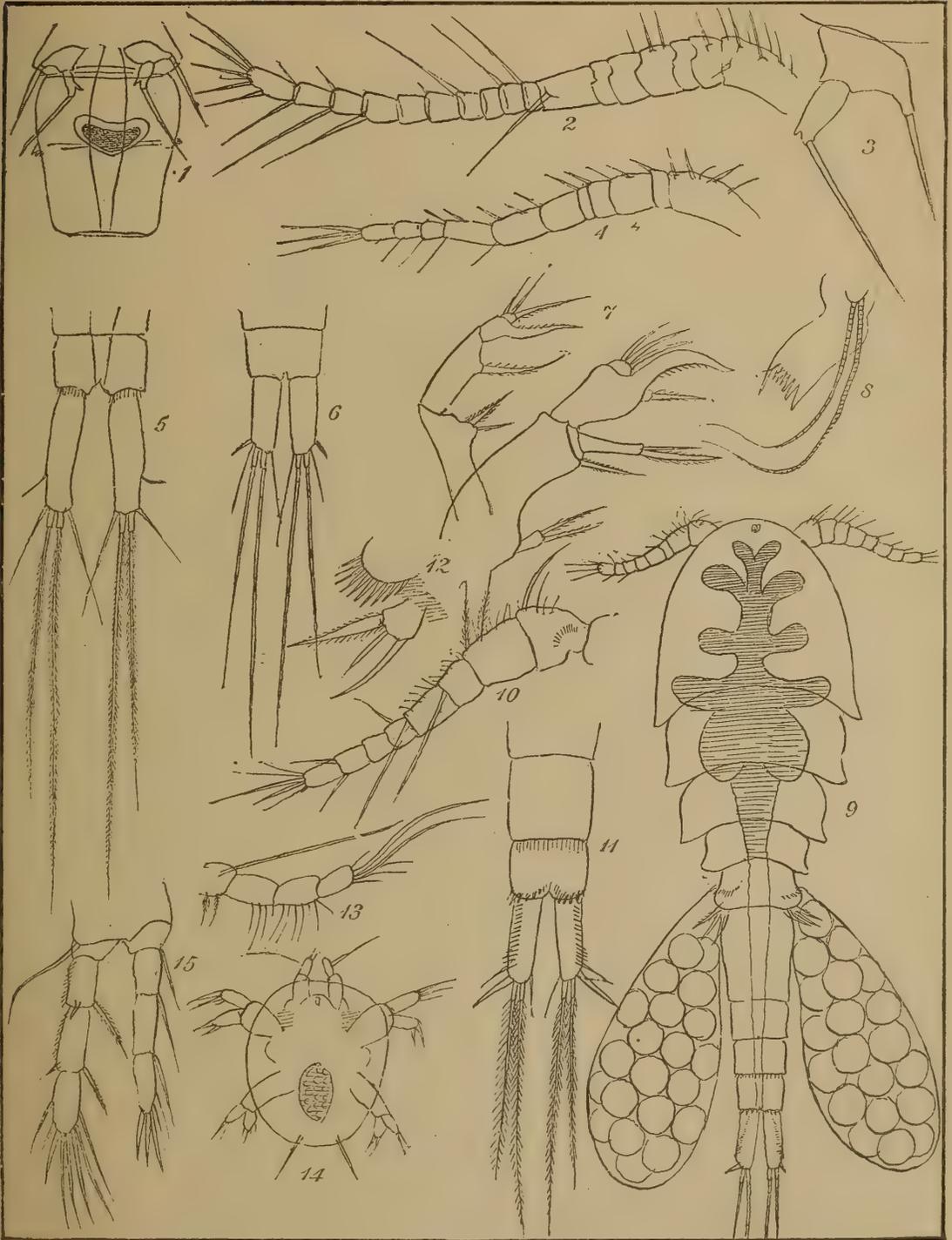


PLATE V.

Cyclops serrulatus.

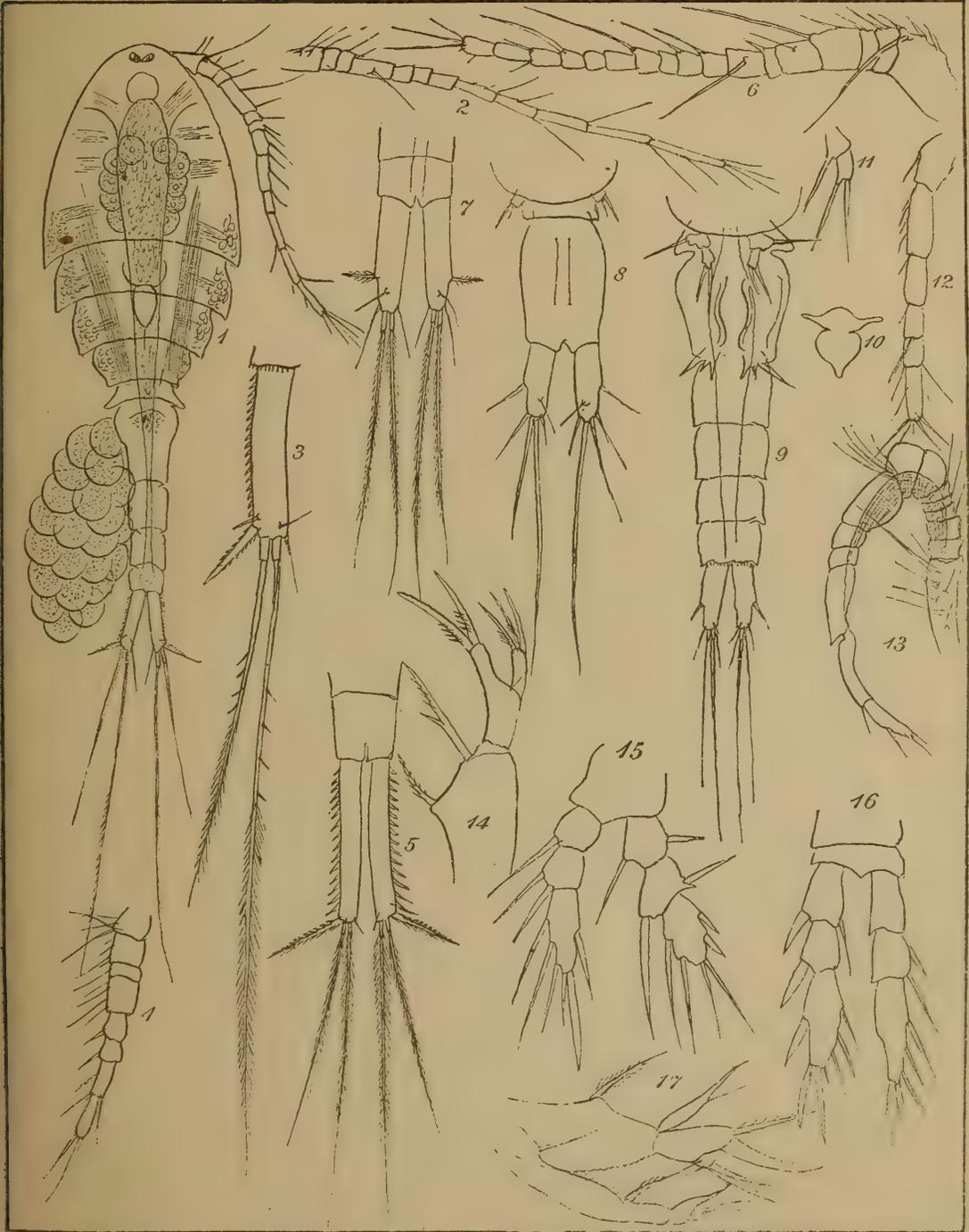
- | | |
|--|------------------------------------|
| 1. Female. | 4. Antenna of very young. |
| 2. Antenna of elongated form. | 5. Stylet of elongated form. |
| 3. Stylet of ordinary form. | |
| | 6. <i>Cyclops navus</i> , antenna. |
| 7. Furca. | 11. Fifth foot. |
| 8. Abdomen of young. | 12. Antenna of young. |
| 9. Abdomen of male. | 13. " male. |
| 10. Opening of spermatophore. | |
| 14. <i>C. "signatus,"</i> maxilliped. | |
| 15. <i>C. navus</i> , swimming foot of first pair. | |
| 16. " " " second pair. | |
| 17. Maxillipeds. | |

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PLATE V.

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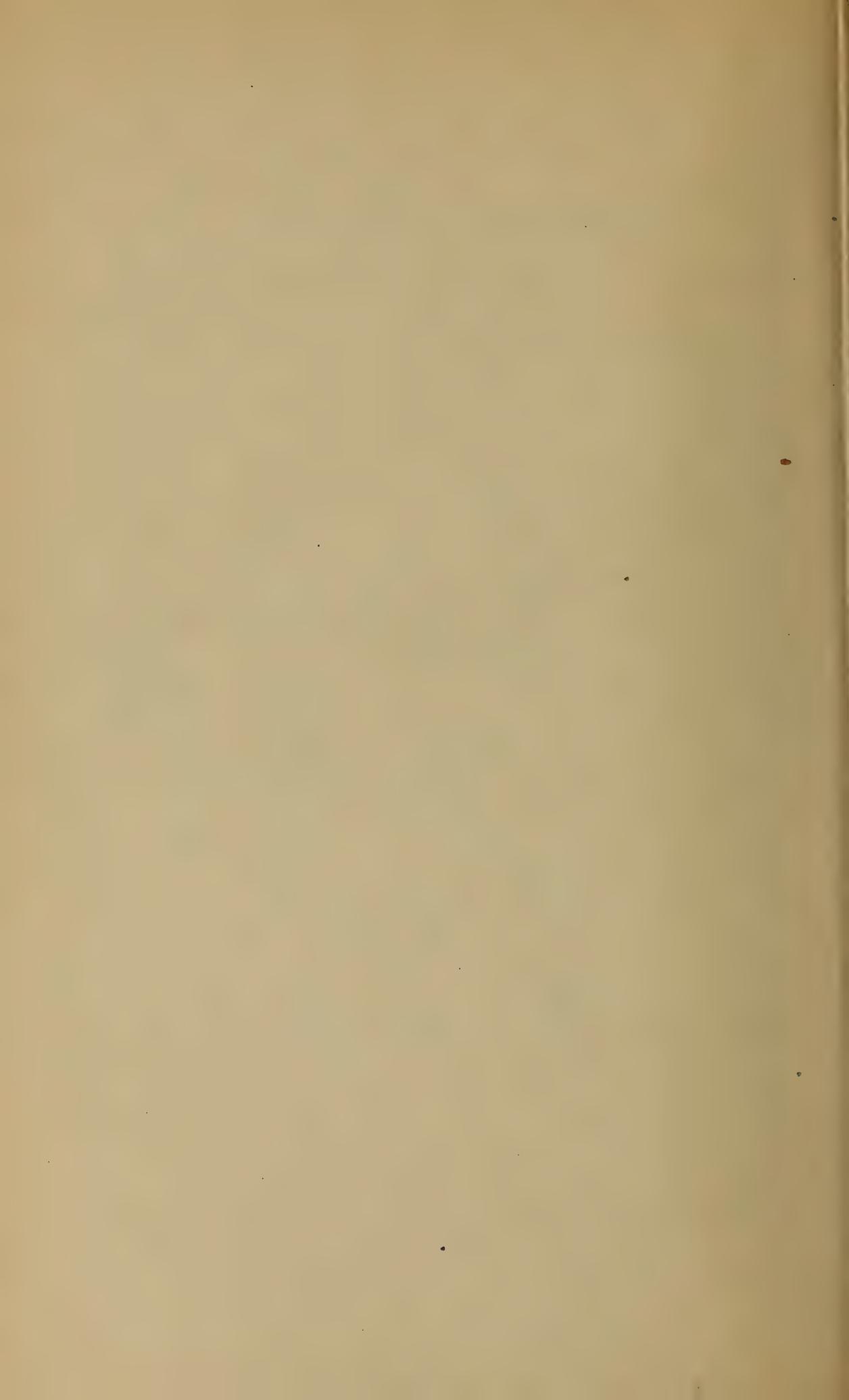


PLATE VI.

Cyclops tenuicornis.

- | | |
|-------------|-----------------|
| 1. Female. | 5. Fifth foot. |
| 2. Mandible | 6. Maxillipeds. |
| 3. Maxillæ. | 7. Antennule. |
| 4. Stylet. | |

C. "signatus."

- | | |
|-------------|-------------------|
| 8. Abdomen. | 10. Fifth foot. |
| 9. Antenna. | 11. Male antenna. |

Cyclops parvus.

12. Abdomen.
13. Antenna
14. Fifth foot.

Cyclops adolescens.

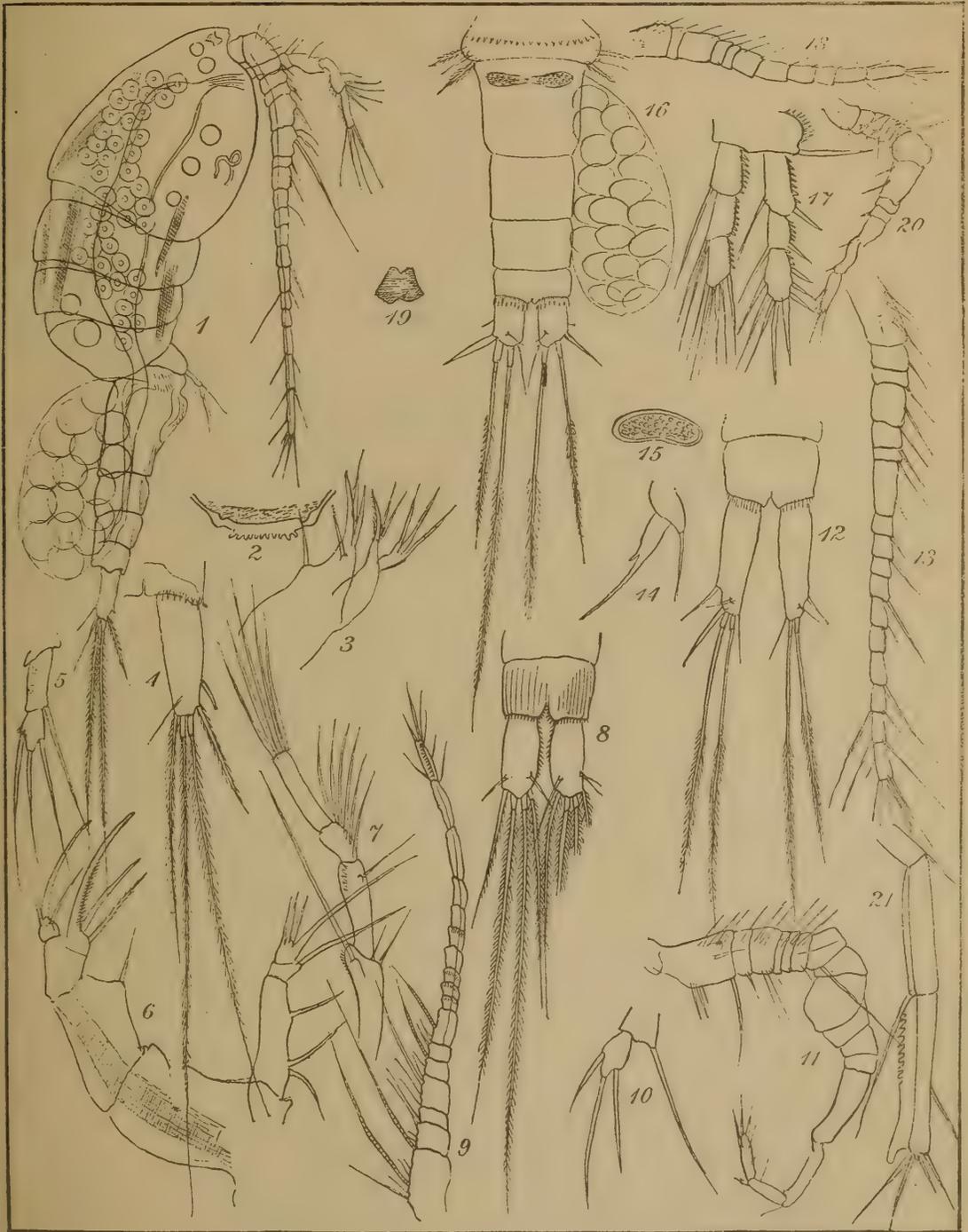
- | | |
|-------------------------------|---|
| 15. Opening of spermatophore. | 19. Eye. |
| 16. Abdomen. | 20. Male antenna. |
| 17. Foot. | 21. End of antenna of a form of <i>C. "signatus."</i> |
| 18. Female antenna. | |

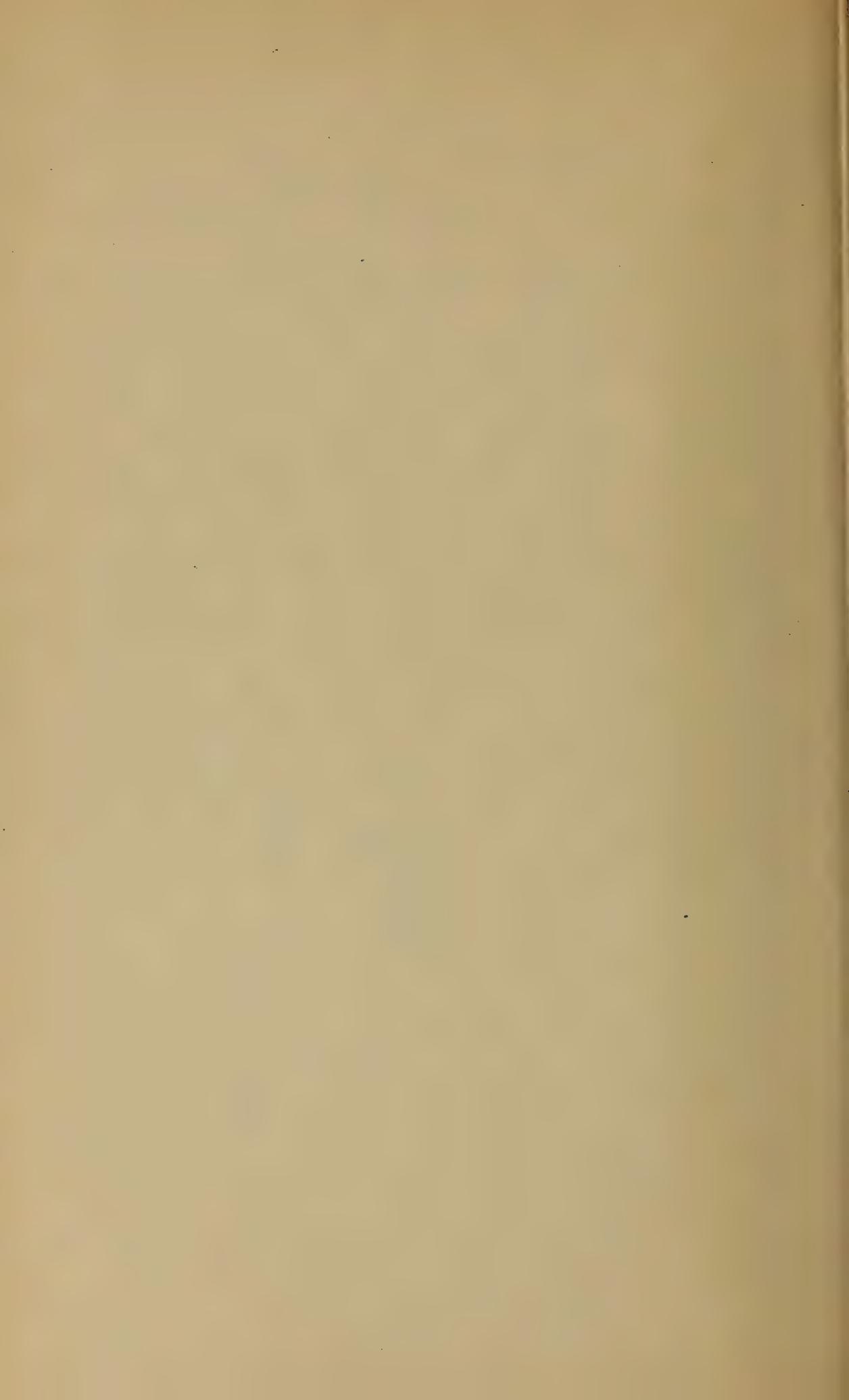
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PLATE VI.

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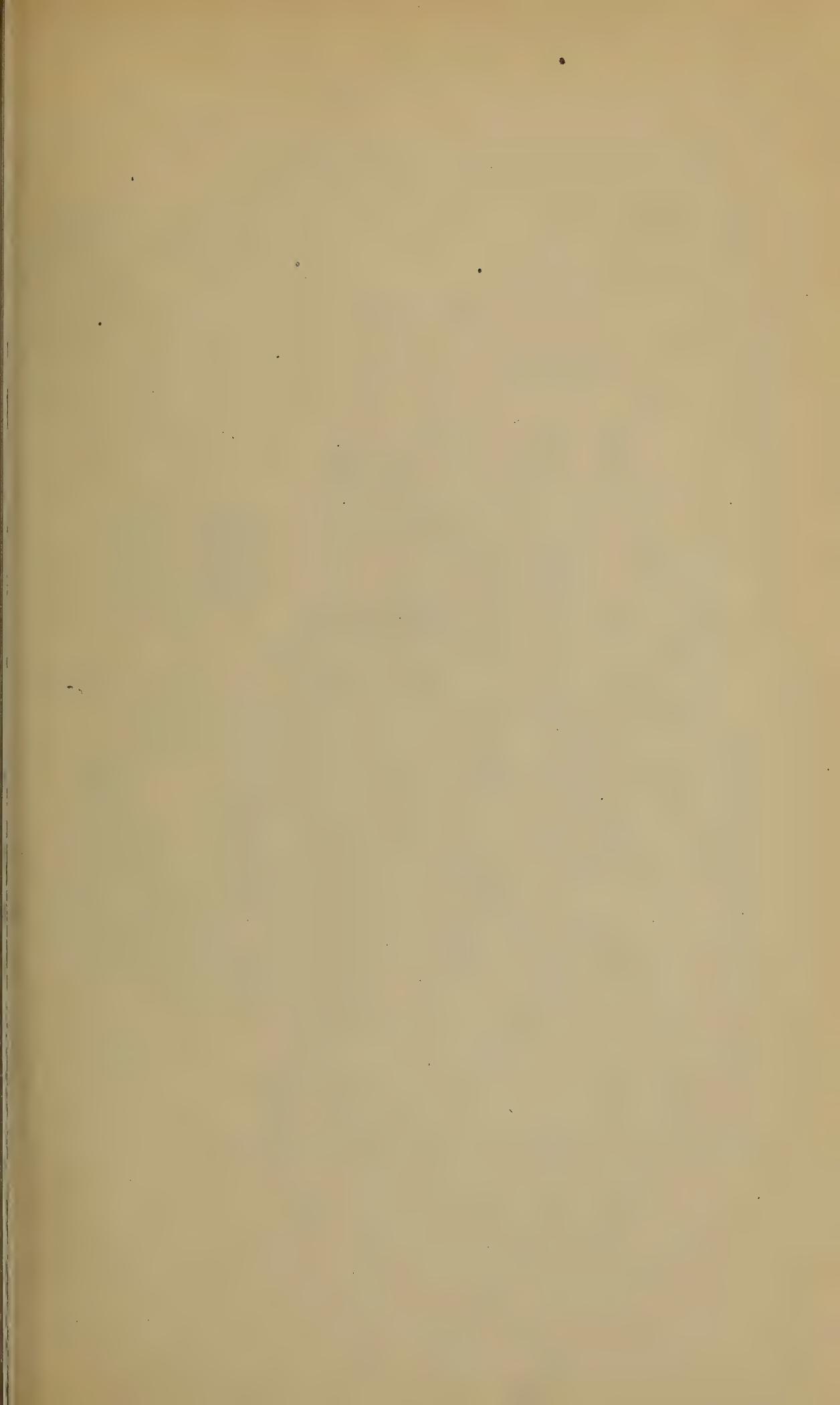


PLATE VII.

1-9. *Cyclops fluviatilis*.

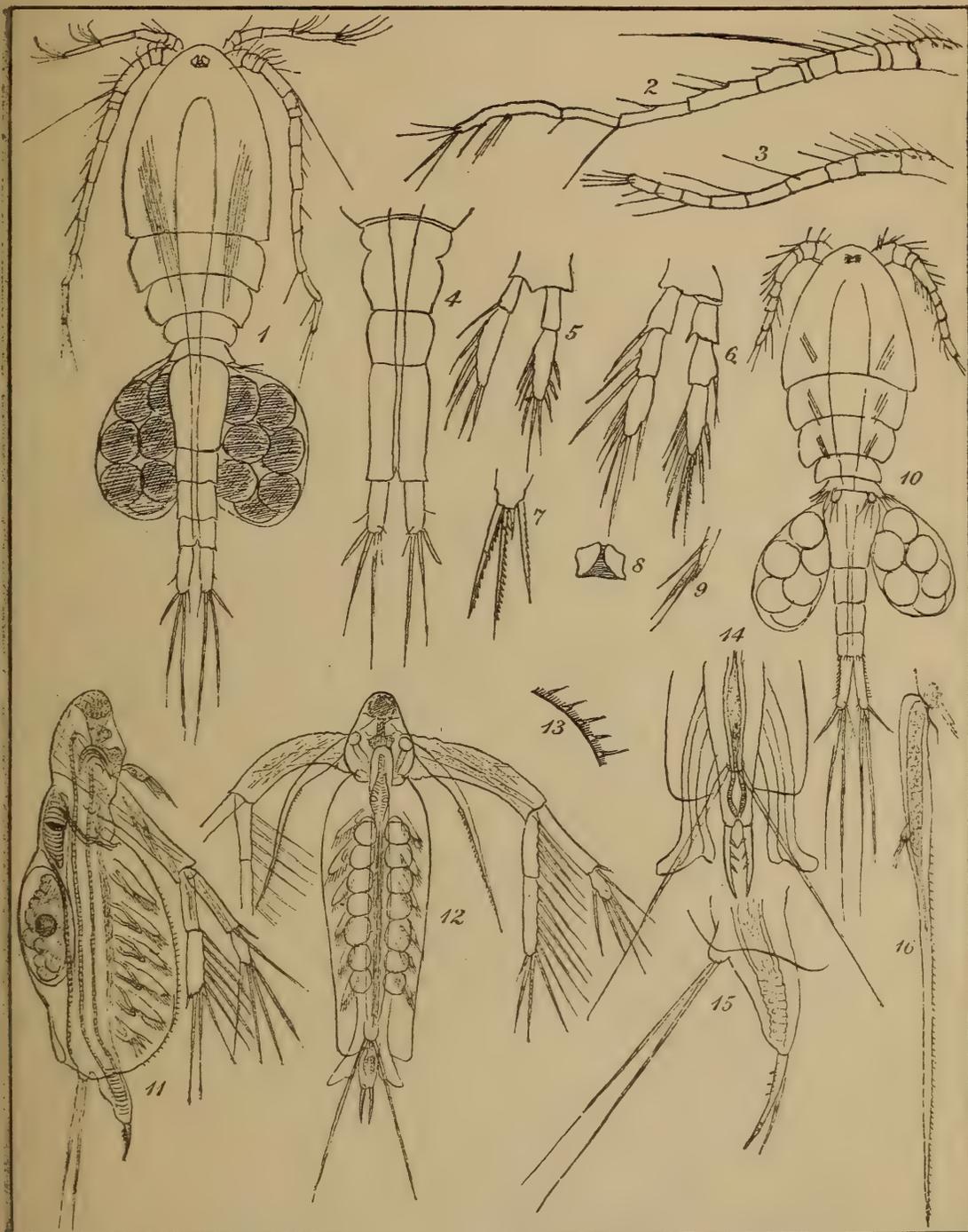
- | | | |
|--|----------------------|-------------------------------------|
| 3. Antenna of young. | 4. Abdomen of young. | 10. Young of <i>C. serrulatus</i> . |
| 11. <i>Daphnella brachyura</i> , female. | | 14. End of male abdomen. |
| 12. " " male. | | 15. End of female abdomen. |
| 13. Part of edge of valves. | | 16. Antenna of male. |

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PLATE VII.

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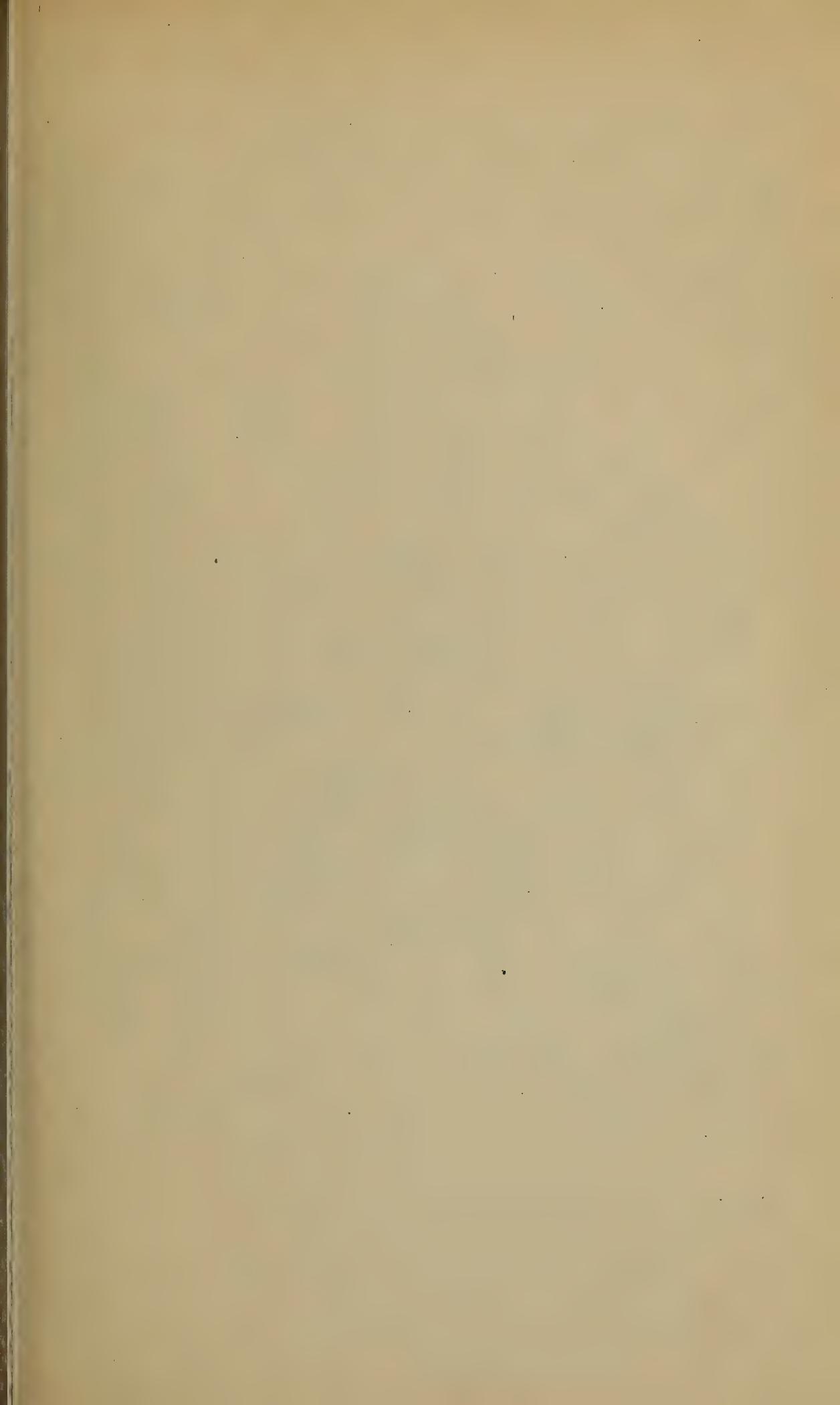


PLATE VIII.

1. *Macrothrix pauper*,
2-6. *Iliocryptus spinifer*.
7-8. *Leydigia quadrangularis*.

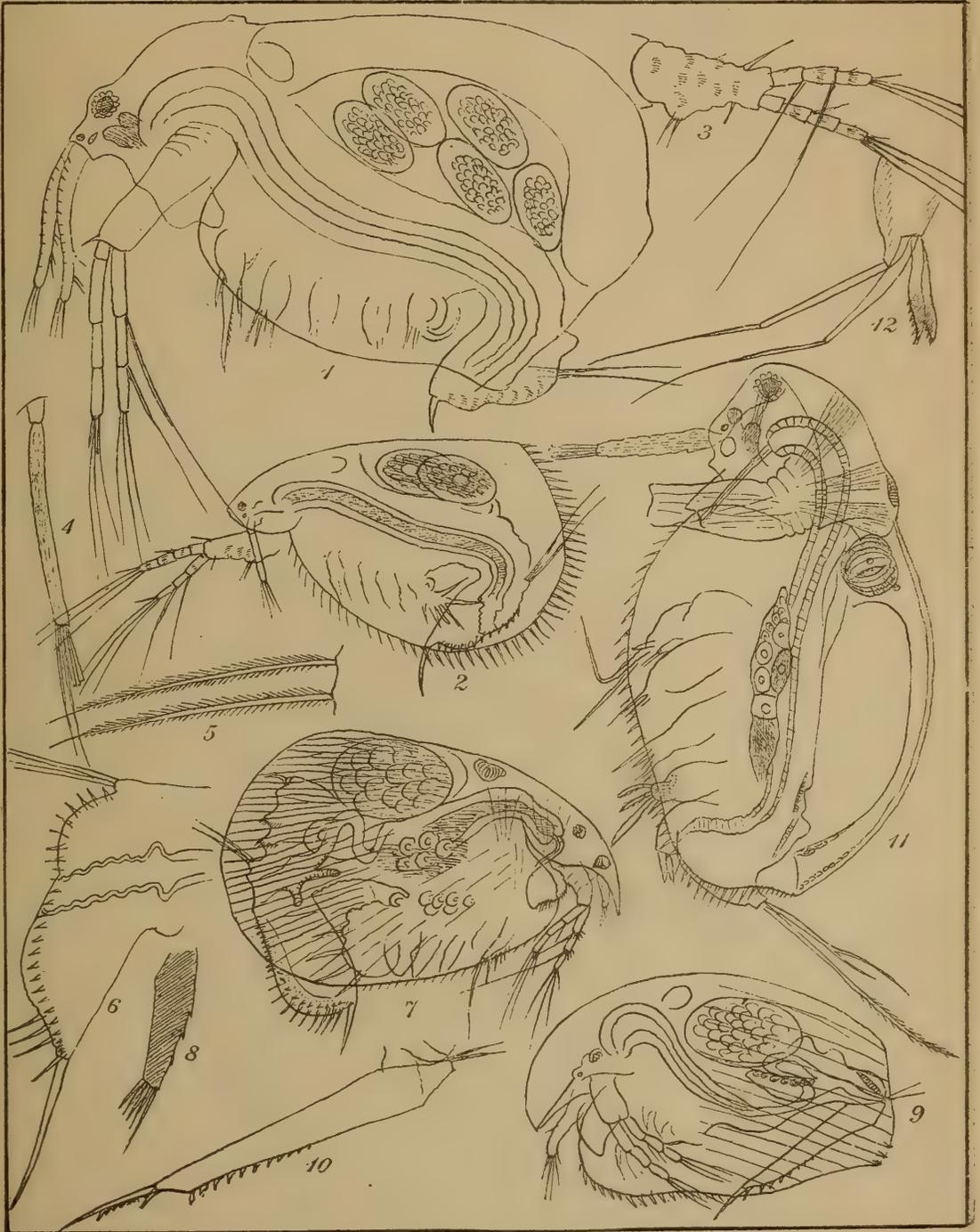
- 9-10. *Camplocercus rotundus*.
11-12. *Lathonura rectirostris*.

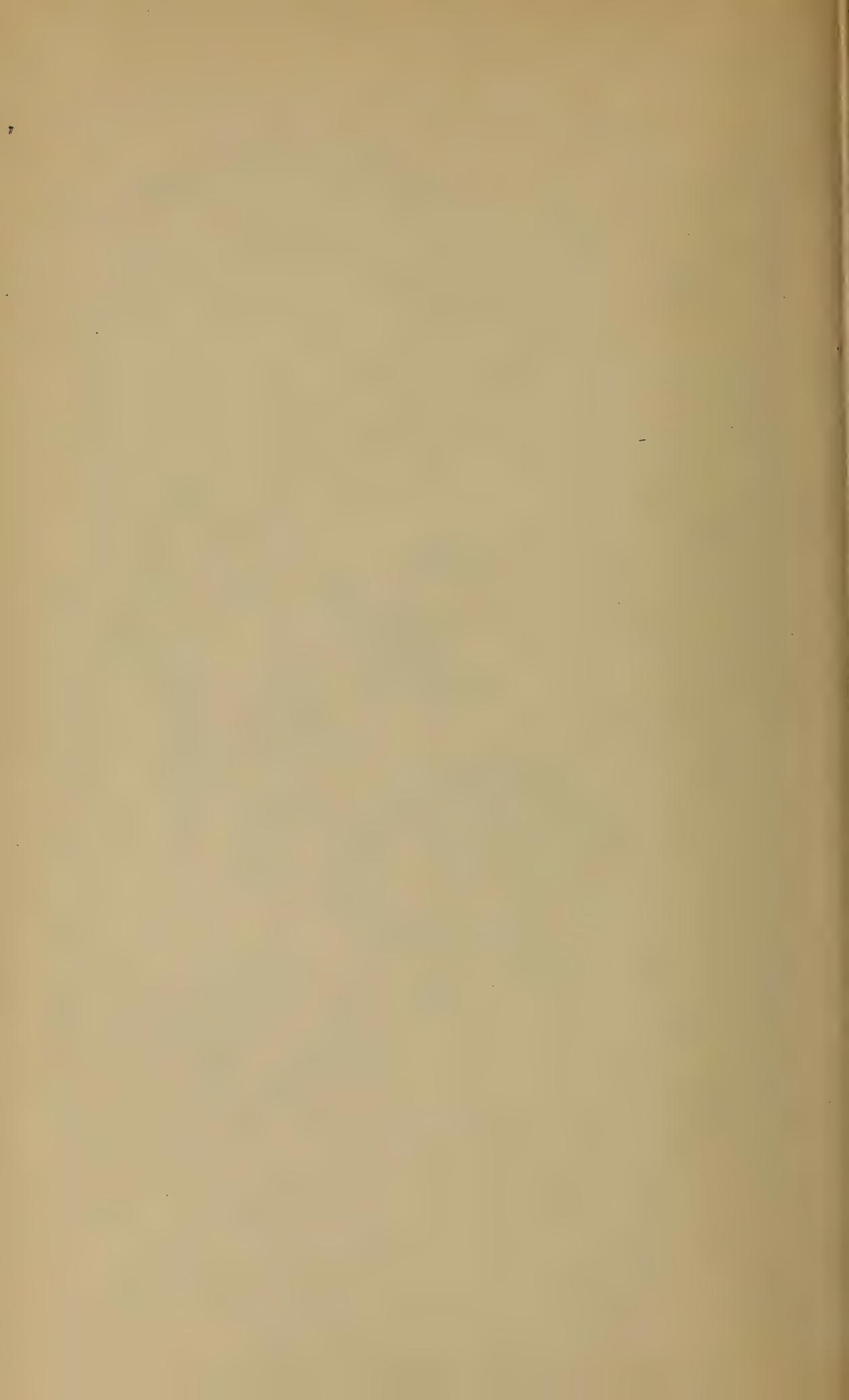
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PLATE VIII.

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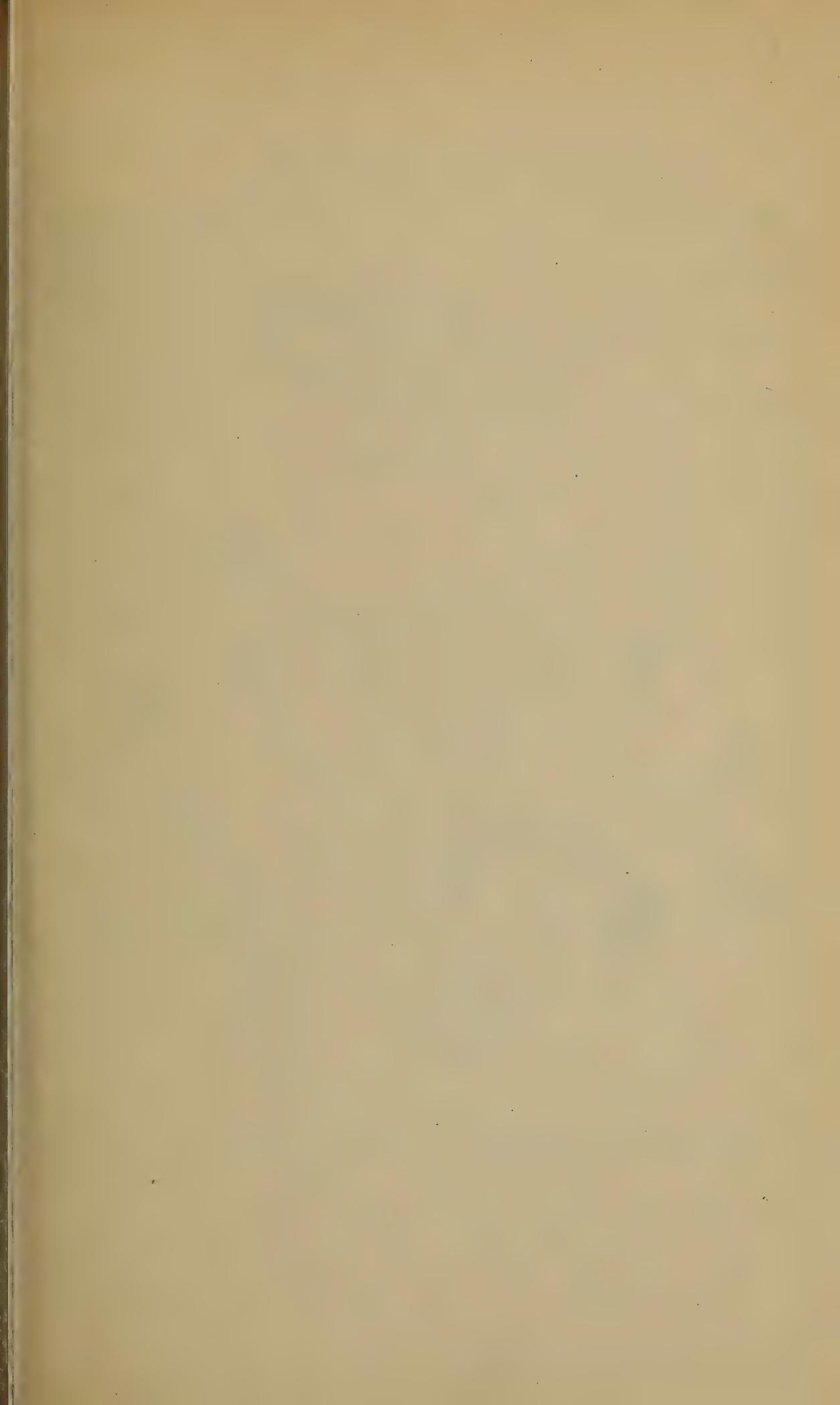


PLATE IX.

1-3. *Lyncodaphnia macrothroides*.

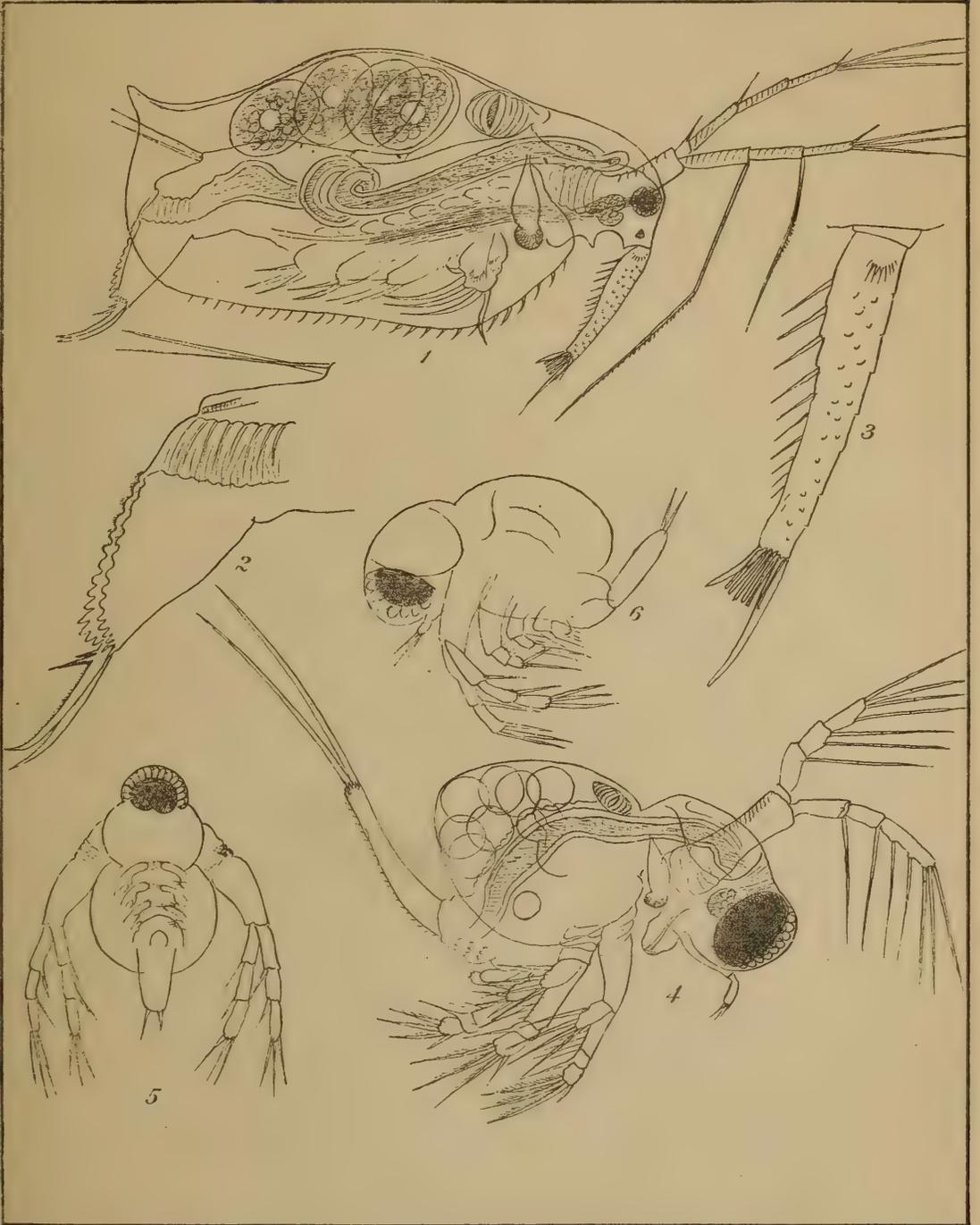
4-6. *Polyphemus pediculus*

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PLATE IX.

Geol. & Nat. Hist. Sur. Minn.



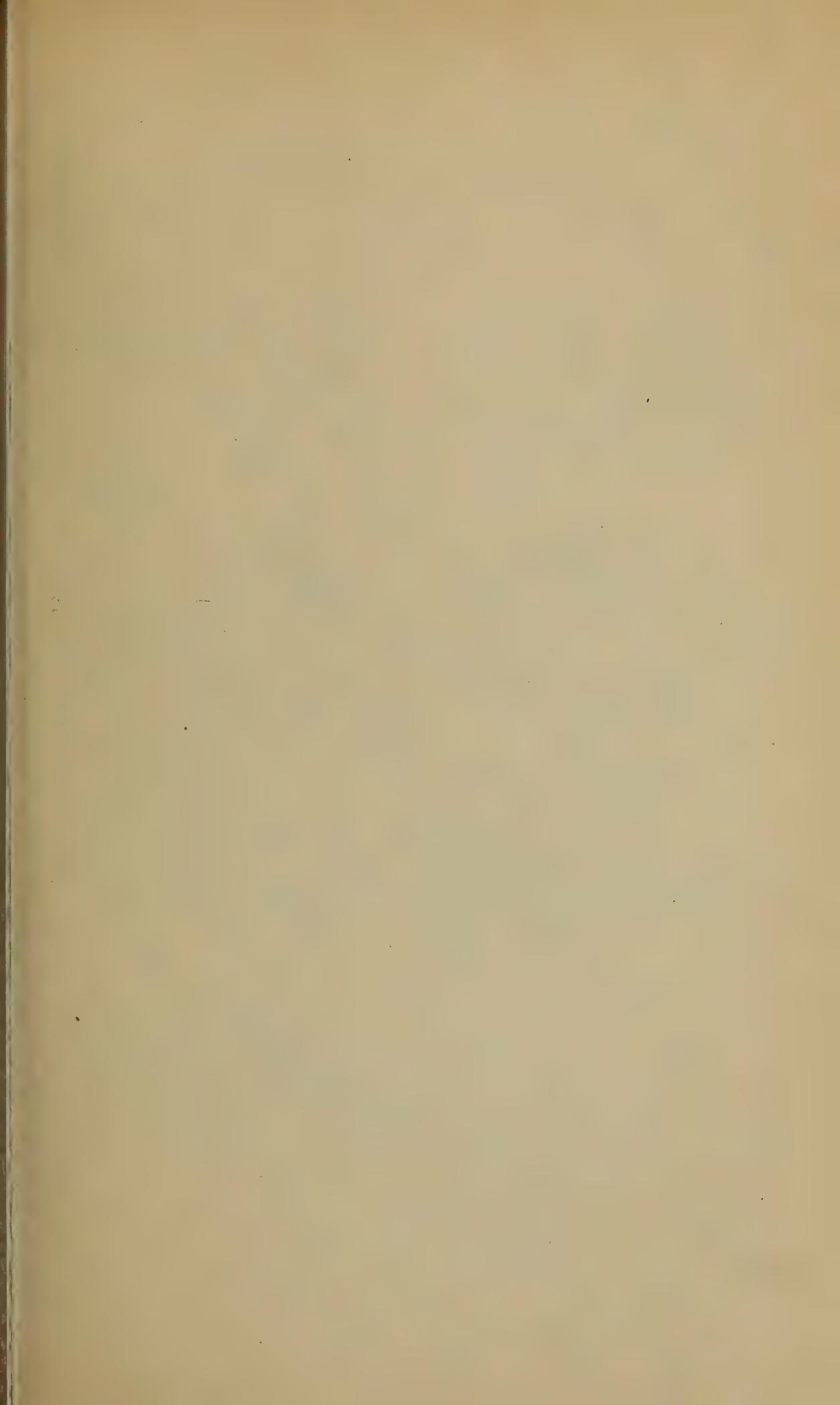


PLATE X.

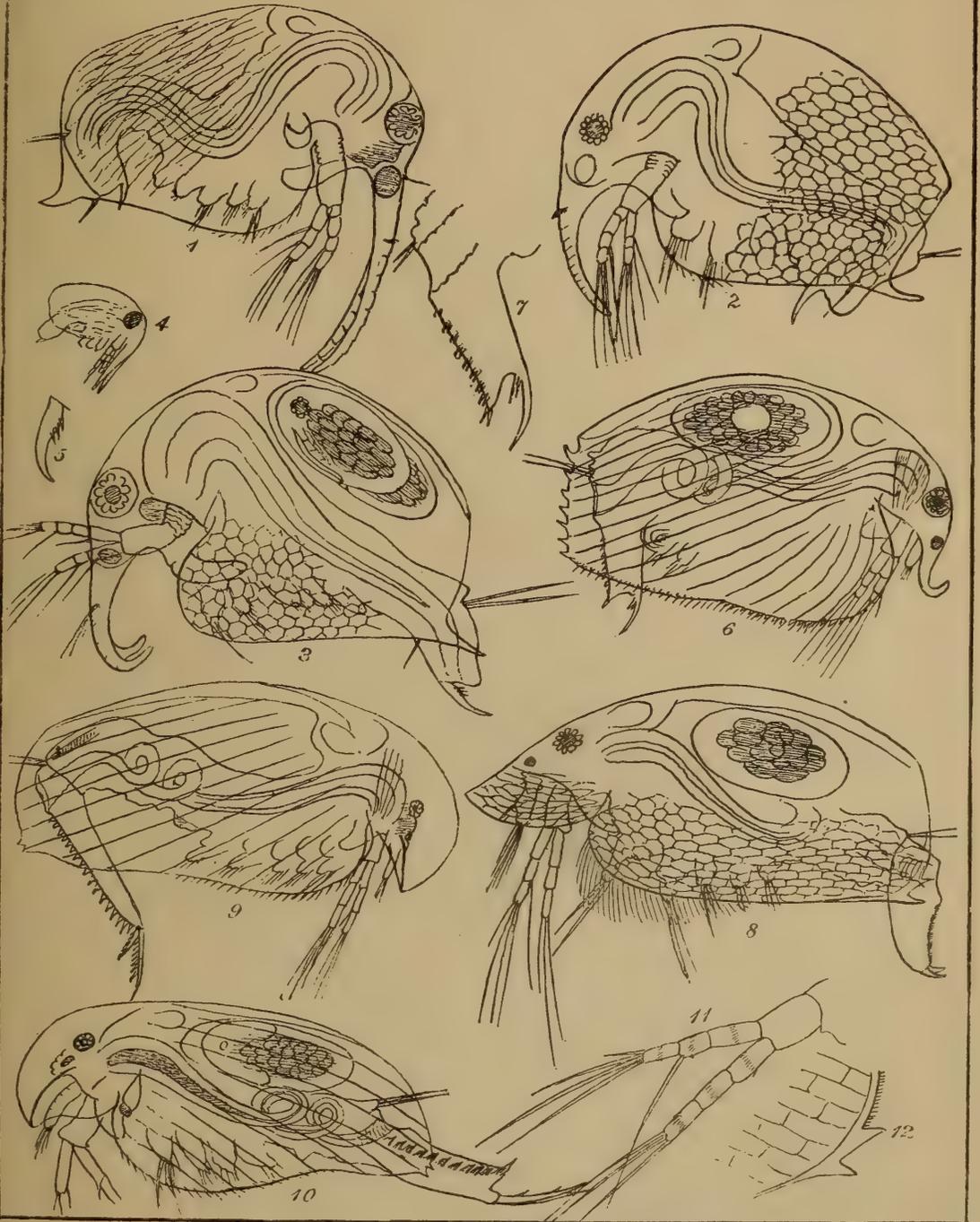
- | | | | |
|------|-------------------------------|--------|------------------------------|
| 1. | <i>Bosmina striata.</i> | 8. | <i>Graptolebris inermis.</i> |
| 2. | “ <i>longirostris.</i> | 10. | <i>Acroperus sp?</i> |
| 3-5. | “ <i>cornuta.</i> | 11-12. | <i>Graptolebris inermis.</i> |
| 6-7. | <i>Pleuroxis procurvatus.</i> | | |

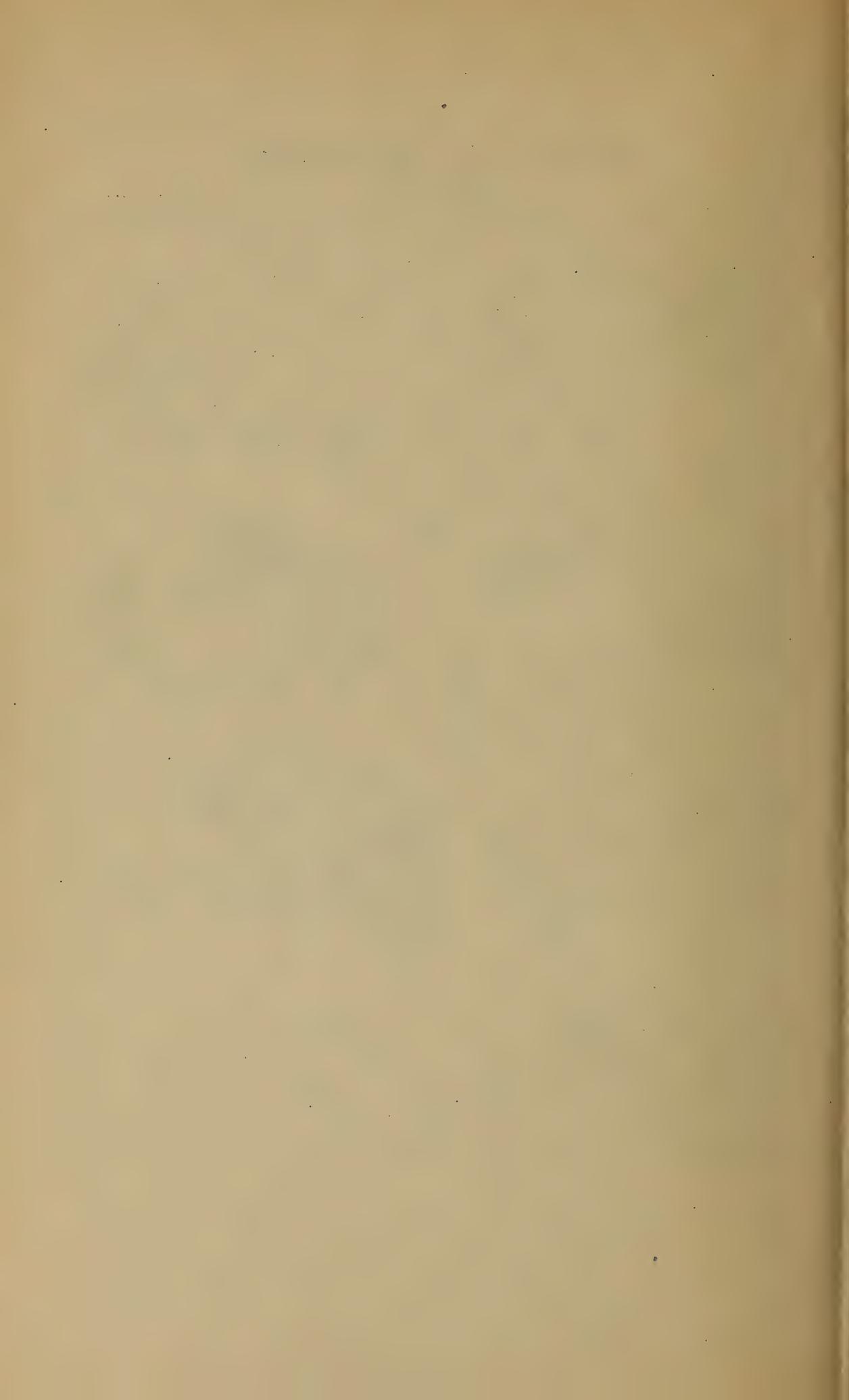
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PLATE X.

Geol. & Nat. Hist. Sur. Minn.





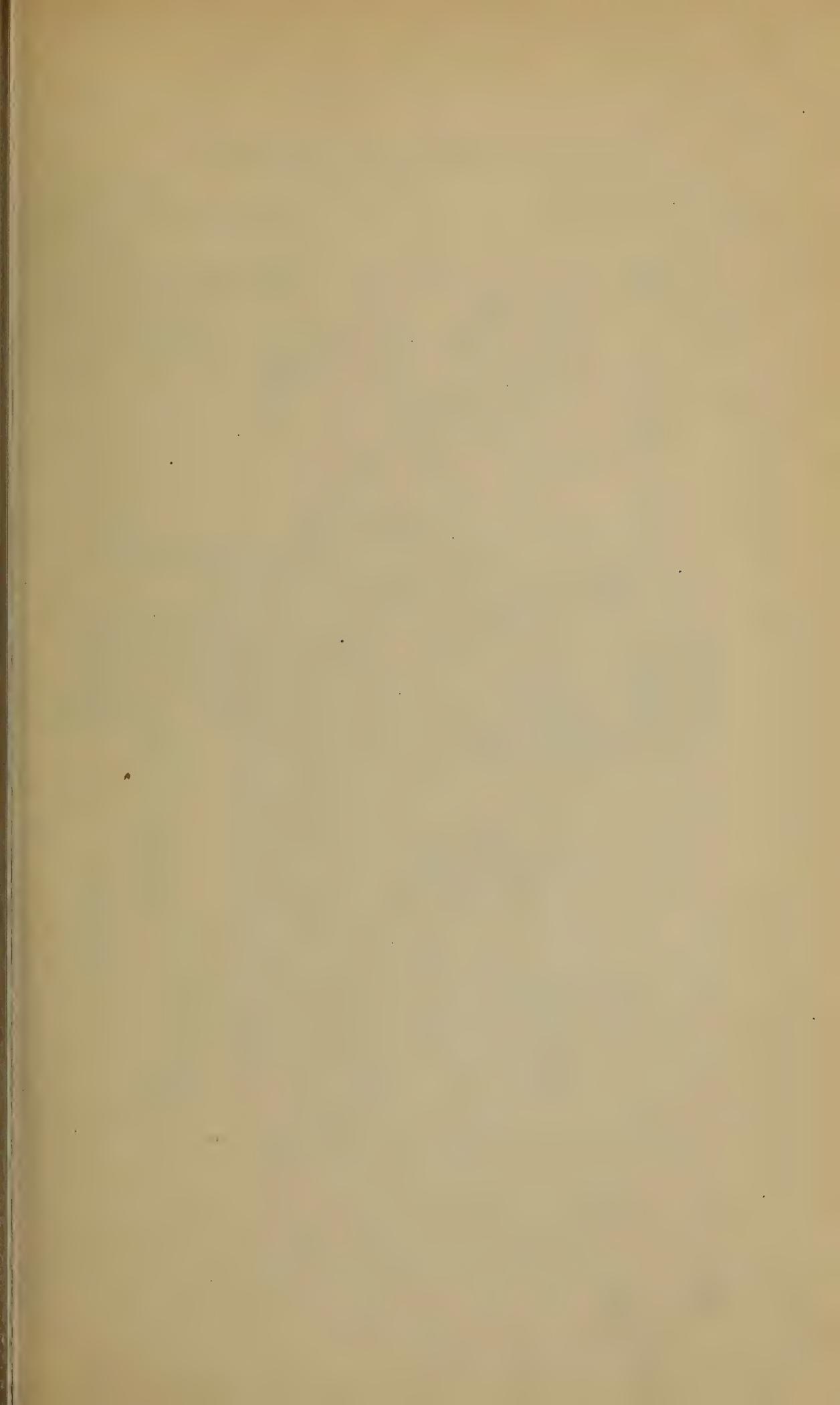


PLATE XI.

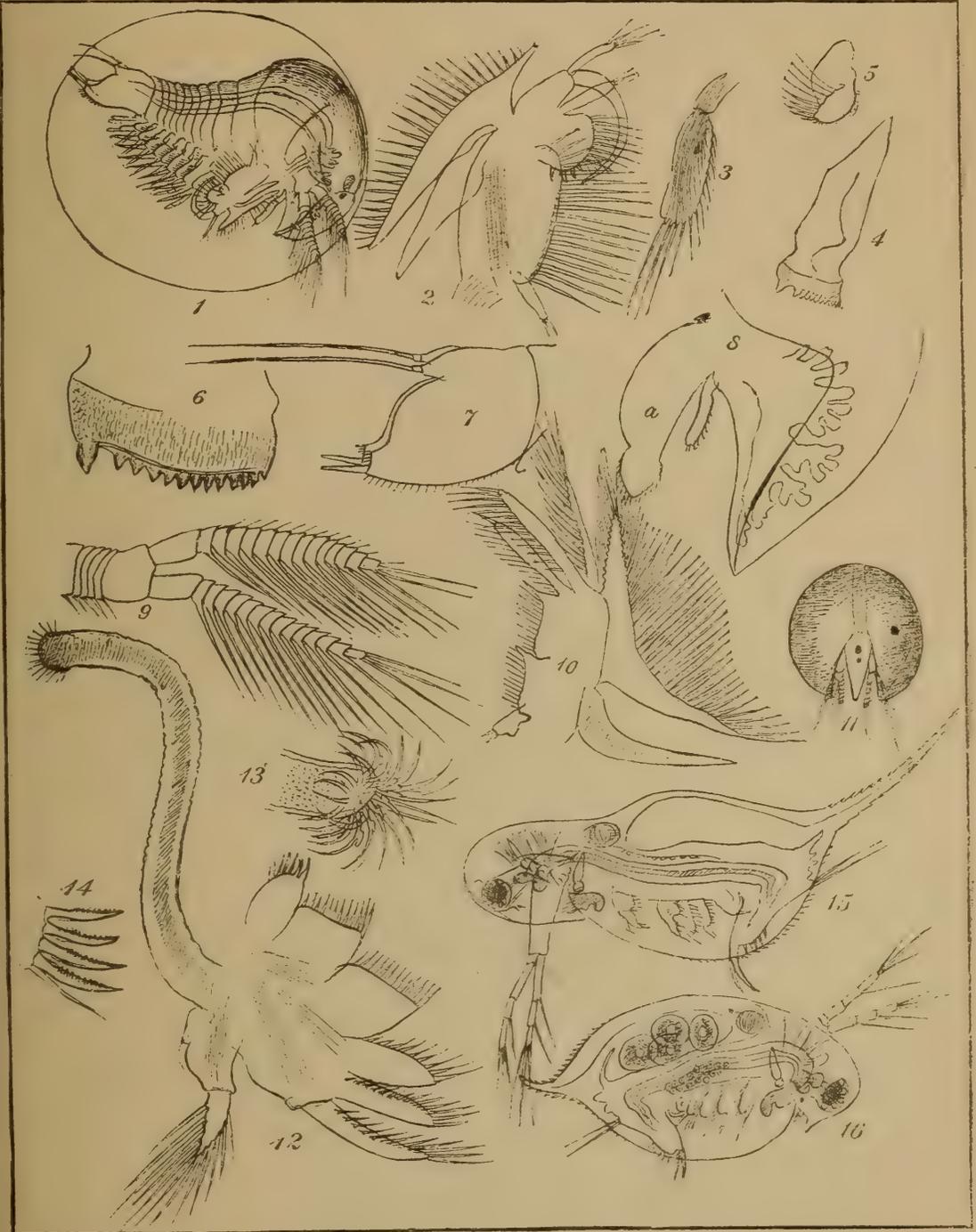
1. *Limnetes* sp? male.
2. First foot of male.
3. Antenna.
4. Mandible.
5. Maxilla.
6. Mandibler teeth.
7. Caudal appendages of female.
8. Head, labrum etc., of female.
9. Antenna (2d) of female.
10. Foot of female.
11. Exterior of whole animal from in front.
12. Modified (sexually) foot of female.
13. End of process of same.
14. Magnified spines of lateral limbs of same.
15. Daphni sp. ?
16. Daphni sp. ?

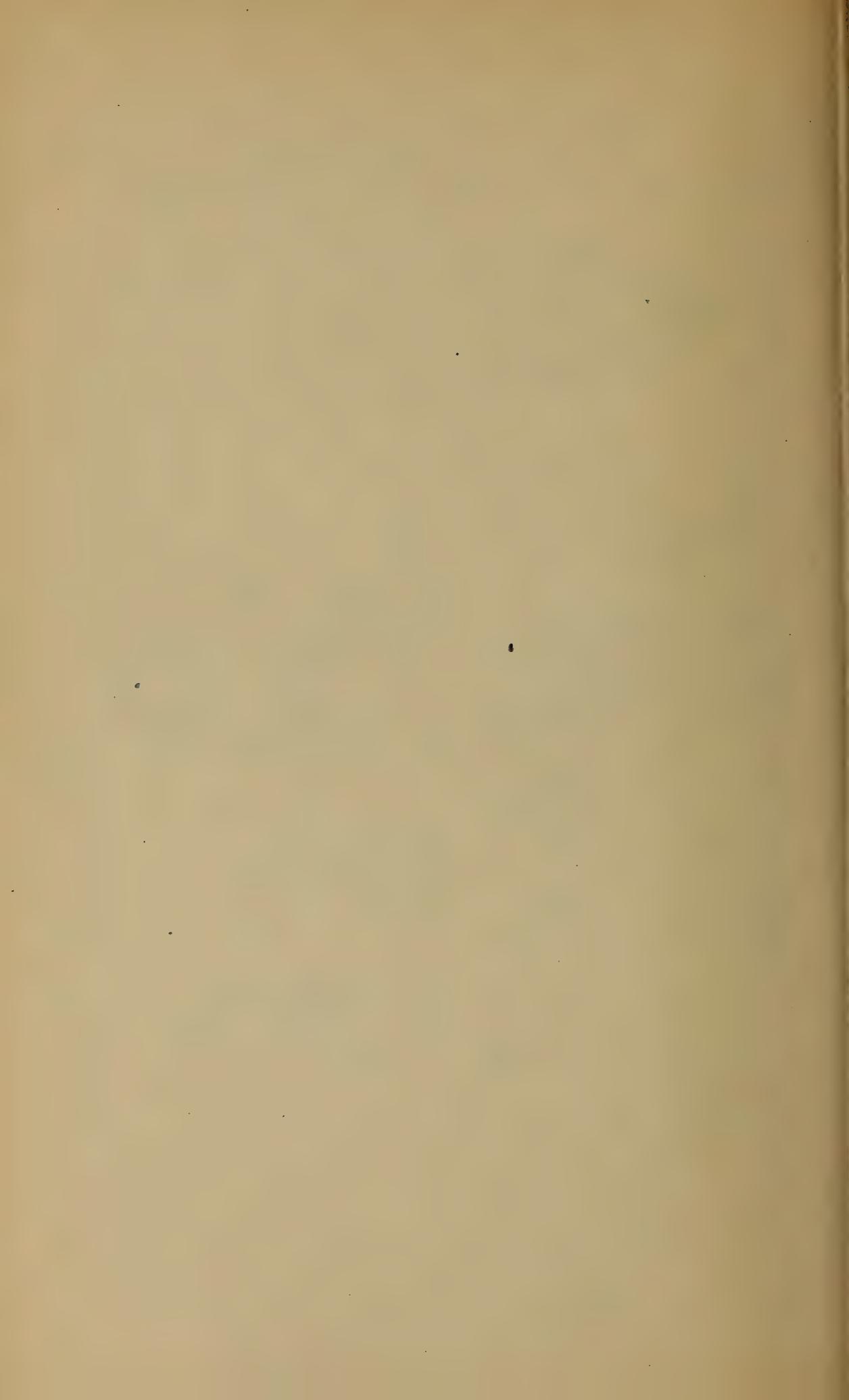
MINNESOTA CRUSTACEA.

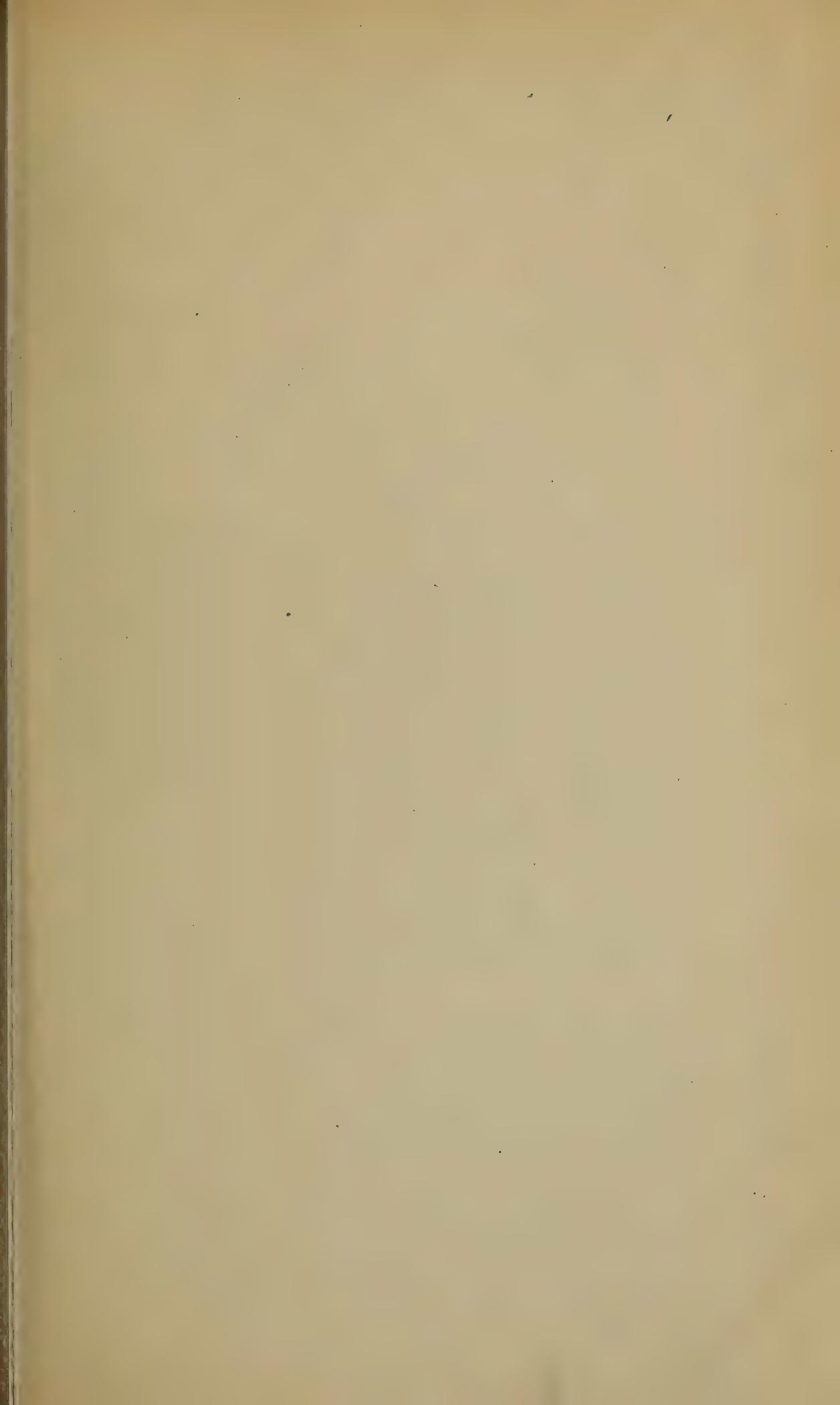
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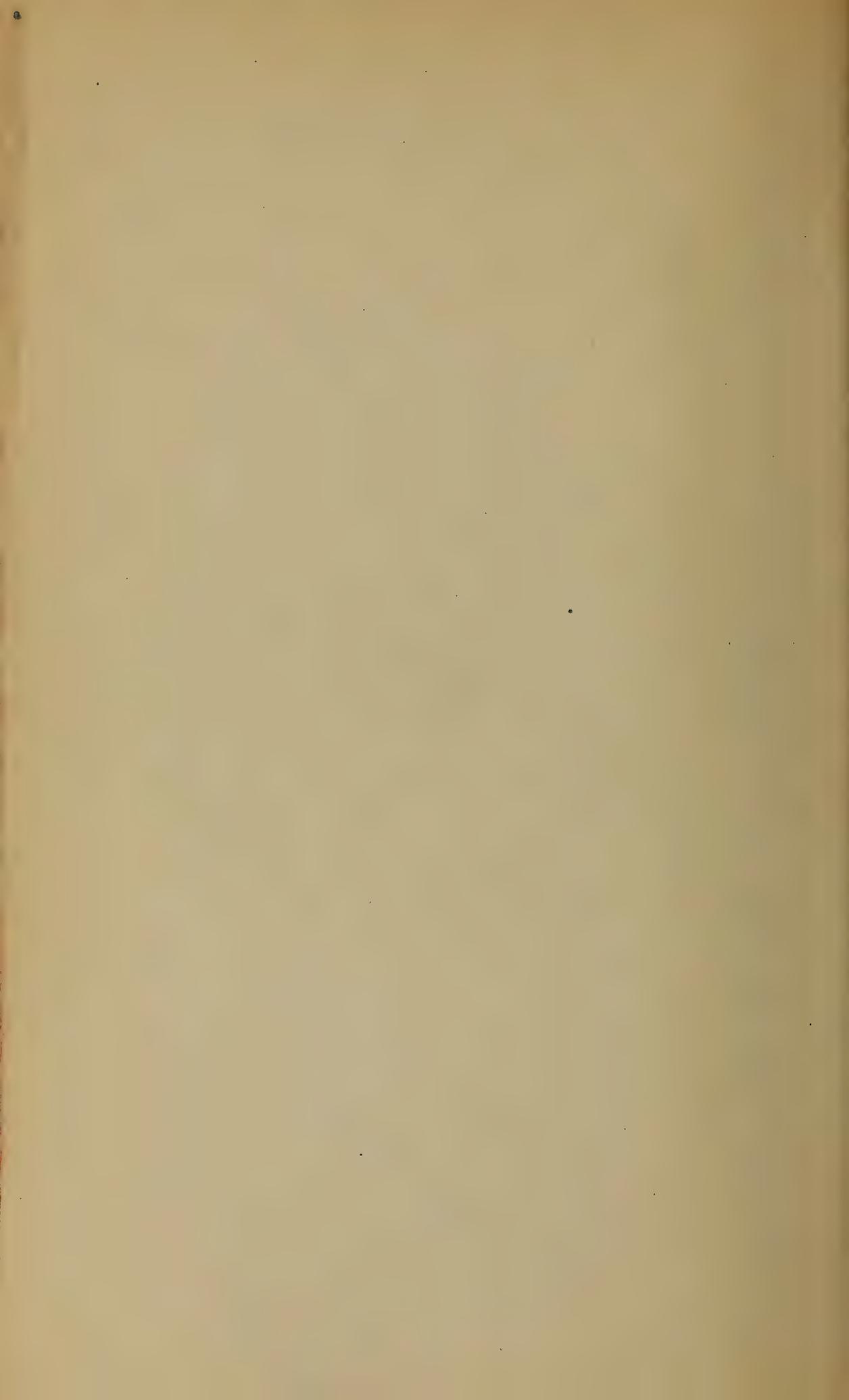
PLATE XI.

Geol. & Nat. Hist. Sur. Minn.









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

ZOÖLOGY.

HABITS OF FRESH-WATER CRUSTACEA.—No one branch of biological study is now bringing forth more interesting and every way useful results than embryology. Throwing light as it does, not only on questions of classification and theoretical biology, but also on the application of such theories to practical life, this new science may be termed at once the root and most typical fruit of a revolutionized biology. No other science furnishes a better illustration of the value of minute, accurate study of the most common and apparently insignificant facts. Sets of isolated facts evolved by conscientious study of different men spring suddenly into line when once the clue is found, and the result may be a new law which renders all these facts eloquent.

To the systematist the merely external study of life histories is of greatest value as a check against redundancy in classification, and furnishes the only reliable method, among lower forms at least, of setting the bounds of species.

Many eminent monographers have been obliged to considerably augment the nomenclature of their specialty with names which, later, have proved to apply simply to larval or immature forms, on account of the impossibility of following the whole life history of each individual.

To confine ourselves to the class Crustacea, many instances of this sort could be recounted. The best known is perhaps that of the common Cyclops which in the earlier days of carcinology enjoyed as many as three names between its exclusion from the egg and maturity. The discovery of the earlier stages in the life of Cyclops opened a new vista in the whole subject, and now we recognize a "*Nauplius stage*" in the life-history of nearly every crustacean.

It has been more recently discovered that similar opportunities for error are afforded by the difficulty of distinguishing the ultimate stage in an animal's life. It has been shown that the functions of reproduction are anomalous in the lower animals. Espe-

cially is this true in Crustacea, in so much that their condition affords no sufficient evidence that the sexually mature animal is in its historically perfect form. The enthusiasm elicited by the discovery that certain amphibians, under some circumstances, reproduce during a larval stage, was almost unparalleled, but I believe it demonstrable that, not only species, but families of lower Crustacea are normally sexually mature in a stage preceding actual maturity.

We most naturally turn to the order Branchiopoda for a test, since the most remarkable cases on record of heterogeneous reproduction have recently been read in their history. We need only mention the parthenogenetic summer brood of *Daphnia*,¹ and the case of heterogenesis discovered by G. O. Sars in *Leptodora*,² in which Sars concludes that *L. hyalina* has both "dimorphous development and alternation of generations." Nor are we disappointed in looking among the Cladocera for examples of heterogenesis. During the winter semester of 1881-82, at Leipzig University, we had the opportunity of studying the development of *Daphnia magna* (= *schäfferi*), and among other interesting facts the following were elicited:

The development proceeds in very much the way described for *Moina* by Grobben.³ The secondary or swimming antennæ have an evident palpus in the nauplius stage, however, which makes the parallel complete between Copepod and Branchipod Crustacea. The heart and circulatory system apparently is formed differently from the method given by Grobben. I may be permitted to say in this connection, that the circulatory system is much more complicated than hitherto described, and seems to originate about a mass of deutoplasm which surrounds the intestinal canal in the embryo, and which is a remainder of the food-yolk, "*Nährungsdotter*," of the egg. The embryo, in a comparatively early age, begins to differentiate the walls of the valves, which first appear as a fold over the maxillary region near the position occupied by the heart, and extends gradually backwards in a thick fold of turgid cells between which fluid flows. Quite remarkable is it that from the dorsal region a process extends, growing much more rapidly than the lateral portion till it reaches the membrane of the egg, when it curves downward and forwards till it reaches a position nearly half way from the extremity of the abdomen to the maxillæ. The method of growth of this tail-like appendage of the shell is obscure, but it seems to stand in close relation to the formation of the brood-

¹ See J. Lubbock; *Phil. Trans.*, Vol. 147, p. 98.

Cfr. R. Leuckart: *Archiv. f. Naturg.*, XXXI, and v. Siebold: *Wahre Parthenogenesis bei Schmetterlingen und Bienen*.

² G. O. Sars: *Om en dimorph Udvikling samt Generations vechsel hos Leptodora*, 1873.

³ *Die Entwicklungsgeschichte der Moina rectirostris*, von Dr. Carl Grobben. Vienna, 1879.

cavity, and is the result of a secondary folding of the common shell envelop. At the close of the development in the egg, this "tail" lies between the valves of the shell, curved beneath like the tail of a frightened dog, although the frequent motions of the post-abdomen are not a little hindered thereby.

On its escape from the egg, the animal swims freely, and soon kicks this pliant appendage backward and upward till it assumes a direction parallel to the long axis of the body, and then very soon its unequal growth causes this tail to be somewhat elevated. The appendage probably serves as a support for the cast off skin in the molt, so that it cannot fall down upon the post-abdomen and then be broken off before that portion of the shell forming the inner covering of the brood cavity can be successfully molted—a danger especially incident to long forms with narrow brood cavities, and to young animals in which the shell is tender. (It may be for this reason that males, in which the part corresponding to the brood cavity is very narrow, and young females, have this spine, while adult females do not, for, as is well known, the males of all this section of the genus are spined through life.) Successive moltings increase the size of the animal, but the spine remains and increases correspondingly, giving the animal a very different appearance from the parent, which was not only of an entirely different form but totally without the spine.

Finally the young female produces eggs parthenogenetically, and is, therefore, according to our customary notions, an adult. We have here, therefore, a case of heterogenesis. Under circumstances where food is not sufficiently abundant, it seems certain that the above-mentioned state is the final one, and that the animal does not reach that condition which we name *Daphnia magna*, but remains in a stage which has received a different specific name.

The same process has since been observed in the case of *Daphnia pulex*, in Minnesota. Some of the so-called varieties are but age-forms. There is in each species what may be called a *post-imago* form, which is only assumed under favoring conditions. Without going into the synonymy of this genus, which will bear a revision in view of this and similar facts, we may safely say that in the Daphnidæ we find heterogenesis almost a rule, at least in the genus *Daphnia*.¹ We may add that every possible provision for the reproduction of these animals seems to be provided. (1) They are very prolific; (2) reproduce both sexually and parthenogenetically; (3) resist great extremes of temperature; (4) accommodate themselves to great alterations in the purity of the water; (5) the winter eggs are provided with a horny covering or *ephippium*, which permits them to be dried in a mass of mud or frozen in a cake of ice without destroying their vitality; (6)

¹ See Birge, Notes on Cladocera, Madison, Plate 11, Fig. 6.

during mild winters both summer and winter eggs are produced, and the successive broods of young after producing agamic young, throw off an ephippium so that the pool is filled with eggs which are calculated to stand any vicissitude. Thus it happens that after a pond has been dried for a long time the first warm shower quickens in it swarming life. The above facts are more significant when we remember that the Cladocera are above all others among Crustacea, the most useful as purifying agencies. The greater number subsist entirely upon vegetable matter, and the only means they have of collecting it is by causing a current of water containing such minute particles as may exist in it to pass between the rotating jaws, though, perhaps, in some cases the labrum is sufficiently prehensile to grasp somewhat larger food. Certain it is, however, that these same minute animals form an indispensable agent in the economy of nature, purifying all our stagnant pools of the decaying vegetation floating therein. One who had given no attention to the number of these creatures would undoubtedly be surprised on carefully examining a given quantity of water from the nearest lake. Here are some figures.

In a quart of water taken by dipping from a lake near Minneapolis, the following were counted:

Ceriodaphnia	1400
Daphnia	9
Simocephalus	56
Cypris	50
Cyclops	28
Amphipods (chiefly young).....	120
Infusoria	35
Mollusks	22
Diptera (larvæ).....	100
Hemiptera.....	9

etc., all visible to the unassisted eye.—*C. L. Herrick.*

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

ZOÖLOGY.

A NEW GENUS AND SPECIES OF THE CRUSTACEAN FAMILY LYNCO-DAPHNINÆ.¹—*Lyncodaphnia*, gen. n. (Plate XVI, Fig. 1-4). Form much as in species of *Alonella*, etc., truncate behind; superior antennæ like *Macrothrix*, attached movably to the end of a blunt prominence beneath the head; second or swimming antennæ slender, four-jointed ramus with three long setæ and a stout thorn at the end of distal segment, the joint following the short basal one with a thorn above, the following joint unarmed (!); three-jointed ramus as in *Macrothrix*, the basal segment armed with a much elongated seta; eye relatively small, pigment fleck (*macula nigra*) present; *intestine twice convoluted*, expanded in front of the rectum, opening in the "heel" of the post-abdomen; post-abdomen slender, sub-triangular, margined behind with a double series of spines; terminal claws large, and furnished with a long and short spine near the base; shell margined below by stout movable spines.

Few more interesting forms than the one forming the type of this very peculiar genus have been found, since it combines in a curious manner those characteristics hitherto regarded as distinctive of the families Daphnidæ and Lynceidæ. Kurz says:² "Keine cladocerenfamilie bildet eine so streng in sich abgegrenztes natürliches Ganze, wie eben die Lynceiden," and this after recognizing the relationship of *Macrothrix* and *Lathonura* to the Lynceids, by placing them in the sub-family *Lyncodaphninæ*. The form above referred to, however, has quite as close affinity to the Lynceidæ as to *Macrothrix*, though it resembles the latter rather more on a superficial examination, indeed if one were to divide the animal back of the heart and examine the two portions independently, it would be impossible to avoid referring the head to *Macrothrix* and the body to some Lynceid genus. Thus is furnished another of those curious intermediate forms which remind us that the possibility of distinguishing families and genera, lies alone in the meagerness of our knowledge.

There can be no doubt that this genus should stand next to *Macrothrix*, but it will be necessary to modify a little the diagnosis of the *Lyncodaphnidæ* to receive it, and it then appears that it cannot longer remain a sub-family of the *Daphnidæ*, hence I have proposed to give it equal rank with that body and the Lynceids as an independent family, *Lyncodaphninæ*, including the genera *Macrothrix*, *Lyncodaphnia*, *Drepanothrix*, *Lathonura* (= *Pasithea*), *Ilyocryptus*. As thus limited a very natural group is formed, in size and isolation corresponding well with the other related families.

¹*Series secunda generum* (Daphnidæ), P. E. Müller, Danmark's Cladocera, p. 134; sub-family *Lyncodaphninæ*, Kurz. Dodekas neuer Cladoceren, p. 24.

²Kurz. Dodekas neuer Cladoceren nebst einem kurzen Übersicht der Cladoceren fauna Böhmens, p. 30.

Lyncodaphnia macrothroides, sp. n. — Form sub-rectangular, greatly elongated; length $\frac{12}{100}$ cm; height $\frac{5}{100}$ cm or less; first antennæ long and slightly curved, bordered behind by about ten spines, and terminating in two or three sword-shaped unequal spines and several sense-hairs, about $\frac{17}{1000}$ cm long; swimming antennæ very slender, as in *Macrothrix*, $\frac{6}{100}$ cm long; head not marked off by a depression from the body, small and extending below into a blunt elevation for attachment of antennæ; labrum rather large; eye small; macula nigra conspicuous but not large; anterior feet strongly armed with curved spines; intestine anteriorly is furnished with cœca, is twice convoluted, broadened before entering the rectum, and opens some distance beyond the anal setæ in the heel of the post-abdomen; post-abdomen rather slender, toothed behind with a double series of about twelve prominences, ciliated near the anus but distally becoming strong, sharp teeth; terminal claws large, curved only at the end, pectinate and bearing near the base a small and large tooth; eggs much like those of *Macrothrix*. Male not seen.

Occurs in Lake Minnetonka, Hennepin county, Minnesota; rare.—*C. L. Herrick*.

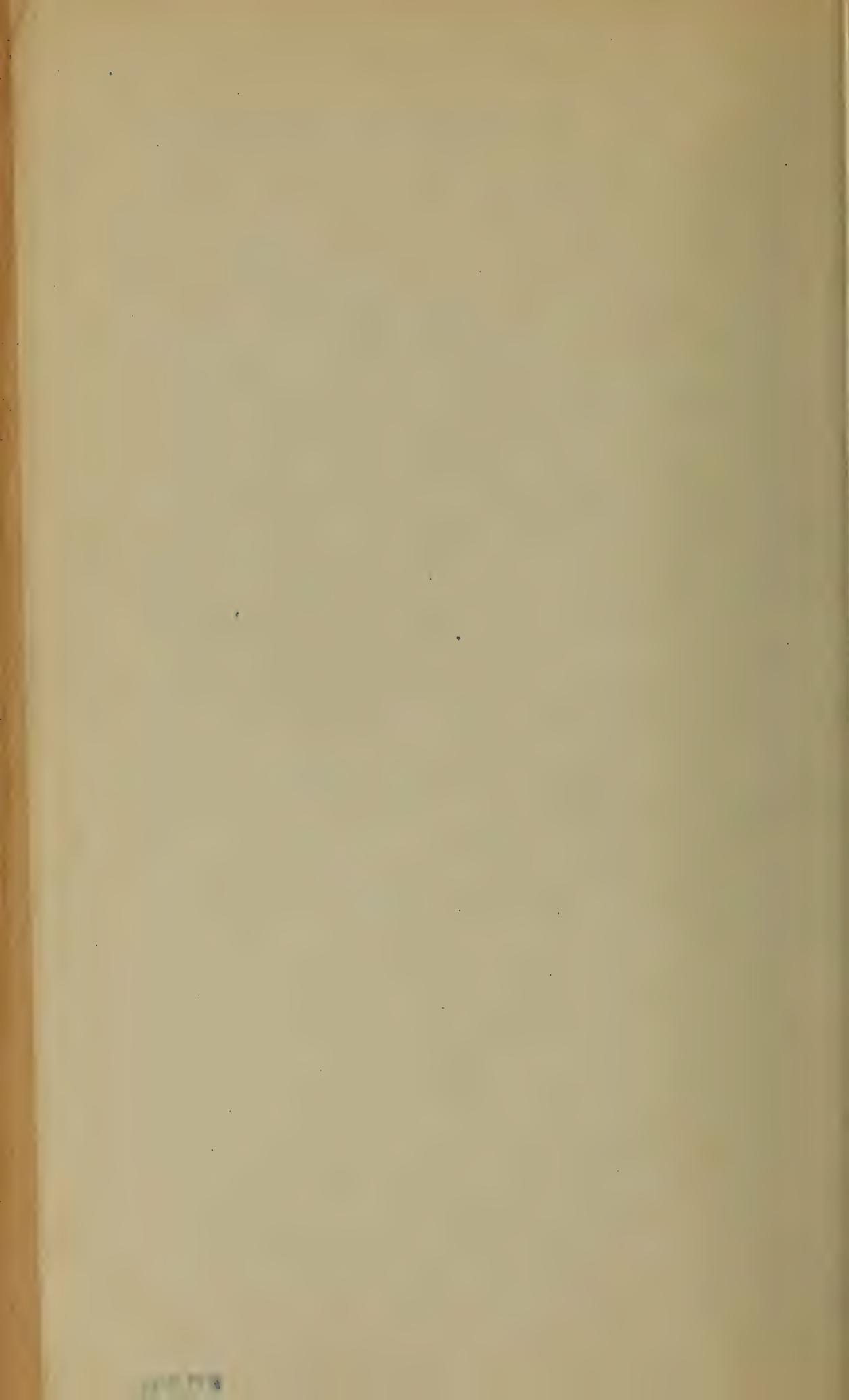
PUBLISHED December 12, 1882.

(From the American Naturalist, February, 1883.)

A BLIND COPEPOD OF THE FAMILY HARPACTICIDÆ.—The interest now centering upon these animals, which through peculiarities in their habitat have dispensed with important organs, may warrant the mention of a case of the disappearance of the eyes in an order of Crustacea in which it has not been hitherto noticed so far as I know.

While collecting marine Copepoda in the Gulf of Mexico a gathering was taken from a very slightly saline marsh, a ditch passing through the marsh affording the only water of sufficient depth in which to use the net. This ditch is about eighteen inches in breadth, but of moderate depth, and extends continuously for some distance; it is so shaded by high salt sedge grass as not to be found save by accident. The gathering here secured proved to contain a new species of the sub-family Longipediinæ and closely allied to the genus *Bradya* established by Boeck in 1872 for a marine Copepod dredged in rather deep waters about North Europe.

The American species, which has been named *Bradya limicola* in allusion to its muddy habitat, was found to lack in both sexes the pigmented eyes which in other Harpacticidæ are so conspicuous in the center of the forehead or on either side. It is to be regretted that lack of opportunity to repeatedly collect this interesting species, and to endeavor to ascertain if truly pelagic species also inhabit our waters, robs this discovery of much of its interest.—*C. L. Herrick.*



(From the *American Naturalist*, February, 1883.)

HETEROGENESIS IN THE COPEPOD CRUSTACEA.—In a former paper we have considered examples of heterogenesis furnished by the Cladocera. Let us now turn our attention to the copepods, the *Cyclopoidea*, with the view to discover if similar conditions exist here also.

The standard books upon the non-parasitic forms of the Copepoda by Claus¹ and Brady² enumerate many species, but do not agree entirely in synonymy, nor does it seem probable that, Claus, who alone has done most of the anatomical and embryological work in this section, has followed the life-history of anything like a large proportion of the species named.

It has been long known that the marine forms of Copepoda have a very extended geographical range, many of them seeming to complete the circuit of the earth's longitude and to extend over several zones of its latitude³. Similar and often identical forms occur in the Mediterranean and North seas, over all Europe and the British Isles. Certain genera, as *Calanus* and *Chetochilus*, seem to extend through all degrees of latitude from the equator to the most northern seas.

A confirmation of these facts may be sought in the works of

¹ C. Claus : Die Frei Lebenden Copepoden. Leipzig, 1863.

² G. S. Brady : Copepoda of British islands, Roy. Soc. 1878-9.

³ Claus ; Op. cit., pp. 83-86.

Claus, Dana, Leydig, Jurine, Baird, Fischer, Müller, Lubbock, Boeck, Brady, Heller, Lilljeborg, Sars, Uljanin, etc. As yet, however, it is too soon to say how far this similarity may extend.

Confining ourselves, for the present, to fresh-water forms, a recent opportunity for comparison of American with European Copepoda has confirmed our impression that a large number of species will be found identical¹. It seems, indeed, somewhat astonishing at first to discover that the isolated pools of the Central United States contain species identical in every particular with those of England, Scandinavia or Germany, but such is certainly the case. In fact the populous genus *Cyclops* has few new species in America relative to the number identical with transatlantic forms.

A *Diaptomus*, believed to be identical with *D. castor* in typical as well as several varietal forms, occurs throughout Minnesota from the shores of Lake Superior to near its southern boundary and in Illinois. Another species believed to be nearly allied to a Scandinavian species is known from Minnesota, Wisconsin and the neighborhood of East St. Louis, Illinois. *Cylops serrulatus* Cls., with similar variations to those noticed by Claus (Op. cit., p. 85) and Brady (Op. cit., vol. 1, plate 22) occurs as our most abundant species.

It may be observed that Brady's work is so strictly systematic that his figures are frequently little more than schematic, and lack the life-like character of those in the earlier work of Claus. It would seem that some of the species of *Cyclops* described by Dana² are identical with the above, although details are wanting to identify positively. Without delaying to discuss the question opened as to whether these widely separated forms have all diverged from a primitive geographical center or have arisen independently from original marine prototypes, as suggested to the writer by Professor Leuckart, we may remark that the former theory is rendered possible by the fact that the feathers of water-fowl often form a vehicle for the transportation of even larger crustacea.

Amphipods, for example, are transported hundreds of miles under the feathers of geese. While it is unlikely that these larger crustaceans or their eggs would survive a long aerial journey, it is quite certain that the eggs of *Cyclops* would pass many hours or even days without being destroyed. On the other hand, it seems that some entomostraca are in a nascent condition which permits a slight change in the environment to induce remarkable alterations in structure which are uniform wherever this change is effected³ and if this be not now the case with all, it may have been so at one time with the prototypes of our fresh-water copepods.

To return to the question of heterogenesis. Selecting the larger

¹ Herrick: Copepoda of Minnesota. Rep. Geol. Surv. Minn. 1881.

² J. D. Dana; Wilke's Exploring Exp. Crustacea.

³ Siebold and Kölliker, Zeitschrift. 1872, p. 293. Packard; synopsis of Phyllopod crust. N. A. U. S. Geol. and Geog. Surv. of Col. 1873. p. 614, etc.

species of Cyclops, say *C. signatus* (= *C. coronatus* Cls.), we find a form not at all rare but less abundant than *C. tenuicornis* with which it seems to be constantly associated. In our investigations we found *Signatus* almost constantly larger, *in the same gathering*, than *Tenuicornis*. The only distinction, among those given by either Claus or Brady, which is constant is the following: in *Signatus* the last joint of the antennæ has a longitudinal ridge shaped like a pruning knife-blade extending beyond the end in a hook with the proximal two-thirds of its length strongly toothed. (The only other species which has teeth on the first joint is a species allied to *C. parvus* Her. found in Alabama, but this has no knife-like ridge.) The two species agree in having the ridge which extends nearly to the base of the antenna; they both have certain series of spines arranged upon definite parts of the antennæ; both have the circular series of spines on the basal joint of the fifth foot; in short there is a complete agreement even to the microscopic details—aside from the teeth above mentioned.

Nevertheless it is possible to pick out *Signatus* from a glass of the other form by its larger size and different color as well as to detect a different relation in proportional length of the caudal setæ, etc. Close examination fails to discover an earlier stage of *Signatus* while *Tenuicornis* is constantly accompanied by males and smaller forms as well as the larval stages. The curious fact is demonstrable that these species of the section of Cyclops with 17-jointed antennæ become sexually mature long before they are perfect in form. In this species it is no uncommon thing to see females of less than half the size of the adult with ova sacs. Indeed it is common to meet larvæ in which the antennæ are as yet composed of but few joints in a similar condition. This fact alters our conception of a species considerably, inasmuch as it has been thought sufficient to prove the maturity of a specimen to find the egg sacs developed. A glance at the literature of this family will suggest that in more than one case a species has been founded upon a larva which was simply prematurely gravid.

In *Cyclops serullatus* the same fact is more easily observed, as the species is so easily recognized as to be unmistakably at an early stage. The var. *Montanus* Brady, is not at all a variety due to station as suggested by him but, if our observations are correct, is the last form, in exceptional cases of the common species. It is but a step further to show that as *C. tenuicornis* is a more advanced stage of the small Cyclops forms with larval characters, so *C. signatus* is but a post-imago of the former. In truth not only in this species but in all others which we have had opportunity to examine, there appear at favorable opportunities unusually large and somewhat altered forms. These large, or post-imago stages appear to be dependent upon abundance of food and a shallow, warm habitat.

The species considered identical with *Diaptomus castor* is abun-

dant and varies in size and particularly in color. So marked are these differences that it would be difficult to believe at first sight that they are not indications of specific distinction but these changes are dependent upon food, light and other similar circumstances. The typical form is found oftenest in rather large pools with no outlet, but which do not actually dry up in summer. In length the female is often $\frac{15}{100}$ cm. sometimes less and not seldom more. In the smaller females the eggs are observed to be usually fewer, but of the same size $\frac{11}{1000}$ cm. to $\frac{1}{100}$ cm. Recently, however in a small and very shallow marsh which is frequently entirely dry, but which lies near a less shallow pool swarming with the common *Diaptomus* (both being half a mile distant from any other water) we found a new species of dimensions considerably exceeding those given by Brady for var. *Westwoodii*¹. Closer examination showed that the size and color were the only marked differences, antennæ and first pair of feet being identical, while the fifth pair of feet were but little different and these differences were seemingly but the intensifying of the characters of the smaller species to form the larger. Here there were two pools, which within our personal recollection formed but a single body of water and were now separated but by a dozen steps, only differing as to depth and muddiness, in the one of which flourished *all stages* of the ordinary form, while in the latter the *one* enlarged form alone existed. The conclusion is almost forced upon us that the second pool needed only similar conditions to bring forth this final stage of twice the usual size (but with eggs but little larger— $\frac{11}{1000}$ cm.). Shortly afterward the more shallow pond dried up entirely so that no more of the larger form could be obtained.

It is not necessary to emphasize the fact that just such insignificant variations furnish the data upon which the generalizations of modern science must stand or fall. A most interesting field is open to any one with the opportunity to rear such forms as these under conditions which can be altered at will in order to discover what farther structural changes can be artificially induced.

The practical value of the fresh-water copepods can hardly be overstated since they are scavengers and almost entirely feeders upon animal matter. The aggregate amount of putrid flesh which the Cyclops fauna of a quart of water will consume is quite remarkable, as any one may satisfy himself by watching the decay of such a creature as a polliwog in a jar of stagnant water.—*C. L. Herrick.*

¹ Op. cit. p. 60.

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almost all their special characters at once, in the White river. The Hystricomorpha, whose home is in South America, are unknown in North America below the Loup Fork or highest Miocene, where Leidy identified a true porcupine, *Hystrix venustus*.

Many of the extinct genera stand in evident genetic connection with existing forms. The Miocene Castors doubtless include the ancestor of the modern beaver. The *Ischyromys* is a primitive type of the *Sciuridæ*, and *Gymnoptychus* connects it directly with the existing forms by the character of its molar teeth. *Eumys* is the primitive form of *Hesperomys*, as *Pacculus* is of *Sigmodon*. *Entoptychus* and *Pleurolicus* are the near ancestors of the *Geomyidæ* of the Pliocene and present periods. *Palæolagus*, *Panolax* and *Lepus* form a direct genetic line. The ancient genera all differ from their modern representatives in the same way; that is, in the greater constriction of the skull just posterior to the orbits and accompanying absence of postorbital processes. This relation may be displayed in tabular form, as follows:

Skull wider behind orbits.		Skull narrower behind orbits.	
Postorbital processes.	No postorbital processes.	Postorbital processes.	No postorbital processes.
.....	Castor fiber.	.....	Castor peninsulatus.
Sciurus.	.....	.....	Ischyromys.
.....	Hesperomys.	.....	Eumys.
Lepus.	.....	.....	Paleolagus.

None of the species of this fauna are of larger size than their modern representatives. In the cases of the beaver, squirrels and rabbits, the ancient species are the smaller.¹

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HETEROGENETIC DEVELOPMENT IN DIAPTOMUS.

BY C. L. HERRICK.

IN a paper in the Report of the Geological and Natural History Survey of Minnesota, the writer suggested that this genus is unusually affected by changes in the environment, and an example is given in the case of *D. castor*. The form called *giganteus* was shown to be probably an enlarged variety of the above. In a paper in the NATURALIST this matter was expanded and an attempt made to parallelize the two forms with the two

¹ For these conclusions see Bulletin U. S. Geolog. Survey Terrs., vi, 1881, 362-3.

stages in adult Cyclopidae. I am now able to set the matter at rest with reference to these two forms at least. Having had occasion to collect fresh-water animals through the entire length of the Mississippi valley from Lake Superior to the Gulf of Mexico, many hundreds of specimens of *Diaptomus* have been examined in the most diverse localities. If it were permissible to establish a species upon slight variations in structure, numbers of them might be distinguished. However the following facts debar me from attempting it: At Decatur, Ky., a series of small pools in various stages of stagnation, furnished an opportunity for studying the variations due to age and conditions of the water.

It is remarkable that in such small bodies of water only one stage may be present in one, while the next, a few feet away, may offer another.

In the same localities the various stages of a Phyllopod could be studied in the same way.

The normal *D. castor*, like Minnesota specimens in its various stages, occurs in some pools, in others, a few steps away, occurred a larger form, at a glance distinguishable from the above by the short antennæ and stylets, and the structure of the fifth feet. I was, however, struck by the fact that all these specimens were immature (though nearly as large as *D. giganteus*), and unaccompanied by the adult stages. Figs. 1, 2, 3 and 9, Plate v, show some of the peculiarities of the normal *D. castor*; 1a and 9b show the effect of senility on fifth feet and antennæ. Figs 4, 5, 6 and 9 show the corresponding parts in the enlarged form.

Further study showed me that the difference distinguishing the second from the first forms, saving the compact build of the former, are just those found in young of *castor*. It then only remained to find the specimens in the process of molting with the combined characters of both (Fig. 8) to convince one that the enlarged form is really identical with *castor*, but by favorable circumstances enormously developed.

Differentiation takes place before the mature stage is reached, in the same way that tadpoles wintered over are greatly enlarged.

I have found the typical *D. sanguineus* of Forbes in Alabama. This form has some peculiarities to distinguish it from the common var. of *D. castor*.

In view of the facts now known regarding the development of *Diaptomus*, we may safely say that *D. stagnalis* Forbes, is an en-

larged variety or age form of *D. sanguineus*, but the writer must still express his decided belief that these must all be referred to the European *D. castor*.

It must be admitted that the intensity of coloration does not depend upon season but upon the conditions of the water which may or may not be influenced by the time of year. In the same month I have found the same species of all colors, from colorless to deep crimson-red or variegated red, yellow and blue or purple. Weissmann seems to have neglected these facts in referring the coloration of many species of Cladocera to sexual selection. I have found in every case where the Diaptomus was intensely red, the species of Cyclops, usually green or bluish, would be more or less red also. In Swan lake, near Decatur, nearly all the Cladocera were brilliantly marked, *sida* and *simocephalus* (?) being most so; in the neighboring lakes these species were pale as usual.

With respect to the identity of our species. 1st. The armature of the last segment of thorax is usually obscured by doubling over. Fig. 12, Plate VI of Brady gives the large thorn but omits the lower process. 2d. Fig. 7, Plate VI of Brady figures the process on the antenna of male. (Claus gives the best figures.) 3d. Fig. 5, Plate I of Cyclopidæ of Minn., Herrick shows that the inner branch of the male fifth foot is armed by three spines (as figured by Brady) in Minnesota specimens. It must be remarked that this applies to young forms only, and that the later forms lose them and become shorter. Brady has probably transposed his numbers as regards the female feet of fifth pair.

The serrature of the spines differs between different age forms.

Diaptomus pallidus Herrick (Plate VII, Figs. 1-6) is quite rare as compared with the foregoing. The peculiarities mentioned in the original notice suffice to distinguish it from any other known to me. *D. sicilis* Forbes, seems to sustain the same relation to *pallidus* that *giganteus* does to *castor*. The two-jointed character of the inner branch of female feet in *sicilis* confirms this view. There are several differences however.

Char. spec.—Extremely slender; head separate from thorax by a suture; antennæ longer than the caudal setæ; setæ very long; fifth foot of female very short, inner branch with only one terminal seta at end; the male fifth feet long; the jaw is like that of *castor*.

Diaptomus leptodus has not been recognized in the South.

Fig. 4 of Plate VIII in the NATURALIST, July, 1882, represents the process or inner branch of fifth foot reversed, probably by pressure; Fig. 6 of the same plate omits one of the setæ on the last joint. Now comparing these figures with others, we see less difference than as given.

EPISCHURA FLUVIATILIS, sp. nov. (Figs. 10-20, Plate v).

The genus *Epischura*, which was founded by S. A. Forbes¹ upon a species of Copepod, *E. lacustris*, inhabiting Lake Michigan, is one of the most interesting as well as anomalous of the genera of Calanidæ. The typical family likeness is preserved, but there are several peculiarities which have no parallel in Copepoda, if elsewhere.

The animal for which the name *Epischura fluviatilis* is proposed, is undoubtedly extremely near the above, but in several respects disagrees with the points in Forbes' description which he seems to rely upon as of generic importance. It might be assumed that these differences have generic value, and I should be inclined to so regard them except that there seems a possibility that Mr. Forbes has slightly mistaken the homologies of the anomalous organs as indicated below.

As no generic characters were given, this second species may warrant an attempt, as follows:

EPISCHURA Forbes, 1882.

Char. gen.—Cephalothorax slender, 5-6-jointed; abdomen 4-jointed in male. 3-jointed in female; second antennæ as in *Diaptomus*; mandibular palp biramose; swimming feet all biramose; inner ramus 1-jointed; left foot of last pair aborted or obsolete, right foot in female slender, last feet of male greatly modified (right?), foot biramose, inner ramus short, lamellate, 1-jointed with claw-like setæ, outer branch nearly like female, left foot coalesced with the first two joints of abdomen, extremity alone free; setæ of caudal stylets three.

Forbes says of *E. lacustris* that the female has a process upon the abdomen and in both sexes the latter is curved and deformed. In *E. fluviatilis* the abdomen of the female appeared normal, 3-jointed, and differs in no way from *Diaptomus* except as to the number of setæ. It is to be remarked that *Epischura* offers an extreme example of the tendency noticed in all Copepods, as well as frequently in higher Crustacea, to diminish or abort the inner branch of biramose organs on either side the median line.

¹S. A. Forbes. On some Entomostraca of Lake Michigan. AM. NATURALIST, July, 1882.

This may be observed in the abdominal feet of Palæmon, the mouth parts of Cyclopidae, but extends to the first pair of swimming feet in Diaptomus, and in this case involves all of them. The advantage of this arrangement, as well as its cause in the law of adaptation, is evident in the case of such animals as rely much upon a current below the body for food or the aeration of the blood. In *Epischura* the antennules rotate and create such a current past the mouth as is seen in other Copepods.

Char. spec.—Cephalothorax imperfectly 6-jointed; antennæ 25-jointed, in the male 6 joints follow the hinge, the enlarged portion is not greatly thickened, the antennæ reach somewhat beyond the thorax; mandibles with about nine teeth, the first of which is large and divaricate, more or fewer of the following ones are emarginate; mandibular palp biramose, inner branch 1-jointed, outer branch 3-jointed; maxillipeds not unlike Diaptomus but shorter and more strongly armed with curved spines; (last feet of female 1-branched with a straight claw terminating the distal segments, or) left foot obsolete and the other 2-branched, each branch 3-jointed, the right male foot of last pair is much more modified, its inner ramus is lamellate and curved in upon itself so as to make a grasping organ of curious form; in this office it is aided by two or more curved movable hooks which may probably be regarded as modified setæ, the second joint of the abdomen bears on its left side an appendage of two joints, the basal joint being flat and extending into a strong curved claw reaching to the base of the furca, while the second is slender and has two small setæ at the end, thus is formed a powerful hand.

I regard this appendage as perhaps the terminal joint of the left of the last pair of feet; indeed there seems to be some internal connection with the last thoracic segment, although externally none remains, the abdomen is otherwise quite normal and straight.

These suggestions with regard to the homologies of the organ are offered with some hesitation, as such a coalescing of a limb with the abdomen has never been described. However I believe the same thing takes place, though to a less degree, in Cyclops. In *C. mulleri*, for example, the fifth foot entirely disappears, leaving only two separate spines to indicate its position. It is suggested that certain spines adorning the first segment of the abdomen in most species of Cyclops may be rudiments of the missing second ramus of the fifth foot. By comparing Figs. 11 and 12 of Plate v with 1 and 3, representing the corresponding parts in Diaptomus. it will be seen that the theory advanced places all the parts in the place demanded by the schema of the limbs in Calanidae.

Comparing the fifth leg of the female, Figs. 12-13, with the preceding one, Fig. 20, it appears to correspond with one leg only,

but both rami are 3-jointed as in the swimming legs of other Calanidæ. On the other hand, regarding both legs as present, the "hand" of the male does not homologize with the left limb, and we have besides to account for a supernumerary 2-jointed limb on the *second joint of the abdomen*..

The present species was found in large numbers in Mulberry creek, Cullman county, Alabama; the color is bluish-green, and the length about $\frac{4}{100}$ in.

ENTOZOIC PARASITES IN ENTOMOSTRACA (Fig. 15, Pl. VI).

We have discussed the relation of the minute fresh-water Crustacea to sanitary science in a paragraph in a recent article in the NATURALIST, but it remains to touch upon another phase of the subject. It may be thought unnecessary to trouble ourselves about the pathological conditions prevailing among such lowly animals, but it can be shown that these same causes of disease may not be unimportant in connection with human diseases.

It is a fact constantly receiving new exemplification, that the parasites infesting small animals, particularly water animals, are frequently but the immature forms of parasites of animals higher in the scales. These altering generations are exceedingly difficult to study, so that while all stages may be separately known, only a fortunate combination of circumstances or patient accumulation of facts can connect the individual factors into the complete cyclus.

Thus, for example, Professor Leuckart has but recently worked out the full life-history of *Distomum hepaticum*, although the adult has been a stock example in helminthological study in the laboratory for years.

The importance of such parasites, even in a commercial view, needs but a reference to trichinosis to illustrate. I am not aware that endo-parasites are known in Entomostraca except in the case of Cyclops. Embryos of *Cucullanus elegans*, a nematoid worm, enter the body-cavity of Cyclops and undergo two molts and then are transferred to the intestinal canal of food-fishes.¹

Taken in connection with the recent discoveries of S. A. Forbes,² showing how dependent our own food-fishes are upon

¹ Claus. Kleines Lehrbuch d. Zoologie, p. 368.

² Forbes. On some Entomostraca of Lake Michigan, AM. NATURALIST, July, 1882.

Cf. Ryder on Food Fishes, Bul. U. S. Fish. Com.

Entomostraca, the significance of these facts cannot fail to appear. A similar parasite of Cyclops is *Filaria medinensis*.¹

The Cladocera are generally quite free from parasites, but I have found in several instances young nematoids in the blood sinus in front of the heart in *Daphnia magna*. These are mouthless but very active round worms, subsisting upon the nutriment in the blood which constantly bathes the animal. True cysts could not be formed in the cobweb-like tissues of the hosts.

This is, so far as I can learn, the first publication of Entozoa from Cladocera. The animals were from "Schimels Teich," Leipzig. While collecting Copepods near Tuscaloosa, Ala., I gathered a number of specimens of *Cyclops tenuicornis* and nearly all were unusually pale and feeble. On examination they proved to be infested with a worm of the sub-order Distomeæ. This sub-order includes many distressing parasites and forms which are adapted to be widely distributed by a long period of adolescence and the number of stages passed through before maturity is attained.

The larvæ live frequently in Mollusca, and in maturity the animal inhabits the intestine of vertebrates.

Upon examination the Cyclops individuals collected were nearly all found affected, some having as many as five parasites of various sizes about the alimentary canal, in the common vascular cavity which corresponds to the entire arterial and venous system of the more highly organized Calanidæ. The Cercarian or tailed stage was not found. Were the life-history known it would probably appear that the larval stage is passed within some young mollusks, and that the adult infests some vertebrate, probably fish, and would thus be perhaps transferred either in food or drink to human system.

It is worthy of notice that the host was soon destroyed by the parasite, the post-imago or Coronatus form being absent; most of the individuals thus infested possessed abnormally persistent larval characters in antennæ, etc.

EXPLANATION OF PLATE V.

FIG. 1. *Diaptomus castor* (?), fifth pair of legs of adult male.

- " 1a. " same (older specimen) showing a greater retrograde metamorphosis of inner ramus.
- " 2. " caudal stylets of adult.

¹Fedschenko. Ueber d. Bau. u. d. Entwicklung d. *Filaria medinensis*, Moscow.

- FIG. 3. *Diaptomus castor* (?) fifth legs of adult female.
 " 4. " fifth legs of male of exaggerated or *giganteus* form (immature).
 " 5. " fifth legs of female.
 " 6. " caudal stylets of same.
 " 7. " margin of last thoracic segment of same.
 " 8. " leg of immature specimen of ordinary form just prior to molt.
 " 9. " antenna of male, *giganteus* form (immature).
 " 9a. " antennæ of male, *castor* adult.
 " 9b. " antenna of male, *castor*, older form.
 " 10. *Epischura fluviatilis*, sp. nov., abdomen and fifth feet of male:
 " 11. " right foot of male.
 " 12. " right foot of female.
 " 13. " right foot of female (young).
 " 14. " mandible.
 " 15. " labrum, mandibles and palpi.
 " 16. " end of maxilliped.
 " 17. " globular upper part of testis.
 " 18. " end of antennules.
 " 19. " antenna of male.
 " 20. " swimming foot.
 " 21. *Cyclops modestus*, sp. nov., fifth foot.
 " 22. " stylets.
 " 23. " end of antenna.
 " 24. *Cyclops tenuissimus*, sp. nov., fifth foot.
 " 25. " terminal joint of antenna.
 " 26. *Schapholeberis angulata*, sp. nov. (a), antenna.
 " 27. " first foot.
 " 28. " lower angle of shell.
 " 29. *Simocephalus vetulus*, outline of posterior portion of shell in old females (a) spines.
 " 30. *Simocephalus daphnoides*.
 " 31. " lower angle of shell.

EXPLANATION OF PLATE VI.

- FIG. 1. *Daphnia longispina*,
 " 2. "
 " 3. "
 " 4. "
 " 5. *Daphnia dubia*.
 " 6. "
 " 7. "
 " 8. "
 " 9. "
 " 10. *Daphnia longispina*.
 " 11. *Ceriodaphnia alabamensis*, sp. nov., end of postabdomen.
 " 12. " head.
 " 12a. " reticulations of shell.
 " 13. *Daphnia dubia*.
 " 14. "

HETEROGENETIC DEVELOPMENT IN DIAPTOMUS.

BY C. L. HERRICK.

(Continued from page 389.)

CYCLOPS INGENS Herrick (*Cyclopida* of Minn., p. 228, Plate IV, Figs. 1-8).

Found in pools near Tuscaloosa, Ala., with *Daphnia pulex* and *Simocephalus daphnoides*. The post-imago is somewhat over $\frac{1}{10}$ in. long, *i. e.*, not quite as long as *C. gigas* according to Brady, which is very little different. Our form has longer stylets and shorter antennæ in the ordinary stage, but the mature or post-imago has shorter stylets. In the last stage prior to maturity the stylets are just as figured by Brady for this stage. It is worthy of remark that *C. kaufmanni* Uljanin, which is certainly founded upon a prematurely gravid larva (feet being 2-jointed and antennæ undifferentiated) corresponds perfectly with larvæ of *C. ingens*.

Brady himself considers *C. helleri* the same species, and we have here apparently an older stage with fully developed feet but not yet provided with mature antennæ.

A variety of *C. ingens* is found in cold springs at Tuscaloosa and elsewhere in Alabama, much less in size and with the proportions of the European *C. gigas*.

The large examples in shallow "prairie pools" were masked by dense algæ coating. The form of the fifth foot and stylets distinguishes the above from other members of the genus, and one is tempted to regard these forms as varieties of *C. gigas* simply. *C. parvus* (Cyclop. Minn., p. 229) might be considered a var. of *C. ingens*.

CYCLOPS PECTINATUS, sp. nov. (Plate VII, Figs. 25-28).

Related to *C. navus*, from which it is chiefly distinguished by a semicircular series of small spines at the base of the greatly elongated caudal stylets. In the post-imago the stylets are nearly half as long as the abdomen; the antennæ reach nearly to the base of the third segment. In the ordinary adult the stylets are less elongate. In all forms the lateral setæ are one-third from the end and the outer and inner terminal setæ are short spines; the fifth foot is as in *Navus* and the operculum valves is a little different. Most characteristic, however, is a circlet of small spines one-fourth from the base of the stylets. Length over $\frac{5}{100}$ in.

CYCLOPS TENUISSIMUS, sp. nov. (Figs. 24-25, Plate V; Figs. 20-21, Plate VI).

Section with 17-jointed antennæ.

Extremely elongated; antennæ reaching a little beyond the first thoracic segment, short jointed, formula $\leftarrow \underline{u} \circ - \underline{u} \circ - \text{UUUUUUUU} \underline{u} \underline{u} \underline{u}$, the terminal joint rather short, armed with three teeth near the extremity; antennules rather long, last two joints slender; fifth foot 2-jointed, second joint with two nearly equal setæ; cauda stylet, as in *C. tenuicornis*; opening of spermathæca elongated.

This species is the most slender Cyclops known to me, and may be recognized by the toothed terminal joint of the antennæ, a character otherwise confined to *C. tenuicornis*, "coronatus stage."

The teeth of this species differ from those of "Coronatus" too much to confuse the two. This species is of the *navus* and *parvus* group, but the caudal stylets closely resemble *tenuicornis*. Near Paducah, Ky.

CYCLOPS MODESTUS, sp. nov.

Antennæ remaining 16-jointed in all individuals seen, very short, formula — 1 — 2 0 — 0 0 0 0 0 0 0 0 — 0; antennules short jointed; fifth foot three-jointed, with unequal spines; caudal stylets of moderate length, lateral setæ about half way to base of stylet, three longest terminal setæ subequal.

This is a small species related to the preceding, but differs in many respects, the form of the spermathæca is oval. The egg sacs are slender, elongate oval. Cullman county, Ala.

POST-EMBRYONAL DEVELOPMENT OF TWO SPECIES OF DAPHNIA.

In a previous paper it was shown that the spine found on the posterior portion of the shell in young and male individuals, in all members of this genus, is a persisting embryonal character, and its possible advantage to the economy of the animal was pointed out. It was indicated that a recognition of the facts brought out, would throw several species into synonymy. It is my wish, in this paper, to illustrate the extent of the variations passed through in the course of later development, by two examples, one of which has been but imperfectly described, while the other is new to America.

These two species differ from any known to me, though they may possibly be found among some of Sars' numerous nominal species.

DAPHNIA LONGISPINA Herrick (Microscopic Entomostraca, 1877).

This name was applied to the young, and in connection a figure was given of a male with the spine on the head which, in the female at least, was indicative of immaturity. The name is not particularly appropriate, for the mature female is not evidently spined.

This name has been long applied to another form in Europe, but apparently to an immature stage of another species, so that it is really vacant.

In a paper (Notes on Cladocera of Minnesota) in the Rep. of Geol. Surv. of Minn. 1881, the post-imago is figured, and a variety of the younger stage (a little distorted in the molt). I am now able to complete the chain from the embryo to the post-imago (see

Plate VII). Fig. 3 is the embryo extracted from the brood cavity, showing that the eye is near the extremity of the elongated head even before the two eye spots have united (Fig. 10). Fig. 2 shows the early stage of post-embryonal growth. Fig. 1 is the adult in the first stage in which all the peculiarities of the species are pronounced. Fig. 4 is the post-imago (see also Plate XI Figs. 15-16 of Notes on Minnesota Crust., and Fig. 4 in the text).

DAPHNIA DUBIA, sp. nov. ?

This species is very nearly related to the preceding, differing, however, in having the eye small and situated nearly in the center of the head, while the previous one has an eye of usual size and near the straight lower margin. The head is much more acute than in the preceding but not carinated (Fig. 9). Both these species have occasionally a horn in young stages (Fig. 14). The claws are smooth or simply pectinate. The spine in the latter species is more elevated. It is remarkable that the same species has both forms of abdominal appendages represented at Figs. 13 and 8.

The post-imago of *dubia* has not been seen. The nearest approach to it had a considerable spine, but the head had already begun to assume the shorter form with a curved lower margin.

The only allied species yet described from America, is *D. lævis* of Birge in which the development is tolerably well completed.

By filling up the gaps till all the stages in each case are known, we have advanced one step toward an accurate determination of species, and require then to learn what variations in the process usually obtaining may be occasioned by alterations in the environment. But in the mean time we are discovering the laws which govern development and the historical affinities of the different genera and species.

DAPHNIA PULEX.

This common species is subject to variations which are perplexing, but there seems to be no reason for the separation of the var. *denticulata*, as done by Birge. The differences relied upon are the fine teeth down the claw and the abrupt curvature of the lower margin of the head. Fig. 4 of Plate I in P. E. Mueller's work figures this peculiarity of the claws. Quite typical *D. pulex* from Tuscaloosa, however, do not have the fine teeth and only 12-15 teeth on the abdomen.

SCAPHOLEBERIS ANGULATA, sp. nov. (Figs. 26–28, Plate V).

The genus *Scapholeberis* at present consists of two species, *S. nasuta* Birge,¹ and *S. mucronata* with its three varieties (*a*) *fronte lævi*, (*b*) *fronte cornuti* of Europe, and (*c*) *armata*,² found in Minnesota, Illinois and Tennessee. With regard to the European varieties it is remarkable that although they are not local varieties,³ the horn upon the head appears in the larger individuals and not as would be expected from the analogy of *Daphnia*, in young and small individuals. However, it is to be noticed that the spines of the valves in *Scapholeberis* are not persisting embryonic characters like the spine in *Daphnia*, but the young are like *Ceriodaphnia*. It may be that in like manner the crest upon the head in *Scapholeberis* is, instead of an embryonic appendage as in *Daphnia*, a later production. It might then be suggested that *Scapholeberis* is now undergoing differentiation or, in other words, is a new genus historically, while *Daphnia* is past the acme of its activity in the direction in which it has differentiated, and now retains its peculiarities by inheritance, and tends to continue them only so far as they are of functional value.

The horn which sometimes appears in young of certain species of *Daphnia* (*D. galeata*) and seems so capricious in its production, may be not unlike that of this species.

Were it not that *S. mucronata* is known to be very variable, it might be admissible to create var. *armata* a new species. Additional details are given for this variety in Figs. 23–24, Plate vi.

Scapholeberis angulata, sp. nov.—Head of medium size; rostrum directed downward and backward; eye of moderate size; macula nigra indistinct; formices and basin for antennæ well developed; antennules long curved, armed with two lateral sense hairs as well as the terminal olfactory? filaments; cephalic portion of the basin of antennæ marked by longitudinal lines connected at intervals by cross lines, inferior portion of the part of the basin on the valves reticulate; “mucro” absent, the inferior posterior corner of shell simply sharply angled; inner wall of shell furnished with a row of small spines below and posteriorly for a part of the height of the shell; caudal teeth 5–7 in adult, being more numerous than in any other known species; size large.

The “mucro” is absent in the smallest individuals seen. *Scapholeberis* seems to lie between *Daphnia* and *Ceriodaphnia*, agreeing with the former in being a divergent member of the family, but still with more affinities to the latter. Near Decatur, Ala.

¹ Birge. Notes on Cladocera.

² Herrick. Notes on Crustacea of Minnesota, Geol. Rep. 1881.

³ Kurz. Doclekas neuer Cladoceren, etc., p. 22.

SIMOCEPHALUS DAPHNOIDES, sp. nov. (Figs. 30, 31, Plate V; Fig. 16, Plate VI).

Four nominal species of *Simocephalus* are described: *S. vetulus* Müller, *S. expinosus* Koch, *S. serrulatus* Koch, *S. americanus* Birge. The differences in some cases seem quite trivial, since the form of the *macula nigra* certainly varies with age along with the shape and armature of head and the general shape of the body. However, the present species is so unmistakable that it is not requisite to enter upon a discussion which lack of material makes undesirable.

Simocephalus daphnoides, sp. nov.—General shape very like *Daphnia*; head regularly curved and not strongly angled in front, not marked off from the body by a strong depression; eye of moderate size, *macula nigra* oval to rhomboidal; antennules long curved; anterior portion of shell as deep as the posterior; the three curved spines at the lower posterior angle of shell are wanting; abdomen much as in *S. vetulus*; claw fringed part way with weak spines.

This species is recognized by its oval shape and the *Daphnia*-like shape of head. In old females the spine is about midway of the depth of the shell, but the upper outline is regularly curved and not keeled as in *vetulus* (Fig. 29, Plate V). Quite characteristic is the absence of the three or four curved spines on the shell angle (comp. Fig. 31 with 29a). On the whole in this species an approach to *Daphnia* may be seen. Near Decatur, Ala., with *Scapholeberis angulata*, also in all Southern Alabama.

CERIODAPHNIA ALABAMENSIS, sp. nov. (Figs. 11-12. Plate VI).

Ceriodaphnia is a very perplexing genus, and one in which the effect of age has not been studied. Three species have been mentioned from America, *C. cristata* Birge, *C. consors* Birge, and *C. reticulata* (= *dentata* Birge), there remaining *pulchella*, *rotunda*, *punctata*, *laticauda* (?) and *quadrangulata*, as described in Europe.

Quite typical *C. reticulata* were collected back of Paducah, Ky. The peculiar shape of the fornices figured by P. E. Mueller can be produced by pressure. I have little doubt that this is the same animal described from Massachusetts and Wisconsin by Birge. The head is not so suddenly angled behind the eye as figured by Birge, but more so than represented by Mueller.

C. alabamensis, sp. nov.—The form for which this name is offered, is known from a single gathering at Tuscaloosa, Ala., but it differs from any known species so much as to leave no

doubt that it is a new species. A complete diagnosis unfortunately cannot be given.

Head remarkably small and produced downward; eye very small; the head extends into a beak-like prolongation below the eye; the antennules are very long and pendant as in *Moina*; the body is longer than in *reticulata*, and the reticulations have a double contour line as in *C. pulchella*; the abdomen is slender and the sides nearly parallel, the claws being short and truncate, the spines of the usual size. Two summer eggs were in the cavity of the animal figured.

A fifth species of *Ceriodaphnia* was found in cold springs near Tuscaloosa, Ala., which is not greatly different from *C. reticulata* as defined by P. E. Mueller and Kurz.

CERIODAPHNIA (reticulata) var.) PARVA, sp. (vel var.) nov.

$\frac{23}{1000}$ — $\frac{25}{1000}$ in. long, transparent; head not strongly depressed, somewhat abruptly angled in front of antennules; fornices not very prominent; antennules short, conical, shell oblong, ending in a sharp angle posteriorly, simply reticulated; abdomen rather short, not narrowed very much, distally rounded at the extremity; claws rather short, smooth, spines short curved.

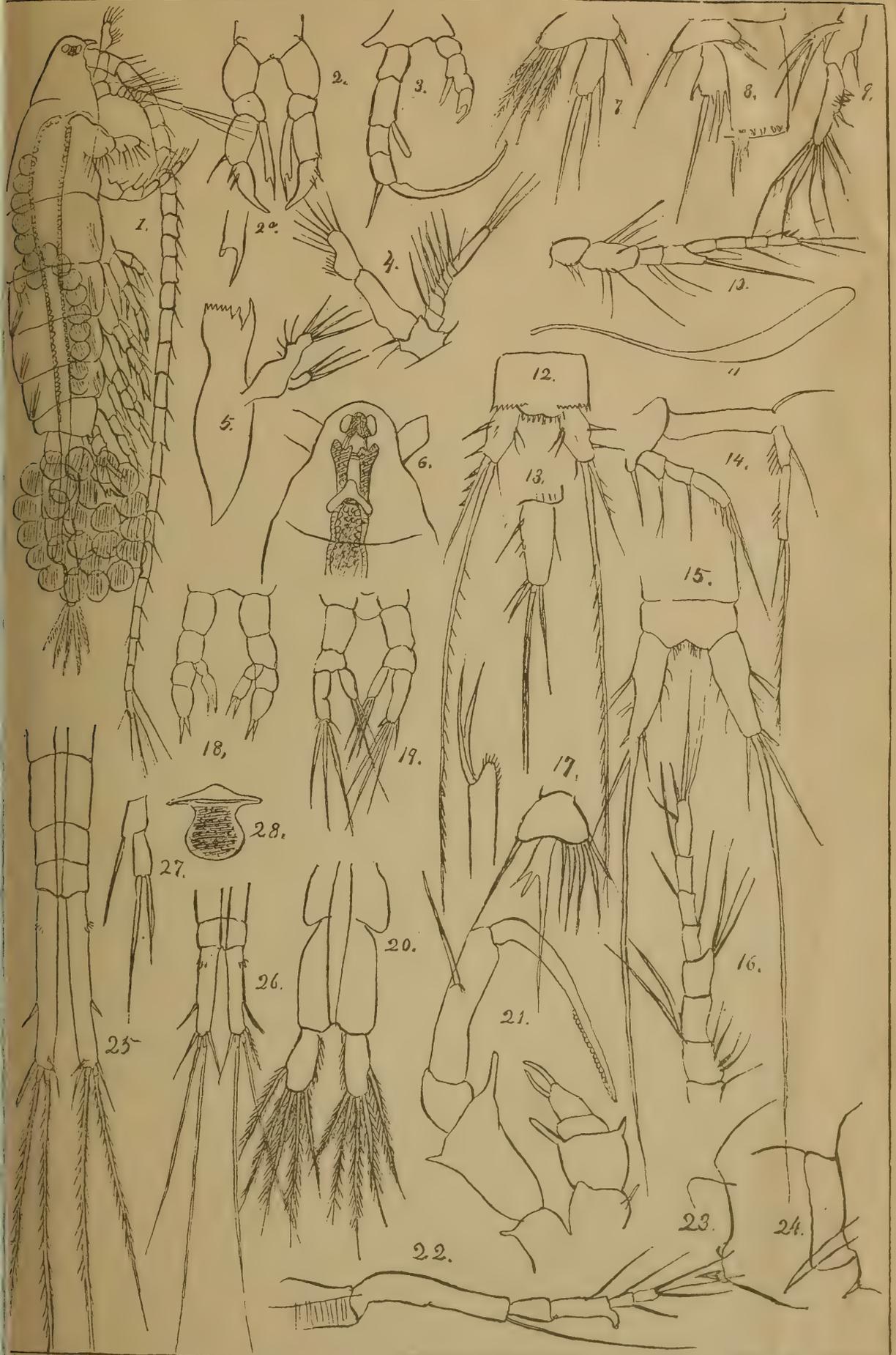
This very small species was found in considerable numbers, but very little variation in size was noticed. *C. pulchella* Sars, is 0.5–0.6^{mm}, but the head is quite different, though the abdomen is similar. Kurz says also, "Die schalensculptur ist doppel-linig," which is not the case in our species.

C. quadrangula is 0.6^{mm}, but several important differences are observable between the two species. In that species the head is said to be "valde depressum, ante basin antennarum ferme non angulatum;" the antennules are large and the abdomen narrow.

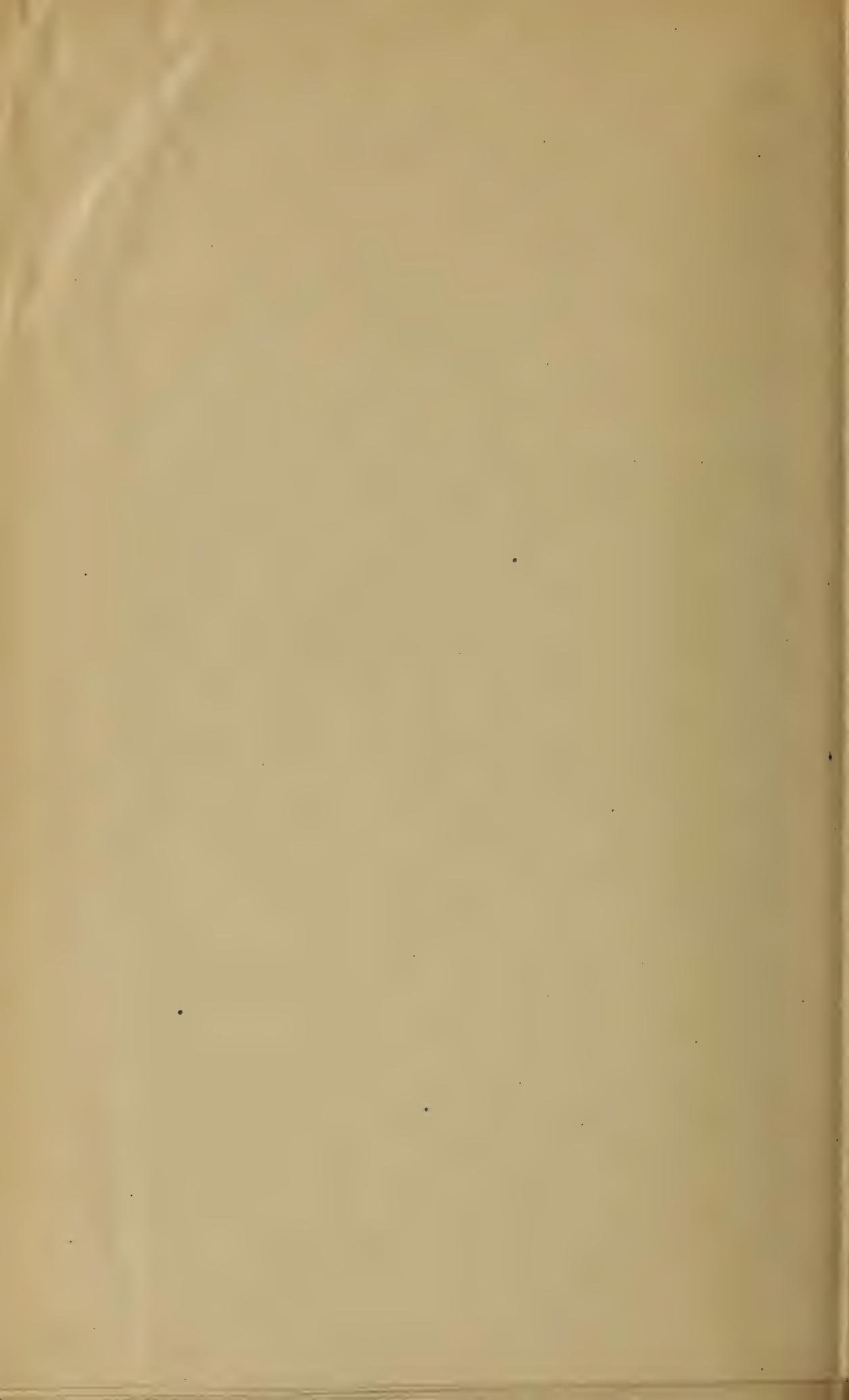
In general appearance this species is a reduced copy of *C. reticulata*, but the claws are smooth. Kurz speaks of a small var. of *reticulata* with smooth claws, but the fornices are then said to be sharp.

EXPLANATION OF PLATE VII.

- FIG. 1. *Diaptomus pallidus*, female.
 " 2. " fifth feet of female.
 " 3. " fifth feet of male.
 " 4. " antennules.
 " 5. " mandible.
 " 6. " head.
 " 7. *Canthocamptus*, sp. n. ? fifth foot of female.
 " 8. " fifth foot of male.
 " 9. " antennules.
 " 10. " antenna of female.
 " 11. " spermathæca.
 " 12. " stylets of female.
 " 13. " stylet of male.
 " 14. " maxilliped.



HETEROGENETIC DEVELOPMENT IN DIAPTOMUS.



- FIG. 15. *Canthocamptus*, sp. n., stylets of female.
 " 16. " antenna.
 " 17. " fifth foot of female.
 " 18. *Diaptomus* "*sanguineus*," fifth feet of larva (♂).
 " 19. " fifth feet of larva (♀).
 " 20. " abdomen of larva (♀).
 " 21. " fifth foot of adult (♂).
 " 22. " antenna of adult.
 " 23. *Diaptomus* "*castor*," margin of last segment (♂).
 " 24. " margin of last segment (♀).
 " 25-28. *Cyclops pectinatus*.
 " 29. *Diaptomus pallidus*, inner ramus of fifth foot (♀.)

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REMARKS ON THE MORPHOLOGY OF ARTERIES, ESPECIALLY THOSE OF THE LIMBS.¹

BY FRANK BAKER, M.D.

IT is generally taken for granted that the variability of arteries is such that they are of but little use in morphological studies. Anatomists are usually of the opinion that since the function of the arteries is to nourish the tissues, their course from the heart to their destination is of too slight importance to the race to have become a fixed character, and all search for law is abandoned. But it is questionable whether some biologists have not too hastily come to this conclusion.

Morphological laws are always obscure when studied in the adult individual alone. To trace them we must examine the different phases of individual development and investigate the anatomy of related forms.

There is a period when the embryo of a vertebrate animal is not provided with a proper vascular system. During the early stages of the segmentation of the ovum, no vessels exist, the young cells receiving the necessary nutriment from an interstitial plasma, as do those of the lowest Protozoa.

This stage is of short duration. Throughout the minute disk-shaped object which is hereafter to be a fully developed vertebrate, certain cells appear, of a slightly reddish color, dotting the disk in a peculiar marbled manner. From their appearance and isolation these are known as *blood-islands*. They touch each other finally as they increase in number, either at some part of

¹Abstract of a paper read before the Montreal meeting of the Amer. Assoc. for the Advancement of Science.

their contour or by means of processes which they throw out, so that there results a net-work, at first indistinct but gradually increasing in clearness and color as the cells enlarge.

Each of these blood-islands then undergoes vacuolation, a portion of the protoplasmic contents becoming liquified and leaving a cavity. By a budding process new cells are formed in the interior of the mother-cells and becoming detached float free in the fluid which fills the vacuole. At this period, therefore, the blood-islands present an outside cell-wall with a contained fluid in which float free cells or corpuscles, the whole arranged in a close mesh-work.

Next the cell-walls wherever in contact thin away and disappear, there resulting a tube the walls of which are the original cell-walls of the blood-islands, the contents a fluid, plasma, in which swim free blood-corpuscles. There is at first no special difference in size among the vessels thus formed, nor is there any structural difference by which we can distinguish arteries from veins. No trunks or branches can as yet be made out, it is in fact a *capillary plexus* that appears, all vessels lying on the same plane and communicating equally with each other.

But a difference soon begins to be manifest. The rapidity of growth varies greatly. Along certain lines the vessels begin to increase in size so that soon there is visible distinction of capillaries, branches and trunks. This process of capillary and trunk formation extends from without inward, attains the proper body of the embryo, finally reaching the rudimentary vesicle which represents the heart. (Plate VIII.)

It should be noted that the development is *centripetal*. Nothing is more natural than to look upon the arteries as a system proceeding *centrifugally* from the heart outward.

However convenient this may be to the physiologist or the surgeon, to the anatomist it embodies a fallacy. The capillaries are the first formed, next the arterioles, then the branches of larger size, finally the trunks. It is owing to the subtle persistence of this fallacy that the study of the arterial system has advanced no farther.

I have mentioned that the rapidity of growth is greater along certain lines, thus leading to the formation of trunks. It is conceivable that these trunk-lines should be intermediate in direction, but in fact they usually become established in certain definite situations. What can be ascertained as to the causes for this?

ursula, should not be considered a sufficiently good species.—The entomological papers from the transactions of the Iowa State Horticultural Society, for the year 1882, have been published separately for gratuitous circulation, and contain much information of practical value from Hon. J. N. Dixon, Miss Alice Walton, and Professor Herbert Osborn.—The monthly meetings of the Brooklyn Entomological Society will hereafter be held on the last Saturday of each month in Wright's business college, corner of Broadway and Fourth Streets.—The Stettiner Entomologische Zeitung, Vol. 44, 1883, Nos. 7-9, contains beside others of less general interest the following papers: Dr. H. A. Hagen's contributions to a monograph of the Psocidæ (continued); Remarks upon the influence of change of food upon morphological varieties, especially in the species of the genus *Eupithecia*, by Dr. A. Speyer; H. B. Möschler's notice of Fernald's catalogue of N. A. Tortricidæ; and Dr. C. A. Dohrn's list of Zeller's entomological papers, published after the appearance of Hagen's *Bibliotheca*.—At the fiftieth anniversary meeting of the London Entomological Society, held May 2d of this year, Professor J. O. Westwood was elected by acclamation titular life-president of the society.

ZOÖLOGY.

THE SEA PENS OR PENNATULIDA.¹—Professor Milnes Marshall and Mr. W. P. Marshall give an important and interesting account of the Pennatulida collected in the Oban Dredging Excursion of the Birmingham Natural History and Microscopical Society. *Funiculina quadrangularis*, *Pennatula phosphorea* and *Virgularia mirabilis* were the three forms collected.

The very primitive nature of the first of these is indicated by the irregular arrangement of the polyps, their independent insertion into the rachis, and in the comparatively slight difference between the polyps and the zooids, as well as by the shortness of the stalk, or part of the colony devoid of polyps. In *Pennatula* we have the polyps fused into leaves, and there is a considerable difference in the size of their constituent parts, as well as great anatomical differences between the polyps and the zooids; the stalk is also relatively much longer.

Virgularia is shown to be the most modified by the restriction of the reproductive organs to imperfectly developed polyps, and, in addition to these points, by the presence of the so-called radial vessels which are absent from the other two forms.

A very curious discovery has been made with regard to *Virgularia*; with but one exception all the known specimens of *Virgularia* are mutilated, the lower end being generally, and the upper always wanting; as a hypothesis, the author some time ago suggested that the tips were probably bitten off by some marine ani-

¹8vo, Birmingham, 1883, pp. 81 (4 pls.).

mals, probably fish. Since then they have (through Mr. R. D. Derbyshire) been able to examine the contents of a stomach of a haddock, which consisted of five fragments of *V. mirabilis*, and of these, three were "actual perfect upper ends;" as a possible explanation of this mutilation it is suggested that the apparent absence of stinging-cells from this species is not only apparent but real, so that the fish are enabled to bite at them with impunity. As the specimens examined were not in a thoroughly satisfactory condition for histological study, the question must be examined again with more satisfactory specimens.

The evidence afforded by the dredging leads to the supposition already suggested by Richiardi and K lliker, that *Funiculina forbesi*, the supposed British species, is only the immature form of *F. quadrangularis*, which is well known from the Mediterranean. The most complete example from Oban is only thirty-nine inches long, but at Hamburg there is a stem eighty-nine inches in length.

The foregoing notice has been taken from the Journal of the Royal Microscopical Society. Having received from the authors a copy of the book, we can bear testimony to the excellence of the plates. The authors quote Dalyell's statement that *Virgularia* when in captivity "remains contracted during the greater part of the day, and the organs are seldom displayed before five or six in the afternoon;" but the authors with more reason suggest that *Pennatula* appears to be "nocturnal" when brought to the surface, "simply because the amount of light it receives in broad daylight is vastly in excess of what it receives normally at the sea bottom, and that it is only towards evening that it is placed under what to it are normal conditions as to amount of light."

The authors are strongly in favor of the now generally accepted view that *Pennatula* lives upright, planted in the sea bottom.

As regards the phosphorescence observed in the majority of the *Pennatulida*, *P. phosphorea* receiving its name from having this property, the authors say: "This was well seen in the Oban specimens while living; the more perfect female specimens when suspended in a jar of sea water in the dark, and irritated or excited by gently brushing the leaves, exhibited a fine display of phosphorescence, the different polypes, when touched, showing minute brilliant points of light which appeared to flash over the whole surface of the feather in rapid irregular corruscations." Panceri's observations on this subject are adopted, and his views presented at some length.

11. HETEROGENETIC DEVELOPMENT IN DIAPTOMUS, ETC., CORRECTIONS.—The editors kindly allow me space to make the following emendations to the article entitled Heterogenetic Development in Diaptomus, rendered necessary by an unfortunate loss of proof in the mail.

Cyclops pectinatus (p. 499) should have stood "*C. thomasi*

Forbes?" It is at least the southern representative of this species, which consequently is distributed from the Great lakes in Minnesota to the gulf. The similarity to *C. bicuspidatus* Cls., is very close.

The description of *Epischura* (pp. 384-85) was written before the second part of Mr. Forbes' paper was obtained, and in making up for the press, the generic description given in that place was not referred to. It might be inferred from remarks on p. 384, that in *E. lacustris* the female has a structural modification of the abdomen, which is obviously not stated by Forbes.

Although the writer has since succeeded in rearing one Copepod (*Canthocamptus*), and observing the transition from one of the dimorphic conditions to another, and the two stages, in both of which eggs are carried, are strikingly diverse, it should be admitted that perhaps too much confidence was expressed in the inferred conclusions upon *Diaptomus*.

It may be that Brady has confused two distinct species in his account of *D. castor*, inasmuch as his descriptions disagree with those of Sars. It is evident that the same peculiarities of distribution maintain in England as here, however explained. Corrections and information bearing upon these questions are earnestly solicited.

An opportunity for comparing types of *Diaptomus pallidus* with *D. sicilis* shows that the differences are even less than indicated, consisting of the greater robustness of the latter and a greater elongation of the antennæ in the former. There is a difference of .1^{mm} in the length of the living adults seen.—*C. L. Herrick.*

THE COXAL GLANDS OF ARACHNIDA AND CRUSTACEA.—In this journal for September, 1875, we described certain gland-like organs of *Limulus*, supposed to be renal in their nature, situated at the base of the legs. We then said that the organ "in its general position and relations was probably homologous with the green gland of the Decapod Crustacea, and its homologue in the lower orders of Crustacea, which is supposed also to be renal in its nature. It may also possibly represent the organ of Bojanus in the Mollusca, which is said to be renal in its function. It perhaps represents the glandular portion of the segmented organs in worms."

In the Proceedings of the Royal Society, No. 221, 1882, Professor Lankester, in a paper "On the coxal glands of *Scorpio*, hitherto undescribed and corresponding to the brick-red glands of *Limulus*," revoking his first expressed opinion (*Quart. Journ. Mic. Sci.*, 1881) that these were not "of a glandular nature at all," concludes from histological examination that they are glands, and calls them "coxal glands." He was also unable, as were ourselves, to find any openings into the great veins, or "to detect the situation of their opening to the exterior." Lankester then de-

scribes the coxal glands of Scorpio, and also finds that the coxal glands of Mygale are elongated and lobed as in Limulus. He remarks: "Possibly such coxal glands are in all cases the modified and isolated representatives of the complete series of tubular glands (Nephridia) found at the base of each leg in the archaic Arthropod Peripatus." As will be seen in the foregoing note on Peripatus, that animal is provided with a series of paired organs which Moseley and Balfour, with Sedgwick, regarded as Nephridia, homologous with those of Chætopod worms.

It now appears that homologous organs exist in a third type of Arachnida, for not only do the spiders and Pedipalpi possess coxal glands, but also the mites. In his excellent "Observations on the Anatomy of the Oribatidæ," in the February number of the Journal of the Royal Microscopical Society, Mr. A. D. Michael describes a sac which he believes to be glandular, and which he calls the "super-coxal gland." The organ was first recognized in the mites of this family by Nicholet, who supposed it to be connected with what he and others imagined to be the stigma.

When the upper part of the cephalothorax, and the adipose tissue which underlies it, has been removed, "what appears to be the enlarged, blind end of a fine colorless sac, may be seen on each side of the body, the seemingly blind end being nearest to the eye; the sac descending obliquely downward and slightly forward, and being attached close to the acetabulum of the coxa of the second leg; a closer examination shows that this is not the only attachment, but that the lower end is apparently bifurcated, and that the second branch is attached much nearer to the center of the body, and higher in level than the coxal branch. On dissecting out this sac, and carefully extending it, a matter by no means easy, it will be found that what seemed to be the blind end was not the end at all, but that the whole organ is an elongated sausage-shaped sac, bent upon itself in the middle and taking a single turn, so that the two halves cross, but for some distance the two limbs of the horseshoe (if I may call them so) lie over each other, or are so closely pressed against one another as to appear one; it is only toward the end, that they stand free from each other when *in situ*."

Mr. Michael suggests that these glands are analogous to the nephridia (segmental organs) of Vermes, and the green gland of Astacus and other Crustacea, and the coxal glands in scorpions and Limulus. The resemblance to the segmental organs of worms, especially the leech, is very considerable as regards the general form of the organ, and to a lesser extent in the minuter structure, and if the double lines described in Michael's account be tubules, "they would be analogous to those in the nephridia. The sac (super-coxal gland) would correspond with the gland in the nephridium, and the globular body with the vesicle."

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V.

CRUSTACEA.



C. L. HERRICK.

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12th Ann. Rep., for the Year 1883.

THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

N. H. WINCHELL, STATE GEOLOGIST.

A FINAL REPORT

ON THE

CRUSTACEA OF MINNESOTA

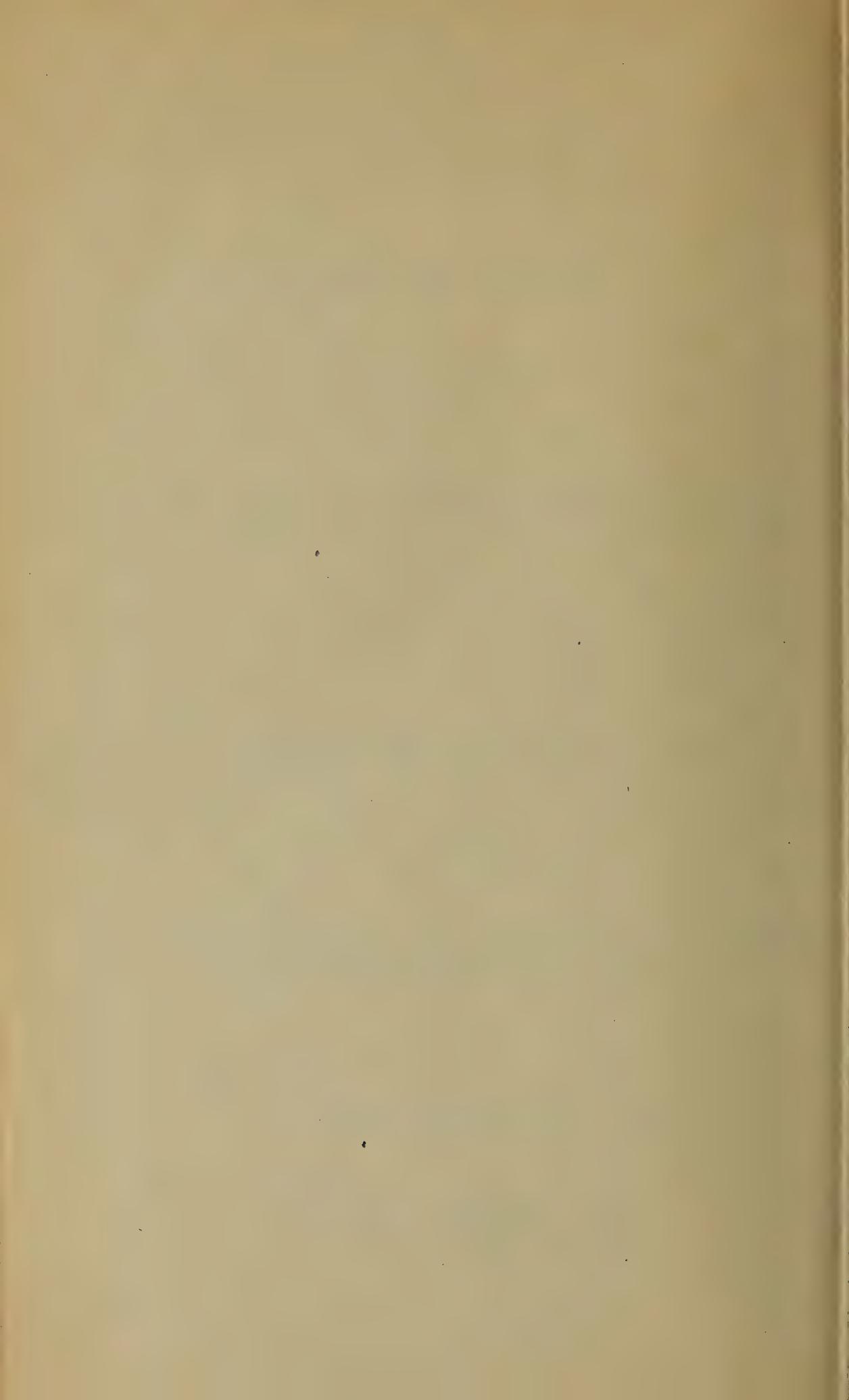
INCLUDED IN THE ORDERS

CLADOCERA AND COPEPODA,

Together with a synopsis of the described species in North America, and keys to the known species of the more important genera.

By *C. L. HERRICK*, Assistant in Zoology.

MINNEAPOLIS :
JOHNSON, SMITH & HARRISON.
1884.



—✻ PREFACE ✻—

IN presenting what may be denominated a final report of the work done in this state upon the group of crustacea best represented, and, all things considered, most important, the author must admit that the term "final" refers only to his own opportunities and the limitation of time imposed by circumstances.

While a comparatively large proportion of all the species existing within our limits have been examined during the progress of these investigations, there undoubtedly remain many additional and curious forms to reward the search of the student. A great variation in the degree of completeness with which the different genera and species have been treated will be observed, due in part to the circumstances under which they were studied, and frequently to the poverty of material. The entomostracean fauna is quite different at different seasons, and a complete knowledge of even our local fauna requires a long period of observation. Even the dead of winter is a favorable time to study some groups. The late autumn is, perhaps, the most favorable opportunity; for then, in one group, the sexual activities are just at their height, and both sexes may be studied. A number of cladocera are restricted to this season. There are a number (how large it is not yet possible to tell) of species in both groups which are to be sought by night though no phosphorescent species are yet known. Our larger, and, especially, deeper lakes have a quite different fauna from the shallow pools and rivers. In general, the flowing waters are poor in entomostraca. The cladocera or shelled entomostraca, have here received a large share of attention, and more particularly the Lynceidæ, which are the most minute of arthropods. This study has been rewarded with an unexpectedly large number of forms, and a particularly large number of species identical with those of Europe and elsewhere. Prof. Birge is the only American writer who has attempted this group, and his valuable work has made us familiar with the more striking new species. A few new species are included in our list and several varieties hardly yet known in Europe. The remarkable *Monospilius* is among these. This animal has but a single larval eye in the middle of its forehead, and

wears its old covering over the newly-formed shell till the latter is a curious patchwork mass. The attempt has been made to incorporate a brief description of all American species with those found in Minnesota, and also to frame keys for the larger genera, so that the place of a species among its congeners may, at least approximately be found. The difficulty of framing such keys is very great; for few authors have employed the same distinctions in their descriptions, and it is necessary to select points sharply distinctive and conspicuous from the often meagre remainder after striking off scattering particulars. In some cases this difficulty has been greatly enhanced by the possibility that some of the species should be considered synonyms or varietal forms. The tendency to combine questionable forms thus produced it was necessary to offset by what may seem a too great conservatism. Faulty, however, as these keys may be, it is hoped that they will serve a good purpose in the extent which they cover. While the limits of this work preclude much more than a systematic outline, opportunity is taken here and there to admit a word on the anatomy or development. Such allusions must be considered simply accidental, for a complete treatment of these subjects would require large volumes, and the material will be long in gathering. A larger proportion of the rare males of the cladocera are here referred to than in any previous work of equal extent. The genus *Cyclops*, one of the bugbears to fresh-water carcinologists, is perhaps somewhat summarily treated. The excuse must be the condition of the synonymy. However, most of the combinations made were the result of careful study of large series from different localities. The sketches illustrating this paper are photo-printed from the writer's own drawings, and, without the elegance of lithographs, serve the purpose of explaining points of structure which cannot be communicated verbally. I am indebted to Prof. A. S. Forbes for very timely aid in bibliography, without which the paper could not have been completed. To Dr. Lindthal, through my friend Mr. Oestlund, I am indebted for a like service. But my obligation is deepest to Prof. Rudolph Leuckart of Leipzig, who kindly afforded access to almost a complete set of works on European entomostraca. Prof. C. W. Hall has collected at much expenditure of time and labor a set of specimens from different parts of the state which he kindly placed in my hands, thus enabling me to observe the great similarity of widely-separated faunæ. Mr. Lieberg also sent specimens of *Diaptomus stagnalis* from saline pools in Dakota.

INTRODUCTORY.

"Evading e'en the microscopic eye,
 Full nature swarms with life ; one wondrous mass
 Waiting the vital breath, when Parent Heaven
 Shall bid the spirit blow. The hoary fen,
 In putrid streams, emits the living cloud
 Of pestilence. Through subterranean cells,
 Where searching sunbeams scarce can find a way,
 Earth animated heaves. The flowery leaf
 Wants not its soft inhabitants. Secure
 Within its winding citadel, the stone
 Holds multitudes. * * where the pool
 Stands mantled o'er with green, invisible
 Amid the floating verdure, millions stray.
 * * Nor is the stream
 Of purest crystal, nor the lucid air,
 Though one transparent vacancy it seems,
 Void of their unseen people."—*Cowper*.

To the poet only, and the man of science, is it given to meet these "unseen people" on those familiar terms which warrants the use of the word intimacy; yet may not we who, like Sam Weller, find our "vision limited," because we have only eyes, avail ourselves of the kind introduction these people give us, and shake hands, as it were, though perhaps a little stiffly, with our neighbors, the unseen people.

Whether we like it or not—Cowper intimates we shall not—these people, in one way or another, touch us constantly, and like diminutive sprites are ever active in hatching mischief or doing their little favors to humanity. Happily most of these are amiable goblins, and are tireless in endeavors to secure us against our insidious enemies of their own ilk. With your permission we will draw the curtain which separates us from the naiades of our pools and streams.

The numbers of living forms to be found in any pool is a constant surprise even to the student of this subject, and the variety and unique character of the animals, particularly, cause a constant flow of wonder and admiration. Confining ourselves to the crus-

tacean forms which are, perhaps, most typical, abundant and interesting of the smaller animals of fresh waters, it is to be remarked that they are of a practical value to an extent which can hardly be correlated with their seeming insignificance.

To understand this fact it is first necessary to recollect that water in some form is an indispensable vehicle for the nidus of disease germs as well as of all life; desiccation means death. The abundantly-watered portion of our country must become permeated with the pestilential hordes ingendered in its fens did not this army of devouring animalculæ destroy the decaying matters accumulating in the waters.

Their importance depends largely on their minute size and unparalleled numbers. The majority of non-carnivorous crustaceans are so constituted that their diet is nearly confined to such floating particles of matter as are present in the water, in a state of more or less fine comminution; for, nearly without prehensile organs, these animals, by means of a valvular or, at most, ladle-like labrum, dip from the current of water kept flowing by the constant motion of the branchial feet, such fragments as the snail and scavenger-fish have disdained. All is fish which enters the net. Think of it, poor dyspeptic, a constant supply of food of every variety and no question asked for stomach's sake! Bits of decaying algæ or the broken fragments of a disintegrated mosquito, all alike acceptable and unhesitatingly assimilated.

Nor is the sanitary aspect the only one in which the *entomostraca*, as our minute crustacea are collectively called, command attention; they are valuable also as a food supply.

Now, does some one jump at the conclusion that the water we drink is filled with aliment in such pleasant form as that represented above—that Dr. Tanner after all lived on a watery solution of entomostraca? Too fast, my friend—food for fishes, but not therefore an insignificant element in our cuisine economy; for it has recently been shown by Prof. Forbes of Illinois, that some of our best fresh-water food fishes are almost dependent on some one or more species of entomostraca. Darwin shows that cats regulate the clover crop of England via field-mice and humble-bees, but it is not half as far from our “bugs” to the price of trout and white-fish.

Still we are not prepared to be surprised at this, for have we not long understood that whales go fishing, with their whalebone nets, for little mollusks not big enough to excite the cupidity of the catorial small boy?

The fact is, that the principle laid down by the Deacon (of venerable memory) that "the weakest pint must stand the strain," maintains in nature aside from the nature of "shays." The minutest forms are in some sense the most important, for they are the links which stand nearest the rock, and if they be loosened the dependent series falls.

The animals of the above group are, it is likely, the best criteria by which to judge of the purity of natural waters if their distribution were correctly understood. The presence of some species in great numbers is sufficient evidence of organic impurity. A critical study of the contents of samples of such waters will enable us to determine their character almost as well as by analysis. The following list of the animal life visible in a quart of filthy pond-water, taken by simple dipping, will perhaps be suggestive on this point:

<i>Daphnia pulex</i>	6
<i>Ceriodaphnia</i>	1400
<i>Simocephalus</i>	56
<i>Cypris</i>	50
<i>Cyclops</i>	30
<i>Sand-fleas</i>	120
	<hr/>
Total Crustacea	1662
Infusoria.....	35
Arachnida (<i>Hydrachna</i>).....	1
Vermes.....	5
Insecta—	
<i>Coleoptera</i> (larvæ).....	8
<i>Diptera</i> (larvæ).....	11
<i>Hemiptera</i>	10
Mollusca.....	35
	<hr/>
Total	1767

The above are simply the animal forms visible to the (trained) unassisted eye; the truly microscopic forms number vastly more.

But each gathering includes specimens of carnivorous entomost-raca as well, and these are not less interesting and bizarre than the cladocera.

The common cyclops, busy picking the bones of a luckless polliwog (must we say purwiggy?), is not less benevolent than the animate filters mentioned above. The amount of such material that they will dispose of in a short period of time is truly astonishing. It is the province of the following chapters to describe briefly such of these animals as fall in the two groups Cladocera and Copepoda and have been noticed in America.

CHAPTER I.

THE ENEMIES OF ENTOMOSTRACA.

First among these rank the young of various fishes which prey upon, and find their entire support in, these minute animals. This subject has been fully treated by Forbes, Ryder and others.

The enemy next most dreaded by entomostraca is, perhaps, the "spectre animalcule" or the larva of the little frost-gnat, corethra. It is no unusual thing to see a corethra carefully gorging itself with a fat cyclops, suddenly seized by the protractile jaws of the dragon-fly larva, shaken for a minute and then engulfed in the tomb-like cavernous mouth below. Nor is the road to the stomach of the dragon-fly always so circuitous. Water-tigers also, with other larvæ, prey upon these unfortunates. The hydra considers them a dainty morsel, and at once paralyzes them by the touch of his nematocystiferous arms; in other words, by the poisonous barbs coiled in concealment in the cells of the tentacles.

If the animal flies from these ubiquitous enemies he almost certainly is betrayed by carnivorous plants which abound in all our waters. Forbes says: "In ten bladders of *Utricularis vulgaris*, taken at random, I found 93 animals, either entire or in recognizable fragments, and representing at least 28 species. Seventy-six of the animals found were entomostraca, and belonged to 20 species." "Just one-third of all the animals found in these bladders belonged to the single species *Acroperus leucocephalus*, Koch."

But among the ranks of enemies must be included certain parasites, both external and internal, of which a variety are known. A few of the most remarkable of these will be mentioned. I may be permitted to quote from an article in the American Naturalist, April, 1883:

"We have discussed the relation of the minute fresh-water crustacea to sanitary science in a paragraph in a recent article in the Naturalist, but it remains to touch upon another phase of the subject. It may be thought unnecessary to trouble ourselves

about the pathological conditions prevailing among such lowly animals, but it can be shown that these same causes of disease may not be unimportant in connection with human diseases.

It is a fact constantly receiving new exemplification, that the parasites infesting small animals, particularly water animals, are frequently but the immature forms of parasites of animals higher in the scale. These alternating generations are exceedingly difficult to study, so that while all stages may be separately known, only a fortunate combination of circumstances or patient accumulation of facts can connect the individual factors into the complete cyclus.

Thus, for example, Prof. Leuckart has but recently worked out the full life-history of *Distomum hepaticum*, although the adult has been a stock example in helminthological study in the laboratory for years.

The importance of such parasites, even in a commercial view, needs but a reference to trichinosis to illustrate. I am not aware that endo-parasites are known in entomostraca except in the case of cyclops. Embryos of *Cucullanus elegans*, a nematoid worm, enter the body cavity of cyclops and undergo two moults and then are transferred to the intestinal canal of food fishes.¹

A similar parasite of cyclops is *Filaria medinensis*.²

The cladocera are generally quite free from parasites, but I have found in several instances young nematoids in the blood sinus in front of the heart in *Daphnia schæfferi*. These worms subsist upon the nutriment in the blood which constantly bathes the animal. True cysts could not be formed in the cobweb-like tissues of the hosts. This is, so far as I can learn, the first publication of entozoa from cladocera, and the parasites are figured in Plate T, Fig. 15. The animals were from 'Schimels Teich,' Leipzig.

While collecting copepods near Tuscaloosa, Ala., I gathered a number of specimens of *Cyclops tenuicornis*, and nearly all were unusually pale and feeble. On examination they proved to be infested with a worm of the sub-order Distomeæ. This sub-order includes many distressing parasites and forms which are adapted to be widely distributed by a long period of adolescence, and the number of stages passed through before maturity is attained."

"The larvæ live frequently in mollusca, and in maturity inhabit the intestine of vertebrates.

Upon examination, the cyclops individuals collected were nearly

¹Claus. Kleines Lehrbuch d. Zoologie, p. 368.

²Fedschenko. Ueber d. Bau. u. d. Entwicklung d. *Filaria medinensis*, Moscow.

all found affected, some having as many as five parasites of various sizes about the alimentary canal, in the common vascular cavity which corresponds to the entire arterial and venous system of the more highly organized Calanidæ. The Cerцерian or tailed stage was not found. Were the life-history known it would probably appear that the larval stage is passed within some young mollusks, and that the adult infests some vertebrate, probably fish, and would thus be perhaps transferred either in food or drink to the human system.

It is worthy of notice that the host was soon destroyed by the parasite, the post-imago or coronatus form being absent; most of the individuals thus infested possessed abnormally persistent larval characters in antennæ, etc." (See also below on *Lagenella mobilis*).

The external parasites are more numerous but, in the main, less dangerous. Among these are a variety of algæ, and colonies of *Vorticellæ* and related animals. There is almost always a colony of *Acineta* near the anus of *Cyclops phaleratus*. Rarely *Stentor* is found upon the body of *Cyclops*.

The most remarkable ectoparasite among the protozoa is the remarkable louse-like ciliate protozoan, to be described beyond, found as a parasite of *Diaptomus pallidus*.

Finally, certain of the rotifera are very constant enemies of the entomostraca, one species making its diet almost exclusively of *Chydorus sphaericus* and stowing them away with remarkable facility with its forceps-like jaws.

A NEW SPECIES OF CORETHRA.

(Plate V. Figs. 1-4)

The *Corethra plumicornis* as known in the larval form is one of the most abundant of the inhabitants of our inland waters, and its form and habits are sufficiently well known. (See *Types of Animal Life* by the author for description and figures.)

A second, and presumably new, species was found in a night gathering from Lake of the Isles near Minneapolis. In motion it differed so entirely, though indescribably, that the eye recognized it at once as new. The few specimens then obtained were all that have been seen, but I will here give a brief description of the larva and pupa in hope that the imago may finally be encountered.

The form is more slender than in *C. plumicornis*. The tracheal vessels are of a different form and color, and the viscera have obvious differences. Most conspicuous variations, however, are seen in the shape of the head, which is slender and attenuated toward the insertion of the antennæ. The antennæ are shortish and have a spine outwardly. The cuticular appendages have an unusual form as has the labrum. The anterior part of the head is spiny. The armature of the end of the abdomen is peculiar.

The posterior rudimentary appendages are of a different form, and the claws are replaced by club-shaped bodies. A curious appendage below is indicated in the name. The pupa has an extraordinarily elongate abdomen which terminates in two paddle-like appendages loosely ciliated outwardly. This species may be called

***Corethra appendiculata*, sp. n.**

A NEW ECTOPARASITIC PROTOZOAN.

(Plate V. Figs. 12-13.)

The very strange monocellular animal referred to was found scurrying over the body of *Diaptomus pallidus* in a manner like that of a louse scrambling over a bare spot upon its host. The body is disc-shaped and about .04 mm. in diameter. The lower or ciliated side is flat and circular. The upper or aboral portion is convex with an annular depression of greater or less regularity about half way from the center to the margin. The lower side has a chitinous barred ring, corresponding to the depression above, containing about 25 radially arranged bars, each of which, apparently, forms the support for a long cilium which with the others forms a circlet extending beyond the margin. These cilia are used as feet and by them the animal is able to move in any direction, apparently with none of the uncertainty of motion usual to ciliate infusoria. The protoplasm is granular and contains one or more contractile vesicles, one of which appeared very regularly in the center of the chitinous ring before mentioned. These animals can also swim freely, but after a short excursion usually came quickly back, and after shuffling or sliding over the smooth surface of the crustacean assumed a position of repose. The generic affinities of this protozoan

are uncertain (*Chilodontidæ*?); the specific name may, perhaps, be safely applied as follows:

pedicularis, sp. n.

Cragin notices the occurrence in American species of Cyclops of *Lagenella mobilis*, Rehberg. This gregarine (?) was found by him at Cambridge, inhabiting in large numbers the digestive tract of species of Cyclops, and has since then been observed in Minnesota.

CHAPTER II.

ORDER CLADOCERA.

This very extensive group contains a variety of types, but there are sufficiently evident connecting links uniting the extremes of structure. The Gymnomera which, following the usual custom, we include here, stand distinct from the other groups, yet have sufficiently evident cladoceran affinities. It is very unfortunate for ætiological speculation that this the only truly marine group should stand thus isolated from its fellows. According to the notions at present prevailing, the Phyllopods stand nearest the primitive type of crustacea. There are unmistakable hints at an early origin for that group, and not less evident are certain analogies with both Cladocera and Copepoda.

There has, however, recently been made an attempt to derive the Phyllopods from an original cladoceran stem with, as we think, somewhat unsatisfactory results. Do we not rather see in both groups two like phases which may be looked upon as incidental and comparatively trivial. The shelled and the shell-less phasis appears in both. The most closely shelled Phyllopod is unmistakably nearer Branchipus even than any of the Cladocera. It would seem that the brief and imperfect embryonic nauplius condition of the latter sufficiently indicated their later origin. Again no fanciful analogy can unite the Ostracoda with the Lynceidæ. We know of no recent discoveries casting discredit on the remark of Balfour: "the independent origin of the Ostracoda from the main crustacean stem seems probable."

Prof. Packard says:¹

"We imagine that when a permanent body of fresh water became established, as, for example, in perhaps early Silurian times, the marine forms carried into it in the egg-condition, possibly by birds

¹"A Monograph of the Phyllopod Crustacea," etc., *XIIth Annual Rep. U. S. Geol. and Geog. Surv. Terr.*

[sic?] or by high winds, hatched young, which under favorable conditions, changed into Sida, Moina, and Daphnia-like forms. The Cladocera are, then, probably the more generalized forms, from which the Phyllopods, at this time and probably ever since Devonian times, *par excellence* a fresh-water assemblage of forms, took their origin." Whatever affinity there may be between the shelled Phyllopods and the Cladocera, it would seem that the evidence is conclusive that the latter group is not the direct continuation of the line of development inaugurated by an ostracode ancestor. As shown beyond, the present centre of the group seems near Moina with indications of a divergence from this rather generalized type, especially of degradation and heteronomy on the side of the Lynceids.

It seems at the present time that more might be accomplished for ætiology by a careful study of such groups as the present, in which are a variety of closely allied forms than by the attempt to join widely separated groups. When we shall have siezed upon the latest eddies and mapped their direction, it may become possible to combine the indications in such a way that lines of divergence thus traced accurately through some small part of their course may be produced backward to their intersection. This then is our present duty—the accurate mapping of minute districts and the careful noting of any moving straws, competent to indicate movements in the vast complex of vitalized nature. We conceive the cladocera to have had a comparatively recent origin, and to express the culmination and retrograde development of a plan of structure first differentiated after the appearance of clear bodies of fresh water. All the species save a very few are confined to inland waters. Accepting the above mentioned theory, the Sididæ will occupy the first place as departing least from the type from which the whole group sprang, while it is connected by the genus Daphnella with the Daphnidæ. The Daphnidæ, beginning with Moina, find their ultimate development in some monstrous forms of the genus Daphnia, but pass into the Lyncodaphnidæ by way of Macrothrix. The links uniting all these minor groups are very obvious.

Our own ideas of the relationships among the Calyptomerous Cladocera are expressed in the accompanying table. This table is to be considered a projection of a portion of a genealogical tree, seen from below, in which the genus Moina forms the arbitrarily chosen fixed point. The heavy dotted line is imagined as directed downward vertically. That branch rising toward the top of the

page is growing obliquely upward. The Daphnidæ are represented as expanding upon the same plane as Moina, and the Lyncodaphnidæ extend diagonally downward, producing the Lynceid branch. The Bosminidæ spring from the stem at a lower point. These relations are made obvious by the figure giving a view of the ideal tree as seen from the side.*

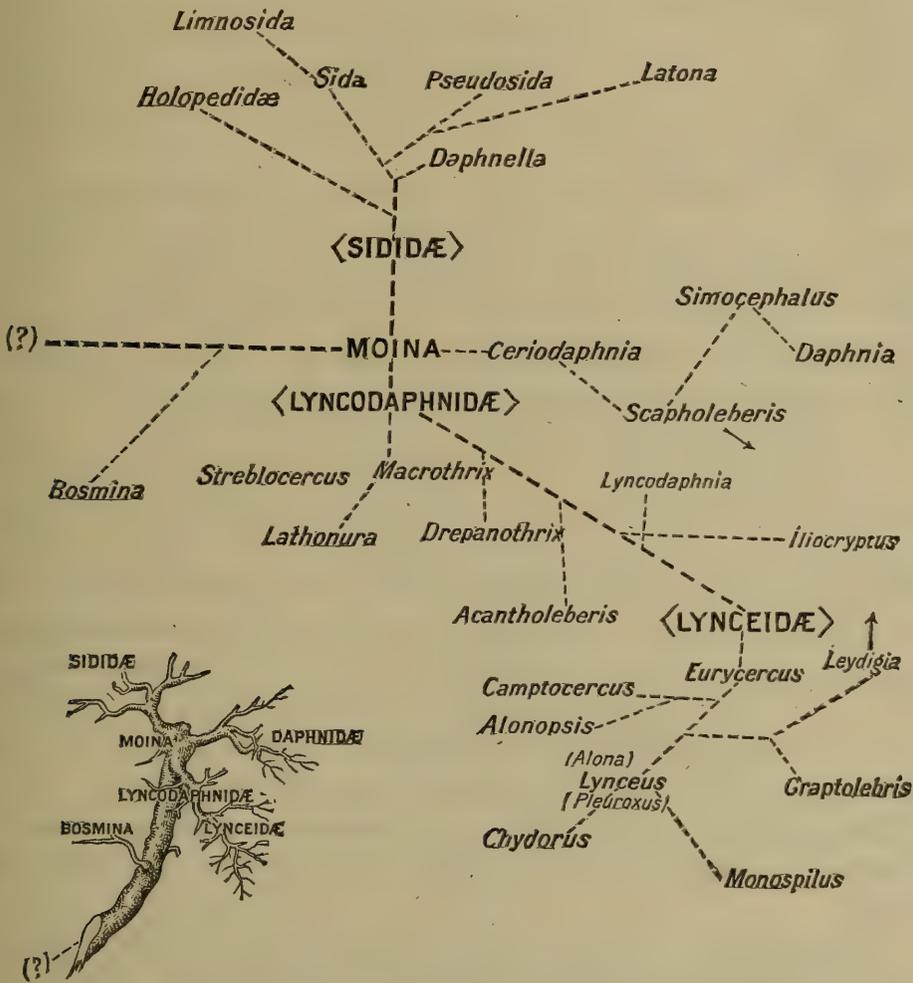


FIG. 1.—TABLE ILLUSTRATING THE RELATIONS OF THE CLADOCERA CALYPTOMERA.

*NOTE.—To adapt the diagram to the theory that the Lynceidæ are the progenitors of Cladocera, it is only necessary to revolve the imaginary line to the right, till it coincides with the axis of that family. The question mark may be understood to indicate that the source of the pivotal group, Moina, is uncertain. The author must confess that his inclination is toward a belief that the line culminating in the Daphnidæ diverged from a group of organisms resembling Phyllopoda, more definitely, resembling Limnetes. There is a very remarkable resemblance between the larva of Limnetes and Bosmina. The lateral spines of the former are, as will be shown true homologues of the antennules of Bosmina. The later origin of the Phyllopoda in their present form may be well admitted.

¹ Entomostraca, seu Insecta testacea, quæ in aquis Daniæ et Norwegiæ reperit descripsit, etc. *Otho Friedric Mueller*, 1785.

² Monoc. qui se trouvent aux Envir. de Geneve.

The Cladocera or Daphnoidea are characterized by the more or less leaf-like feet, and the lamina of thin chitine which encloses the greater part of the body, or at least forms a sac for the protection of the eggs. This so-called shell springs as a fold from the maxillary segment and is the most conspicuous and variously formed, while really least important, of the structural peculiarities.

All Cladocera begin life with a single median eye, but some lose it during later life. In one case it remains the only visual organ.

The outer covering is in most cases changed by frequent moults. The period of the moult is one of the most precarious in the life history of the animal.

Although figures and brief descriptions of animals belonging to this group are to be found in the works of Swammerdam, Leewenhoek, Trembley and other of the older authors, Mueller¹ was the first to produce a systematic work upon these in common with other minute fresh-water crustacea. He may be called the father of the study of micro-crustacea. Jurine,² an eminent Swiss naturalist, was the next to contribute important discoveries relating to these interesting animals, though Ramdohr had given anatomical details of several species. Gruisthuisen, a little later gives farther details of *Daphnia sima* (*Simocephalus*). The work of Milne Edwards gives a resume of what was known regarding these animals in that period. Soon afterwards the work of Baird became the beginning of a new era, and the study of the minute crustacea sprang into importance at once. The Scandinavian peninsula being the birth-place of the science, it is proper that the most exhaustive work on the group should be performed there.

The most important of the later writers are Leydig, Schoedler, Fischer, Lilljeborg, P. E. Mueller, Sars, Weismann, Claus and Kurz.

The complete bibliography of the subject up to Mueller's time is found in Baird's *British Entomostraca*; the greater part of the later bibliography is to be found in P. E. Mueller's *Danmark's Cladocera*. A few only of the more important works are here mentioned.

Koch, C. L., Deutschlands Crustaceen, etc.

Schoedler, J. E., Ueber *Acanthocercus rigidus*, etc.

Dana, J. D., Crustacea of the Wilkes' Exploring Expedition.

Lievin, Die Branchiopoden der Danziger-Gegend.

Fischer, Leb., Ueber die in der Umgegend von St. Petersburg vorkommenden Crustaceen, etc., 1851.

Lilljeborg, W., De Crustaceis ex ordinibus tribus, (or) Om de inom Skane forekommande Crustaceer af ordningarne Cladocera, Ostracoda och Copepoda.

This valuable work is particularly good on the Cladocera, but is unfortunately without Latin descriptions; so that the Swedish text is a hindrance to its usefulness. It is chiefly of historic value now. Large 8vo; Lund, 1855.

Schoedler, J. E., Die Branchipoden der Umgegend von Berlin, 1858.

Smitt, F. A., Sur les Ephippes des Daphnes.

Lubbock, J., An account of the two methods of reproduction in Daphnia, etc.

Leydig, Fr., Naturgeschichte der Daphniden.

The most magnificent work published.

Lilljeborg, W., Leptodora hyalina, 1861.

Sars, G. O., Om Crustacea Cladocera, iagttagne i Omegnen af Christiania, 1862.

This valuable work is difficult of access, printed on thin paper and without illustrations. A second paper by the same author in 1863 is mentioned, but I have never seen it.

Schoedler, J. E., Neue Beitrage zur Naturgeschichte der Cladoceren, 1863.

One of the most important works on the Lynceidæ. The author is rather too credulous and inclined to form new species.

Klunzinger, Einiges zur Anatomie der Daphniden nebst kurzen Bemerkungen ueber die Susswasserfauna der Umgegend Cairo's.

Sars, G. O., Norges Ferskvandskrebssdyr Cladocera ctenopoda, 1865.

The best work on the Sididæ, etc.

Mueller, P. E., Danmark's Cladocera.

One of the most useful books on the subject. Especially good on Lynceidæ and Bosminidæ.

Plateau, Felix, Recherches sur les Crustaces d'eau douce, etc., 1867-69.

Mueller, P. E., Note sur les Cladoceres des Grands Lacs de la Suisse.

Weismann, A., Bau und Lebenserscheinungen Leptodora hyalina.

Sars, G. O., Om en dimorph Udvikling Samt Generationsvexel hos Leptodora, 1873.

Claus, C., Zur kennt. d. Organ. u. d. feineren Baues der Daphniden.

Claus, C., Zur kennt. des Baues, etc., der Polyphemiden.

Gruber and Weismann. Ueber einige neue oder unvollkommen gekannte Daphniden.

Weismann, Thierleben im Bodensee, 1877.

Lutz, A., Untersuchungen ueber Cladoceren der umgebung von Bern.

Claus, C., Die Schalendruse der Daphniden, 1874.

Spangenberg, Fr., Ueber Bau und Entwicklung der Daphniden.

Lilljeborg, W., Crust. Sueecorum Ordin. Branchiop. et Subord. Phyllop., 1877.

Pavesi, P., Nuova Serei di recherche della fauna pelagica nei laghi Italiani, 1877-1879.

Grobben, C., Zur Entwicklungsgeschichte d. Moina rectirostris, 1789.

Weismann, Beitrage zur Naturgesch. der Daphnoiden, Leipzig, 1876-79. (Valuable on the physiology).

The American literature may be catalogued in a few lines. The first descriptions and figures with which I am familiar are those in the Rep. of the U. S. Fish Commission, 1874, where S. I. Smith notes *Daphnia galeata*, *D. pellucida* and *D. pulex*; also a species of *Bosmina*, *Eurycercus lamellatus* and *Leptodora hyalina*.

A. E. Birge was the first to systematically study Cladocera in America, and his "Notes on Cladocera" furnished a basis upon

which to build. A few notes were published by the writer a little later.

A few additional notes and descriptions of new species were published in the *eleventh annual report of the Minnesota geol. and nat. hist. survey*.

Prof. Birge published other notes in the *Medical Journal and Examiner* of Chicago, which I have not seen.

Prof. Forbes of Normal, Ill., in an article in the *American Naturalist*, July, 1882, adds a number of facts and one new species.

In addition to the above, a figure of *Sida* was printed in one of Hayden's Survey Reports, and some account of the Cladocera of lake Michigan was given by B. W. Thomas, I believe, in one of the official reports of the Chicago Water Commission.

CLASSIFICATION OF THE CLADOCERA.

SUB-ORDER I.—CALYPTOMERA (membrane-clothed).

Body enclosed in a bivalve shell. Mandibles truncate below. Maxillæ distinct, spiny. Thoracic ganglia discrete.

TRIBE I.—CTENOPODA.

Feet six, similar, foliaceous, all distinctly branchiate.

FAM. 1.—SIDIDE.

Swimming antennæ with two unequal rami, intestine simple.

FAM. 2.—HOLOPEDIDÆ.

Swimming antennæ simple, elongate cylindrical (in the male prehensile), intestine with two lateral dilations.

TRIBE II.—ANOMOPODA.

Feet five (or six) pairs, the anterior pair more or less prehensile and destitute of branchiæ.

FAM. 1.—DAPHNIDÆ.

Rami of antennæ three and four-jointed, five pairs of feet, the last with a curved appendage guarding branchial sac; antennules of female short, one-jointed.

FAM. 2.—BOSMINIDÆ.

Six pairs of feet, antennules elongated, many-jointed.

FAM. 3.—LYNCODAPHNIDÆ.

Antennules of female elongated, but one-jointed; intestine simple or convolute.

FAM. 4.—LYNCEIDÆ.

Antennæ with both rami three-jointed, intestine convolute, with abdominal but no anterior cæca.

SUB-ORDER II.—GYMNOMERA (destitute of covering).

Body without or nearly destitute of bivalve shell; feet not branchiate, spiny. Anterior thoracic ganglia in one mass.

FAM. 1.—POLYPHEMIDÆ.

Abdomen curved, terminating in two long stylets.

FAM. 2.—LEPTODORIDÆ.

Abdomen straight, ending in short claws.

FAMILY SIDIDÆ.

Head separated from the body by a depression, without prominent fornices (or spreading shields) over the base of the antennæ. First pair of antennæ, or antennules, as we shall uniformly call them, one-jointed, usually rather small in the female, but extending into a very strong flagellum in the male. Antennæ long, biramose, with unequal branches. Mandibles truncate at the end. Maxillæ armed with large spines. The form is usually elongate, and the abdomen often extends beyond the edge of the shell behind. The male openings are usually in the end of long appendages which depend from the base of the post-abdomen. This interesting family is represented in America so far by four species, one of which constitutes a new genus. Others will undoubtedly be found upon a careful study of the fauna of the great lakes. Most of the species prefer the clearer and colder water of large lakes. The processes of development, as traced by the writer, vary very little from the method exhibited by *Moina*. The ephippial condition, however, is not found in these animals which are less subject to destructive influences of the climate. They do, however, produce so-called winter eggs which are laid in October and are distinguished from the summer eggs, which hatch in the brood cavity, by a brown color and the presence of fatty spheres. These eggs are produced in large numbers in distinction from most other Cladocera in which the winter eggs are very few. These eggs are permitted to settle to the bottom and there develop at the proper time. *Sida crystallina* is often found in immense numbers in large lakes which contain abundant plant growth. The size, and especially the reproduction activity, is very dependent on the environment, and hence little success is obtained in preservation in aquaria. Some of the genera are nocturnal and should be sought at the surface on quiet evenings.

I.—GENUS SIDA. Straus.

(Plate N. Figs. 12-14.)

Body elongate, hyaline. Head small, quadrate. Fornices absent. Antennules of female small, truncate; of male, with a long

flagellum. Second antennæ with the rami two and three-jointed. Male with the sexual openings just behind the last pair of feet. It is the upper or longer branch of the antennæ which in *Sida* is three-jointed, while the reverse is the case in the next genus. The only species, according to P. E. Mueller, is the ubiquitous *S. crystallina*. The *S. elongata* of Sars is distinguished by the smaller head and its concave lower margin and more elongate shell. The terminal joint of the longer ramus has one less seta than *S. crystallina*, while the post-abdomen has more numerous spines. We incline to believe it a valid variety at least. The bibliography below is extracted from a previous report:

- Daphne crystallina*, MUELLER.
Daphnia crystallina, LATREILLE, BOSC.
Sida crystallina, STRAUS, Mem. Mus. Hist. Nat.
Sida crystallina, M. EDWARDS, Hist. Nat. Crust.
Monoculus crystallinus, GMELIN, MANUEL, FABRICIUS.
Monoculus elongatus, DE GEER, Mem. servir. Hist. Ins.
Sida crystallina, LIEVIN, Branch. d. Danziger Geg.
 BAIRD, Brit. Entom.
 LILLJEBORG, De crust. ex ord. trib.
 FISCHER.
 SCHOEDLER, Die Branch. d. Umg. v. Berlin.
 Neue. Beitr.
 LEYDIG, Naturg. d. Daph.
 SARS, Norges Ferskv-Krebsdyr.
Sida elongata, SARS, " " "
Sida crystallina, P. E. MUELLER, Danmark's Cladocera.
 KURZ, Dodekas Neuer Cladoceren.
 BIRGE, Notes on Cladocera.
 HERRICK, Microsc. Entom.
 LUTZ, Untersuch. u. d. Cladoceren d. Umg. v. Bern., 1878.
 WEISMANN.
 GROBBEN, Entwicklung. Moina.
 HERRICK, Crustacea of Minnesota.

II.—GENUS PSEUDO-SIDA. Herrick. (Genus n.)

Similar to *Sida*. Antennules of the female, with a long flagellum, like that of the male of *Sida*, sensory setæ lateral. Body elongate, head short, extending into a sharp beak. The post-abdomen is armed with groups of sharp spines or bristles. Most characteristic, however, is the fact that the antennary joint, which in *Sida* is two-jointed, in this species is tri-articulate, and the two-jointed ramus has a great number of setæ (16-17).

Sp. 1. *Pseudo-sida bidentata*, Herrick. (Sp. n.)

(Plate K. Fig. 9.)

Post-abdomen armed with 12-14 clusters of spinules in a transverse row; the terminal claw armed with two long basal spines, and with numbers of fine teeth on the inside. The two-jointed

ramus of the antennæ has six setæ on the basal, and ten or eleven on the terminal joint, while the three-jointed ramus has a short terminal joint bearing three spines. The valves are marked with sparse spines on the lower margin. In most respects this species is like *Sida*, which it resembles in size. In the form of the female antennæ it is like *Latona* which it also somewhat resembles in the number of joints of the antennæ and the numerous setæ they bear. It is certainly an interesting transition form. Found only in swamps bordering Mobile bay, Ala., but whether in brackish or fresh water my notes do not inform me. *Sida crystallina* lives far out in the bay, and *Daphnella* is found in pools along shore.

III.—GENUS LIMNOSIDA. Sars.

(Plate N. Fig. 9.)

Head crested; eye in a conical prominence. Shell elongated, produced above in an acute angle. Antennules small, truncate in the female; in the male of enormous size; antennæ very long. Post-abdomen smooth; terminal claw spiny.

The one species, *L. frontosa*, Sars, is not yet known in America.

IV.—GENUS DAPHNELLA. Baird.

Neither beak nor fornices present. Antennules of female small, truncate; those of male long, flagellate. Antennæ with two-and three-jointed rami. Male with a hook on the first foot, and large copulatory organs attached to the base of the post-abdomen.

Sp. 1. *Daphnella brachyura*, Lievin.

Sida brachyura, LIEVIN, Branch. d. Danziger Geg.

Daphnella wingii, BAIRD, Brit. Entom.

Sida brachyura, LILLJEBORG, De crust. ex ord. trib.

Diaphanosoma brandtianum, FISCHER, Ergänzig. Berichtig.

Daphnella brandtiana, SARS, Norges Ferskv.—Krebsdyr.

Daphnella brachyura, P. E. MUELLER, Danmark's Cladocera.

Daphnella brachyura, LUTZ, Untersuchung u. die Cladoceren d. Umg. v. Bern.

Sida brachyura, PAVESTI, Nuova serie di ricerche della fauna pelagica nei laghi Italiani (L. Trasimene).

Daphnella brachyura, HERRICK, Notes on Crustacea of Minnesota.

(Compare also *D. expinosa*, BIRGE, Notes on Cladocera p. 3.)

The species of *Daphnella* found about Minneapolis, occasionally abundant, seems not to differ in any important character from European types of *D. brachyura*, although I formerly regarded it as distinct (*D. winchelli*, Microscopic Entom., Addenda).

Head less than $\frac{1}{2}$ the body (about .27 mm., while the body is .6 mm. long); eye about $\frac{1}{4}$ head; antennæ when reflexed extend a little beyond $\frac{2}{3}$ the length of body. Male, .7 mm. long; antennæ

reflexed, reaching base of shell; anterior antennæ extremely long; copulating organs reaching nearly to end of claws. Having carefully compared our specimens with the descriptions and figures given by Birge for his *D. expinosa*, the evidence seems to indicate not only that they are identical, but both are really *D. brachyura*. The distinctive characters of *D. expinosa* are a greater indentation between head and body, absence of caudal teeth, greater length of male appendages, and the opening of the vasa deferentia below the "instep" of these appendages.

The absence of teeth upon the post-abdomen is of even generic importance according to Sars, who gives it in his synopsis of genera as typical for *Daphnella*. In our specimens the claws are at least pectinate if not serrate, while the appendages of the male reach generally nearly to the middle of the claws. The relative length of these appendages and the antennæ of the male is variable.

Sp. 2. *Daphnella brandtiana*, Fischer.

Head as long as half the body, antennæ when reflexed reaching beyond the posterior margin of the valves. Length 0.8 mm. Of the validity of this species we can form no conclusion. It is usually considered a variety or phase of the above.

V.—GENUS LATONA, Straus.

(Plate N. Fig. 8.)

Body elongate, broad; head large and square, appendaged below with triangular laminæ; fornices present. Antennules rather large. The larger ramus of the antennæ is two-jointed and has an expanded process at the base. The lower posterior angle of the shell has a peculiar diverging set of setæ. The shell is often ornamented with numerous flecks of bright color. There is a copulatory apparatus in the male.

***Latona setifera*, Mueller,**

Is the only species, and is not yet recognized in Minnesota, but was found by Prof. Birge in lake Michigan.

FAMILY HOLOPEDIDÆ.

GENUS HOLOPEDIUM, Zaddach.

(Plate N. Fig. 11.)

The peculiar animal bearing the name *Holopedium gibberum* has the brood cavity greatly elevated, and the whole upper part of

the animal is covered by a jelly-like mass secreted as a protection or float. The antennæ are simple in the female and extend through a slit in this covering. In the male they are prehensile and have rudimentary inner rami. It would be difficult to recognize the affinity of the female with its monstrous form were it not for the male and particularly the development history. Found in this state probably only in lake Superior. Forbes mentions it from lake Michigan.

FAMILY DAPHNIDÆ.

The family Daphnidæ contains the genera *Moina*, *Ceriodaphnia*, *Scapholeberis*, *Simocephalus* and *Daphnia*, which include the commonest, as well as some of the largest, Cladocera. The genera may be distinguished by the following table:

- | | | |
|------|--|------------------------|
| I. | Head rounded, not beaked; antennules long in both sexes, shell not covering the end of the abdomen..... | <i>Moina</i> . |
| II. | Head rounded; antennules rather short; shell enclosing whole body..... | <i>Ceriodaphnia</i> . |
| III. | Head somewhat beaked below, shell angled below or extending in long spines from the lower angle, pigment fleck roundish... | <i>Scapholeberis</i> . |
| IV. | Head beaked below; shell rounded below, with a blunt spine above; pigment fleck elongate..... | <i>Simocephalus</i> . |
| V. | Head beaked below; shell extending in a sharp spine at the upper posterior angle; pigment fleck small..... | <i>Daphnia</i> . |

THE CIRCULATORY SYSTEM OF THE DAPHNIDÆ.

In the *Daphnidæ*, and, indeed, the Cladocera in general, we meet an instance of great development of surfaces at the expense of solidity of form and compactness of organs. The whole body is composed of an aggregate of laminæ, and the appendages all approximate more or less toward this fundamental modification. Thus, for example, the head is a leaf-like body with a laminate shield above and a pair of flat organs beneath. The abdomen terminates in a knife-like post-abdomen, while the thorax, with its narrow form, foliaceous feet and, far more, the enormous development of the outer wall to enclose, more or less fully, the entire body, is the typical illustration of this fact. Necessarily this structural modification exerts a formative influence on the internal organs which are all more or less influenced by it; and this is peculiarly the case with the more external and, in general, the paired organs. Thus the "shell glands," so called, which in Copepoda are generally coiled tubes, become here greatly flattened organs closely united with the shell. The physiological result of this modification is the

sensitiveness to changes in the environment, which is universal among the *Daphnidae*. The compact Copepoda survive the vicissitudes of confinement with comparative immunity, but the first taint in the water destroys the delicate organism of *Daphnia*. The cause for this may be found in the exposure of the most vital and delicate parts of the organism to the influences of the surrounding aqueous medium. In particular the circulatory and respiratory systems, which here are not easily to be distinguished one from the other, constitute a relatively very large area of close contact with the water. It thus happens that the central organs are influenced in a very short time by whatever deleterious substances may be disseminated in the water.

Notwithstanding this lack of centralization, the structure of these animals is of a very considerable degree of complexity and, presenting so many instructive modifications under circumstances so favorable for study, has been very thoroughly investigated. The very transparency which has made it possible to clear up many questionable points in crustaceology from the lessons learned in *Daphnia*, has rendered the investigation of certain sets of organs extremely difficult, and among these may be mentioned the circulatory system. The circulation of the nutritive fluid and the general facts connected with the heart were indeed early understood; but there remains many a detail and some important relations which are as yet either imperfectly known or entirely misunderstood. The following notes are offered as a contribution to the, as yet incomplete, knowledge of the circulatory apparatus.

The observations were confined for the most part to *Daphnia schaefferi* and *Simocephalus vetulus*, with occasional comparisons with *Eurycerus*, *Pleuroxis*, *Pasithea* and others. It is greatly to be desired that the study might be carried to the *Sididæ*, in which the larger size and superior transparency would doubtless reward the search with several, as yet doubtful details. The circulation of the nutritive fluid in the *Daphnidæ*, then, is somewhat complicated, but may be divided into a superficial and a deep system. It must be remarked that this distinction is arbitrary and only used for its convenience. The one extends over the entire inner surface of the carapace, while the latter is in close relation with the vegetative organs, and extends into the branchial vessels of the feet. The nutritive fluid which is normally colorless and supplied with corpuscles of organized nutriment, (it seems doubtful if they should be called blood corpuscles) is confined for the most, if not its entire, course within membranous walls of connec-

tive tissue which, however, instead of assuming a definite form as "blood vessels," for the most part conform to the contour furnished by the firmer organs.

This membrane which is frequently folded upon itself and invests the body walls and the inner organs, is in some places free, and may be seen as a pulsating, swinging film, or, more frequently, it can only be detected as a swaying line (seen in optical sections), thus giving rise to the misapprehension that one is dealing with a thread, or as moving grains, in which case the film is itself invisible but its presence is indicated by the attached grains of protoplasm. About the heart the free swaying portions of this membranous layer are so numerous as to render it almost impossible to distinguish the essential from the accidental appearances.

This membrane must serve the most various purposes; aside from the mere retention and direction of the blood currents, it is often transformed into a branchial surface. At definite points it becomes the bearer of the cells which were above mentioned as grains of protoplasm. These are most numerous in young and well-fed animals, and in particular in gravid females, while, on the contrary, mature males and females after the escape of the young, are nearly devoid of such bodies. These are most numerous in angles of the membrane, particularly about the heart, shell glands, ovaries, intestine and the branchial spaces in the feet.

These cells vary in size from that of the blood corpuscles to larger cells with nuclei of comparatively very large size. It would be too much to say that such cells are developing blood corpuscles; but that they are reservoirs of nutriment which serve to supply the increased demand upon the blood in exigencies of the existence of the animal, cannot be doubted. It is a well known fact that the number of blood corpuscles, so called, likewise varies, and apparently under the same conditions. It seems altogether probable that the two facts may be considered as supplementary, *i. e.* that the same process of depauperating of the blood, which deprives it of its corpuscles in an earlier stage, lays waste those supplies laid up in the cells referred to (whether by their actual separation as blood corpuscles or simply desolving of the contained material is of little importance). These cells also are thus parallelized with the "oil globules" of *Copepoda*. In such copepods as *Cyclops* and *Canthocamptus*, which appear to have no differentiated heart, there are always present drops of colored fluid, which are most numerous in well-fed and pregnant specimens. These

drops occupy the same relative position as the blood globules of other Crustacea, *i. e.*, they lie within a very thin membrane corresponding to the vascular walls of other animals. This membrane, in general, invests the alimentary canal, as can be very readily seen in the abdomen, where it encloses a considerable space about the intestine, which is filled with fluid, investing more or less completely the muscles and other organs. As there is no rapid circulation of blood, these "oil drops" are comparatively stationary, and yet are moved slowly by the constant contraction of the walls of the alimentary canal which, in the anterior part, or stomach, are thick and glandular, while in the abdomen they seem to be more fitted for respiratory function.

The above arrangement in *Cyclops* is correlated with its compact habit and thick carapace, and forms a simple starting-point for the study of the circulatory system in arthropods. It seems that the walls of the membranous blood cavity are themselves also, in places, furnished with muscles, so that the fluid is not dependent entirely on the vermiform or the peristaltic motions of the intestine for its escape from stagnation. If this be correct, we here have an indication of the origin of the central organ of the circulatory system.

But to return to *Daphnia*, the heart lies in the dorsal region over the intestine upon which it may be said to ride, as it were astride, though as we shall see, it is separated from the intestine by other organs. In *Eurycercus* this is most evident, as here the heart is more obviously bifurcate.

The heart and circulation in *Daphnia* has been described more or less at length by many authors, in particular *Claus* (Zur Kenntniss der Daphniden und verwanter Cladoceren. Zeitsch. f. Wiss. Zool. Bd. xxvii.) and *Gruithuisen* (the work of this author I have not seen), while *Weismann* (Ueber Bau und Lebenserscheinungen von *Leptodora hyalina*, 1874) describes the heart of *Leptodora*, and *Claus* (Zur Kenntniss des Baues und der Organ. der Polyphemiden), that of the Polyphemidæ. Other authors, except *G. O. Sars*, who elucidates some points in the circulation of blood in *Sida*, seem to have added little or nothing to our knowledge of this interesting subject.

As already often described, the heart occupies a place in a definite space—the *pericardial chamber*—the summit of which is the dorsal shield which, we believe, should be distinguished from the remainder of the so-called cephalic shield. (It is usual to describe the shell of *Daphnia* as consisting of a bivalve posterior

portion or *ormostegite*, and a simple anterior *cephalostegite*; but it seems much more proper to consider that portion of the shell which covers the pericardial space, and is the point of attachment of the powerful muscles of the abdomen and of the membranous walls of the pericardium, as a distinct portion of the carapace, as it often evidently appears through the presence of a distinct suture, or, in its absence, through the peculiar sculpture of the shell. In such case it might also be proper to distinguish two regions on the lateral appendages of this dorsal shield, an upper and a lower, separated by the more or less obvious line, extending from the union of the lateral lines of the dorsal and cephalic shield in nearly a straight line toward the posterior portion of the shell, and indicating the insertion of the muscles which move the feet and post-abdomen. The lateral walls of the pericardial space are the shell-walls themselves, and the floor is formed by a membrane supported on, and investing in part, the strong muscles which connect the abdomen with the upper anterior part of the dorsal plate. Thus a space is left between the pericardium and the intestine which is occupied by a special blood sinus leading toward the posterior and lower part of the abdomen. The posterior wall of the space is formed by a chitinous partition which bounds the brood space, or its homologue, and is connected by chitinous processes (*stutzbalken*) with the outer skeleton. The anterior, on the other hand, is only bounded by the supporting ligaments of the abdomen above described and membranous partitions. As usually described, the heart lies suspended in the cavity thus defined, by slender muscular threads, more or less like those of the heart of *Corethra* larvæ and the like; and such seems to be the case at first, but a more careful study shows that this is far from correct. On the contrary, the chief supports of the heart are membranes which, seen in cross-section with the attached grains or blood globules, assume the appearance of exceedingly slender structureless threads. The action of re-agents indicates that these supposed threads are not muscles, but composed of connective tissue; while by changing the focus the sharpness of the line is frequently not altered, but *its relative position is changed*,—a simple test which often serves to dispel an illusion of this sort. That there are some threads of the character above mentioned is not to be doubted, as in connection with the valves of the heart; but the proper support of the heart is found in the membranes which invest it in part, and are reflected upon the walls of the shell and, anteriorly, of the intestine. It is not yet possible to fully describe

the insertion of these tissues, as there is so large a number, especially about the anterior opening, where they lie in all directions and at all angles, and are so transparent, that only their vertical sections appear as dark lines. Thus the same membrane appears and disappears, only to re-appear in a different position where it might be readily taken for a distinct membrane. In general, however, I hope to make no serious error in the following summary. Before going into detail, however, it will be necessary to consider the intimate structure of the heart, as well as its general shape and position.

The general shape is that of an irregular oval with the greatest convexity posterior (*Daphnia*, etc.), or it may be strongly bifid and thus somewhat Y-shaped (*Eurycercus*, etc.). It is held in position in the pericardial cavity by the membranes above alluded to, to which it is attached at definite points, the principal of which are two slight enlargements on the lower posterior portion, which are in part opposed to each other and also to a superior posterior point of insertion. All three of these points are thus held in relation with the shell with which the attached membrane is connected on either side below and above. The membrane then extends part way along the heart wall towards the anterior and is then reflected to the shell wall. The result of this is that the pericardial space is an angular cavity opening in front. It would seem as though the membrane attaching the heart were identical with that lining the cavity itself. The heart proper is obviously composed of series of muscular elements, which are considered as simple cells by Claus, and which in young individuals show very distinct nuclei of comparatively large size. These are arranged like the meridian lines of a globe uniting above and below, thus forming the most effective apparatus possible for contracting the heart. In the smaller Daphnidæ, as stated by Claus, there seems to be but a single layer of muscular rays, but in *D. schæfferi* and *Simocephalus* I have repeatedly satisfied myself that some of the longitudinal rays sink below the others and form a series of *longitudinal muscles*, as stated by earlier writers. These are furnished with a nucleus which is frequently more or less external, appearing like a spherical appendage. In *Leptodora* Weismann has shown the heart to consist primarily of a membrane of connective tissue, upon which the muscular fibres or cells sit in somewhat the same position as in *Daphnia*, except that there is not the same regularity in the arrangement. There are many considerations which would lead us to expect the same structure in *Daphnia*, though it is not yet

demonstrated; and the structure of the anterior opening seems to point in the same direction. At any rate there is a close connection between the muscular and connective parts of the heart. We have, then, in the heart of *Daphnia* a highly developed apparatus for closing it, but apparently none for its opening. This certainly is not accomplished by the few fibers which connect the heart with the shell, the very contractility of which is doubtful. Nay, more, these are insufficient even to hold it in its place in the cavity. Still less can we assume that the heart, from any inherent power, can open itself. This must be explained by the operation of two factors which are interdependent, *i. e.*, the elasticity of the supporting membranes and the unequal pressure of the blood in different parts of the body. 1. The membranes which support the heart are attached not at right angles, but, on the contrary, in a direction more nearly parallel to the walls of the heart, and thus whatever elasticity they possess is greatly increased; and the diminishing of the size of the heart draws these membranes out of their position at the expense of their elasticity, which tends to restore them to their original position when the pressure is removed, in the same way a drum-head returns after a blow to its normal position. This factor is, however, only operative so long as the whole system of membranes to which these belong is distended with fluid. If this blood cavity be punctured, the fluid flows out and the heart shrivels. It may continue to beat for some time, but it will be seen that the effort consists simply in a vigorous contraction which is followed by no perceptible enlargement. 2. After the systole the blood of the heart is forced toward the head, whence it is prevented from re-entering the pericardial space directly by the valves and the membrane enclosing the arterial blood. The pressure is therefore increased in all parts of the system, except the pericardial chamber where it is greatly diminished. The membranes supporting the heart are thus unusually tense, and the muscular effort having ceased, the walls of the heart are distended, and blood flows in in the direction of the least resistance through the two lateral openings or ventral valves of the heart. The contraction of the heart during the systole is not simultaneous in different parts, but begins by the contraction of the posterior part where, being nearly free, the motion is more marked. At the close of the systole the heart is irregularly contracted, the points of attachment above described being more distended than the remaining portions. The anterior of the heart is rendered very difficult to study by the fact that its opening is

covered by the muscles of the mandibles and obscured by the many supporting and vibrating membranes alluded to.

It is, however, suspended by two folds of membrane which I have been inclined at times to believe blood-vessels through appearances resulting from the confused currents flowing about them. The upper margin is also attached by a pair of cords directly to the superior part of the shell. The anterior opening or arterial valve is most perplexing, and the following description which applies only to *Daphnia schæfferi* must be subject to some doubt. It appears however that it has been in a measure misunderstood by previous writers, and namely by Claus, who compares it with that of *Leptodora*, which if correctly described by Weismann, is not at all identical in form, but quite comparable with one of the sides or lips of the venous opening. It does not seem to be connected by a thread, as stated for *Leptodora*, with the aortal bulb, for in reality there is no aortal bulb; the heart simply is connected with the system of membranes which more or less inclose the system. The floor of the so-called aortal space is a membrane which separates the outflowing stream from a current which flows toward the abdomen and passes directly under the arterial opening, so that it appears as though there was a stream entering the heart from before as well as at the sides; the arterial opening being nearer the dorsal part of the heart than is naturally expected, and the slight enlargements at the attachment of the supporting membrane favoring the impression that there is here a veritable opening. The out-flowing blood stream is bounded at first by the membrane above mentioned, which is farther on reflexed onto the shell and intestine so that the streams in the head flowing just under the shell are separated from the deep dorsal stream flowing from the heart.* This main current passes to the region of the eye between the horns of the cæca of the alimentary canal, and thence beneath the stomach, and here divides, part becoming external and a deeper part passing under the intestine, thence in front of the heart, flows into the deep sinus which, as before said, passes beneath this organ. Other portions of the returning stream flow around the angle of the union of the head and body and constitute a stream just above the feet in which the current flows vigorously.

Yet other portions flow into the region of the shell-gland and are united with blood which here passes through the numerous sinuses described by Claus as surrounding this organ (Die Schalen-

*In *Pasilthea rectirostris* this septum is easily seen as a swaying membrane, which near the eye is reflexed to the top of the shell.

druse der Daphnien) and thence flows into the abdomen, uniting with the other two streams. A part also of the current in the head flows into the antennæ where it follows a deep course through the basal joint in which the corpuscles may be seen to emerge to the surface from two points where are spaces between the powerful muscles, the first being near the base and the second near the extremity of this joint, and then to return and join the superficial current.

The corpuscles appear to enter the rami very rarely if at all. That part of the superficial stream which reaches the interior of the pericardial chamber passes between the muscles of antennæ and jaws and seems to find its way into the great current beneath the heart, though I have also thought to have seen it flow directly into the pericardial space as the lateral superficial streams do. That part of the superficial stream which reaches the posterior margin of the shell returns through a canal formed by the walls of the shell and the brood-space, between the "stutzbalken" of which the blood corpuscles can be seen to glide more rapidly than in the free lateral spaces.

Lastly, it only remains to follow the fortune of the strong stream flowing along the neutral surface of the abdomen. The strong current flowing beneath the heart enters a broad sinus which lies over the intestine and extends for over a third of its length, where its walls unite with the surface of the intestine above and thus open downward on either side.

The stream thus directed flows toward the openings of the base of the feet. The structure of the branchiæ has not yet been clearly described. Instead of nearly spherical or oval chambers they are really tubes which connect, on one hand with the opening above, and below with the general cavity of the limb, whence the blood returns to the abdomen. The current is very rapid through these tubes. The blood having been returned to the abdomen, courses in the well known manner through the post-abdomen and flows over the intestine, thence over the back-flowing stream to the posterior lower opening of the pericardial chamber.

The study of the actions of the heart is rendered more difficult by the fact that in order to secure the greatest possible transparency, the living animal must be covered and a little pressure applied, which is frequently attended with abnormal variations of the circulation. In particular if the usual exit of the blood be stopped by the cæca of the intestine, as is frequently the case, the operation of the heart may be reversed, when a vigorous stream may be

seen to enter the arterial opening and emerge from the ventricles. This process would be impossible if the anterior valve were as described by Claus and Weismann; while being really more like the venous valves, it is easily and frequently permitted. The current of the blood in this case stagnates except near the heart.

The rapidity of the pulsations of the heart varies with age and condition of rest or motion.

In *D. schæfferi* this variation may range from about 150 per minute to perhaps 250, 200 being probably a fair average. In a young *Simocephalus* I have observed a heart beat 300 times in a minute. Again, in a specimen of *D. Schæfferi* at rest the heart was beating 170, but during the spasmodic motion of feet and antennæ the pulse rose to over 200.

I.—GENUS MOINA. Baird.

The systematic position of this genus has been the theme of some discussion, it being claimed, with good reason, that there are many resemblances to the Lyncodaphnidæ (P. E. Mueller considers it a transition to the Bosminidæ and lyncodaphnids); on the other hand, Leydig and Kurz regard it more closely allied to the Sididæ, with equally good reason. The long antennæ, long narrow antennules and many peculiarities in form, etc., suggest the macrothroid crustaceans; the extended abdomen and especially the location of the male seminal opening are like *Daphnella*, which *Moina* resembles in motion and habit very strikingly. The absence of the pigment fleck is no more a characteristic of the Sididæ than of other groups. After all has been said, the immediate affinities of the genus are acknowledged to be with the Daphnidæ.

The true place of the genus, as it appears to the writer, was hinted at by Birge (Notes on Cladocera). *Moina* seems to be the pivotal point of the Cladocera, at least of the families above mentioned. Without going into phylogenetic speculation, it is suggestive that this genus can and does by preference live in very impure water and may therefore have had an early origin. From *Moina* diverges the stem of the Daphnidæ by way of *Ceriodaphnia*, *Simocephalus* and *Daphnia*. These two latter genera are intimately connected by *Simocephalus daphnoides*, Herrick. *Scapholeberis* is connected with *Ceriodaphnia* through *S. angulata*, Herrick. The Sididæ seem to diverge by the way of *Daphnella*, through which by means of *Pseudo-sida* the genus *Sida* is reached, and finally *Limnoscida*, *Latona* and *Holopedium*. The relationships of the curious *Polyphemidæ* are less evident.

The Lyncodaphnidæ make an easy transition to the Lynceids proper, while the Bosminidæ are still quite isolated, but are suggested by *Macrothrix pauper*. The fact that *Moina* stands thus related to radiating groups is simply suggestive, but it is suggestive of its possible antiquity and synthetic character.

The three species of this genus stand very poorly distinguished from one another and their specific validity may be doubted.

The most exhaustive study of the embryology of the Cladocera was based on *Moina*. (*Grobben, Entwick d. Moina, etc.*)

The genus is characterized by Weismann and Gruber¹ about as follows:

Head prone; separated by a depression from the thorax; fornices obscure; rostrum none; pigment fleck absent; antennules of the female large, moveable, furnished with a sensitive seta near the middle, flagelliform; antennules of the male very large, hooked at the end. The setæ of the antennæ are all ciliate; the tri-articulate ramus with five setæ; posterior margin of the valves thicker in the median line; caudal setæ very large, about twice in the length of the animal; anus above the claws; feet of the first pair of the male with a strong hook.

Weismann has shown that both summer and winter eggs originate from groups of four cells, one of which only is transformed into the egg, the remaining three serving simply as a supply of nourishment for the egg, which absorbs it directly. Both eggs and nutrient cells develop from the epithelium of the termination of the ovary. The summer eggs have less yolk than the winter brood, and the yolk is bluish in the summer eggs and deep red in the winter eggs of *Moina rectirostris*; while in *M. paradoxa* the summer eggs have yellow and the winter set snow-white yolk. There are never more than two winter-eggs in any of the Daphnidæ, but there are as many as twenty summer eggs in some cases in *Moina*. In *M. rectirostris* only one winter egg is produced, which is one of the best distinctions of the species, as this is, perhaps, the only case. (*Naturgeschichte der Daphnoiden, Weismann.*) The first generation, springing from the winter eggs (impregnated eggs), is composed solely of females which reproduce parthenogenetically; the second brood contains sexual males and females, thus completing the cyclus.

¹ *Ueber einige neue oder unvolkommen gekannte Daphniden, Freiburg, 1877.*

Sp. 1. *Moina rectirostris*, Mueller.

(Plate A. Figs. 2, 5, 8, 10, 11.)

A. Var. vera.

- Daphnia rectirostris*, O. F. MUELLER, LATREILLE, BOSC, DESMAREST, SCHRANK, LEYDIG.
Monoculus rectirostris, GMELIN, FABRICIUS, MANUEL, JURINE.
Pasithea rectirostris, KOCH.
Moina rectirostris, BAIRD, WEISMANN, KURZ, BIRGE.

B. Var. brachiatus.

- Monoculus brachiatus*, JURINE.
Daphnia brachiata, DESMAREST, EDWARDS, LEYDIG.
Moina brachiata, BAIRD, WEISMANN.

C. Both varieties.

- Moina brachiata*, P. E. MUELLER, LILLJEBORG.

The only tangible difference between the two forms thus united is the fact that *M. rectirostris* produces but a single winter ovum and hence has a one-chambered ephippium, while *M. brachiata* has a two-chambered ephippium.

The head is separated from the thorax by a marked depression; there is a deep depression above the eye; the margins of the shell have few bristles. The post-abdomen, which extends far beyond the edge of the valves, bears about eleven hairy spines on either side, the lower spine being two-cleft at the end; the base of the claws bears a comb of small teeth, and the posterior margins are bristled. The ephippium is oval; and the single cavity in *M. rectirostris* has its longer axis horizontal, while the two cavities of *M. brachiata* are vertical. The depression above the eye is deeper in the males, in which sex also the antennæ are longer and bent at the middle. The seminal bodies are stellate. Length 1, 2 mm. The form is subject to the greatest variation due to the varying number of summer eggs. Birge finds this species abundant. I have found both this and the following species in various parts of the Mississippi valley from Mobile to the upper river region.

Sp. 2.—*Moina paradoxa*, Weismann.

(Plate A. Figs. 1, 3, 6, 7, 9.)

The species differs in a few very insignificant points from the previous one. The head is short and nearly evenly convex above, with no deep depression above the eye; teeth of terminal claws reduced to bristles which are only a little longer than the series extending down the claw as in the above species; the first

¹Gruber and Weismann, ueber einige neue oder unvollkommen gekannte Daphniden Freiburg, 1877

foot of the male is furnished with a long bristle; the lower shell margins are more bristly than in the previous forms; the ephippium has two cavities, while the seminal bodies are crescent-shaped.

Sp. 3.—*Moina micrura*, Kurz.

This form may be of specific value, but it is not sufficiently distinguished to make this certain. As described by Kurz, it seems to be smaller (1 mm.) and most to resemble *M. paradoxa*, which was not at that time described. The post-abdomen is short and has few (6) spines, while the terminal claws are short and smooth; the head has a sinus above the eyes; the eyes are smaller, with numerous lenses; the antennules are shorter (?) than in *M. rectirostris*; the mandibles are partly exposed, while the shell margin overlying is notched. Males and ephippial females were not observed. Not distinguished in America.

II.—GENUS CERIODAPHNIA, Dana.

The genus *Ceriodaphnia* is the successor to *Moina*, which some species greatly resemble; the post-abdomen, however, is shorter and has a habitus resembling *Daphnia*; the antennæ are smaller, and the shell is thick and coarsely reticulated.

Ceriodaphnia has the same general mode of life as *Moina*, living in muddy pools in late summer and bearing numerous broods which often greatly extend the brood cavity. The antennules are shorter but have a similar form; the male antennæ show a transition in the various species from forms adapted for prehension to such as are found in *Daphnia*. The brood cavity is closed by two ridges on the abdomen instead of one, as in *Moina*, or three, as in *Daphnia*.

The ephippium contains but a single ovum. In general, the form is oval or quadrate, angled but not spined posteriorly; head separated from the body by a deep depression; pigment fleck present; beak absent; antennules moveable, rather short; antennæ with the three-jointed ramus with five setæ; first foot of the male with a hook or flagellum.

The members of this genus are danger signals from a hygienic point of view, for they frequent water containing decaying matter; as many as 1,400 were counted in a single quart of such water. The genus is particularly perplexing, as the varieties named seem to be hardly entitled to specific rank and are so similar as to require great care to properly distinguish.

The following artificial key, it is believed, will assist in placing the specimens which may be obtained in America. There seems no reason to doubt that our fauna is very similar to that of north Europe. Of the twelve species here enumerated at least one-third may be synonyms and others of the remainder are with difficulty distinguished.

ARTIFICIAL KEY TO THE GENUS CERIODAPHNIA.

A. Shell irregularly striate.

1. *C. megops*, Sars.
2. *C. cristata*, Birge.

B. Shell with hexagonal meshes.

a. Shell with doubly contoured markings.

(aa) Head broad, short.

3. *C. pulchella*, Sars.

(bb) Head narrowed, depressed.

4. *C. rotunda*, Straus, (antennules normal.)
5. *C. alabamensis*, Herrick, (antennules elongate.)

b. Shell simply marked.

(cc) Claws with teeth.

6. *C. reticulata*, Jurine.

[7]. *C. dentata*, Birge.

(dd) Claws without teeth.

I. Antennæ very long.

8. *C. punctata*, P. E. Mueller.

II. Antennæ normal or short.

* Post-abdomen broad.

9. *C. laticaudatus*, P. E. Mueller. 1 mm. long.

[10]. *C. consors*, Birge. 0.5 mm. long.

** Post-abdomen narrow.

† Head not angled behind the eye.

11. *C. quadrangula*, Mueller.

†† Head abruptly angled behind the eye.

12. *C. scitula*, Herrick.

C. Shell reticulate with rectangular meshes.

13. *C. nitida*, Schoedler.

[14]. *C. textilis*, Dana.

Sp. 1. *Ceriodaphnia megops*, Sars.

(Plate A. Figs. 16, 20.)

Ceriodaphnia megops, Sars, P. E. MUELLER, KURZ. (The earlier synonymy is doubtful. See note, page 26, Schoedler's *Neue Beiträge zur Naturgeschichte der Cladoceren*.)

This species is one of the largest and most readily distinguished as well as rarest of the genus. Very characteristic is the fine anastomosing striation which breaks up into reticulation only near the shell margins. This species seems to form the transition toward *Simocephalus* with *Scapholeberis*, which, however, diverges along its own peculiar track. The length is sometimes 1 mm. The head is obscurely angulated in front of the antennules, which are large. The antennules of the male are long and have a hooked setæ at the end.

Typical *C. megops* has not yet been found in America, but the following form takes its place.

Sp. 2 *Ceriodaphnia cristata*, Birge.

The description given by Birge would apply in almost every particular to *C. megops*, though he seemed to overlook the close conformity. The size is much less (0.7 mm.), and the post-abdomen seems more abruptly truncate; moreover the number of anal spines is less. The crest upon the dorsal margin may be the effect of prominences such as are described by P. E. Mueller; at any rate, in view of the fact that but few specimens were discovered, the suggestion lies near that *C. cristata* is the young or, at least, a reduced form of *C. megops*.

Found at Southampton, Mass.

Sp 3.--*Ceriodaphnia pulchella*, Sars.

(Plate A. Figs. 14, 19,)

Ceriodaphnia pulchella, Sars, P. E. MUELLER, KURZ.

Very much like *C. reticulata*, but smaller. Head large, turgid, and angled in front of the antennules, forming almost a right angle; fornices moderate; antennules rather large; shell oval, reticulated with double contour lines; post-abdomen of medium size, narrowed toward the end, slightly truncate, with about nine spines; terminal claws short, smooth. The flagellum of the male antennæ is but slightly hooked, 0.5—0.6 mm. long. This species is not certainly identified from America, though a form with smooth claws and small fornices occurs with *C. dentata* in some places.

Sp. 4. *Ceriodaphnia rotunda*, Straus.

(Plate B. Fig. 1. Plate A. Figs. 13 and 23.)

Daphnia rotunda, STRAUS, BAIRD.

Ceriodaphnia rotunda, SCHOEDLER, Sars, P. E. MUELLER, KURZ.

As said by Kurz, this species is not easily mistaken; the small head (only paralleled by the following), the very evident reticulations and the broad abdomen give it a peculiar habitus which is unmistakable.

Head depressed, small, spiny below, not angulated; fornices prominent, thorned; body rotund, almost spined above; shell doubly reticulate; post-abdomen broad, with seven or eight anal spines; claws large, smooth. The male antennules are little larger than those of the female. I have not yet seen this species in America.

Sp. 5. *Ceriodaphnia alabamensis*, Herrick,

(Plate B. Fig. 2.)

(American Naturalist, May 1883. Plate v, Figs. 11, 12.)

This species was seen but once and is insufficiently known. The body is elongate, quadrate, the shell reticulated with double contour lines, the head very small and produced downward below the eye, which is very small, the antennules are longer than in any other species, obviously two-jointed, with a lateral seta; the antennæ are very long; post-abdomen long and rather narrow, with the margins nearly parallel, truncate at the end, with over nine anal spines; claws smooth, abruptly truncate. My drawing represents a daphnia-like set of processes for closing the brood cavity. Length 1 mm. (?)

Tuscaloosa, Ala.

Sp. 6 *Ceriodaphnia reticulata*, Jurine.

Monoculus reticulatus, JURINE.

Daphnia reticulata, BAIRD, LEYDIG.

Ceriodaphnia quadrangula, SCHOEDLER.

Ceriodaphnia reticulata, SARS, P. E. MUELLER, KURZ, HERRICK.

Head long, obscurely angled in front of the antennules; fornices very prominent; antennules small; post-abdomen of moderate size, rounded at the end, slightly tapering; about eight long anal teeth; terminal claws with a series of sharp spines at the base. The reticulations are sharp but simple. The flagellum of the male antennule is either straight or moderately curved. Kurz says that some varieties have the fornices blunt while others are sharp. I have seen only the blunt form which is then much like the next.

Sp. 7. *Ceriodaphnia dentata*, Birge.

This form differs from the above only in having the inside of the claws fringed with minute bristles (sometimes absent), the angle

of the head being more marked and the fornices less prominent. It is difficult to say whether our Minnesota specimens most resemble this or the typical *C. reticulata* of Europe. They seem intermediate, some having fornices with an abrupt angle. It may be instructive to quote Kurz on the European *C. reticulata*—"Examples occur 0.8-0.9 mm. long, others on the contrary only 0.5-0.6 mm. long and combining with the smaller size some differential characters. In the larger variety I found the fornix obtuse, while in the smaller it extends in a sharp thorn directed upward and outward. In this small sub-species the secondary teeth of the claws of the post-abdomen seemed to be absent, though in *C. reticulata* 3-5 are constantly present."

Sp. 8. *Ceriodaphnia punctata*, P. E. Mueller.

(Plate A. Figs. 1-3.)

Head depressed, rounded at the end, not angulated, ornamented with minute spines within the hexagonal areas. Fornices slightly prominent, either smooth or spiny; antennules very long; shell rotund, reticulated; post-abdomen of medium size, width nearly uniform, truncate below at an obtuse angle; anal spines large, increasing toward the end; claws smooth. Length 0.7-0.9 mm.

Found as yet only in Scandinavia.

Sp. 9. *Ceriodaphnia laticaudata*, P. E. Mueller.

(Plate A. Fig. 22.)

Ceriodaphnia quadrangula, Sars, (fide MUELLER.)

Head small, depressed, rounded at the end, not angulated; fornices prominent; shell roundish, or sub-quadrangular, moderately reticulated; antennules rather large; post-abdomen broad, narrowed from the middle to the end; the nine or ten small anal spines nearly equal; claws large and smooth. In P. E. Mueller's time males unknown. Length 1 mm. Specimens 0.6 mm. long from Minnesota agree in most respects, but the reticulation is very marked and irregular and the terminal claws are pectinate. This form constitutes a transition to the next.

A species related to *C. laticaudata*, but only half the size, was found in Clarke's lake, a small but very deep pool, containing a fauna like that of the great lakes. The appearance is like the small form alluded to under that species, but the claws are smooth, the head is slender and strongly angled behind the eyes, and the antennules are of rather large size. The fornices are not very

prominent. The shell is large-reticulate and the abdomen is large and obliquely truncate, the anal teeth being very large and strongly curved. The only individuals seen were ehippial females measuring .55 mm. This may be.

Sp. 10. *Ceriodaphnia consors*, Birge.

This species differs from *C. laticaudata* in one or two points, being about one-half the size and having fewer caudal teeth. Birge says the abdomen is broad and obliquely truncate. The difference between being obliquely truncate and narrowed at the end in some circumstances disappears, so that really this species seems quite close to *laticaudata*.

Found in Madison, Wis.

Sp. 11. *Ceriodaphnia quadrangula*, Mueller.

(Plate A. Figs. 17-18.)

Daphnia quadrangula, O. F. MUELLER.

Daphnia reticulata, BAIRD.

Ceriodaphnia quadrangula, P. E. MUELLER.

Head depressed, rounded at the end, only slightly angled; fornices prominent, antennules large; post-abdomen narrow, of equal width for the lower half, rounded at the end, with about eight small spines; claws smooth, length about 0.6 mm. This species resembles a smooth-clawed *D. reticulata*.

Sp. 12. *Ceriodaphnia scitula*, (Sp. n.)

(Plate B. Figs. 5-7.)

One of the most abundant species of *Ceriodaphnia* in Minnesota is a large form much resembling *C. quadrangula*. The post-abdomen is exactly as in *C. reticulata* or *C. dentata*, which latter it resembles in having a sharp angulation in front of the antennules. The shell is oblong and heavily marked with minute, regular hexagonal lining; the upper angle is rather sharp. The head is closely appressed, the fornices are prominent and abruptly truncate at the tip, the eye is small, the pigment fleck also small; antennules short. The post-abdomen is of moderate size, narrowed toward the end and armed with about ten powerful curved spines; the terminal claw itself is large and curved, armed only with fine spines extending down the entire inner side. The size is 0.8—1.0 mm.; color pinkish, opaque; antennæ, especially, often bright pink. Male 0.6

mm., flagellum of the male antennæ long; sensory filaments lateral, also one anterior, lateral flagellum.

Distinguished from *C. quadrangula* by the prominent fornices, large anal spines, small reticulations, form of head and larger size.

A small variety resembling the above very closely is the commonest form in our larger lakes; the reticulation is commonly larger but less distinct, the head is depressed and narrowed, with a sinuous upper outline. The fornices are prominent and the form of the post-abdomen is exactly as in the last. The spines of the post-abdomen are very long and seated on small eminences. The length hardly exceeds .55 mm. The claw is densely ciliated, but not spined; these smaller forms have but few eggs (two). The young have a thorn on the angle of the fornices. Plate J. Fig. 1 represents the ehippial female of this species. There seems no reason to doubt that this is only a variety of *C. scitula*. The small form of *C. reticulata* mentioned by Kurz might be referred here, while the larger form with less prominent fornices is not so different from the American *C. dentata*.

Sp. 13. *Ceriodaphnia nitida*, Schcedler.

Ceriodaphnia quadrangula, LEYDIG.

This species seems to be characterized by the quadrangular form of the meshes of the shell-markings and the presence of teeth upon the claws.

Sp. 14. *Ceriodaphnia textilis*, Dana.

This species is not sufficiently fully figured to allow of a suggestion as to its affinities.

Daphnia rotundata, Say, is very probably a member of this genus, though the description is hardly intelligible. "Body rounded behind; upper antennæ three-branched, a small spine above at the joints; lower five-branched; color white. Length 0.5." It is probable that we should read "upper branch of antennæ with three setæ", etc., in which case we may identify the above with *Chydorus* or the like.

III.—GENUS SCAPHOLEBERIS.

The genus *Scapholeberis* stands rather closely related to *Ceriodaphnia*, from which it is at once distinguished by the angled or spined lower posterior angle of the shell. The head is rather

clumsy, and the continuation of the fornices runs toward the apex of the incurved beak, which commonly lies within the valves of the shell. The lower anterior angle has a prominence and there is a basin-shaped area inclosing the base of the antennæ, part of which lies on the shell and part on the head. This area is more strongly lined or reticulated than the rest of the shell. The lower margin is straight and terminates, in most forms, in a long scythe-shaped spine which is directed backward. The shell itself is usually indistinctly reticulate or unmarked, and commonly is deep colored. The post-abdomen is very like *Ceriodaphnia* or more as in *Simocephalus*; the anal spines are few and the older specimens have more than the young; the place at which additional spines are to appear is marked by prominences. The eye is of moderate size, the pigment fleck rather small and the antennules short and hidden by the beak. The antennæ are of small size and generally dark colored. The ephippium contains but one egg; the males do not have altered antennæ or feet. The sexual periods fall in early summer and in autumn, according to Weismann; the males appear but sparingly. The species *S. mucronata* is very abundant everywhere, while the others are less frequently seen.

Sp. 1. *Scapholeberis mucronata*, Mueller.

(Plate J. Fig. 5.)

Daphnia mucronata, MUELLER, LEIVIN, LILLJEBORG, FISCHER, LEYDIG, BAIRD, HERRICK.

Scapholeberis mucronata, SCHOEDLER, P. E. MUELLER, KURZ, WEISMANN, BIRGE, HERRICK.

This well-known species with rather short spines below is found abundantly everywhere. In this country at least it is characterized by a dark color. The head is large, rounded in front of the large eye, serrate below and extending posteriorly into a roundish beak, back of which are the short antennules. The fornices are very short and rounded; a line connects the fornices with the beak by a sudden deflection downward; it sets off the area which forms a part of the basin of the antennæ. A second line springing from just above the termination of the fornices passes over the eye by a broad curve. The post-abdomen is truncate and bears beside the terminal claws four or more spines which rapidly decrease in size. The claws are minutely spined; the spines on the shell are of variable length, but do not exceed one-fourth the length of the remainder of the lower margin. This species ranges over all Europe and eastern United States.

Length 0.6 mm.—0.8 mm.

Sp. 2. Scapholeberis cornuta, Schcedler.

(Plate T. Fig. 6.)

Monoculus bispinosus, DEGEER.*Daphnia mucronata*, var. *acule rostrata*. BAIRD.*Scapholeberis mucronata*, var. *fronte cornuta*, P. E. MUELLER.

This species differs from the above only in having a sharp curved horn on the head in front of the eye. The use of this appendage can only be conjectured; but it may be that, like the curved beak of *Ripophilus*, it serves to clear away rubbish in the filth in which these animals frequently live. This form, be it variety or species, is not known in America.

Sp. 3. Scapholeberis armata, (Herrick.)

(Plate B. Figs. 10-11.)

Scapholeberis mucronata, var. *armata*, HERRICK.

A very beautiful and unique species, which possesses the extreme development of the peculiarities of the genus. The head is shaped very much as in the previous species, the fornix is squarish, the basin for the antennæ is small. The upper lines from the fornix meet behind the eye; the form of the shell is as in the above, but the spines upon the lower margin are longer. The scythe-like spine on the lower angles of the valves is extremely long, falling little short, in extreme cases, of being as long as the entire lower margin, in others about one-half as long. There are the usual lines parallel to the lower edge of the shell. The specimens having the longest spines were found in fresh water about Mobile, Ala., but the species occurs in Minnesota and intermediate points, though sparingly.

Sp. 4: Scapholeberis nasuta, Birge.

Form much as in the last, head shorter, "prolonged into a rather sharp beak, at whose apex the continuations of the fornices unite. The beak does not project downward as in *S. mucronata*, but backward, and in its natural position lies between the valves." The usual reticulated and lined areas are present and the balance of the shell is covered with "small pointed projections." "The antennules are much larger than in *S. mucronata*, though they do not project beyond the rostrum." The pigment fleck is long and large; the post-abdomen is much as in the preceding species; the terminal claws have several fine teeth. The males have the open-

ing of the vas deferens close behind the terminal claws; mucro short and blunt, length 1 mm. This species is very near the next, but differs in several particulars. It forms the transition to the next, which is the extreme of the genus in a direction converse to that pursued by the *S. armata*.

Sp. 5. *Scapholeberis angulata*, Herrick.

(Plate B. Fig. 9. Plate T. Fig. 7.)

American Naturalist, 1883.

Form as in the above, but comparatively larger; valves quadrangular, anterior margin strongly arched; head short, only slightly concave below the eyes; the beak is as in *S. nasuta*, but seems to be directed more nearly directly downward than in that species. The antennules are long and resemble those of *Simocephalus*. The pigment fleck is square and rather large; the antennæ are of the usual size. The reticulated areas are as in the other species. The post-abdomen is more as in *Daphnia*, not so squarely truncate and with five to seven large teeth; the first foot has one elongated jointed seta; the posterior angle of the shell has no spine, at most there is a somewhat prominent acute angle, the inner shell layer is armed at this point with some elongated teeth as in the corresponding situation in *Simocephalus*. On the whole, there is a similiarity to that genus in this as well as in the previous species. *S. nasuta* has a short spine and elongated pigment fleck; the present species has a squarish but rather large fleck and no spine; the post-abdomen has a greater number of spines than any other species. South of Tennessee river, in Alabama and Mississippi.

The species of this genus are predominatingly American, four out of the five being found in the United States; the fifth, moreover, is more often regarded a variety of one of the others; in fact, the absence of *S. cornuta* from America is one of the most important supports of the specific independence of the two forms. All the species delight in disporting themselves near the surface in sunny weather.

IV.—GENUS SIMOCEPHALUS.

Although a very well circumscribed group, this genus passes into the next rather directly by means of *S. macrothroides*. The connection on the other hand seems to be by the way of *Scapholeberis*, though there is a rather broad separation between even *Scapholeberis angulata* and any known *Simocephalus*. The en-

larged spines near the angle of the shell and the form of the antennules as well as some other points, show a transition through that species toward the present genus. The general form is quadrate with the lower posterior margin sinuate; in young specimens the shell is nearly a perfect rectangle. The upper margin is produced more or less at the point of union with the free posterior margin and the shell is either arched or very abruptly angled above the prominence in old females. The head is produced into a projection at the eye while the beak proper is between the anterior margins of the valves; the pigment fleck is rather large and variously shaped. The fornices are larger than in *Scapholeberis* and extend to the front of the head over the eyes; the antennules have a lateral flagellum which is large and lance-shaped. The post-abdomen varies very little in shape; it is truncate and excavated below and very broad. The anal teeth are few, large, curved, pectinate; the claws are straightish and pectinate or spined; the labrum is shaped as in *Daphnia*; the anterior part of the stomach has the usual cæca.

The members of this genus are among the most abundant and conspicuous of the family and are more persistent during the changing seasons than any other form. *S. vetulus*, the commonest species, stands in the centre of the genus, while two extremes are expressed by the other members of the group.

The winter or sexually produced eggs are lodged in an ephippium or saddle-like modification of the shell, which is finely reticulate; while the shell is usually marked by fine anastomosing lines which, in some species, show clearly their derivation from a rather fine hexagonal marking.

The sexual periods, when males are produced, occur in autumn and spring. The males have few distinguishing characteristics, the form being that of the young female.

The opening of the vasa differentia is back of the anus, hence these ducts cross the course of the intestine. They have ejaculatory muscles about the lower part. The smaller species are frequently deeply colored with pink, purple and brown fatty deposits and the markings are more conspicuous than in the American *Eurycercus*, which is itself often brightly spotted with blue or purple. The aspect in the water is between that of *Eurycercus* and *Daphnia*.

The first mention made of any member of this genus in America is Say's description, repeated in Dekay's *Crustacea of New York*, of *Daphnia angulata*. This description which follows is quite suffi-

cient to identify the genus, and indeed to indicate that either *S. americanus* or a related form is intended, but it is hardly competent to alter names the significance of which is quite clear.

"Sides striate with numerous parallel minute oblique lines; hind edge of the body with a prominent angle in the middle. Antennæ with four filaments on the upper and five or the lower branch. Color white or red. Length 0.1; stagnant water in the forests of the Southern States."

Sp. 1. *Simocephalus vetulus*, Mueller.

Daphnia vetula, BAIRD, HERRICK.

Daphnia sima, MUELLER, LATREILLE, BOSC, RAMDOHR, GRUITHUISEN, DESMAREST LAMARCK, M. EDWARDS, KOCH, GMELIN, MANUEL, JURINE, LILLJEBORG, LEYDIG.

Simocephalus vetulus, SCHOEDLER, P. E. MUELLER, KURZ, WEISMANN, CLAUS, LUTZ, BIRGE.

This commonest and one of the largest species is apparently distributed over the northern hemisphere and abounds in all the more shallow lakes. The head is rounded in front and is not angled between the prominence of the eye and the beak. The body is very large and not abruptly angled above, the spine of the shell being inconspicuous and high, so that the free posterior edges of the shell lack little of equalling the greatest height of the shell. The shell is covered with minute dense striations which spring from the free edges. The pigment fleck is elongated in old specimens and the upper angle follows up beside the suture separating the antennary basin from the rest of the shell of the head. The antennules are ornamented with minute spines. At the lower angle of the shell are three curved spines which differ from the preceding filaments. The number of eggs which are produced at once is truly immense. Under favorable circumstances this species reaches a large size, falling little if any short of 3 mm. *S. vetulus* lives, by preference, among the leaves of aquatic vegetation. With us this species seems to live in the smaller pools as well as in lakes of some size. I am not able to see any difference in this respect between the various species.

Sp. 2. *Simocephalus serrulatus*, Kech.

Daphnia serrulata, KOCH, LIEVIN, FISCHER, LILLJEBORG.

Simocephalus serrulatus, LEYDIG, SCHOEDLER, P. E. MUELLER, KURZ.

Head narrow, extending anteriorly into a sharp spiny angle in front of the eye. Dorsal line of the shell abruptly angled or curved posteriorly, projecting to form a broad obtuse spine behind;

this spine is serrate with sharp teeth and lies somewhat above the middle of the height of the animal, so that the free posterior margins of the shell fall much short of reaching the greatest height of the shell. Post-abdomen of the usual form, with the claws armed with two series of spines or bristles, the outer being much the larger; anal teeth curved or angled, dentate; pigment fleck triangular or rhomboidal. Length 2.0 mm., 2.5 mm.

I am not sure that the three following species are more than varieties; the first in particular is very close to the European type.

Sp. 3.—*Simocephalus congener*, Birge.

My own observations of this form made throughout the Mississippi valley are not in complete accord with the description of Birge, but it seems improbable that there is any mistake in the identification. The very generally distributed form on which this species rests is subject to marked variations within certain limits. This species differs from *S. serrulatus* in the following points. The head, although prominent and spiny near the eye, is not angled between this prominence and the beak; in fact, it is either straight or simply curved. The pigment fleck is usually rhomboidal and only occasionally oval, triangular or irregular. In other respects the agreement is rather close; the terminal claws have two series of spines, one of which is larger (not, as said by Birge, equal); the outer series is not so much larger as in *S. rostratus*, but not nearly as inconspicuous as in *S. vetulus*. The terminal claws are rather evenly curved. This species is frequently colored with pink or brown markings. In old females the back is squarely angled above, forming a pocket for the eggs. The size falls short of that of the last species. I have found this species from the gulf of Mexico to Minnesota.

Sp. 4.—*Simocephalus rostratus*. (Sp. n.)

This form is of the size and color of *S. americanus*, and approaches nearest to Schodler's *S. expinosus* in general characters. The back is arched above but not abruptly angled; the spine is as in *S. americanus* but not so low. The free posterior shell margins are somewhat shorter than the greatest height of the shell. The head is produced below the eyes in an angle like a right angle, which is not spiny. The lower margin of the head is excavated to form a right angle, and in front of the smooth antennules forms a very prominent beak, beyond which the antennules reach but a short

distance. The terminal claws of the post-abdomen are straightish and are more heavily spined than in the preceding; the anal spines are doubly curved or geniculate. The pigment fleck is rhomboid or pentagonal; the antennules are smooth. The abdominal processes differ somewhat from the previous species, in which the second one is rounded above, for in this it is squarely truncate. This species was found only in shallow pools at Ocean Springs, Mississippi, and was very carefully compared with *S. americanus* which is also found there.

Sp. 5. *Simocephalus exspinosus*, Koch.

Head extending into an obtuse angle at the eye, pigment fleck rhomboidal. Shell without a spine; maximum height of the shell greater than that of the free posterior margin. Caudal claws with an unequal series of spines; anal spines evenly curved. There is little to distinguish the above from this species save the geniculate anal spines and the presence of a blunt spine on the shell.

Var. congener, Schoedler,

has the lower outline of the head sinuate instead of angled.

Sp. 6. *Simocephalus daphnoides*, Herrick.

American Naturalist, 1883.

A curious transition form, found only south of the Tennessee river, was described in the American Naturalist in May, 1883, under this name. By an oversight a comparison made with *S. americanus* appeared as though made with *S. vetulus*. The general shape is oval; the greatest height of the valves lies near the middle and not posterior to it as in all the other species. The head is short, depressed, rounded in front; the beak is wanting; the lower margin of the head is straight. The pigment fleck is small, oval or irregular; the fornices are small and short. The antennules are smooth.

The post-abdomen is narrow, shaped more as in *Daphnia*; the terminal claws are straightish and fringed part way with spines; the anal spines are slightly curved. The processes of the abdomen are long, as in *Daphnia*. The shell is covered by the characteristic striations and extends into a blunt spine. In every detail, almost, there is an approach toward the genus *Daphnia*, while the general result is sufficiently like *Simocephalus*. The lower angle of the shell is not armed with the peculiar curved spines as in all the other

species. This species becomes over 1-10 inch long. In such old individuals the spine is nearly midway of the height.

One could wish a trifle closer link to *Scapholeberis* than that furnished by *S. angulata*; but, on the whole, the position of this genus can not well be called in question. America has four species out of the six known and but one of these certainly identical with the European, though others are probably too closely related.

NOTE.—On p. 47 read *S. Americanus*, Birge, not *S. Congener*.

V. GENUS DAPHNIA.

Long considered the type of the family, this genus is most frequently seen, or, at least, is more conspicuous than any other group. It has already been pointed out that the forms here united are the extreme development of a diverging line. *Simocephalus* is the link connecting it with the typical forms of the family. As might be expected, this genus presents more puzzling problems than any of the others. It contains more peculiarities of structure and diversities of habit and development than any other of the genera. Here the sexual differences are most interesting. The young are hatched with a pendant appendage attached to the upper posterior angle of the shell, which soon becomes the rigid spine characteristic of the younger stages and males of the genus. The females almost immediately after birth commence the production of eggs by an asexual process. Groups of epithelial cells containing four each are formed and one of the cells of each group develops at the expense of the others, forming the egg. Many such eggs are laid simultaneously and deposited in the cavity between the shell and the dorsal part of the animal. The eggs are prevented from escaping by means of three long processes, of which the first is much the larger and curves forward. At stated periods in spring and autumn the males appear; the females of the generation in which occur the males have a tendency to produce eggs of a different sort charged with a different mission. At the same time the upper portion of the shell (that surrounding the brood cavity) becomes finely reticulated and pigment is deposited between its layers. This ephippium, as it is called, in allusion to its saddle-like form, is the case in which the winter egg is to pass the period of cold or drought which is to follow. The method of the formation of the ephippium is obscure and, in spite of the investigations of Lubbock and Smitt, considerable remains to be learned with reference to this interesting modification of the shell. Some rather careful study has been devoted to this

subject by the writer, but it was unfortunately interrupted before completion. The most promising method of pursuing the investigation is that of sectioning ehippial females in various stages with the microtome. A preparation of soap was employed with partial success as a medium for embedding, and figures of some of the many sections made are drawn on plate P. Figure 10 is a vertical section through the middle of an ehippium which has been cast off. The outer and inner shell layers are distinct and one of the eggs is divided in the middle. No pigment or protecting material was deposited in this case, which is the simplest possible. Fig. 9 represents a section just back of the head; it passes diagonally, severing the heart longitudinally (h). The intestine (a), the ovaries (g), the mandible (m), the labrum (l), and certain suspensorial muscles (?) are seen *in situ*. Only a portion of the ehippium is cut and the double layers enclose a large mass of protective matter. Fig. 8 is a vertical section through the middle of the animal, and the usual form of the ehippium is seen with its large amount of protective matter obscuring all else. Fig. 7 is a longitudinal section of an ehippium similar to that seen in Fig. 10. It is hoped to present at some more appropriate time a fuller account of the formation and process of moulting this saddle.

DEVELOPMENT OF DAPHNIA.

Although the careful researches of Claus and Grobben have added much to our otherwise rather meager knowledge of the development of the cladocera, there still remain many interesting points, particularly with reference to the individual species, which merit careful study.

The following observations relate to the single species (*D. schæfferi*) which was available during a short stay in Leipzig:

The winter eggs of *D. schæfferi* are two in number and are lodged in the well known manner in an ehippium.

The shape of these eggs is sharply ovoid, there being no distinguishable difference between the two ends. The position in the ehippium is not, as might be expected, with the longer diameter paralld to the axis of the body, but the posterior end is slightly elevated. This is undoubtedly due to frequent elevation of the abdomen between the valves during the extrusion of the eggs.

The color is dark green and the only protection as the egg leaves the ovary is a thick, tough shell which is at first so soft as to be susceptible to pressure. It is thus reticulated, apparently through the simple pressure of the walls of the ehippium.

The length is 0.43 mm.; width .33 mm. in the average, though eggs were occasionally found of an elongated form, measuring .48, .31 mm. The contents of the egg consist of spheres of greenish plasma of various sizes and fat or oil drops. These oil globules are not very numerous as compared with those of the summer eggs, and likewise never attain the dominant size seen in the latter. The various forms assumed by the plasma balls are perplexing but frequently result from the action of external agents. The cleavage stage was not seen, and if actual segmentation takes place, it must be inconspicuous as would be expected from the large quantity of yolk present. The differentiation of the blastoderm occurs very early, perhaps in the ovary itself, and the result is a tolerably uniform layer of prismatic cells. The egg now comes to a period of repose after the blastoderm has produced a second external envelope apparently by simple secretion.

This envelope consists of a fine structureless membrane. The egg, under ordinary circumstances, remains dormant during the winter in this most favorable stage. The reason for which is evidently the fact that the differentiation has proceeded to the extent of producing the greatest number of protective layers without materially increasing the complexity, and thus the sensitiveness, of the organism. Under favorable circumstances the development proceeds farther and near one pole appears a slight indenture of the surface which grows deeper and seems to form a true invagination. This blastopore, if such it really be, remains for some time, generally till the two "scheitel" plates appear. These "scheitelplatte" are formed by a simultaneous thickening and lengthening of the cells of limited areas on opposite sides of the egg, near the opposite pole from that occupied by the blastopore. The "scheitelplatte" are situated at right angles to a plane perpendicular to the blastopore. The nuclei of the cells of the "scheitelplatte" are nearly .0208 mm. in diameter, while those of the other blastoderm cells are about half that size.

The egg remains a long time in this stage, while the following stages are passed through quite rapidly till the embryo assumes its nauplius form. The remainder of the development agrees, so far as seen, quite fully with that of the summer eggs, to which we will now return.

The summer eggs vary greatly in size and number, but are nearly as large as the winter eggs. The number is sometimes reduced to two or three or rises to as many as fifteen or even more. In color the eggs also vary from green to brown. The fresh egg

consists, as the winter egg, of two sorts of yolk spheres. The plasma or formative yolk contains colored globules of rather small size, distributed throughout the whole of the mass quite uniformly. The food yolk or oil globules assort themselves in two sizes; first, a few (generally three) very large oil drops, which persist throughout the earlier stages of the embryo; second, smaller globules of apparently the same character, which are quite numerous and form a very considerable part of the contents of the egg. In an egg of about .35 mm. in diameter, the largest of the smaller size of oil drops measured .029 mm. while the larger three exceeded .060 mm. The oil drops are distinguishable by their light refractive power, pellucidity and the intense dark brown or black color assumed when treated with osmic acid. The latter reagent affects the formative yolk but slightly. It will be seen that though the summer egg is nearly as large as the "daueri" in some cases, yet the relative amount of formative yolk is more diverse than at first appears.

The great similarity between the two sorts of eggs in *Daphnia schaefferi* is throughout striking as compared with *Moina*, the only one of the Daphnidæ the development of which is fully studied. In the summer eggs I have not been able to see the complete segmentation described for *Moina*. The following stages are much as described by Grobben. An invagination occurs and a median swelling appears on the ventral aspect of the egg.

Labrum and second antennæ bud out and are soon followed by the antennæ, mandibles and two pairs of maxillæ, after which the five pairs of feet soon appear. In an early stage there is present a basal palpus to the second antennæ, a fact not before observed, and this persists as the small two-bristled wart found on the basal joint of the antenna. It is a conspicuous object in the embryo and is thus a true embryonic organ.

The eyes of the embryo appear as two separate pigmented flecks which approximate and are covered with an oval refractive body, which later is penetrated by the pigment and divides to form the small lenses. Soon after this the shell grows over the eye as described for *Moina*.

The first indication of the shell appears as two folds of the maxillary region of the back, being thickest laterally. These grow forward and backward to form the cephalic and body shield. At a little later stage there appears a very interesting modification of the shell which stands in close relation to the growth of the brood sac. A slight protuberance appears on the margin of the shell in

the median dorsal line and extends toward the abdomen. It grows much more rapidly than the other parts of the shell and, in a later stage, forms a comparatively enormous tail, which curves under the animal between the shell valves which now extend beyond the body. This "tail" extends well along the ventral margin of the shell and reminds, by its position, of the tail of a frightened dog. The true tail, or post-abdomen, is, in the meanwhile, well developed and is constantly kicking the useless protuberance of the shell upwards. As the animal leaves the egg this projection becomes straightened as in the young *D. pulex*, finally becoming the still considerable spine, though it is proportionately much shorter than in the embryo. The spine becomes shorter with successive moults and the mature form has only a slight rounded knob in place of a spine more than half the length of the body.

The use of the long spine in the young *Daphnia* is a matter of interest. Its length agrees pretty well with that of the brood cavity and it seems possible that it serves to prevent the shell from bending abruptly down when it is only partially removed during the moult and thus breaking off and so leaving a portion of the clothing of the brood-cavity therein to become a source of irritation. This is more necessary for the young since the brood cavity is narrow and the shell weak, so that while the outer shell is removed like a glove from the finger, it can not be pulled upward or downward, but directly backwards. It is well known that male *Daphniæ* often have the spine, while the females may have none, and here again it is possible that the narrower cavity over the abdomen requires this assistance, while this is not the case with the females.

The shell gland is early formed and the branchial lamellæ of the feet appear almost simultaneously with the feet themselves as distinct lobes. The branchial chamber is not a simple chamber, but is essentially a curved tube as can be very well seen in the last foot of the adult. This tube doubles upon itself and crosses in the manner of a loop and a constant stream flows rapidly through it.

The nervous system is, at first, paired from beginning to end and first unites anteriorly, the ocular ganglia fuse after the union of the two pigment flecks in the compound eye, then the cephalic ganglion is formed by the union of the two pre-oesophageal ganglia, the commissures passing about the oesophagus. I have not been able to determine if the sub-oesophageal ganglia become fused. From the anterior ganglia spring the nerves to the antennæ and

jaws, which latter are the larger in the embryo, being exceedingly large nerves.

This key contains the majority of the genus, but falls short of completeness. The following species are uncertain. W. Schmanke-witsch described as new *D. degenerata* and *D. rudis*, from salt or brackish waters. These he regards as degenerate forms produced by the inferior aeration of dense waters. The author does not appear to recognize the modern distinctions of genera so that, not having seen the work, even the generic position can not be definitely stated. His investigations seem to show that the proximity of salt waters influence the form of the body, or, perhaps, that there is a constant interchange between the sub-marine and fresh-water species. *Daphnia brevicauda*, Chambers, is an incorrectly figured and described Simocephalus.

KEY TO THE GENUS DAPHNIA.

Section I. Pigment fleck present.

- A. Head short, equally rounded.
 - 1. *D. psittacea*, Baird.
- B. Head not regularly rounded, more or less beaked.
 - (a) Claws spiny.
 - I. Abdomen broad, series of anal spines nearly equal, neither head nor back keeled.
 - † A marked sinuosity in the posterior outline of post-abdomen.
 - 2. *D. schæfferi*, Baird.
 - D. ovata*, Sars.
 - D. pennata*, Mueller.
 - †† No well marked depression.
 - 3. *D. pulex*, Mueller.
 - 4. *D. schædleri*, Sars.
 - D. hastata*, Sars.
 - D. obtusa*, Kurz.
 - II. Abdomen narrow, shell keeled somewhat dorsally.
 - 5. *D. minnehaha*, sp. n.
 - 6. *D. carinata*, Sars.
 - (b) Claws nearly or quite smooth.
 - I. Head not crested.
 - 7. *D. longispina*, Leydig.
 - 8. *D. rosea*, Sars.
 - 9. *D. similis*, Claus
 - D. lacustris*, Sars.
 - D. cavifrons*, Sars.
 - 10. *D. hyalina*, Leydig.
 - 11. *D. dubia*, Herrick.

D. pellucida, P. E. Mueller.

D. galeata, Sars.

12. (?) *D. lævis*, Birge.

Section II. Pigment fleck absent.

A. Head but slightly crested.

1. *D. longiremis*, Sars.

B. Head strongly crested.

2. *D. cristata*, Sars.

3. *D. cucullata*, Sars.

D. apicata, Kurz.

4. *D. kalbergensis*, Schoedler.

D. cederstromii, Schoedler.

D. retrocurva, Forbes.

D. vitrea, Kurz.

5. *D. magniceps*, sp. n.

SECTION I.

A. *Head short, evenly curved.*

Sp. 1. *Daphnia psittacea*, Baird.

Mentioned by SCHOEDLER, FRIC and KURZ.

This species is at once recognized by the head, which is very short and evenly curved, or nearly so, from the heart to the beak. The shell is high, oval, with a rather short spine. The fornices are wide and angled behind; the antennules are longer than in most species; the post-abdomen is very large, but narrows toward the end and has comparatively few anal teeth, which are of unequal size. This is one of the largest of the genus. Not yet found in America.

B. *Head more or less concave below, at least not evenly arched.*

Sp. 2. *Daphnia schæfferi*, Baird.

(Plate M. Figs. 1—4.)

Daphnia pennata, MUELLER.

Daphnia pulex, STRAUS, KOCH, (fide P. E. MUELLER.)

Daphnia magna, LILLJEBORG, LEYDIG, etc.

Daphnia schæfferi, SCHOEDLER, KURZ.

The largest species of the genus, is of an elongated oval and ventricose form. The spine is entirely absent in old females and of only moderate length in the young. The antennules of the male are long and have a very long flagellum. The post-abdomen is narrowed suddenly below the anus so that the spines consist of two sets; the terminal claws are spiny at the base. Although

very similar to *D. pulex*, it may be recognized at once by the concavity of the dorsal margin of the post-abdomen. The plate will make any detailed description superfluous. A common species in Europe, but not yet found in America.

Daphnia ovata, Sars, seems probably this species, but Sars was troubled by Straus' mistaken reference.

Daphnia pennata of Sars may also be this species or, more probably, *D. pulex*. The Latin description given by Sars is appended for convenience of reference.

***Daphnia pennata*, Sars.**

"Antecedenti (*D. pulex*) simillima, caput autem a latere visum latius, rostro brevior, supra visum testa cetera parum angustius fere cordiforme, antice acuminatum. Processus anteriores duo disjuncti. Margo posterior postabdominis in medio sinulo parvo et infra hunc utrinque aculeis 16-18 armatus. Color ut in antecedente. Longit. $2\frac{1}{4}$ mm."

***Daphnia ovata*, Sars.**

"Caput a latere visum ante oculum fere angulatum, margine inferiore leviter concavo in rostrum longum apicem versus attenuatum, extremitate tenuissima exeunte, spura visum ut in *D. pennata* cordiforme. Testa cetera a latere visa ovata, margine superiore et inferiore in femina adulta fere æquæ arcuatis, postice in medio spinam formans brevissimam vel omnino obsoletam. Processus anteriores duo abdominis disjuncti. Margo posterior postabdominis in medio sinuatus, utrinque aculeis 20-22 armatus. Color albido-flavescens vel-virescens. Longit. circit 3 mm."

Sp. 3. *Daphnia pulex*, Mueller

This commonest of our Daphnids is apparently circumpolar in distribution. I have found it in Alabama near the Gulf and it also occurs near lake Superior.

Oval, either elongate or short, spine springing from the upper angle of shell or in some cases near the middle. The spine is rather long in young individuals but becomes very narrow in older ones or entirely disappears. The abdominal processes are long, not coalescent, or slightly united at the base. The head is concave below and extends into a prominent beak. This species is either very variable or several species are frequently united under the term. Two types have been recognized in America. One, abundant in spring in smaller ponds in Minnesota, is rather short, arched above, and in old females with the spine situated near the middle of the posterior margin. This form is quite typical for the species and occurs from April to mid-summer. Another variety was found in Alabama in late autumn, and similar animals in mid-winter in lake Calhoun, Minnesota. This type has a much more elongate body, the very slender but rather short spine springs from the upper

margin of the shell or is quite wanting. This longer form has the beak slightly arched so as to resemble a "Roman nose." The anal spines are less numerous (10-14 while typical *D. pulex* has nearly 20). The young of this form, which may be called

***Daphnia pulex*, var. *nasutus*, (Var. n.)**

(Plate N. Figs. 1-4.)

vary much among themselves but, in general, resemble the young of the European form.

Daphnia pulex has been mentioned by a number of authors in America, Smith, Birge, Chambers and Herrick having noted its occurrence in various parts of the United States. *D. obtusa*, Kurz, is apparently only the spineless condition of the above or a related species. No *Daphnia* is without the spine through life; such a form would constitute a new genus at once.

Sp. 4. *D. schoedleri*, Sars.

Seems to resemble *D. pulex* very closely but differs in having the lower margin of the head nearly straight, terminating in a short straight beak. The spine springs from the middle of the posterior margin. The anal spines are 14-16 in number. Length 2.33 mm.

This name is applied by Sars to Schoedler's *D. longispina* which is not *D. longispina* of Leydig.

Sars' *D. hastata* is so insufficiently defined that it will probably be necessary to drop it from the list.

Sp. 5. *Daphnia minnehaha*, (Sp. n.)

(Plate K, Figs. 1, 2; Plate L, Figs. 1, 2.)

This species, which occurs in small pools in autumn (affluents of Minnehaha creek, etc.,) closely corresponds apparently to Sars' *Daphnia carinata* but differs in numerous points. It, in fact, is more nearly related to *D. pulex* than the group under which that species is placed.

The form is oval, arched above, narrowed posteriorly, terminating in a rather short spine which curves lightly upwards. In males and young females the spine springs from the upper angle, but in old females having many summer eggs the spine is nearly median. The head is depressed, strongly arched and keeled slightly above the eye, which occupies the extreme end of the forehead. The keel of the head extends into a slight angle over the heart and continues

down the back. In young females and in males the slight angle is replaced by a strong knife-like projection which extends into from 1 to 4 sharp teeth, the anterior tooth being directed forward. The males, in particular, have this feature emphasized. *D. longispina* has a somewhat similar projection but the more nearly related forms seem not to show this peculiarity. The beak is slightly curved and the lower margin of the head is slightly sinuate. The shell has the usual square reticulations and is usually very transparent but in peaty waters becomes brownish. The size is small but variable; 1.8 mm. is a common measurement. The post-abdomen is narrow, the claws are armed with four or more teeth and a series of lateral bristles. The anal spines are eleven or more in full grown females and decrease only moderately upward. The processes of the abdomen are distinct. The males are smaller and strongly carinated above and of the same form as young females. The antennules are rather long, with a short lateral and a long terminal flagellum, which latter is more than twice the length of sensory setæ which are partially lateral. The first foot has a strong claw and a long flagellum, while the second feet have a small spiny hook. There is a single abdominal process which is not hairy as in *D. pulex*.

Sp. 6. *Daphnia carinata*, Sars.

Very similar to the last but, according to Sars, the claw has no well marked teeth, a short flagellum on the male antenna, and the abdominal processes are united at the base (which may indeed be sometimes the case in the above.)

D. cavifrons, Sars, has a prominence on the forehead and the lower margin of the head is strongly concave, otherwise hardly distinguishable save by the absence of the keel above.

Sp. 7. *Daphnia longispina*, Mueller.

D. longispina, O. F. MUELLER. BAIRD, LEYDIG, SARS, P. E. MUELLER, KURZ, WEIS-MANN, etc.

Oval, elongate; head large, rounded in front, lower margin somewhat concave; rostrum long. Spine very long, springing from the middle of the posterior margin. Post-abdomen attenuated toward the end. Terminal claws smooth or simply ciliate, spines few. The abdominal processes are united at the base a very little. Flagellum of the male antennule hardly longer than the sensory setæ. The young have three teeth above as in *D. minnehaha*. There is

a great deal of diversity of opinion as to the value of this name. Not that there is any doubt of the existence of a widely distributed form which in general is that intended by Leydig and others, but the variation is so great that the possibility remains that more than one species is included under the one title.

P. E. Mueller recognizes two varieties depending chiefly upon the length of the spine.

D. lacustris, Sars, is nearly related, if not a variety of the above.

Sp. 8. *Daphnia rosea*, Sars.

(Plate K. Figs, 10-12.)

In form very like *D. longispina*, this species, which is the only representative of this smooth-clawed, unkeeled group yet found in America, might perhaps be appropriately re-united with that species, but, as there seems little doubt of the identification with Sars' variety, as above, I prefer to use his name.

Body oval, moderately ventricose; head of moderate size, lower margin nearly straight; eye situated in the anterior prominence. The beak is not very prominent. The upper outline of the head is slightly concave above the eye or rather less convex. The head is separated from the body by a marked depression. The spine of the shell springs from the upper angle or is quite wanting. The post-abdomen is of moderate size, somewhat narrowed toward the end. The claws are smooth, the anal spines nearly equal, straight, about 14 in number. The abdominal processes are not coalesced or but slightly so. Length 1.50 mm. to 2.0 mm. The species was collected sparingly in a large gathering of *D. pulex* from a small lake in early spring.

The size and conformation of the abdominal processes is very variable and the long and very slender spine is frequently absent.

Sp. 9. *Daphnia similis*, Claus.

The description of this species, which was bred in confinement from eggs brought in mud from Jerusalem, I am, unfortunately, unable to quote. Judging however, from the figures which alone I now have access to, it belongs in the group of *D. longispina*, though in many particulars it resembles *D. schæfferi*. The form is elongate, the spine short and springing from the upper margin. The antennule of the female is very large and flagellate, while that of the male is like that of *D. schæfferi*. The flagellum and hook of the first foot of male are rather small.

We now come to a group of related species which are most difficult to circumscribe on account of their extreme variability. According to the view of Lutz they would all fall into the old *D. hyalina* of Leydig. More probably, however, some of these forms are of nearly or quite specific value.

Sp. 10. *Daphnia hyalina*, Leydig?

(Plate L, Figs. 3, 5.)

Daphnia longispina, HERRICK.

I have elsewhere given a brief account of the post-embryonic development of a species which agrees best with Leydig's figures of *D. hyalina*.

The lower outline of the head is nearly straight, the eye being always approximated toward it. In young specimens the head is sharp in front and crested. The lower margin of the head appears very long and the beak turns backward. The spine is very long in young forms but is short in old females. The male resembles very much the young female. The post-abdomen is narrowed toward the end, the terminal claws are smooth, the anal teeth few and the abdominal processes united. Our specimens are from Paducah, Ky., south of the Ohio river.

I do not know how to distinguish *D. lævis*, Birge, from *D. hyalina*, save that the abdominal processes are said to be distinct. Both forms were observed in the above mentioned gathering. If, however, Birge's figures are characteristic, he had a different variety before him from ours; it seems somewhat like *D. galeata*.

D. pellucida, P. E. Mueller, differs from *D. hyalina* in the presence of a series of small teeth on the caudal claws, and a more strongly curved beak.

It is just now brought to my attention that P. E. Mueller, in a late work, identifies *D. pellucida* with *D. hyalina*, though he still holds *D. galeata* distinct.

***Daphnia galeata*, Sars.**

(Plate T. Figs. 7, 8.)

According to P. E. Mueller, this species differs from *D. pellucida* in the absence of teeth on the caudal claw, and, in one variety, by the acuminate head, which seems the only form for which the name is distinctive. Kurz found only the var. *frons rotundata*. According to Forbes, both varieties, the first of which he identifies with *D. pellucida*, occur in lake Michigan.

S. I. Smith finds both in lake Superior, and seems to have no doubt of their distinctness. One of the forms which I have seen differs a little from either of the above, and had a different habitat. Kurz has described the male, which has a very short flagellum upon the antennule. A single source for *D. galeata* was found in a small pool known as Clarke's lake. This is the more remarkable, as this species, which is almost confined to larger bodies of water, is found nowhere else in the vicinage of Minneapolis, while this minute lake, though as deep, perhaps, as any of the largest in the county (say 40 feet), contains a number of forms known otherwise only in the Great Lakes. Kurz's remarks on the specimens collected by him apply equally to these. Were the claws dentate, the animal would pass as *D. pellucida*. The young have no horn on the head. The spine of the shell is nearly as long as the whole animal in the young. The male of our form is 1.2 mm, long, excluding the spine which measures 47 mm. The flagellum is a very little longer than the sensory setæ, and there is a very minute lateral flagellum. A peculiarity of this species is the scattered thorny armature of the spine of the shell. There is but little change in the form of head with age. The form of the last feet is peculiar. The ephippium occupies comparatively a small part of the valves and the spine becomes very short and quite smooth. The sexual period occurs in September and October.

The above statements regarding *D. galeata* require a modification, for in another deep lake the writer has since secured the typical crested *D. galeata* with even a higher crest than that figured by P. E. Mueller. The head ends in a sharp angle. The single female seen was in company with the rounded variety and numbers of *D. kalbergensis*, which it resembles in many respects. Our fauna therefore is quite complete in these remarkable forms.

(See Plate U. Fig. 6.)

Sp. 11. *Daphnia dubia*, Herrick.

(Plate L. Figs. 7, 8.)

American Naturalist, 1883.

The life history of this form is insufficiently known, but there seems no reason for doubting that it constitutes a new and easily recognizable species. It is nearly related to *D. hyalina*, but the head is strongly crested all round and the eye is withdrawn, in young as well as old specimens, toward the middle of the head. This peculiarity is shared in this degree by no other *Daphnia*

The form is as in *D. pellucida*, but the spine is more slender and directed upward. The head is shaped much as in *D. vitrea* in the young, but is much less prominent. The older form has a shorter and more slender spine (none were seen in the ultimate or spineless stage). The head is more evenly rounded, but still well crested. The abdomen is very slender and the anal teeth diminish rapidly in size from below upward. The claws are very short and armed down the whole length with fine bristles. The abdominal processes are well united at the base in old specimens, so that the second seems a small process of the first. The shell is very transparent and the spine is longer than in any other Daphnid. In a young specimen the spine was 1. mm., the body 0.7 mm., and the head 0.4 mm. In this specimen the spine was slightly curved, the head elongate with a slight ridge in front. Another individual had the spine 1.1 mm. long, while the remainder of the animal was 1.3 mm. This specimen also had a knife-like hyaline ridge on the crest, which was obliquely truncate in front; it also had numerous summer embryos in the brood sac. The spine was perfectly straight and but slightly inclined upward. Older individuals have a rounded crest as figured and no ridge. The spine is relatively somewhat shorter but much more slender. The characters which most clearly distinguish this species are the well crested head, which in young as well as sometimes older specimens has a median hyaline ridge, the withdrawal of the eye from the margin and the very long spine. It resembles *D. galeata* in earlier stages. It is very much like *D. lævis* or, in other words, is in the group of *D. hyalina*; but the study of a considerable number of specimens from different localities convinces me that it can not be united with that species in any of its varieties. This species has only been found in autumn, Sept.—Nov., lake St. Croix and Richfield in Hennepin county.

SECTION II.

Pigment fleck wanting. Head crested. The small, hyaline species constituting this section, elevated by Schøedler to the rank of a genus (*Hyalodaphnia*) and by Sars to that of a subgenus (*Cephaloxus*), are chiefly residents of the deeper parts of our larger lakes. These forms, from their rarity, have been little studied and it is uncertain how far the assumed specific distinctions are valid.

Two species are known in America and they are not confined to large lakes.

Sp. 1. *Daphnia longiremis*, Sars.

Hyaline, compressed, seen from the side, rounded, lower margin strongly arched; spine long, straight, oblique. Head rounded, lower margin nearly straight, ending in a beak directed downward, acute anteriorly. Eye small. Antennæ very long. Length 1 mm.

The abdomen is said to be similar to that of *D. longispina*. From the brief description given by Sars it would appear that this species is characterized by a rounded and uncrested or slightly crested head. Though imperfectly described, it is here mentioned to direct attention toward any such species as may be found in America.

Sp. 2. *Daphnia cristata*, Sars.

Compressed, long. Head acute in front, strongly crested, lower margin nearly straight. Dorsal line of body little curved, spine long in the young, strongly curved. Head of male smaller, flagellum of antennule twice as long as the setæ; first foot well clawed. Length of female 1.33 mm.

Sp. 3. *Daphnia cucullata*, Sars.

D. berlinensis, SCHOEDLER.

Very like the above, but the margin of head is not straight below, is, however, extremely variable and ends in a sharp angle. The eye lies nearly midway between the heart and the end of the head and near the lower margin. The two anterior processes of the abdomen are united for most of their length. The flagellum of the male antenna is about as long as the terminal setæ.

D. apicata, Kurz, seems to be a large variety lacking the sharp spine of the head. In the main it agrees quite well. Although the post-abdomen is broader than figured by Mueller, the number of teeth corresponds with Sars' description.

Sp. 4. *Daphnia kalbergensis*, Schoedler.

(Plate U. Figs. 1—3).

Form oval, spine long. Head high, compressed, enormously elongated, beak obtuse. Eye small. Abdominal processes not united. Caudal claws ornamented with small setæ. Antennæ of male with a short flagellum. Length of head nearly equal to that of body exclusive of spine.

D. vitrea of Kurz seems not improbably a varietal form of the above though the crest is lower, the size is less and the post-abdo-

men is more slender and has fewer teeth; the differences are, however, hardly specific.

I am not convinced that either *D. cederstromii*, Schoedler, or *D. retrocurva*, Forbes, are really distinct species, although the latter, with its more strongly crested head, is said also to have a series of teeth on the terminal claw. Perhaps it forms with *D. cederstromii* the fifth and extreme phase of this group.

Since writing the above account of *Daphnia kalbergensis* this truly monstrous species has come to light in the vicinity of Minneapolis. The opportunity is thus afforded to verify the suspicion expressed above that a number of species must be united under this name. P. E. Mueller gives the following measurements for *D. kalbergensis*: head 0.9—1.0 mm., body 1.0—1.1 mm., spine 0.7—0.75 mm. Kurz for his *D. vitrea* gives a length of 0.85 mm. plus 0.25 mm., the length of the spine. Judging from his figure, the head would not measure over 0.35 mm.

Forbes says of his *D. retrocurva* that the head is two thirds as long as the body.

Our specimens measured as follows:

No. 1. 1.6 mm, head somewhat more than half the body and almost exactly like *D. vitrea* in form.

No. 2. Head 0.6 mm., body 0.9 mm., spine 0.5 mm.; about 9 anal spines. Head in this case moderately curved upward.

No. 3. Head 0.95 mm., body 0.95 or less, spine 0.5 mm.; or the head as long as or, indeed, considerably longer than the body and directed upward.

The males have the crest much lower, the spine longer, and the form of antennules figured by P. E. Mueller. In the older females the beak is elevated above the antennules, as remarked by Forbes, but in smaller individuals there is very little difference between our specimens and Mueller's figures.

The claws of the post-abdomen have, besides the row of fine teeth mentioned by Mueller, a cluster of sharp teeth just at the base.

Found, together with typical *D. galeata* and the rounded form, in a small deep lake or expansion of a creek not far from Medicine lake, Hennepin county, Minn.

Sp. 5. *Daphnia magniceps*, (Sp. n.)

(Plate U. Fig. 15).

The peculiar form figured in the Tenth annual of this survey seems indubitably new and is distinguished by the peculiar shovel-shaped head, which is scarcely crested but is broadest beyond the

middle. The spine is long, the claws smooth, the abdominal processes united and the shell transparent. The eye is near the end of the rounded head and is large; the pigment fleck was apparently absent. Found with *Daphnia minnehaha* in a shallow swampy pool in autumn.

FAMILY BOSMINIDÆ.

The sole genus of the family, *Bosmina*, contains over a dozen nominal species which are among the most difficult to define of any cladocerans. The number is here reduced to nine and the probable position of the rejected species is indicated. This is not done because the author presumes upon the slender material at hand to revise the genus; but simply from the fact that the descriptions of the earlier writers do not permit a proper discrimination; so that this necessity is entailed upon any one who would give a birds-eye view of the members of the genus. The *B. diaphana* is founded upon a different twist in the antennules and no hesitancy is felt in uniting it with Sars' *B. lilljeborgii*. The other species, *B. brevirostris* and *B. nitida*, are omitted simply because there seems to be no way of separating them satisfactorily from *B. maritima* and *B. obtusirostris* respectively. Three species have been found in Minnesota, but practically no attention has been given to the genus here.

Bosmina macrorhyncha found in Egypt is not here included, its description being inaccessible to me.

B. lævis, Leydig, seems simply a smooth condition of other species. Whether *B. curvirostris*, Leydig, is or is not valid must, so far as I am concerned, remain at present doubtful.

GENUS BOSMINA.

A. Shell extending into a spine behind.

(a) Antennæ curved outward.

1. *Bosmina cornuta*, Jurine.

(b) Antennæ not curved outward,

I. Shell reticulated, at least in part.

† Flagellum midway between eye and the sensory setæ of antennæ.

2. *Bosmina longirostris*, Mueller.

†† Flagellum nearer eye.

3. *Bosmina maritima*, P. E. Mueller.

4. *Bosmina longispina*, Leydig. (*B. brevirostris*?)

II. Shell striate.

† Antennules long.

5. *Bosmina striata*, Herrick.

†† Antennules short.

* Rostrum long.

6. *Bosmina lacustris*, Sars.

** Rostrum short.

7. *Bosmina obtusirostris*, Sars. (*B. nitida*, Sars?)

B. Shell not spined behind.

(a) Shell strongly arched above.

8. *Bosmina tilljeborgii*, Sars. (*B. diaphana*?)

(b) Shell moderately curved above.

9. *Bosmina microps*, P. E. Mueller.

Concerning the identification of *Bosmina longispina*, Leydig, with *B. brevirostris*, P. E. Mueller, it must be said that the bow is drawn at a venture, for Mueller, in his paper on the Cladocera of Swiss Lakes, in a fit of absent-mindedness refers to *B. lacustris*, P. E. Mueller, citing p. 149 of Denmark's Cladocera. On the page in question are descriptions of *B. maritima* and *B. brevirostris* of which the latter is probably the one meant. Sars' *B. lacustris* seems quite different, being strongly marked by longitudinal lines, while Leydig says of *B. longispina* "shell striped and small reticulate," and P. E. Mueller says in *B. brevirostris* the shell is "utydeligt reticuleret" i. e. indistinctly reticulate.

The three species so far identified in America are *B. longirostris*, of which a figure is given (plate J, fig. 2,) *B. cornuta* and *B. striata*, which may possibly be yet identified with one of the European species, though it seems improbable. I have also seen a species like Leydig's *B. lævis*, but considered it a smooth variety of *B. longirostris*.

FAMILY LYNCODAPHNIDÆ, Sars, 1861; Herrick, 1881.

This is a rather small family with seven genera of minute animals which are abundant only in summer. Many and, indeed, most of the species are among the rarer of fresh-water crustaceans of this group, and a few are among the rarities which only now and then reward the collector. This family undoubtedly is the link connecting the Daphnidæ with the Lynceidæ, relationships to which are expressed by *Macrothrix*, on the one hand, and *Lyncodaphnia*, on the other.

The rank of this group as a family must be, of course, a matter largely of opinion. Sars was the first to adopt this view, sustained by certain curious transition forms leading toward Lynceidæ. Later writers seem never to have found these genera and the group was

again included with the Daphnidæ. The writer, upon the discovery of the Lyncodaphnia, was forced to regard this group as of equivalent grade with the above mentioned families and again proposed the family name Lyncodaphnidæ.¹

The genus *Ilyocryptus* is a little one side the normal course of the family and seems related to the lynceid genus *Leydigia*.

The waters of the northern United States are very rich in members of this family.

The aberrant family *Bosminidæ* finds its only connection with other *Cladocera* through this group by means of the remarkable *Macrothrix* (?) pauper; and here it is only vaguely hinted at in the elongated antennules and angled lower margin of shell, as well as the presence of certain bodies near the base of the antennules. It has been affirmed that none of the *Lyncodaphnidæ* have an ephippium, i. e. the saddle-shaped thickening of the shell walls to include and protect the winter eggs; but I have discovered it in the case of *Macrothrix tenuicornis*, Kurz, and presume it may occur exceptionally in others. Kurz says that *Ilyocryptus* has no moult proper, but this probably refers only to the European *I. sordidus*. The American species differs from the generic description given by Kurz, and may be different in this respect also.

In this family the regularity in the disposition of the setæ on the antennæ is broken and the fringing of these hairs serves the purpose of specific distinction. The antennules are always long and frequently differ considerably in the sexes. The pigment fleck is always present (Kurz is in error in denying its existence in *Lathonura*). In many forms there is no free posterior margin of the valves, while the lower is generally thickly beset with movable spines. The *Lyncodaphnidæ* will be distinguished from *Ceriodaphnia*, which they resemble, by their motion, which is a succession of quick bounds, while the broader *Ceriodaphniæ* hobble along as though heavily weighted by the enormous mass of eggs with which they are generally laden. The abdomen is usually short and the anus is behind the terminal claws, but in *Ilyocryptus* the claws are long and spined at the base. In the American *I. spinifer* the anal opening is elevated to a point nearly underneath the stylets, and there is a rudimentary anal cæcum as in *Lynceids*.

The males have the opening of the vasa deterentia in front of the claws, which may be absent; the antennules are also modified, being longer and curved. In *Lathonura* the abdomen is elongated

¹ Notes on Some Minnesota Cladocera. 1881.

posteriorly till it begins to suggest a transition to *Polyphemus*. The known genera and their distribution is as indicated below.

Half of the known species are found in America; one sixth being peculiar to it.

GENERA.	Total number of species.	European.	Also American.	Only in America	Total American.
1. <i>Macrothrix</i>	4	3	2	1	3
2. <i>Lathonura</i>	1	1	1	.....	1
3. <i>Drepanothrix</i>	1	1	.....	.....	.....
4. <i>Streblocercus</i>	1	1	.....	.....	.....
5. <i>Acantholeberis</i>	1	1	.....	.....	.....
6. <i>Ofryoxus</i>	1	1	1	.....	1
7. <i>Lyncodaphnia</i> ?	1	.....	.....	1	1
8. <i>Ilyocryptus</i>	3	2	.....	1	1
Totals	13	10	4	3	7

I. GENUS *MACROTHRIX*, Baird.

Body oval, pointed behind; head broad; antennæ of first pair long, nearly straight, beset with spines, olfactory threads terminal; swimming antennæ large and powerful, propelling the animal by bounds; three-jointed ramus with a greatly elongated seta which is thorned and jointed; labrum with the basal joint enlarged, resembling that of Lynceids; first foot with a hook in both sexes; last foot with a long process (respiratory body); abdomen short; claws short; caudal stylets often with a bush of hairs at tip. The intestine is straight and without cæca in front or behind.

The first one to observe a member of this genus, apparently, was O. F. Mueller whose *Daphnia curvirostris* is usually referred to *Macrothrix laticornis*.

The name *Echinisca* was proposed by Lievin, but *Macrothrix* was applied by Baird in 1843. Four species are known, three of which occur in America and without doubt the fourth will ultimately be found. No males of this genus were known till 1877 when the male of *M. laticornis* was described and figured.¹ Nearly two years later the male of *M. rosea* was described from Wisconsin by E. A. Birge. Descriptions of the male of *Lathonura* are also given in both the above mentioned sources.

Sp. 1. *Macrothrix laticornis*, Jurine.

(Plate C. Figs. 7, 8 and 9.)

Daphnia curvirostris(?), MUELLER.

Monoculus laticornis, JURINE.

Lynceus laticornis, DESMAREST.

¹ Gruber und Weismann, Ueber einige neue oder unvollkommen gekannte Daphniden. Freiburg.

Macrothrix laticornis, BAIRD, Ann. Mag. Nat. Hist.

Acanthocercus curvirostris (?), SCHOEDLER, Erichs. Archiv, 1846.

Daphnia curvirostris, FISCHER.

Macrothrix laticornis, LILLJEBORG, LEYDIG, BAIRD, P. E. MUELLER, FRIC, KURZ, SARS, LUTZ, CLAUS (Die Schalendruse d. Daphnien), NORMAN and BRADY (Monogr. Brit. Entom.), GRUBER and WEISMANN, WEISMANN, (Beitrag zur Naturgeschichte d. Daph.)

This is the commonest European species and is the type of the genus, showing its rather conservative position by the broad tip of the antenna which is a feature exhibited by embryos and young of other species. The shell has a warty surface and is toothed above, while the lower margins are fringed with long unequal spines in groups of threes or fours.

The form is roundish with a blunt posterior angle, the ventral margin being regularly curved. The antennules are short and enlarged at the end. The form is an irregular pentagon; a pair of slender spines sits at the angle near the base.

The swimming antennæ with the seta on the first joint of 3-jointed ramus very long. Post-abdomen truncate at the end, short, posterior margin beset with series of bristles.

Length of male 0.5—0.6 mm., of female 0.4 mm.

This is the smallest of the genus and will undoubtedly be found in America.

Sp. 2. *Macrothrix rosea*, Jurine.

(Plate C. Figs. 5, 6, 11, and 13.)

Monoculus roseus, JURINE.

Lynceus roseus, DESMAREST.

Daphnia rosea, M. EDWARDS, JURRELL.

Echinisca rosea, LIEVIN.

Macrothrix rosea, BAIRD, LILLJEBORG, P. E. MUELLER, BIRGE.

The body is sub-oval, terminating behind in an acute angle; the lower margin is less conspicuously spined than the last or the following; the antennæ are but slightly dilated at the end and nearly straight. The longest seta of the antennæ is longer than in the last, reaching beyond the tips of the terminal setæ; abdomen more slender, sinuate in front, beset with short hairs.

Length 0.6 mm, male 0.3 mm. The male has no claws on the end of the post-abdomen, and the antennules are curved and elongated. Figures 5 and 13 are copied from Birge.

Sp. 3. *Macrothrix tenuicornis*, Kurz.

(Plate C. Figs. 1, 1 a, 2, 3, and 12.)

(See Notes on Cladocera of Minnesota, p. 245.)

The body is oval, produced posteriorly in a sharp point; the abdomen is strongly arched, while the upper outline of the head is a regular curve or slightly extended in front of the eye; the antennules are long, nearly straight and a very little narrowed toward the end, just in front of which is a series of short teeth; there is no lateral spine, but a strong terminal one in addition to the sensory filaments; the pigment spot is large, the eye small and the lobus opticus well separated from the ganglion; the antennæ have a very powerful basal joint; the elongated seta is very stout and densely spiny, with a tooth at its flexure; two of the terminal setæ are spiny, for the basal half; the valves are beset with very long spines in sets of three each, all having different positions; the abdomen is nearly as in *M. rosea*, but the posterior margin has a series of long sharp teeth; the mandibles are nearly completely exposed by the arched anterior margin of the valves.

The labrum, in this species, is an odd link between that of the *Daphnidæ* and *Lynceidæ*. The basal segment is greatly enlarged and is sub-triangular in outline, with a movable lip attached to the inner free face; the typical daphnoid structure is preserved, but the enlarged salient angle of the basal portion shows how the transition to the great triangular labrum of *Alona*, etc., is made. In young specimens the head is proportionately larger, the antennules are broader at the tip, and the dorsal outline is less convex; the marginal spines of the valves are also proportionally larger, as are the appendages of the first and last pairs of feet. This is one of the largest species of the genus, 0.75 mm. being the length. This is very close to *M. rosea* but seems distinct.

This form is quite common about Minneapolis, Minn., but is not yet noted elsewhere in America.

Sp. 4. *Macrothrix pauper*, Herrick.

(Plate C. Fig. 4.)

This species is described from a single specimen from L. Minnetonka, and I can add nothing to the very meager notice given then.¹

¹ Notes on some Minnesota Cladocera. 1831. C. L. Herrick.

The body is broad and very narrow, the lower outline is angled and nearly unarmed; the pigment fleck and eye are small and approximated; antennules very long and curved backward and outward; abdomen short, ciliate below; claws short, ciliated. This female had a full complement of eggs but the antennæ resemble those of a male. This is unusually interesting and should be rediscovered and studied; for there seems to be some affinity between this species and *Bosmina*, and it is probable that it requires to be distinguished generically from *Macrothrix*.

II. GENUS LATHONURA, Lilljeborg.

The form is oval; the head is curved more than in *Macrothrix* and the shell is more obtuse behind, sinuate below where it is beset with short spines anteriorly; first antennæ long, straight; second antennæ with five setæ on each ramus; only four pairs of feet apparent; abdomen short, prolonged upward to the insertion of the caudal stylets; male similar but smaller.

Sp 1. *Lathonura rectirostris*, O. F. Mueller.

(Plate D.)

Daphnia rectirostris, O. F. MUELLER.

Pasithea rectirostris, KOCH, Deutschland's Krust., etc.

Daphnia brachyura, ZADDACH, Syn. Crust. prussicorum. LIEVIN, Die Branch. d. Danziger Gegend.

Daphnia mystacina, FISCHER, St. Petersb. Branchiop.

Lathonura rectirostris, LILLJEBORG, De Crust. ex ord. trib.

Pasithea rectirostris, LEYDIG, Naturg. d. Daph.

Lathonura rectirostris, NORMAN and BRADY, Monogr. Brit. Ent.; P. E. MUELLER, Danmark's Cladocera.

Lathonura spinosa, SCHOEDLER, Branchiop. d. Umg. v. Berlin.

Pasithea rectirostris, GRUBER and WEISMANN, Ueber einige neue od. unvollk. gekannte Daph.

Lathonura rectirostris, BIRGE, Notes on Cladocera. HERRICK, Notes on Minnesota Cladocera.

The only species of the genus is distributed probably over the entire northern temperate zone. It has been found in America at Cambridge, Mass., and in the vicinity of Minneapolis, at both of which places it is very rare.

The form is a rather quadrangular oval, the head being strongly arched to the beak which is much farther posterior than in *Macrothrix*, in this respect resembling the *Daphnidae*; the eye occupies the center of the lower part of the head margin, and is of moderate size; the pigment fleck is near the base of the antennules and well removed from the eye; the antennæ are straight and long, with a

sensory bristle near the base in front and two bristles a third from the end; the second antennæ are furnished with a powerful basal joint, while each of the main subdivisions of the rami has its bristle, which are nearly equal; two of the terminal setæ are toothed for the basal half and pectinate distally, but the others are feathered throughout; the four-jointed ramus has a spine on the second joint and a longer one at the end, and all the joints of both rami are ornamented with triple series of spines; the maxillæ are three-spined at the end and are in almost constant motion; the first pairs of feet have curious comb-like bunches on some of the setæ; the abdomen is very short and terminates in inconspicuous teeth, the posterior part of the abdomen being ornamented with teeth flattened longitudinally so as to look like spines from the side; the last foot is simple but bears a large appendage; the posterior third of the shell is fringed by extremely minute spines, but anteriorly by lanceolate stiff spines flattened longitudinally like the spines of the abdomen; the caudal setæ are seated on a high prominence of the abdomen, and are fringed along their whole length, not merely at the end. The female is 1 mm. long, the male 0.5—0.6 mm., in which sex the antennules have more numerous lateral bristles, the first foot has a claw and the back is less elevated. The semen bodies are irregularly round with small nuclei.

III. GENUS STREBLOCERCUS, Sars.

In form like *Macrothrix laticornis*, head terminating in a long rostrum bearing the long, twisted antennules. Antennules very large, curved backward and outward. Head not separated by a distinct depression from the body, very high, slightly arched above, abruptly curved below with spines upon the margins. The antennæ are large; four-jointed ramus much the longer, with four setæ. Labrum with a large process. Post-abdomen as in *Macrothrix laticornis*. Eye near the beak; pigment fleck small, below it at the base of the antennules. Length .33 mm. *S. minutus* is the only species.

Our *Macrothrix pauper* seems a near approach to this genus; both have a strong spine or claw on the first foot which projects beyond the shell, but there are many differences. *M. pauper* is 1 mm. long.

IV. GENUS DREPANOTHRIX, Sars.

The head not separated from the valves by a depression; fornices moderate; rostrum rather acute, distant from the anterior edge of the valves. The form is subrotund; reticulate, with the margins of shell fringed below by long movable spines; pigment fleck present; swimming antennæ with three ciliated setæ on the 4-jointed ramus, the 3-jointed ramus with its basal joint armed with an unjointed, strong, spinous seta and four ciliated setæ on the remaining joints. The post-abdomen is broad. The male has longer antennæ and a hook on the first foot.

Sp. 1. *Drepanothrix dentata*, Euren.

(Plate C. Fig. 14.)

Acantholeberis dentata, EUREN.*Drepanothrix setigera*, SARS.*Drepanothrix hamata*, SARS.

This animal is only 0.5 mm. in length. The antennules are laterally curved in the middle and ornamented with notches on the margins; the pigment fleck is quadrate and rather large; the post-abdomen is truncate at the end, convex behind and ornamented with a series of small spines. Only found in Scandinavia as yet.

V. GENUS ACANTHOLEBERIS, Lilljeborg.

Head separated by a depression from the body, with fornices above the base of the swimming antennæ; rostrum erect, rather acute; shell oblong, truncate behind, ciliate below with long setæ; macula present; antennules rather long, movable, sensory setæ terminal, bifid at the apex.

The tri-articulate ramus has a long spiny seta on the basal joint; feet six pairs; no abdominal process; post-abdomen wide, large; intestine without cæca.

Sp. 1. *Acantholeberis curvirostris*, Mueller.*Daphnia curvirostris*, O. F. MUELLER.*Acanthocercus rigidus*, SCHOEDLER, LIEVIN.*Acantholeberis curvirostris*, LILLJEBORG, P. E. MUELLER.

This species of a genus approximating the Lynceids has not yet been found in America but is to be expected.

The abdomen is rounded toward the end and spiny posteriorly; the terminal claws are furnished with two strong teeth at the base,

followed by a series of fringing bristles. The length, according to Mueller, is 1.5 mm. This is a rare form in Europe.

VI. GENUS OFRYOXUS, Sars.

The single species constituting this genus seems to have been seen by no writer save Sars. At the time my previous paper on Cladocera was published, Sars' description seemed not to apply to the form called *Lyncodaphnia*. Since then several stages in the growth of *Lyncodaphnia* have been encountered, which so far agree with what is said of *Ofryoxus gracilis* that it is doubted if the two forms are not identical.

VII. GENUS LYNCODAPHNIA, Herrick.

(Plate B. Figs. 12, 15; Plate B₁, Figs. 1, 3.)

Body elongated, somewhat rectangular as seen from the side, greatest width and height of shell a little posterior to the heart; head separated by a depression from the body, truncate below; antennæ and antennules much as in *Macrothrix*; 4-jointed ramus of antennæ with no lateral setæ; eye small, pigment fleck present; intestine twice convoluted, expanded posteriorly, with anterior but no posterior cæca, opening near the "heel" of the post-abdomen; post-abdomen large, triangular; terminal claws long, rather straight, with two accessory spines at the base.

The species upon which this genus was founded¹ occurs in August and September in the larger lakes of Minnesota.

Lyncodaphnia is, as was suggested, a curious transition form linking the *Daphnidæ* with the *Lynceidæ*.

A farther study of the genus shows that, in some respects, it is more closely allied to both groups than before suspected. The habit and appearance in the water reminds us of *Simocephalus*, a resemblance which an occasional spot of pink or blue color heightens.

L. macrothroides not only has the disc-like last foot colored but the swimming antennæ are banded with purple as in *Simocephalus rostratus*, Her., and *S. americanus*, Birge. The intestine has anterior cæca, which is not the case in lynceids nor, indeed, in other *Lyncodaphnidæ*.

The four-jointed ramus of the antennæ approaches *Lynceidæ* in the absence of a lateral seta, but the other ramus is as in *Macrothrix*. The convolution of the intestine, the form of the post-abdomen and the situation of the anus, are all of a strictly lynceid

¹ Notes on Minnesota Cladocera, p. 247.

type; moreover the flattened appendage of the last foot is like that of *Eurycercus*.

Even in the form of the shell there is a combination of characters; the anterior part of the shell has the form peculiar to *Lyncodaphnidæ*; but posteriorly it again expands and becomes truncate behind; the form in the adult is not unlike that of some *Lynceidæ*, but the young has a long spine posteriorly exactly like the spine of *Daphnia*. The latter fact is very instructive, for it indicates that the theory proposed (*Am. Naturalist*, 1882, p. 815) to explain the origin of this appendage is probably the correct one. Professor Leuckart suggested that this spine was a balancing rod intended to keep the proper equipoise over the center of gravity; but it is difficult to see why these long-bodied forms, in which the greater part of the weight lies "abaft" of the pivotal point—the base of the antennæ—should be thus provided while the shorter forms are not. We conceive that it is an apparatus for effecting the moult of the inner lining of the brood cavity of long-bodied and tender-shelled animals such as *Daphnia* and the present genus. The great development of the head in the crested *Daphnidæ* may undoubtedly be explained upon Prof. Leuckart's theory.

Sp. 1. *Lyncodaphnia macrothroides*, Herrick.

(Perhaps = *Ofryoxus gracilis*, Sars.)

Notes on Cladocera of Minn., p. 247.

Sub-rectangular, greatly elongated, truncate behind, with a slight spine above; head and eye small, fornix moderate, beak truncate; antennules rather long, slightly curved, tapering a little toward the end, whence spring three lanceolate spines and several sensory filaments, five stout spines behind, above the middle, and several more slender ones; swimming antennæ very long, terminal setæ smooth to the joint; labrum as in *Daphnia*; mandible attached behind a salient angle of the front margin of the shell; no abdominal processes; post-abdomen broad above, triangular; terminal claws pectinate, furnished with one very large toothed accessory spine and a smaller one; the first foot has a hook; the last foot consists of a large oval plate which bears posteriorly the ordinary branchial coil, here shaped like a thumb and forefinger. The young is of a different shape and bears a long spine. The male is unknown.

VIII. GENUS ILYOCRYPTUS.

Form compact, short; head short, triangular, with large fornices forming a roof over the head; the posterior margin of shell nearly as long as the inferior; lower angle a broad curve; antennules two-jointed, basal joint very short, second joint straight, rather long; setæ terminal, but one seta near the base; the four-jointed ramus of the antenna with but three (terminal) setæ; six pairs of feet, last pair rudimentary; tail large, as in *Lyncodaphnia*, anus elevated; intestine straight, without cæca, but an expansion near the rectum sometimes simulates one; the margin of the shell is bordered with long spines, which may be branched or simply pectinate. There is often, perhaps generally, a failure to entirely remove the moulted shell; when this occurs, the newly-formed shell from each moult remains under the older ones till the animal seems to be wearing six or more overcoats, and the spaces so formed become filled with algæ and filth till the animal is no longer able to swim. P. E. Mueller and Kurz, who seem to have seen only *I. sordidus* agree that *Ilyocryptus* can not swim, but poles along in the mud on the bottom by means of antennæ and abdomen; our *I. spinifer*, on the other hand, swims freely till loaded up with old clothes and filth.

This genus is also closely allied with the *Lynceidæ*.

Sp. 1. *Ilyocryptus sordidus*, Lievin.

(Plate C. Figs. 15, 16, 17.)

Acanthocercus sordidus, LIEVIN, LEYDIG.

Ilyocryptus sordidus, SARS, NORMANN, P. E. MUELLER, KURZ.

Body higher than long; head small, terminating anteriorly in almost a right angle; posterior part of the shell margins covered with branching, thorny spines; antennules cylindrical; antennæ short; four-jointed rami with no lateral setæ; post-abdomen large, broad; terminal claws with two spines at the base; anus in the middle of the posterior margin, which is very heavily armed with spines; a hairy abdominal process is present according to Kurz.

There are no anterior cæca (my statement that P. E. Mueller described such cæca was an error; see Notes on Cladocera of Minn., p. 246).

Sp. 2. *Ilyocryptus spinifer*, Herrick.

(Plate C. Figs. 18—19.)

Usually longer than high; head rounded, almost exactly like *I. sordidus*, but the form of the post-abdomen differs a little in the higher situation of the anus and the great elongation of four or five of the lower spines of the posterior margins; the margins of the shell are beset with pectinate setæ which do not branch. The nearest approach to branching setæ yet seen are figured on plate C, fig. 18 a; this consists in the outgrowth of a spine from near the base, and such setæ are found only on part of the posterior margin.

It seems that our form is rather close to *I. sordidus* though clearly distinct.

This species occurs in many of our lakes, and is found most frequent in late summer.

Sp. 3. *Ilyocryptus acutifrons*, Sars.

This species is only mentioned in the appendix to the paper of Sars on the Cladocera from the vicinity of Christiania. The following is a condensation of the description.

Head large, acute in front. Shell truncate behind, with shorter setæ behind than below. Antennules shorter and thicker than in *I. sordidus*. Antennæ long and robust. Abdomen with a short, obtuse process. Post-abdomen shorter than in *I. sordidus*, posterior margin continuous, anus terminal; caudal claws straight, very long, with two minute basal spines. Pigment fleck almost touching the eye. Length less than in *I. sordidus*.

This species seems in some respects more like a true lyncodaphnid than either of the other species. It is doubtful if it belongs here.

FAMILY LYNCEIDÆ.

GENERA.	Number of known species.	European.	Also in America	In America only.	Total American.
1. <i>Eurycercus</i>	1	1	1	.....	1
2. <i>Acroperus</i>	2	2	1	.....	1
3. <i>Camptocercus</i>	6	5	1	1	2
4. <i>Alonopsis</i>	3	2	1	1	2
5. <i>Leydigia</i>	2	2	2	.....	2
6. <i>Graptoleberis</i>	2	2	1	.....	1
7. <i>Crepidocercus</i>	1	.....	.....	1	1
8. <i>Alona</i>	21	14	6	7	13
9. <i>Alonella</i>	5	5	2	.....	2
10. <i>Pleuroxus</i>	14	8	1	6	7
11. <i>Harporhynchus</i>	1	1	.....	.....	.....
2. <i>Chydorus</i>	8(?)	6(?)	3	.....	3
13. <i>Anehistropus</i>	1	1	.....	.....	1(?)
14. <i>Monospilus</i>	1	1	1	.....	1
Totals.....	68	50	20	16	37

Out of the fourteen genera, two (or perhaps only one) are not yet known from America, while one is restricted to it. The American species, 45 per cent of which are new, aggregate 72 per cent of the European. 54 per cent of all the known species are American, and most of these have been found within a range of ten miles of Minneapolis. It is probable that the number of species peculiar to America is too high proportionately rather than the reverse, and the comparatively high per cent of new species is due to an actual larger fauna in the New World, while many Old World species remain to be identified. A few of the European species are very likely synonyms, permitting farther reduction.

This family, which is numerically the largest among the Cladocera, is, in the main, well limited, though there are transitions toward the Lyncodaphnidæ, which are quite direct. The genera Lyncodaphnia, Ofryoxus and Ilyocryptus lead toward the Lynceidæ unmistakably. Most of the members of this family are small, comparatively few exceeding one millimeter in length. The head is covered with an arched shield, which frequently passes with no indentation into the shell of the body. This head-covering generally extends forward and downward to form more or less of a sharp angle in front, while in several genera it is simply rounded in front. It, in either case, arches over the more fleshy lower side of the head from which hang the two short antennules and the labrum, while the strong two-branched antennæ spring from well up under its posterior expansion. The rounded sides of this shield, which protect the insertion of the antennæ, are called the fornices. Above the insertion of antennules is a dark fleck lying near or on the lower angle of the brain; this is the larval or nauplius eye, which is the first to appear in all these small crustacea. This *macula nigra* is not infrequently as large as the eye itself,* or even larger, and in one genus it is the only visual organ. The antennules are small and bear on the end several sensory filaments as well as a lateral flagellum. The antennules of the male differ very little from those of the female. The labrum is furnished with a process, which is triangular or semicircular and is usually larger than the terminal portion. The mandibles are as in Daphnidæ but usually shorter. Maxillæ are often conspicuous, but the first pair of feet serve, by a slight alteration at the base, the same purpose. There is rarely an indication of the sixth pair of feet, and the antennæ have both rami three-jointed. The terminal part of the body, or

* The name "Lynceus" is derived from that of the son of Aphareus who was famous for the sharpness of his vision.

post-abdomen, is usually enlarged, and the anal opening is near its base; the armature is usually considerable. The form of the post-abdomen is one of the best criteria for distinguishing genera and species—a process often attended with much difficulty.

The shell is of various forms, frequently beautifully sculptured. The number of eggs produced at one time is limited, and the winter eggs are very often laid in the brood-cavity with no preparation of the shell previous to it, in other words, the ephippium may be absent. On the other hand, sometimes the shell is considerably modified, and generally there is a deposit of dark pigment in the upper part of the shell. The males are very rare and until recently few were known. The diligence of Kurz has added a great many, and we now have a fair idea of the sexual variations. These consist usually in a narrower body and shorter beak, in a strong hook of chitin on the first foot and certain modifications of the post-abdomen. The hook mentioned is simply an enlargement of one of the terminal bristles of the foot, and serves to fasten the animal to the shell of the female. In one American species of *Pleuroxus* we find an approach to this structure in the female—an interesting example of inheritance of sexual peculiarities across the sexes. The alterations in the form of the post-abdomen consist in a narrowing or excavation of that organ to permit its introduction into the brood-cavity, and in some forms (*Chydorus*) this change can only be understood by observing the form of the shell of the female about to produce winter eggs. In general, as in other Cladocera, males are found only at the period when the females are sexually perfect. The ordinary method of reproduction is by virgin-bearing or parthenogenesis. In some cases it would seem from Weismann's observations that the sexual method occurs only incidentally. The orifice of the male organs is between, or anterior to, the terminal claws of the post-abdomen (*Eurycerus* alone excepted). The males are usually but not always smaller. Plate E gives views of typical Lynceidæ. Fig. 1 is particularly instructive, for in it the details which can be usually made out in the living object are represented. The following points may be especially noticed. The large size of the pigment fleck, the large antennules (A^1), the keel of the labrum (Lb.), the peculiar modification of the first pair of feet to assist the maxillæ (not shown) which are exceedingly small, the largely developed anal gland (A. g.), the form and muscular mechanism of the abdomen, which, however, is better illustrated by fig. 10 of the same plate. Fig. 1 contains an embryo seen from the side with the partially developed limb. Fig. 3 shows the appearance of a differ-

ent embryo from below and in an earlier stage. Fig. 2 illustrates the relation of the brain to the eye and the very small optic ganglion. Fig. 9 of plate G gives details of the feet in another species, and the modifications seen in the male of the same species are sufficiently shown in fig. 1 of the same plate, which also well illustrates the various sculpture of the shell displayed by this group. Figures 4 and 9 of plate F show curious modifications of the post-abdomen of the male, and fig. 7 exhibits the structural peculiarity of sexually perfect females which is correlated with it or, perhaps we may say, occasions it.

SUB-FAMILY I.—EURYCERCINÆ.

A single species constitutes the sub-family, and it will be necessary to point out only those points which are distinctive.

The Eurycercinæ differ from the true Lynceidæ and approach the Lyncodaphnidæ in having the digestive tract not coiled, with two cæca in front and the anus at the end of the post-abdomen. Many eggs are produced at once. The male opening is at the base of the abdomen, as in Sididæ. The general habitus is, however, lynceid. The males appear in autumn or when, by the gradual drying up of the water or other causes, the continued existence of the animals is threatened.

I. GENUS EURYCERCUS, Baird.

Characters of the sub-family.

Eurycercus lamellatus, O. F. Mueller.

(Plate H, Figs. 5–6.)

Lynceus lamellatus, MUELLER, EDWARDS, KOCH, ZADDACH, LIEVIN, LEYDIG, ZENKER
Eurycercus lamellatus, BAIRD, LILLJEBORG, SCHOEDLER, P. E. MUELLER, KURZ, BIRGE,
HERRICK.

Eurycercus laticaudatus, FISCHER, SCHOEDLER.

A gigantic lynceid, reaching the dimension of 3 mm. The figure of the male given will sufficiently illustrate the general form. The abdomen is broad and armed behind with a dense row of saw-teeth. The eye is larger than the rather small pigment fleck, and the intestine is bent upon itself but not coiled. The last foot is found in few other Lynceidæ. *Acroperus* has the same, and *Pleuroxus unidens* also has a rudimentary sixth foot.

SUB-FAMILY II.—LYNCEINÆ.

Intestine coiled; anus near the end of the post-abdomen; opening of vas deferens nearly terminal. There are no anterior cæca but usually a single anal diverticle of the intestine. Rarely or never more than two embryos produced at once.

SERIES A.

Head or dorsal line keeled or ridged; abdomen long; shell marked with diagonal striæ. This section is proposed for the old genera *Camptocercus*, *Acroperus* and *Alo-nopsis*, which seem to form a natural group though passing directly into *Alina*.

II.—GENUS CAMPTOCERCUS (>*Camptocercus*, Baird).

This easily recognizable genus contains two groups, each with several nominal species, which are distinguished mainly by the width of the post-abdomen. In both the shell is elongated, more or less quadrangular, longitudinally striate, armed behind with one to four minute teeth. The head and back are keeled and the former strongly arched. The antennules rarely extend beyond the beak and are commonly curved laterally. The eye is proportionately small. The post-abdomen is long and furnished with a lateral row of scales. The terminal claws have a single basal spine and are serrate. There is an ephippium, and the male opening is in front of the terminal claws.

SUB-GENUS 1.—ACROPERUS, Baird.

Post-abdomen broad, margins parallel; anal teeth very minute lateral scales large and usurping their place. Antennæ with eight setæ ($\frac{300}{311}$). Three species are described, one of which is very abundant in Minnesota.

Sp. 1. *Acroperus leucocephalus*, Koch.

(Plate E, Fig. 5. Plate I, Fig. 9.)

Lynceus leucocephalus, KOCH, FISCHER.

Acroperus harpæ, BAIRD.

Acroperus leucocephalus, SCHOEDLER, P. E. MUELLER, KURZ.

Acroperus sp., HERRICK.

Acroperus striatus, JURINE, M. EDWARDS, LIEVIN, LILLJEBORG, LEYDIG, etc., seems to belong here, but I am able to add nothing to the elucidation of the puzzle.

Body rounded above, angled behind; head moderately arched and carinated. Lower margin of the shell pectinate, terminating in

two teeth. The antennæ are long and when reflexed the setæ reach nearly to the posterior margin of the shell. The posterior angle is not always as prominent as shown in fig. 5.

Sp. 2. *Acroperus angustatus*, Sars.

(Plate I. Fig. 10.)

Acroperus angustatus, P. E. MUELLER, KURZ.

This species is distinguished from the former by the head, which is higher and very strongly arched. The dorsal contour is nearly straight. The antennæ are shorter. The form of the post-abdomen of the male is less different from that of the female than in the above. The length of both species is about 0.7 mm.

The American form figured in fig. 5 of plate E differs from both the above slightly. The head is carinated and incurved almost as in *C. angustatus*; the antennæ fall a little short of reaching the posterior margin of the too low and oblong shell; there is an obvious depression between the head and body. However, in the main there is close agreement with *C. leucocephalus*, to which it has been previously referred. There is always a rudiment of an additional pair of feet.

A. cavirostris, P. E. Mueller, is not known in the female sex. The male has a twisted caudal claw.

SUB-GENUS 2.—CAMPTOCERCUS, Baird.

Although the general form is similar to the last section, the body is usually longer; the post-abdomen narrows toward the end; the anal teeth exceed the lateral row; the antennæ have usually but seven setae ($\frac{300}{310}$).

The species enumerated are so closely related as almost to baffle definition.

KEY TO THE SUB-GENUS CAMPTOCERCUS (verus).

Beak pointed.

(a) Head depressed.

I. Pigment fleck larger than the eye.

1. *C. biserratus*, SCHOEDLER.

II. Pigment fleck smaller than the eye.

2. *C. macrurus*, O. F. MUELLER.

(b) Head directed forward.

3. *C. rectirostris*, SCHOEDLER.

Beak truncate below.

4. *C. latirostris*, KURZ.

Beak cleft below or with a forward projection.

(a) Antennules shorter than the beak.

5. *C. lilljeborgii*, SCHOEDLER.

(b) Antennules longer than the beak.

6. *C. rotundus*, HERRICK.

Sp. 1. *Camptocercus biserratus*, Schoedler.

(Plate I. Fig. 4.)

Is very nearly related to the next, from which it is distinguished chiefly by the fact that the pigment fleck is larger than the eye. Schoedler overlooked the fact that in *C. macrurus* there is a lateral line of scales on the abdomen, and relied upon that character to distinguish this form. (Schoedler says that the pigment fleck in *C. macrurus* is smaller than the eye, P. E. Mueller says they are nearly equal, while in our specimens they are much smaller or nearly equal.) If much variability is found, Schoedler's species seems to rest on a slender basis. The basal spine of the claw, however, seems to be peculiar in sitting on a distinct prominence.

Sp. 2. *Camptocercus macrurus*, Mueller.

(Plate E. Fig. 10.)

Lynceus macrurus, LILLJEBORG, SCHOEDLER, P. E. MUELLER, KURZ, BIRGE, HERRICK.

This universally distributed species occurs in our larger bodies of water and is not rare, though hardly abundant.

The body is long and nearly rectangular; the head strongly arched and keeled. The keel of the head is extended down the whole dorsal line. The dorsal line is moderately curved, while the shell is but slightly excavated below. The head extends into a blunt beak looking downward; the direction of the head is somewhat variable (from vertical to an angle of about 30°). The eye is much larger than the pigment fleck; the antennules are shorter than the beak, and have one elongated terminal seta. The post-abdomen is very long and has numerous anal teeth as well as a lateral row of scales. The basal spine of the claws is large and serrate, the claw itself being nearly straight and armed with an increasing series of spines to beyond the middle. The lateral scales of the post-abdomen are inconspicuous. The shell gland is long. The antennules reach to almost the end of the beak, are curved and bear a lateral flagellum. The first foot of the female has a sort of hook (branchial sac?). The labrum is armed with teeth on the posterior face of the triangular process. The intestine is very strongly, almost twice coiled. The lower margins of the valves are

feebly spined for three-fourths their length, and armed with from one to four teeth at the angle. Length 0.8 mm. to 1.0 mm.

Sp. 3. *Camptocercus rectirostris*, Schoedler.

(Plate I. Figs. 1—3.)

Camptocercus rectirostris, SCHOEDLER, P. E. MUELLER, KURZ.

Distinguished from the above, which it closely resembles, by the form of the head, which is less rounded and directed anteriorly. It hardly exceeds half the height of the body. The beak is sharp. I am not sure that Weismann's figures (l. c., plate XI, figures 13 and 14) really belong to this species, for the drawing of the post-abdomen does not agree with that of P. E. Mueller fully. Outline copies of the former are given in plate I, figs. 1 and 2. The male has a hook upon the first foot. Not yet recognized in America.

Sp. 4. *Camptocercus latirostris*, Kurz.

(Plate I. Figs. 5—6.)

C. lilljeborgii, P. E. MUELLER (?).

Closely allied to the next, but distinguished by the position of the head, which is a little less depressed, and, especially, by the truncate beak. The dorsal margin is convex and crested; the lower outline is also convex. The claws are toothed more as in *C. macrurus* than the following. The basal spine springs from the claw itself and not from the post-abdomen as in the next. Length 0.9 mm. to 1.0 mm.

Sp. 5. *Camptocercus lilljeborgii*, Schoedler.

(Plate I. Figs. 7—8.)

Head depressed, rounded in front: beak divided at the end by the extension of the fornices. The terminal claws are pectinate for their entire length, and the basal spine is seated on the end of the post-abdomen. This species, in the main, closely resembles *C. macrurus*.

Sp. 6. *Camptocercus rotundus*, Herrick.

The second of the two species found in America is this short, strongly carinated form, which is known from a single gathering. It differs from all the above species, with which it agrees pretty well in shape, by its more compact form; high dorsal keel (which extends the entire length of the body); the long antennules, which extend far below the beak; and the somewhat pointed beak. The

head is much as in the last, but it is not certain that the beak is cleft, although it has a peculiar form (not indicated in the figure) near the end. The length is 0.7 mm. The terminal setæ of the antennules are very unequal; but in most points, as in the armature of the post-abdomen, the details resemble *C. macrurus*.

III.—GENUS ALONOPSIS, Sars.

This curious genus includes three species of small lynceids, which exhibit a combination of characters. The form of the beak and head is like that of *Pleuroxus*, which the form and sculpture of the shell otherwise resembles. The back is extended more or less in a knife-like ridge above, thus resembling *Acroperus*, a resemblance heightened by the excavated lower margin. The form of the post-abdomen approaches that of *Acroperus*, but in that genus it is of about equal width throughout and in this it rapidly narrows. The internal organs and feet are of the typical lynceid form, while the antennæ are as in *Pleuroxus*.

The type of the genus, *A. elongata*, is apparently much closer to *Acroperus* than the two species which have been identified in America.

Shell sub-rectangular, high, produced into a ridge above; lower margin convex anteriorly, concave behind; beak rather long; antennules slender; antennæ with eight setæ; abdomen long, narrowed toward end, incised at the extremity; claw rather large, with median spines and a basal thorn; third foot with a long bristle. Male smaller, without the carina above; orifice of sexual organs in front of the claw, which is removed from the anterior margin. The young are more elongate and (sometimes) have hexagonal reticulations instead of the usual strong diagonal striæ. Motion slow.

Sp. 1. *Alonopsis elongata*, Sars.

Lynceus macrurus, LIEVIN.

Lynceus macrurus, ZENKER, LEYDIG.

Alona elongata, SARS.

Acroperus intermedius, SCHOEDLER.

Alonopsis elongata, P. E. MUELLER.

The shell is wide, the upper margin forming an even curve, manifestly angled behind; ventral margin nearly straight, ciliated throughout, with a single tooth behind. Fornices large; head narrow, not carinate. Post-abdomen compressed, truncate at the end, armed with a series of marginal spines and of lateral scales; caudal claws large, with a single spine at the base and two median spines followed by a series of minute setæ.

This form I have never seen, and it seems somewhat doubtful that the following really belong with it.

Sp. 2. *Alonopsis latissima*, Kurz.

(Plate E, Fig. 8. Plate G, Figs. 1 and 9.)

Body very high, compressed, with a high dorsal keel or ridge; the upper outline strongly and evenly arched, terminating behind in no angle; lower margin almost angled at the anterior third, rounded behind, fringed with long bristles anteriorly, with short ones posteriorly. Head very narrow; beak extremely long; fornices small; antennules nearly as long as the beak, straight and narrow; pigment fleck smaller than the eye. The abdomen is long, somewhat narrowed toward the end, where it is deeply cleft; the terminal claw is furnished with a large and small basal spine, while there is an increasing series of spines extending to the middle.

The elongated spine of the third foot is pectinate and reaches nearly to the posterior margin of the shell. The shell is marked by few strong striæ which are diagonal except anteriorly where are a few parallel to the front margin. The male is small and lacks the crest on the back, while the lower margin is straight; the antennæ are longer than the beak and differ somewhat from those of the female. The first foot has a claw. The post-abdomen lacks the anal teeth. Kurz gives the size as 0.5 mm.

The American form varies between 0.45 mm. and 0.55 mm., and seems to have a higher dorsal keel and longer beak. Kurz speaks of but a single accessory spine on the terminal claws; there is, however, a second very minute spine or cluster of hairs in this as well as the following.

Found in the same gathering with the following near Minneapolis (marshy off-set from Bassett's creek near Oak Lake Addition).*

*NOTE TO ALONOPSIS LATISSIMA. (See Fig. 1, Plate G.) Since writing the above the males of our American form have been found; they are shaped as the females, with a high dorsal keel; the post-abdomen is rounded, with transverse series of small bristles; the claw has a minute median spine, and the *porus genitalis* is anterior and elevated.

Sp. 3. *Alonopsis media*, Birge.

(Plate E. Fig. 9.)

I give Birge's description verbatim:

"Rostrum prolonged, and shell sharp, somewhat quadrangular in shape, marked by striæ. The dorsal margin is convex, the hinder margin nearly straight. Its lower angle is rounded and without teeth. The lower margin is concave and has long plumose setæ.

The front margin is strongly convex. The post-abdomen is long and slender, resembling that of *Camptocercus*, and is notched at the distal extremity; it has two rows of fine teeth and some fine scales above them. The terminal claws are long, slender, with a basal spine, a spine in the middle, and are serrated. The antennules are long and slender, but do not reach to the end of the rostrum. They have each a flagellum and sense hairs. The antennæ are small and have eight ($\frac{300}{311}$) setæ and two ($\frac{100}{100}$) spines. The labrum resembles that of *A. leucocephalus*, but is slightly prolonged at the apex. The intestine, cæcum and color resemble those of *Acroperus*. There is a trace of a keel present on the back."

The specimens seen in Minnesota resemble this species very nearly, apparently, but there are some differences. The terminal claw of the post-abdomen has an increasing series of spines to the middle; there seems to be no lateral row of scales beside the anal teeth; the abdomen is rather broad at the base and narrows toward the end. The shell is not square behind. The lower margin has a few long hairs anteriorly which are followed by a series of teeth, and in the concave part a somewhat longer set to a point just before the lower curved angle.

The pigment fleck is nearly or quite as large as the eye. The antennule is shorter than the beak (which is almost as in *Pleuroxus hastatus*), and has a flagellum about midway; at its base it is narrowed and inserted on a prominence.

The embryo still in the brood sac had a more elongate form and hexagonal reticulations upon the shell, while the antennules were longer than the very long beak, and the pigment fleck was smaller than the eye. Length of female 0.52 mm. The color is darker, and the striæ more numerous, than in *A. latissima*.

SERIES B.

This section includes forms with (usually) no keel above, or, if keeled, the post-abdomen is not long. The majority are highly arched dorsally, and have comparatively short post-abdomen and pointed beak. The antennæ are usually feeble and the motion slow.

- A. Post-abdomen nearly round in outline, armed with very long stout spines, terminal claw with one minute basal spine or none; greatest height of shell about equal to the posterior margin.
 1. Genus *Leydigia*.
- B. Greatest height of shell moderately exceeding that of posterior margin; post-abdomen more or less triangular, armed with bristles; shell marked with hexagonal meshes.
 - (a) Head nearly horizontal, blunt; post-abdomen prominent in the anal region.
 2. Genus *Graptoleberis*.

- (b) Head depressed, acute ; post-abdomen excised near the anus.
3. Genus *Crepidocercus*.
- C. Post-abdomen more or less quadrangular, armed with one or two rows of small teeth on either side behind ; terminal claws with one or two basal spines ; hight of posterior shell margin usually less than the greatest hight of shell.
4. Genus *Lynceus*.
- D. Greatest hight of shell little less than that of posterior shell margin ; post-abdomen terete ; terminal claws very minute.
5. Genus *Phriavura*.
- E. Greatest hight of shell more than double that of posterior margin.
- (a) Eye and first foot normal.
6. Genus *Chydorus*.
- (b) First foot with a claw which extends beyond the shell.
7. Genus *Anchistropus*.
- (c) Eye absent, only pigment fleck used for vision.
8. Genus *Monospilus*.

IV.—GENUS LEYDIGIA, KURZ.

In this genus, both the known species of which are found in America, the posterior part of the shell and body is emphasized at the expense of the anterior. The curved posterior margin is equal to the greatest hight of the shell. The head and anterior part of the body are of the form characteristic of *Alona*; indeed, the whole body is in plan like *Alona*, but in the back part the organs are all enlarged. The general form of the body and abdomen recalls *Ilyocryptus*; the post-abdomen, in particular is very like that genus. The last two pairs of feet are much enlarged. The shell is usually irregularly marked with longitudinal striæ; the lower margin is covered with long spine-like setæ. The post-abdomen is armed with several sets of long spines and aggregations of bristles and small spines; it is almost round and enormously enlarged. The intestine is coiled and expanded at the end, but the anal cæcum is rudimentary. The antennæ are heavily spined and have eight setæ; the labrum is more or less hairy. The male has a strong hook on the first foot, and between the terminal claws of the abdomen is a peculiar intromittent organ.

Sp. 1. *Leydigia quadrangularis*, Leydig.

(Plate H. Fig. 4.)

Lynceus quadrangularis, LEYDIG, FRIC.

Alona leydigii, SCHOEDLER, P. E. MUELLER.

Leydigia quadrangularis, KURZ.

The shell is comparable to that of *Alona quadrangularis*, but higher behind; the markings are not very distinct; shell transparent. The head is very small; the eye smaller than or of about the size of the pigment fleck. The post-abdomen is very broad, the

posterior margin nearly the segment of a circle, armed with numerous very long unequal spines which extend only about half the height, being replaced by short close hairs; the anal opening is very high; the terminal claws are long, straightish, and have a small thorn near the base.

The males are smaller than the females, and the abdomen is less broad; the antennules are longer than the beak and furnished with a flagellum. The sexual period occurs in September or irregularly. This species has only been encountered once, during September, in Poplar river, Cullman county, Alabama.

Sp. 2. *Leydigia acanthocercoides*, Fischer.

Lynceus acanthocercoides, FISCHER, LEYDIG.

Eurycerus acanthocercoides, SCHOEDLER.

Alona acanthocercoides, P. E. MUELLER.

Leydigia acanthocercoides, KURZ.

Leydigia quadrangularis, HERRICK.

This species, reported in a previous paper, is, as was said, nearest like *L. acanthocercoides*; and I am now able to verify the very inconspicuous differences upon which the two are separated. Our specimens of the *L. quadrangularis* have the pigment fleck fully as large as the eye, Kurz to the contrary notwithstanding, and the claw of the post-abdomen is present, while in the present species the pigment fleck is much larger and furnished with lenses; the spine of the claw is wanting; the labrum is densely hairy; the abdomen is narrower, and the shell higher. The shell is very obviously striped in the posterior portion. The anus is higher than in the previous species. In other respects the two seem alike.

v.—GENUS GRAPTOLEBERIS, Sars.

A genus containing two closely allied species, having some affinities with *Alonella*. The shell is entirely reticulated, and there is a sort of crest along the back; while, on the other hand, the head is flattened and rounded in front. There can hardly be said to be a beak. Seen from above, the animal resembles some species of *Alonella*, but the head is larger proportionally and more horizontal. The lower posterior angle is spined. The antennæ have seven setæ and are very long, in this respect resembling *Camptocercus*. The dorsal contour is not greatly arched. The post-abdomen has short claws and anal bristles, but no teeth.

Sp. 1. *Graptoleberis testudinaria*, Fischer.*Lynceus testudinarius*, LEYDIG, LILLJEBORG.*Lynceus reticulatus*, FRIC.*Alona testudinaria*, SCHOEDLER.*Graptoleberis testudinaria*, KURZ.*Graptoleberis inermis*, BIRGE.

Form trapezoidal; lower margin straight, armed behind with two teeth, thickly beset with long hairs in front; the dorsal margin is not greatly elevated, rounded at the posterior angle, forming a slight "hump" where it unites with the head shield. The head and shell are reticulated with hexagonal or quadrangular markings. The shell gapes below and rises to a sharp ridge above. The antennæ have long rami, the antennules being hardly longer than the fornices. The eye is large; the pigment fleck is small. The post-abdomen is narrowed toward the end, rounded in front; the terminal claws are small and have two basal teeth. The dorsal margin of the post-abdomen is covered with tufts of hairs. The winter eggs have no ephippium. Length 0.55 mm. to 0.7 mm. The male is smaller and has a lower dorsal keel; the post-abdomen is excavated behind.

The only differences between the Minnesota specimens and the typical European form seemed to be the absence of the very minute spines on the front of the terminal claws. The eye and pigment fleck are of about the proportions figured by Kurz. Birge's figure of the post-abdomen does not agree with his description fully. Our Minnesota specimens have an obvious but not high keel.

Sp. 2. *Graptoleberis reticulata*, Baird.*Alona reticulata*, BAIRD, P. E. MUELLER.*Lynceus reticulatus*, LILLJEBORG, LEYDIG.*Alona esocirostris*, SCHOEDLER.*Graptoleberis reticulata*, SARS, KURZ.

Shell almost rectangular, reticulate, ventral margin straight, ciliate anteriorly, with two teeth behind. Pigment fleck smaller than the eye. Post-abdomen short, narrowed towards the end, dorsally covered with clusters of spines; caudal claws with a minute tooth at the base. Length 0.4 mm. to 0.5 mm.

The pigment fleck is nearer the end of the beak than the eye, and is smaller than in the previous species, but, on the whole, there is perhaps, too great similarity.

VI.—GENUS CREPIDOCERCUS, Birge.

The characters of this group place it rather near *Alonella* or between that and *Pleuroxus*. Form sub-quadrate with rounded angles; dorsal line uniformly arched, terminating in a sharp angle behind; lower margin convex, armed behind with a single spine as in *Pleuroxus unidens*, and along the entire length with loose setæ. Beak of moderate length, acute. Post-abdomen deeply incised in the anal region; lower posterior margin straight, rounded at the apex; ventral margin straight or concave; claws with a single basal spine and a few teeth. The post-abdomen is shoe-shaped and armed with transverse rows of setæ.

The antennæ are large, having eight setæ and the usual spines. Shell smooth or reticulate.

Sp. 1. *Crepidocercus setiger*, Birge.

(Plate F. Fig. 13.)

Length 0.4 mm. to 0.5 mm. Minnesota specimens measured 0.5 mm. This, the only species of the genus, is but rarely encountered, and is so peculiar as to be easily recognized when seen. *Alona intermedia* has a post-abdomen with clusters of bristles, but in *Crepidocercus* the post-abdomen is more as in species of *Graptoleberis* than any other genus. The markings upon the shell are very indistinct.

VII.—GENUS LYNCEUS, O. F. Mueller.

The perplexing inter-relations between the three genera *Alona*, *Alonella* and *Pleuroxus* give rise to the utmost confusion. No two authors are agreed as to their respective limits, and the points given by Kurz, who has carefully gone over the ground, are obviously insufficient. Although there may be practical benefits to be derived from the continuance of the nomenclature in use for groups which in the general view can be distinguished, the value from a theoretical standpoint is reduced to a minimum.

The genus *Camptocercus* (including here *Acroperus*, which differs solely in the form of the abdomen, as a sub-genus) passes through *Alonopsis* into the group represented by *Alona*. *Leydigia*, although very near such forms as *Alona quadrangulata*, may be conveniently distinguished as a transition to species like *Ilyocryptus*.

Phrixura, Graptoleberis and Crepidocercus, each containing few species which can be readily recognized, fill a place in the system; but it is practically impossible to distinguish Alona from Pleuroxus without instituting the very indefinite genus Alonella to contain a variety of small intermediate forms. Percantha, Rhyphophilus, Harporhynchus and Pleuroxus seem to be pretty generally regarded as constituting a single group which may be recognized by the long rostrum, high shell and greater development of the antenna bristles. Alona, on the other hand, with its broader fornices, shorter beak, fairly developed antennæ, and more rectangular shell, is, perhaps, the pivotal point of the group. According to this view, then, the old name *Lynceus* is revived for the aggregate; and the other names are retained, in part, as titles of largely conventional groups or sub-genera, thus:

GENUS LYNCEUS.

Sub-genus ALONA.

Section A. *Alona vera*.

Section B. *Alonella*.

Sub-genus PLEUROXUS.

Section A. *Pleuroxus verus*.

Section B. *Leptorhynchus*.¹

Characters of Percantha and Rhyphophilus are combined in the species *P. procurvus*, Birge, so that one must be dropped or new diagnoses formulated. I am not sure that the same species is not at first *Pleuroxus verus*² and only later assumes the form known as Rhyphophilus. So with Percantha the amount of serrature of the posterior margin is in part a question of age.

SUB-GENUS ALONA.

This group contains two sections which resemble each other in form and, in general, in detail; but it is exceedingly difficult to formulate a diagnosis that shall strictly limit it. The form is generally sub-quadrangular with rounded corners; the terminal claw is armed with but a single spine at the base; the beak is rather short; and the prevailing marking consists of longitudinal lines.

Section A. *Alona (vera)*. Baird.

This genus contains a large number of minute animals which are widely distributed.

¹ Instead of Harporhynchus, a name preoccupied in zoology.

² Embryos of *P. procurvus* have the part which is to be curved forward attenuated before leaving the brood-cavity, however.

The authors who have done the most to elucidate this genus are Schoedler, P. E. Mueller, and Kurz. Birge has contributed most largely, thus far, to the knowledge of American species, which are, for the most part, identical or very close to the European. No other genus is so difficult among the Lynceidæ, for the most minute differences are relied upon to distinguish species. The species of this genus are not greatly altered by the production of the winter eggs. The males are frequently but little smaller than the opposite sex, and are recognized by the altered form of the post-abdomen and the presence of a hook on the first foot. The form is more perfectly rectangular than in the next section; the shell is only exceptionally reticulated and very rarely tuberculate, occasionally smooth. The lower angle of the shell is not armed with spines, but is generally rounded. There is only one basal spine upon the claw of the post-abdomen, which usually bears a row of scales beside the anal spines. The antennæ have eight setæ. The claw of the male post-abdomen is removed from the lower angle.

About twenty species are known, all of which that seemed recognizably defined have been included in the following key, which is believed to be more nearly natural in its arrangement than that of Kurz, which would separate the European and American representatives of the *A. parvula* group. Many more forms remain to reward the labor of American students. Those mentioned from Minnesota could probably all be found by a few days search in one locality.

KEY TO SECTION A, ALONA.

A. Shell reticulate.

(a) Reticulations horizontal.

1. *A. guttata*, Sars.

(b) Reticulations oblique.

2. *A. angulata*, Birge.

B. Shell lined, smooth or tuberculate.

(a) Over 0.5 mm. in length.

I. Shell densely striate.

3. *A. sanguinea*, P. E. Mueller.

II. Shell normally, evidently striate.

* Post-abdomen narrowed at the end.

† Armed with elongate teeth below.

4. *A. tenuicaudis*, Sars.

†† Teeth of post-abdomen nearly equal.

5. *A. lineata*, Fischer. (Shell arched.)

6. *A. modesta*, Herrick. (Shell straight above.)

** Post-abdomen not narrowed.

† Antennæ with seven setæ.

(?) 7. *A. costata*, Sars.

†† Antennæ with eight setæ.

8. *A. quadrangularis*, Mueller.

III. Shell faintly, irregularly striped; eye of same size as pigment fleck.

9. *A. oblonga*, P. E. Mueller.

IV. Shell smooth.

10. *A. affinis*, Leydig.

(b) Under 0.5 mm. in length.

I. Post-abdomen armed with a row of hairs terminating in large teeth.

11. *A. dentata*, P. E. Mueller.

II. (One or) two rows of teeth present.

* Shell densely and evenly striate.

12. *A. elegans*, Kurz.

** Shell not densely lined.

† Shell smooth or lined longitudinally.

‡ Teeth of post-abdomen unequal, the lower ones enlarged.

13. *A. porrecta*, Birge.

‡‡ Teeth nearly equal.

§ Form elongated; abdomen with a lateral line of spiny scales.

14. *A. spinifera*, Schoedler.

§§ Form squarish; abdomen with a lateral line of simple spines or bristles, or neither.

15. *A. parvula*, Kurz.

16. *A. glacialis*, Birge.

‡‡‡ Clusters of bristles, not spines, on the posterior edge of the post-abdomen.

17. *A. intermedia*, Sars.

†† Shell smooth or tuberculate.

18, 19. *A. tuberculata*, Kurz, Herrick.

Sp. 1. *Alona guttata*, Sars.

A small species of sub-quadrangular form. The beak is very short; the eye small, but larger than the minute pigment fleck. The shell is short, with a rounded posterior angle and marked by hexagonal or rectangular meshes running about parallel with the lower margin. The post-abdomen is of moderate size, rounded at the apex, with a series of stout teeth behind; the terminal claw has a minute basal spine. P. E. Mueller, in Denmark's Cladocera, confused this with *A. intermedia*, which he described under this. The post-abdomen in that species is larger, less rounded behind, and armed with clusters of spines instead of teeth. The length is about 0.3 mm. in both.

Sp. 2. *Alona angulata*, Birge.

Dorsal margin considerably arched, terminating in a more or less obvious angle at the hinder corner; the hinder edge is convex, as is also the front margin; the ventral margin bears plumose setæ. Beak pointed, extending nearly to level of ventral margin of the valves. Fornices broad. Shell obviously striated diagonally and less obviously marked by cross lines. Post-abdomen broad, truncate; about twelve anal teeth, with a series of scales and hairs back of them. The pigment fleck is much smaller than the eye. Male smaller; beak shorter; post-abdomen with a lateral row of hairs; anterior feet hooked; sculpture less distinct. [Birge.] Length of female 0.4 mm; male 0.35 mm.

Sp. 3. *Alona sanguinea*, P. E. Mueller.

(Plate I. Fig. 20.)

Body nearly rectangular; ventral margin nearly straight, with short setæ; posterior angle rounded, unarmed. Beak short; pigment fleck much larger than the eye. Post-abdomen large, the end truncate, broadened; posterior margin rounded, with a series of spines and a lateral row of scales; terminal claw with a small spine. The shell is ornamented with fine, close, longitudinal striations. Length 0.9 mm. *Alona elegans* is very near to this and should have followed. In August, 1878, I took an *Alona* marked as in *A. sanguinea* and agreeing with Mueller's description in all points which can be verified in the drawing. The small size of the eye is remarkable for so large an animal. I have never again seen this species; it seems to be very rare here and in Europe.

Sp. 4. *Alona tenuicaudis*, Sars.

(Plate I. Fig. 11.)

Alona tenuicaudis, Sars, P. E. Mueller, Kurz.*Alona camptocercoides*, Schoedler.

Form nearly rectangular; ventral margin rounded, with long setæ, posterior angle rounded. Beak short, pigment fleck smaller than the eye. Post-abdomen with sides parallel, long, incised below; lower angle armed with about six strong teeth, remainder of the series small; a lateral line of scales present; claws with a strong basal spine. The shell is striate with longitudinal lines. Length 0.5 mm.

One of the most easily recognized species; not identified in America.

Sp. 5. *Alona lineata*, Fischer.

Lynceus lineatus, FISCHER, LEYDIG.

Alona lineata, SCHOEDLER, P. E. MUELLER, KURZ.

Alona rectangularis, SARS.

The upper margin is rounded, the lower one somewhat sinuate, with setæ of moderate length. The beak is tolerably long, reaching nearly to the level of the lower margin of the shell; the pigment fleck is less than the eye, to which it is much nearer than to the end of the beak. Post-abdomen short, broad and tapering toward the end, truncate, armed with about ten large teeth; caudal claws with a small basal tooth. Shell marked with distinct lines running horizontally. The ehippial females are recognized by a deep color and the greater elevation of the back. Length 0.5 mm., 0.6 mm. The male has a weak hook on the first foot, and the post-abdomen is narrowed toward the end; the terminal claw has no spine.

The Minnesota representative of this widely distributed species differs in some respects. The lower margin is nearly straight and rather sparsely hairy; the beak is blunt, but, on account of the spreading of the extremely wide fornices, does not appear so except under pressure.

The beak reaches nearly to the lower shell margin. The antennules are narrow, one or more of the setæ being elongated. The dorsal margin is either nearly straight or strongly arched behind; in either case the greatest height of the shell is back of the middle. The pigment fleck is large. The post-abdomen is just as in *A. lineata*, but the lateral row seems to be of spines rather than fringed scales. The shell is marked by rather evident or indistinct lines. The form agrees pretty well with Schoedler's figure, except that the posterior shell margin is much higher. The antennæ have eight setæ, but the last one is very weak. The terminal setæ seem sometimes to be spined, as figured by Schoedler, but in some specimens they are perfectly smooth. There is a circlet of spines on the second joint of the setose ramus. There is a hair on the inner aspect of the protuberance of the labrum. The eye is somewhat nearer the pigment fleck than is the end of the beak. If it is desirable to apply a new name to a form at least so near the European *A. lineata*, it may bear the name first given it in my note-book.

? Sp. 6. *Alona modesta*. (Sp. n.)

(Plate H, Fig. 3; and Plate Q, Fig. 4.)

The length varies between 0.41 mm. and 0.55 mm. The smaller forms have the back most rounded, while a specimen 0.55 mm. long will appear very like *A. quadrangularis*. Males are elongate; hook of first foot strong, accompanied by a heavy growth of small spines; terminal claw of abdomen with a minute spine.

? Sp. 7. *Alona costata*, Sars.

Founded practically upon the absence of the eighth seta of the antennæ. The description given by Sars will not render it recognizable so that there is no occasion to repeat it here. In all the species of this section the eighth seta is small and may be absent.

Sp. 8. *Alona quadrangularis*, Mueller.

(Plate E. Figs. 1—2.)

Alona sulcata, SCHOEDLER.

Alona quadrangularis, P. E. MUELLER, KURZ, HERRICK. The further synonymy of the species may well be doubtful, for there are species so closely allied as to render a strict determination difficult.

Lynceus quadrangularis, O. F. MUELLER, is the name employed, and is thought to be identical with the *Alona quadrangularis* of Baird.

Shell quadrangular, highest behind; lower margin straight; posterior margin curved; lower angle rounded, striped with rather evident lines which are parallel and straight. The beak is quite long; the pigment fleck is smaller than the eye. The post-abdomen is broadest near the end, where it is strongly rounded; the numerous anal spines are strong and emarginated, supported by a lateral series of scales; the terminal claw and its basal spine (in American forms) are denticulate (Kurz says smooth in European specimens). The feet are of the typical *Alona* form (see plate E, fig. 1). The shell gland is rather conspicuous; no true ephippium. The abdomen of the male lacks the spines, but is otherwise similar. Length 0.6 mm. to 0.7 mm. Less abundant in Minnesota than the next. Both this and the following species were recognized in 1878, but were thought to be the same species. (See *Microscopic Entomostroca*, p. 109.)

Sp. 9. *Alona oblonga*, P. E. Mueller.*Alona oblonga*, KURZ, BIRGE.*Alona quadrangularis*, LILLJEBORG.

Differs from *A. quadrangularis* in the following points:—the greatest height of the shell is anterior to the middle; the lines are

less evident, and all confined to the lower part of the shell, while the centre of the valves is marked with very minute striæ; the pigment fleck equals the eye; and the post-abdomen is of about the same width throughout and hardly as round below. This and the preceding species have a well marked keel on the process of the labrum. The size is greater, this being one of the largest and most abundant, as well as one of the most striking species. It, perhaps, should rank as a well marked and permanent variety of the above. Length 0.9—1.0 mm. The abdomen of the male is narrowed at the end and lacks the teeth. Lakes about Minneapolis.

(A small form of *A. quadrangularis* in lake Calhoun had the eye and pigment fleck equal and the terminal claw smooth.)

Sp. 10. *Alona affinis*, Leydig.

(Plate F. Fig. 14.)

Lynceus affinis, LEYDIG.

Alona affinis, SCHOEDLER.

Form sub-quadrangular; height about once and one-half in length; the dorsal outline forming a regular and low curve from end of head to upper posterior margin; lower outline very slightly sinuate, anterior one not at all; posterior angles rounded; head nearly horizontal; eye of moderate size; pigment fleck considerably smaller; antennules rather large, with unequal sensory hairs at the end, one spine just above the end in front and a bunch of minute hairs near the base behind; antennæ comparatively large, basal joint spiny, outer ramus with three setæ, two of which have thorns at their middle, also a terminal spine; inner branch with two of the terminal setæ thorned and the upper lateral seta reduced. The post-abdomen is very broad and short, expanded below and rounded at the end; the terminal claws are straightish, denticulate, and the spine at the base is also dentate; there is a series of heavy spines on the upper margin of the post-abdomen, accompanied by a series of scales on the side. The shell is unornamented and fringed below with short bristles. Length 0.9 mm., or more. This fine species is recognized by its smooth shell, the horizontal position of the head, and the form of the post-abdomen; it belongs among the largest of the genus. Lakes near Minneapolis, not rare.

Birge quotes *A. spinifera* from Wisconsin. In all probability that species is the younger stage of the above.

Sp. 11. *Alona dentata*, P. E. Mueller.

(Plate I. Figs. 12—13.)

Form sub-rectangular, somewhat arched above, obscurely longitudinally striated; lower angle obtuse, margined below with short setæ. Post-abdomen small, slender, armed with a lateral line of scales and two strong teeth at the lower angle; claw with a minute basal spine. The form of the post-abdomen is identical with "*Harporynchus*" *falcatus*, Sars, which this species also resembles in having the pigment fleck larger than the eye, and in general form and the character of the striation. The beak, however, is very short. In size P. E. Mueller says it is among the smallest of the genus.

Sp. 12 *Alona elegans*, Kurz.

(Plate I. Fig. 14.)

Form rectangular; back slightly elevated, posterior margin high, lower margin straight. Shell covered with minute striations springing from the region of the attachment of the head shield. Head rather large, pigment fleck smaller than the eye. The antennæ have eight setæ and a circlet of spines on the second joint of the inner ramus, and a single thorn on its first joint. The post-abdomen is short and broad, rounded at the end, and is armed with about ten anal teeth and a lateral row of scales. Length 0.4 mm.-0.5 mm.

Sp. 13. *Alona porrecta*, Birge.

Sub-rectangular; ventral line nearly straight; valves marked by longitudinal striæ; beak short. Post-abdomen truncate, with about twelve teeth, three or four of which at the end are larger, and a row of hairs above the teeth. Male similar. Length 0.34 mm. Distinguishable from the following small species in the armature of the post-abdomen.

Sp. 14. *Alona spinifera*, Schoedler.

If not the young of *A. affinis*, this little species mimics it very closely. The head is less horizontal and more acute than in that species, otherwise almost identical excepting in size which is about one-third. The sensory setæ of the antennules are said to be nearer equal. Found by Birge in Massachusetts and Wisconsin, but not yet encountered in Minnesota.

Sp. 15. *Alona parvula*, Kurz.

The body is sub-quadrangular, arched above; ventral margin straight, rounded behind. Shell marked by longitudinal, feeble and irregular lines. The post-abdomen is narrower toward the end, with eight or more teeth; the row of scales is absent; at the end it is sharply truncate and incised; the claws have short basal spines. Hardly to be distinguished from the next.

(18) *Alona parvula*, var. *tuberculata*, Kurz.

Alona tuberculata, KURZ.

Alona verrucosa, LUTZ.

The species described by Kurz in 1874, and more at length by Lutz under a different name in 1878, appears to be simply a tuberculate variety of the above. Observations upon the American representatives of the two forms indicate a close relationship between them. The shell is covered with rows of tubercles (or depressions?) which vary in number greatly.

Sp. 16. *Alona glacialis*, Birge.

(Plate G. Figs. 2, 3 and 8.)

I do not know how to distinguish this certainly from *A. parvula*. It, however, seems to have the lower angle of the post-abdomen less squarely truncate and the incision less obvious. Birge says that the abdomen is rounded. I have found specimens which apparently belong here, with the post-abdomen rather sharply angled and deeply incised; there were about fourteen teeth with a row of hairs in front. The form is hardly to be distinguished from another variety which has a shorter post-abdomen, rounded below, and with only about seven or eight teeth and with a smooth shell. This form passes directly into a tuberculate variety, having the post-abdomen similar but the shell covered with numerous rows of tubercles. Sometimes a transition from a lined shell to a tuberculate shell is seen (as in plate G, fig. 14). *Alona tuberculata*, Kurz, is said to have a truncate and incised post-abdomen with no lateral row of hairs. Birge thinks these identical; if so, our form referred to *A. glacialis* is identical with *A. parvula*. There is also a form found with the above in which no markings are visible and the shell is considerably arched; these were, however, nearly all ephippial females or approaching that period.

(19.) Alona glacialis (?), var. tuberculata, (Var. n.)

(Plate G. Figs. 4—7 and 14),

will, then, be our tuberculated *Alona* with a lateral row of scales and a series of fine spines along the anus.

***Alona glacialis* (?), var. *lævis*, (var. n.)**

is the smooth form with higher dorsal margin.

The antennæ of the two last have spines at the end of the rami of the antennæ, a circlet of spines on the outside of the second joint of the setose ramus, and a spine on the basal joint of the other ramus; two of the setæ at the end of the setose ramus have spines at the angles. The males found among the above small forms have the same characters as var. *lævis* and the abdomen is rounded at the end; the claw is situated in the middle of the lower margin, in front being the opening of the *porus genitalis* and behind a cluster of hairs; the spines are absent, but there is a lateral row of long bristles. A strong hook is found on the first foot. Length 0.3 mm

Sp. 17. *Alona intermedia*, Sars.

(Plate I. Fig. 15.)

Alona guttata, P. E. MUELLER.

Form sub-rectangular, rounded below; beak short; shell marked by longitudinal lines, which may be broken into indistinct rectangular meshes. Post-abdomen short and wide, rounded at the end, ornamented by clusters of minute spines behind as well as a lateral row of scales. About 0.3 mm. long.

Section B. ALONELLA, Sars.

In this group are included small species with a combination of characters, forming the link between *Alona* and *Pleuroxus*. An obvious character is the fact that the shell is usually partly marked by oblique striæ, which run in two directions: first, a set extending forward and upward from the lower posterior angle of the valves; second, a set springing from the anterior and lower angle, running across the others. At the central part where these two series intersect, they each become zigzag; the result is a series of hexagonal markings, which may extend to the middle of the lower margin.

The beak is short and the fornices broad; the shell is more or less rectangular, but somewhat elevated in the middle above.

There are usually but seven setæ on the antennæ, or the eighth is a minute hair; on the ramus having the lateral setæ one of the terminal setæ is frequently reduced. In many cases the whole shell is marked by minute striæ in addition to the proper markings, but this is also found in some species of the true *Pleuroxus*. Kurz gives, as a character of *Alonella*, the presence of but a single basal spine to the claw of the post-abdomen; but P. E. Mueller figures two spines on the claws of one of his species (*A. exigua*), and Schoedler figures eight setæ on the antenna of *A. excisa*. American specimens of *A. excisa* and of *A. pygmæa* both certainly have a very minute eighth seta. There remains, therefore, positively no point which can be relied upon to distinguish these little lynceids from *Pleuroxus* or *Alona*. Perhaps, however, these species, as a group, may be recognized by what has already been said. Three species are found in Minnesota.

A. Rostrum long, bent backwards.

1. *A. rostrata*, Koch.

B. Rostrum short.

I. Lower posterior angle toothed.

(a) Shell more or less reticulate.

* Reticulated areas minutely striate.

2. *A. pulchella*, Herrick.

3. *A. excisa*, Fischer.

** Reticulated areas smooth.

† Head depressed.

4. *A. exigua*, Lilljeborg.

†† Head horizontal.

- (?) 5. *A. grisea*, Fischer.

(b) Shell marked by lines running diagonally upward and backward.

6. *A. pygmæa*, Sars.

II. Lower posterior angle smooth, shell longitudinally striate.

7. *A. striata*, Schoedler.

Sp. 1. *Alonella rostrata*, Koch.

Lynceus rostratus, KOCH, LILLJEBORG, SCHOEDLER.

Alonella rostrata, SARS, KURZ,

Alona rostrata, P. E. MUELLER.

Body long, rapidly narrowed behind; dorsal line strongly arched in front toward the depressed head; the lower margin straight, with 0—3 small teeth at the angle. The fornices are broad, but the beak is sharp; the pigment fleck is but little smaller than the eye, to which it is three times nearer than to the beak. The post-abdomen is long, very much as in *A. excisa*, but longer. Length 0.4—

0.5 mm. Schoedler says the lower margin is concave and the angle unarmed, a condition not inconsistent with specific identity, as can be seen in many other species. The shell seems to be variably marked, but most conspicuous are the diagonal, curved striæ. Schoedler compares the sculpture to *P. exiguus*; Kurz, however, leaves the impression that only slight reticulation is present in the female.

The male has the post-abdomen narrowed, ornamented with clusters of hairs behind, and the small claws have no basal spine, while the genital opening is in front of the claws.

Sp. 2. *Alonella pulchella*. (Sp. n.)

(Plate Q. Figs. 1—3.)

A minute form very recently obtained is described under the above name. Although closely allied to *A. exigua*, this species is more like *Graptoleberis* than any other member of the genus. It is the smallest of the lynceids, excepting *A. pygmæa*. The shell is high and rather strongly arched; the posterior margin is short and armed with four teeth below, which point in different directions as in *Graptoleberis*. The head is short and the antennules long. The pigment fleck is of moderate size, but smaller than the eye. The post-abdomen is short, rounded below, and armed with sharp and small anal teeth, besides which is an inconspicuous row of minute setæ. The claw is very small, and has a single very minute tooth. The shell is marked by reticulations, which below are regular hexagons but above pass into elongated meshes, and finally on the beak and head become longitudinal striations. The areas are lined as in *A. excisa*. Thus this species combines the form of abdomen of *A. exigua* with the teeth of *Graptoleberis* and the markings of *A. excisa*.

Length hardly 0.27 mm. Motion active. The specimen figured contained a single large ovum. The head may possibly have been somewhat protruded by pressure. Habitat, vicinity of Minneapolis.

Sp. 3. *Alonella excisa*, Fischer.

(Plate E, Fig. 6; and Plate G, Figs. 10. 11.)

Lynceus excisus, FISCHER.

Pleuroxus excisus, SCHOEDLER.

Alonella excisa, KURZ.

? *Pleuroxus insculptus*, BIRGE.

This species is closely allied to *Alonella exigua*; yet that species shows appreciable differences, (which can hardly be claimed, per-

haps, for *Pleuroxus insculptus*.) The various authors who have written of this lynceid have all laid emphasis upon the sculpture of the shell, almost to the exclusion of other points in the description. Prof. Birge has found a quite different form, apparently, which has the same peculiar markings; and even the common *Alona oblonga* has a part of the valves covered by minute striations. Schoedler's figure of this species is unrecognizable; but, as identified by Kurz, the species seems undoubtedly the same that is common in shallow pools in Minnesota, during autumn, and probably also in Massachusetts.

The variations to which this species is subject are considerable and may account for the marked disagreement in the accounts of our different authors. Schoedler gives his specimens a length of .20-.25 mm., while Kurz says .35 mm. Birge gives .27 for the length of *Pleuroxus insculptus*, and our specimens varied in the same gathering between .24 mm. and .40 mm. Schoedler figures three teeth at the lower posterior angle; Kurz says "several (4);" Birge describes one or two, and Minnesota specimens show gradual transitions from an inconspicuous angle to three or perhaps four teeth. These teeth are the extensions of some of the strong ridges or crenulations which mark the shell. P. E. Mueller's figures of the shell and abdomen of *P. exigua* would apply to our species perfectly, save the absence of minute striations; Kurz's statements with reference to the differences between these two forms seem to agree only in part with those of Schoedler. I must here express my suspicion that the *Pleuroxus aculeatus*, *P. exiguus* and *P. excisus* all belong under this species. I have seen a small form which lacked the fine striations; and there appeared to me to be, at times, a slight indication of a second series of hairs upon the post-abdomen.

The form is oblong, truncate behind, variously arched above, but usually with a rather low, evenly curved dorsal contour; the lower shell margin is either nearly straight or convex in front and concave along the posterior third, and is heavily beset with very long pectinate bristles. The head is moderately depressed, with a very broad, blunt and short beak (in some positions this beak seems acute, but it is an optical delusion); the fornices are very broad, covering the antennules completely; seen from above the head is broad and truncate in front; the eye is larger than the large pigment fleck, which is nearer it than the end of the beak. The antennæ have eight setæ, the last of which is minute; the five-

spined ramus has a strong thorn on the end, and the inner terminal seta is reduced. The post-abdomen is rather broad and truncate or somewhat rounded below; its length is very variable, being short in small individuals; its form is subject to concomitant variations. The seven to eleven anal spines extend in a series of minute bristles above the anus. The lower posterior angle of the shell bears one to four teeth; the marking consists of wavy ridges and striæ, producing, by the crossing of two sets springing from the two lower angles, a reticulation covering more or less of the entire shell. The head-shield and the spaces between these markings are densely striated. Color yellowish, often opaque. Length 0.24-0.40 mm. At times abundant. Birge alone has seen the males; his description agrees with Kurz's account of the male of *A. exigua*, save that the former speaks of spines, and the latter of thorns, along the post-abdomen.

Sp. 4. *Alonella exigua*, Lilljeborg.

Lynceus exiguus, LILLJEBORG, LEYDIG, FRIC.

Alonella exigua, SARS, KURZ.

Pleuroxus exiguus, SCHOEDLER, P. E. MUELLER.

? *Lynceus aculeatus*, FISCHER.

Aside from the differences in the male sex as above indicated, this form is said to have a convex lower margin, a rounded post-abdomen, and the pigment fleck nearer the end of the beak than the eye. The absence of the fine striation, finally, is the most marked characteristic. Length 0.30-0.33 mm. Not identified in America.

(?) Sp. 5. *Alonella grisea*, Fischer.

This species is included here on the authority of Kurz. The shell may or may not be toothed at the lower corner, and is partly lined and partly reticulate; but the only character which at all separates this species from the above seems to be the position and form of the head, which is said to be blunt and nearly horizontal, as in *Camptocercus rectirostris*. Is this a transition to *Graptoleberis*?

Sp. 6. *Alonella pygmæa*, Sars.

(Plate H. Fig. 7.)

Alona pygmæa, SARS.

Pleuroxus transversus, SCHOEDLER.

Alona transversa, P. E. MUELLER.

Lynceus nanus, FRIC.

Alonella pygmæa, KURZ.

The form is rotund, much like species of *Chydorus* in the highly arched dorsal outline; the beak is rather short and depressed; the lower outline of the valves is very convex in front, and barely sinuate behind, where it terminates in a minute spine. The shell is marked, as in no other lynceid, by lines running diagonally backward, and only on the lower part reticulated, if at all.

The post-abdomen is short, broad and rounded below; the claw has a single basal spine. Length 0.20 mm.—0.28 mm. This is the smallest member of the Cladocera. In form it so nearly resembles *Chydorus* that upon first sight the writer took it for a member of that genus. Our one specimen measured 0.25 mm. The shell is marked by plications rather than striæ, which arch over the back.

Sp. 7. *Alonella straiat*, Schoedler.

This species is said to resemble *A. exigua* in habit and sculpture of shell; the form is quadrangular and not greatly elevated in the middle; the lower margin is nearly straight and fringed with bristles; the posterior angle is rounded and unarmed. The antennules with their setæ extend beyond the beak; the pigment fleck is smaller than the eye and half way to the beak. The post-abdomen is long and narrowed toward the end; there are seven or eight anal spines, and two spines on the terminal claw. Length about 0.5 mm.

SUB-GENUS *PLEUROXUS*.

Section A. *Pleuroxus (verus)*, Baird.

This group of lynceids is most obviously defined by the long "beak", formed by the extension of the chitinous covering of the head. (There is rarely a beak in the sense of that word as applied in the case of *Scapholeberis* or *Daphnia*, but the antennules are simply attached to low prominences on the under side of a broad shield-like projection of the shell.) This beak-like projection is acute and often long and either curved backward or even bent forward. The fornices, or lateral projection of the head-shield, are narrow. The form varies much, but is almost always very strongly convex above, and the posterior margin is thus only a fraction of the whole height of the animal. In some American species the body is very much elongate, and these also depart from the characteristic habitus of the genus in having strong longitudinal striæ instead of reticulations. The lower posterior shell angle has teeth which, in a few cases, extend across the entire posterior margin. The post-

abdomen is slender, usually truncate and armed behind with a single set of sharp teeth on either side; the terminal claw has usually two spines and may be serrate.

The male has a shorter beak, the post-abdomen is more or less modified, and the first foot has a powerful hook. The winter eggs frequently have a true ephippium; and sometimes this structure is like that of *Chydorus*, toward which the round forms of this genus seem to lead. There are upwards of a dozen valid species, several of which are American.

KEY TO SECTION A, PLEUROXUS VERUS.

§ Beak not curved forward.

A. Shell reticulate.

(a) Post-abdomen very narrow.

1. *P. hastatus*, Sars.
2. *P. stramineus*, Birge.

(b) Post-abdomen not very slender.

* Terminal claws with two spines.

3. *P. trigonellus*, O. F. Mueller. (?)
- ? *P. ornatus*, Schœdler.

** Terminal claws with a single spine.

4. *P. acutirostris*, Birge.

B. Shell smooth, except upon the front margin.

5. *P. adunctus*, Jurine.

C. Shell striped.

(a) Shell very long and low.

* With one tooth below.

10. *P. unidens*, Birge.

** Without a tooth; female with a hook upon the first foot.

8. *P. hamatus*, Birge.

*** Without a tooth on the shell or claw on the foot.

9. *P. affinis*, Herrick.

(b) Shell high.

* Lower angle spined.

† Antennæ with eight setæ, anterior margin of valves toothed.

7. *P. denticulatus*, Birge.

†† Antennæ with seven setæ.

6. *P. bairdii*, Schoedler.

** Whole posterior margin of shell spined (Percantha.)

11. *P. truncata*, O. F. Mueller.

§§ Beak procurved (*Rhyppophilus*.)

A. Shell reticulate.

* Faintly and regularly.

13. *P. glaber*, Schoedler.

** Strongly and irregularly.

14. *P. personatus*, Leydig.

B. Shell striped.

* Posterior margin toothed.

12. *P. procurvus*, Birge.

** Only lower angle toothed.

15. *P. uncinatus*, Baird.

Sp. 1. *Pleuroxus hastatus*, Sars.

(Plate I. Fig. 16.)

Pleuroxus laevis, Sars.

Pleuroxus hastatus, P. E. MUELLER.

Form somewhat oval, dorsal line strongly curved, posterior margin short, with a tooth below; head short, beak very long, straightish; shell obscurely reticulate. Post-abdomen very long, narrow, with small teeth; claw with two basal spines. Color corneous. The sculpture consists of faint reticulations. The ephippium forms a truncation of the upper part of the shell. Length 0.50—0.55 mm. The male has a shorter beak; the first foot has a weak hook, and the spermatozoa are spherical.

? Sp. 2. *Pleuroxus stramineus*, Birge.

This form is the American representative of the preceding, if not identical with it. Birge mentions minute striæ in the meshes. *P. stramineus* is said to be lower than *P. hastatus*, while its beak is shorter. Undoubted specimens of *P. denticulatus* exhibit the same differences, an increase in the convexity of the shell accompanying an increase in the length of beak. The form of the abdomen appears nearly identical, if we compare P. E. Mueller's plate IV, fig. 18, with the outline given by Birge at plate II, fig. 11. The color in both is deep, especially during the period when the winter egg is forming. The direction of the reticulations is said to differ, but P. E. Mueller's figure does not furnish positive evidence of this. Length 0.6 mm.

Sp. 3. *Pleuroxus trigonellus*, O. F. Mueller.

Lynceus trigonellus, O. F. MUELLER, LIEVIN, LILLJEBORG, LEYDIG, FRIC.

Pleuroxus trigonellus, SCHOEDLER, P. E. MUELLER, KURZ.

? *Pleuroxus ornatus*, SCHOEDLER.

Dorsal line strongly arched; the beak rather long, straightish; pigment fleck smaller than the eye. Shell faintly reticulate, the markings consisting of transparent ridges. Post-abdomen widest in the middle, attenuated slightly toward the end, which is truncate; claw large, with one long and one very small basal spine. The anal

margin of the post-abdomen has a series of small spines, and the lower shell-margin is hairy. The post-abdomen of the male is somewhat as in *Crepidocercus*, and densely hairy; the first foot has a moderate hook.

To judge from Kurz's statements, *P. ornatus*, Schoedler, is not specifically distinct. Not yet identified in America.

Sp. 4. *Pleuroxus acutirostris*, Birge.

This form, with *Harporhynchus*, imitates in some respects the *Alonellæ*, from which they differ in having the beak elongated and recurved. Birge's description does not state what the form of the fornices is, but he intimates that the general resemblances are with *Pleuroxus*. The general shape is as in *P. hamatus*.

"The post-abdomen is broad, compressed, truncated, with numerous fine caudal teeth. The terminal claws have only one basal spine." "The valves are reticulated as in *P. [Alonella] insculptus*, although not so plainly." Length 0.35 mm. Southampton, Mass.

Sp. 5. *Pleuroxus adunctus*, Jurine.

Monoculus adunctus, JURINE.

Pleuroxus adunctus, SCHOEDLER, P. E. MUELLER, KURZ.

Very like *P. trigonellus*, but with the back more strongly arched. The anterior part of the shell is striped. The beak is shorter than in *P. trigonellus*, but no other permanent differences are discoverable. The temptation to believe this a mere varietal form of *P. trigonellus* is great. Indeed, four species (the two here noted, *P. bairdii* and *P. denticulatus*, Birge,) are very nearly related. The ephippium, where known, is marked by minute punctation and a darker color.

Sp. 6. *Pleuroxus bairdii*, Schoedler.

Pleuroxus trigonellus, BAIRD.

Pleuroxus bairdii, KURZ.

This form, so far as can be gathered from Baird's brief description and figures, differs from the others in having the shell marked by straight parallel lines running diagonally backward and upward, and in lacking one of the terminal bristles on the 5-setose ramus of the antennæ. The first is a possible but unusual structure, while the second might result from an overlooking of the very small seta which fills this place in the other forms. Baird himself did not distinguish it from *P. trigonellus*.

Sp. 7. *Pleuroxus denticulatus*, Birge.

(Plate G. Figs. 12—13.)

Resembling very closely *P. adunctus*, which, however, has a broader post-abdomen than the ordinary *P. denticulatus*. The posterior angle of the shell is armed with from one to four (generally three) teeth. The beak is very long.

The character most emphasized by Birge is a series of teeth along the anterior margin of the valves. The same thing is found in *P. procurvus*, as I have repeatedly satisfied myself. In certain positions these teeth do not show, or the smaller teeth on the lower margin only appear. *P. adunctus*, as figured by Schoedler, has similar teeth on the lower margin, and very likely has them anteriorly. The edges of the valves are heavily fringed with pectinate setæ. The male has a shorter beak and the post-abdomen simply rounded without the peculiar modification seen in *P. adunctus*.

There seem to be two varieties in Minnesota both of which have the characteristic irregular striations of the shell, which radiate from an irregularly marked or unmarked area in the center toward the edges; both have the toothed posterior angle and the serrated posterior angle and the serrated anterior margin. But the common form is much longer, with the dorsal margin less convex and the beak shorter. The robust form has a larger pigment fleck, while the post-abdomen is shorter and more robust, resembling more nearly Schoedler's figures of the abdomen of *P. adunctus*. There is another variation or abnormality, in which the lower margin is quite concave. The resemblance to *P. procurvus* is remarkable in some phases.

I have collected this species in Blount springs, Ala., in the St. Croix river, and at various intermediate points, as well as very often in Minnesota.

Sp. 8. *Pleuroxus hamatus*, Birge.

(Plate H. Fig. 1.)

This species is smaller than those of the preceding group and forms a transition to the two next to be described in the greater elongation of the shell, which is, however, higher and more strongly arched. The head and beak are much as in *P. denticulatus*. The lower margin is concave posterior to the middle and slightly convex at the posterior angle, which is unarmed. The lower margin is hairy. The markings are as in *P. denticulatus*, but, in addition,

there is a set of horizontal striæ all over the shell. The post-abdomen is widest in the middle and almost exactly as in *P. denticulatus*. The first foot bears a claw such as ordinarily distinguishes the males.

The only specimens which I have seen were from the Tennessee river, near Waterloo, and near Decatur, in Alabama. My notes contain no reference to the minute striations, which could perhaps be hardly seen with the instrument employed. The process of the labrum is long and rather acute, the beak moderate, and the pigment fleck very large. The markings on the anterior of the valves are irregular and are inter-connected by cross lines or anastomoses. Ova two. (The genus *Anchistropus* has a hook upon the first foot, but is like *Chydorus*.)

Sp. 9. *Pleuroxus affinis*. (Sp. n.)

(Plate H. Fig. 2.)

A small species with elongated shell and longitudinal striæ, forming a link between the preceding and the next, to which it is closely related. Shell broadest in front, upper contour nearly straight; anterior part of the lower margin evenly arched, posterior margin rather low. Head very short; beak very long, narrow and somewhat incurved; antennules and antennæ very small; eye evidently larger than the pigment fleck. The post-abdomen is as in *P. denticulatus*, or a little longer proportionately. The markings, so far as observed, consist of diagonal, faint, numerous and parallel lines posteriorly, and others springing from the anterior margin. There is no tooth behind; the teeth on the post-abdomen are small and not numerous. The upper margin of the shell is not sharp but rounded. Thus this pretty and unique form is clearly distinguished from all its allies although unfortunately only this very imperfect description and schematic figure can be given. Found in Weakly pond, Culbert county, near Florence, Alabama, where with an *Alona*, *Chydorus sphaericus* and *Scapholeberis*, it formed the cladoceran fauna of the pool.

Sp. 10. *Pleuroxus unidens*, Birge.

(Plate F. Fig. 15).

An extreme among these elongated species, the length of body falling little short of double the height. The dorsal line is very flat and slightly but evenly arched; the lower margin is evenly convex

or nearly straight, covered by long pectinate bristles. The head is short, and the beak is long and sharp; the antennules are of moderate size, with a lateral seta one-fourth from the end; pigment fleck less than the eye; antennæ rather long, with strong thorns on the terminal joints. The post-abdomen is long, as in *P. hastatus*, sides nearly parallel; anal teeth sharp, small and numerous; claws pectinate, with two strong basal spines. The shell is strongly striate with longitudinal striæ, which are parallel with the different margins. Birge says that there is a reticulated area. The lower angle is rounded, and anterior to it is a small tooth directed backward. This species is distributed throughout the Mississippi valley. I have notes of it from Swan lake, near Decatur, Alabama. It is often rather abundant about Minneapolis, but is thought by Birge to be absent from the eastern states. Almost all the specimens I have seen are very dark, often brown, so as to appear to the eye like dark specks as they swim about. The length varies from 0.55 mm. to 0.85 mm. About 0.60 mm. is a common size, according to my observation. Birge mentions a rudimentary sixth foot in this species. This organ is found in *Eurycercus* and other lynceids, according to Schoedler.

Sp. 11. *Pleuroxus truncata*, O. F. Mueller.

Lynceus truncatus, MUELLER, KOCH, ZADDACH, LIEVIN, FISCHER, LILLJEBORG, LEYDIG, FRIC.

Percantha truncata, BAIRD, SCHOEDLER, KURZ.

Pleuroxus truncatus, P. E. MUELLER.

Percantha brevirostris, SCHOEDLER.

This species is widely distributed in Europe, but is replaced in America by the following. The shell is high, the dorsal contour arched; beak rather long and straight; lower margin slightly convex, setose; posterior margin straight, armed with very strong teeth entirely across it; the anterior margin also is dentate, as in the next. The valves are covered with strong striæ, springing from the antero-central part and radiating toward the free margins. The post-abdomen is of moderate size and in form much as in the next. The ephippium causes a considerably change in form and coloration. In the male the beak is shorter, and the abdomen has finer teeth. The first foot has an extraordinarily large hook. The length is about 0.5 mm. to 0.6 mm. *Percantha brevirostris*, Schoedler, differs in the length of the beak only.

Sp. 12. *Pleuroxus procurvus*, Birge.

(Plate E. Figs. 3, 4.)

In size and general appearance this most interesting species is similar to the above, and, especially, to *P. denticulatus*. The general form and even the details of structure agree almost to identify with the latter. The structure of the posterior margin is like *Percantha*, while the rostrum is bent abruptly upwards as in *Rhypophilus*. In small individuals the length is greater proportionally. The lower margin is slightly convex or nearly straight, and fringed by bristles which are strongly pectinate; the anterior and lower margins are toothed as in *Percantha*. The shell gland is more as in the *Daphnidæ* than most lynceids. The number of posterior teeth is variable. The ephippium is as in *P. denticulatus*. Length 0.40 mm. to 0.50 mm. Not rare, but less common than *P. denticulatus*. The male post-abdomen is like that of *P. denticulatus*; the rostrum is as in the female.

Of the species following it may suffice to say that they are corpulent, filth-loving representatives of *P. trigonellus*, *P. adunctus* and *P. bairdii*, respectively, which have turned up their noses at a superficial existence and buried themselves in the mire and debris at the bottom of the pools. It might be fanciful to assume that the curved snout is used for "rooting," but the fact that these "Schmutz-peterchen" lynceids would find a long straight beak in the way is suggestive.

Sp. 13. *Pleuroxus (Rypophilus) glaber*, Schoedler.*Pleuroxus personatus*, P. E. MUELLER.

The shell is high and squarish, the fornices narrow, the beak slightly pro-curved, the lower margin nearly straight, with two or more teeth at the posterior angle. The antennæ have seven setæ only. The male is almost exactly as that of *P. trigonellus*. Length 0.55 mm. to 0.65 mm.; male 0.5 mm.

Sp. 14. *Pleuroxus (Rypophilus) personatus*, Leydig.

That this species is really distinct is by no means certain; however, it is stated that the shell is less regularly and more markedly reticulated, and the markings lack the elevations described under *P. trigonellus*, which are present in the previous species. It lives in filth and covers itself with it.

Sp. 15. *Pleuroxus* (*Rypophilus*) *uncinatus*, Baird.

The shell is ridged with lines running upward and backward, as in *P. bairdii*; the lower angle of the shell has three teeth, and the beak is more horizontal than in the above. In size and characters this is almost identical with *P. bairdii*, with which it occurs in England.

This completes the list of swine-like members of the genus; these well deserve to be studied from a morphological stand-point.

Pleuroxus nasutus, Gay, is a poorly described form from Chili, resembling, according to Schoedler, *P. ornatus* = *trigonellus*.

A species of *Percantha* (*Lynceus armatus*, Gay) is found in Chili.

NOTE TO PLEUROXUS.—The two species *P. unidens* and *P. affinis* are quite diverse from the type of the genus and approach in some respects to *Leptorhynchus*. *P. affinis*, particularly, has a recurved beak. I am in doubt about *P. hamatus* and *P. acutirostris*, which is said to be reticulated; but it seems likely that the species above mentioned stand in closest relation to *Leptorhynchus*.

Section B. *Leptorhynchus*, Herrick.¹

The species for which Sars formed the genus *Harporhynchus* is of *Alona*-like habit, but has a beak which exceeds that of any known *Pleuroxus* in length, being simulated in this respect by the American *P. acutirostris*, which is, however, in other respects more nearly allied to *Pleuroxus*.

***Leptorhynchus falcatus*, Sars.**

Harporhynchus falcatus, Sars.
Alona falcata, Sars, P. E. MUELLER.

Body oblong, arched above; ventral margin nearly straight, setose, with a spine at the posterior angle; beak strongly curved, folded laterally; pigment spot larger than the eye. The post-abdomen is wide, sides nearly parallel, armed with a few strong teeth below and a lateral line of spines; caudal claw with a single small basal spine.

VIII.—GENUS PHRIXURA, P. E. Mueller.

Oblong, wide; posterior shell-margin little less than whole height. Post-abdomen terete, obtuse at the end, which is armed with a cluster of spines of which the terminal ones are similar to the others.

¹ *Harporhynchus* is preoccupied in ornithology.

Sp. 1. *Phrixura rectirostris*, P. E. Mueller.

(Plate I. Fig. 18.)

Beak acute; shell striated longitudinally, slightly arched above; ventral margin rounded, with a round and unspined angle behind. Length 0.5 mm. Not yet encountered in Minnesota.

IX.—GENUS CHYDORUS, Leach.

This genus, if it be really of generic value, contains minute rotund animals which appear in the water like animate pin-heads of small size. Their motion is a rolling, wavering hobble; and they live by preference upon vegetation, or in slime at the bottom of pools. Occasionally they may be seen in sunshiny weather, disporting themselves near the surface in immense numbers. There are two common species, and six more which are more rare or in part not valid.

The sexual period occurs at two different periods (i. e., May—June, and December), but in probability is not confined to any periods. The males, which only rarely are found even in these periods, have the abdomen narrowed or excavated to accommodate it to the peculiar alteration of the brood-cavity which takes place in the sexually mature female. The connection takes place by the insertion of the abdomen within this chamber, which is facilitated by the reduced size of the abdomen. The modification of the shell of the brood-cavity above referred to consists in the thickening of the wall posteriorly, which may or may not result in the deforming of the shell, as shown in plate F, fig. 7, taken from Kurz. This may be termed an ephippium, although it differs somewhat from the modified shell so called in *Daphnia*. The male element consists of nearly round nucleated cells, and the opening of the vas deferens is anterior to the terminal claws. The members of this genus are among the most minute forms of the family or the entire group. Concisely put, the characters are as follows:

Form globose, not obviously truncate behind; head terminating in a sharp, long, curved beak, which lies close upon the anterior margins of the valves; antennæ short; eye larger than the pigment fleck; abdomen flattened, excavated in the male; intestine with no anterior cæca, doubly convoluted, with an anal cæcum. Three species found in Minnesota.

Sp. 1. Chydorus sphæricus, Mueller.

(Plate F. Figs. 4, 7, 8 and 10.)

Lynceus sphæricus, O. F. MUELLER, M. EDWARDS, KOCH, ZADDACH, LIEVEN, FISCHER
LILLJEBORG, LEYDIG, TOTH, ZENKER, FRIC.*Monoculus sphæricus*, JURINE.*Chydorus muelleri*, LEACH.*Chydorus sphæricus*, BAIRD, SCHOEDLER, P. E. MUELLER, LUTZ, KURZ, BIRGE.

Form nearly spherical, as seen from above broadly oval; in young specimens truncate behind; antennules of moderate size, in the male very large, with curved flagellum near the middle of anterior margin; pigment fleck often nearly as large as eye; beak of moderate length, blunt in the male; first foot strongly hooked in the male; post-abdomen short, broad, rounded at the end, armed with 8—9 sharp teeth; shell reticulated with polygonal meshes. Color light, unspotted. Length 0.50 mm.

This species occurs in Spring earlier than most forms, and is ranked as the most abundant of the micro-crustacea, being found over the whole circumpolar land-area. The ephippium for the winter egg was observed by Kurz, but the period at which it is formed seems variable.

C. sphæricus of a previous report seems to have been the following species which is more common in Minnesota in the clearer lakes. A small form in our large lakes measures 0.3 mm.; it may be distinct.

Sp. 2. Chydorus globosus, Baird.

(Plate F. Figs. 1, 2, 3 and 9.)

Chydorus globosus, BAIRD, LILLJEBORG, SCHOEDLER, LEYDIG, P. E. MUELLER, FRIC,
KURZ, BIRGE.

Form globose, very broad; antennules very large with a strong lateral seta on a small elevation; swimming antennæ exceedingly small; the shell gland is well developed; the pigment fleck is much smaller than the eye; beak very long and incurved; post-abdomen rather long, more slender than the last, broader near the end which is truncate, bearing about 20 spines on the margin near which is a lateral series of minute bristles; the terminal claws are straightish, spined along the basal half, and have an accessory spine; the shell is very indistinctly reticulated and spotted; color dark; length 0.7-0.8 mm.; male 0.55 mm. The males have the abdomen very narrow for the entire length.

This species is considered rare elsewhere, but is not infrequent in August near Minneapolis.

Sp. 3. Chydorus ovalis, Kurz.

(Plate F. Fig. 11.)

Form oval, nearly twice as long as high; beak long; antennules two-thirds as long as the beak, with two elongated sensory filaments above the others; pigment fleck nearly as large as the eye; antennæ small; shell margins heavily fringed anteriorly; post-abdomen of moderate size, rounded at the end, with about 8 teeth near the end; shell smooth. Length 0.4 mm.

This species is rather near *C. sphaericus*, differing in having the shell smooth, antennæ shorter, and beak longer. This species is not yet known in America.

Sp. 4. Chydorus cælatus, Schoedler.

(Plate F. Fig. 12.)

Chydorus adunctus, SCHOEDLER.

This small species is about 0.4 mm. long, and resembles the young of *C. globosus* in form, from which as well as from all known species it is distinguished by the markings of the shell, which consist of series of rounded elevations (or depressions?) arranged parallel to the lower margins of the shell and head. The description is very incomplete, and the only other author who appears to have seen the animal is Kurz, who adds that the sensory filaments of the antennæ are unequal in height, and that the so called elevations are really depressions. A form with a few depressions about the edge and characters of this species was once seen in the vicinity of Minneapolis.

Sp. 5. Chydorus nitidus, Schoedler.

(Plate F. Figs. 5, 6.)

Shell smooth and regularly punctate; the head resembles *C. sphaericus*, but the pigment fleck is much smaller than the eye, to which it is much nearer than to the end of the beak; the post-abdomen is broader near the end, and bears a row of 10—12 teeth on either side.

(?) Sp. 6. Chydorus latus, Sars.

Very possibly a variety of *C. globosus*, from which it differs in the shorter beak and greater size. Length 0.66 mm.

Sp. 7. Chydorus piger, Sars.

Sub-rotund, prominent above, sinuate behind; lower and posterior margins rounded, lower margin ciliated. Head movably united to the body; beak long, separated by an indentation from the head shield. The shell is broad, as seen from above. Shell punctate anteriorly and marked below by indistinct oblique striæ. Antennules with seven setæ and two small thorns on the end of each ramus. Post-abdomen truncate; the terminal claws with a minute tooth at the base; posterior margin sinuated, rounded below and there densely armed with minute teeth. Abdominal setæ long and flexible. Pigment fleck of medium size, much nearer to the eye than to the beak. Length about 0.33 mm.

(?) **Chydorus latifrons**, Dana. (U. S. Exploring Expedition, Rep. on Crust., vol. II, p. 1274.)

Very tumid; in side view rotund, head not separate, very short-beaked; beak slender and close to the body, acute; in upper view animal very broad, truncate anteriorly, the front thereby nearly as broad as the body; behind low, triangular and obtuse. Feejee islands.

(?) Chydorus albicans, Gay,

from Chili, is imperfectly described; but it is interesting to note the occurrence of this genus there.

X.—GENUS ANCHISTROPUS, Sars. (?)

Very similar in form to *Chydorus*; valves gaping below anteriorly; antennules small; process of labrum rounded. Post-abdomen attenuated toward the end, densely covered with fine teeth; terminal claws denticulate. First foot with a powerful claw, protruding beyond the shell. Eye very large. Shell indistinctly reticulate. Sars says of his *Anchistropus emarginatus* that on cursory inspection it would be taken for the young of *Chydorus globosus*. He found but few specimens, about 0.35 mm. long. The suggestion is still possible that the young males of some *Chydorus* are here mistaken for a new genus. The males of *Chydorus globosus* were not known till 1878, and their early form is still unknown. The young females have a tolerably strong claw, though it is not much curved. I have once found a peculiar lynceid measuring 0.46 mm., with

unevenly but distinctly reticulate shell, slender abdomen, and a strong claw which was dentate. There were several young (more than two), and the shell in these was more regularly reticulate. All efforts to find a second specimen failed, and the one seen was somewhat mutilated; hence I am unable to determine its real position.

XI.—GENUS MONOSPILUS, Sars.

Head separated by a depression from the body; shell high, compressed, posterior margin somewhat less than the greatest height of the shell. Post-abdomen broad, ornamented with lateral and posterior spines; claws large, with a single basal tooth. The compound eye is absent, its place being taken by the pigment fleck, which is the functional eye.¹

Monospilus dispar, Sars.

(Plate I. Fig. 21.)

Lynceus tenuirostris, FISCHER, Abh. ueber einige neue Daph. und Lynceidæ, p. 427, tab. III, figs. 9–10 (*vide Sars*).

Monospilus dispar, SARS, Crust. Cladoc. i Omgn. af Christiania, p. 165.

Monospilus dispar, MUELLER, Danmark's Clad., p. 196.

Shell roundish; ventral margin setose; posterior angle rounded, marked above with numerous impressions. Antennules small; antennæ long, with seven setæ. Post-abdomen short and broad, bearing a series of spines along the excavated posterior margin, and ornamented on the sides with clusters of bristles. The shell in old individuals is not moulted but remains as in *Ilyocryptus*, covering the greater part of the new shell. The figure shows an old individual with its successive coverings still clinging to it. Like *Ilyo-*

¹ So much interest attaches to this species that we reproduce the Latin description of Sars. "Testa in adultibus valvulis composita pluribus, altera alteri imposita, a latere visa lata, latitudine maxima in parte antica sita; margine superiore antice valde prominente, posteriore et inferiore ciliato rotundatis. Caput mobile, perparvum et valde depressum, supine impressione parva sed distincta, a testa cetera disjunctum, deorsum in rostrum rectum et breve apice obtuso exiens. Animal supra visum sat compressum, latitudine maxima capite majore ante medium sita. Pars superior testæ et capitis impressionibus numerosis rotundatis notata. Antennæ 1-mi paris minutæ structura ut in ceteris Lynceidibus; 2-di paris sat longæ, ramo altero setas 4 et aculeum unum apicalem, altero setas 3 et aculeos duos, quorum alter longus articulo primo ejusdem rami adfixus est, gerunte. Postabdomen breve et latum, apicem versus truncatum; margine posteriore supra obtuse angulato, ad angulum inferiorem rotundatum seriebus duabus aculeorum inque lateribus setis vel spinulis brevibus numerosis præditum; ungues terminales ad basin aculeo longo armati. Intestinum, ut in ceteris Lynceidibus, in thorace laquem fere duplicem format. Macula nigra unica minima prope basin antennarum 2-di paris; maculæ infra oculari in ceteris Lynceidibus simillima, in capite conspicitur, quæ, quum oculus verus compositus in omnibus ceteris Crustaceis Cladocercis distinctus omnino absit, organum quamquam rudimentare visus habenda est. Animal parum pellucidum, colore fulvescente. Longit. parum supra $\frac{1}{2}$ mm "

cryptus, this animal passes its life in filth at the bottom of pools, and rarely emerges to the light of day. What little visual function there may be is vested in the larval organ.

The specimen from which the drawing was made measured 0.45 mm. The first glance at this rarest of all entomostraca affords proof of its unique character. The strongly arched shell is so compressed as to bear little resemblance to *Chydorus*. The dorsal line passes with little angle into the high posterior margin. There is a rounded angle below, armed with two teeth—the shortened representatives of the fringing spines of the straight lower margin. The head is depressed and very short, but the narrow beak is produced to below the margin of the valves. It is rounded so as to resemble, as seen in front, a duck's bill. The fornices are narrow and flare so that the eye is left partly exposed upon the side. The antennules are not long but slender. The labrum has a very large lamella, which is crenulate in front and acute below, the labrum proper being large. The systematic position of this genus is a matter of considerable interest, for it is the only member of the whole order in which the larval eye is the only one developed, and the first thought would be that this must be a primitive synthetic type, in other words, historically the oldest of Cladocera. Closer study does not warrant the theory. There is much to indicate that, though essentially lynceid, it stands in close connection with the higher members of the family and perhaps has more than a superficial resemblance to such degraded lyncodaphnids as *Ilyocryptus*. All things considered, however, our diagram stands with this genus as a degraded offshoot of the more typical stem of Lynceidæ.

SUB-ORDER II.—GYMNOMERA.

This group is easily recognized by the almost entire absence of the shell, which forms so conspicuous a part in the greater number of the Cladocera. Here it serves simply to form a pouch or brood-sac for carrying the eggs and embryos. The feet are nearly terete and prehensile, with but slight indications of branchial appendages.

FAMILY POLYPHEMIDÆ.

Feet five pairs. Antennæ with the rami three- or four-jointed.

I.—GENUS POLYPHEMUS, De Geer.

Head very large, separated by a depression from the compact

body; shell covering but a part of the dorsal region. Feet all with an internal dentate, and an external lamellate appendage. Caudal seta upon a long process of the post-abdomen.

Sp. 1. *Polyphemus pediculus*, Linn.

(Plate B¹. Figs. 4—6.)

Monoculus pediculus, LINNÆUS, 1746. GMELIN, Linn. Syst. Nat. FABRICIUS, Ent. Syst., etc. SULZER, Insecten. MANUEL, Encyclop. Meth.

Monoculus pediculus ramosus, DE GEER, Mem. pour serv. a l'Hist. des Ins.

Polyphemus oculus, MUELLER, Zool. Dan. Prod. et Entomost. CUVIER, Tab. element LATREILLE, Hist. Nat. Crust., etc. LEACH, Edin. Encyc.

Polyphemus stagnorum, LEACH, Dict. Sc. Nat. LATREILLE, Cuv. Rig. An. DEMAREST, Cons. Gen. Crust.

Polyphemus pediculus, STRAUS, Mem. Mus. d'Hist., etc. M. EDWARDS, Hist. Nat. Crust.

Monoculus polyphemus, JURINE, Hist. Nat. Monoc.

Cephaloculus stagnorum, LAMARCK, Hist. An. Vert. BOSCH, Man. d'Hist. Nat. Crust.

Monoculus oculus, GMELIN, Linn. Syst. Nat.

Scalicerus pediculus, KOCH, Deutsch. Crust.

Polyphemus pediculus, BAIRD, Brit. Entom.

Polyphemus oculus, LIEVIN, Branch. d. Danz.

Polyphemus stagnorum, FISCHER, Ueber die in d. Umg. von St. Petersburg, vorkom. Crust.

Polyphemus pediculus, LILLJEBORG. De Crust. ex ord. trib.

Polyphemus oculus, LEYDIG, Naturg. d. Daph.

Polyphemus pediculus, SCHOEDLER, Neue Beitr. zur Naturg. d. Cladoceren.

Polyphemus kochii, " " " "

Polyphemus oculus, " " " "

Polyphemus pediculus, P. E. MUELLER, Danmark's Cladocera. KURZ, Dodekas neuer Cladoceren. WEISMANN, Beitr. zur Naturg. der Daphnoiden. BIRGE, Notes on Cladocera.

Polyphemus occidentalis,¹ HERRICK.

There are two well-marked varieties of this species: one is found commonly in the clear lakes; the other, which I have only once seen, was found in a very shallow weedy marsh. The difference in size is quite remarkable. Our ordinary form measures less than 1 mm. The larger form, including the stylets, is 1.6 mm. The ordinary variety, although highly colored, is yet transparent, while the large variety is deep red and quite opaque. The relationship between the two forms is quite like that maintaining between *Diaptomus stagnalis* and *D. sanguineus*. Some slight structural differences are observable between the two varieties, as in the form of the antennules, yet quite insignificant when compared with the striking difference in size and coloration. Number two may be called

¹ *Polyphemus occidentalis*, Dekay = *Limulus*.

Sp. 2. Polyphemus stagnalis. (Sp. n.)

In order to make the relation clear between these forms, I add measurements of this species, following each with the corresponding measurement of *P. pediculus* in parenthesis; animals of the same age, as far as possible, being chosen. Head (capsule of eye) 0.3 mm. (0.2 mm.); head and thorax 0.7 mm. (0.45 mm.); abdomen 0.7 mm. (0.56 mm.); caudal stylet 0.36 mm. (0.26 mm.); caudal filaments 0.36 mm. (0.3 mm.). Whole length of antennæ 0.54 mm. (0.42 mm.); first, second and third joints of the 3-jointed ramus 0.08, 0.06 and 0.10 mm., respectively. The formation of the resting eggs or "dauer-ei" seems to go on at the same time with the parthenogenetic reproduction.

II.—GENUS BYTHOTREPES, Leydig.

Much like *Polyphemus*, but the external appendage of the feet is rudimentary, and the abdomen extends out into a most enormous spine. The single species is that described by Leydig as *B. longimanus*, which was found in the stomach of *Coregonus wartmanni*. *B. cederstromii*, of Schoedler and P. E. Mueller, the latter author now identifies with the above, and concludes that the supposed differences arose from "l'etat de maceration des examplaires examines." (*Les Cladoceres des Grands Lacs de la Suisse*, p. 11.) This species may be looked for in the depths of the Great Lakes. (See plate U, fig. 10.)

III.—GENUS PODON.

IV.—GENUS EVADNE.

These are compact oval forms confined to the sea. See Claus, *Zur Kenntniss des Baues der Polyphemiden*, Vienna, 1877, for the best account of the anatomy.

FAMILY LEPTODORIDÆ.

Feet six pairs. Antennæ with both rami four-jointed. Body elongated, not curved; shell very much reduced.

Leptodora hyalina, Lilljeborg,

(Plate N. Figs. 6, 7),

the only species, is found rarely in the larger lakes of Europe and America.

See *Bau und Lebenserscheinung von Leptodora hyalina*, Weismann, 1874; also, *Om en dimorph Udvikling samt Generationsvexel hos Leptodora*, G. O. Sars, 1873; also, *Bidrag til Cladocerenes Forplantningshistorie*, P. E. Mueller.

The work of Sars is particularly valuable, showing that the young produced from the winter eggs pass through a metamorphosis not experienced by the summer or parthenogenetic brood. P. E. Mueller mentions the pathological condition induced by the plants of the Saprolegnia.

CHAPTER III.

ORDER COPEPODA.

This extensive order contains minute and predominatingly predaceous animals which constitute no inconsiderable part of the fauna of fresh and salt waters. They serve a beneficent purpose both as scavengers and as providing food-supply for the fry of fishes and other aquatic animals.

Copepods are never enclosed in a bivalved shell but ordinarily exhibit a more or less elongated cylindrical form composed of two obvious sub-divisions. There are a few species which, by the great prolongation and expansion of some of the tergites or dorsal shields, seem to simulate shelled crustacea. The anterior part of the body, or cephalothorax, is composed of ten somites which are frequently considerably united or fused. Five of these segments constitute the head and bear respectively the following appendages: first, a pair of several- to many-jointed antennæ which are never primarily sensory in function, although they usually are provided with sense hairs or other like organs; second, a pair of two-branched antennules, which sometimes become almost simple or prehensile; third, a pair of mandibles in the form of masticatory or piercing organs, these being usually provided with a palpus; fourth, a pair of maxillæ of various form and function; fifth, a pair of maxillipeds which not infrequently subdivide in later life to form what appear to be two distinct pairs.

The five thoracic segments have each a pair of swimming feet consisting typically of a two-jointed base and two like, three-jointed rami. The symmetry is frequently broken by the retardation of the development of the inner ramus, while the fifth pair of feet may become rudimentary and in various ways subserve the organs of sex. The five abdominal segments are nearly devoid of appendages and are continued posteriorly by two caudal stylets which bear strong setæ constituting, in many forms, a tail-fin or spring.

All copepods, even such as are, in later life, parasitic, begin their existence as free-swimming nauplii, such as are represented on plate S, fig. 13, and plate K, fig. 8.

Though the vast majority of genera and species are marine, it would seem that fresh-water copepods make up in the number of individuals what they lack in variety.

As we are dealing primarily with the fresh-water species, no lengthy description of the group is here necessary.

The earlier history of our knowledge of the animals of this order is given by Baird. According to this authority, the first to mention any fresh-water species of this group was *Stephan Blankaart*¹ in his *Schou-burg der Rupsen, Wormen, Ma'den, en vliegende Diekens tot Amsterdam*. *Leeuwenhoek* adds numerous interesting details and is accredited by Hoek with being the first to discover the relation between the remarkably diverse stages which occur in the history of the cyclops. However, it is evident that he had a very incomplete knowledge of the metamorphoses.

De Geer gives rather characteristic figures of a cyclops in *Memoires pour servir a l'Histoire des Insectes*, vol. vii, 1778.

Mueller, in his great work on *Entomostraca*, adds new facts, defines species and forms the genus *Cyclops*.

Ramdohr in 1805 gave sundry additions to the knowledge of these animals in his *Beitraege zur Naturgeschichte einiger Deutschen Monoculus-arten*. In this work the post-embryonic history is quite fully outlined.

Jurine, in his classic work *Histoire des Monocles qui se trouvent aux Environs de Geneve*, 1820, crystallized what previous authors as well as his own original experiments had brought to light of the anatomy and biology of these animals.

Ferussac (*Memoire sur deux nouvelles especes d'Entomostraces*) redescribes known species.

Gunner, Stroem, and Viviana, seem to have had little effect on the knowledge of the group, though they wrote prior to *Jurine*.

A recent author attempts to revive the names of *Jurine*, though hitherto it has been thought hazardous to attempt a specific identification.

The German author, *C. L. Koch*, who only incidentally studied this group, distinguished more or less perfectly, a variety of species which have been reinstated in our literature by *Rehberg*. Although

¹ Latinized *Stephanus Blanchardus*. Hoek recognized *Cyclops brevicaudatus* or *C. bicuspidatus* as the one described, chiefly through knowledge of the present inhabitants of the locality.

this proceeding seems quite unjust to the careful authors whose descriptions are recognizable in themselves, the law of priority must probably prevail. Koch's *Deutschlands Krustaceen* appeared in 1838.

Baird's British Entomostraca, without greatly extending our knowledge of this order, put in readable form and made available to English readers what was known, and added interesting facts. He distinguished two families of Copepoda, (1.) Cyclopidae, (2.) Diaptomidae. The first included the genera (1.) Cyclops, (2.) Canthocamptus, (3.) Arpacticus, (4.) Altheutha; and the second the general (1.) Diaptomus, (2.) Temora, (3.) Anomlocera.

Fischer, who contributed not a little to our knowledge of the distribution of fresh-water Cladocera, was the next to describe valid species. He described the species found near Moscow and St. Petersburg, Russia.

Ouchakoff is likewise a Russian author, but his writings are quite unknown to me.

The justly famous Swedish naturalist, *W. Lilljeborg*, who has left his mark on so many branches of natural science, has not neglected the microscopic crustacea of his fatherland. *Om de inom Skaane foerekommande Crustaceer af ordningarne Cladocera, Ostracoda och Copepoda* is the somewhat formidable title of his work, published in 1855. He recognized the following genera of Copepoda: Diaptomus, Temora, Dias, Ichtyophorba, Tisbe, Tachidius, Harpacticus, Canthocamptus, and Cyclops. A species each of Diaptomus and Canthocamptus is described, and two species of Cyclops. (It would seem from authors' quotations that other species are described in an appendix, but the copy I have seen lacks this.) The author who has done most for micro-carcinology in general is *Carl Claus*, of Vienna. His principal works are:

1. "Das Genus Cyclops," etc. In *Wiegmann's Archiv fuer Naturgeschichte*. 1857.
2. "Weitere Mittheilungen ueber die einheimischen Cyclopiden." The same, 1857.
3. *Die Freilebenden Copepoden*, 1863.

The later work especially is indispensable to the student of Copepoda, though in reality it is more important in respect to marine Copepoda.

In the meantime a work appeared in Norwegian, with Latin descriptions, from the pen of *G. O. Sars*. This has been largely overlooked. It is, unfortunately, unaccompanied by plates, but the descriptions bear the stamp of the naturalist.

A little later a second brief contribution from this author was published, but I have not seen it.

Sir John Lubbock in 1863 describes species of fresh-water copepods, but the publication seems no longer necessary.

Heller, in Tyrol, *Fric*, in Bohemia, and *Uljanin*, in Asia, have studied the copepod fauna.

A Russian paper by *Poggenpol* and *Uljanin* is quoted as "A Catalogue of the Copepoda, Cladocera and Ostracoda of the vicinity of Moscow," by *Rehberg*, and as from the *Protokolle der kais.-naturw. anthropol. und ethnogr. Ges. in Moskau*, but by *Cragin* who publishes a translation apparently of the same paper, in part, as from the "Bulletin of the Friends of Natural History."

Hoek, in the *Tijdschrift der Nederlandsche Dierkundige Vereeniging* (Magazine of the Zoological Society of the Netherlands) 1875, and later in German in the *Niederlaendisches Archiv fuer Zoologie*, gave excellent figures and descriptions of some species which *Claus* had too hastily treated.

In 1878 *A. Gruber* gave descriptions of "Two fresh-water Calanidæ."

In the same year the first volume of *Brady's* fine "British Copepoda" appeared. A purely technical work and briefly written, it is yet very comprehensive and in the main reliable. This is a worthy successor of the Ray Society's earliest publication on entomostraca—*Baird's* great work.

In the sixth vol. of the *Abhandlungen d. naturwissenschaftlichen Vereine zu Bremen*, *Herman Rehberg* gives a systematic review of synonymy, and in the revision unites several species in a manner that the present writer had independently been driven to do. It is probably impossible either to substantiate or positively deny some of this writer's identifications of the species of the older authors.

This paper also contains an observation of a hermaphroditic cyclops, which it is interesting to compare with similar anomalies, described by *Kurz* in Cladocera.

In the vii Band of the same periodical, *Rehberg* adds to and modifies some of the views expressed above. In the same number is a description of a new species of *Temora* by *Poppe*. (The same species occurs in the semi-saline waters of the Gulf of Mexico, and had well-nigh gone into print under a new name when this was seen.)

In the above review we have noticed only the more important foreign works on the Copepoda and those including fresh-water forms. *Dana's* magnificent *Crustacea of the Wilkes' Exploring*

Expedition is not included because it is essentially restricted to the marine species, the few descriptions of fresh-water species, being quite valueless. Among important contributors to the exclusively marine Copepoda, are *Boek* (*Oversigt over Norges Copepoder* and *Nye Slægter og Arter af Saltvands-Copepoder*), *Brady* and *Robertson*, *Lubbock* and *Claus*.

The history of the American literature can be quickly traced.

Say described imperfectly an American species of Cyclops in 1818. *Haldeman* describes in vol. viii, of the Proc. of Phila. Academy of Science, p. 331, *Cyclops setosa* (which may be *C. serrulatus*). *Pickering* very imperfectly described a new genus of copepods from lake Ontario in *Dekay's Zoology of New York*. This genus is, most likely, *Epischura* of *Forbes* and, in strictness, ought to rank it. In 1877 appeared "A List of Illinois Crustacea," by *Prof. Forbes*, in which two species of Copepoda were described which may rank as the first descriptions at all adequately framed of American members of the order. In the *annual report of the Minnesota state geologist* for 1878, a brief article by *C. L. Herrick* outlined, in the light only of the then English literature, the micro-crustacea of Minnesota. No attempt was made to treat the Copepoda, but two species of *Diaptomus* are indicated which will prove valid. Occasional papers in the *American Naturalist* and elsewhere follow till, in July and August of 1882, *Prof. Forbes* added two new genera and several species of Copepods, constituting by far the most considerable addition to the subject yet produced.

In the *report of the state geologist of Minn.* for 1881, *C. L. Herrick* makes a considerable addition to the knowledge of American Cyclopidae, enumerating ten species, of which six seemed new. This writer also describes a new genus and several new species of Calanidae, some of which unfortunately are identical with those described by *Forbes* and published about simultaneously.

Several articles in the *Naturalist* bring the bibliography up to May, 1883, when *F. W. Cragin* published in the *Trans. Kansas Academy of Science*, "A Contribution to the History of the Fresh-water Copepoda." In this paper ten species of Cyclops are described or mentioned. The author ignored previous American literature and thus adds somewhat to synonymy. The plates are lithographic, and are carefully, if not artistically, prepared. A valuable feature is the translation of the descriptions of *Poggenpol's* species from the Russian.

These papers, together with the outline presented beyond, it is hoped, will form a basis for future work.

Since writing the above, it is brought to my notice that in April, 1881, *V. T. Chambers* gave some account of a species of the Harpacticidæ referred by him to *Tachidius*. This species is particularly interesting on account of its novel habitat. *Tachidius* (?) *fonticola*, Cham., is found in the saline waters of Big Bone Springs, Ky., and thus is very distant from any marine congeners. It is perhaps doubtful if the generic reference can be sustained, but the species is worthy of further study. The *Diaptomus* described by the same author is hardly recognizable.

FAMILY CALANIDÆ.

This group is pre-eminently marine and contains diverse and graceful forms mostly with very elongated bodies and antennæ. Of the six genera here enumerated as more or less habituated to the use of fresh water, two are found as yet only in America and one is confined to Europe.

Heterocope, namely, is very near *Epischura*, both being restricted to fresh water. *Diaptomus* and *Osphranticum* are likewise only accidentally found in the seas, though their nearest allies are marine. The genus *Limnocalanus* is as yet found in America only in the Great Lakes.

In the distribution of genera we here follow Brady, whose definition of the family Calanidæ, including Calanidæ and Pontellidæ of authors, we quote: "Body elongated; composed of from ten to twelve [obvious] segments. Abdomen nearly cylindrical, much narrower than the cephalothorax and prolonged at the posterior extremity into two more or less cylindrical caudal branches [stylets]. First segment of thorax often anchylosed with the head; fourth and fifth segments also often coalescent. Head only rarely divided into two segments. Anterior antennæ very long and composed of twenty-four or twenty-five joints; that of the right side in the male often modified for grasping [geniculate]. Posterior antennæ large, composed of a basal joint, from which spring usually two branches, the primary branch consisting of two, the secondary of several joints. Mandibles strongly toothed at the apex, palp (usually) two-branched. Maxillæ strong, and provided with a many-lobed palp. Foot-jaws strongly developed: first pair very broad; the basal joints having on the inner margin wart-like processes, from which spring long ciliated bristles; the distal extremity divided into three short joints which are thickly beset with strong

and long, ciliated setæ; second pair longer and more slender, basal portion forming two long oval joints; apical portion usually 4-6-jointed. First four pairs of feet 2-branched, the outer branches always three-jointed. Fifth pair either like the foregoing, or much modified, unlike on the two sides, and in the male forming clasping organs. A heart is present. Eyes either median and stalked or paired (lateral) and sessile; in the latter case being often coalescent and composed of several lenses. Sexual organs in the female symmetrical, in the male asymmetrical. Ovisac single, borne in front of [below] the abdomen.

I.—GENUS HETEROCOPE, Sars.

Cephalothorax 7-jointed; abdomen of female three-jointed; caudal stylets short, with three large setæ and other small spines. Antennæ long, slender, 25-jointed; right male antenna geniculate, the six joints preceding the nineteenth swollen slightly, the previous ones coalescent; external ramus of the antennules 7-jointed; labrum tri-lobate; feet of the four anterior pairs with the inner rami one-jointed; fifth feet of female with a single ramus, three-jointed, with a terminal spine. The right foot of the male is cheliform, four-jointed, second joint extending into a long cylindrical process, the terminal joint with two apical claws.

The writer is familiar with but three species—*H. appendiculata*, Sars, *H. saliens*, Lilljeborg, (= *H. robusta*, Sars,) and *H. alpina*, Sars. None of these have as yet been positively identified in America* and their place seems supplied by the following genus.

II.—GENUS EPISCHURA, Forbes.

(= *Scopiphora*, Pickering?)

Undoubtedly the most remarkable of fresh water copepods are the two American species of this genus. It is not yet certain that the second species may not be a young stage of the first but it seems quite improbable.

Related with *Heterocope*, Sars. The antennæ are 25-jointed, the right of the male being geniculate. The thorax is 6-jointed, the last two segments being partially coalesced. The abdomen is five-jointed in the male and four-jointed in the female, one branched, in the male modified for prehension. Abdomen of male with a

**Heterocope* is said by Patten (Cragen) to be common at Watertown, Conn.

prehensile appendage on the left side, often more or less distorted. Inner rami of swimming feet one-jointed. Caudal stylets with three long setæ. The first mention of an animal of this genus seems to be Pickering's description of *Scopiphora vagans* from deep water in lake Ontario. It seems almost certain that the species so imperfectly described in Dekay's *Crustacea of New York*, is none other than a species of *Epischura*, but I hesitate to substitute for a name accompanied by good descriptions and figures, and one which has already been incorporated, to some extent, into our literature, one which is founded on a description so imperfect and general that one incidental character alone enables one to guess its application. The following is Pickering's description:

"Body small, eye single, near the anterior margin of the shield. Antennæ large, and as long as in the preceding genus [*Cyclops*], and has the same motions in the water. Abdomen terminating in two styles, each with three setæ; last or three last joints. Ovaries none; legs spiny."

What is meant by the "brush" fails to appear, unless the specimens were ornamented with some parasitic plants or animals. The three setæ of the caudal stylets and long antennæ will place this form in no American genus save *Epischura*. But even this statement of Pickering may be held doubtful.

Sp. 1. *Epischura lacustris*, Forbes.

(Plate Q. Fig. 15.)

"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 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 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. Length .065 in.

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."

Occurring in Minnesota, probably in lake Superior.

Sp. 2. *Epischura fluviatilis*, Herrick.

(Plate Q. Figs. 14 and 16.)

Similar to the above but smaller (.04 in.) The females are very similar, though the fifth feet are more elongate and differently spined. The abdomen is perfectly straight and the three caudal setæ are of nearly equal size. The claw is armed with eight teeth, all but the first of which are emarginate. The abdomen of the male is straight, but has a strong process on the left side which bears a movable claw laterally and a small second segment which terminates in two small spines. The fifth foot of the male is peculiar; the inner ramus (or the left foot) lamelliform, one-jointed, with two opposable claws; the right branch is simple and 3-jointed, in form like that of the female. Here we have the most marked difference between the two species. Found in Mulberry creek, Cullman county, Alabama. Although a considerable number were examined no oviferous females were found, while the males contained the spermatophores and can hardly be thought immature, and, as it is in the male that the most marked differences appear, the two species seem certainly distinct.

III.—GENUS TEMORA, Baird.

(Plate H. Figs. 8—16.)

This genus contains several marine forms and two which are found also in streams opening into the sea. The species seem to be as follows: *T. velox*, Lilljeborg, *T. longicornis*, Mueller, (= *T. finmarchia*, Baird, = *Diaptomus longicaudatus*, Lubbock), *T. armata*, Claus, *T. inermis*, Boeck, and *T. affinis*, Poppe. *T. clausii*, Hoeck, is said by Poppe to be certainly identical with *T. velox*. Hoeck's figures are incomparably better than any of the preceding, but he seems to have been misled by errors in Lilljeborg. The species described by me before the Academy of Sciences of Minnesota (but still unpublished) as *T. gracilis*, from the brackish waters bordering the gulf of Mexico, agrees very closely with *T. affinis*, Poppe. (*Abhandlungen v. naturw. Vereine z. Bremen*, 1880, p. 55.) This name must therefore take precedence. This species has been found in the Rhine and rivers flowing into the gulf of Mexico, as well as in the marine or brackish waters into which these rivers flow. The occurrence of the genus in American fresh waters, justifies its mention here.

IV.—GENUS OSPHRANTICUM, Forbes.

(=Potamoichetor, Herrick.)

First reported as Potamoichetor before the Minnesota Academy of Sciences in 1879, but owing to a disastrous fire, publication was prevented. Priority probably belongs to Forbes' name, since, although first printed in the tenth annual of this survey, the edition was not distributed till after the August issue of the American Naturalist of 1882, containing the description above alluded to. Forbes says this genus has antennæ 23-jointed; all the specimens we have gathered from Minnesota to Alabama had 24-jointed antennæ. The original description of "Potamoichetor" is appended.

"Cephalothorax six-jointed, distal segments evident; abdomen, in the male, five-jointed, in the female four-jointed; antennæ twenty-four-jointed, the right geniculated as in Centropages (= Ichthyophorbia); first pair of feet with the rami both three-jointed, like the following; feet of the fifth pair, in the female, like the preceding, but with a spine of the joint preceding the terminal one enlarged and divaricated somewhat as in Centropages; in the male, the right with a two-jointed outer ramus, the terminal joint of which is spined and bears near its base a blunt expansion of its inner margin; outer ramus of left foot three-jointed, armed with unequal spines; inner branches smaller, similar, three-jointed; the terminal joint bearing curved spines; ovary and testes as in Diaptomus, with which the mouth parts agree in the main; eyes median, confluent."

Our own experience is that the single species of this genus prefers estuaries of running water. Forbes, however, has taken it from swamps and wayside pools.

Sp. 1. Osphranticum labronectum, Forbes.(Plate Q². Figs. 1—8 and 13—14.)*Potamoichetor fucosus*, HERRICK, Cyclopidaë of Minnesota, etc., p. 224.

"Rather slender, and in size, as well as general appearance, resembling the smaller forms of Diaptomus; antennæ rather stout, reaching but little beyond the feet, appendaged as in Diaptomus, in the male strongly geniculated, but somewhat variously so; the six joints preceding the terminal four are thickened; those preceding the joint or hinge are arcuate on the distal margins; the secondary antennæ are about as in Diaptomus; mandibular palp two-branched, the outer three-jointed, the inner two-jointed; the terminal joint of

the shorter branch bearing seven setæ, of the other four, the proximal joint of the former with three stout spines; the maxillæ nearly like *Diaptomus*; the processes have respectively the following numbers of setæ: the basal plate eight, the small processes at base of posterior branchial appendage one, the appendage itself twelve, terminal portion three groups, first containing nine, the second three, and the third four or five, the upper of the anterior processes two, and the lower three; fifth feet nearly like the others in size; the right in the male having the outer branch but two-jointed by the coalescence of the two outer to form an arcuate and deformed appendage, armed at the end with three stout equal spines; corresponding branch of left foot three-jointed; the terminal joint bearing three unequal spines, each of the preceding joints only one; inner branches similar, three-jointed; terminal joint being short and armed with three short lanceolate setæ and three longer ones, two of which are curved so as to be slightly prehensile; fifth foot of female with both rami three-jointed; inner ramus much smaller; antepenult segment of the outer ramus extending into a large lanceolate process; ova-sac long-ellipsoidal or spherical, reaching nearly to the end of the caudal setæ."

V.—GENUS *DIAPTOMUS*, Westwood.

The most widely distributed and well-known of fresh water Calanidæ, inhabiting in various species the smallest as well as the largest bodies of standing or sluggishly-flowing fresh water. Apparently a recently formed group whose nearest known ally is the curious *Pseudo-diaptomus*, found in the gulf of Mexico. The animals of this genus are apparently very susceptible to the influences of the environment, and are consequently extremely variable not only in color but in minor structural points. In America there is a curious fact, which is susceptible of different explanations, one of which was given in the *American Naturalist* at various times during the year past. The species or varieties fall in pairs, one of which is smaller and less highly differentiated, while the other is greatly enlarged and has the peculiarities emphasized. These sets occur in open and shallow water respectively. The large varieties are, as the rule, restricted to such shallow weedy pools as dry up during summer and freeze solid in winter. The forms intermingle slightly, but there are seasonal differences of greater or less extent.

The body is composed of an elongated thorax, with which the head is united, forming a six-jointed cephalothorax. The abdomen

is five-jointed, though in the female these joints are so united as to cause the abdomen to appear three-jointed. The antennæ are twenty-five-jointed, and the right male limb is modified by a coalescing of some of the terminal joints, a thickening of others and the development of certain spines, hooks, and knife-like ridges to form a prehensile organ. The first pair of feet has two-jointed inner rami. The remainder have both rami three-jointed, save the last. This fifth foot is differently formed in the sexes, the inner branch of the fifth foot being one or two-jointed. Terminal joint of the outer ramus of this limb in the female very small or apparently absent, second joint produced to form a stout curved claw. The left foot is reduced in the male, serving, in some species, to affix the spermatophore to the body of the female, while the abdomen is held by the right foot. The last segment of the thorax has one or two sharp spines below. The spermatophore, or sperm case, is a long tube with coagulating expansive lining, which forces out its contents on exposure to the water. The colors are frequently brilliant.

Three or four species of this genus are known in Europe, the first being *Diaptomus castor* which seems universally distributed. It can hardly be doubted that the six forms mentioned below belong among the varieties of this species; yet these forms can be distinguished very well, and are deserving of distinct names. Two other forms are nearest *D. gracilis* of Sars, but sufficiently distinct. These stand related as do the pairs of the other section, and can not be readily distinguished.

The following is the most convenient arrangement of the genus I have been able to devise.

KEY TO THE GENUS DIAPTOMUS.

I. Form robust; right antenna of the male with a hook, much swollen anterior to the geniculating joint.

A. Head not greatly dilated.

* Last segment of thorax prolonged into a sharp-spined angle or tooth.

† With but one tooth (?).

1. *D. castor*, Jurine.

†† With two teeth.

‡ Length under 3 mm.

§ Inner rami of fifth feet in the female 1-jointed.

2. *D. sanguineus*, Forbes.

4. *D. armatus*, Herrick.

§§ Inner rami 2-jointed.

3. *D. minnetonka*, Herrick.

‡‡ Length over 3 mm.

5. *D. stagnalis*, Forbes.

** Last segment of the thorax more or less united with the previous one, bearing very small spines.

6. *D. longicornis*, Herrick.

(a) Length under 2 mm.

var. leptopus, Forbes.

(b) Length over 2 mm.

var. similis, Herrick.

B. Head enlarged.

7. *D. laticeps*, Sars.

II. Form slender, elongate; head divided into two portions; antennæ long, slightly altered in the male.

A. Antenna of male with a hook.

8. *D. gracilis*, Sars.

B. Antenna of male without a hook.

9. *D. pallidus*, Herrick.

(a) Antennæ much longer than the body, inner rami of fifth pair of feet in the male 1-jointed.

var. pallidus, Herrick.

(b) Antennæ little longer than the body, inner ramus of fifth feet bi-articulate.

var. sicilis, Forbes.

Sp. 1. *Diaptomus castor*, Jurine. [Sars.]

"Corporis forma sat robusta. Cephalothorax in femina postice parum antice vero magis attenuatus, angulis laminarum segmenti ultimi obtusis. Segmentum 1-mum abdominale absque mucrone laterali. Rami caudales brevissimi segmento antecedente vix longiores setis crassis et brevibus. Antennæ 1-mi paris mediocris longitudinis reflexæ segmentum 3-tium abdominale vix superantes, animali natante leviter arcuatæ adque latera vergentes; articulus ultimus (?) antennæ dextræ maris in hamulum exiens acuminatum. Ramus antennarum 2-di paris exterior interiore parum modo longior, articulo ultimo quam antecedentibus 5-junctis brevior. Articulus ultimus pedum 5-ti paris in femina rudimentaris tuberculum solum minimum aculeo uno parvo instructum formans; unguis intus curvatus maximus validusque; appendix interna indistincte bi-articulata longitudinem articuli 3-ti superans; unguis terminalis pedis dextri maris longissimus leviterque arcuatus. Saccus oviferus parva et multa continet ova colore castaneo. Color animalis variat ex fulvo, cæruleo vel rubro. Longit. fem. interdum fere 3 mm. Habitat in aquis stagnantibus."

The description quoted above from Sars does not agree with Claus' or Brady's account of the same species. From what Brady says of the English *Diaptomi* one would conclude that the same variations occur there as here. *D. westwoodii*, which he unites with *D. castor*, is certainly as different from that species as our *D. stagnalis* is from *D. sanguineus*. An actual comparison of specimens will be necessary to clearly define the relation of the American and European species.

Sp. 2. *Diaptomus sanguineus*, Forbes.

(Plate Q, Fig. 12.)

A species found with us in stagnating pools in early spring, frequently following *D. stagnalis* and giving place to *D. leptopus*. It prefers pools less foul than those affected by the latter, though not rarely found with it temporarily. The species is quite variable, and the variations are in directions suggestive of other species. Measurements taken of specimens from a gathering from two pools, one being more stagnant than the other, showed the following results:—males from the less stagnant 1.7 mm.; males from the other pool 2.0 mm.; a difference of 0.3 mm. (Males of *D. stagnalis* from the latter gathering measured 3.4 mm., while the females of that species vary between 3.8—3.9 mm.) Females measure about 1.8 mm. on an average, of which 1.3 mm. is the length of the thorax. Such individuals have antennæ 1.7 mm. long. The greatest width is anterior to the middle, being about 0.5 mm.

This species differs from *D. stagnalis* of which, in most respects, is a miniature, by the long antennæ, short abdomen and peculiar armature of the fifth feet.

In the female the fifth foot is about 0.5 mm. long, and the outer ramus has two small spines on the terminal joint, while the segment before the last has a powerful toothed claw. The inner ramus is not evidently two-jointed. The first abdominal segment is spurred on either side. The last thoracic segment extends into a strong angle which bears a heavy spine terminally, and a smaller spine dorsally. On the dorsal median line is a protuberance or "hump" on this segment. In the male the outer ramus of the right foot of fifth pair is long, and terminates in a powerful curved, toothed claw. The inner ramus is small and narrowed toward the end; on the outside of the segment from which it springs is a blunt spine, which is nearly as large as the ramus itself, and has been mistaken for it. The left foot is very fleshy and its inner ramus very rudimentary. The color is brilliant red or purple but variable. Found in the southern states in autumn.

Sp. 3. *Diaptomus minnetonka*, (Sp. n.)

(Plate Q. Figs. 8—10.)

A small species, smaller than either *D. longicornis* or *D. sanguineus*, was gathered in a pool bordering lake Minnetonka, which contained also *D. longicornis*. It unites the characteristics of both

species. The antennæ reach beyond the stylets, the color is dark, the margins of the last segment of the thorax is rather strongly spined, very much as in *D. sanguineus*. The fifth feet of the female resemble very much those of *D. leptopus*, but the first segment of the abdomen has a strong spine. The fifth foot of male resembles that of *D. sanguineus* more than that of *leptopus*. This species was seen but once, and no measurements can be given save that of the male which was 1.4 mm.

Sp. 4. *Diaptomus armatus*, Herrick,

Is founded upon an imperfectly known form in which the antennæ do not reach the end of the abdomen; the thickened part of the male antennæ short; the antenna armed as in *D. sanguineus*; the terminal claw of the fifth foot of the male with a tooth near the base; the claw being nearly as long as the ramus.

Sp. 5. *Diaptomus stagnalis*, Forbes.

(Plate Q. Figs. 11 and 13.)

D. giganteus, HERRICK.

The largest species of the genus and, not improbably, too close to *D. westwoodii*, Lubbock. The general characters are like those of *D. sanguineus*, but the form is much more robust and the antennæ only moderately exceed the thorax. The proportions may be gathered from the measurements given. In the female the length of thorax is 2.5 mm.; abdomen 1.2 mm.; antennæ 2.3 mm.; stylets 0.1 mm. The caudal stylets are as broad as long, or nearly so. The last thoracic segment extends into an irregular process 0.1 mm. long, bearing a spine dorsally. The first abdominal segment is spurred on either side. The fifth feet in the female have two-jointed inner rami. The terminal segment of the outer ramus is more than ordinarily distinct, while the claw is biserrate. The right foot of the fifth pair in the male is very long, its claw being strongly toothed. On the inside of the second joint from the base is a disc-like appendage peculiar to this species. The left foot is short. The longer ramus is three-jointed, but the terminal joint is a mere curved spine, opposing a spine from the penultimate segment, which is covered with minute spines or teeth. The basal joint of the ramus has a bristly protuberance distally. The inner ramus is marked with oblique ridges. The right antenna has a powerful hooked spine on the antepenult segment, the two segments beyond which coalesce in

maturity as in the other related species. For measurements see above. Color deep opaque red or purple. Appearing in early spring as soon as the ice is melted from the pools which it inhabits. In the south it occurs in autumn. The name above given seems to have the priority, although this species was figured and described at about the same time in the annual of this survey.

Sp. 6. *Diaptomus longicornis*, Herrick

This name was applied somewhat loosely, the description given being incomplete, but re-examination of types shows it to belong unquestionably to the form since described as *D. leptopus*. In our state we have found another variety, in general, almost identical with the type specimens, but nearly twice as large. It is now proposed to extend the significance of this name so as to include both varieties, which will undoubtedly be found connected by intermediate forms, thus retaining the name given by Forbes for the variety to which it in particular applies.

(a) **var. *leptopus*, Forbes.**

This species is the commonest member of the genus in small lakes and clear pools. It is tolerably constant in coloration, but varies somewhat in size. The original description is insufficient to identify the species definitely, but taken in connection with the figure and the measurement, could hardly be referred to either of the other American forms. This species is characterized by the very compact thorax, the margin of the last segment of which has two very minute spines; and by the form of the fifth feet. The antennæ reach nearly to the end of the caudal setæ, while in the next they fall short of the length of the stylets. The outer spines of the swimming feet are denticulate on the outer margin and setose within. The fifth feet of the female are compact, the inner ramus is more or less obviously two-jointed; the third joint of the outer ramus is almost obsolete and has two short spines; the claw of second joint is strongly denticulate. The male fifth foot has a rather long inner ramus which is very imperfectly two-jointed; the left foot is rather long; the claw of the right foot is armed with crenulate teeth. Length 1.5—1.7 mm., without setæ. The body, which is broadest anterior to the middle, is bluish; the tips of the antennæ are deep purple. The eggs are not as numerous as in the next.

(b) **var. similis.** (Var. n.)

(Plate Q. Figs. 5—7.)

This form is twice as large as *D. leptopus*, but otherwise scarcely distinguishable. It occurs in autumn (and spring?) in shallow pools, which can but be frozen solid. The following differences are the only points yet noticed. Females of both of the species were placed side by side upon a slide and examined. *D. leptopus* measured 2.4 mm., exclusive of caudal setæ; the antennæ reached hardly to the base of the stylets; the eggs measured 0.12 mm., while those of *D. longicornis* measured 0.8 mm.; the egg-sac measured 0.8 mm., while that of *longicornis* was 0.5 mm. A few other minute differences were noticed, but the general form and color was identical. The peculiar doubling of the edge of the last segment is characteristic of these two forms; each has a small spine on either side of the abdomen. The base of the inner ramus of left foot of fifth pair of the male has a double series of spines.

Sp. 7. Diaptomus laticeps, Sars.

"Cephalothorax antice dilatatus, latitudine maxima in parte antica capitis sita, postice sensim attenuatus, segmento ultimo feminæ ad latera parum extante angulis lateralibus acuminatis. Segmentum 1-mum abdominale feminæ antice latum mucrone brevi laterali armatum, postice sensim attenuatum. Rami caudales sat magna segmenta antecentia 2 juncta longitudine æquantes setis brevissimis et robustis instructi. Antennæ 1-mi paris feminæ longitudinem corporis æquantes, animali natante rectæ et quam in *D. gracili* adhuc magis postice vergentes; articulus antepenultimus antennæ dextræ maris hamulo armatus. Ramus exterior antennarum 2-di paris interiore multo longior articulo ultimo longitudinem articulorum antecedentium 5 æquante. Pedum 5-ti paris feminæ articulus ultimus parvus, cylindricus, non vero tam rudimentaris quam in *D. castore*, aculeo uno brevi apicali instructus; appendix interna ne tertiam quidem longitudinis articuli 3-ti partem æquans et uniarticulata; pedis dextri maris articulus 3-tius extrorsum aculeo forti armatus, ungue terminali valde flexuoso et sub-sigmoides; sinister aculeis duobus rectis terminatus. Saccus oviferus sat multa continet ova. Color pleurumque læte cæruleus, interdum pallidior, albescens. Longit. feminæ circit. 1½ mm."

Sp. 8. Diaptomus gracilis, Sars.

"Corpus quam in *D. castore* gracilius, cephalothorace et antice et postice attenuato, latitudine maxima in medio sita. Anguli laminarum segmenti ultimi thoracalis feminæ in mucrones tenues et acuminatos producti, et mucrone simili sat magno segmentum 1-mum abdominale utrinque armatus est. Rami abdominales breves setis in femina valde divergentibus. Antennæ 1-mi paris feminæ perlongæ et tenues, longitudinem totius animalis longe superantes, animali natanti rectæ et aliquantum postice vergentes; articulus antepenultimus antennæ dextræ maris hamulo longior, articulo ultimo rami dimidium longitudinem æquante. Pedum 5-ti paris feminæ articulus ultimus distinctus, quadratus aculeis duobus apicalibus quorum interior apicem fere unguis articuli penultimi attingit instructus; appendix interna articulo 3-tio brevior; unguis terminalis pedis dextri maris apicem versus valde curvatus. Saccus oviferus semper ova continet paucissima et magna regulariterque distributa. Animal pleurumque pelluci-

dum colore albido, interdum vero facia transversa lata coloris fuscī saturati in medio cephalothorace ornatum. Longit. feminæ parum supra 1 mm."

The two forms following are sufficiently distinct from the above and form a closer link with the marine Calanidæ. It is doubtful if any absolute line of demarkation exists between these varieties, although they are here distinguished.

Sp. 9. Diaptomus pallidus, Herrick.

(Plate Q. Fig. 17.)

Length 1.20 mm.; length of antennæ 1.35 mm. Colorless. Head separated by a suture into two parts; form very slender. Antennæ with elongated setæ, which are very plumose. The right male antenna has no hook. The inner rami of the fifth feet are one-jointed in both sexes. Left foot of the fifth pair of the male of peculiar form (see plate Q, fig. 17, for an extreme instance). Entire Mississippi valley.

var. sicilis, Forbes.

(Plate Q. Fig. 18.)

Like the above, but larger. Length 1.45 mm. Length of antennæ 1.5 mm. Inner ramus of male feet of fifth pair two-jointed, those of the female one-jointed. The form of feet varies a little from the above. This species has been but once encountered in Minnesota, the previous species occurring abundantly in our larger lakes.

D. kentuckyensis, Chambers, is referable to one of the above species, probably *D. longicornis*.

For a full account of synonymy see Rehberg, *Beitrag z. Kenn. d. freileb. Suesswasser Copepoden*, p. 552.

VI.—GENUS LIMNOCALANUS, Sars.

Cephalothorax 6-jointed, slender; abdomen in the female 3-jointed, in the male 5-jointed. Antennæ shorter than the body, 25-jointed. Caudal stylets long. Feet of the four anterior pairs with both rami 3-jointed; external ramus of the fifth foot in the female 3-jointed, second joint produced into a spine; inner rami 3-jointed in both sexes and like those of the previous pairs; external rami 2-jointed in the male, the right and left dissimilar.

Sp. 1. *Limnocalanus macrurus*, Sars.

A species similar to *L. macrurus* has been found in lake Michigan, and probably occurs also in this state in lake Superior. We can do no better than quote Sars' description.

"Corpus gracile et angustatum. Cephalothorax supra visus elongato ovatus, latitudine maxima in medio sita antice et postice æqualiter attenuatus. Caput annulum unicum præbens, a latere visum parte antica altiore et convexa sinu distincto a posteriore disjuncta, margine antico oblique descendente. Segmentum ultimum thoracis parvum neque ad latera extans in femina et mare simile. Abdomen sub-cylindricum thorace longius. Rami caudales valde elongati et angustati tertium longitudinis abdominis partem superantes, supra et ad latera spinulis vel pilis brevibus obsiti, intus ciliati, setis 5 majoribus uniarticulatis et ciliatis, quarum 2-da ab interiore numerata omnium longissima ceteræque extus graduatim longitudine decrescentes, exteriore ceteris minore absque apice sat remota; seta adest præterea alia intus adfixa ut in generibus antecedentibus tenuissima et simplex. Frons a latere visa obtuse acuminata appendicibus tentaculiformibus duabus perbrevis instructa. Antennæ 1-mi paris reflexæ segmentum penultimum abdominis minime attingentes, articulo ultimo setis 5, quarum posteriores 2 longissimæ, instructo, articulis antecedentibus 3 setæ simili postice vergente præditis; dextra maris articulatione inter articulum 18-mum et 19-mum geniculans. Antennarum 2-di paris ramus exterior interiore et longior et latior, 7-articulatus, articulo 2-do omnium maximo, sequentibus 4 minimis junctis articulo ultimo brevioribus setisque longissimis instructis. Mandibulæ ad extremitatem inferiorem in dentes exeuntes 9, quorum exteriores 3 ceteris majores, interiores 2 tenues et setiferes sunt; palpus longus et angustatus 3-articulatus, articulis ultimis 2 brevissimis, ramo exteriore, vel appendice branchiale, parvo. Maxillæ 1-mi paris eadem fere structura ac in Diap-tomo. Maxillæ 2-di paris validissimæ 8-articulatæ, articulis ultimis 5 in ungues exeuntibus longissimos et fortissimos margine altero sparsim pilosos, ad apicem falcatum vero nudos vel aculeis persubtile et dense obsitos; 3-tii paris [Maxillipedes] valde elongatæ et angustatæ antice vergentes articulis 7 setis pleurumque longis præditis compositæ. Pedes omnes biramosi natatorii, ultimo pari in mare bi-articulatus in pede dextro et sinistro dissimilis, articulo ultimo in illo brevi et robusto ad apicem quasi truncato dentibusque 3 parvis et obtusis armato intus vero in aculeum magnum et validum exeurrente, in hoc valde elongato extus et ad apicem aculeato intus vero nudo. Oculus unicus propius marginem inferiorem capituli situs. Animal quamquam pellucidissimus et fere omnino hyalinus, facile tamen accumulatione in thorace sat magna liquoris oleosi læte fulvo-rubide colorati se prodit. Longit. circit. 2½ mm."

FAMILY CYCLOPIDÆ.

Contains five genera, viz: *Thorellia*, *Cyclops*, *Oithona*, *Lophophorus* and *Cyclopina*; passing, by the genera *Misophria* and *Pseudo-cyclops*, into the *Calanidæ* or marine copepods. The affinities of these little known genera need further study, as they are very interesting, the question being still open in how far the cyclopoid forms are altered by adaptation to saline habitat, if such an adaptation takes place at all.

Cephalothorax ovate and usually much more robust than the abdomen; anterior antennæ seldom longer than the cephalothorax, those of the male alike on both sides and modified for the purpose of clasping; posterior antennæ unbranched (i. e. palpus wanting);

palps of mandibles and maxillæ usually well-developed; foot-jaws mostly less developed than in *Calanidæ*; first four pairs of feet as in *Calanidæ*, fifth pair rudimentary, alike in both sexes, and usually one- or two-jointed; ovisacs two.

The circulatory system of this family is partly lacunal and has been thought to be entirely so in the genus *Cyclops*. closer observation, however, shows that there is something like an imperfect central organ at the point occupied by the heart of higher Copepods. This was figured in my previous report, plate V, fig. 1, but no mention was made of the discovery. It has since been verified. The apparatus referred to is a modification of that described under *Canthocamptus*. In the second thoracic segment there is a set of swaying membranes which constitute a valvular apparatus, chiefly moved by the action of the stomach.

GENUS CYCLOPS.

The sole representative of the genera of the Cyclopidæ here treated is the best known of the Copepoda. Every one is familiar with the "common cyclops," but few realize how many are the species included under this name. An attempt is here made to enable the student to recognize the more obvious distinctions upon which the genus is subdivided and to identify such of the species as seem valid and at the same time recognizable without recondite study of development. Without attempting a complete elucidation of the synonymy, which is practically an impossibility, a proximate classification of all the species known to me is attempted. Thirty sufficiently well marked species are enumerated, and the position of a number more is indicated.

Antennæ 18-jointed.

Sp. 1. *Cyclops elongatus*, Claus.

This species, cited hitherto, apparently, by but one other author than Claus, is distinguished from the *C. pulchellus* group by the 18-jointed antennæ, which are hardly longer than the first thoracic segment. The caudal stylets are longer than the two preceding abdominal segments, and bear rather short setæ. *C. elongatus* has been found by Cragin near Cambridge. That this species, found thus far by but a single author in Europe, appears in America, may serve as a warning not to decide too hastily from its habitat that a copepod is new.

of equal width; caudal stylets longer than the last two segments of the abdomen terminal; setæ of moderate size, inner three times as long as outer, internal pair nearly equal. Antennæ as long as first two segments. The inner ramus of fourth foot has the exterior thorn very small. The second joint of the fifth foot is small and the external thorn very small. Length 1.5 mm.

Not seen in America.

B.—First joint of fifth foot of moderate size.

(a) Terminal segment of fifth foot with one long seta and a short thorn.

These small species pass into the above group and constitute one of the most difficult groups of the genus. The distinctions offered are very small and specific variation considerable.

Sp. 6. Cyclops strenuus, Fischer.

? *C. pictus*, KOCH.

C. brevicaudatus, CLAUS, LUBBOCK, HELLER, FRIC.

C. strenuus, SARS, BRADY.

Antennæ reaching about to the end of the third segment; caudal stylets slender, three times as long as the last segment; the outer of the caudal setæ shortest. The third seta is over once and one half the length of the stylet.

Sp. 7. Cyclops lucidulus, Koch.

C. lucidulus SARS.

C. furcifer, CLAUS.

C. vernalis, FISCHER.

This species is given on the authority of Rehberg. Claus considered *C. furcifer* a large variety of the above species.

The antennæ are as long as the first segment; the fifth foot is peculiar in form, with the second joint armed with a spine and a hook; length 1.3 mm.

Neither this nor the previous species is known in America.*

Sp. 8. Cyclops robustus, Sars.

Antennæ shorter than first segment, thick. Body depressed, first segment broad and rounded anteriorly, the others spreading; caudal stylets nearly parallel, long; inner median seta much the

**C. pulchellus*, Brady is not *C. pulchellus*, Koch, and may be the above species.

longer, external setæ very short. Terminal joint of outer rami with three spines externally and four setæ internally. Length 1.3 mm. I know nothing of this species save the description of Sars, a part of which is quoted above.

Sp. 9. *Cyclops parvus*, Herick.

(Plate R. Fig. 22.)

Cyclops parvus, HERRICK, Crustacea of Minnesota, p. 229; Plate VI., Figs. 12—15.

In form and general appearance greatly resembling *Cyclops thomasi*, which it nearly equals in size. The chief differences are found in the length of the caudal stylets and antennæ and in the form of the fifth foot. The antennæ are shorter than, or about as long as, the first thoracic segment. The formula expressing the length of the joints corresponds with that for *C. thomasi*. The antennules are shortish. The labrum is rather narrow, projecting below into obtuse angles, the middle of the lower face being occupied with nine rather small teeth. The terminal joint of the larger branch of the maxilliped bears four hairs. The second joint has a moderately large dactyl, the movable finger of which is small and sparsely spiny, the immovable finger is ornamented by an oblique series of blunt prominences and a small seta at its base. The first pair of feet has two terminal and two interior setæ and two external spines on the ultimate joint of the outer ramus, while the corresponding joint of the inner ramus bears one inner seta and large spine and three outer setæ. The fourth foot has, in the first case, two outer spines, a terminal spine and seta and three internal setæ, and, in the second, one external seta, two subequal terminal spines and two internal setæ. The fifth foot is two-jointed, bearing on the short basal joint a moderate seta and on the larger second joint a considerable seta and a small oval spine on its side. The caudal stylets are short and the lateral seta is near the end (about 1.5). The outer seta is but three-fourths the length of the inner. The inner of the median setæ is considerably longer than the outer. The shape of the operculum of the female is very characteristic, it being nearly oval. The last two joints of the thorax are acute. The entire length is about 1.5 mm.

Sp. 10. *Cyclops brevispinosus*. (Sp. n.)

(Plate S. Figs. 7—11.)

The form for which this name is proposed takes the place of the

above in the larger lakes. It appears to be but a modified condition of the above species, from which it differs in its slender form and especially in the very slender caudal stylets. The outer caudal seta is reduced to a short ciliate thorn. The fourth foot is also modified by the great enlargement of the spines and the reduction of the setæ. The number of the setæ is the same, but they are differently disposed. The form of the operculum vulvæ is also slightly different.

(?) **Sp. 11. *Cyclops uniangulatus*, Cragin.**

Cyclops uniangulatus, CRAGIN. A Contribution to the History of Fresh-water Copepoda, p. 6.

Cragin was not conversant with the description of *C. parvus*, with which his description agrees save in one point. It differs from *C. parvus* in having three inner setæ on the terminal joint of the outer ramus of the first foot. It would be officious to suggest a possible oversight here, but *C. parvus* has only two in type specimens (though in all this group the corresponding ramus of the *second foot* has three setæ), so that at present the two must be kept distinct.

Sp. 12. *Cyclops scutifer*, Sars.

Not having identified this and the following species it will be best to quote the descriptions.

C. strenuo affinis. Cephalothorax sat elongatus, segmentis ultimis duobus in femina ad latere valde prominentibus inque processos exeuntibus laminares et hyalinos utrinque inter se contiguos, quare thoracis pars posterior tamquam clypeo fornicato quadrangulari oblecta esse videtur. Segmentum 1-mum abdominale ad basin valde dilatatum latitudine quam ad marginem posteriorem duplo majore. Rami caudales segmentes antecedentibus duobus junctis parum longiores, introrsum ciliati, setis apicalibus brevissimis, intermediarum interiore ceteris multo longiore. Antennæ 1-mi paris 17-articulatæ, reflexæ segmentum 2-dum corporis superantes setis plurimisque longis obsitæ. Pedum structura eidem in *C. strenuo* similis. Articulus scilicet ultimus rami exterioris pedum natatoriorum setis 5 instructus in paribus anterioribus duobus 3, in sequentibus duobus 2 modo aculeis marginis exterioris armatus; aculeorum apicalium rami interiores pedum 4-ti paris exterior brevis et rudimentaris. Pedum 5-ti paris articulus ultimus sat magnus articulo basali parum minor extrorsum sparsim pilosus introrsum aculeo armatus ciliato setaque longa terminali. Sacci oviferi parvi globosi abdomen magna ex parte obtegentes. Longit. circit. $1\frac{1}{2}$ mm.

Sp. 13. *Cyclops abyssorum*, Sars.

C. strenuo et *scutifero* sat affinis. Cephalothorax ovatus antice obtuse truncatus, segmentis parum ad latera extantibus. Rami caudales longi et tenues satisque divergentes, longitudinem segmentorum antecedentium 3 superantes, setis apicalibus longioribus intermediarum interiore duplam longitudinem furcæ superante, exteriori quam illa parum brevior. Antennæ 1-mi paris 17-articulatæ longæ et fere rectæ distincte postici

vergentes, reflexæ segmentum 3-tium corporis fere attingentes. Pedum natatoriorum structura fere eadem ac in speciebus antecedentibus; aculeorum apicalium rami interioris pedum 4-ti paris exterior dimidiam fere interioris attingens longitudine. Pedum 5-ti paris articulus basalis minimus ultimo multo brevior parumque latior. Sacci ovi-feri mediocres rotundato-ovales abdominique appressi. Longit. circit. 2 mm.

(b) Terminal segment of fifth foot with two rather long setæ.

* External and internal caudal setæ not extremely short.

Sp. 14. *Cyclops oithonoides*, Sars.

(Plate S. Figs. 2—6.)

? *C. hyalinus*, REHBERG.

? *C. tenuissimus*, HERRICK.

This most interesting species occurs under peculiar circumstances. It is perhaps the rarest member of the genus and seems, beyond a doubt, nocturnal in its habits. It was first found by Sars in saline water and named, on account of its slender form, from the marine *Oithona*. A similar species which, though about half as large, is hardly distinct, was found by Rehberg near Bremen. Rehberg mentions particularly that it was found oftener at night than during the day. In America a similar species was described from near Paducah, Ky., under the name *C. tenuissimus*; but the possibility of identity with the Scandinavian species seemed excluded by the habitat. A gathering taken at night from one of the lakes near Minneapolis contained a few specimens of similar characters, and there no longer seems to be a doubt of the identity or very close relation between these forms.

The antennæ are longer than described for *C. tenuissimus*, nearly equalling the thorax. The last joint of the antennæ is short, but the toothed character was not noted. The fifth feet are small, the spines are very long and slender. The margins of the abdominal segments are irregularly toothed. The species will be confused with no other. It is marked with blue in spots. Length 0.5—1. mm.

Sp. 15. *Cyclops simplex*, Poggenpol.

Cyclops Leeuwenhoekii, HOEK (fide Rehberg).

This species is of more compact form than the last, which it resembles in the form of the caudal stylets and the fifth foot. The antennæ are nearly as long as the thorax, the last two joints being elongate and having a knife-like ridge which has at the end teeth like those figured in *C. tenuissimus*. Length 1.—2. mm.

** The two median setæ much longer than the external.

The species of this section are the most perplexing of the genus. The best that I can now do is to indicate the relations of the nominal species and express the conviction that most are of varietal value simply.

Sp. 16. *Cyclops pulchellus*, Koch.

C. bicuspidatus, CLAUS.

† Terminal joint of outer ramus of feet with two spines outwardly.

16 a. *C. thomasi*, Forbes.

16 b. *C. navus*, Herrick.

†† With three spines.

16 c. *C. bisetosus*, Rehberg.

= *C. bicuspidatus*, Sars.

= (?) *C. insectus*, Forbes.

There are at least three well marked varieties in America, which may probably rank as species and have been ranked as such by Forbes. I give verbatim Forbes' description.

(16a) *Cyclops thomasi*, Forbes.

(Plate U. Figs. 4, 5, 7 and 8.)

"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 white-fish their earliest food."

(16c) **Cyclops insectus**, Forbes.

(Plate U. Fig. 9.)

"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."

Both forms probably occur in Minnesota, though the second has been seen but once, and the identification lacks confirmation. The differences between the two are almost exactly those prevailing between *C. bicuspidatus* (= *pulchellus*) and *C. bisetosus*, Reh., if I correctly understand Sars. Claus' description does not agree with that of Sars. Further study of the European types will be necessary before a satisfactory settlement can be reached.

(16b) **Cyclops navus**, Herrick.

Cyclops navus, HERRICK, Copepoda of Minnesota, p. 279.

This name, proposed at nearly the same time as *C. thomasi*, applies to a very closely related form which I can but regard as a variety of that species. It seems constant in its differential characters in given localities, but we are now familiar enough with the fact that changed conditions in the water occasion changes in forms in the copepods.

This form inhabits shallow pools. It is larger than *C. thomasi*,

minal three-spined division; caudal stylets twice as long as last abdominal segment; setæ all nearly terminal, inner one long. Length 2.5 mm.

Common in America, England, continental Europe, etc. *C. clausii*, Poggenpol, is known to me only from the citations of Rehberg and the translation given by Cragin, hence I can not judge authoritatively of its validity. Certain points in the translation are obviously erroneous, as where the larger branch of the fifth foot is spoken of. No distinctions sufficiently clear to enable us to separate it from *C. tenuicornis* can be gathered.

III.—FIFTH FOOT 3-JOINTED.

(See *Cyclops modestus*.)

Antennæ 16-jointed.

There are a few forms which, although they might more properly be ranked with the previous section, seem rarely or never to acquire more than sixteen joints.

Sp. 18. *Cyclops languidus*, Sars.

Thorax attenuated posteriorly, caudal stylets exceeding in length the two preceding segments, internal seta short, half as long as the outer, the inner of the median setæ as long as the abdomen. Both rami of the first foot and the inner of the second are two-jointed. Second joint of the fifth feet sub-linear, armed with a seta and a spine. The fact that some of the feet have two-jointed rami suggests a young stage of some other forms.

This species has not been seen in America.

Sp. 19. *Cyclops modestus*, Herick.

(Plate R. Figs. 1—5.)

American Naturalist, 1883, p. 500 (May).

This small species, 1.0 mm. long, was first recognized in Cullman county, Alabama, but occurs also in our lakes. The color varies, but very characteristic is the peculiar shining or glaucous surface of the strongly arched thoracic shield and the evenly curved segments of the abdomen. The antennæ reach but little beyond the very long first segment; they are usually 16-jointed, but I have notes of a similar form in which the antennæ are 17-jointed. The feet are

all 3-jointed and are peculiar in their armature. The fifth foot is obscurely 3-jointed, the second joint bearing a short spine and the terminal joint two spines of varying length. The stylets are once and a half as long as the last segment and are peculiarly excavated for more than the lower third, from the point where the lateral spine is situated. The outer terminal seta is short, the others being sub-equal and also short. The opening of the spermatheca is elongated, oval. The antenna of the male is divisible into five regions, the third being formed by the thickening and coalescing of four or more segments.

Antennæ 14-jointed.

Sp. 20. *Cyclops insignis*, Claus.

The two forms here belonging might be considered atavic varieties of *Cyclops pulchellus*. Brady's figures and description of his *C. insignis* (= *C. lubbockii*) agree almost exactly with what Rehberg says of *Cyclops helgolandicus* (Abh. v. naturw. Vereine zu Bremen, vii. 1. pp. 62—64). Rehberg regards that species as an atavic sub-species or variety of *C. pulchellus*. With *C. insignis*, Claus, the case seems to be different. The occurrence of this species is not conditioned by marine influence. I found it abundant about Leipzig, Saxony. The differences between it and the *C. insignis* of Brady are, as the latter says, very slight. Figs. 11—14 of plate T are drawn from Leipzig specimens, from osmic acid preparations. The first foot, outer ramus, has three external spines on the distal segment, two setæ at the end, and three within; the inner ramus has one internal seta, a spine and a seta terminally, and three external setæ on the distal segment. The outer terminal segment of the fourth foot is like the first; the inner one has only two external setæ. The external setæ of the caudal stylets exceed half the length of the stylet and are pectinate. The fifth foot has a short basal joint armed with a single seta, the second joint being slender and armed with two unequal setæ. The gathering above mentioned, taken near Leipzig, Dec., 1881, contained scarcely a female among scores of males in various stages of development. This is so contrary to what is expected that, notwithstanding the apparently good characters on which the species is founded, an uncertainty exists in the mind of the writer as to the permanent adult characters of this species.

Antennæ 12-jointed.**I.—FIFTH FOOT 2-JOINTED.**

A.—*Terminal segment of fifth foot with a seta and a small spine.*

Sp. 21. Cyclops capillatus, Sars.

“Cephalothorax sub-ovate; anteriorly uniformly rounded; segments projecting somewhat laterally, the last being scarcely wider than the first abdominal segment. Abdomen attenuated posteriorly; caudal rami almost as long as the last three abdominal segments, hardly divergent, the external and internal apical setæ short and nearly equal; the interior of the median setæ as long as the abdomen; lateral seta about in the middle of the stylet. Antennæ of the first pair robust, slightly exceeding the first segment of the body when reflexed, with the twelve joints densely covered with long and divergent hairs. The last joint of the outer rami of swimming feet are elongated and armed externally with three spines, internally with four setæ; the interior apical spine of the interior rami of the fourth pair of feet longer than the exterior. Feet of the fifth pair large, with a large and thick basal segment and a small oval second joint bearing one long seta and a short spine. Ova-sacs small, narrow and divergent. Eye very small. Length nearly 2 mm.”

Very close to *C. viridis* in many points. Found only in Scandinavia.

Sp. 22. Cyclops crassicaudis, Sars.

Cephalothorax elongate-ovate; segments produced laterally, especially the last, which extends into a somewhat procurved process. Abdomen short and thick, first segment somewhat excavated; caudal rami equalling the last two segments of the abdomen. External apical seta longer than the internal, both short; median setæ long. Antennæ of the first pair 12-jointed, scarcely longer than the first segment. Swimming feet short and thick, spines and setæ short; the interior apical spine of the last joint of the inner ramus of the fourth foot almost twice as long as the exterior spine. Terminal joint of the fifth foot small, armed with a spine and a seta; seta of the basal segment short. Ova-sacs oval, somewhat divergent. Length 0.75 mm.

Found only in Scandinavia.

II.—FIFTH FOOT 1-JOINTED.

Sp. 23. *Cyclops varicans*, Sars.

“Cephalothorax ovate, attenuated about equally in front and behind, with the last segment wider than the abdominal segments, produced laterally and bearing a long seta. Abdomen elongate; caudal rami scarcely as long as last two segments; the internal apical seta twice as long as the outer; median pair elongated, the internal one as long as the abdomen. Antennæ 12-jointed, robust, shorter than the first thoracic segment. * * Both rami of swimming feet two-jointed. * * Feet of fifth pair rudimentary, with a single linear segment bearing a long spine. Ova-sacs long, divergent. Length 1 mm.”

Very possibly the young of some species not now identifiable. Only mentioned by Sars. (Compare *C. diaphanus* below.)

Sp. 24. *Cyclops serrulatus*, Fischer.

(Plate O. Figs. 17—19.)

? *Cyclops agilis*, KOCH (fide Rehberg).

Cyclops serrulatus, LILLJEBORG, CLAUS, SARS, LUBBOCK, HELLER, FRIC, HOEK, BRADY.

Cyclops longicornis, VERNET.

Cyclops pectinifer, CRAGIN.

Although Rehberg positively asserts that Koch's name applies to the present species, none of the numerous authors who have mentioned this most widely distributed form have employed any other than the familiar designation, and the practical advantage to be derived from its use seems to outweigh a quibble of doubtful synonymy.

Cephalothorax oval, compact; abdomen slender and short, suddenly enlarged previous to its union with the thorax; antennæ slender, reaching nearly, but not quite to the last thoracic segment; the last three joints are attenuated and furnish the most evident character of the species; formula — \sphericalangle — \sphericalangle — \sphericalangle — \sphericalangle — \sphericalangle — — —; during life the antennæ tend to assume the form of a rude Z, the proximal four joints forming the base; antennules small, reaching about to the sixth joint of antennæ; jaws small with large teeth; the single segment of the fifth foot with three equal spines; egg-sacs oval, as long as the abdomen; eggs few, dark; caudal stylets very long and slender, spined along the outer margin; lateral setæ small and approximated to the upper one; outer terminal seta short, spine-like, in life set nearly at right angles to the others, spined or beaded on

one margin and bristled on the other; the next seta is as long as the abdomen, being somewhat exceeded by the following one; inner seta as long as the outer, but feeble; upper seta nearly as long, approximated; length less than 1 mm.

A well marked variety of the above occurs in America, which might rank as a species, were it not probable that it is simply a post-imago form occurring only under favoring circumstances. This variety has no connection with Brady's var. *montanus*.

***Cyclops serrulatus*, var. *elegans*. (Var. n.)**

Distinguished from the type by the greater size, and the elongation of antennæ and caudal stylets. We will first of all give the measurements which afford a criterion for judging of the form and proportions.

Total length 1.34 mm.; thorax 0.76 mm.; abdomen 0.40 mm.; stylets 0.18 mm.; greatest width 0.42 mm.; inner median caudal seta 0.60 mm.; outer median seta 0.36 mm.; inner seta 0.08 mm. The first segment of the thorax is long proportionally (0.40 mm.) The antennæ are very long, reaching to the base of the third segment (.68 mm.). The egg-sacs are elongate-oval, being more slender even than in typical *C. serrulatus*; in the animal measured they were 0.50 mm. long, by 0.19 mm. wide. The caudal stylets are slightly shorter than the last two segments of the abdomen. The antennules are very short, and each joint has its series of fine teeth. The free lower margins of the thorax are ornamented with series of prominences, while the last segment is extended into a blunt angle bearing long teeth. The last segment of the abdomen is spiny-margined and is ornamented with a double row of spines at the anus. The armature of the stylets as well as that of the feet is identical with that in typical *C. serrulatus*. The last two joints of the antennæ measure 0.1 mm. each, while the two previous measure unitedly 0.12 mm. The color is not opaque as in the smaller form usually, Brady's var. *montanus* has shorter stylets than the type, but seems nearest the small dark form found in peaty waters in America. *Cyclops pectinifer*, Cragin, has no distinctive points, it being typical *C. serrulatus*.

Sp. 25. *Cyclops macrurus*, Sars.

Cyclops macrurus, BRADY.

Closely allied with *C. serrulatus*. Cephalothorax ovate, rounded

anteriorly; last segment fringed at the angles with numerous fine hairs. Antennæ much shorter than in *C. serrulatus*, about as long as the first thoracic segment, otherwise similar. Abdomen attenuated, penultimate segment margined posteriorly with spine-like setæ, the other segments pectinated. Caudal stylets very long and slender, about equal in length to the three segments preceding, bearing a group of four to five spines on the outside near the end, otherwise unarmed. Length 1.3 mm.

Here is the natural place for *C. spinulosus*, of Claus, but there is strong reason to suspect the validity of the species so very imperfectly characterized.

Sp. 26. *Cyclops fluviatilis*, Herrick.

(Plate Q⁵. Figs. 1—9.)

Cyclops magnoctavus, CRAGIN.

This small species with twelve-jointed antennæ and conspicuous coloration is widely distributed through the Mississippi valley. The original description is appended.

“Body elongated; thorax very long; abdomen slender; stylets about as long or longer than last abdominal segment; setæ all very short, not [always] pectinate; lateral and dorsal setæ very small; outer one spine-like, short and stout; two median setæ short; inner one very small and inconspicuous; antennæ reaching nearly to the base of abdomen [or beyond]; formula $-\simeq\cup-\simeq-----$; the three joints following the six basal are much elongated, while the terminal ones are but moderately so, a character which is peculiar to this species; terminal segment slightly but evidently hinged and, together with pair preceding, somewhat curved; feet with the terminal spines strongly toothed; fifth foot very small, one-jointed, bearing three small setæ; operculum vulvæ heart-shaped; egg-sacs sub-quadrangular; eggs large; abdomen in the young much elongated. Color deep indigo. Length 0.7 mm.”

The first foot has upon the last joint of outer ramus three external spines, two apical setæ and three internal setæ; the outer branch of fourth foot has three external spines, apically a spine and seta and internally four setæ.

Males of this species are slender, measuring about 0.75 mm.; the abdomen being 0.28 mm., stylets 0.6 mm., first thoracic segment 0.28 mm., and the longest caudal seta 0.24 mm. The antennæ are long and much modified so as to resemble superficially the antennæ of *Diaptomus*.

Antennæ 11-jointed.

Sp. 27. *Cyclops diaphanus*, Fischer.

(Plate R. Fig. 12.)

? *Cyclops bicolor*, SARS.? *Cyclops minutus*, CLAUS, HELLER.

If not the young of other species, this is a widely distributed form, being known from Russia, Norway, continental Europe, Madeira, and America. The synonyms above given are upon the authority of Rehberg.

The following description applies to our American form found always in connection with *C. thomasi*, *C. parvus*, or *C. navus*.

Very small, measuring 0.81 mm., setæ not included. The thorax is 0.5 mm., the abdomen .31 mm., the stylets .06 mm., the longest caudal seta 0.4 mm., outer median seta .36 mm., the first thoracic segment 0.3 mm., and the egg-sacs sometimes 0.4 mm. The thorax is oval, the first segment being quite large, as in larval cyclops. The antennæ rarely reach the end of the first segment and are either 11-jointed or obscurely 12-jointed; their formula is $\text{---}\text{---}\text{---}\text{---}\text{---}\text{---}\text{---}\text{---}\text{---}\text{---}\text{---}\text{---}$. The first joint is very large.

The second antennæ are of rather small size; the maxillipeds are armed as in *C. navus*. The feet have usually but 2-jointed rami, but in large individuals some of the rami are obscurely 3-jointed. The first foot has the terminal joint of the outer ramus armed with three exterior spines, two terminal setæ and three interior setæ; the inner branch has one internal spine, a terminal spine and seta and three external setæ. The fourth foot has the terminal joint of the outer ramus with two external spines, a terminal spine and seta and four internal setæ; the inner ramus has one internal spine, two unequal spines and three internal setæ. There is also a series of teeth at the place where the middle joint should appear. The fifth foot consists of a broad, basal segment nearly fused with the abdomen and bearing laterally a long spine; the terminal segment is terete and small, having a single terminal spine. The caudal stylets are but little longer than the last abdominal segment, which bears teeth below; the sides are parallel, and the lateral seta is $\frac{2}{3}$ from base. The median setæ are long and toward the end show false jointing. The inner seta is longer than the outer which is, however, heavier. Eggs eight to twenty, in narrow elongate sacs. Not uncommon, everywhere.

Sp. 28. *Cyclops phaleratus*, Koch.

(Plate R. Figs. 6—10.)

(var. a.)

C. canthocarpoides, FISCHER, CLAUS, LUBBOCK, FRIC.*C. phaleratus*, KOCH, SARS, ULJANIN, BRADY, REHBERG.

(var. b.)

C. affinis, SARS.*C. pygmæus*, REHBERG.*C. adolescens*, HERRICK. (= *C. perarmatus*, CRAGIN.)? *C. lascivus*, POGGENPOL.

That the two varieties here united are very closely allied must be admitted; that they are merely age forms is possible. Claus in figure 2 of his plate II (Freilebenden Copepoden) figures some other species than the one described as *C. canthocarpoides*, as can be gathered from the elongated stylets and the eight-jointed antennæ. Our Minnesota specimens combine the eleven-jointed antennæ of *C. affinis* with the short stylets and peculiar form of the fifth feet of the first mentioned. Rarely one is found with ten-jointed antennæ and at the same time sexually mature. The characteristic oblique lines of spines at the base of the stylets may be absent. Rehberg's figures of *C. pygmæus* agree very well with our species, but he has decided that it is not specifically distinct from *C. affinis*.

It appears to me undesirable to institute a new species for the American form, neither is it possible to sufficiently identify it with any of the above.

I here append a brief description of *Cyclops adolescens*, Herrick (= *C. perarmatus*, Cragin,) for comparison with the description of *C. affinis* as transcribed below. Thorax oval, broad, acute anteriorly; last segment large and separated by a constriction from the anterior ones. The head is beaked below; first throacic segment large and long (.36 mm.): last thoracic segment wide, united closely with the first abdominal segment, armed with series of teeth. Abdomen short, especially the last segment, which is toothed behind; stylets very short. The antennæ are much shorter than the first segment, eleven-jointed. The maxillipeds are very small. All the feet are armed with a row of very large teeth or lanceolate spines down one side; fifth foot one-jointed, with three spines, the outer being smooth, the others spiny; egg-sacs variable, narrow, appressed; eggs large, color usually dark. The animal moves like *Canthocamptus*, and is able to progress out of water better than other species. The following measurements will give an idea of the proportions: Length 1.26 mm.; thorax, 0.76

mm.; abdomen, 0.44 mm.; stylets, .06 mm.; longest seta, 0.34 mm.; antennæ, 0.28 mm.; width of thorax, 0.44 mm.

Cyclops affinis, Sars.

"Antecedenti [*C. phalerato*] simillimus. Corpus autem minus robustum colore cœruleo vel potius glauco sat saturato insignæ. Segmentum ultimum thoracicum ad marginem posteriorem extrosim pilis vel spinulis subtilissimis pectenatim exornatum. Rami caudales quam in *C. phalerato* aliquanto longiores, setarum apicalium interna quam externa multo brevior, intermediarum interiore altera fere triplo longiore longitudinemque abdominis superante, in medio aculeata dein vero subtile ciliata. Antennæ 1-mi paris segmento 1-mo corporis multo breviores, tenues, articulis 11 compositæ. Pedes 5-ti paris distincti, uniarticulati, setis 3, quarum interior ceteris multo major et ciliata, instructi. Sacci oviferi parvi abdomini appressi. Longit. circit. $\frac{3}{4}$ mm."

Cyclops ornatus, Poggenpol (= *C. clausii*, Heller, fide Rehberg,) is almost certainly, in our judgment, a young or atavic condition.

C. helleri, Brady, though not identical, is no more worthy a specific name. If every form with eleven-jointed antennæ and egg-sacs be worthy a distinct name, it will be possible to duplicate all the seventeen-jointed forms. Fortunately, however, many species agree together in this condition, so that the number of spurious species derived from this source is rather small; among these is to be reckoned *C. nanus*, Sars, which is obviously very near the pulchellus group.

Antennæ 10-jointed.

No valid species have permanently 10-jointed antennæ. *C. phaleratus* is frequently found with 10-jointed antennæ. *C. kaufmanni* is without much doubt an immature form.

Antennæ 8-jointed.

• **Sp. 29. *Cyclops fimbriatus*, Fischer (fide Rehberg.)**

(Plate R. Fig. 11.)

C. crassicornis, Sars, Brady, Herrick.

C. greideri, Heller.

C. pauper, Fric.

C. poppei, Rehberg.

(? *C. magniceps*, Lilljeborg.)

Our American species corresponds to that described by Rehberg as a new species. The differences mentioned in the previous report (see Cyclopidæ of Minnesota, p. 233) are just those which have led Rehberg to establish the *C. poppei*, which, by the way, was

found with the type. I see no reason, especially in view of the latter fact, to regard it as even a well marked variety.

C. crassicornis is widely distributed in America as well as Europe, but is never very common. The color is always reddish.

Antennæ 6-jointed.

Sp 30. *Cyclops æquoreus*, Fischer.

A brackish-water species, .85 mm. long, which in a number of characters departs from the type of the genus. Those who have the opportunity to search the brackish pools along our coast would do science a service by looking for this interesting species.

NOTE.—*Cyclops navicularis*, Say, is perhaps *C. viridis* of this report. *C. setosus*, Haldeman, (Phila. Acad. Sci., Vol. VIII, p. 331) is referred in my notes to *C. serrulatus*, I do not now know with how much reason.

The reader is referred also to *Cyclops latissimus*, Poggenpol, as quoted by Cragin, which, although belonging to the section having seventeen-jointed antennæ, and having feet like *C. tenuicornis*, is said to have a disc-like body, long-jointed antennules with no armature, and the basal joint of the abdomen very long.

Cyclops ornatus is quoted by Cragin, but we are left in doubt as to the number of segments in the antennæ, a point quite essential to the definition of species.

(See under *C. phaleratus*.)

Cyclops longicaudatus and *C. igneus* are thought to be simply prematurely gravid young of known species.

(See Cragin, l. c., (pp. 12—13.)

Cyclops fischeri of the same author agrees with *C. æquoreus* in having six-jointed antennæ, but in nothing else apparently. It is, if correctly described, a very remarkable form, with no setæ on the antennæ.

FAMILY HARPACTICIDÆ.

Numerically the largest of the families of the Copepoda, this group contains predominately marine and mostly minute animals, frequently of strange and grotesque form. A few of the marine forms, inhabiting the gulf of Mexico, are figured in the report of the Minnesota Academy of Sciences for 1881. Of the over thirty genera of the family less than a half dozen are not exclusively marine, and of these most are brackish-water residents. The genus *Bradya* contains blind copepods living in slime.

The name was proposed by Dana, but was dropped in the final report. Again revived by Claus, it is now in use by the best authors. The general form and structure closely resembles that of the Cyclopidæ. The following characters are the more important ones in distinguishing the family from the other families of the order:

Body flattened or sub-cylindrical. Abdomen usually not much smaller than the thorax, from which it is not separated by a sudden constriction; antennæ rather short, 4- to 10-jointed; mandibles strongly toothed, palpate; maxillæ well developed, palpate; first pair of maxillipedes with strong teeth at the end, second pair usually forming a claw. The first pair of feet are often turned forward or prehensile; fifth pair one- or two-jointed, serving as egg supports in the female.

Most species live among sub-aquatic vegetation.

THE SUB-FAMILY CANTHOCAMPTINÆ,

to which our sole genus belongs, is further distinguished from the other sub-families of Harpacticidæ by the fact that the second maxilliped has a prehensile hook. The feet of first pair are not clawed, but have the inner branch elongated, and the palp of the mandible is one-branched.

GENUS CANTHOCAMPTUS, Westwood.

These little animals may be secured in considerable numbers by gathering a supply of water from among weeds in shallow ponds, and permitting the debris to settle in a spot where light only touches the jar from one side, when the *Canthocampti* congregate on the exposed side.

Canthocamptus is an elongated animal, with the body divided rather obscurely into two portions, of which the first, or anterior portion, is largest. This part of the body has five segments, each of which has at least one pair of appendages. The first, consisting of the head proper with one of the somites of the body or thorax, as is discovered by observing that a pair of legs is attached to it, is the largest segment of the body.

As seen from above, it is triangular and extends in front into a short, stout beak or snout, like the rostrum of a cray-fish. Above the beak, in the center of the forehead, is the eye, consisting of pigment and two lenses, showing that we really have to do with two eyes confluent on the median line. This is the simplest form of a compound eye. The same method of compounding the eyes is exhibited in a more complicated manner by *Daphnia* and other Cladocera. On either side of the beak springs an antenna with six to nine joints of unequal size. The first three joints are profusely

covered with hairs. The fourth joint is more slender than the preceding, and terminates in a process below, which bears besides a long hair a peculiar blunt bristle, that serves some unknown purpose—probably being sensory in function like the similar hairs on the antennæ of some Cladocera. The next joint is shorter than the rest, while the remaining three are spined at definite points. The antennæ of the male are curiously altered, or *geniculate*, on both sides, as in Cyclops. The three basal joints are shortened, while more or fewer of the following ones are coalescent, followed by a hinge joint and two elongated segments.

The second antennæ or antennules are two-jointed, and the basal joint has a two-jointed branch or palp; the terminal joint is covered with spines; at the end are longer and curved spines, jointed in the middle.

The mandible is a flattened plate with digitate teeth at the end, on one side of which springs a two-jointed palp, and from the other a blunt process. The maxilla is somewhat like it, but has rudiments of other elements.

The first pair of feet have two three-jointed rami. The outer ramus is shorter and with the longer branch is directed forward. The fourth foot has the inner branch two-jointed. The inner branch of the third foot of the male is peculiarly modified to form a prehensile organ, as it is this foot which fastens the spermatophore to the female. The fifth feet are composed of two flat plates.

The second division of the body, the abdomen, consists of five segments, of which, however, the first two are united in the female. The last segment of the abdomen bears two stylets, which are sometimes considered as together constituting an additional segment. Each of these stylets has, with several small spines, two elongated caudal setæ, one of which is usually as long or longer than the entire abdomen. The stylets are usually considerably longer than wide, but the proportions vary somewhat in different species.

Viscera. The body cavity is traversed by the alimentary canal, which is a straight tube with no lateral cæca or blind sacs, as in some other Copepoda. The canal is divided into four more or less distinct portions; the first section is a slender, muscular tube, extending from the mandibles nearly through the first segment, opening into the stomach proper, which is a muscular and glandular sac or tube, filling the greater part of the thorax; at the beginning of the abdomen, the sac is constricted and becomes the intestine proper; near the extremity again there is another change and the intestine loses its glandular character, and, by a peculiar

adaptation becomes a sort of force-pump, which, during life, is constantly pumping water in and out, serving as a means of respiration. This anal respiration is quite common among aquatic animals in this as well as other orders. This latter section of the canal is the rectum, and opens beneath a toothed anal plate, above and between the stylets. No special divarications or cæca are appended to the digestive tract, and the only other organ which is at all considered to belong to the alimentary system, is what is known as the "shell-gland," present in most crustacea, but till recently thought to be absent in *Canthocamptus*. It is a coiled tube found in the lower part of the first segment of the thorax. It is impossible to find this organ in *Canthocamptus*, in every case, it being very obscure; and its office is uncertain, though it is supposed, perhaps with little reason, to be hepatic in function.

There is no functional heart in this animal, but its place is taken by a peculiar apparatus, hitherto undescribed; this consists of a tube, surrounding the posterior portion of the alimentary canal. This sac around a sac is open in front, and serves by a double mechanism the office of a pulsating heart, though in a very imperfect manner.

There are no true hæmatic or lymph corpuscles in this animal; so far, at least, none have been discovered. The place of these blood corpuscles is taken by globules of yellowish or red color of the most diverse size. These nutritive globules, or fat globules, as they have been called, are undoubtedly reservoirs of nutriment in a shape convenient for the animal's use, and equally certainly are derived from the contents of the intestine. In those Copepoda which have a functional heart, it is open anteriorly into a general body-cavity in the same way as in this animal. That a portion of the vascular system should surround the alimentary canal, is no unexampled thing, for in *Daphnia* a large sinus embraces a portion of the canal. The same provision as this described in *Canthocamptus* occurs in the Cyclopidæ. The nutritive globules are often very large, and are frequently extremely abundant, especially in females soon to become gravid. Three-hundredths mm. is not a large measurement for the diameter of such drops.

The nervous system is very hard to trace, consisting of a large pear-shaped ganglion just below the eye, from which extend commissures around the œsophagus, connecting them with the ventral ganglia lying between the bases of the feet. The senses are not apparently well developed, for, excepting the eyes, we cannot locate with certainty the organs of any sense. There are,

however, two spots which are evidently devoted to special sense: first, the processes on the fourth joint of the antennæ, which may be simply the seats of tactile sense, or may have nerves suitable for perceiving chemical stimuli; second, the area on the forehead bordered by a raised line and covered with little pits, each with a small bristle. The character of this organ can be but conjectured; it may be homologized with the frontal nervous organs of the Cladocera.

The sexual organs are quite extensively developed, and periodical-ly obscure the remaining viscera. In the male the simple testis is situated in the second segment, and the single vas deferens after numerous windings through nearly the entire length of the body, opens at the base of the first abdominal segment under a spined plate. A part of the vas deferens is of a glandular character and secretes an elongate tube, the *spermatophore*, which serves to contain the spermatozoids, and is fastened by the male at the opening of the median pore of the female; on contact with the water this tube, which is at first soft, contracts and presses the contents into the opening of the female organs. So long is the vas deferens that as many as three spermatophores are sometimes seen in the body at once. The spermatozoids are very small. The geniculated male antennæ are used in grasping the setæ on the tail of the female, and the curiously modified inner branch of the third foot of the male may assist in fastening the spermatophore upon her body. The ovary occupies the same position as the testes, and the two ducts are coiled in the body from end to end, opening in the median pore behind the fifth pair of feet. When the eggs are ready to be laid, they are forced out, carrying with them a film of the secretion of the lower, glandular portion of the ducts, which is of a collodion-like consistency, and which forms the enclosing sac. The young become fully developed sexually before they assume their final form, and it is not unusual to find ova-bearing females which are not only much smaller than the parent, but with considerable differences in the various organs.

This sort of heterogenesis is not uncommon among lower crustacea, for the young may differ much from the mother till after they have themselves produced young.

Four species have been recognized in America, of which one is certainly identical with a widely distributed European form, and a second is probably identical with an English species. *C. palustris*, Brady, seems to depart considerably from the norm of the genus and may prove a type of a marine genus. No true *Canthocamptus* is more than accidentally marine.

The ten species below enumerated are all that have fallen under the author's notice, though others may have been mentioned.

KEY TO THE GENUS CANTHOCAMPTUS,

Inner ramus of 4th foot:	2-jointed.	In. ram. of 1st foot	{	2-jointed. {	1 mm. long; basal joint of 5th foot small..... <i>C. gracilis</i> , Sars.
				0.5 mm. long; basal joint of 5th foot long. <i>C. brevipes</i> , Sars (?).	
	3-jointed.	{	Inner ramus of 2d foot 2-jointed.	{	Antennæ thick <i>C. crassus</i> , Sars.
					Antennæ slender. { <i>C. trispinosus</i> , ¹ Brady. <i>C. northumbicus</i> , Brady.
3-jointed.	{	Inner ramus of 2d foot 3-jointed.	{	Stylets rather long. <i>C. minutus</i> , Mueller.	
				Styl. short, oval, <i>C. illinoisensis</i> , Forbes	
3-jointed.	{	Male antenna normal			<i>C. hibernicus</i> , Brady.
		Male antenna reduced, hooked at the end			<i>C. ? palustris</i> , Brady.

Canthocamptus elegantulus, *C. mareoticus* and *C. horridus* are uncertain, probably referred to the wrong genus. *C. stromii*, Baird (= *Dactylopus stromii*), *C. rostratus*, Claus (= *Stenhelia ima*), *C. virescens*, *C. linearis*, and *C. roseus* of Dana, are marine Harpacticidæ of uncertain affinities. *C. minutus* of Claus is not sufficiently described, but appears to be the earlier condition of *C. minutus*, Mueller (*C. staphynalis*, Jurine).

Sp. 1. *Canthocamptus gracilis*, Sars,

Is elongated linear, with the abdominal segments smooth. Caudal stylets long and slender; external caudal seta about one-fourth the inner. All the feet with two-jointed inner rami; outer branch of fourth foot longer than the others, inflexed; basal process of fifth foot slightly expanded. Length 1 mm.

At Decatur, Alabama, was found a species of *Canthocamptus* which is different from any American species, and seems in many points nearest the above but, unfortunately, only a hasty sketch could be made at the time, and the notes are insufficient to define it. The form is not remarkably slender; the first and second abdominal segments are very large. The caudal stylets are slender and elongated, the inner seta being very long and curved, while the outer is quite short. The anal plate is covered with hairs only. The antennæ are normal, of moderate length, and the fifth foot has but a narrow process at the base.

¹ Distinguished from the following by the presence of only three spines on the process of the basal joint of the fifth foot.

If this form be worthy a distinctive name, it may be called

Sp. 2. *Canthocamptus tenuicaudis*. (Sp. n.)

(Plate O. Figs. 15 and 16.)

? Sp. 3. *Canthocamptus brevipes*, Sars.

This small form is almost certainly the young stage of some other species; yet I transcribe the description.

"Corporis forma et magnitudine *C. pygmæo* non dissimilis. Segmenta abdominalia vero postice magis attenuata seriebusque aculeorum destituta. Rami caudales elongati duplo longiores quam latiores, setis apicalibus brevisculis parumque divergentibus, exteriori dimidiam longitudinem interioris non attingente. Operculum anale absque dentibus. Antennæ 1-mi paris breves, articulis ultimis duobus in unum confluentibus articulum. Pedes natatorii brevissimi, ramo exteriori intus setis destituto, interiore biarticulato in pedibus 1-mi paris longitudinem exterioris æquante, in sequentibus multo brevioribus. Pedum 5-ti paris articulus basalis intus in processum foliiformem, sat magnum et angustatum, articulum ultimum elongato-ovatum aliquanto superantem, exit. Color albidus. Longit. parum supra $\frac{1}{2}$ mm."

Sp. 4. *Canthocamptus crassus*, Sars.

Robust; segments margined with pectinate bristles. Caudal stylets oval, contorted, constricted at the base. Antennæ thick, densely covered with long setæ. Fifth feet with long setæ; basal process rather small. All the feet excepting the first, with bi-articulate inner rami. Length 0.75 mm.

Sp. 5. *Canthocamptus trispinosus*, Brady.

(Plate O. Figs. 6—14.)

This species with the last and next has all the feet save the first with bi-articulate inner rami. Very near the next, from which it differs in the form of the fifth foot of the female, which has the basal process smaller, bearing only three spines, while the next has six, the second joint being longer and narrow. The male is unknown. Not yet identified in America.

Sp. 6. *Canthocamptus northumbricus*, Brady.

Body robust; antennæ long as first segment, nine-jointed; mandibular palp minute. In the male the inner branch of the third foot is three-jointed and dactylate, as in *C. minutus*.

Canthocamptus northumbrius, var. americanus. (Var. n.)

(Plate O. Figs. 6—14, 20—22.)

One of our most common species is very near the English form, so near, in fact, that I dislike to remove it from it. A few points of divergence, however, may be mentioned.

The form and proportions are much like those of *C. minutus*. The head is large and ends in a prominent bent beak. The antennæ are rather long and slender and have a well marked flagellum. (Brady figures no flagellum). The palp of the antennule is as in *C. minutus*. The mandibular palp is small. The first pair of feet normal, rather small; all the other swimming feet with two-jointed inner rami, save in the case of the male third foot. The fifth feet are exactly as figured by Brady, save that there is a prominence or tooth of the basal segment near the point of attachment of the terminal joint which is quite long. The sensory area of the head is oval and pointed. The male antenna has a long flagellum, not, as figured by Brady, a very short one. The egg-sac is very large, oblong. The animal seems to fall short of the size of the English species, though measuring upwards of 0.65 mm. Our form is very well distinguished from any other species. It is found in lake Minnetonka, lake Calhoun, and elsewhere.

Sp. 7. Canthocamptus minutus, Mueller.*Monoculus staphylinus*, JURINE.*Canthocamptus minutus*, LILLJEBORG, BAIRD, SARS, ULJANIN, BRADY, HERRICK.*Canthocamptus staphylinus*, CLAUS, FRIC.*Canthocamptus minutus, var. occidentalis*, HERRICK.

A well known species which has been frequently described and seems quite circumpolar in its distribution.

First mentioned from America in a paper by the writer in 1878. A pretty full description will also be found in the author's *Types of Animal Life*. A very abundant species, frequent in muddy pools, but somewhat variable in abundance. It may frequently be found in great numbers in winter.

Sp. 8. Canthocamptus illinoisensis, Forbes.

(Plate O. Figs. 1—5.)

This robust and pretty species was first taken near Minneapolis, by Mr. A. W. Jones, a student of the University, who found it in a peaty ditch. Forbes' description is appended.

"Length 1 mm. Head and first segment united; five abdominal

segments in male, four in female. The suture between the first and second segments is not wholly obliterated above in the female.

Last abdominal segment is deeply and acutely emarginate. Branches of *furca* as wide as long, inner bristle plumose, a little longer than abdomen; outer plumose only on outer side, about half the length of the inner. The second to fifth *abdominal segments* have each a row of spinules along ventral portion of posterior,

Male with *anterior antennæ* composed of seven joints, the fourth joint very short. The front outer angle of the third is produced, the blunt process bearing three long bristles surrounding a slender olfactory club which is as long as the three following joints. The penultimate joint bears a strong spine or slender appressed process at the middle of its posterior margin. The five outer joints constitute the grasping organ. The *posterior antennæ* bear five long bristles at tip, three of which are made prehensile by the occurrence of from eight to twelve short articulations in the middle of the hair, allowing it to be bent forward. At the base of these articulations on the outer bristle, are two short spinules. Two nearly longitudinal rows of five or six strong, short spines each appear on the under surface of the outer joint of the antennule. The secondary flagellum, borne as usual on the middle of the basal joint, is not articulated, and bears four long bristles, two terminal and two on distal half of inner side. The outline of the *mandible* is exactly like that figured by Claus, but it bears about ten teeth, the upper thick and blunt, the inner sharp, slender and longer. Several are notched at tip. The lower angle bears a long simple bristle. *Mandibular palpus* two-jointed, second joint with three long terminal hairs and a shorter spine attached at basal third of anterior margin, jointed at base and directed towards tip, like a dactyl. The *maxilla* and *maxillary palpus* are scarcely to be distinguished from those of *C. staphylinus*.

The first maxillipeds are three-lobed, the outer lobe constituting a long, strong claw. The second and third are about one-third as long as the first, and bear each one strong simple spine and one weak branched hair. The inner lobe is widest, about two-thirds as wide as long. The dactyl of the *posterior maxilliped* is spinous on its inner edge, and the same edge of the hand is ciliate and bears a short, stout, sparingly plumose bristle at its base, just beyond the tip of the closed dactyl. The width of this joint (the second) is nearly half its length.

Basal joint of inner ramus of *first pair of legs* nearly or quite as long as outer ramus, the second wider but only half as long as the

third, and obliquely truncate. Inner ramus of *third pair of legs* in male is three-jointed, [the outer two-jointed,]* chelate. The finger is ovate, truncate, terminating in two long plumose hairs. The dactyl is linear, curved at base, and twice as long as finger. The inner ramus of the *fourth pair of legs* is about half as long as outer, two-jointed, basal joint short, terminal joint about as long as middle joint of outer ramus. The *fifth pair of legs* is best developed in the female. In the male the length is not over one-third the width. The basal portion bears three plumose hairs on its very broadly rounded anterior margin, of which the innermost is longest. The outer plate is nearly orbicular and bears five spines on its terminal margin, of which the second from the internal angle is the longest. *Genital plates*, found in male at posterior border of first abdominal segment, beneath, are short, slightly expanded internally, with internal angles rounded, and externally bear three sub-equal bristles, jointed at base, the inner largest and strongest and semi-plumose. The *antennæ* of the female are eight-jointed, extending backward to the first free segment. The basal joint of the *fifth pair of legs* is sub-elliptical in outline, with the basal half produced externally into a broad, triangular process which bears the second joint on its posterior margin. The free end of the basal joint bears six large plumose bristles of which the inner is longest. The greatest width of the joint is nearly equal to its greatest length. The second or outer joint is ovate, sub-truncate, spined on each margin, and bears four plumose bristles at tip and one at the middle of its outer margin. Its length is about twice its breadth."

Sp. 9. *Canthocamptus hibernicus*, Brady.

A small species differing from all others save the next in having a three-jointed inner ramus of the fourth foot.

"Anterior antennæ of the female slender, 8-jointed, about as long as the first body segment, and much like that of *C. minutus*. Inner branch of the second antenna very small, 1-jointed. Posterior foot-jaw having a broad hand armed with a long apical claw. Inner branch of the first pair of feet scarcely twice as long as the outer; first joint longer than the entire outer branch, and nearly twice as long as the united second and third joints, both of which are extremely small. Inner branches of the second, third and fourth pairs shorter than the outer, and 3-jointed, the first joint

* Evidently a misprint, for it is the inner ramus which is chelate.

being very small. Inner segment of the basal joint of the fifth pair of feet in the *female* elongated, fringed, bearing two long and three short apical setæ; second or outer joint sub-ovate, finely fringed internally; externally bearing six long marginal setæ. In the *male* the limb is smaller, the basal joint short, broad and having six short setæ of equal length; second joint nearly like that of the female. Caudal segments somewhat longer than broad; inner seta about twice as long as the outer; anal operculum denticulate. Length .65 mm." Not found in America.

Sp. 10. *Canthocamptus palustris*, Brady.

(Plate K. Fig. 5.)

A brackish-water species about .9 mm. long, found in a number of places in the British Isles. The species presents several anomalies.

The antennæ of the female are 8-jointed; those of the male robust, the last joint forming a hook. The first four pairs of feet have both branches 3-jointed; the fifth pair in the *female* are 2-jointed, with a short and broad basal joint, the second joint being sub-ovate, bearing five long apical setæ; in the male the fifth pair is obsolete, being reduced to a minute setiferous lobe. Caudal segments short, bearing two principal setæ, the outer half as long as the inner.

Sp. 11. *Canthocamptus minnesotensis*. (Sp. n.)

(Plate T. Figs. 1—6.)

Since the manuscript of this genus was finished, a small species has been found which seems undoubtedly distinct from any of the above. A single pair were taken in a gathering from Bassett's creek containing *C. minutus* in abundance. Unfortunately the characters of the swimming feet are not certainly known, but they were apparently all three jointed save the last. The antennæ are very short and thick, 8-jointed, with a long flagellum; the antennules are of the usual form, and the mouth parts rather large. The first pair of feet have the two rami of nearly equal length. The form is moderately elongate. The caudal stylets are very short, quadrate in outline and well armed with spines. The fifth foot of the female has four long and two short spines on the inner lamina, and the terminal joint has five unequal spines. In the male the fifth foot has two spines on the lamina and six on the second joint.

one being a small bristle. The male antenna is of peculiar form. The teeth of the anal plate are large and emarginate (see fig. 4.)

The swimming feet are all armed with very strong spines, aside from the usual quota of spines at the end of each joint. Length .65 mm.

NOTE.—*C. frontinalis*, Rehberg. This author seems to have parted with his usual acumen in the remarks upon this species. After describing a *Canthocamptus* with the inner ramus of the first foot "reichlich doppelt so lang wie die beiden Grundglieder des Aussennasts," he draws a moral on the mutability of genera from the fact that Brady founded the genus *Attheyella* "auf grund der Einglieder des innenastes am fierten Fusspaare und einer derartigen Bildung des ersten Fusses, wie er bei *C. frontinalis* beschreiben ist." Brady says (Brit. Copepoda, p. 58): "inner branch of first pair of feet scarcely at all elongated, and either 2- or 3-jointed," etc. The distinctive characters being the 1- or 2-jointed 2d and 3d feet and the 1-jointed inner ramus of the fourth foot, it is doubtful if *C. frontinalis* is really new.

II. GENUS ATTHEYELLA, Brady.

This genus, the diagnostic characters of which have been above indicated, contains three nominal species. It is quite difficult to say what differences exist between Sars' "*Canthocamptus*" *pygmæus* and *Attheyella spinosa*. Brady did not seem to recognize the fact that his diagnosis included that species. The third species is the blind *A. cyrptorum*, of Brady, which it is interesting to compare with the blind *Bradya limicola* of the coast of the gulf of Mexico.

PÆCILOSTOMATA.

This group, consisting of animals more or less like *Cyclops* in appearance, but, during part of their existence, semi-parasitic, has been very little studied in America. Most of the fresh-water species inhabit the gill-cavities of fishes. The gills of fishes should always be examined (if practicable, microscopically) for these interesting animals.

The mouth parts are greatly reduced and their homologies uncertain.

GENUS ERGASILUS, Nordmann.

Body shaped much as in *Cyclops*; anterior antennæ short; antennules in the female large, four-jointed, terminating in a strong claw. Mouth opening in the center of the very large head, which is not beaked in front. The mouth parts are inconspicuous, but the maxilliped is a stout organ terminating in a long claw. The three anterior pairs of feet are bi-ramose, and each ramus is three-

jointed; the outer ramus of the fourth foot is two-jointed; the fifth pair is absent or rudimentary. The abdomen is four or five-jointed, and the stylets are rather short. Ova-sacs two, large.

Ergasilus depressus, Sars.

(See Forhandlinger i Videnskabs-Selskabet, 1862.)

The form figured in plate S., fig. 1, is known from a gathering taken under the same circumstances as Sars' specimens, and consisted only of males. The animal is very transparent with deep blue markings below, especially between the bases of the feet. Sars thinks the males are always free, while the females early retire to the gill-cavities of fishes. This species may be distinct from the Norwegian form, but there is no reason for declaring that it is so.

E. depressus is probably the young of the widely distributed *E. sieboldii*.

NOTE.—As the systematic part of this work draws to a close, a note is received from Prof. Birge, who was so kind as to glance through advance sheets of the portion upon Cladocera. Prof. Birge informs me that his *Scapholeberis nasuta* is the same as *S. (Daphnia) aurita*, Fischer, as published in 1849 in the *Bull. Naturforsch. Gesellsch. in Moskau*, Bd. 22. This paper I have not seen. At Prof. Birge's suggestion, then, read on page 43.

Sp. 4. Scapholeberis aurita, Fischer.

Daphnia aurita, FISCHER.

Scapholeberis nasuta, BIRGE.

CHAPTER IV.

COLLECTING, PRESERVATION AND MISCELLANEOUS
NOTES.

The appliances employed in the capture and study of Entomostraca are, in the main, those employed by the student of aquatic vegetation. The first in order of importance is the hand-net and its accompaniment, long rubber boots, such as cover the entire leg being preferable. Thus equipped, the student can collect by far the greater number of fresh-water crustacea. The net is best made by obtaining an ordinary gaff or dipping net of extra strength but small size. If jointed, the ferrule must be unusually strong, not, indeed, because of the weight or activity of the prizes, but because it is often necessary to lift a net full of water, which is a greater strain than the strongest fish would produce in a net with open meshes. The ring of such a net is furnished with a medium-sized bag of some porous but still rather close fabric. The writer usually uses for this purpose the thinner variety of flour sacking. This material fulls a little when wet, and permits the water to pass rather too slowly, but this is a good fault. The net is used in shallow water and among weeds. After the net has been repeatedly filled and permitted to drain nearly empty, the bottom of the net is seized and the small remaining amount of water is thrown by a dexterous movement of the hand into a large-mouthed jar, several of which are needed. By this method the animals can be secured in any desired degree of concentration, so to speak, provided care is taken to avoid fouling the net with fine mud or debris. A single jar should usually contain only a gathering from a single locality. In case the collection is not to be examined at once, the gathering, which must now be quite free from admixture of mud and filth, is concentrated as much as possible,

and then poured into a thin filter-paper or a thin muslin bag. When nearly dry, the funnel is held over a small bottle, an opening is made in the apex of the filter, and the contents washed through with slightly dilute glycerine. Soon after pure glycerine is added so as to bring up the whole to the required degree of concentration. A sufficiency must be used to well cover up the whole. In case of haste the end of the filter containing the gathering may be torn off and placed at once in a bottle of glycerine or alcohol.

For the collection of Cypridæ it is recommended to use a very thin fine net, and gather as much as possible of the finely comminuted debris which settles in weedy pools. Spread this material in shallow pans and in an hour or so skim the surface with a small spoon-like hand-net, and transfer with the addition of clear water to shallow porcelain plates. Such gatherings may contain *Ilyocryptus*, *Monospilus*, the hook-nosed *Pleuroxids* (= *Percantha*) and, perhaps, also species of *Canthocamptus*.

The entomostraca of the larger lakes must be sought by a different method. A net of larger size, and composed of very thin material is drawn after a boat which is kept moving in different parts of the lake. Such a net should be so weighted as to receive water from the surface as well as from several inches below it. The net is emptied occasionally with plenty of water into large bottles, which may preferably be placed in the dark if to be unexamined for some time. Water kept in the dark will preserve its animal life for a much longer time than if exposed to the sunlight.

A similar net may be placed in a rapid stream in such a way that it remains partly full, but does not overflow. The accumulations of a day may be thus gathered into little space. The faucets of the city water will frequently afford a good supply of animal life, and unfortunately in Minneapolis a rather large number of forms are worms of a suspicious and unpleasant appearance. It must be observed that for this purpose the faucet must be well open so that a good current is secured, otherwise most of the impurities will be dropped on the way. A friend mentioned that very little life was found in the city water after long and careful experiment, during which, however, a very small stream was allowed to trickle through the complicated set of graduated screens. But the writer at the same time secured a rather large supply both of entomostraca and vegetable forms by simply permitting the water from the hydrant faucet to flow with full head through a muslin net.

But our methods are not yet exhausted. The dipping bottle

frequently brings up animals quite different from those collected by the towing net at the surface. This consists of a large bottle weighted by a suitable bit of lead or iron and fitted with a tight-fitting cork or wooden stopple. The stopple is attached to the line fastened at the neck of the bottle in such a way that a sudden twitch of the cord opens the bottle when it has sunk to the required depth. Another method, when one does not object to mingling forms from all depths, is to lower a net weighted with a heavy ring to the bottom, there agitating it slightly and drawing it vertically upward. This serves in a poor way in the place of a dredge and will secure a larger gathering than the dipping bottle, and is quite as easily rigged. The collections secured in either of the above ways are placed in large shallow porcelain plates and, the microscope being ready, the study may begin. With a rather large hand-magnifier, with which, however, the student will soon be able to dispense entirely, the various forms seen swimming or creeping or springing about are scanned, chiefly for the purpose of noting their motions. The little black, brown or yellow imps springing on the surface are rapidly skimmed off as hindrances, and (if the student is interested in the *Poduræ*) consigned to a bottle of spirits. Next a great *Belostoma*, *Corixa*, *Water-skater*, *Ranatra*, or *Dysticus* requires the same treatment. Perhaps a half dozen "whirligig-beetle" require more time to dispose of, and then a careful removal of the dragon-fly larvæ and "water-tigers" leaves the coast comparatively clear save for sand-fleas and dipterous larvæ which must be endured as necessary evils.

With a narrow slip of paper folded trough-wise the desired animal is captured by a quick movement and the water permitted to drain off, when the specimen is placed on the object-carrier, and a square cover glass, one corner of which has been armed with a bit of wax, is placed over the animal and then adjusted so as to give the requisite amount of pressure to quiet its restless motions. The slip of paper is, in every way, more convenient than a dipping tube and avoids flooding the object-carrier. With a half-inch objective and suitable eye-piece the whole animal is drawn in as natural a position as possible, either with the aid of a camera or free hand, by the assistance of careful measurements and a given scale. A one-fifth inch objective is now substituted and all possible details added. If any dissections are necessary, the cover glass may be removed, the slide placed upon a slip of black paper and the parts separated as far as possible by the aid of a watchmaker's glass or dissecting microscope.

Up to the present time almost the only reagent which could be employed for the instantaneous killing of Entomostraca with the body in its natural position and the preservation of the same was osmic acid, which partly on account of its expense, perhaps, seems rarely to find its way into our laboratories. And even this is but partially successful or causes such a dark color as to obscure what one most desires to see. The desideratum seems to have been supplied by the discovery of Prof. Hermann Fol that ferric perchloride produces not only an instantaneous death but a fixation of all the parts with very little coloration or shrinkage. The alcoholic solution is diluted to about 2 per cent. and applied to a small quantity of water in which the animal is swimming, or a more concentrate solution is added at once to the water of a vessel containing numerous Entomostraca. The water is poured off and the animals washed with alcohol of 70 per cent., to which a few drops of nitric acid may be added to remove the ferric salts. According to Fol, in transparent animals the appearance is very little changed by this process. Specimens thus prepared may be preserved in alcohol and afford preparations for making thin sections. They do not take color well, but may be stained with gallic acid without difficulty.

As a preservative, glycerine does admirably for Copepoda, but no known fluid works satisfactorily for the Cladocera unless after such treatment as above indicated. Sections may be made by imbedding in soap, but the tissues of the Cladocera are so delicate that the writer never succeeded in making permanent preparations of such sections. Either the alcohol or the balsam as it flows in almost inevitably disturbs the natural position. 50 grammes of soap are dissolved in 200 cu. cent. heated alcohol of 96 per cent. The soap should be shaved very thin. A shallow paper trough is prepared and filled with the still warm mixture, and the animal, which lies in concentrated alcohol, is transferred into the solution and agitated till its tissues are permeated with the soap. When cold, the bit of soap is cut into the required form and is ready to be placed in the microtome.

As a preservative medium for Copepoda, Carpenters' gelatine answers well. It consists of clarified gelatine, one ounce to six fluid drachms of pure glycerine. The preparations mounted in this require no cement, as the gelatine is quite firm when cold.

APPENDIX.

The previous pages refer to the fresh-water crustacea simply and will give a tolerable idea of the variety exhibited in the fauna of the lakes and rivers of America. The majority of Copepoda are marine and the coasts of the United States will afford the student of marine entomostraca a rich harvest of curious forms. These animals are now being investigated, it is understood, by competent naturalists. In the meanwhile any notes may be of a temporary interest. The following jottings, which are the result of a few days stay on Mississippi sound, will give an idea of the fauna of the gulf of Mexico. They are extracted from a paper offered the Minnesota Academy of Natural Sciences.

FAMILY CALANIDÆ.

GENUS PSEUDO-DIAPTOMUS. (Gen. n.)

Resembling *Metrida* and *Diaptomus*; compactly framed; cephalothorax 6-jointed, last two segments coalescent above; head rounded in front, beaked; eye small; antennæ appearing 22-jointed in both sexes, longer than the thorax; the right male antennæ geniculate as in *Diaptomus*; antennules bi-ramose, both rami rather short, inner one seeming but two- or three-jointed; mandible ten-toothed; maxillipedes well developed; feet all bi-ramose save the last, both rami 3-jointed; first feet smaller; fifth feet with inner ramus obsolescent, in the male nearly as in *Diaptomus*, in the female rather slender, simple, three-jointed; abdomen in the female 3-jointed, in the male 5-jointed; stylets in the female longer; ova-sac single; spermatophore pear-shaped.

This genus is of unusual interest on account of its close approach to the fresh-water section of the family.

The spermatophore in this genus is large and swollen and, as

seen through the body of the male, is liable to be mistaken for eggs.

Pseudo-diaptomus pelagicus. (Sp. n.)

Rather compact; thorax alike in the sexes, antennæ short, seeming 22-jointed; first foot small, both rami 3-jointed; fifth feet in the male with but small rudiments of the inner rami, basal portion heavily armed with short teeth, otherwise almost as in *Diaptomus*; fifth feet of female slender, alike; abdomen in male very slender, with short stylets armed with five terminal setæ and a series of bristles on the inner margins, distal margin of segments of abdomen toothed; a series of spines also ornaments the middle of the first segment below; abdomen of female short and very spiny, first joint thick, second slender, oblong, third joint short; length of abdomen supplemented by that of the elongated stylets, which are spinulous on their edges; ova-sac ovoid, eggs numerous; opening of operculum vulvæ with lateral projecting lips.

This species is ornamented with irregular markings of brownish color which give it a strange appearance not observed in any other copepod. The size is like *Temora velox*, which the female resembles a little, a resemblance enhanced by the elongated stylets. By some changes in the definitions of *Metrida* and *Pleuromma* these three genera could be united, but there would then be no valid excuse for not admitting *Diaptomus*, so that, on the whole, it may be well to let matters stand until we reach some better understanding of the natural generic affinities of these animals.

Habitat, Mississippi sound, gulf of Mexico.

GENUS DIAS, Lilljeborg.

Slender; cephalothorax very long, narrow in front; abdomen with five segments in the male, in the female with three; antennæ 20-jointed, nodose; secondary branch of antennules one-jointed, small; labrum large; posterior maxillipeds short; swimming feet with 2- and 3-jointed rami; fifth feet with a single ramus.

Dias longiremis, Lilljeborg ?

Unfortunately the gathering was insufficient to determine with certainty the identity of our species with the above, but the female agrees quite well; and those points in the young males seen

which could be compared with the descriptions of *D. longiremis* were sufficiently concordant. This species ranges, in the eastern hemisphere, from the North sea to the Mediterranean, and could be expected here. It is a very active animal and represents a well differentiated type.

GENUS TEMORA, Baird.

Elongate; thorax five-jointed, fourth and fifth segments closely combined; abdomen with four segments in the male, three in female; antennæ 24- or 25-jointed; right antenna of the male geniculate; mouth parts as in *Calanus*; inner branches of second, third and fourth pairs of feet two-jointed, of first one- or two-jointed; fifth feet with but one branch, prehensile in the male.

Temora affinis, Poppe.

= *T. gracilis*, HERRICK, MS.

The shallow bays and estuaries along the Gulf of Mexico swarm with a species of *Temora* but little unlike *T. velox*.

The body is much less compact, it being rather slender in both sexes; in like manner the caudal stylets are very much elongate, being nearly as long as in *T. longicornis* of Mueller, from which it is clearly distinguished by many obvious characters, and which seems to show an approach to *Metrida*.

The antennæ in male and female are just as in *T. velox*, and the fifth feet are little, if at all, dissimilar; the spine on the second joint in the female is not serrated, however, and the basal joint of the abdomen in this sex has three teeth on either side. The caudal stylets are about six times as long as broad in the female and densely spined, as is the last abdominal segment. The stylets are more slender in the male and have few spines, but the last abdominal segment has three larger spines on either side. Inner ramus of the first foot one-jointed. The animal is generally colorless, in autumn at least, but may be variously ornamented with prismatic colors, the most constant of which markings are a band about the stylets and across the thorax and between the bases of the feet. The ova are very numerous and carried as in *Diaptomus*. This species is littoral in habitat and ranges from salt-water bays to the fresh waters of rivers, along with several varieties of *Cyclops*, *Sida*, etc.

FAMILY HARPACTICIDÆ.

GENUS AMYONE, Claus.

Body much compressed; dorsal margin strongly curved; head very large, produced and angled below; antennæ 6- to 8-jointed; antennules palpate, 3-jointed; second maxillipeds long, chelate at the end; last thoracic and anterior abdominal segments enlarged; fifth feet leaf-like, large.

A very small crustacean, little over $\frac{1}{2}$ mm. long, occurs in the gulf of Mexico in shallow water among vegetation. Insufficient material prevented its complete study, but it is nearly allied to *A. spherica*, Claus, from which it differs in several particulars.

I can do no better than quote the remarks of Claus, the original discoverer of this peculiar genus.

"The body of this highly remarkable form, represents, in its general form, an intermediate stage between the nauplius (cyclops larvæ) and the mature copepods. The oval, almost spherical form, the slight development of the abdomen and the enlargement of the anterior thoracic segment recall the structure of the larva, while the almost complete segmentation of the body, the jointing of the antennæ and the swimming feet, as well as development of the reproductive organs, make the maturity of the creature certain." (Beitr. zur Kenntniss der Entomostraken.)

GENUS LAOPHONTE, Philippi.

Rather slender; antennæ 4-, 8-jointed; palp of antennules 1-jointed; mandibular palp 1- or 2-jointed; maxillæ palpate; first pair of feet slender, outer branch short, 3-jointed, inner branch elongated, 2-jointed; three following pairs with one ramus 3-, the other 2-jointed.

Laophonte similis, Claus?

The small crustacean which is referred to the above species occurs sparingly in the brackish waters of Mobile bay, and with *Temora* seems to be the only entomostracean not also found in the fresh waters adjacent.

From the few specimens found it could not be certainly determined that our species is identical with the European. The differences are, however, such as might be expected in immature speci-

mens. Brady figures a similar reduction in the number of joints of the antennæ as that seen in our specimens. The fifth foot too, is less well armed with spines, but otherwise the agreement is tolerably close.

GENUS HARPACTICUS, Milne-Edwards.

Elongate or expanded laterally; head united with the first thoracic segment; first and second abdominal segments coalescent; antennæ 8-, 9-jointed; mandibular-palp 2-branched, large; second pair of maxillipeds strongly developed; outer ramus of the first pair of feet 2- or 3-jointed, inner ramus 2-jointed; first and second joints of outer ramus elongated, second joint of inner ramus short; both rami of following pairs of feet 3-jointed; ova-sac single.

Harpacticus chelifer, Mueller. (var. n. ?)

The species inhabiting the gulf of Mexico resembles *H. gracilis*, Claus, in the length of the setæ and some other peculiarities; but the antennary palp is more like *H. chelifer*, with which it closely agrees in most respects. Remembering that the entomostraca have their highest development in temperate and arctic regions, the small size and greater proportional length of setæ and stylets may be explained. *H. gracilis* from the Mediterranean takes the place of the true *H. chelifer* of the North sea, and is regarded by Brady as the same species. Our form would, in this case, stand more nearly related to the typical form. Both branches of the first feet are two-jointed and the antennary palp has three spines on its distal segment.

GENUS BRADYA, Boeck. (1872.)

Antennæ very short, 6-, 7-jointed; antennules of moderate size longer than antennæ, with a 2- or 3-jointed palp; mandibular palp large; maxillipeds rather large, outer branch (first foot-jaw of Brady?) much as in *Calanidæ*; first four pairs of feet nearly alike; fifth pair small, not lamellate.

This peculiar genus is not yet well circumscribed and defined, and it is much to be regretted that lack of time prevented from ascertaining how far the western species agrees with the generic characters of the European form and thus determining the validity of the assumed generic criteria. That our species is a member of the genus can not be doubted, but the hurried examination which could be devoted to it failed to cover the entire structure.

Bradya limicola. (Sp. n.)

Body flattened; free margins of the segments of the dorsal carapace rather long; little separation between abdomen and thorax; abdomen cylindrical, rather long; stylets short; distal margin of the segments spined; antennæ very short, 6- or 7-jointed, hardly longer than the movable beak; second antennæ much longer, 3-jointed; palp long, two-jointed; mandibles palpate, teeth fine, much as in Calanidæ; palp bi-ramose, second ramus very small; maxillæ of moderate size; maxillipeds large, outer one as in Calanidæ; first four pairs of feet bi-ramose, each ramus 3-jointed; fifth foot small, with two terminal digitate processes and a seta on either side. The male is at least a third smaller and has longer caudal stylets; the antennæ are modified, but very short. *The eyes are wanting in both sexes.* This very interesting species was collected in the brackish water of a ditch shaded by high sedges so that the sun could hardly penetrate. I did not find any representative of the genus in the open waters neighboring, but it is hardly to be doubted that such exist. This species is quite distinct from *Bradya typica* of north Europe.

The only other blind copepod with which I am familiar is *Attheyella*, which is circumstanced somewhat as the above.

The European *B. typica* is pelagic; ours dwells in darkened ditches and seems to furnish another illustration of the effects of seclusion upon the visual organs. Brady seems to have transposed the maxillipeds; these are really but branches of the same organ, as shown by the development, and the outer ramus is, probably, what Brady usually calls second foot-jaw but here first foot-jaw. In the characters of the mouth parts and fifth feet our species seems to show an affinity with the elongated higher copepoda.

Ocean Springs, Mississippi.

Caligus americanus, Dana and Pickering ?

A species of *Caligus* was collected at dusk far out in Mississippi sound in considerable numbers. The animals were floating in a bank of vegetation and swam freely. They seem not to differ greatly from the species described by Dana and Pickering in 1838 from the cod near New York. The fish lice are remarkable for their flattened bodies and the paired sucking organs on the head.

A species of *Corycæus* allied to *C. varius* of Dana was also collected.

NOTE.—Prof. Forbes, to whom advance sheets of the portion on Copepoda were sent, writes me that he somewhat questions the identity of the Minnesota species of *Diaptomus* referred to *D. leptopus* with the species for which that name was proposed. I do not know of any facts casting doubt upon the reference, but wish to call the reader's attention to the suggestion of Prof. Forbes.

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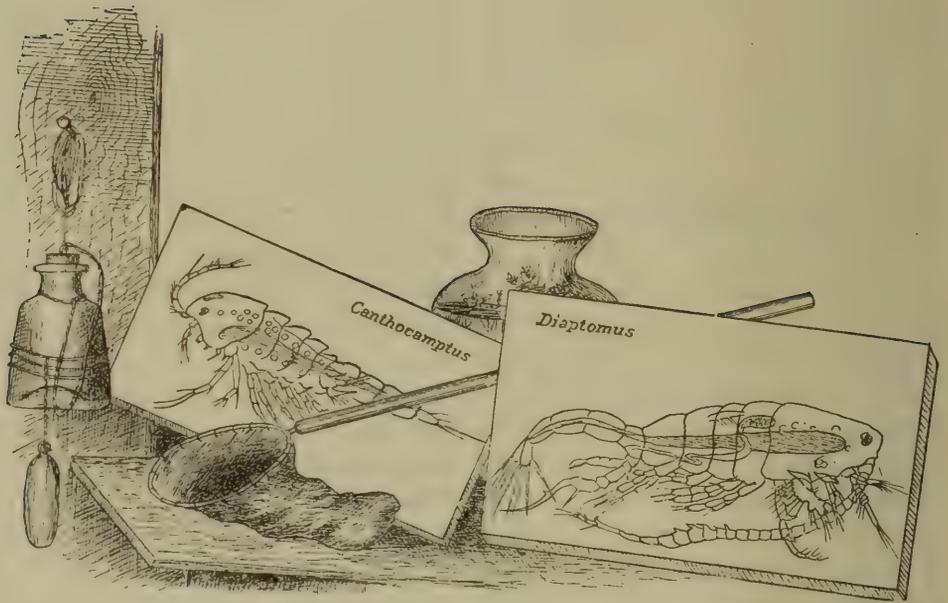
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PLATES OF PART V.

PLATE A.

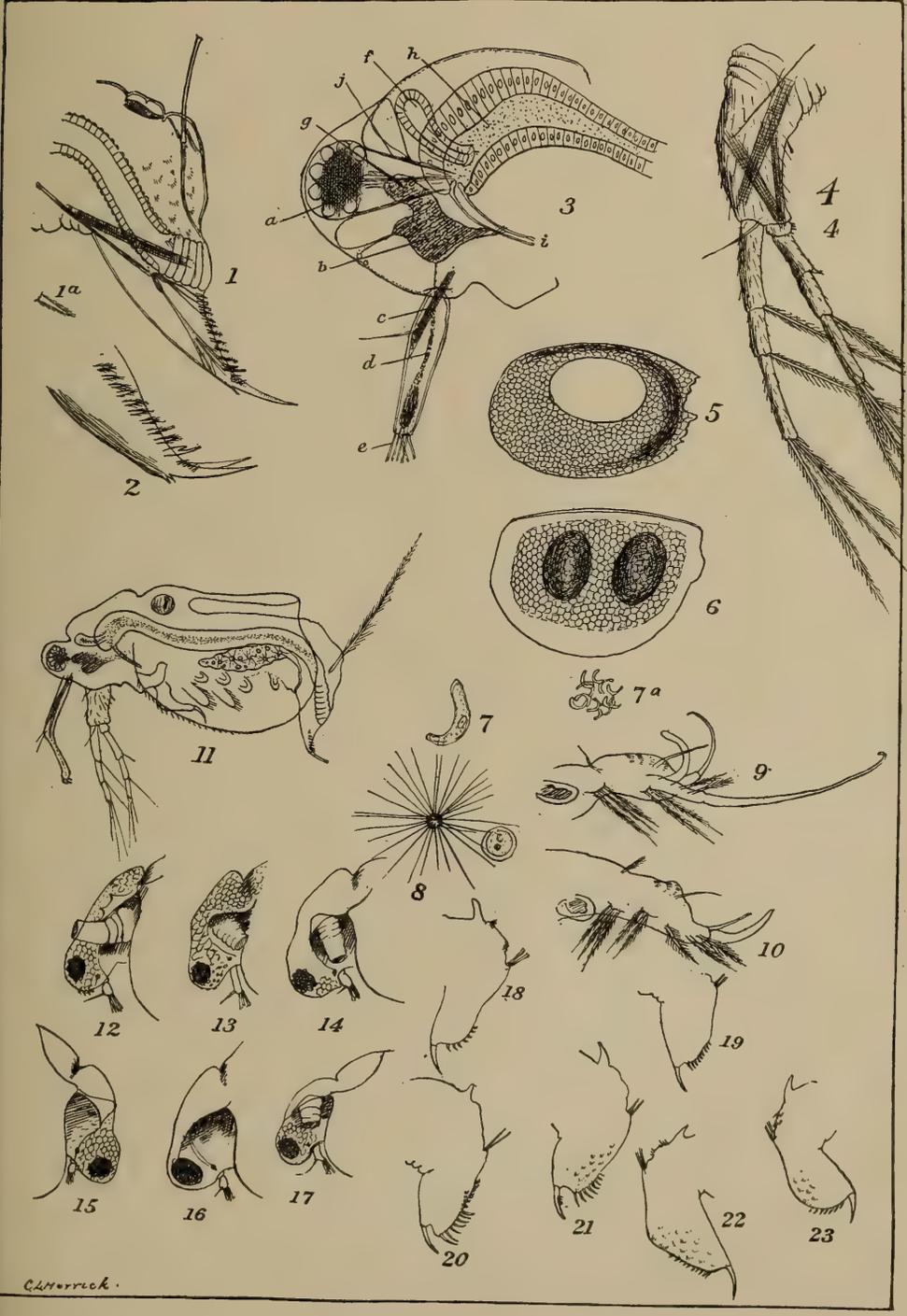
- Fig. 1. abdomen of *Moina paradoxa*, female, from Minnesota.
Fig. 1a. spine from post-abdomen.
Fig. 2. post-abdomen of *Moina rectirostris*.
Fig. 3. head of *M. paradoxa*, female, showing (a) eye with pigment and lenses, (b) supra-oesophageal ganglion, antennule with (c) its muscle, (d) its nerve, and (e) its terminal sensory filaments, (f) the cæcum of stomach, (g) optic ganglion, (h) stomach, (i) oesophagus, (j) the muscles which move the eye, also part of the labrum.
Fig. 4. antennæ of same.
Fig. 5. ephippium of *M. rectirostris*.
Fig. 6. " of *M. paradoxa*.
Fig. 7. seminal cell of *M. paradoxa*; 7a, a group less magnified.
Fig. 8. seminal cells of *M. rectirostris*.
Fig. 9. first foot of male of *M. paradoxa*.
Fig. 10. " " " " " *M. rectirostris* (from Weismann).
Fig. 11. male *M. rectirostris* (from Weismann).
Fig. 12. head of *Ceriodaphnia rotunda*. (This and the following numbers after P. E. Mueller.)
Fig. 13. head of *C. punctata*.
Fig. 14. " *C. pulchella*.
Fig. 15. " *C. reticulata*.
Fig. 16. " *C. quadrangula*.
Fig. 17. " *C. quadrangula*.
Fig. 18. post-abdomen of *C. quadrangula*.
Fig. 19. " *C. pulchella*.
Fig. 20. " *C. megops*.
Fig. 21. " *C. reticulata*.
Fig. 22. " *C. laticaudata*.
Fig. 23. " *C. rotunda*.

MINNESOTA CRUSTACEA.

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PLATE A.

Geol. & Nat. Hist. Sur. Minn.



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PLATE B.

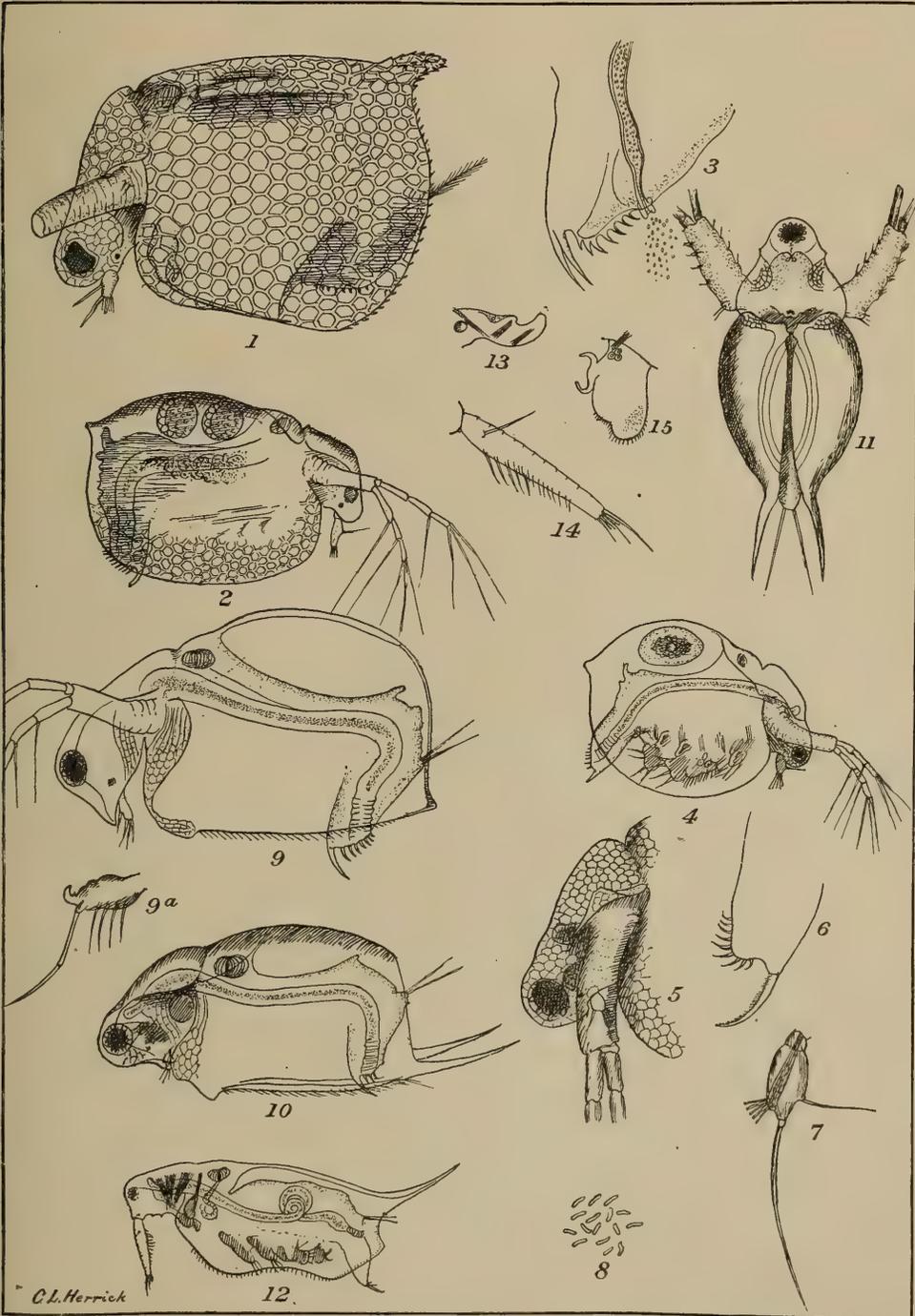
- Fig. 1. *Ceriodaphnia rotunda*, male (after Kurz).
Fig. 2. *C. alabamensis*, female.
Fig. 3. *C. reticulata*, post-abdomen of male with opening of vas deferens (after Weismann).
Fig. 4. *C. consors* ? ?
Fig. 5. *C. scitula*, head of female.
Fig. 6. do., post-abdomen.
Fig. 7. do., antennule of male.
Fig. 8. do., semen cell of male.
Fig. 9. *Scapholeberis angulata*, adult female; 9a. first foot.
Fig. 10. *Schapholeberis armata*, "
Fig. 11. do., view from below.
Fig. 12. *Lyncodaphnia macrothroides*, young.
Fig. 13. do., labrum.
Fig. 14. do., antennule.
Fig. 15. do., last foot, purple pigment in lower part.

MINNESOTA CRUSTACEA.

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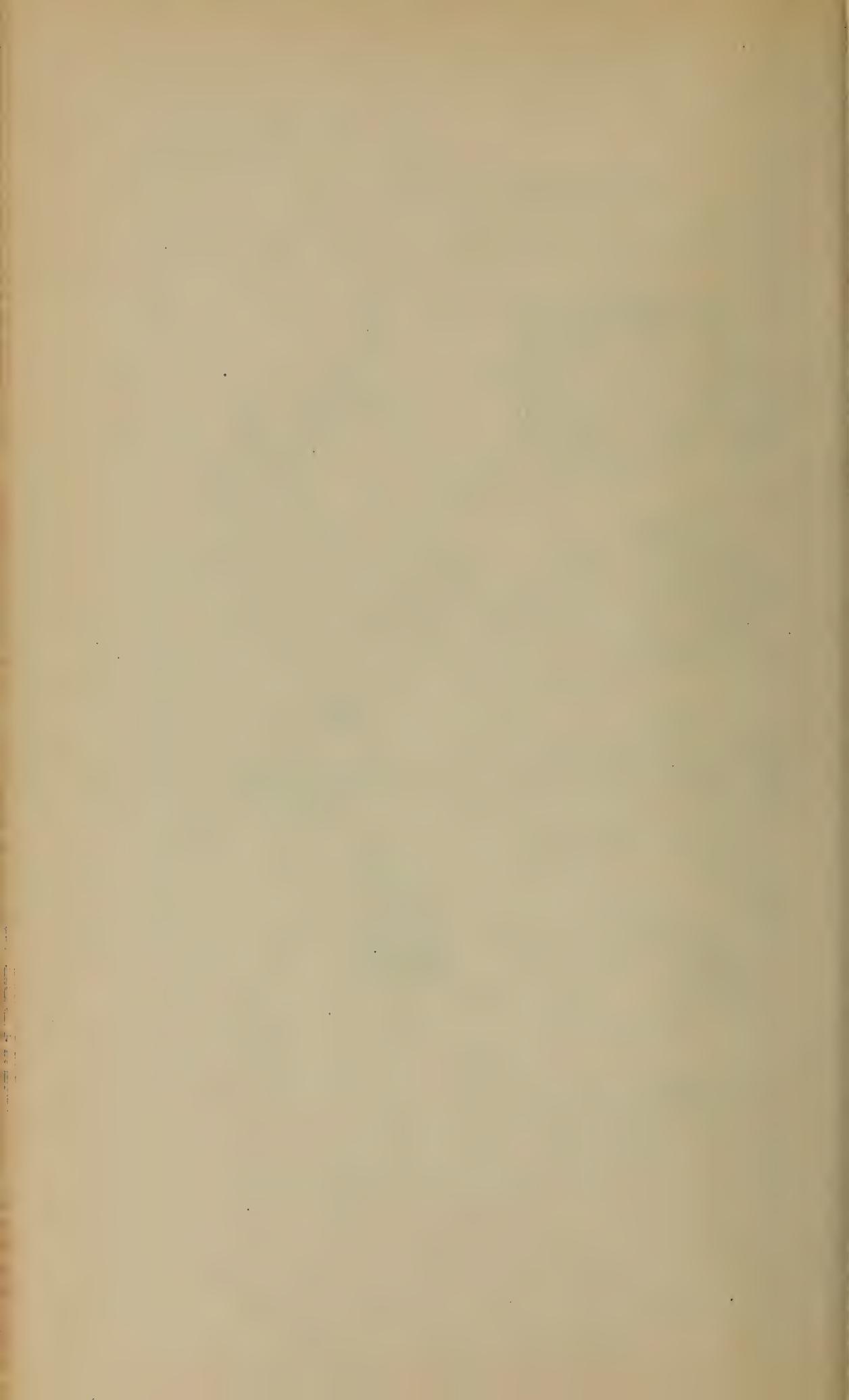
PLATE B.

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C.L. Herrick

12.



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PLATE B¹.

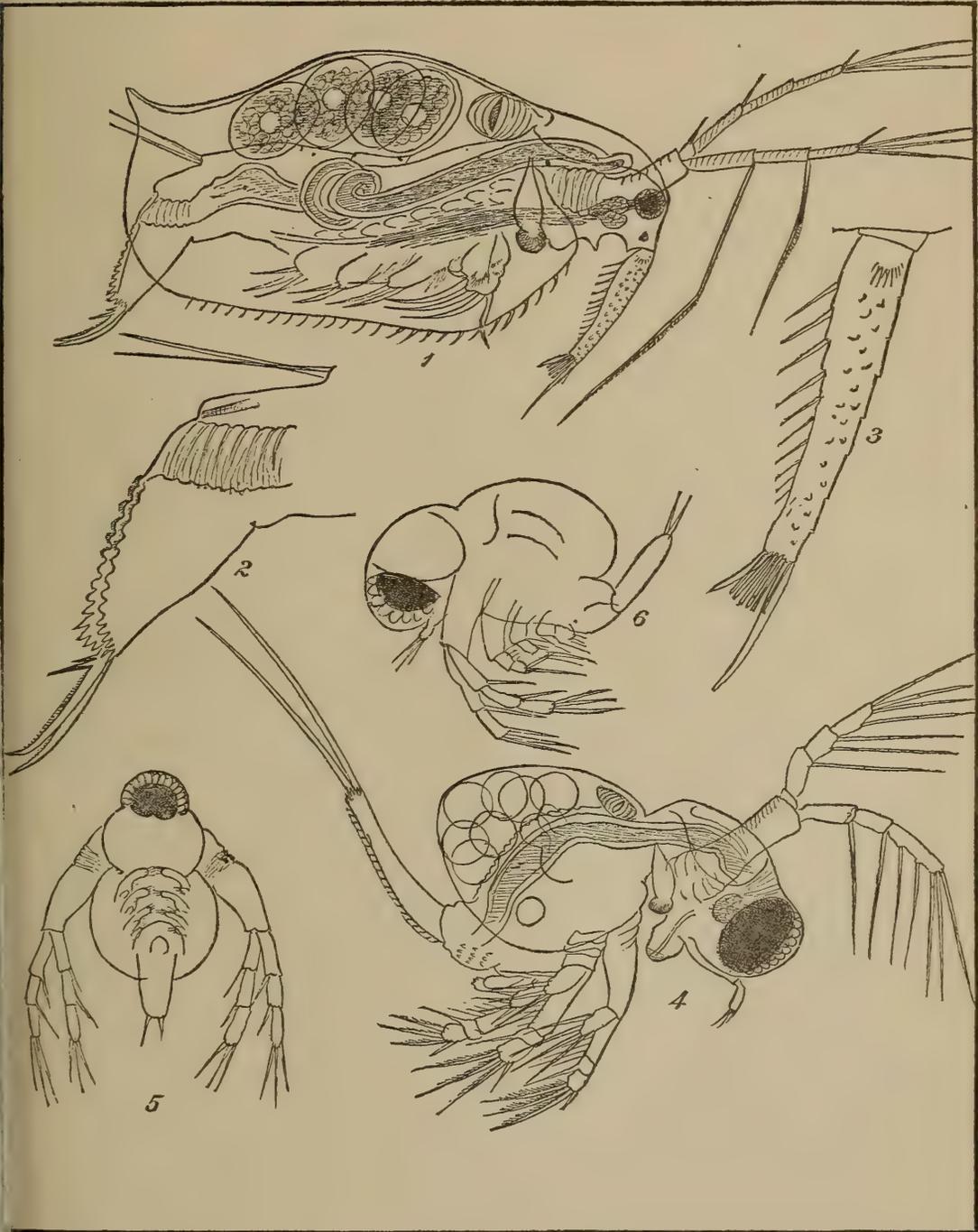
- Fig. 1. *Lyncodaphnia macrothroides* (= *Ofryoxus*?), adult female, showing coiled intestine, elevated anus, long antennules, elongated seta of second antennæ, anterior cæca, etc.
- Fig. 2. post-abdomen of the same.
- Fig. 3. antennule.
- Figs. 4--6. *Polyphemus pediculus*, young and adult females.

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PLATE B¹.

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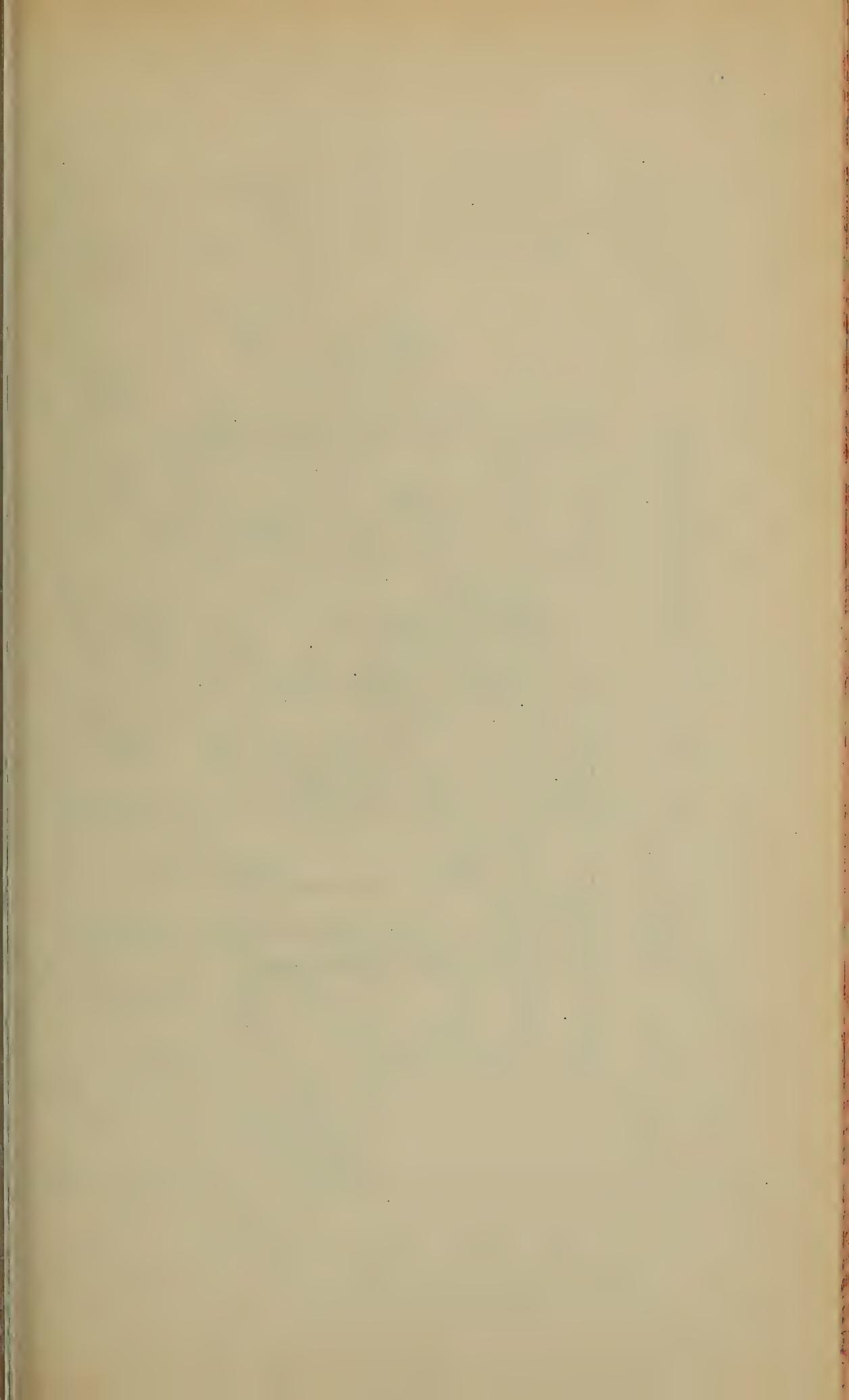
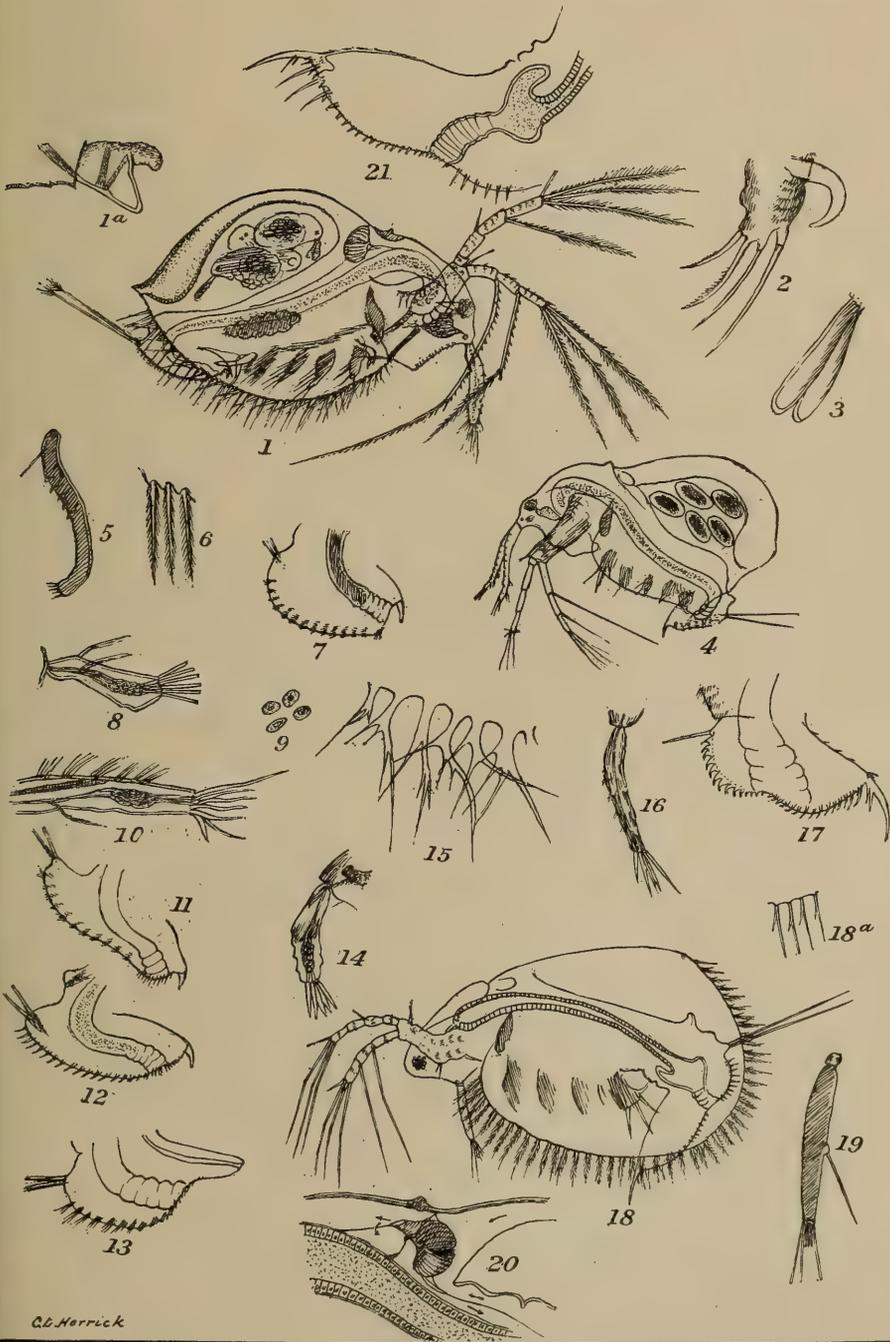


PLATE C.

- Fig. 1. *Macrothrix tenuicornis*, 1a. labrum.
Fig. 2. do., first foot.
Fig. 3. do., antennæ of young.
Fig. 4. *Macrothrix pauper*.
Fig. 5. *Macrothrix rosea*, antenna of male.
Fig. 6. do., spines of shell-margins.
Fig. 7. do., post-abdomen.
Fig. 8. *Macrothrix laticornis*, male.
Fig. 9. do., semen cells.
Fig. 10. *Pasithea rectirostris*, male antenna.
Fig. 11. *Macrothrix rosea*, post-abdomen.
Fig. 12. *Macrothrix tenuicornis*, "
Fig. 13. *Macrothrix rosea*, post-abdomen of male.
Fig. 14. *Drepanothrix dentata*, antenna.
Fig. 15. *Ilyocryptus sordidus*, marginal spines.
Fig. 16. do., antenna.
Fig. 17. do., post-abdomen.
Fig. 18. *Ilyocryptus spinifer*, 18a. marginal spines.
Fig. 19. do., antenna.
Fig. 20. *Macrothrix tenuicornis*, heart and accompanying vessels.
Fig. 21. *Ilyocryptus spinifer*, post-abdomen.

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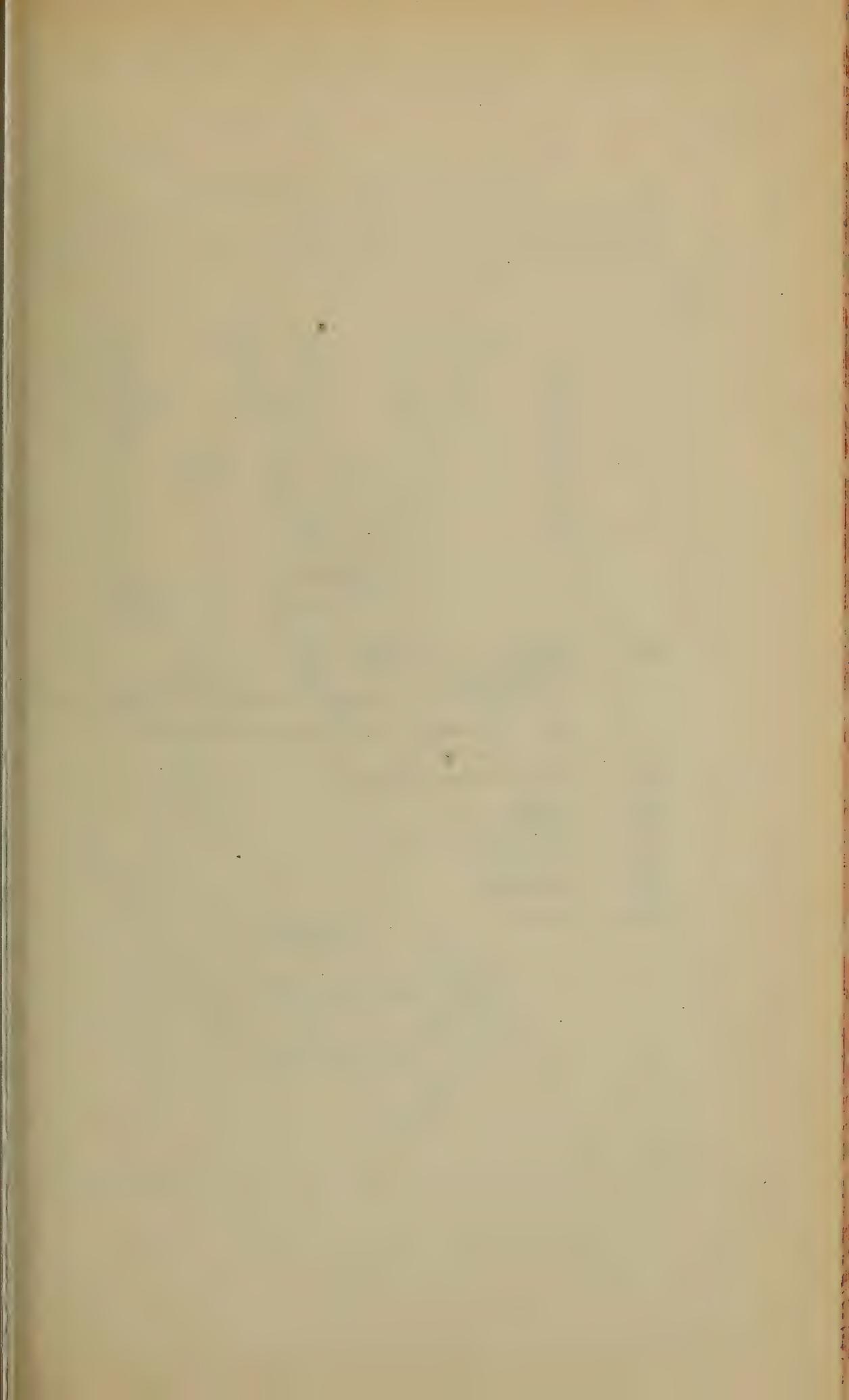


PLATE D.

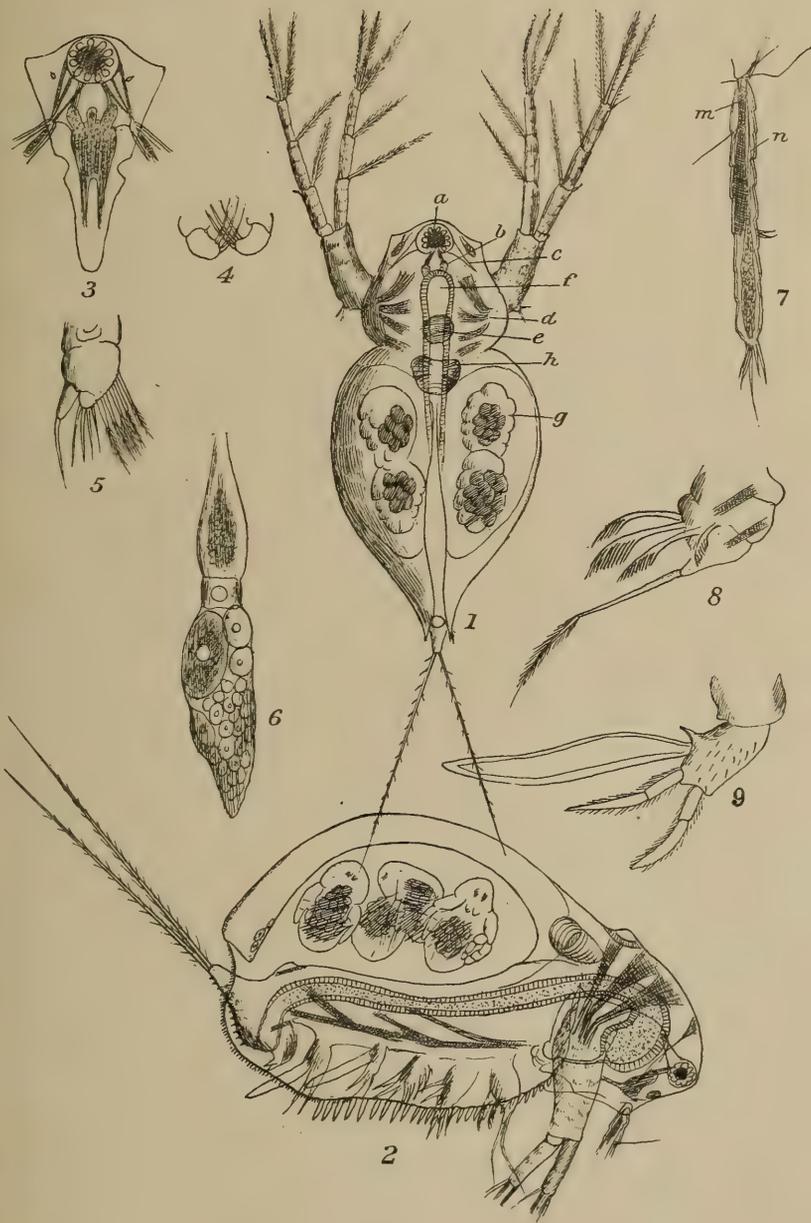
- Fig. 1. *Lathonura rectirostris*.
female, from above. a. eye. b. optic ganglion. c. muscles of eye. d. muscles of antenna. e. dorsal sucking disc. f. stomach. g. young in brood cavity.
- Fig. 2. female, from side.
- Fig. 3. head seen from below.
- Fig. 4. maxillæ.
- Fig. 5. first foot.
- Fig. 6. ovary.
- Fig. 7. antennule.
- Fig. 8. last foot.

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PLATE D.

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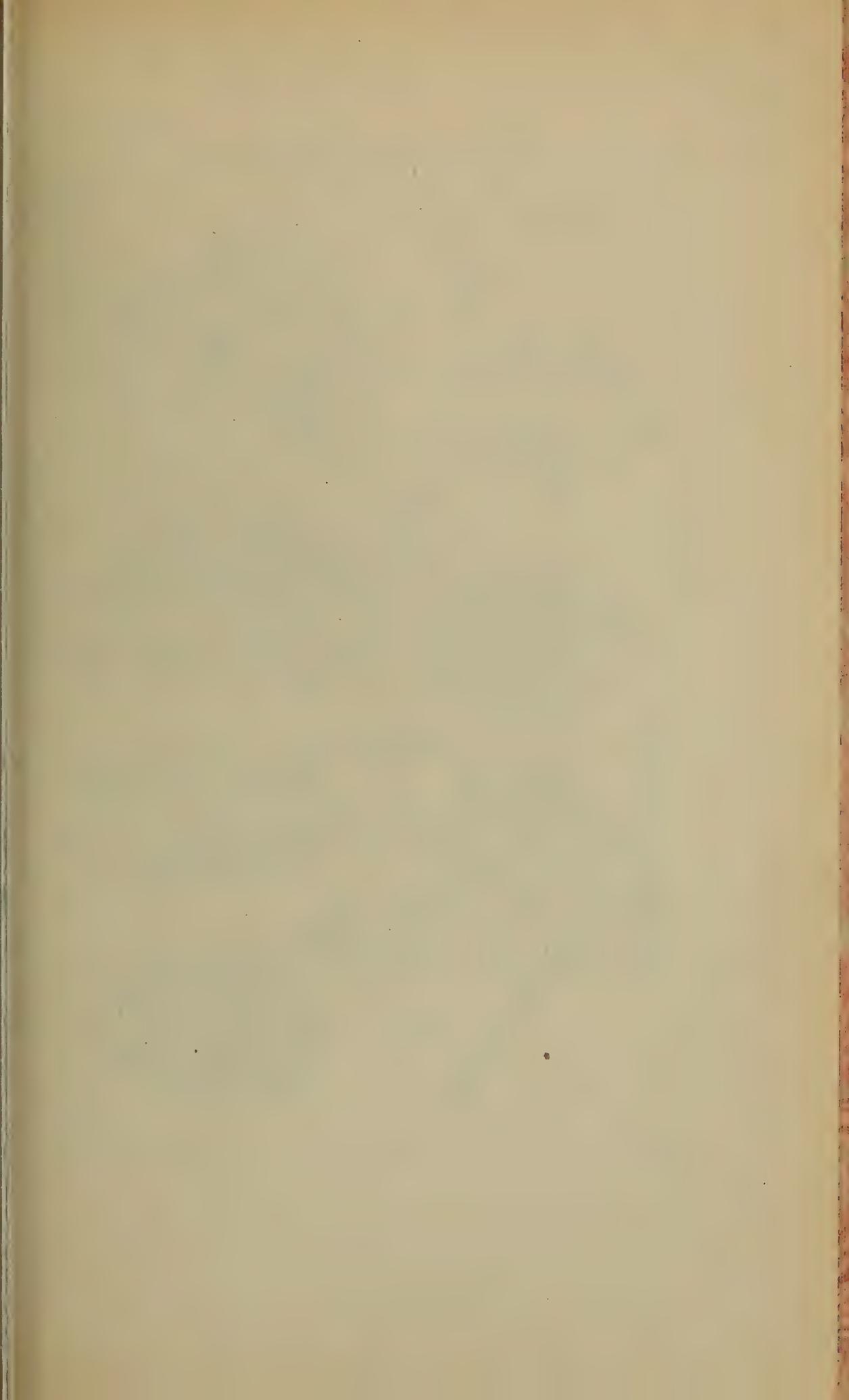


PLATE E.

- Fig. 1. *Alona quadrangularis*, female.
A. antennule. Lb. labrum. Md. mandible. P-a. post-abdomen. An. anus. F. c. musculus flexor caudalis. E. c. musculus extensor caudalis. A. g. anal gland. n. g. nutritive globule in embryo. t. tail of embryo. I, II, III, IV, V. five pairs of feet of embryo. mx. maxilla of embryo. at². antennæ of embryo. at¹. antennules of embryo. H. heart. Sh. g. shell gland. Ov. ovary. Md. m. muscle of mandible. At.² m. muscle of antennæ. E. eye. s. œ. g. supra-œsophagal ganglion. P. F. pigment fleck.
- Fig. 2. brain, eye and pigment fleck of same.
- Fig. 3. *Pleuroxus procurvus*, female.
- Fig. 4. foot of same.
- Fig. 5. *Acroperus leucocephalus*.
- Fig. 6. *Alonella excisa*, female; 6a. shell of same.
- Fig. 7. antennæ of same.
- Fig. 8. *Alonopsis latissima*, female.
- Fig. 9. *Alonopsis media*, female.
- Fig. 10. *Camptocercus macrurus*, post-abdomen.
- Fig. 10a. lower angle of shell of same.

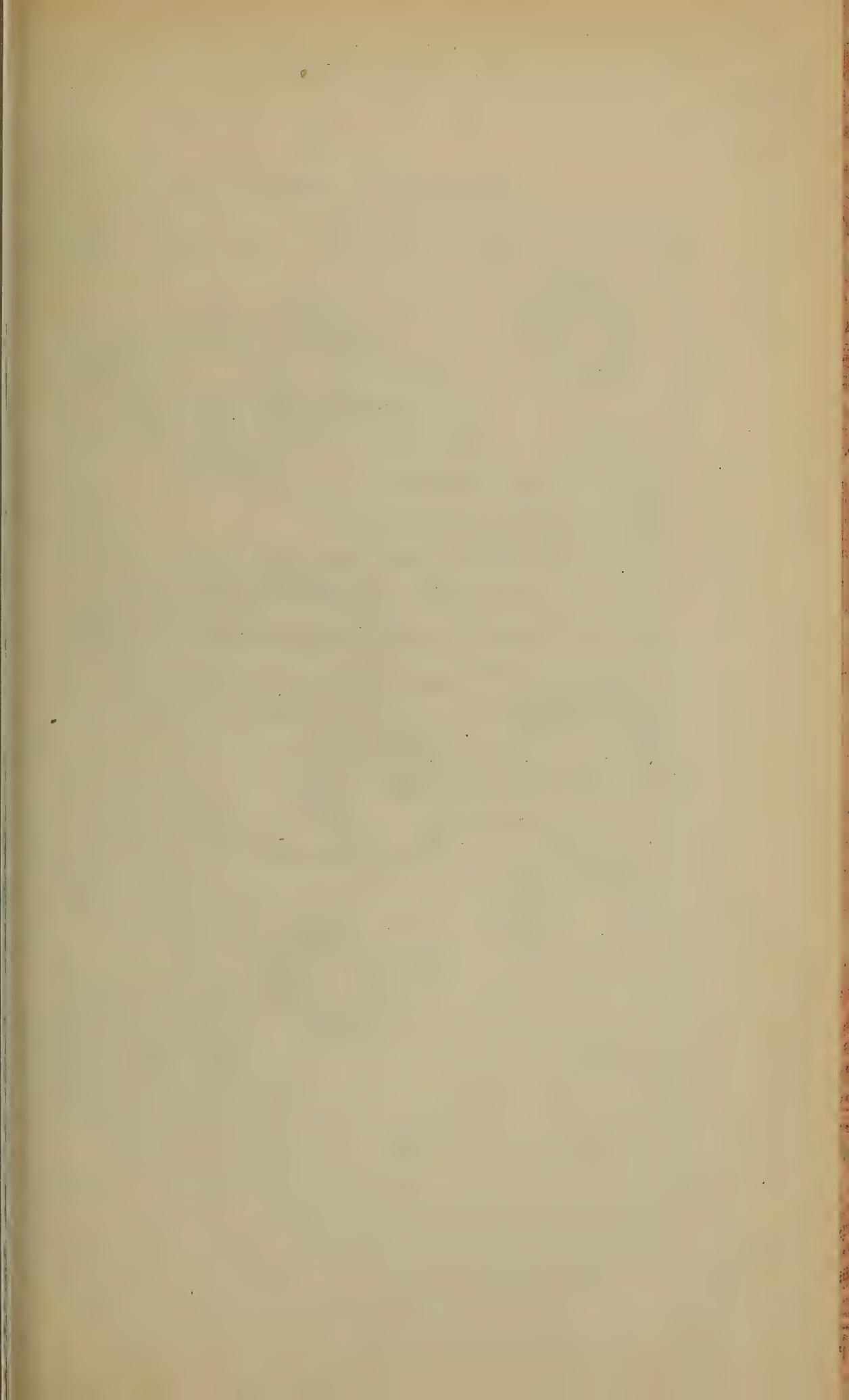


PLATE F.

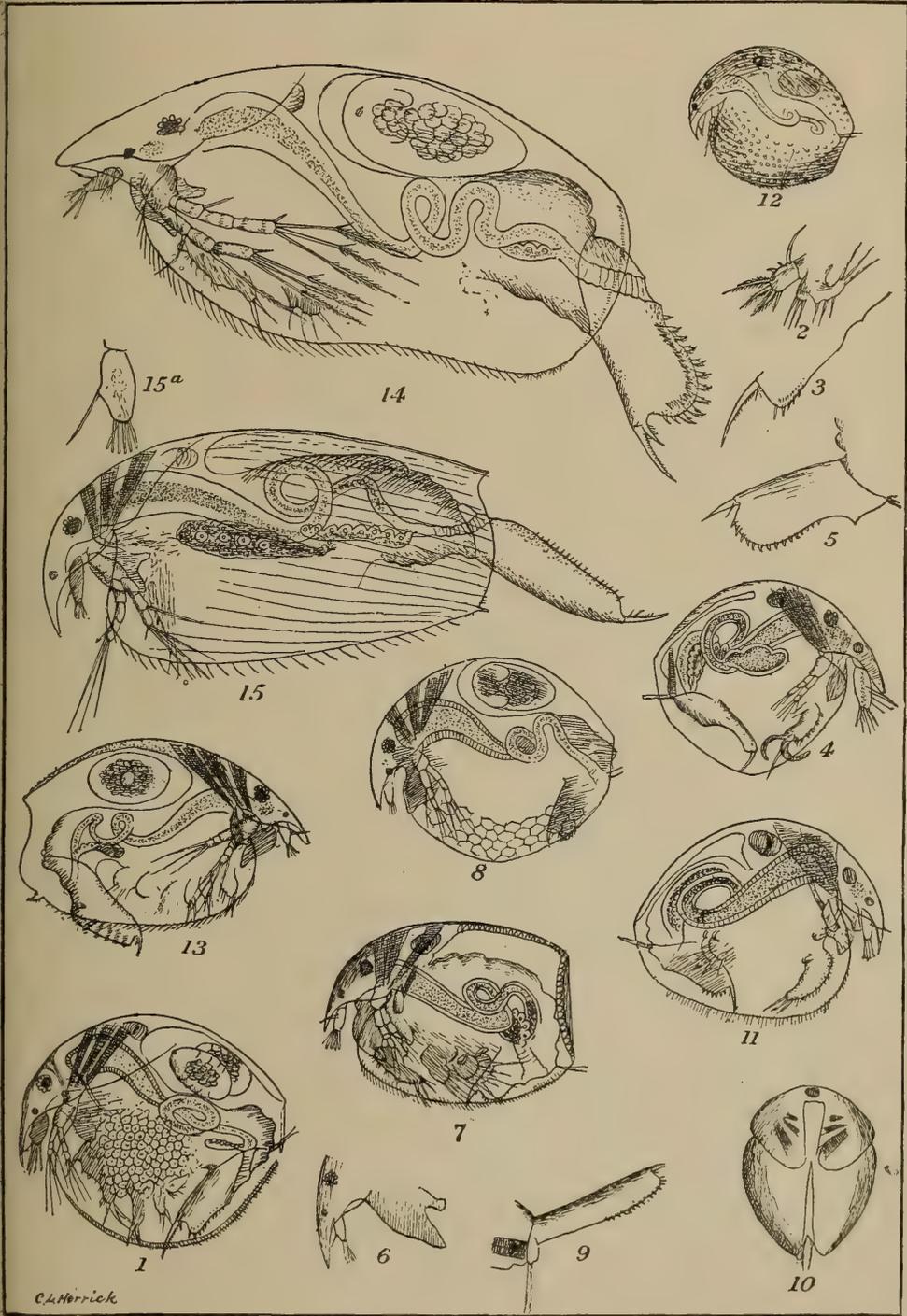
- Fig. 1. *Chydorus globosus*.
Fig. 2. do., first foot.
Fig. 3. do., end of post-abdomen.
Fig. 4. *Chydorus sphaericus*, male.
Fig. 5. *Chydorus nitidus*, post-abdomen of female.
Fig. 6. *Chydorus nitidus*, head.
Fig. 7. *Chydorus sphaericus*, ephippial female.
Fig. 8. do., female.
Fig. 9. *Chydorus globosus*, post-abdomen of male.
Fig. 10. *Chydorus sphaericus*, from above.
Fig. 11. *Chydorus ovalis*.
Fig. 12. *Chydorus caelatus*.
Fig. 13. *Crepidocercus setiger*.
Fig. 14. *Alona affinis*.
Fig. 15. *Pleuroxus unidens*; 15a. antenna.

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PLATE F.

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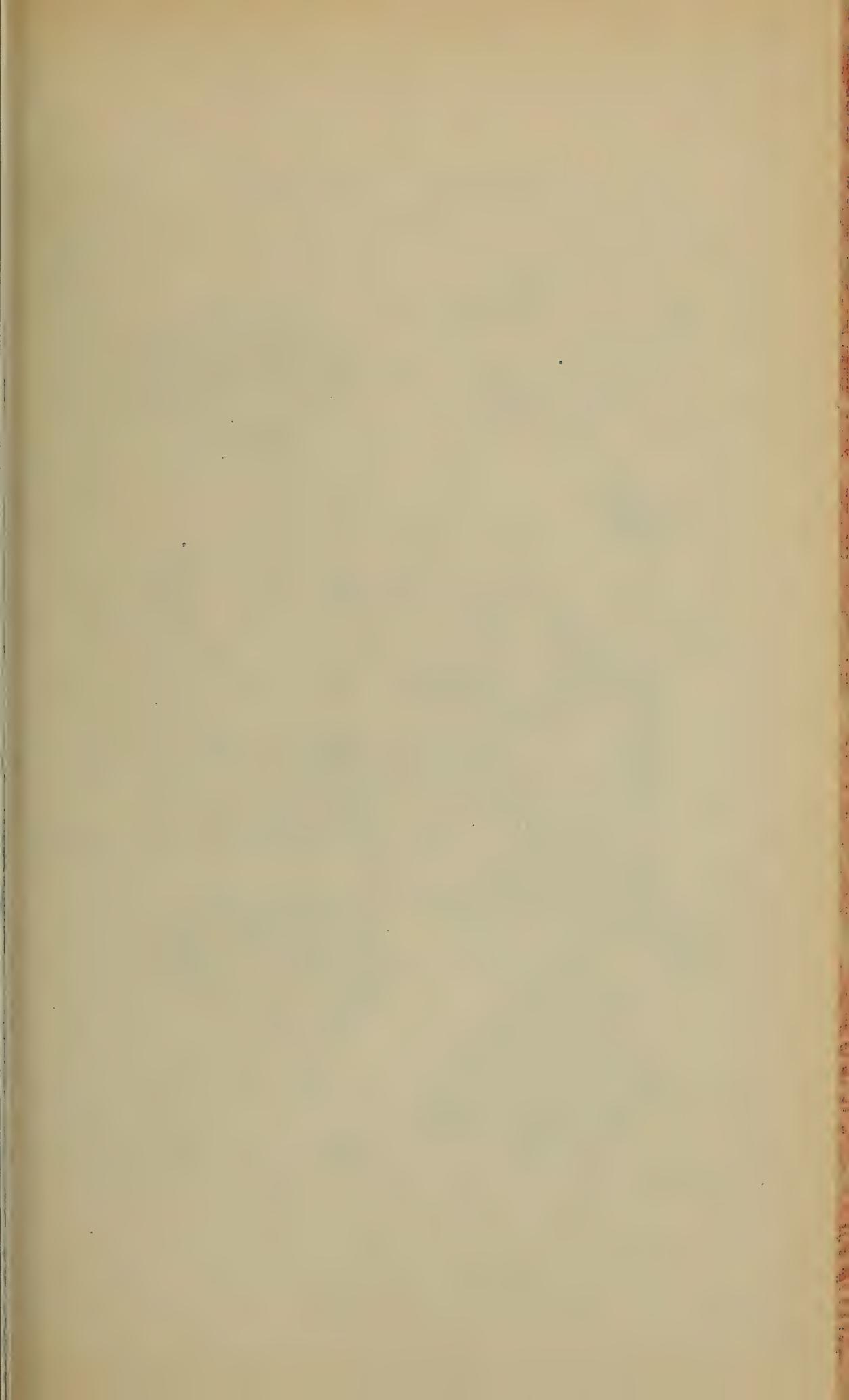


PLATE G.

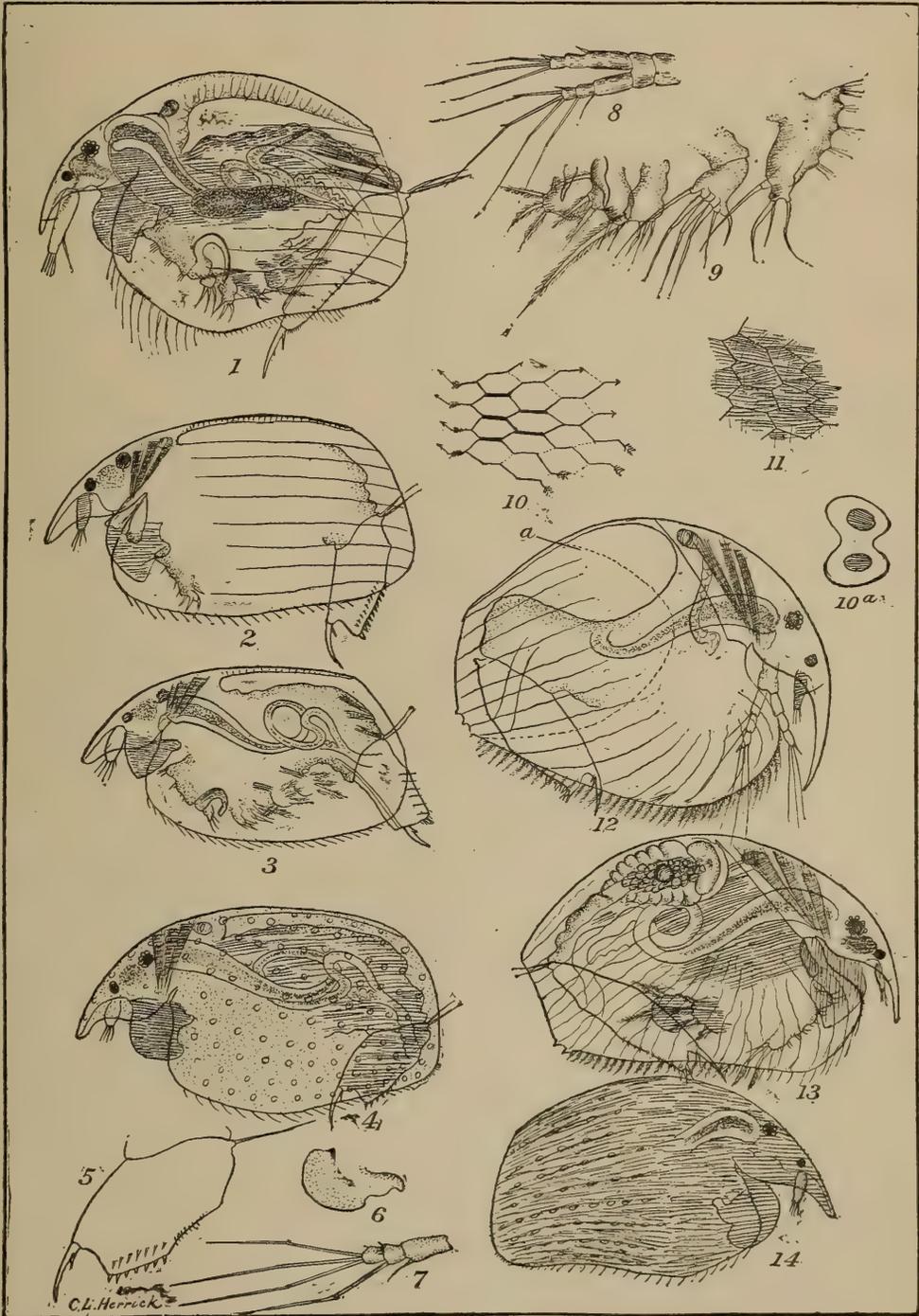
- Fig. 1. *Alonopsis latissima*, male.
Fig. 2. *Alona glacialis* ? female.
Fig. 3. do., male.
Fig. 4. *Alona tuberculata*.
Fig. 5. do., post-abdomen.
Fig. 6. do., labrum.
Fig. 7. do, antenna, setose branch.
Fig. 8. *Alona glacialis*, antenna.
Fig. 9. *Alonopsis latissima*, feet.
Figs. 10, 11. *Alonella excisa*, details of shell sculpture.
Fig. 12. *Pleuroxus denticulatus*, female; 10a. outline of ehippium.
Fig. 13. do., common variety.
Fig. 14. *Alona tuberculata*, var.

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PLATE G.

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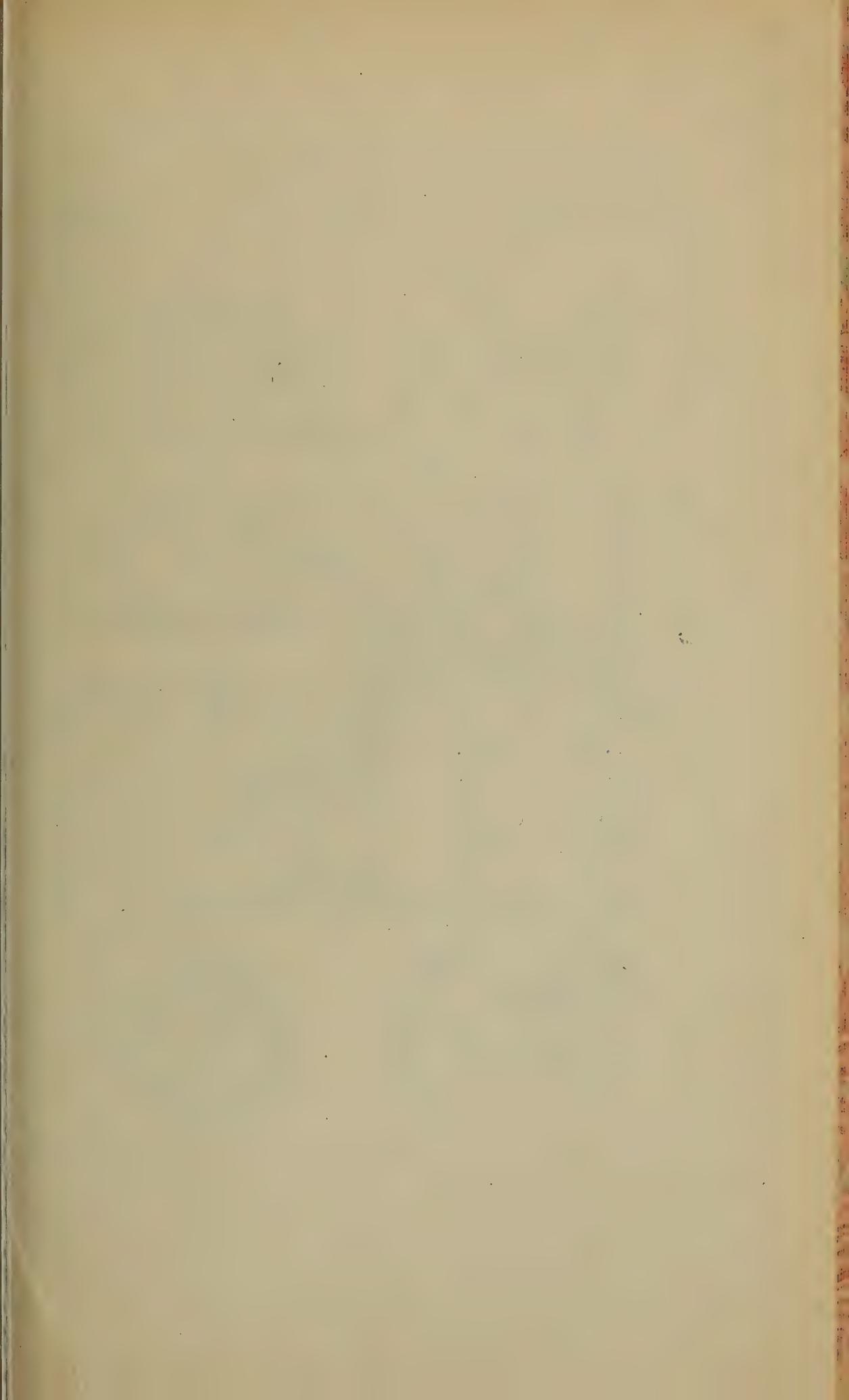


PLATE H.

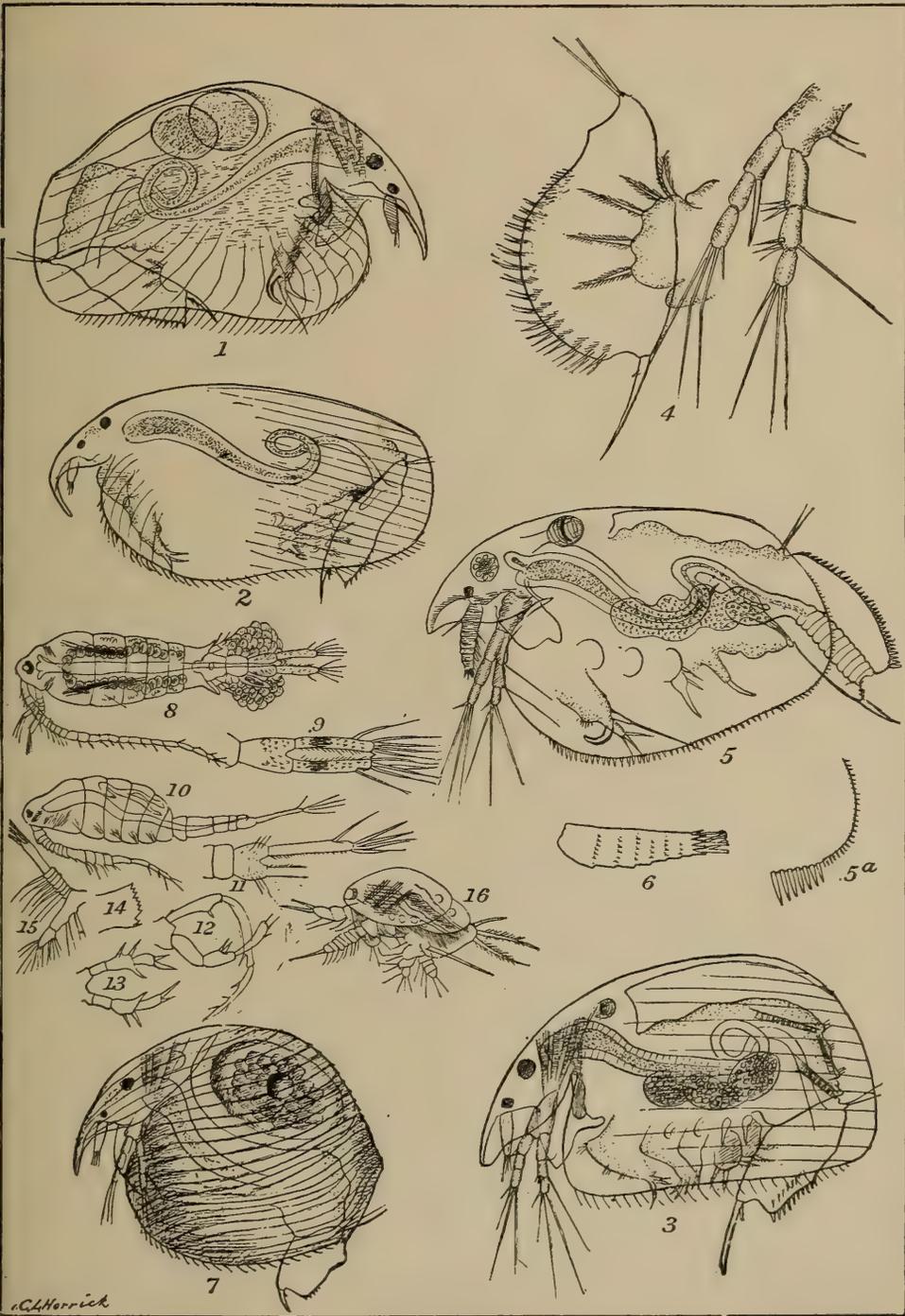
- Fig. 1. *Pleuroxus hamatus*, post-abdomen and antenna.
Fig. 2. *Pleuroxus affinis*.
Fig. 3. *Alona modesta* (= *lineata*?)
Fig. 4. *Leydigia quadrangularis*.
Fig. 5. *Eurycercus lamellatus*, male; 5a. posterior margin.
Fig. 6. do, antenna of female.
Fig. 7. *Alonella pygmæa*.
Fig. 8. *Temora affinis*, Poppe. female.
Fig. 9. do., abdomen of female.
Fig. 10. do., male.
Fig. 11. do., abdomen of male.
Fig. 12. do., fifth feet of male.
Fig. 13. do., " " of female.
Fig. 14. do., jaw.
Fig. 15. do., antennule.
Fig. 16. Nauplius larva of this or a related species.

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PLATE H.

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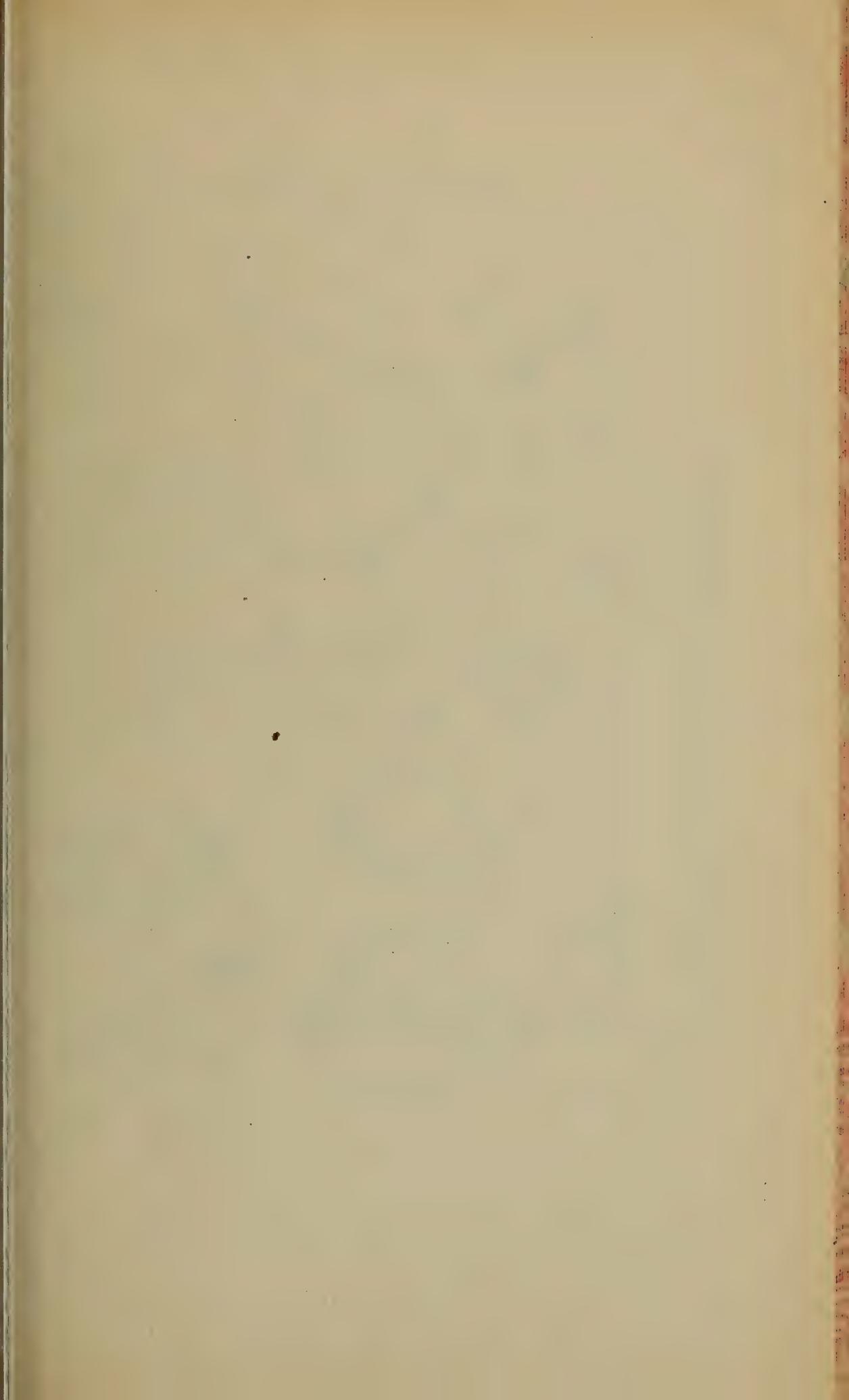


PLATE I.

- Fig. 1. *Camptocercus rectirostris*, post-abdomen of female.
Fig. 2. do. post-abdomen of male.
Fig. 3. do. male.
Fig. 4. *Camptocercus biserratus*, head.
Fig. 5. *Camptocercus latirostris*, head of male.
Fig. 6. do., head of female.
Fig. 7. *Camptocercus lillgeborgii*, head.
Fig. 8. do., post-abdomen of female.
Fig. 9. *Acroperus leucocephalus*, post-abdomen of male.
Fig. 10. *Acroperus angustatus*, " "
Fig. 11. *Alona tenuicaudis*, post-abdomen.
Fig. 12. *Alona dentata*, post-abdomen.
Fig. 13. do. female.
Fig. 14. *Alona elegans*.
Fig. 15. *Alona intermedia*.
Fig. 16. *Pleuroxus hastatus*.
Fig. 17. *Leptorhynchus falcatus*.
Fig. 18. *Phrixura rectirostris*.
Fig. 19. *Eurycercus lamellatus*, first foot of female.
Fig. 20. *Alona sanguinea?* shell markings.
Fig. 21. *Monospilus dispar*; 21a. do., head seen from in front.

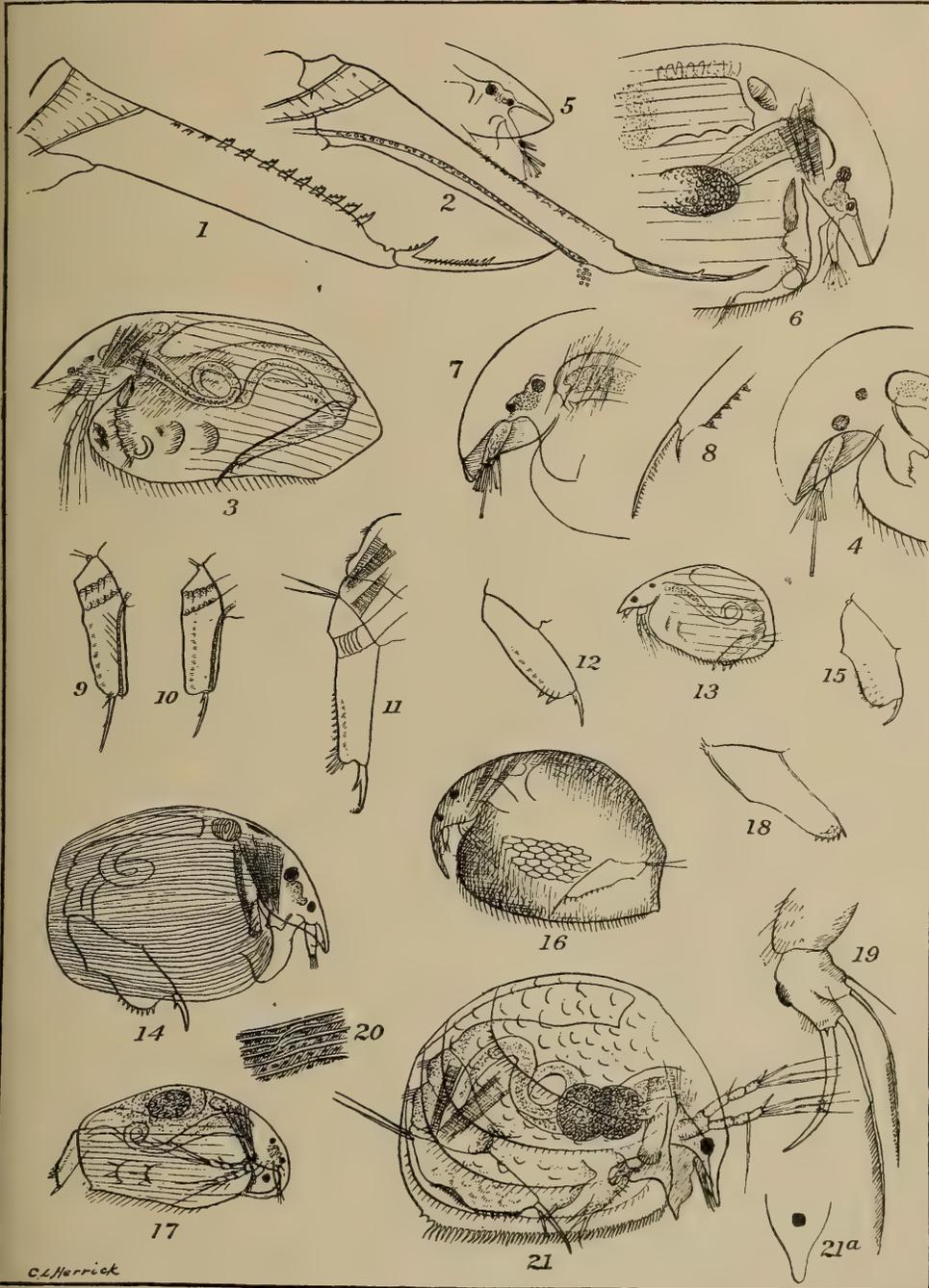
Figures 19-21 original, others from Kurz, P. E. Mueller and Schoedler.

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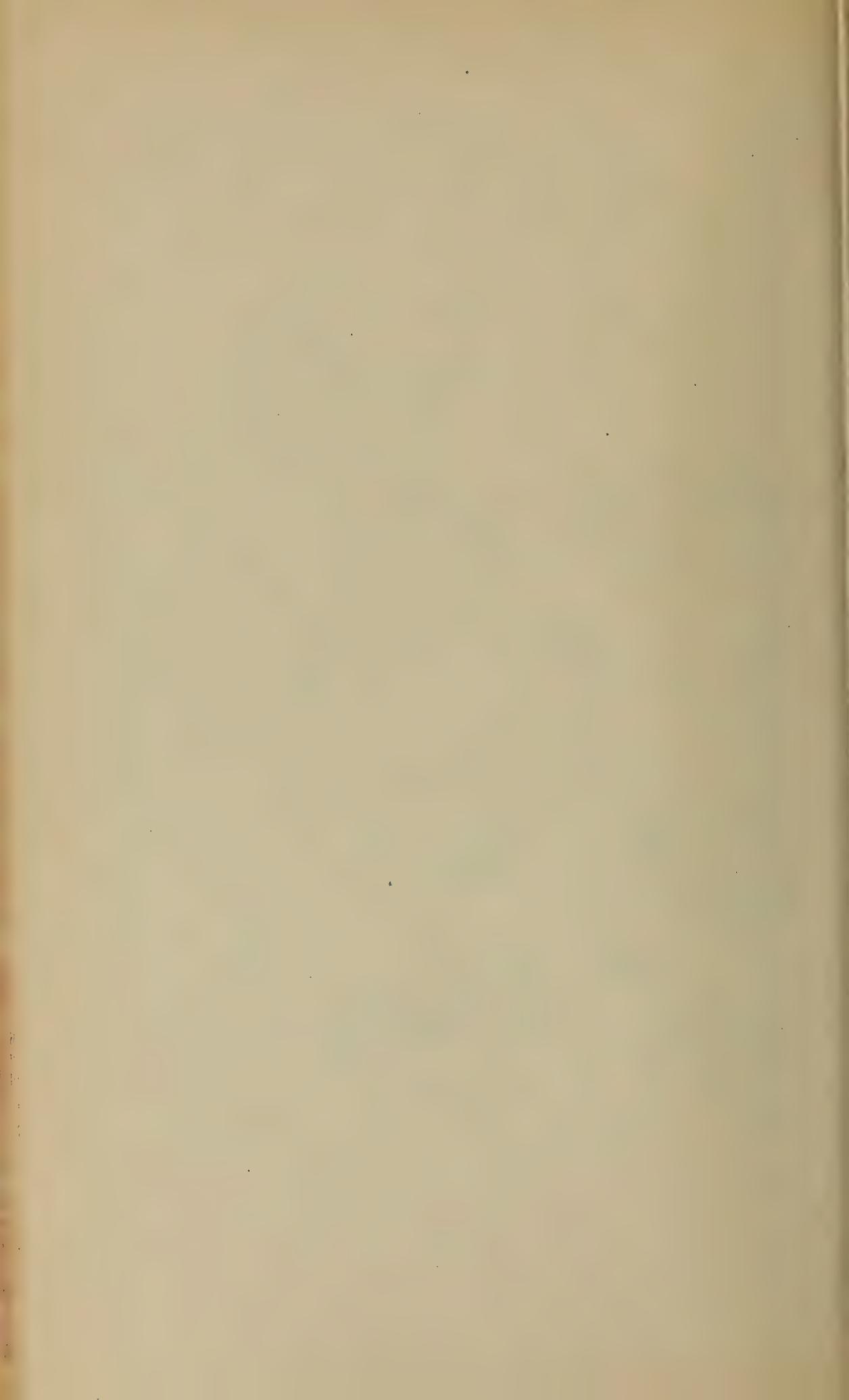
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PLATE I.

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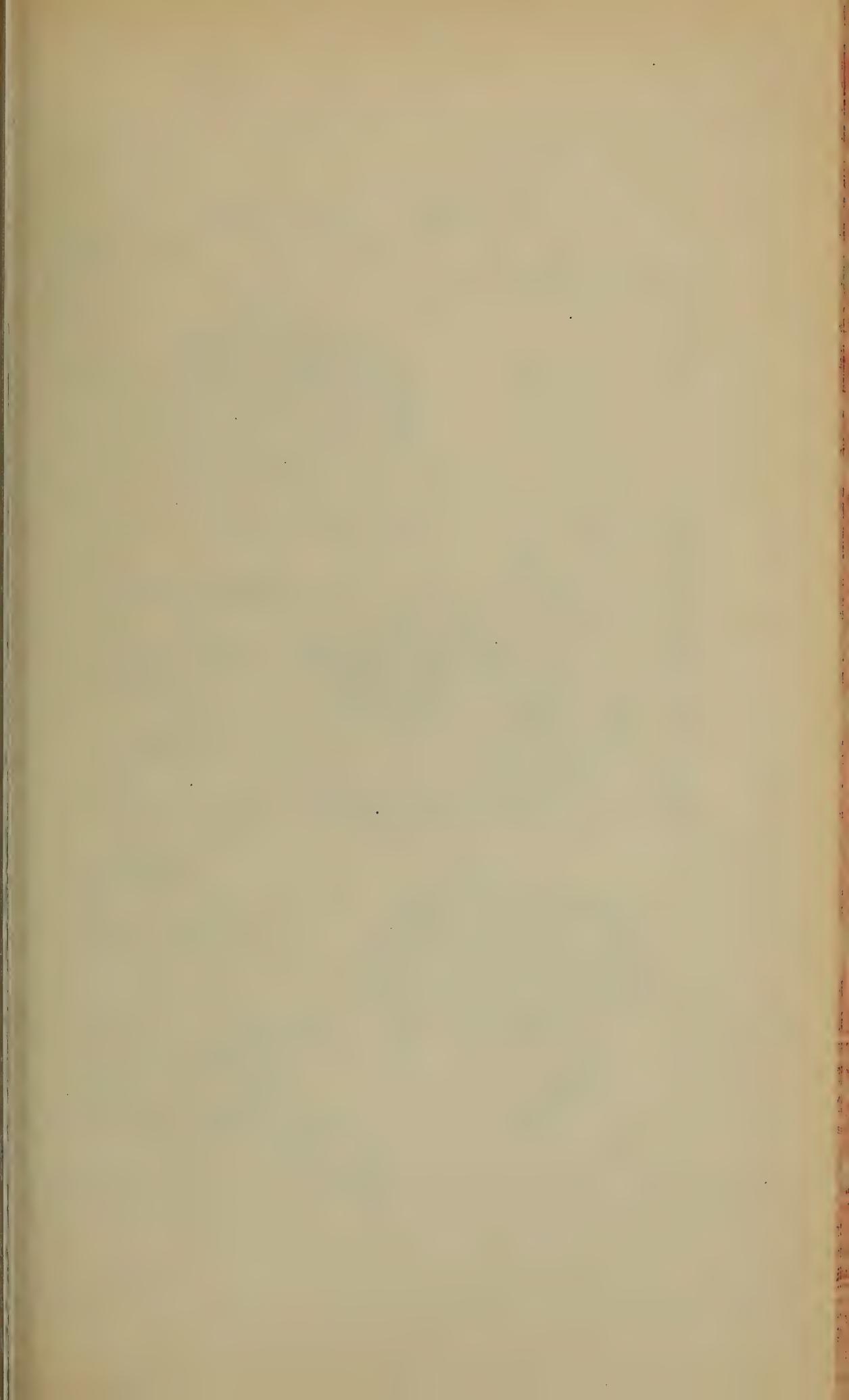


PLATE J.

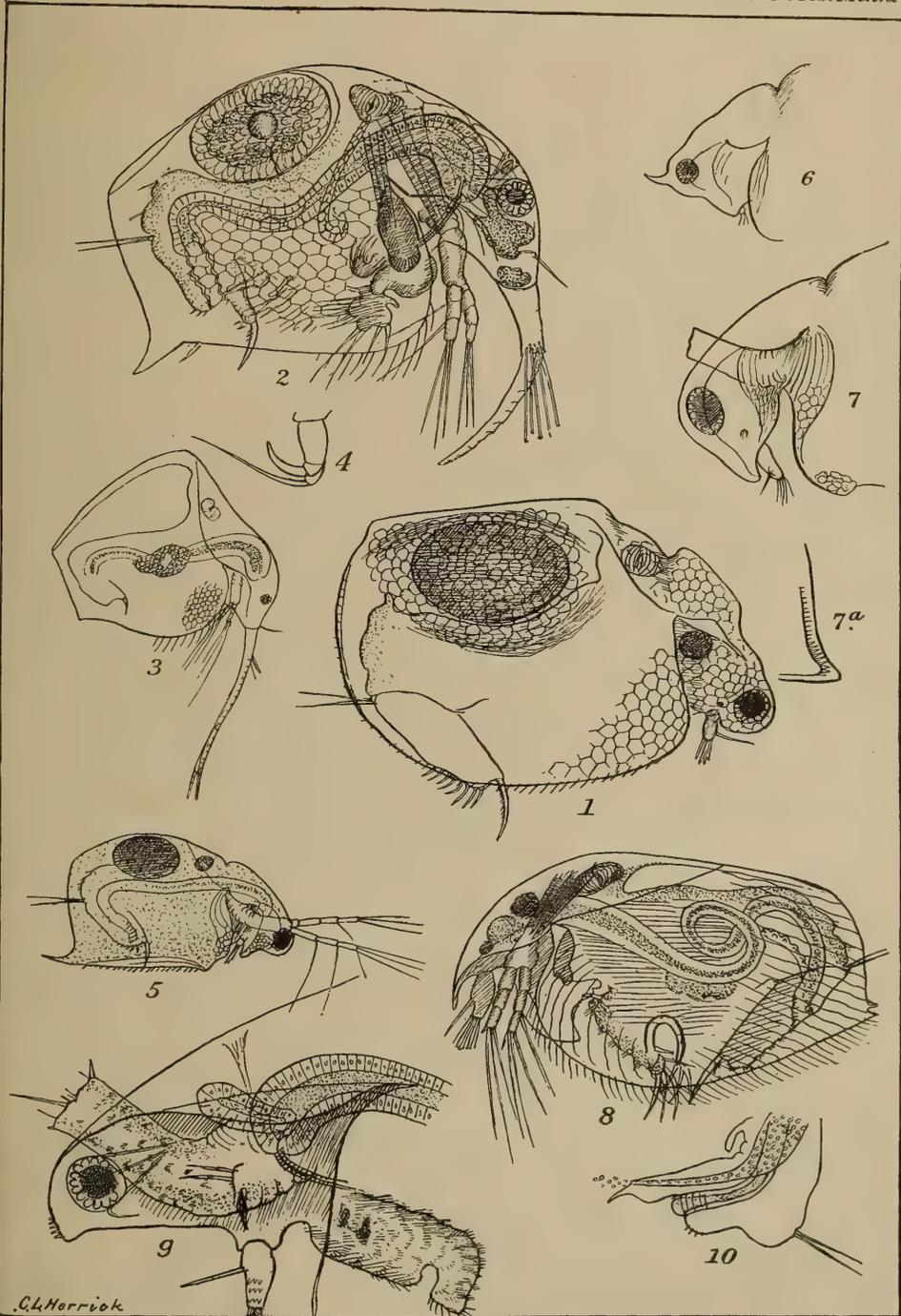
- Fig. 1. *Ceriodaphnia scitula*, (small var.) ehippial female.
Fig. 2. *Bosmina longirostris*.
Fig. 3. *Bosmina lilljeborgii*. After P. E. Mueller.
Fig. 4. *Bosmina*, hook on the first foot of male.
Fig. 5. *Scapholeberis mucronata*.
Fig. 6. *Scapholeberis cornuta*, head.
Fig. 7. *Scapholeberis angulata*, head; 7a. angle of shell.
Fig. 8. *Pleuroxus denticulatus*, male.
Fig. 9. *Simocephalus americanus*, head of female.
Fig. 10. *Bosmina*, post-abdomen of male (after Weismann).

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PLATE J.

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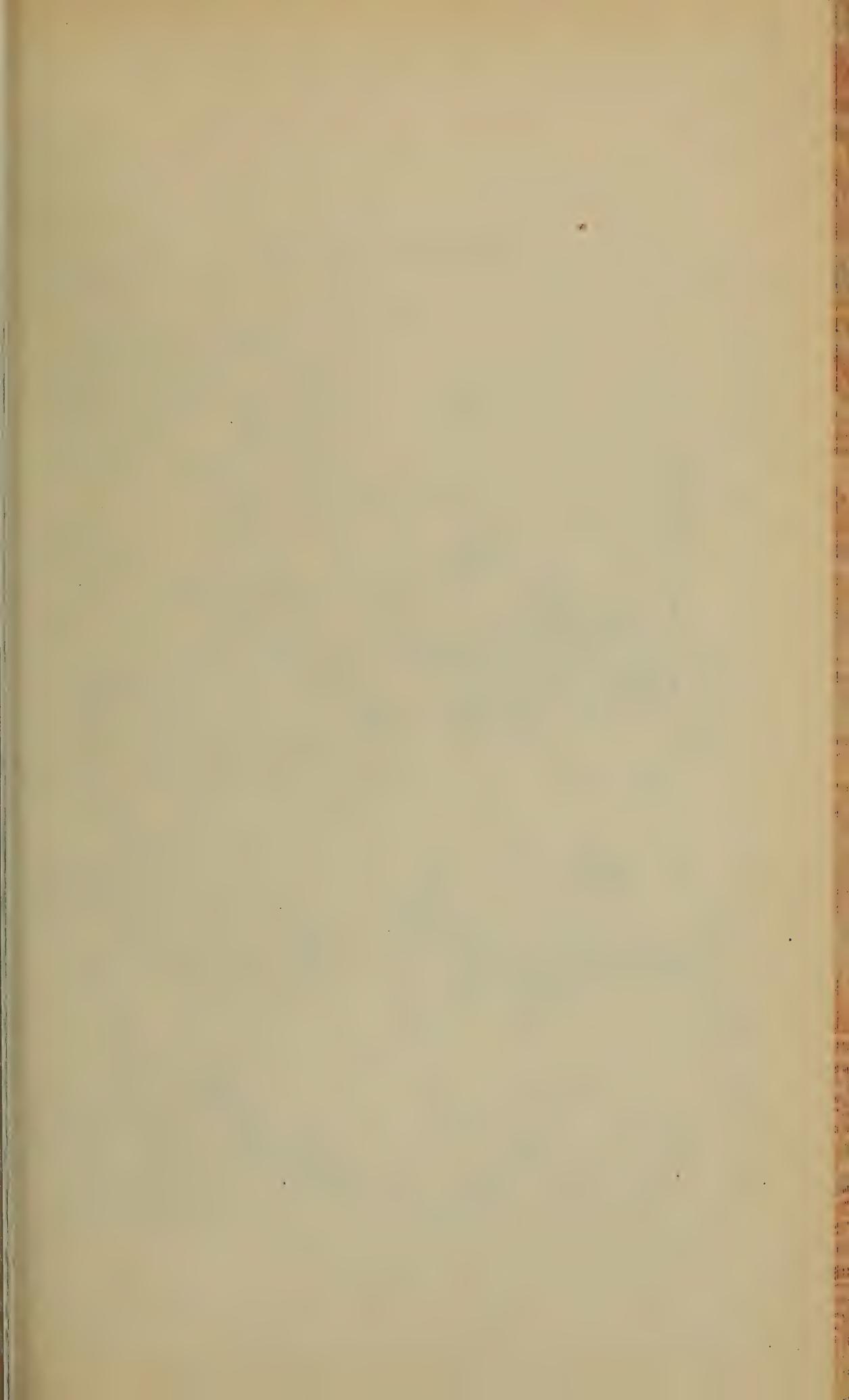


PLATE J¹.

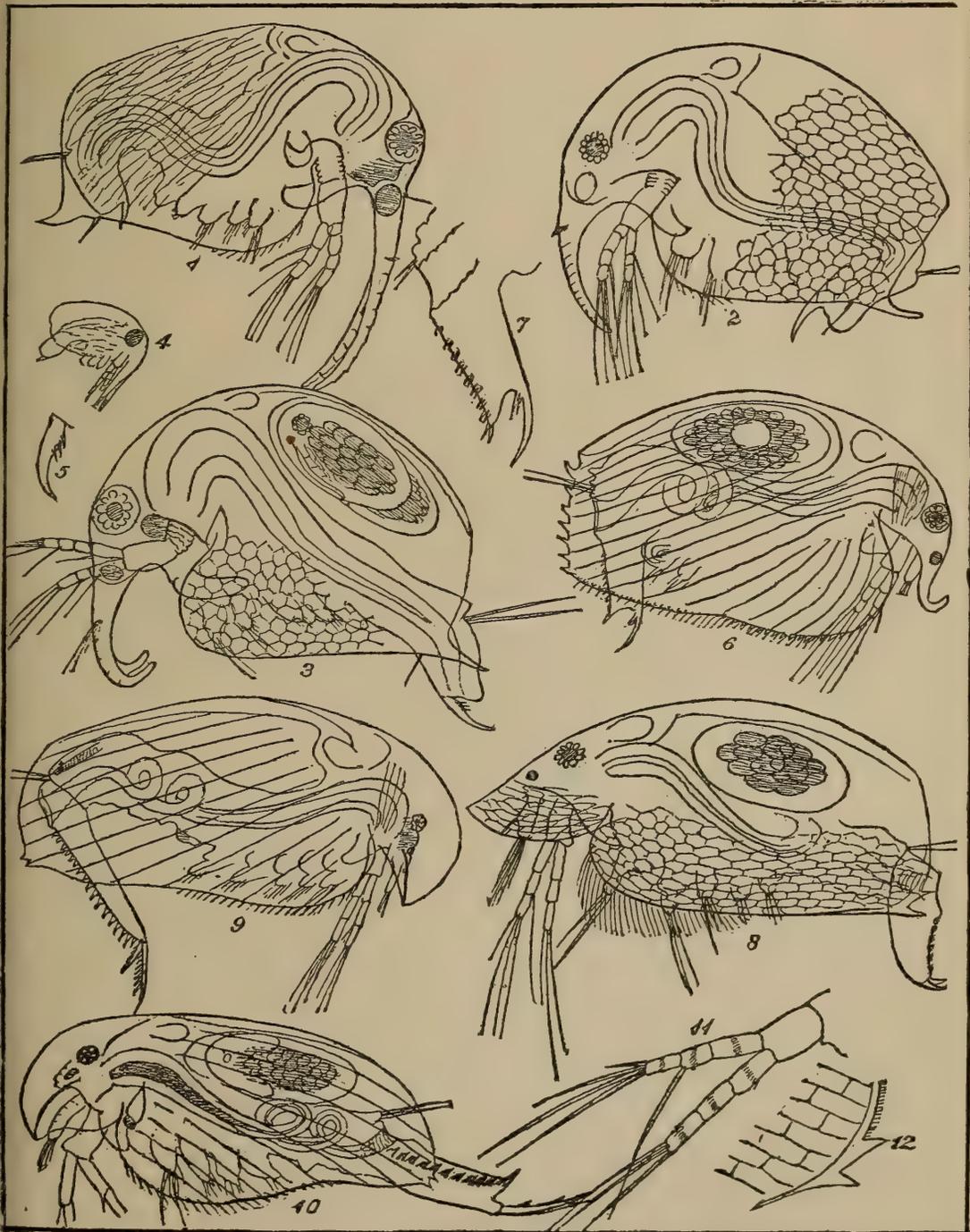
- Fig. 1. *Bosmina striata*.
Fig. 2. *Bosmina longirostris*. (See plate J, fig. 2.)
Figs. 3-5. *Bosmina cornuta*.
Figs. 6, 7. *Pleuroxus procurvatus*.
Fig. 8. *Graptoleberis inermis*.
Fig. 10. *Acroperus* sp.
Figs. 11, 12. *Graptoleberis inermis*.

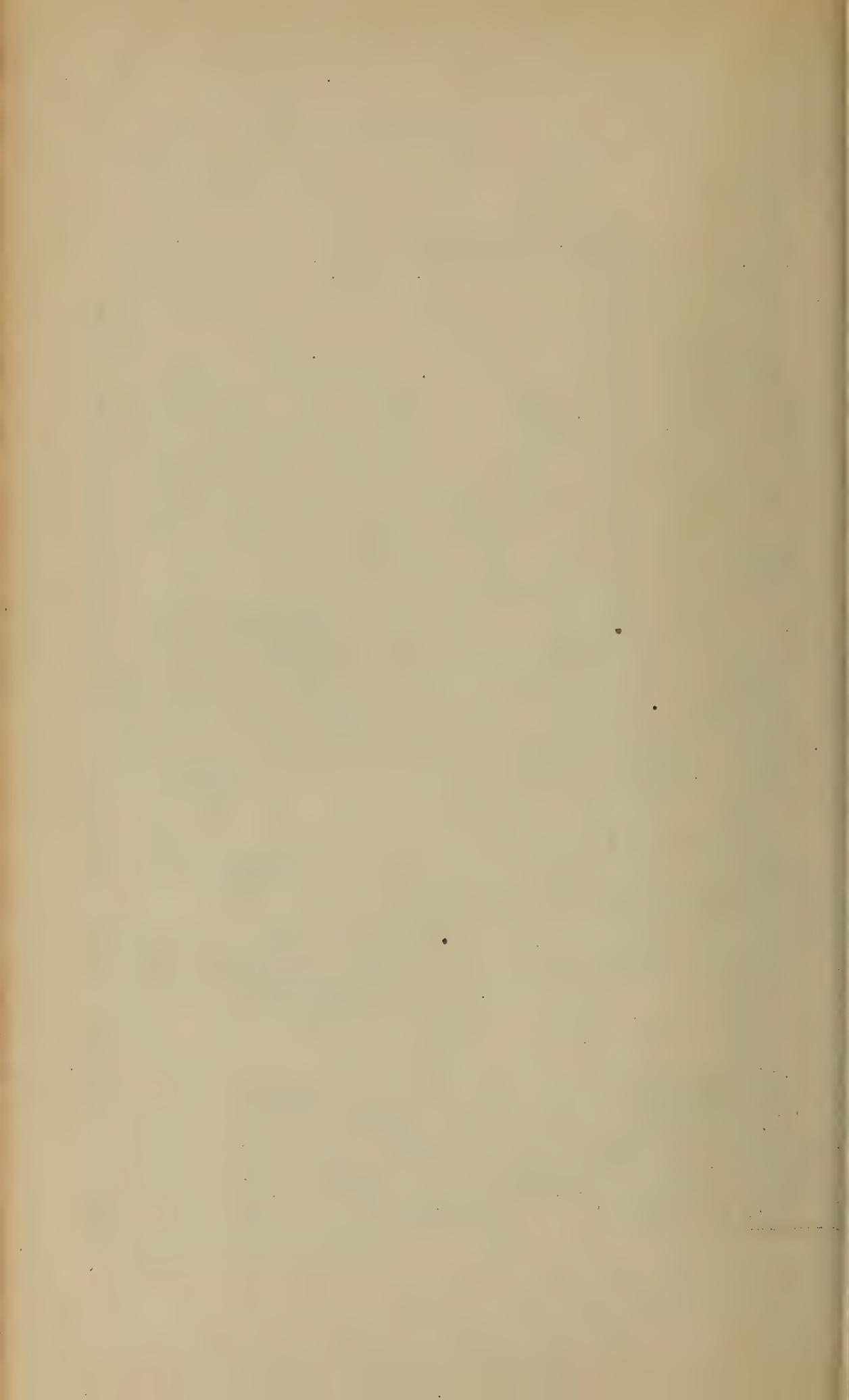
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PLATE J₁.

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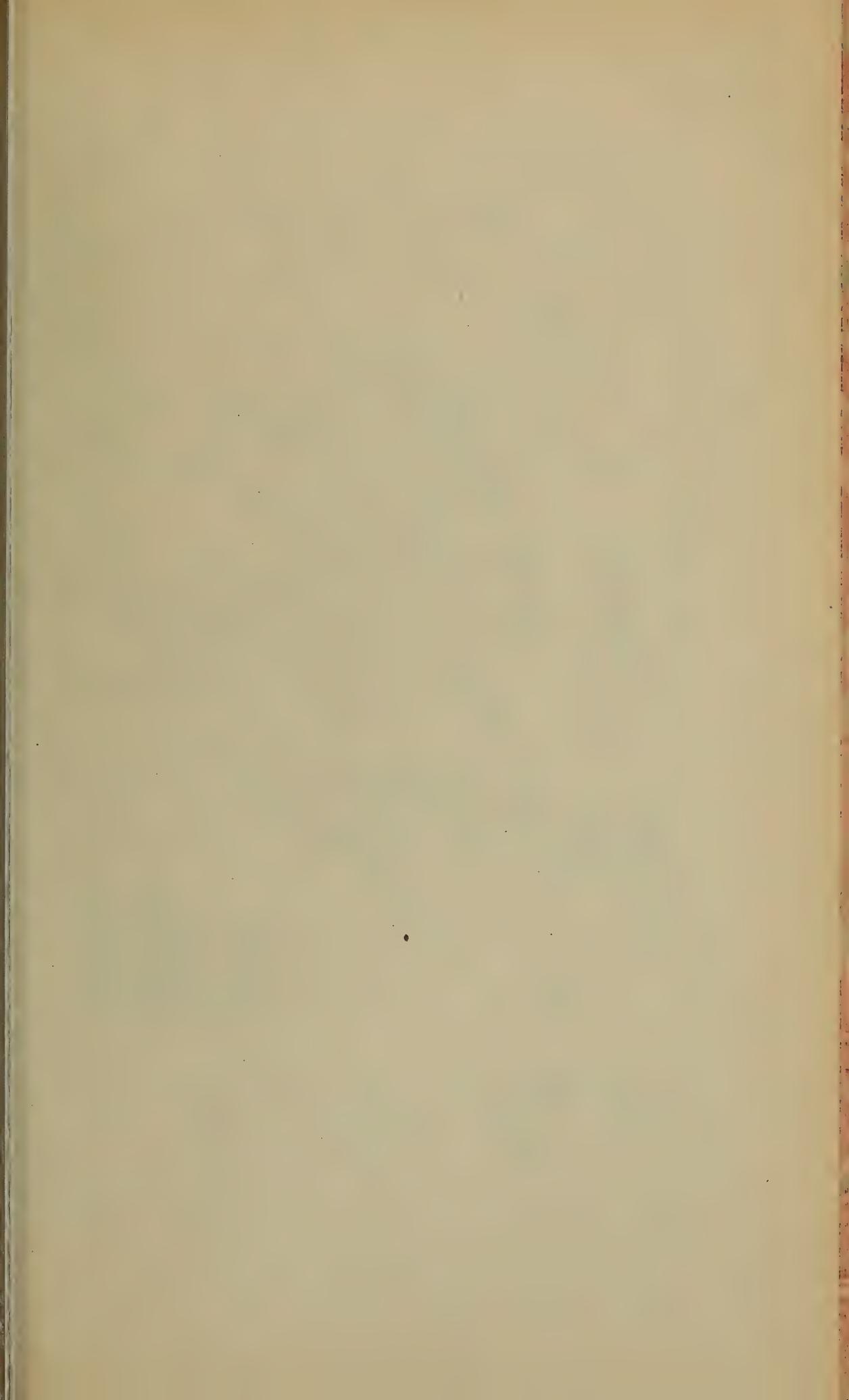


PLATE K.

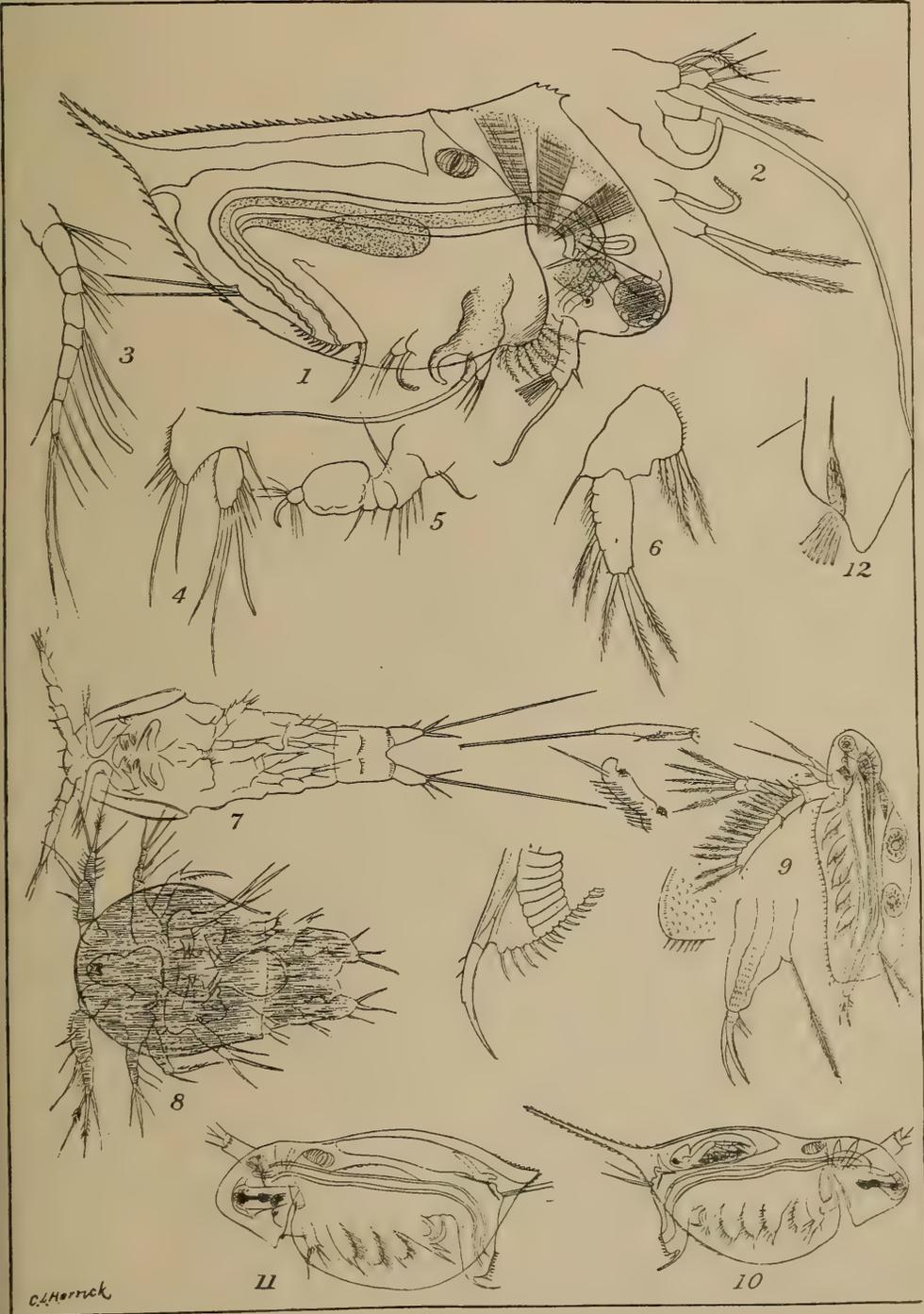
- Fig. 1. *Daphnia minnehaha*, male.
Fig. 2. " " part of feet of first and second pair.
Fig. 3. *Canthocamptus hibernicus*, antenna of female.
Fig. 4. " " fifth foot of female.
Fig. 5. " *palustris*, antenna of male.
Fig. 6. " *trispinosus*, fifth foot of female.
Fig. 7. " *minutus*, young.
Fig. 8. " " nauplius form.
Fig. 9. *Pseudo-sida bidentata*, adult female, antennule, labrum,
angle of shell and post-abdomen.
Fig. 10. *Daphnia rosea*, young female.
Fig. 11. " " post-imago.
Fig. 12. " " beak.

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PLATE K.

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C. Hornick

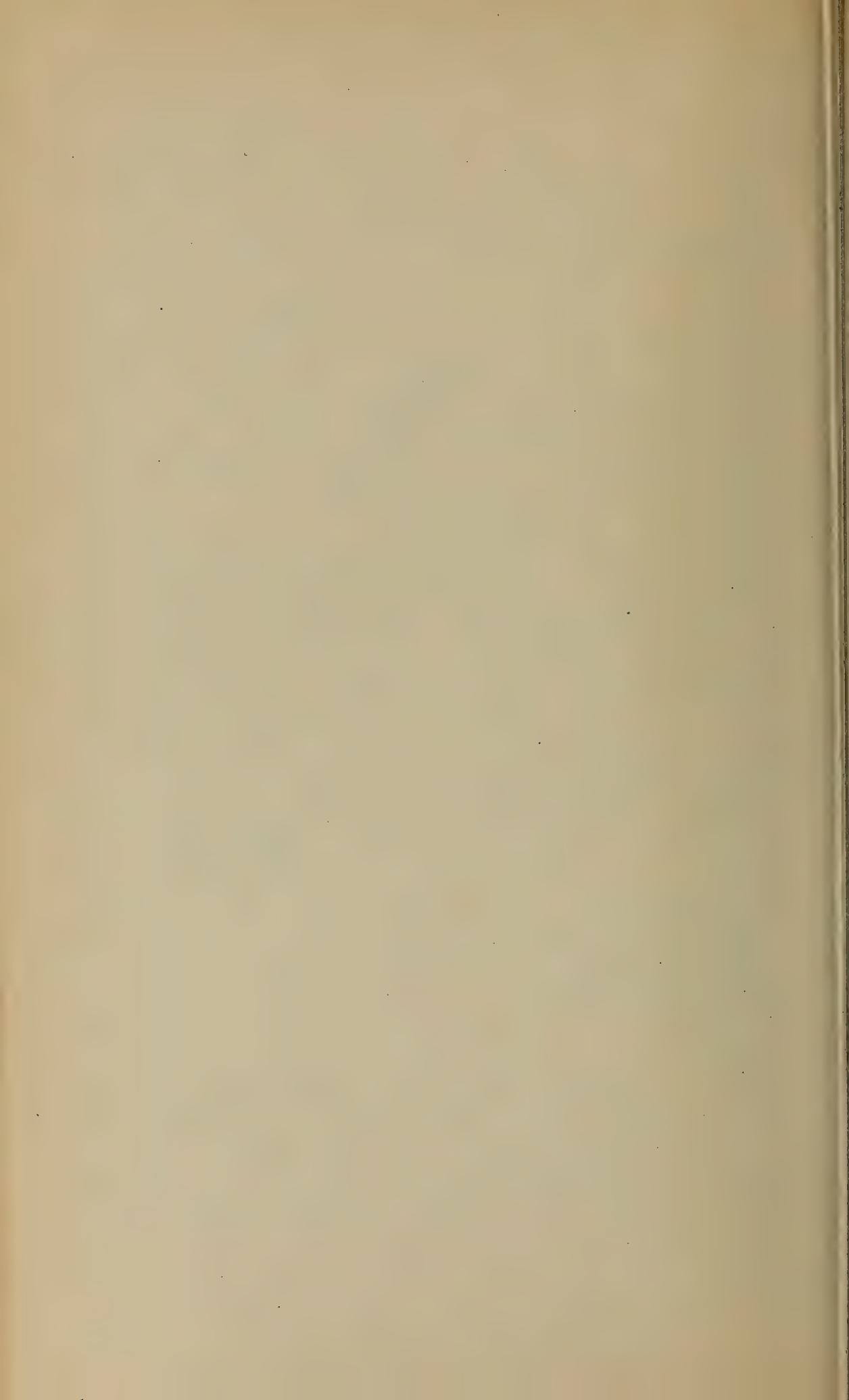


PLATE L.

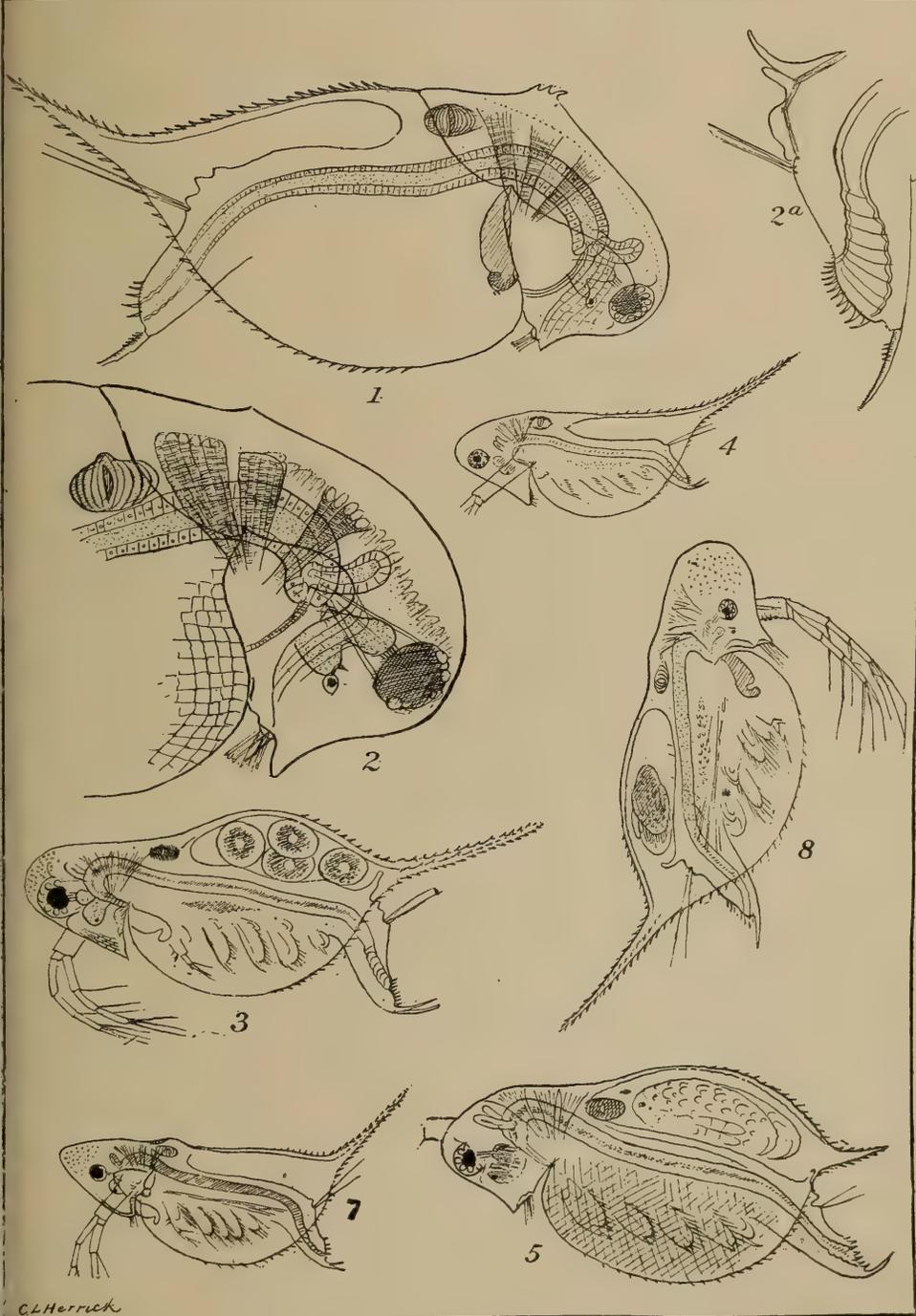
- Fig. 1. *Daphnia minnehaha*, young female.
Fig. 2. " " head of female; 2a. post-abdomen.
Fig. 3. " *hyalina*, young female.
Fig. 4. " " young.
Fig. 5. " " post-imago.
Fig. 7. " *dubia*, young.
Fig. 8. " " older female.

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PLATE L.

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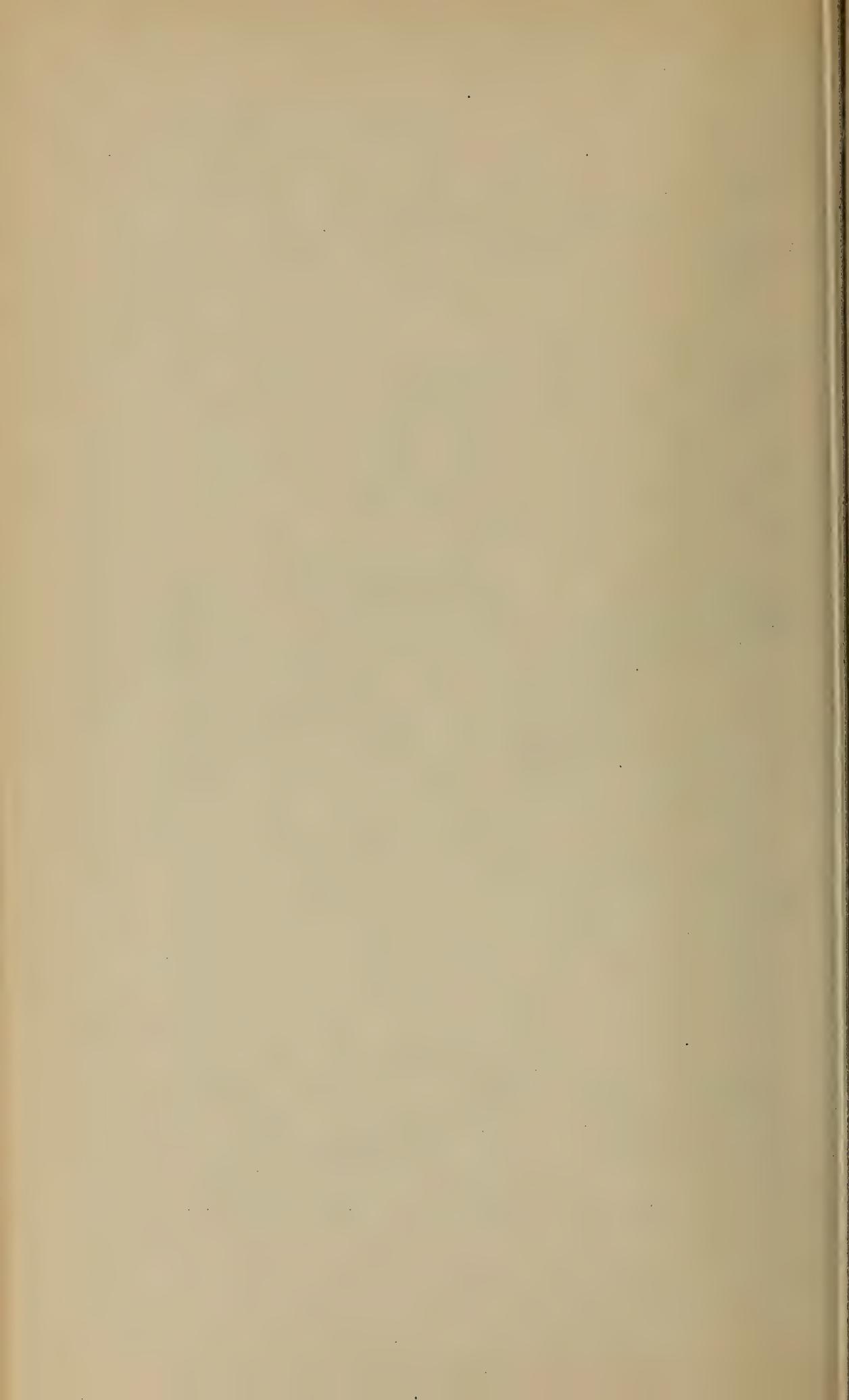
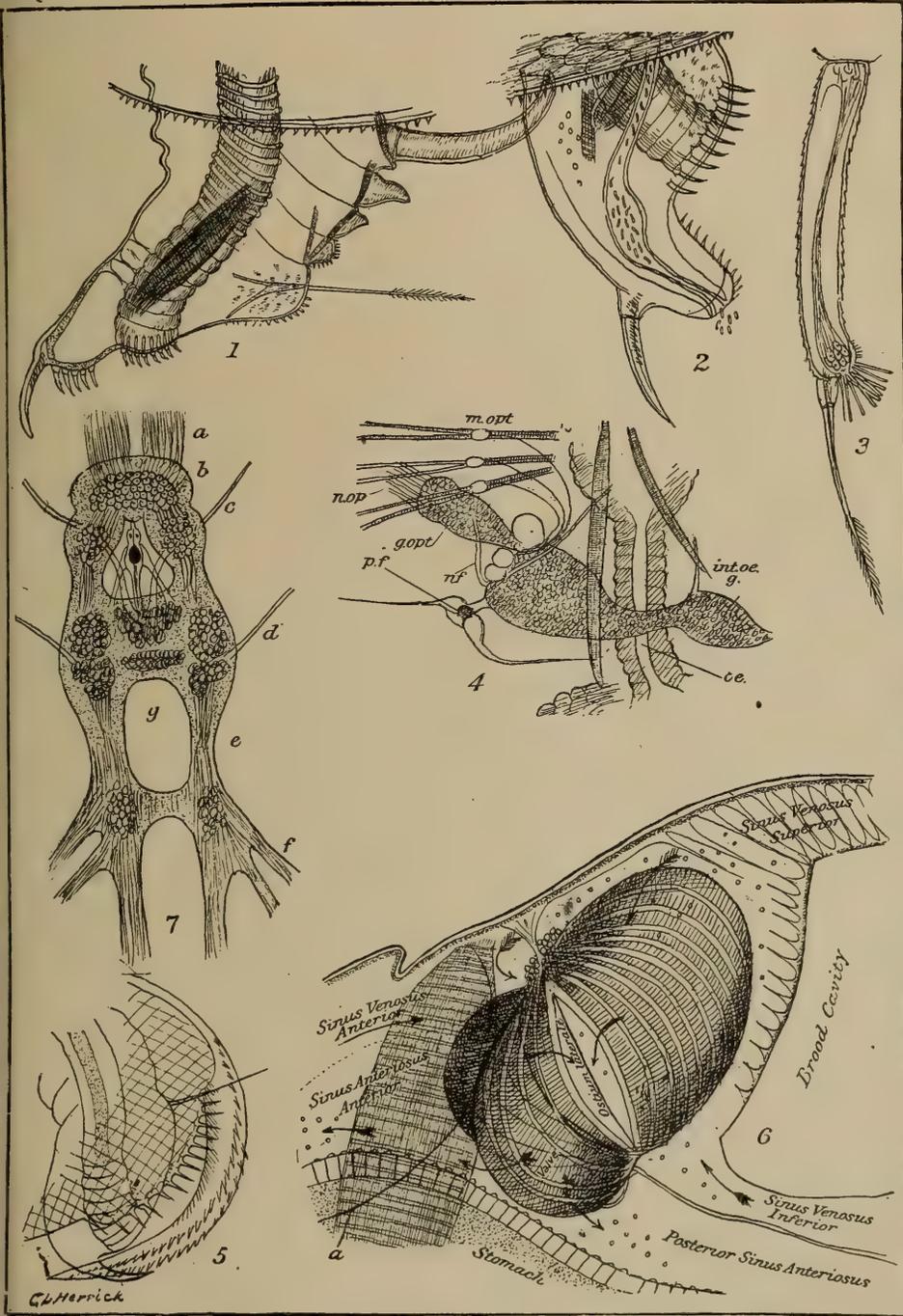


PLATE M.

- [Fig. 1. *Daphnia schæfferi*, post-abdomen of female.
Fig. 2. " " " " male.
Fig. 3. " " male antennule.
Fig. 4. " " brain and nerves.
inf. œ. g. infra-œsophagal ganglion with nerves to antennæ; œ. œsophagus; n. f. frontal nerve; g. opt. optic ganglion; m. opt. muscles which move the eye; p. f. pigment fleck; n. opt. optic nerve.
- Fig. 5. *Daphnia schæfferi*, posterior part of embryo.
Fig. 6. *Eurycercus lamellatus*, heart, showing the anterior bifid portion between the lobes of which is the arterial opening and valve. The vaned arrows represent deeper currents while the unvaned indicate superficial ones. The dotted line represents the position of the pulsating membrane separating the venous from the arterial currents and seen in section at (a).
- Fig. 7. *Daphnia similis*, anterior part of the nervous system seen from below. a. optic nerve; b. optic ganglion; c. frontal nerve; d. nerve to antennules; e. commissure connecting upper and lower œsophagal ganglion; f. nerves to antennæ and mandibles.

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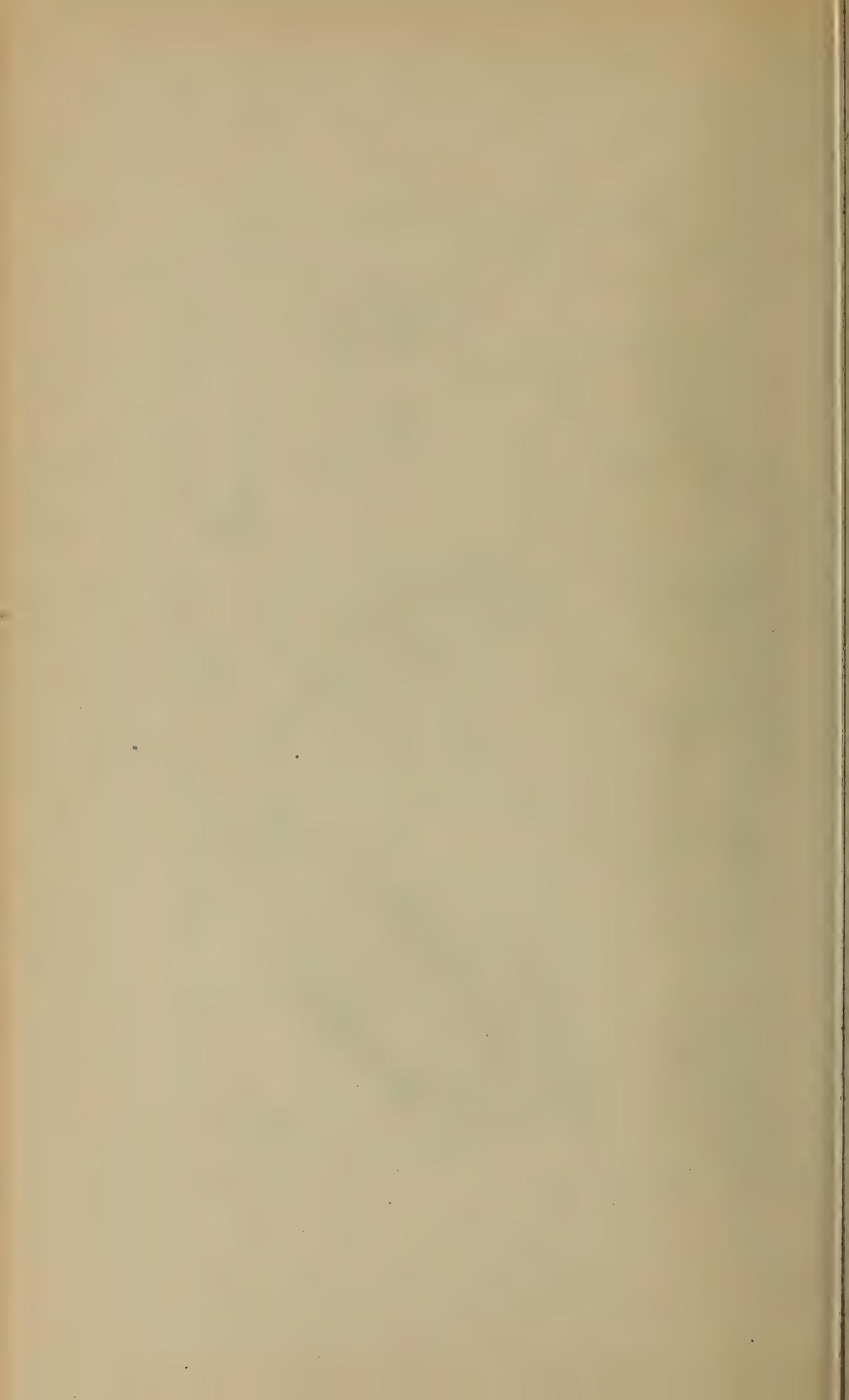


PLATE N.

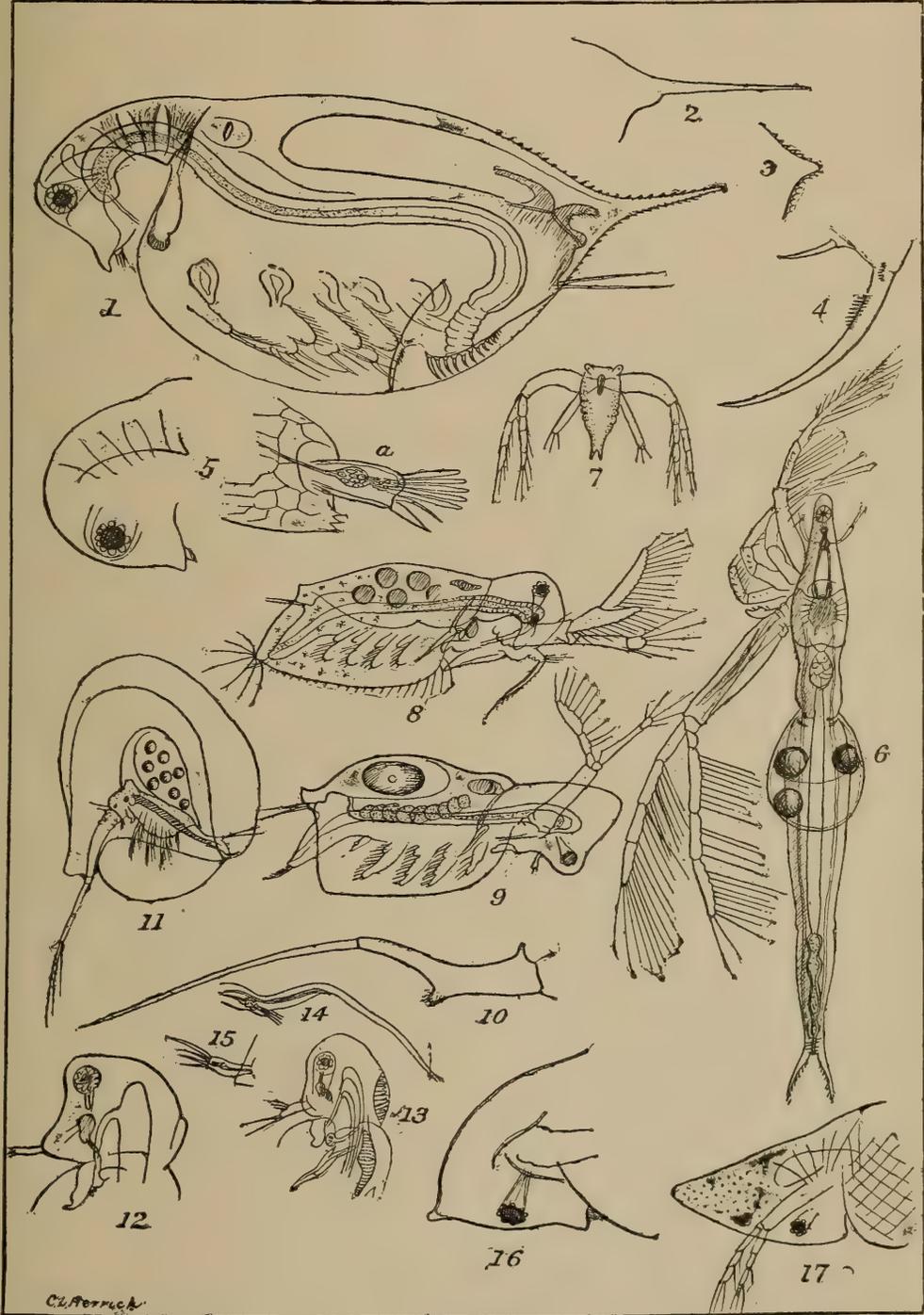
- Fig. 1-4. *Daphnia pulex*, var. *nasutus*.
Fig. 5. outline of head and (a) beak of *D. similis*.
Fig. 6. *Leptodora hyalina*, seen from above.
Fig. 7. " " larva.
Fig. 8. *Latona setifera*, female.
Fig. 9. *Limnosida frontosa*, female.
Fig. 10. " " antennule of male.
Fig. 11. *Holopedium gibberum*, female.
Fig. 12. *Sida elongata*, head outline.
Fig. 13. *Sida crystallina*, head outline of young female.
Fig. 14. " " antennule of male.
Fig. 15. " " " of female.
Fig. 16. *Daphnia galeata*, outline of head.
Fig. 17. " "*vitrea*" " " "

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PLATE N.

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C. L. Pettrich

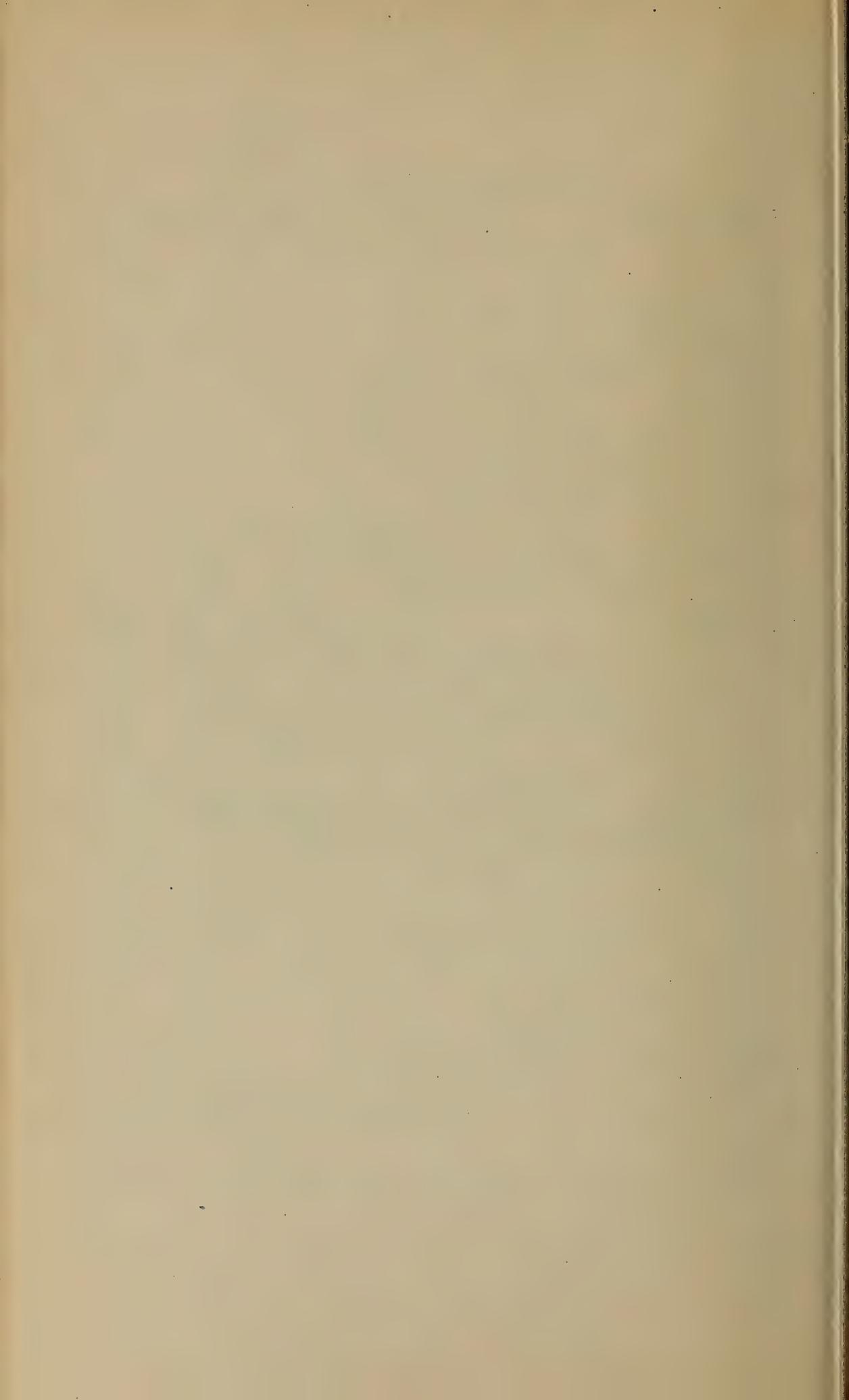


PLATE O.

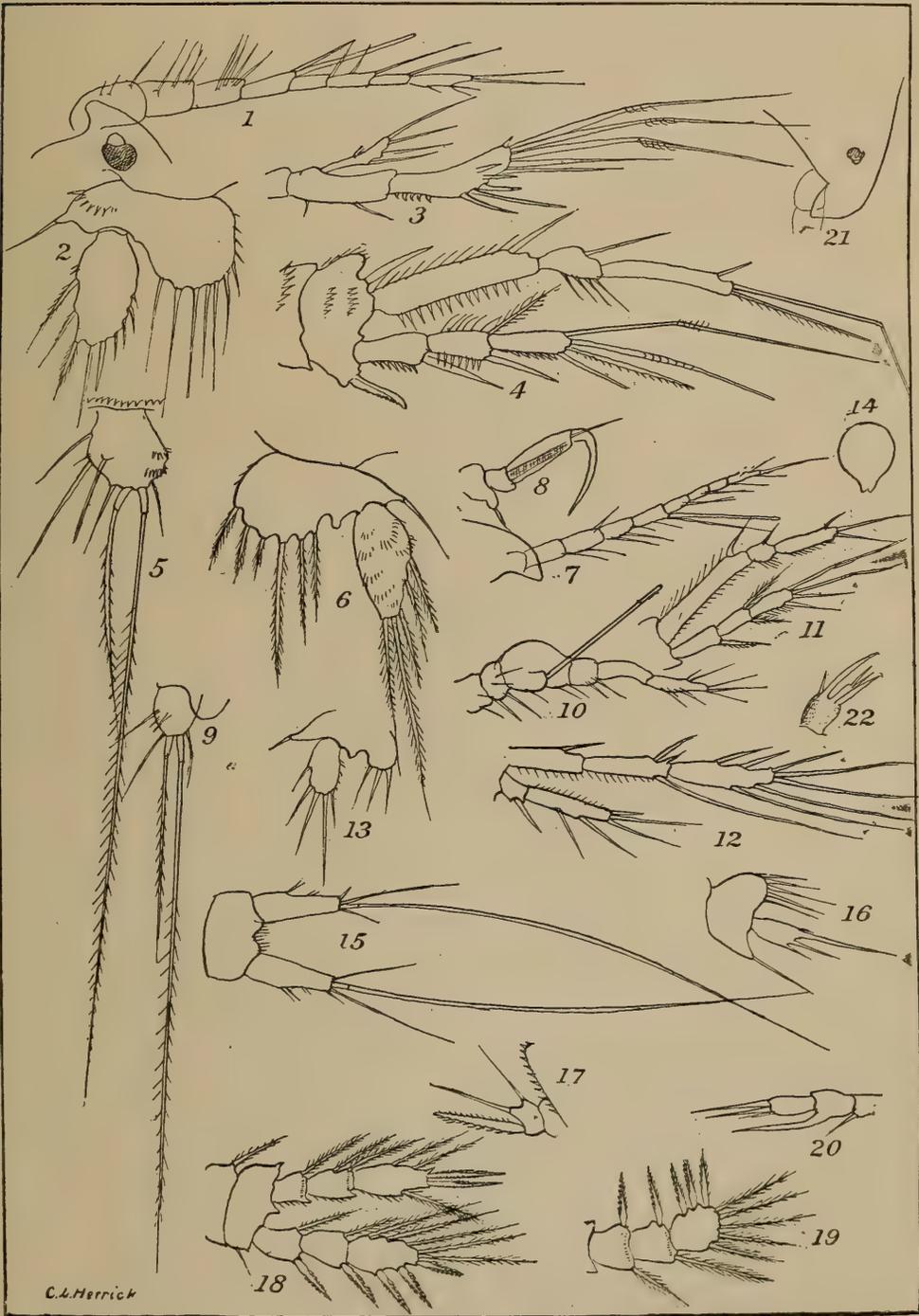
- Fig. 1. *Canthocamptus illinoisensis*, antenna of female.
 Fig. 2. " " fifth foot of female.
 Fig. 3. " " antennule.
 Fig. 4. " " first foot.
 Fig. 5. " " caudal stylet.
 Fig. 6. *Canthocamptus northumbricus*, var. *americanus*, fifth
 foot of female.
 Fig. 7. " " antenna of female.
 Fig. 8. " " maxilliped.
 Fig. 9. " " caudal stylet.
 Fig. 10. " " antenna of male.
 Fig. 11. " " first foot.
 Fig. 12. " " fourth foot.
 Fig. 13. " " fifth foot of male.
 Fig. 14. " " frontal area.
 Fig. 15. *Canthocamptus tenuicaudis*, stylets.
 Fig. 16. " " fifth foot of female.
 Fig. 17. *Cyclops serrulatus*, fifth foot.
 Fig. 18. " " fourth foot.
 Fig. 19. " " outer ramus of first foot.
 Fig. 20. *Canthocamptus northumbricus*, inner ramus of third
 male foot.
 Fig. 21. " " beak.
 Fig. 22. " " maxilla.

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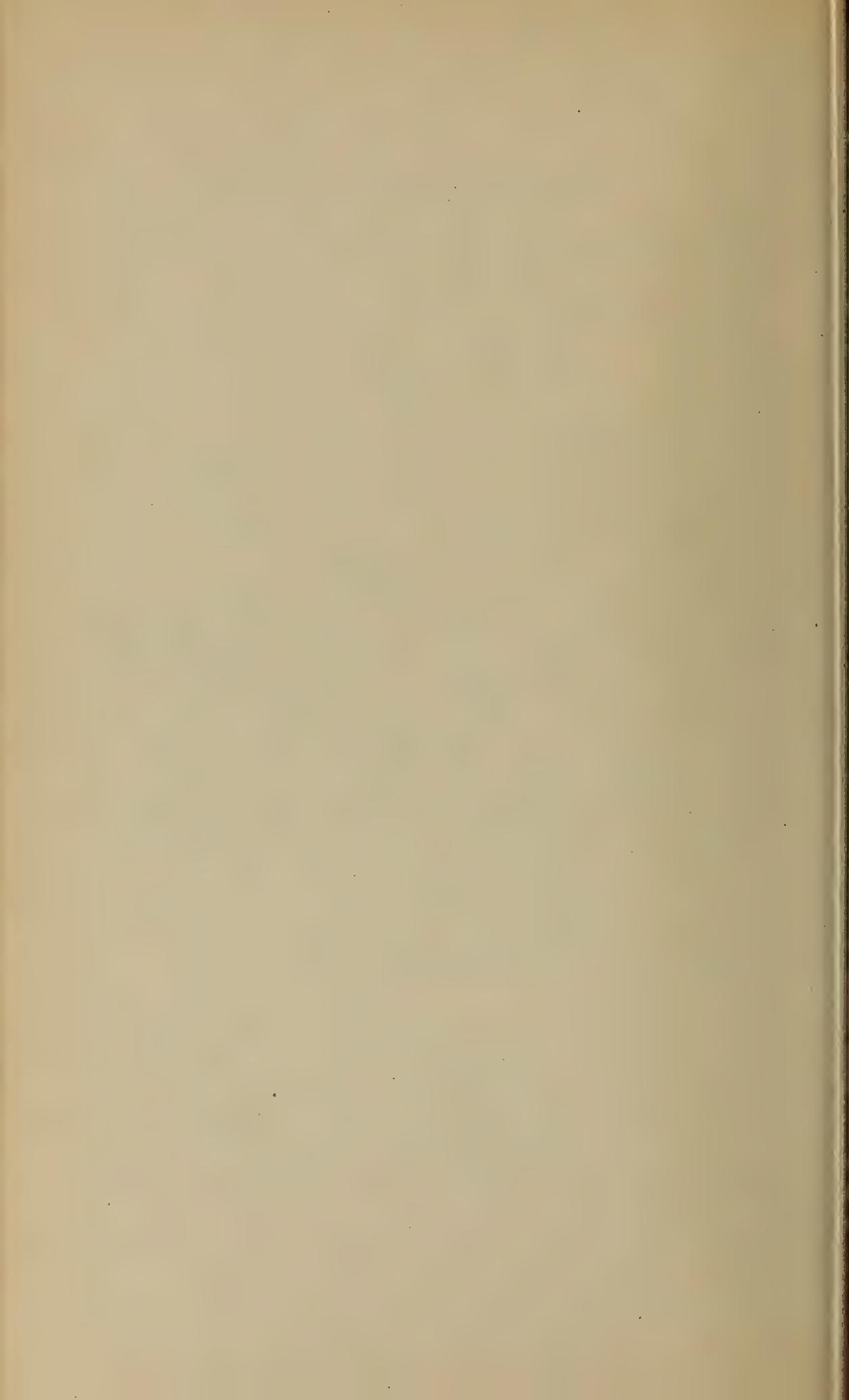
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PLATE O.

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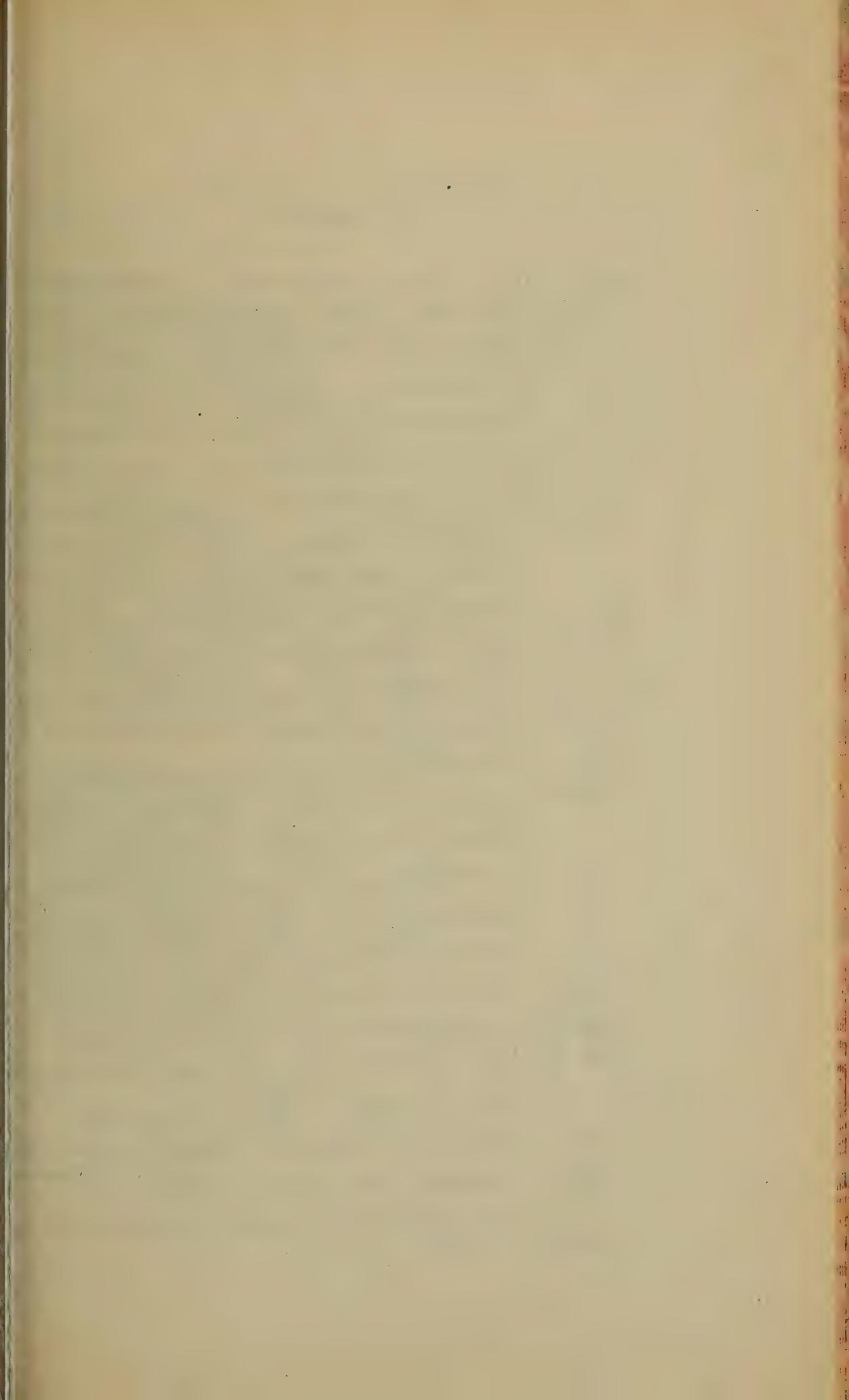


PLATE P.

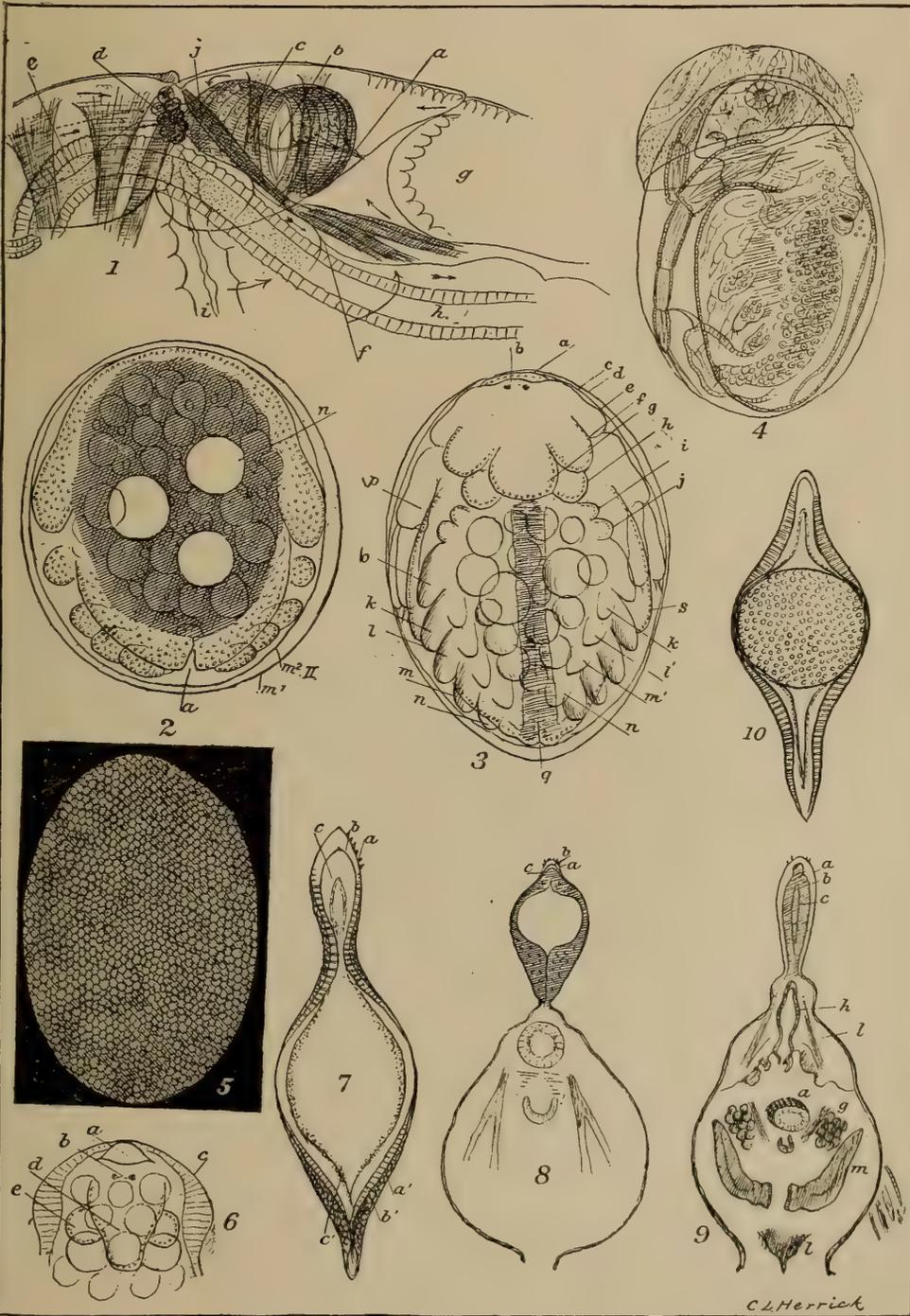
- Fig. 1. Heart of *Simocephalus vetulus*. a, tendons attached to lateral walls of heart. b, venous opening of heart. c, muscular bands supporting the abdomen, connected by transverse bands. d, cells of nutritive matter hiding the arterial opening. e, thin membrane seen in section which separates the venous from the arterial blood currents, is in focus near the side, but its situation in the center is shown by the dotted line. Above this or outside it is the attachment of the powerful antennary and mandibular muscles. f, posterior arterial sinus. g, brood-sac. h, alimentary canal with thick glandular cell walls. i, shell gland or excretory organ. j, powerful muscles supporting and moving the abdomen.
- Fig. 2. An early stage of the embryo of *Daphnia schæfferi*. a, anus. n, nutritive globules or fat drops characteristic of the summer embryo. m¹, m², outer and inner envelope of the embryo. This is a nauplius stage, but not the first or proper nauplius. The portion darkly shaded is nutritive yolk.
- Fig. 3. A well advanced winter embryo of *D. schæfferi*. a, shell growing over the eyes. b, c, inner shell. d, outer shell. e, lateral part of the head. f, antennules. g, labrum. h, mandibles. i, maxilla. j, second maxilla? k', l', m', n', branchial appendages of the 2d-5th pairs of feet. represented by k, l, m, n. o, first foot. p, antenna, q, anus and intestine partly completed. s, shell growing out from the maxillary region.
- Fig. 4. Older embryo bursting outer shell.
- Fig. 5. Egg after extrusion into the brood cavity.
- Fig. 6. Head of young embryo. a, lenses in formation. b, eyes appearing as dark flecks. c, shell growing over the head. d, labrum. e, antennule.
- Fig. 7. Longitudinal section through an ephippium.
- Fig. 8. Vertical section through an ephippial *Daphnia schæfferi*.
- Fig. 9. Somewhat oblique section through the ephippium (a, b, c), heart (h), mandibles (m), and labrum (l).
- Fig. 10. A vertical section through the ephippium and its egg.

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PLATE P.

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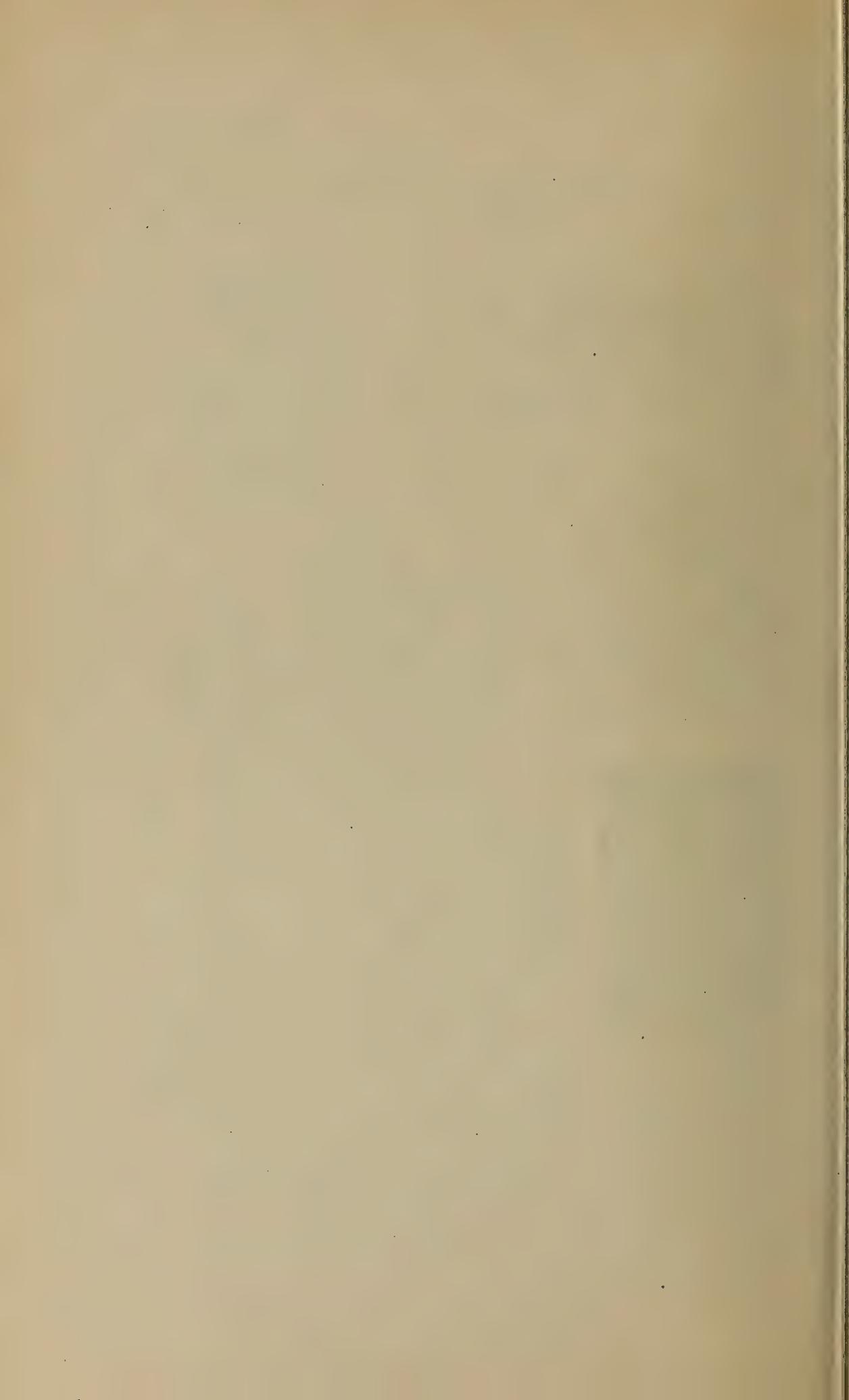


PLATE Q.

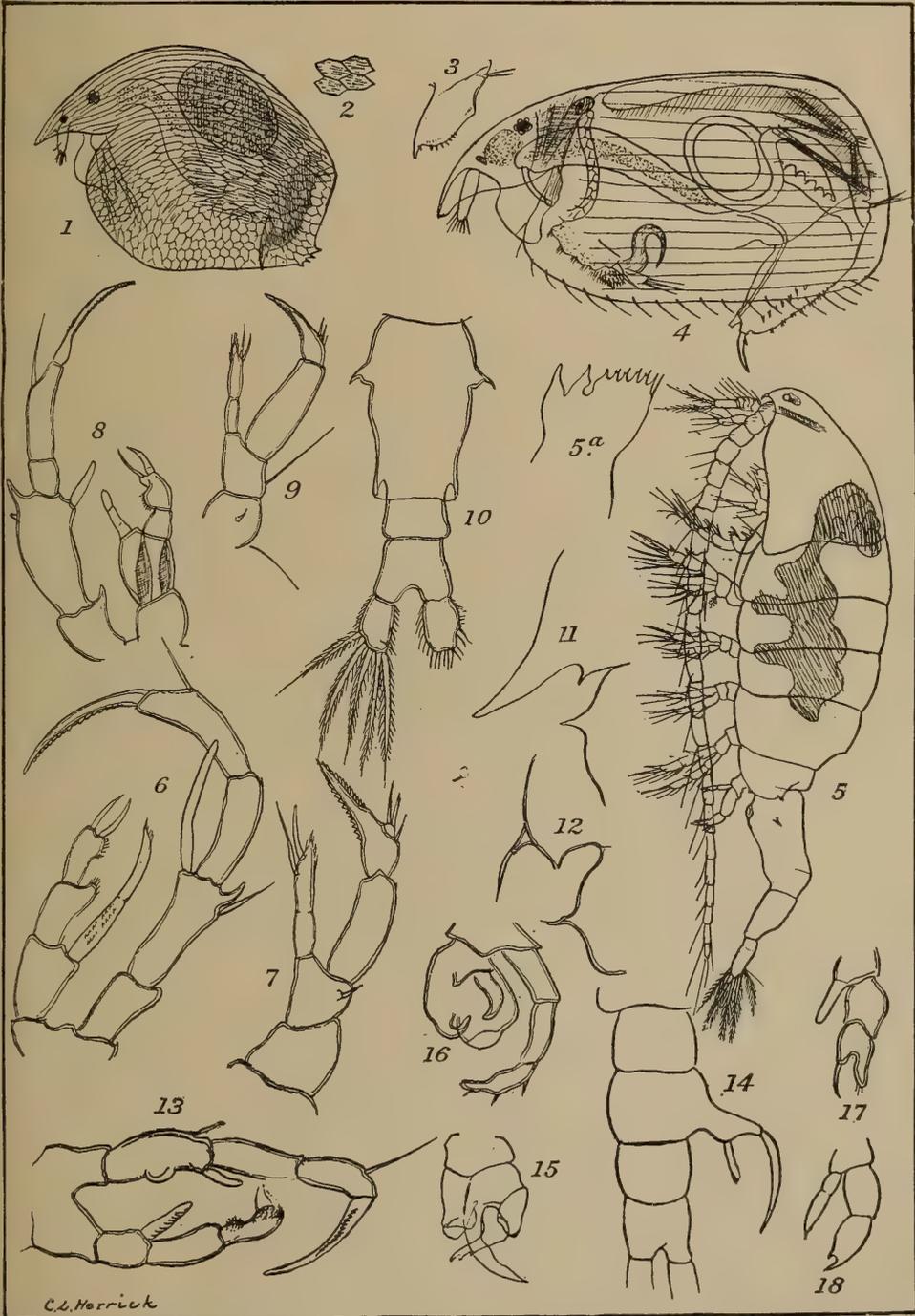
- Fig. 1. *Alonella pulchella*, female.
 Fig. 2. " " reticulations.
 Fig. 3. " " post-abdomen.
 Fig. 4. *Alona modesta*, male.
 Fig. 5. *Diaptomus similis*, female. 5a. jaw.
 Fig. 6. " " fifth foot of male.
 Fig. 7. " " " " " female.
 Fig. 8. " *minnetonka*, fifth foot of male.
 Fig. 9. " " " " " female.
 Fig. 10. " " abdomen of female.
 Fig. 11. " *stagnalis*, margin of last thoracic segment.
 Fig. 12. " *sanguineus*, " " " " "
 Fig. 13. " *stagnalis*, fifth foot of the male.
 Fig. 14. *Epischura fluviatilis*, abdomen of male.
 Fig. 15. " *lacustris*, fifth feet of male.
 Fig. 16. " *fluviatilis*, " " " "
 Fig. 17. *Diaptomus pallidus* " " " " inner ramus.
 Fig. 18. " *sicilis* " " " " " "

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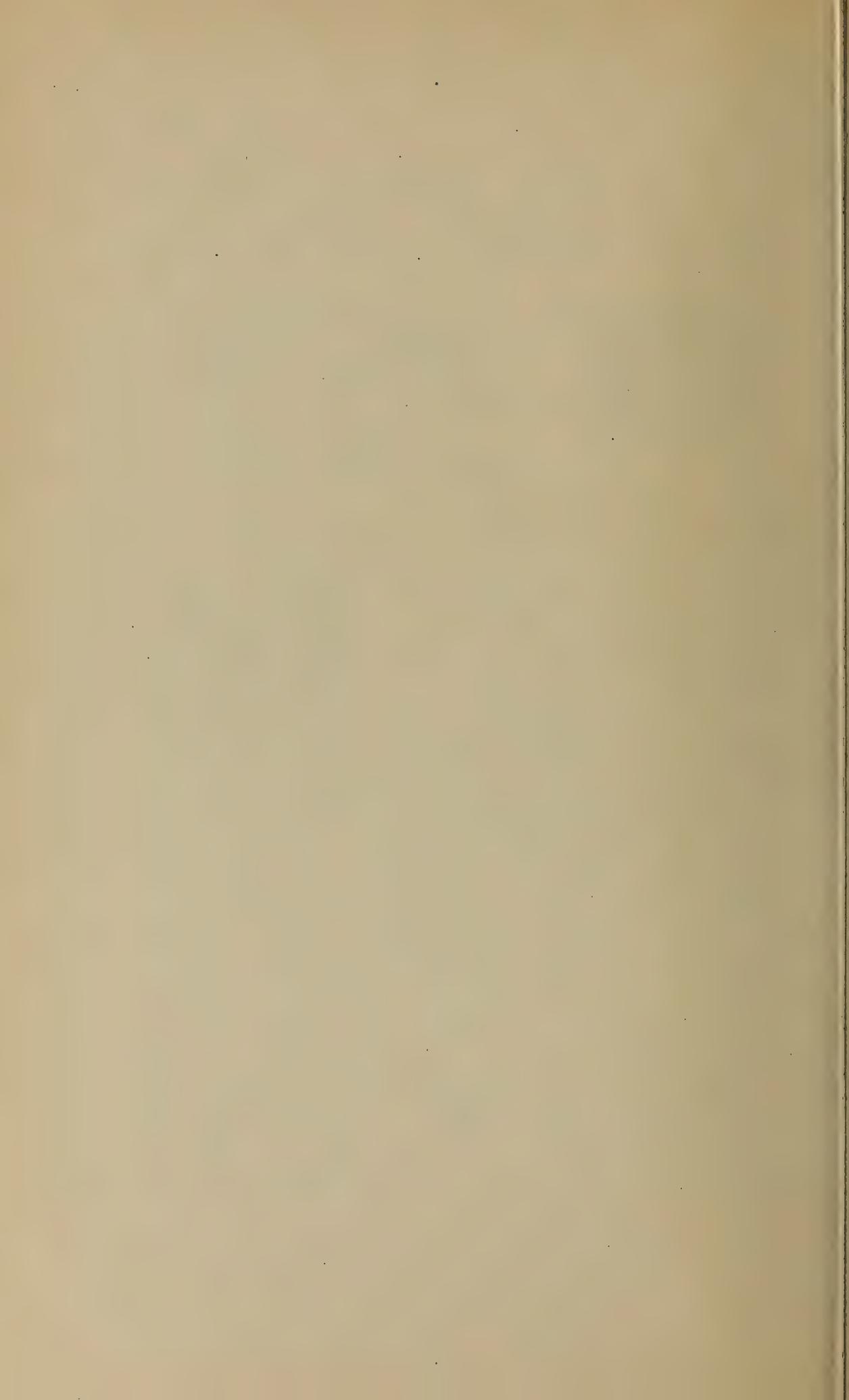
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PLATE Q.

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C. C. Horrick



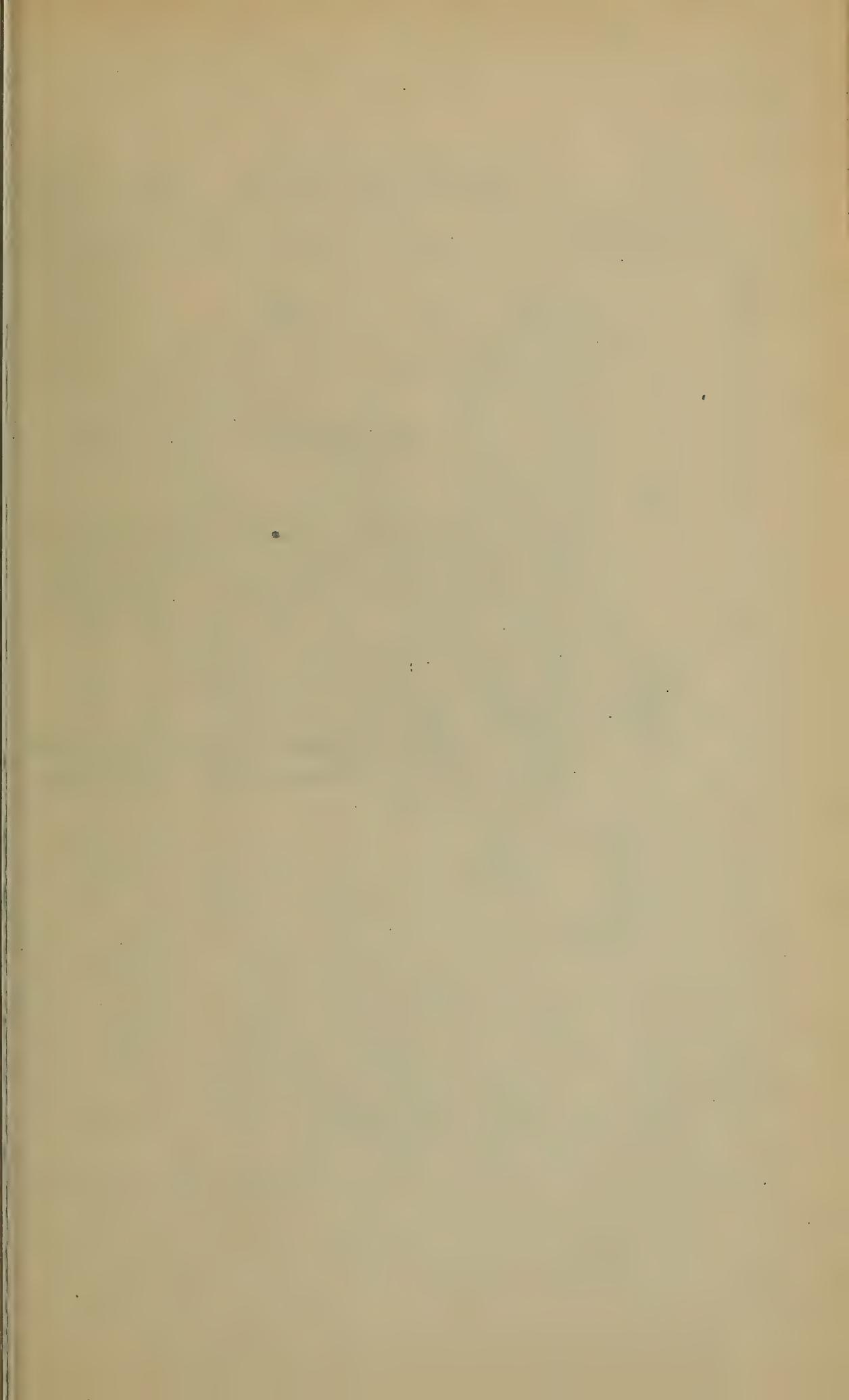


PLATE Q¹.

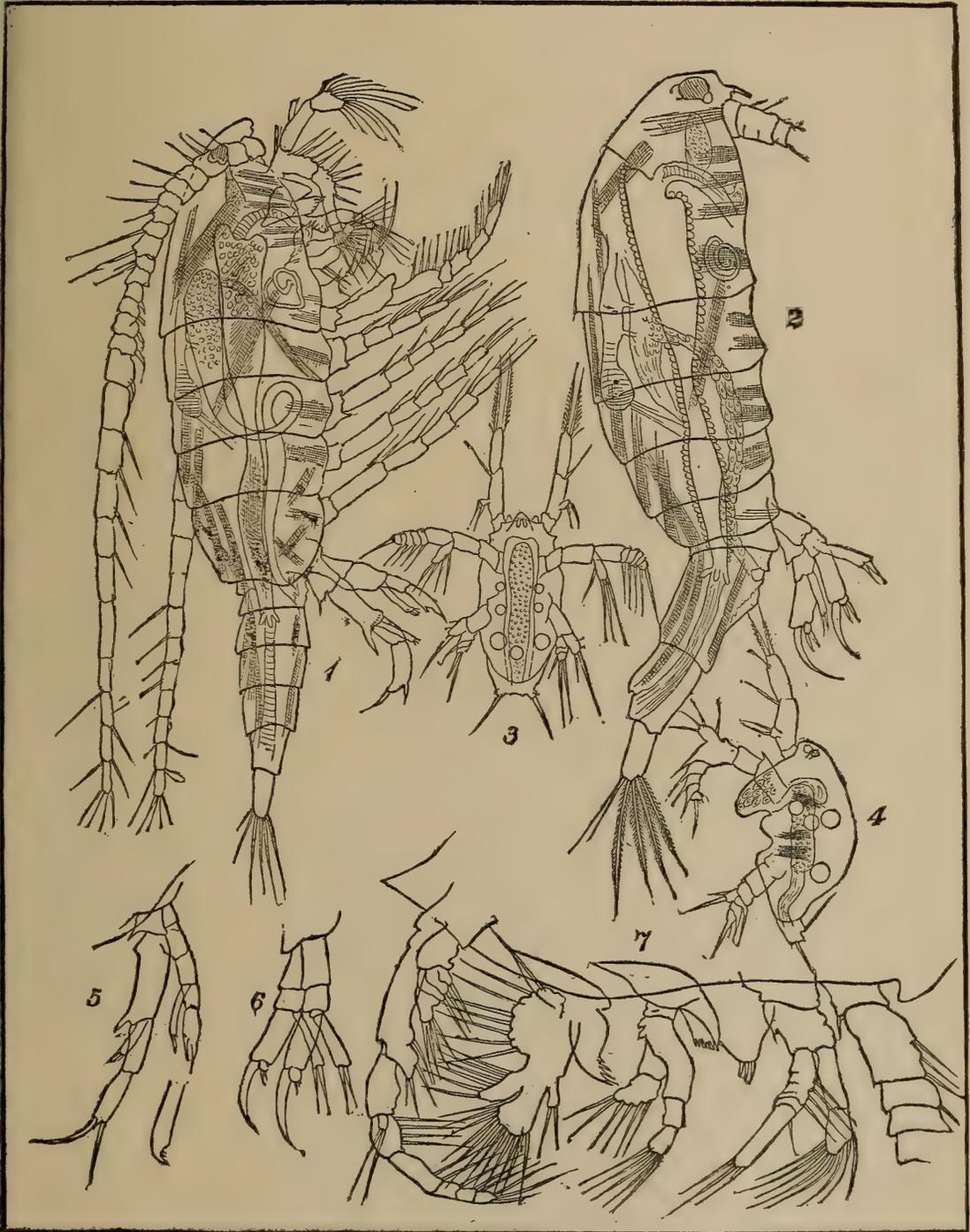
- Fig. 1. *Diaptomus* sp. Young male; external parts as yet but partly developed showing alimentary and reproductive systems as well as a portion of the muscular system. The looped tube is the vas deferens. The small irregularly coiled tube anteriorly is the shell-gland or kidney.
- Fig. 2. female with ovary, oviducts and heart.
- Figs. 3-4. Nauplius larva of same.
- Figs. 5-6. fifth pair of feet of male and female.
- Fig. 7. mouth appendages, anteriorly the base of antennæ followed by antennule, labrum, mandible with palp, maxilla and maxilliped.

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PLATE Q¹.

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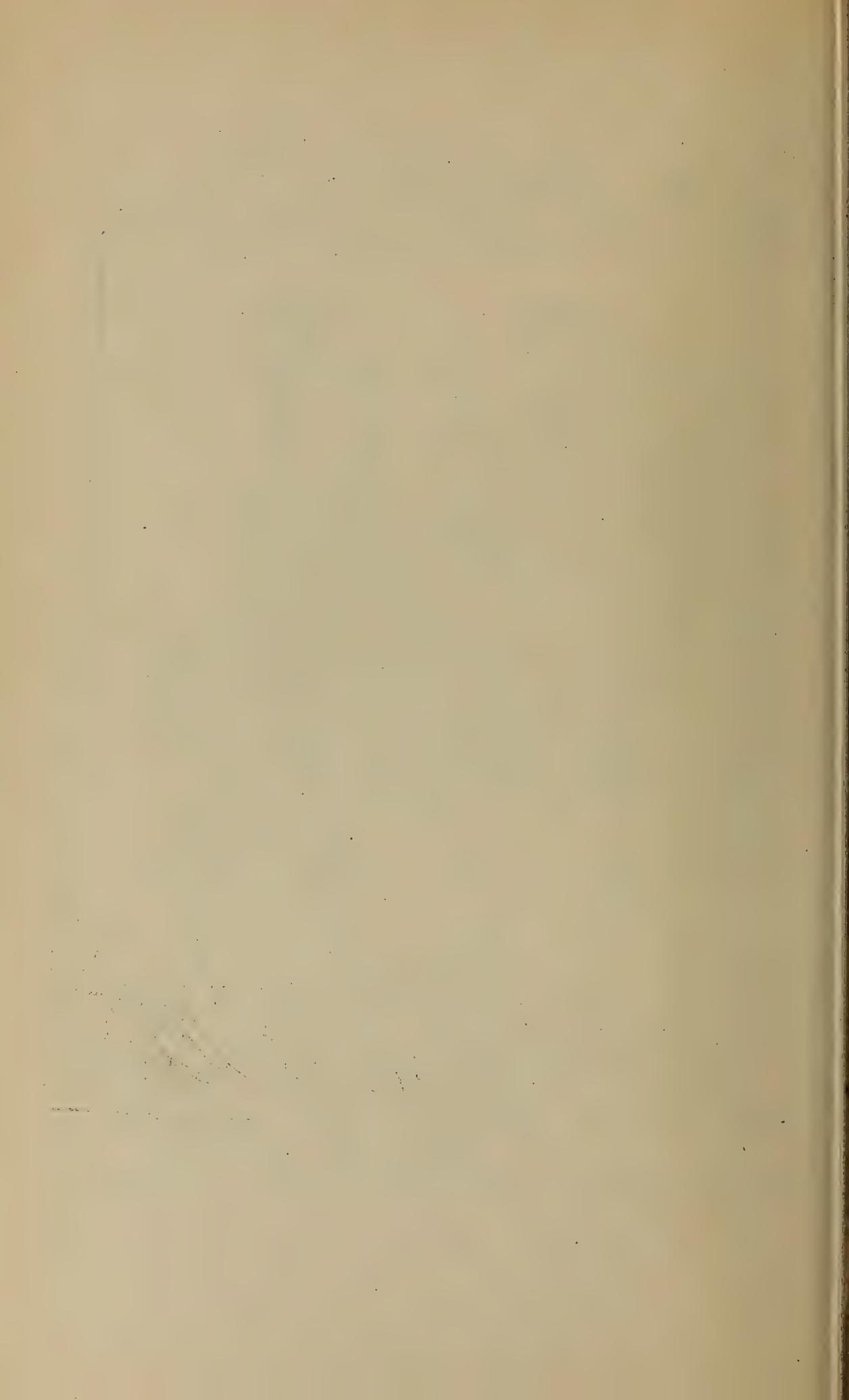


PLATE Q².

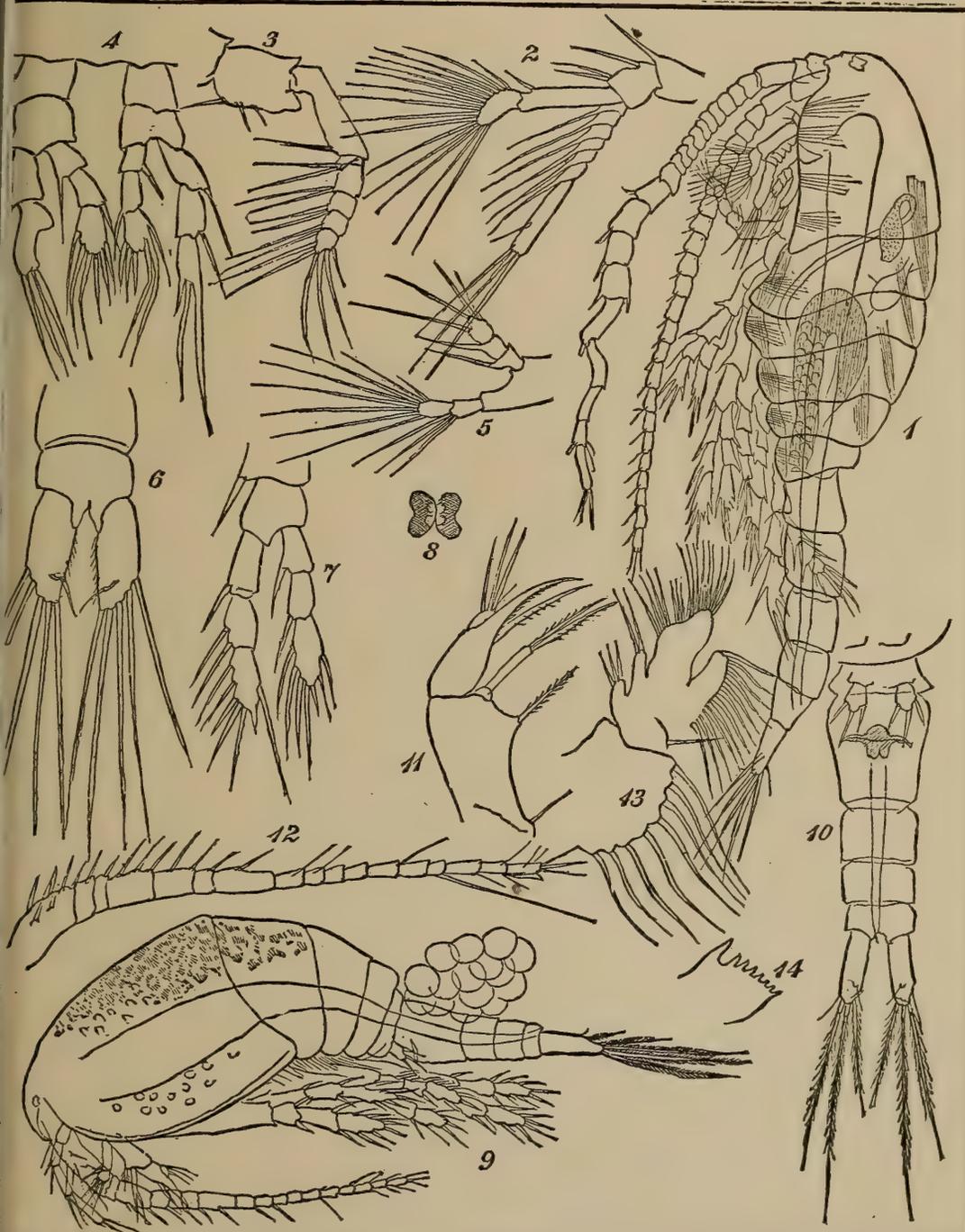
- Fig. 1. *Osphranticum labronectum* (*Potamoichetor*), male.
Fig. 2. antennule.
Fig. 3. maxilliped.
Fig. 4. fifth feet of male.
Fig. 5. palp of mandible.
Fig. 6. end of abdomen.
Fig. 7. feet of first pair.
Fig. 8. eye.
Fig. 13. maxilla.
Fig. 14. mandible.
Fig. 9. *Cyclops ater*, female.
Fig. 10. abdomen.
Fig. 11. maxilliped.
Fig. 12. antenna.

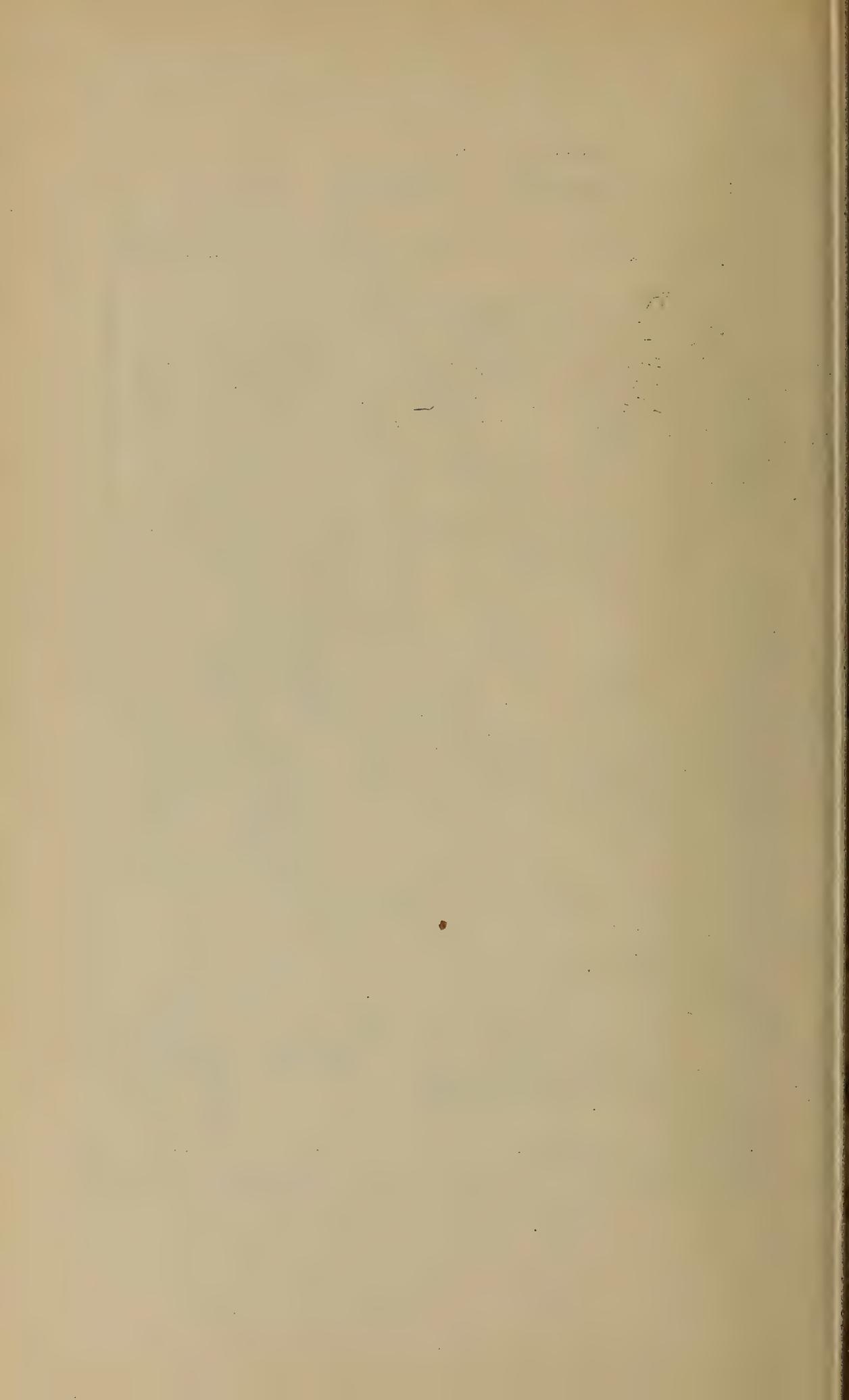
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PLATE Q².

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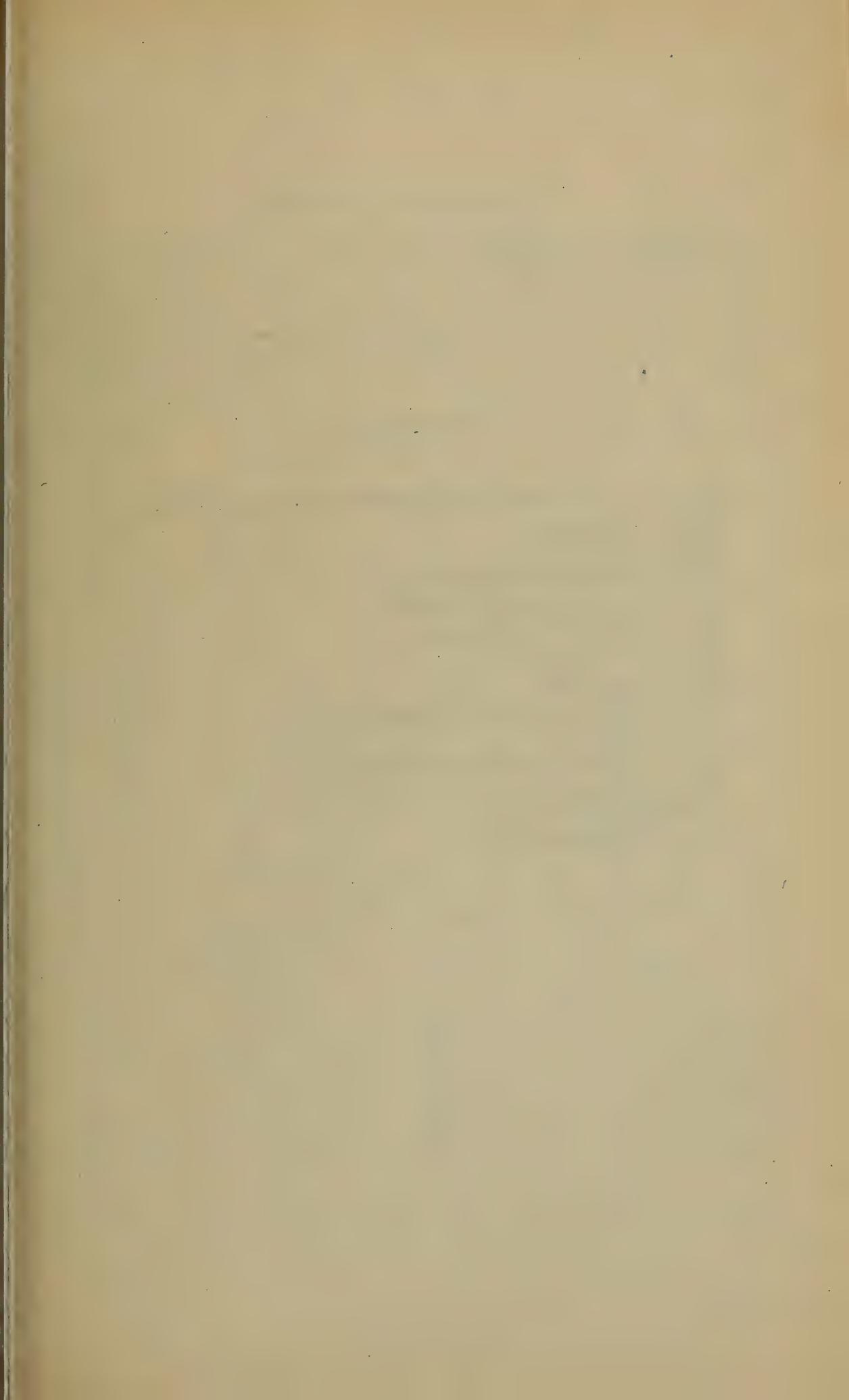


PLATE Q³.

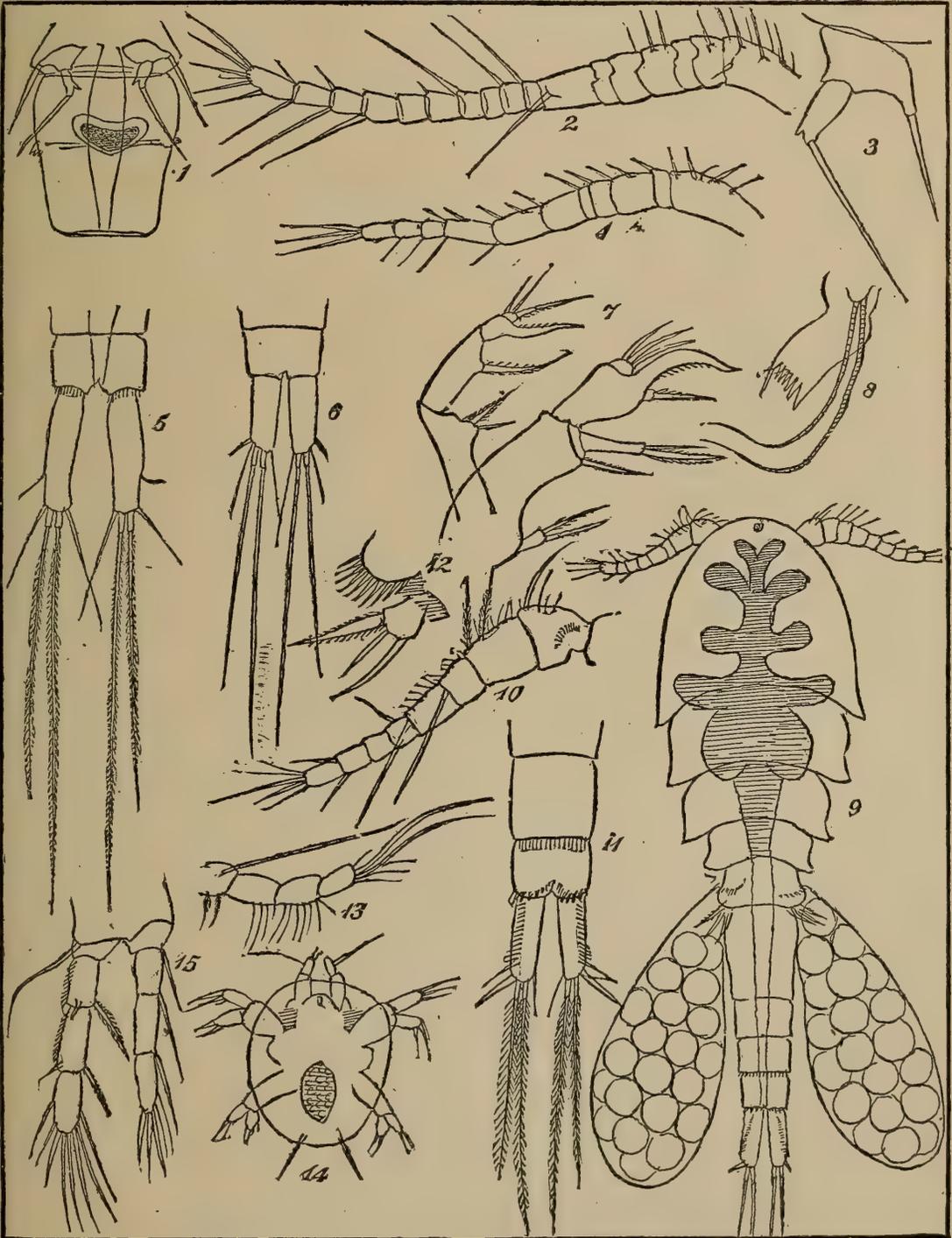
- Fig. 1. *Cyclops ingens*, first segment of abdomen of female.
Fig. 2. antenna.
Fig. 3. fifth foot.
Fig. 4. antenna of young male.
Fig. 5. stylets of mature female.
Fig. 6. stylets of young male.
Fig. 7. maxilliped.
Fig. 8. mandible.
Fig. 9. *Cyclops fimbriatus*, female.
Fig. 10. antenna.
Fig. 11. terminal portion of abdomen.
Fig. 12. female fifth foot.
Fig. 13. second antenna.
Fig. 14. Nauplius form.

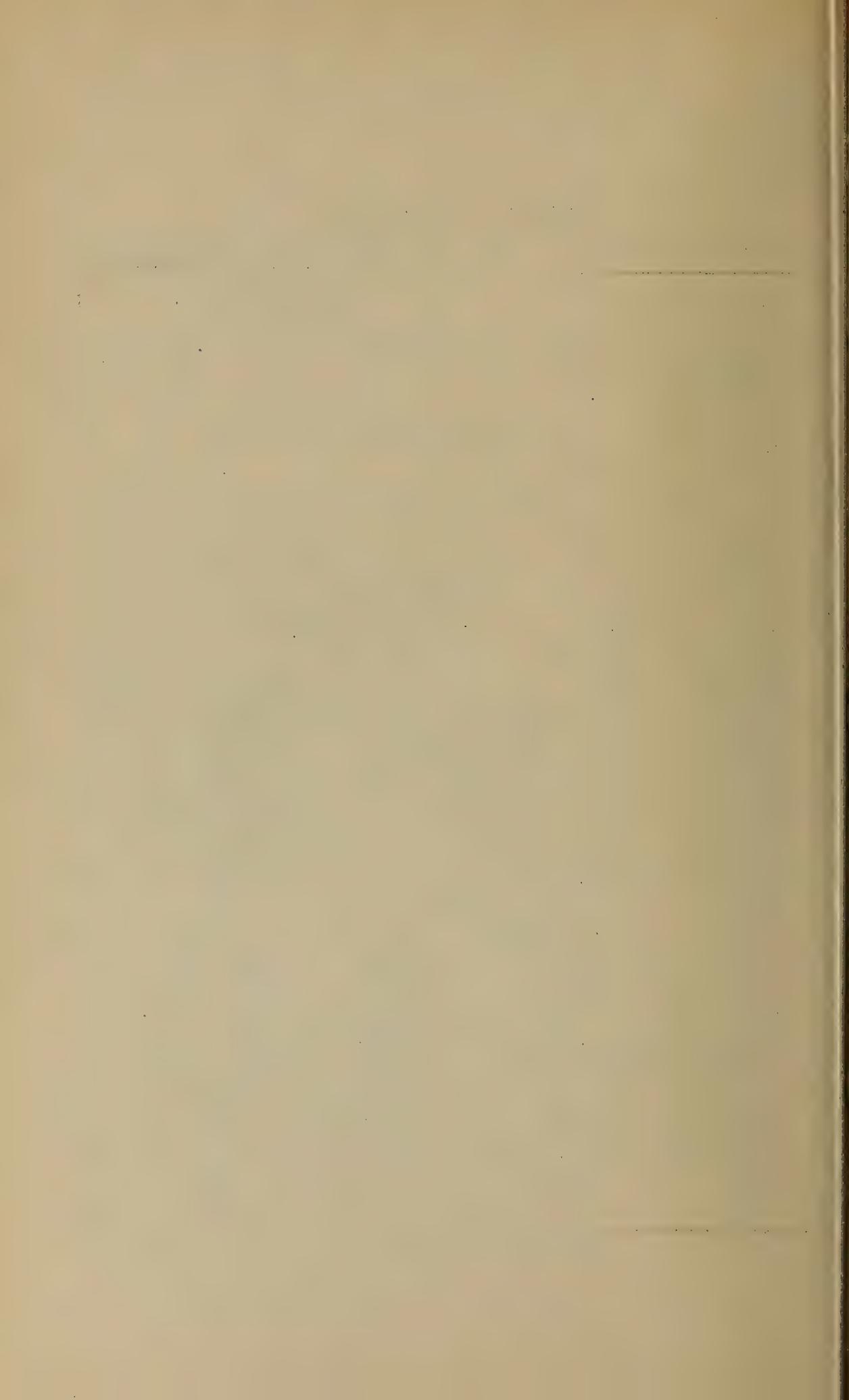
MINNESOTA CRUSTACEA.

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PLATE Q³.

Geol. & Nat. Hist. Sur. Minn.





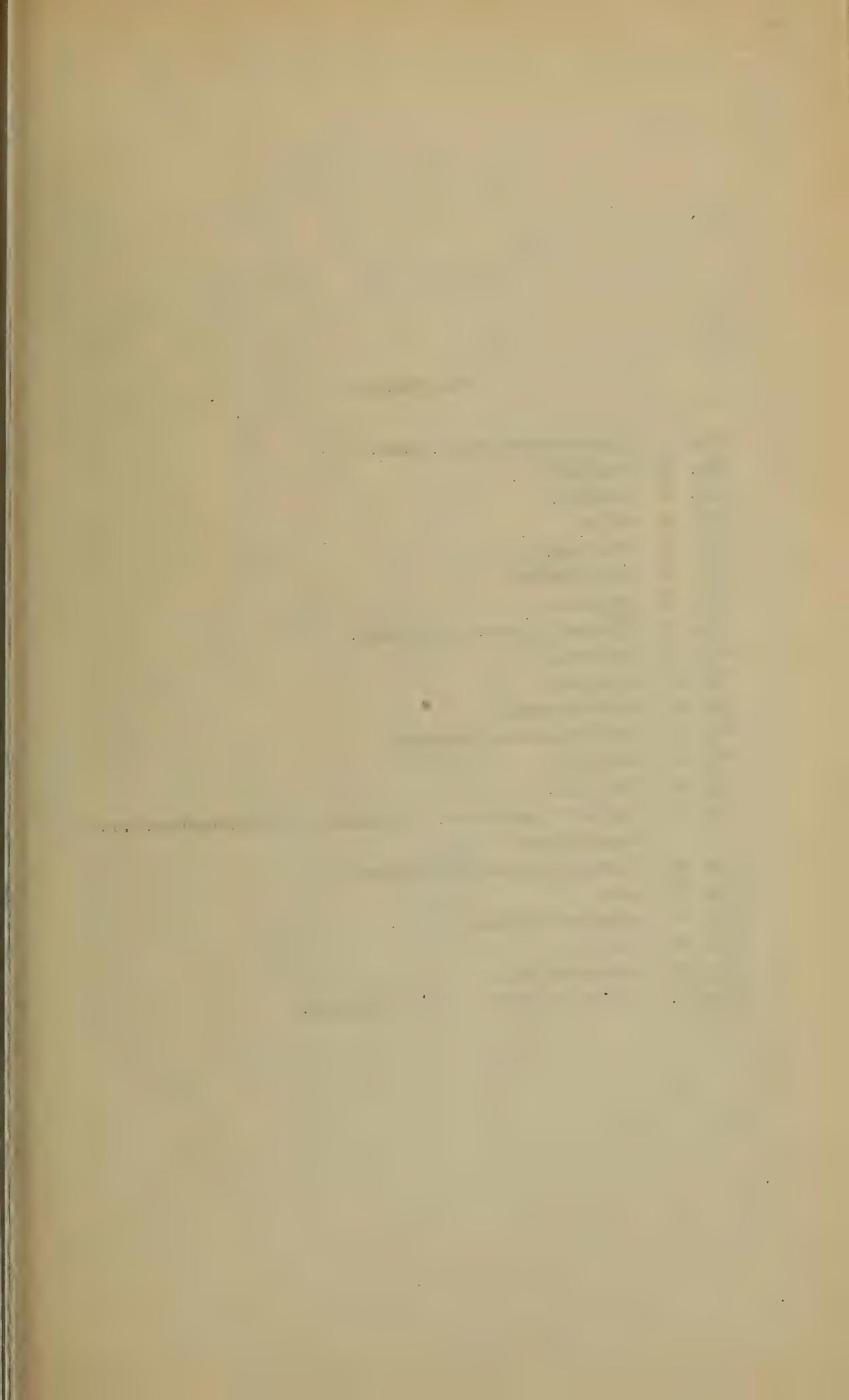


PLATE Q⁴.

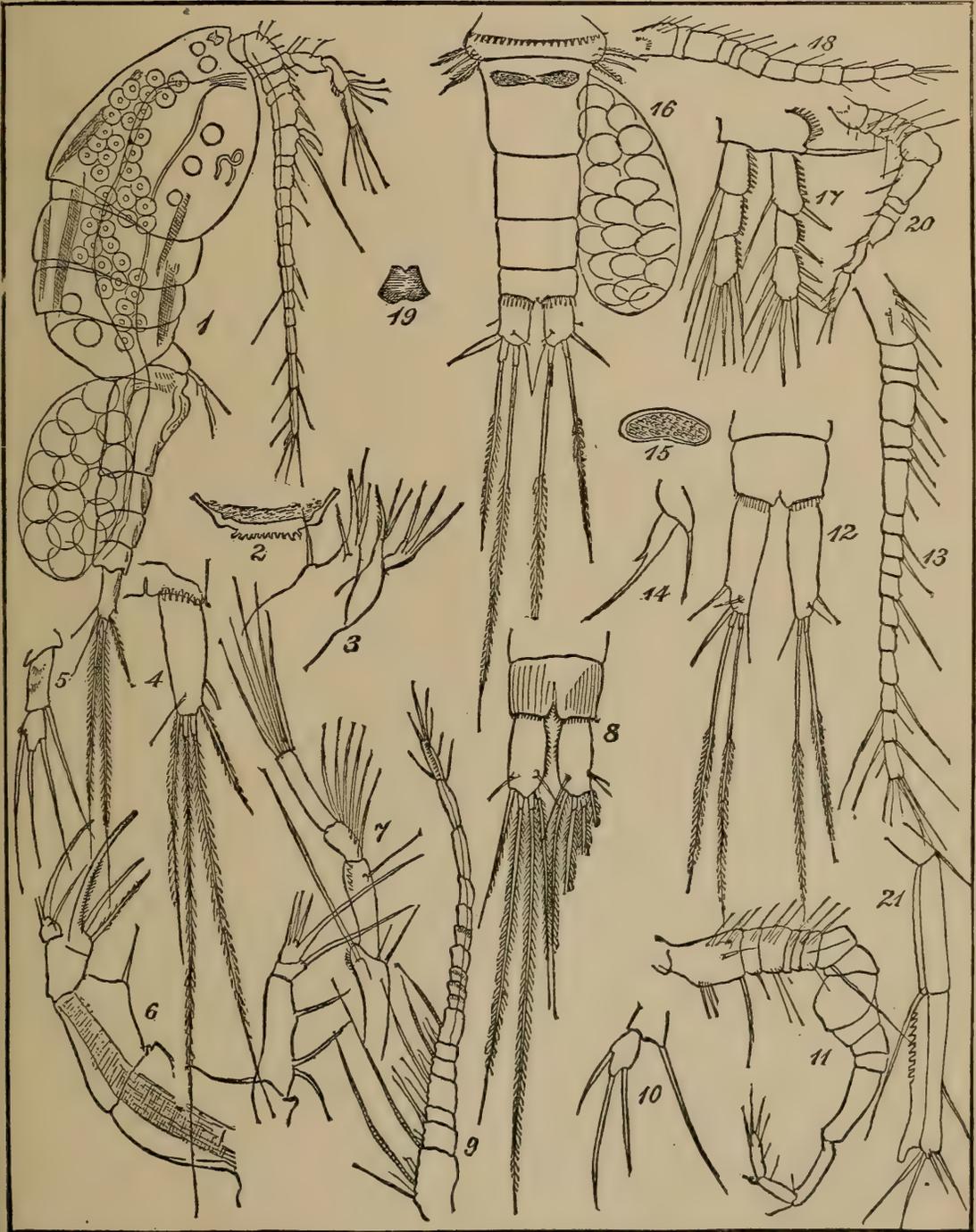
- Fig. 1. *Cyclops tenuicornis*, female.
Fig. 2. mandible.
Fig. 3. maxillæ.
Fig. 4. stylet.
Fig. 5. fifth foot.
Fig. 6. maxillipedes.
Fig. 7. antennæ.
Fig. 8. *Cyclops "signatus,"* abdomen.
Fig. 9. antenna.
Fig. 10. fifth foot.
Fig. 11. male antenna.
Fig. 12. *Cyclops parvus*, abdomen.
Fig. 13. antenna.
Fig. 14. fifth foot.
Fig. 15. *Cyclops "adolescens,"* opening of spermatheca and cement gland.
Fig. 16. *Cyclops "adolescens,"* abdomen.
Fig. 17. foot.
Fig. 18. antenna of female.
Fig. 19. eye.
Fig. 20. antenna of male.
Fig. 21. *Cyclops "signatus,"* end of antenna.

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PLATE Q⁴.

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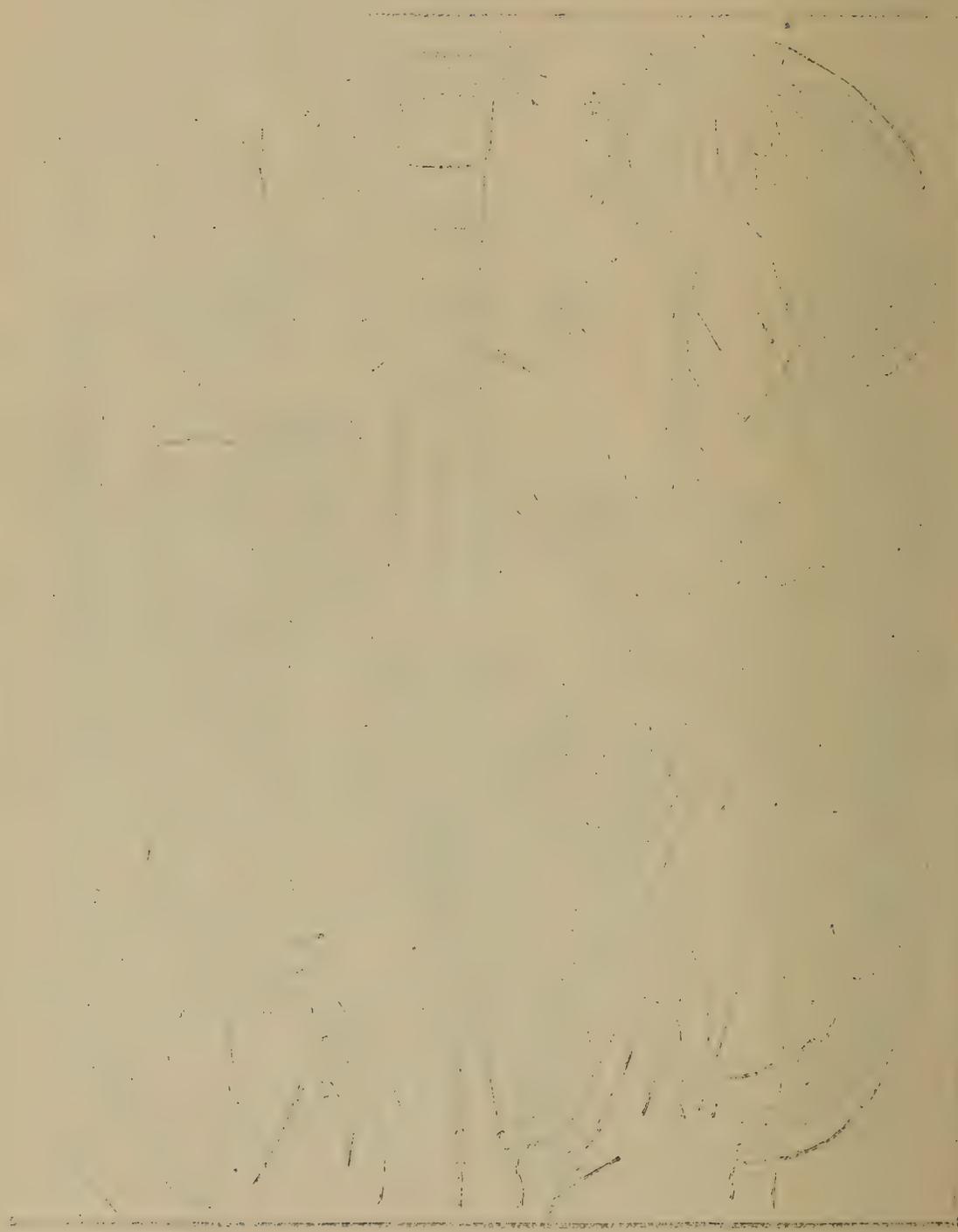


PLATE Q 5.

- Fig. 1. *Cyclops fluviatilis*, female.
Fig. 2. antenna.
Fig. 3. antenna of young.
Fig. 4. abdomen of young.
Fig. 5. foot of young.
Fig. 6. foot of adult.
Fig. 7. fifth foot.
Fig. 8. eye.
Fig. 10. *C. serrulatus*, young.
Fig. 11. *Daphnella brachyura*, female.
Fig. 12. *Daphnella brachyura*, male.
Fig. 13. edge of valves.
Fig. 14. abdomen of male.
Fig. 15. abdomen of female.
Fig. 16. antenna of male.

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PLATE Q⁵.

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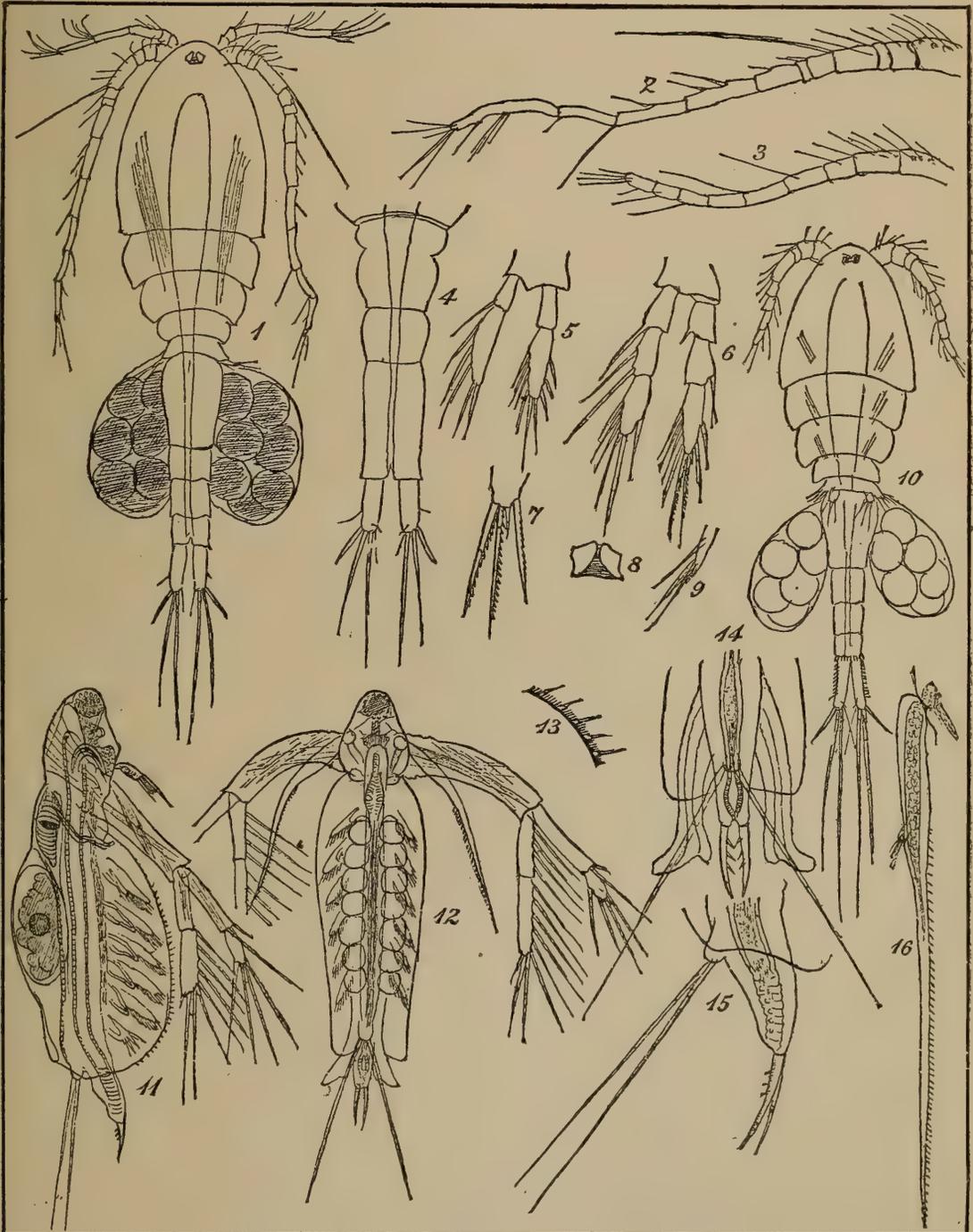


PLATE R.

- Fig. 1. *Cyclops modestus*.
 Fig. 2. " " end of abdomen.
 Fig. 3. " " outer ramus of first foot.
 Fig. 4. " " " " " second foot.
 Fig. 5. " " fifth foot.
 Fig. 6. " *phaleratus*, fourth foot.
 Fig. 7. " " outer ramus of first foot.
 Fig. 8. " " fifth foot.
 Fig. 9. " " caudal stylets.
 Fig. 10. " " antenna of young otherwise perfect.
 Fig. 11. " *fimbriatus*, end of abdomen.
 Fig. 12. " *diaphanus*, abdomen.
 Fig. 13. " *ater*, inner ramus of first foot.
 Fig. 14. " " outer " " " "
 Fig. 15. " " " " " fourth foot.
 Fig. 16. " "*signatus*," fourth foot.
 Fig. 17. " *ater*, inner ramus of fourth foot.
 Fig. 18. " " stylet.
 Fig. 19. " *sp.?* first foot.
 Figs. 20, 21. " " terminal segments of fourth foot.
 Fig. 22. " " fifth foot.
 Fig. 23. *Chydorus globosus*, first foot of male.

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PLATE R.

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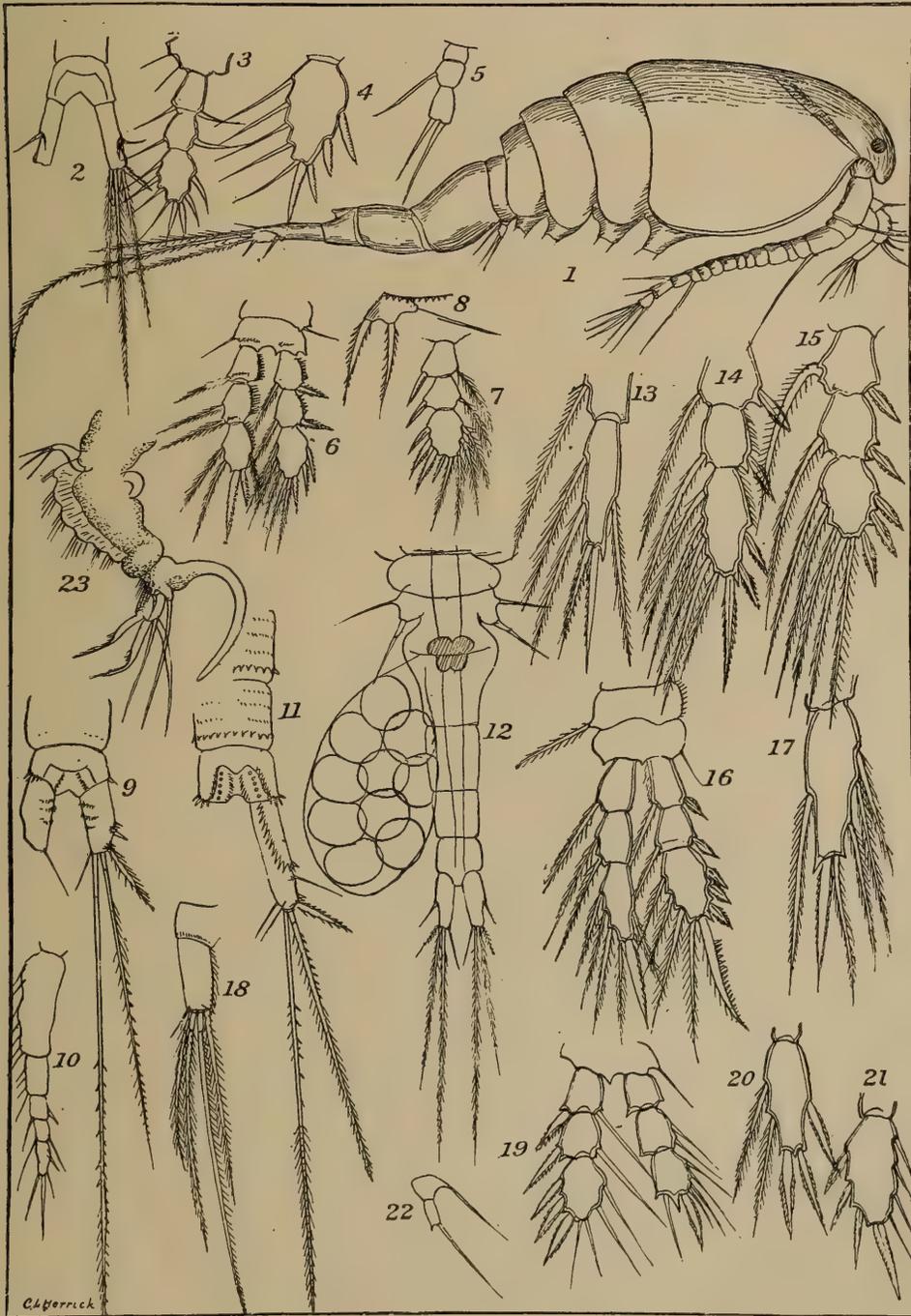


PLATE S.

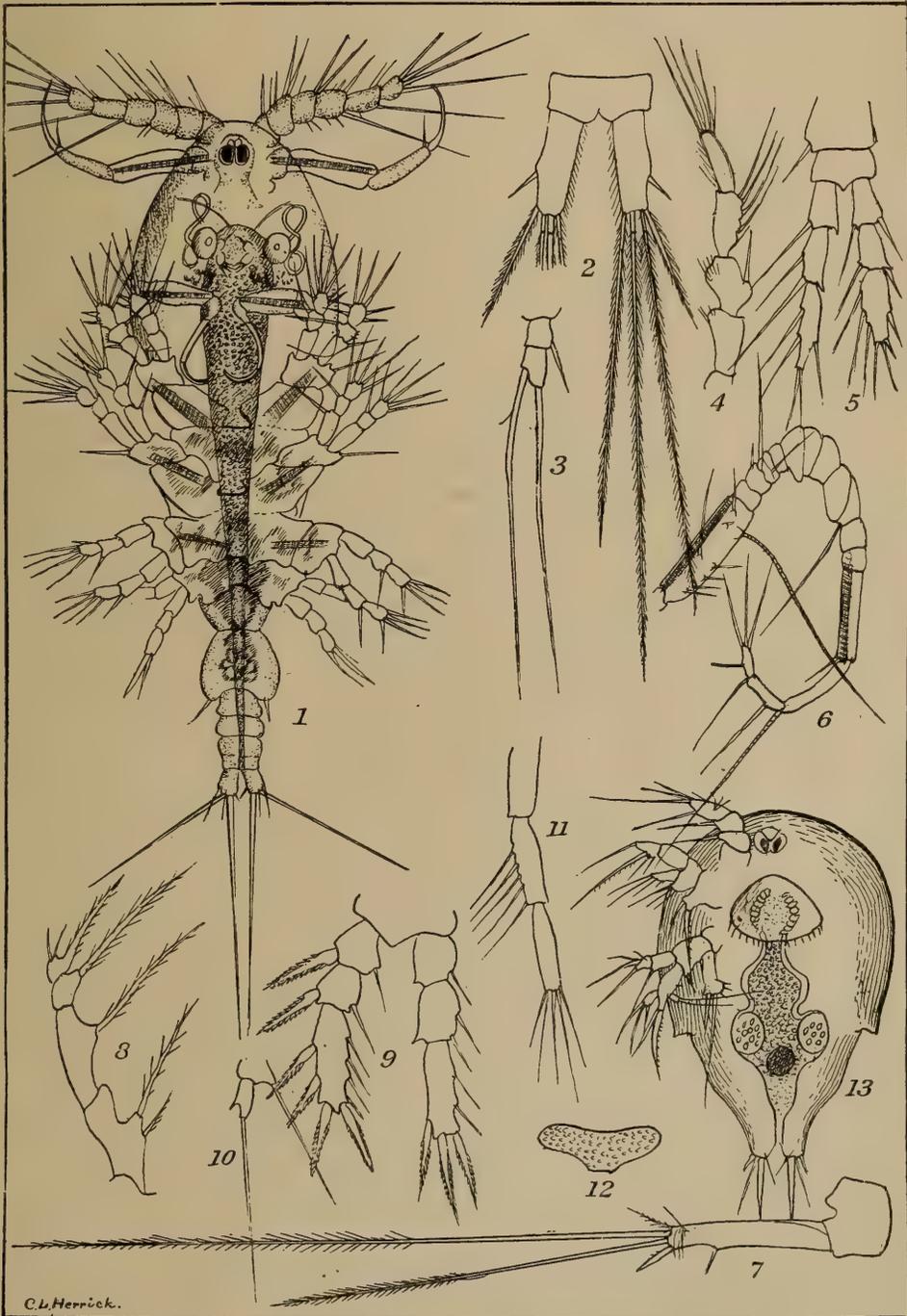
- Fig. 1. *Ergasilus depressus*, male.
Fig. 2. *Cyclops oithonoides* (Amer. *C. tenuissimus*, var.), stylets.
Fig. 3. " " fifth foot.
Fig. 4. " " antennules.
Fig. 5. " " fourth feet.
Fig. 6. " " antenna of male.
Fig. 7. " " *brevispinosus*, stylet.
Fig. 8. " " " inner maxilliped.
Fig. 9. " " " swimming foot.
Fig. 10. " " " fifth foot,
Fig. 11. " " " antennule.
Fig. 12. " " " opening of spermatheca.
Fig. 13. *Cyclops sp.?*, nauplius.

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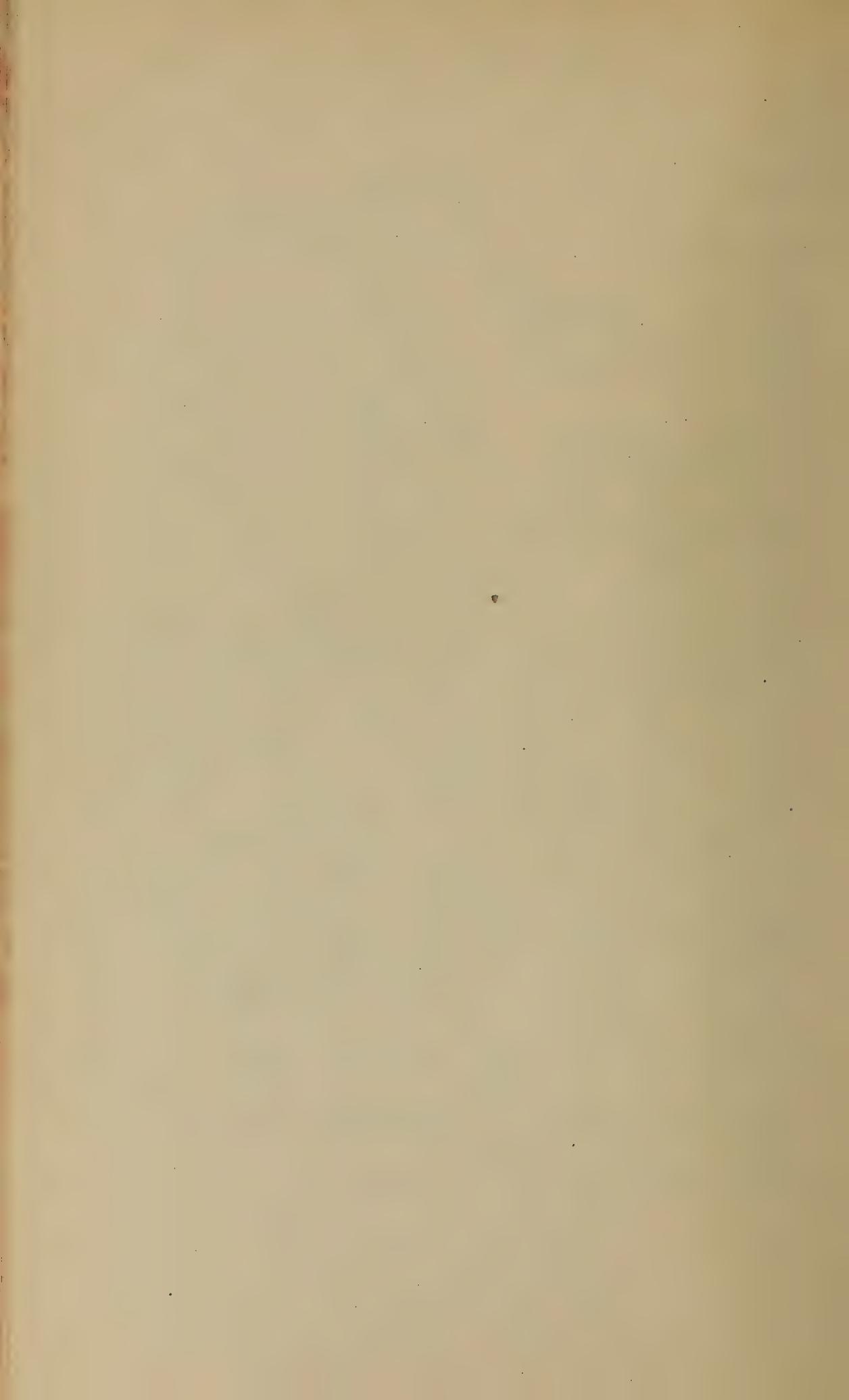
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PLATE S.

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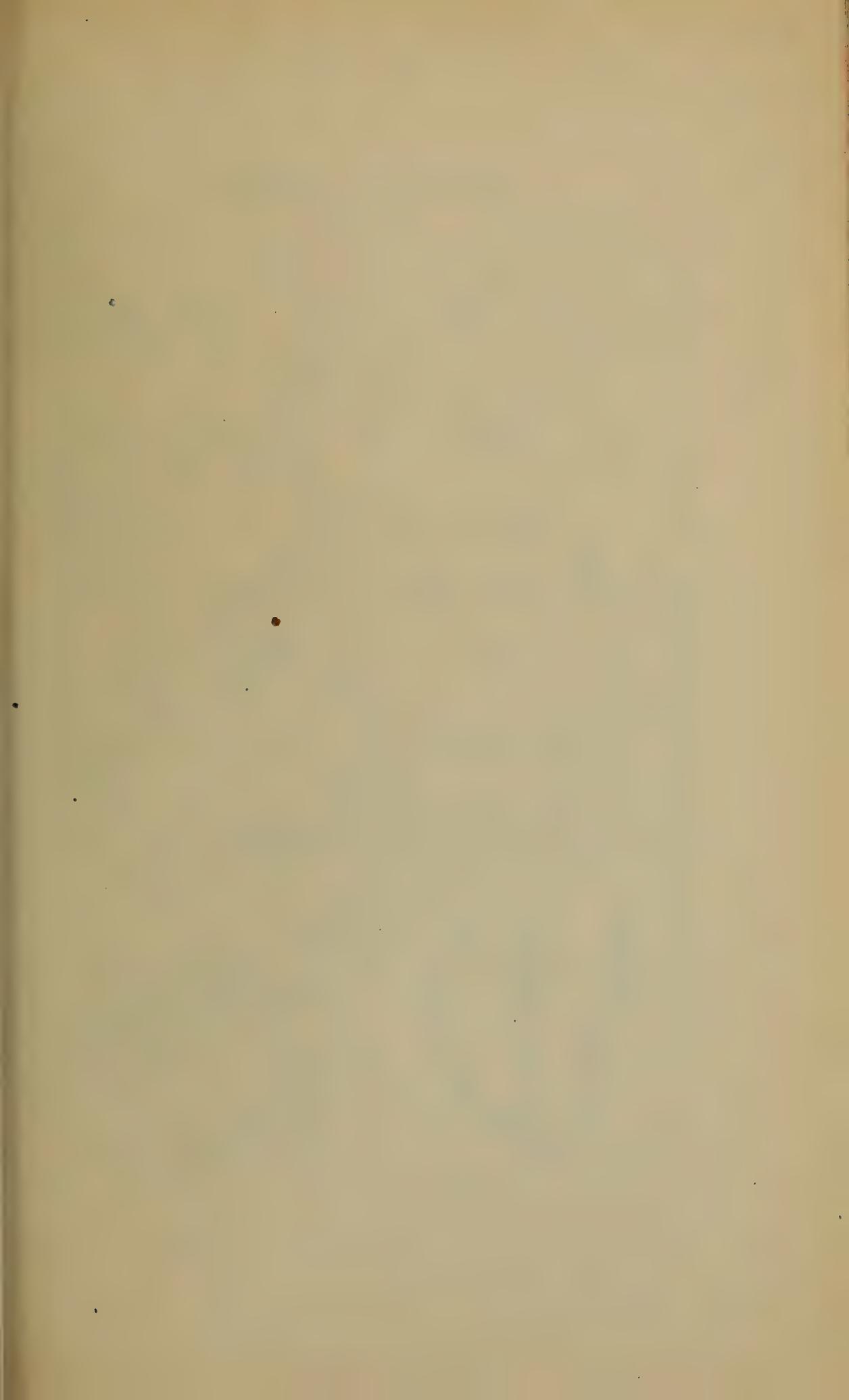


PLATE T.

- Fig. 1. *Canthocamptus minnesotensis*, first foot.
Fig. 2. " " stylets.
Fig. 3. " " antenna of female.
Fig. 4. " " fifth foot of female.
Fig. 5. " " " " " male.
Fig. 6. " " antenna of male.
Fig. 7. *Daphnia galeata*, young.
Fig. 8. " " male.
Fig. 9. *Camptocercus leucocephalus*, male.
Fig. 10. *Alonella excisa*, male.
Fig. 11. *Cyclops insignis*, first foot, outer ramus.
Fig. 12. " " fifth foot.
Fig. 13. " " fourth foot.
Fig. 14. " " stylet.
Fig. 15. Worm parasitic in arterial sinus of *Daphnia schæfferi*.

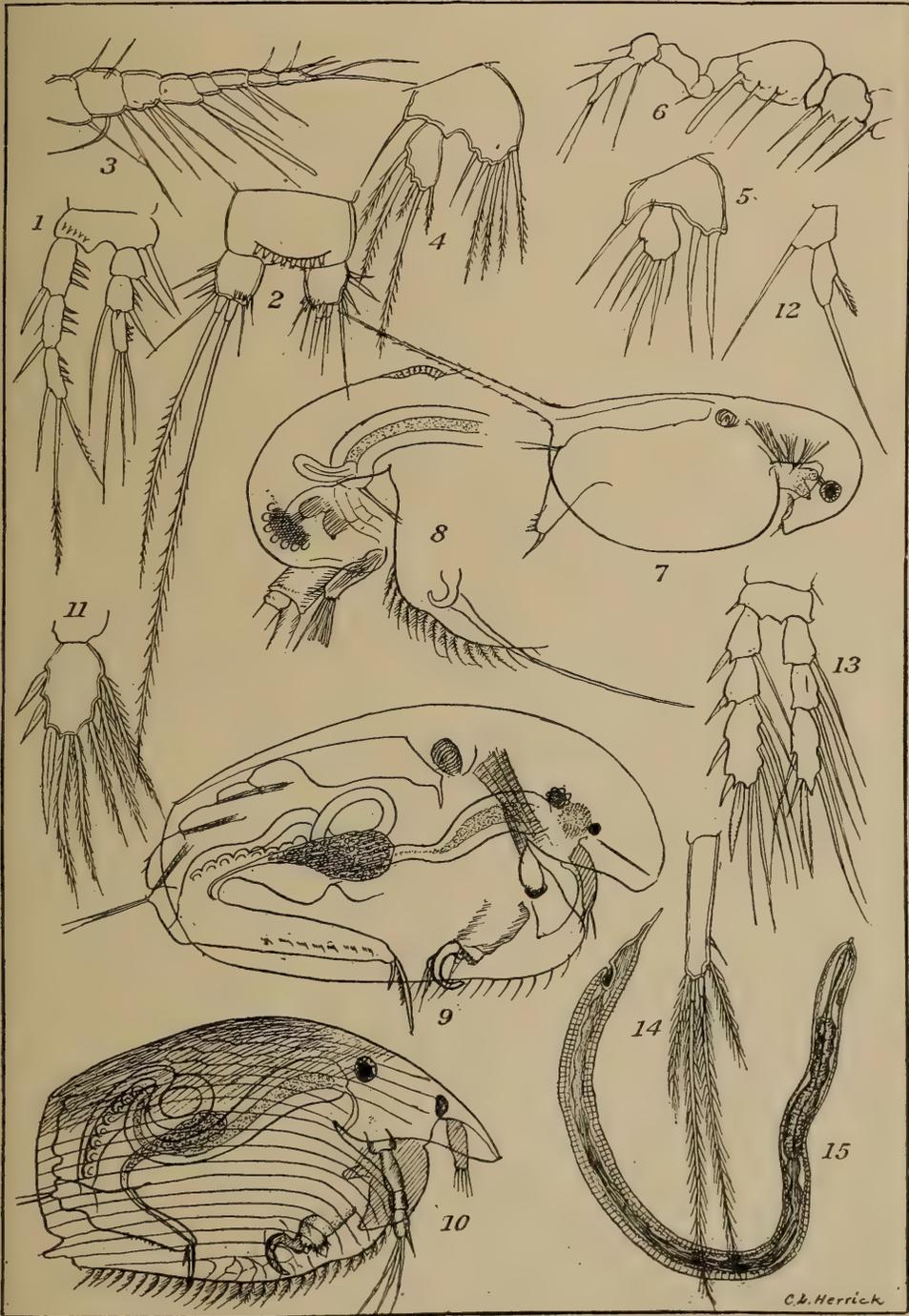
NOTE. On pages 43 and 44, for " Plate T," read Plate J.

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PLATE T.

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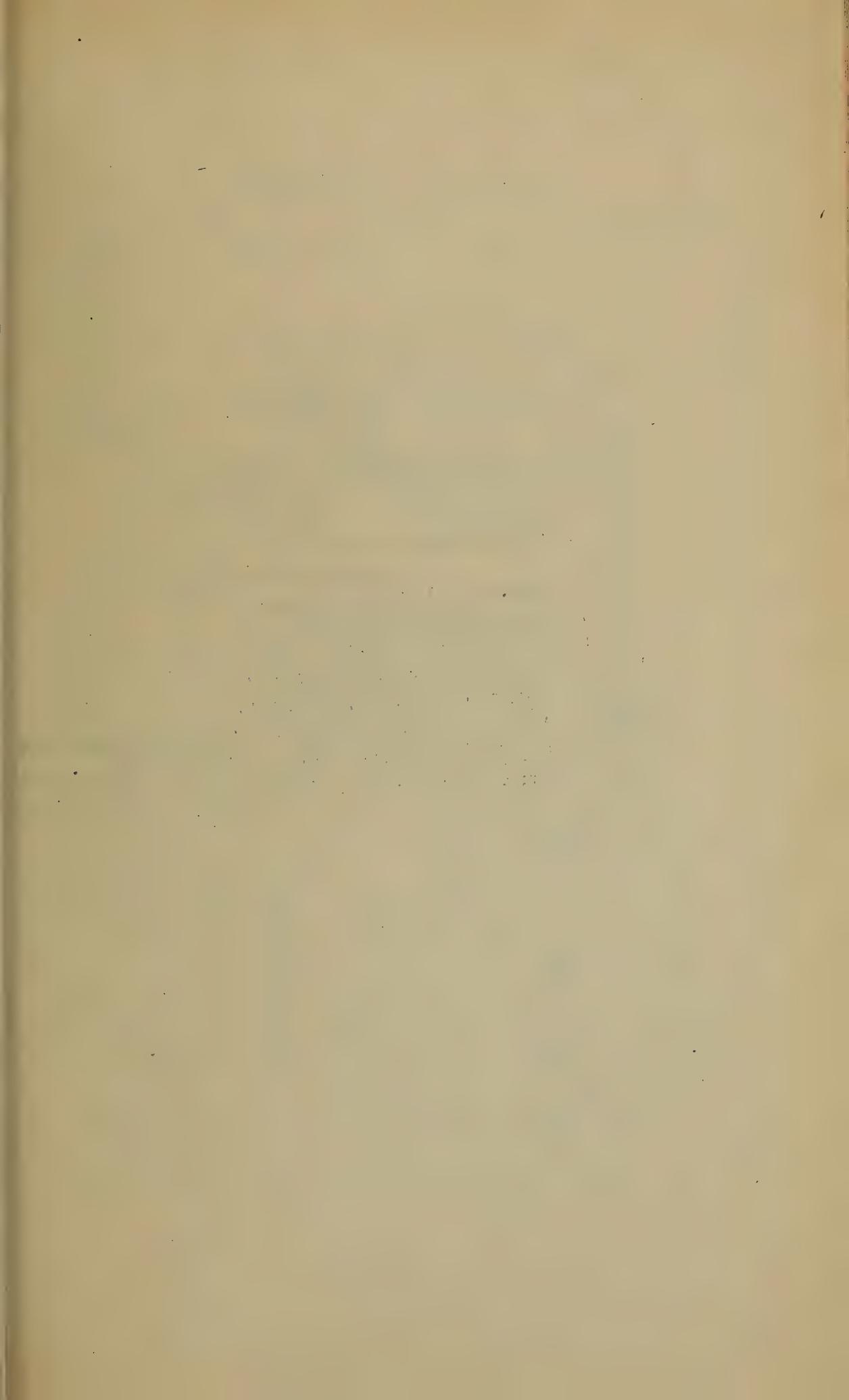


PLATE U.

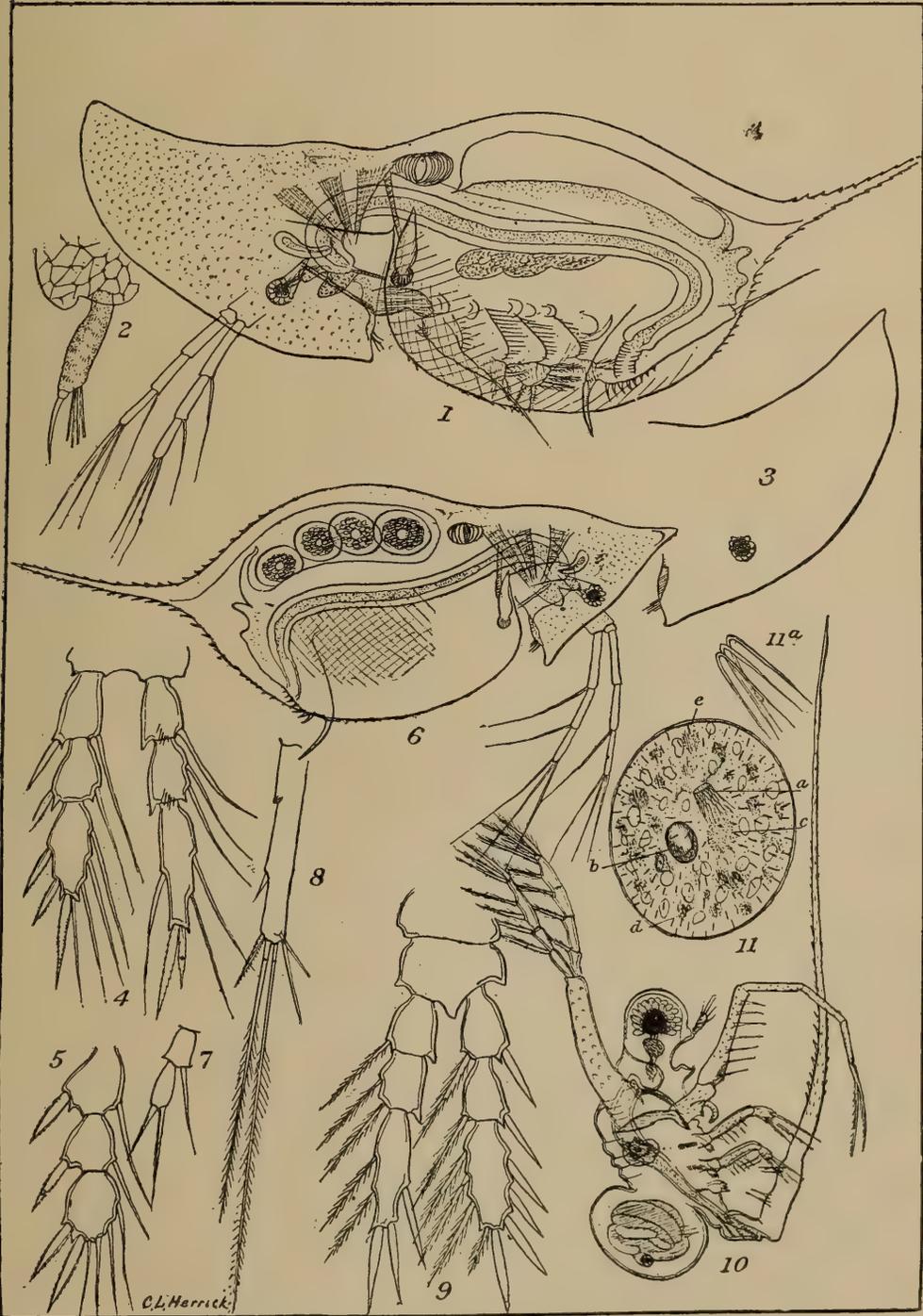
- Fig. 1. *Daphnia kalbergensis*, of moderate size.
Fig. 2. " " antennule of male.
Fig. 3. " " head of var.
Fig. 4. *Cyclops thomasi*, fourth foot.
Fig. 5. " " outer ramus of first foot.
Fig. 6. *Daphnia galeata*, typical form.
Fig. 7. *Cyclops thomasi*, fifth foot.
Fig. 8. " " stylet.
Fig. 9. *Cyclops (insectus?)*, fourth foot.
Fig. 10. *Bythotrephes longimanus*, female.
Fig. 11. A curious large protozoan; a. infundibulum frame work
b. pulsating vacuole; c. nucleus; d. food and digested mat-
ter; e. protective rods; 11a. spicules of the infundibulum.

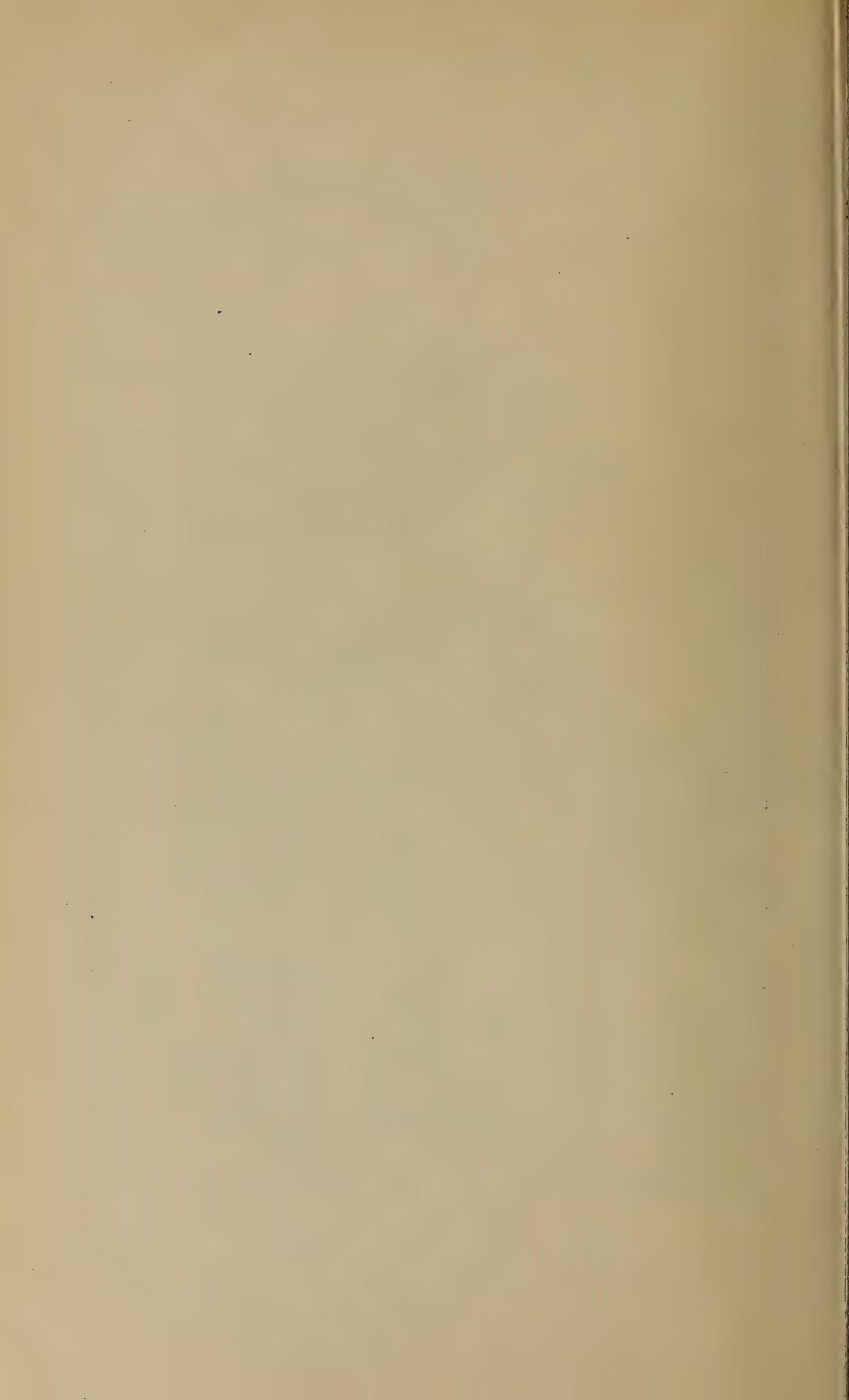
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PLATE U

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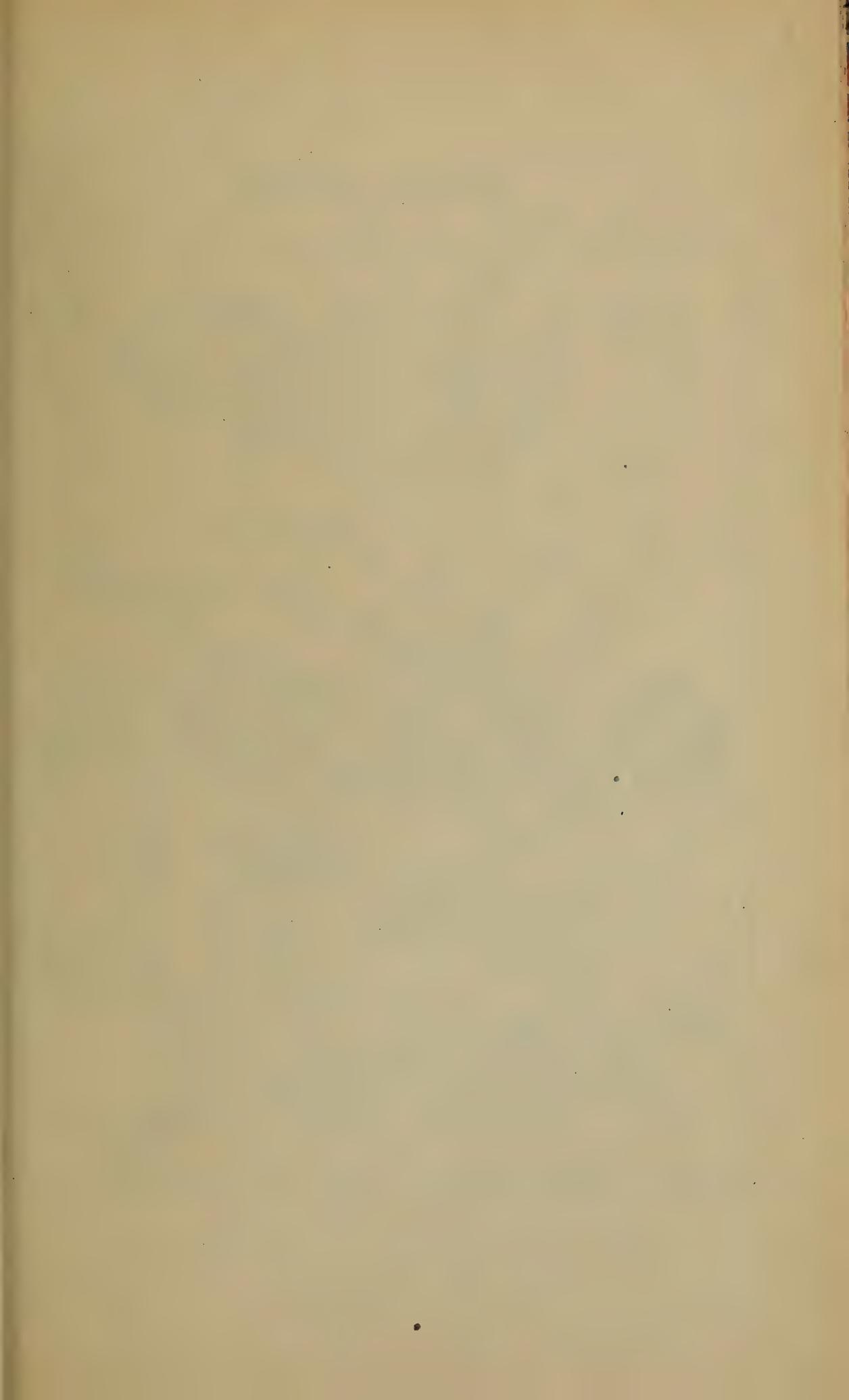


PLATE U¹.

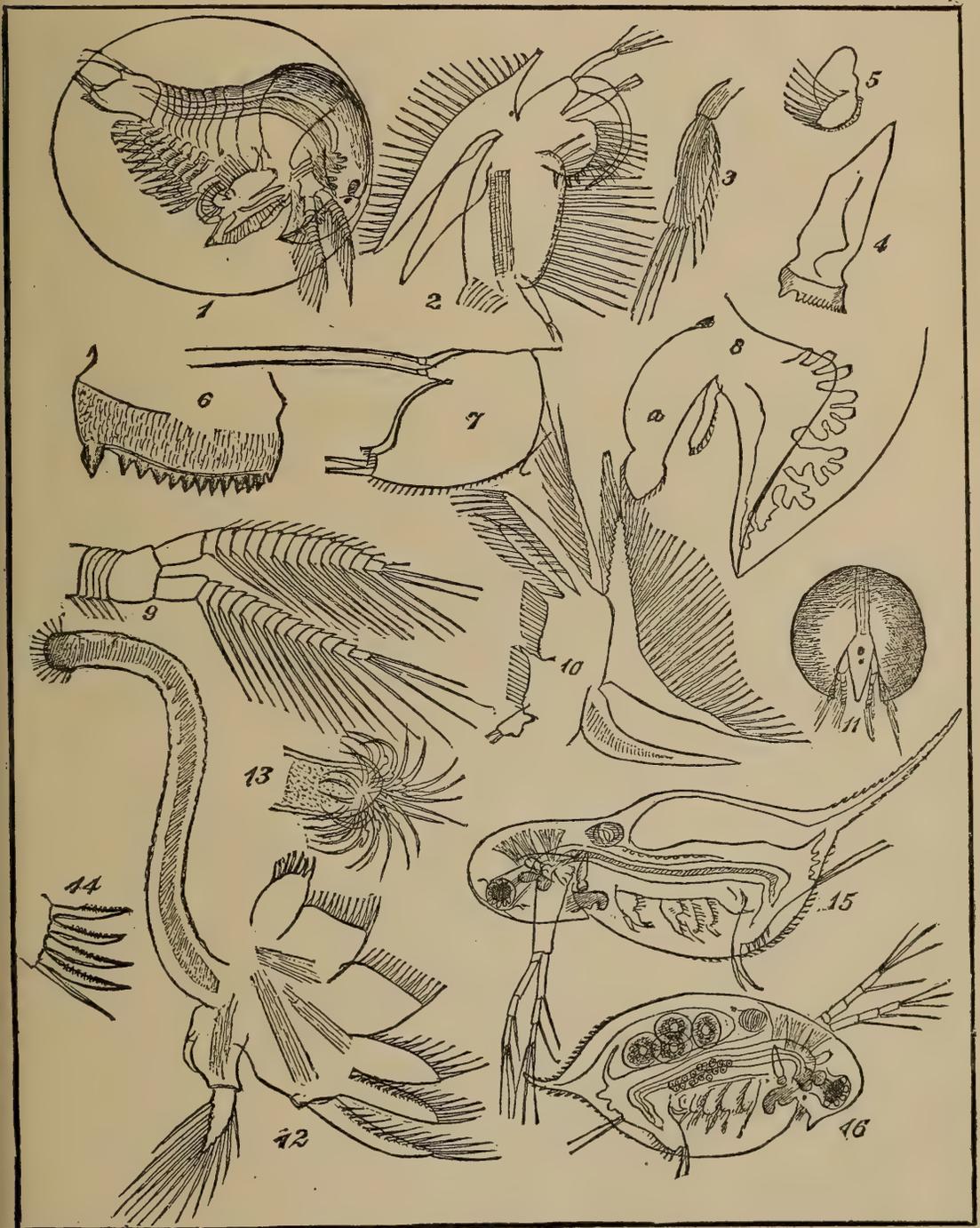
- Figs. 1-14. *Limnetes gouldii*, Baird.
Fig. 15. *Daphnia magniceps*, female.
Fig. 16. *Daphnia minnehaha*, female.

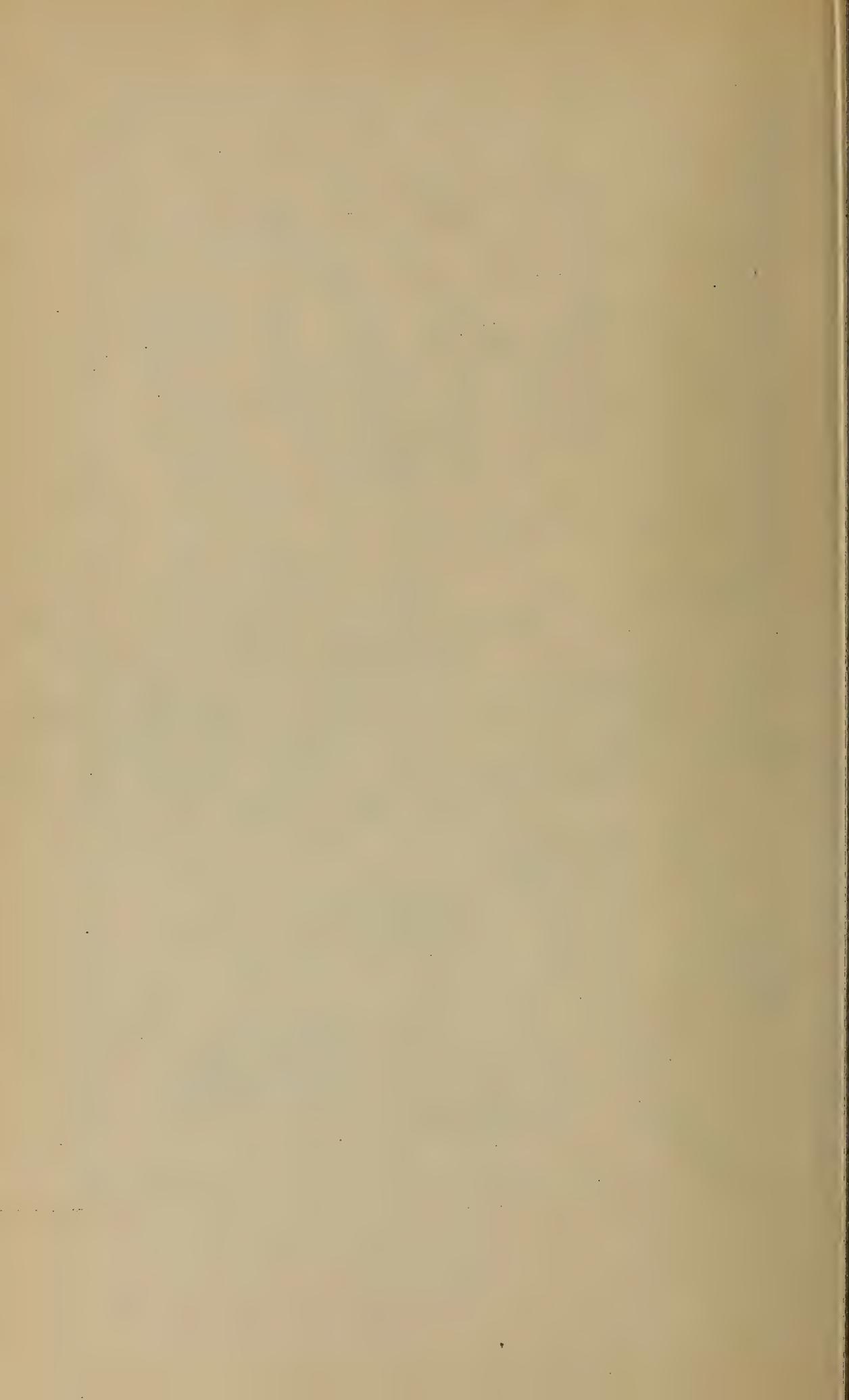
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PLATE U 1.

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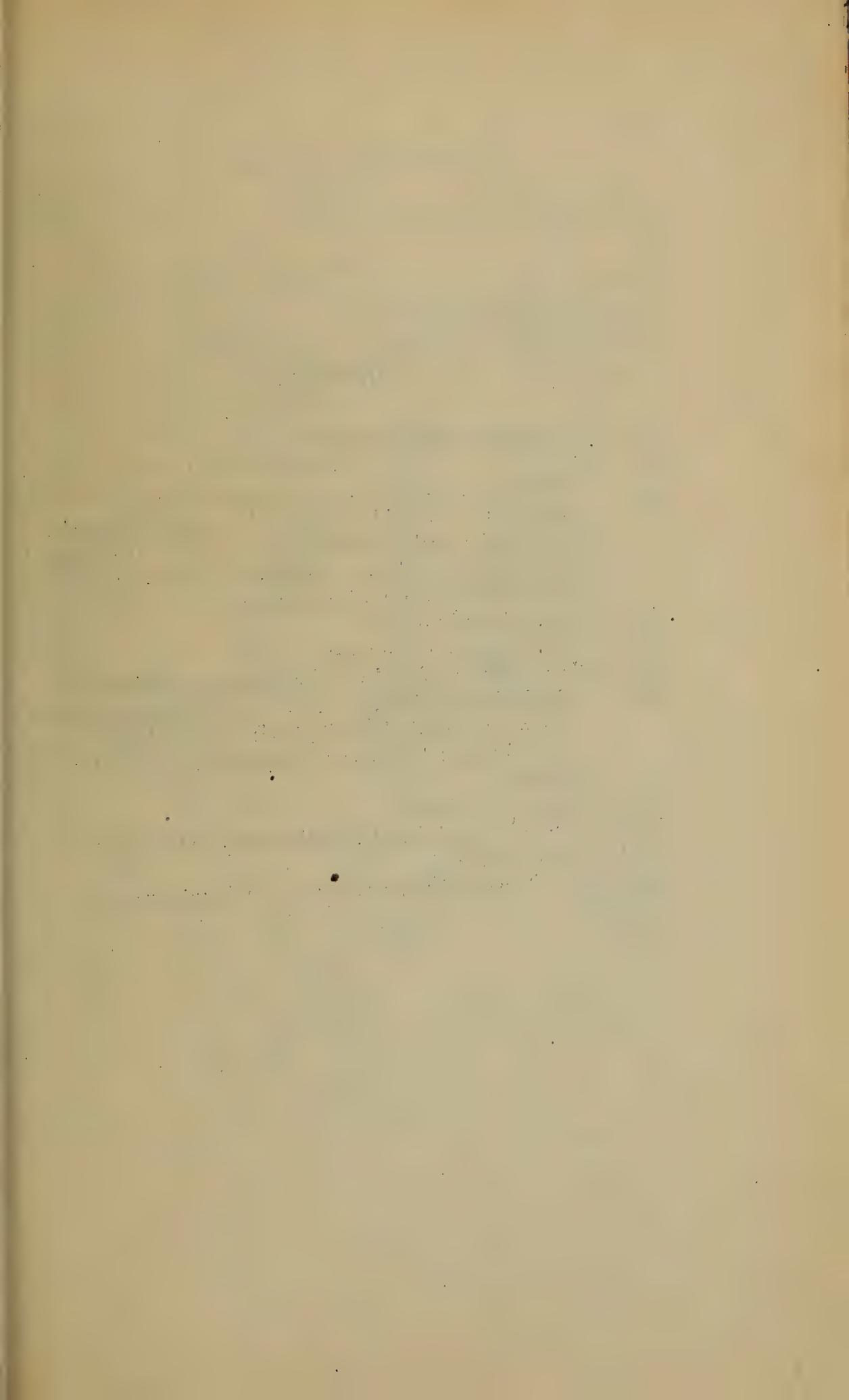


PLATE V.

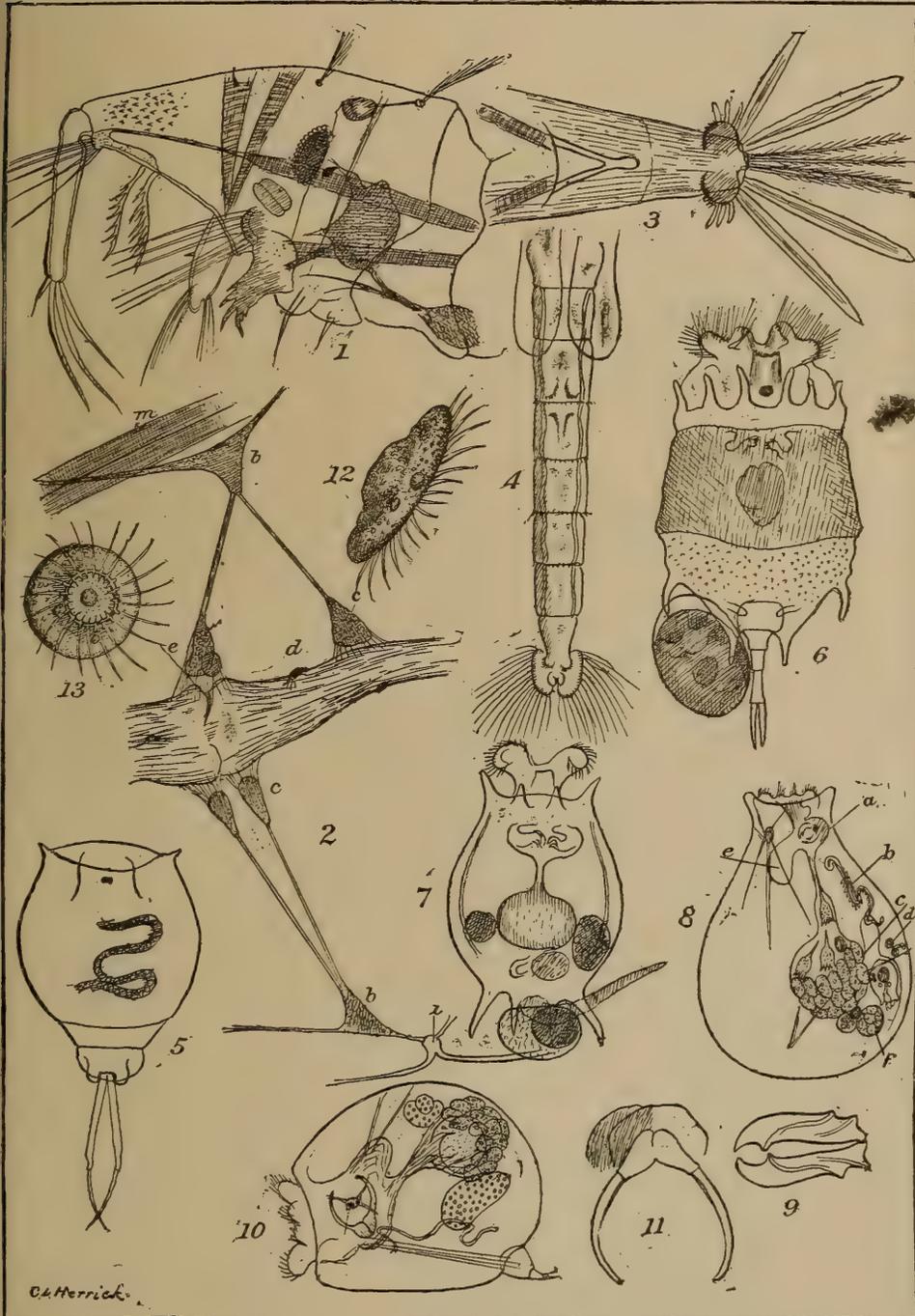
- Fig. 1. *Corethra appendiculata*, head of larva.
Fig. 2. " " portion of heart with its muscles.
a. chitinous projection of the body wall to which are attached two muscular threads; b. peripheral muscle; c. proximal muscle attached to the wall of the heart; d. muscles scattered over the surface of the heart, serving as contractors; e. venous opening.
Fig. 3. do., extremity of body.
Fig. 4. do., abdomen of the pupa.
Figs. 5, 6, 7. Rotifera found with entomostraca in Minnesota.
Fig. 8. Flask-shaped rotifer, hermaphrodite, with eggs and sperm.
a. jaws and head; b. shell gland; c. glandular portion of the stomach; d. testes; e. œsophagus; f. one of several embryos.
Fig. 9. jaws of the above.
Fig. 10. similar animal, female, deadly enemy to *Chydorus*.
Fig. 11. jaws of same.
Figs. 12, 13. ? pedicularis, ecto-parasite of *Diaptomus*.

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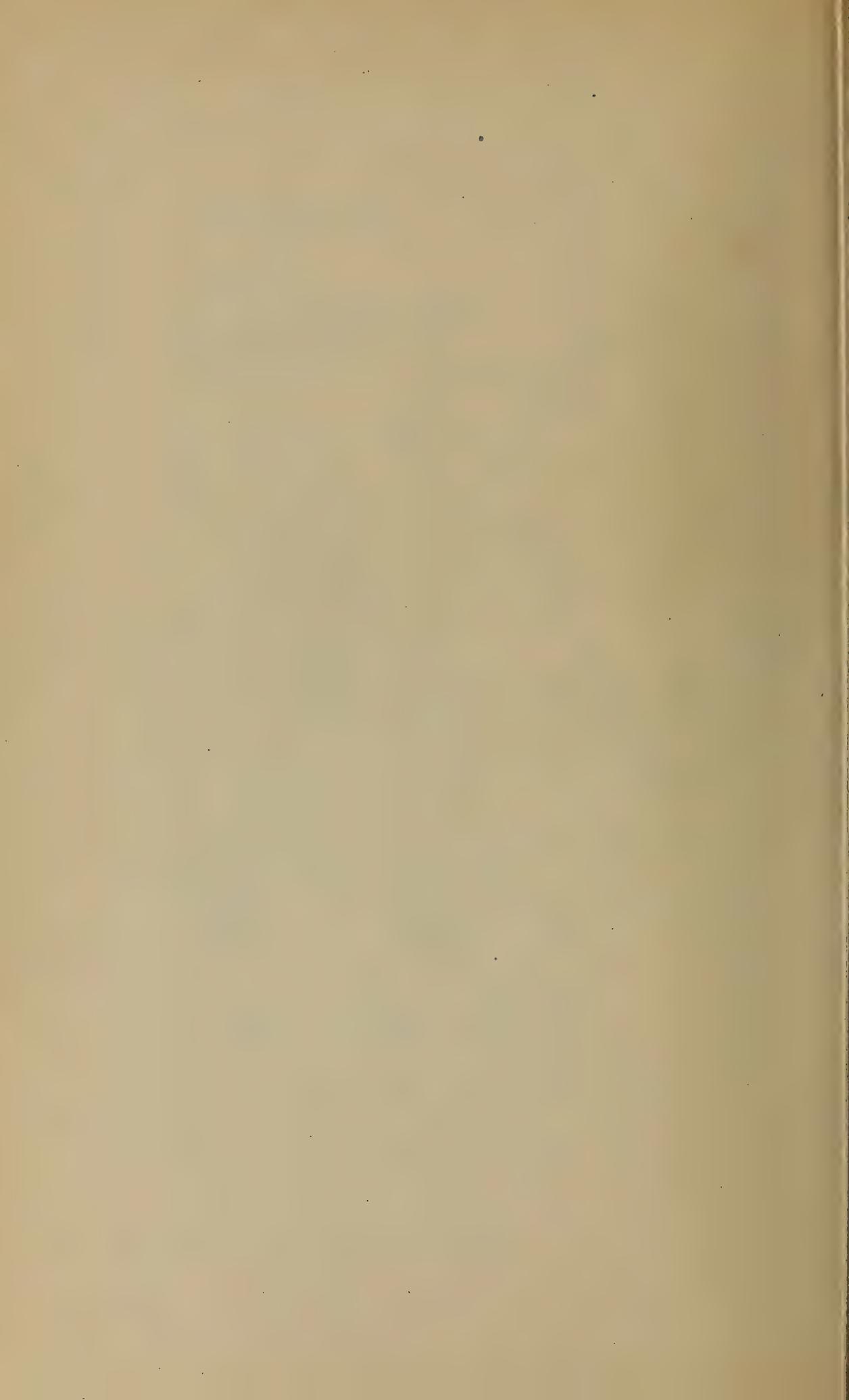
PLATE V.

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Geol. & Nat. Hist. Sur. Minn.



C. A. Herrick.



With compliments

BULLETIN

B. Rathbun

OF THE

SCIENTIFIC LABORATORIES

OF

DENISON UNIVERSITY,

EDITED BY

C. L. HERRICK, M. S.,

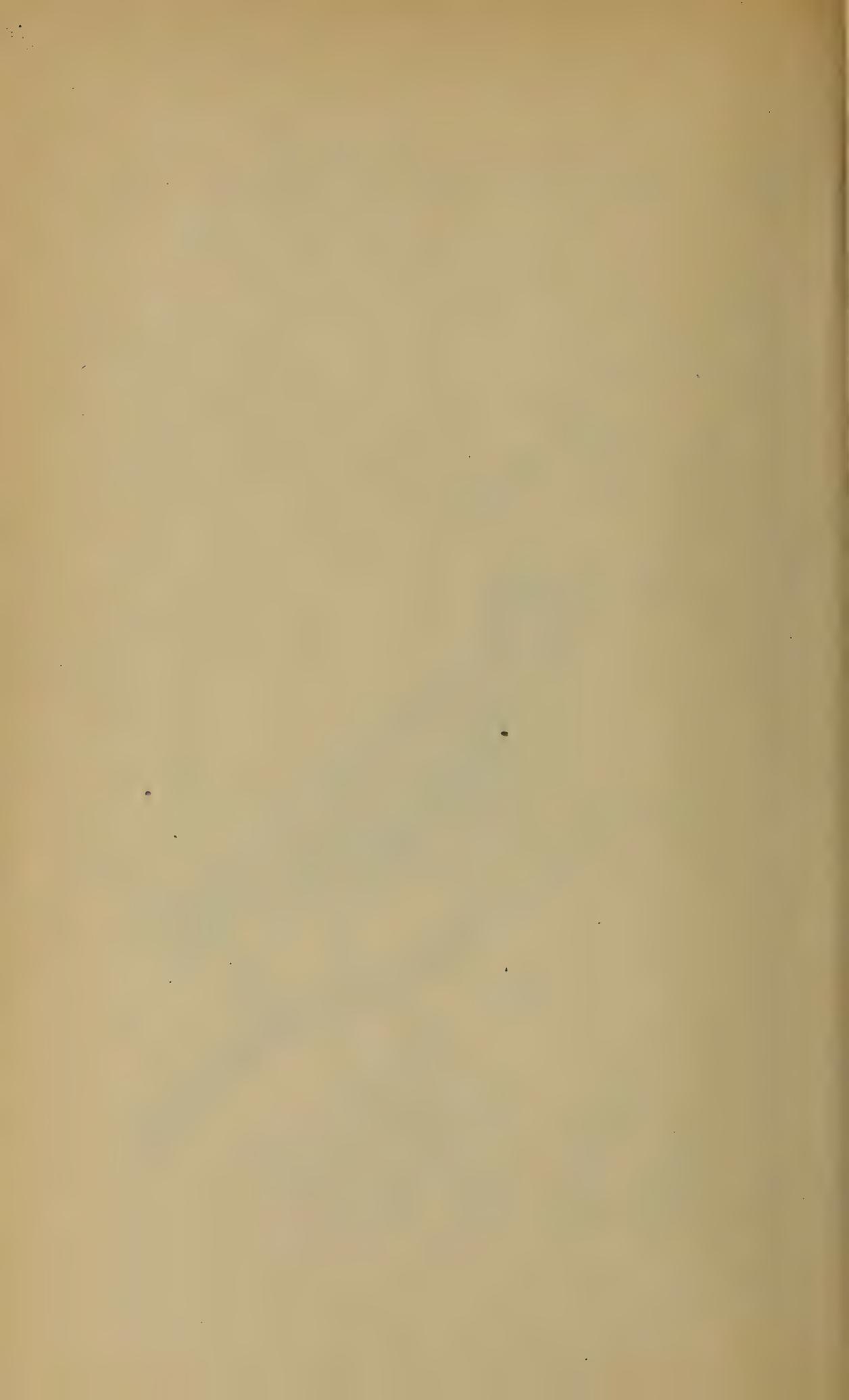
PROFESSOR OF GEOLOGY AND NATURAL HISTORY.

VOL. I.

GRANVILLE, OHIO, DEC., 1885.

Downs & Kussmaul,
PRINTERS,
Granville Ohio.





12

B. Bathbun.

BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY,
GRANVILLE, OHIO.

EDITORIAL STATEMENT.

Every well conducted institution of learning should form a recognized centre of scientific activity ; and legitimately concerns itself, not only with the instruction of those who directly entrust themselves to its charge, but with the dissemination and conservation of information relating to the subjects taught. Moreover, in connection with the laboratory drill, it often happens that facts of general scientific interest are brought to light which the student may be ill prepared to appreciate in all their bearings. Such facts, if preserved, may, at another time, become very valuable, while, if not thus preserved, they would be lost. Still again, instructors will, as a rule, be unable to instill enthusiasm if they themselves do not come in contact with nature at first hands, while the fragments of time, which are often frittered away, can be made most useful to themselves and others by being applied to studies in advance of the work required by the curriculum.

The present publication, which we are able to present through the generous co-operation of numerous friends, is a step toward filling a need hinted at in the above paragraph. The bulletin is intended to represent the life of the college in its scientific departments and may incidentally serve to illustrate to distant friends the facilities for work afforded, as well as needs still unsupplied. To the scientific students of the country we confidently appeal for support and indulgence, since it is hoped to devote an increasingly large portion of space in each number to technical papers which have more interest to the student than to the general public. To the teacher, with still greater confidence, we look for encouragement, as it is entirely in the interest of better school work that this bulletin is prepared. While limited means has, in this first number, prevented the use of costly illustrations, it is hoped that the generous patronage of this volume will enable us to extend to the contributors to the following one more elegant, if not more perspicuous graphic aids.

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A considerable number of papers prepared for this number have been necessarily delayed, on account of the limited space allotted, and yet our limits have been extended. The lithographs were executed by the editor and printed by a process making them cheaper than any other available, and any failure to realize the ideal of such work will, no doubt, be pardoned on this account.

For information relating to the departments here represented, the reader is referred to the advertisement appearing elsewhere. The fact that the chemical laboratory has afforded us no material for this number, may be attributed to the change in administration in that department, occasioned by the death of the lamented Prof. Osbun.

I.

THE EVENING GROSBEAK—*Hesperiphona vespertina*, Bonap.

[PLATE I AND FRONTISPIECE.]

Among the rarities in the cabinet of most ornithological collectors is the Evening Grosbeak, which excites interest as much by its comparative rarity and exceeding capriciousness in distribution as on account of its odd note and eccentric behavior. First found by Mr. Schoolcraft, in 1823, near Sault St. Marie, in Michigan, it was described by Cooper. The indefatigable naturalist, Sir John Richardson, encountered it upon the Saskatchewan, where seems to be its natural home, and from whence it issues forth, guided by any whim, and wanders far to the East and South, though seeming to avoid the coast. The genus is Asiatic and our two species are obviously derived from the Old World, via Alaska. In Europe there is a closely allied genus *Coccothraustes*, which differs in the shape of the secondary wing feathers. The genus is distinguished from all other finches of the United States by the very large beak and the following points:

“Feet short; tarsus less than the middle toe; lateral toes nearly equal, and reaching to the base of the middle claw. Claws much curved, stout, compressed. Wings very long and pointed, reaching beyond the middle of the tail. Primaries much longer than the nearly equal secondaries and tertiaries; outer two quills longest; the others rapidly graduated. Tail slightly forked; scarcely more than two thirds the length of the wings, its coverts covering nearly three-fourths of its extent.”—*Baird*.

[In America we have the two species, *H. vespertina* (with its two varieties), and *H. abeillii*, Scl., which lives in the mountainous portions of Mexico, southward.]

In very few places in the United States does this bird appear with sufficient constancy to be set down as more than an accidental visitor. In this respect Minneapolis, Minn., is particularly favored for, during a number of years, these grosbeaks have rarely failed to make a longer or shorter winter visit, sometimes coming early in the Autumn and remaining until the trees are in full leaf, when, in a few cases, their much

mooted song has been heard. The most eastern point yet reached by these birds seems to be Cleveland, Ohio, and isolated cases of their occurrence in Wisconsin and Illinois are also known. The species is highly gregarious and individuals are rarely or never met with singly. Even the destructive inroads of the collector, before whom they are absolutely defenseless, do not scatter or break up the flock. Unsuspecting and without fear, they continue to feed until the last individual falls a victim. The migrating colony seems well satisfied with itself and its temporary home and, while feeding, a constant chorus of answering cries is kept up. The note is not loud but is remarkably piercing, and yet not unmelodious. The early belief that these birds are silent except at evening is entirely erroneous. In spring, upon the approach of the breeding season, the males cultivate the muses in an odd but not displeasing little song. This song consists of several successive repetitions of a short warble, followed by a similar strain closing with a shrill cry, like the finale of a black-bird's song. The phrase which makes up the body of the song is musical, but is so abruptly terminated (as though from lack of breath or of ability,) that it is annoying when heard singly, for one is subjected to much the same nervous expectancy felt in listening to a hen's cackle when quite leisurely "working up the agony" sufficiently to sound the final note. A flock of a dozen or more singing together produce a very musical effect. The food almost entirely consists of the seeds of various trees, among which the box elder, the maple, poplar, and pine are pre-eminent. Buds of cherry and other trees are also eaten, and this regime is varied by occasional insect larvae, etc.

O. B. Johnson, who mentions this grosbeak from the Willamette valley, speaks of it as plentiful during migrations, and states that "the only note heard was a loud 'yeeip,' strikingly like the call of a lost chicken." Of the nest and eggs we as yet know nothing, and so of the many interesting traits which make up the sum of its true home-life we must be content to remain ignorant. From its inaccessible summer home it continues to descend during the severe winter weather and, almost under the very roofs of the factories of a busy city, contentedly passes the short days, heedless of the noise and regardless only of the oily kernels of the keys of the box elder, which it displays a very awkward skill in plucking as it swings (head downwards or otherwise) from the pendulous branches.

These brief remarks are designed simply as introductory to the

notes on the osteology appended. Before preceding to these the following description will suffice to make the bird recognizable.

Sp. char. Bill, yellowish green, dusky at base; anterior half of body dusky yellowish olive, shading into yellow to the rump above, and the under tail coverts below. Outer scapulars, a broad frontal band continued on each side over the eye, axillaries, and middle of under wing coverts, yellow. Feathers along the extreme base of bill, the crown, tibiae, wings, upper tail coverts, and tail, black; inner greater wing-coverts and tertiaries, white. Length, 7.30, wing, 4.30, tail, 2.75. In the female the head and back is dull olivaceous brown. Below, the body is pale yellowish ash. There is an obscure black line on either side the chin. There is more white upon the wings and tail. (See plate, which is intended to give simply the *tout ensemble* without strict accuracy as to color.)

Osteology of Hesperiphona vespertina.

The anatomy of the Evening Grosbeak is of more than usual interest, not only on account of the rarity of the bird and the air of mystery which has associated itself with it, but because it stands at the head of American *Fringillidae*, by virtue of possessing the extreme development of the finch type of structure. Our observations are based on the study of three more or less perfect skeleta, which, so far as we know, are the first which have been studied.

The skull. The most striking peculiarities of the skull are those which are correlated with the extraordinary development of the beak. The angle, for instance, formed by the quadratojugal-jugal bony pillar with the lower margin of the maxilla is greater than usual, chiefly on account of the great size of the quadrate bone. In this way a firm support is afforded to the upper jaw. But we pass to a detailed description. As seen *from above*, the skull is, in outline, a perfect triangle, with a narrow rounded base. The apex of the triangle is formed by the remarkably large and strong (though correspondingly very light) beak. The bones entering the beak are cancellated within, forming a firm but light organ. These bones are, first, the *premaxilla*, which makes up the bulk of the bony frame-work of the beak and is early ankylosed with the maxillaries in the family under consideration. Although we can not separate the parts, we may distinguish in the *maxillary* bone a superior or nasal process which separates the opening of the nares and unites with the nasal bones, two lateral or maxillary processes, and two palatine processes which are within the mouth-opening. The distance from the apex of the beak to the subcircular nares is .6 inches, the distance between them, .10. The *nasals* are inseparably

united and form a quadrate bone making an angle of 25° with the culmen or upper line of the beak, their combined width is .45, and they form the posterior borders of the nares, being united laterally with the maxillaries, anteriorly with the intermaxillary, below with the lacrymals, and posteriorly with the frontals. The distance from the angle of the mandible to the top of the nasals is .40. Occupying the top of the skull, and apparently restricted to the space between the orbits, are the concave *frontals*. The distance between the orbits is about .35. The remainder of the roof of the skull is formed by the confluent *parietals* which occupy a larger area than usual on the top and back of the skull. From above can be seen a small prominence behind, which covers the cerebellum, and hence is called the *cerebellar prominence*. The sides of the triangle are continued backward from the ends of the maxillaries by a slender rod consisting of the *quadratojugal* and the *jugal* which can be studied to advantage when the skull is viewed *from the side*. In this position the skull is seen to present the outline of two triangles, the smaller of which, forming the beak, is set at an angle of 45° with the other. The cutting edges of the jaw (*tomia*), supported chiefly by the *maxillary* bones, are slightly curved. The *tomia* are .80 long. The slender rod passing backward and downward and forming the lower outline of the second triangle is, in the young, composed of two bones, the *jugal* and *quadratojugal*. Their combined length is .54, the posterior articulation being upon the outermost process of the peculiar *quadrate* bone. This bone is considered the homologue of the little ear bone of mammals, known as the malleus, but in birds has a very important function—that of giving the necessary movability and yet stability to the beak. It is the point of attachment of the two important supports of the facial part of the skull. The form of the quadrate is very irregular, consisting of a body and six processes. The styloid process is the largest and is that which connects the bone with the base of the skull; it is a flattened vertical pillar with a large articular surface; jutting out anteriorly is the orbital process, about .30 long, which extends into the orbit. Just below the orbital is the pterygoid process of rather small size. The mandibular end bears two curved processes so situated that the glenoid surfaces oppose the rami from within and behind, while the jaw is completely locked by the large articular process of the mandible. A more complete articulation could scarcely be conceived. The malar process extends out horizontally and offers an oblique surface to the head

of the quadrato-jugal. The *lachrymal* bone is very large and hoe-shaped, occupying the whole anterior aspect of the orbit. A very slender curved process extends backward from its lower angle. The lachrymo-nasal space between this and the maxillary permits the free movement of the beak on the skull. The lachrymo-nasal foramen is quadrate. The optic foramen occupies its usual position on the margin of the *ali-sphenoid*, which is inseparably united with the *septum intraorbitale* and this with the *ethmoid* still farther forward. There is a large irregular foramen above the optic. The greater part of the side of the skull behind the orbit is formed by the *squamosal*, which is strongly ridged and forms, first, a strong flange-like process behind the orbit and, second, a very long process projecting forward toward the corresponding process of the lachrymal. The *orbito-sphenoid* was not detected as a distinct bone, but irregular processes on the *ali-sphenoid* may represent it. The *sclerotals* are membranous bones, which unite to form a ring about the globe of the eye. As seen from below, several new bones appear. At the back of the skull is the large *foramen magnum*, subcordate and quadrate in form and about .20 in width. Above, it is bounded by the *supraoccipital*, laterally by the *exoccipitals*, and below by the *basioccipital*. These bones are intimately united and the sutures quite obliterated. There is an impressed line on either side the foramen. The single occipital condyle is a small knob-like process. The *basioccipital* is quadrate and near its lateral margins are the foramina of the carotid and the seventh, ninth, tenth and eleventh nerves. The *squamosal* expands into a large shield-like covering over the auditory meatus. Just inside of the quadrate bone can be seen a bony sheath which indicates the former point of union of the Meckel's cartilage. Within the meatus the minute auditory ossicles can be seen with a glass. The *sphenoid* is a pyramidal bone, soon becoming a vertical plate fusing with the ethmoid and inter-orbital septum. Here also the obliteration of sutures is complete. The *vomer* is present but inconspicuous. The *maxillaries* form the sides of the beak and, in connection with the premaxillary, form a continuous bony ceiling to the roof of the mouth, which is covered with a thick horny sheath, so thickened on the edges as to make the knife-like cutting *tomia*. The *palatals* are movably articulated to the edges of the maxillaries by broad bases so that they nearly meet on the median line and reach nearly to the jugal, externally. Posteriorly, the palatals extend into forked processes, making the whole length .40 of an inch. From

this process, which descends below the level of the jugal, a nearly vertical plate extends upward to form a sliding sheath which clasps the *presphenoid* and plays back and forward upon it. The flattened ends of the long (.50) *pterygoids* are fused with these vertical plates by expanded, overlapping plates. There are two curved flanges springing from the point where the pterygoids unite with the palatals. The *ethmo-turbinal* plates are more or less ossified and are seen on either side of the rudiment of the vomer. The pterygoids are stout but very unusually long and, on account of the size and position of the quadrate bones, are quite distant from the basis cranii. Near the point of union of the pterygoid with the quadrate bone, a small hooked process, about .12 long, extends upward from the former bone. What the use or the homologies of these processes may be, we do not know, although they occur in finches and in other birds.

At the posterior of the two mandibular processes of the quadrate bone is a bone as large as the head of a large pin, but of irregular shape, which may be regarded as either a sesamoid contributing to lock the jaw or an independent portion of the quadrate. There is also a very minute sesamoid at the union of the quadrato-jugal and the quadrate. The lower jaw shows no evidence of its composite character. The whole anterior half is enlarged and forms a simple trough of cancellous bone which may be assumed to consist of the dentary elements of both rami. The surangular, angular and splenial elements of the rami are not distinguishable. The articular portion consists of a huge flange, extending inward and upward and is perforated at the middle of its inner surface for the entrance of Meckel's cartilage.

What corresponds to the surangular portion is a broad triangular plate extending upward inside the jugal bones and serving to further lock the jaw. Thus, as we have seen, the whole skull is modified in harmony with the enormous rhinencephalic development.

The *hyoid arch* is well developed and consists of seven bones, whose homologies, in the present state of our knowledge, cannot be made out. The anterior pair are pointed before and behind and attached at the middle to each other and the end of the *azygos* bone which next follows. The first mentioned bones are called *entoglossal*, by Gegenbaur, by some American authors, *ceratohyals*, with no real evidence that they are homologous with the bones so called in other animals. The following element may be called *basihyal* (*copula* of Gegenbaur,) and is flattened to form a vertical plate and bears on

either side, posteriorly, the *cornua*, which each consists of one straight shaft, .50 long, and a shorter fusiform segment. Between these the *urohyal* extends backward as a support to the trachea. The atlas and axis are fused together more or less fully. There is no neural spine on the *atlas*, but its dorsal surface is perfectly plane. The *axis*, or second cervical vertebra, has a well developed spine and posterior zygapophyses and also a very large hæmal spine, which curves backward. The *third cervical* has a smaller neural spine and its posterior zygapophyses project upward. Its hæmal spine (hypapophysis) curves forward. There is a slight inferior lamella of its transverse process. The *fourth cervical* introduces a new type, having a low spine, nearly horizontal posterior zygapophyses, and elongated styloid inferior lamellæ. It has a smaller hæmal spine. The following cervicals have no neural or hæmal spines, the posterior zygapophyses decline, and the styloid appendages are very long. The thirteenth and fourteenth (last) cervicals have *pleuropophyses* (ribs), those of the former being mere rudiments, while those of the latter are large but have no connection with the sternum. These vertebræ, in common with the first of the dorsals, have strong hæmal spines. They also have the *capitula process* well developed to receive the head of the rib. The transverse process has its normal *tubercular facet* to sustain the tubercle of the rib. There are six *dorsal vertebræ*, which are more or less firmly co-ossified. The transverse processes are large and the spines of uniform size. The last dorsal is firmly united with the following nine vertebræ, which form the vertebral framework of the sacrum. Seven free vertebræ follow, forming the free *caudal* series. Each of these has a strong transverse process and a more or less perfect neural spine. Upon the last two there are also hæmal spines. The last bone or *pygostyle* is remarkable for the great development of its neural spine.

The sternum is normal for the group and is 1.20 inches long. The keel is well-developed, being .50 high. The mid-xiphoid process is .40 wide at the end. The lateral xiphoids are separated by an excision one half as wide and rather more than .40 deep. The transverse sternal angle (that between the two sides of the body of the sternum,) is sharp and considerable. The costal processes are strong, while the coracoid grooves are .25 in width. The manubrium is particularly large and is bifid. Each of the six ribs, as well as the last cervical rib, has a well developed uncinatè process.

The strongest bone in *the shoulder girdle* is the *coracoid*, which is expanded below and obliquely winged for a short distance, then is cylindrical and then curves inward, throwing off a flange-like process where the scapula is articulated, and ends in an articular surface against which the flattened upper part of the clavicle is pressed. From the lower angle of this surface a strong tendon passes to the process of the manubrium on that side. The *clavicles* are of the usual form, forming the merry-thought in connection with the anchylosed interclavicle. The *scapula* is united to both clavicle and coracoid and with the latter furnishes a glenoid surface for the humerus. Between these three bones, at their union, is a cavity, *foramen triosseum*, permitting the passage of the tendon of the sub-clavus muscle.

The *anterior extremity* is of moderate size. The *humerus* is .95 long and is much expanded proximally where it is .33 in breadth. The radial crest is short and quite prominent. The ulnar tuberosity is very large and outwardly presents a large triangular surface and within excludes two extensive fossæ, divided by a strong septum, from the end of which a strong process is developed. The opposite or distal end of the humerus is less highly developed, but still shows a high degree of perfection of the spinous appendages. The trochlea, consisting of the radial and ulnar tubercles, are about as usual. The radial condyle is a small prominence directed forward at the base of the radius, while the ulnar condyle is a larger acute process, extending in the opposite direction. The *radius*, the smaller bone of the arm, is but slightly curved and measures 1.20 in length. The ulna curves considerably, proximally, so that the sigmoid cavity is quite oblique to the shaft, and the olecranon process is small and styloid. The carpus contains two bones which have the usual positions. The *ulnare* is applied to the back side of the ulna and rotates upon its smooth articular surface. The *radiale* caps the ulnar and is overlapped by the radius in front. The three metacarpals are fused at the base. The first one can not be distinguished and its phalanx measures but .20. The second metacarpal is .65 long and is fused at both ends with the slender third metacarpal. The second digit consists of two phalanges, the first of which is .30 long and consists of two bars connected by a thin plate of bone, the second being a triangular plate .15 long. The third digit consists of a styloid phalanx .20 long. (The two ossicles described by Schufeldt, in certain birds, as the *cuneiform* and the *pentosteon*, are not discoverable in any of the skeleta before me.

The *pelvis* is papery and yet very complete. The obturator fissure, separating the *ischium* and *pubic* moiety of the pelvis is divided into an elongated posterior and smaller circular anterior foramen. The ilio-siatic foramen is quadrate, with rounded angles. The pubic bone is produced into a slender curved process, as usual in this group. The femur is .91 long and nearly straight and requires no description.

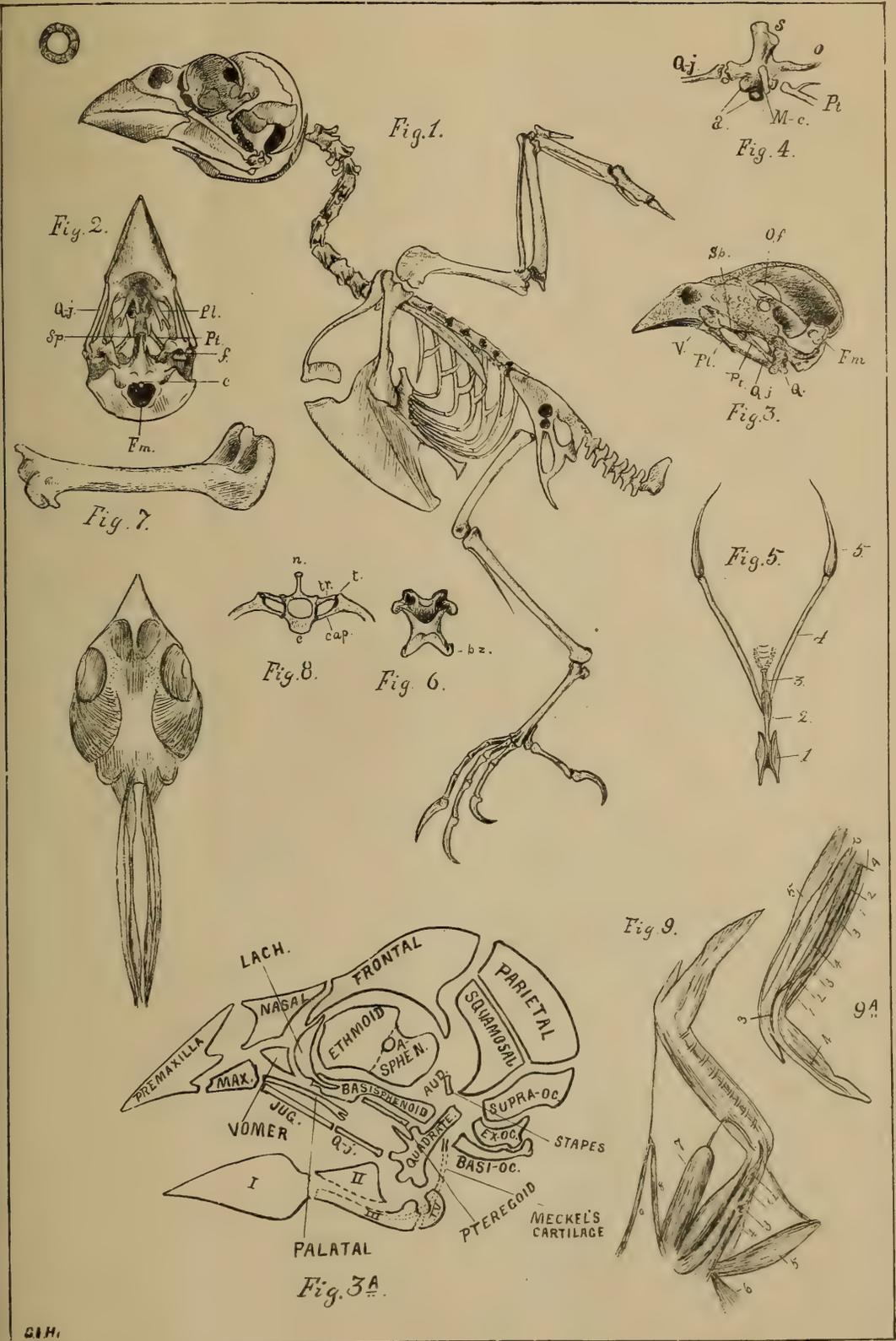
The *tibia* is a symmetrical straight bone, 1.30 long, while the fibula is nearly free from it and is about half its length. In the skeleta of adult birds, such as those before us, it is useless to attempt to distinguish the tarsal bones which unite with its epiphyses, thus forming the *tibio-tarsus*, nor yet the composition of the succeeding segment of the leg, the *tarso-metatarsus*. The latter is .80 long and is furnished with a strong process ("calcaneal,") behind, which is at present causing so much discussion. The subdivision at the distal extremity into the four metatarsals is distinct. The first of these, the *hallux*, is provided with a separate metatarsal, the *accessorius*, which is quite large and descends to the level of the other united metatarsals. The phalanges of the hallux are two in number, the first being very large, .32 long. The claw borne by the following phalanx is the strongest on the foot. The second toe has three phalanges, the third, four, and the shorter fourth, five, as is the case in all of the present group of birds.

Such a bare description as is above given of points in the osteology of a species of bird, is of little value, except as furnishing a basis for comparison with others of its own and other groups. Such a comparative study we cannot at present attempt, but may, perhaps, profitably note some points of difference between the present species and others of its own family, *Fringillidae*. Quite at the other extreme of the family may be found the genus *Pipilo*, which is represented in our region by the Chewink or Ground Robin, *P. erythrophthalmus*, a bird of singular appearance, in some points resembling the Orioles, while mimicking the habits of the Brown Thrush. A comparison with this species then may be expected to give us the limit of divergence in structure within the family, and those points which are identical in both may, with some probability, be assumed to be of family, ordinal or class rank.

The skull is of very different form, but the differences are chiefly those accompanying the reduction in the size of the beak, which in the Chewink is slender, almost Icterine. This slender pointed beak does not extend backward so far as in the true Finches, but

the malar pillar is much longer and the angle of the beak and the end of the tomia are forward from the orbit. The opening of the nares is much larger and the lachrymo-nasal space is a very large triangular opening. On this account the ascending process of the maxillary is quite slender. As seen from above, the skull of *Pipilo* is much narrower between the orbits and the facial portion of the skull is easily distinguished from the cranial. The orbits are rather larger and not nearly as well guarded. The lachrymal is of the same shape, but lacks the long slender process directed backward, below. The lachrymo-nasal foramen is small. The interorbital septum is very poorly developed, two oblong foramina extending longitudinally leave but a narrow bridge between them. The ethmoid is therefore greatly reduced. The back of the skull is alike in both, but the opening of the bullæ is directed more forward. The palatal bones are quite similar, but the posterior processes are not bifid. Two curved slender rods, which seem at least partially ossified, pass from the palatal processes of the maxillary to that part of the palatals farthest forward and highest. The pterygoids are of the usual shape and are flattened anteriorly to slide over the sphenoids. The quadrate is smaller and of the same form, but has a rather longer orbital process, proportionally. The quadrato-jugal has the same hamular process posteriorly as described in the Grosbeak. The lower jaw is, like the upper, rather weak. The various parts entering into each ramus are indicated by the presence of a large oval foramen separating the surangular, angular and splenial, and the flange of the articular is large. The differences in the shoulder and arm are slight and are such as might occur in species of the same genus. The sacrum is relatively much stronger and the spinous armature is greater, this corresponding to the greater demand upon the muscles there finding origin. The foramina are of the same number, but the lower one is more elongated to correspond to the greater development of the pubic bone. The femur is of ordinary form, but the tibiotarsal segment is greatly enlarged. The fibula is quite well developed and is ankylosed with the tibia about one half an inch from the head, for a short distance, but is free above and below. The head of the tibia develops two huge processes and there is a small patella. The condyles are very large. The "calcaneal" process, strangely enough, is very small and poorly ossified. The foot itself is not particularly enlarged.

The form of the sternum is very closely alike in these birds; in



fact, the sternum is a valuable osteological index, for, not only is it pretty constant in a given family, but it presents points of constant difference between many families. The manubrium is larger, if anything, than in the Grosbeak.

Such are some of the differences noted between these species and they may be taken as indications of those points in the osseous structure most readily responding to changes in habit or habitation as induced by changes in the environment. It is by the elimination of the variable elements of different degrees of constancy that classification can be placed upon a permanent and correct basis. The variable points may be employed in distinguishing species, genera, etc., in accordance with their relative permanence or value.

PLATE I. *Anatomy of Hesperiphona.*

Fig. 1. Lateral view of entire skeleton.

Fig. 2. Skull seen from below. *Qj*, quadratojugal; *Pl*, palatal; *pt*, pterygoid; *sp*, sphenoid; *e*, condyle; *Fm*, foramen magnum; *L*, internal flange of mandible.

Fig. 3. Transverse section of skull. *V*, vomer; *Q*, quadrate bone; *Of*, optic foramen; other references as above. *3A*, diagram of bones of skull.

Fig. 4. Quadrate bone and articulations. *Pl*, pterygoid; *Qj*, quadratojugal; *a*, accessory ossicles; *mc*, sheath of Meckel's cartilage.

Fig. 5. Hyoid arch.

Fig. 6. Superior surface of a cervical vertebra.

Fig. 7. Humerus.

Fig. 8. A dorsal vertebra, from behind.

Fig. 9. Muscles of the wing seen from above.

Fig. 9A. Anterior part of wing from below.

Fig. 10. Skull denuded of skin and showing certain cervical muscles.

II.

METAMORPHOSIS AND MORPHOLOGY OF CERTAIN PHYLLOPOD CRUSTACEA.

[PLATES V—VIII AND PLATE X.]

The group *Phyllopoda* is one of the most remarkable among crustaceans, on account of the peculiar form and life history of most of its members. About the animals of this group there clings a certain air of mystery which may lead one to regard them as almost "uncanny." A pool by the wayside is suddenly formed by a shower and almost instantly becomes populated with a swarm of animal life, which no one ever saw there before and for the like of which we might search an hundred miles in vain. In a few days the little tragedy is played and the uncouth actors have disappeared, no one knows whither, having sown the clay at the bottom of the now dry pool, with eggs which, under favorable circumstances, may again put the play on the boards, but only after being themselves thoroughly dried by the sun. In short, in the study of these animals the unexpected is always appearing and known laws, or at least theories, are again and again negated. We calmly institute a species when, lo! the change in certain conditions attending the development occasions the change to an entirely different genus in our system.

(See V. Siebold, in *Sitzungsberichte d. math.-phys. Classe zu Muenchen*, 1873, and the paper by Schmankewitsch in the *Zeitschrift fuer Wissenschaftliche Zoologie*, XXV Suppl., 1875.)

In spite of many able papers and works on American Phyllopods (notably the monograph, by Prof. Packard, in *The Geol. Surv. Terr.*, 1868, *Part I, Sec. 2.*) many points of deepest interest remain to be cleared up, and particularly such as relate to the development history and homologies of organs. In the present paper a few observations made some years ago, are presented with no attempt to discuss their bearing upon the questions in dispute. The student conversant with the literature of this subject will observe, however, that these facts

make necessary a modification of views at present in vogue in several important particulars. The work was arbitrarily closed by circumstances and the material was long suppressed, in the hope of continuing a study which proved of absorbing interest; but, as this hope is now extinct and no motive remains for further delay, the observations are presented in their necessarily fragmentary form, hoping to fill a place in the life-history of these remarkable animals.

The Phyllopora are extremely well adapted for use in biological laboratories and the outline here given may make the process of development plainer to the student who is fortunate enough to be supplied with such material for study. The two animals described may be found in early spring and late summer, in many temporary pools throughout the eastern zoographical province of North America.

A. Larval Development of Limnetis gouldii, Bd.

Limnetis is a genus of the FAMILY LIMNADIADÆ of Baird, which includes crustaceans enclosed in a bivalved shell, within which is concealed a body like that of a Water Flea, but having ten to twenty-seven pairs of leaf-like swimming feet. The very large head projects from between the valves in front and is flanked on either side by a biramous second antenna, while the first pair of antennæ is very small. A figure of the adult of the present species will be found in the monograph by Dr. Packard, and also in a paper by the present writer, in the 10th Annual of the Minnesota Geological Survey.

The earliest stage seen (Plate VI, Fig. 2.) was the simple nauplius-form common to all this group of crustacea, but so curiously modified as to at first almost defy recognition. The animal, as viewed from above, seems covered almost entirely by an oval shield, which is thickly studded with spines arranged in anastomosing lines. The head extends into a frontal prominence, which is densely bearded. The posterior part of the body forms a blunt prominence, bearing two spines. The eye, occupying the front of the head, consists of a single pigment fleck, with at first a single lense (?). The digestive tract is simple and similar to that of other Phyllopod larvæ. In the protuberance which represents the future abdomen, the muscles producing the pumping action of the rectum are well developed and anal respiration at once begins.

The appendages differ only in form from those of other larvæ. The antennules are long and curved prolongations of the frontal region

and project laterally. They are covered with a spiny cuticle, like the antennules of the nauplius of *Chirocephalus*, but are less movable and less obviously tactile organs. It has been denied that these are really antennæ, but the history of their further development makes it clear that they are really representatives of those organs, though obscured by their covering.

Although the nauplius of *Limnetes* is said by authors (Packard, Monogr. Phyllopod Crust, etc.) to be distinguished from other nauplii by the small size of the labrum, this is founded upon a mistake. The labrum is really the most prominent of the larval organs. It is, indeed, of monstrous form and is so enlarged as to become a valve nearly as large as the shield-like expansion of the body above. The larva resembles a small turtle, from the edge of whose shell protrude two pairs of appendages.

The labrum is thorned, as is the whole body, and is slightly, if at all, movable. In this respect it differs little from other young nauplii. Like the first pair of antennæ, the labrum is obscured by its larval envelope, similar to that which extends the carapace of the body to form a false shell. The second antennæ are of the usual form among Phyllopods, the anterior branch being five-, the lower one two-jointed. The basal portion is furnished with a prominence bearing two heavy claws. The palp of the mandible is of the usual form.

In the next stages slow changes accompany the increase in size. A dorsal area is marked off over the maxillary and mandiblar segments, from which the shell develops under the larval covering. The nauplius eye becomes associated with a pair of club-shaped sensory hairs. A ventral swelling becomes distinct and proceeds to segment itself and elaborate limbs. (Fig. 1, Plate VII.) In figure 11 of this plate, which gives a semi-diagrammatic under view of the abdomen, is shown that, as in other Phyllopods, the appendiculate segments seem to appear at once and the development goes on then from before backward. Prior to the appearance of feet (stage of Fig. 1.) the animal is about 0.33 mm. long, but becomes over 0.50 mm., before the metamorphosis. In the last stage prior to assuming the characteristics of the adult, the antennules seem smaller, the labrum has become cordate and very wide, while a prominence appears below the eye. Rudiments of the compound eye are visible and the sensory filaments overlying the pigment fleck are developed. The anterior part of the digestive tract has bifurcated and its branches extend toward the labrum.

The accessory branch of the second antenna, with its forceps, has become large. Now the hypodermic contents of the antennules withdraw from its shell and compact themselves into the mature form, developing, at the same time, sensory rods in their substance. The contents of the labrum fall away from the walls and gather into a lobe-like body. Feet have formed, and a single-chambered heart is actively pulsating. The future shell may now be seen under the larval covering, connected only with the back over the segments bearing gnathites, and hanging free about the edges. When the moult is effected the labrum falls within the valves, carrying with it the small tactile antennules, which hang pendant by a slender stalk. The frontal prominence, however, is elongated, forming the beak. The larva is now a diminutive of the adult. In its future development the form elongates and finally again becomes rounded and assumes the familiar appearance. The branches from the stomach fill the front of the head with so-called liver-lobes. The compound eye becomes perfected, while the nauplius eye is covered by filaments charged with some unknown sensory function. The heart becomes multi-chambered and the genital organs appear. For a figure of a young *Limnetes*, see *Types of Animal Life, etc.*, by the author; for figures of the adult and a discussion of relationships, see Packard's "Monograph of the Phyllopod Crustacea of America"; *U. S. Geol. Surv. of Terr.* 1878, *Part I.*

Farther details may be gathered from the plates. It is a matter of regret that Grube's work on the development of the European *Limnetes brachyura* was not accessible to me during the period which was covered by this paper. My recollection is, however, that the processes are, in the main, identical, but that Grube fails to identify all the organs of the embryo.

B. Post-embryonic Development of Chirocephalus.

The species studied is assumed to be the common *C. holmani*, Ryder, although the oldest male seen differed in several particulars from the description of that species. One must imagine a fish-like, transparent animal, about one-half inch long, balancing itself in the water by the movement of eleven pairs of lamellate swimming feet. The colors are brilliant and do not interfere with an almost perfect transparency of the body.

The earliest stage seen is that figured on Plate V, Fig. 1. The animal is at that period .93 mm. long and the antennæ measure about

.57 mm., the antennules .32 mm. The form is that of a nauplius toward the end of its first phase. The antennules are much like those of males of *Moina*, being curved abruptly near the middle. They are clothed with a spiny larval integument, which disappears in the next stage. The sensory ganglia in the end and the connecting nerves are present; of the latter there seem to be two bundles having a different course. The larval eye in the middle of the head is distinct and has two lenses, or, rather, crystalline bodies.

The antennæ are of the form usual to larvæ of this family, the rami being unequal, the shorter being very indistinctly two-jointed, the longer eighteen-jointed. Near the base a small prominence bears long spines, later to serve a temporary purpose in bringing food to the mouth. The mandiblar palp is indistinctly 6-jointed, the inner ramus of this limb, or mandible proper, has a single spine.

The thoracic segments are already indicated and rudimentary limbs lie under the larval skin. The abdomen bears two styles, and has a set of muscles adapted to produce anal respiration in the rectum. The stomach is simple and glandular. Although no heart could be distinguished, blood corpuscles crowd the antennæ and other parts of the body, (see figure 4.) Rudiments of the compound eyes are seen on the sides of the head where pigment is collected.

In the next stage the animal may be .98 mm. long (Fig. 2.) and several changes appear. A well marked scutum covers the mandiblar and maxillary segments. The antennules have lost their spiny covering and the proportions of the antennæ have changed. At the base of the antennæ certain organs develop, which present great resemblances to the branchial sacs of the other feet, but which become the shell-glands of the adult. This is parallel to the like origin of these organs in copepods, as we have demonstrated in *Diaptomus*. In *Limnetes* it was impossible to follow the development of the shell-gland. (See figure 6, *o*, shell gland; *M*, mouth; *L*, labrum; *Md*, mandible; *Mx*, maxilla; *Mx 2*, second maxilla.) The brain lobes or supra-oesophageal ganglia resemble those organs in cladocera, the optic-lobes being apparently hollow, however. The posterior part of the body is now considerably elongated. The segments of the thorax seem to be all differentiated at once and the segmentation is obscured by a false segmenting of the posterior part of that region or the apparent absence of segments. The region about the rectum is open and crossed by the muscles giving it motion. It frequently seemed to me

that this chamber was that in which the blood-corpuses (or, better, lymph-cells) were formed. The rectum is covered with irregular masses of cells of varying size, and I more than once thought to have observed their change to lymph-cells. It was impossible, unfortunately, in the time allotted to observe the development of the circulatory system, but it would seem that the heart differentiates from the connective tissues between the stomach and the scutum.

(Fig. 3 illustrates not only the formation of the posterior appendicular segments, but the rectal sinus with its muscles and lymph-cells. A simple valvular apparatus separates the rectum from the anterior part of the digestive tract.)

The next stage is illustrated on Plate VI, Fig. 1. A change in proportion and in size is all that requires notice. Figures 3-6, illustrate the growth of the appendages. Fig. 3 is the first foot of the right side of an individual over 1.5 mm. long. Fig. 4 is the same of a younger individual of which Fig. 5 is the sixth and Fig. 6, the ninth foot. Fig. 7 shows how the matrices of the caudal spines are developed from enlarged cells as are the corresponding parts in *Daphnia*.

Fig 2, of Plate VII, illustrates the general characters of the animal when about 2 mm. long. The maxilla have become larger and the feet begin to assume their definitive form.

Fig. 3 shows the growth of the caudal stylets and the character of the valve at the opening of the anus, as well as the prolonged matrix at the setæ. Fig. 4 illustrates the differentiation of the optic lobes and of the anterior part of the stomach. The heart is by this time well formed and whatever part the rectal cells may have played in originating lymph-cells, is lost. The liver lobes grow out from the stomach and the labrum becomes reduced. The antennæ now undergo a rapid and remarkable transformation. In the male the shorter ramus becomes atrophied as shown in Fig. 10, and from the base an epipodal body is formed just as in the case of the feet. At first this pouch resembles homologous organs in the feet, but soon it alters and becomes greatly modified. In the female the change is similar, save that this branchial sac fails to develop (Fig. 9.) The palpus of the mandible is likewise reduced to a mere rudiment (Fig. 8.)

The sexual organs of the female appear as lobed glands (Fig. 12.) The caudal stylets are of considerable size. A male, in the stage above mentioned, measures 3.5 mm. In the following stages growth is rapid. The antennæ modify rapidly.

Figs. 2 and 3, of Plate VIII, show the form of the antennæ of the female and male in this stage, the former being .78 mm., the latter .79 mm. long. In the male the palp is gone and the appendage is considerably developed, the longer ramus still showing its primitive form. Fig. 4 figures the fourth foot of a male $\frac{3}{8}$ inches long. Fig. 5 shows the abdomen of a larger male, and Fig. 6, the stylets when they are .78 mm. in length. Fig. 7 shows the form of the head of a male some time prior to maturity, and Fig. 8 illustrates the external genital organs of one side at the same period. The testis, only part of which is shown, is a double chamber. The penis is paired and each factor is spiny. A common muscle protrudes them both by lateral pressure, while a muscle peculiar to each serves as a retractor. Fig. 7 illustrates the form of the male antenna, previous to the branching of the so-called frontal organ. As to the homologies of the "frontal organ," there is no doubt that in *Chirocephalus*, as stated many years ago, it is an appendage of the base of the antenna and the development shows it related in position and formation to the branchial sacs of the other limbs.

There is a curious dimorphism among these animals, as in copepods. The males, under certain circumstances, become sexually mature, while the antennæ retain an undifferentiated character. The antenna in this stage, has a short basal process and the remainder is rather short and bifid at the tip, one of the branches bearing a sharp spine. The frontal appendage is simple, coiled, and regularly crenulate in this stage. The next stage is characterized by the elongation of one of the short branches at the end of the male antennæ and the modification of the frontal organs.

EXPLANATION OF PLATES.

Plate V.

Fig. 1. Young nauplius larva of *Chirocephalus*.

Fig. 2. The same in an advanced stage.

Fig. 3. End of body of individual of same age as figure 1, showing cavity about the rectum and its muscles, the cells springing from the walls of the rectum, the blood corpuscles, the valve at the posterior end of the stomach, and the primitive segments outlined in the cellular mass.

Fig. 4. End of the longer branch of the second antennæ, with massed blood corpuscles.

Fig. 5. Mandible and palpus.

Fig. 6. Lower view of anterior part of a larva, about the size of that shown in figure 2, *oc.* nauplius eye; *At*, antennæ; *e*, eye; *g*, upper ganglion; *g1*, optic lobe; *A 2*, swimming antennæ (base only shown); *M*, mouth opening, bordered on either side by commissures passing to the infra-oesophagal ganglion; *L*, labrum; *Md*, mandible and palp; *Mx*, first maxilla; *Mx 2*, second maxilla; *I, II, III, IV*, etc., feet in different stages of development.

Plate VI.

- Fig. 1.* *Chirocephalus* larva in an advanced stage, seen from above.
Fig. 2. *Limnetes gouldii*, early stage.
Fig. 3. First right swimming foot of *Chirocephalus* when 1.4 mm. long.
Figs. 4-6. First, sixth, and ninth feet of younger larva.
Fig. 7. Abdomen of same.

Plate VII.

- Fig. 1.* Larva of *Limnetes* .33 mm. long. *A*, first antennæ; *A 2*, swimming antennæ; *Md*, mandiblar palp. *e*, eye; *l*, lense; *L*, liver, budding from anterior part of stomach; *s*, sensory filament; *m*, muscles of rectum.
Fig. 2. Larva of *Chirocephalus*, from below.
Fig. 3. Caudal stylet of same.
Fig. 4. Head, showing organs of one side, *L*, liver.
Fig. 5. Muscles of swimming antennæ.
Fig. 6. Maxilla. *Fig. 7.* End of abdomen of an older individual. *Fig. 8.* Mandible and palpus (*p*) in this stage. *Fig. 9.* Antennæ of female. *Fig. 10.* Antenna of male; *p*; inner ramus; *g*, frontal organ.
Fig. 11. Part of *Limnetes* older than figure 1.
Fig. 12. First abdominal segment of female, seen from below.

Plate VIII.

- Fig. 1.* Head of male approaching maturity.
Fig. 2. Antenna of female, (length of antenna .78 mm.)
Fig. 3. Antenna of male of about the same age, (length of antenna .79 mm.)
Fig. 4. Fourth foot of male $\frac{3}{8}$ inches long.
Fig. 5. Abdomen of young male.
Fig. 6. Caudal stylets of same, (.78 mm. long.)
Fig. 7. Antenna of same.
Fig. 8. Copulatory organs of one side, *m*, muscle common to the sheaths of both male organs; *p*, penis or forceps; *t*, testis.
Fig. 9. End of sensory antenna; *a*, sensory rods, enlarged.
Fig. 10. View of the surface of the basal knob on the male antenna.

Fig. 11. Larva of *Limnetes* when .5 mm. long, showing withdrawal of the hypoderm and its contents from the walls of the antennules and labrum. *A*, antennules inside the sheath formed by their old covering. *L*, labrum inside its old shell, *L1*.

Plate X.

Fig. 1. Head of *Chirocephalus*, male, nearly adult.

Fig. 2. A typical foot of the same.

Fig. 3. One of the swimming feet of *Limnetes*.

Fig. 4. Outline of the head of *Limnetes*, after the metamorphosis, showing relation of labrum and antennules and also the position of the beak, eye and sensory fleck.

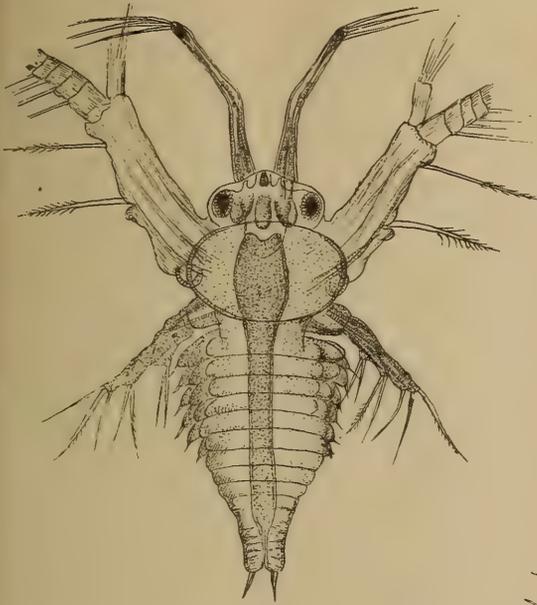


Fig. 2.

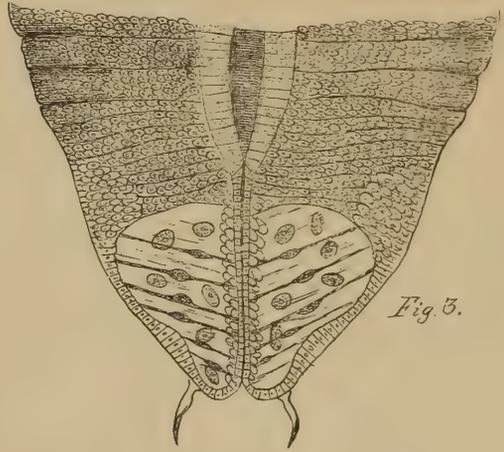


Fig. 3.

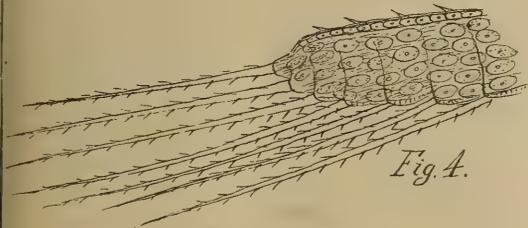


Fig. 4.

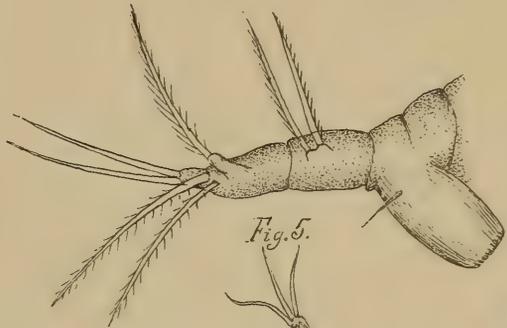


Fig. 5.

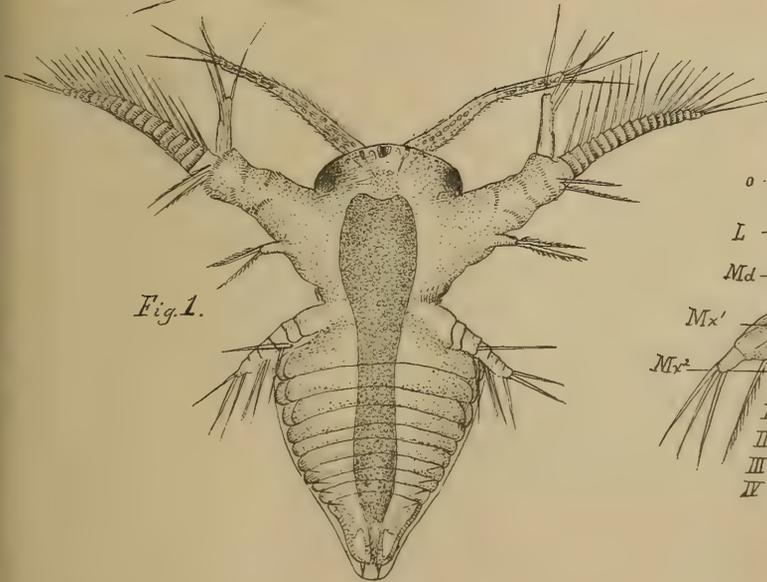


Fig. 1.

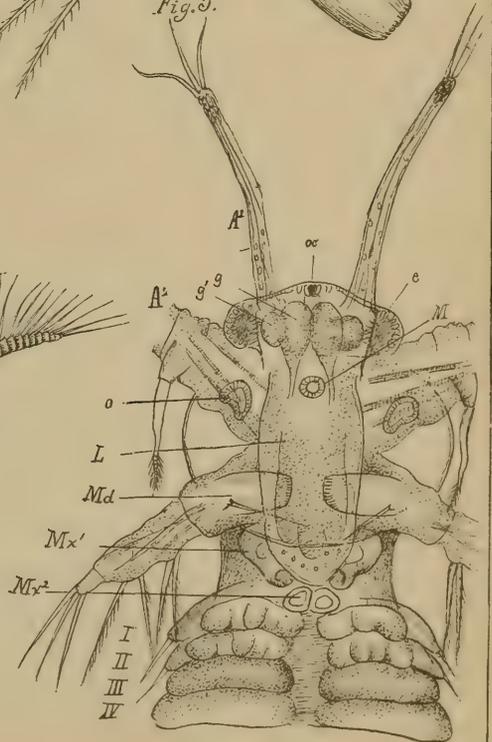


Fig. 6.

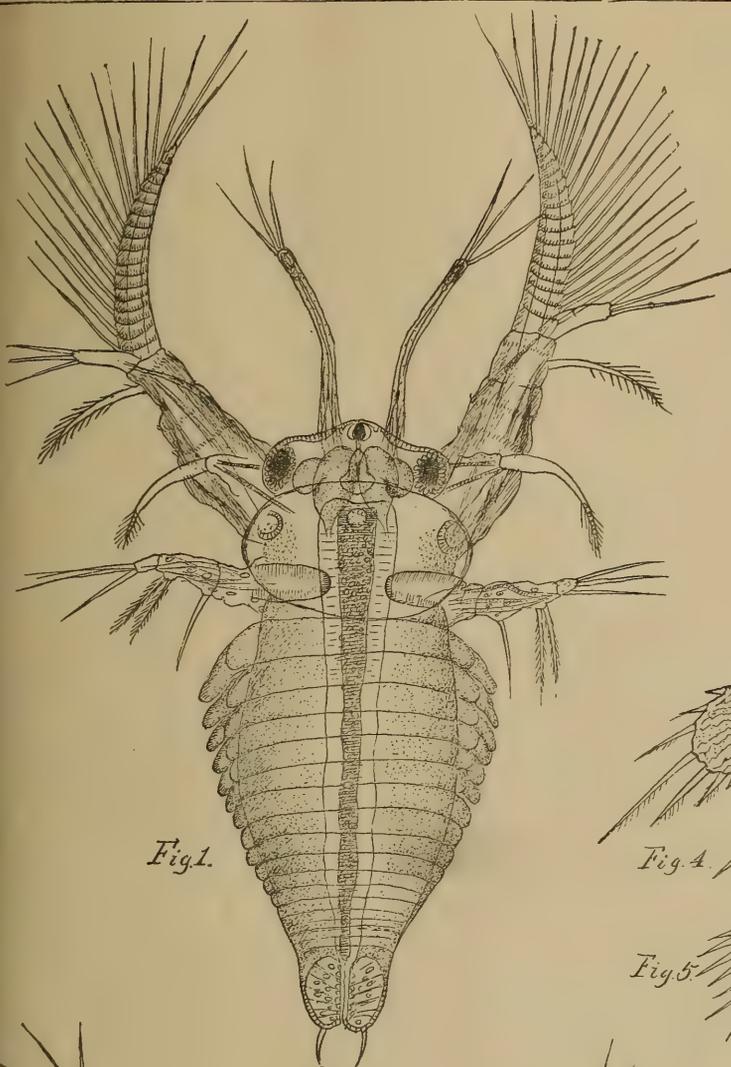


Fig. 1.

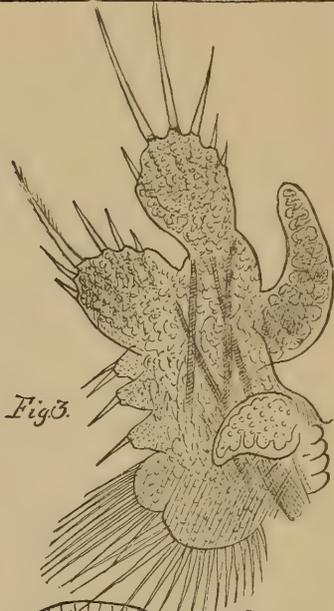


Fig. 3.

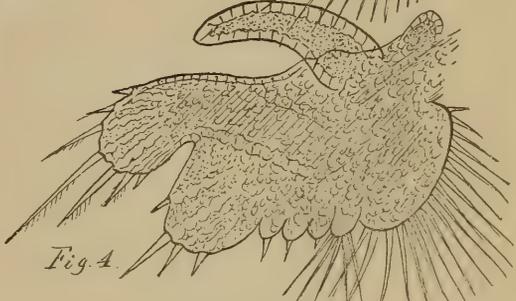


Fig. 4.



Fig. 5.



Fig. 6.

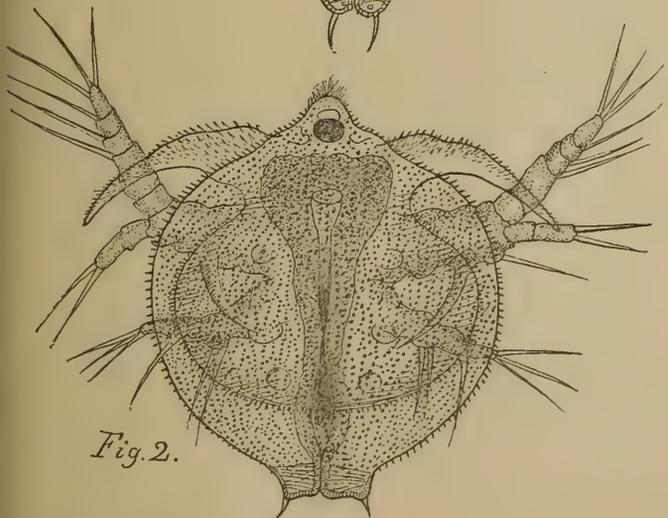


Fig. 2.

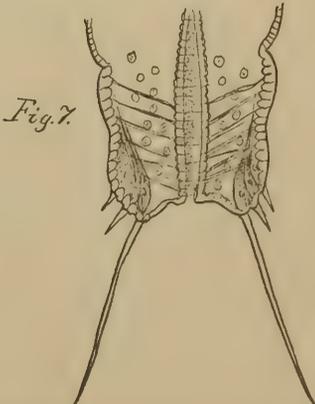
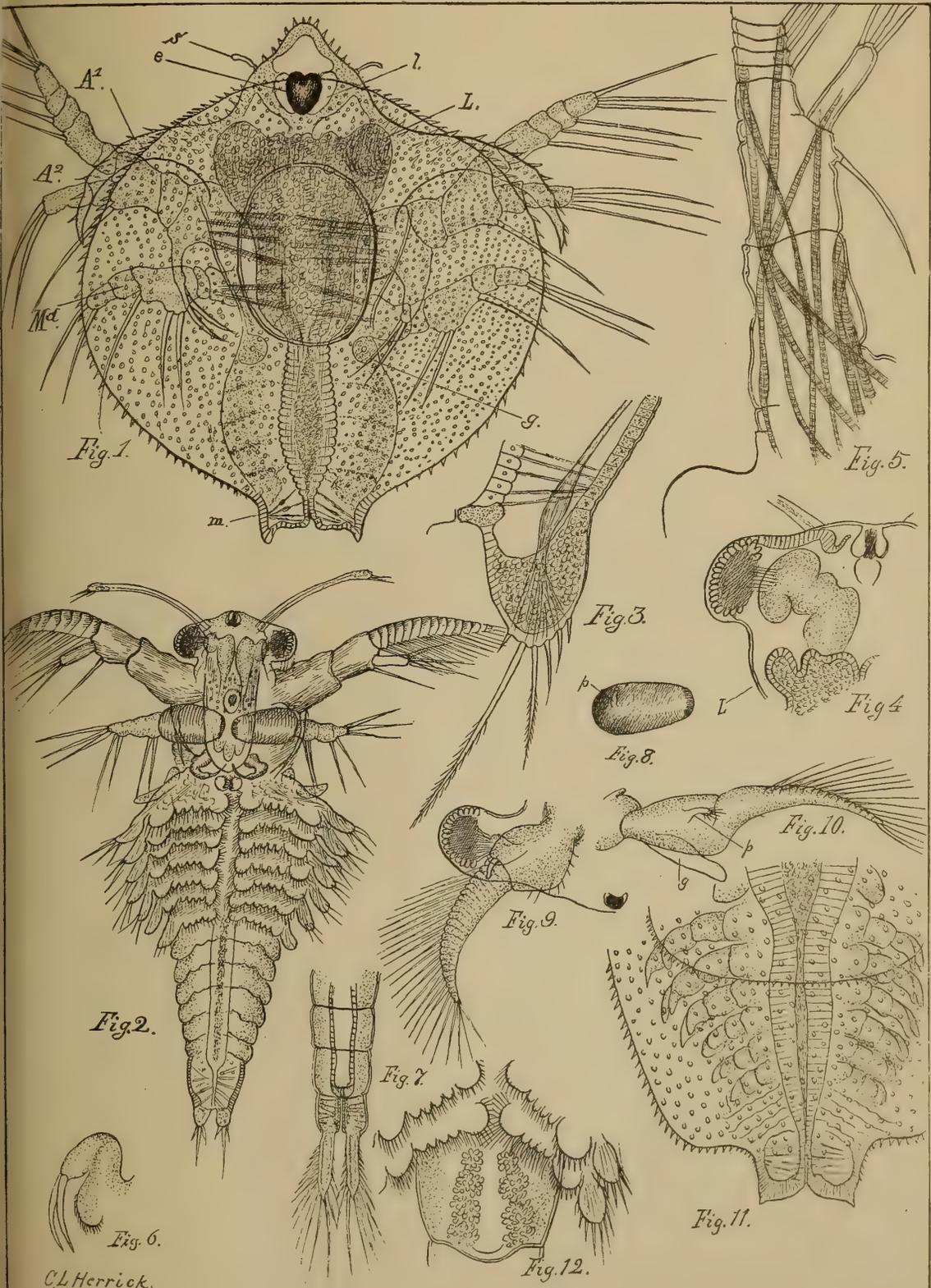
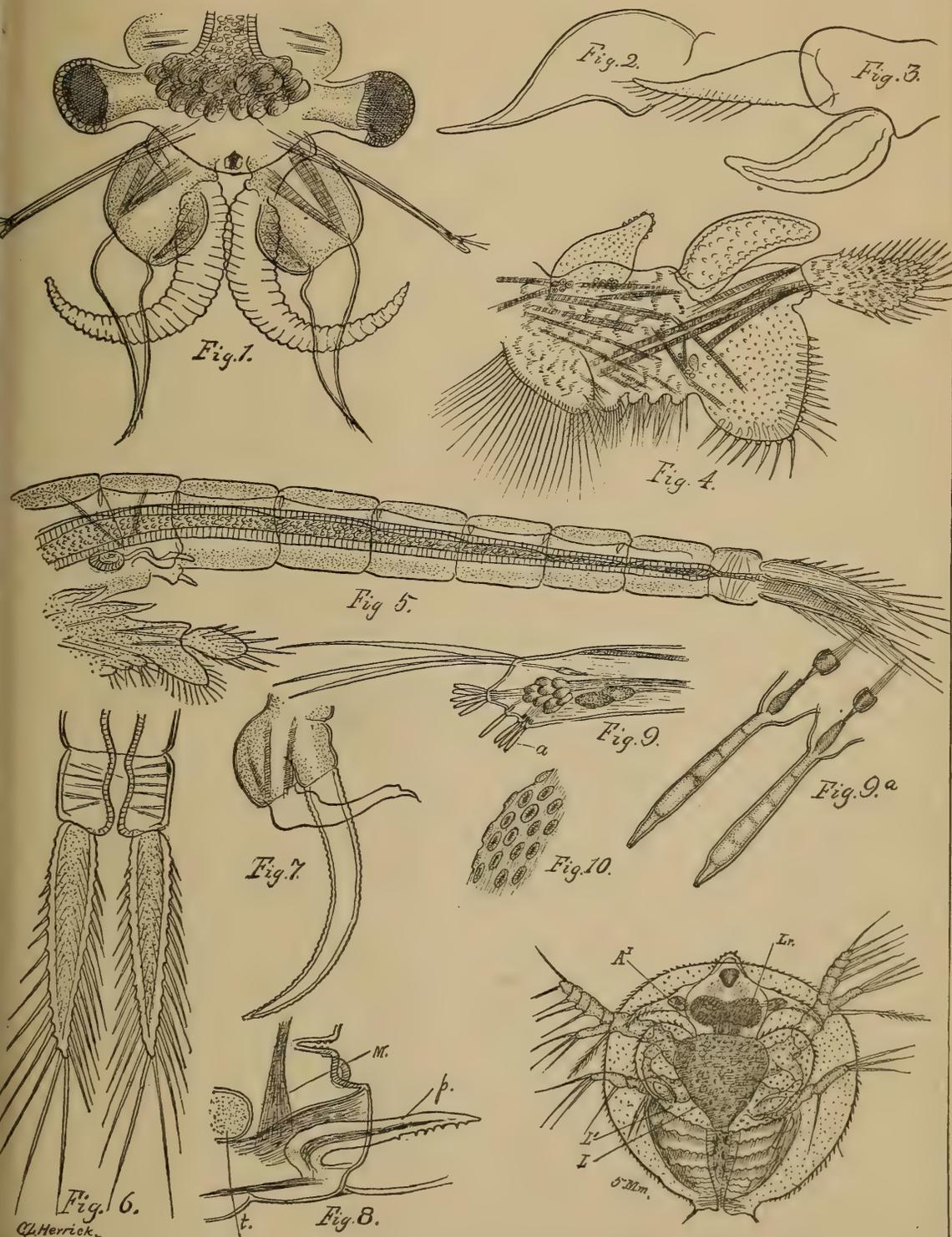


Fig. 7.

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IV.

MUD-INHABITING CRUSTACEA.

Plate IX.

Among the curiosities of pond life are certain minute crustaceans which spend their entire life in the soft debris and mud forming the superficial deposit at the bottom. The *Canthocamptus* among copepods is commonly found in such situations, but this is less surprising than that members of the cladocera, or shelled entomostraca, with their delicate organization and frail structure should have become adapted to such a life. In many marine crustaceans (copepoda) the accommodation to such a reclusive life is manifested in the retrograde development of many of the organs—eyes, even, being absent in several cases. The present paper is concerned only with a few cladocera, which are peculiar to America or rare both here and elsewhere, and which exhibit curious and instructive modifications as a result of such a habitat. The reader who wishes to familiarize himself with the systematic classification of the group would do well to consult *Die Cladoceren Boehmens*, by Hellich, Birge's *Notes on Cladocera*, and the writer's *Final Report on Crustacea of Minnesota*, while, for a thorough study of the physiology, Weisman's *Beitraege zur Naturgeschichte der Daphnoiden*, is necessary. A special paper on the limicole or mud-loving cladocera was published in the *Zeitschrift fuer Wissenschaftliche Zoologie*, in 1878, by Dr. Wm. Kurz, and entitled *Ueber limicole cladoceren*. Reference will be frequently made to this paper and this must be understood in all cases of reference to Kurz, unless otherwise specified. These mud-dwellers are happily called "*schmutz-peterchen*" cladocera, *i. e.* "Smut-Johnny," or chimney-sweep water fleas. In America the following species are pre-eminently worthy of the name: *Monospilus tenuirostris*, *Leydigia quadrangularis*, *Alona sanguinea*, *Alona quadrangula*, *Pleuroxus procurvus*, and several other members of the genera *Alona* and *Pleuroxus*. The typical cladocera

are graceful in movements and slender in form. Very generally they are more or less boat-shaped and the polished shell is modeled like a clipper, the head-shield forming the prow, while, in a few cases of the best swimmers, (as *Camptocercus*, *Acroperus*, and *Alonopsis*) there is developed a sharp ridge upon the back which bears an unmistakable resemblance to the keel of a boat and, since the animals swim upon the back, may not impossibly serve a similar purpose.

In the mud-loving species, on the contrary, the body is clumsy and approaches the spheroid in form, the antennæ, which normally are oar-like and long, bearing fringed setæ, are short and are armed with claw-like spines and smooth setæ. The post-abdomen or tail, which in the natatory species is reduced in size and subordinated in function, is here enlarged and armed with numerous and considerable spines. The front of the head is either reduced and pointed, or, if there be a long beak, it is turned up out of the way. The meaning of all this is that the animal no longer swims on its back, but creeps humbly and prone and requires the efforts of post-abdomen and antennæ, as pushing poles to make its way through the debris in search of food. The effect of this manner of life is seen in several other ways, as in the structure of the shell itself. In several of our species the shell, which is renewed periodically, is not, as in other cladocera, moulted, but remains as a sort of outgrown overcoat, after the new shell has become perfected.

The result of this is what might be expected from the sluggish nature of the animal, the supply of clothing thus accumulated becomes so onerous a burden that it no longer could swim if it desired and is thus fettered to the life it early chose. While this is true of a few only, yet in all the limicole cladocera the cuticle becomes indurated and it follows that respiration, which normally takes place from the entire surface of the body, becomes restricted to those membranes in contact with the water within the valves of the shell. As a partial offset to this disadvantage, the strictly respiratory appendages on the feet are enlarged more than in most groups. The sensory organs are modified in several ways. Kurz calls attention to the fact that the antennules are movably joined to the body in the limicole cladocera; they are also, as a rule, rather large and well endowed with sensory apparatus. The compound eye is small and, in one species, as we shall see, fails to develop at all.

MONOSPILUS DISPAR, Sars. is the most remarkable of all filth-dwellers. This animal may probably lay claim to be called the rarest of

the family and has been seen but few times. First described and figured by Fischer, from Russia, it next turns up in Scandinavia, where Sars gives a full Latin description. Norman and Brady find it in England, and Mueller in Denmark, and, finally, Heilich records it in Bohemia. It was also reported from Minnesota, by the writer, in 1884.

Unlike most other limicole cladocera, the body is narrow and high, rather than globose, the head is much depressed and terminates in a slender rounded beak, like the bill of a duck. The fornices or free margins of the head-shield are narrow and flaring. The shell of an old individual is a curious pile of overlapping valves, and is ornamented with concentric series of depressions. The lower margin is nearly straight and bears a row of long curved teeth (not free spines), back of which are two small teeth. The antennæ are short and the antennules rather slender. In this respect our specimen seemed to disagree with the figure given by Hellich. The labrum is of large size and is produced into an acute appendage below, as in most Lynceids. The compound eye is quite absent, but its function is subserved by the larval organ, a quadrate and rather large fleck at the base of the antennules. The intestine is coiled once and one-half times and opens in about the middle of the flat, pentagonal post-abdomen. The latter bears straight terminal claws, each with a single basal spine, a series of rather small triangular teeth, posteriorly, and irregular areas of fine spines upon the sides. The male is not known and many points of interest remain to be made out.

The two species of *Leydigia*, both of which occur in America, are familiar enough and are sufficiently well described to render a repetition of the description needless. It is otherwise with the only species of *Ilyocriptus* yet found in America.

ILYOCRYPTUS SETIFER, Herrick.—The description given in my "Final Report, etc.," is very brief and no comparisons were there instituted with the *I. agilis* of Kurz which is its nearest ally in Europe. The paper by Kurz referred to gives detailed descriptions of the three European species accompanied by elegant plates. We are able, therefore, to draw up the following distinctive diagnosis of the species, hoping thereby and by means of the figures to show the relations of the four species at present known. It is almost certain that we have more than one species in America and the careful description of the known form may make the detection of others easier.

The size varies greatly, a full grown female with eggs in the brood cavity is nearly .90 mm. long and .70 high, while a smaller female measures .65 mm. long by .44 high. The form of the shell is nearest like that of *I. acutifrons*, the height being less than in *I. sordidus*, and the angle between the ventral and posterior margins less than in *I. agilis*. The entire length of the post-abdomen in the large female is .56 mm. measured to the base of the caudal stylets, of which length .168 mm. pertains to the claws. The width of the post-abdomen is but .14 mm. Thus it is evident that the proportions of the post-abdomen differ greatly from any of the other species, it being very long and narrow. The terminal claws are exactly as in *I. agilis*, having two small basal spines and a few sharp serrations near the apex, anteriorly. Near the base of the claw is a cluster of small spines of two sizes, then begins a series of about sixteen lateral teeth averaging .02 mm. in length and extending to the sides of the anus. Above this point the contour of the margin is convex and is ornamented with nine spines twice as long as the preceding. Then follow the prominences which bear the long and simple caudal setæ. Besides the above mentioned spines there are four spines on either side upon the lower posterior angle of the post-abdomen which are four times as long as those of the previously mentioned continuous series (*i. e.* .08 mm.) Above, the abdomen is hirsute or thorny as in *I. agilis*, and the process for closing the brood sac is similar. It will be seen that the post-abdomen differs in armature as much as in form from other species. From *I. sordidus* it differs in the following points:—the claws are not pectinate behind but are serrate in front, the anal opening is higher and the details of the spines vary; from *I. acutifrons* it differs in that the claws are not pectinate, neither is there a spine in front of the claws, and the anus is not terminal; from *I. agilis* it differs, in that the shape is different, there are fewer enlarged spines, and the shape of the nine spines above the anus is different. The head is convex, resembling *I. sordidus* most nearly, but the antennules are much longer and more slender than in any other known species. They are .17 long and about .016 mm. wide, while the longest seta is .084 long. The antennæ are almost exactly as in *I. sordidus*. The labrum has the usual shape, as have the jaws and other appendages. The margins of the shell are ornamented with spines simply pectinate or barbed, as in *I. agilis*. In *I. sordidus* these spines are variously branched and in that form alone of the European species, according to Kurz, is there a failure to per-

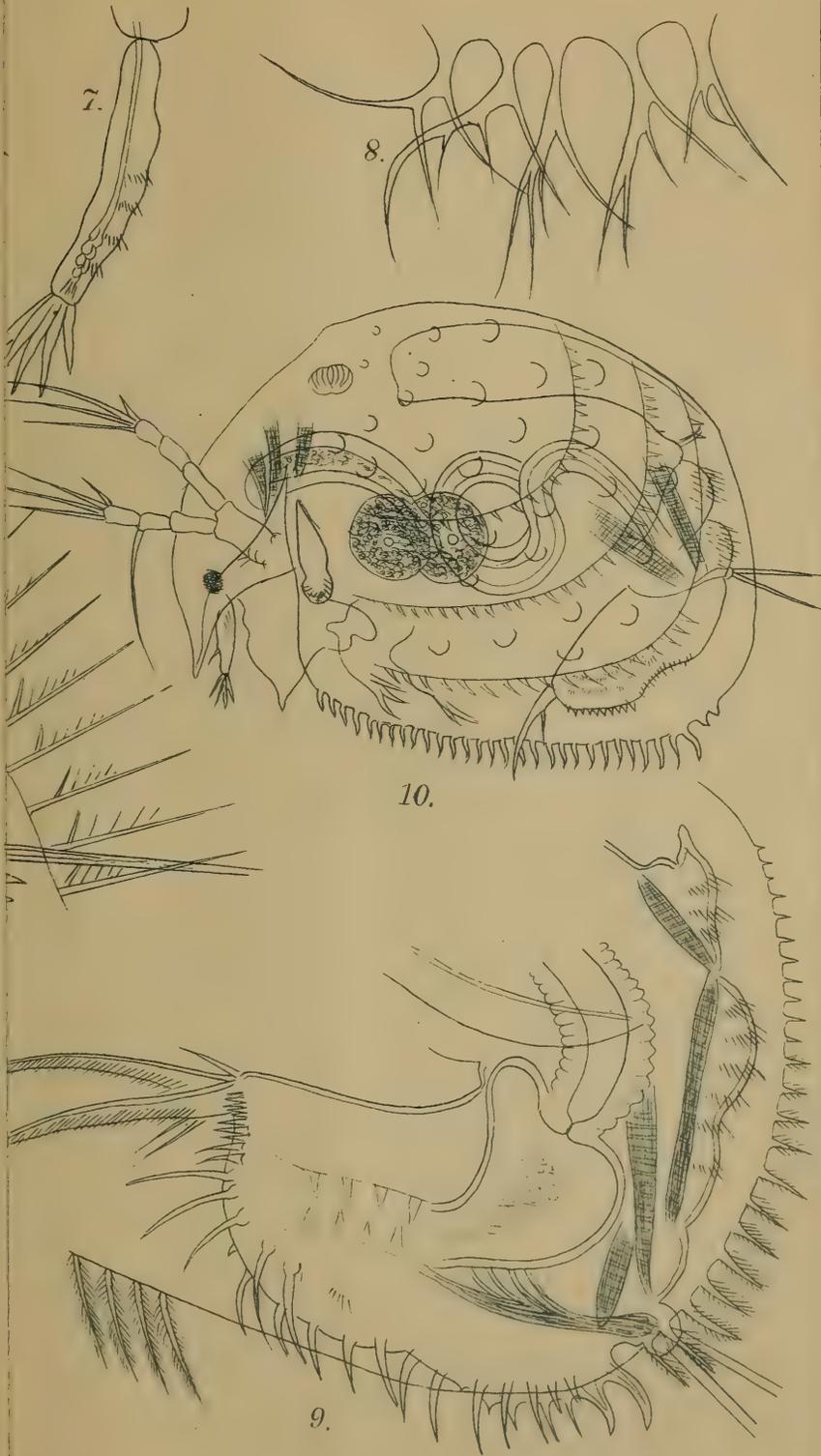
fect the moult; in our species, which has simply pectinate setæ, the old coverings are all but uniformly retained. The spines of the lower posterior margin are from .16 mm. to .20 mm. long.

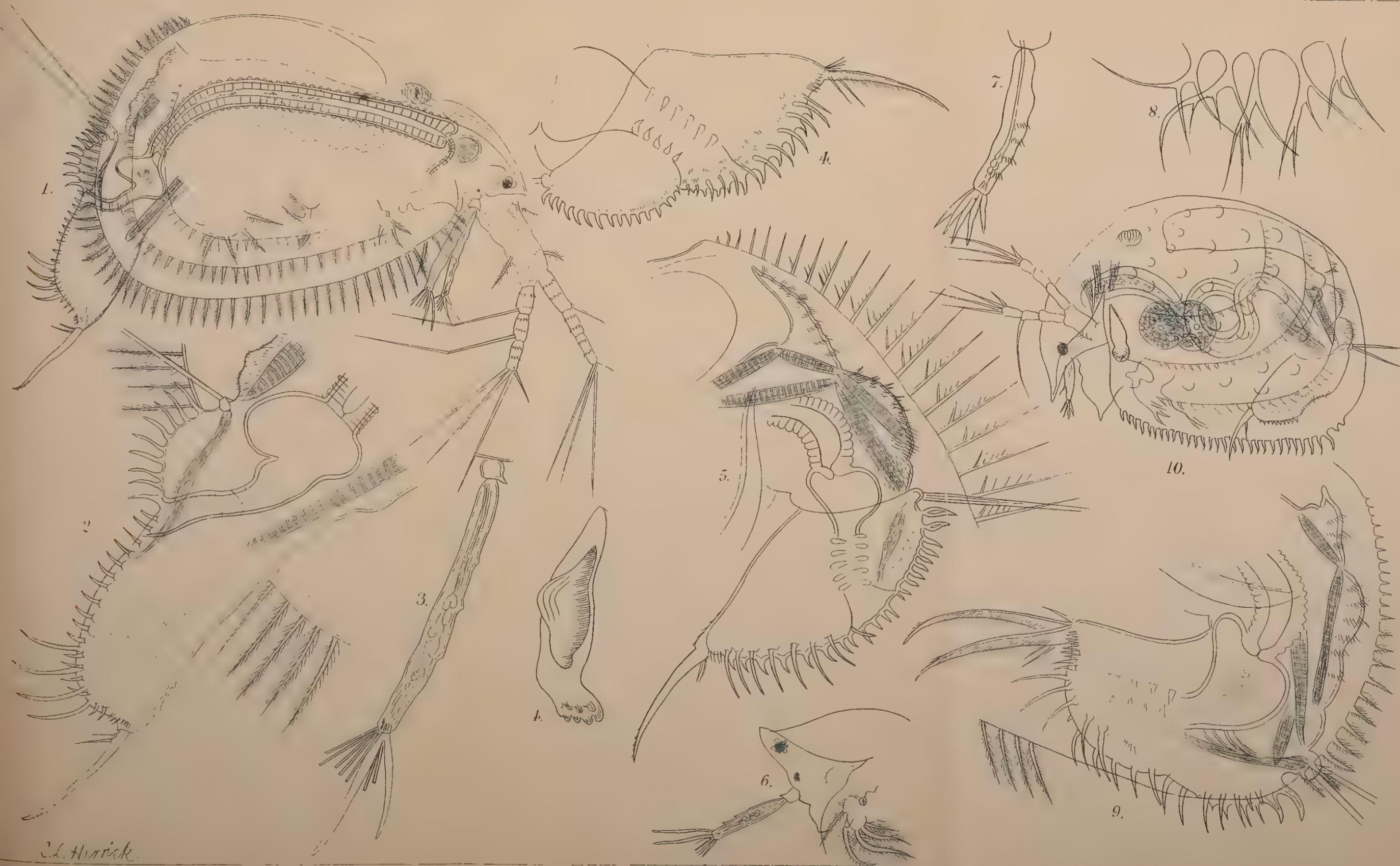
Such are some of the chief peculiarities of the species, but, to make the relation between the four species of this little-known genus even clearer, if possible, the following comparative table is appended.

The shell moulted periodically —	{ <i>I. agilis.</i> <i>I. acutifrons.</i>
The shell not moulted but retained—	{ <i>I. sordidus.</i> <i>I. spinifer.</i>
Antennules not more than eight times as long as broad—	{ <i>I. sordidus.</i> <i>I. agilis.</i> <i>I. acutifrons.</i>
Antennules more than eight times as long as broad—	<i>I. spinifer.</i>
Claw of post.abdomen pectinate—	{ <i>I. sordidus.</i> <i>I. acutifrons.</i>
Claw of post.abdomen not pectinate—	{ <i>I. agilis.</i> <i>I. spinifer.</i>
A strong spine in front of claw—	<i>I. acutifrons.</i>
Fine bristles or none in front of claw	{ <i>I. sordidus.</i> <i>I. agilis.</i> <i>I. spinifer.</i>
Anus opening near the claws—	<i>I. acutifrons.</i>
Anus about midway of the posterior border—	{ <i>I. sordidus.</i> <i>I. agilis.</i> <i>I. spinifer.</i>
Marginal spines of shell much branched—	<i>I. sordidus.</i>
Marginal spines nowhere much branched—	{ <i>I. agilis.</i> <i>I. acutifrons.</i> <i>I. spinifer.</i>
Elongated anal spines on either side, four or five, very long—	<i>I. spinifer.</i>
Elongated anal spines more numerous—	{ <i>I. agilis.</i> <i>I. acutifrons.</i> <i>I. sordidus.</i>
Upper (one to three) spines of the supra-anal series modified and enlarged—	{ <i>I. acutifrons.</i> <i>I. agilis.</i>
Upper spines like the others—	{ <i>I. sordidus.</i> <i>I. spinifer.</i>

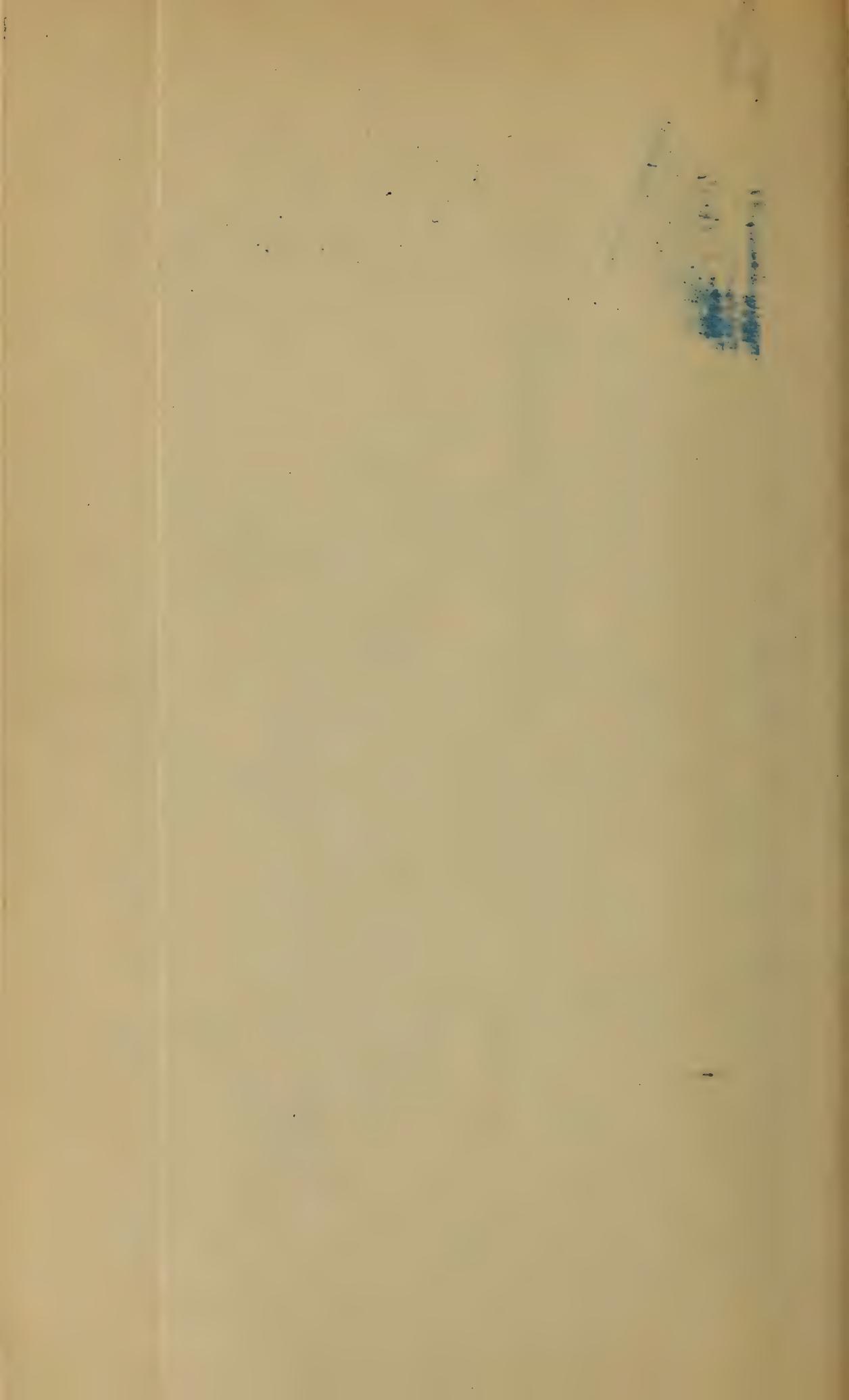
Plate IX.

- Fig. 1.* *Ilyocryptus spinifer*, Her., female.
Fig. 2. Post-abdomen of same.
Fig. 3. Antennule of same.
Fig. 4A. Jaw of *I. sordidus*.
Fig. 4. Post-abdomen of same.
Fig. 5. Post-abdomen of *I. agilis*.
Fig. 6. Head of same, antennæ being removed.
Fig. 7. Antennule of *I. sordidus*.
Fig. 8. Spines on edge of shell of same.
Fig. 9. Post-abdomen of *I. acutifrons*.
Fig. 10. *Monospilus dispar*, female.





C. L. Herrick.



V.

NOTES ON AMERICAN ROTIFERS.

BY C. L. HERRICK.

[*Plates II—IV, and Plate X.*]

Introduction.—In the series of papers here begun, it is expected to treat the subject in somewhat the following order: First, in an introductory section, an outline of the general characteristics will be given, then we shall proceed to a description of species without attempting to treat them in systematic order, finally, if permitted, space may be devoted to a review of the classification and a more detailed discussion of anatomy and development. The present installment attempts simply to describe a few of the common species of a number of genera.

A rotifer may be described as a worm-like, bilateral, metazoan, moving by means of a circum-oral trochal disc, and either adherent or free-swimming. Many of the animals of this group are exceedingly small and are greatly exceeded in size by certain Infusoria, and it was this circumstance, as well as a certain outward similarity in appearance, which led Ehrenberg to include both under the one head and to ascribe to Infusoria the same complicated structure he was able to make out in rotifers. Living in all fresh waters, these animals are among the most accessible objects for the microscope, yet, on account of the care necessary in their study and the scattered literature, they have been much neglected in America.

The body of all rotifers exhibits a tendency to segmentation, which is, however, mainly confined to the integument. The inner organs are but slightly affected by the jointing, except the muscular system which is, moreover, largely responsible for the number and arrangement of the segments. Very generally the body terminates posteri-

only in a several-jointed abdomen or "foot," which bears two caudal stylets and contains glands which secrete a gummy fluid used by the animal in temporarily adhering to other objects. The form varies from nearly spherical or round lense-shaped to terete and extended. The cuticle is modified in various ways, sometimes appearing like a bivalve shell and thus heightening the resemblance to certain entomostraca and explaining why older naturalists classed the rotifers under crustacea. The cuticle may be smooth or beautifully ornamented and produced into long spines or marked off into areas outlined by impressed or raised lines. The cuticle is secreted by a hypodermic layer which is often seen obviously to consist of cellular tissue. Notwithstanding the protection afforded by a chitinous shell, some species (as *Melicerta ringens*) build for themselves a tube composed of materials gathered from the water and apparently connected by a cement secreted in a gland near the mouth. Such an envelope may be compared to those swallows' nests eaten in Asia, or the case of a caddis-fly. Some of the species live in colonies, and when the colony is spherical, as in *Conochilus*, it is a veritable microcosm—a sphere of active, voracious creatures whirling through aqueous space. In only one case is it certainly known that a moult takes place, and facts seem to be unharmonizable with the theory that such a change of coats is affected.

The cilia of the trochal disc or "wheel" are arranged in the greatest variety of ways in different genera. The attempt is made to refer all these forms back to a fundamental form—*i. e.* a double circlet of cilia, the outer of which is largest and serves as locomotory, while the inner set is under the control of voluntary nerves and serves simply to bring food within the pharynx. In many cases there is really no indication of such a distribution and the cilia seem to be merely isolated clusters of hairs scattered about the oral end of the body. Several of the rotifers are parasitic and cling to the less exposed parts of the body of certain Amphipods, or on Annelides, or are endoparasitic. The muscles are often very conspicuous and, when large, show the striated structure well. The alimentary canal, maxtax, and the contractile water vessel have muscular tissue of another sort.

The nervous system is most difficult to study and little is certainly known of its structure. Usually there can be made out a considerable granular mass over the maxtax and in close proximity to the eyes, this is assumed to be the principal ganglion. From the chief or central ganglion fine nerves pass to the muscle and organs of sense.

The eyes are double or single and are sometimes supplied with a lense; they are always furnished with a dark red pigment and, very generally, rest directly upon the ganglion. There are ocelli at various points in the trochal disc of some species. The sense of touch is delicate, and there is often a special tactile tentacle, or palpus with minute tactile rods. This may be reduced to a slight papilla or a pit, with sensory hairs. No other sensory organs have been discovered, although Huxley fancies that to be an octocyst, which the Germans call the "Kalk-beutel," *i. e.* the lime-sac. This is a spheroidal sac, containing irregular grains of lime. The function is unknown, but it may be simply a reserve supply to be used in preserving the rigidity of the indurated parts of the body.

The mouth is more or less ventral, while the anus is dorsal. The mouth leads by the pharynx into a roomy and expansible crop or directly into the maxtax or masticatory organ, and this is armed with chitinous appendages of the most various form, but referable to a simple type. Here there is a central anvil-like part called the *incus* and two lateral *mallei* which consist of a handle (or *manubrium*) and a head (*uncus*) which beats upon the incus and reduces the hard parts of the food. The maxtax opens into a narrow ciliated œsophagus which, in turn, leads to the stomach proper.

The stomach is sometimes quite distinct from the succeeding parts of the system, but sometimes can only be distinguished by the large size and absorbtive character of its cells. Into the stomach is poured the secretion of a pair of glands which may be compared to the so-called salivary glands of insects or the liver and salivary glands of vertebrates. The size of the glands is dependent on the diet of the animal. In carnivorous species the glands are small, while in others they become quite conspicuous. The intestine is clothed with long cilia and opens into the cloaca or common receptacle of the reproductive, water vascular, and alimentary systems. In some species, however, the stomach is a cœcum and has no anus. Males uniformly lack the alimentary system and are short-lived creatures of love. In some cases evident messenteries support the digestive tract.

The excretory system consists of a pulsating bladder, opening into the cloaca, and two lateral vessels of various form, upon which are flagellate chambers which contribute to keep up a circulation between the cavity of the body and this vascular system.

Respiratory and circulatory organs, in the received sense, are absent,

respiration taking place, as in many small entomostraca, through the body surface, and circulation is affected by the rythmical movements of the digestive tube and the ciliary action in the later vessels.

In mature females much of the body cavity is filled by the ovary and the yolk masses or eggs. The ovary is disc-shaped, botryoidal or variously contoured and in the grey substance exhibits hyaline spots containing the nucleated ovule cells. A part of the ovary temporarily secretes the yolk when the egg reaches maturity, so that the appearance of the viscera differs greatly at different times. The egg, after extrusion, is commonly carried about in a delicate external brood-sac as in copepoda.

To add here the details of the development of the egg would lead us too far. The male, as before said, has no functional digestive tract and is not only much smaller than the female, but suffers a reduction in many organs. The sensory organs are, however, well developed. The testis is spindle-shaped or oval and opens in a papilla, which also contains the opening of the water chamber or pulsating vessel. The spermatozoa are rod-like or thread-like and motile.

The Rotifera are found in fresh and salt water over the entire globe. Some species may be found in damp situations on land. They exceed even the lower crustacea in their great adaptability to changes in outward surroundings. Not only is drought not destructive to the eggs, but the animal itself endures a long period of dissiccation. Other notes upon the habits must find their place under the special descriptions.

Descriptive Part.--As above stated, the following descriptions are given without attempt at orderly arrangement, with the expectation of ultimately attempting a systematic review. In cases where lack of literary aids make positive identification impossible, the description alone will be given, awaiting future identification.

GENUS FLOSCULARIA, *Oken*.

The head is margined by five oval processes bearing exceedingly long setæ of excessive fineness. The mouth is central, with a funnel-form opening. There is a crop-like vestibule, separated by a partition from the pharynx, except in the centre, which is perforate, the opening being margined by several pendulous cilia. The adult is attached by a long, jointed foot, but the young is motile and possesses eyes, which are aborted after the metamorphosis.

FLOSCULARIA ORNATA, *Ehr.*

is not a rare inhabitant of the pools of Minnesota. The very full descriptions of this species, given by various authors, would seem to have exhausted the subject, but we do not even yet feel sure that the so-called species are not local or age variations. The other species are *F. appendiculata*, *F. proboscidea*, *F. complanata*, *F. longiloba*, and *F. trifolium*.

Of *Rotifer* and *Callidina* we find a number of species, but reserve the consideration of the group for another occasion.

Notommata furnishes several species which are very abundant and striking, but a large number of works are necessary for their study.

GENUS EUCHLANIS, EHR.

The lorica is oval and composed of an arched dorsal shield and a plane ventral one. The lorica in front is broad and presents a large opening for the head. The shell often has a carina above, while the dorsal shield is movable upon the ventral. The trochal disc is strongly ciliate and bears two terminal sensory organs with clumps of tactile hairs. There is a single cervical eye and the viscera are highly differentiated. The foot has four short segments and two terminal lanceolate claws.

EUCHLANIS (DILATATA) HIPPOSIDEROS, *Gosse.*

[*Plate III, Fig. 2.*]

The identification of our species with the above is made in spite of minor points of disagreement which may be looked upon as the result of faults in the descriptions or slight variations in structure. Eckstein gives the length at .45 mm., while Eyferth says .23 mm. Our species varies only between .22 and .24 mm. and is quite uniform, so far as observed. The form is oval, the lorica being excavated before and behind, as shown in the figure, although it is not often seen as clearly as drawn.

The trochal disc has two broken circlets of cilia, and on either side the head is a pit densely ciliated within. The drawing given by Eckstein shows the arrangement well. Two curious sensory organs occupy the very front of the head. The ganglion is very large and quadrate, the eye being near its anterior part and quite large. The maxtax is quadrate, showing the component parts well. The stomach is ob-pyriform and there are two accessory glands. The ovary has very large nuclei and the egg is of great size. The contractile vessel

is clearly seen and all the details of the water vascular system may be made out with ease. The lateral vessels are tortuous canals, while upon them are seated beaker cells, the flask-shaped base of which connects directly, by means of a curved tube of less diameter, with the main canal. The mouth of the flask is directed downwards and has a small opening near which is the point of insertion of a long cilium which extends upward into the flask, where it is constantly in motion. There seems to be no reason to doubt that by means of these beaker-cells the vascular system is in communication with the perivisceral cavity. The foot is comparatively slender and has, aside from distinctly cross-striate muscles, two large foot glands which open in the ends of the rather long dagger-shaped claws. A pair of fine bristles springs from the dorsal surface of the last segment of the foot.

The following measurements were taken :

No. 1.	lorica	.22 mm. long.	No. 2.	.22	No. 3.	.24
	"	.14 mm. wide.		.14		.15
	foot	.06 mm. long.		.06		—
	claws	.07 mm. long.		.07		.072
	jaw capsule	.06 mm. long.		.06		.048

Found in Minnesota during the whole summer among water plants.

EUCHLANIS AMPULIFORMIS, sp. n.

[Plate II, Fig. 3.]

This species, which deviates toward *Salpina*, is smaller than the above and, in outline, is somewhat flask-shaped. The back is carinate and the flat ventral plate is excavated posteriorly with a cordate opening. The head is produced and densely hairy below. The maxilla is small, but the cervical eye is very large. The nuclei of the ovary are very conspicuous, although the egg is not as large in proportion as in the above. The foot is four-jointed and the claws are elongated and somewhat curved. The lorica is .16 mm. long, the claws .08 mm. Another individual measured .20 mm. and the claws were .12 mm. long. This species was seen but twice, June 18th, 1884, in Minnesota.

POLYARTHRAEA.

The family includes the two genera, *Triarthra* and *Polyarthra*. In both genera the foot is wanting and appendages of the sides of the body take its place. The body is not segmented except anteriorly and the form is not definite. The genus first mentioned has two lateral and a ventral appendage, while in *Polyarthra* the appendages are collected in groups upon the opposite sides. In both genera the egg is carried about as in *Anurea*,

GENUS POLYARTHRA, EHR.

A single species has so far been encountered and I am able, with the works at hand, to discover no reason to doubt its identity with *P. platyptera* of Ehrenberg.

When swimming freely this animal seems to consist of two quadrilateral segments, the first, or head segment being considerable shorter than wide in outline, while the body is a third longer than wide. The trochal ciliation is slight. Two sensory organs are conspicuous upon the front of the head and the eye occupies the middle of the first segment near its posterior margin. The maxtax is very large and the stomach is short, with a tubular intestine. There are two prominences on either side of the body near the front, each bearing three lanceolate spines. The egg is very large and is perhaps half as bulky as the whole body. The contractile vessel is small and little could be seen of the lateral vessels. The length is .10 mm. ; width, .08 mm. ; setæ, .088 mm. long. This species seems rare and was found among plants in standing water during June and July of 1884 and 1885 near Minneapolis.

The group of genera termed *Macrodactylea* or *Longiseta* includes such animals as have a more or less elongate and frequently cylindrical body, often strongly curved, and possess the following characters. The cuticle is considerably indurated; the terminal segment of the foot is long; there is usually a lack of symmetry exhibited by the claws or maxtax; and the cilia are sparse upon the trochal disc.

The following genera are at present included in the family :

Scaridium, *Monura*, *Furcularia*, *Distemma*, *Monocerca*, *Mastigocerca*, *Diurella*, *Heterognathus*, *Rattulus*.

GENUS DIURELLA, BORY DE ST. V.

The body is more or less perfectly cylindrical, and curved either ventrally or dorsally. The claws are rather long and frequently seem united, and are curved ventrally. The eye is cervical and single. There is a sensory tube upon the upper (dorsal) part of the disc. Three species are described, although doubt exists as to the specific value of one of these; they are *D. tigris*, Ehr., *D. Rattulus*, Eyferth, and *D. stylata*, Eyferth, to which a species is added below under the name *D. insignis*. The common species in America is

DIURELLA TIGRIS, (Ehr.) Bory.

The descriptions and figures of European authors vary remarkably in this instance, but from them all we are able to gather sufficient to

make it reasonably sure that our species is really *D. tigris*. It is quite variable in size and form. The cylindrical body is strongly curved ventrally. The head is distinctly set off from the body by a suture as represented by Eyferth but not by Eckstein. The sides of the neck extend into a sharp spine on either side, which, however, may be easily overlooked. There is a sensory cylinder which forms a third prominence upon the front. The foot consists of but a single evident segment which is quite short. The appendages assume a variety of appearances. Usually they seem to form a flattened triangular plate curved in the same plane as the body. This appearance is figured by Eckstein, though he describes the appendages as consisting of two pairs, the outer half as long as the inner, both being united at the tips into one plate. Eyferth says, on the other hand, that the foot bears two unequal, bristle-like, curved claws, but his drawing shows two *equal* claws. Our experience confirms Eyferth's account. Like *Rattulus*, this species moves in circles or arcs of circles when lashing its tail, but has the power of moving in a straight line by the use of the cilia alone. The maxtax is nearly as drawn by Eckstein. The chief organs are two anchor-like indurated processes which are unlike in length and form. The walls of the maxtax are furnished with ring-muscles. The stomach is glandular and its cells contain large globules of fatty matter. The intestine is pear-shaped and furnished with numerous cilia. The contracting vessel is large but the lateral vessels are not easily seen and I can add no details. The single cervical eye is large and seated on a large elongate ganglion. The ovary is small and the egg, when present, occupies the left side of the body on its ventral aspect. The total length is about .20 mm. of which the body forms .16 mm. The longer claw measures, in large specimens, .048 mm. and the shorter only .036 mm. Sometimes I fancied that I saw two lateral spines as described by Eckstein. The width of the lorica is about .65 mm. This species was encountered in Ohio and Minnesota in all situations and seasons.

DIURELLA INSIGNIS, *sp. n.*

(Plate IV. Fig. 6.)

A larger species than the above is found in Minnesota. The length, exclusive of the claws, is from .17 to .20 mm. The claws are .06 mm. long, one being much longer than the other. There are spines in the cervical region similar to those described in in the above.

The body is much more slender, while the viscera do not differ essentially from *D. tigris*.

GENUS MONOCERCA, EHR.

This genus includes elongated, nearly cylindrical or conical forms, having a single greatly elongated claw and more or fewer accessory spines on the last segment of the foot. The maxilla is elongate, with unequal indurated ridges. The stomach is oval and the intestine cylindrical.

The only specimens of this genus as yet seen resemble very closely *M. rattus* of Ehrenberg but are somewhat longer. The lorica is .30 mm. long while the claw is .22 mm. The foot consists of two segments, both of which are very short, while the last carries four or more unequal spines. The pulsating vessel is elongate oval but the details were not studied. This rotifer is quite rare.

GENUS DINOCHARIS, EHR.

The lorica is cylindrical or prismatic, with a wide opening in front. The head is distinct and feebly ciliated. The eye is cervical. The foot is long, rigid, and three jointed. The claws are long and the foot bears, beside these, long spines anteriorly and behind. The whole shell is densely covered with granulations or spinules.

DINOCHARIS POCILLUM, Ehr. (?)

(Plate II. Fig. 1.)

The most abundant form of this genus in America varies so greatly in both size and details of structure that one is tempted to identify it with the most frequent species of Europe in spite of variations from the descriptions of authors. The outline of the lorica is cup-shaped and its symmetry is broken by two ridges near the posterior edge, passing transversely. It is 1.5 times as long as wide. The first segment of the foot is short and bears two long curved spines above. The middle joint is twice as long and nearly cylindrical. The third segment is about as long as the first and bears two curved claws four times as long as the segment and also a short spine about as long as the segment.

The whole body is about .24 mm long, including the claws, which measure .08 mm. The eye is large and is seated on an ovoid ganglion. The ovary is large and the nuclei are quite distinct. The egg is obliquely placed and nearly as long as the width of the lorica. Two curved elliptical glands lie in front of the stomach. The lateral vessels of the vascular system are large. Encountered only in Minnesota.

A somewhat larger form, also found in Minnesota, has more slender claws and seems to lack the spine on the last joint of the foot. The shape is otherwise the same.

The cast-off shell of still a different form, in which there is an indication of segmentation near the anterior of the lorica, was once seen.

GENUS SALPINA, EHR.

Somewhat resembling *Euchlanis*, but having spines upon the front and posterior margins of the laterally compressed lorica. There is a median area above, which is less perfectly indurated than the sides, giving rise to two ridges. The foot is short, three-jointed, and bears two lanceolate claws. The eye is single and the ciliation of the trochal disc rather strong. The maxtax is large and the digestive tract well differentiated. Water-vascular system with two or three beaker-cells on either side. The egg is carried about with the parent after extrusion.

SALPINA AFFINIS, *sp. n.*

(*Plate II., Fig. 4.*)

This species is so allied to *S. mucronata*, Ehr. that it is with some hesitation that a new name is proposed. While agreeing in most characters, it differs from that species in having the upper pair of anterior spines much longer than the lower and curved downward and in having the lower pair of posterior spines much longer than the single upper one and curved upward. *S. mucronata* is said to measure but .15 to .16 mm., while our form is .22 to .24 mm. long and .10 mm. wide. The anterior spines measure .045, length of claws, .06 mm. The whole shell is granulated and there is a band in front, set off by a distinct line. There is a sensory tube which bears a bundle of cilia at its end, and which usually projects from between the two dorsal spines of the lorica. The eye is lunate and seated on a very large, almost spherical ganglion. The maxtax is very large and opens into a slender œsophagus. The stomach is glandular and saccate. The very large egg is ventral. No careful study was made of the viscera. Minneapolis, May.

The species of the genus, aside from those mentioned, are *S. spinigera*, Ehr., *S. brevispina*, Ehr., *S. ventralis*, Ehr., *S. bicarinata*, Ehr., *S. redunca*, Ehr., *S. dentatus*, Duj., and *S. polyodonta*, Schm. There is reason to suppose that several of these are but varietal forms.

GENUS MONOSTYLA, EHR.

Shell depressed, oval; head opening large, notched before and behind. The foot has two short basal segments and a long terminal one ending in a small spine, hence appearing as though bearing one long spine. The eye is single and situated at the base of a large ganglion. The maxtax is large and quadrate. The viscera are simple.

MONOSTYLA (QUADRIDENTATA, *Ehr.* ?)

Two species of *Monostyla* have been thus far encountered, one of which may be identical with *M. quadridentata* of Ehrenberg. The body is bell-shaped or inverted pear-shaped, the oral margin being produced into two sickle-shaped spines turned outward, which are distinct from the acute margins of the shell itself. The body is composed of two segments or apparent segments, the second being small and conical. The terminal joint of the foot is slender and elongate, bearing a thorn-like spine. The ganglion is very large. The maxtax is also large and opens into a sack-like alimentary canal not evidently subdivided. The shell in this species is ornamented with granules. Length of lorica, .15 mm., width, .11 mm., terminal caudal joint, with spine, .08 mm. Found in June, in Minnesota.

A second species is smaller, measuring from .11 to .12 mm., foot .04 to .08 mm., width, .11 mm. The shell is smooth and the curved spines are absent.

The following species are known :—

Monostyla lunaris, Ehr., *M. cornuta*, Ehr., *M. closteroerca*, Schm., *M. ophthalmia*, Schm., and *M. macrognatha*, Schm.

GENUS DISTYLA, ECKSTEIN.

Shell ovate conical, closed behind, except for the small opening admitting the foot. In front, the opening is wide and guarded on either side by projecting angles. The foot is one-jointed and bears two equal, divaricated spines. The shell may be smooth or ornamented with raised lines and serrations. The eye is single and seated upon a considerable ganglion. Two species are described by Eckstein from Europe (*D. gissensis* and *D. ludwigii*) and two additional ones occur in America.

DISTYLA MINNESOTENSIS, *sp. n.*

This is a large species, .25 mm. long, with a pear-shaped body of two segments, the first being .20 mm. long and of equal width. The second segment is .05 mm. long and has an oval slit behind for the insertion of the foot and permitting its free lateral motion. The claws

are .13 long and slender, the terminal third being attenuated. The ganglion is small and bears a single red eye. The trochal disc is retracted by four powerful muscular bands. The stomach is globular and glandular. The short segment of the foot is moved by pairs of evident muscles. This species was but once seen in July.

DISTYLA OHIOENSIS, *sp. n.*

The lorica is .12 mm. long and its form is much as in the previous species. Width of lorica .084 mm., length of claws .028 mm. The sides of the lorica project in front to form a tooth on either side of the head. The lorica is sculptured into regular areas upon the first segment. There is a quadrate plate projecting over the base of the claws. The latter are attenuated toward the end. The details of structure are not known.

GENUS SQUAMELLA, EHR.

The three genera *Squamella*, *Metopidia*, and *Lepadella* agree closely together, being characterized by the presence of four, two, or no eyes respectively. The organization is much as in *Euchlanis*. The lorica consists of an oval, arching, scale-like shield above, and a flattened plate below. The foot consists of three short joints terminating in two acute claws. The head terminates above in an oval scale-like appendage.

They only species belonging to this group as yet seen was hastily identified with *Squamella bractea* and, in absence of further information, we will simply give measurements in addition to the figure, in which, by the way, but one pair of eyes is represented, leaving us to infer that the animal is *Metopidia* rather than *Squamella*.

Length .08 mm.—.14 mm. Width (in the latter case) .12 mm. Found several times in Minnesota.

GENUS STEPHANOPS, EHR.

The lorica is depressed, and frequently extends into spines posteriorly. Head covered with a shield, which, when viewed from before or behind, is in shape like a halo. There are two eyes, occupying the extreme sides of the head. The foot is three-jointed and ends in two lanceolate claws, between which springs an awl-shaped spine.

STEPHANOPS MUTICUS, *Ehr.*

(*Plate X, Fig. 9.*)

A specimen of this species was taken in July, 1885. The lorica is oblong oval, seeming two-jointed behind. There is a slight crest

above. Both segments extend dorsally into prominences which only appear when the animal is viewed from the side. The head is covered by a thin semi-circular shield, which is slightly arched. The cilia of the disc are feeble, but the sensory tube is distinctly seen. The first joint of the foot is quadrate, the two following being of equal length but different diameter. The claws are ovate lanceolate and short. The accessory spine is awl-shaped and shorter than the claws. The length is about .10 mm. Eckstein gives very good and accurate figures of this species, his description of the viscera is also valuable.

The following species of this genus are known: *S. lamelleris*, Ehr. with three spines behind. *S. cirratus*, Ehr. with two spines behind. *S. longispinatus*, Tat. *S. ovalis*, Schm. *S. tridentatus*, Fr.

GENUS BRACHIONUS, EHR.

A large genus containing curiously armed and ornamented species. The body is depressed, oval or quadrate in outline, presenting a very large anterior opening always guarded by spines or teeth. Behind, the shell may be rounded or armed with spines like those in front. There is only a small opening upon the ventral aspect through which extends the foot. The ventral surface of the body is generally plane while the back is arched and may be set off into areas by elevated lines. The maxilla is prismatic and complicated. The egg is carried about attached to the body of the parent, as in *Anurea*. The males are said not to be rare in this genus.

BRACHIONUS BAKERI, Ehr.

A single gathering taken in Granville, O., in September, contained a species belonging in the section of this genus characterized by the multiarticulate foot.

Our species is sub-quadrate in outline and more or less expanded back of the middle. The whole length, including spines, is from .30 to .40 mm. for adult females. The oral margin, above, is produced into six spines. The median pair are longest and curve decidedly outward and may be from .05 to .08 mm. long; between them is an incision, through which ordinarily projects the sensory tube. The outer pair of spines are half as long and also curve outward. Midway between these pairs is a short spine or tooth. The ventral edge is notched in the middle, but not toothed. The width of the body is from .18 to .22 mm. The posterior portion of the shell extends into two pairs of spines, of which the outermost are very long (.10-.14 mm.) and project directly backward or slightly outward or are uniformly curved. The inner pair of spines immediately border the

opening for the exit of the foot and are curved plates. The foot, which can be almost wholly withdrawn within the lorica, is composed of a closely ringed basal portion terminated by a short rigid joint, bearing two conical claws and blunt processes. The claws are perforated by the ducts of large cement glands. The flexibility and extensibility of the foot are truly wonderful. The whole shell is covered above with fine granules, but is not otherwise marked. The eye is large and is seated on the ventral side of a large ganglion. The maxilla is very wide and short. The manubrium is a curved plate and the uncus consists of several fused plates (see drawing). I have seen the animal attempt to masticate a large diatom and, after failing to crush it, reject it by reversing the usual movement of the jaws. The pharynx is ciliated and funnel-form. The œsophagus is not ciliated, but has ringed muscles which, when in motion, give the appearance of a valvular arrangement. The stomach and intestine are strongly curved upon each other, the former being glandular with fatty spheres in its walls, while the latter is furnished with a dense coating of cilia. The pulsating vessel is not large, but the lateral vessels with their beaker cells are quite conspicuous. This species, which agrees with *Br. Bakeri* closely, is common in Ohio, (September).

Another species, known only from a single gathering and imperfectly studied, differs from all known species in having a single pair of spines before and behind and a foot which at the base is multiarticulate, but ends in the two long segments, the last with two quite long claws. The shell is nearly smooth. This species may be called *Br. intermedius*, as it partakes of the characters of both sections.

BRACHIONUS MILITARIS, *Ehr.*

(*Plate X, Fig. 10.*)

It is interesting to compare with the above a related species which is quite common in the west and which belongs to that section of the genus characterized by the absence of the ringed basal arrangement of the foot. This form, which may not be properly *Brachionus*, resembles decidedly the above in the form of the body. The anterior margin extends into ten teeth, of which the superior median are longest and curve ventrally. All the other anterior teeth are doubly curved, the points extending outward. The posterior part of the body bears two pairs of spines, the relative position (and size) of which is not constant. The outer pair are always longer and project outward and

backward. The foot consists of three slender joints, the last of which bears two lanceolate appendages somewhat longer than the segment preceeding. The whole shell is covered with minute points. The trochal disc is broken up into five lobes and the cilia are of two sizes. The measurements of one specimen are given as illustrating the proportions. Length .20 mm. exclusive of foot, width .14 mm., terminal stylets .024, lateral, posterior spines .028 mm., anterior spines about .04 mm.. From the side, the ventral surface (in outline) is seen to be plane while the dorsal is composed of two inclined planes (or is "humped.") The foot is moved by two pairs of muscles. The contracting vessel is unusually large. The maxilla and the position of the viscera seem to be as in other species of *Brachionus*. The animal seems most to resemble *B. militaris*, Ehr. of the European species.

PLÆSOMA LENTICULARE, *gen. et sp. n.*

(See figures facing Index.)

The animal for which the above generic name is proposed, was several times seen in a gathering taken at the reservoir near Hebron, Ohio, in November. The general form is very similar to that of many minute bivalved crustacea (*Chydorus*), with which it was associated. The lorica is composed of two ovate valves, which are partially united below, so that the foot springs from the middle of the ventral margin. The animal is laterally compressed. On the dorsal aspect of the lorica are several distinct ridges arranged about as follows: A pair of short transverse markings occupy a point posterior to the middle of the dorsal aspect; anterior to these, and beginning at either end, spring diverging lines which lead to notches of the anterior margin; behind, two ridges lie on either side the median line and extend to the acute posterior end of the shell. Several lines border the above described markings on either side and are approximately parallel to the axis of the body. Seen from the side, the lorica is elliptical and is truncate in front and acute behind. The dorsal line is a uniform curve, while the ventral is prominent near the middle at a point some distance in front of the point of union of the valves. Seen from above, the front half is quadrate, while the posterior half is triangular. The lorica is lenticular, considered as a whole, and is marked by minute hexagonal or irregular depressions.

The head is armed with two long sensory organs and has two sorts of cilia. The outer series is quite feeble, but the ventral prominence

bears several elongated setæ. The maxilla is oval and seems to be but slightly armed. It is furnished, however, with distinct annular bands of muscles. The eye is cervical, and is seated on the under side of a considerable ganglion. The foot is multiarticulate at the base, as in *Brachionus*. Two distinct joints follow this portion, the last being longer and bearing two oval, appressed spines. Of the internal organs little was seen. The stomach is glandular and the egg of but moderate size. The vascular system was not seen.

Length, .24 mm., height, .15 mm., width, .10 mm. Frontal processes, .03 mm., spines of foot, .025 mm., last joint, .02 mm.

GENUS ANURÆA, EHR.

Closely related to *Noteus* and *Brachionus* is a genus of curious rotifers in which the foot is entirely absent, so far, at least, as can be seen. As in *Brachionus*, the anterior opening is protected by spines or teeth, while there may or may not be similar teeth behind. The lorica is usually distinctly separable into a dorsal and ventral shield, and the dorsal scutum is marked off into geometrical figures by raised lines. There is a single cervical eye. The egg very generally remains attached to the body and may be mistaken for a part of it.

ANURÆA SP.

A species differing from all European forms is very common in the West. The form is hexagonal in outline, the length being 1.4 times the width (exclusive of spines). The anterior margin of the hexagon is wider than the posterior. The dorsal scutum is produced into six long spiny teeth, of which the middle pair are much the longest and are strongly curved outwards and downwards. The remaining pairs are sub-equal and project outwards like the horns of an altar. The ventral part of the anterior margin is excavated in the middle and bears a series of small sharp teeth. The whole shell is ornamented with circular prominences, and, in addition to this, above there are strongly raised lines blocking off the shell into thirteen regular areas and leaving two other areas about the front. The character of these ridges is best seen from a side view. The eye is cervical and the trochal cilia are strong for the genus. There is also a sensory tube.

The following measurements, owing to an accident, may not be accurate, but will give the proportions: Length, .1 mm., width, .054 mm., longest spine, .024 mm.

GENUS PTERODINA, EHR.

The lorica is flattened, round, or ovate in outline and flexible. Head funnel-shaped, entirely withdrawn into the body when at rest, furnished with two lines of cilia. Stomach sac-like with large cilia. The foot is ventral and consists of a ringed basal portion and a short terminal joint which bears no claws. The intestine is said to be continued through the tail having the anal opening at its end.

The Pterodina is a good subject for use in obtaining a knowledge of the rotifers as the viscera are quite distinct, the cross striation of the muscles and the ciliated or beaker-cells of the lateral vessels being particularly distinct.

PTERODINA PATINA, *Ehr.*

(*Plate I, Fig. III.*)

The form is circular with a slight emargination in front for the withdrawal of the head. The head is funnel-shaped and bears a double disc having good sized cilia. When extended, the eyes are seen to occupy a position about one-third the width of the disc from its sides. The pharynx is closely ciliated and leads into a comparatively large maxtax in which a partial fusion of parts has taken place. The stomach follows upon a very narrow oesophagus and is a curved sac composed of large cells, each of which is filled with granular contents and has fatty spheres within it. On either side the stomach is a strong muscle passing from the sides of the head to the posterior third of the body where it is fastened. When the head is withdrawn the muscles are curved, but upon the protusion of the head become straight. On either side the stomach is a large glandular mass composed of numerous lobes made up of fused cells with large translucent flecks which may be globules of the secretion. These glands open back of the maxtax. While the stomach is curved to one side, the intestine lies behind the tail and is curved upon itself, opening, as claimed by Eckstein, into a canal excavated in the tail. It is indeed certain that the tail contains a canal and is ciliated at the distal extremity but we have never been able to verify the statement referred to. The tail seems to be more slender in our specimens than figured by European writers, though it is exceedingly contractile. The contractile vessel seems to be absent but two very distinct lateral canals are to be seen. The breaker vessels are long and the cilia active. The ovary occupies one side of the body, while the egg nearly fills the other when mature. Large nuclei are discernible imbedded in a granular mass of yolk. The

margin of the shell seems to be granulated and extends beyond the body-cavity. The tail often is directed at right angles to the body and is then overlooked. The lorica is about .20 mm. in longest diameter. The tail measures over .07 mm. The trochal disc, when expanded, is .05 mm. wide. A small specimen, but fully adult was but .17 mm. long. Mr. Stokes mentions a species of this genus but does not identify it. There are two other species, viz. *P. elliptica* and *P. clypeata*, Ehr., which latter occurs as a parasite on species of *Assellus*. I have a confused recollection of having seen such a rotifer parasitic upon *Gammarus*. *Pterodina complanata* of Gosse is almost certainly identical with *Pt. patina*.

FAMILY ASPLANCHNÆA.

This family includes abberant rotifers, which lack the posterior opening of the digestive organs and are considerably reduced in other respects. The foot is sometimes almost entirely absent, its position being marked in these cases by the glands simply. The body is sac-like and often consists of a single segment in which the various internal organs are very readily seen. The head is broad and sparsely ciliated. The maxtax is enlarged and to it is appended an extensible crop, while the incus is not highly indurated and the mallei are modified to form a prehensile pair of nippers or pliers. The stomach may be very extensible and a part is very highly glandular. The water-vascular system is highly developed and there is generally an accessory canal bearing the minute beaker cells, while the lateral vessels themselves are tortuous and elaborate. Most of the species are carnivorous, while others live upon algæ and like plants.

GENUS ASPLANCHNÆA, GOSSE.

The genus is characterized by the sac-like body and the large size and well differentiated organism as compared with *Ascomorpha*. The details mentioned under the family apply.

ASPLANCHNA MAGNIFICUS *sp. n.*

(*Plate II, Fig. 2.*)

This, the largest species of the genus, is most like *A. Myrmeleo*, but is considerably larger and appears to differ from it in several other particulars. The general form is a prolate spheroid truncated anteriorly and slightly flattened ventrally. The oral end is furnished with six

discrete clumps of cilia and two sensory processes. The crop is large and distensible, the forceps are smooth and toothless. The œsophagus is long and muscular. The stomach is composed of very large cells and is held in place by bands of connective tissue. There are accessory glands between the stomach and crop. The ovary is pear-shaped (not horse-shoe-shaped, as in *A. Myrmeleo*), and can be seen to be made up of an elongated ribband of cells folded upon itself. The pulsating vessel is exceeding large and powerful, while the lateral vessels are convoluted canals; accessory to the latter, there are nearly straight tubes bearing about twenty beaker-cells. The foot is two-jointed and contains small glands. The muscular system is highly developed and consists of strong bands passing backward from the head and frequently branching before they are inserted upon the very pliable external wall. Two pedate cells lie upon the viscera and may represent the visceral nervous system. The nervous system was otherwise found to consist of ganglia upon the oral aspect, one of which bears a single red eye, and which send nerve-fibers to all parts of the body. The animal feeds upon species of minute crustacea, especially of the genus *Chydorus*. The greatest length is .9 mm., width, .66 mm., foot, .15 mm. This species was figured in the writer's Final Report on the Crustacea of Minnesota, where also may be found the figure of

ASPLANCHNA sp?

This species, which seems to resemble *A. Brightwellii* of Gosse, is purse-shaped, being constricted about the head. The jaws are bidentate at the end and ribbed. The foot is entirely absent, but its position is indicated by the orifice of small glands. The stomach of the only individual of this species seen contained a number of the lorica of what may be *Anuræa longispina*, Kellicott.

EXPLANATION OF PLATES.

Plate II.

- Fig. 1.* *Dinacharis pocillum*, Ehr.?
Fig. 2. *Asplanchna magnificus*, sp. n.
Fig. 3. *Euchlanis ampuliformis*, sp. n.
Fig. 4. *Salpina affinis*, sp. n.

Plate III.

- Fig. 1.* *Pterodina patina*, Ehr.

- Fig. 2. *Euchlanis hipposideros*, Gosse.
 Fig. 2.¹ do portion of lateral vessel with beaker cell.
 Fig. 3. Undetermined.
 Fig. 4. *Amphileptus gigas*, C. & L.

Plate IV.

- Fig. 1. Undetermined.
 Fig. 2. *Squamella bractea*, Ehr.
 Fig. 3. *Monostyla quadridentata*, Ehr, (?). The foot is somewhat too long in the drawing.
 Fig. 4. *Polyarthra platyptera*, Ehr.
 Fig. 5. Undetermined.
 Fig. 6. *Diurella insignis*, sp. n.

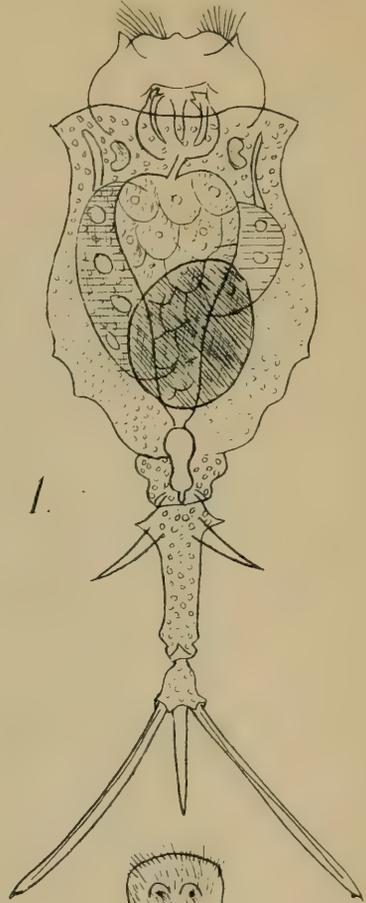
Plate X.

- Fig. 5. *Spirostomum teres*.
 Fig. 6. *Ophridium paradoxum*.
 Fig. 7. *Anurœa* sp.
 Fig. 8. *Distyla Minnesotensis*, sp. n.
 Fig. 9. *Stephanops muticus*, Ehr.
 Fig. 10 *Brachionus miliatris*, Ehr.

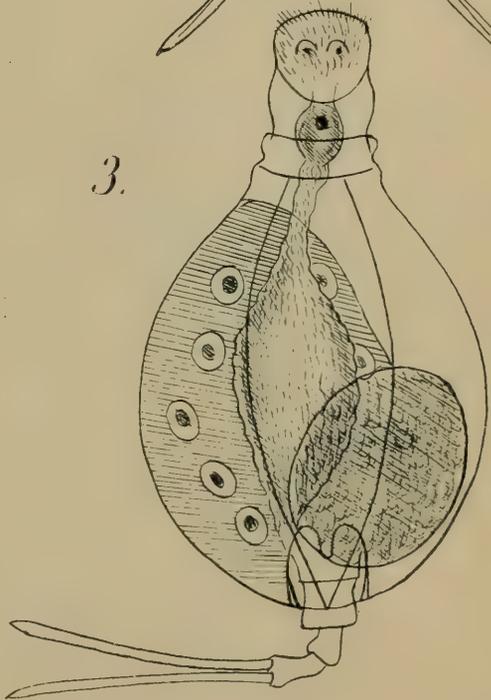
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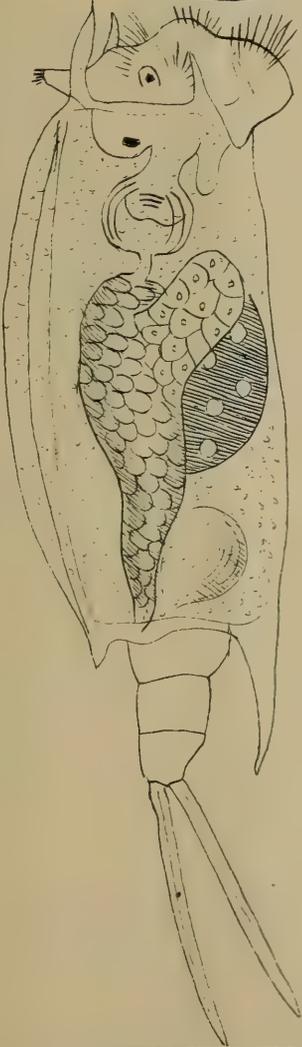
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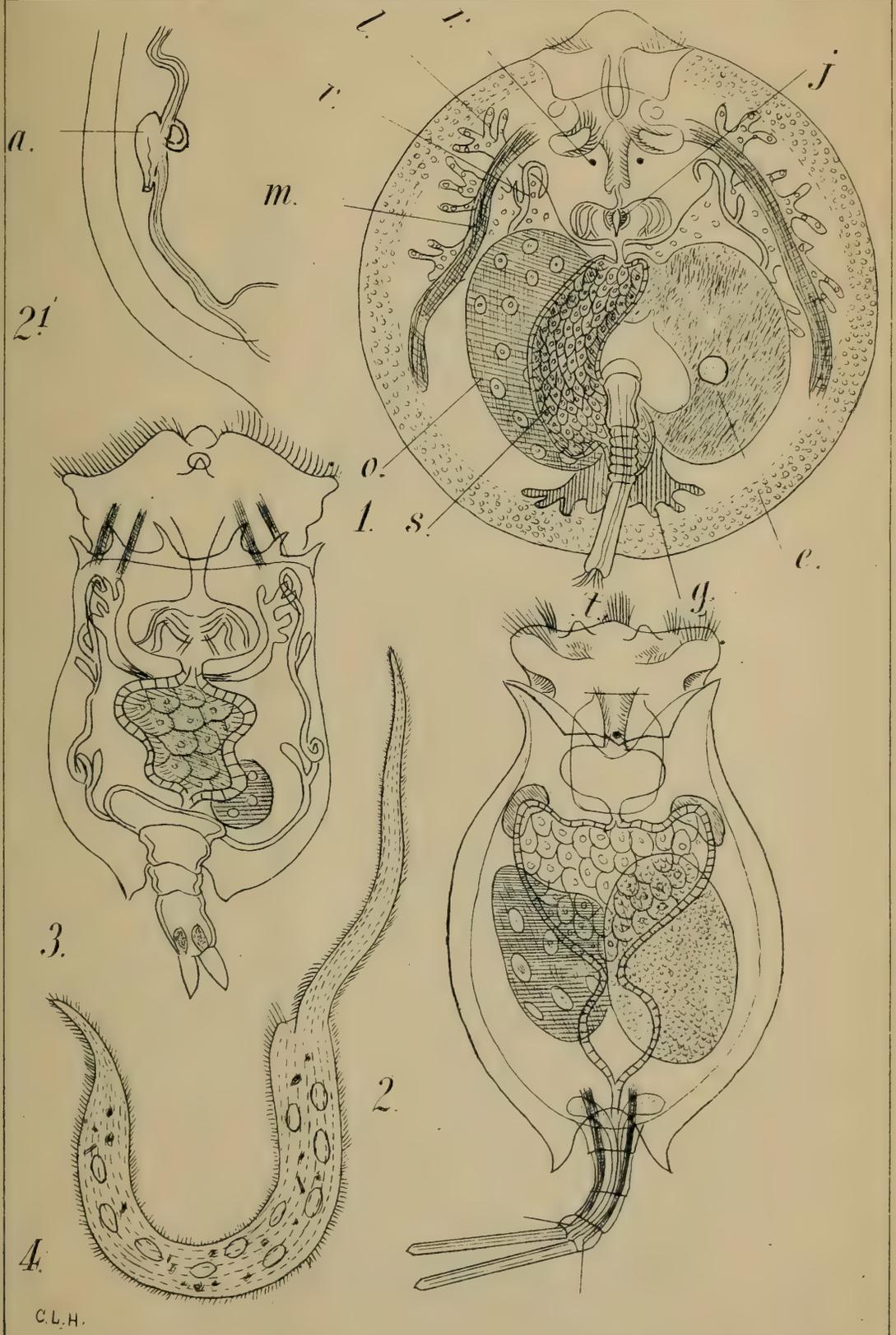


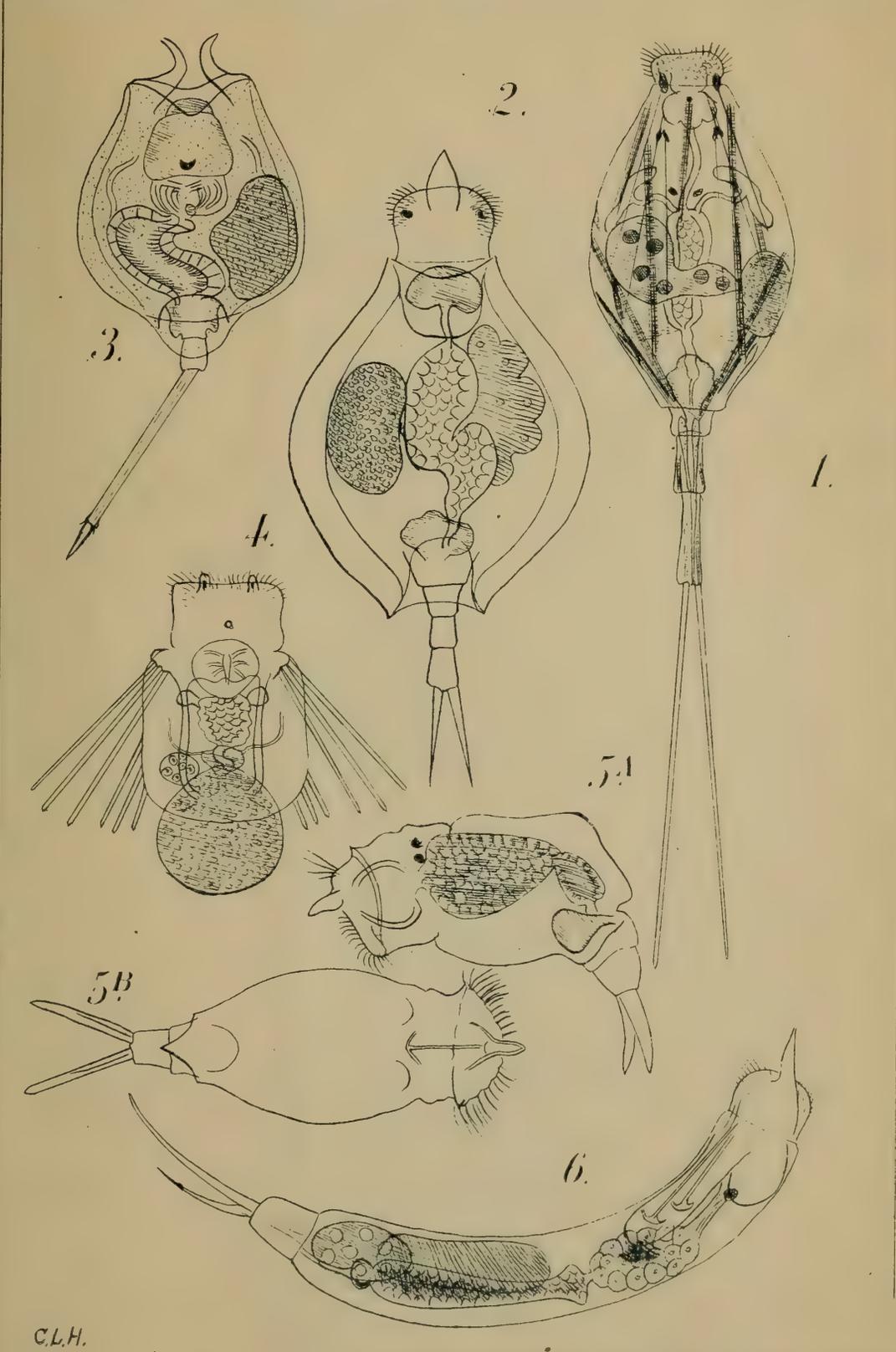
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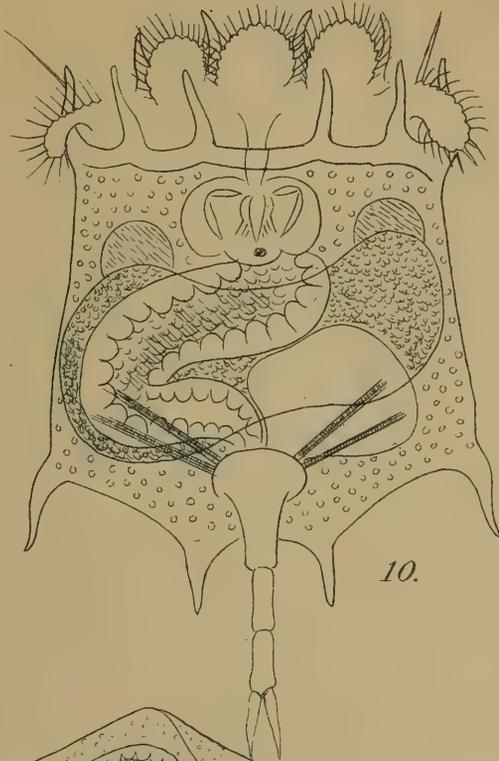
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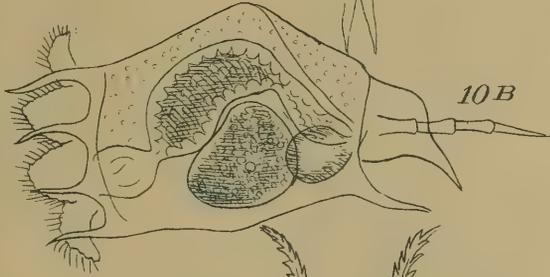




C.L.H.



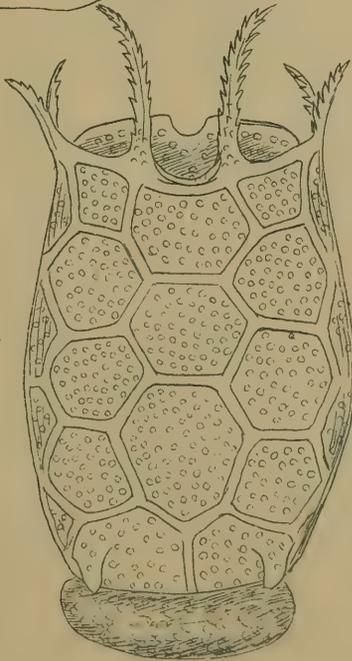
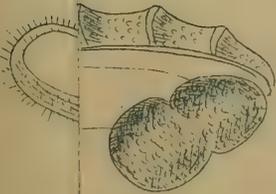
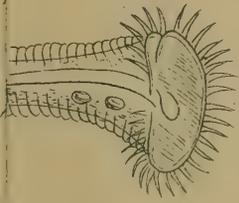
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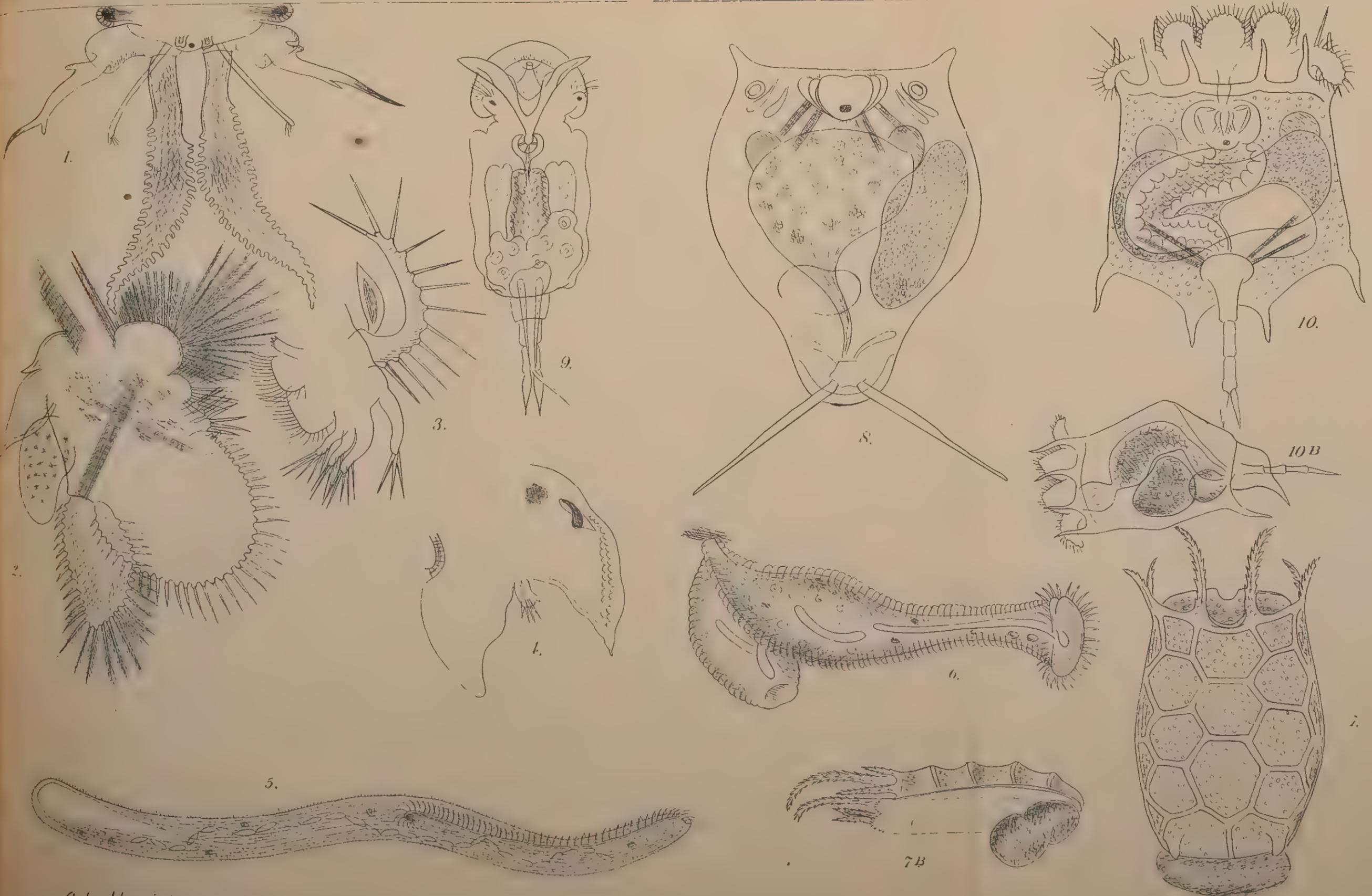
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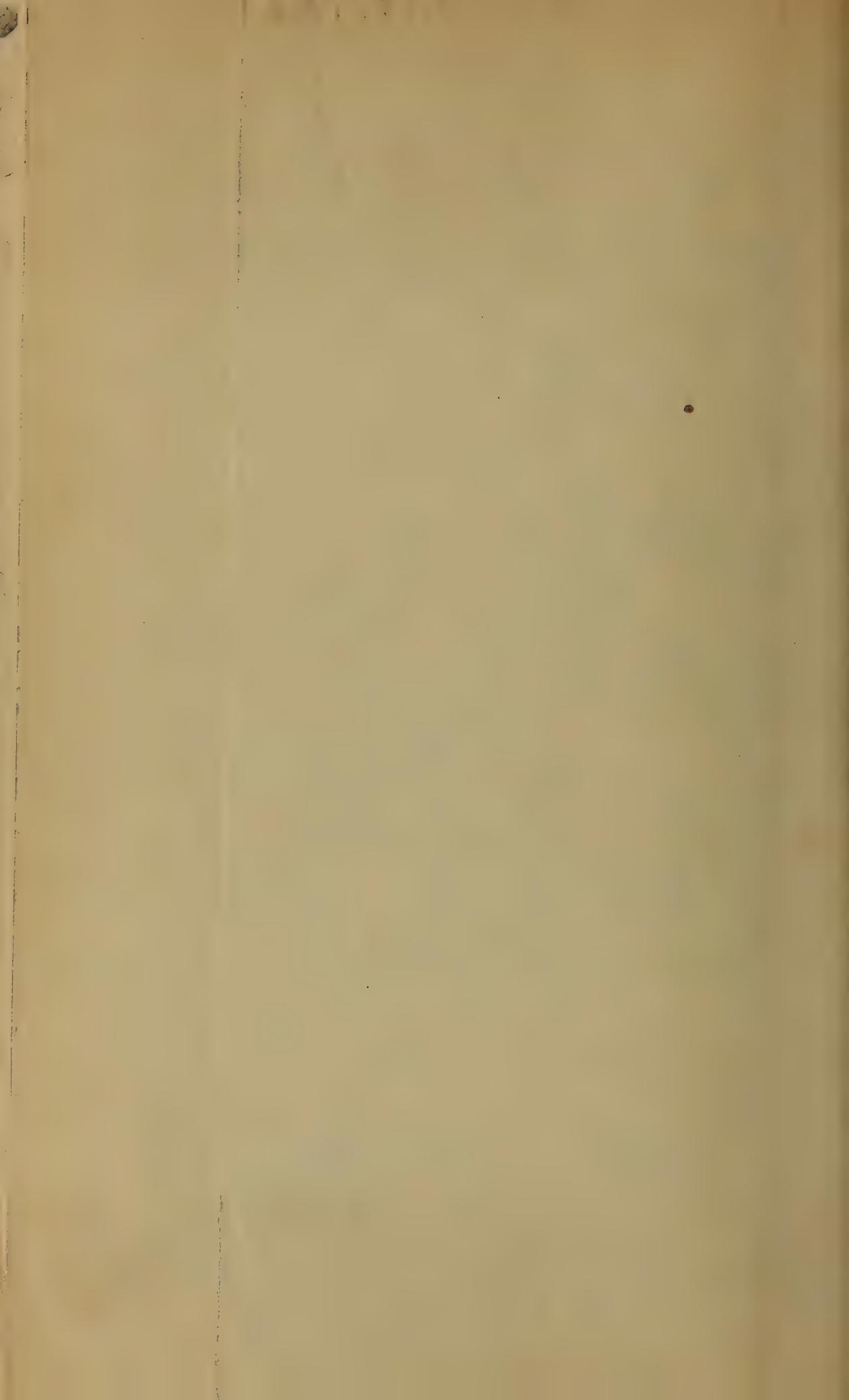
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7.



C. L. Herrick



of the State of New York, p. 52, also in the Aquarium, Jan. 1894, p. 91, and again in the Fishing Gazette of May 31, 1894, with references in each case to the original. I am pleased to see that Mr. F. H. Herrick, in the Zoologischer Anzeiger, No. 454, Aug. 13, 1894, p. 29, confirms my observations on times, rates, and on variations along our coasts, etc., even though he does not make it entirely clear why he should prefer to give the impression that my work was first published in the Aquarium of January 1894.

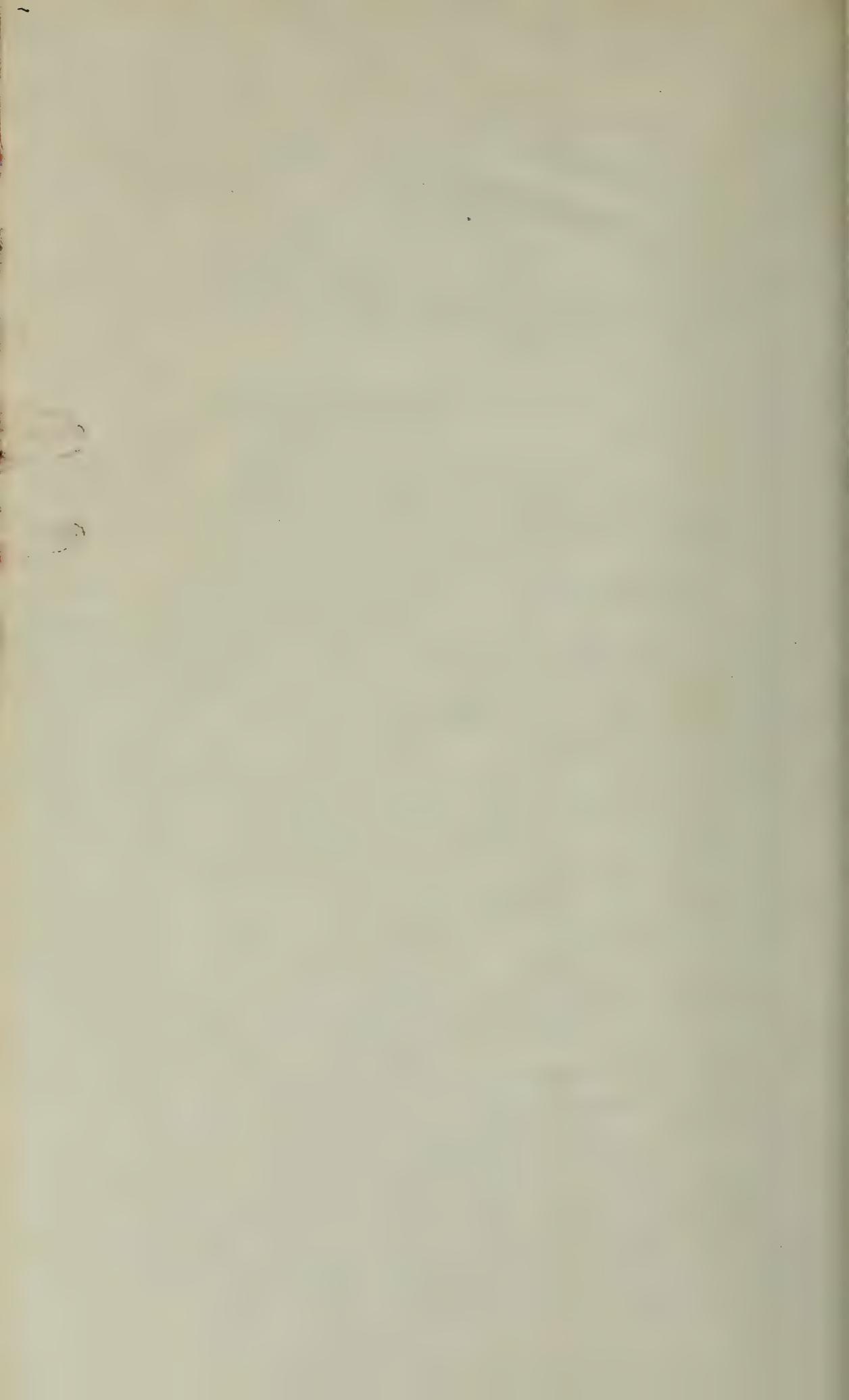
3. Microcrustacea from New Mexico.

By C. L. Herrick, Professor in Denison Univ.

eingeg. 30. November 1894.

The valley of the Rio Grande passes through a region which is by nature almost a desert, although capable of great fertility under irrigation. Although the year is almost rainless there are a few weeks during which copious showers fill such natural reservoirs as exist. In these pools there soon appear large numbers of Phyllopod Crustacea, *Apus*, *Branchipus*, *Nebalia*, etc. — a fauna sufficiently known through the labors of Professor Packard and others. Among these types which are characteristic of the western plains are a few species of the strictly Microcrustacea which deserve special study. These are chiefly members of the orders Copepoda, Cladocera and a few Ostracodes. Although one would expect a priori a rather limited representation of such types, there is no lack of individuals. The numbers of *Moina* which appear in fresh rain pools is enormous, and curiously enough, we find *M. rectirostris*, *M. brachiata* and a third form either associated in the same pool or in adjacent waters. *Moina* and several species of *Ceriodaphnia* may rank with the *Phyllopods* as "occasionalists" or desert crustacea. We were also surprised to find in the less transient pools numerous examples of the American *Latonopsis occidentalis* Birge, which is closely allied with the Australian *L. australis* Sars. *Simocephalus* and *Scapholeberis* with *Chydorus* and a small *Pleuroxis* are not uncommon, but a single example of a new species of *Daphnia* almost completes the list of Cladocera so far encountered.

The Cyclopidae are represented by *C. tenuicornis* Claus, *C. bicolor*, *C. serrulatus* and *C. viridis americanus* Marsh. No unique species occur, while the *Calanidae* and *Harpacticidae* are all new. With these introductory words I beg to pass to the description of a few forms which seem worthy of present notice though all will be illustrated in full in the forthcoming report to the state Zoologist of Minnesota upon the Microcrustacea of Minnesota.



Genus *Marshia*¹, gen. nov.

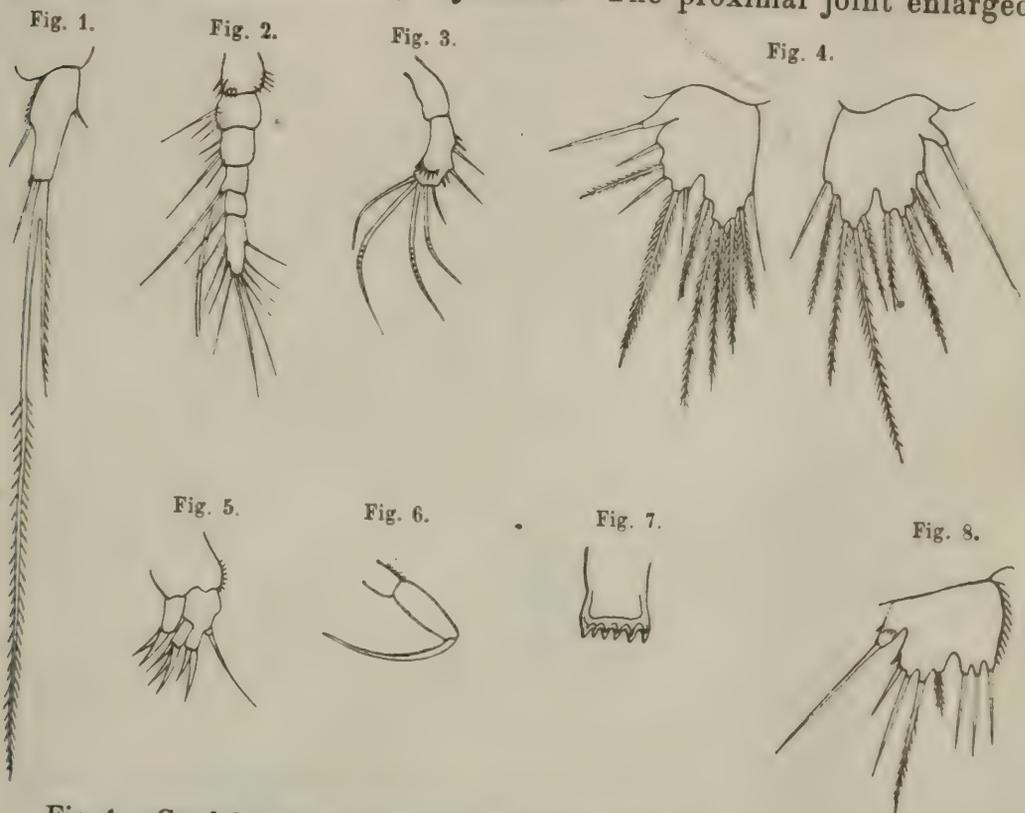
Allied with *Attheyella*. Inner branch of first foot 3-jointed, scarcely elongated, barely sub-prehensile.

Second and third feet with outer rami 2-jointed, short. Fourth foot with outer ramus 1-jointed. Fifth feet 1-jointed. Antennae 6-jointed, the fourth joint with a slender hyaline process longer than the end of the antennae. Antennule without obvious palpus, prehensile. Mandiblar palp simple (?). First foot-jaw with a uniciliate tubercle-like palp. Second foot-jaw with a long claw-like apical joint. Antennae of the male strongly modified. Fresh or brackish waters of the Rio Grande valley.

Marshia albuquerquensis n. sp.

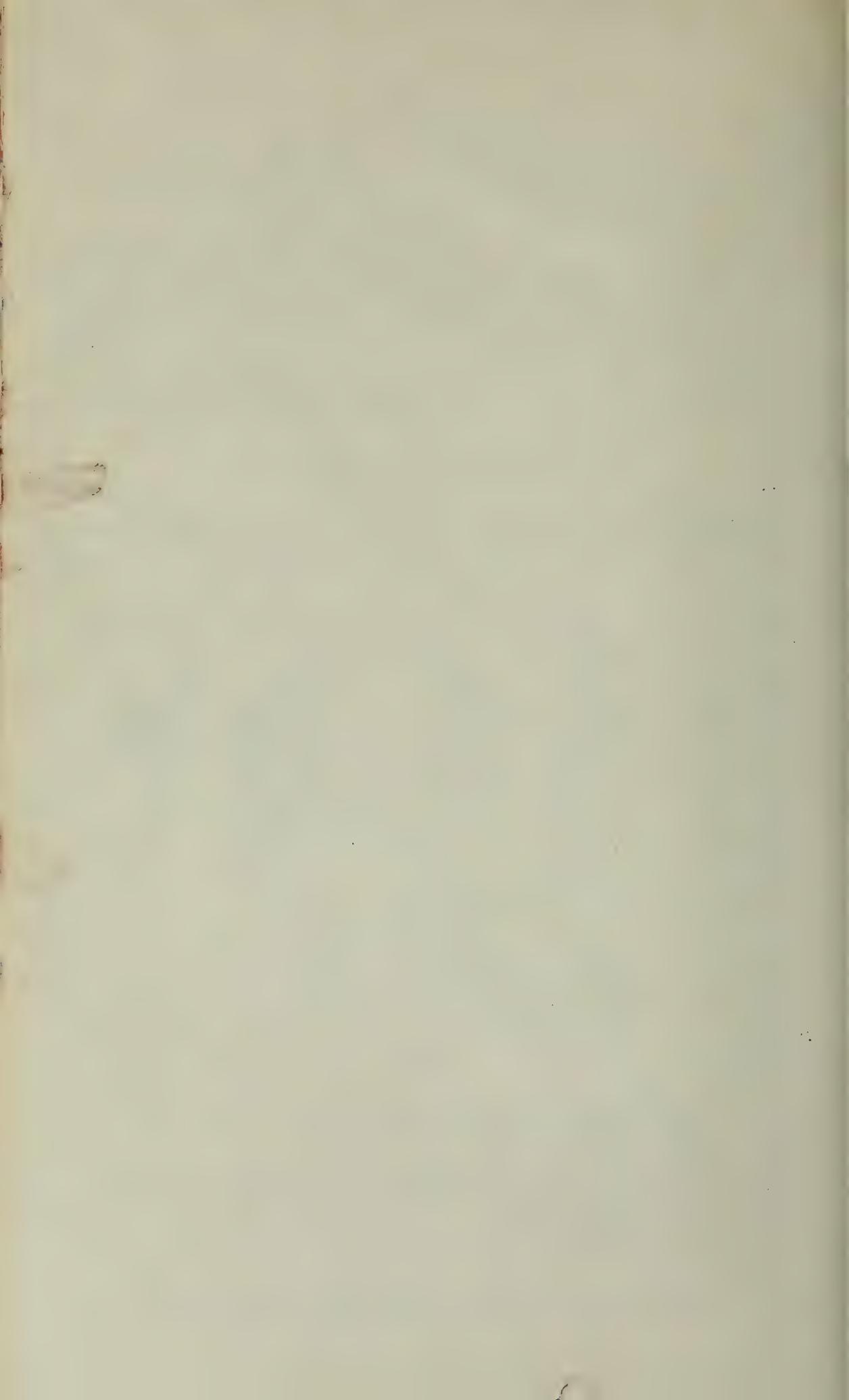
(Figures 1—11.)

Body with ten obvious segments, having the aspect of *Canthocamptus*. Antennae short, 6-jointed. The proximal joint enlarged



- Fig. 1. Caudal stilet of *Marshia albuquerquensis*, ♀.
 Fig. 2. Antenna of female.
 Fig. 3. Antennule.
 Fig. 4. Feet of right and left sides of a female, the right foot anomalous.
 Fig. 5. Anterior foot-jaw.
 Fig. 6. Posterior foot-jaw.
 Fig. 7. Mandible.
 Fig. 8. Fifth foot of male.

¹ In compliment to Professor C. Dwight Marsh of Ripon, Wisconsin.



and spinous; second joint also tumid, with three or more cilia; third joint longer; fourth with a long seta and a still longer flagellum; fifth joint very short; apical joint elongate, bearing about ten setae. Antennules short, prehensile, with four geniculate setae apically and several short spines, especially a transverse row of sharp teeth on the dorsal aspect. Mandibles with six sharp teeth. Anterior maxillipeds with a minute unisetose palpus and three processes bearing claw-like spines. Posterior maxilliped with an apical claw longer than the preceding segment. First foot with the outer ramus nearly as long as the inner, 2-jointed, bearing at the apex three pectinate setae. The basal

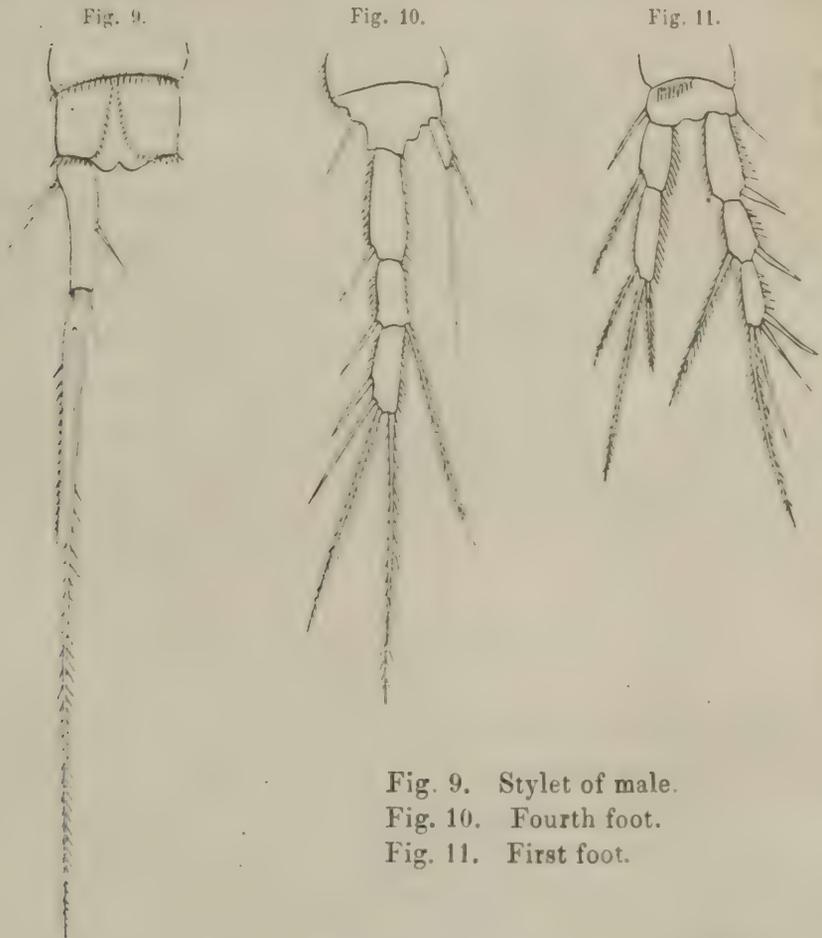


Fig. 9. Stylet of male.

Fig. 10. Fourth foot.

Fig. 11. First foot.

joint has one pectinate seta externally and a spine internally. The inner aspects of all the joints of both rami are spinous, the outer setose. The outer ramus of the second foot is two-jointed and has one pectinate seta apically, one spine internally and a spine externally, while the corresponding segment of the third foot has two pectinate setae apically, one internal seta and two external spines.

The fourth foot has a minute one-jointed outer ramus which bears one long pectinate seta and a short external spine. The fifth foot seems

to consist of one piece which is armed as follows: Externally a conical projection near the base with a long simple seta; outer apical lobe = the homologue of the second joint) with five setae, the second and fourth of which are pectinate and longer than the rest; the inner apical lobe bears six (sometimes only five) setae, all but the innermost being pectinate. The two lobes are separated by a simple rounded incision and repeated examination of a number of individuals failed to discover any signs of division or segmentation. The abdomen is very slender, and, like the thorax, its segments are all ornamented along the caudal margin with a row of teeth. Caudal stylet two and a half times as long as wide, with one or two small spines externally at a point one-third the length from the base and one longer spine near the middle of the inner margin which is ciliate. The two median apical setae are fused at the base and the inner is three times as long as the outer, which is twice as long as the stylet. The inner apical seta is short, the outer obsolescent.

In the male the antennae are reduced to a thick tumid member with third and fourth segments greatly enlarged. The apical segment is furnished with three hook-like claws. Flagellum slender and of uniform width throughout.

The fifth foot has on the outer apical lobe four setae and one spinule and on the inner lobe three non-pectinate setae. Caudal stylets greatly elongate, over four times as long as wide and nearly twice as long as the preceding segment.

• *Marshia brevicaudata* n. sp.

(Figures 12—15.)

The second species of this genus at present known may be described comparatively. Similar to *M. albuquerquensis* in most respects but differing at least in several obvious particulars. The caudal stylets are short, about twice as long as broad, the longest seta being seven times the length of the stylet while the outer median is twice and a half the length. The median setae are not fused at the base as in the preceding species.

In the male the proportions of the stylet are nearly the same as in the female but the longest seta is nine times as long as the stylet. The fifth foot of the female is nearly the same as in the preceding species, but the proportions of the setae differ. The fifth feet of the male closely resemble those of *M. albuquerquensis*. The antennae of the male differ. The flagellum is shorter and clavate. The swimming feet seem to be similar in the two species. Length of male, .56 mm:

length of first segment, .15 mm.; length of stylet, .04 mm; length of longest seta, .28—.34 mm.

The stylets of the female of *M. albuquerqueensis* measure .072 mm and those of the male over .08 mm, the longest seta being .37 mm.

Fig. 12.

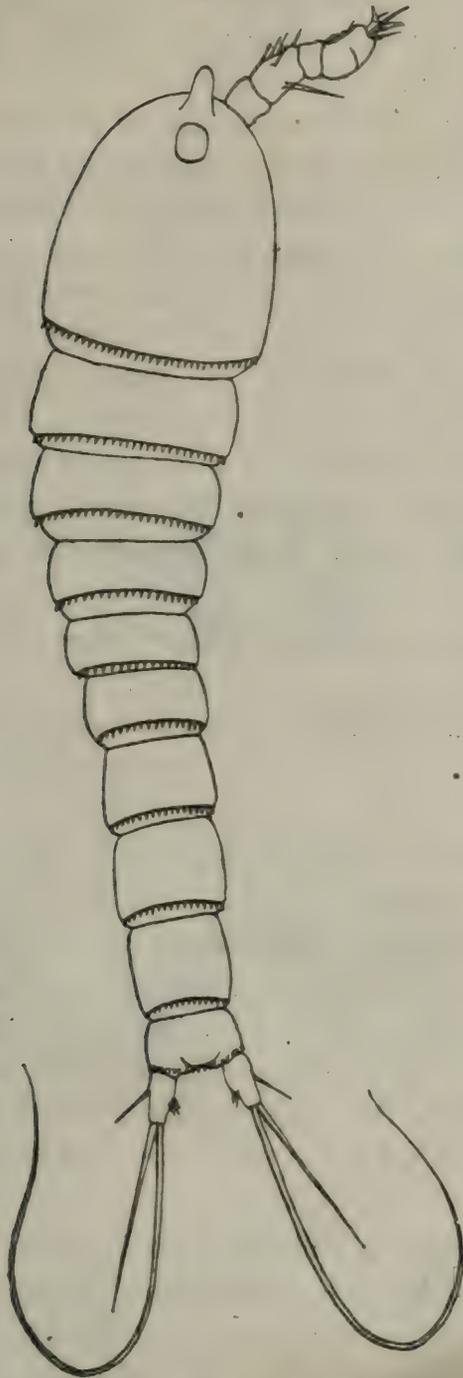


Fig. 13.



Fig. 14.

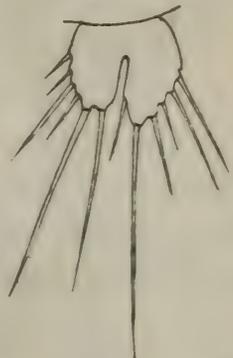
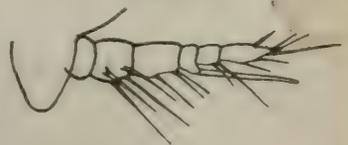


Fig. 15.



- Fig. 12. Habitus outline (cameralucida) of *Marshia brevicaudata*, ♂
 Fig. 13. Fifth foot of male.
 Fig. 14. Fifth foot of female.
 Fig. 15. Antenna of female.

and .42 mm respectively. It must remain for larger experience to determine the value of these distinctions which rest upon comparatively few individuals in the case of *M. brevicaudata*.

Diaptomus albuquerqueensis n. sp.

(Figures 16—26.)

Species of moderate size. The cephalothorax is widest near the middle. The last two segments are fused and the last projects laterally where it is armed with two strong spines; there is also a dorsal protuberance from the last segment. The first abdominal segment is

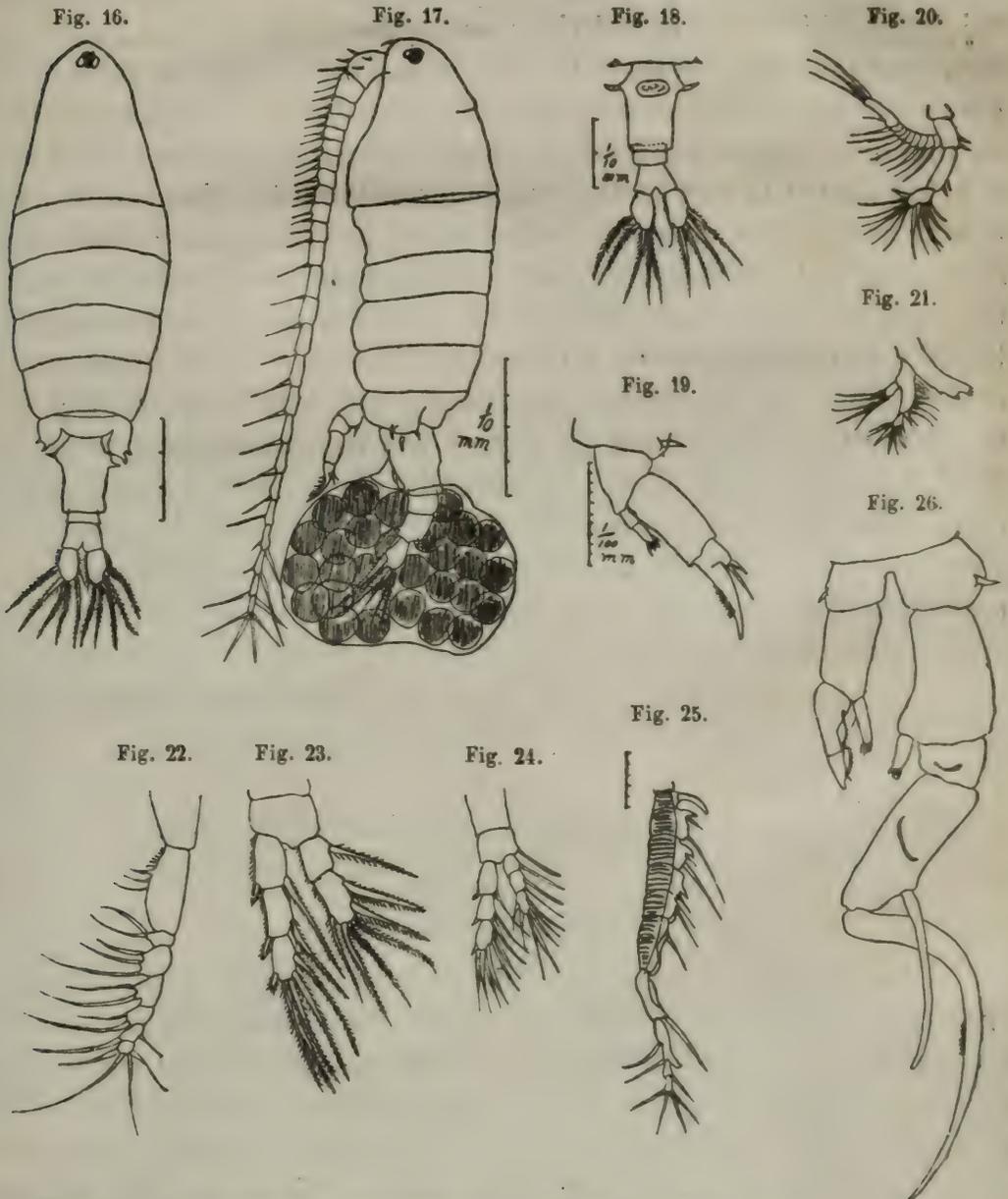
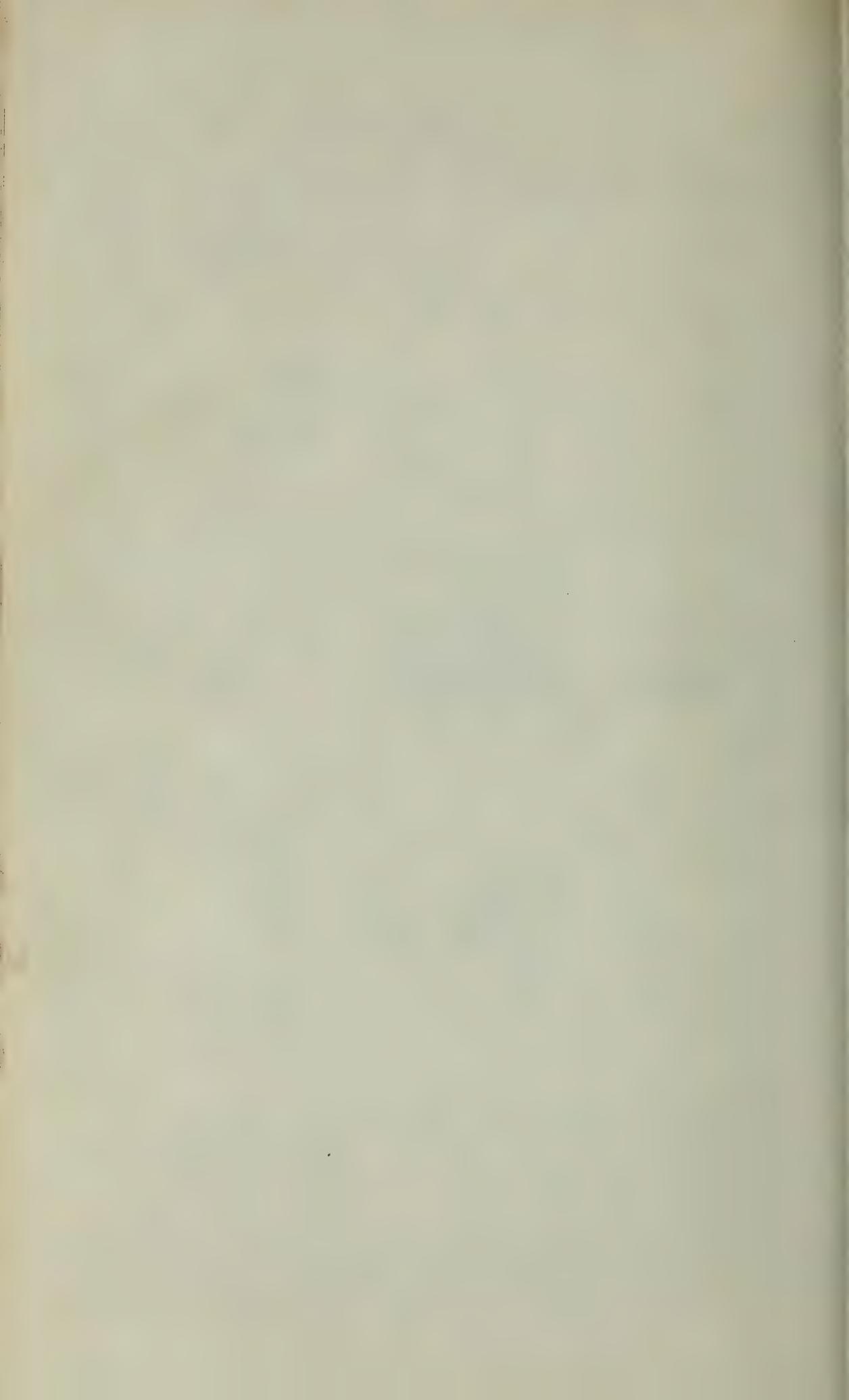


Fig. 16. *Diaptomus albuquerqueensis*, dorsal view.
 Fig. 17. Lateral view of female.
 Fig. 18. Abdomen.
 Fig. 19. Fifth foot of female.
 Fig. 20. Antennule.

Fig. 21. Jaw.
 Fig. 22. Maxilliped.
 Fig. 23. First swimming foot.
 Fig. 24. Fourth foot.
 Fig. 25. Male antenna.
 Fig. 26. Fifth feet of male.

longer than the remainder and projects laterally into two strong spines; second segment very short, invaginatedly concealed in the preceding. Caudal stylets short but nearly as long as the preceding segment,



ciliated on the mesial aspect, setae strongly pectinate. Antennae extending to or beyond the end of the stylets, purple-tipped, 25-jointed. The antepenult joint of the right male antenna with a curved hook. The fifth foot of the female with very short inner ramus which is more or less distinctly two-jointed or simply attenuated beyond the middle, armed apically with two or more spines and setae. External branch 3-jointed, third segment obvious and armed with one long and one shorter spine. Claw rather straight, armed for the middle third of its concave aspect with sharp teeth. The right fifth foot of the male has, on the outer ramus, a long sickle-shaped claw with few teeth or none, it being nearly as long as the remainder of the leg. The penult joint is long and bears a long thick spine which is slightly curved and may be dentate and is affixed at a point of the segment one fourth its length from the end. The basal joint of the outer ramus is very short and, like the next following has a lateral hyaline plate. The inner ramus is very short and 1-jointed. The second protopodite segment of the left foot is nearly as long as that of the right, the inner ramus is 1-jointed and simply ciliate at the end. The apical segment of the outer ramus is acute and bears a short, ciliated, conical process and a minute spine apically as well as a ciliated internal lamina. The preceding joint also has such a lamina or a patch of short spinules upon a protuberance.

Color pellucid, with purple upon the tips of the antennae and caudal stylets.

Length of female, 1.4—1.6 mm.

Waters about Albuquerque New Mexico very abundant.

Diaptomus novomexicanus n. sp.

(Figures 27—29.)

A species of moderate size, rather robust, with the greatest width of the thorax near the middle. Last two thoracic segments distinct, the last with two small spines. First abdominal segment very long, much exceeding the remainder. Second segment short. Stylets about as long as the preceding abdominal segment. Antennae reflexed reach to the base or end of the stylets, 25-jointed. Antepenult segment of right male antenna with a hyaline lamina which does not extend the entire length of the joint and ends in a rather short scarcely hooked process distad. The outer ramus of the fifth feet is obviously three-jointed, the apical joint being small and armed with two subequal spines. A small spine is inserted near the base of this joint. The claw is curved and dentate near the apex. The inner ramus is as long as the basal joint of the outer ramus, 1-jointed, and armed at

the apex with two subequal spines. The inner rami of the fifth feet of the male are both 1-jointed, acute and minutely ciliated. The apical claw of the right foot is long and slightly curved. The accessory spine is weak and inserted one-third the length of the second

Fig. 27.

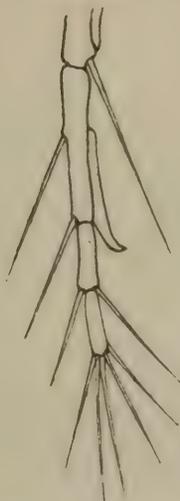


Fig. 28.

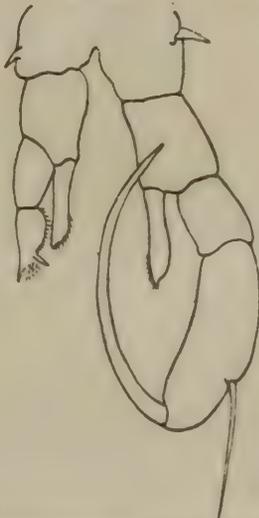


Fig. 29.

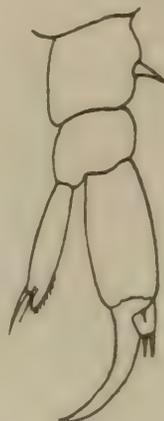
Fig. 27. *Diaptomus noromexicanus*. End of right male antenna.

Fig. 28. Fifth feet of male.

Fig. 29. Fifth foot of female.

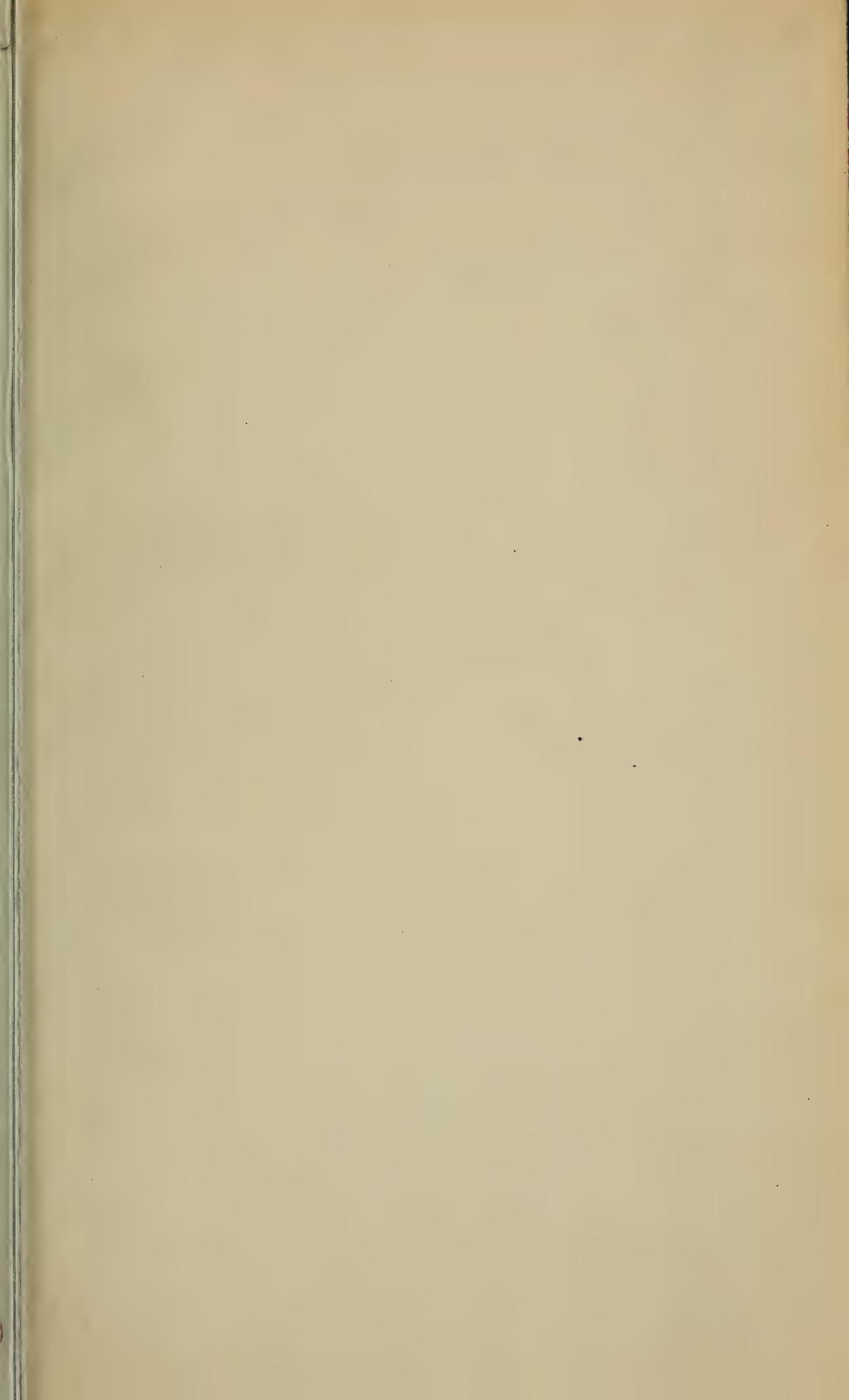
joint from its end. The apical joint of the outer ramus of the left foot is armed with a cushion of short spines and two longer ones and also bears a ciliated lamina internally. Length of female, 1.1—1.2 mm.

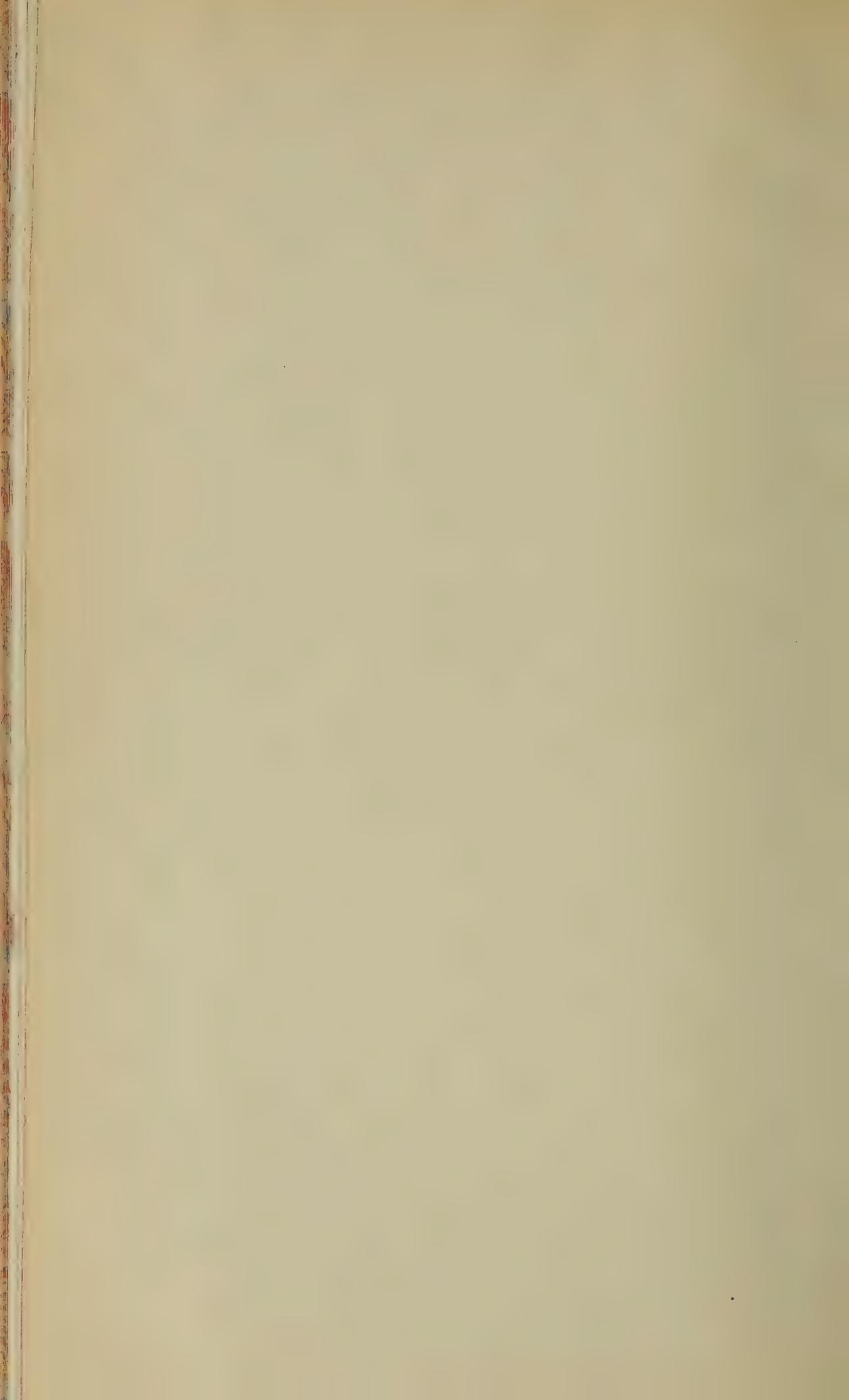
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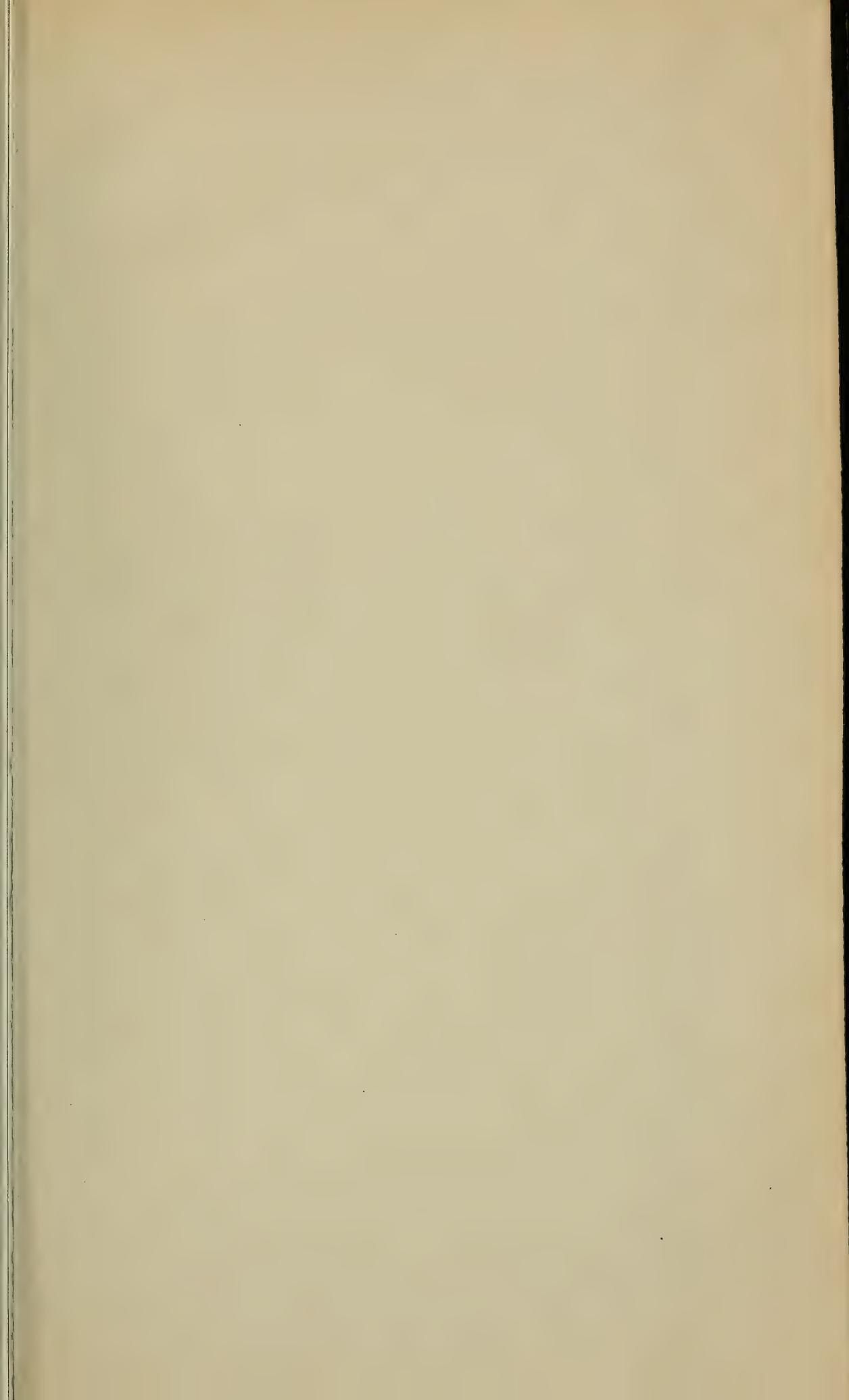
Zoological Society of London.

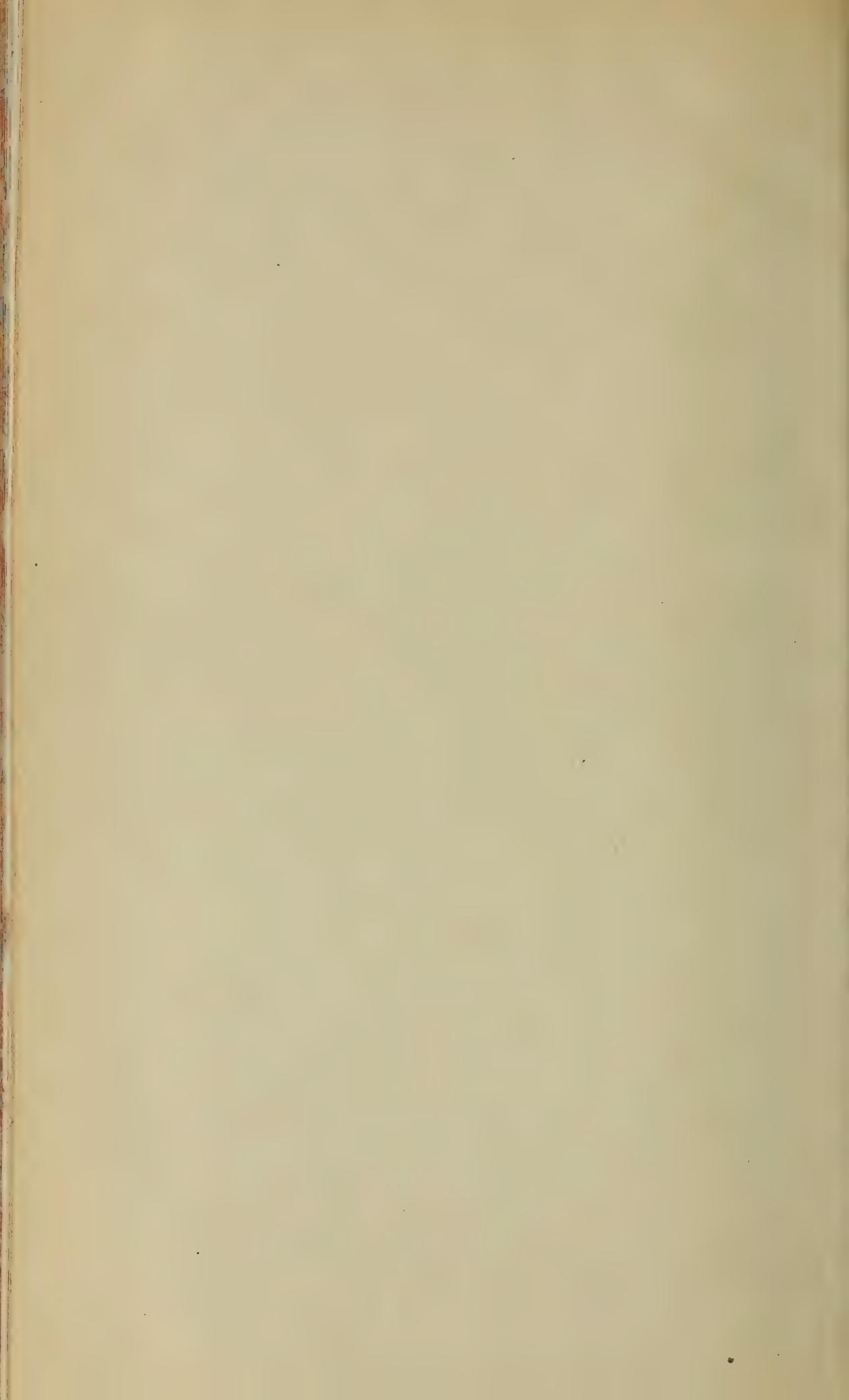
15th January, 1895. — The Secretary read a report on the additions that had been made to the Society's Menagerie during the month of December 1894, and called attention to two Tapirs recently deposited in the Society's Gardens, which he believed to be referable to Dow's Tapir (*Tapirus Dowi*) of Central America. — Mr. P. Chalmers Mitchell, F.Z.S., exhibited and gave an account of a tibia and other bones of an extinct bird of the genus *Aepyornis* from Central Madagascar, which had been lent to him for exhibition by Mr. Joseph H. Fenn. With these bones was associated a skull of a species of *Hippopotamus*. — Prof. G. B. Howes, F.Z.S., exhibited and made remarks on the photograph of an embryo of *Ornithorhynchus*. — The Secretary exhibited, on behalf of Mr. R. Lydekker, a life-sized drawing of *Idiurus Zenkeri*, a new and remarkably small form of Flying Squirrel from West Africa, recently described at Berlin. — Lord Lilford, F.Z.S., sent for exhibition the skin of a Duck, believed to be a hybrid between the Mallard (*Anas boschas*) and the Teal (*Querquedula crecca*), that had been caught in a decoy in Northamptonshire. — The Rev. T. R. R. Stebb-

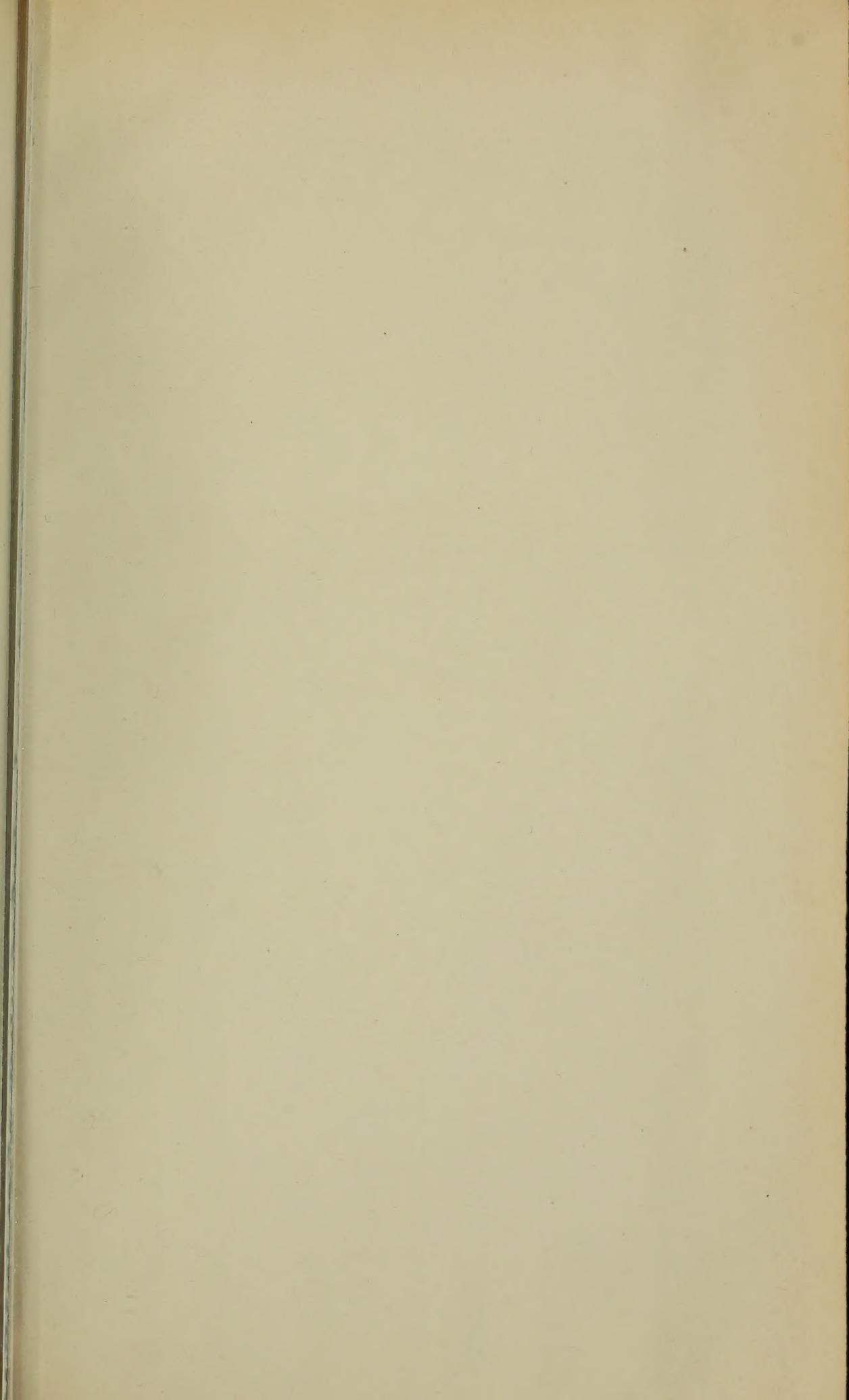
Lehman

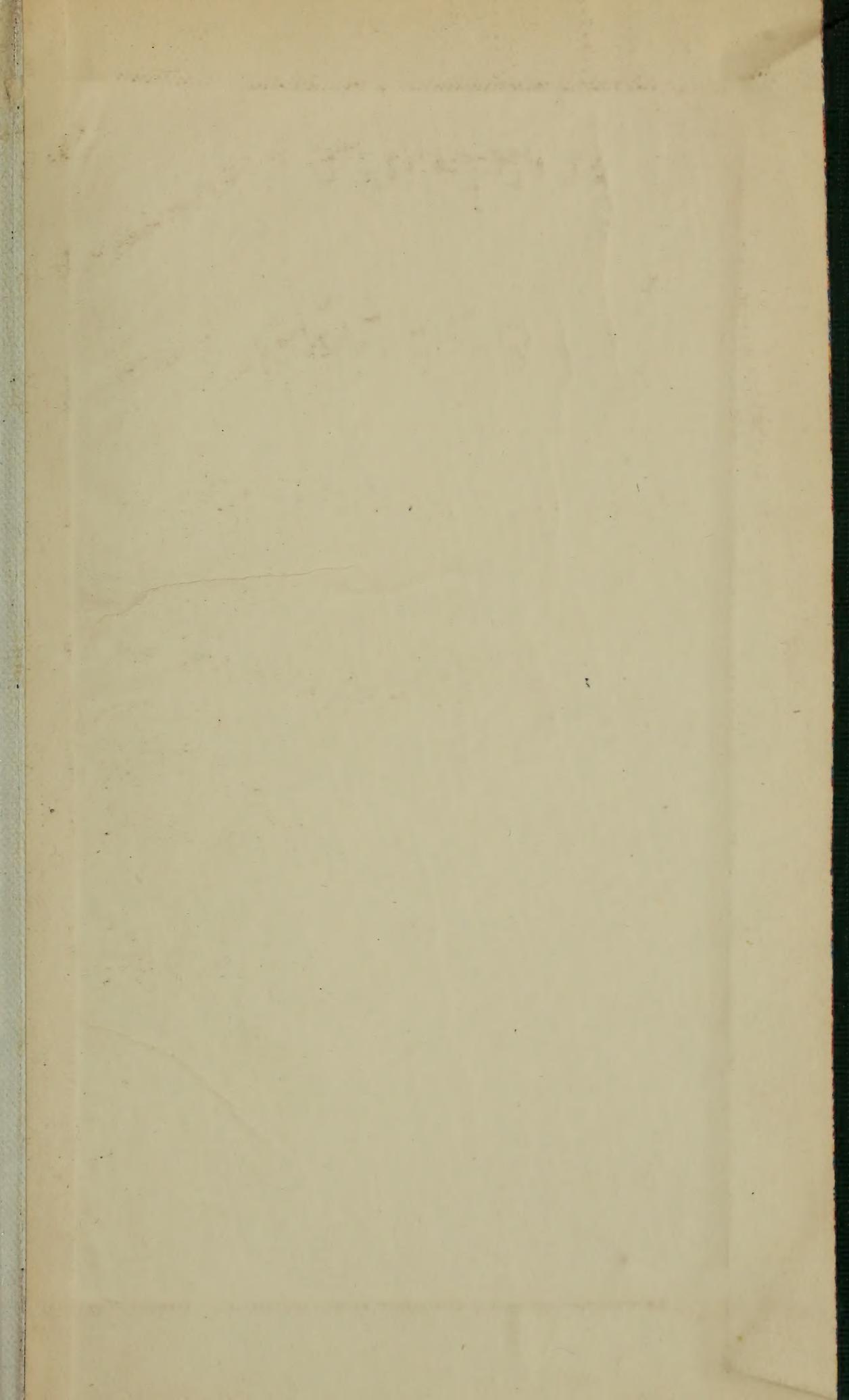




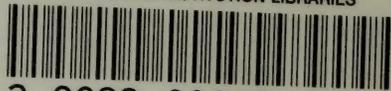








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