PART III

ANTARCTIC ROTIFERA

BY JAMES MURRAY

Among the various forms of freshwater life the Rotifera were most conspicuous. They were found among mosses and in the lakes and ponds. In the former situation they were relatively scarce, while in the lakes they were extremely abundant, and were often associated in such numbers as to affect the colour of the water.

Some sixteen species were distinguished, representing three of the recognised orders, and five or six distinct families. The predominance of the Rotifera was entirely due to the Bdelloida, of which a dozen species were found. In the other orders there were only one or two members of each family present.

Five of the Bdelloids are species previously unknown. Most of the others differ more or less from the types of their species. Only two non-Bdelloids species were recognised (*Hydatina senta* and *Diaschiza tenuior*), the others were only assigned to their genera. No Rotifera were found in the sea.

I have been able to find no record of any species of rotifers found on the Antarctic Continent or on any of the islands which, though lying outside the Antarctic Circle, possess a polar climate. The German Expedition found Rotifers on the Gaussberg, just on the Antarctic Circle (Richters, **31**); * the Swedish Expedition obtained them at Snow Hill Island, not far from the Circle (Richters, **32**), and the Scottish Expedition at the South Orkneys, a little farther north (Murray, **26**).† All of these were unrecognisable.

The only species doubtfully identified from this whole great area is *Callidina papillosa*, Thomp. (**40**). Richters found an egg in moss from the Gaussberg which resembled the egg of *C. papillosa* figured by Janson (**20**). The identification of this egg can never be certain, as there are several other Bdelloids which have similar eggs, covered with blunt processes.

To find definite records of Rotifera in the southern hemisphere we must go far

* Figures in heavy type enclosed in brackets refer to list of books at the end of the paper.

† The *Rotifer vulgaris* casually recorded in that paper must be regarded with doubt. As all the others were dead, it had probably been accidentally introduced into the bottle.

beyond the Antarctic Region. A few species have been found in Gough Island (Murray, 29), and Amsterdam Island (Richters, 31). Hilgendorf (19) has published a list of over forty species from New Zealand, in about latitude 43° S., and these are the nearest neighbours to the Antarctic Rotifers of which I can find any notice.

Order—BDELLOIDA

Family—PHILODINADÆ

Genus—*Philodina*

Philodina gregaria, sp. n. (Plate XI., Figs. 7*a*–7*e*)

Specific characters.—Large, corona large, narrower than trunk, wider than collar, space between discs wide, the rounded lobes springing from collar large, the interspace with two smaller convexities; collar very prominent, but scarcely marked off from pedicels; rostrum short and broad; antenna short; eyes large, pale brown; teeth $2^{+1}/_{1+}2$; foot of four joints, spurs slender, acute, moderately divergent, separated by broad flat interspace; viviparous; found aggregated in great numbers, forming larger or smaller patches.

Detailed description.—Size variable; smallest about $\frac{1}{60}$ inch long, in the feeding attitude (= 416 μ); longest measured $\frac{1}{31}$ inch (= 800 μ) when fully extended creeping: a fairly large example had the following measurements, diameter of corona $\frac{1}{150}$ inch (= 166 μ), of collar $\frac{1}{190}$ (inch = 132 μ), of neck $\frac{1}{235}$ inch (= 106 μ), of trunk $\frac{1}{117}$ inch (= 213 μ), length of jaw $\frac{1}{530}$ inch (= 47 μ), of spur $\frac{1}{1000}$ inch (= 25 μ). Central setæ were not detected on the discs. The very prominent collar passes insensibly into the pedicels, the junction marked only by the line of fine cilia (secondary wreath). The rostrum bears short lamellæ, a brush of active cilia, and four stout straight setæ, corresponding to the tactile setæ of *P. brevipes* (25) and some other species, but they were not seen in motion. The length of the antenna is about equal to half the diameter of the neck segment which bears it.

The brain is fairly large. Each jaw bears two strong teeth and one thin one, and in addition the usual fine striæ. There is a prominent hook at the back of the ramus. The stomach is very voluminous, and of a very bright deep ruby or crimson colour, due to the presence of coloured granules and globules. The central trunk is the broadest part of the body, and varies in size with the number of young carried. It is regularly plicate, the folds shallower on the back, deeper on the sides.

The reproduction is viviparous. Usually there are two or three young carried at a time. Whatever the number, they appear to be all at the same stage of development. At any rate they are all of the same apparent size, and after the jaws are developed they appear to be alike in all. It is very different with the genus *Rotifer*, in which

the young are obviously of very different ages, one being fully developed while another shows no detail at all. The yolk mass contains eight nuclei.

The spurs vary greatly in size, generally most closely resembling those of *P. acuticornis* (25). The interspace is relatively broader. Occasionally they are very long and apparently two-jointed. The last foot-joint is long. The ventral toes are very large, and the dorsal ones very small.

The vibratile tags are short, and broadly spindle-shaped. Three pairs have been seen.

Habitat.—In lakes and ponds at Cape Royds, Cape Barne, and at the Stranded Moraines on the west side of McMurdo Sound. It was absent from the very saline Green Lake, but was in nearly all the other waters examined. It was much the most abundant species in the district. Its abundance in Coast Lake and in the lake at the Stranded Moraines was remarkable. In winter it was got by digging out ice containing plants from the lakes. As soon as these were thawed the rotifers were found active in great plenty. In summer blood-red patches began to form on the stones at the margin of Coast Lake. These attained to a diameter of an inch. Similar patches were on the plants, but these were more difficult to detect owing to the orange-red colour of the plants. In the lake at the Stranded Moraines, Priestley reports that the patches reached to six or eight inches in diameter, and were of appreciable thickness. These patches were formed solely of *P. gregaria*, which were fixed side by side, as close as they could stand.

To obtain them a handful of weed was taken and washed in a bucket of water, being vigorously shaken in order to detach all the adherent microscopic organisms. The sediment thus obtained was strained through a coarse silk net, in order to remove the larger particles, and the fine sediment was then bottled and allowed to settle. At first it was of a dull green colour, from the preponderance of blue-green Algæ. After an hour or two a red film, like blood, appeared on the surface of the mud. The rotifers have crept out of the mud. After a time they leave the mud and creep up the sides of the bottle into the clear water above; eventually they reach the surface of the water and there form a ring of red round the bottle. They may then be collected in thousands with a brush and put into clean water. This process may be continued with one lot for days, an hour or two being sufficient time for new hosts of the endless procession to reach the surface.

Habits.—*P. gregaria* is ordinarily rather a restless animal. It is ready enough to feed, and remains fixed in one spot for a long time, but it swings about continually so that it is not easy to get a good portrait. Though normally anchoring itself, in company with its myriad neighbours, it occasionally casts off and goes swimming. In Coast Lake it was got in the tow-net, and a few might be seen if a bottle of the lake water was held up to the light. According to Priestley it was much more plentiful in the water of the lake at the Stranded Moraines.

It was particularly amenable to treatment with mild narcotics. When a very

dilute solution of Eucaine was added to the water, it at once changed both habits and appearance. It ceased its restless swaying about and went on feeding so steadily that it could easily be photographed. The circular muscles were slightly contracted, thus deepening the constrictions between the principal divisions of the body. The foot was inclined to be further retracted than in the normal condition. Otherwise there was little change in form, and the corona was quite unaltered. The effect of the narcotic was much less than on *P. laticeps*. When that species is treated with Eucaine it partially retracts the foot, expands the usually narrow central trunk, and reduces the width of the corona, in fact it so completely alters its proportions that it is not recognisable for the same species, and might be mistaken for some species of the central group (*P. citrina*, *P. brevipes*, &c.) unless particular attention were paid to the spurs.

Affinities.—*P. gregaria* belongs to the central group of the genus, possessing eyes and tapering spurs of moderate size. There is nothing distinctive in the general form. The viviparous reproduction distinguishes it from all the species of that group. The red colour is differently distributed from that of *P. roseola*, in which the red is diffused. In this species it is limited to the stomach. The slender spurs, with broad interspace, are like those of *P. laticeps* and *P. acuticornis*. The short antenna separates it from both. It is of larger size than any of the other species in the central group, except perhaps *P. citrina*.

The large size, red stomach, viviparous reproduction, and slender spurs set far apart, will distinguish it from all known species of *Philodina*. The absence of a groove between the prominent collar and the pedicels is also a good character.

Natural history.—As the dominant species in the lakes of Cape Royds the natural history of *P. gregaria* received a good deal of attention, and many experiments were made to elucidate it. These will not be detailed here, but a short summary of the facts will be given.* Its extraordinary abundance must indicate that it is possessed of great powers of resistance to all the adverse influences which would be supposed to attend upon it in such a rigorous climate, or else that it is of remarkable fecundity. It appears to triumph in both ways.

It is perhaps inaccurate to call it "gregarious." It is found in large "flocks," but it is doubtful if they ever "flocked" together. The great crowds in which they occur appear to arise from the rapidity with which they reproduce themselves. Several young, probably sometimes as many as six or eight, are produced at a time, and they seem to stay and fix themselves where they are born. Thus the patches increase till they reach inches in diameter, and as there is not foothold for all, they stand on one another's heads (so to speak) till a layer of measurable thickness is produced.

They withstood all the tests applied to *Adineta grandis* except the heating, which was not tried on them. They are normally frozen in the ice of the lakes for the greater part of the year, and revive at any time that the ice is thawed. When dried and exposed to the lowest air temperatures for a long time, they were not killed, nor

* The detailed account of the observations and experiments will be found in a paper on "Life under Polar Conditions," in a later number of this series of Reports.

did they die when alternately thawed and refrozen at weekly intervals for several months. They lived for a month in sea-water and in a much more saline solution, and became active again immediately on being transferred to fresh water. They were dried while in the Antarctic by exposing to the air till all the ice passed off by ablation, and were then conveyed by a long voyage through the tropics to England, where they revived within an hour of being moistened and could be seen alive in London a year after they were collected.

In England they were subjected to a temperature of −78° Cent. for many hours, by Mr. J. H. Priestley, of Bristol, and survived.

Philodina antarctica, sp. n. (Plate X., Figs. 5*a*–5*c*)

Specific characters.—Large, elongate: corona of moderate breadth, wider than the prominent collar, discs with central papillæ, each bearing several fine setæ; antenna long: teeth 2/2: foot four-jointed, long, slender; spurs with broad triangular basal portion, and narrow apical portion of about equal length (Fig. 5*b*); last joint of foot short, dorsal toes nearly as large as the ventral ones: pale brown eyes.

Detailed description.—The size is variable. The shortest measured was 380 μ in length, in the feeding attitude, and with the foot well drawn in. The longest measured 714 μ, fully extended, creeping. In a large example the diameter of the corona was 96 μ, of the collar 73 μ, of the neck 60 μ, of the trunk 106 μ: the length of the spur was 30 μ.

The stomach is of a deep ruby-red colour, the anterior part of the body of a faint brown, and the foot clear and hyaline. The longitudinal folds of the trunk are deep at the sides and shallow on the back. The discs are separated by a space equal to half the diameter of a disc. Into this come the low rounded lobes terminating the collar. They are slightly separated, and the part between is convex. The collar appears two-lobed in dorsal view, and is distinctly marked off from the pedicels. The rostrum is short and broad. The length of the antenna is equal to the diameter of the neck segment bearing it. The reproduction is unknown. Neither eggs nor embryos were ever seen. The yolk mass has the eight nuclei usual in the order. The vibratile tags were not detected.

It was an extremely difficult animal to study, on account of its restless disposition. It went wriggling and twisting and creeping about, often stopping to feed for a moment, but never still. There were no narcotics available when it was first found in considerable numbers, and it afterwards proved to be a rare species, and very uncertain in its occurrence. For this reason no photographs were obtained, and no specimens could be preserved.

Habitat.—Among plants in the ice of several lakes at Cape Royds and Cape Barne. It was never got except by thawing the ice of the lakes. Most of the lakes in which it lived did not melt in either of the two summers we spent in the district.

Affinities.—Belonging also to the central group of species, there is little in its general proportions and characters to distinguish it from several other species. It is more

elongate than most of them, and in that respect comes nearest to *P. erythrophthalma* Ehr. (15). The characteristic spurs, consisting of a narrow blunt apical portion springing abruptly from a broad conical base, will separate it from that and all other known species when well developed. Sometimes the narrow part is considerably reduced. No other member of the genus has such spurs, but very similar spurs, differing only in being sharper pointed, are possessed by *Callidina hexodonta*, Bergendal (3), formerly regarded (from the possession of cervical eyes) as belonging to the genus *Philodina*.

The slender foot, which can be elongated much more than the drawing (Fig. 5*a*) shows, the lack of interspace between the spurs, and the deep red stomach are also good characters.

Philodina alata, sp. n. (Plate X., Figs. 4*a*–4*f*)

Specific characters.—Size moderate: corona broad, diameter about equal to that of the trunk (exclusive of the processes) in ordinary extension; collar inconspicuous, the lobes going to the upper lip not reaching beyond the line of the bridge joining the pedicels: interspace between discs equal to diameter of disc; central setæ on discs: teeth 2/2: trunk plicate, bearing two large rounded lateral processes (one on each side) a little way in front of the widest part of the central segments: rump short, with a rounded boss in the middle of the preanal segment: foot short, four-jointed, spurs diverging, tapering, conical, rather blunt. Eyes brown.

General description.—Length 300 μ, in the feeding attitude. The stomach is of the same deep red as in *P. gregaria*, the colour being seated in small granules and globules. The rostrum is short and rather narrow. The length of the antenna is about equal to the diameter of the neck. On the fairly large brain are seated the pale brown eyes. The jaws are rather small, and bear two teeth each. The trunk is regularly plicate, the dorsal folds being wider and shallower than the lateral ones. The trunk is sometimes decidedly viscous, and has extraneous matter adhering to it, but this is not always so. It is sometimes quite clear.

The lateral processes are not thickenings, like most of the trunk processes of Bdelloids. They are large, hollow, approximately conical protuberances, with skin no thicker than that of the trunk, unless at the extreme apex, where it is a little thicker. They are controlled by special muscles, by which the apex may be more or less pulled in and inverted, making the form truncate, as shown in Fig. 4*a*. Sometimes, when creeping or feeding, the processes are so far inverted that they are scarcely visible in dorsal view, but this is not always the case, as shown in Fig. 4*c*, where they are fully extended when the animal is creeping. In complete contraction of the animal they have their greatest projection, and are then more directed forward than at any other times.

No suggestion as to the function of these curious processes has been offered. In other Bdelloids having warts on the body they are supposed to have a defensive

function. It can hardly be so with *P. alata*, as the processes are, from their form, more vulnerable than the trunk wall would be.

The boss on the preanal segment is of another nature. It is a thickening, and may have a protective function.

The vibratile tags are short and somewhat broadly spindle-shaped (Fig. 4*e*).

Habitat.—Among weeds from the Narrows between the two portions of Blue Lake, pretty numerous, March 27, 1908. Afterwards found in several lakes at Cape Royds and Cape Barne, always scarce and uncertain. A few could usually be got when wanted from the Narrows of Blue Lake.

It was living, among scraps of weed, at a depth of 11 feet in Blue Lake.

Habits.—A quiet animal and slow in its movements. When feeding, which it rarely did, it could be easily studied. Under the influence of a narcotic (Eucaine) it behaved in a very unsatisfactory manner. It kept the corona expanded and continued feeding, but contorted itself till it was not recognisable except by the side processes. No good photographs of it could be obtained, but under pressure some were made which showed the internal structure and the characteristic processes.

Affinities.—*P. alata*, like the other two Antarctic members of the genus, belongs to the central group of species. The lateral processes, which are unique in the order, serve to distinguish it from all other *Philodinæ* and Bdelloids. The boss on the preanal is an uncommon character. Without these processes it would be very difficult to characterise.

Philodina, sp. (Plate X., Fig. 6)

Description.—Size moderate. Corona narrow, about equalling the prominent collar, and less than the trunk. Upper lip with two rounded lobes meeting in the middle line. Two pale or colourless eyes. Teeth 2/2. Foot short (number of joints ?); spurs broad short cones slightly diverging and with no interspace.

This species, which is undoubtedly distinct from all the other Antarctic species, was only once seen, and is insufficiently studied. The form of the upper lip and spurs are like those of *P. plena* (4). There is little to separate it from that species except the possession of eyes. It is doubtful if the presence or absence of eyes constitute characters of even specific value, as several species are variable in this respect (*P. rugosa*, *P. macrostyla*, &c.).

It had not the red stomach of nearly all the Antarctic Bdelloids, but that might merely indicate youth.

Habitat.—Among weed from the Narrows of Blue Lake.

Genus—*Callidina*

Note.—The genus *Callidina* contains a host of species, many of them not at all closely related, and offering material for many genera. *C. constricta* and *C. angularis*

in our list should be in a different genus from *C. habita*. As the whole order requires revision by a competent authority,* the old names are retained here.

Callidina constricta, Duj. (14) (Plate XII., Figs. 13*a*, 13*b*)

Dujardin's meagre description would fit equally well a considerable number of those *Callidinæ* which mould the food into pellets, and which are distinguished from one another by characters requiring more careful examination than the Bdelloids usually receive. The commonest of those species which have numerous teeth on the jaws, the corona somewhat less in diameter than the widest part of the head, the discs close together, and the spurs short divergent cones, may be taken as the type of *C. constricta*.

To establish *C. constricta*, Duj., and *C. elegans*, Ehr. (15), and to distinguish them from the numerous related species, it would be necessary that both should be re-described by a competent authority. Janson (20) briefly describes them, but scarcely with the detail necessary to firmly establish them, neglecting, for example, the form of the upper lip, a character of the utmost importance in all Philodinadæ. Janson gives *C. constricta* as having fewer teeth than *C. elegans* (8/8 instead of 10 or 11) and a shorter jaw. There is nothing so difficult as to make certain of the number of teeth in those pellet-making *Callidinæ* which have many teeth. They can be clearly enough seen, but the anterior ones are usually thickest, and the others diminish successively till they cannot be distinguished from the fine striæ which are found on the rami of all Bdelloids. Very commonly there are four strong teeth, the fourth (counting from the anterior end) much thinner than the first; then there is an abrupt transition to finer teeth which are still thicker than the striæ, but merge gradually into them.

The Cape Royds *Callidina*, which I identify as *C. constricta* (*see* Plate XII., Fig. 13), is a small animal, about $\frac{1}{100}$ inch in length (250 μ). It is not much enlarged in the central trunk, which is faintly plicate and not obviously stippled. The small discs are touching, and the whole diameter of the corona is distinctly less than the widest part of the head. The jaws are long and narrow, and each bears four distinct teeth, diminishing in thickness backwards, succeeded by finer teeth which continue to diminish in thickness to the posterior end of the jaw. The rump is clearly marked off from the central trunk, but its two segments are only seen as the animal extends itself in creeping. The foot is short, of three joints, and the spurs are very short, quickly tapering, and widely divergent.

Habits.—It is a quiet sedate animal, moving steadily and readily feeding. It often swims free, rotating on its long axis.

Habitat.—In most of the lakes at Cape Royds. Common, but not abundant. It is one of the two Bdelloids found in Green Lake.

Eggs.—In company with *C. constricta* two different forms of egg have been

* Mr. D. Bryce is at present engaged on such a revision.

found, which may belong to this species or to *C. angularis* (Plate XII., Figs. 12*c*–12*d*). Each of these eggs was found with the jaws of the contained young so well grown that the numerous teeth could be seen. As there are only the two species known at Cape Royds which have many teeth, it is practically certain that these eggs belong to them, but as they were never found in the bodies of the rotifers it cannot be determined to which each belongs.

Callidina angularis, sp. n. (Plate XII., Figs. 12*a*–12*d*)

Specific characters.—Small, yellow, much widest in central trunk; strongly nodose from the lateral projection of certain segments, from the neck to the preanal: trunk strongly plicate, and stippled (except head, neck, and foot). The head is widest at the cheeks, and the corona is distinctly smaller, and about equal in diameter to the neck. Rump narrower than the fourth central segment, its two segments distinct. Foot short, of three segments. Spurs small, divergent, acuminate and acute. Food moulded into pellets. Jaws narrow, teeth many.

General description.—Length when feeding about $\frac{1}{100}$ inch, rather greater when creeping. The diameter of the corona is about $\frac{1}{500}$ inch (50 μ), and of the widest part of the trunk about $\frac{1}{250}$ inch (100 μ). The rostrum is short and broad and the antenna short. There are from eight to ten teeth in each jaw, and they diminish rapidly in thickness towards the posterior end of the jaw. The anterior edges of the three segments succeeding the neck are strongly produced outward, giving a nodose appearance to the anterior trunk. The mid-trunk is also laterally produced into an angle. The fourth central and preanal segments are also produced at their posterior edges. The trunk has few broad clearly marked folds. The preanal has two folds near the middle line. The three toes are short and obscure.

The upper lip is a somewhat triangular area. The central portion forms a pointed arch, or may be rounded or slightly cleft. The collar is very inconspicuous. The voluminous stomach is red or brown or pale yellow. The pellets are very obscure.

Habitat.—In most of the lakes at Cape Royds.

Reproduction.—The absence of living young makes it practically certain that the species is oviparous. Associated with it were eggs (already referred to under *C. constricta*) which could only belong to one of these species.

Affinities.—*C. angularis* is undoubtedly derived from *C. constricta*. There are so many points in common that they were for long considered to be identical. The outline of a Bdelloid rotifer can vary so much during the different movements that it was considered inadvisable to put much importance on the angular outline of this species. It was only when the peculiar form was found to be always associated with a stippled skin that it came to be regarded as distinct from *C. constricta*.

Eggs.—As to the eggs of this species, *see* remarks under *C. constricta*.

Callidina habita, Bryce (4) Variety (Plate XI., Figs. 8*a*–8*e*)

Description.—Large, stout, hyaline or yellowish, much widest in central trunk, which is plicate with broad folds. Length when feeding, up to 570 μ, diameter of trunk 125 μ and upwards, of corona 95 μ. The corona is much wider than the collar, and that is much wider than the neck. The discs are large and bear central setæ. They are separated by a space equal to half the diameter of the disc. The collar is prominent and appears two-lobed in dorsal view. It is continued on to the upper lip as two large rounded lobes which meet in the middle line.

The rostrum is stout, and the lamellæ appear to be quite separated. The antenna is equal to one-third the diameter of the neck. The jaws are large and have a thickened border, sometimes coloured brown. The teeth are two in each jaw, witha thinner one.

The voluminous stomach is of a deep crimson colour, and the walls are filled with larger and smaller globules. The yolk-mass contains eight nuclei. The two segments of the rump are obscurely distinguishable. The foot is four-jointed, but there is often difficulty in making out more than three. The spurs are stout, almost cylindrical, quickly tapering to the acute points, divergent. The first foot-joint has a thickening forming a more or less distinct boss.

The egg is elliptical and is produced at each pole into a rounded prominence (Fig. 8*d*).

This variety, which is typical in every other respect, differs conspicuously in the form of the spurs. Those of the type are broad and very acuminate, the lower edge making an ogee curve. The highly coloured stomach is an important feature, but it cannot be considered of much specific value.

Another variety.—Rather smaller, the two lobes of the upper lip less distinct, separated only by a small notch. Spurs in form like the type, but smaller, and the curvature of the lower edge less marked. The foot-boss more distinct. Otherwise like the type (Plate XI., Fig. 8*b*).

Both forms were fairly common in most of the lakes at Cape Royds. They did not occur in Green Lake. In Blue Lake at a depth of fifteen feet.

Family—Adinetadæ

Genus—*Adineta*

The genus *Adineta*, the only one yet described in the family, is a small one. It contains at present some eight recognised species. It is better represented in the Antarctic Region than any of the other genera of Bdelloids.

Five species were recognised, of which one (*A. grandis*) is new to science.

None of them, except *A. grandis*, is very common. That species swarms in numbers only inferior to those of *Philodina gregaria*.

Adineta grandis, sp. n. (Plate XII., Figs. 10*a*–10*d*)

Specific characters.—Very large, stout, rostrum philodinoid, with lamellæ and brush of cilia as in *Philodina;* posterior margin of mouth pectinate: spurs short broad cones, separated by straight interspace, reproduction viviparous.

Detailed description.—Large examples measure 750 μ in length. The colour is light brown or yellowish, darker in the alimentary tract. It has the graceful form usual in the genus, very broad in the central region of the trunk and tapering to narrow extremities. The trunk is regularly, and not very deeply, plicate. The neck is slightly constricted below the head, then there is an expansion at the normal level of the mastax.

The head is ovate, and rounded in front. The rostrum is short and stout, and is quite like that of a typical philodine, except that it is not retractile. In ventral view the lamellæ, which are relatively smaller than is usual in the genus, appear to meet in the middle line. Beneath them is the brush of cilia, looking as they do in a philodine when contracted, but the tip was never seen everted so as to make the brush project. On each side, close to the edge of the lamellæ, is a longer cilium, moving like the tactile setæ occurring in the same situation in *Philodina macrostyla*, &c. Only one could be distinguished at each side. The antenna is short and broad.

The pectinate part of the mouth appears to be a fold within the margin proper. The processes are flat plates, with the spaces between about equal to the thickness of the plates. They are rounded at the ends. The number varies from six to ten on each side. At the inner end of each series the terminal process is drawn out into a longer narrow rod, which appears to be attached to the flat surface of the corona. The furred surface is uninterrupted from side to side, but at the anterior end a tooth-like process projects backwards in the median line. The jaws are normal, with the usual two teeth on each.

The stomach is large and of a warm brown colour. The intestine is elliptical. The two segments can be distinguished in the rump, which tapers gradually in line with the stout four-jointed foot. The spurs are stout and subacute. They diverge widely and are separated by an interspace about equal to the diameter of the spur at its base. The terminal joint of the foot is of moderate length and the three toes are small and short.

The stoutness of the trunk varies greatly according to the number of young carried, and their degree of development. It becomes enormous when it contains six or seven young almost full-grown. The largest number observed was seven, but the usual number was three. It was noticed that when the young were well enough

grown to show definite structures (such as the teeth) all of them were in the same degree of advancement, as far as could be perceived. This is different from what is the case in the genus *Rotifer*, in which all the species are viviparous. There the two or three embryos are at different stages. The yolk-mass, which could rarely be seen, contained eight nuclei. On one occasion (March 27, 1908) a yolk-mass was seen divided up into six portions, each containing a nucleus, no doubt a brood at an early stage. Three pairs of narrow spindle-shaped vibratile tags have been seen.

Habits.—*A. grandis* has not the restlessness which is characteristic of the genus. It is sufficiently active, but it creeps steadily, and "right side up," like many of the Philodinadæ, and can therefore be more easily studied. It feeds on minute organic particles, among which there is rarely any recognisable organism.

Habitat.—Among the brown vegetation in the lakes at Cape Royds. It was the most generally distributed of all the Antarctic rotifers, and occurred in saline lakes from which most of the other species were absent.

Natural history.—A detailed study of *Adineta grandis* will be made in another paper.* A summary of the ascertained facts will be here given. The species is the only rival to *Philodina gregaria* in abundance, and in this connection it is important to note that it shares with it the viviparous mode of reproduction. It is found in a greater number of lakes than *P. gregaria*, but it never appears to be in such prodigious numbers. This may be due merely to its less conspicious colouring, which is almost identical with that of the plant on which it lives.

It is not extremely abundant in the freshwater lakes, where it has many competitors, but in the very saline Green Lake, from which all the other species but *Callidina constricta* are absent, it is almost as abundant as *P. gregaria* is in Coast Lake, and may be collected in the same way. When the fine debris washed from the weed of Green Lake is allowed to stand undisturbed for some hours a pale brown layer appears on the surface. This may be taken up by the pipette and is found to be pure *Adineta grandis*, without admixture of other organisms. The rotifer has crept out of the mud to the surface. This habit allows quantities to be got for study and makes it easy to make simple experiments upon them. It did not usually creep up the sides of the bottle, as *P. gregaria* does, but on one occasion, when a moderate number were mixed with that species, they also crept to the surface of the water. They could be obtained at any time during the winter by melting some ice from Green Lake enclosing some of the brown weed. They usually began to move as soon as released.

In its power to endure extreme changes of temperature and other adverse conditions, *Adineta grandis* is the most interesting of the Antarctic rotifers. From its large size and great abundance, it was the species selected for most of the experiments made with the object of finding the limits to the vitality of Rotifers. It survived the lowest temperatures experienced at Cape Royds (– 40° F.), and repeated

* On "Life under Polar Conditions."

freezing and thawing. It was the only species subjected to the heating experiment, in which a proportion of them lived after the bottle containing them (in the dry condition) was immersed in boiling water for a short time. It was one of the rotifers which was to be seen alive and active in London in September 1909, after being dry for about a year, and spending some months in tropical and subtropical climates. It revived in about an hour after being moistened. It was immersed in sea-water, and in the much more saline fluid obtained from under the ice of Green Lake (of which it is a native), and kept there for one month, after which it revived quickly when transferred to fresh water. The diameter of the contracted animal in fresh water was 225 μ—in the brine of Green Lake it contracted to 150 μ, or two-thirds of the normal diameter.

It is indifferent to the interruption of its active vital functions by freezing, often for long periods, and quickly resumes activity when thawed. The development of the young likewise does not appear to suffer from its interruption at any stage. In consequence of interruption development may often take many years for its completion, but in the periods when the lakes are melted it probably only occupies a few days, and many generations may be completed in the few weeks of summer.

Affinities.—A. grandis shows most resemblance to *A. vaga* Davis (12). The pectinate margin to the mouth is a character which may readily be overlooked in species of this genus, as the structures of the head of an *Adineta* are very difficult to see, on account of the restless contortions of the animal. The pectinate border is easily seen in *A. grandis* owing to its large size.

The species may be a derivative of *A. vaga*, but of very long standing, as the profound changes show. A different mode of reproduction has been adopted, and the form of spurs and rostrum, &c., changed. The ciliated surface of the face of *A. vaga* is described as divided into two parts by an unciliated band. This is not the case with *A. grandis*, in which there is no perceptible interruption of the furred surface from side to side.

Adineta barbata, Janson? (20) (Plate XII., Figs. 9*a*–9*c*)

Description.—Of moderate size. Head ovate; rostral tip produced laterally into little sharp points; lamellæ long, slender, curved, rounded, accompanied by several long bristles; spurs divergent, curved, tapering, acuminate.

While corresponding in general to the type of *A. barbata*, the animal found at Cape Royds differs in two particulars: the spurs taper from the base and are acuminate; in the type the thickness is maintained to near the tip, and the tapering is then abrupt; the processes on the rostrum which correspond to the lamellæ of the Philodinadæ are very long and slender, and in dorsal view look like antennæ of insects.

Janson does not describe the lamellæ as of this narrow elongate form, and his figure shows them quite moderate. The difference is of specific value, but as the

Antarctic species was not at the time studied critically enough, and the knowledge of the peculiar lamellæ is only gathered from my sketches, I prefer to leave it meanwhile as a form of *A. barbata*, to which it appears to be closely related.

The pectinate border of the mouth was difficult to see, owing to the restless movements of the animal, but it was clearly seen in a well-grown young in the egg (Fig. 9*c*).

The first eggs found confirmed the belief that the animal is distinct from *A. barbata*. They were elliptical, and lacked the knobs characteristic of the egg of *A. barbata*. Later on a different egg was found, which had the knobs as in *A. barbata*, but much reduced in size (Fig. 9*c*).

Adineta vaga, Davis (12)

The type of this species (which is the var. *minor* of Bryce) was found in several lakes soon after we landed at Cape Royds. It was not seen later, and was thus never subjected to a very critical examination.

Habitat.—Blue Lake, Clear Lake, and Coast Lake.

Adineta gracilis, Janson (20)

Habitat.—Blue Lake, Clear Lake, and a little pond on the lower slopes of Mount Erebus. The examples appeared to be quite typical.

Adineta longicornis, Murray? (27)

Description.—Small, head ovate, rostral part divided into two large, evenly rounded lobes. The spurs are long, slightly divergent, and taper to acute points.

Habitat.—Among moss from the High Moraines, Cape Royds, January 1909, one example seen.

It is with hesitation that this animal is referred to *A. longicornis*. The spurs are shorter than in the type, and the head is of slightly different shape. As the rostral structures were not clearly made out, it cannot be confidently separated from that species.

NOTE

Additional Species.—In April 1910, just as we go to press, an additional Bdelloid has been found alive, in moss collected by Priestley at the Stranded Moraines. It is a pellet-maker having three teeth in each jaw, and may be identified as *Callidina* (*Macrotrachela*) *tridens*, Milne. That species is very similar to *C. constricta*, except in the very distinct teeth. A more detailed description of it is wanted.

This addition, with the identification of the *Floscularia* as *F. cornuta*, brings up the list of recognised Antarctic Rotifera to 16 species.

Order—RHIZOTA

Family—Flosculariadæ

Genus—*Floscularia*

Floscularia, sp. (Plate XIII., Fig. 15) *

On January 18, 1909, among weed from a pond between Cape Barne and Cape Royds, a species of *Floscularia* was found in some abundance. When examined after reaching the hut they were moving languidly and showing an inclination to expand. The long setæ, which exceeded the trunk in length, projected as a long brush. The lobes were not unfolded, and there was little time to wait for it.

Although there is no hope of identifying the species, a sketch of it in the partly contracted condition is given, in order to complete our records of the rotifera of the region.

In this state the length, exclusive of the setæ, was 284 μ. The foot is transversely wrinkled in the usual manner, and terminates in a conical portion, tapering to a narrow apex (probably the adhesive disc unattached at the time).

Neither tube nor eggs were observed. The teeth and the various viscera were seen, but detailed studies under pressure could not be made.

Order—PLOÏMA

Family—Hydatinadæ

Genus—*Hydatina*

Hydatina senta, Ehr. (Photograph from life. Plate II., Fig. 7)

No description need be given, as the Antarctic examples appear to be quite typical. The species was identified with certainty by Mr. Rousselet from preserved examples. It was found in great abundance in Coast Lake when it was tow-netted for the first time on January 2, 1909. It might have been found much earlier if the lake had been examined in a suitable manner, as there was some open water from the end of November 1908, and the temperature of the water, as early as December 4, was +47° Fahr. When the *Hydatina* was first found the temperature had gone down to +40°. On January 18, 1909, the temperature had gone up again to +45°, and the *Hydatina* was much less plentiful.

Large oval smooth brown eggs were known, which proved to be those of *Hydatina*.

Under the influence of Eucaine *Hydatina* behaved well, retaining the normal form

* An example having the corona fully expanded has since been found, which allows of its identification as *F. cornuta*, Dobie.

perfectly, but remaining so still that it could easily be photographed while living and feeding.

Hydatina was only seen in Coast Lake. Its restriction to one lake led Mr. Rousselet to suggest the possibility of its recent introduction, say by the *Discovery* Expedition. It is not impossible, though hardly probable. *Hydatina* is a common animal in ponds around farmhouses, and eggs might readily enough adhere to farm produce such as hay or straw. When Captain Scott and Dr. Wilson camped for a short time at Cape Royds, close by the spot where we afterwards had our hut, they may have had some straw packing among their gear. In this connection it is worth noting that we dredged in Back-door Bay a stalk of old sodden straw on which a sponge had grown. This straw could hardly be of older date than the *Discovery* Expedition. Against the theory of the recent origin of *Hydatina* is the fact that Coast Lake is a mile from Captain Scott's camp, and that several suitable lakes lie nearer the camp. Still, one egg is enough for the introduction, and the straw bearing the one egg may have blown to Coast Lake.

Family—Notommatadæ

Genus—*Pleurotrocha*

Pleurotrocha, sp. ? (Plate XIII., Figs. 14*a*–14*c*)

Description.—Of large size, 520 μ in length. In lateral view greatly elevated just behind the middle of the trunk. Head long, mouth narrow. Jaws very like those of *P. grandis*, Western, and some related species. Toes longer than those of *P. grandis*. Stomach large, orange-coloured.

This large active animal was found in Blue Lake early in the season, before the requisites for narcotising and preserving were available. It was fairly abundant then but was not obtainable afterwards, when it could have been photographed and preserved. We are therefore dependent for our knowledge of the animal on a few sketches by one little acquainted with the order to which it belongs. Mr. Rousselet has examined the sketches critically, taking such points as could be best trusted, and compared them with the same points in the species coming nearest to our one.

It is undoubtedly very near *P. grandis* (41), which is like it in size and activity. The jaws differ in being more ovoid in form, diminishing backward from the widest part. In *P. grandis* the greatest width is maintained for some distance backward. The toes are considerably longer and narrower than in *P. grandis*. The general outline of the jaws is very similar to that of *Diglena permollis*, Gosse (16), as shown in a drawing by Mr. Dixon-Nuttall.

Reproduction.—Two kinds of egg have been seen which contained animals having jaws exactly like those of the *Pleurotrocha* (the drawing, Fig. 14*c*, is made from an example in an egg). One of the eggs was elliptical and smooth. The other was

also elliptical but was thicker shelled, and was covered with little points projecting from the surface (Fig. 14*b*).

Genus—*Diaschiza*

Diaschiza tenuior, Gosse? (17) (Plate XIII., Figs. 16*a*–16*f*)

Of the species described in Dixon-Nuttall and Freeman's Monograph of the genus (13) the Antarctic *Diaschiza* can only be *D. tenuior*. It differs only in being somewhat laterally compressed, and in carrying the toes more ventrally than usual. The length of the toes easily separate it from *D. cæca*, Gosse.

With it was associated a much smaller animal, which may be the male of the same species (Figs. 14*c*–14*d*). It has a large head and comparatively insignificant body. The corona has the large strong cilia common to most males, and it swam powerfully. The dorsal cleft is seen on the trunk. The segment between the trunk and the toes is well marked. The toes are small, conical, divergent and decurved. Unlike most males it possesses teeth. The male organs were not definitely seen, nor were any viscera distinguished.

In the female the setæ at the base of the toes were not made out, but we were working with very poor light.

The elliptical, smooth, thin-shelled egg was seen, containing the young. A smaller egg, with thick shell, through which obscure lines passed obliquely in various directions (Fig. 16*f*), contained an animal with jaws like those of the supposed male.

Remarks on the Antarctic Rotifer Fauna

Its Composition.—The Rotifer Fauna of Cape Royds, comprising not much more than a fiftieth part of the known species, is very remarkable in its composition. When the number of species is so small it is curious that all the orders of Rotifera are represented [the Scirtopoda being, as a result of Beauchamp's studies (2), reduced from ordinal rank].

The great preponderance of the small order Bdelloida (with twelve species) over the Ploïma (with four species) is not surprising in view of the well-known remarkable vitality and facility of distribution of these animals.

The proportions in which the various genera of Bdelloids occur in the fauna are very curious and interesting. The four species of *Philodina* are all unknown elsewhere. The large genus *Callidina*, which elsewhere contains half, or more than half of the species in the entire order, has only three species at Cape Royds. Two of these are known species and one is new. The small genus *Adineta*, of which only seven species have been described, has no fewer than five species at Cape Royds. Only one of these is new to science. The genus *Rotifer* is absent.

The sixteen species of Rotifera are thus distributed: eight known species, five new species, three not identified. While there are only five new species named, one of the others (*Philodina*, sp.) though not sufficiently studied to be named, is certainly new, and several of the known species differ more or less from their types, and may be incipient species resulting from long isolation in peculiar conditions.

Peculiarities.—The distinctive characters of the new species are not very remarkable. They consist in the forms and proportions of the spurs, head, upper lip, &c., or in the possession of peculiar processes (*Philodina alata*). There are no peculiar types. Development has gone on lines similar to those it might have followed in any region. The rotifers may have acquired peculiar physiological properties, enabling them to resist the rigours of the Antarctic climate, but such adaptation (if it has taken place) is not correlated with any peculiarity in outward form.

Reviewing the rotifer fauna as a whole, its most notable features are the general prevalence of red colour among the Bdelloids, and the viviparous reproduction acquired by some of them belonging to groups which are rarely viviparous.

Colour of Bdelloids.—All the *Philodinæ*, except the unnamed species, have the voluminous stomach coloured of a vivid deep crimson. This colour is shared in equal degree by *Callidina habita*. *Callidina constricta* and *C. angularis* have the stomach sometimes red, sometimes brown, and occasionally pale yellow. None of the *Adinetæ* have red stomachs. *A. grandis* has the alimentary tract of a warm brown colour, the others are pale yellow or colourless.

The prevalent red colour may be related to the nature of the food. *Callidina habita* and *C. constricta* are not normally red in other countries. All the species live among the same plants, which are of a warm orange colour, but associated with this are numerous green and blue-green Algæ, so that there is a variety of food available, and the different species may select different foods. We have no exact information as to the kinds of food actually eaten by the Antarctic species. Though they can be readily watched feeding, they rarely swallow organic matter in recognisable condition, but fine, flocculent material, the result of decomposition. Bdelloids have the power of selecting their food. A pair of knuckle-like processes in the gullet can be brought together, and these are opened or closed according as the particles swept down the funnel are acceptable or not.

There were no red-coloured rotifers in Green Lake, which was very saline. The only two Bdelloids which occurred there were *Adineta grandis* and *Callidina constricta*. *A. grandis* was never red in any lake, but in freshwater lakes *C. constricta* had sometimes a red stomach.

Reproduction.—Of the Antarctic rotifers seven are oviparous, two are viviparous, and the reproduction of the remaining seven is unknown. The genus *Rotifer*, all the members of which are viviparous, is unknown in the region.

The two viviparous species, *Philodina gregaria* and *Adineta grandis*, preponderate enormously in numbers over all the other species. This mode of reproduction

appears therefore to be best adapted to secure success in the struggle for existence under the severe conditions experienced at Cape Royds.

Dispersal.—Most of the Bdelloid Rotifers were found generally distributed among the lakes of the district. Dispersal from one to another is therefore probably easy. The most striking exception is Green Lake, where there are only two of the species. There is little doubt that the qualities of the water are responsible for the limitation in that lake, as there are other lakes close by from which rotifers might be derived.

Hydatina is only known in Coast Lake. It is the only normally free-swimming rotifer in the region, and very likely its large eggs fall to the bottom in the deeper part of the lake, and are not likely to be in the marginal zone which is exposed by the ablation of the ice. Even so it is to be expected that some eggs would get among the weeds which are thus exposed.

No rotifers were found in Pony Lake, but the proximity of the penguin rookery renders the water so foul that it would be surprising if there were rotifers in it, always excepting *Hydatina*, which frequents such situations.

There are only two probable means by which rotifers can be transferred from one lake to another. One is by the agency of birds, and the other is by means of the wind. The skua gulls are the only birds which frequent the fresh water. They are very fond of bathing, and stand in the shallow parts of the lakes, where the water is a few inches deep and the bottom usually covered with weed and rotifers, and there they splash the water about with great gusto. Fragments of weeds may adhere to their feet or may get on their feathers as the water splashes over them. The skuas may visit several ponds in the course of their flights and thus distribute the rotifers over the countryside.

At the margins of the lakes there is generally a zone of dried weed, which increases in breadth as the winter advances, as a result of the ablation of the ice surface. This zone varies in colour from brown to dull green. The weed is strongly wrinkled and very light. Pieces of it might easily be torn off by the wind and blown about the country till the next summer, when it might happen to get into another body of water. Fragments of weed were often seen blowing about. In Coast Lake the ablation of the ice exposed the weed on the bottom, which was in small flakes. Showers of these flakes were blown by the wind over the shore and out to sea.

Dispersal by the wind and conveyance from lake to lake in a small district like Cape Royds is easily understood. The prevalent strong winds in the region are all from the south, and it is therefore difficult to imagine that the plants and their living freight could be transferred in this way over long distances where there are not intermediate resting-places, except from south to north. It is, however, possible that northerly gales occur at long intervals, which would help to disperse the species in the opposite direction.

Distribution.—Of the distribution of the Rotifera in the Antarctic Region there is

nothing to be said, as there are no previous records, except the doubtful egg of *Callidina papillosa* mentioned by Richters (31). Richters gives details of the jaws and teeth of four species from the Gaussberg, and figures them, as well as other details of two of the species. These are insufficient for certain identification, though if the rotifer fauna of the Gaussberg could be studied in life we might have a good guess as to what those four were. As our knowledge at present stands we cannot connect any of them with the species found at Cape Royds, though it may be suggested that the figures five and six on his Plate XVII. may be *Callidina constricta*, which was the only moss-dwelling species identified at Cape Royds.

As the thirteen species found at Cape Royds appear to be the first recorded for the continent, we can only study the distribution over the world of those of the species which are not new to science. The distribution is most clearly seen when the facts are given in tabular form. It is not claimed that the records tabulated are complete, but I have given all which I could find.

TABLE SHOWING THE GENERAL DISTRIBUTION OF ALL RECORDED ANTARCTIC ROTIFERA.

	Antarctic.	Australasia (N. Zealand).	Europe.	Asia.	Africa.	N. America.	S. America.	Arctic.
Philodina gregaria, sp. n.	×	—	—	—	—	—	—	—
„ *antarctica*, sp. n.	×	—	—	—	—	—	—	—
„ *alata*, sp. n. .	×	—	—	—	—	—	—	—
Callidina angularis, sp. n.	×	—	—	—	—	—	—	—
Adineta grandis, sp. n. .	×	—	—	—	—	—	—	—
Callidina constricta, Duj.	×	×	×	—	×	×	×	×
„ *habita*, Bryce? .	×	×	×	×	×	×	×	×
„ *papillosa*, Thomp.	?	×	×	×	—	×	—	×
Adineta vaga, Davis . .	×	×	×	×	×	×	×	×
„ *barbata*, Janson ? .	×	×	×	—	×	×	—	×
„ *gracilis*, Janson . .	×	×	×	—	×	×	×	×
„ *longicornis*, Murray ?	×	×	—	×	×	—	—	—
Hydatina senta, Ehr. . .	×	×	×	—	×	×	?	×
Diaschiza tenuior, Gosse .	?	×	×	—	—	—	—	—

The facts made use of in the above table are compiled in part from the following sources: for the Antarctic from a paper by Richters (31): for Australasia from Hilgendorf's list (19) and from my own unpublished notes which will appear in a later number of this series: for Europe from papers by Bryce, Janson (20), and others: for Africa from a paper by Rousselet (33) and unpublished notes: for N. America from a paper by Jennings (21) and from unpublished notes: for the Arctic Region from papers by Bryce (5), Bergendal (3) and myself (28).

The new Antarctic species are placed at the top of the list in order that the other facts may be compactly grouped. The facts of distribution of the nine previously

known species are given under eight headings, being a column for each continent, for Australasia, and for the Arctic and Antarctic regions. This covers the greater part of the earth's surface, only excluding oceanic islands. It may fairly be said that an animal which occurs in all of these broad divisions is "generally distributed."

Callidina habita and *Adineta vaga* are in every column; *C. constricta*, *A. gracilis*, and *Hydatina senta* are absent from one region only; *C. papillosa* and *A. barbata* from two; *A. longicornis* from four; and *Diaschiza tenuior* from five. These facts have very little significance, as some of the regions have been very little worked.

Considered in another way the table shows that all the previously known species are also in New Zealand, all but one in Europe, all but two in Africa, N. America, and the Arctic, all but four in S. America, and all but five in Asia. For the reason given in the preceding paragraph these facts have no special significance. Were the world more fully explored we would in all probability find that all the species are ubiquitous.

The Rotifera of the southern hemisphere, from which any migrants to the Antarctic have most probably come, are very imperfectly known. In New Zealand Hilgendorf's was the only work, and in the Index Faunæ Novæ-Zealandiæ (19) he gives a list of over forty species then known. In Australia short lists were published by Anderson (1) and Shephard (34 to 37), and Whitelegge (42) in 1889 summed up the known species, giving a list of 110. In Africa there were short lists by Milne (24) and Kirkman (22 and 23). Rousselet (33) in 1905 visited S. Africa, and in his paper summarises all that was known, giving a list of 156 species. In S. America Schmarda (39) found many rotifers, but his descriptions and figures are such that most of the species are unrecognisable. Recently Daday wrote upon the Rotifera of Patagonia (9), Chile (10), and Paraguay (11). He enumerates 106 species, including some noted by Wierzejski (43). There may be isolated references to rotifers of the southern hemisphere in works other than those cited, but they comprise almost all that was known till recently.

All those lists are noticeable for the very subordinate position occupied by the Bdelloids. This is due to the fact that it was not suspected that mosses supported a very rich fauna of rotifers and other animals. Some of the early investigators of these animals, who were more interested in their physiology than in the discrimination of species, distinguished between the moss-dwellers and water-dwellers.

In papers by Thompson (40) and Bryce (6) such terms as "moss-haunting" are found in use, and in Germany also the word "Moosbewohner" [Richters (32)] is recognised. So little was the existence of the moss-fauna known among naturalists that in some of the latest expeditions the mosses were taken only as botanical specimens, and were treated with preservatives which killed the fauna.

Much work has in recent years been done on the Rotifera of all parts of the globe, from specimens procured from moss. No easier method of collecting is possible than by bringing home dried mosses; and it is to be hoped that future expeditions

will realise the desirability of collecting some moss for the sake of its fauna. The moss-fauna of rotifers consists chiefly of Bdelloids, though there are a few others which have adopted the same habitat.

Origin of the Rotifer Fauna.—In the present state of our knowledge it would be premature to discuss the origin of the Antarctic Rotifer Fauna with any expectation of arriving at definite conclusions. We know almost nothing of the geological history of Antarctica, especially of its recent glaciation; we know nothing of the distribution of the Rotifera round the fringe of the continent (the heart we may infer to be as dead as anything on earth); and our knowledge of the Rotifera of the nearest land-masses and of the scattered islands of the southern hemisphere is inadequate.

It may, however, be permitted to discuss in a tentative manner the bearing of the known facts. It may safely be assumed that the Antarctic Region has known periods of greater glaciation or of greater cold than at present, and periods of temperate or warm climate. Is it possible that the rotifer fauna is aboriginal, and has survived through the various climatic changes of long geological ages?

Judging from the summer condition of the Antarctic coast at present, it does not seem too much to suppose that during the coldest periods there might always be some rock faces so inclined as to make the most of the northern sun, and so form little pools where the rotifers might live. The rotifers have been proven to survive a lower temperature than any yet known under natural conditions on the earth, and we have seen (under descriptions of *Adineta grandis* and *Philodina gregaria*) that they do not ask for much in the way of luxury. Give them a week or two of warm weather (+ 40° F. or so) and they are content to be frozen up for years.

Periods of intense cold need not be periods of great precipitation, as we see in the present low snowfall in South Victoria Land, and thus the bearing of temperature on the problem falls to be separately discussed from that of glaciation. Has there ever been a period when the glaciation was such that the very mountain peaks were covered by a thick ice-cap which would scrape the rotifers, in common with all other living things great or small, off the surface of the continent? That will not be discussed here, but short of such a mechanical destruction as extreme glaciation or complete submergence would achieve, I see no reason why there should not always have been rotifers on the coast at least of the Antarctic continent.

The peculiarities of the species of rotifers which at present appear to be peculiar to the Antarctic are not very great, morphologically considered, yet they are great enough to require us to presuppose a very long isolation if they have been acquired in their present location. For four of them it would be difficult to suggest a probable ancestor among known species. Although our list of fourteen species shows five new and nine previously known, the amount of peculiarity is greater than these figures would indicate. Three species indicated by marks of interrogation in the table given differ more or less from their supposed types elsewhere. It was doubtful whether they should be regarded as new species or as varieties. In such cases one has

to decide whether the advance of knowledge will be better served by emphasising the affinities in using the old names or pointing the differences in bestowing new names.

If the rotifers are not aboriginal but have reached the Antarctic by immigration in comparatively recent times, since the last period in which the conditions were such as to prevent the continuance of life on the continent, we must look for some possible means of immigration.

The Rotifera share with the lowest forms of life that facility for distribution which makes them, as Jennings (21) puts it, "potentially cosmopolitan." The agent of distribution is the wind. When some rotifers, and the eggs of others, are dried they may be blown in the form of dust for long distances. There is no difficulty in supposing the Antarctic peopled in this way, though there is no region where such distances of sea must be crossed in the process; but all round the Antarctic continent the storm-winds generally blow off the land, and so could play no part in bringing a rotifer population to the country.

There are numerous small islands scattered over the Antarctic Ocean, and there are some storms which blow from the north: even in the Antarctic they are known, though rare. While it is difficult to believe the wind currents of the lowest strata of the atmosphere adequate to transport rotifers over the wide ocean separating, for example, New Zealand and South Victoria Land, they might transport them from one island to another, and thus the rotifers might in long ages work their way by slow and intermittent steps from the one land to the other.

There is yet another way in which the wind might be supposed to effect the transference. If a violent local storm were capable of whirling rotifer dust up till it was caught in those high currents which set to the southward, then they might conceivably be carried all the way and dropped on land. If, however, it were as easy as all that, we would expect a much more extensive rotifer fauna.

In one region, south of Cape Horn, the Antarctic continent approaches very near one of the other continents, and there the rotifer dust might readily be blown across. From such a point of easy access the animals might get distributed all round the Antarctic coast by the aid of wind and birds.

The paucity of the rotifer fauna, as far as we know it, points to great difficulty of access. The varying degrees of peculiarity exhibited by the different species suggest that some have been longer resident in the Antarctic than others. *Hydatina senta* may be a recent immigrant, may even have taken passage with Captain Scott in the early days of the present century: *Callidina habita* and *C. angularis* may have been there for a few hundreds or thousands of years: whilst *Philodina alata*, *P. gregaria* and *Adineta grandis* may be aborigines of immense antiquity.

That great difficulties lie in the way of emigration to the Antarctic, and difficulties quite apart from the climatic rigours which meet the immigrants, we have one more indication in the adaptability of many rotifers to various climates. Not only do a great many species extend from the temperate into the Arctic Region, but

rotifers taken from a subtropical forest in the extreme north of New Zealand, and subjected to low temperatures at Cape Royds, revived on being moistened. Many Rotifers, Bdelloids at least, do not require much, if any, extension of their powers of endurance to fit them for life in the polar regions, so that if species are few in the Antarctic it is almost certainly because of mechanical difficulties in the way of getting there.

Vitality of Rotifers.—Observations on the Biology of the Rotifera constituted the most interesting part of the naturalist's work in the Antarctic. Many experiments, of a very simple nature, were made upon them in order to ascertain their powers of resistance to every kind of adverse circumstance which might affect them in the course of a migration to Antarctica, or from place to place in it.

These observations and experiments will be described in detail in a paper now in preparation. A short summary of the most interesting points will be found under the descriptions of *Philodina gregaria* and *Adineta grandis* in the preceding pages.

List of Works referred to in the Text

1. Anderson, H. H. and Shephard, J., Victorian Rotifers, *Proc. Roy. Soc. of Victoria*, iv., 1892, pp. 69–80.
2. Beauchamp, P. de, "Recherches sur les Rotifères," *Arch. de Zool. Expériment. et Gén.*, t. x., p. 43, 1909.
3. Bergendal, D., "Beiträge zur Fauna Grönlands," *K. Fysiograf. Sällskapets Handl.*, N.F., 1891–2, Bd. iii.
4. Bryce, D., "Further Notes on 'Macrotrachelous Callidinæ,'" *Journ. Quekett Micr. Club*, Ser. II., vol. v., 1894, p. 451.
5. „ „ "Contributions to the Non-Marine Fauna of Spitsbergen," *Proc. Zool. Soc. London*, 1897, pp. 793–9.
6. „ „ "Moss-dwelling Cathypnadæ," *Science Gossip*, 1892, p. 271.
7. Certes, A., "Mission à Cap Horn, 1889.
8. „ „ "Infusoires et Rotifères," *Act. Soc. Scient. Chili*, iv., 1894.
9. Daday, E. von, "Mikro-Süsswasserthiere aus Patagonien," *Term. rajzi füz.*, Bd. 25, 1902, p. 201.
10. „ „ "Süsswasser-Mikrofauna von Chile," *Term. rajzi füz.*, Bd. 25, 1902, p. 436.
11. „ „ "Süsswasser-Mikrofauna Paraguays," in *Chun's Zoologica*, Bd. 18, H. 44, Stuttgart, 1905.
12. Davis, H., "A New Callidina," &c., *Month. Micr. Journ.*, ix., 1873, p. 201.
13. Dixon-Nuttall, F. R., and Freeman, R., "The Rotatorian Genus Diaschiza," *Journ. Roy. Micr Soc.*, 1903, p. 1.
14. Dujardin, F., "Histoire Naturelle des Zoophytes," *Suites à Buffon*, 1841.
15. Ehrenberg, C. G., "Organisation der Infusorien," *Abhandl. K. Akad. Wiss. Berlin* (1831), 1832.
16. Gosse, P. H., "Catalogue of Rotifera found in Britain," *Ann. Nat. Hist.*, vol. viii., 1851, p. 197.
17. „ „ In "The Rotifera," Hudson and Gosse, London, 1889, vol. ii., p. 81.
18. Hilgendorf, F. W., "A Contribution to the Study of the Rotifera of New Zealand," *Trans. and Proc. of New Zealand Inst.*, vol. xxxi. (14 of New Series), 1898, pp. 107–134.
19. „ „ "Rotatoria," in *Index Faunæ Novæ-Zealandiæ*, 1894.
20. Janson, O., "Rotatorien-Familie der Philodinæen," Marburg, 1893.
21. Jennings, H. S., "Rotatoria of the United States," *U.S. Fish. Comm. Bull.* for 1899, p. 81.
22. Kirkman, T., "Rotifera of Natal," *Journ. Roy. Micr. Soc. London*, 1901, pp. 229–241.
23. „ „ "Second List of Rotifera of Natal," *Journ. Roy. Micr. Soc. London*, 1906, pp. 263–268.

24. Milne, W., "On the Function of the Water-vascular System in the Rotifera," *Proc. Phil. Soc. Glasgow*, 1907, pp. 1–12.
25. Murray, J., "The Rotifera of the Scottish Lochs," *Trans. Roy. Soc. Edin.*, vol. xlv., 1906, pp. 151–191.
26. „ „ "Scottish National Antarctic Expedition, Tardigrada of the South Orkneys," *Trans. Roy. Soc. Edin.*, xlv., 1906, p. 323.
27. „ „ "Some Rotifera of the Sikkim Himalaya," *Journ. Roy. Micr. Soc.*, 1906, p. 643.
28. „ „ "Arctic Rotifers," *Proc. Roy. Phys. Soc. Edin.*, vol. xvii., 1908, pp. 121–7.
29. „ „ "Microscopic Life in Gough Island," *Proc. Roy. Phys. Soc. Edin.*, vol. xvii., 1908, pp. 127–9.
30. „ „ "Some African Rotifers," *Journ. Roy. Micr. Soc. London*, 1908, p. 669.
31. Richters, F., "Fauna der Moosrasen des Gaussbergs und Einiger Südlicher Inseln," *Deut. Südpol. Exped.*, 1903, Bd. ix. Zool., p. 261.
32. „ „ "Moosbewohner," *Schwed. Südpol. Exped.*, 1901–3, Bd. vi., 1908.
33. Rousselet, C. F., "Rotifera of South Africa," *Journ. Roy. Micr. Soc. London*, 1907, pp. 395–414.
34. Shephard, J., "A New Rotifer, *Lacinularia elongata*," *Victorian Naturalist*, xiii., No. 2, May 1896, pp. 22–4.
35. „ „ "A New Rotifer, *Lacinularia elliptica*," *Victorian Naturalist*, October 1897.
36. „ „ "A New Rotifer, *Lacinularia striolata*," *Proc. Roy. Soc. of Victoria*, August 1899, pp. 20–35.
37. Shephard, J., and Strickland, W., "A New Rotifer, *Melicerta fimbriata*," *Victorian Naturalist*, xvi., No. 3, July 1899, pp. 38–40.
38. Strickland, W., "The Rotifer in Melbourne," *Victorian Naturalist*.
39. Schmarda, L., "Neue Wirbellose Thiere," Leipzig, 1859.
40. Thompson, P. G., "Moss-haunting Rotifers," *Science Gossip*, 1892, p. 56.
41. Western, G., "Notes on Rotifers," *Journ. Quekett Micr. Club*, 1893, pp. 155–160.
42. Whitelegge, T., "Invertebrate Fauna of Port Jackson and Neighbourhood," *Journ. and Proc. Roy. Soc. of New South Wales* for 1899, pp. 308–17.
43. Wierzejski, A., "Rot. W. Argentinie," *Bull. Acad. Cracovie*, 1902, p. 158.

NOTE

In the preparation of this paper I have been indebted to several friends for assistance, which I desire here to acknowledge. Mr. D. Bryce examined the drawings of the Bdelloid rotifers, and gave me the advantage of his opinion on the values of the species. Mr. C. F. Rousselet did the same for the non-Bdelloid rotifers, and helped me with the list of literature. Mr. D. J. Scourfield experimented on the dried rotifers brought from the Antarctic, and demonstrated that some had survived the many changes of climate which they had experienced. Mr. J. H. Priestley subjected some of the rotifers to a temperature of -78° C. for many hours, and showed that some were not killed by this, thus completing the simple series of experiments commenced in the Antarctic.

Mr. Rousselet was also good enough to remount the few specimens of the new species of Antarctic rotifers, which had been mounted in a temporary way, thus saving them from destruction.

PLATE IX

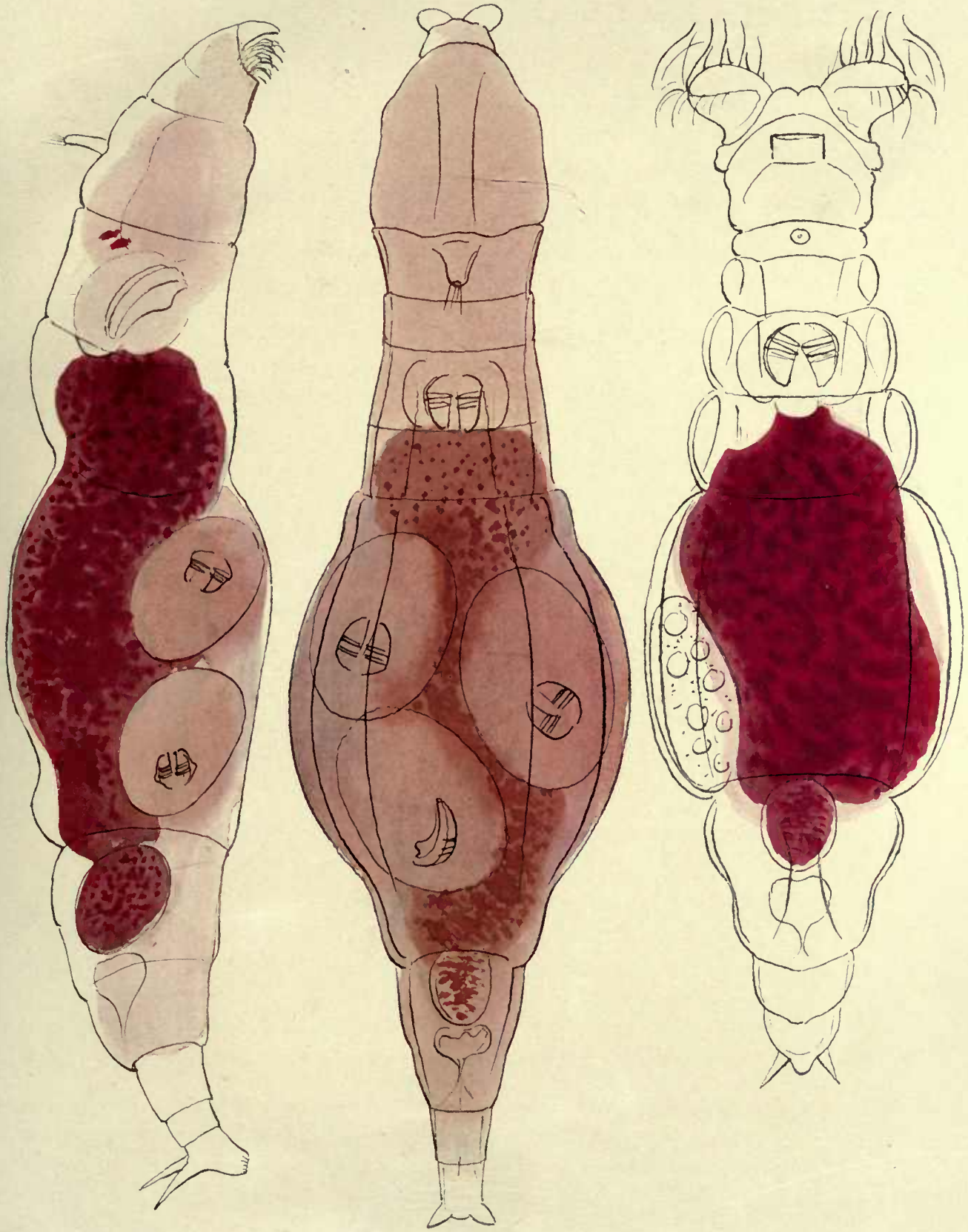
This plate is designed to illustrate the bright coloration which distinguishes most of the Antarctic Bdelloids. The brilliant red of the stomach of *Philodina gregaria* and *Callidina habita* (Figs. 1 and 3) may give the impression of being overdone. If we have not caught the precise shade of the red, it is not that it was less vivid than we show it. It was a deep, clear, pure crimson or ruby. When seen in large mass the colour approaches blood-red, but by transmitted light it appears crimson under the microscope.

When we succeeded in reviving a few examples of *Philodina gregaria* and showed them to a naturalist in London, he exclaimed, "Are they so red as all that."

FIGURE 1.—*Philodina gregaria*, lateral view, showing the red stomach and eyes, small antenna, and two young.

FIGURE 2.—*Adineta grandis*, dorsal view, showing the brown colour deepest in the alimentary tract.

FIGURE 3.—*Callidina habita*, dorsal view. The distinctive spurs of this variety are shown, and the prominent foot-boss.



(1) P. gregaria. (2) A. grandis. (3) C. habita.

Colours of Antarctic Rotifers.

J. Murray, del. ad. nat.

PLATE X

FIGURE 4*a*.—*Philodina alata*, sp. n., dorsal view, feeding: the lateral processes, which distinguish it from all other known species, are in this figure slightly drawn in at the tips (which is accomplished by special muscles, shown in Fig. 4*e*).

FIGURE 4*b*.—The same, fully contracted. The lateral processes are then turgid from the pressure of the body-fluid, and are projected to their fullest extent and somewhat forward.

FIGURE 4*c*.—The same, in the creeping attitude: usually the lateral processes are drawn in, almost out of sight, among the skin-folds when creeping, but in this instance they were fully extended.

FIGURE 4*d*.—Jaw of the same with its two teeth and wide border.

FIGURE 4*e*.—One of the lateral processes of the same. It is seen to be hollow, and special muscles enter it and are attached near the top. One of the vibratile tags is seen at the base of the process. It is unusually short and wide for a Bdelloid.

FIGURE 4*f*.—Foot and rump of the same seen from the side. The prominent boss of the preanal segment can also be seen as a curved line in Fig. 4*c*.

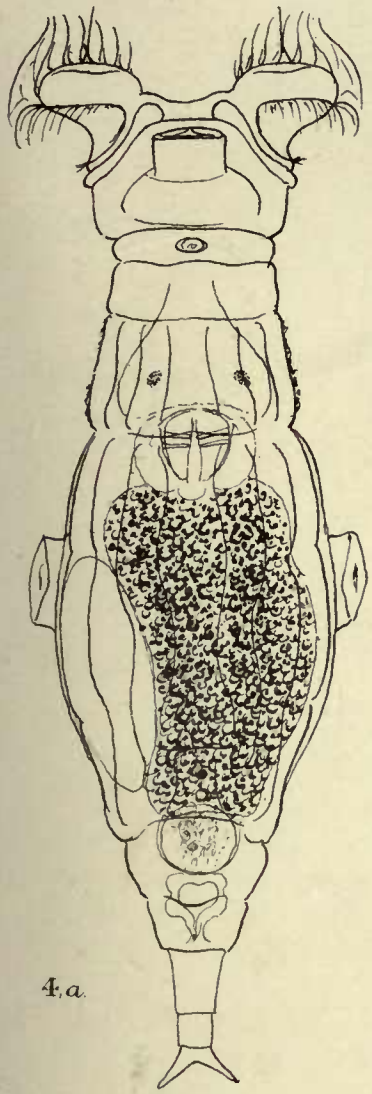
FIGURE 5*a*.—*Philodina antarctica*, sp. n. The figure shows the prominent collar, the eyes on a conspicuous brain, the elongate foot, and the peculiar spurs. The basal portion of the spurs is badly drawn in this figure (it is correctly shown in Fig. 5*b*).

FIGURE 5*b*.—Spurs of the same. These, with the broad triangular bases and peg-like apices, are the best character of the species. The distinction of the two parts is sometimes obliterated. Even then the absence of interspace will distinguish this from *P. gregaria*, and there are many other differences of general proportions and details, requiring, however, careful study.

FIGURE 5*c*.—Lateral view of the foot of the same. The dorsal toes are almost as thick as the ventral, though shorter. This is a point of difference from *P. gregaria*, in which the dorsal toes are relatively very small.

FIGURE 6.—*Philodina*, unnamed species.

MURRAY: ANTARCTIC ROTIFERA.



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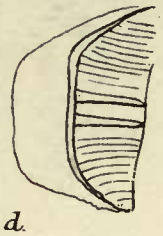

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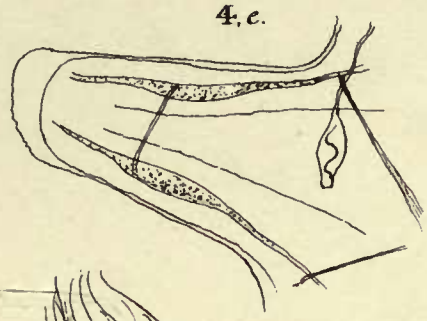

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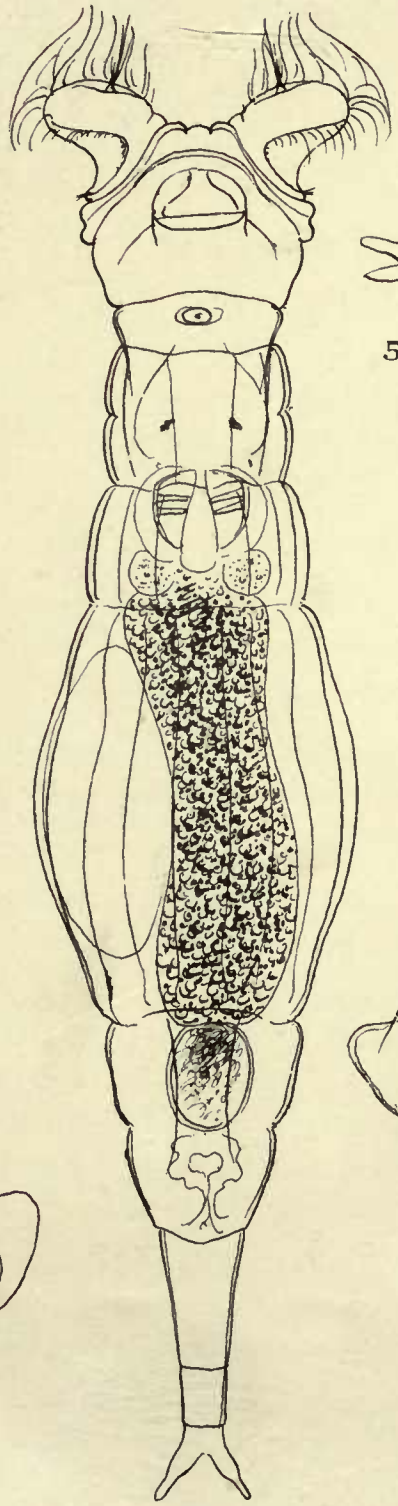

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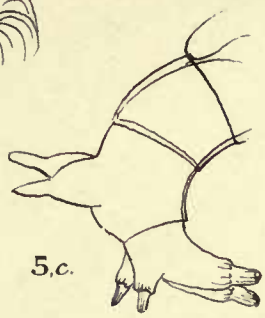
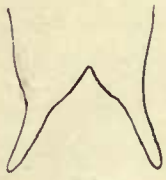


5, c.



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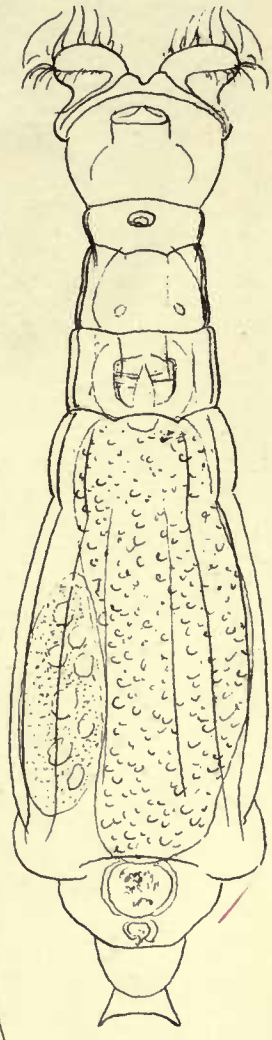

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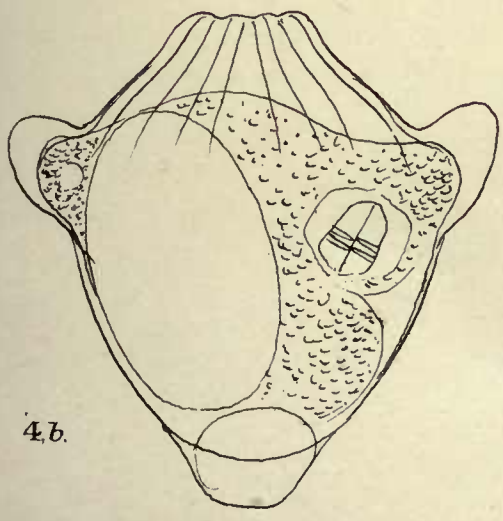

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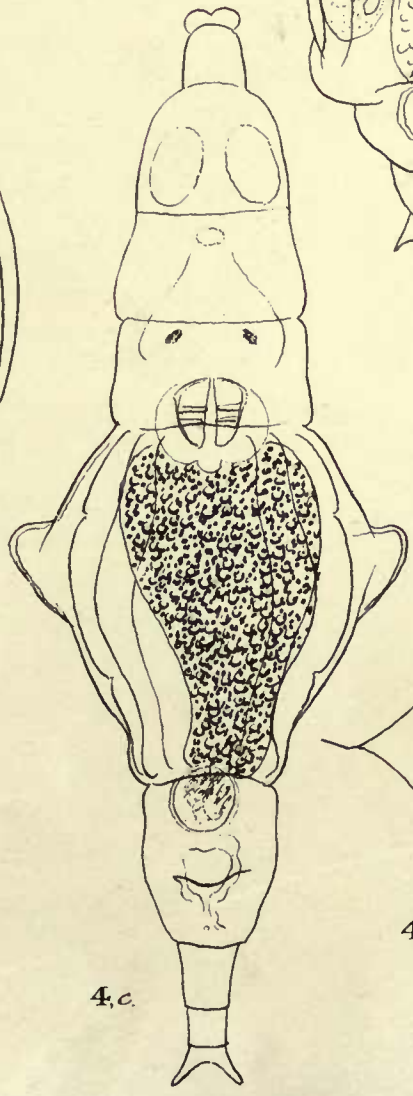

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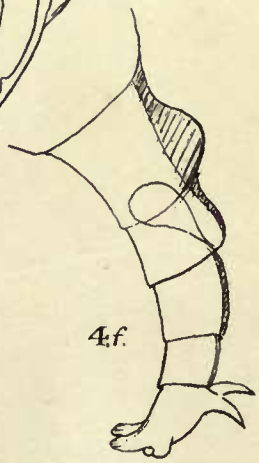


4, f.

4. PHILODINA ALATA, sp. n. 5, P. ANTARCTICA, sp. n. 6. PHILODINA, sp.

J. Murray, del. ad. nat.

PLATE XI

FIGURE 7*a*.—*Philodina gregaria*, sp. n. dorsal view of the animal when feeding. The very prominent collar is only marked off from the pedicels by the cilia of the wreath. Two well-grown young are seen.

FIGURE 7*b*.—Spurs and toes of the same. The dorsal toes are seen to be greatly smaller than the ventral.

FIGURE 7*c*.—One of the spindle-shaped vibratile tags of the same.

FIGURE 7*d*.—Jaw of the same, with two strong teeth, one thinner tooth, and many fine striæ.

FIGURE 7*e*.—Lateral view of the jaw of the same, showing the process of the ramus behind.

FIGURE 8*a*.—*Callidina habita*, dorsal view of a variety which differs from the type in the form of the spurs.

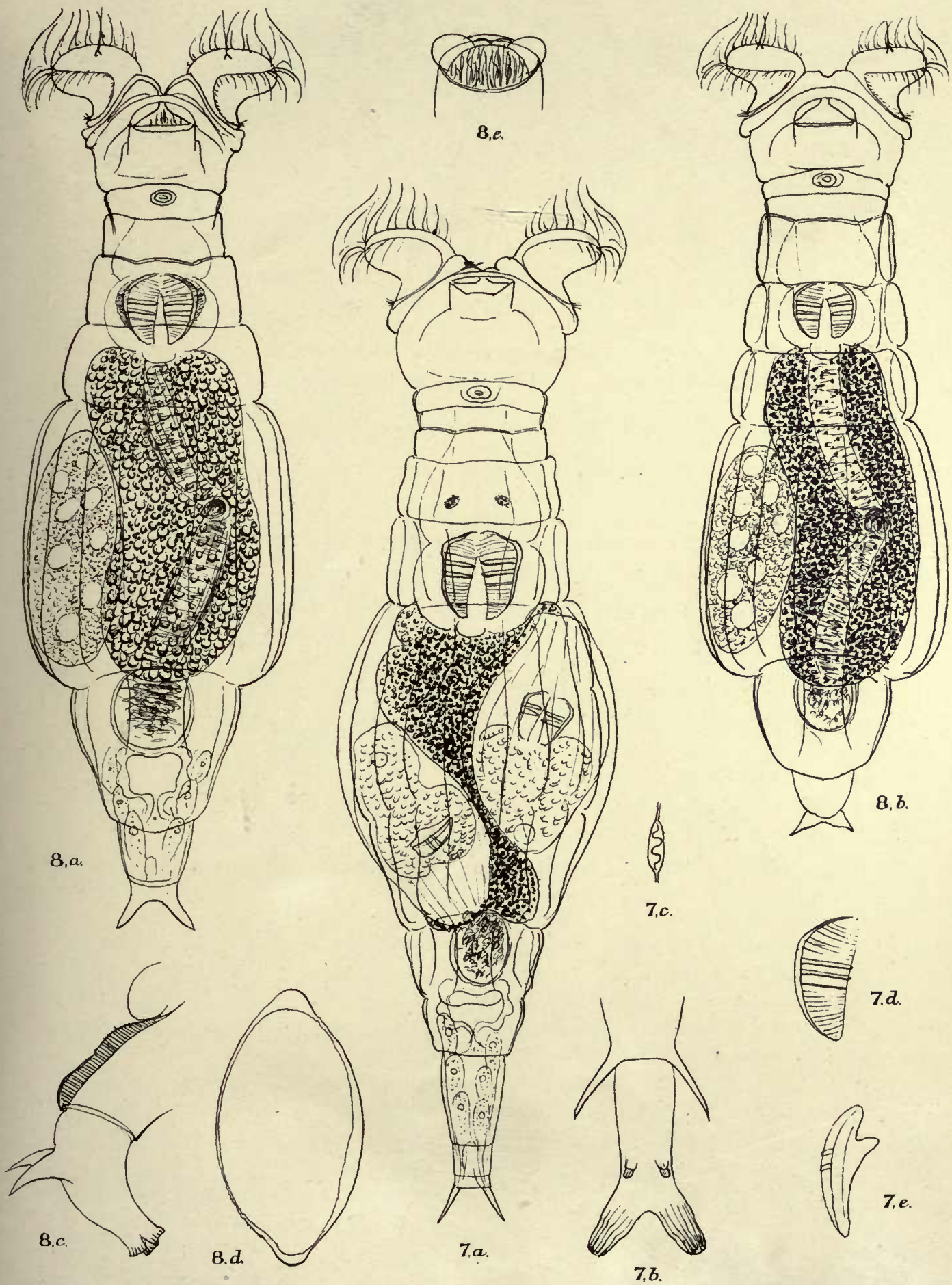
FIGURE 8*b*.—The same, a variety having spurs nearer the typical form, but smaller.

FIGURE 8*c*.—Lateral view of the foot of the same showing the thickened part of the first foot-joint which forms the boss.

FIGURE 8*d*.—Egg of the same, elliptical in form, with each pole produced into a process.

FIGURE 8*e*.—Tip of rostrum of the same. The lamellæ are widely separated.

MURRAY: ANTARCTIC ROTIFERA.



7. PHILODINA GREGARIA, sp.n. 8. CALLIDINA HABITA BRYCE.

Murray del. ad nat.

PLATE XII

FIGURE 9*a*.—*Adineta barbata*, Janson ?

FIGURE 9*b*.—Egg of the same from Blue Lake; one pole is produced, and there are no other processes.

FIGURE 9*c*.—Egg from Deep Lake, Cape Barne, from which a similar *Adineta* was hatched on September 24, after the egg had been dry for about a year, and had been conveyed from Antarctica to Britain.

FIGURE 10*a*.—*Adineta grandis*, large stout example, showing six young, apparently all in an equally advanced state of development, and with the jaws well grown.

FIGURE 10*b*.—Head of the same, ventral surface, showing the lamellæ, brush of cilia and motile setæ, pectinate folds at posterior margin of corona, &c.

FIGURE 10*c*.—Jaw of the same, showing the projection at back of ramus.

FIGURE 10*d*.—Yolk-mass of the same, dividing into six parts, each containing one nucleus. The number of nuclei is normally eight, as in most Bdelloids. In this instance the full number may be present, two of them hidden behind the centre of the mass.

FIGURE 11*a*.—*Adineta longicornis ?* The rostral part is not of the same form as in the type, but allowing for a different angle of inclination it may be the same.

FIGURE 11*b*.—Spurs of the same. They are considerably shorter than in the type, but are still relatively much longer than in any other known species.

FIGURE 12*a*.—*Callidina angularis*, sp. n., dorsal view, showing angular outline and stippled surface.

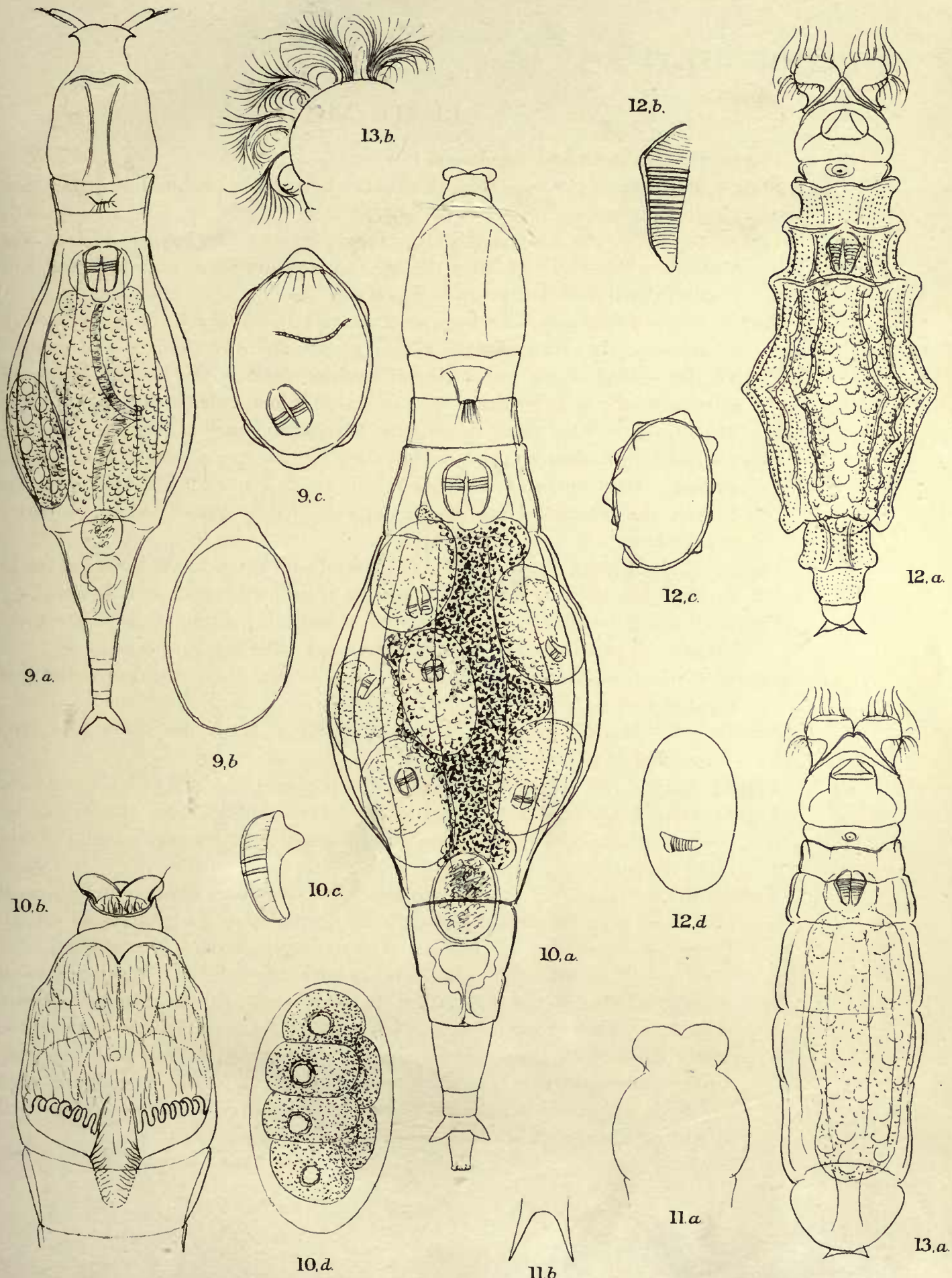
FIGURE 12*b*.—Jaw of the same, with four principal teeth and many finer ones diminishing backwards.

FIGURES 12*c* and 12*d*.—Eggs found associated with this species and with *C. constricta*.

FIGURE 13*a*.—*Callidina constricta*, Duj., dorsal view, illustrating the differences between this species and *C. angularis*; the outline is not angular and the skin is not stippled.

FIGURE 13*b*.—Part of one disc of the corona of *C. constricta*, showing the groups of cilia which give the appearance of toothed wheels to the philodinoid corona. Diagrams elucidating the motions of the cilia which cause the appearance of teeth have often been published. This is not a diagram, but a drawing from an example which had just been killed and fixed with osmic acid while in the act of feeding. Each group has cilia at every stage of the stroke, thus showing the course followed by each. The specimen was mounted in fluid and preserved. Unfortunately, as was only to be expected, the slight difference of density between the fluids within and without the body has resulted in making the disc turgid and opened out the groups of cilia into one uniform fringe.

MURRAY: ANTARCTIC ROTIFERA.



9. ADINETA BARBATA? 10. A GRANDIS, sp. n. 11. A LONGICORNIS.
12. CALLIDINA ANGULARIS, sp. n. 13. C. CONSTRICTA.

J. Murray, del. ad nat.

PLATE XIII

FIGURE 14*a*.—*Pleurotrocha*, sp. A large active animal resembling *P. grandis*, but with longer spurs and some other differences.

FIGURE 14*b*.—Elliptical papillose egg of the same.

FIGURE 14*c*.—Jaws of the same, drawn from an example in the egg.

FIGURE 15.—*Floscularia*, sp., semi-contracted.

FIGURE 16*a*.—*Diaschiza tenuior*, lateral view with the foot drawn well under the body.

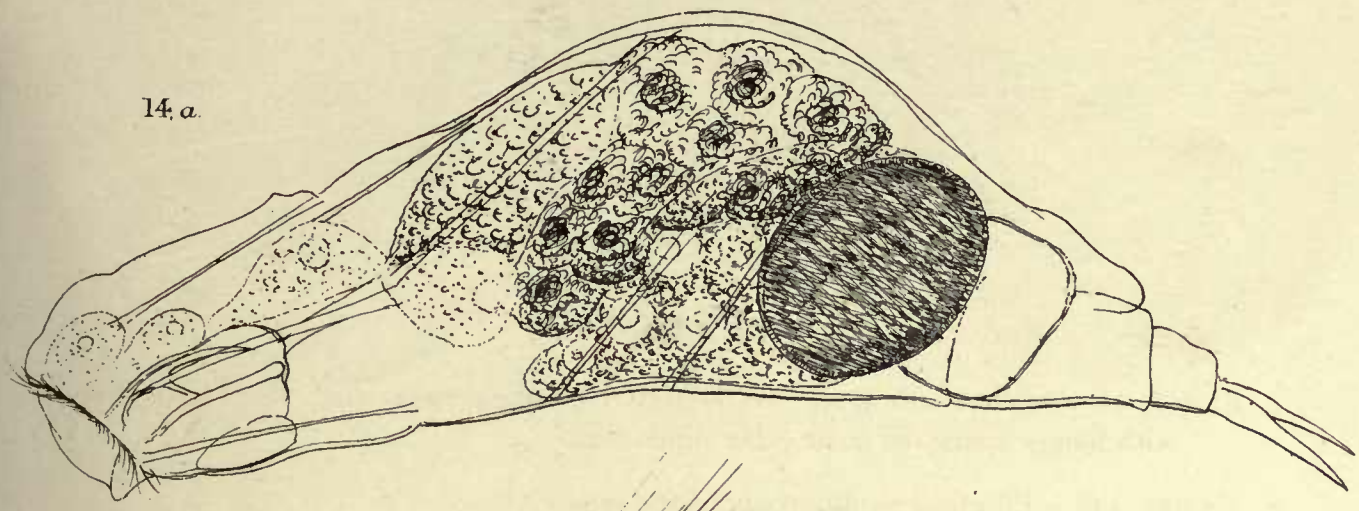
FIGURE 16*b*.—The same, dorsal view.

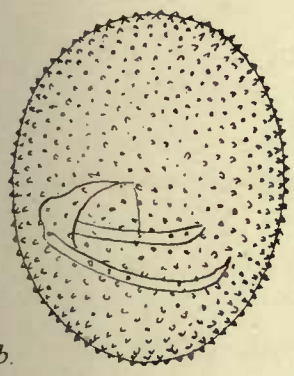
FIGURE 16*c* and 16*d*.—Dorsal and lateral views of a supposed male of the same, having rudimentary jaws.

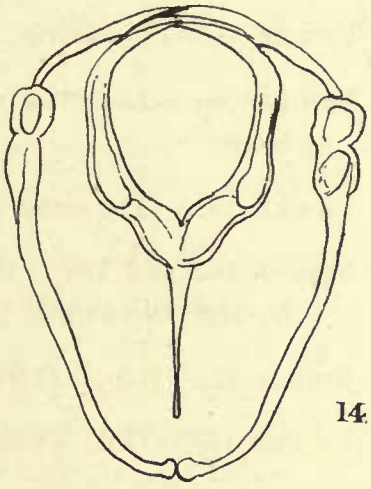
FIGURE 16*e*.—Rough sketch of jaws of the female.

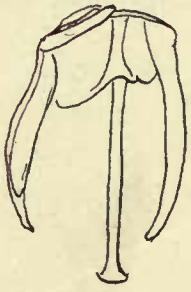
FIGURE 16*f*.—Thick-shelled egg containing jaws similar to those of the supposed male (Figs. 16*c* and 16*d*).

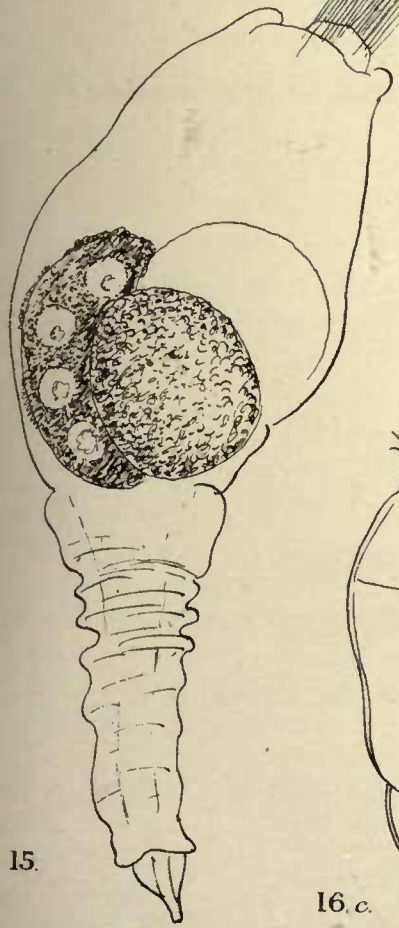
MURRAY: ANTARCTIC ROTIFERA.

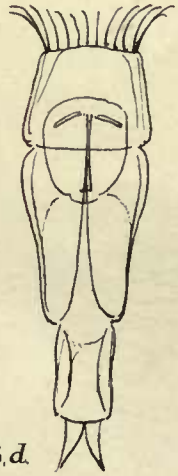


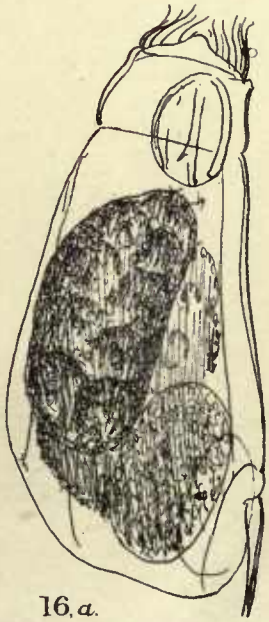


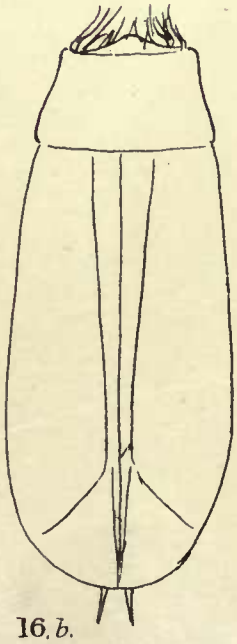












14, PLEUROTROCHA, sp. 15, FLOSCULARIA, sp. 16, DIASCHIZA TENUIOR.

J. Murray del. ad. nat.