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TRANSACTIONS, VOL. XVI, PART II, NO. 3.

AN UNREGARDED FACTOR IN LAKE TEMPERATURES.

EDWARD A. BIRGE.

[Notes from the Laboratory of the Wisconsin Geological and Natural History Survey. V.]

In this paper I wish to call attention to one of the factors regulating the distribution of heat in lakes, which seems to have been overlooked hitherto. It is well understood that the heat of the sun is delivered almost wholly to the surface strata of a lake; most of it to the upper meter. This heat is distributed from the surface to the lower strata by various agencies. Chief of these is the wind, which mixes the warmer surface water with the cooler water below. The efficiency of the wind as a distributing agent is opposed and limited by the *thermal resistance to mixture* offered by the decreased density of the warmed surface water. I wish to point out that the effectiveness of this thermal resistance increases as the temperature of the water, which the wind is trying to mix, departs from the temperature of maximum density and decreases as the temperature approaches 4°. A given temperature difference causes a thermal resistance which varies according to the position of that difference on the scale of the thermometer. This variability aids to explain many of the phenomena associated with the distribution of heat.

It is a well known fact that the density of water is at a maximum at 4°, and that it decreases as the water is cooled below or warmed above that temperature. This fact lies at the foundation of all considerations on the distribution of heat in lakes. It is an equally well known fact that the decrease in density corresponding to one degree increase of temperature is not constant but increases as the temperature departs from 4°, either toward 0° or toward a higher temperature. General references to this fact have been made by writers on lake temperatures, but no one called especial attention to it, so far as I am aware, until Groll ('05) showed its application in the production of convection currents. I desire to apply the same fact in the reverse direction and to show its relation to the thermal resistance offered by the warmer upper strata of the lake to the distribution through its mass of the heat received by its surface. Convection currents are far less important agents for distributing heat than are mechanical currents caused by wind. Indeed, it would be difficult to show that convection currents have any such efficiency in carrying heat as to make them worth serious consideration. Currents caused by wind do more work in equalizing temperatures and in carrying heat to the deeper strata than do all other agencies combined. Any factor which seriously modifies or limits their action has corresponding importance in the temperature changes of a lake.

The following table corresponds in part to that given by Groll ('05, p. 48). Column II shows the density of water from 0° to 30°, as given by Landolt and Börnstein.* The numbers show also the weight of a liter of water at the temperature stated. Thus a liter weighs 1.000000 kg. at 4°; at 10° it weighs 0.999727 kg. or 999,727 mg. The numbers in columns III–VI do not stand opposite the numbers of column II but are opposite the spaces between these numbers. Each represents the result of a change of temperature in a unit volume of water, corresponding to the degrees in column I immediately above and below the number in question; or it relates to a column of water whose surfaces have the temperatures immediately above or below.

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* Physicalische chemische Tabellen, 3rd ed., 1905, p. 37.

I. Temp.	II. Density.	III. Difference.	IV. Rel. Dif. for 1°.	V. Ergs.	VI. Liters for 1 kg. Auftrieb.
0	0.999868				
		+0.000059	7.38	0.0491	17000
1	0.999927				
		+0.000041	5.12	0.0342	24400
2	0.999968				
		+0.000024	3.00	0.0200	41700
3	0.999992				
		+0.000008	1.00	0.0067	125000
4	1.000000				
		—0.000008	1.00	0.0067	125000
5	0.999992				
		—0.000024	3.00	0.0200	41700
6	0.999968				
		—0.000039	4.88	0.0325	25600
7	0.999929				
		—0.000053	6.62	0.0441	18900
8	0.999876				
		—0.000068	8.50	0.0566	14700
9	0.999808				
		—0.000081	10.12	0.0675	12400
10	0.999727				
		—0.000095	11.88	0.0791	10500
11	0.999632				
		—0.000107	13.38	0.0891	9300
12	0.999525				
		—0.000121	15.12	0.1008	8300
13	0.999404				
		—0.000133	16.62	0.1108	7500
14	0.999271				
		—0.000145	18.12	0.1208	6900
15	0.999126				
		—0.000156	19.50	0.1299	6400
16	0.998970				
		—0.000169	21.12	0.1408	5900
17	0.998801				
		—0.000179	22.38	9.1491	5600
18	0.998622				
		—0.000190	23.75	0.1583	5300
19	0.998432				
		—0.000202	25.25	0.1683	5000
20	0.998230				
		—0.000211	26.38	0.1758	4700
21	0.998019				
		—0.000222	27.75	0.1849	4500
22	0.997797				
		—0.000232	29.00	0.1993	4300
23	0.997565				
		—0.000242	30.25	0.2016	4100
24	0.997323				
		—0.000252	31.50	0.2099	4000
25	0.997071				
		—0.000261	32.62	0.2174	3800
26	0.996810				
		—0.000271	33.88	0.2257	3700
27	0.996539				
		—0.000280	35.00	0.2332	3600
28	0.996259				
		—0.000288	36.00	0.2399	3500
29	0.995971				
		—0.000298	37.25	0.2482	3400
30	0.995673				

Column III shows the differences between the successive numbers of column II and indicates the change in density caused by a temperature change of 1°. The significant figures also show the difference in weight, in milligrams, between a liter of water at any given temperature and at a temperature one degree lower. Thus, a liter of water at 10° weighs 81 mg. less than one at 9°; at 25° a liter is 252 mg. lighter than at 24°. These numbers, therefore, express the differences in density and weight which for a temperature difference of 1°, (1) enable a layer of water to set up convection currents if it lies above a warmer stratum, and (2) which enable a stratum of water, warmer above and cooler below, to resist mixture attempted by mechanical agencies.

It is evident that the differences shown in column III for a rise or fall of one degree become greater as the temperature rises above or sinks below 4°. From this fact it follows that a given mass of water—say, a cubic decimeter—which has been cooled one degree below the temperature of the water beneath it, will act with greater energy in setting up convection currents in proportion as the initial temperature was distant from 4°. It also follows that a column of water of unit area and height whose upper surface has a temperature one degree higher than its lower surface, will offer a thermal resistance to mixture greater in proportion as the average rises above 4°; it being assumed that the temperature gradient in the column is uniform.

Nor is this difference a small one, as may be seen from column IV. In this column the convection capacity (if I may coin an equivalent for the German word *Auftrieb*), and the thermal resistance to mixture corresponding to the temperature difference of one degree at 4°–3° or 4°–5°, is taken as unity and the relative value is given for the same difference at higher and lower temperatures. At 10° its value is more than ten times as great as at 4°; at 15° it has increased eighteenfold; at 20° more than twenty-five fold; and at 30° it is more than thirty-seven times larger than at 4°.

Groll's paper (p. 48) expresses this fact in relation to convection by stating the number of liters of water which would be needed to make a mass that weighs 1 kg. less than the same mass of water one degree cooler. Such a mass of water is necessary at the given temperature to secure "1 kg. Auftrieb." The number of liters stated is the reciprocal of the numbers in column III. I have repeated his results in column VI; the numbers being slightly changed as the values for density are not quite the same as those employed by Groll.

In order to give a similar picture of the thermal resistance, I have stated in column V the amount of work in decimals of a erg, which would be required to mix a column of water 1 sq. cm. in area, 1 m. high, in which the temperature gradient is uniform and whose upper and lower surfaces differ in temperature by 1°.

The formulas from which these results have been computed have been worked out and furnished to me by Dr. H. C. Wolff of the department of mathematics, University of Wisconsin, whose valuable assistance I wish to acknowledge with thanks. The work done against gravity in mixing a column of water whose density varies with the depth, so that it shall become one of uniform density is

$$\text{(1)} \qquad W\,(\text{ergs}) = A \int_0^C f(z) \left[z - \frac{C}{2} \right] dz$$

where A is the area of the cross-section of the column in sq. cm., C the height of the column in cm. and f (z) the function expressing the density in terms of z, the distance from the top of the column. The density of water at 4°C. is to be taken as unity.

If f(z) is a rational integral function of the second degree (1) reduces to the simple form

$$\text{(2)} \qquad W\,(\text{ergs}) = \frac{AC^2}{12} [D_2 - D_1]$$

where D_1 and D_2 are respectively the density of the lower and upper strata of the column. This condition is satisfied when the temperature gradient is uniform and when the relation between the density (D) and the temperature (T) is of the form $D=\alpha T^2+\beta T+\gamma$ where α β and γ are constants. If the temperatures at the surfaces of a column are assumed to be full degrees centigrade, the density can be taken directly from the table and the ergs computed from the equation given above. If A=1 sq. cm. C=100 cm. and D_1 and D_2 are two of the numbers in column II, then the number of ergs is 833 times the difference between D_2 and D_1. These results are shown in column V.

If it is desired to compute the thermal resistance directly from the temperatures observed, the following formulas will yield approximate results. An empirical relation between the density and temperature of water at temperatures above 4° is

$$D = 1 - \frac{93\,(T - 4)^{1.982}}{10^7}. \tag{3}$$

A very close approximation to this is

$$D' = 1 - \frac{6\,T^2 - 36\,T + 47}{10^6} \tag{4}$$

which gives as an approximate value for work

$$W\,(\text{ergs}) = \frac{AC^2}{10^6}\left\{T_m - 3\right\}(T_1 - T_2).. \tag{5}$$

Below are given the differences between D and D′, showing the degree of approximation reached by formula (4).

T	D′	D	D—D′
4°	1.00000	1.00000	+0.00000
5°	0.99998	0.99999	+0.00001
10°	0.99971	0.99973	+0.00002
15°	0.99914	0.99913	—0.00001
20°	0.99827	0 99824	—0.00003
25°	0.99710	0.99707	—0.00003
30°	0.99563	0.99567	+0.00004

The values of W, as computed by formula 5 differ in the third decimal place from those derived directly from the tables of density and computed according to formula 2.

Formula 5 also shows that the approximate value of the work done in mixing a column of water is proportional to the temperature gradient $\frac{T_1 - T_2}{C}$, provided that the mean temperature, T_m, remains constant. That is to say, if the temperature gradient of a stratum of water is uniform and the average temperature remains the same, the thermal resistance will rise and fall in proportion to the difference in temperature between the upper and lower surfaces. If, under these conditions, the temperatures of the surfaces are 11° and 8° respectively, the resistance will be three times as great as if they were 10° and 9°; the average temperature being the same in both cases but the gradient being steeper in the first example.

If the temperature gradient is not a uniform one, then the temperature, T, is not a linear function of z. In such cases $f(z)\left[z-\frac{C}{2}\right]$ can be plotted and the value of W found by means of a planimeter.

The fact that the thermal resistance to mixture increases as the temperature rises has important and wide applications. First, it has much influence on the rapid distribution of heat through the lake in the spring as compared with its slow penetration later in the season. Even in our deepest Wisconsin lakes, like Green Lake (72 m.) the temperature of the bottom water goes up to 5°, or even 6°. So, too, the water at all depths of the lake acquires heat most rapidly in spring and early summer. A lake of considerable depth gains little heat after the first of July. Its gains are greatest in April, May, and the early part of June. Yet the surface receives more calories during July and August than during the earlier months. This rapid gain and distribution of heat in spring has forced some students of lake temperatures to conclude that the water is more diathermous in spring than in summer. So Ule ('01, p. 126) says that from the rapid gains of heat in spring we must draw the conclusion that the diathermancy becomes less in the course of the summer. This may or may not be the case, but it never happens to a degree which makes any notable difference; since in all lakes and at all times the upper meter of water receives most of the heat.

But the wind and the currents derived from its influence are mixing agencies which become less efficient as the lake warms, if equal temperature gradients are assumed. At 10° they are 10 times less efficient than at 5°; only one-third as efficient as at 6°; and less than one-half as efficient as at 7°.

When the temperature rises to 15° the resistance is nearly doubled as compared with 10°, and the efficiency of the distributing agents is correspondingly reduced. It is not surprising, therefore, that the distributing agents can work very effectively during the spring and carry the heat received by the surface to considerable depths. It is not surprising also that during the spring they can distribute this heat so rapidly as to prevent the surface temperature from rising so fast as to offer considerable resistance to their action; while they lose a great part of their power as the season advances.

There are, of course, other factors which work in the same direction, aiding to increase the efficiency of the forces which distribute heat in the early part of the season and checking this distribution as the summer advances. Students of lake temperature, however, have felt that these forces were not adequate to explain the observed facts. I believe that if the increased thermal resistance is also taken into account the phenomena will find a full explanation.

A second point where this principle finds important application is at the thermocline. No one fact in lake temperatures so arouses surprise in the mind of the student as does the ease with which the thermocline can be disturbed and the difficulty with which it can be permanently displaced. Violent winds in summer may raise or depress its surface by several meters in the larger inland lakes, yet it returns to its old position with barely a trace of change. In Lake Mendota the thermocline may be reduced to a temperature amplitude of 2°, or less in late September or October, and may lie within a meter or two of the bottom. This position it may retain for days, if not for weeks, unless an unusually vigorous wind upsets it. No such slight difference of temperature would, or does, persist in the spring. The reason is that the temperatures in the spring are in the region of 6° or 8°, while in the fall they lie at 12° or 14°, and therefore offer much more resistance to mixture.

At the junction of thermocline and epilimnion the fall of temperature is rapid. A decline of 4° or 5° in a meter is not uncommon and this is from a high temperature, 20°, or more. The thermal resistance to mixture is, therefore, very great and it is increased by the processes which tend to cause mixture. When the wind sets up currents in the epilimnion and blows it to the leeward side of the lake, the accumulating mass of warm water presses the cooler hypolimnion downward and outward. The first effect of this process is to condense the isotherms at the very point where the influences tending to cause mixture are greatest. A decline of temperature amounting to 8° or 10° in a meter is thus often produced. In this way is developed a resistance to mixture several hundred times as great as any that is possible in April, or early May, and this lies exactly at the place where it is most effective in preventing mixture. Thus we may explain the fact that the thermocline is but little affected in summer, even by violent and long continued winds.

During early and midsummer the temperature of the epilimnion is not uniform but the surface is always somewhat warmer than the stratum immediately above the thermocline. Since the temperature of the surface at this time is high—from 22° to 25°, or even more—a small temperature difference between the surface and the strata below presents a very great resistance to mixture. This is an important factor among those which keep the thermocline at a practically constant average position during several weeks in summer.

It is obvious that no fair comparison can be made between the ability of the wind to mix the water in summer and that which it may have in late autumn or winter after the surface has fallen below 4°. Many writers have found it hard to believe that the wind is able to mix the water of a lake from top to bottom during the process of cooling below 4°. Richter, for example, ('97, p. 49) finds it necessary to reject the wind as the agent in effecting this cooling, because the wind is not able to disturb the thermocline in summer. He is forced to set up a rather complex theory to account for the fall of temperature in deep water below 4°, and one which is not satisfactory to himself. In a similar way Ule ('01, p. 124) neglects the wind in discussing this process while Groll ('05, p. 54) rejects it for lakes of considerable depth. Yet the resistance to mixture at temperatures below 4° is so small that we need not be surprised that the whole mass of water is readily cooled by circulation to 3°, or even 2°. On the other hand, the rapid increase of resistance to mixture per degree as zero is neared indicates one reason why the temperature curve of inverse stratification is never a straight line, and why, even in larger lakes and at the moderate depth of 20 m. to 25 m., bottom temperatures are rarely so low as 1°. I ought to add that Wedderburn ('09) seems to understand this relation very fully. His paper was received just as this is going to press.

Thus many of the facts of lake temperature find an easy explanation when the principle is accepted that the thermal resistance to mixture increases as the temperature departs from 4°. I have called especial attention to its bearing on those problems for which students of limnology have found only a partial solution. Among these are the rapid warming of the lake in spring and early summer; or stated in a different way, the rapid descent of the isotherms as the lake begins to warm, as compared with the slow penetration later in the season of isotherms representing higher temperatures. Similar problems are the cooling of the lake below 4°; the position, persistence, and stability of the thermocline in spite of disturbance by violent winds. In all of these and other cases which involve the work of the agents for distributing heat, the fact must be considered that a limit is always set to the efficiency of these agents by the thermal resistance to mixture. Water is so nearly a perfect fluid that if its temperature could rise without a change of density the distributing agents in any lake would quickly distribute the warmer surface strata through the whole mass of the water. The most effective means of limiting this distribution is the rapid increase of the rate of decline of density as the temperature rises.

In this discussion it has been assumed that water is a perfect fluid. This is not the case; water is viscous and its viscosity is not without influence on the ability of the wind to mix it. If a lake were composed of a perfect fluid, thermal resistance would be the only force opposing mixture. In a lake filled with a very viscous fluid, like glycerine, viscosity would be far more effective than thermal resistance in opposing mixture.

The amount of the viscosity of water at temperatures between 0° and 30° may be seen from the following table.

Table of viscosity, from Landolt and Börnstein.

Temperature.	Dynes per sq. cm.	Relative viscosity
0°	0.01778	2.23
5°	0.01510	1.89
10°	0.01303	1.63
15°	0.01134	1.42
20°	0.01002	1.26
25°	0.00891	1.12
30°	0.00798	1.00

From this it appears that water has sufficient viscosity to offer some resistance to the action of the wind which attempts to move the particles on each other and thus to mix them. It appears also that the viscosity is very small, but that it is greater at low temperatures and that it increases at a rate which rises as the temperature falls.

Viscosity offers a hindrance to mixture which cannot be stated in terms of ergs. It has been impossible to find a quantitative relation between thermal resistance and viscosity so as to ascertain exactly how much the increase of the latter at low temperature would affect the influence of the wind. Yet it seems clear that it does not have a great influence. The present question is one of the relative influence of viscosity at different temperatures, and viscosity plainly increases far more slowly at low temperatures than thermal resistance diminishes.

If we attempt to mix in a unit of time a column of water, the area of whose base is 1 sq. cm. and whose height is 1 m., viscosity will offer a resistance to be overcome. From the table given above it appears that this resistance is about twice as great at 4° as at 30°. The thermal resistance to mixture for a temperature difference of 1° decreases 37.5 times if the average temperature falls from 30° to 4°. Between 10° and 4° the thermal resistance decreases over ten times, while the viscosity increases by less than 20%, or less than 1-50 as much. Thus it appears that the decline of the thermal resistance is far more rapid in water than is the increase of viscosity, and the increased ratio of decline as the temperature nears 4° is much greater than the ratio of increase of viscosity.

It is impossible to say how much must be added to the numbers in column V if it is desired to express by them not only the work done against gravity but also that against viscosity in mixing a unit column of water in a unit of time. But it is clear that the addition, whatever it may be, cannot be more than doubled between 30° and 4°.

This is not the place for a complete discussion of the various factors aiding or opposing the distribution of the surface water through the lake, but it may be pointed out that since the influence of the wind will vary as the square of its velocity, the greater amount of wind in the spring will more than compensate for any increase in viscosity. The average velocity of the wind in Madison in July is about 8.3 miles per hour and in April 11.6 miles. The ratio of the squares of these numbers is about as 1 to 2, showing that the mixing power of the wind in April is about twice as great as in midsummer.

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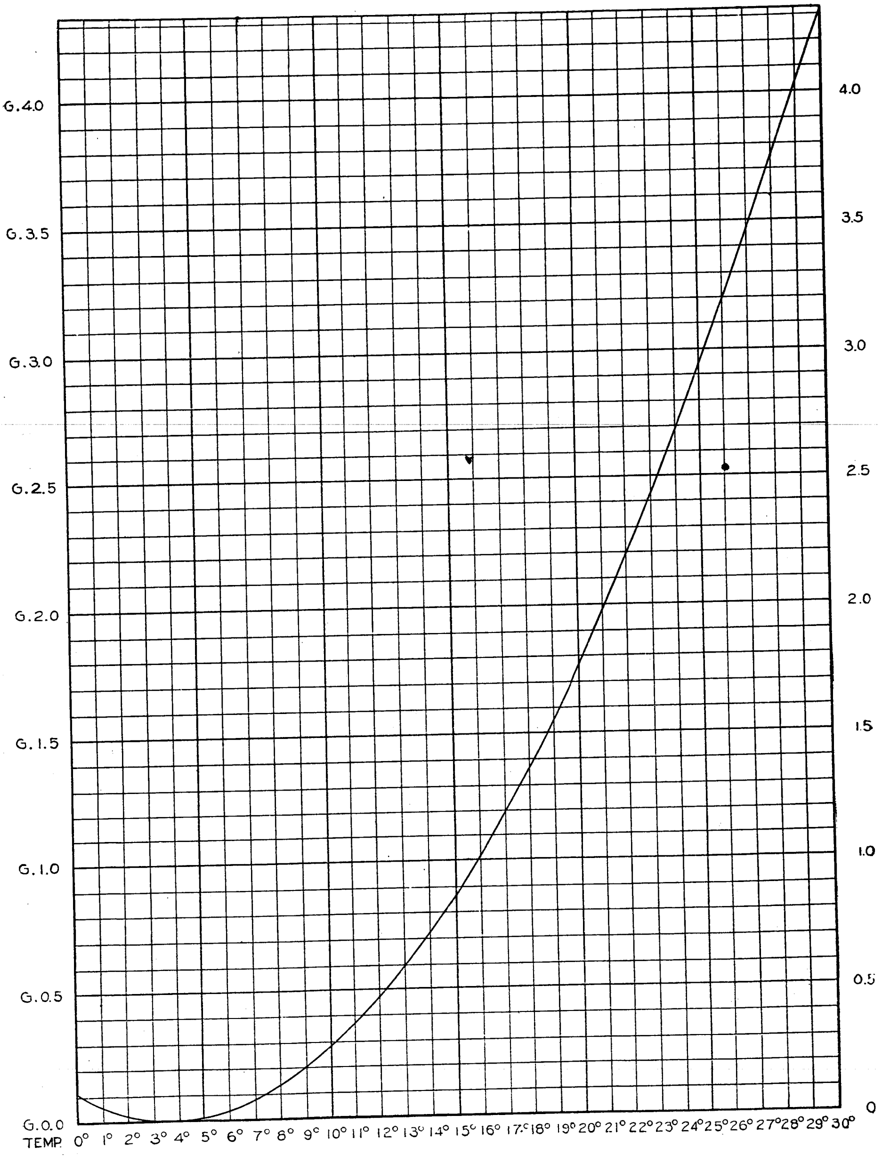
PLATE LXIV.

EXPLANATION OF PLATE LXIV.

Plate LXIV, from Groll, '05, represents the change of density in water due to rise of temperature and gives in graphic form the facts of column III, p. 991. The degrees are given at the bottom of the plate and the loss of weight, in grams per liter for each rise of 1, is platted on the vertical scale. The ordinates show the difference in weight between a liter of water at any given temperature and at 4°.


G.4.0
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G.2.5
G.2.0
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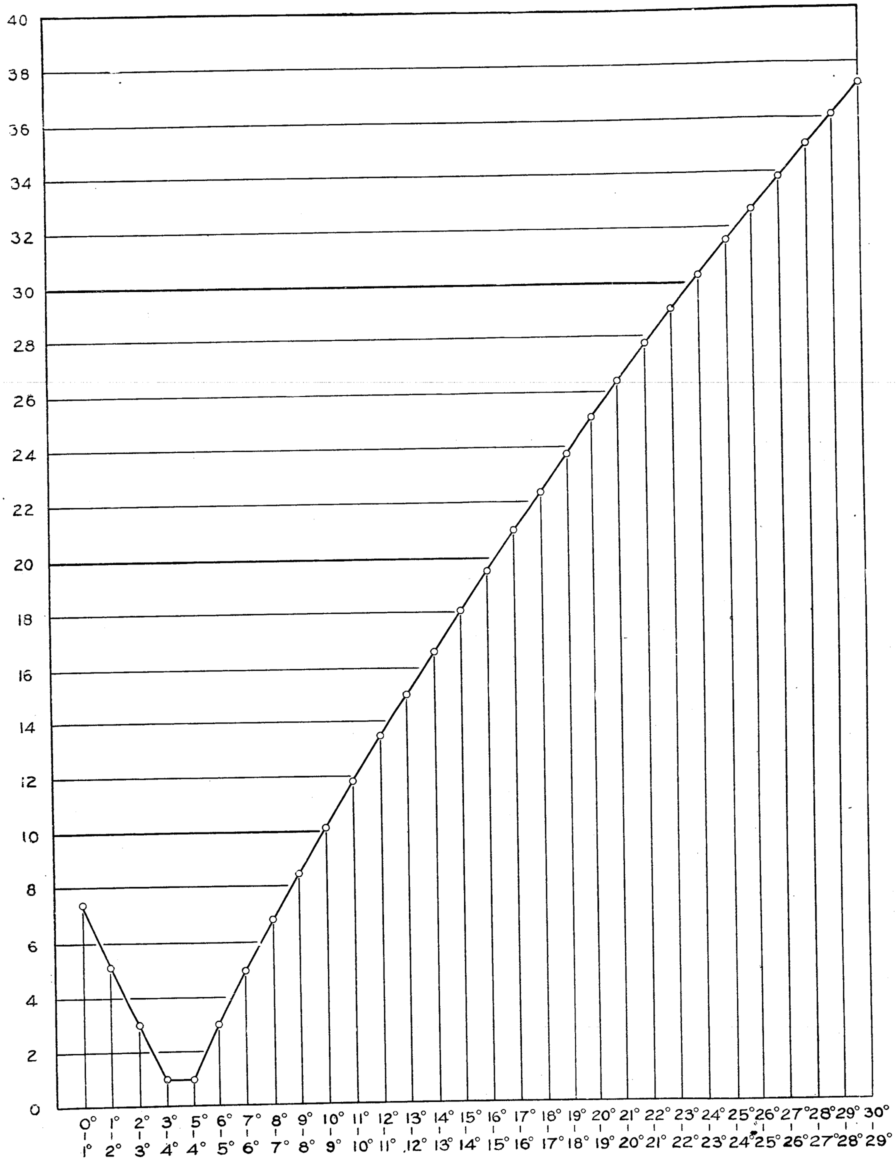
G.0.0
TEMP.
0° 1° 2° 3° 4° 5° 6° 7° 8° 9° 10° 11° 12° 13° 14° 15° 16° 17° 18° 19° 20° 21° 22° 23° 24° 25° 26° 27° 28° 29° 30°
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0

PLATE LXV.

EXPLANATION OF PLATE LXV.

In plate LXV the facts of column IV, p. 991, are shown graphically. The numbers at the bottom of the plate give the temperatures of the upper and lower surfaces of a column of water having unit area and height. Ordinates express the relative thermal resistance to mixture, that at 3°–4° and at 5°–4° being taken as unity.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1° 2° 3° 4° 4° 5° 6° 7° 8° 9° 10° 11° 12° 13° 14° 15° 16° 17° 18° 19° 20° 21° 22° 23° 24° 25° 26° 27° 28° 29°

ON THE EVIDENCE FOR TEMPERATURE SEICHES.

EDWARD A. BIRGE.

[Notes from the Laboratory of the Wisconsin Geological and Natural History Survey. VI.]

The term *temperature seiche* was introduced by Watson ('04) in discussing certain periodic oscillations of temperature in the deep water of Loch Ness. He thought that these oscillations show that the isotherms of the lower water "are swinging as a whole about a transverse central axis." His explanation conceived a swinging of the hypolimnion*, as if the thermocline were the upper surface of water in a trough, above which floated a layer of lighter oil, representing the epilimnion. In 1907 Wedderburn ('07 a) reported experiments on a trough thus arranged, showing the possibility of a seiche, such as that postulated by Watson. Watson computed the period of a seiche in the hypolimnion of Loch Ness and found that it agreed with the observed period of the oscillations of temperature. His paper reported only the temperatures found at the depth of 200 feet, where the maximum oscillations occurred, and no profitable criticism of his theory could be made until the whole series of temperature records was published. This was done

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* I employ two new words in this paper, which seem convenient in writing of the temperature and other phenomena of lakes. These terms are *epilimnion*, for the upper warm layer of water which develops in the lake in summer, and *hypolimnion*, for the lower colder water. These two parts of the lake differ widely in their temperature changes, as well as in their chemical and biological phenomena. It seems advisable, therefore, to assign definite names to them. The word *thermocline*, first used by me in 1897, is the equivalent of Richter's term *Sprungschicht*, or the *discontinuity layer* of Wedderburn. It lies at the top of the *hypolimnion*.

by Wedderburn ('07), who printed all of the observations and also (pp. 420-427) repeated the theory in more detail. The next year Wedderburn ('08) recapitulated the theory and says that after the epilimnion has been established the variations of temperature in the lower water are "principally due to the temperature seiche." Our ideas regarding the change of temperature in the hypolimnion will be greatly changed—or rather revolutionized—by this theory, if it is correct. An examination of the evidence for it is, therefore, not out of place.

Wedderburn's paper of 1907 is by far the most complete one on this subject and my remarks are based mainly upon it. It does not appear that the observations of 1903, which were employed by Watson, can be profitably discussed in detail, since they were taken at intervals of about twelve hours—morning and afternoon—and so give no detailed picture of the movements of the water or of the wind. Wedderburn, however, gives an admirable series of temperatures, taken in Loch Ness in 1904, chiefly from a yacht anchored near Fort Augustus at the southwest end of the lake. Besides very numerous series of temperatures, taken at less frequent intervals, observations were made every two hours, day and night, from Aug. 1 to Aug. 24. I do not know any similarly complete series of lake temperatures from any other source. It is from this series that Wedderburn draws his chief illustrations of seiches, and to this I shall refer.

In discussing the question of temperature seiches it should be said that no one doubts the presence of oscillations "in the lower layer independent of movements progressing in the upper layer" (Wedderburn, '07, p. 422), or of temperature changes resulting from them. These have been frequently observed; they are always going on and are very numerous and complex. The undecided questions are (1) whether there are present in the hypolimnion stationary waves, series of pendular movements of the whole mass of this water, and (2), if so, what are the extent and importance of such movements. It is plain that there is no general or *a priori* reason why such temperature seiches should not exist; on the contrary, they might be expected to be present. The action of the wind, depressing the hypolimnion on the lee side of the lake and raising it on the windward side, furnishes the conditions for starting a seiche. But as the wind declines or ceases and the hypolimnion swings back toward its former position, does it continue its movement, rising above the normal at the lee side of the lake, and then falling so as to start a series of pendular oscillations? Or is the return so slow and the hypolimnion so loaded by the epilimnion that movement practically ceases when the isotherms have returned to the horizontal position? If the first question is answered in the affirmative, then what are the extent and influence of such pendular oscillations? These questions are to be answered on the basis of observation. If periodic movements of considerable magnitude can be shown which, started by the wind, are thenceforward independent of the wind and of the movements of the epilimnion, then the case is proved.

I must confess that I find the evidence adduced by the Loch Ness observers insufficient to prove their case. Neither Watson nor Wedderburn seems to have carefully discriminated movements directly associated with wind from those which are possibly independent of it. All movements of the surface of the hypolimnion are apparently referred to indiscriminately as seiches. Even the greatest temperature changes are listed as seiches, which, if they were such, would involve a vertical swing of the water amounting to 200 feet, or more. An amplitude of 100 feet is said by Wedderburn to be quite ordinary. Many of the movements in July, 1904, as well as all of those of August, seem to be regarded as seiches. Certainly there must have been some movements which were correlated with the wind, and it would seem that Watson and Wedderburn should analyze the complex movements of temperature in and below the thermocline and should point out which are due to seiches and which are of other types. Yet no attempt is made to do this and I cannot see that either author furnishes any criterion by which to discriminate temperature changes due to a seiche from those due to other movements of the hypolimnion.

It should also be noted that the position of the yacht, (Fig. 1) where the temperatures were taken, was singularly well adapted to show movements of the water caused by wind and ill adapted for recording seiches. It lay close to the shore, about 300 yards from the southwest end of the lake and in 300 feet of water. The main lake extended, like a broad river, for 20 miles to the northeast. Every northeast wind must fill this end of the lake with warm surface water, and every southwest wind must blow it out again. The yacht lay so close to the shore that the underwater movements induced by wind must readily affect the temperatures. Every student of lake temperatures will also notice the fact that the yacht lay at one side of the outlet of the small bay that forms a pocket at the end of the lake. Any wind that pushed the water at all obliquely against the southeastern shore would fill this pocket and thence the warm water would gradually work out toward the yacht, moving up toward the northern shore.

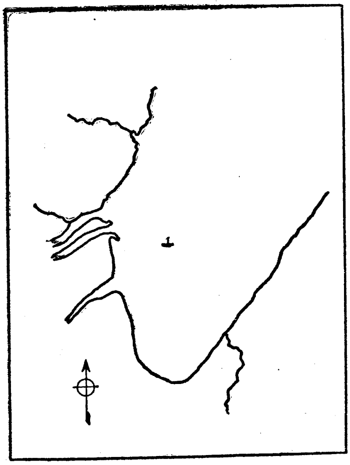

Fig. 1. Sketch map of the south-west end of Loch Ness, showing position of yacht used as observing station. Scale, 1.5″=1 mile.

The observations of August, 1904, are far more valuable in this discussion than all of the others combined, since they were taken at frequent intervals day and night; the thermocline was present; and the force and direction of the wind were recorded. I shall, therefore use these in my discussion, especially as Wedderburn's illustrations are almost wholly taken from them.

The diagram of temperature movements which Wedderburn gives ('07, p. 421) is not easily read. I have, therefore, platted on a different scheme and a larger scale his observations from noon of Aug. 14 to noon of Aug. 21, (Plate LXVI). This period includes three of the five major movements ot the thermocline which came in August, and also includes the swing that looks to me most nearly as I suppose a great seiche would appear. The rise of temperature in the hypolimnion, shown in the center of the diagram (Aug. 17), is that chosen for special illustration and discussion by Wedderburn. It seems to me plain that this great swing of the isotherms was not a seiche, as defined by Watson. Examination of the diagram will show that during Aug. 16 the wind was constantly from the southwest, off shore, and the isotherms steadily rose as the warmer surface water was blown away, until in the afternoon the epilimnion practically disappeared. At 4 a. m. of Aug. 17 the wind shifted to east and then to northeast and blew from that quarter for nearly 20 hours. Under its influence the warm surface water returned to fill the end of the lake, crowding down the hypolimnion. After some ten hours of this wind, the filling extended out to the yacht and caused a sudden and great rise of temperature. Then as the northeast wind dropped and was followed by calms and southwest breezes, the displaced hypolimnion swung back toward its normal position and the isotherms rose with it. This is my reading of the movement, nor can I see ground for a different interpretation. It is certainly clear that the movement was by no means independent of conditions in the epilimnion but, on the contrary, was directly associated with changes of wind which must shift the epilimnion and so tend to cause the movement of temperature in the hypolimnion. These forces also seem wholly adequate to effect it and there is no need of supposing a seiche in order to explain it.

If this temperature change was caused by an on-shore wind, it is obvious that the sudden downward sweep of the isotherms, corresponding to the great change of temperature in the deeper water, does not represent a corresponding and equally rapid vertical movement of the water, or indeed any considerable vertical movement at all. If this and similar temperature changes are due to seiches, then the vertical movements of the isotherms, as platted on the diagram, represent equally well the vertical movements of the water. Wedderburn does not hesitate to accept this result. He assigns an occasional amplitude of 200 feet to the temperature seiche ('07, p. 426) and thinks that an amplitude of 100 feet is nothing out of the ordinary. He also states ('07, p. 422) that on August 17 the temperature rose 8.3° F. in 15 minutes at a depth of 100 feet. This change, if due to the lowering of the surface of the thermocline, means a movement of at least 50 feet in the same time, and in the course of the general temperature movement of this day there would have been a depression of the thermocline amounting to over 100 feet during two hours. I find it difficult to believe in such great movements of the hypolimnion. They are so large and so rapid that they should cause serious disturbances at the surface of the water, which have never been observed. But if the explanation of these temperature changes, which I have given above, is accepted, no such violent and rapid movements of the hypolimnion need be assumed. As the space between the yacht and the shore was gradually filled with warm water, forced to the end of the lake by the wind, the colder water was crowded downward and outward. The front of this growing mass of warm water gradually moved out into the lake as new additions were made to it, and when it reached the observing station the thermoneter recorded a very sudden and great rise of temperature, which however, involved no corresponding movement of the water but only a comparatively small displacement, chiefly lateral.

The complex phenomena, caused by wind, with their resulting temperature changes, cannot be readily analyzed from observations made at a single point, but before we can accept temperature seiches as their cause, there must be observations sufficient in number and position to exclude other and more easily received explanations.

In like manner may be seen that all of the considerable rises of temperature in the deeper water of Loch Ness during August were preceded or accompanied by a northeast or on-shore wind. The relation is plain in the movement of Aug. 15, as is shown on the diagram. The similar movement of the isotherms on the night of Aug. 22–23 coincided with an on-shore wind. The same is true of the movements on Aug. 11 and the night of Aug. 19–20, although they need separate discussion. The decline of temperature at a depth of 50 feet on Aug. 8, referred to as a seiche by Wedderburn ('07, p. 422) was accompanied by southwest or off-shore wind and by a fall of surface temperature certainly due to this wind. The similar drop of temperature at 50 feet on Aug. 14, also referred to by Wedderburn, coincided with a shift of wind from northeast to southwest and the temperature rose again when the wind turned, at 10 p. m., to the northeast. Thus every considerable shift of temperature in and below the thermocline during August was precisely that which might have been predicted as probably resulting from the meteorological changes; the position of the observing station and the direction of the wind being known. So far from the evidence showing that these major oscillations are independent of changes in the epilimnion, they coincide with such changes and with meteorological forces directly adapted to cause them.

I do not mean to say that we are able thus to account for every change of temperature at every depth in this series of observations. We are ignorant of the underwater currents in Loch Ness, and of the minor effects of the winds; and their major effects are matters of inference rather than of observation. We know that these effects are numerous and complex. When a mass of warm water is once established at the lee end of a lake it often shifts and moves about in an irregular and quite incalculable fashion. It is acted upon by numerous forces, each quantitatively unknown, including not only wind currents but convection currents, as well as underwater currents set up in the past, and the numerous and doubtful interactions between this warm mass and the cold outer water crowding in upon it. But if seiches are to be asserted as the main factor in temperature changes in the hypolimnion, the temperature phenomena must be clearly analyzed and it must be shown which of them are due to the immediate influence of wind, which to irregular movements of the hypolimnion, and which to stationary waves or seiches.

There remain to be considered the movement of midnight Aug. 19–20 and also that of Aug. 11, which though of smaller amount is a similar case and open to similar explanation. Wedderburn does not refer to these movements of the isotherms, although they appear more like temperature seiches than any of the other swings of temperature in August. This is especially clear in the movement of Aug. 19–20. Reference to the diagram will show that on Aug. 19 a northeast wind began at 2 a. m. and caused a slight but obvious descent of the isotherms at 6 and 8 a. m. After 10 a. m. there was little, or no wind recorded during the day; at 8 p. m. it was northeast again, followed by light southwest breezes and calm during the night. Between 6 and 8 p. m. began a rapid descent of the isotherms, culminating at midnight. They remained about stationary during four hours, or more, then swung back to their former position, and later, on Aug. 22, to a still higher level under the influence of a southwest wind.

In this case there is plainly an on-shore wind associated with the rise of deep water temperatures. It is plain also that the rise is greater than would have been expected from the amount of wind and that it came later than in the other cases. Thus the descent of the isotherms seems not wholly but to some degree independent of the movements of the epilimnion and their rise is practically independent of the wind. It is also to be noted that the 45° isotherm began to move downward some four hours before the 50° isotherm. The question is not one of association of these movements with an on-shore wind, but of the adequacy of the wind to produce so great a swing of the isotherms, which, with a much smaller amount of wind than on Aug. 17, is a swing of the same general order of magnitude as that.

I believe that this movement was a secondary effect of that of Aug. 17 and that it was directly caused by underwater currents set up by the northeast wind of Aug. 19 and which continued to move slowly after the wind died away. It must be remembered that conditions on Aug. 19 were very different from those on Aug. 17. When the northeast wind began on the former date, the southwest wind, extending through the preceding twenty-four hours, had blown all of the warm water from the southern end of the lake. Several hours and much wind were, therefore, necessary to bring it back. But on Aug. 18 there was little wind; a large mass of warm water remained at the yacht and there was doubtless much more in-shore. It required, therefore, only a small amount of northeast wind to put the deeplying warm water into motion again. I suppose that the mass of warm water, accumulated by the wind of Aug. 17, moved out to the observing station, causing the rise of temperature before midnight of Aug. 19–20, and then was either crowded back or pushed past the station, causing the fall of temperature in the early morning of Aug. 20. I am very glad to admit that this movement looks like a temperature seiche, but the evidence that it is such is by no means complete, or even adequate. We do not know how much warm water lay in the southwest end of the lake on Aug. 19, nor do we know the extent or shape of the mass. We do not know that there was any corresponding movement of temperature in a reverse direction on Aug. 19–20 at the other end of the lake, or indeed that there was any movement of temperature at all. So far as the facts at hand give evidence, there is no reason which requires us to conclude that the disturbance of Aug. 19 was a different kind of phenomenon from that of Aug. 15, 17, or 22; in each of which not only is the qualitative relation to the wind distinctly marked but the quantitative relation seems adequate.

Thus after a review of the clearest evidence for temperature seiches, adduced by Wedderburn, I am forced to give my vote for the Scotch verdict of "not proven". I am quite ready to accept seiches of any period or amplitude that can be proved, but I cannot see that we ought to accept seiches of 200 feet amplitude, or even of any amplitude, on the evidence presented.

It is unfortunate for the establishment of the seiche theory that Loch Ness is so long. The period of its oscillation, about two days, is so great that it must be difficult to find considerable movements which are not interfered with by the changes of weather and it is correspondingly difficult to eliminate the possible effects of wind. Still further, the fact that even in August the epilimnion may practically disappear, as it did on Aug. 16, adds to the difficulties of analysis of observations. A smaller lake of similar shape with an oscillation period of a few hours and with a much warmer epilimnion would offer far better opportunities for settling the question of the presence of temperature seiches, of their magnitude, if present, and of their importance in the temperature changes of the hypolimnion. Loch Ness, of course, has an advantage over a smaller lake in possessing a hypolimnion of enormous mass, so great that the loading due to the epilimnion may well be inadequate to damp the temperature seiches, if such are started.

If I may hazard a doubtful opinion, I would say that I believe that such seiches may be found to exist. I believe also that in most lakes they will be of small extent and of small influence upon the temperature. Great and rapid changes of temperature in the hypolimnion are due mainly to definite movements of its water, directly caused by the shifting of the epilimnion under the action of the wind. Minor changes and the slow rise of temperature in the hypolimnion seem to be caused chiefly by the irregular currents which result from the major movements and which may persist long after their direct cause has disappeared.

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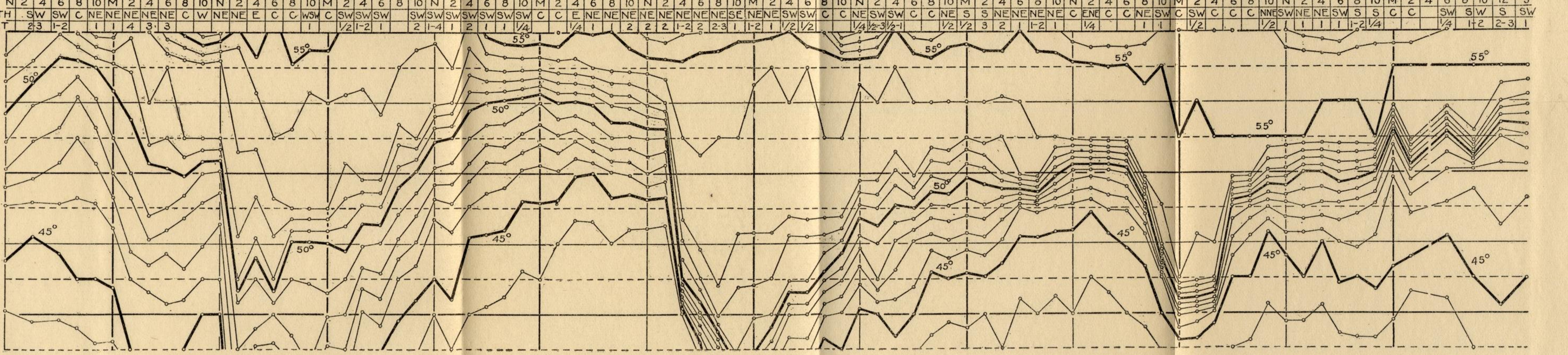
Wedderburn '07a: An experimental Investigation of the Temperature Changes occurring in Fresh-Water Lochs. E. M. Wedderburn. *Proc. Roy. Soc. Edinb.,* xxviii, pt. i; pp. 2–20; figs. 1–14. Edinburgh, 1908. (Issued separately, Dec. 1907.)

Wedderburn '08: Notes on the Temperature of the Water in Loch Ness. E. M. Wedderburn. *Geog. Jour.,* xxxi: pp. 41, 52–56; figs. 1–3. London, 1908.

EXPLANATION OF PLATE LXVI.

This plate shows the movement of temperature in Loch Ness, Aug. 14–21, 1904. In the heading of the diagram, the first line gives the hour of the day; N represents noon, M, midnight. The second line gives the direction of the wind and the third gives its force. Temperatures are recorded in Fahrenheit degrees and depths in feet. The data are taken from Wedderburn '07, pp. 472–474. In this paper the temperatures are recorded for intervals of 25 feet. From these data the position of the full degrees has been platted, assuming a uniform temperature gradient in each 25-foot stratum. These points are indicated by small circles, and the successive positions of each degree are connected by straight lines. The lines representing 45°, 50°, 55° are made heavier than the others.

Thus the diagram represents the movements of the isotherms in the water, as influenced by sun, wind, and currents.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125
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NOTES ON CLADOCERA. IV.

EDWARD A. BIRGE.

I have recently sent to the press a brief synopsis of the known Cladocera of the United States, for a forthcoming work on fresh-water biology by Professor H. B. Ward. In the course of preparing this synopsis it was necessary to settle, provisionally at least, several questions of nomenclature, one of which is more fully discussed here. It seemed also advisable to include in the synopsis several species hitherto undescribed. I publish, therefore, the following notes in order that the matters in question may appear in a scientific journal and in more complete form than is possible under the conditions of extreme brevity imposed by the limits of a general work.

Type specimens of all new species described are preserved in the collections of the Wisconsin Geological and Natural History Survey at Madison.

1. *Pseudosida bidentata* Herrick.

Plate LXVII, figs. 1–9; Plate LXVIII, fig. 1.

In 1903 I visited the southern part of the United States, collecting entomostraca; being especially desirous to clear up the confusion which exists with regard to the genus *Pseudosida*

NOTE.—The former papers of this series have been published as follows:

Notes on Cladocera. Trans. Wis. Acad., Vol. 4, pp. 77–110, pl. I, II. Madison, 1878.

List of Crustacea Cladocera from Madison, Wisconsin. Trans. Wis. Acad., Vol. 8, pp. 379–398, pl. XIII. Madison, 1891.

Notes on Cladocera. III. Trans. Wis. Acad., Vol. 9, pp. 275–318, pl. X–XIII. Madison, 1893.

My stock of separates of these papers has been distributed.

and hoping to find specimens both of *bidentata* and *tridentata;* to be able to describe them more carefully than had been done by Herrick and to discriminate them accurately. Near New Orleans I found numerous representatives of the form which I readily identified with Herrick's *P. bidentata* and which is described later. Nothing was found which corresponds to *P. tridenta,* as Herrick calls it. In seeking information which should aid me in working up my material, I applied to Professor C. Judson Herrick of Denison University, Ohio, and through his kindness I received all of the notes and drawings left by his brother, the late Professor C. L. Herrick, regarding entomostraca, and also such few specimens as remained of his collection. I have, therefore, all of the original notes regarding these species. The specimens were of no value. It appears that Professor Herrick was not in the habit of keeping a collection of the species which he described and all of the entomostraca which had been preserved at Denison University were destroyed some years ago in a fire. The note-books, however, contain the original sketches from which the drawings were made that Herrick gave in the original descriptions of *P. bidentata* and *tridentata.* The first note-book contains numerous sketches of *P. bidentata.* The sketches are not dated and only a few words of description are given. It is apparent that they were made from living or fresh material during a journey which Herrick took through the southern states, probably not later than 1882, as species drawn in the note-book are described by him in a paper published in 1883. The note-book contains the sketch, which forms the basis of plate K, fig. 9, in Herrick's paper of 1884. In the published figure the antennules, the antenna, and postabdomen are put in from the sketches on adjoining pages. In the separate drawing of the antennule, which is given on this plate, Herrick has unfortunately used one of the poorest of the sketches which he made, so that it is plain that he never compared his sketches with preserved specimens. In a sketch of the animal seen from the dorsal side Herrick shows one antennule very well, giving the characteristic curve, (See Pl. LXVII, fig. 2) and also the peculiar form of the base at its junction with the flagellum. Of this sketch, however, he made no use, but the published figure shows the position of the olfactory setae, which is important in characterizing the genus. There is no difficulty in identifying the specimens belonging to this species from Herrick's plate and description of 1884.

I found no specimen of *P. tridenta* or *tridentata;* but some light, though unfortunately not as much as could be wished, has been thrown on the subject by Stingelin's discovery ('06) of two poorly preserved specimens from Paraguay, which seem to belong to the species. Stingelin is undoubtedly correct in stating that Herrick in his *Pseudosida tridentata* had a different species from that which he had formerly described under the name *bidentata.* The drawings of this species are contained in a different note-book, also undated, but labeled "Later Gulf of Mexico, etc." The sketches do not contain any drawing of the species as seen from the side. In this particular Stingelin's remark is instructive, that the species, unlike *P. szalayi,* does not naturally lie on its side when placed under the microscope. I found that *P. bidentata,* like *Sida,* and unlike *Latonopsis,* does lie on its side. Herrick gives no sketches which would aid in the identification of the form, more than the published drawings do. The only important difference between the sketches and the published drawings lies in the antennule, which in the engraving ('87, Pl. III, fig. 3) shows a gradually tapering connection between the basal part and flagellum. This is not present in the sketch and is no doubt an error made in copying the sketch. The postabdomen is also broader and blunter in the sketches than in plate III, fig. 4. Mr. E. Foster of New Orleans has suggested to me that possibly Herrick had before him *Latonopsis fascicnlata* Daday—a form which Mr. Foster has found at New Orleans and which I have also found in other localities in the south. So far as most of the details of structure are concerned, this is not improbable; but the outline of the animal, as seen from above, does not suggest *Latonopsis,* nor is the postabdomen similar. Future investigation will be necessary to decide with reference to the form represented by *P. tridentata.* It may well be that the species which Herrick had is the same as that described by Stingelin ('06) and regarded by him as identical with Herrick's species. This conclusion is probable, especially in view of the close relation between the fauna of the southern United States and that of South America, but it is not certain. Herrick's sketch of the antenna of *P. tridentata* is very carefully drawn, apparently with the aid of a camera lucida. It shows that the 3-jointed ramus is two-thirds as long as the other and bears five nearly equal setae. In Stingelin's drawing this branch is much shorter and bears four setae of very different size, like those of *P. bidentata.* No emphasis should be laid on the difference in number of setae. There is full warrant for Stingelin's remark ('06, p. 4, footnote) on the difficulty in determining the number of antennary setae. Those of the 3-jointed ramus, especially, break off very easily and leave no trace. Daday ('04, p. 11; '05, p. 218) makes the possession of four setae on this branch of the antennae a characteristic of his genus *Parasida,* while Herrick assigns five setae to his species *P. bidentata.* My specimens confirm Herrick's statement; but the setae are of very different size and one or more are often absent. Probably not more than 20% of the 100 or more individuals of *P. bidentata* that I have examined possessed 5 setae. Their number, therefore, cannot well be used as a differential specific or generic character.

Since Herrick's papers are indispensable to any student of American entomostraca it may not be out of place to say a few words regarding his manner of work, as shown by comparing his note-books with his published papers. Probably no modern writer on entomostraca has done so much good work in a way so exasperating as has Herrick. He collected and described widely; he had a good eye for the general situation; and is usually right in his statements, as far as they go. But his descriptions are uncritical and often so incomplete that they tell little about the species. It is usually easy, however, to recognize his species when they are rediscovered, as was the case with *P. bidentata.* The note-books which I have show clearly his method of work and also the source of the vague and unsatisfactory nature of many of his figures and descriptions. He made many sketches while on his collecting trips through the South, employing living or freshly collected material. He did not ordinarily employ a camera lucida, nor did he take exact measurements. The sketches rarely bear date or locality and very few notes, only a word here and there. From these sketches he prepared his descriptions and his final drawings, which last were often tracings from the sketches. He does not seem to have preserved his specimens for study at home. At any rate, there are no figures of southern Cladocera in his papers of 1884 or 1887 which are not based on the sketches of the note-books and the published figures do not show any facts that the note-books do not contain. There is no evidence that the sketches were corrected by dissections made later on preserved material, but there is every reason to believe that these field sketches were all he had when writing his papers. I believe that the same statement may be made regarding the rest of the crustacea in these papers but I have not traced out the originals of all of the very numerous figures. So far as I have examined them they are all in the note-books. In preparing his paper of 1887 Herrick does not seem to have taken the trouble to consult his earlier note-book, as this would have shown him at once that he had before him another species than his *P. bidentata.*

There is some confusion regarding the generic name of *P. bidentata.* In attempting to clear it up a statement of the facts is necessary. In 1884 Herrick established the genus *Pseudosida* on specimens found by him at Mobile, Ala. ('84, p. 20; Pl. K, fig. 9), to which he gave also the specific name *bidentata.* In 1887, as a result of later studies, he changed the name of the species to *tridentata* ('84, p. 3), and accompanied the new description with new figures ('87, Pl. III, figs. 2–5). The specific name was erroneously printed *"tridenta"* in this paper. In 1895 Herrick and Turner repeated the last description, including the misprint ('95, p. 147), together with some remarks from the description of 1884, and giving on plates XXXVI and L the figures of the papers of 1884 and 1887. No animals belonging to either species or to this genus were seen for more than a decade after 1887. In 1898 Daday ('98, p. 64) described *P. szalayi,* a *bidentata* form, from Ceylon. In 1904 Stingelin ('04) reported the same species from Siam and Sumatra. It is, therefore, widely distributed in the eastern tropics.

In 1901 Daday described *P. papuana* ('01, p. 42) from New Guinea. This is a *tridentata* form. In 1904 Daday established the genus *Parasida* ('04, p. 11) for those species included under the genus *Pseudosida,* in which the olfactory setae are not placed at the end of the basal part of the antennule; he leaves in the genus *Pseudosida* of Herrick those species in which the sense hairs are placed at the end of the basal part and in which the antennule resembles in general that of *Latonopsis.* The next year he described from Paraguay two species which belong to his genus *Parasida, P. ramosa* and *P. variabilis* ('05, p. 218–220).

In 1906 Stingelin ('06, p. 2) called attention for the first time to the fact that Herrick in his two papers had before him not, as he supposed, representatives of the same species but two different forms. Stingelin, therefore, concludes that the specific name *tridentata* is not to be rejected as a synonym but is to be retained and applied to a species whose antennule has in general the *Latonopsis* form.

These are the facts regarding the genera *Pseudosida* and *Parasida* and they seem to warrant the following conclusions:

1. Herrick's genus *Pseudosida* 1884 was a monotypical genus, properly founded, and can be readily identified by means of his figures and description. In particular, the position of the olfactory setae on the antennule is perfectly clear from his figure ('84, Pl. K, fig. 9,), although described in his text merely as "lateral" ('84, p. 20).

2. Herrick was wrong in supposing that his form *tridenta* 1887 was co-specific with *bidentata* 1884; and even if he supposed this to be the case he had no right to attempt to change the specific name. This is always contrary to rules of nomenclature. In this particular case, no reason existed for desiring the change. Herrick's earlier sketches were carefully made and, as a matter of fact, showed the claws of the postabdomen correctly. There was no reason to assume that they were wrong, especially as any comparison of the earlier and

later sketches would have shown that other differences, notably in the antennule, existed between the forms under comparison.

3. No change was made in the situation by Herrick's error of 1887. His *P. bidentata* 1884 remains a monotypical genus.

4. Daday in establishing his genus *Parasida* overlooked Herrick's paper of 1884, and supposed that *Pseudosida* was originally proposed for species having an antennule like *Latonopsis.* Writing of his *Parasida* he says: ('05, p. 218) "Die erste Art dieser Gattung hat E. v. Daday unter dem Namen *Pseudosida szalayi* 1898 aus Ceylon beschrieben." He thus ignores the fact that *P. bidentata* Herrick 1884 is the first species and the type of the genus *Pseudosida. Parasida,* therefore, becomes a synonym for *Pseudosida* and if the *tridenta* forms are regarded as belonging to a distinct genus, a new name must be found for it.

5. The question of the specific name *tridenta* or, correctly, *tridentata* Herrick 1887 offers more difficulty; but it need not be discussed until the form which Herrick had before him is determined beyond question. If Stingelin's species ('06) proves identical there is only the question whether the species *tridentata* belongs to him or to Herrick.

Description of P. bidentata.

Female: The general form, as seen from the side, recalls *Sida* in some respects and *Latonopsis* in others. The form of the large head especially resembles the former genus; as there is a rostrum which usually lies close to the valves; though as the head is movable the beak may be at some distance from them, even when the animal is alive and under no pressure. Compare plate LXVII, figs. 1 and 4 both drawn with camera lucida from living specimens, lying free on a slide without cover-glass. In preserved specimens the contraction of the powerful antennary muscles draws the head dorsad and gives it a wholly unnatural position and distorts the general outline. Daday's figure of *P. variabilis* ('05, Pl. XIV, fig. 9), which might be drawn from my alcoholic specimens of *P. bidentata,* may be compared with the figures of living specimens in this paper. The presence of wrinkles on the back of the head, as seen in Daday's figure and in my figure 1, is evidence that the head has been raised. The rostrum is broader and blunter than that of *Sida* but otherwise closely resembles it. The general form of the body is oval, especially in older specimens, whose dorsal margin is considerably arched. The cervical notch is present, but there are no cervical glands. The valves are thin and marked only by granulations; the anterior margin is concave, with a well marked infero-anterior angle; the ventral margin rounds over into the posterior; the posterior margin is convex below with a concavity at the dorsal part, just below the sharp supero-posterior angle. The anterior and ventral margins are fringed with long, thin setae set far apart; these are especially long at the infero-anterior angle; they exttend to the posterior end of the ventral margin; but there is no cluster of long spines there as in *Latona.*

Appendages: The antennules (plate LXVII, fig. 2) are attached on each side of the rostrum, and are borne on small elevations. The basal part is about as long as the ventral margin of the head; somewhat curved; thicker in the middle than at either end. The distal end is truncate and produced on each side into minute sharp projections, almost spine-like. There is a very long, flexible flagellum, much longer than the basal part, covered sparsely with long, fine, straggling hairs. The olfactory setae are sessile, or nearly so, on the side of the base a little distal to the middle.

The antenna is large and powerful. The basal joint bears two large, short, thorn-like spines, a basal and a distal; it has the usual sense seta between the bases of the rami. The rami are 2- and 3-jointed; the setae are $\frac{5\,(6) - 9\,(10)}{0 - 1 - 4}$; the two terminal setae of the dorsal ramus are much longer than the others; that on the second joint of the ventral ramus is even longer and may measure 1.0 mm. in an animal whose total length of about 1.53 mm.; one of the 4 setae on the terminal joint is nearly as long, two of the others are much less than half as long and are proportionally slender, the fourth is still smaller, not as long as the basal joint of the largest. This seta is lost in nearly 80% of the specimens which I have seen, and one or both of the two other small ones are often gone, as well as the terminal joint of the larger ones.

The feet, labrum, mandibles, and maxillae present nothing unusual in their structure. The sixth foot has a branchial sac.

The postabdomen (Pl. LXVII, figs. 3, 6) is in general conical. It bears 11–15 clusters of lancet-shaped spines, 2–5 in a cluster. If there are two or three they stand nearly parallel; if 4 or 5 they diverge. There are besides numerous clusters of fine hairs. The terminal claws are long, curved, with two long basal spines and a third, very small one, proximal to them; they are denticulate and have spinules on the convex side. The postabdomen has no median projection like that of *P. szalayi.* The abdominal setae are long, 2-jointed, plumose and borne on distinct, widely separated papillae.

The shell gland (Pl. LXVIII, fig. 1) has three loops, dorsal, ventral, and posterior. The posterior loop is large and open, and of a form which might serve as a beginning to the extreme development found in *Latonopsis australis.*

The intestine is straight, with a small median forward projection. The eye is large, oval; it lies on the ventral side of the head, with a short optic nerve. The macula nigra is small and oval.

The color is yellowish, semi-transparent. The length of the female is 1.8–2.0 mm.; male, about 0.9 mm.

The male resembles the young female. The antennules (Pl. LXVII, fig. 9) are very long, often two-thirds the length of the animal; curved; the flagellum and base firmly united, the former bearing a row of very fine setae along the distal half. There is a slender process on the base near the attachment to the head, extending toward the median plane. The copulatory organs (Pl. LXVII, fig. 5) are simple, long, cylindrical, as in *Latona.* The endopodite of the first foot is modified into a clasping apparatus, more complex than in any other of the Sididae. The tip is bent over into a strong, curved, movable claw (Pl. LXVII, figs. 7, 8) serrate on the inside. A little way distal from the attachment of the claw there is a large, semi-ellipsoidal enlargement or bulb, densely covered with short hairs, and against which the tip of the claw shuts. In the hollow of the clasping apparatus thus formed and arising from the enlargement of the base is a rather large, transparent, tapering seta, very delicate in structure and apparently sensory in function. This clasping apparatus may be regarded as a development of that found in *Sida.* (See Lilljeborg, '00, p. 26); or it resembles even more closely that of *L. fasciculata* as described later in this paper. *Sida* (Lilljeborg, Pl. II, fig. 3) shows a clasping structure with an enlarged and hairy bulb at the base and a hollow between hook and base; the hook is blunt and finger-like. In *Latonopsis* (Pl. LXVII, figs. 6, 7) the hook is a claw, which bends over against the basal part without leaving a hollow. In *L. fasciculata* the basal part is enlarged and hairy but does not have the hollow found in *Pseudosida.* Along the inner side of the clasper and projecting beyond it is a long, tapering, thin-walled, rather soft extension of the terminal part of the endopodite (Pl. LXVII, fig. 7). This has near its base several long two-jointed setae like those on the edge of the endopodite and forming part of that series. This structure, which I suppose is chiefly sensory in function, is quite like the corresponding part of the male foot in both species of *Latonopsis.* Daday, in describing *P. variabilis* ('05, p. 223) calls this organ "eine mächtige sichelförmige Kralle", but in my specimens it is certainly not a claw; on the contrary, it is thin-walled and filled with soft material which shrinks away from the wall in preserved specimens. Daday also refers to what I have called a sense-seta inside the claspers as "ein kräftiger Dorn". These two small differences in the thickness of walls of parts of the male clasping apparatus are the only tangible differences that I can find between Daday's description and figures of *P. variabilis* and my specimens of *P. bidentata.* I, therefore, with some hesitation, regard the two species as identical. If not so, *variabilis* can have hardly more than varietal rank. The genus *Pseudosida* is a tropical one, as is evidenced by its presence in Ceylon, Siam, Sumatra, and South America. Its presence on the southern coast of the United States is another case of the extension into that region of South American forms.

From this description the following account may be given of *Pseudosida.*

Genus. *Pseudosida,* Herrick 1884.

General form much like *Sida,* but head more depressed and rounded and dorsum more arched. No fornix or cervical glands. Head with rostrum wider and less pointed than that of *Sida,* but having much the same form and position. Cervical sinus present. Antennules inserted or elevations on side of rostrum; basal part very long, stout, curved; olfactory setae sessile or on finger-like projection on posterior side, nearer insertion than distal end. Distal end notched, and from it arises a very long, slender, flexible flagellum, longer than basal part, sparsely provided with long, fine hairs. Antenna stout, much like *Latonopsis,* base with two stout, short, curved, thorn-like spines, and usual sense-setae; dorsal ramus 2-jointed, ventral 3-jointed. Setae $\frac{5\,(6) - 9\,(10)}{0 - 1 - 4}$, of various lengths; the longest is that on the second joint of the ventral ramus, which may equal ⅔ of the total length of the animal, but is often broken*. The terminal joint has one very large seta; others much smaller and one or more often lost. Spines $\frac{1 - 1}{0 - 1 - 1}$, those of dorsal ramus large and somewhat hooked at the tip; that on second joint of ventral ramus large. Valves elliptical; posterior margin rounded over into ventral; anterior margin concave and joins ventral in a well marked angle. Free margin fringed with long, movable setae, much less developed than in *Latona* and not especially elongated at infero-posteal angle. Post-abdomen large, with long abdominal setae on separate papillae. Claws, large, stout, curved, with two long basal spines and a very small one prox-

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*** Dr. Von Daday has been so kind as to send me a specimen of *P. szalayi*, which shows that the inequality of the antennary setae of that species is quite as marked as in *P. bidentata*. The specimen is not that of a full grown animal, and the longest set equals 70% of the total length of the head and valves.**

imal to them; claws denticulate, both inside and outside. Anal spines about 14 clusters of 2–5 diverging spines. Many clusters of fine spinules. Eye on ventral side of head with short optic nerve; macula nigra minute. Intestine with small median coecum.

Shell gland has on the whole the daphnid form; the posterior loop is rounded and open.

Antennule of male long, slender; curved flagellum and base firmly united into one piece; row of spinules along distal part. Olfactory setae on small papilla or sessile; stout spine-like projection near base, extending toward middle line. Simple, cylindrical copulatory organs, as in *Latona.* First foot with complex grasping apparatus.

The following key will show the relations of the species of *Pseudosida.*

A. *Bidentata* forms.

1. Olfactory setae borne on finger-shaped elevation. *P. ramosa* Daday.
   Daday ('05, p. 218) Paraguay; Stingelin ('06, p. 187) Paraguay.

1*. Olfactory setae sessile on antennule or, at most, borne on small elevation.
   2. Postabdomen with median projection on dorsal side near apex. *P. szalayi* Daday.
      Daday ('98, p. 64) Ceylon; Stingelin ('04, p. 336) Siam, Sumatra.
   2*. No median projection on postabdomen. *P. bidentata* Herrick.
      Herrick ('84, p. 20) Southern United States; Daday (*P. variabilis,* '05, p. 220) Paraguay.

B. *Tridentata* forms.

1. *P. tridenta* Herrick ('87, p. 33; '95, p. 147) Southern United States; *P. tridentata* Stingelin ('06, p. 2) Paraguay.
2. *P. papuana* Daday ('01, p. 42) New Guinea.

The descriptions of these two species are still too imperfect to permit differentiation. Very probably they should be assigned to a new genus.

2. *Latona parviremis* sp. nov.

Plate LXVIII, fig. 5; Plate LXIX, figs. 1–3.

The common species of *Latona* in northern Wisconsin and Michigan is not *L. setifera,* although that species occurs there not infrequently. Far more abundant is a new and very distinct form of the genus which I have called *L. parviremis.* This species shows characters which serve to connect *Latona* and *Latonopsis,* and in the possession of one structure—the hepatic coeca—it is unique among the Sididae.

Description of female: The length rarely exceeds 1.8 mm.–2.0 mm., though it may reach 2.5 mm., excluding the setae at the infero-posteal angle; the height of a mature specimen is about 0.6 mm. In general form and structure it closely resembles *L. setifera* but is relatively less broad and flat. The *appendix foliaceus* on the ventral side of the head is well developed though shorter than in *L. setifera.* Many observers must have noticed—though I have not seen the fact recorded—that the organ is concave on its ventral surface and forms a sort of trough or scoop with bottom up (Pl. LXIX, fig. 3). It apparently serves to direct the current of food-bringing water in the proper direction. A small fornix is present and also a thin lamina over the bases of the mandibles; the last best seen from above.

The valves are granulated and otherwise unmarked. No traces have been seen of the villosity sometimes found in *L. setifera* or of the brilliant colors which that species sometimes shows. The valves have the form characteristic of the genus, though the posterior margin is not so oblique to the axis of the body as in *L. setifera.* Compare Pl. LXIX, fig. 1 with Lilljeborg, ('00, Pl. IV, fig. 12). The ventral and posterior margins are closely set with long, slender, plumose setae. At the infero-posteal angle is a cluster, about 6 in maximum number, of very long setae, often quite equalling the length of the valves. These are normally spread out laterally something like the ribs of a fan, and doubtless aid in supporting the animal as it lies on the loose debris of the bottom. The full number is rarely found, and many specimens have lost all of them. At the base of this cluster of setae the shell is produced into a short, blunt spine, which extends beyond the elevations to which the setae are attached. This apparently serves to stiffen the valve at this point. The posterior margin has a row of minute close-set spinules which do not project beyond its edge.

The abdominal setae are moderately long, 2-jointed, plumose, and borne on distinct and widely separated papillae. The postabdomen is conical, bearing 9–15 small, lateral, anal spines, larger toward the distal end of the row. The terminal claws are long, finely serrate, with two long basal spines. The form of the antennule is between that of *Latona* and *Latonopsis,* more nearly approaching the latter genus. There is a short, stout, straight basal part and a long flagellum united with it and forming a continuation of the base. The flagellum is covered with long, fine, straggling hairs much less closely set than in *L. setifera.* The antennules shows no angle at junction of base and flagellum. The latter structure is somewhat stouter than in *Latonopsis.* The olfactory setae are on the distal end and posterior side of the base.

The antennae have a large, stout basal joint, like that of *L. setifera.* It bears a stout, conical spine or thorn at the base and a similar structure on the outer side of the distal end. It has also a stout spine and a slender, plumose sense-hair on the distal end between the insertion of the rami. The dorsal ramus is 2-jointed and has a lateral setigerous expansion of the proximal joint; but this is much smaller than that of *L. setifera,* bearing only 5–6 setae. From this character comes the specific name, *parviremis.* The setae are $\frac{5(6)-8(9)}{0-1-4}$. The ventral ramus has a long seta on the second joint and one of the 4 terminal setae is much larger than the others. The inequality is greater than in *L. setifera,* but not equal to that of *Latonopsis* or *Pseudosida.* American specimens of *L. seti-*

fera show a distinct though small inequality in the length of the setae, instead of the uniformity shown in the figures of Sars and Lilljeborg.

The feet closely resemble those of *L. setifera* except that the sixth pair has the branchial sac.

The intestine is remarkable for having a pair of large hepatic coeca, which extend ventrally from the point of attachment to the intestine toward the place of insertion of the antennule. When seen from the side they conceal the middle part of the brain. It appears that this position is accommodated to the very large antennary muscles and perhaps gives us a hint that the development of these muscles in the Sididae is the cause of the absence of the coeca in the rest of the family. *L. parviremis* is the only member of the Sididae that possesses these organs. The shell gland (Pl. LXVIII, fig. 5) closely resembles that of *L. setifera;* having a dorsal and a ventral loop but hardly a trace of the posterior loop. The eye is oval, as seen from the side, with numerous lenses, set at top of the head, and with a long optic nerve; the macula nigra is small, oval. The heart is elongated, like that of *L. setifera.*

The male in general resembles the young female. The antennule (Pl. LXIX, fig. 2) has the form of that structure in the male *Latonopsis.* It is very long; the base and the long curved flagellum are firmly united; the distal half of the flagellum has a row of short, fine setae; the olfactory setae are borne on the side of the basal part. There is an *appendix ciliata* as in *L. setifera;* this is long, slender, and plumose or ciliate. In this respect it is unlike the smooth projection which occupies a similar place on the antennule of *Latonopsis.* The first foot resembles that of the female, having no hook or other clasping organ. There are two simple, cylindrical, copulatory organs.

L. parviremis is widely distributed in northern Wisconsin and Michigan, having been found in numerous lakes and ponds of that region. I found it first in 1897 in a small pond on the shore of Lake Superior, and it has constantly appeared in collections made since that time. It has never been seen from the central and southern part of Wisconsin, or in collections made south of the lake region of the states named. It has also been found in Maine by Mr. A. A. Doolittle. It inhabits the weedy or marshy margins of the lakes and is sometimes very abundant, though usually appearing as single individuals in a catch. In the autumn of 1903 I found it very abundant in a small opening in the edge of a marsh which borders part of Lake Kawaguesaga at Minocqua. In this and several succeeding years, it was regularly present there, and the males appeared in October. This particular opening was only a few yards in diameter, lying between small projections of the shore of the marsh. One could just enter it with a rowboat and move about within it. The margin was bordered with grass and sedge and the shallow, weedy water at the edge, only a few inches deep, contained very numerous specimens of this species; as well as many other forms usually rare, like *Lathonura.* Adjacent and apparently exactly similar openings in the marsh, separated from this by a few yards only, contained merely the species of Cladocera common in the region. In later years this little area has been invaded by the pickerelweed (*Pontederia*) which grows abundantly at the edge of the water; and with the entrance of this plant and the consequent change of biological conditions all the unusual forms of Cladocera have wholly disappeared from the locality or become very rare.

It is plain that this species serves to bridge the space between *Latona* and *Latonopsis.* The form of the antennule is that of *Latonopsis,* both in males and females. The lateral expansion of the antenna, so characteristic for *Latona,* is small in this species and moreover is indicated in the antennae of *Latonopsis serricauda* Sars and *fasciculata* Daday. The other characteristic *Latona* features are the *appendix foliaceus* on the ventral side of the head, the form of the shell gland, and the absence of the claspers on the first foot of the male. All these *L. parviremis* has, yet it may well be doubted whether it might not have been put into the genus *Latonopsis* had that genus been discovered before *Latona* and if *Latona* were still unknown. But there is no sufficient reason for uniting the two genera, as is indicated by the fact that, if this were done, it would be at once necessary to divide the new genus into two sections corresponding to the two forms which were united.

The discovery of this species makes it necessary to define again the genus *Latona,* as well as the two main species. The genus has had, besides the long known species *L. setifera* (O. F. Mueller) only the very closely allied form *L. groenlandica* Wesenberg-Lund, differing chiefly in the shape of the *appendix foliaceus,* which is more elongated in the arctic form. This is perhaps entitled to rank only as a variety. The presence of the hepatic coeca in *L. parviremis* requires us to omit from the diagnosis of the family Sididae the statement that these structures are absent. See Lilljeborg, '00, p. 15; Sars, '65, p. 21.

Genus. *Latona* Straus.

Body flattened. Head broad and blunt, rounded in front; small cervical sinus. Rostrum absent; the ventral surface of the head prolonged backward into a broad leaf-like expansion, somewhat tongue-shaped as viewed laterally, concave on its ventral surface. Fornices present but small; a thin lamella extends on each side from head to valves, projecting over base of antennae and mandibles. Antennules inserted on sides of ventral surface of head, well forward; their insertion partly covered by small fornix. Antennules stout and long, the shape differing in the two species. Antennae with very stout but not long basal joint; dorsal ramus 2-jointed, its proximal joint with lateral expansion; ventral ramus 3-jointed. Valves sub-quadrangular; dorsal region flattened and nearly straight; posterior margin oblique to axis of body and convex. The whole free edge—anterior, ventral, and posterior—thickly set with long, movable, ciliated setae, each borne on a separate papilla. At the blunt point formed by junction of ventral and posterior margins is a cluster of very long setae, the longest often quite as long as the valves; these are frequently lost, leaving only the papillae to which they were attached. Valves not reticulated. Postabdomen stout, conical, covered by the valves, with small anal spines. Abdominal setae stout, moderately long, set on small papillae placed widely apart. Claws with large base, somewhat curved, with 2 basal spines and denticulate. Eye of moderate size, near dorsum of head; optic nerve very long, macula nigra present.

Simple copulatory organs in male. First foot without hook, resembling female.

On the whole, this genus seems to be northern in its habitat. *Latonopsis* is more abundant in southern and tropical regions, though by no means confined to them, while *Pseudosida* seems to belong to warm countries exclusively.

Species.

1. *L. setifera* (O. F. Müller)

Antennule with very short, stout basal part, large flagellum set on at an angle and appearing as continuation of base so that the antennule is angulated. Olfactory setae on posterior side of base, very small. Flagellum thickly set with long slender hairs. Expansion of basal joint of dorsal ramus of antenna very large. Setae about $\frac{11-12}{0-1-4}$, of somewhat unequal length. Spines $\frac{0-1}{0-1-0}$, that on ventral ramus large. Intestine with small anterior prolongation. Sixth foot without branchial sac. Antennule of male similar in general to that of female, but with a ciliated sensory seta on inner side of basal part. Color yellow, not transparent. The old female often has brilliant colors in late summer.

Length of female, 2.0–3.0 mm.; male, about 1.5 mm.

In ponds and lakes among weeds in shallow water; widely distributed but not very abundant anywhere. Males appear in August or September.

This species has been found in northern Europe, including Russia and Austria. It is said to be absent from France and southern Europe. In the United States it has not been found as yet on the Pacific coast, but is present in all other regions. I have specimens from Baton Rouge, Louisiana, so that it extends to the Gulf coast.

2. *L. parviremis* Birge.

Antennule not angulated; basal part longer than in *L. setifera,* flagellum more slender, hairs not so close set and shorter; the whole organ much as in *Latonopsis.* Expansion of antenna small. Setae about $\frac{5-8}{0-1-4}$; the terminal setae of dorsal ramus longer than others; that of second joint of ventral ramus and one of those on terminal joint are also long. Spines $\frac{0(1)-1}{0-1-0}$; that of ventral ramus large. Intestine with two hepatic coeca, which extend downward toward the insertion of antennules. Leaf-like expansion on ventral side of head smaller than in *L. setifera,* and body less flattened. Sixth pair of feet with branchial sac. Antennule of male long and slender, with row of spinules along distal part, as in male of other Sididae, but with ciliated sensory seta on inside near base. Color yellow.

Length of female 1.8–2.5 mm.; male 1.0–1.5 mm.

In margin of lakes and ponds among weeds. The common species in northern Wisconsin and Michigan. Collected by Mr. A. A. Doolittle in Maine. The range of the species probably extends over the northern United States, at least as far west as the Rocky Mountains.

3. *Latonopsis fasciculata* Daday.

Plate LXVIII, figs. 2, 3, 4, 7, 9, 10.

This species has been found in Louisiana and Texas. I have received numerous specimens, both females and males, from Audubon Park, New Orleans, though the kindness of Mr. E. Foster of that city, to whom I am indebted for many courtesies and for much assistance.

In structure the female very closely resembles *L. serricauda* Sars ('01. p. 6), differing only in the point which caused Daday to make it a new species, viz.: the possession of clusters of spines on the postabdomen instead of the usual row of single spines common in the Sididae. In this feature *L. fasciculata* closely resembles *P. bidentata.* It may also be noted that, like *L. serricauda,* the antenna shows distinct traces of a lateral lobe on the basal joint of the 2-jointed ramus, approaching *Latona* in this detail of structure.

The shell gland has never been described and I give a figure of it (Pl. LXVIII, fig. 3). It has the usual three loops, but the posterior loop shows no trace of the great elongation so characteristic for *L. australis* and related species. On the contrary, the posterior loop is small, much crowded, and does not in the least recall that of the earlier described species. The shell gland of *Pseudosida* resembles a starting point for that of *L. australis* more than does that of *L. fasciculata.* The relationship between *Pseudosida* and *Latonopsis* thus appears to be close and intricate, *L. fasciculata* approaching *Pseudosida* in the structure of postabdomen and first foot of male; while *L. australis* has a shell gland which looks like an extreme development of that of *Pseudosida.*

The male shows no very extraordinary characters. The antennule (Pl. LXVIII, fig. 2) has the regular form, long, curved, with a row of fine spinules on the distal part of the flagellum. There is no *appendix ciliata* or similar projection on the base. The whole structure is proportionally smaller than in *Pseudosida.* The copulatory organs (fig. 10) are simple, cylindrical, as in *L. occidentalis.* The first leg has a very interesting structure and for comparison I give a figure of the foot of *L. occidentalis* as well as *L. fasciculata* (figs. 6, 7, 11). Their general form is similar, differing chiefly in the number and relative length of the long, plumose setae of the expodite. The claspers, in general alike, show noteworthy differences in detail. In *L. occidentalis* the slender process of the endopodite is bent at the tip into a movable claw which shuts against the stem. In *L. fasciculata* the basal part of the process, against which the claw shuts, is swollen and covered with fine hairs. The whole structure, therefore, shows the beginning of a form of clasper which could easily be converted into the complex structure of *Pseudosida.* In both species there is present alongside of the clasper the tapering sensory process of the endopodite.

The species of *Latonopsis* divide into two groups. One section contains *L. australis* Sars, *L. occidentalis* Birge, and *L. breviremis* Daday. These agree in having a shell gland with enormously long posterior loop and simple anal spines on the postabdomen. The other section contains *L. serricauda* Sars and *L. fasciculata* Daday, characterized by a serrate crest on the postabdomen, anal spines in clusters, and a shell gland without large posterior loop. It seems also to be true that the antennule in the *fasciculata* group has a relatively shorter and stouter flagellum than that of the *australis* group. See Pl. LXVIII, figs. 8, 9.

4. *Wlassicsia kinistinensis* sp. nov.

Pl. LXIX, figs. 4–8; Pl. LXX, figs. 1–9; Pl. LXXI, figs. 1, 2.

Some years ago I received from Dr. C. Dwight Marsh a bottle containing a collection made in a marsh at Kinistino, Manitoba, Canada, and dated July, 1902. Among other Cladocera were found numerous specimens of a new species of the genus *Wlassicsia* Daday. Both males and females were present and two females bore ephippia. Among the numerous other Cladocera present were *D. pulex, S. vetulus, C. reticulata, Macrothrix rosea, Pseudalona latissima, Alonella excisa.*

The genus *Wlassicsia* was founded in 1903 by Daday ('03, p. 66) for a Macrothricid which he found in the region of Lake Balaton, Hungary, and which he named *W. pannonica.* The Canadian specimens belong to a closely related but apparently distinct species.

The general form of the female (Pl. LXX, fig. 1), as seen from the side is oval, more nearly resembling that of *Lathonura* than any other member of the family. Like *Lathonura* it has a small crest along the dorsal margin of the valves. Where the dorsal and posterior margins join there is a small notch, above which there is sometimes a rounded projection, hardly to be called a spine. The valves are marked by very fine vertical striae, which unite to form delicate meshes. These are too fine to show on a drawing unless much more enlarged than any here given. The ventral margin bears numerous stout, rather short spines and spinules.

The head is not large; the fornices are of moderate size and continued to the end of the head; the rostrum hardly exists. There is a small cervical gland, but no cervical sinus.

The antennules are freely movable, cylindrical, slightly curved, beset with transverse rows of very fine short hairs. They have a basal sense hair and the olfactory setae are of moderate length and unequal.

The antennae are about as large as in *Lathonura.* The setae are $\frac{0-0-1-3}{1-1-3}$; the proximal seta of the ventral ramus is stiff, but not stout; the others are sparsely plumose, 2-jointed. The spines are $\frac{0-1-0-1}{0-0-1}$, all small.

The labrum has a pair of small, conical elevations near the base; then a very large, characteristic, triangular or conical elevation, and beyond this a small, rounded lobe, extending backward and overlying the small and delicate terminal lobe. In the presence of the two small elevations at the base and the large median elevation *Wlassicsia* resembles *Grimaldina* and *Bunops.* The large projection and most of the rest of the labrum are filled with an opaque granular substance, perhaps glandular. (Pl. LXIX, fig. 4, e, e′ e″)

There are five pairs of feet. I give figures and descriptions of them. I do this partly because my specimens differ in details from the figures given for *W. pannonica* by Daday, and partly because there seems to be some difference of opinion among authors as to the comparative morphology of the appendages, especially the first and second pairs.

The first foot (Pl. LXIX, figs. 5, 6; Pl. LXX, fig. 2) is by far the largest and is bent at an angle. The protopodite and endopodite are beset with clusters of short hairs. The exopodite (d, Pl. LXIX, fig. 6) bears one long two-jointed seta and a second seta on the outer side, much smaller, delicate and plumose. The function of this last is apparently sensory. The endopodite has two main parts: the outer branch (e) and the inner branch (e′ e″). The former is closely united with the exopodite and bears three unequal setae. The inner branch is much larger and shows two lobes; the outer (e′) has four setae, of various type, on its edge; or rather, they do not stand exactly on the edge but alternately more to the anterior and posterior faces. The innermost lobe (e″) has three long setae on its edge and three more on the inner margin; the proximal seta of the last set turns toward the body. (See Pl. LXXI, fig. 1.) Besides these there are two small setae on the inner face of the endopodite; one lies just about at the junction of the two lobes of the inner branch, and is sometimes very short, as shown in Pl. LXIX, fig. 5; in other specimens the outer joint is longer and plumose. The other seta is smaller and is placed close to the insertion of the three lateral setae of the innermost lobe. There is no maxillary process. A small oval branchial sac (ep) is present, in which respect this species differs from *W. pannonica.*

The various interpretations of the first foot are as follows. In order to give in brief space a conspectus of opinion I have employed the notation of my figures and have indicated to which part of the typical appendage each is assigned by various authors. Thus in *Iheringula,* Sars assigns to the maxillary process the parts which I have marked e, e′ e″, and called endopodite. I do not employ in the table the lettering used by the authors mentioned, but there will be no difficulty in understanding their figures, if these are referred to. I make no mention of epipodite, or gill-sac, as there is no difference of judgment regarding this part.

Author.	Reference.	Genus.	Exopodite.	Endopodite.	Maxillary process.
Birge, '09	Pl. LXX, fig. 2	Wlassicsia.	d	e+e′+e″	absent
Lund, '71	p. 156; Pl. IX, fig. 5	Macrothrix	absent	d′+e+e′+e″	absent
Merrill, '93	p. 326; Pl. XV, fig. 1	Bunops	absent	d+e′+e′+e″	absent
Daday, '03	p. 69; Pl. V, fig. 15	Wlassicsia.	d	e+e′+e″	absent
Sars, '00	p. 14; Pl. II, fig. 6	Iheringula.	d	absent	e′+e′+e″
Sars, '04	p. 8; fig. 10	Saycia.	d+e	e′+e″	absent
Lilljeborg, '00	p. 313, Pl. LI, fig. 9	Ophryoxus.	d	e+e′+e″	present

In the second foot (Pl. LXX, fig. 3) the exopodite (d) is a thin, transparent lamella, bearing a long, slender seta and having two finger-like lobes at the end. The endopodite is a broad, short plate, which is divided into three lobes. The outer lobe is the outer branch of the first foot (e); it bears three setae or claws. The outermost of these is far longer than any other seta on this foot or the two succeeding; another is short, weak, and borne on the posterior face of the lobe. The second lobe has three 2-jointed setae on its face and three on its edge; the terminal joints of the last named have a comb-like structure. The outer lobe has on the edge four setae like those on the middle lobe but smaller. The maxillary process is large. It has four finger-like projections on the end, some or all of which are tipped with fine plumose setae; on its face is a short plumose seta, possibly sensory, and above this a row of four long, two-jointed setae, whose outer joints are plumose. The branchial sac (ep) is large, oval in form.

There is more difference of opinion regarding the morphology of the parts of the second foot, as the following table will show:

Author.	Reference.	Genus.	Endopodite.	Exopodite.	Maxillary process.
Birge, '09	Pl. LXX, fig. 3	Wlassicsia	d	$e+e'+e''$	mx
Lund, '71	p. 156; Pl. IX, fig. 6	Macrothrix	d	$e+e'+e''$	mx
Merrill, '93	p. 328; Pl. XV, fig. 2	Bunops	d	$e+e'+e''$	mx
Sars, '00	p. 16; Pl. II, fig. 7	Iheringula	d	e	$e'+e''+mx$
Daday, '03	p. 70; Pl. 5, fig. 16	Wlassicsia	d+e	$e'+e''$	mx
Sars, '04	p. 8; fig. 11	Saycia	d+e	$e'+e''$	mx
Lilljeborg, '00	p. 314; Pl. LI, fig. 10	Ophryoxus	d+e	$e'+e''$	mx
"	p. 343; Pl. LIV, fig. 20	Macrothrix	d+e	$e'+e''$	mx
"	p. 357	Lathonura	doubtful		
"	p. 364; Pl. LVI, fig. 20	Streblocerus	d	$e+e'+e''$	mx

Lilljeborg interprets the appendage of *Drepanothrix* (p. 370, Pl. LVII, fig. 7) and *Acantholeberis* (p. 377, Pl. LVIII, fig. 7) in the same way as *Streblocerus*. The same may be said of the appendages of the Chydoridae.

From the two tables it will be seen that the differences of opinion, with one exception, relate to the proper point of division between exopodite and endopodite. The exception is Sars, who, in discussing *Iheringula* ('00), assigned to the maxillary process of the first foot all that has been called endopodite and also gave the two inner lobes of the endopodite of the second foot to the same part. While he says nothing further in the matter, he seems to have abandoned this view when he described *Saycia* ('04) and it need not be discussed further than to say that the first foot of *Ophryoxus* bears a structure which is very plainly the maxillary process (see Lilljeborg), and that this structure is as plainly lacking in other Macrothricidae. There is, therefore, no reason to homologize the whole of the endopodite with the maxillary process. The question of the relation of endopodite and exopodite appears to be more difficult and indeed Lilljeborg has plainly varied in his interpretation of these parts in different genera. In respect to the third foot there seems to be no difference of judgment. The exopodite of that appendage is so large and distinct that no room for doubt is left. If the second foot of *Acantholeberis* is compared with the third, as they are figured in Lilljeborg, (Pl. LVIII) there will be equally little doubt that the part there lettered *d* is the same as the exopodite of the third foot. It is also plain that the smaller structure which I have lettered *d* in *Wlassicsia,* is also the exopodite; or that it is present in *Ophryoxus* and *Macrothrix,* though still more reduced. This can be seen from Lilljeborg's figures.

If the part that I have called the first lobe of the endopodite, *e,* be followed through in the same way, there will be just as little doubt of its homologies. The large claw of the third foot, mounted on *e,* obviously belongs to the endopodite. This claw is clearly the same as that on *e* of the second foot, and this in turn represents the same structure as that which I have marked *e* in the first foot. In the first foot, one would be inclined to associate *d* and *e* in the exopodite were it not for the relations in the feet that lie behind. But a comparison of the series quite plainly forbids such an interpretation. If an additional reason were needed it might be added that in the Sididae, where the exopodite of the first foot is much developed, the clasper of the male is derived from the outer branch of the endopodite and not from the exopodite. This is an additional reason for assigning to the endopodite the large hook of the first foot of the male *Wlassicsia.*

The third foot (Pl. LXX, figs. 4, 5) has a large exopodite, a thin, somewhat quadrate plate. It bears five large, plumose setae, three on the end and two on the side, of which one bends up and curves around the branchial sac. The endopodite has three lobes. The outer one has two setae, of which the outer is rather to be called a claw, on its end, and one on the posterior face. The middle lobe has one seta on its edge and two or perhaps three on its face; while the inner lobe is much broader and has eight setae, four on the edge and four on the face. All of those on the face form a row of eight setae, extending across the endopodite, nearly evenly spaced and with little reference to the lobes in their arrangement. The maxillary process is well developed. It is bent over so as to form a sort of scoop-shaped structure, concave forward and with finger- or horn-like projections. There are four long, 2-jointed setae on it as in the second foot; there is also a small, recurved, hairy seta on the face of the maxillary process, evidently the same as that which is so large in the fourth foot. The branchial sac is larger than in the second foot and of much the same shape.

The fourth foot (Pl. LXX, figs. 6, 7) is essentially like the third but smaller and with fewer setae. The exopodite has the same structure and the same number of setae; but these are much shorter than on the third foot, except that which bends around the branchial sac. The outer lobe of the endopodite carries a claw-like seta; the middle lobe has one; and the outer lobe two setae. These are 2-jointed, with a thick base and a short second joint, carrying long, close-set hairs; the whole structure having the appearance of a brush. On the posterior face of the endopodite are five setae; one of which apparently belongs to the outer and one to the middle lobe and three to the inner lobe. The maxillary process is much reduced. Its main part is a large, densely plumose, geniculate seta. The branchial sac is large and oval.

The fifth foot (Pl. LXXI, fig. 1) is very different from the preceding; next to the first, it is the largest of the series. As I understand the appendage, there is a large exopodite, bearing one long recurved seta which bends around the branchial sac.

The remainder of the exopodite is a plate with two (Daday finds three) small projections on the ventral edge. These are apparently the rudiments of the other setae of the exopodite. The endopodite consists chiefly of a long, curved, plumose seta. A second, much smaller seta arises from the inner face of the base of this, and close to the insertion of the second seta is a small projection. I have not been able to find any part of the maxillary process, though it may possibly be present. The branchial sac is very large and is oval in form, as in the preceding feet. Daday finds it heart-shaped in *W. pannonica.*

This foot closely resembles the corresponding appendage of *Bunops* and in most particulars that of *Grimaldina.*

My interpretation of the morphology of this appendage is not that of all authors; nor are their judgments wholly consistent with themselves; as may be seen by following the account of the fifth foot in the various genera of Cladocera, as given by Lund and Lilljeborg. All agree that the large, recurved seta belongs to exopodite. There is wide divergence as to whether the plate to which this seta is attached is exopodite, or whether it is endopodite or maxillary process. If the fifth appendage of *Bosmina* is studied and compared with that of *Wlassicsia* (see Lund '71, Pl. IX, fig. 15; Lilljeborg '00, Pl. XXXVIII, fig. 14) it will be difficult to reach any other conclusion than that which I give.

There is a well developed abdominal process of rather irregular form. The abdominal setae are long, 2-jointed, sparsely plumose on the outer joint. The postabdomen (Pl. LXXI, fig. 2) is large, broad, with a thin dorsal edge, and is bilobed. The pre-anal lobe has numerous small spines along its dorsal edge, giving it a serrate appearance near the abdominal setae. The anal lobe has numerous clusters of fine hairs. The terminal claws (Pl. LXX, fig. 8) are small, relatively stout, denticulate, and have a small basal spine.

The intestine has no convolutions, and bears two hepatic coeca. (Pl. LXIX, fig. 4) The eye is large, with abundant pigment and few lenses. The ocellus is rather small, quadrate as seen from the side.

In the ephippial female (Pl. LXX, fig. 9) there is developed on the valves a densely reticulated ephippium, not unlike that of *Iheringula.* There are two ephippial eggs but in the specimens these were not deposited in the ephippium, nor were any cells for them seen. Perhaps they are placed in a circular chamber, as in *Iheringula.*

The male (Pl. LXIX, fig. 8) is about 0.4 mm. long. It has a large antennule; the projections of the labrum are little developed; the vas deferens opens in front of the terminal claws. The first foot (Pl. LXIX, fig. 7) has a large hook, which bears a spine on its inner curve and which is toothed at the end.

From this account of the animal the following generic description may be given, modified from Daday.

Genus. *Wlassicsia* Daday.

Form oval or sub-quadrangular, not compressed. Valves with small dorsal crest, setae on ventral margin; marked by fine, transverse striae, forming delicate reticulation with meshes whose long axis is transverse. Head large, rounded as seen from side; no cervical sinus; small cervical gland; rostrum practically obsolete. Fornices moderate, extending to end of rostrum. Labrum with a pair of processes at the base; a large triangular projection further back; and beyond this another rounded lobe, which extends backward over small, delicate terminal lobe. Antennules freely movable, long, slender; with basal sense hair; olfactory setae short, unequal. Antennae moderate; setae $\frac{0-0-1-3}{1-1-3}$; the proximal seta of ventral branch stiff but not very stout. Five pairs feet. Abdominal process present. Postabdomen large, bilobed. Terminal claws small, curved, with one very small basal spine. Intestine not convoluted, with two hepatic coeca. Eye large with abundant pigment and few lenses. Ocellus small, quadrate. Large, closely reticulated ephippium, with two eggs. Male with large antennule; small processes on labrum; hook on first foot.

Species.

1. Sub-quadrate in form. No branchial sac on first foot. Length 0.6–1.3 mm. *W. pannonica* Daday. Hungary.
2. Oval in form. First foot with branchial sac. Length, female 0.8 mm.; male 0.4 mm. *W. kinistinensis* Birge. Canada.

Wlassicsia, like all genera of the Macrothricidae, shows rather complicated relations to other members of the family. Its closest affinities are with *Grimaldina* and *Bunops,* and in some ways it represents the simpler form from which these genera depart. *Grimaldina* has developed the enormous post-abdomen, while *Bunops* is much compressed and has a large dorsal crest. Apart from general resemblances, the agreement is particularly close in the structure of the labrum and the feet, in which respects the three genera agree more closely with each other than any of them agree with any other genus.

5. *Odontalona,* a new genus of Chydorina.

General form that of *Alona.* Post-abdomen long, slender; with numerous marginal denticles, ending in a group of very large denticles at angle of post-abdomen. Lateral fascicles present. Terminal claw with one large basal spine, attached some way distal to base of claw.

This genus (which is possibly rather a sub-genus) is proposed for two species, *Alona tenuicaudis* Sars, and for another species first found by Daday in material from Paraguay and which he assigned (erroneously, as I believe) to Sars' species. The name is based on the large denticles of the post-abdomen.

O. longicaudis sp. nov.

Pl. LXXI, figs. 3, 4, 7.

The form is on the whole that of *Alona,* though recalling also that of *Euryalona.* The head is not noticeably small, the rostrum reaching nearly to the ventral margin of the valves.

The rostrum is not acute. The antennules are slender but do not reach the end of the rostrum; the olfactory setae are equal. The valves are not inflated in antero-ventral region. They have markings concentric with ventral and posterior margins; one such being usually visible. In most specimens the valves are otherwise unmarked. In one specimen, however, are visible longitudinal striations like those of *Leydigia,* and in another (from South America) can be seen reticulations like those sometimes seen in *Alona.* The entire ventral margin bears rather long, thick-set setae. The labrum has a rounded angle behind. The post-abdomen is very long, slender, narrowed toward apex. It bears about 16 marginal denticles; all of them long, except those nearest the anus; and the apex of the post-abdomen bears two which are far larger than any others. The last and largest one is serrate on its concave margin. Next anterior to these come three denticles, which are somewhat smaller than those proximal to them. From this point the series gradually diminishes in size toward the anus. Lateral fascicles of very fine spinules are present. The terminal claw is notably long, and rather straight. Its basal part is thicker for about one-third of the length of the claw, and the single long basal spine is inserted at this point. Daday's figure ('05, Pl. XV, fig. 13) shows that the basal part is denticulated, but no such structure can be found in my specimens, though it would be expected. The first foot has no specially developed hook or claw. The eye is small, larger than the ocellus, which is nearer the eye than the apex of rostrum.

Color yellow-brown. Length of female 0.54–0.62 mm. Male unknown.

Some dozen specimens of this species were found by me in collections made among water hyacinths in Lake Charles, La., in October, 1903. I have also found exactly similar specimens in collections from Demerara, South America, made by Mr. E. T. Owen in 1901. It is co-specific with a Paraguayan form described by Daday ('05, p. 178) as belonging to Sars' species *A. tenuicaudis,* and which Daday assigns to *Euryalona.* I believe that the specific identification is incorrect. At any rate, the species differs widely from the American form, which I have identified with *A. tenuicaudis* and which occurs in Lake Charles, as well as elsewhere in the United States. I give figures of the post-abdomen of a specimen taken from the same collection as the *Odontalona* figured. (Pl. LXXI, figs. 5, 6.) The differences are obvious. *O. tenuicaudis* has a cluster of 3 or 4 long, marginal denticles at the apex of the post-abdomen, and all the rest are very small. *O. longicaudis* has but two large denticles and those of the rest of the row are good sized. The post-abdomen is much longer and narrower than in *O. tenuicaudis,* although that species differs considerably in this respect. In Lilljeborg's figure ('00, Pl. LXVIII, figs. 4, 5) it is much longer than in that of P. E. Mueller ('68, Pl. III, fig. 2) and this in turn is longer than in the figure of Matile ('90, Pl. IV, fig. 33). All of our specimens in America seem to be nearer to the form shown by Matile than to any of the others, although shorter and broader than any figured by European authors. The post-abdomen of northern specimens is longer than those from the south. In all cases the form and attachment of the basal spine of the terminal claw are characteristic for the species (Pl. LXXI, fig. 6), and in this respect *O. tenuicaudis* differs from all other Chydorina. The structure of this region in *O. longicaudis* is also unique but decidedly different from *O. tenuicaudis.* The labrum of *O. tenuicaudis* has the regular *Alona* form, while in *O. longicaudis* it is more nearly angled behind.

It is not easy to settle the generic relations of this species. It is certainly very close to *O. tenuicaudis* and that species must go into the same genus. No one before Daday thought of separating *O. tenuicaudis* from *Alona.* The color and general habit of the new form strongly recall *Euryalona,* and I assigned it at first to that genus without hesitation. This is the opinion of Daday. Yet careful study convinced me that this position could not be given to it; since it lacks almost every character used by Sars to characterize the genus *Euryalona* ('01, p. 80). The head is not noticeably small; the valves are not tumid and gaping in front; the setae are not restricted to the middle of the ventral margin; the first foot has no strong foot in the female; the terminal claw has no secondary denticle in the middle. Still other features are wanting if *O. tenuicaudis* is also drawn into comparison. If these species are to be placed in *Euryalona* there are left practically no characters to separate that genus from *Alona*.

This is another of those cases, numerous in this region of the Chydorina, where it is hard to determine the generic position of a species, not because of our ignorance so much as because of the close and conflicting inter-relationships of species. The new form cannot be placed in *Alona,* nor can it be separated from *A. tenuicaudis,* and I see no other solution but to make a new genus for the two species. It is possible that a reviser of the group might prefer to make this a sub-genus; but I believe it is as well distinguished as several other genera of Chydorina.

This species is not included in my list of species, referred to in the first paragraph of this paper; and in the same list *O. tenuicaudis* is placed under *Alona.* When that list was prepared I had not carefully studied all of my southern material.

6. Note on the Genus *Alonella.*

The genus *Alonella* was proposed by G. O. Sars in 1861 ('62, p. 288) for the form described by him a little earlier in the year as *Alona pygmaea* and which had been still earlier described by Baird as *Acroperus nanus.* To the same genus Sars assigned *Lynceus rostratus* Koch and *L. excisus* Fischer; to these *L. exiguus* Lilljeborg must necessarily be added. The judgment of later writers has varied with respect to the genus thus established. Kurz ('73) accepts it in full. P. E. Mueller ('67), Hellich ('77), Daday ('88) place *A. rostrata* in the genus *Alona* and the rest in *Pleuroxus.* Lilljeborg ('00) places *A. rostrata* in his genus *Lynceus* (=*Alona*), although with doubt, and the others in *Alonella;* as also does Stenroos ('95). Stingelin ('04) places *A. excisa* in *Alonella* and Daday ('05) does the same thing. In 1888 Sars added to the genus two species originally described by King as belonging to *Alona.* These were *A. karua* and *diaphana;* constituting a very distinct section of the genus. He added later ('01) the species *lineolata, sculpta* (=*globulosa* Daday) and *dentifera.* These are accepted by Daday ('05) as belonging to *Alonella.*

Daday ('05) placed *A. rostrata* in the genus *Leptorhynchus* Herrick, a genus established for the form *Alona* (*Harporhynchus*) *falcata.* He added a new species *L. dentifer,* which is closely related to *A. nana.* This change seems to make for confusion rather than order. *Leptorhynchus falcatus* (G. O. Sars) with its peculiar form, extremely long rostrum, and its unique postabdomen, is very different from either of the species with which Daday seeks to unite it. It appears to be as well defined a genus as any of the other monotypical genera of Chydorina, such as *Graptoleberis.*

This sketch, which does not pretend to be exhaustive, shows that on the one hand authors have recognized the difficulty of limiting and defining a genus *Alonella,* to which to assign the species in question, and on the other hand have found it hard to place these species in other genera or to separate them from each other. It seems to have been largely a matter of personal choice and of convenience whether these species shall be doubtfully attached to other genera, or doubtfully put together in a single genus, but on the whole the tendency has been to follow Sars in recognizing a genus *Alonella* as an assemblage of forms, widely differing, yet so interrelated as to be inseparable; closely related to other genera yet not readily included in them. In my synopsis of the Cladocera of the United States, I have chosen the latter alternative. I recognize that the genus is not such in any proper sense. The species included in it have so few common peculiarities that no good definition can be framed. It may be divided into three subgenera, as follows:

a. *Alonella* proper. Rostrum long, slender, recurved; always much exceeding antennules. Postabdomen with marginal denticles only; claws with one basal spine. *A. rostrata* (Koch); *A. nana* (Baird); *A. dadayi* Birge (=*Leptorhynchus dentifer* Daday). The specific name of the last species must be changed from that given by Daday if it is to be included in *Alonella;* as *dentifera* was already employed by Sars.

b. *Paralonella.* Rostrum short, hardly exceeding antennules. Postabdomen with very small marginal denticles, usually with, but rarely without, lateral fascicles, which if present are larger than the marginals; claws with one basal spine. *A. karua* (King); *A. diaphana* (King); *A. dentifera* Sars; *A. globulosa* Daday; (=*sculpta* Sars); *A. lineolata* Sars. Related to these, but with better developed postabdominal dentices is *A. punctata* Daday, whose striation recalls *A. nana.* In general form these approach *Alona.*

c. *Pleuroxalonella.* Rostrum exceeding antennules but not recurved. Postabdomen with marginal denticles only; claws with two basal spines. General form of body and postabdomen *Pleuroxus*-like. *A. excisa* (Koch); *A. exigua* Lilljeborg; *A. chlathratula* Sars; *A. breviceps* Stingelin.

There remains one species which does not fit into any of these subgenera: *A. nitidula* Sars. In general form this closely resembles a *Chydorus* of the *barroisi* group; but the postabdomen is quite different and of the *Alonella* type.

I do not offer this arrangement as satisfactory, yet I can see nothing better at present. Some might prefer to make independent genera instead of subgenera out of these three groups. But the interrelations of the various species are so close that I see little or no advantage in so doing, at any rate until the whole family is carefully revised; when this is done the systematic arrangement is pretty sure to be changed from that here indicated or from any as yet proposed.

All students of the Cladocera know that the genera of the Chydorina are very unsatisfactory. This has always been true, and as the number of known species increases the dissatisfaction becomes more acute. Two policies have been tried in order to better things: By one, a large section of the family was included in one genus, with numerous subgenera. This was tried by Herrick ('84), who united under *Lynceus* the genera *Alona, Alonella,* and *Pleuroxus.* If the plan were tried again *Chydorus* (which Herrick doubtfully separated) would have to be included, as the *barroisi* forms connect immediately with *Pleuroxus.* This plan has been before students for twenty-five years and no one has followed it; so it plainly does not promise any improvement. The other tendency is best represented by Sars: that of multiplying small genera for those species which seem to be only doubtfully assignable to the older and larger genera.

Whatever may be done in future we are, I think, compelled to recognize the following facts at present:

1. The species of Chydorina are readily distinquishable. They seldom intergrade and are not very variable. The genera are in many cases ill-defined and in some cases seem to be indefinable.

2. In the center of the family is a large assemblage of species, clearly enough distinguished specifically; but which it is impossible to place in well-marked and easily separable genera. There are certain centers around which many of these species may be grouped. Such are *Alona, Pleuroxus, Chydorus;* the last two hardly separable. But when these groups of species have been taken from the assemblage there remains a number of species not assignable to any of these genera, though obviously related to one or more of them; related also to each other, though without many definable characters in common. These species may, for the sake of convenience, be included in the genus *Alonella.*

3. A second and smaller group of species can be distinguished, more readily divisible into genera; perhaps because fewer species are known. This is the *Alonopsis* group, containing that genus with *Euryalona, Pseudalona, Acroperus,* and as its extreme type, *Camptocercus.* These, as the names of some indicate, are related to *Alona* in the larger group.

4. Several genera, each with one or a very few species, are also related to *Alona* but are developed in different directions from that taken by the preceding group. Such are *Graptoleberis, Leydigiopsis, Leydigia,* and *Leptorhynchus.*

5. Several genera, each also with one or few species, are marked by the development of a number of characteristics to such a degree that they are far removed from the central group. These are *Anchistropus,* which seems related to *Chydorus; Dunhevedia, Monospilus* and *Dadaya,* which seem to look toward *Alona.*

7. Note on *Pleuroxus hamatus* Birge and *Alonella dadayi*, sp. nov.

P. hamatus.

This species was first described by me in 1878. It appears that the specific name *hamatus* was first used by Baird in 1835 as the specific name for a species of *Pleuroxus* (See Baird '50, p. 136) which proved to be founded on a male of some other species. The name, therefore, cannot be used again for a species of *Pleuroxus* and in place of it I substitute the name *Pleuroxus hamulatus.* The characters of the species remain unchanged.

A. dadayi sp. nov.

The shape is oval-rotund. The valves are strongly reticulated all over; the infero-posterior angle is rounded, with several minute teeth. The rostrum is long, pointed, recurved. The keel of the labrum is acuminate behind and with one projection on the ventral margin. The post-abdomen is short and wide; the pre-anal angle strongly marked, as in *Chydorus*; with numerous small denticles; apex rounded. Claws with one basal spine. Male with usual characters.

The color is yellow to brown, often opaque. The length of the female is 0.25—0.3 mm.; male about 0.2 mm.

This species is identical with *Leptorhynchus dentifer* Daday. The reasons demanding a change of name are given above, p. 1049. For figures see Daday '05, pl. X, figs. 18–23.

8. List of Southern Species new to the United States.

In 1903 I visited the southern United States collecting Cladocera, chiefly in Louisiana and Texas. The following species, new to the United States, appeared in my collections, of which I hope to publish later a more complete account.

Name.	*Locality.*	*Reported also from*
Latonopsis fasciculata Daday	Louisiana	South America.
Holopedium amazonicum Stingelin	Louisiana	South America.
Ceriodaphnia rigaudi Richard	Louisiana, Tex.	Asia, Africa, Australia, South America.
Moinodaphnia macleayii (King)*	Louisiana, Tex.	Asia, Africa, Australia, South America.
Streblocerus pygmaeus Sars	Louisiana	South America.
Grimaldina brazzai Richard	Louisiana	Africa, South America.
Bosminopsis deitersi Richard	Louisiana	South America.
Alona monacantha Sars	Louisiana	South America.
Odontalona longicaudis Birge	Louisiana	South America.
Alonella diaphana (King)	Louisiana, Tex.	Australia, Asia, South America.
Alonella karua (King)	La., Tex., Ark.	Australia, Africa, South America.
Alonella dadayi Birge	Louisiana, Tex.	South America.
Alonella dentifera Sars	Louisiana, Tex.	South America.
Alonella globulosa Daday	Louisiana	South America.
Euryalona occidentalis Sars	Fla., La., Tex.	South America.
Dunhevedia serrata Daday	Louisiana, Tex.	Asia.
Dadaya macrops (Daday)	Texas	Asia, South America.
Chydorus barroisi (Richard)	Louisiana	Asia, Africa, South America.
Chydorus hybridus Daday	Wis., Mich., La., Texas.	South America.
Chydorus poppei Richard	Louisiana, Cal.	South America.

*Almost certainly identical with M. alabamensis Herrick.

In all cases "Asia" means Ceylon, Siam, Sumatra, or other part of tropical Asia. All of these species, therefore, belong to tropical or subtropical waters. To the list may be added *Pseudosida bidentata,* which is apparently identical with *Parasida variabilis* Daday. It appears, therefore, that 21 tropical species of Cladocera are found along our southern coast, only one of which extends its range to the north, so far as now known. All but one of these species are found in South America, and this will probably be discovered there; since it would be singular if this should prove to be present in the United States and Ceylon and not in South America. No doubt a more complete study of southern Cladocera will show many more forms common to this country and South America.

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Zoological Laboratory,
University of Wisconsin.
September, 1909.

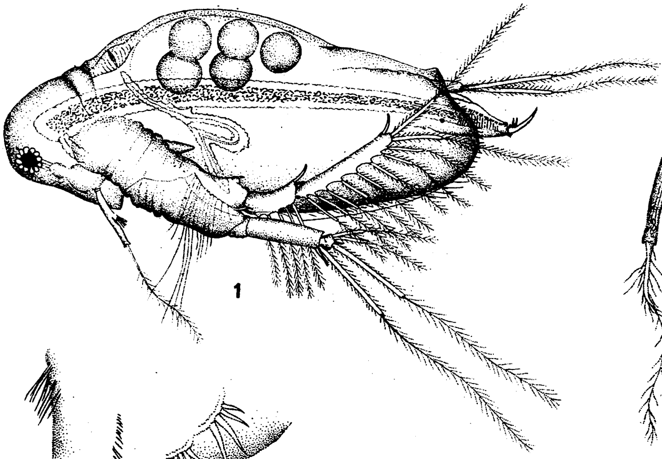
PLATE LXVII.

EXPLANATION OF PLATE LXVII.

1. *Pseudosida bidentata.* Enlarged 35 diameters. From drawing by Mr. E. Foster of New Orleans.
2. *Pseudosida bidentata.* Antennule. Enlarged 75 diameters.
3. *Pseudosida bidentata.* Apex of abdomen and base of claw. Enlarged 500 diameters.
4. *Pseudosida bidentata.* Old female with head in natural position. Enlarged 25 diameters.
5. *Pseudosida bidentata.* Post-abdomen of male. Enlarged 100 diameters.
6. *Pseudosida bidentata.* Post-abdomen of female. Enlarged 75 diameters. Anal spines enlarged 500 diameters.

7, 8. *Pseudosida bidentata.* Clasper from first foot of male. Enlarged 500 diameters.

9. *Pseudosida bidentata.* Antennule of male. Enlarged 100 diameters.



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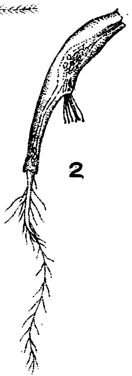

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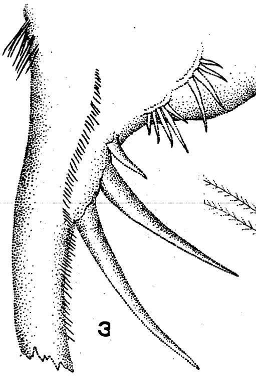

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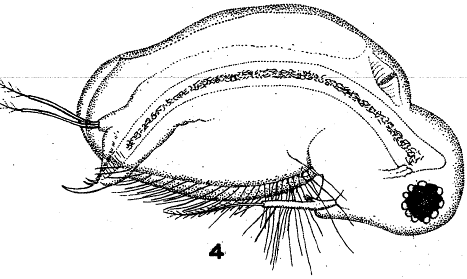

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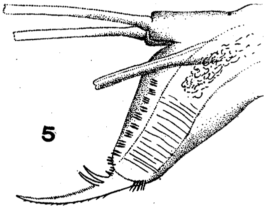

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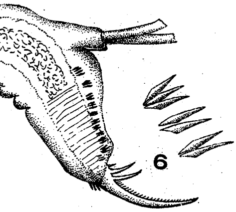

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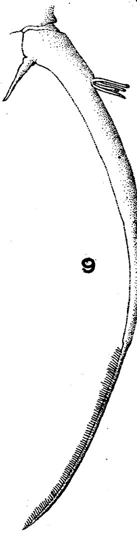

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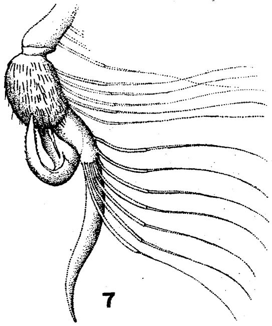

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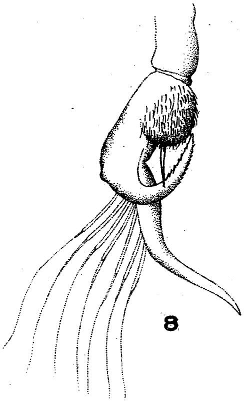

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PLATE LXVIII.

EXPLANATION OF PLATE LXVIII.

1. *Pseudosida bidentata.* Shell gland. Enlarged 100 diameters.
2. *Latonopsis fasciculata.* Male antennule. Enlarged 100 diameters.
3. *Latonopsis fasciculata.* Shell gland. Enlarged 100 diameters.
5. *Latona parviremis.* Shell gland. Enlarged 100 diameters.
4. *Latonopsis fasciculata.* Post-abdomen of female. Enlarged 75 diameters. Anal spines. Enlarged 500 diameters.
6. *Latonopsis occidentalis.* First foot of male. Enlarged 300 diameters.
7. *Latonopsis fasciculata.* First foot of male. Enlarged 300 diameters.
8. *Latonopsis occidentalis.* Antennule of female. Enlarged 100 diameters.
9. *Latonopsis fasciculata.* Antennule of female. Enlarged 100 diameters.
10. *Latonopsis fasciculata.* Post-abdomen of male. Enlarged 100 diameters.
11. *Latonopsis occidentalis.* Tip of first foot of male. Enlarged 300 diameters.

In figures of shell gland; d, dorsal loop; p, posterior loop; v, ventral loop.

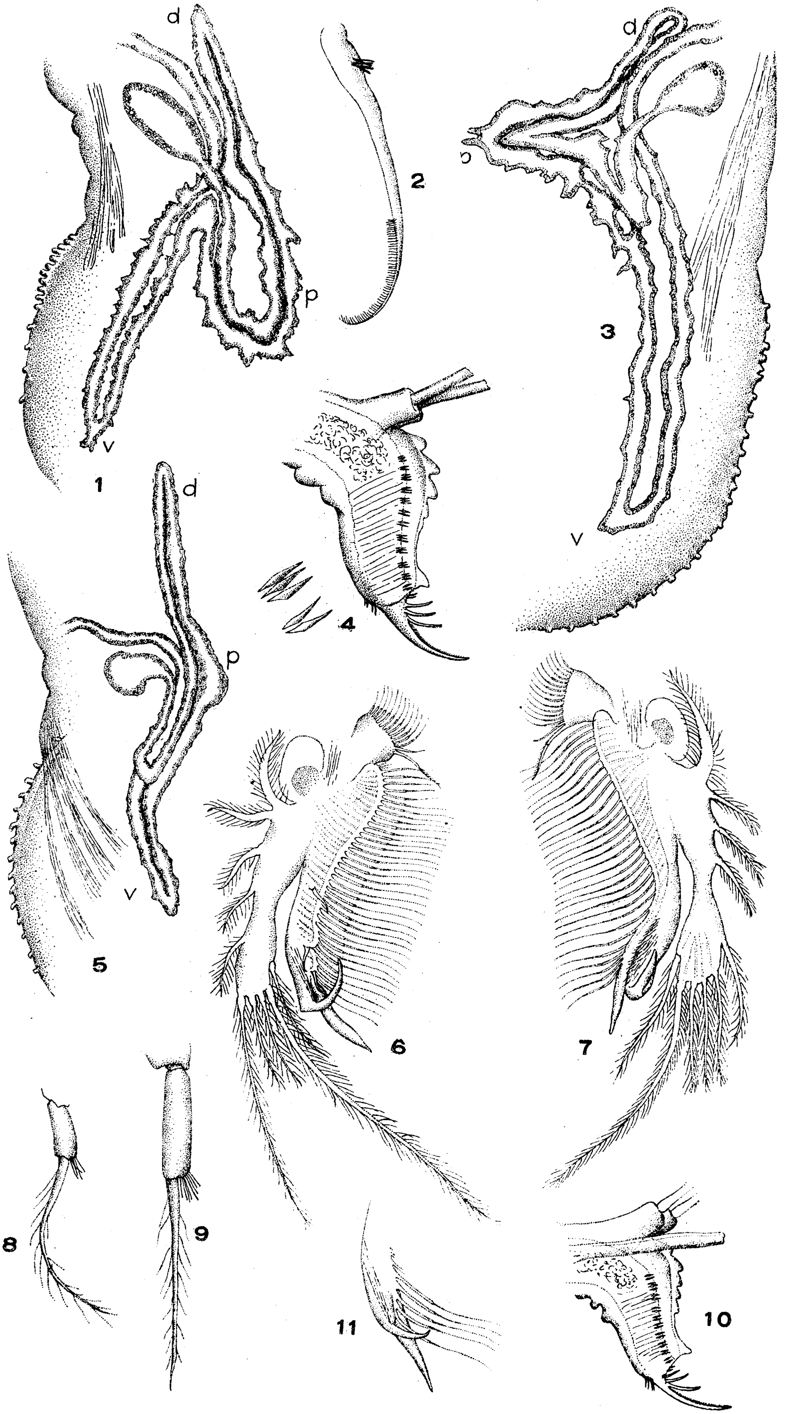

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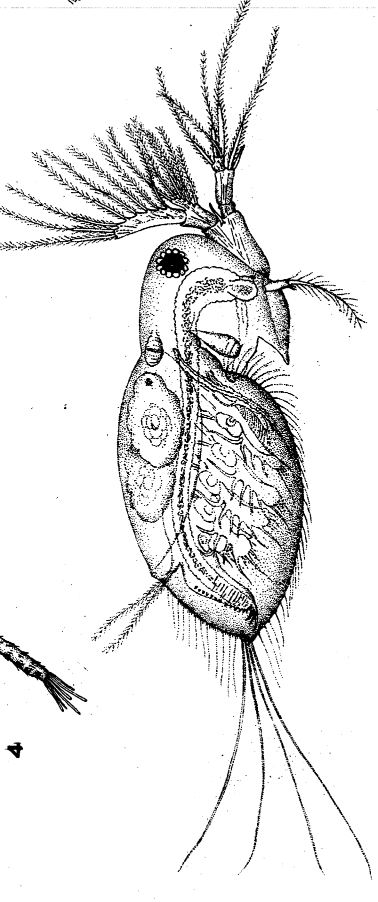
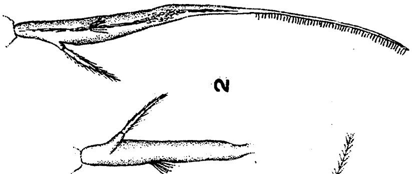
PLATE LXIX.

EXPLANATION OF PLATE LXIX.

1. *Latona parviremis.* Enlarged 30 diameters.
2. *Latona parviremis.* Antennule of male. Enlarged 100 diameters.
3. *Latona parviremis.* Cross section of head. Enlarged 120 diameters. ap, appendix foliaceus; b, brain; c, hepatic coeca; oe, oesophagus.
4. *Wlassicsia kinistinensis.* Head of female. Enlarged 150 diam. e, e′, e″, elevations on labrum.
5. *Wlassicsia kinistinensis.* First foot from inside. Enlarged 150 diam.
6. *Wlassicsia kinistinensis.* First foot from outside. Enlarged 150 diam. d, exopodite; e, outer branch of endopodite.
7. *Wlassicsia kinistinensis.* First foot of male. Enlarged 200 diam. d and e as in fig. 6.
8. *Wlassicsia kinistinensis.* Male. Enlarged 80 diameters.





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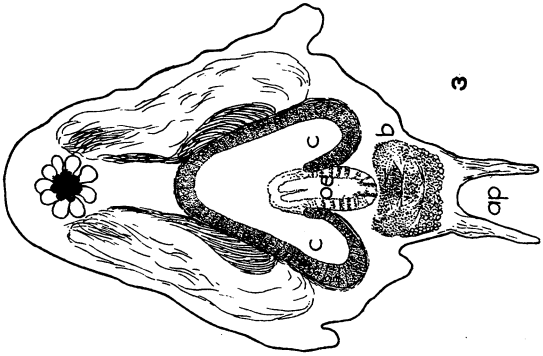

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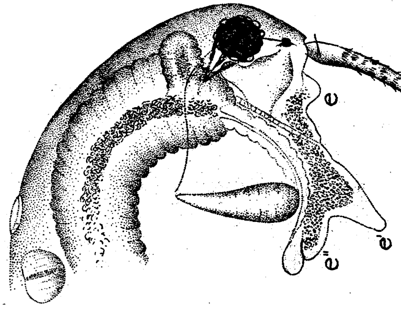

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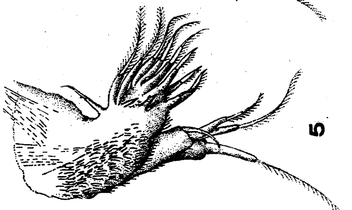

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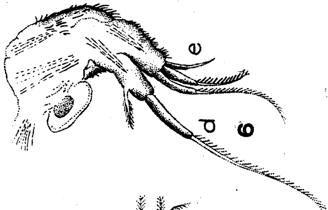

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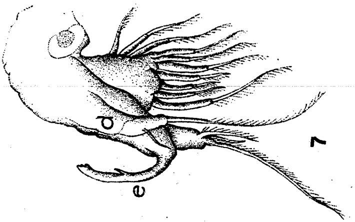

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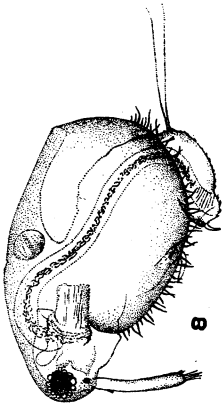

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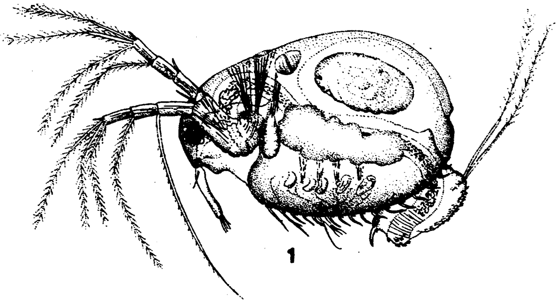
PLATE LXX.

EXPLANATION OF PLATE LXX.

In all figures of feet: d, exopodite; e, outer branch of endopodite; e′, outer lobe of inner branch of endopodite; e″, inner lobe of inner branch of endopodite; ep, branchial sac or epipodite; mx, maxillary process; a, protopodite.

1. *Wlassicsia kinistinensis.* Female. Enlarged 60 diameters.
2. *Wlassicsia kinistinensis.* First foot from outside. Enlarged 150 diameters.
3. *Wlassicsia kinistinensis.* Second foot from behind. Enlarged 280 diameters.
4. *Wlassicsia kinistinensis.* Third foot from behind. Enlarged 200 diameters.
5. *Wlassicsia kinistinensis.* Third foot from before. Enlarged 250 diameters.
6. *Wlassicsia kinistinensis.* Fourth foot from behind. Enlarged 200 diameters.
7. *Wlassicsia kinistinensis.* Fourth foot from before. Enlarged 250 diameters.
8. *Wlassicsia kinistinensis.* Caudal claw. Enlarged 500 diameters.
9. *Wlassicsia kinistinensis.* Female with ephippium. Enlarged 65 diameters.



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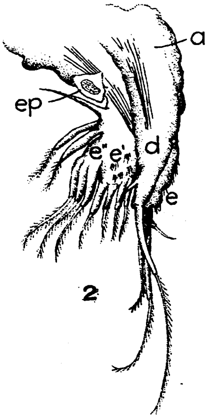

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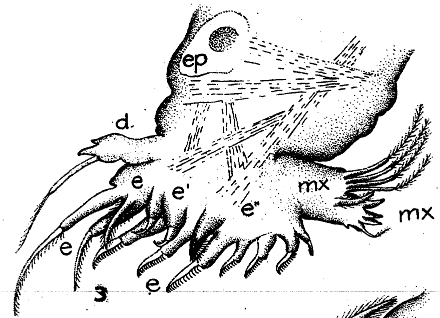

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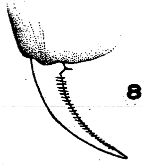

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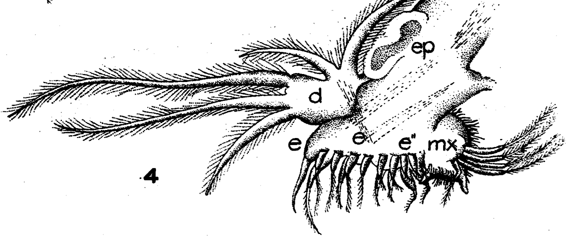

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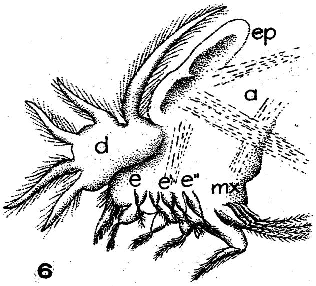

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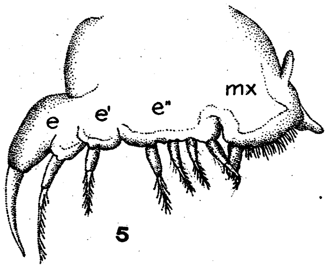

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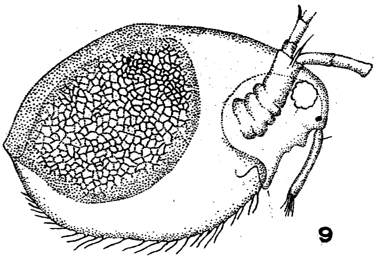

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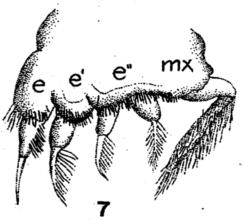

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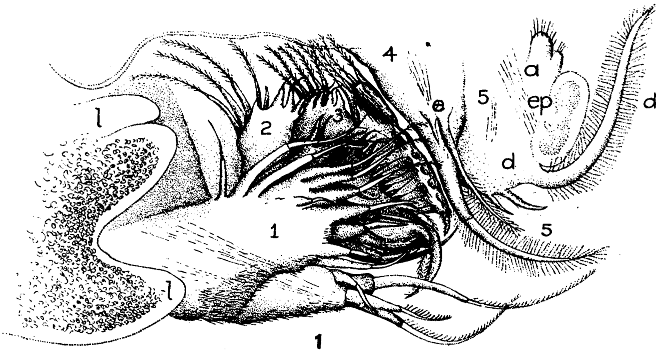
PLATE LXXI.

EXPLANATION OF PLATE LXXI.

1. *Wlassicsia kinistinensis.* Feet from inside. Enlarged 200 diameters. This figure shows the feet in their natural position, as seen from the median plane of the animal. The line on upper side of figure is the cut membrane of the ventral wall of the body. l, l, posterior part of labrum; 1, first foot; 2, second foot. The number lies on the maxillary process; the rest of the foot is concealed except the large recurved claw of the endopodite. 3, third foot; 4, fourth foot. The recurved seta lies vertically below the number; the edge of the endopodite can be seen with its setae foreshortened. 5, fifth foot; a, protopodite, d, d, exopodite, e, endopodite, ep, branchial sac. It will be noted that in the natural position the setiferous edges of the 2, 3, and 4 feet are turned toward each other and toward the median plane of the body.
2. *Wlassicsia kinistinensis.* Post-abdomen. Enlarged 150 diameters.
3. *Odontalona longicaudis.* Apex of post-abdomen. Enlarged 500 diameters.
4. *Odontalona longicaudis.* Female. Enlarged 70 diameters.
5. *Odontalona tenuicaudis.* Post-abdomen. Enlarged 200 diameters.
6. *Odontalona tenuicaudis.* Apex of post-abdomen. Enlarged 500 diameters.
7. *Odontalona longicaudis.* Post-abdomen. Enlarged 150 diameters.



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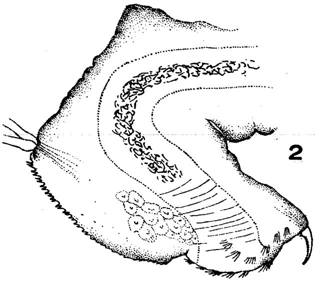

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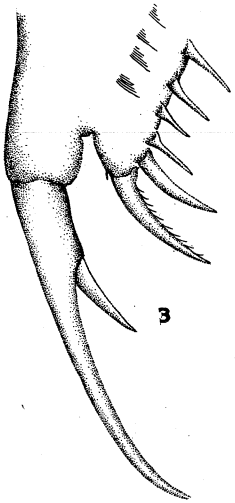

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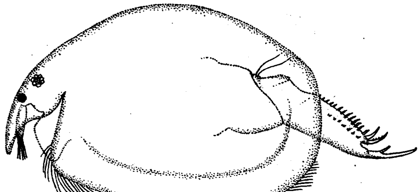

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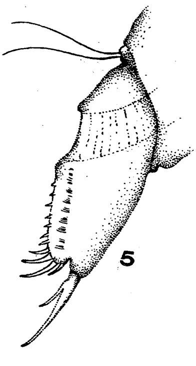

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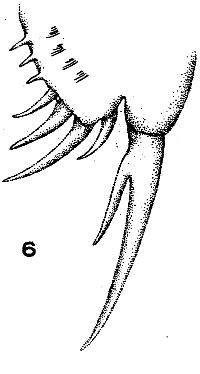

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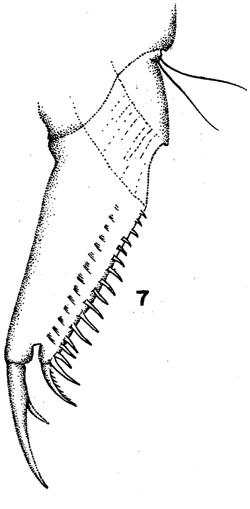

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E. O. COCKAYNE, BOSTON

A REVISION OF THE NORTH AMERICAN SPECIES OF CYCLOPS.

C. DWIGHT MARSH.

As collections are made more and more widely from all parts of the world and as these collections are studied more thoroughly, it becomes increasingly evident not only that the genus of *Cyclops* is distributed over the whole world, but that individual species have an exceedingly wide distribution. Many of the species which have been described as peculiar to America have been clearly shown either to be identical with species in Europe or merely varieties of those species. Little by little it has been necessary to reduce to synonyms the names which have been proposed for American species. It can not yet be said that all American species are identical with those in Europe, but it is very evident that most of them are. Most of the species of *Cyclops* have wide limits of variation, and it is these variations which, at a time when the knowledge of the entomostraca was imperfect, lead to the introduction of many new names for species which we now know are only varieties.

This leads to a great deal of confusion when students of anatomy or plankton, who may have no particular interest in a systematic knowledge of Entomostraca, attempt to name the species which they are studying. So great is this confusion that many students of plankton do not attempt to use specific names, but simply describe the distribution of "*Cyclops*." This is extremely unfortunate, for the species of *Cyclops* have very different habits and a discussion of plankton with all the species of this genus grouped together has very little value so far as Entomostraca are concerned. It may be a matter of doubt whether the general student of Zoology is ever likely to determine the species of Copepoda easily, as special training is almost necessary for such work. But, even if one had patience and a willingness to do the necessary work, authoritative publications have not been available. Probably the majority of students of North American Entomostraca refer to Herrick and Turner's work because it is more comprehensive than any other work published. This is now, however, pretty thoroughly out of date, and it is very aggravating to a student to feel that his book of reference is unreliable.

A much more accurate paper is that of E. B. Forbes (Forbes '97) and it seems to me that the real value of this paper has never been recognized. It is now ten years since Forbes's paper was published and additions have been made to our knowledge of the genus, and facts which lead to a reconsideration of some of his statements.

It has seemed to the author that the time has come when a paper which would accurately present our knowledge of the genus today, would be of real assistance to those students who have anything to do with Entomostraca. There is really very little to add that is new from the standpoint of the species maker, only one new species is suggested, but it is worth while to know what it is best to call the old species which have been recognized under different names.

In preparing this paper we have accepted the work of Schmeil as authoritative for European species. Sometime it is to be hoped that equally thorough work can be done for our American species, but it does not seem wise to undertake it at present. Our knowledge of the distribution of species in America has been very much enriched in the past few years, but nothing like thorough work has been done. The present paper is based on collections made from the northern Canadian provinces to Mexico and the West Indies, and from the Atlantic to the Pacific, but vastly the most complete collections have been made in the Mississippi Valley.

It will be noticed, doubtless, that the sub-generic names that have been adopted by some authors have not been recognized. The species of *Cyclops* certainly fall into certain groups, but it is the feeling of the author that our knowledge of the relationships of the species in these groups is not yet sufficiently wide to warrant the formality of fixed sub-generic names. I must confess to a dislike of multiplying names in systematic work, and do not enjoy sub-generic names under any circumstances, preferring to avoid them when practicable. The number of species in the genus *Cyclops* is not very large, and the addition of subdivisions in our present state of knowledge is distasteful to me.

A considerable number of figures has been used to illustrate the paper, enough, it is hoped, to make clear the diagnoses. The synopsis is not published as a final production. No one appreciates better than the author how much work remains to be done on these forms. On the other hand the paper is the result of accumulations of material covering many years. A large number of slides have been made from these collections, and while the work is confessedly incomplete, it is perhaps due to others who are interested in these animals to make some of the results available for use. The systematic study of entomostraca is, at best, a very laborious process, and it is hoped that this brief paper may help in lightening the labors of others who may wish to use specific names for the *Cyclopidae*.

The key is based on the characteristics of mature females and includes only those species which are recognized members of the American fauna.

KEY TO SPECIES OF CYCLOPS FOUND IN NORTH AMERICA.

- Antennae composed of 17 segments
  - Fifth foot composed of one segment, armed with one spine and two long setae,—a large species of dark color, *ater*
  - Fifth foot composed of two segments,
    - Second segment of fifth foot armed with seta and short spine *viridis*
    - Second segment of fifth foot armed with two setae,
      - The second segment of the fifth foot is elongate, its length as much as twice its width, the seta of the inner distal angle spine-like, less than one half the length of the outer seta, *bicuspidatus*
      - The second segment of the fifth foot is shorter, length less than twice its width, armed with two nearly equal setae,
        - The seventeenth antennal segment is armed with a serrate hyaline plate, *Leuckarti*
        - The seventeenth antennal segment is not armed with a hyaline plate, *tenuis*
    - The second segment of the fifth foot is armed with three setae
      - The twelfth antennal segment has a sensory club, the egg-sacs stand out from the abdomen, the hyaline plate of the seventeenth antennal segment is serrate, or smooth, *albidus*
      - The twelfth antennal segment has a sensory hair, the egg-sacs lie close to the abdomen, the hyaline plate of the seventeenth antennal segment is deeply notched, *fuscus*
- Antennae composed of sixteen segments, fifth foot of three segments, *modestus*
- Antennae composed of twelve segments, fifth foot of one segment.
  - Fifth foot armed with three setae, rami of swimming feet of three segments.
    - Furca of variable length, armed externally with a row of spines, found almost everywhere. *serrulatus*
    - Furca short, without spinous armature, a small limnetic species, *prasinus*
  - Fifth foot armed with one seta, rami of swimming feet of two segments, *varicans*
- Antennae composed of eleven segments,
  - Rami of swimming feet composed of three segments, *phaleratus*
  - Rami of swimming feet composed of two segments, *bicolor*
- Antennae composed of eight segments, *fimbriatus*
- Antennae composed of six segments, *aequoreus*

CYCLOPS ATER HERRICK.

Plate, LXXII. figs. 1 to 6 and 9.

1882.	*Cyclops*	*ater*	Herrick,	p. 228, pl. III, figs. 9-12.
1884.	“	“	“	p. 145, pl. Q, figs. 9-12.
1887.	“	“	“	p. 14.
1895.	“	“	Herrick and Turner,	p. 89, pl. VI, figs. 11-12.
1895.	“	“	Marsh,	p. 13, pl. VI, figs. 1-4 and 6-12.
1897.	“	“	Forbes,	p. 49, pl. XIV, pl. XV, figs 1-3.
1909.	“	“	Byrnes,	p. 5, pl. I, figs. 1 to 6.

A large species, conspicuous both on account of its size and its brilliant colors. The cephalothorax is oval and very broad. The length and breadth of the first segment are about equal, and this segment comprises more than two-thirds the entire length of the cephalothorax. The cephalothorax is nearly three times the length of the abdomen, exclusive of the furcal rami.

The first abdominal segment is short and stout and very little enlarged at its anterior end. The succeeding segments are nearly equal in length, each being about one-third the length of the first segment. The posterior margin of the last segment is armed with small spines.

The furcal rami are about twice as long as wide. Herrick has a figure in which the furcal rami are ciliated on the inner margin. I do not find the cilia in my specimens, and Forbes (Forbes '97) states that they are not ciliate. The lateral spine is situated near the end. Of the terminal setae, the outer is slightly shorter than the inner, the second is about twice as long as the outer, and the third about three times as long.

The first antennae are 17-segmented and reach nearly the full length of the cephalothorax. The twelfth segment has a sensory club, and the sixteenth and seventeenth segments have a lateral hyaline lamella with an entire edge. This lamella, in the seventeenth segment projects as a blunt process beyond the end of the segment.

The spinous armature on the terminal segments of the exopodites of the swimming feet is represented by the formula 3, 4, 4, 3.

The fifth foot is composed of one segment and is armed with a stout serrate spine and two long setae.

The form of the *receptaculum seminis* is shown in plate LXXII, fig. 5.

Average length of the female 1.77 mm. This is the size of my specimens. Herrick gives 2.1 mm. as the average length and Forbes 1.77 mm. to 2.88 mm.

The deep blue of the ordinary coloration is very marked. This color is most pronounced in the appendages and caudal setae and in the posterior margins of the segments of the cephalothorax. Sometimes the cephalothorax is of a deep red or brown.

Herrick's description was written from specimens collected in Mud lake, Hennepin Co., Minn. He afterwards stated that it was found from Alabama to Minnesota, and more abundantly towards the south. Reighard collected it in Lake St. Clair. I have obtained it from Round lake, Twenty-sixth lake, Intermediate lake and Susan lake in Michigan, and from Rush lake, Catfish lake, and Lake Winnebago in Wisconsin. Forbes reports it from the shallow lakes near Havana, Ill. These are the only recorded localities. It appears to be a rather rare form.

CYCLOPS VIRIDIS JURINE.

Plate LXXII, figs. 7 and 8. Plate LXXIV, figs. 1 and 2. Plate LXXIX, figs. 6 and 7.

1820. *Monoculus quadricornis* var. *viridis* Jurine, p. 46, pl. III, fig. 1.
1851. *Cyclops viridis* Fischer, p. 412, pl. IX, figs. 1–11.
1857a. " *brevicornis* Claus, p. 32, pl. III, figs. 12–17.
1857b. " *gigas* Claus, p. 207, pl. XI, figs. 1–5.
1863. " *brevicornis* Claus, p. 99, pl. IV, fig. 11.
1863. " *gigas* Claus, p. 100.
1863. " *brevicornis* Lubbock, p. 200.
1870. " " Heller, p. 71.
1870. " *Clausii* Heller, p. 73, pl. I, figs. 1 and 2.
1872. " *Clausii* Fric, p. 220, fig. 13.
1872. " *gigas* Fric, p. 220, fig. 14.
1875. " *viridis*, Uljanin, p. 30, pl. VII, figs. 3–9.
1876a. " *brevicornis* Hoek, p. 13, pl. I, figs. 5 and 6.

1878. *Cyclops gigas* Brady, p. 105, pl, XX, figs. 1–16.
1880. " *viridis* Rehberg, p. 540.
1880. " *gigas* Rehberg, p. 541.
1882. " *ingens* Herrick, p. 228, pl. IV, figs. 1–8.
1882. " *parcus* Herrick, p. 229, pl. VI, figs. 12–15.
1882. " *insectus* Forbes, p. 649, pl. IX, fig 6.
1883. " *viridis* Cragin, p. 3, pl. IV, figs. 8–16.
1883. " *uniangulatus* Cragin, p. 6, pl. IV, fig. 17.
1884. " *viridis* Herrick, p. 145.
1884. " *parcus* Herrick, p. 148, pl. R, fig. 22.
1884. " *orevispinosus* Herrick, p. 148, pl. S, figs. 7–11.
1884. " *uniangulatus* Herrick, p. 149.
1884. " *insectus* Herrick, p. 152, pl. U, fig. 9.
1885. " *viridis* Daday, p. 214.
1886. " " Vosseler, p. 196, pl. IV, figs. 11–14.
1888. " " Sostaric, p. 64, pl. I, fig. 7.
1890. " " Thallwitz, p. 79.
1890. " " Lande, p. 44, pl. XIX, figs.117–124, pl. XX, fig. 125.
1891. " " Schmeil, p. 29.
1891. " " Richard, p. 226, pl. VI, fig. 4.
1891. " " Brady, p. 17, pl. V, figs. 6–10.
1892. " " Schmeil, p. 97, pl. VIII, figs. 12–14.
1893. " *americanus* Marsh, p. 202, pl. IV, figs. 8–10.
1893. " *brevispinosus* Marsh, p. 204, pl. IV, figs. 11 and 12.
1893. " *parcus* Marsh, p. 208, pl. IV, fig. 16, pl. V, fig. 1.
1895. " *viridis* Herrick and Turner, p. 90, pl. XIV.
1895. " *americanus* Herrick and Turner, p. 91, pl. XIV.
1895. " *ingens* Herrick and Turner, p. 92.
1895. " *parcus* Herrick and Turner, p. 93, pl. XX, figs. 12–15, pl. XXI, fig. 22, pl. XXIII, fig. 8, pl.. XXXIV, figs. 1–8.
1895. " *brevispinosus* Herrick and Turner, p. 95, pl. XXIII, figs. 1–4, pl. XXIV, figs. 7–12.
1895. " *uniangulatus* Herrick and Turner, p. 96.
1895. " *brevispinosus* Marsh, p. 14, pl. VII, fig. 12.
1895. " *parcus* Marsh, p. 15.
1897. " *viridis* Forbes, p. 37, pl. X, figs. 1–3.
1897. " " var. *brevispinosus* Forbes, p. 41, pl. XI, figs. 1 and 2.
1897. " " var. *insectus* Forbes, p. 41, pl. XI, figs. 3–6.
1897. " " Steuer, p. 6.
1897. " " Matile, p. 128, pl. II, figs. 15 and 16.
1898. " " Scourfield, p. 324.
1898. " *americanus* Brewer, p. 132.
1901. " *gigas* Lilljeborg, p. 5, pl. I, figs. 1–5.
1901. " *viridis* Lilljeborg, p. 8, pl. I, figs. 6–11.
1903. " " Graeter, p. 523, pl. 15. fig. 6.
1903. " " Scourfield, p. 534.
1903. " *parcus* Byrnes, p. 152.
1905. " " Jensen, p. 118.
1905. " " var. *insectus* Pearse, p. 150.

1909. *Cyclops americanus* Byrnes, p. 13, pl. V, figs. 1–3.
1909. " *parcus* Byrnes, p. 14, pl. VI, figs. 1–8, pl, X, figs. 1–3.
1909. " *brevispinosus* Byrnes, p. 16, pl. VII, figs. 1–9.
1909. " *ingens* Byrnes, p. 22, pl. VIII, figs. 1–4.

Cephalothorax oval, its breadth rather more than one-half its length. The cephalothorax is about twice as long as the abdomen exclusive of the furcal rami. Each cephalothoracic segment projects beyond the one following it.

The anterior part of the first abdominal segment is larger than the posterior, but this difference is not so marked as in some other species. The posterior margins of all the abdominal segments except the last are serrate,—the last segment is armed with small spines; this armature of the abdominal segments is more marked in the immature forms.

The furcal rami are very variable in length. They may be scarcely longer than the last abdominal segment or they may be four times as long. In some varieties the rami are ciliate on the inner margins. The lateral seta of the furca is commonly well towards the distal end, varying in position from two-thirds to four-fifths the length of the ramus. Of the terminal armature of the furca, the outermost is very variable; it may be a slender plumose seta, or it may be a short, blunt spine. It is never, however, very much elongated.

The first antennae are 17-segmented and reach to or a little beyond the posterior margin of the first cephalothoracic segment. The twelfth segment has a club-shaped sense hair.

The spinous armament of the terminal segments of the exopodites of the swimming feet may be 2, 3, 3, 3, or 3, 4, 4, 4. The terminal segment of the endopodite of the fourth foot may have exteriorly either a seta or a spine.

The fifth foot, Plate LXXII, figs. 7 and 8 consists of two segments. The first segment is broad, its breadth ordinarily equalling or exceeding its length; on its inner distal segment it bears a long plumose seta. The second segment is of about the same length as the first segment, while its width is one-half or less than that of the first segment; on its distal end near the outer margin is a long plumose seta, at the inner angle on the distal end is a small, lanceolate spine; in some varieties this spine is separated from the segment by a joint, while in others, this joint does not appear.

The form of the receptaculum seminis is shown in the figure, Plate LXXIV, fig. 2.

It varies greatly in size. The common American varieties are 1.25 to 1.5 in length. It may reach, however, as much as 5 mm.

Cyclops viridis seems to be universally distributed in the northern hemisphere.

Cyclops viridis var. ingens, Herrick.

This variety, which is also mentioned by E. B. Forbes, is distinguished by three features, first its greater size, second by the fact that the spine of the second segment of the fifth foot is not separated from the segment by a joint, and third by the ciliated internal margins of the furca. It corresponds, doubtless to the *gigas* of Claus. Inasmuch, however, as so good an authority as Schmeil considers that *gigas* differs from typical *viridis* only in size, it seems to me wise to retain Herrick's name for the American variety.

Ingens occurs in pools.

Cyclops viridis var. brevispinosus Herrick.

Brevispinosus is rather elongate in form, the furcal rami are long and slender, and the terminal appendage at the outer angles of the furcal rami is a short thick spine, Plate LXXIX, fig. 7, shaped much like the blade of a knife. The formula for the spines of the terminal segments of the exopodites of the swimming feet is 3, 4, 4, 4. The terminal segment of the endopodite of the fourth foot has a spine on its outer margin.

Brevispinosus is most common in larger bodies of water where it frequently has a limnetic habitat. It is by no means confined to large bodies of water, however, as it is found in many of the smaller lakes of Wisconsin and Michigan.

Cyclops viridis var. parcus Herrick.

Parcus has the second segment of the fifth foot with the spine separated by a joint. The formula for the spines of the terminal segments of the exopodites of the swimming feet is 2, 3, 3, 3, the terminal segment of the endopodite of the fourth foot is armed with a seta. The outer terminal appendage of the furca is a short seta.

Parcus is most common in shallow bodies of water. It does not appear to have a very wide distribution.

Cyclops viridis var. americanus Marsh.

Americanus has the furcal rami of varying length, the outer terminal appendage a short seta. (Plate LXXIX, fig. 6.)

The spine of the second segment of the fifth foot is separated by a joint. The terminal segments of the exopodites of the swimming feet have as the formula of the spines 3, 4, 4, 4. The terminal segment of the endopodite of the fourth foot has externally a seta.

Americanus is the most abundant variety of *viridis* in American waters, being found almost universally especially in the smaller bodies of water. This is the form which E. B. Forbes calls *insectus,* reviving the name proposed by S. A. Forbes, but never so described as to make it possible to identify the form. It is evident that in this case *americanus* has the rights of priority, as it was possible to recognize *insectus* only after the publication by E. B. Forbes in 1897, and he recognizes the identity of the two forms.

Discussion of viridis.

The first to recognize clearly the identity of the forms which are here grouped under the common specific name of *viridis* was E. B. Forbes, and the synonomy which I have adopted does not differ materially from that proposed by him. I agree with him that all the varieties distinguished above merge the one into the other with no clear cut dividing line. This is my impression from the study of my somewhat extensive collections from nearly all sections of North America.

The work of Miss Lehmann (Lehmann '03) proved this in regard to the distinctions between *brevispinosus* and *americanus.* And yet I am inclined to put much more stress than does Forbes on the varietal distinctions. While we can find connecting forms, if we look for them, yet it is true that collections from any locality are apt to contain only one variety in abundance. It is true that one can find the blunt furcal spine of *brevispinosus* merging by insensible stages into a seta, but it is also true that we can make collections in which practically all the individuals have the blunt spine. These same individuals will have, correlated with the blunt spine, elongated furcal rami, a formula for the spines of the terminal segments of the exopodites of the swimming feet represented by 3, 4, 4, 4, and a spine on the external margin of the terminal segment of the endopodite of the fourth swimming feet. One may find *brevispinosus* forms with a seta on the external margin of the terminal segment of the endopodite of the fourth swimming foot, but this is by no means common. So when one finds *parcus* forms he is not likely to find other forms mingled with it. So with the *americanus.* There are grades connecting this with the other varieties, but in any given collection where *americanus* is found, nearly all will be typical *americanus.*

It is true that the armature of the swimming feet may vary, but variation is not so common, in my experience, as would be inferred from the statements of Forbes. I have even found a form in which the right and left fourth feet in the same individual had a different spinous armature, but this is so unusual, that it may be considered, in all probability, as the result of some mutilation.

I have sometimes thought that we might well consider these varieties as distinct species, and that the intermediate forms were the result of hybridizing. Whether this is true or not could only be determined by a course of breeding, and it is likely to be a long time before we shall know the pedigrees of the species of *Cyclops.* Meantime students who must discuss these forms as elements in the plankton, and who, perhaps, have no interest in the taxonomic side of the question, must have some means of designating the forms, and it makes little difference to them whether they are called species or varieties. This is my excuse for proposing the use of these varietal names.

The European type of *viridis* does not have the spine of the second segment of the fifth foot separated by a joint, has for the spine formula of the terminal segment of the exopodite of the swimming feet 2, 3, 3, 3, and has the internal margin of the furcal rami ciliate. There are, among the European forms, however, all the variations noted in the American forms. The typical form is vastly the more common in Europe, while in America *americanus* is the most widely distributed variety, *ingens* and *parcus* being comparatively rare.

CYCLOPS BICUSPIDATUS Claus.

Plate LXXIII, figs. 1–11; Plate LXXIX, fig. 11.

1857a. *Cyclops bicuspidatus* Claus, p. 209, pl. XI, figs. 6 and 7.
1863. " " " , p. 101.
1863. " *pulchellus* Sars, p. 246.
1870. " *bicuspidatus* Heller, p. 71.
1872. " " Fric, p. 221, fig. 16.
1875. " *odessanus* Schmankewitsch.
1876a. " *bicuspidatus* Hoek, p. 17, pl. I, figs. 7–11.
1880. " *pulchellus* Rehberg, p. 543.
1880a. " *helgolandicus* Rehberg, p. 64, pl. IV, fig. 5.
1882. " *pulchellus* Vejdowsky, p. 63, pl. VII, figs. 11 and 12.
1882. " *Thomasi* Forbes, p. 649, pl. IX, figs. 10, 11 and 16.
1882. " *navus* Herrick, p. 229, pl. V, figs. 6–13, 15–17.
1883. " *gigas* G. M. Thompson, p. 96, pl. IX, figs. 8–10.
1883. " *pectinatus* Herrick, p. 499. pl. VII, figs. 25 and 28.
1883. " *Thomasi* Cragin, p. 3, pl. III, figs. 1–13.
1884. " " Herrick, p. 151, pl. U, figs. 4, 5, 7 and 8.
1884. " *navus* Herrick, p. 152.
1885. " *pulchellus* Daday, p. 220.
1885. " *Entzii* Daday, p. 221, pl. I, figs. 1–6.
1886. " *pulchellus* Vosseler, p. 194, pl. V, figs. 19–29.
1888. " " Sostaric, p. 66, pl. I, figs. 8 and 9.
1890. " " Lande, p. 50, pl. XXI, figs. 146–155.
1890. " " Thallwitz, p. 79.
1891. " *Thomasi* Forbes, p. 707, pl. II, fig. 8.
1891. " " Brady, p. 14, pl. VI, figs. 1–4.
1891. " *bicuspidatus* Schmeil, p. 27.
1891. " " Richard, p. 229, pl. VI, fig. 6.
1892. " " Schmeil, p. 75, pl. II, figs. 1–3.

1892. *Cyclops pulchellus* Lande, p. 161.
1893. " " Marsh, p. 207, pl. IV, figs. 18 and 19.
1893. " *minnilus* Forbes, p. 247.
1893. " *serratus* Forbes, p. 247.
1895. " *pulchellus* Herrick and Turner, p. 101, pl. XXVII, figs. 4 and 5, pl. XXVIII, figs. 5–8.
1895. " *pulchellus* var. *navus* Herrick and Turner, p. 102.
1895. " *minnilus* Herrick and Turner, p. 103.
1895. " *Forbesi* Herrick and Turner, p. 104.
1895. " *pulchellus* Marsh, p. 15, pl. VII, fig. 14.
1897. " *bicuspidatus* Forbes E. B., p. 44, pl. XII, figs. 1–4.
1897. " *bicuspidatus* Steuer, p. 5, pl. III, fig. 1.
1898. " *pulchellus* Brewer, p. 133.
1898. " *navus* Brewer, p. 132.
1901. " *bicuspidatus* Lilljeborg, p. 11, pl. I, figs. 12–17, pl. II, fig. 1.
1903. " " Graeter, p. 528, pl. XV, figs. 23 and 32.
1909. " *bicuspidatus* Byrnes, p. 25, pl. X, figs. 4–7.

The cephalothorax is elongate oval, its length being considerably more than twice its breadth. Seen from above the lateral angles of the segments back of the first are somewhat extended backward. The cephalothorax is rather more than twice as long as the abdomen exclusive of the furcal rami.

The first abdominal segment is only slightly narrower than the last cephalothoracic segment, and its anterior part is considerably wider than the posterior. The first abdominal segment about equals in length the three following. The posterior margins of the abdominal segments are more or less clearly marked with serrations, with the exception of the last segment which is armed with small spines.

The furcal rami (Pl. LXXIII, figs. 3, 7 and 8, pl. LXXIX, fig. 11) vary greatly in their length. The length may exceed little more than twice the breadth, or it may reach to six or eight times the breadth. The inner margins of the rami are ordinarily ciliate, although this is not an invariable characteristic. At about one-quarter of the distance from the proximal end is a row of small spines on the lateral margin. These spines are almost invariably present on the forms with elongated furcal rami but are not found on those with the very short rami. The lateral seta, which is surrounded with minute spines, is placed at about two-thirds of the length of the ramus. Of the terminal setae, only the inner ones are elongated.

The antennae consist of 17 segments. Richard (Richard 1891) and Steuer (Steuer '97) have shown that the number of antennal segments varies in the European forms, but I have not found this to be true in my American collections. The antennae vary somewhat in length, reaching about to the end of the first cephalothoracic segment, but they may fall short of this length or exceed it. The twelfth segment bears a sensory club. The setae arming the segments are rather short.

The spinous armature of the terminal segments of the swimming feet is 2, 3, 3, 3.

The fifth foot (Pl. LXXIII, figs. 10 and 11) consists of two segments. The breadth and length of the first segment are about equal; it bears on its outer distal angle an elongate plumose seta. The second segment is commonly twice as long as broad, but it may be still more slender; on its outer distal angle it bears an elongate and plumose seta, on its inner distal angle it bears a spine like seta which is less than half the length of the outer seta. This inner seta may be serrate as in the European forms, but neither the serration of this seta nor the plumose character of the other setae is very commonly seen in our American forms. The outer seta is borne upon a process of the segment, the outer margin of the segment being longer than the inner.

The size is somewhat variable, the American forms, apparently, being smaller than those found in Europe. The female is commonly about 1.1 mm. in length but may be not more than .95 mm.

C. bicuspidatus is found in all our northern states north of the Ohio river, and has been collected as far north as the Saskatchewan.

Generally speaking those found as limnetic forms have an elongated form, while those in shallow bodies of water and pools are shorter. Herrick's *navus* (Pl. LXXIX, fig. 11) is an example of this short form. There is no doubt that *navus* is simply a variety of *bicuspidatus* for I can verify the statement of Forbes that all intermediate forms can be found. *Bicuspidatus* is the common limnetic form of the Great Lakes, and in its elongated form is common in other deep lakes, although it is not confined to them. I have already discussed (Marsh 1903) its occurrence in Wisconsin lakes. It seems to prefer cold water, and my work in Wisconsin seemed to show that it might be considered as preeminently a winter form.

Miss Pratt (Pratt 1898) finds it a winter form in Lake Bassenthwaite in England. I have found it in small bodies of water in Indiana in the winter, while in the cold lakes of the Rocky Mountains it is a summer form.

Birge and Juday, in a recent paper (Birge and Juday 1908) have noted an interesting fact in the life history of *C. bicuspidatus*. In certain of the Wisconsin Lakes, in the summer season it is found in large numbers in a resting stage enclosed in a cocoon, hatching out in the fall. The authors find themselves unable to correlate this cocoon stage with either changes of temperature or oxygen content of the water. It would seem to us from our knowledge of the habits of the species, that it is probable that temperature will be found to be the controlling cause of this encystation.

CYCLOPS LEUCKARTI Claus.

Plate LXXIV, figs. 4–11; Plate LXXV, figs. 1–3.

1857. *Cyclops Leuckarti* Claus, p. 35, pl. I, fig. 4, pl. II, figs. 13 and 14.
1863. “ “ Sars, p. 239.
1863. “ “ Claus, p. 101.
1874. “ *simplex* Poggenpol, p. 70, pl. XV, figs. 1–3.
1875. “ *tenuicornis* Uljanin, p. 30, pl. IX, figs. 12 and 13.
1876a. “ *Leeuwenhoekii* Hoek, p. 19, pl. III, figs. 1–12.
1876b. “ *Leeuwenhoekii* Hoek, p. 132, pl. VII, figs. 1–12.
1880. “ *simplex* Rehberg, p. 542.
1884. “ “ Herrick, p. 150.
1884. “ *oithonoides* Herrick, p. 150, pl. S, figs. 2–6.
1884. “ *Léuckarti* Herrick, p. 146.
1885. “ “ Daday, p. 218.
1885. “ *simplex* Daday, p. 236.
1885. “ *pectinatus* Daday, p. 223, pl. I, figs. 7–13.
1886. “ *simplex* Vosseler, p. 193, pl. IV, figs. 15–17.
1887. “ “ Herrick, p. 17, pl. VII, fig. 1, a–j.
1890. “ “ Thallwitz, p. 79.
1890. “ “ Lande, p. 55, pl. XVI, figs. 42–45, pl. XVII, figs. 46–50,

1891. *Cyclops Leuckarti* Schmeil, p. 25.
1891. " " Richard, p. 230, pl. VI, fig. 20.
1891. " *edax* Forbes, p. 709, pl. III, fig. 15, pl. IV. figs. 1–20.
1891. " *Scourfeldi* Brady, p. 10, pl. IV, figs. 1–8.
1892. " *Leuckarti* Schmeil, p. 57, pl. III, figs. 1–8.
1892. " *simplex* Lande, p. 161.
1893. " *Leuckarti* Marsh, p. 209, pl. IV, fig. 17, pl. V. figs. 2–6.
1895. " *Leuckarti* Herrick and Turner, p. 96, pl. XVI, figs. 1–11, pl. XVIII, fig. 1, a–j, pl. XXIV, figs. 2–6.
1895. " *Leuckarti* Marsh, p. 15, pl. VII, fig. 15.
1897. " *Leuckarti* Forbes, p. 31, pl. VIII, figs. 1–3.
1897. " *edax* Forbes, p. 33, pl. IX, fig. 1–3.
1897, " *Leuckarti* Scott, p. 322, pl. IX, figs. 23–25.
1897. " " Steuer, p. 32.
1898. " " Brewer, p. 131.
1900. " " Burckhardt, p. 640.
1901. " " Lilljeborg, p. 35, pl. II, figs. 28–29.
1903. " " Graeter, p. 509, pl. 15, figs. 26 and 30.
1905. " " Van Douwe, p. 681.
1909. " *pulchellus* Byrnes, p. 24, pl. X, figs. 1–3.

A conspicuously slender species. The length of the cephalothorax compares with that of the abdomen as 7 to 4. The breadth of the cephalothorax is about one-half its length. The elongated oval form of the cephalothorax is a characteristic peculiarity of this species. The segments of the cephalothorax do not project markedly on the sides.

The abdomen (Pl. LXXIV, fig. 3) is slender. The first segment is equal in length to the remaining segments, and its anterior end is only slightly larger than the posterior. The succeeding segments are all of about the same length. The last segment is armed posteriorly with a row of spines.

The furcal rami equal in length the two preceding segments. Generally the inner margins are ciliated, although this is not always the case. The lateral seta is so situated as to divide the furca in the ratio of three to two. The terminal setae vary in their length; of the four, the inner is more than twice as long as the outer, the outer is commonly not far from the length of the furca.

The first antennae are 17-segmented and reach to the fourth cephalothoracic segment. The twelfth segment bears a sensory club. Upon the sixteenth and seventeenth segments is a lateral hyaline lamella. The lamella on the seventeenth segment is serrate on its margin, and has besides either a single deep depression near its distal end, or four or five such depressions. The figure (Pl. LXXIV, fig. 10) shows a common form. I do not find, in our American forms the spines spoken of by Schmeil on the antennal segments.

The segments of the second antenna (Pl. LXXV, fig. 3) are elongated. The lower margin of the second segment of the outer maxillipede always has a number of shallow depressions, giving it a more or less crenulated appearance. This appearance is described by the German authors under the term *geperlte*. While, in some of our forms, this term could be properly applied, more frequently crenulated would describe the appearance more accurately. The figures (Pl. LXXIV, figs. 4, 5, 6) show the extreme forms as they occur in America. In one (Pl. LXXIV, fig. 4) this appearance is confined to only a small part of the margin, but is there very distinct, while in the other (Pl. LXXIV, fig. 6) it is not so marked but extends through the greater part of the length of the margin. Pl. LXXIV, fig. 5 shows another form intermediate between the others.

The second segment of the inner maxillipede has on its anterior margin a number of scattered and rather long setae (Pl. LXXIV, fig. 11). This seems to be a constant characteristic of this species; I think it was first mentioned by Brady (Brady 1891) in his description of *Scourfeldi*. It is not mentioned by Schmeil but it is shown in his figure of the inner maxillipede.

The spinous armature of the terminal segments of the exopodites of the swimming feet is represented by the formula, 2, 3, 3, 3. The membrane connecting the feet of the fourth pair is armed on the posterior border with two blunt spines. (Pl. LXXV, fig. 1.) Each segment of the rami is armed on the distal border with a row of spines.

The fifth feet (Pl. LXXIV, figs. 8, 9) are two-segmented. The first segment is short and broad and bears upon its distal outer angle a plumose seta; this seta is ordinarily long as in Pl. LXXIV, fig. 9, but sometimes it is quite short, as in Pl. LXXIV, fig. 8. The second segment bears a long plumose seta on its distal end, and an almost equally long one on its inner side. This appendage of the inner side is spoken of by Schmeil as a spine, but in most of our specimens it would more properly be called a seta. There is a good deal of variability in the form and proportions of the fifth feet as shown in the figures of the plate.

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

The form of the *receptaculum seminis* is shown in Pl. LXXIV, fig. 7. Average length of females is about 1.14 mm.

This is a truly cosmopolitan species, being found in nearly all parts of the world. In India it is reported as found not only in fresh water but in brackish ponds. (Annandale 1907.)

The synonomy of this species prior to 1891 has been discussed by Schmeil and there is no reason to dissent from his conclusions.

As pointed out by me in an earlier publication (Marsh '92) it appeared from Forbes's original description of *edax,* that the only reason for separating it from *Leuckarti* was the absence of hyaline membranes on the 16th and 17th antennal segments. E. B. Forbes (Forbes '97) redescribes the species. He states that the hyaline membranes are present on the 16th and 17th segments.

He makes the following points of difference between *edax* and *Leuckarti*:

1st. The hyaline membrane of *edax* has several deep indentations, *Leuckarti* but one.

2nd. In *edax* the 16th and 17th antennal segments are equal, in *Leuckarti* the 16th is a fourth longer.

3rd. The crenulations of the second segment of the outer maxillipedes are less marked.

4th. The abdominal stylets are more divergent in *edax.*

5th. In *edax* the surfaces of attachment of the setae of the terminal segment are parallel, in *Leuckarti* the surface of attachment of the proximal seta is at an angle of about forty-five degrees with the long axis of the segment, instead of at right angles. In *edax* the distal segment is broader.

6th. Other differences which can only be recognized by a long series of measurements, but such "that one well acquainted with these species can distinguish them at a glance."

In regard to these points of difference, I can only say that none of them seem to me of more than varietal value. In regard to the indentations in the hyaline membrane of the last antennal segment, I find both forms in the same collection with every reason to think that they grade the one into the other. I have found, in my collections, the form with a single indentation the more abundant.

Burckhardt (Burckhardt 1900, p. 640) recognizing this possibility of variation, states that in his specimens, the outer three-fourths of the membrane was uniformly indented.

I have already discussed the variations in the crenulations of the second segment of the outer maxillipede. There is great variation in this characteristic.

The other points of difference are minor things, differences which one would expect within species limits. The sixth point of difference, of course, can hardly be taken seriously, for differences which can not be accurately defined should not be used in the diagnosis of a species. Without doubt, if we are to recognize the differences on which E. B. Forbes distinguishes *edax* we should have to use the name of *Leeuwenhoekii* Hoek, which has prior standing.

The figures in Brady's plate (Brady '91) make it evident that *Scourfeldi* is the same as *Leuckarti.*

It seems probable that *pulchellus* of Miss Byrnes (Byrnes 1909) is *Leuckarti.*

CYCLOPS TENUIS sp. nov.

Plate LXXV, figs. 4–9; Plate LXXIX, fig. 5.

A long slender species. The cephalothorax is oval, its length being more than twice its breadth; it is twice as long as the abdomen exclusive of the furcal rami. The segments of the cephalothorax do not project at their posterior angles.

The anterior end of the first abdominal segment (Pl. LXXV, fig. 5) is somewhat larger than the posterior end; this segment is less in length than the three following.

The furcal rami are rather slender, nearly equalling in length the last two abdominal segments. The lateral seta is at about one-half the length of the ramus. Of the terminal setae, the outer is short, while the inner one is rather unusually long.

The first antennae (Pl. LXXV, fig. 7) are long, exceeding the second cephalothorax segment. The antenna is composed of seventeen segments, the twelfth bearing a sensory club. The terminal segments of the antenna have no special armature.

The spinous armature of the terminal segments of the exopodites of the swimming feet is 2, 3, 3, 3.

The fifth foot consists of two segments. The length of the first segment is rather less than twice its breadth; it bears on the outer distal angle a long seta. The second segment is twice as long as broad; on its outer distal angle it bears a seta; on its inner distal angle, but set back a little from the end, it bears a slender serrate spine or seta; this inner spine nearly equals in length the outer seta.

The form of the receptaculum seminis is shown in the figure (Pl. LXXV, fig. 9).

The females are about 1.1 mm. in length.

This was found in Calabasas, in southern Arizona.

C. tenuis resembles, in its form, *C. Leuckarti,* but differs in the form of the fifth feet, in the lack of armature on the antennal segments, and of crenulatons on the outer maxillipede, and in the form of the receptaculum seminis.

It seems to be most nearly related to the European *oithonoides.* I at first thought it should be a variety of that species. The difference in the form of the fifth foot, however, with the lack of antennal armature and the somewhat different receptaculum seminis have led me to consider it a new species.

CYCLOPS ALBIDUS JURINE.

Plate LXXVI, figs. 1–9.

1820. *Monoculus quadricornis albidus* Jurine, pp. 44 and 47, pl. II, figs. 10 and 11, pl. III, fig. 24.
1841. *Cyclops annulicornis* Koch, H. 21, pl. VI.
1850. " *quadricornis* var. b Baird, p. 202, pl. XXIV, fig. 4.
1857. " *tenuicornis* Claus, p. 31, pl. III, figs. 1–11.
1857. " *pennatus* Claus, p. 35, pl. III, figs. 12–17.
1863. " *tenuicornis* Claus, p. 99, pl. I, fig. 3, pl II, fig. 17, pl. IV, fig. 5.
1863. " *tenuicornis* Sars, p. 242.
1863. " *annulicornis* Sars, p. 243.
1863. " *tenuicornis* Lubbock, p. 202.
1870. " *tenuicornis* Heller, p. 71.
1872. " *tenuicornis* Fric, p. 219, fig. 12.
1874. " *Clausii* Poggenpol, p. 70, pl. XV, figs. 4–14.
1875. " *signatus* Uljanin, p. 29, pl. IX, figs. 6–11, pl. XI, fig. 8.
1876a. " *tenuicornis* Hoek, p. 12.
1876b. " *tenuicornis* Hoek, p. 130.
1878. " *tenuicornis* Brady, p. 102, pl. XVIII, figs. 1–10.
1882. " *tenuicornis* Herrick, p. 227, pl. VI, figs. 1–11 and 20, pl. V, fig. 14.
1883. " *tenuicornis* Cragin, p. 3, pl. II, figs. 1–14.
1883. " *signatus* var. *fasciacornis* Cragin, p. 2, pl. II, fig. 15.
1884. " *tenuicornis* var. a Herrick, p. 153, pl. Q^4, figs. 1–7.
1885. " *tenuicornis* Daday, p. 211.
1886. " *tenuicornis* Vosseler, p. 189, pl. IV, figs. 6–10.
1887. " *tenuicornis* Claus, var. *distinctus* Richard, p. 162.
1888. " *tenuicornis* Claus, var. *annulicornis*, Richard, p. 61.
1888. " *albidus* Sostaric, pl. I, figs. 3, 4 and 12.
1890. " *tenuicornis* Thallwitz, p. 79.
1890. " *tenuicornis* Lande, p. 36, pl. XVI, figs. 22–32.
1891. " *gyrinus* Forbes, p. 707, pl. II, fig. 9, pl. III, fig. 14.
1891. " *albidus* Schmeil, p. 23.
1991. " *annulicornis* and *tenuicornis* Richard, p. 224–226.
1892. " *albidus* Schmeil, p. 128, pl. I, figs. 8–14b, pl. IV, fig. 15.
1892. " *tenuicornis* Lande, p. 156.
1892. " *gracilicornis* Lande, p. 158.
1893. " *signatus* Marsh, p. 211, pl. V, figs. 7–9.
1895. " *signatus* var. *tenuicornis* Herrick and Turner, p. 106, pl. XV, figs. 5–7, pl. XX, figs. 1–7, pl. XXXIII, figs. 1 and 2.
1895. " *albidus* Marsh, p. 17, pl. VI, figs. 8–10.
1897. " " Forbes, p. 47, pl. XIII.
1897. " *tenuicornis* Matile, p. 121, pl. II, figs. 4 and 5.
1898. " *signatus* Brewer, p. 129.
1901. " *albidus* Lilljeborg, p. 49, pl. III, figs. 21, 22.
1901. " *distinctus* Lilljeborg, p. 47, pl. III, figs. 16–20.
1903. " Graeter, p. 481, pl. 15, fig. 8.

1905. *Cyclops albidus* Pearse, p. 150, pl. XIV, figs. 11 and 13.
1906. " *distinctus* Brady, p. 697.
1909. " *signatus* var. *annulicornis* Byrnes, p. 10, p. IV, figs. 1–6.
1909. " *virido-signatus* Byrnes, p. 23, pl. IX, figs. 1–8.

A rather large species. The cephalothorax is oval in form, but the tapering at the posterior end is not so pronounced as in some species. The length and breadth compare as about 5 to 3. The cephalothorax is a little more than twice as long as the abdomen exclusive of the furcal rami. The projection of the posterior angles of the segments is not very marked. The dorsal surface of the fifth segment is more or less clearly marked with four rows of small spines.

The first abdominal segment (Pl. LXXVI, fig. 5) is not markedly larger at its anterior end; this first segment is somewhat longer than the sum of the three following. The last abdominal segment has a row of spines on its posterior margin.

The furcal rami are about twice as long as wide. The inner margins of the furcal rami are not usually armed with cilia; sometimes, however, they are present. I have found this condition in specimens collected in Michigan and in some collected in Colorado. The lateral seta is situated near the end of the furca. Of the four apical setae, the outer is very short, not much exceeding in length the ramus; the inner is about three times the length of the outer.

The first antennae are composed of seventeen segments, and reach about the full length of the cephalothorax. The last three segments (Pl. LXXVI, fig. 8) bear a hyaline plate, which in the last segment may be finely serrate on the margin. In occasional specimens this hyaline plate may be seen in some of the preceding segments, and in exceptional cases may be traced the whole length of the antenna, being represented in most of the segments by a row of small spines. Occasionally, too, the eighth, ninth, tenth, twelfth, thirteenth and fourteenth segments may have a row of spines on the posterior border as in *C. fuscus.* The twelfth segment has a long seta and a club-shaped sensory seta. The first two segments may have irregular rows of spines. In exceptional cases, there may be rows of spinules on the fourth, fifth, sixth and seventh segments.

In the second antenna, the inner margins of the first two segments are usually setose. The third segment is short, but little exceeding the second in length. (Pl. LXXVI, fig. 7.)

The spinous armature of the terminal segments of the exopodites of the swimming feet is 4, 4, 4, 3.

The distal seta on the inner margin of the endopodite of the fourth foot is rudimentary, being represented by a small spine; very rarely there is a short seta in this place; I have never found a seta of full length. (Pl. LXXVI, figs. 1, 3.)

The fifth foot is of two segments (Pl. LXXVI, fig. 6). The first segment is longer than wide. It has a patch of spines on the inner margin near the base, and a few spines about midway of its inner margin which may extend over part of the surface of the segment in a curved line. The distal margin is armed with small spines. On its distal outer angle is a long seta. The length of the second segment about equals the breadth of the first. It bears a long median seta and two stout serrate setae, one at each distal angle; the inner of these lateral setae is the longer.

The form of the receptaculum seminis is shown in the figure, (Pl. LXXVI, fig. 9).

The egg sacs of the female stand out from the abdomen almost at right angles.

The females measure upwards of 1.5 mm.

Cyclops albidus is universally distributed in North America. It belongs to the litoral rather than to the limnetic fauna.

Under *C. fuscus* there is a brief discussion of the distinguishing points between these two species.

C. *annulicornis* Sars, C. *tenuicornis* var. *distinctus* Richard, and C. *gracillicornis* Lande are doubtless identical, and the names have been given to separate a form supposed to be intermediate between *albidus* and *fuscus*. Brady (1906) and Lilljeborg (1901) make a distinct species using the name *distinctus* of Richard. Nothing has appeared in our American copepod fauna which seems to need a distinct species name, and I am inclined to agree with Schmeil that there is no good reason for separating this form from *albidus*. Accordingly I have placed them in the synonomy.

From the description it is impossible to establish the identity of *virido-signatus* of Miss Byrnes, but it would seem that this is probably a larval form of either *albidus* or *fuscus* with the chances in favor of *albidus*.

CYCLOPS FUSCUS JURINE.

Plate LXXVII, figs. 1–7.

1820. *Monoculus quadricornis fuscus* Jurine, p. 47, pl. II, fig. 2.
1841. *Cyclops signatus* Koch, H. 21, pl. VIII.
1850. " *quadricornis* var. c. Baird, p. 203, pl. XXIV, fig. 5.
1857. *coronatus* Claus, p. 29, pl. I, fig 5, pl. II, figs. 1–11.
1863. " " " p. 97, pl. II, fig. 16, pl. X, fig. 1.
1863. " *signatus* Sars, p. 242.
1863. " *coronatus* Lubbock, p. 199.
1870. " " Heller, p. 71.
1872. " " Fric, p. 218, fig. 11.
1876a. " " Hoek, p. 12.
1876b. " " Hoek, p. 129.
1878. " *signatus* Brady, p. 100, pl. XVII, figs. 4–12.
1882. " *tenuicornis* Herrick, p. 227, pl. V, fig. 14, pl. VI, figs. 1–11, and 20.
1884. " " Herrick, p. 153, pl. R, fig. 16, pl. Q^4, figs. 8–11, and 21.
1885. " *signatus* Daday, p. 208.
1886. " Vosseler, p. 189, pl. IV, figs. 1–5.
1888. " *fuscus* Sostaric, p. 58.
1890. " *signatus* Thallwitz, p. 79.
1890. " " Lande, p. 33, pl. XV, figs. 1–12.
1891. " *fuscus* Schmeil, p. 22.
1891. " " Richard, p. 223, pl. VI, fig. 6.
1891. " *signatus* Brady, p. 6, pl. II, fig. 5.
1892. " *fuscus* Schmeil, p. 123, pl. I, figs. 1–7b, pl. IV, fig. 2.
1893. " *signatus* Marsh, *fuscus* included under this.
1895. " *signatus* var. *coronatus* Herrick and Turner, p. 106, pl. XV, figs. 1–4.
1895. " *fuscus* Marsh, p. 16, pl. VI, figs. 5, 7 and 11.
1897. " *coronatus* Matile, p. 120, pl. II, figs, 1, 2 and 3.
1901. " *fuscus* Lilljeborg p. 44, pl. III, figs 12–15.
1903. " " Graeter p. 473, pl. 15, fig. 37.
1905. " " Pearse, p. 150, pl. XIV, fig. 12.
1906. " *signatus* var. *coronatus* Byrnes p. 193, pl. VII, figs. 1–6, pl. VIII, figs. 1–3.
1909. " " " " Byrnes p. 9, pl. II, figs. 1–7, pl. III, figs 1–5.

The cephalothorax is oval, narrowing decidedly toward the posterior end. Its width is rather more than one-half its length and the cephalothorax compares in length with the abdomen as seven to four. The posterior angles of the segments of the cephalothorax are not especially prominent. The first segment is about three-fourths of the length of the whole cephalothorax.

The first abdominal segment (Pl. LXXVII, fig. 1) is only slightly enlarged at its proximal end. Its length is rather less than the combined length of the three following segments. The last segment is armed on its posterior border with small spines.

The furcal rami are twice as long as wide, and ciliated on their internal margins. The lateral seta is near the distal end. Of the four terminal setae both the outer and the inner are elongated. The inner is seldom more than twice the length of the outer. All the terminal setae are strongly plumose.

The first antennae are composed of seventeen segments, and reach to the end of the cephalothorax. The twelfth segment bears a sensory hair. The eighth, ninth, tenth, twelfth, thirteenth and fourteenth segments have rows of large spines on their posterior borders (Pl. LXXVII, fig. 3). The last three antennal segments bear a lateral hyaline plate (Pl. LXXVII, fig. 4). In the last segment this hyaline plate is deeply notched on the first two-thirds of the segment, having four especially deep notches. The latter third of the plate is finely serrate. As in *albidus* these hyaline plates in some cases extend back upon the preceding segments. I find, as does Schmeil, contrary to the statement of Vosseler, that the indentations in the membrane of the last segment do not disappear in mounted specimens, but remain permanently like other cuticular structures.

In the second antennae, the inner margins of the first three segments are setose. The second segment is short and the third very long as compared with the corresponding structures in *albidus*. (Pl. LXXVII, fig. 5.)

The spinous armature of the swimming feet is 4, 4, 4, 3. This is as I have found it in all my American specimens. Schmeil gives it 3, 4, 4, 3. Vosseler gives it, however, as I have found it.

A structure not mentioned by any of the European authors is found on the third segment of the endopodite of the fourth foot. The larger of the two terminal spines is armed on its inner margin with long irregular teeth instead of the short spines as is customary. (Pl. LXXVII, fig. 2.)

This feature I have found constant in specimens from the northern states, but it is absent in most of those that I have examined from the southern states.

The structure of the fifth foot is like that of *albidus.*

The form of the receptaculum seminis is shown in the figure, Plate LXXVII, fig. 6.

The egg sacs of the female hang close to the abdomen.

The female measures 3 to 4 mm. in length, according to Schmeil. American specimens are smaller, being little over half of this length.

This species is found widely distributed in the northern continents, although nowhere very abundantly. In the U. S. Herrick found it in Minnesota. Later I reported it from Wisconsin and Michigan. E. B. Forbes adds localities in Illinois and Massachusetts. Pearse reported it from Nebraska. I have found it also in collections from Arkansas and Louisiana, and it is probable that it is universally distributed.

As will be seen from the literature of the subject, *albidus* and *fuscus* have been confused with each other until Schmeil made the clear distinction between the two species. By the difference in size, the darker color of *fuscus,* and the different habit of the egg-sacs the two are easily distinguished at a glance. In *albidus* the egg-sacs stand out from the abdomen, while in *fuscus* they cling close to it. In *albidus* there is a sensory club on the twelfth antennal segment, while in *fuscus* that segment bears a sensory hair. In *albidus* the hyaline plate of the last antennal segment is finely serrate; in *fuscus* it is deeply notched. In *albidus* the third segment of the second antenna is short; in *fuscus* this segment is long. In *albidus* the distal seta on the inner margin of the third segment of the endopodite of the fourth foot is rudimentary. In *fuscus* this seta is of the usual size, and commonly the large terminal spine of this segment is armed with long irregular teeth on its outer margin. In *albidus* the inner margins of the furcal rami are usually without cilia; in *fuscus* they are thickly beset with cilia.

CYCLOPS MODESTUS Herrick.

Plate LXXVIII, Figs. 1–4.

1883. *Cyclops modestus* Herrick, p. 500.
1884. “ “ “ p. 154, pl. R, figs. 1–5.
1887. “ “ “ p. 14.
1893. “ “ Marsh, p. 213, pl. V, figs. 10–13.
1893. “ *capilliferus* Forbes, p. 248, pl. XL, figs. 14–17, pl. XLI, fig. 18.
1895. “ *modestus* Herrick and Turner, p. 108, pl. XXI, figs. 1–5.
1895. “ *capilliferus* Herrick and Turner. p. 109, pl. VI, fig. 13, pl. XXVIII, figs. 1–4.
1909. “ *modestus* Byrnes, p. 26, pl. XI, figs. 4 and 5.

A rather stout species. Cephalothorax broadly oval, its breadth exceeding one-half its length. The cephalothorax is considerably more than twice as long as the adbomen exclusive of the furcal rami. The first segment comprises nearly two-thirds of the length of the cephalothorax. The posterior lateral angles of the segments project very little.

The abdomen (Pl. LXXVIII, fig. 4) is very slender and tapers little posteriorly. The first segment equals in length the rest of the abdomen exclusive of the furcal rami; it is wider at the anterior end, and the lateral prominences are each armed with a minute spine. The second and third segments are about equal in length, while the fourth is shorter. The abdominal segments are ciliate on their posterior borders.

The furcal rami are rather slender. They are about two and one-half times as long as the last abdominal segment. The inner margins are ciliate. The lateral seta is situated at about one-half the length of the ramus, and the ramus is peculiarly excavated backward from the seta. Of the terminal setae, the outer is short and plumose, and the inner is rather long, being three times the length of the outer.

The antennae (Pl. LXXVIII, fig. 2) are sixteen segmented. Herrick states that he has seen individuals “of a similar form” with seventeen segments. They reach, in the female, to the middle or end of the second cephalothoracic segment. The setae of the antennal appendages are unusually long.

The spinous armature of the terminal segments of the exopodites of the swimming feet is 4, 4, 3, 3. This is an ununusual armature.

The fifth foot (Pl. LXXVIII, fig. 3) is three segmented. The first segment is short and without armature. The second segment is nearly square and bears a seta on its outer distal angle. The third segment is narrower, longer than wide and bears two apical setae. Frequently the outer of these setae is bent over the inner.

Length of the females 1.2 to 1.25 mm.

This was first described by Herrick from Alabama, and he afterwards reported finding it in Minnesota. I found it in two localities in Wisconsin and Forbes reports it from Wyoming, and states that it is an uncommon species in the north central states. I have received specimens from R. A. Spaeth collected at Haverford, Pennyslvania, and from C. F. Baker collected at Auburn, Alabama.

CYPLOPS SERRULATUS Fischer.

Plate LXXVIII., Figs. 5–9, Plate LXXIX, Figs. 4 and 8.

1851.	*Cyclops*	*serrulatus*	Fischer, p. 423, pl. X, figs. 22, 23, 26–31.
1853.	"	"	Lilljeborg, p. 158, pl. XV, fig. 12.
1857.	"	"	Claus, p. 36, pl. I, figs. 1–3.
1863.	"	"	" p. 101, pl. I, figs. 1 and 2, pl. IV, fig. 12, pl. XI, fig. 3.
1863.	"	"	Sars, p. 254.
1863.	"	"	Lubbock, p. 197.
1870.	"	"	Heller, p. 72.
1872.	"	"	Fric, p. 222, fig. 18.
1875.	"	"	Uljanin, p. 34, pl. VIII, figs. 1–8.
1876a.	"	"	Hoek, p. 22.
1878.	"	"	Brady, p. 109, pl. XXII, figs. 1–6.
1878.	"	"	var. *montanus* Brady, p. 110, pl. XXII, figs. 7–14.
1880.	"	*agilis*	Rehberg, p. 545.
1882.	"	"	Forbes, p. 649.
1882.	"	*serrulatus*	Herrick, p. 230, pl. V, figs. 1–5, pl. VII, fig. 10.
1883.	"	"	G. M. Thompson, p. 96, pl. XI, figs. 19–22.
1883.	"	*pectinifer*	Cragin, p. 6, pl. IV, figs. 1–7.
1884.	"	*serrulatus*	Herrick, p. 157, pl. 0, figs. 17–19.
1884.	"	"	var. *elegans*, Herrick, p. 158.

1885. *Cyclops agilis* Daday, p. 240.
1886. “ “ Voseler, p. 190, pl. V, figs. 29–31.
1890. “ “ Thallwitz, p. 79.
1890. “ “ Lande, p. 60, pl. XVII, fig. 69, pl. XVIII, figs. 70–80.
1891. “ *serrulatus* Brady, p. 18, pl. VII, fig. 1.
1891. “ *agilis* Forbes, p. 710.
1891. “ *serrulatus* Richard, p. 234, pl. VI, fig. 19.
1891. “ “ Schmeil, p. 29.
1892. “ “ DeGuerne & Richard, p. 11.
1892. “ “ Schmeil, p. 141, pl. V, figs. 6–12.
1892. “ *agilis* Lande, p. 164.
1893. “ *serrulatus* Marsh, p. 215, pl. VI, figs. 2–5.
1893. “ “ Richard, p. 8.
1893. “ “ Scott, p. 73.
1895. “ “ Herrick and Turner, p. 111, pl. XV, figs. 8–11, pl. XIX, figs. 2–5, pl. XXVI, fig. 10, pl. XXIX, figs. 17–19.
1895. “ “ Marsh, p. 19.
1897. “ “ Forbes, p. 54, pl. XVII, pl. XVIII, figs. 1–3.
1897. “ “ Steuer, p. 34.
1897. “ “ Matile, p. 131, pl. II, figs. 18 and 19.
1898. “ “ Brewer, p. 134.
1901. “ “ Lilljeborg, p. 81, pl. V, figs. 1–6.
1901. “ *macruroides* Lilljeborg, p. 85, pl. V, figs. 7–11.
1901. “ *varius* Lilljeborg, p. 87, pl. V, figs. 12–15, pl. VI, figs, 1–9.
1901. “ “ var. *speratus*, Lilljeborg, p. 88, pl. V, figs. 12–15.
1901. “ “ “ *proximus*, Lilljeborg, p. 89, pl. VI, figs. 1–4.
1991. “ “ “ *brachyurus*, Lilljeborg, p. 90, pl. VI, figs. 5–9.
1903. “ “ Graeter, p. 489, pl. XV, figs. 6, 9, 17 and 19.
1903. “ “ var. *denticulata* Graeter, p. 491.
1905. “ “ Jensen, p. 120.
1906. “ “ Brady, p. 698.
1909. “ *serrulatus* Byrnes, p. 27, pl. XII, figs. 1–5.

Cephalothorax (Pl. LXXIX, fig. 8) elliptical rather than oval, its breadth more than half its length. The segments do not noticeably project over the following ones. The cephalothorax is more than twice as long as the abdomen exclusive of the furcal segments.

The first abdominal segment is enlarged at the anterior end. The second, third and fourth segments are about equal in length. The last segment is bordered posteriorly by a row of spines, and the preceding segments are commonly dentate on their posterior borders.

The furcal rami vary greatly in length. At one extreme we have the short stout form, perhaps one and a half times as long as the last abdominal segment, and at the other extreme the slender form in which the furca may be three times as long as the last abdominal segment. The form shown in the plate, (Pl. LXXVIII, fig. 7) may be considered typical while the figure in plate LXXVIII, fig. 6 is of the slender form. The outer margin of the furca is bordered by a row of short spines. These are not present in the male, and while always present in the female, are very variable in size. It was noted by DeGuerne and Richard ('92) that the specimens collected at Rufisque showed these spines much less clearly than did the European specimens. Brady (Brady 1906) also states that the serrulations in the New Zealand specimens are less marked than in those in Europe. There is much variability even in the same general region. These short spines are commonly much more prominent at the distal end of the furca. The lateral seta is at the end of the furca. Of the terminal setae the outer is short, sometimes spine-like, and, in the specimens with a short furca, commonly stands at nearly right angles with the furca. The second and third setae are prolonged; the third is rather less than twice as long as the second and only slightly exceeds the combined length of the abdomen and furca. The fourth seta is slender and weak, seldom much exceeding the first in length, and sometimes is shorter.

The first antennae are twelve-segmented and reach to the third segment, or sometimes nearly to the fourth; their length is quite variable. The last three segments (Pl. LXXVIII, fig. 5) bear an inconspicuous hyaline membrane. Some of the European authors say that these hyaline membranes are sometimes finely dentate, though commonly with entire margins. This dentation has never been noticed in American specimens.

The spinous armature of the terminal segment of the exopodites of the swimming feet is 3, 4, 4, 3.

The fifth foot (Pl. LXXVIII, fig. 8) is composed of a single segment. It is armed on its inner distal angle with a stout spine with serrate edges, and on its outer distal angle with a slender seta. Midway between these, on a prominent base is a long slender seta, considerable exceeding in length the outer seta.

The form of the receptaculum seminis is shown in the figure, (Pl. LXXVIII, fig. 9).

The egg-sacs are elongate and stand out from the abdomen. The number of eggs is variable.

The size is variable, commonly running between .8 and 1.25 mm., but greater extremes are not unusual.

The species has been found so widely distributed that it may be considered cosmopolitan.

It is convenient to use the varietal names *montanus* Brady and *elegans* Herrick in speaking of the extreme forms. *Montanus* is small, dark colored with short and stout furca, and with few eggs in the egg sacs. *Elegans* is larger, slender, with long and slender furcae, and numerous eggs in the egg sacs. As indicated by me in a former publication (Marsh '92) *montanus* is more common in pools and *elegans* in lakes. *Elegans* may be considered as limnetic and *montanus* as litoral. There are exceptions to this distribution, however, for *elegans* may be found in shallow waters, and in collections in the southern states it is not unusual to find both forms in the same collection.

CYCLOPS PRASINUS FISCHER.

Plate LXXVIII, figs. 1, 2, 3 and 10.

1860. *Cyclops prasinus* Fischer, p. 652, pl. XX, figs. 19–26a.
1871. " *longicornis* Vernet, p. 44, fig. 3.
1882. " *fluviatilis* Herrick, p. 231, pl. VIII, figs. 1–9.
1883. " *magnoctavus* Cragin, p. 5, pl. II, figs. 14–23.
1884. " *fluviatilis* Herrick, p. 159, pl. Q^5, figs. 1–9.
1886. " *pentagonus* Vosseler, p. 191, pl. V, figs. 32–37, pl. VI, figs. 11 and 12.
1887. " *pentagonus* var. *vichyensis* Richard, p. 162.
1887. " *fluviatilis* Herrick, p. 15.
1888. " *prasinus* Richard, p. 65.
1891. " *magnoctavus* Brady, p. 19, figs. 1–4.
1891. " *pentagonus* Schmeil, p. 31.
1891. " " Blanchard & Richard, p. 515.
1891. " " Richard, p. 233, pl. VI, fig. 8.
1892. " *prasinus* Schmeil, p. 150, pl. V, figs. 1–5.
1893. " *fluviatilis* Marsh, p. 214, pl. V, figs. 14 and 15, pl. VI, fig. 1.
1895. " *fluviatilis* Marsh, p. 18.
1895. " *fluviatilis* Herrick and Turner, p. 114, pl. XXVI, figs. 1–8, pl. XXX, figs. 1.

1897. *Cyclops prasinus* Forbes, p. 57, pl. XIX, figs. 1 and 2, pl. XX, figs. 1 and 2.
1898. " *fluviatilis* Brewer, p. 135.
1903. " *prasinus* Graeter, p. 486, pl. 15, figs. 3 and 4.
1909. " *fluviatilis* Byrnes, p. 28, pl. XV, figs. 1 and 2.

A small slender species. Its breadth exceeds one-half its length, and its length is rather more than twice the length of the abdomen exclusive of the furcal rami. The first segment is two-thirds the length of the entire cephalothorax. The last segment has a row of very fine hairs.

The first abdominal segment (Pl. LXXIX, fig. 1) is very slightly enlarged at its anterior end and the whole abdomen tapers gradually to the end of the furca.

The furca is short, being about one and a half times the length of the last abdominal segment. The lateral seta is situated at about the middle. Of the terminal setae the outer and inner are short and slender, the inner being the longer. The second and third are produced, the third being much the longer.

The first antennae (Pl. LXXIX, fig. 2) are composed of twelve segments and reach to the end of the third cephalothoracic segment. The last three segments bear a very minute hyaline membrane. The antennae are bent in a way that is peculiar to this species.

The spinous armature of the terminal segments of the exopodites of the swimming feet are 3, 4, 3, 3.

The fifth foot (Pl. LXXIX, fig. 10) is composed of one segment. It bears at the inner distal angle a slender spine, on the outer distal angle a seta, and between, on a conical base, an elongated seta.

The egg-sacs lie close to the abdomen.

The females average about .48 mm. in length. This is considerably smaller than the sizes given for the European specimens.

This species is widely distributed in Europe and has been reported from the Azores (Richard 1896), Ceylon (Daday '98) and Calcutta (Gurney 1906 and 1907). It is known to occur in America from the Rocky Mountains to the Atlantic and as far south as Mexico. Its characteristic habitat is lakes rather than pools. It is one of the common species in the limnetic regions of the Great Lakes.

CYCLOPS PHALERATUS Koch.

Plate LXXIX, fig. 9; plate LXXX, figs 1–6.

1838.	*Cyclops*	*phaleratus*	Koch, H 21, pl. IX.
1851.	"	*canthocarpoides*	Fischer, p. 426, pl. X, figs. 24, 25, 32–38.
1853.	"	"	Lilljeborg, p. 208.
1857.	"	"	Claus, p. 37, pl. I, figs. 6–10.
1863.	"	"	Claus, p. 102, pl. IV, figs. 1–4.
1863.	"	"	Lubbock, p. 202.
1863.	"	*phaleratus*	Sars, p. 255.
1872.	"	*canthocarpoides*	Fric, p. 223, fig. 19.
1874.	"	*lascivus*	Poggenpol, p. 72, pl. XV, figs. 22–24, pl. XVI, figs. 7 and 8.
1874.	"	*Fischeri*	Poggenpol, p. 73, pl. XV, fig. 28, pl. XVI, figs. 12–15.
1875.	"	*phaleratus*	Uljanin, p. 38, pl. IX, figs. 1–5.
1878.	"	"	Brady, p. 116, pl. XXIII, figs. 7–13.
1882.	"	*adolescens*	Herrick, p. 231, pl. VI, figs. 15–20.
1883.	"	*perarmatus*	Cragin, p. 7, pl. I, figs. 9–18.
1884.	"	*phaleratus*	Herrick, p. 161, pl. R, figs. 6–10.
1885.	"	"	Daday, p. 252.
1887	"	"	Herrick, p. 14, pl. VII, figs. 2, a–d.
1888.	"	"	Sostaric, p. 74, pl. II, figs. 21–22.
1890.	"	"	Lande, p. 75, pl. XX, figs. 126–136.
1891.	"	"	Brady, p. 25, pl. IX, fig. 2.
1891.	"	"	Richard, p. 238, pl. VI, fig. 12.
1891.	"	"	Schmeil, p. 36.
1892.	"	"	Lande, p. 171.
1892.	"	"	Schmeil, p. 170, pl. VIII, figs. 1–11.
1893.	"	"	Marsh, p. 216, pl. VI, figs. 6 and 7.
1895.	"	"	Herrick, and Turner, p. 120, pl. XVII, figs. 1–7, pl. XVIII, figs. 2–2d, pl. XIX, fig. 1, pl. XXI, figs. 6–10.
1895.	"	"	Marsh, p. 19.
1897.	"	"	Forbes, p. 59, pl. XX, fig. 3.
1901.	"	"	Lilljeborg, p. 105, pl. VI. figs. 20–21.
1903.	"	"	Graeter, p. 499.
1909.	"	"	Byrnes, p. 31, pl. XV, figs. 1–9.

The cephalothorax (Pl. LXXX, fig. 1) is elliptical; its breadth is two thirds of its length. The first segment comprises nearly one-half of its length. The fifth segment is armed posteriorly with a row of spines.

The abdomen is broad (Pl. LXXX, fig. 6), its first segment being only slightly smaller than the last cephalothoracic segment. Schmeil states that the second and third segments of the female and the second, third and fourth of the male are serrate on their posterior borders. I find some variations in these serrations in our forms.

The furcal rami are short, broad and tapering. They are armed upon their surfaces with rows of spines. The lateral setae are well towards the end, with spines at their bases. Of the terminal armature, the outer is a broad, stout spine, the inner a slender, short seta. The median setae are long and stout. The inner margins of the rami are ciliate.

The first antennae (Pl. LXXX, fig. 3) reach beyond the middle of the first cephalothoracic segment and, in American specimens are commonly composed of eleven segments. Herrick and Forbes claim to have collected mature specimens with ten segmented antennae. The eighth segment has a sensory hair.

The second antenna (Pl. LXXX, fig. 4) is short and broad. Besides the rows of small spines on the surface of the second segment, there is upon the anterior margin a row of curved tooth like spines. Near the end of the second segment is a stout spine, and a similar spine is located near the end of the third segment.

The spinous armature of the terminal segments of the exopodites of the swimming feet is 3, 4, 4, 3. The outer margins of the segments of the feet are armed with stout spines, and the first basal segment is armed posteriorly with a row of small spines.

The fifth feet (Pl. LXXIX, fig. 9) are widely separated from each other and each consists of a broad plate armed with three stout setae.

The form of the receptaculum seminis is shown in Plate LXXX, fig. 5.

The egg-sacs lie rather close to the abdomen.

Length of female about 1.2 mm. according to Schmeil, but American forms average somewhat smaller.

Cyclops phaleratus occurs in shallow lakes and stagnant pools, and is world wide in its distribution, although not abundant anywhere.

The question of the identity of our form with that of Europe has been discussed by Schmeil, and I think we must agree with his conclusion. Really the only reason for separating our form is the fact that it ordinarily has eleven segments in the antenna. If we recognize this as a specific difference we should call the American form *perarmatus* Cragin.

CYCLOPS VARICANS SARS.

1862. *Cyclops* *varicans* Sars, p. 252.
1875. " *orientalis* Uljanin, pp. 33–34, pl. VII, figs. 10 and 11; pl. X, figs. 8–13; pl. XI, figs. 1 and 2.
1890. " *varicans* Lande, p. 64, pl. XVIII, figs. 81–90.
1891. " " Schmeil, p. 33.
1892. " " Lande, p. 164.
1892. " " Schmeil, p. 116, pl. VI, figs. 1–5.
1893. " " Richard, p. 8.
1895. " " Herrick, p. 116, pl. XIX, figs. 12–13; pl. XXX, figs. 2–8.
1895. " " Richard, p. 1.
1897. " " Forbes, pp. 63–64.
1897. " " Matile, p. 130, pl. II, fig. 17.
1897. " " Scott, p. 322, pl. IX, figs. 26–28.
1901. " " Lilljeborg, p. 72, pl. IV, figs. 23, 24.
1903. " " Graeter, p. 528, pl. XV, figs. 22, 25.
1905. " " Van Douwe, p. 682.
1906. " " Pearse, p. 249.
1909. " *bicolor* Byrnes, p. 29, pl. XIII, figs. 1–5.

This is a species of world wide distribution, and it would be expected in our American fauna. I have never found it in any of the collections that have come under my observation. It is mentioned by Herrick, E. B. Forbes and Pearse as being found in America. Herrick states that he found it but once. His figures are not exact, but he gives twelve segments in the antenna of the female which should distinguish it from the closely related form *bicolor*. Forbes speaks of it as fairly common in America, but he gives neither description nor figures.

Pearse states that he found it on Nantucket Island, but he too, gives neither description nor figures.

The *bicolor* of Miss Byrnes has antennae of twelve segments and must be considered as *varicans.*

Because of the very close resemblance of this species to *bicolor* one cannot help being a little skeptical in regard to some of these recorded occurrences, in spite of the fact that it might be expected to be a member of the American copepod fauna.

CYCLOPS BICOLOR Sars.

Plate LXXX, figs. 7–9; Plate LXXXI, figs. 1 and 2.

1863. *Cyclops bicolor* Sars, p. 253.
1880. " " Rehberg, p. 547.
1884. " " Herrick, p. 160, pl. R, fig. 12.
1885. " " Daday, p. 246.
1885. " *brevisetosus* Daday, p. 255, pl. III, figs. 3, 5 and 10.
1887. " *diaphanus* Herrick, p. 16, pl. VII, figs. 3 a–e.
1888. " *bicolor* Lande, p. 67, pl. XVIII, figs. 91–98.
1891. " " Schmeil, p. 34.
1892. " ” Schmeil, p. 118, pl. VI. figs. 6–13.
1892. " " Lande, p. 165.
1893. " " Marsh, p. 217.
1895. " " Herrick, p. 118, pl. XVIII, figs. 3–3e, pl. XXI, fig. 12.
1895. " " Marsh, p. 20.
1901. " " Lilljeborg, p. 78, pl. IV, figs. 27 and 28.
1903. " " Graeter, p. 533, pl. 15, figs. 34–36.

Cephalothorax oval, its breadth being slightly more than one-half its length. The first segment comprises considerably more than one half of the cephalothorax. The cephalothorax is rather more than twice as long as the abdomen exclusive of the furcal rami. The fifth cephalothoracic segment bears upon each side a long seta.

The first abdominal segment (Plate LXXXI, fig. 1) is somewhat enlarged anteriorly and equals in length the remainder of the abdomen exclusive of the furcal rami. The last segment is armed with small spines on the ventral surface and is coarsely dentate on the dorsal surface.

The furcal rami do not equal the length of the last two abdominal segments. The lateral seta is at about three-fourths of its length. The first and fourth of the terminal seta are short and slender, the inner exceeding the length of the outer.

The antennae (Plate LXXXI, fig. 2) have eleven segments, the third and seventh being the longer.

The swimming feet (Plate LXXX, figs. 7 and 8) are composed of two segments. The spinous armature of the terminal segments is 3, 4, 4, 3.

The fifth foot (Plate LXXX, fig. 9) consists of a single segment. It is slender and bears at the tip a single seta.

Average length of mature females .5mm.

Cyclops bicolor occurs in stagnant pools, and is widely distributed, although nowhere common.

I have notes of a mature female with antennae of ten segments. In this female the egg sacs contained only four or five eggs each while the more ordinary number is from fifteen to twenty.

This species, as described, does not correspond perfectly to the diagnosis of *bicolor* as given by Schmeil. There is a difference in the form of the fifth cephalothoracic segment and in the proportions of the furca.

There is, apparently some variation in the position of the fifth foot on the last cephalothoracic segment, and in some individuals, it resembles somewhat *rubellus* of Lilljeborg. The characters of the swimming feet, however, as given by Lilljeborg make a clear cut distinction between *rubellus* and *bicolor*. One might consider the American form a distinct species. The differences are slight, however, and besides are, for the most part, differences in structures which vary in other species, so that it seems to me better to consider our form as a variety of the European species. It may be added that because of its comparative rarity, a large number of individuals have not been studied, and a larger amount of material may show a closer relationship to the European form than now appears.

C. FIMBRIATUS Fischer.

Plate LXXXI, figs. 3–7.

1853. *Cyclops fimbriatus* Fischer, p. 94, pl. III, figs. 19–28 and 30.
1863. " *crassicornis* Sars, p. 256.
1870. " *Gredleri* Heller, p. 74, pl. I, figs. 3 and 4.
1872. " *pauper* Fric, p. 223, fig. 20.
1875. " *crassicornis* Uljanin, p. 39, pl. VIII, figs. 9–16, pl. XII, fig. 1.
1878. " *crassicornis* Brady, p. 118, pl. XXIII, figs. 1–6.
1880. " *Poppei* Rehberg, p. 550, pl. 6, figs 9–11.
1880. " *fimbriatus* Rehberg, p. 548, pl. VI, figs. 7 and 8.
1882. " " Vejdowsky, p. 63, pl. VII, figs. 9, 10 and 13.
1882. " *crassicornis* Herrick, p. 232, pl. IV, figs. 9–14.
1884. " *fimbriatus* Herrick, p. 162, pl. R, fig. 11.
1885. " " Daday, p. 262.
1885. " *margoi* Daday, p. 264, pl. III, figs. 20–25.
1886. " *fimbriatus* Vosseler, p. 192, pl. VI, figs. 4–8.
1888. " *crassicornis* Sostaric, p. 75, pl. II, figs. 23 and 24.
1890. " *fimbriatus* Lande, p. 79, pl. XXI, figs. 166–169.
1891. " " Schmeil, p. 35.
1891. " " Brady, p. 25, pl. IX, fig. 1.
1891. " " Richard, p. 238, pl. VII, figs. 13 and 14.
1892. " " Schmeil, p. 161, pl. VII, figs. 8–13.
1892. " " Lande, p. 173.
1893. " " Marsh, p. 218, pl. VI, figs. 8 and 9.
1895. " " Herrick, p. 121, pl. XVII, figs. 8 and 9, pl. XXI, fig. 11, pl. XXV, figs. 9–14.
1897. " " Steuer, p. 7.
1901. " " Lilljeborg, p. 94, pl. VI, figs. 12–14.
1903. " " Graeter, p. 503, pl. 15, fig. 1.
1909. " " Byrnes, p. 33, pl. XV, figs. 3–7.

Cephalothorax (Plate LXXXI, fig. 3) oval, its breadth being a little more than two-thirds of its length. The cephalothorax is about one and seven tenths as long as the abdomen exclusive of the furcal rami. Each segment of the cephalothorax projects somewhat over the succeeding segment.

The last cephalothoracic segment is armed laterally with rather long hairs.

The anterior part of the first abdominal segment is somewhat larger than the posterior part. The last segments are armed posteriorly with spines.

The furcal rami (Pl. LXXXI, fig. 6) are commonly slender, slightly curved in outline, and with their outer extremities widely separated. Schmeil says that the length nearly equals the last three segments. In our forms this is rarely the case, the length being more generally equal to the last two and a half of the third, or about three times the length of the last segment. In some cases the rami are shorter yet, as in some specimens collected in the Saskatchewan. The lateral seta is situated at about two-thirds the length of the furca on the dorsal surface. A row of spines extends from the outer margin of the furca, on the dorsal surface opposite the seta, curving nearly to the center of the furca, and then nearly to the proximal end of the furca. Of the apical setae, the outer is spine like and short, the inner is slender and somewhat longer than the outer; the longest of the two middle ones nearly equals in length the cephalothorax.

The first antennae (Pl. LXXXI, fig. 2) of the female are composed of eight segments, are about two-thirds as long as the first cephalothoracic segment, and in repose lie nearly at right angles with the long axis of the animal. The fourth segment is the longest, and the fifth bears a sensory seta. The setae with which the antennal segments are armed, are, for the most part, long and stout. The segments near the base are quite stout, the first two being four times as wide as the terminal segment.

The external margins of the segments of the swimming feet (Pl. LXXXI, fig. 5) are armed with short, stout spines. The spinous armature of the terminal segments of the exopodites of the swimming feet is represented by the formula, 3, 4, 4, 3.

The fifth foot (Pl. LXXXI, fig. 4) consists of a single segment, and is armed with one spine and two setae.

The egg-sacs, pl. LXXXI, fig. 3, lie alongside the abdomen, and contain only a small number of eggs.

The length of mature females varies from .7 mm. to .84 mm. This is somewhat smaller than the figures given by Schmeil for the European forms.

Cyclops fimbriatus is not a common species, but is cosmopolitan in its distribution.

The synonomy is given before the description, and no explanations are required as it has been thoroughly discussed elsewhere.

CYCLOPS AEQUOREUS FISCHER.

1853. *Cyclops magniceps* Lilljeborg.
1860. " *aequoreus* Fischer, p. 654, pl. XX, figs. 26–29.
1863. " " Claus, p. 103.
1868. " " Brady, p. 128, pl. IV, figs. 9–16.
1878. " " Brady, p. 119, pl. XIX, figs. 8–10; pl. XXI, figs. 10–17.
1883. " *Dumasti* Joly, p. 120, figs. 1–8.
1883. " *aequoreus* G. M. Thompson, p. 97, pl. XI, figs. 16–18.
1888. " *Dumasti* Richard, p. 67.
1891. " *aequoreus* Blanchard and Richard, p. 515.
1891. " " Brady, p. 26, pl. X, fig. 1.
1892. " " Lande, p. 173.
1893. *Hemicyclops aequoreus* Claus, p. 348, pl. III, figs. 11–17.
1893. *Cyclops aequoreus* Scott, p. 74.
1895. " " Herrick, p. 122, pl. XXIII, fig. 5.
1895. " " Scott, p. 33.
1901. " " Lilljeborg, p. 102, pl. VI, figs. 17–19.

Cyclops aequoreus was first recognized in our fauna by Herrick. It is an inhabitant of brackish water. It has never appeared in any of my collections, but Mr. E. Foster tells me that he has collected it in Lake Ponchartrain and connecting waters. It seems likely that further collections in brackish waters will show that this is not an uncommon form. It is readily recognized by the six segmented antennae of the female and the peculiar form of the fifth foot.

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EXPLANATION OF PLATE LXXII.

Fig. 1. *Cyclops ater;* fourth swimming foot (x 120).

Fig. 2. *Cyclops ater;* abdomen of female (x 103).

Fig. 3. *Cyclops ater;* fifth foot (x 340).

Fig. 4. *Cyclops ater;* eleventh to fourteenth antennal segments of female (x 425).

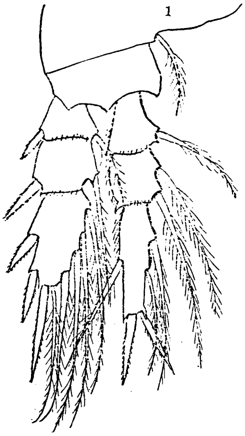
Fig. 5. *Cyclops ater;* receptaculum seminis (x 321).

Fig. 6. *Cyclops ater;* antennule of female (x 103).

Fig. 7. *Cyclops viridis* var. *americanus;* fifth foot (x 340).

Fig. 8. *Cyclops viridis var. parcus;* fifth foot (x 340).

Fig. 9. *Cyclops ater;* last three segments of female antenna (x 212).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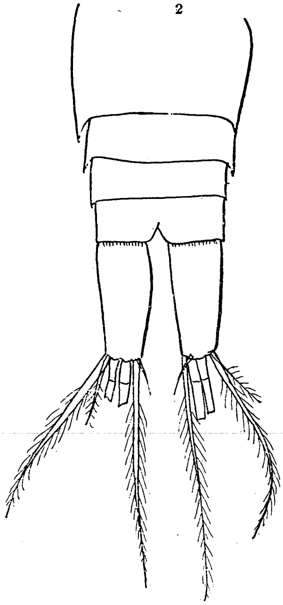
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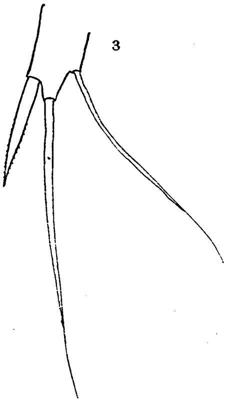
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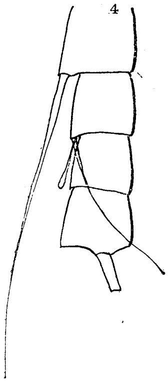
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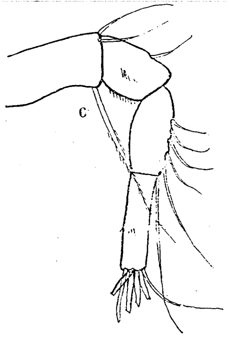
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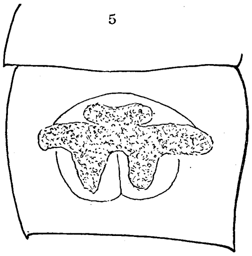
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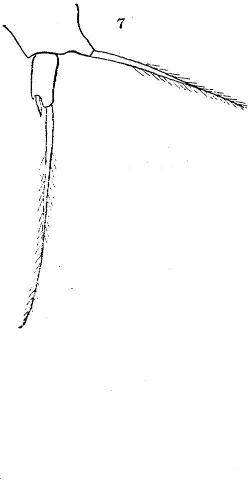
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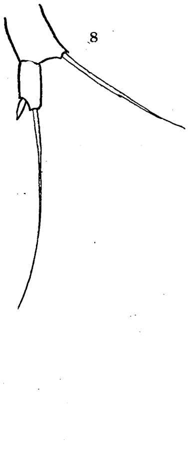
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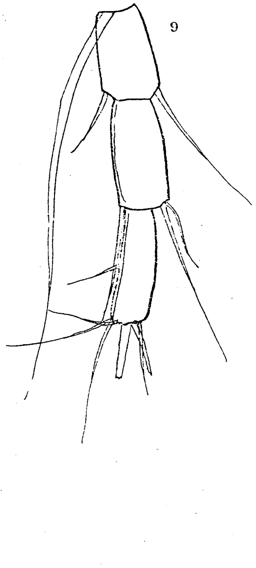
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PLATE LXXIII.

EXPLANATION OF PLATE LXXIII.

Fig. 1. *Cyclops bicuspidatus;* first antenna of female (x 212).
Fig. 2. *Cyclops bicuspidatus;* second antenna of female.
Fig. 3. *Cyclops bicuspidatus;* furca of female (x 340).
Fig. 4. *Cyclops bicuspidatus;* mandible (x 340).
Fig. 5. *Cyclops bicuspidatus;* outer maxillipede (x 212).
Fig. 6. *Cyclops bicuspidatus;* fourth swimming foot (x 212).
Fig. 7. *Cyclops bicuspidatus* var.; abdomen of female (x 103).
Fig. 8. *Cyclops bicuspidatus;* abdomen of female (x 103).
Fig. 9. *Cyclops bicuspidatus;* labrum (x 475).
Fig. 10. *Cyclops bicuspidatus;* fifth foot (x 475).
Fig. 11. *Cyclops bicuspidatus;* fifth foot (x 475).

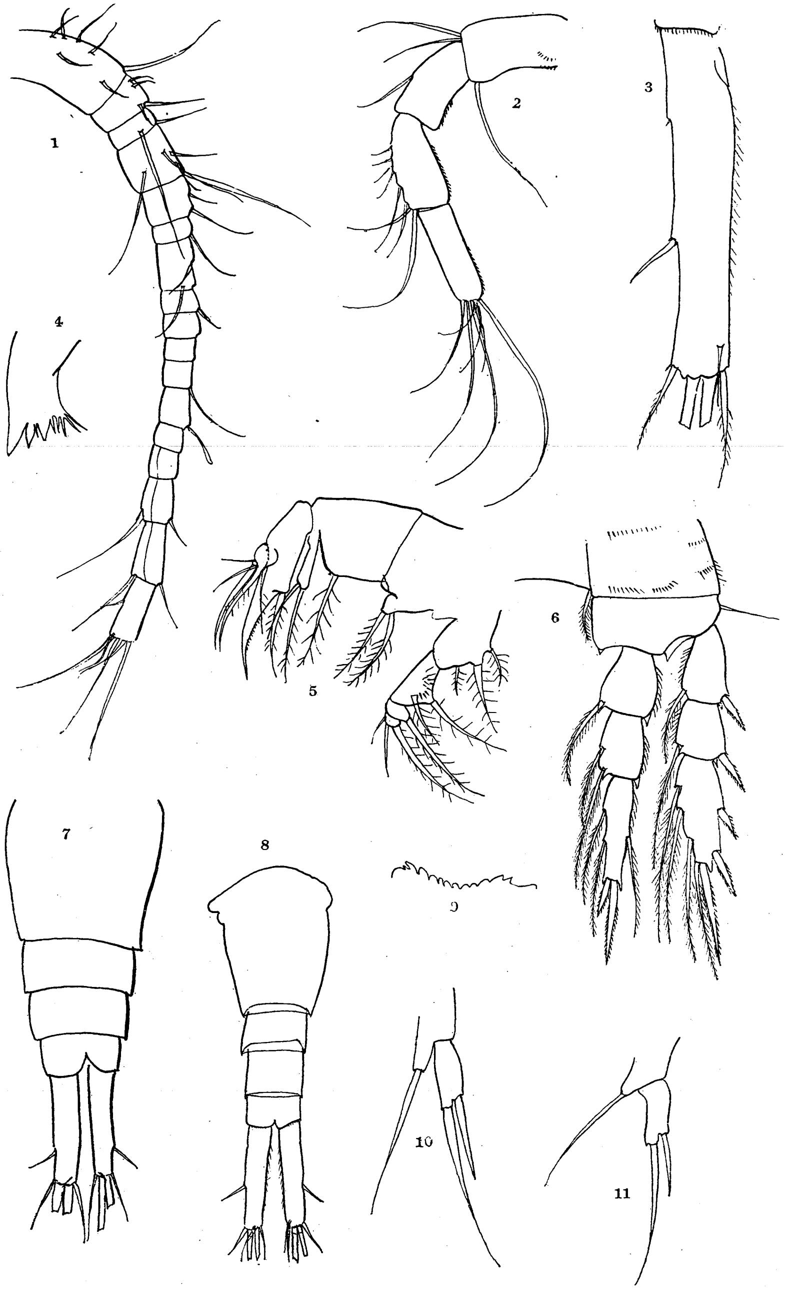
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PLATE LXXIV.

EXPLANATION OF PLATE LXXIV.

Fig. 1. *Cyclops viridis* var. *parcus;* fourth foot (x 212).

Fig. 2. *Cyclops viridis* var. *americanus;* receptaculum seminis (x 212).

Fig. 3. *Cyclops Leuckarti;* abdomen of female (x 103).

Fig. 4. *Cyclops Leuckarti;* second segment of outer maxilliped (x 212).

Fig. 5. *Cyclops Leuckarti;* second segment of outer maxilliped (x 212).

Fig. 6. *Cyclops Leuckarti;* second segment of outer maxilliped (x 212).

Fig. 7. *Cyclops Leuckarti;* receptaculum seminis (x 165).

Fig. 8. *Cyclops Leuckarti;* fifth foot (x 340).

Fig. 9. *Cyclops Leuckarti;* fifth foot (x 340).

Fig. 10. *Cyclops Leuckarti;* terminal segment of female antenna (x 340).

Fig. 11. *Cyclops Leuckarti;* inner maxilliped (x 212).

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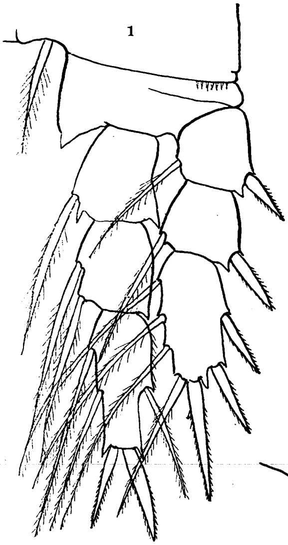

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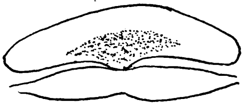

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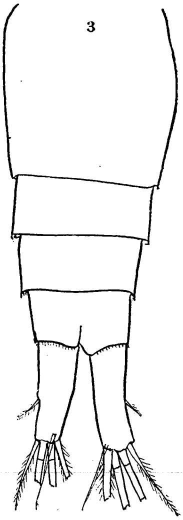

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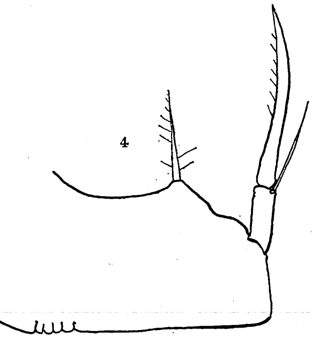

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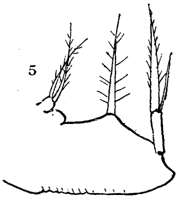

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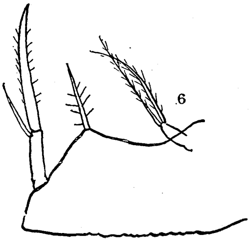

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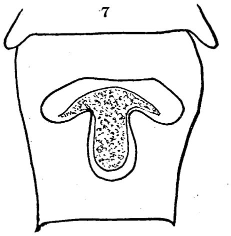

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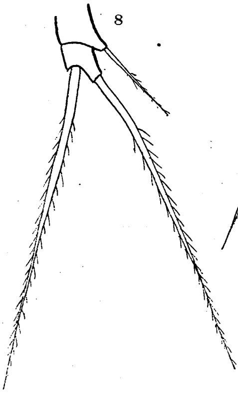

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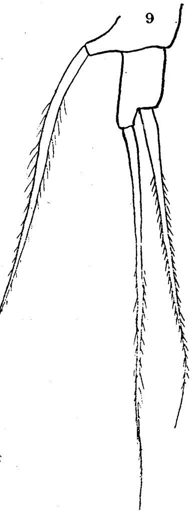

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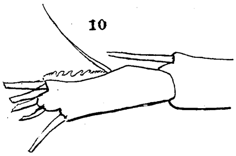

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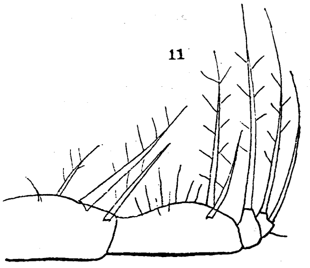


PLATE LXXV.

EXPLANATION OF PLATE LXXV.

Fig. 1. *Cyclops Leuckarti;* fourth foot (x 212).

Fig. 2. *Cyclops Leuckarti;* twelfth to fifteenth antennal segments of female (x 300).

Fig. 3. *Cyclops Leuckarti;* second antenna (x 212).

Fig. 4. *Cyclops tenuis;* fifth foot (x 340).

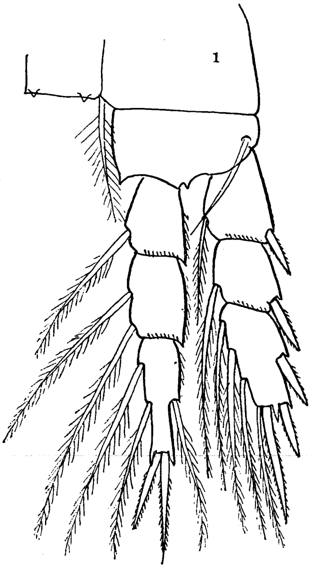
Fig. 5. *Cyclops tenuis;* abdomen of female (x 212).

Fig. 6. *Cyclops tenuis;* labrum (x 475).

Fig. 7. *Cyclops tenuis;* antenna of female (x 120).

Fig. 8. *Cyclops tenuis;* cephalothorax and abdomen of female (x 70).

Fig. 9. *Cyclops tenuis;* receptaculum seminis (x 212).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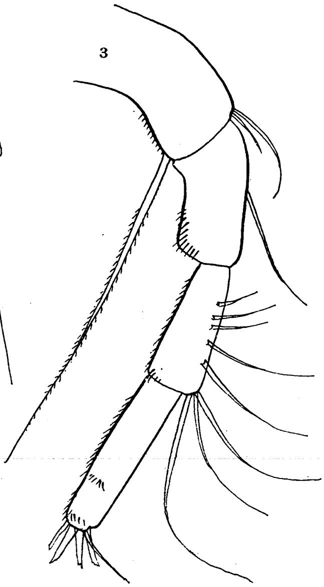
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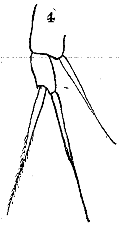
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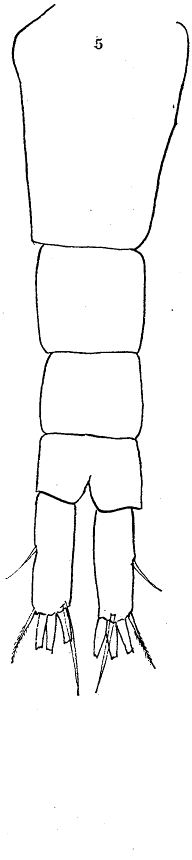
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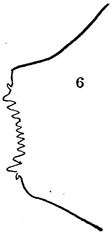
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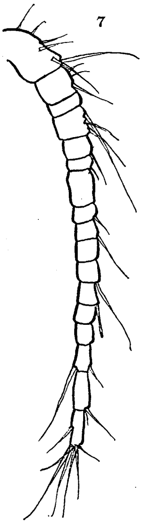
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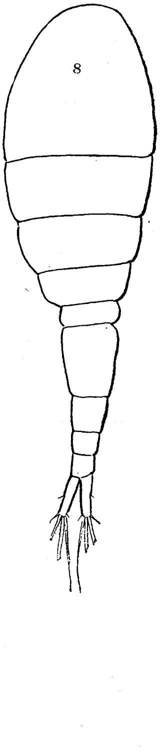
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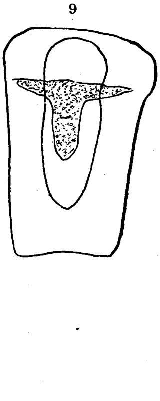
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PLATE LXXVI.

EXPLANATION OF PLATE LXXVI.

Fig. 1. *Cyclops albidus;* terminal segment of endopodite of fourth foot (x 340).

Fig. 2. *Cyclops albidus;* eleventh to fourteenth segments of antenna of female (x 212).

Fig. 3. *Cyclops albidus;* fourth foot (x 212).

Fig. 4. *Cyclops albidus;* inner maxillipede (x 162).

Fig. 5. *Cyclops albidus;* abdomen of female (x 103).

Fig. 6. *Cyclops albidus;* fifth foot (x 340).

Fig. 7. *Cyclops albidus;* second antenna (x 212).

Fig. 8. *Cyclops albidus;* sixteenth and seventeenth segments of antenna of female (x 216).

Fig. 9. *Cyclops albidus;* receptaculum seminis (x 212).

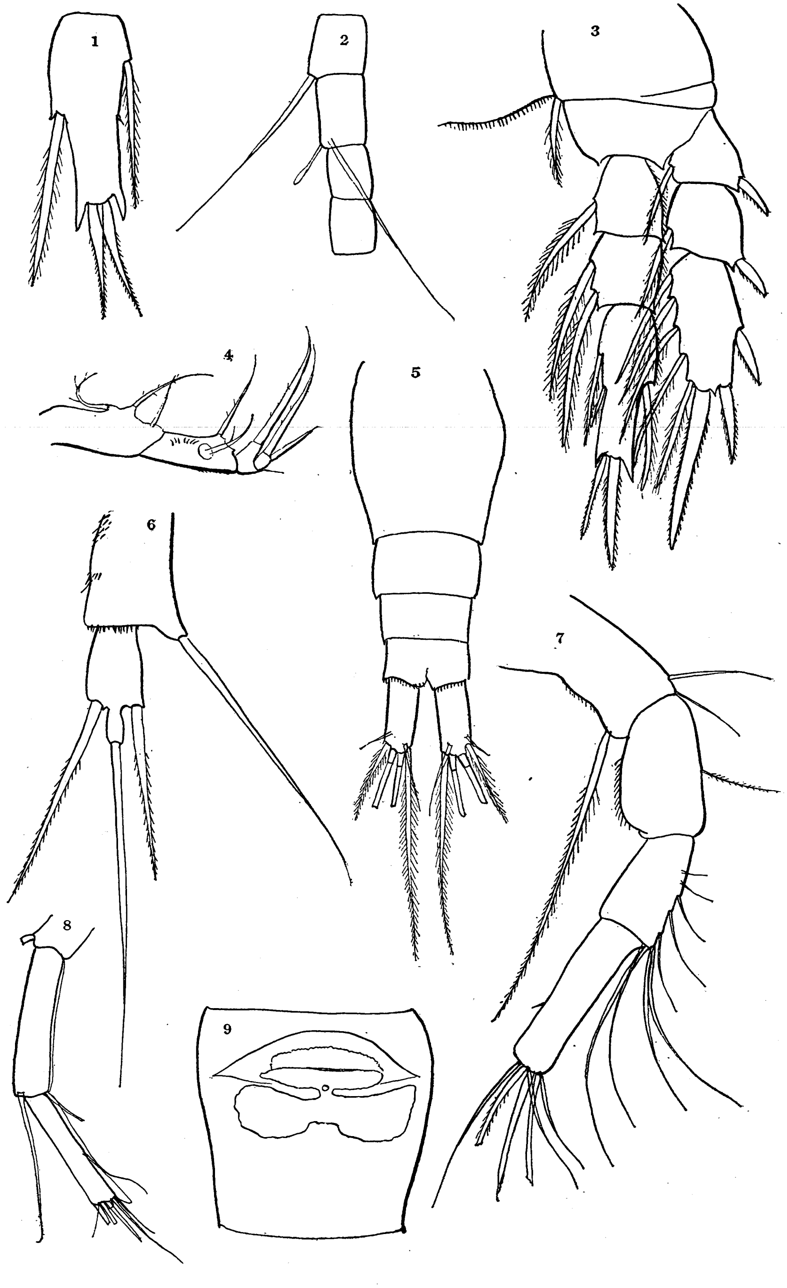
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PLATE LXXVII.

EXPLANATION OF PLATE LXXVII.

Fig. 1. *Cyclops fuscus;* abdomen of female (x 103).

Fig. 2. *Cyclops fuscus;* terminal segment of endopodite of fourth foot (x 212).

Fig. 3. *Cyclops fuscus;* segments eight to fourteen of antenna of female (x 214).

Fig. 4. *Cyclops fuscus;* segments fifteen to seventeen of antenna of female (x 212).

Fig. 5. *Cyclops fuscus;* second antenna (x 212).

Fig. 6. *Cyclops fuscus;* receptaculum seminis (x 168).

Fig. 7. *Cyclops fuscus;* first segment of antenna of female (x 212).

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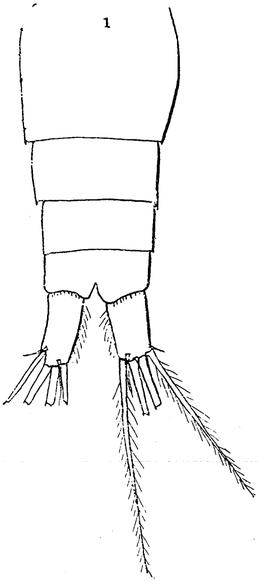

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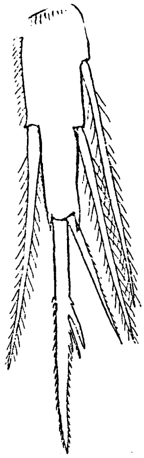

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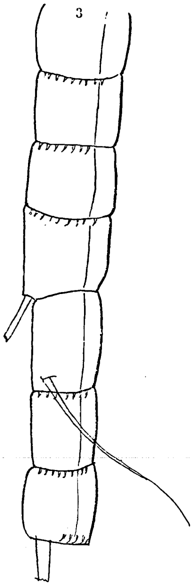

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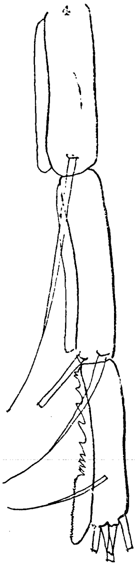

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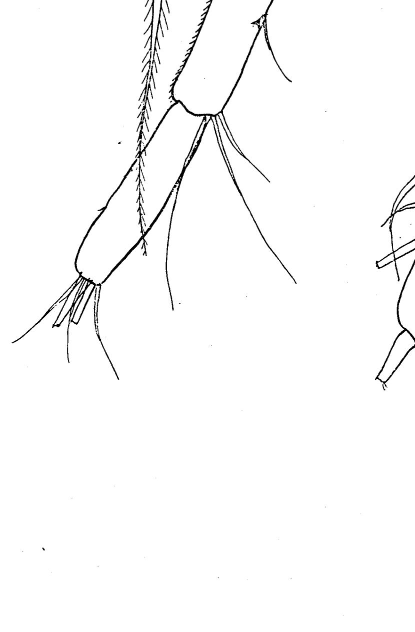

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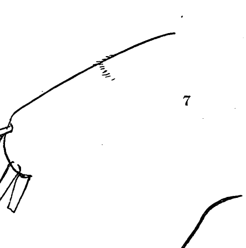

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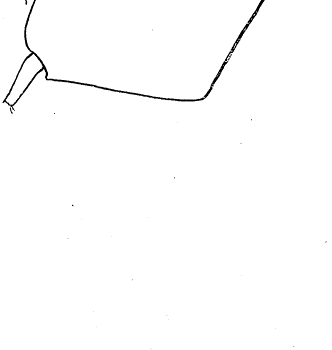

PLATE LXXVIII.

EXPLANATION OF PLATE LXXVIII.

Fig. 1. *Cyclops modestus;* female (x 103).

Fig. 2. *Cyclops modestus;* first antenna of female (x 212).

Fig. 3. *Cyclops modestus;* fifth foot (x 340).

Fig. 4. *Cyclops modestus;* abdomen of female (x 212).

Fig. 5. *Cyclops serrulatus;* fifteenth, sixteenth, and seventeenth segments of antenna of female (x 340).

Fig. 6. *Cyclops serrulatus;* abdomen of female, slender form var. *elegans* (x 103).

Fig. 7. *Cyclops serrulatus;* abdomen of female, most common form (x 103).

Fig. 8. *Cyclops serrulatus;* fifth foot (x 475).

Fig. 9. *Cyclops serrulatus;* receptaculum seminis (x 212).

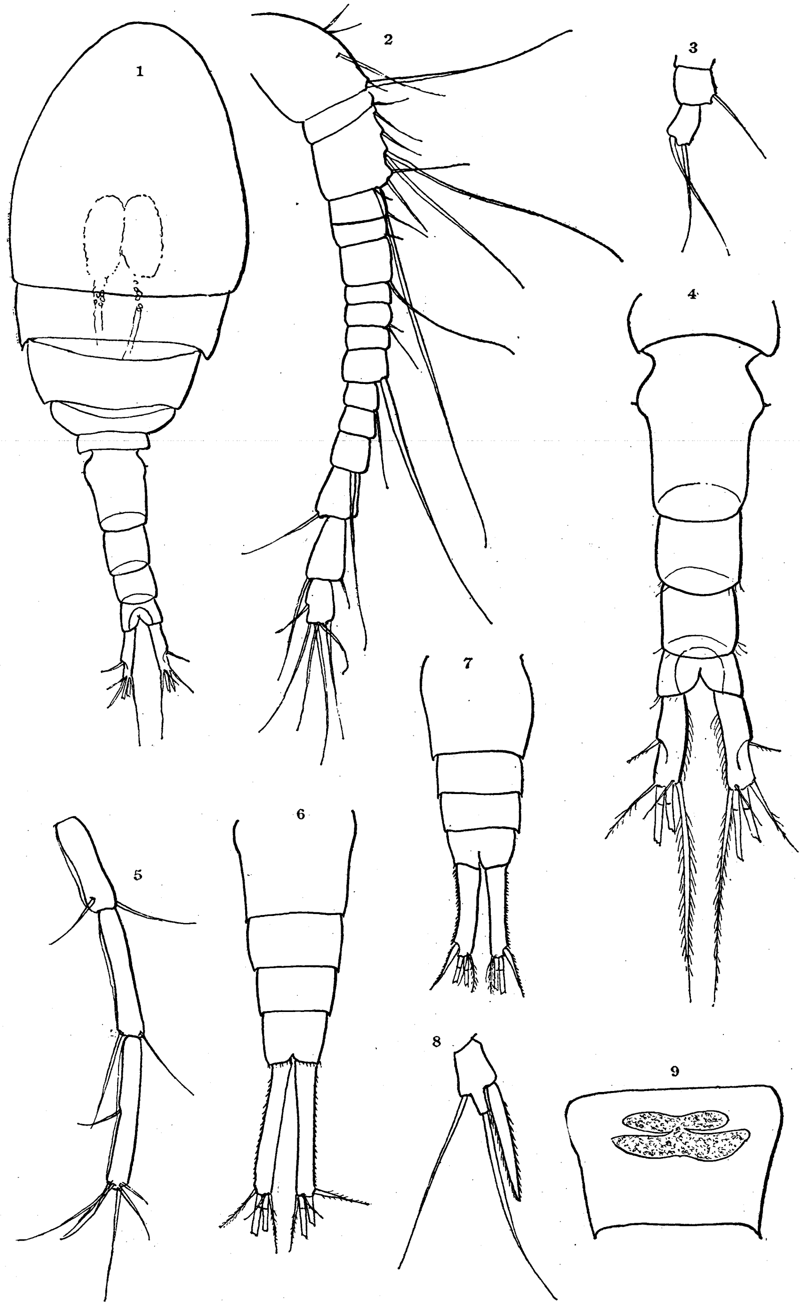
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PLATE LXXIX.

EXPLXANATION OF PLATE LXXIX.

Fig. 1. *Cyclops prasinus;* abdomen of female (x 212).
Fig. 2. *Cyclops prasinus;* first antenna of female (x 212).
Fig. 3. *Cyclops prasinus;* fourth foot (x 340).
Fig. 4. *Cyclops serrulatus;* fourth foot (x 212).
Fig. 5. *Cyclops tenuis;* fourth foot (x 212).
Fig. 6. *Cyclops viridis* var. *americanus;* abdomen of female (x 103).
Fig. 7. *Cyclops viridis* var. *brevispinosus;* abdomen of female (x 103).
Fig. 8. *Cyclops serrulatus;* female (x 103).
Fig. 9. *Cyclops phaleratus;* fifth foot (x 340).
Fig. 10. *Cyclops prasinus;* fifth foot (x 475).
Fig. 11. *Cyclops bicuspidatus* var. *navus;* abdomen of female (x 103).

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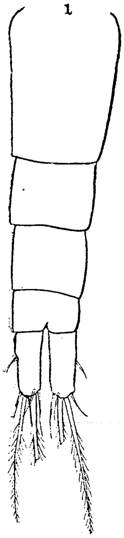

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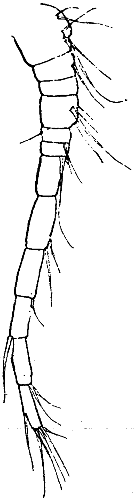

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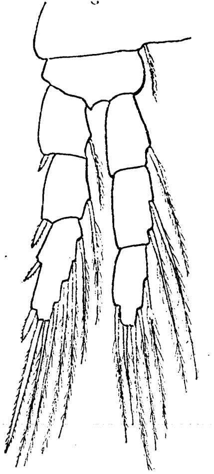

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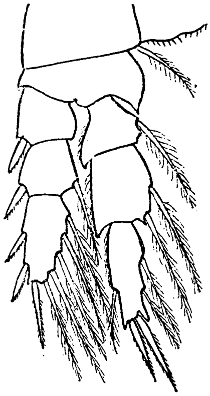

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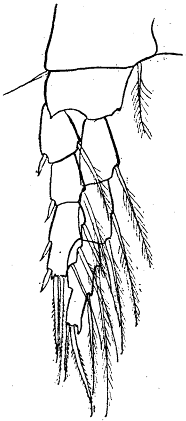

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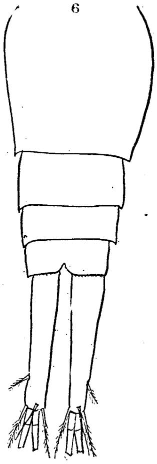

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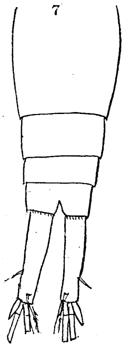

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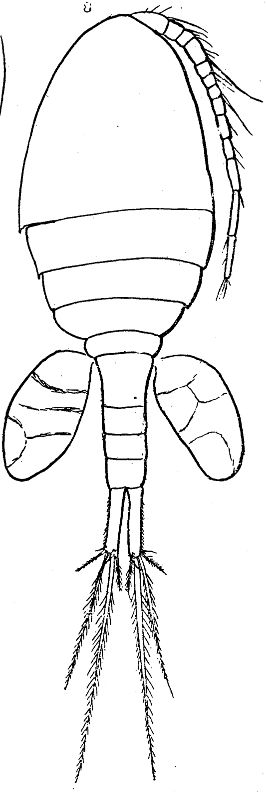

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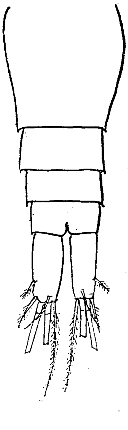

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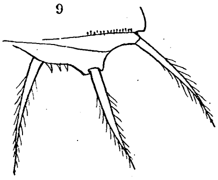

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PLATE LXXX.

EXPLANATION OF PLATE LXXX.

Fig. 1. *Cyclops phaleratus;* female (x 58).
Fig. 2. *Cyclops phaleratus;* fourth foot (x 212).
Fig. 3. *Cyclops phaleratus;* antenna of female (x 212).
Fig. 4. *Cyclops phaleratus;* second antenna of female (x 340).
Fig. 5. *Cyclops phaleratus;* receptaculum seminis (x 212).
Fig. 6. *Cyclops phaleratus;* abdomen of male (x 103).
Fig. 7. *Cyclops bicolor;* second foot (x 340).
Fig. 8. *Cyclops bicolor;* fourth foot (x 340).
Fig. 9. *Cyclops bicolor;* fifth foot (x 340).

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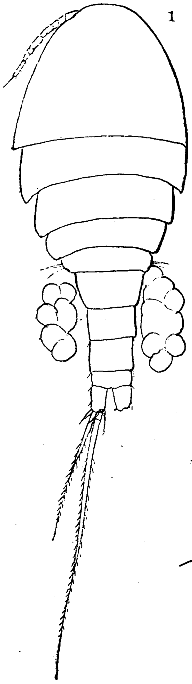

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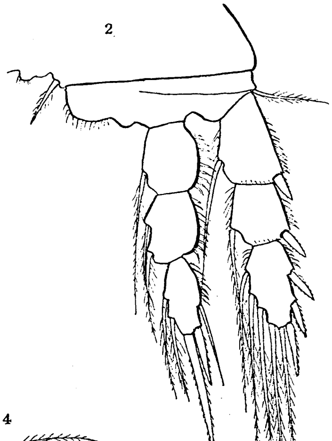

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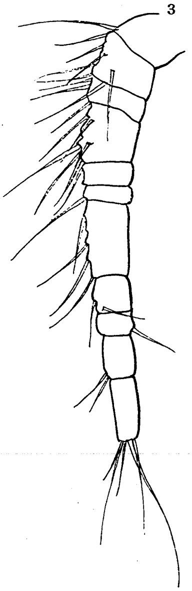

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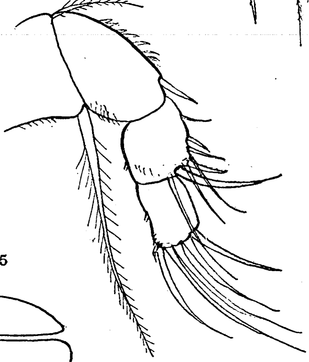

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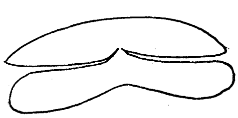

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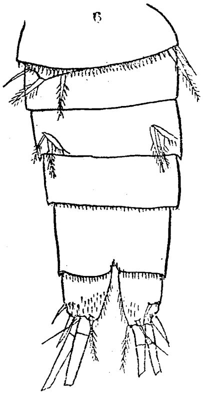

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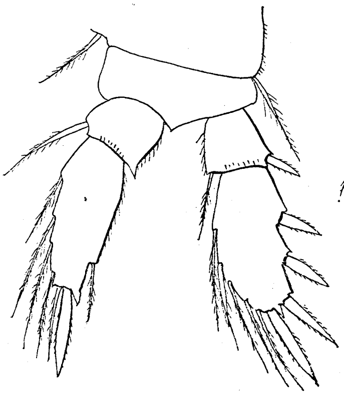

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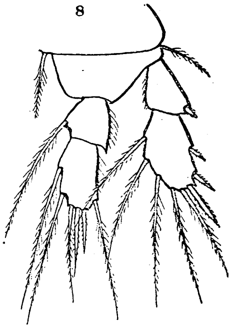

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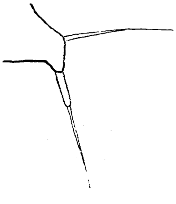

PLATE LXXXI.

EXPLANATION OF PLATE LXXXI.

Fig. 1. *Cyclops bicolor;* abdomen of female, dorsal surface (x 300).
Fig. 2. *Cyclops bicolor;* first antenna of female (x 340).
Fig. 3. *Cyclops fimbriatus;* female (x 72).
Fig. 4. *Cyclops fimbriatus;* fifth foot (x 340).
Fig. 5. *Cyclops fimbriatus;* fourth foot (x 348).
Fig. 6. *Cyclops fimbriatus;* furca (x 348).
Fig. 7. *Cyclops fimbriatus;* antenna of female (x 300).

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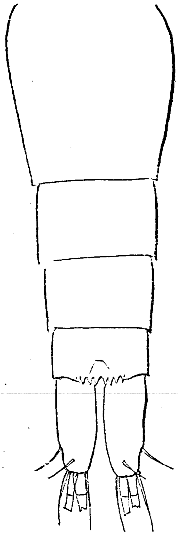

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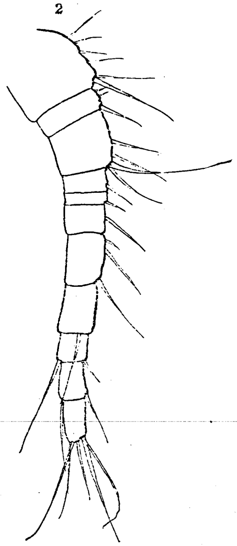

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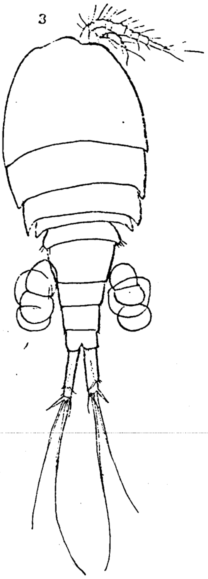

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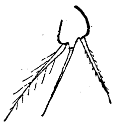

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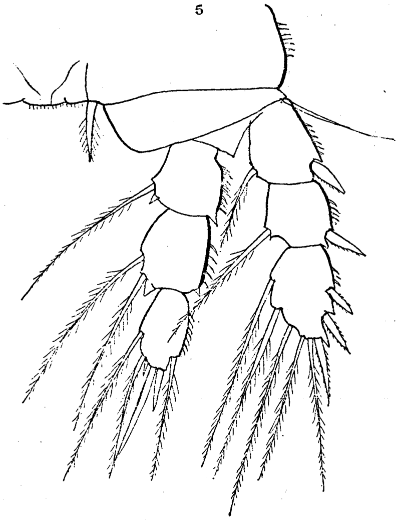

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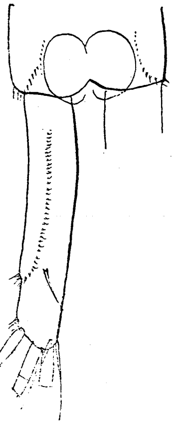

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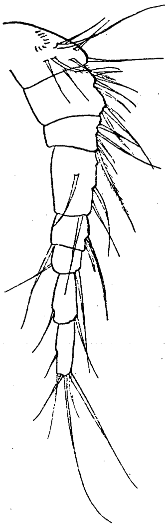

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