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THE TARDIGRADA OF THE SCOTTISH LOCHS.

BY

JAMES MURRAY.

[WITH FOUR PLATES.]

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XXVII.—The Tardigrada of the Scottish Lochs. By James Murray. *Communicated*
by Sir JOHN MURRAY, K.C.B., etc. (With Four Plates.)

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INTRODUCTION.

Although they are thoroughly aquatic animals, the Tardigrada are not very abundant in permanent waters. They are most thoroughly at home in situations where the supply of moisture is intermittent, and are therefore conspicuous members of that numerous community of animals known as moss-dwellers. They share with the Bdelloid Rotifera the power of withstanding desiccation.

Although they have their headquarters in land mosses, many species are quite at home in ponds, rivers, and lakes.

As lacustrine animals they belong entirely to the littoral region, into which they no doubt continually migrate from the adjoining mosses. A favourite habitat is that strip of shore between the highest and lowest levels of the lake, the 'grève inondable' of FOREL. Into this often mossy margin they may migrate in the ordinary way, when the loch is low. The next step may be involuntary—the loch rises during floods, and the bears, in common with many other animals, find themselves, willy-nilly, converted into lake-dwellers. It appears to be certain that of the water-bears introduced into lakes, by whatever means, some have found the conditions very congenial. Several species have hitherto been found nowhere but in lakes.

The condition which renders the margins of lakes favourable to many of the moss-haunting animals is, I believe, the thorough aeration of the water resulting from the perpetual lapping of the waves upon the shore; the water of the lake in this respect resembling running water; and there are many species of microscopic animals, so sensitive to impurity that they are never found in bogs or other stagnant waters, which abound in running streams and in the littoral region of large or pure lakes.

No Tardigrade is known to swim—they have no place in the pelagic region of the lakes—nor are any of them truly abyssal, though, like so many other animals in Scottish lochs, they may extend to considerable depths, and several species have been obtained at depths of about 300 feet in Loch Ness.

The observations of the Lake Survey upon Tardigrades have been chiefly made in Loch Ness and Loch Morar. A few collections were made in Loch Treig and one or two other lochs, and an examination of these confirms the belief that some of the water-bears are characteristic of lake margins.

In the preparation of this paper I have been greatly indebted to Mr D. G. SCOURFIELD, and to Prof. RICHTERS of Frankfort, who kindly consented to examine my drawings, and assisted me with advice, and with literature to which I had not myself access. Without this willing help the considerable material at the disposal of the Lake Survey could not have been utilised.

References to the bibliographical list are throughout the text made by figures enclosed in parentheses, thus (1), (15).

The animals are all drawn to the same scale, so that their relative sizes may be seen. The principal measurements are given both in fractions of an inch and in microns. For convenience of reduction the inch is taken as equal to the round 25,000 microns, which is a near enough approximation for practical purposes.

STRUCTURE.

The Tardigrada are articulated animals, regarded as having their nearest relatives in the Arachnida.

The structure is only treated here in so far as is necessary for systematic purposes.

Water-bears are segmented animals, having four pairs of jointed legs, the segmentation of both body and limbs very obscure and superficial. The blood consists simply of a body-fluid, filling the whole of the body cavity between the skin and the alimentary canal. In the body-fluid are usually numerous large nucleated cells, formerly regarded as blood-corpuseles, but now called fat-cells (13); small dark granules may also be present.

Skin.—This may be smooth and hyaline, pigmented, papillose, warted, or spiny, indistinctly segmented or thickened dorsally and formed into a series of protective plates, symmetrically arranged (*Echiniscus*).

Legs.—There is usually a distinct basal portion of each leg, the skin of which seems to be an extension of that of the body, forming a kind of sheath for the leg proper; two joints may sometimes be distinguished in this. There may be one or many claws on each leg, which may all be free, or united into groups of two or three.

Head.—Two joints, sometimes three, are distinguishable in the head. There may be many palps and setæ on the head, or none; eyes may be present or absent; there may be a rostral prolongation, or not.

Masticating Apparatus.—This is somewhat elaborate, the food being acted upon by two sets of organs which function as teeth. The *teeth* proper are a pair of straight or curved rods, looking very much like chop-sticks, tapering in front to very fine stiletto-form points which enter the *mouth*, a short, funnel-shaped expansion of the anterior end of the alimentary canal, or the *throat*, a narrowed portion of the tube, separating the mouth from the gullet. These stiletto-like points pierce the cells of the plants or animals which serve as food, which are then sucked. The teeth are much enlarged posteriorly, and usually forked; they may be connected with the gullet by supports

called the *bearers*. The food passes by the *gullet* to the *pharynx*. This is a strong muscular bulb, through the centre of which the alimentary canal passes. The function of this organ is supposed to be to force the food into the stomach, which it does by a pumping action. In several genera there are rows of hard rods or nuts round the tube passing through the pharynx; in these cases the rods seem to have the further function of pounding the food as it passes, thus acting as a second set of teeth. The pharynx, with its rows of hard rods, has some analogy with the mastax of rotifers. A short *oesophagus* leads from the pharynx to the stomach. The large cells forming the walls of the stomach have contents of a characteristic colour—brown, yellow, red, or blue.

Reproduction.—So far as known, all Tardigrades are oviparous. The eggs are spherical, oval, or elliptical, smooth, viscous, or spiny. They are either deposited free, in which case they are spiny or viscous; or they are laid several together in the skin as it is moulted, being then always smooth. In some genera, the larvæ do not differ in any important degree from the adults; in others, they differ considerably, and gradually acquire the adult form through a series of moults.

There is a marked uniformity of structure throughout the whole group, the main classification being founded on no more important characters than the texture of the skin, the number of claws, the form of teeth and pharynx, and the presence or absence of certain feelers on the head.

ECHINISCUS.

Generic Characters.—Skin of the back thickened and forming a number of plates or shields, symmetrically arranged singly or in pairs. Claws two or four, separate and independent. Two eyes. Teeth and gullet long, straight; no bearers. Four short setæ and two blunt palps near the mouth; two longer lateral setæ between the head and the next segment.

Plates.—The number of plates varies, ten being most common. When this normal number is present they have almost invariably the same arrangement:—(1) The *head plate* or frontal plate; (2) The *shoulder plate*, a larger plate, crossing the back and extending down the sides; (3) *First median plate*, a small triangular plate in the middle of the back, the apex pointing backward; (4) *First pair of plates*, two equal plates, meeting in the middle of the back, and extending down the sides; (5) *Second median plate*, triangular, with apex pointing backward, sometimes quadrangular; (6) *Second pair*, similar to the first pair; (7) *Third median*, triangular, apex directed forward; (8) *Lumbar plate*, a large plate, covering the whole posterior part of the body, and the fourth pair of legs, usually cut into a trefoil by two deep incisions. The middle portion of the trefoil I distinguish as the *tail-piece*. In many species described by RICHTERS it is quite separated from the lumbar plate, and is then called the *anal plate*.

If the number of plates were constant, or if a greater or less number were due to subdivision or suppression, the homologous plates could be distinguished through all the species by their names or numbers. There are, however, some species—(*E. islandicus*)

(13)—in which there are extra plates, the homologues of which are difficult to trace. The third median is often lacking, or it may be united to the lumbar; the second median also is sometimes absent.

Owing to these variations, it is judged better to give under each species a formula setting forth the number and arrangement of the plates, and of the various processes (setæ, spines, knobs) which they bear. When the homologous plates are recognisable, they will be numbered as above.

RICHTERS (9) divides the body into six principal segments:—I. (= *head plate*); II. (= *shoulder plate*); III. (= *first pair*); IV. (= *second pair*); V. (= *lumbar plate*); VI. (= *tail-piece or anal plate*).

Processes.—All the species have processes of some sort; many have numerous setæ, spines, or short knobs. Six setæ are invariably present, viz., the four near the mouth, and a pair behind the head. Besides these, there are usually some dorsal and lateral hairs or spines. The dorsal processes arise (with the single exception of *E. gladiator*) from the posterior margins of the plates which bear them. The lateral processes also spring from the posterior margin, at the ventral limit of the plates (postero-ventral angle). They are regarded by RICHTERS as arising independently of the two plates between which they are found; but they seem to me to be always more intimately connected with the anterior of the two, and are often as rigidly joined to it as are the dorsal processes, remaining attached to it after the skin has been cast, and the softer integument between the plates decayed away.

Following the practice of PLATE (5) and subsequent writers, the four short setæ of the face are disregarded (as being invariable) and only the longer head pair reckoned among the lateral setæ. It is understood that all processes are paired, and rise from the posterior edges of the plates (except the median spine of *E. gladiator*).

Dorsal processes are rarely found on any but the paired plates; lateral processes may be on any or all of the plates which extend over the sides.

RICHTERS (12) distinguishes the lateral processes by the letters *a, b, c, d, e*; *a* = the head seta, *b* springs from the shoulder plate, *c* from the first pair, *d* from the second pair, *e* from the cut separating the tail-piece or anal plate from the lumbar plate; *e* might as readily be reckoned dorsal as lateral, as when it is a spine it often rises some distance up the back. The positions of the various processes have been usually indicated by their relations to the four legs; they can be more accurately located by reference to the plates. The lateral processes, *b, c, d, e*, are over the four legs respectively.

Texture of Skin.—The plates may be quite smooth (*E. islandicus*), but are usually covered with larger or smaller granules, which may be of equal size and uniformly distributed, or irregular both in size and spacing. Some appear to have perforations in place of granules, or show other peculiarities, which will be noticed in the detailed descriptions. The whole of the skin, as well as the plates, is sometimes finely granular, the proximal part of the legs in some species coarsely so.

There is some doubt as to the precise nature of the apparent perforations of the dorsal plates of certain species. I suspect that they may arise by decay of the granules, and for this reason have made no use of them as specific characters. They are found in living animals, but are commoner in empty skins. That they are of some specific value is shown by their constant occurrence in association with definite arrangements of plates and spines. Where they occur, the perforations are very distinct, and marked by clean sharp edges.

Legs.—The first leg has often a small sharp spine, the last leg a similar spine, or more commonly a blunt palp, near the base. Both of these have probably been generally overlooked, and may yet be found to be always present. The last leg has, in most species, a serrate fold of skin about the middle of its length, which I call the *fringe*. The claws are four in number in most species, probably in all, when fully grown and mature. Generally the inner claws of each four have a decurved spine, called the *barb*, near the base, or as high as half-way up the claw. The outer claws are devoid of barbs, except in a very few species (*E. blumi*, etc.). The barbs of the outer claws are straight, and point outwards or upwards. The barbs of the last legs are larger than the others, and often these alone have them; there may be as many as three barbs on each outer claw of the last legs.

Teeth and Pharynx.—The teeth are always very long and straight, enlarged and forked at the ends, which are often closely applied to the pharynx; the points enter the mouth. The pharynx is sometimes minute and round, sometimes pretty large and somewhat cordate. As a rule there are no rods, such as are found in *Macrobotus*, two obscure curved lines which diverge from the end of the gullet probably representing them; but RICHTERS has seen rods in *E. islandicus*. I have never seen *simplex* forms in this genus.

Reproduction.—All lay the eggs in the moulted skin. It has been thought that the number of eggs is characteristic, as it is in many species of *Macrobotus*. To a certain extent this is so; but two species have been observed to lay eggs when still very small (*E. mutabilis* and *E. reticulatus*), laying then only one egg, while larger examples laid two, three, and four respectively.

Development.—Comparatively few of the species have been seen to hatch out, all which have been so observed having only two claws, which leads RICHTERS to suppose that all hatch in this form. Against this must be placed the fact that some individuals, of species which lay large eggs, have been found, so small that they might easily be supposed to be newly-hatched larvæ, but with four claws and all the outward characters of the adult. These species were abundant in the collections where they occurred, and increased in them, yet two-clawed larvæ were never found (e.g. *E. reticulatus*).

The larvæ usually lack some of the setæ possessed by the adult, and those which they have are relatively shorter. I don't know that any example has ever been kept under observation from its hatching to maturity; but where a species is abundant, examples may be selected at all stages of growth. In examples which I have seen

moulting, there was a considerable elongation of all the dorsal and lateral processes, as well as development of the fringe and of the barbs of the outer claws. Many observations of a species, common in Loch Morar, and which I regard as belonging to *E. granulatus*, are instructive as bearing on the value of all those points as specific characters (Plate II. figs. 6a to 6j). The larva was not certainly seen, but many moults of large animals were observed. The youngest individuals seen had four claws, without barbs on the outer ones; the fringe consisting of short blunt processes standing far apart; the dorsal processes being a large spine on the first pair of plates, a short spine on the second pair, and a mere knob on the lumbar plate; the lateral setæ were *c* and *d* (RICHTERS).

In a single moult the large dorsal spine elongated till it might be called a seta, the short dorsal spine became a long one, the knob became a spine, the fringe acquired long teeth standing close together, straight barbs appeared on the outer claws of the last legs, and the lateral setæ elongated. In the last stage seen there were two pairs of dorsal setæ, the first very long; the lateral setæ were also very long; the outer claws of all the legs had straight barbs, and those of the last legs had three such barbs.

Although no new processes appeared during these moults, except the barbs of the outer claws, the changes are sufficiently great to render imperative extreme caution in separating species by any of those characters, even if sexually mature individuals are seen. We may fully expect that the working out of the life histories would lead to the union of several of the earlier described species, and perhaps of some of the later ones as well.

Species.—All observers have agreed in basing their species chiefly upon the number and position of the spines or other processes; but it now begins to be suspected that this may carry us too far, and give us a multitude of species founded upon larval forms. RICHTERS advises that no species be described unless the eggs have been seen, or there is some very marked peculiarity. Now that it is known that some species lay eggs when not nearly full grown, even this rule may not be a perfect safeguard. It is a safe rule that no form should be separated from a known species merely because of one pair of spines more or less, or a difference in size of these appendages, unless there are other characters, whether of texture, claws, fringe, or what not, to support it. Another rule, laid down by JENNINGS (7) in regard to Rotifera, might well be applied to Tardigrada, viz., that no species should be described without an accompanying figure. JENNINGS' remark, that in most instances the description could be better dispensed with than the figure, applies equally to all microscopic biology.

Echiniscus arctomys—EHR. (4), (5), (9).

Specific Characters.—Small; nine minutely punctate dorsal plates. No setæ or spines except the six invariably present on the head. Legs slender, no fringe on last pair; all claws without barbs.

In many respects this seems like the larva of some larger species, but the eggs have been frequently seen. It is distinguished mainly by the lack of characters (fringe, barbs, setæ), which most species have when full grown. No formula of the arrangement of the plates can be given, as in the examples observed they were obscurely separated, the median plates being especially uncertain, and the separation of the pairs indistinct. The number, nine, is that given by PLATE. The whole skin is punctate. There is a blunt palp on the fourth leg.

Loch Ness, frequent, 1904.

Echiniscus gladiator, n. sp. (Plate I. figs. 1a to 1c.)

Specific Characters.—Small, yellow or pale red, all minutely punctate. Plates obscure, the median slightly developed, the pairs hardly divided. Large median recurved spine on anterior edge of second pair of plates. Lumbar plate deeply trefoliate. Legs slender, no fringe on last; inner claws with decurved barb, very strong on those of last legs. Eyes clear, not pigmented.

This is related to *E. arctomys*, which it resembles in narrow form, slender legs, lack of fringe, and minute punctation, and like that it might be a larva. The eggs have not been observed in this instance; but it differs markedly from *E. arctomys*, the only species to which it has any resemblance, not only in the great median spine, but in the strong barbs of the last inner claws.

Length, up to about $\frac{1}{3}$ inch (= 269 μ).

Among mosses and hepatics from the shores of Burlom Bay, Loch Ness, frequent; in Loch Ness, rare, February 1904.

Echiniscus mutabilis, n. sp. (Plate I. figs. 2a to 2d.)

Specific Characters.—Fairly large, narrow, yellow, all minutely punctate with pellucid dots. Plates many, scarcely of firmer texture than the rest of the integument—partly outlined by folds, partly indicated only by interruption of the dots. Median line on most plates caused by cessation of the dots. No fringe on last legs. Inner claws with small decurved barb.

Arrangement of Plates.—(1) Head, entire, with usual six setæ and two palps; (2) Shoulder, divided in pair or four; (3) Median, triangular, divided in three; (4) Pair, entire; (5) Median, triangular, divided in three; (6) Pair, entire; (7) Median, triangular, divided in two; (8) Lumbar, divided in five (an anterior pair, and the usual trefoil).

The usual ten plates are present, the additional ones arising from division of these. Two varieties are distinguished:—(a) Plates sharply outlined, the lumbar having its anterior portion separated as a distinct pair of plates, which partly overlap the posterior trefoil; dots comparatively large, regularly spaced. (Plate I. fig. 2a.) (b) Plates

rather more numerous (from further subdivision), some of them only faintly indicated, the lumbar with its anterior portion not forming separate plates—general arrangement the same; dots very minute, as in *E. arctomys*. (Plate I. fig. 2*b*.)

These two varieties can be distinguished among the smallest individuals, and appear to be constant, no intermediate states having been found. The differences are not sexual, both having been repeatedly found with eggs. A spine on the first leg, and palp on the fourth, have been frequently seen in both varieties.

Reproduction.—Eggs from one to four in number, laid in the moulted skin. An example measuring $\frac{1}{2}\frac{1}{16}$ inch (about 116μ) laid a single narrow egg, which measured $\frac{1}{5}\frac{1}{80}$ inch by $\frac{1}{9}\frac{1}{45}$ inch (43μ by 26μ). Larger examples laid two, still larger three, and the largest observed four eggs, which are larger and relatively broader, those in one skin measuring $\frac{1}{3}\frac{1}{75}$ inch by $\frac{1}{5}\frac{1}{60}$ inch (66μ by 50μ). They are usually dull yellow, but sometimes pale red. It appears from the above measurements that the species lays eggs when far from full grown. The newly-hatched larva has not been seen, but young measuring no more than $\frac{1}{2}\frac{1}{27}$ inch (110μ) had four claws, the inner barbed, and all other outward features of the adult.

Related to *E. arctomys*, which it resembles in narrow form, obscure plates, slender legs, lack of fringe, and in the finely punctate skin, it differs in the larger size, more numerous plates, and in having barbs on all the inner claws. Size, up to $\frac{1}{3}\frac{1}{3}$ inch, exclusive of legs (= 269μ).

In Loch Ness, Loch Morar, and ponds at Fort Augustus, abundant—1903–4.

Echiniscus wendti—RICHTERS. (Plate I. figs. 3*a* to 3*c*.) (10), (15).

Specific Characters.—No setæ except the usual six on the head, the lateral setæ at the back of the head twice as long as in *E. arctomys*. A fringe on the last legs. A strong decurved barb on inner claws of last legs. Granulation small and uniform. A spine on the first leg, and a blunt palp at the base of the fourth.

Arrangement of Plates.—(1) Head; (2) Shoulder; (3) Median triangular; (4) Pair; (5) Median triangular; (6) Pair; (7) lacking; (8) Lumbar, trefoliate.

Its discoverer distinguishes the species by the long head seta, the fringe, and the strong barb. Examples from Loch Morar agree in all those characters, but the granulation is rather coarse, and appears to be variable.

Loch Morar, 1904, frequent.

Echiniscus reticulatus, n. sp. (Plate I. figs. 4*a* to 4*c*.)

Specific Characters.—Stout, broad, bright red. Plates ten, arranged on the normal plan. Lateral setæ on head very long. Plates covered with pattern of large hexagons or circles, a slightly raised rim enclosing a flattish depressed surface. A long

sharp spine on front legs, a blunter spine on the last legs. Fringe on last legs. All inner claws with very small decurved barb near base.

Resembling *E. wendti* in having very long lateral setæ on the head and no other setæ on the body, it differs in the texture of the plates, the small barbs of the inner claws, and the presence of the third median plate. This plate is variable, and sometimes appears to be united to the lumbar plate, though at other times quite distinct. The hexagonal pattern on this plate is very faint or quite obsolete. The lumbar plate is rendered trefoliate by two deep cuts, and is besides divided into four facets, the two lateral and the posterior facets being bent at a sharp angle to the median facet. This gives the appearance of a separate anal plate; but there is no real separation, the pattern passing uninterrupted over the angle. The length of the lateral seta is equal to the diameter of the body at the shoulder, or much greater. The teeth of the fringe are often bifid.

Reproduction.—One to four eggs laid in the cast skin, the larger number laid by larger, and presumably older, individuals. A skin measuring $\frac{1}{117}$ inch (214μ) contained three bright red eggs of $\frac{1}{351}$ inch by $\frac{1}{422}$ inch (71μ by 59μ). The head seta in this measured $\frac{1}{78}$ inch (142μ). The newly-hatched larvæ have not been seen, but individuals so small that it might be supposed they had not moulted since hatching had four claws, with the inner barbed, and the reticulated plates quite distinct.

Loch Morar, very abundant, Loch Ness, rare—1903-4. It has not yet been found anywhere except in lakes.

Echiniscus oihonnæ—RICHTERS. (Plate I. figs. 5a-5b.) (10), (15).

Specific Characters.—Small, plates ten, only two median triangular, anal plate separate. Five lateral setæ or spines, and two dorsal spines, on each side. Fringe on last legs. Barbs on the inner claws, those of the last claws very strong.

Arrangement of Plates.—(1) Head, with longish lateral seta; (2) Shoulder, long lateral spine and smaller one above it; (3) Median, triangular; (4) Pair, lateral seta and small spine, strong dorsal seta; (5) Median, triangular; (6) Pair, lateral curved spine and short spine, dorsal short spine; (7) lacking; (8) Lumbar, very long whip-like seta; (9) Anal. In Scottish examples the anal plate is not separate.

Only two examples seen; no eggs. Margin of Loch Ness, February 1904. Loch Earn.

Echiniscus granulatus—DOY. (Plate II. figs. 6a to 6f.) (3), (5).

Specific Characters.—Plates nine, arranged in the normal manner, coarsely granulate. Three long lateral setæ, and a short spine at the junction of the tail-piece with the lumbar plate; two dorsal setæ or spines on each side. Spine on front leg, and blunt palp on last leg. Fringe on last leg. Inner claws with decurved barbs.

Arrangement of Plates.—(1) Head, with moderate lateral setæ; (2) Shoulder;

(3) Median, triangular; (4) Pair, long lateral seta, and strong dorsal spine or seta; (5) Median, triangular; (6) Pair, long lateral seta, and strong dorsal spine or seta; (7) lacking; (8) Lumbar, trefoliate, with short spine.

Among forms agreeing with *E. granulatus* in having three dorsal processes, on the first and second paired plates and the lumbar plate respectively, diminishing in size from the first backwards, there is considerable variety in the size of the processes and in the number of lateral setæ. The dorsal processes may all be spines; or the first, or both first and second, may be setæ. There may be only two lateral setæ, *a* and *d*; or they may be three, *a*, *c*, and *d*. There is no justification for separating any of these as distinct species, unless after a full study of the development, as the eggs are unknown. Three varieties were found in Loch Morar.

First (figs. 6*a* and 6*b*). An elongate, large animal, with only two lateral setæ, *a* and *d*, one dorsal seta, and two spines. Straight barbs on the outer claws of last legs. Granules variable in different examples—very coarse or moderately fine; uniform. Pharynx large, cordate.

Though large, it has not been seen with eggs.

Size, $\frac{1}{85}$ inch = 294 μ

Second. Two large dorsal spines and a small one; three lateral setæ, *c* and *d* very long. Barbs of outer claws not seen. Granules moderate. Size, $\frac{1}{90}$ inch = 277 μ .

Third (figs. 6*c* and 6*d*), like the second, but first dorsal process a very long seta. Straight barbs on the outer claws, up to three on those of the last legs. Granules moderate. Size, up to $\frac{1}{80}$ inch = 312 μ .

The species resembles *E. blumi* (15) in having barbs on the outer claws. That species has, however, more numerous lateral and fewer dorsal processes. The elongation of the last dorsal process in *E. granulatus* would produce an animal like *E. blumi*. The absence of the barbs of the outer claws from descriptions of species must not be regarded as of much importance, as they may have been overlooked, or they may only appear at a late stage in development. For fuller account of appearance of barbs in this species, see *ante*, under development of *Echiniscus*.

Habitat.—Loch Morar, abundant; Loch Ness, frequent.

A larva, probably of this species, is shown in fig. 6*e*.

The first variety described above differs from this larva in that the second lateral process is on the second paired plates, instead of the first; so it may prove to belong to another species.

Echiniscus spitzbergensis—SCOURFIELD. (Plate II. figs. 7*a* to 7*c*.) (6).

Specific Characters.—Plates nine, arrangement normal. Four lateral setæ (one on the head, shoulder, and each of the paired plates); long dorsal seta on first pair, and shorter spine on second pair. Inner claws with small decurved barbs. Granules very large.

I identify as this species an animal rare in Loch Morar. Though differing in some details from Mr SCOURFIELD'S species, I do not think we would be justified in separating it, considering that there were no eggs seen in either case, and in view of the great change in the size of the processes which takes place during development. Only empty skins of the Loch Morar animal were seen. In place of the granules the plates were covered by large quoit-like rings, the centres perforate, which I believe to originate in the decay of the granules. They further differed in the dorsal spines on the second pair of plates being long, and the small spines of the same plates lacking. The lateral setæ, *a*, *b*, *c*, *d* (RICHTERS), increase in size from *a* to *d*, which is very long. The lumbar plate is trefoliate; in SCOURFIELD'S examples, entire.

Length, Loch Morar examples, $\frac{1}{100}$ inch (250 μ).

DOUBTFUL SPECIES.

Many examples of *Echiniscus* have been found which, while differing more or less from the descriptions of all known species, could not, in the absence of eggs, be certainly identified, or regarded as distinct species. They are figured here, with short descriptions, as an assistance to other observers. All were sufficiently large to be regarded as probably nearly full grown, though size is not a quite safe criterion of age.

Echiniscus, sp. ? (Plate II. figs. 8a-8b.)

Plates ten, normal. Lateral setæ five, increasing in length from front to back. Dorsal processes—a long seta on the first paired plates, a short knob on the second pair. Fringe on last legs. Mid claws barbed. Granules of moderate size. The section of the genus having five lateral processes contains about a dozen species. Some of them (*E. duboisi*, *E. conifer*, *E. spinulosus*, *E. oihonnæ*, etc.) have very distinct characters. If we bear in mind the elongation of the processes during development, many of the other species will appear less certain, and it is noteworthy that the eggs of most of these are unknown (14). Some of the forms having fewer lateral processes may be younger stages of the same species. This and the two following forms belong to this section, differing mainly in the proportions of the processes.

Loch Ness, at pier, 7th February 1904.

Echiniscus, sp. ? (Plate II. figs. 9a-9b.)

Plates normal. Four of the lateral processes are long spines (? setæ) with bulbous bases. Dorsal processes—a long spine on the first paired plates, a very short broad spine on the second pair. Granular or perforate. This form, with small perforations, as shown in fig. 9c, was frequent in Loch Morar, and was regarded as a distinct species till another form was observed, identical with it in all else, but with fairly large

uniform granules. It is a curious fact that the perforations have a quite different size and arrangement from the granules, so that they could not be derived from them, as was supposed to be the case with a similar form of *E. spitzbergensis*. (Plate II. fig. 7a.)

Echiniscus, sp. ? (Plate II. fig. 10a.)

Two lateral setæ (one after the plates of the first pair). Dorsal seta on plates of first pair, short broad spine on plates of second pair. Spine on front leg. Fringe. Inner claws barbed. Nearest *E. aculeatus*, differs in lateral process not double. (5).

Loch Ness, November 1903.

TWO-CLAWED LARVÆ.

Three larval forms having two claws were seen. Two of these are referred to under the species to which they are supposed to belong (*E. wendti*, *E. granulatus*). The third could not be identified.

Echiniscus, sp. ?, larva. (Plate II. fig. 11.)

Plates ten, arrangement normal. Three lateral processes—a short curved spine on plate of second pair, a longer seta at junction of tail-piece and lumbar plate. No dorsal processes. Granules moderate. Fringe of longish blunt spines. Claws two, the barbs large. Blunt palp on last legs. Mouth palp appears to spring from elongate curved process which bears the anterior mouth seta. Size $\frac{1}{16}$ inch.

Shore of Loch Ness at Fort Augustus.

MACROBIOTUS.

Generic Characters.—Obscurely segmented, without hardened dorsal plates. Claws four, united in pairs, or one pair and two free claws. Teeth with bearers; gullet short, rigid. Pharynx with several rows of hard rods or balls.

The genus *Doyeria* cannot now be maintained, as it has been shown by RICHTERS that most (and probably all) species of *Macrobotus* may get into a condition in which the teeth are as in PLATE'S genus *Doyeria*. The distinction of the genus *Diphascion* is also a slender one, there being intermediate forms between it and *Macrobotus*.

The species of *Macrobotus* are distinguished by the form of the claws, the texture of the integument, and the number and arrangement of the pharyngeal thickenings.

The last character is most reliable, but in many individuals its value is lessened by a curious reduction of parts which takes place. The eyes are of little importance, as

they may be present in some individuals of a species and not in others. The fat-cells in the body-fluid have a characteristic colour; in most species they are clear and hyaline, but in a few they are golden yellow or dark brown.

The segments of the body are superficial, affecting the skin only. There appear to be usually two segments to the head, one to each pair of limbs, and intermediate segments—ten in all; but they are often increased in number by subdivision, and there are very commonly two between the third and fourth legs.

Simplex Forms (15).—Individuals of species of *Macrobotus* are often found which exhibit a remarkable reduction of the masticating apparatus: the teeth are straight, without stays—they are not functional; the rods of the pharynx disappear; in extreme cases, the mouth and gullet are quite obliterated. This state can only be temporary, or the animals would die; and they often appear in good health, and may have the stomach filled with food. I can only suggest that it is temporary, and a preliminary to moulting; but if this is so, it is a remarkable parallel, among animals so high in the scale, to the disappearance of the mouth in ciliata during fission.

In exceptional cases, the pharynx and teeth entirely disappear.

Reproduction.—Two forms of eggs are laid, the one kind round and spiny, the other smooth and oval or elliptical. The spiny eggs are laid singly and free; the smooth eggs are laid in the moulted skin, which serves as a protective capsule for them. So far as known, the same species always lays the same kind of egg. The smooth and spiny eggs are not, as from analogy we would expect, the summer and winter eggs of the same species; but further observation on the point is needed. The laying of smooth eggs in the cast skin is the prevalent mode of reproduction in the genus as in the order. It is very difficult to trace which species lay spiny eggs, as, for some unexplained reason, animals containing such eggs are very rarely seen. When the young contained in the smooth eggs are ready to hatch, it is seen that the teeth and pharynx are very large and fully developed. The stiletto-like teeth are continually applied to one spot in the shell till they weaken and finally pierce it. At this stage the pharynx is not very greatly inferior in size to that of the mature animal, and the characteristic thickenings are all present.

Two groups of species are to be distinguished in the genus. The first, typified by *M. hufelandi*, have the two pairs of claws similar, the claws strong, the claws of each pair rigidly united and one of them slightly larger than the other, the larger claw of each pair with a strong supplementary point. The second group includes species having the two pairs of claws dissimilar, slightly united at the base only, the larger pair having one very long slender claw and a much shorter one, the other pair similar but smaller, or of two nearly equal claws—supplementary points none, or very fine.

I believe all species of the first group lay spiny or viscous eggs; those of the second, smooth eggs enclosed in the skin. The species having two single claws and a pair form an extension of the second group.

Macrobotus hufelandi—C. SCH. (1), (14).

Specific Characters.—Large, dark-coloured, dark granules, in addition to the fat-cells, in the body-fluid. Pharynx large, shortly elliptical, with two narrow rods and a small nut in each row of thickenings. Teeth large, strong, curved, with strong bearers, entering the throat. Claws, two similar pairs, each pair of a longer and a shorter claw closely united, the larger claw of each pair with a double point (supplementary claw near apex).

This is the water-bear *par excellence*, though no doubt the early observers confused several species together under this name. It appears to be widely distributed over the world, though perhaps less so than was formerly supposed.

There is a group of species, all very closely related to *M. hufelandi*, some so closely that they can only be distinguished by the different forms of the egg spines. These occur all over the world, and have no doubt been often mistaken for *M. hufelandi*, in the absence of eggs.

One of the largest Tardigrada, attaining to $\frac{1}{40}$ inch (625 μ), and perhaps upwards. Eyes are normally present—the blind condition having been described as a distinct species (*M. schulzei*, GREEFF).

Habitat.—Common in the shallow waters of lakes; in Loch Ness it has been found at a depth of 300 feet. Loch Morar; Loch Treig.

Macrobotus echinogenitus—RICHTERS. (10), (14), (15).

Specific Characters.—Hardly distinguishable from *M. hufelandi* except by the eggs, which are covered with conical processes, having acute—often curved—tapering points. Those of *M. hufelandi* have the processes narrower cones, expanding at the apices into little discs.

I have seen only the *simplex* form of this. The eggs are, however, very abundant in Loch Morar.

Habitat.—Loch Ness, Loch Morar; common.

Macrobotus islandicus—RICHTERS. (Plate III. figs. 12a to 12c.) (13).

Specific Characters.—Hyaline, except stomach. Teeth strongly curved, with bearers; teeth enter the mouth. Pharynx round, two short rods in each row, each about twice as long as broad, besides a little round nut attached to the end of the gullet. Claws, two unequal pairs, the longer claw of each pair with a supplementary point. Stomach cells filled with dark blue granules.

The eggs were not seen, but RICHTERS found them in Iceland.

Loch Ness, common, 1903–4. Not yet seen elsewhere.

Macrobotus ornatus—RICHTERS. (Plate III. figs. 13a to 13c.) (8).

Specific Characters.—Glabrous and spineless, or finely or coarsely papillose, covered with large granules on the back, or with many rows of long spines on the back and sides. With or without eyes. Teeth somewhat weak, slightly curved, with bearers. Pharynx circular, thickenings three in each row, round or nearly so. Claws, two similar pairs, one of each pair longer.

I follow RICHTERS in making the verrucose and spiny forms mere varieties of one species, although I have seen no intermediate varieties, and would have regarded them as distinct. As a logical consequence, the glabrous form must also be united with them. Of the three varieties, the warted one is largest, and is the only one possessing eyes (in Scottish examples). The spiny form has only been found in ground moss and in ponds, not yet in lakes. The other two varieties are lacustrine, the glabrous one being very frequent at lake margins.

Glen Roy, 1902—pond at Fort Augustus (var. *spinosissimus*); Loch Ness (var. *verrucosus*); Loch Ness, Loch Morar, Loch Treig, smooth variety.

The eggs have not been observed in Scotland, but RICHTERS found them in the cast-off skin.

Macrobotus annulatus, n. sp. (Plate III. figs. 14a to 14c.)

Specific Characters.—Skin pale yellow, stomach brown. All papillose except face and distal portion of legs. Papillæ large, round, equal; on back and sides arranged in regular lines running round the body, but lost on the under surface. The usual apparent segments of *Macrobotus* here divided into lesser segments, on each of which are two or three of the rows of tubercles. Two black eyes. Teeth strong, curved, with bearers. Pharynx nearly as broad as long, round or slightly cordate. Two narrow rods in each row, and a lesser round nut next the end of the gullet. Claws, two pairs slightly united, one claw of each pair longer than the other. Longer claws, with fine supplementary points.

Reproduction.—Three elliptical eggs are usually laid in the moulted skin; they measure about $\frac{1}{384}$ inch (67μ) long. A curious habit prevails, which I have not observed or heard of in any other Tardigrade. The skin is not completely moulted, but remains attached to the front of the head, and is carried about, with its contained eggs, for a long time, in some cases till the eggs hatch. As all my observations were made upon animals kept in captivity, and therefore under conditions different from those to which they would be subjected in their natural home, we cannot be sure that this habit is normal. It is noteworthy, however, that on every occasion when it was observed the eggs were thus carried, and other species kept in the same way did not do so. It was under almost continuous observation for more than a year, and many hundreds of examples were seen carrying the skinful of eggs, and the practice was repeated by successive generations.

It is difficult to imagine how the eggs can be deposited in the skin while it remains attached to the head, so that one is tempted to suppose that the moult is completed in the usual way, and the skin picked up again afterwards; but this has not been seen.

The egg measuring $\frac{1}{384}$ inch (67μ), produced a larva $\frac{1}{176}$ inch (142μ) long. The pharynx was $\frac{1}{1056}$ inch (24μ) long. There was no trace of eyes nor of papillæ on the skin or supplementary points to the longer claws, but otherwise the form was as the adult.

Size, about $\frac{1}{60}$ inch (417μ) or larger. Having some resemblance to *M. granulatus*—RICHTERS (10), which has, however, claws of quite different structure. The supplementary points of the longer claws of each pair are much more distinct than is usual in species having smooth eggs.

Habitat.—Bog pool at Fort Augustus, very abundant; margin of Loch Morar, rare, 1904.

Macrobotus papillifer, n. sp. (Plate III. figs. 15a to 15c.)

Specific Characters.—Hyaline, two black eyes. Back and sides covered with conical acuminate processes, arranged in transverse and longitudinal rows. Similar processes on the head, or lacking. Teeth strong, curved, with bearers. Pharynx nearly as broad as long, with three equal thickenings in each row, which are about twice as long as broad. Claws, two nearly equal pairs, one claw of each pair longer.

Length, up to $\frac{1}{100}$ inch (250 microns). Eggs laid in the cast-off skin. Five eggs were laid in one skin, the animal being seen to leave the old skin by the anterior end.

Habitat.—Loch Ness, common; Loch Morar, rare.

This species is comparable with *M. tuberculatus*—PLATE (5). The processes are more numerous and of different form; but this would not justify its separation, if we had not a more reliable character in the relatively large pharynx, with three short rods in each row of thickenings. PLATE says that there are only two rods in each row in *M. tuberculatus*, though his figure shows three.

SCOURFIELD, who has seen *M. tuberculatus*, regards this as distinct.

Macrobotus oberhäuseri—DOY. (3).

Specific Characters.—Dorsum, with nine transverse bands of a brown colour. Pharynx, small round, with three short oval thickenings in each row. Claws, one pair and two single claws. Eggs laid in the cast-off skin.

Various diverging if not conflicting diagnoses of this species are given by different authors, and it is probable that different species have been confused together. An animal having the transverse bands of colour and small pharynx was observed in Loch Ness, but it had not the two free independent claws which, according to PLATE, this species should have. This probably indicates only different interpretations of the structure of the slightly united larger pair of claws.

Habitat.—Frequent in Loch Ness and Loch Morar; occurring at considerable depths in Loch Ness.

Macrobiotus macronyx—DOY. (Plate III. figs. 16*a* to 16*d*.) (2), (11), (12).

Specific Characters.—The claws of each pair of unequal sizes, independently movable (5). Teeth and pharynx as in *M. hufelandi*, but the thickenings are slender rods. Two eyes. Numerous eggs laid in the cast skin.

In a short stream draining Loch Geireann Mill, North Uist, abundant among *Fontinalis*. High tides reach to the spot where it was found, May 1904.

From a drawing sent to him RICHTERS determined the Lake Survey examples to belong to this species, but the animal differs in some respects both from PLATE'S description and from RICHTERS' own figure (11). The smaller claw of each pair is relatively much smaller than RICHTERS draws it, and I saw no indication that they were separately movable. The lesser claws of all the legs, except the fourth, appeared so reduced and closely united to the larger claws as to resemble the barbs of the inner claws of *Echiniscus*. The lesser claws of the fourth pair of legs are considerably larger, but even these do not appear to be separately movable.

Macrobiotus intermedius—PLATE. (5).

Specific Characters.—Claws, two similar pairs, strong, one of each pair longer and with double point. Pharynx small, round; no eyes.

Resembling *M. hufelandi* in the form of the claws, and *M. oberhäuseri* in the small round pharynx.

Habitat.—Margin of Loch Ness, frequent.

Macrobiotus, sp. ? (Plate III. figs. 17*a* to 17*c*.)

Only cast skins enclosing eggs having been seen, the animal cannot be named or fully described. It is of moderate size, the whole of the skin covered by a hexagonal reticulation, very uniform and regular. Each hexagon is a slight concavity surrounded by a raised edge. There is a boss on each of the last legs. The claws are two pairs of nearly equal size, stout, closely united, with no supplementary points. The five eggs are very small.

Loch Morar, rare.

EGGS OF MACROBIOTUS. (Plate IV. figs. 18 to 22.)

It has been already pointed out that several species related to *M. hufelandi* lay spiny eggs. RICHTERS supposes that the spiny armature serves to secure dissemination through the action of rain. It appears that there are more species of *Macrobiotus* in

the Scottish Lakes than have been recognised, as several forms of eggs have been found which cannot be identified as those of any known species. Five forms are here figured, only two of which can be named. The others are not proven to be even Tardigrade eggs, but they are so similar to eggs of known species as to leave little doubt on the matter.

M. hufelandi—C. SCH. (Fig. 18.) (14).

Processes narrow, tapering, expanded at ends into discs. There is a good deal of variation in the size of the eggs, and in the size and spacing of the spines.

Loch Ness and Loch Morar, common.

M. echinogenitus—RICHTERS. (Fig. 21.)

Processes conical, acuminate, papillose, the long points usually curved over (in Scottish examples). There appears to be even more variation than in *M. hufelandi*, according to RICHTERS (14). Since, as he says (10), the two species can hardly be distinguished except by the eggs, it may well be contended that some of these varieties of eggs represent equally good species.

Loch Morar, very abundant.

Macrobotus, sp.? (Fig. 19.)

Possibly a variety of *M. echinogenitus*, but more probably distinct. Loch Morar.

Macrobotus, sp.? (Fig. 20.)

This beautiful egg is also possibly a variety of *M. echinogenitus*. It is most like RICHTERS' variety with blunt processes (14), but they are here acuminate. Loch Morar.

Macrobotus, sp.? (Fig. 22.)

Conical processes close together at the bases. Loch Ness.

DIPHASCON.

Generic Characters.—Gullet elongated between the teeth and the pharynx into a flexible tube; otherwise as *Macrobotus*.

In those species which have the flexible gullet well developed this seems to be a sufficiently distinct genus, but it is connected with *Macrobotus* by *D. angustatum*, in which the flexible portion is very short and hardly distinguishable, and the two genera may have to be united. All the species known to me are destitute of eyes. Teeth-bearers are usually present, but they are often weak, and in *D. angustatum* they are frequently absent.

Diphascon chilense—PLATE. (Plate IV. figs. 23a–23b.) (5).

Specific Characters.—Pharynx small, nearly circular, the thickenings short, roundish, four or five in each row. Throat and gullet slender. Claws of two nearly equal pairs, one claw of each pair somewhat longer.

This description is based on PLATE'S figure, as he gives no specific characters. The Lake Survey specimens were hyaline, and measured about $\frac{1}{110}$ inch (227μ). The short diameter of the elliptical pharynx was fully $\frac{3}{4}$ of the long diameter. There were three short rods in each row, with a smaller round nut at each end of the row, the anterior one connected with the end of the gullet.

This species, on which PLATE founded the genus, is widely diffused. RICHTERS found it as far north as Tromsö, and it ranges into the antarctic circle. It shows some variation in different localities, but not enough to justify the separation of varieties.

Habitat.—Among moss at the margin of Loch Ness, not in the loch, February 1904.

Diphascon spitzbergense—RICHTERS. (Plate IV: figs. 24a–24b.) (10), (15).

Specific Characters.—Pharynx narrow, elongate, short diameter $\frac{2}{3}$ to $\frac{1}{2}$ of long diameter; thickenings of straight rods—(1st) at anterior end a short rod, (2nd) a longer rod, (3rd) a little round nut. Teeth longer and stronger than in *D. chilense*, nearly straight, with strong bearers. Gullet much thicker than in *D. chilense*, and shorter.

The specimens taken in Loch Ness, though differing in some small particulars, must be referred to this species. The pharynx is relatively broader, but the arrangement of rods is identical. The animal is hyaline; the claws two unequal pairs, the longer claw of one pair considerably longer than that of the other.

Habitat.—Loch Ness, March 1904.

Diphascon angustatum, n. sp. (Plate IV. fig. 25a to 25c.)

Specific Characters.—Large, hyaline, broadest about the third legs, thence tapering to the narrow snout-like head. Pharynx narrow, twice as long as broad; two slender rods in each row—first short, second twice as long. Gullet very short and wide, marked by annular rings, very slightly flexible. Mouth and throat wide. Teeth straight, only slightly divergent, with or without small weak bearers. Claws two unequal pairs, one pair with one claw long and slender.

Distinguished from *D. spitzbergense* by the general form, tapering anteriorly, the shorter and wider gullet, still narrower pharynx, and number of pharyngeal thickenings.

Habitat.—Loch Ness, February 1904. Common. RICHTERS has also observed this species in Germany.

MILNESIUM.

Generic Characters.—Mouth surrounded by circlet of six blunt palps; two similar palps further back, as in *Echiniscus*; pharynx narrow, without hard rods; each foot with four claws, of which two are long and slender, the others short and two- or three-branched.

Resembling *Echiniscus* in having a pair of blunt processes on the face, otherwise nearer *Macrobiotus*.

Milnesium tardigradum—DOY. (Plate IV. figs. 26a to 26c.) (3), (9).

Specific Characters.—Large, hyaline; fish-shaped, tapering to both ends. Mouth and gullet very wide and short; teeth short, with weak bearers. Pharynx about twice as long as broad. A pair of black eyes. The single claws very long and slender, with expanded base; the triple-hooked claws short, broad, two of the hooks nearly equal, a smaller one near base.

According to RICHTERS, *M. alpigenum* (EHR.) is not a distinct species.

This is a widely distributed form.

Habitat.—Loch Ness, among moss growing on pier, February 1904.

LIST OF WORKS REFERRED TO.

- (1) SCHULTZE, C. A. S., "Macrobiotus hufelandi," *Isis* of Oken, 1834, p. 708.
- (2) DOYÈRE, *Ann. Sc. Nat.*, Paris. II. Sér. T. 10. 1838.
- (3) DOYÈRE, *Ann. Sc. Nat.*, Paris. II. Sér. T. 14, p. 269. 1840.
- (4) EHRENBERG, *Mikrogeologie*, 1854; Atlas, pl. 35B.
- (5) PLATE, L. H., "Naturgeschichte der Tardigraden," *Zool. Jahrb.*, Bd. iii., *Morph. Abt.*, 1888, pp. 487-550.
- (6) SCOURFIELD, D. J., "Non-marine Fauna of Spitzbergen," *Proc. Zool. Soc. Lond.*, 1897, p. 791.
- (7) JENNINGS, H. S., "Rotatoria of the United States," *U.S. Fish. Comm. Bull.*, 1899, p. 67.
- (8) RICHTERS, F., *Ber. Senckenbg. Natf. Ges.*, 1900, p. 40.
- (9) " " "Fauna der Umgebung von Frankfurt-a-M." *Ber. Senckenbg. Natf. Ges.*, 1902, p. 3.
- (10) " " "Nordische Tardigraden," *Zool. Anz.*, Bd. xxvii., 1903, p. 168.
- (11) " " "Der kleine Wasserbär," *Prometheus*, 1903, p. 44.
- (12) " " "Verbreitung der Tardigraden," *Zool. Anz.*, Bd. xxviii., 1904, p. 347.
- (13) " " "Islandische Tardigraden," *Zool. Anz.*, Bd. xxviii., 1904, p. 373.
- (14) " " "Eier der Tardigraden," *Ber. Senckenbg. Natf. Ges.*, 1904, p. 59.
- (15) " " "Arktische Tardigraden," *Fauna Arctica*, Bd. iii., 1904, p. 495.

EXPLANATION OF PLATES.

The figures of the complete animals are all drawn to the same scale, to enable comparisons to be made; the details are drawn larger, but to no uniform scale. Where the granulation of the plates is minute it is omitted from the drawings, as it could only be indicated in an exaggerated form. The coarser granulation or reticulation of some species is shown.

PLATE I.

1. *Echiniscus gladiator*, n. sp.

a, dorsal view.
b, lateral view.
c, inner claw of last legs.

b, larva with two claws.
c, claws of larva.

2. *Echiniscus mutabilis*, n. sp.

a, dorsal view of typical example, three eggs.
b, dorsal view of variety.
c, inner claw of last legs.
d, small example of type, with one egg.

4. *Echiniscus reticulatus*, n. sp.

a, dorsal view.
b, reticulation, to larger scale.
c, inner and outer claws of fourth leg.

3. *Echiniscus wendti*—RICHTERS.

a, dorsal view.

5. *Echiniscus oihonnae*—RICHTERS.

a, dorsal view.
b, inner claw of last leg.

PLATE II.

6. *Echiniscus granulatus*—DOY.

a, variety, dorsal view.
b, outer and inner claws of last leg of same.
c, older and more typical example.
d, two claws of last leg, showing three barbs on outer claw.
e, two-clawed larva, probably of this species.
f, claws of the larva.

8. *Echiniscus*, sp.?

a, dorsal view.
b, outer and inner claws, last legs.

9. *Echiniscus*, sp.?

a, dorsal view.
b, granules seen on some examples.
c, irregular perforations seen on others.

7. *Echiniscus spitzbergensis*—SCOURFIELD.

a, dorsal view.
b, the apparent rings on the plates.
c, outer and inner claws of last leg.

10. *Echiniscus*, sp.?

a, dorsal view.

11. *Echiniscus*, sp.?, larva.

a, dorsal view.
b, teeth and pharynx.
c, claws of last leg.

PLATE III.

12. *Macrobiotus islandicus*—RICHTERS.

- a*, dorsal view.
- b*, claws.
- c*, teeth and pharynx.

13. *Macrobiotus ornatus*—RICHTERS.

- a*, dorsal view, var. *spinosissimus*, RICHTERS.
- b*, lateral view, var. *verrucosus*, RICHTERS.
- c*, teeth and pharynx.

14. *Macrobiotus annulatus*, n. sp.

- a*, mature example, carrying skin with eggs.
- b*, teeth and pharynx.
- c*, claws, under pressure.

15. *Macrobiotus papillifer*, n. sp.

- a*, dorsal view.
- b*, teeth and pharynx.
- c*, claws.

16. *Macrobiotus macronyx*—DOY.

- a*, lateral view.
- b*, teeth and pharynx.
- c*, pair of claws of last leg.
- d*, pair of claws of first leg.

17. *Macrobiotus*, sp. ?

- a*, empty skin with five small eggs.
- b*, part of reticulation, on larger scale.
- c*, claws.

PLATE IV.

18. Egg of *Macrobiotus hujelanti*, C. SCH.

19. Egg of *Macrobiotus*, sp. ?

20. Egg of *Macrobiotus*, sp. ?

21. Egg of *Macrobiotus echinogenitus*, RICHTERS.

22. Egg of *Macrobiotus*, sp. ?

23. *Diphascon chilense*—PLATE.

- a*, dorsal view.
- b*, teeth and pharynx.

24. *Diphascon spitzbergense*—RICHTERS.

- a*, dorsal view.
- b*, teeth and pharynx.

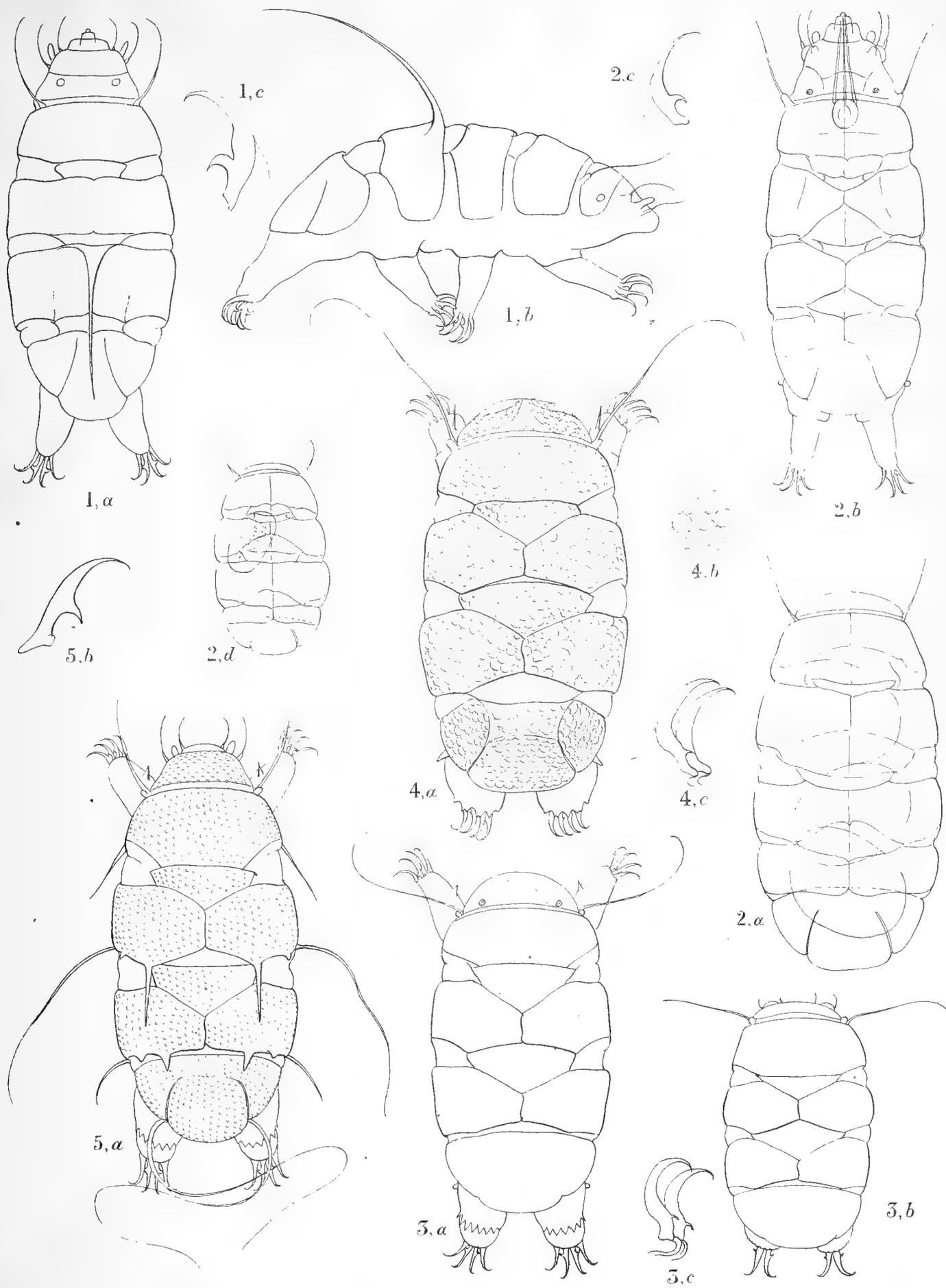
25. *Diphascon angustatum*, n. sp.

- a*, dorsal view.
- b*, teeth and pharynx.
- c*, claws.

26. *Milnesium tardigradum*—DOY

- a*, dorsal view.
- b*, teeth and gullet.
- c*, claws.

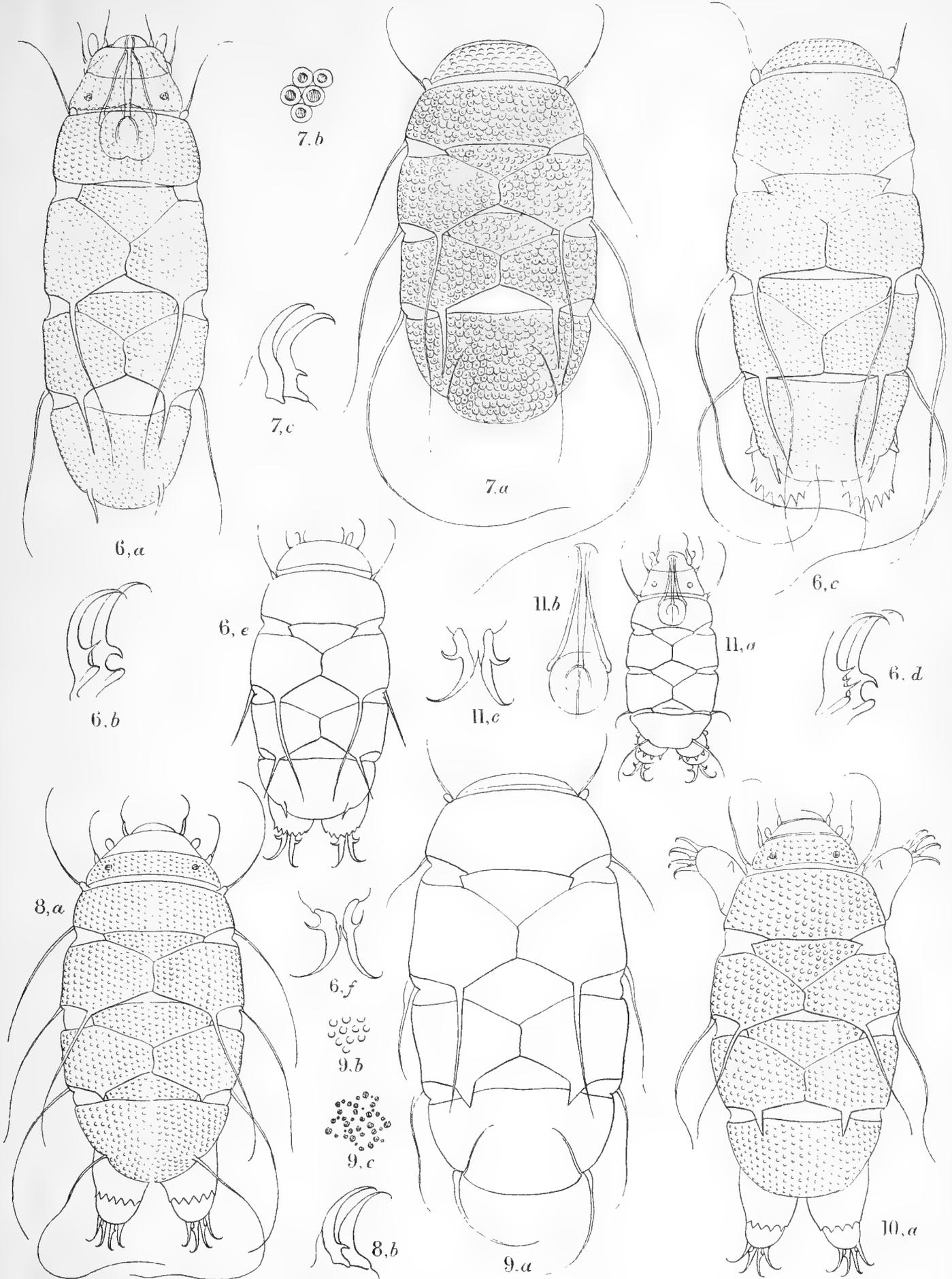
MURRAY: TARDIGRADA OF THE SCOTTISH LOCHS.—PLATE I.



1. ECHINISCUS GLADIATOR, n. sp. 2. E. MUTABILIS, n. sp. 3. E. WENDTI, Richters.
 4. E. RETICULATUS, n. sp. 5. E. OIHONNÆ, Richters.

M'Farlane & Erskine, Lith Edin'

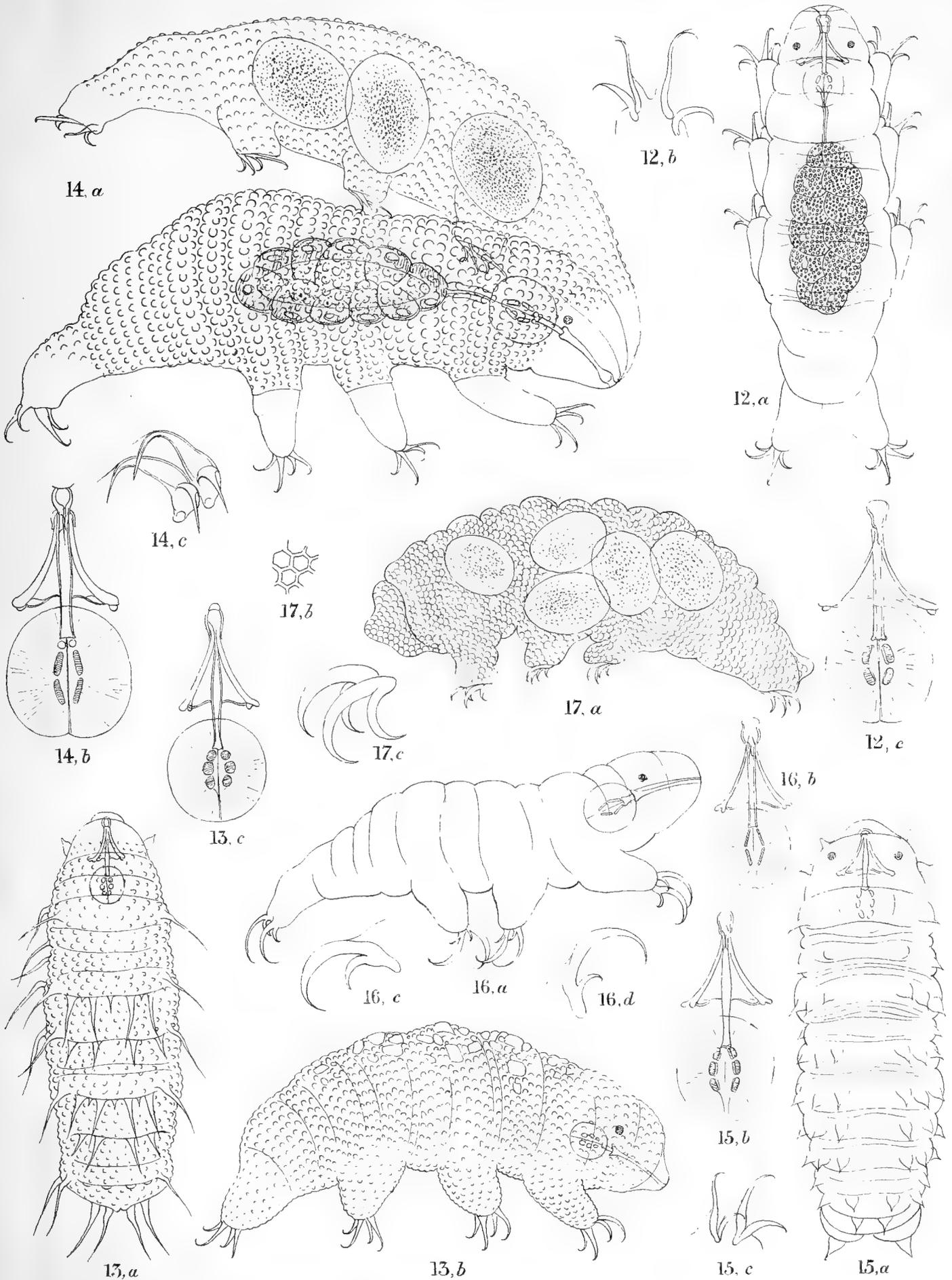
MURRAY: TARDIGRADA OF THE SCOTTISH LOCHS.—PLATE II.



McFarlane & Erskine, Lith. Edin.

6, ECHINISCUS GRANULATUS, Doy. 7, E. SPITZBERGENSIS SCOURFIELD. 8, ECHINISCUS, sp.?
 9, ECHINISCUS, sp.? 10, ECHINISCUS, sp.? 11, ECHINISCUS, sp.? LARVA.

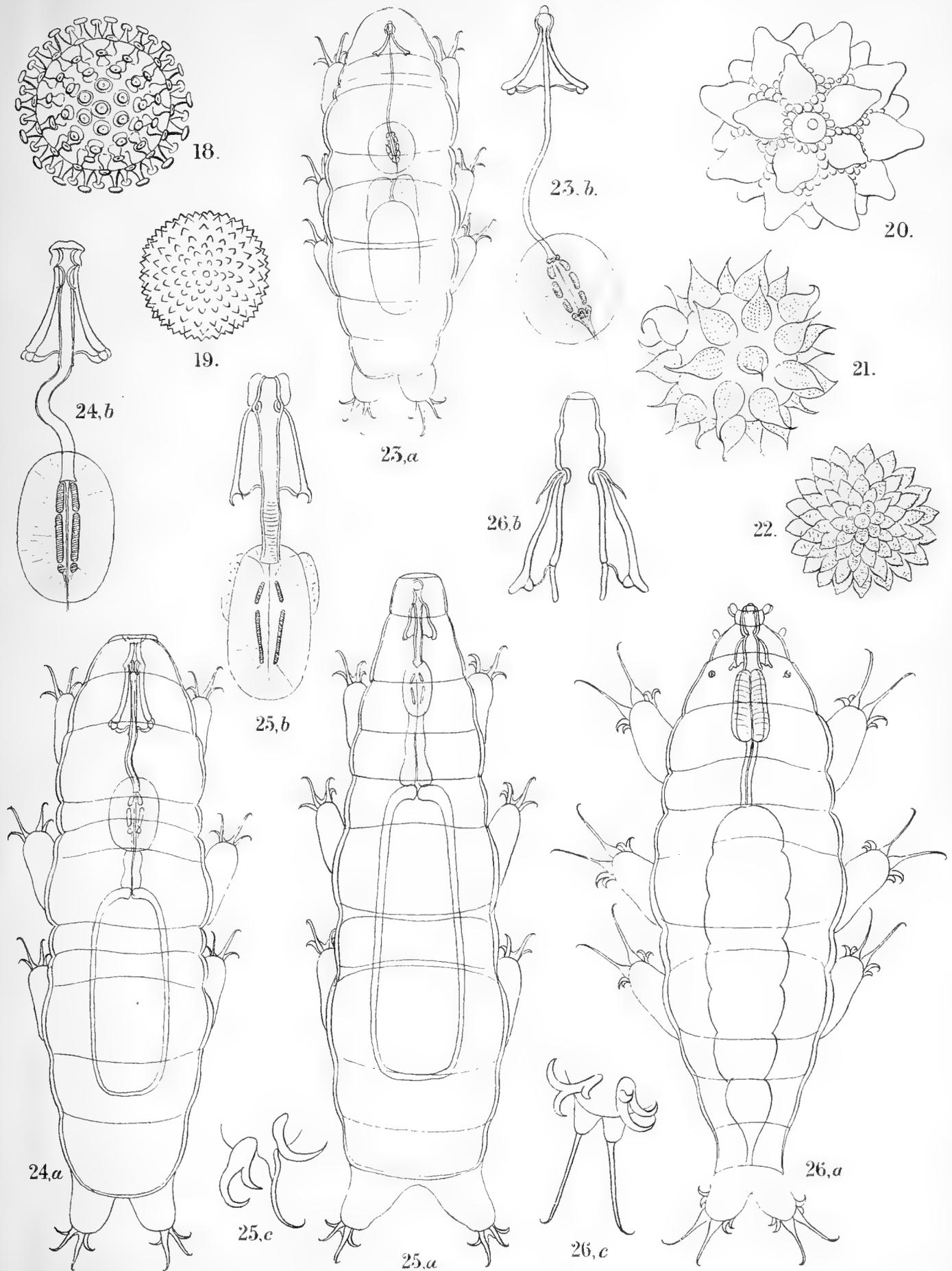
MURRAY: TARDIGRADA OF THE SCOTTISH LOCHS.—PLATE III.



M'Farlane & Erskine Lith Edin^r

12. *MACROBIOTUS ISLANDICUS*, Richters. 13. *M. ORNATUS*, Richters. 14. *M. ANNULATUS*, n. sp.
 15. *M. PAPILLIFER*, n. sp. 16. *M. MACRONYX*, Doy. 17. *MACROBIOTUS*. sp.?

MURRAY: TARDIGRADA OF THE SCOTTISH LOCHS.—PLATE IV.



18, MACROBIOTUS HUFELANDI, C. Sch., Egg.
23, DIPHASCON CHILENSE, Plate.

19, 20, 22, EGGS OF MACROBIOTUS, sp.?
24 D, SPITZBERGENSE, Richters.

21, M. ECHINOGENITUS. Richters.
25, D. ANGUSTATUM, n.sp.

26, MILNESIUM TARDIGRADUM, Doy

M'Farlane Lith. Edin.

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