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ON A NEW FAMILY AND TWELVE NEW SPECIES
OF ROTIFERA OF THE ORDER BDELLOIDA,
COLLECTED BY THE LAKE SURVEY.

BY

JAMES MURRAY.

[WITH SEVEN PLATES.]

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XV.—On a New Family and Twelve New Species of Rotifera of the Order Bdelloida, collected by the Lake Survey. By JAMES MURRAY. Communicated by Sir JOHN MURRAY, K.C.B., F.R.S. (With Seven Plates.)

(MS. received January 13, 1905. Read January 23, 1905. Issued separately March 3, 1905.)

INTRODUCTION.

The new species here described were found in the course of the work of the Lake Survey on Loch Ness and other Highland Lochs. Half of the number were found in lakes, though they are not exclusively lacustrine, three in ponds, two from moss growing on the shores of Loch Ness, and one in a stream running into Loch Ness.

Structure.—A short account of the structure of a typical Bdelloid will be necessary, in order to render intelligible the terms used in the descriptions. A Bdelloid is a Rotifer which can creep like a leech or caterpillar. The body is segmented, and consists of head, neck, trunk, and foot. The head, neck, and foot are telescopic, and can be completely withdrawn into the trunk. The normal number of segments is sixteen, but there may be more or less, the variation being chiefly in the foot. The head consists of three segments, the neck of three, the trunk of six. It is believed that the number of segments in each of those portions of the body is invariable, but two or more segments may be so united as to be indistinguishable. The foot is more variable, the number of segments, normally four, varying from one to six. Beginning at the anterior end, the first and second segments of the head form the rostrum. The first has an inverted tip, from which rise the two rostral lamellæ, numerous motile cilia, and sometimes larger tactile setæ. The third segment is the *oral*, and bears the mouth, and the corona when present. The *first cervical* bears the antenna, and frequently a number of prominences. The second and third *cervical* have no appendages. The first, second, third, and fourth segments of the *trunk* are called the *central*, and form the broadest part of the body. The next two segments of the trunk, the *pre-anal* and the *anal*, together form the *rump*, which is generally clearly marked off both from the central part of the trunk and from the foot. At the end of the anal segment is the *anus*. The segments beyond the anus constitute the *foot*. The first joint of the foot commonly has the skin on the dorsal surface thickened, and often bears a rounded *boss* or other processes. The *penultimate* joint bears the spurs. The *last* joint bears the toes, or the perforate disc which takes their place. The segmentation is superficial, and affects only the skin. When the animal is fully extended, the various organs usually occupy definite segments, though the arrangement is not invariable. The *brain*, generally somewhat triangular, occupies the *second cervical*, but when large may extend

through all three *cervical* segments. The *eyes*, when present, are in the rostrum, near its tip, or on the back of the brain. The *mastax*, containing the jaws with their teeth, is in the *third cervical* or *first central*. The *stomach* extends through all four *central* segments, which also contain the *ovaries* and the eggs or young. The *pre-anal* contains the intestine, the *anal* the *contractile cloaca*. The *foot-glands* occupy all the joints of the foot, and may extend into the *anal*, or even into the *pre-anal*. The *toes* are three or four in number, or they are united to form a *disc*, which is perforate with pores for the passage of the *mucus*.

The *corona* of the Philodinadæ consists mainly of two nearly circular *discs*, borne on *pedicels*. The *principal wreath* borders the discs. The *secondary wreath* runs round the bases of the pedicels from back to front, and merges in the cilia of the mouth. Near the centre of each disc is in many species a seta, or pencil of setæ, or several short motile cilia, which usually rise from a small papilla or a larger process. The *lower lip* is the central portion of the under side of the mouth, and is shaped like a V. The *upper lip* is the space between the bases of the pedicels and the front of the rostrum. Its form is very characteristic for each species. Its most important structures are two folds of skin, which continue those prominences at the sides of the mouth known as the *collar*. These folds run round the bases of the pedicels, close to the secondary wreath, and may meet in the middle line just in front of the rostrum, or may terminate at some distance apart, in processes of various form. In the middle line, between the pedicels, is often found a peg-like process, known as a *ligule*. The water-vascular system, with its *vibratile tags*, usually about six pairs, is difficult to observe. The number of pairs of tags seen is always noted, though this may not be the full number present.

The skin may be smooth and hyaline, stippled with pellucid dots, viscous, papillose, or variously warted or spiny. The back and sides of the trunk are longitudinally plicate. The ventral side is obscurely transversely plicate. In a few species the ventral transverse folds are numerous and deep.

Habits.—The great majority of the known species are free and independent animals. None are truly pelagic. Even those which are in the habit of swimming only do so for short distances, and in the shelter afforded by mosses and other water plants. Those which do not swim creep in caterpillar fashion on the plants among which they live or on the mud of ponds. When feeding they anchor themselves by the foot. The Adinetadæ and some *Callidinæ* can also glide forward by the action of certain cilia—in the Adinetadæ those of the corona, in the *Callidinæ* those of the rostrum. Several species secrete protective cases; others accumulate irregular tubes of débris.

Parasitism.—A number of species are ectoparasites upon other animals. None are internal parasites or feed upon their host. They are commensals or messmates. They attach themselves by the foot to some crustacean, insect larva, or other animal. They seem to desire from their host only protection, conveyance from place to place, possibly a share of food. *Asellus* is a favourite host, and often carries several species together. All the Bdelloids known to me which have taken to the parasitic mode of life are large

animals. They are distinguished by bulk of body, long and powerful foot, large strong spurs, and usually ample corona. The life agrees with them. Signs of degeneration are not lacking, however. Their affinities are with genera which normally possess eyes, but most of these parasites are blind, and have smaller brains than are possessed by free-living species of the same genera.

Symbiosis.—A number of Bdelloids have the foot of a peculiar type, in which there are no distinct toes, their place being taken by a disc, which is perforated by numerous pores for the passage of the mucus. It has been suggested that the species having this kind of foot live in symbiotic relationship with certain Hepatics, such as *Frullania*, which have some of their leaves in the form of little pitchers. The suggestion is plausible, inasmuch as such Hepatics are seldom found without the pitchers occupied by the Rotifers. There is, however, something to be said against the belief that the relation is one of symbiosis. There is no evidence of any advantage to the plants, though it has been guessed that the animals are in some way beneficial to them, and that to obtain this benefit the pitchers have been developed as an attraction to Rotifers. It is more probable that the pitchers of the Hepatics serve the sole purpose of retaining moisture, and that many species of Rotifers have found and taken advantage of those little reservoirs. In that case there is no symbiosis, only a mild form of parasitism. Bdelloids having the discoid foot are not only found on Hepatics. They abound in many other situations. Nor are they the only Bdelloids which frequent *Frullania* cups. Many species with the ordinary foot are commonly found there. It might be supposed that a Bdelloid would have less need of a strongly adhesive foot in the shelter of a *Frullania* pitcher than in many more exposed situations. The discoid foot is an advantage to a species in any situation, and it is to be noted that all the species having it are large, powerful animals.

Two species having the discoid foot are here described. One is from a lake, the other from a pond, and neither has yet been found on Hepatics.

Formation of food-pellets.—Four of the species described in this paper belong to that section of the genus *Callidina* in which the food is moulded in the œsophagus into pellets. All the animals having this characteristic agree in many other points of structure, such as the small size of the corona, and form a very natural group. Most of them have the neck very long and the gullet correspondingly elongated, and forming a large loop when the neck is contracted. The pellets differ greatly in consistence in different species. Some are loosely put together, and quickly disintegrate when passed into the stomach. In some species they seem to be mixed, while in the œsophagus, with something which gives them coherence. Such pellets maintain their size and form unchanged during the whole of their passage through the alimentary canal, and are finally voided entire. When first passed into the stomach they are granular, and often dark from the admixture of food particles. They gradually lose the granular character as they move through the stomach, till when passed out they are clear spheres.

BDELLOIDA.

All the Bdelloid Rotifera hitherto known have been included in two families, distinguished by different types of corona. The Philodinadæ have the corona divided into two discs, which bear the primary and secondary wreaths of cilia. The Adinetadæ have no discs, the corona consisting of a flat surface, furred with short cilia, divided by a non-ciliated space in the middle line, which may correspond to the space separating the discs in the Philodinadæ.

An animal discovered in Loch Vennachar in 1902, in the course of the work of the Lake Survey there, could not be referred to either of the known families. After prolonged study, continued for more than two years, it is now proposed to constitute a new family for its reception.

MICRODINADÆ, n. fam.

No corona, the ciliated alimentary tract ceasing at the mouth; jaws intermediate between the *ramate* type of all other Bdelloida and the *malleo-ramate* type of *Melicerta*.

The only species at present known is a Philodinoid animal. It resembles the genus *Philodina* in general form, in the rostrum, and in having four toes. The absence of corona would not of itself have justified the establishment of a new family. It might have been regarded as a degenerate *Philodina* which had taken to a different mode of feeding, and lost its corona from disuse. It was only after the peculiar structure of the jaws was understood that it became evident that the definition of the family Philadinadæ could not be modified to include it.

As now understood, the new family is seen to differ more from the other two families of the order than they do from one another. The Adinetadæ differ from the Philodinadæ only in the form of the corona, and in the partly adnate rostrum, free at the tip. They have the same form of jaws and of all other structures.

The Microdinadæ differ from both, not only in the lack of corona, but in the shape of the jaws. It comes nearer to the Philodinadæ in the free rostrum and the number of toes. On the other hand, the form of mouth might more readily be derived from that of *Adineta*. In Plate II. are shown heads of Philodinadæ (fig. *a*), Adinetadæ (fig. *c*), and Microdinadæ (fig. *b*). They are drawn from the ventral side in order to show the similar form of lower lip in all. On the same plate are drawn three pairs of jaws:—fig. *d* shows the ramate jaws of Philodinadæ and Adinetadæ, fig. *e* those of *Microdina*, fig. *f* those of *Melicerta*. It will be seen that the jaws of *Microdina* differ about as much from the *ramate* as from the *malleo-ramate* type, and sufficiently approach the latter, in the anterior position of the teeth and the less rigid union of the various parts, to constitute in some degree a link between the Bdelloida and the Rhizota.

Microdina, n. gen.

Toes, four. Yolk-mass with four nuclei. Gullet very short. Teeth, three or four on each side, at anterior end of jaws.

The terminal cilia of the gullet, which project a little way and assist in seizing the food, might be regarded as constituting a rudimentary corona. It is not usual, however, to regard the end of the gullet in a Philodine as part of the corona, that term being restricted to the discs and the two wreaths. It seems, therefore, more correct to consider *Microdina* as having no corona.

The parts of the jaws are movably articulated, not rigidly united as in other Bdelloids. The rami have large curved processes on the ventral side. The manubrii may have no loops, or may have from one to three, more or less distinct.

In Philodinadæ and Adinetadæ the larger teeth cross about the middle of the jaw, and there are finer striæ towards each end. In Microdinadæ the large teeth are all at the anterior end, and fine striæ only cross the posterior half of the jaws.

Owing to the shortness of the gullet, the jaws are close to the mouth.

Microdina paradoxa, n. sp. (Plates I. and II.)

Specific characters.—Of moderate size, stout, enlarged at level of mastax and at posterior part of trunk, contracted between those parts. Œsophagus and large granular mass connected with it, of a bright crimson colour. Stomach voluminous, its walls filled with coloured globules. Foot of three joints. Spurs short, stout, somewhat bottle-shaped, a broader basal portion contracting into a narrower apical portion, obtuse, separated by narrow convex interspace. Toes large and thick, the ventral pair much larger than the dorsal. Foot-glands forked. Antenna two-jointed, flattened. Oviparous.

General description.—Greatest length $\frac{1}{100}$ to $\frac{1}{80}$ inch. Always fiddle-shaped, owing to the narrowing between the head and the enlargement of the trunk. The position of the posterior enlargement varies. When an egg is carried, the broadest part will be in the second or third *central* segment. When there is no egg and the ovaries are undeveloped, the *fourth central* or *pre-anal* may be broadest. The rostrum differs in no way from that of a typical Philodine. The mouth is small and somewhat trifoliate. The lower lip is of the V-shape usual in the order. The upper part is obscurely two-lobed. The sides of the mouth are finely longitudinally striate. The whole animal is sometimes pale rose-colour or purple. More generally it is colourless, except for the crimson gland and œsophagus, the stomach and the egg. The globules in the stomach walls vary greatly in colour. They have been seen red, yellow, greenish, orange, magenta, sienna, or umber. The two last colours are commonest, and are used in the illustrations. The egg is of a tawny yellow. A clear fleshy mass fills the head

between the rostrum and the œsophagus. The posterior portion of this mass is, from its position and its connection with the antenna, regarded as the brain, but its outline could not be traced. Between the mastax and the stomach are two clear gastric glands, which meet on the ventral side.

Habits.—Of tireless activity. It creeps without ceasing on the stems of algæ and mosses, feeding all the time. Its mode of feeding is unlike that of any other Bdelloid, though *Adineta* resembles it in some respects. A biting action is continually repeated. In this the rostrum takes part. The food is caught between the rostrum and the lower lip, and pushed close to the mouth by the bending down of the rostrum. The cilia of the mouth, working downwards, catch the food that is thus brought near and sweep it into the gullet. The brush of cilia on the rostrum contributes to the action by sweeping downwards also, and to some extent compensates for the lack of discs. It was never seen to pause or rest, as other Bdelloids do occasionally.

The deposition of the egg was on one occasion seen. The animal was fully contracted. When the egg was almost completely passed out, the end which still remained in the aperture was seen to be surrounded by a circlet of clear spherical bodies. Most of these adhered to the egg when it separated, but a few remained attached to the aperture (Plate I. fig. *d*).

Variation.—Only one species of the family is known with certainty. The lack of corona deprives us of several characters of great service in distinguishing species of Philodinadæ. Various forms of spurs have been seen in Microdinadæ, but it is not yet clear whether any of these belong to distinct species (Plate II. figs. *g* to *j*).

The jaws also differ in different examples. While agreeing in general features, the degree of development of the loops of the manubrium varies greatly in different individuals. Some show no trace of any loops, while others have three well developed, two on the outer side and one on the inner, passing behind the teeth.

Habitat.—At the margins of large lakes and of clear hill lochs, also occasionally in pure running water.

Discovered in Loch Vennachar, 20th May 1902, on the occasion of the visit of the Scottish Natural History Society, as guests of Sir JOHN MURRAY; Loch Ness and Loch Morar, 1903; hill lochs on Carnahoulin, Fort-Augustus, 1904; Loch Treig, December 1904. Very abundant in Loch Vennachar and frequent in Loch Ness.

PHILODINADÆ.

Classification.—The Ehrenbergian division of the Philodinadæ into genera distinguished by the presence or absence of eyes, and by the position of the eyes when present, has long been recognised as artificial. In those genera unrelated species are brought together, and closely related species are separated. Suggestions for a more natural classification have been made, notably by MILNE, but none have been generally

accepted. The number of known species belonging to this family is now so great that some subdivision of the genera would be desirable, even if those genera were natural. Many of the new species show the artificial character of the old genera, and render a revision imperative.

I understand that a revision of the genera is now being prepared by Mr BRYCE, who, from his long experience of the order, is so well qualified to do so. This being so, I shall here only amend the definitions of the genera *Philodina* and *Callidina* so as to render them more natural. The classification based upon the eyes having proved defective, other characters of a more reliable nature have been sought. The number of toes has been suggested by MILNE* as a basis for classification. The mode of reproduction was thought of. It was found that large groups of species agreeing in the number of toes, also agreed in the mode of reproduction. One or two exceptions, however, lessen the value of the mode of reproduction as a generic character, and it must be abandoned in the meantime.

PHILODINA.

Generic character.—Toes, four. MILNE'S suggestion is adopted, though it is recognised that the genus will have to be divided. Thus defined, the genus does not differ greatly from that of EHRENBURG. All the species having eyes in the neck (*i.e.* seated on the brain) are found, with one exception, to have four toes. The main result of the alteration will be the transfer to *Philodina* of several species hitherto included in *Callidina*.

CALLIDINA.

Generic characters.—Toes, three; or foot ending in a disc. Normally oviparous.

This definition is simply provisional. It is unsatisfactory, in that it includes a character, *viz.*, the mode of reproduction, which is not quite invariable. It is only by using this character that the genus *Rotifer* could be kept separate.

As formerly distinguished by a single negative character, *viz.*, the absence of eyes, the genus *Callidina* became the receptacle for all the homeless wanderers of the family, till it now includes a host of species, many of which have little affinity one with another. It is with this genus that a revision of the family will be mainly concerned. Four of the new species here described belong to that very natural section of the genus in which the food is moulded into pellets. Two have the discoid 'symbiotic' foot. This type of foot might be made the basis of a genus, were it not that it is in some cases impossible to determine whether there are separate toes or not. It is, moreover, suspected that the discoid foot may have been independently acquired by unrelated animals.

* *Proc. Phil. Soc. Glasgow*, vol. xvii. p. 134, 1886.

Callidina angusticollis, n. sp. (Pl. III. figs. 2a to 2k.)

Specific characters.—Small, colourless; form pitcher-shaped in lateral view, the lower lip large, elevated, spout-like. Discs small, close together, inclined obliquely towards the mouth. Oral segment elongate, encircled about midway by a series of four thickenings. Food moulded into pellets. Foot minute, not obviously segmented; spurs short, acute, decurved, meeting at base. Dental formula 2/2. Secretes a brown flask-shaped protective case.

General description.—Greatest length $\frac{1}{90}$ to $\frac{1}{100}$ inch when feeding. Head laterally compressed, elongate from front to back. Discs sloping downward and outward from middle line as well as forward towards the mouth. Lower lip larger, relatively to the size of the animal, than in any other species known. Thickenings on oral segment diagonally placed, as shown in section, fig. 2e. Rostrum of moderate length, with fairly large lamellæ. Antenna of two joints, length equal to $\frac{2}{5}$ diameter of neck. Neck with large rounded thickenings at each side of antenna, and ventral thickening. Neck very long and slender. Gullet correspondingly elongated. Stomach voluminous, filled with round, clearly-outlined pellets of uniform size. These are coherent, and do not disintegrate in their passage through the alimentary canal. They are voided whole.

No eyes. Reproduction oviparous. Case oval, slightly flattened on ventral side, pale yellow when young, dark brown when old. Neck of case long, with annular striæ, mouth slightly expanded.

The foot, being apparently useless inside the case, which the animal never seems to leave, is very small. It can only be seen when the animal is forced out of its case. No separation of the first and second joints can be distinguished. The rudiments of toes probably exist, as the spur-bearing joint is not closed at its lower end, but they were not seen.

Habits.—Trusting apparently to the protection afforded by its shell, it is not at all shy, and usually resumes feeding very soon after being disturbed. When feeding, the neck is bent backward. Before beginning to feed, the head is often put out and the neck bent sharply over the edge of the case till the rostrum touches the outside of the case. The case is believed to be secreted from the skin, but the process has not been observed. The animal may occupy empty (or even inhabited) shells of Rhizopods, such as *Diffugia* or *Nebela*. Careful examination has always revealed a normal case inside the shell thus occupied. On one occasion the *Callidina* was seen in a shell of *Diffugia* which was shorter than its case. The projecting neck of the case was viscous, as shown by adherent matter, and nearly colourless. It had probably been just completed. Old animals show no viscosity, either of skin or case. The case is thin, smooth, and brown, and does not adhere to the animal. It is a cleanly animal. The pellets, which at first contain the food, are eventually passed out as clear spheres. After voiding them it clears them out by fully contracting its body and rolling about from side to side of the case till they are forced out through the neck.

Habitat.—On the leaves of mosses and hepatics in a great variety of situations, in peat bogs, on the ground, walls, or trees, most frequently seen on *Fontinalis* growing at the margins of lakes. First seen in Loch Morar, common about Fort-Augustus; occurs also in North Uist. Probably widely distributed. Before the animal came under my notice Mr BRYCE had made some studies of it, and suggested the specific name. Dr PENARD has also studied it in Switzerland.

Callidina annulata, n. sp. (Plate III. figs. 3a to 3f.)

Specific characters.—Small, colourless, in lateral view pitcher-shaped, the lower lip spout-like. Discs inclined towards mouth, their surfaces parallel to long axis of body. Oral segment much elongated, marked by annular plicæ, which are stronger towards the base. First neck segment with similar plicæ. Antenna very small, its length equal to $\frac{2}{5}$ of the diameter of the neck. Teeth, seven or eight in each jaw. Food moulded into pellets. Foot short, of three joints. Spurs, short cones, meeting at base. Reproduction oviparous.

General description.—Length about $\frac{1}{100}$ inch when feeding. Oral segment twice as long as broad. Discs reniform, separated by very narrow sulcus. Neck and gullet very long. Rostrum short and broad, with small lamellæ. Stomach large, nearly filling the trunk, containing clear rounded pellets of uniform size.

Resembling *C. angusticollis* in size and general form, it may be easily distinguished from that species by the smaller lower lip, greater forward inclination of the discs, longer oral segment, with annular plicæ and without thickenings, numerous teeth, larger foot, and lack of protecting case. Some examples carried large, oval eggs. Intestine, glands, and vibratile tags were not observed.

Habits.—Being unable to secrete a case for itself, as is done by *C. eremita* and other species, it seeks shelter, like the hermit crab, in the empty shells of other animals. Shells of *Diffugia*, *Nebela*, and other Rhizopods are commonly occupied. It was first observed in cases of *C. angusticollis*, the original occupants of which had died, leaving only the tough jaws behind. The presence of those jaws, with their pairs of teeth, led to the two species being confused for some time. It also frequently takes cover in the pitchers of *Frullana* and other Hepatics. It is often found creeping about without protection of any sort, but it has never been seen to feed unless when in a shelter of some kind. When feeding it is not timid. It may frequently be observed, in detached pitchers of *Frullana*, whirling rapidly about, regardless of collisions.

Habitat.—Among aquatic mosses growing in Loch Morar, October 1903, Loch Ness, 1904. Not confined to lakes. Common on Hepatics, Fort-Augustus, Blantyre Moor.

Callidina crenata, n. sp. (Plate IV. figs. 6a to 6d.)

Specific characters.—Small, colourless. Trunk and foot papillose. Head and neck smooth. Neck with a prominence on each side of the antenna. Teeth, seven or eight in each jaw. Foot of three joints. A crenate boss on first joint. Spurs short, tapering, acuminate, divergent. Toes, three. Food moulded into pellets. Posterior margin of pre-anal segment with a rounded prominence, free from papillæ, on each side. Oviparous.

Description.—Length $\frac{1}{30}$ inch when fully extended. Rostrum short, with lamellæ of moderate size. About twelve longitudinal folds on the trunk, at equal distances apart, not fainter dorsally. Papillæ not crowning the folds, as in *C. aspera*, Bryce, but regularly distributed over the whole surface of the trunk, smaller than in *C. aspera*, rounded, without pits or pores, diminishing in size on the foot. Spurs dotted. Toes short, blunt. Egg elongate, narrowed at anterior end.

This description is incomplete, as the animal was never seen to feed. Seen in the retracted state the discs are small and close together. The only other species which moulds the food into pellets, and at the same time has the skin papillose, is *C. aspera*, Bryce. From that it is distinguished by the more numerous teeth, smaller papillæ, and pre-anal processes.

Habits.—Although fairly abundant in several collections, nothing could be learned as to its habits. All the examples studied were very sluggish in their motions. They crept about very slowly; and though some of them were watched for long periods, they showed no disposition to feed.

Habitat.—Among ground moss and hepatics from the shores of Loch Ness and elsewhere near Fort-Augustus, February 1904, frequent; not yet found anywhere else.

Callidina pulchra, n. sp. (Plate IV. figs. 5a to 5f.)

Specific characters.—Small, colourless. Trunk very broad, strongly stippled. Corona narrower than neck or collar, with central setæ on discs. First neck segment with the anterior edge turned outwards like a rim all round. Rostrum short and broad, with a large brush of long cilia. Teeth, three to five in each jaw. Food moulded into pellets. Foot short, of three joints. Spurs short, divergent, acuminate. Toes, three.

General description.—Length about $\frac{1}{100}$ inch when creeping, $\frac{1}{120}$ inch when feeding. Very short and broad. Skin not papillose, but covered with uniform large clear dots. Trunk longitudinally plicate; dorsal folds faint, lateral deep. Stomach very voluminous, filled with large pellets.

Very similar to *C. lata*, Bryce, to which it is closely related. It agrees with that species in the breadth of trunk, the shape of the corona, the central setæ on the discs, and the dental formula. It differs in the oval rather than ovate trunk, the stippled skin, the projecting edge of the first neck segment, and the shorter spurs. The shape of the

trunk makes it a more elegant animal than *C. lata*, the great posterior breadth of which imparts a clumsiness of gait as it moves.

Habits.—In its steady, deliberate motions and mode of feeding it resembles *C. lata*. When creeping it goes steadfastly forward, increasing the length of each step by a gliding movement produced by the cilia of the rostrum. It feeds for shorter periods than *C. lata*.

Habitat.—In ponds near Fort-Augustus, February 1904. Found among the sediment obtained by washing aquatic mosses. It was very abundant in some ponds. When a portion of the sediment was put into a bottle with some water and tightly corked the animal continued to abound, and increased in numbers for some months, though the water was never changed.

Callidina muricata, n. sp. (Plate V. figs. 7a to 7h.)

Specific characters.—Of moderate size, narrow. Trunk with strong longitudinal plicæ, covered with low rounded tubercles. Corona narrower than neck. Discs large, separated by very small interstice. Rostrum narrow, with large lamellæ, which project laterally. Antenna slender, length equal to half diameter of neck. Neck with large thickenings on each side of antenna. Brain large, elongate; no eyes. Dental formula 2/2; border of jaws crenate. Food not moulded into pellets. Foot short, of four joints. Spurs slender, tapering, meeting at base, divergent, incurved. Toes, three; large, tapering. Reproduction oviparous.

General description.—Greatest length $\frac{1}{70}$ to $\frac{1}{100}$ inch. Skin of trunk yellowish, viscous, with little extraneous matter adhering. Stomach large, its walls containing small dark-greyish globules. Yolk-mass with eight nuclei. Egg large, oval. Discs nearly touching. Border of jaws brown.

The tubercles are of equal size, rounded, and disposed in transverse and longitudinal rows. They are probably permanent, and not mere hardened secretions as in *C. incrassata*, but this is not proven. On the back they are hidden by the deep longitudinal plicæ. The transverse rows, about nine on the trunk, give a false appearance of close segmentation. The tubercles are more obvious on the ventral side, and all over when fully retracted. The glands, intestine, and cloaca were normal. Vibratile tags not seen. Apart from the tubercles, the species may be known by the close approximation of the large discs and by the caliper-like spurs.

Habits.—Very slow in its motions. It extends itself with studied deliberation, like *Rotifer tardus*, and is not often willing to feed. It feeds steadily, but only for a short time. On all the occasions when it was seen feeding the ventral side was uppermost, so that the details of the upper lip could not be seen.

Habitat.—In the sediment of ponds, Fort-Augustus, January 1904, frequent; Blantyre Moor.

Callidina crucicornis, n. sp. (Plate V. figs. 8a to 8g.)

Specific characters.—Large, slender, elongate. Rostrum very long, of two conspicuous joints, with very large, spreading lamellæ. Antenna very small. Brain large; no eyes. Jaws relatively very small; dental formula, 2/2. Stomach voluminous; food not moulded into pellets. Foot short, of three joints, very prominent dorsal boss on first joint. Spurs long, tapering, with distinct shoulder on inner side at base, capable of being brought together at the points or crossed over one another. Last joint of foot long, with three very large toes.

General description.—Greatest length $\frac{1}{50}$ to $\frac{1}{60}$ inch. Every part elongate except the foot. Colour dull yellow or greyish. Longitudinal plicæ few, fainter on back. Salivary glands well developed, one long narrow pair extending beyond the mastax to the upper part of the stomach. Walls of stomach thick, filled with larger and smaller dark yellow globules. Intestine oval, its long axis transverse, partly covered in dorsal view by stomach. Yolk-mass large, with eight small nuclei. Space between spurs straight or convex, according to position of spurs. Terminal toes long, slender, two-jointed. Dorsal toe as long as the others, but usually extended to only half the length. Foot-boss pointing backwards.

Owing to its disinclination to feed, the description cannot be completed. In the retracted state the discs are large and elongate. The species has a superficial resemblance to *Callidina longirostris* in the long rostrum and spurs, and also to *Philodina macrostyla* and its allies. It is believed to have no close affinity with any of those species, all of which are viviparous, while this is oviparous. The rostrum tapers gradually from the oral segment, and is not abruptly narrowed as in *C. longirostris*.

Habits.—Although it has been known for more than two years, and has been under constant observation for nearly one year, and thousands of examples have been carefully studied by three or four observers, little is known of its habits, as it has never once been seen to feed. It creeps slowly and deliberately, examining everything it encounters with its rostrum, which appears to be a very delicate organ of touch. It is very mobile, and can be bent backwards and forwards and from side to side. The lamellæ, which are only inferior in size to those of *C. cornigera*, are waved about in the way characteristic of that species, and which has led to the supposition that they are organs of smell.

When washed out of the mosses among which it lives, and allowed time to settle down among the sediment, it is found that it takes up its position, not on the surface of the sediment, but a little way down in it. The stomach is often seen to be well filled with food. These facts, together with its disinclination to feed, lead me to suppose that it may have an aversion to light, and will not feed unless in darkness. If this is so, it may be impossible to complete the description of the head. Against the

suggestion is the fact that though it will not feed, it does not appear to be uneasy in the glare of the microscope lamp.

Habitat.—In lakes and ponds. Bottom of Loch Rannoch, at depth of 9 or 10 feet, April 1902. Abundant in pond near Fort-Augustus, January 1904. It thrives well in tightly corked bottles, and may continue in them for months.

Callidina armata, n. sp. (Plate VI. figs. 10*a* to 10*h*.)

Specific characters.—Large, massive. Corona broader than trunk. Rostrum short, broad; lamellæ small. Antenna as long as diameter of neck, clavate. A pair of tooth-like processes close below the mouth. Jaws relatively small, with two teeth on each. Stomach voluminous, reddish. Foot short, of three joints. A broad rounded fold at base of first joint. Spurs small, acuminate, incurved and decurved, interspace equal to diameter of base of spur. Foot ends in round perforated disc.

General description.—Greatest length when creeping, $\frac{1}{65}$ inch. Trunk with few longitudinal folds, dorsal faint, lateral deeper. All colourless, except alimentary canal. Food not moulded into pellets. Walls of stomach containing small reddish globules. Intestine roundish. Foot-glands of few cells, terminal cell largest. First foot-joint marked with annular striæ. Terminal joint long, disc perforated by many pores, ducts in common sheath. Four pairs of vibratile tags were seen.

Resembling *C. symbiotica* and allied species in massive build and discoid foot, it may be distinguished from all other species by the ventral processes below the mouth, the heavy antenna, and the dorsal fold at the base of the foot.

Habits.—Strong and active, like all the 'symbiotic' species. As it creeps rapidly about, the disc is exposed for an instant. It is a steady feeder. The function of the processes below the mouth could not be gathered from its actions.

Habitat.—On water weeds growing in Loch Ness and the Caledonian Canal at Fort-Augustus; although abundant during November and December 1903, it was not again found till December 1904, when it once more became common. The same beds of weeds, chiefly *Myriophyllum* and *Fontinalis*, were frequently examined during the intervening months without the species being once found. This may indicate that it has only a short season, though it is unusual for Bdelloids to have any seasonal limits.

Callidina incrassata, n. sp. (Plate VI. figs. 9*a* to 9*f*.)

Specific characters.—Large, stout. Trunk protected by thick plates formed of a hardened secretion. Rostrum short and very broad, with small ciliate lamellæ. Antenna considerably longer than diameter of neck. Neck with large process at each side of antenna. Corona as wide as trunk, discs large, interstice equal to half diameter of disc. Central papillæ on discs. Foot very short, of three joints. Spurs small, twice

as long as broad, acuminate, divergent, obtuse, incurved. Jaws with broad, brown, pectinate border, dental formula $5/4$. Food not moulded into pellets. Oviparous.

General description.—Greatest length $\frac{1}{60}$ to $\frac{1}{80}$ inch. Trunk dark yellow. Anterior row of tubercles more prominent than the others, sometimes so long that they hang down over the next two rows. Third segment of neck, close to tubercled trunk, viscous, and with a little extraneous matter adhering. Rostrum slightly broader towards apex, ciliated cup usually quite everted, the lamellæ then standing far apart. Papillæ on discs, only once seen, like little curved thorns. Viscera difficult to see through the dark, thickened skin. Under strong pressure stomach seen, with its walls filled with small clear globules. Brain large. Glands, intestine, cloaca, and vibratile tags not seen. Arrangement of teeth unusual. Three large teeth in one jaw fit into the spaces between four large teeth in the other. There is an additional thinner tooth at each end of the row of three.

In the contracted state the tubercled trunk is so similar to that of *Philodina macrostyla*, variety *tuberculata*, that it might be passed over for that species. When it extends itself it is found to differ in everything else. Every part of the Philodine is long and slender, of the Callidine short and broad, except the antenna. This is straight, not elbowed as in *P. macrostyla*. The foot appears to end in a disc, as in the 'symbiotic' *Callidinæ*. It is a very small and obscure disc, and no perforations could be seen. It may yet be found to have short, broad toes. The tubercles could be removed by rolling the animal under the coverslip.

Habits.—Very slow and cautious. After being disturbed it may remain fully contracted and motionless for a long time. It puts out its head very gradually, feeling carefully about with its long antenna before venturing out. When it has gained confidence it walks forward rather briskly for an animal so heavily armoured. The very short foot is only momentarily seen, the disc not at all, unless it happens to be walking upside down. It was not eager to feed, and when it tried to do so was evidently annoyed by the débris surrounding it, and soon desisted.

Habitat.—In the sediment of one or two ponds at Fort-Augustus, February 1904. It was pretty abundant for a time in one pond.

Philodina laticornis, n. sp. (Plate VII. figs. 12a to 12c.)

Specific characters.—Very large. Foot and rump together about $\frac{2}{3}$ of greatest length when creeping. Corona narrower than trunk, discs with small central papillæ. Rostrum short, broad, with very small ciliate lamellæ. Antenna stout, length equal to $\frac{3}{5}$ diameter of neck. Brain fairly large, with pair of large, oblique, yellowish-red eyes. Two teeth in each jaw. Foot of three joints. Spurs large, broad, divergent, interstice slightly exceeding diameter of spur at base. Dorsal toes small, ventral long,

incurved. Reproduction viviparous. Swims free, with spurs brought close together and discs also approximated.

General description.—Greatest length $\frac{1}{50}$ to $\frac{1}{40}$ inch when creeping. All colourless except the alimentary canal. Longitudinal folds of trunk few, dorsal faint, lateral stronger. Brain elongate, triangular. Stomach ample. Intestine elongate, elliptical. Rump and foot of about equal length. First foot-joint long, with faint annular striæ. Second joint with stronger striæ, crossed above the spurs by two oblique folds of skin, which nearly meet in the middle line, and give the appearance of an extra joint. Spurs with obscure shoulder on inner side at base, then slightly contracted and expanded again nearer tip. Foot-glands rather small, with very long ducts. Most examples with two well-grown young, showing teeth and corona, and one younger fœtus. Vibratile tags, five on each side seen.

Habits.—The large size, lanky form, and large spurs and toes, suggest that the animal is a parasite, but it has not yet been found attached to any host. On the other hand, its readiness to swim, and its characteristic attitude when swimming, spurs and discs being brought together as though to lessen the resistance, are like the actions of a free-living animal. Several species of parasitic Bdelloids have small brains and are blind, and there is some reason to believe that this reduction is a consequence of the mode of life. The power of swimming might be of advantage to an ectoparasite by enabling it to change its host if necessary. When swimming, the rostrum is kept fully extended. When creeping, the toes are often kept out during the whole of the step.

Habitat.—Among aquatic mosses growing at the margin of Loch Ness, at Fort-Augustus, April 1904; in the Caledonian Canal, Fort-Augustus, December 1904.

Philodina laticeps, n. sp. (Plate VII. figs. 11a to 11h.)

Specific characters.—Very large, elongate, yellowish. Corona very large, much wider than trunk, discs broad, concave, separated by space nearly equal to diameter of disc. On each disc an elevated conical papilla, with broad apex bearing several short motile cilia. Rostrum short and broad, with minute lamellæ. Antenna short, length equal to $\frac{1}{3}$ diameter of neck. Brain a minute triangle, no eyes. Teeth, two on each jaw, with one thinner tooth. Foot and rump together just under half of total length. Foot of four joints. Spurs large, broad, blade-shaped, divergent, interstice equal to diameter of spur. Dorsal toes small, ventral long, incurved. Parasitic on insect larvæ. Oviparous.

General description.—Greatest length $\frac{1}{50}$ to $\frac{1}{40}$ inch when creeping. All hyaline except alimentary canal. Trunk longitudinally plicate, central segments covered with a hair-like growth, which is probably a vegetable parasite. Corona broadest and discs largest known in the order. Yolk-mass with eight or nine nuclei; the large egg pointed at anterior end. Intestine long, elliptical. Foot-glands long, with very long ducts. Four vibratile tags on each side seen.

Habits.—Parasitic on insect larvæ which live in running water. It has been found on larvæ of several species, adhering to the thorax, between the bases of the legs. When separated from its host it is little disturbed, immediately begins to creep actively about, and readily feeds. When feeding it is very restless, and sweeps the great corona from side to side and all over the field. The apparent breadth of the corona is often increased by a peculiar habit the animal has of pulling in the sides of the trunk till it resembles a stem supporting a large flower. It is then more like one of the large-headed Rhizota, such as *Æcistes velatus*, than a typical Philodine (fig. 11*h*). When feeding it draws the rostrum in till it is depressed below the surrounding surface of the head.

Comparison of P. laticeps with P. laticornis.—The two species resemble one another very closely in some characters, and differ greatly in others. The agreement is so close that it is difficult to avoid the conclusion that they are related animals. On this supposition an interesting comparison of the differences of structure in relation to the different modes of life may be made. *P. laticeps* is a parasite; *P. laticornis* has only been found free. They agree in general form, in the rostrum, spurs, and long curved ventral toes, so closely that but for the longer foot of *P. laticeps* the same drawing of the extended animal could represent both. *P. laticornis* has a large brain and eyes, small papillæ on discs, larger antenna, and shorter three-jointed foot. *P. laticeps* has much larger corona, very large papillæ on the discs, shorter antenna, longer four-jointed foot, much smaller brain, and no eyes. If the parasite *P. laticeps* has been derived from the free-living *P. laticornis*, it is interesting to note that while it has gained a larger mouth, it has lost its eyes and most of its brain. Should *P. laticornis*, as is possible, prove to be also parasitic, the force of the comparison is diminished, but not altogether lost. The habit of swimming might enable a parasite to change its host when necessary, and so render it less dependent, and the retention of the large brain and eyes may be attributed to this habit.

P. laticeps is oviparous, *P. laticornis* viviparous. This is the only instance known to me of closely related Bdelloids differing in the mode of reproduction.

Habitat.—In a little stream entering Inchnacardoch Bay, Loch Ness. Very abundant during the winter of 1903–4. Any handful of *Fontinalis* taken from this stream and shaken in water yielded thousands of examples. Early in the summer of 1904 the stream dried up, and remained in this condition till October. When the water returned to the channel insects and rotifers had disappeared, and up till the end of November neither had again been found. Similar streams in the same district were searched, but though larvæ were found, there were no rotifers upon them.

Philodina humerosa, n. sp. (Plate IV. figs. 4*a* to 4*g*.)

Specific characters.—Small, dull grey, strongly plicate on trunk. Ventral transverse folds, fourteen or fifteen. Central setæ on discs spring from large conical

prominences. Space between discs equal to half diameter of disc. Rostrum short, shaped like an acorn, basal joint papillose. At back of oral segment, on each side of rostrum, a large rounded papillose prominence. Length of antenna equal to diameter of neck. Neck with rounded prominence at each side of antenna. Foot of three joints, stippled. Spurs small, tapering, divergent. Dorsal toes tapering; ventral larger, obtuse. Two teeth on each jaw. Oviparous.

General description.—Greatest length when creeping, $\frac{1}{100}$ to $\frac{1}{30}$ inch. Skin of trunk dull yellowish-gray, opaque, finely stippled, foot more strongly stippled. The prominence from which the central seta arises occupies nearly the whole of the upper surface of the disc. The great papillose bosses on the back of the oral segment are unique. They are conspicuous when the animal is creeping as well as when feeding. The skin of the first foot-joint is thickened dorsally, but does not form a boss.

Related species.—This species is closely related to *Philodina alpium* (*Callidina alpium*, Ehr.) and *P. brycei*, (*C. brycei*, Weber). The three species form a very natural group. They are semi-loricated. The skin of the trunk is thick. Its anterior edge is cut into definite forms and bears six knobs or processes. Its ventral surface is crossed by deep transverse folds, 9 to 15 in number. Though not quite rigid, it alters little in shape. When the animal is fully retracted the deep longitudinal folds allow the anterior edge of the trunk to be closed. In *P. alpium* and *P. brycei* the two anterior dorsal processes of the trunk form a fork which receives the antenna, as in *Anuræa* and *Brachionus*. In all three species the central setæ rise from large conical processes. There are four toes.

Habits.—Like its relatives *P. alpium* and *P. brycei*, it is very slow in its movements. When it has been left undisturbed for a time it feeds with confidence. It ceases feeding at short intervals, but resumes again at the same spot.

Habitat.—Found in ground moss and *Frullania* growing on stones. Old pier at the Monastery, Fort-Augustus, 7th February 1904. At several spots near Fort-Augustus. Not yet seen anywhere else.

EXPLANATION OF PLATES.

The drawings of the complete animals are all made to a uniform scale, with the exception of *Microdina*, which is drawn larger. The separate details are drawn of any convenient size. In the descriptions the only measurement given is the greatest length of the animal. All other measurements obtained are put into the drawings. Whenever possible the width of the corona, collar, neck, trunk, rump, and foot are measured, also the length of head, neck, trunk, foot, spurs, and jaws. These sizes, expressed in figures, convey but a vague impression of the appearance of an animal unless accompanied by a drawing. They are therefore omitted from the text.

The form of the upper lip is carefully drawn, but is not included in the descriptions, as no common names for its various parts have yet been agreed upon.

PLATE I.

1. *Microdina paradoxa*, n. sp.

<i>a</i> , dorsal view, example from L. Vennachar, 1902.	<i>e, f</i> , antenna in different degrees of extension.
<i>b</i> , lateral view, another L. Vennachar example.	<i>g</i> , foot, showing toes and glands under pressure.
<i>c</i> , ventral view, variety from L. Treig, 1904.	<i>h</i> , toes, dorsal view.
<i>d</i> , deposition of egg.	<i>i</i> , rostrum, ventral side.

PLATE II.

<i>a</i> , head of <i>Callidina papillosa</i> , ventral side.	<i>k, l, m, n, o</i> , jaws of <i>Microdina</i> , five views of same pair.
<i>b</i> , head of <i>Microdina paradoxa</i> , " "	
<i>c</i> , head of <i>Adineta barbata</i> , " "	
<i>d</i> , jaws of <i>Philodina brycei</i> .	
<i>e</i> , jaws of <i>Microdina</i> , form with three loops.	
<i>f</i> , jaws of <i>Melicerta</i> .	
<i>g, h, i, j</i> , four varieties of spurs of <i>Microdina</i> .	
	<i>k</i> , direct ventral.
	<i>l</i> , oblique ventral.
	<i>m</i> , direct dorsal.
	<i>n</i> , dorsal, under pressure, rami turned on side.
	<i>o</i> , lateral.

PLATE III.

2. *Callidina angusticollis*, n. sp.

<i>2a</i> , animal in case, feeding, dorsal.	<i>2g</i> , spurs.
<i>2b</i> , side of head, feeding.	
<i>2c</i> , jaws.	
<i>2d</i> , head seen from above.	
<i>2e</i> , section of oral segment at thickenings.	
<i>2f</i> , section of neck.	
	<i>2i</i> , animal in case, in characteristic attitude.
	<i>2j</i> , side of rostrum.
	<i>2k</i> , front of rostrum.

3. *Callidina annulata*, n. sp.

<i>3a</i> , animal in <i>Frullania</i> cup, feeding, dorsal.	<i>3d</i> , jaws.
<i>3b</i> , side of head.	
<i>3c</i> , front of rostrum.	
	<i>3e</i> , antenna.
	<i>3f</i> , spurs.

PLATE IV.

4. *Philodina humerosa*, n. sp.

4 <i>a</i> , dorsal view, feeding.	4 <i>e</i> , section of neck.
4 <i>b</i> , ventral view, creeping.	4 <i>f</i> , toes.
4 <i>c</i> , back of head.	4 <i>g</i> , jaws.
4 <i>d</i> , side of rostrum.	

5. *Callidina pulchra*, n. sp.

5 <i>a</i> , dorsal view, showing stippling.	5 <i>d</i> , side of foot.
5 <i>b</i> , dorsal view, feeding.	5 <i>e</i> , spurs.
5 <i>c</i> , antenna.	5 <i>f</i> , jaws.

6. *Callidina crenata*, n. sp.

6 <i>a</i> , dorsal view, creeping, showing papillæ.	6 <i>c</i> , section of neck.
6 <i>b</i> , ventral view, creeping, showing internal structure.	6 <i>d</i> , jaws.

PLATE V.

7. *Callidina muricata*, n. sp.

7 <i>a</i> , dorsal view, creeping.	7 <i>e</i> , side of antenna.
7 <i>b</i> , ventral view, feeding.	7 <i>f</i> , jaws.
7 <i>c</i> , side of rostrum.	7 <i>g</i> , side of foot.
7 <i>d</i> , section of neck.	7 <i>h</i> , spurs and toes.

8. *Callidina crucicornis*, n. sp.

8 <i>a</i> , dorsal view, creeping.	8 <i>e</i> , spurs crossed.
8 <i>b</i> , side of rostrum.	8 <i>f</i> , side of foot.
8 <i>c</i> , front of rostrum.	8 <i>g</i> , spurs and toes.
8 <i>d</i> , jaws.	

PLATE VI.

9. *Callidina incrassata*, n. sp.

9 <i>a</i> , dorsal view, feeding.	9 <i>d</i> , side of antenna.
9 <i>b</i> , front of rostrum.	9 <i>e</i> , spurs and disc.
9 <i>c</i> , jaw.	9 <i>f</i> , section of neck.

10. *Callidina armata*, n. sp.

10 <i>a</i> , dorsal view, feeding.	10 <i>e</i> , section of head, showing tooth-like processes.
10 <i>b</i> , ventral view, creeping.	10 <i>f</i> , dorsal view of foot, showing fold and glands.
10 <i>c</i> , side of head.	10 <i>g</i> , side of foot.
10 <i>d</i> , jaw.	10 <i>h</i> , spurs and disc.

PLATE VII.

11. *Philodina laticeps*, n. sp.

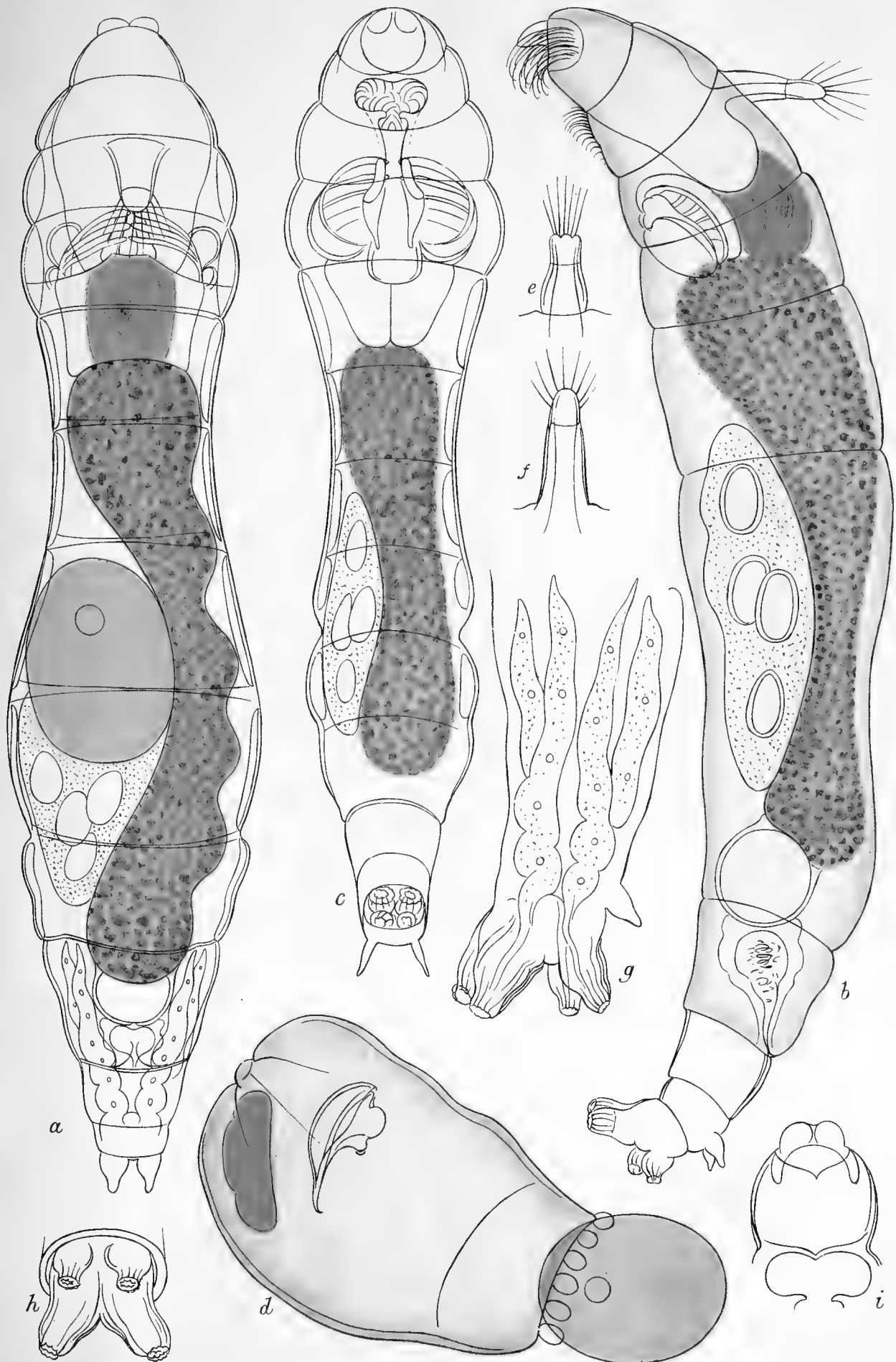
11*a*, dorsal view, feeding.
11*b*, front of antenna.
11*c*, side of antenna.
11*d*, papilla on disc.

11*e*, jaw.
11*f*, spurs and toes.
11*g*, back of rostrum.
11*h*, characteristic attitude, with trunk narrowed.

12. *Philodina laticornis*, n. sp.

12*a*, dorsal view, swimming.
12*b*, dorsal view, creeping, showing viscera.

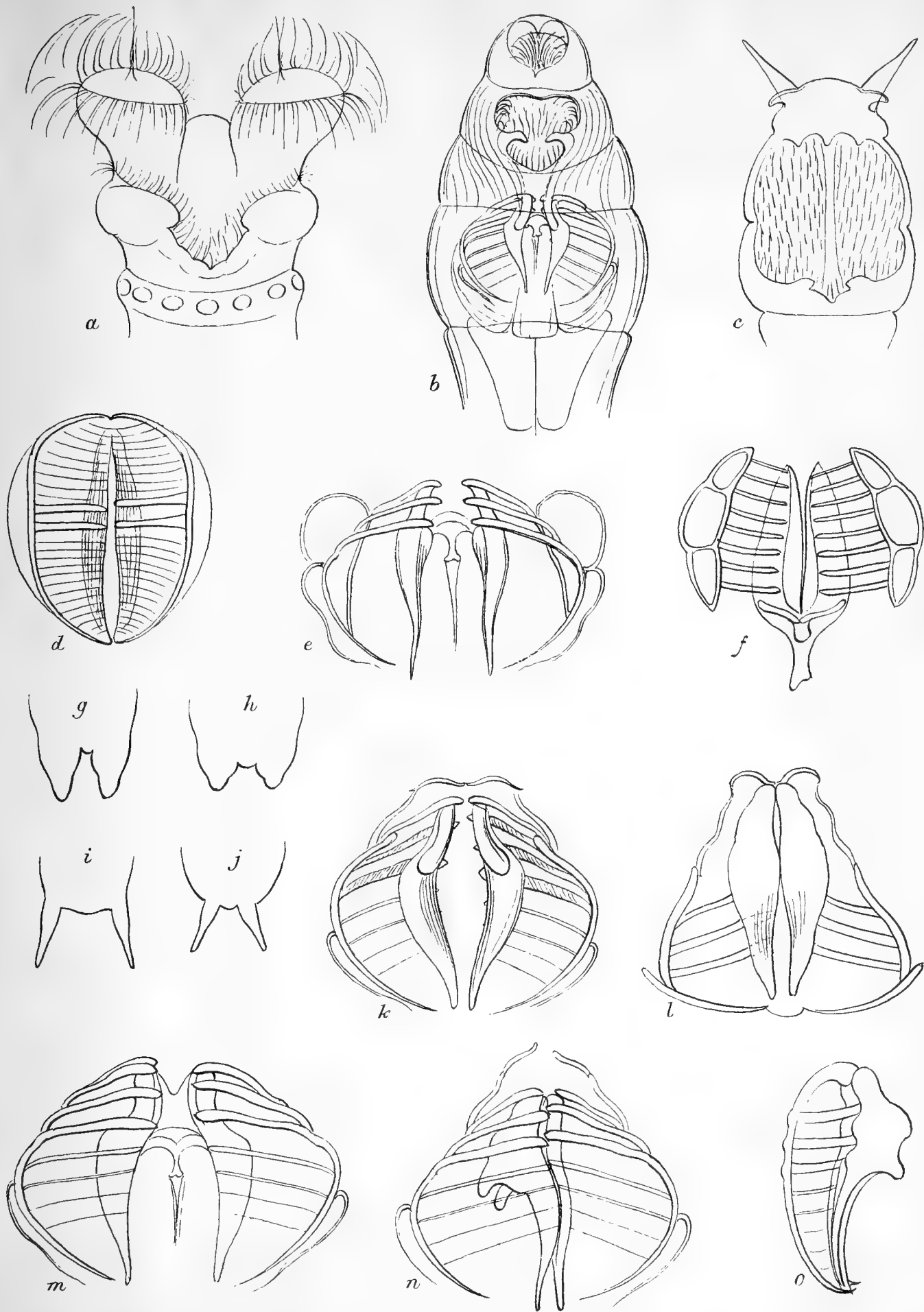
12*c*, side of antenna.



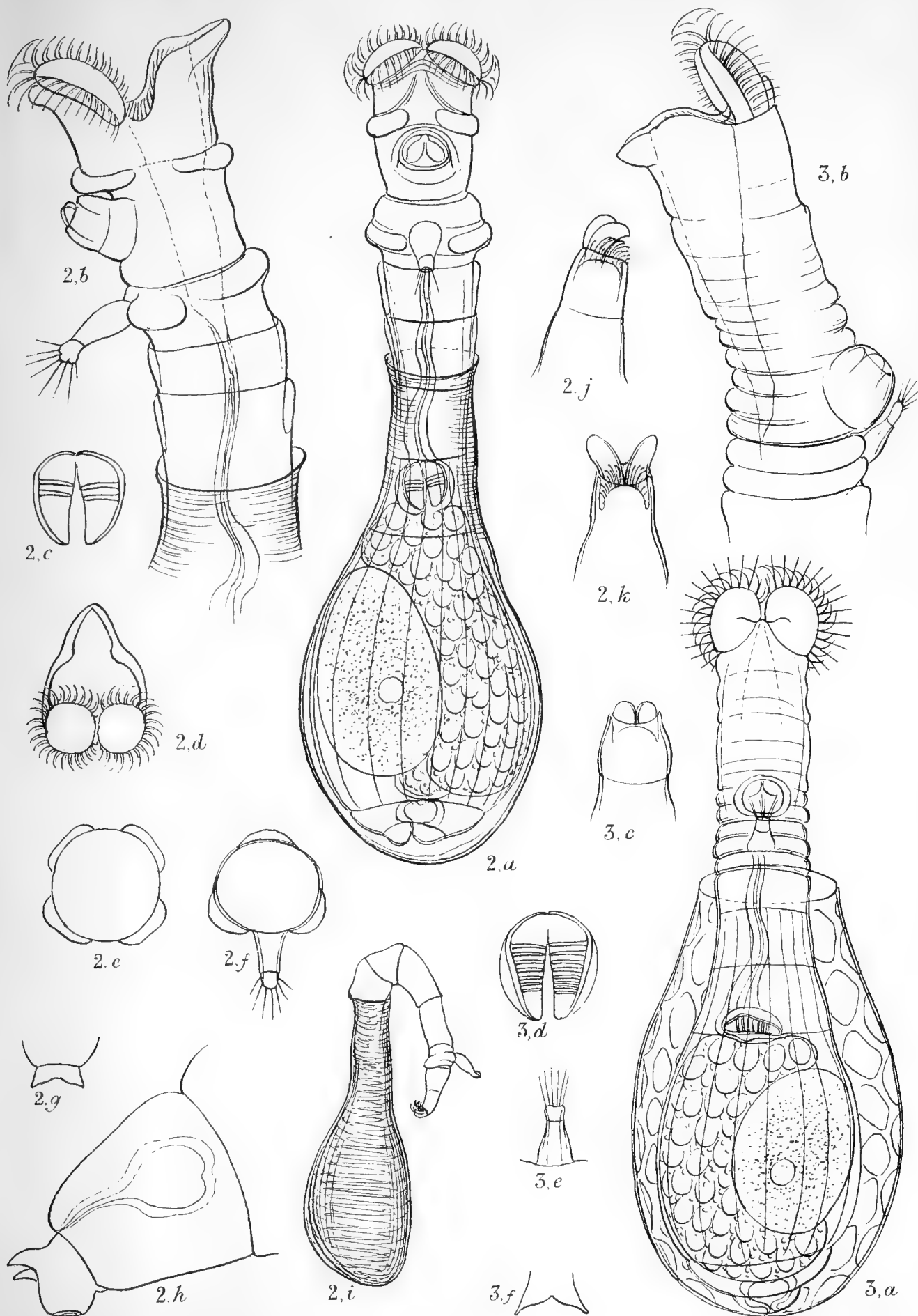
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MICRODINA PARADOXA, n. sp.

MURRAY: A NEW FAMILY AND TWELVE NEW SPECIES OF BDELLOIDA.—PLATE II.



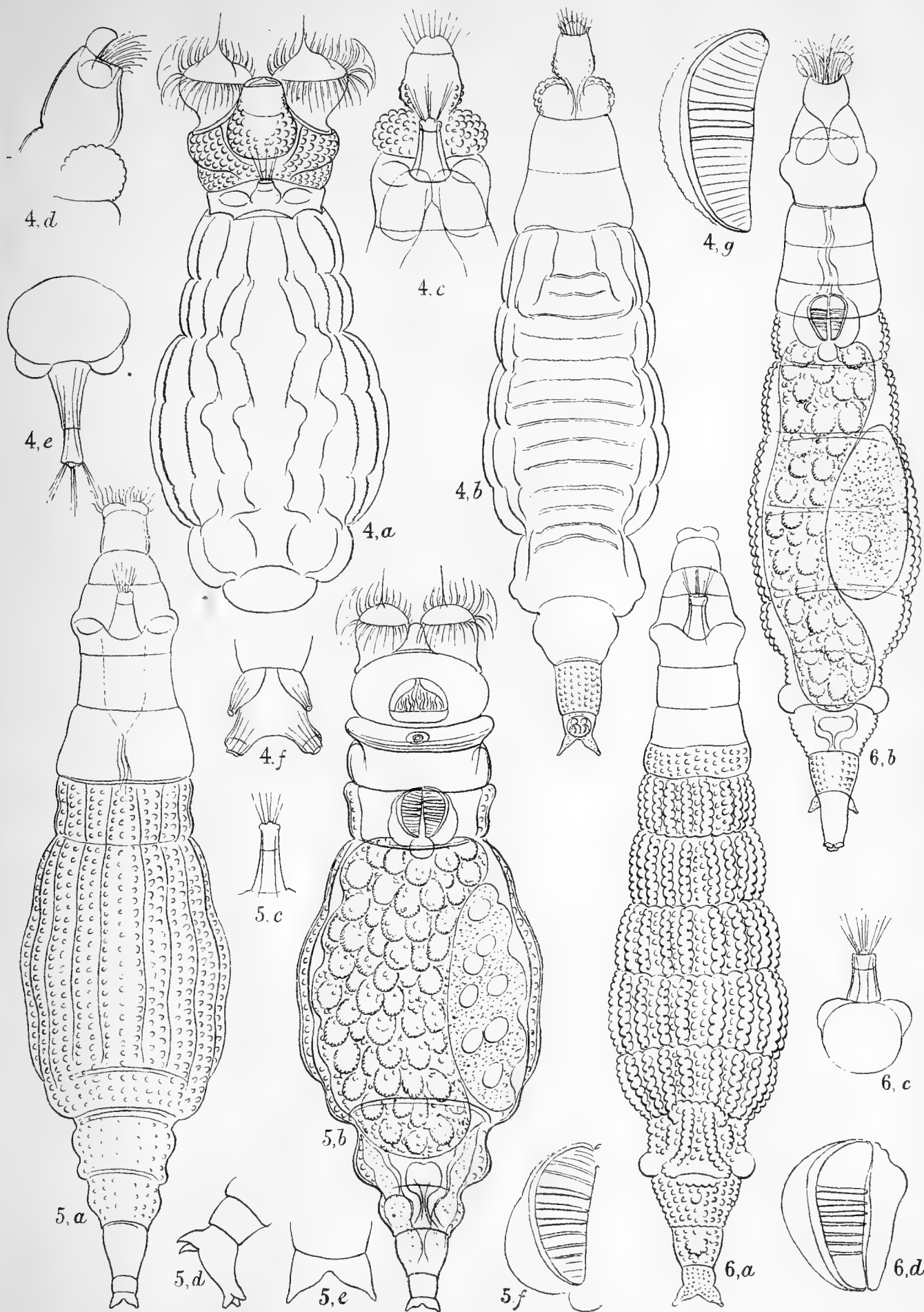
MURRAY: A NEW FAMILY AND TWELVE NEW SPECIES OF BDELLOIDA.—PLATE III.



2, CALLIDINA ANGUSTICOLLIS, n. sp.

3, CALLIDINA ANNULATA, n. sp.

MURRAY: A NEW FAMILY AND TWELVE NEW SPECIES OF BDELLOIDA.—PLATE IV

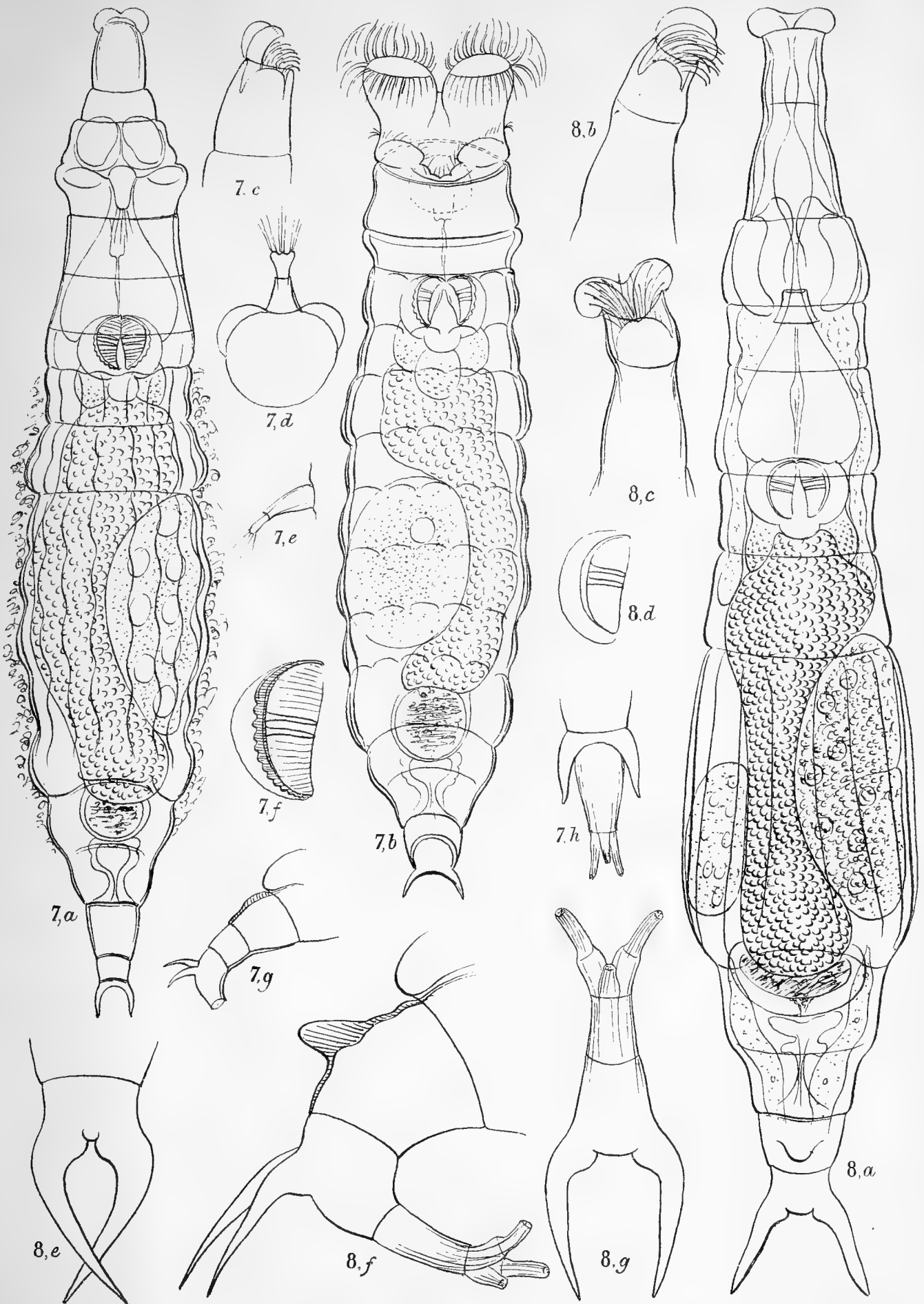


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4, PHILODINA HUMEROSA, n. sp.

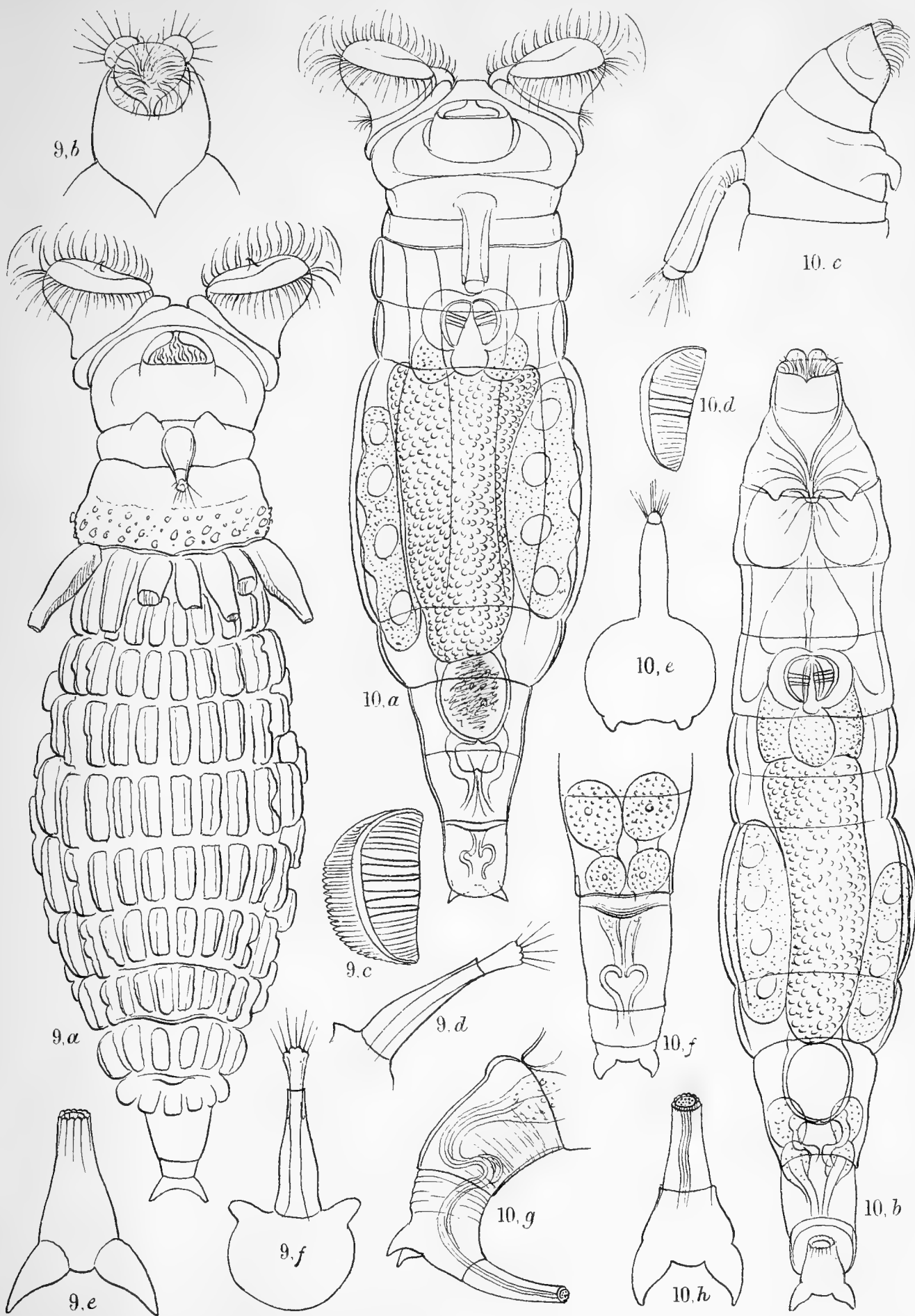
5, CALLIDINA PULCHRA, n. sp.

6, CALLIDINA. CRENATA, n. sp.



7, *CALLIDINA MURICATA*, n. sp.

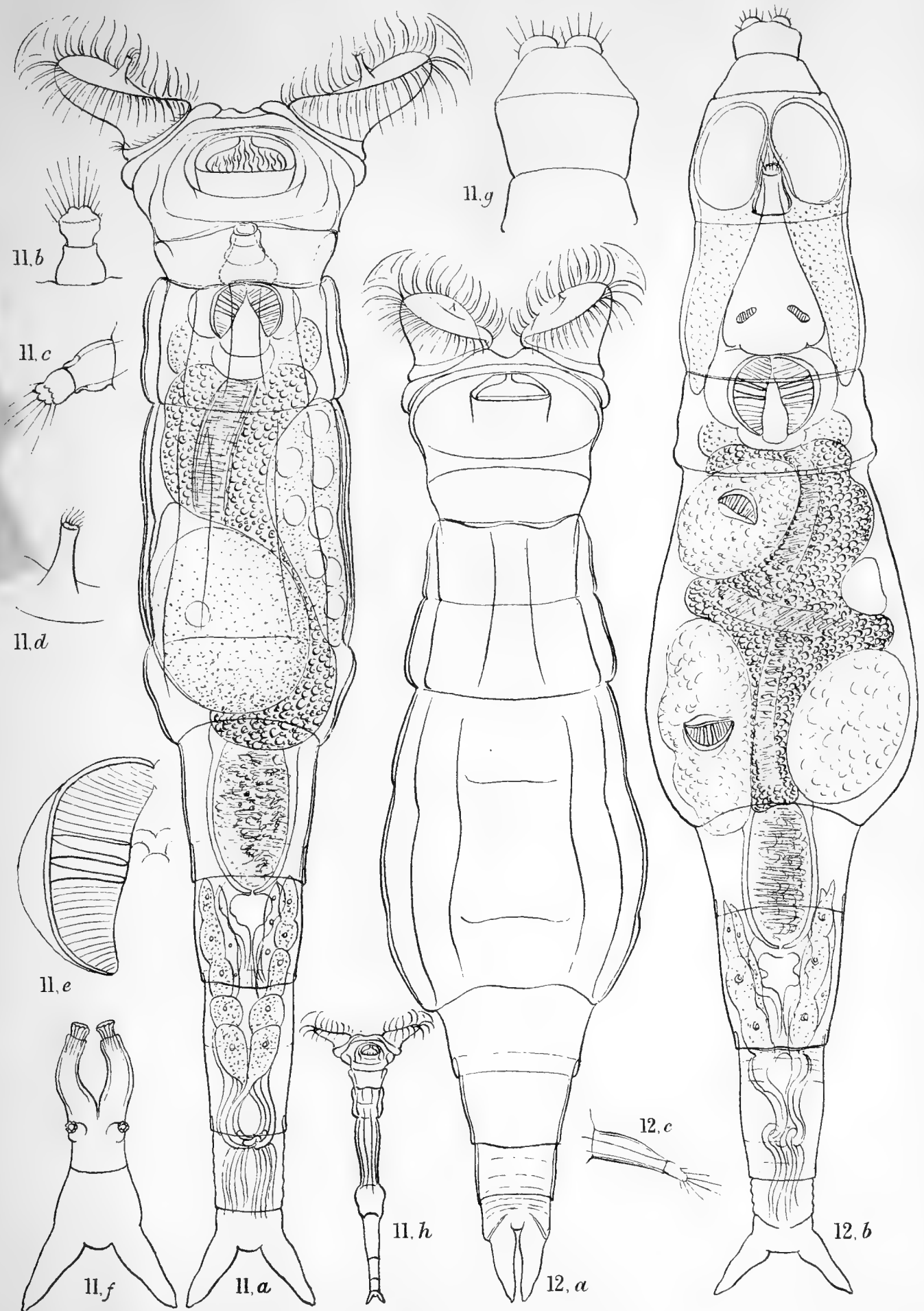
8, *CALLIDINA CRUCICORNIS*, n. sp.



9, CALLIDINA INCRASSATA, n. sp.

10, CALLIDINA ARMATA, n. sp.





11, PHILODINA LATICEPS, n. sp.

12, PHILODINA LATICORNIS, n. sp.

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XXXV.*Part 1.	2 2 0	1 11 0			
„ Part 2.	1 11 0	1 3 6			
„ Part 3.	2 2 0	1 11 0			
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„ Part 2.	1 16 6	1 7 6			
„ Part 3.	1 0 0	0 16 0			
XXXVII. Part 1.	1 14 6	1 5 6			
„ Part 2.	1 1 0	0 16 0			
„ Part 3.	0 16 0	0 12 0			
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„ Part 3.	1 10 0	1 3 0			
„ Part 4.	0 7 6	0 5 8			

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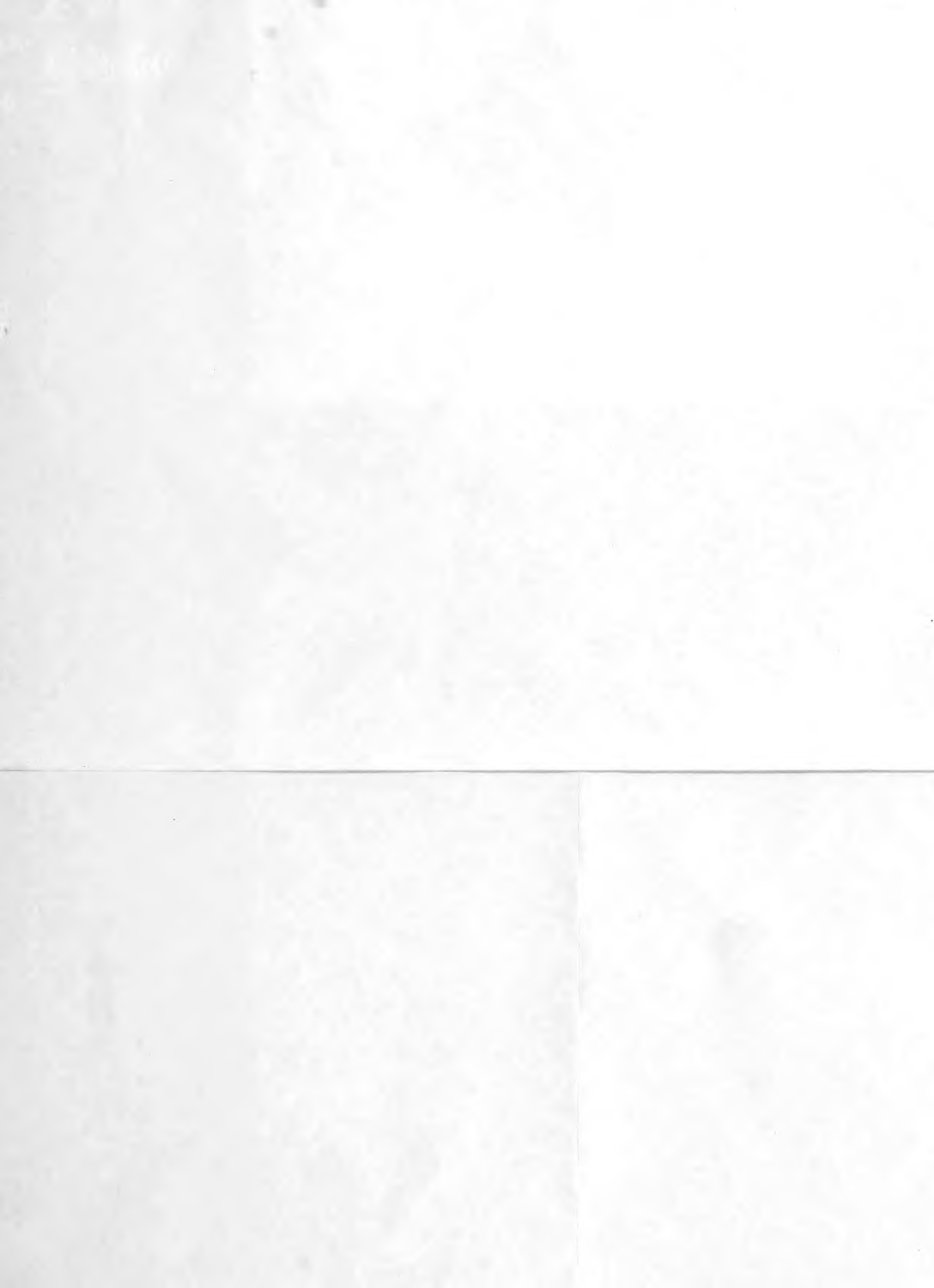
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