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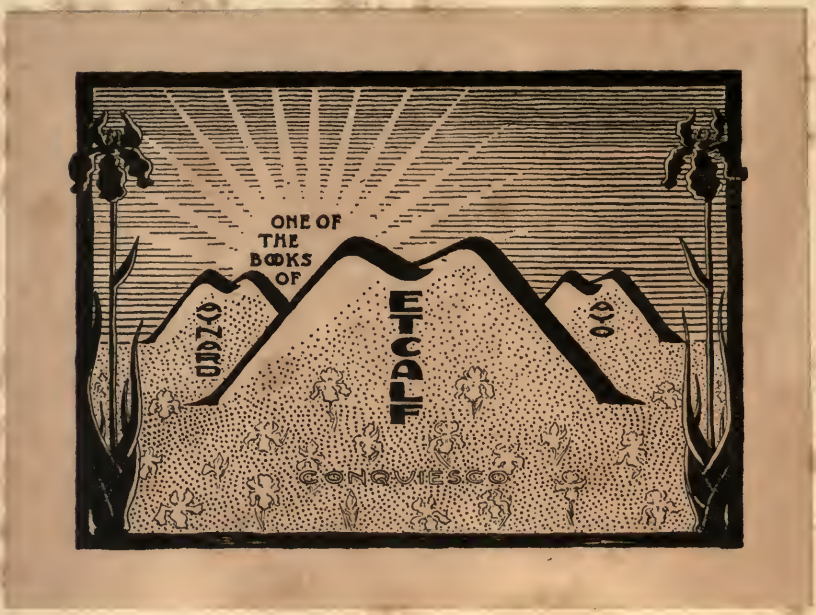

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THE

BRITISH FRESHWATER RHIZOPODA AND HELIOZOA

BY

JAMES CASH

AND

GEORGE HERBERT WAILES, F.L.S.

ASSISTED BY

JOHN HOPKINSON, F.L.S., F.Z.S., F.R.M.S.

Secretary of the Ray Society

VOLUME IV

SUPPLEMENT TO THE RHIZOPODA

BY

G. H. WAILES

AND

BIBLIOGRAPHY

BY

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PREFACE.

In the present volume are described those species of Rhizopoda which belong to the genera treated in Volumes I and II and had not been recorded from the British Isles when those volumes were published, also such British species as have since then been first described.

Since the death of Mr. Cash in 1909 very few records of Rhizopoda occurring in the British Isles have been published except those by Mr. J. M. Brown and myself; from these this volume of supplementary species and varieties is compiled.

Owing to my absence abroad, and occupation on work connected with the war during the last three years, my own records consist almost entirely of those obtained from the gatherings made by myself or sent to me by friends which are acknowledged in the preface to Vol. III. From these gatherings also were obtained numerous records of localities in which occur most of the Conchulina and many of the Amœbina described by Cash, thus sufficing to show that the majority of the species described in Vols. I and II are generally distributed over the British Isles wherever the habitat is suitable.

Owing to war-time restrictions it has not been possible to obtain Dr. Penard's assistance, but my thanks are due to him for his permission to reproduce several of his published figures. I am also indebted to Mr. J. M. Brown for placing his records and descriptions at my disposal, and to Mr. Hopkinson for undertaking the bibliographical work and for his assistance in seeing the volume through the press.

G. H. WAILES.

SHEFFIELD,
25*th November*, 1918.

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All the figures in the plates have been drawn by Mr. Wailes except those stated to be "after Brown" which are original drawings by Mr. J. M. Brown; those stated to be "after Penard" are from published figures by Dr. Eugene Penard.

The figures in the text are reproduced direct from published figures except fig. 173 which is from an original drawing by Mr. Wailes, and figs. 165, 166, and 176 which have been enlarged by Mr. Hopkinson from published figures.

All the illustrations have been engraved by The Sun Engraving Company (formerly André, Sleigh & Anglo), Ltd., of London & Watford.

All measurements are expressed in micromillimetres (μ). $1\,\mu = 0{\cdot}001$ mm. or 0·00003937 in. ($\frac{1}{25400}$).

BRITISH FRESHWATER RHIZOPODA.

During the publication of the earlier volumes of this monograph records of several genera and numerous species and varieties of Freshwater Rhizopoda have been added to the British Fauna.

When the third volume was issued fifty genera had been described, now by the addition of *Pyxidicula*, *Capsellina*, *Diplochlamys*, *Microcorycia*, *Bullinula*, *Cucurbitella*, *Averintzia*, *Parmulina*, and *Plagiophrys*, and the omission of *Ouramœba*, the number is increased to fifty-eight. In this volume descriptions are given of the genera, species, and varieties thus added to our list. They include six newly-described species :

Capsellina timida. *Hyalosphenia ovalis.*
Microcorycia radiata. *Nebela tubulata.*
Cryptodifflugia eboracensis. *N. scotica.*

In the following enumeration of the genera the original arrangement and numbering is retained for the sake of easy reference. *Quadrulella* is substituted for the pre-occupied name *Quadrula* (26) and *Ouramœba* (6) is omitted as it has been found to be an *Amœba* with parasitic algæ as explained in Vol. II (p. viii).

Order I. AMŒBINA.

Family 1. Lobosa.

(1) *Amœba*, (2) *Dactylosphærium*, (3) *Mastigamœba*, (4) *Pelomyxa*, (5) *Lithamœba*.

Family 2. Reticulosa.

(7) *Gymnophrys*, (8) *Biomyxa*, (9) *Penardia*, (10) *Chlamydomyxa*.

Family 3. Vampyrellida.

(11) *Vampyrella*, (12) *Hyalodiscus*, (13) *Nuclearia*, (14) *Archerina*.

Order II. CONCHULINA.

Family 1. Arcellida.

A. *Arcellinæ:* (15) *Arcella*, (15a) *Pyxidicula*, (15b) *Microcorycia*, (15c) *Parmulina*, (16) *Pseudochlamys*, (16a) *Capsellina*, (16b) *Diplochlamys*, (17) *Centropyxis*. B. *Difflugin*æ*:* (18) *Difflugia*, (18a) *Bullinula*, (18b) *Plagiopyxis*, (18c) *Cucurbitella*, (19) *Pontigulasia*, (20) *Lesquereusia*, (21) *Phryganella*, (22) *Difflugiella*, (23) *Cryptodifflugia*. C. *Nebelinæ:* (24) *Hyalosphenia*, (25) *Nebela*, (26) *Quadrulella*, (27) *Heleoprea*, (27a) *Averintzia*. D. *Pseudonebelinæ:* (28) *Leptochlamys*, (29) *Cochliopodium*, (30) *Amphizonella*, (31) *Zonomyxa*.

Family 2. Euglyphina.

(32) *Euglypha*, (33) *Placocysta*, (34) *Assulina*, (35) *Sphenoderia*, (36) *Paulinella*, (37) *Cyphoderia*, (38) *Campascus*, (39) *Trinema*, (40) *Corythion*.

Family 3. Gromiina.

A. *Pseudogromiinæ:* (41) *Lecythium*, (42) *Pseudodifflugia*, (43) *Diaphoropodon*, (44) *Clypeolina*. B. *Allogromiinæ:* (45) *Microgromia*, (46) *Lieberkuehnia*, (47) *Allogromia*, (48) *Rhynchogromia*.

Family 4. Amphistomina.

(49) *Diplophrys*, (50) *Amphitrema*.

Construction of the Tests of the Conchulina.

Owing to the wide range of variation in the form of tests which occurs in many species of testaceous Rhizopoda, the determination of the limits of species and varieties is a subject fraught with difficulty and one upon which there are many diverse opinions. A brief resumé of the conditions, so far as we know them, under which these tests are constructed, would seem not out of place here and should be helpful in considering the problems so frequently presented to observers of Rhizopod life.

There are broadly two classes of tests, those secreted by the animal itself and those which it builds up of extraneous materials; the former are less subject to variation than the latter, not of course taking into account those variations of shape in flexible tests which the animal can execute at will or which are due to ingested food, and this greater conformity to type is only what might be expected to occur in the case of those tests which are formed of natural secretions and are moulded on the animal's body. There are forms of secreted tests in which whilst the elements of the test are secreted naturally in the plasma, the test as a whole is built up from these elements by the efforts of the animal itself; thus, in the genus *Euglypha*, when a new daughter test is about to be produced, all the necessary elements may be seen accumulated in readiness in the plasma; aperture-scales, body-scales, spine-scales, or loose spines can all be distinguished among the collection, but their sorting-out, building-up, and cementing together are dependent upon the animal's more or less voluntary efforts, and when the apparently very inadequate equipment of the animal for this purpose is considered, it is surprising that the tests should exhibit so much uniformity.

Of those Rhizopoda which form their tests from

extraneous materials the genus *Difflugia* may be taken as the type. In this case the substances used are selected by the animal from among its surroundings; some species choose only fine grains of sand of nearly equal size, others grains of various dimensions, others again prefer diatom-frustules exclusively or mixed with quartz-particles; it is very seldom that vegetable débris is utilized although one or two species (e. g. *D. leidyi*) normally incorporate a few pieces of vegetable origin in the structure of their tests.

Some species construct their tests either partially or almost entirely from scales or plates which have formed tests belonging to other species or genera, and it seems not improbable that such tests are disintegrated for the purpose, as isolated scales from decayed tests are far from common, at any rate are rarely found in gatherings of mud or sand.

The uniformity of choice of extraneous matter by each species indicates that the proper material, so far as possible, is chosen instinctively, but at the same time a search and a choice has to be made among the mud, sand, and débris amid which the animal exists.

We sometimes find that although the body of the test is fairly uniform in size, shape, and materials, the spines, horns, and projections may vary considerably, within, of course, certain limits, either in form, number, or position; thus, among the *Euglyphæ*, whilst the type may have a moderate number of spines on its test, varieties occur nearly or quite glabrous, or on the other hand provided very numerously with spines; again, among the *Difflugiæ*, the number of the horns on cornuted tests often varies considerably; thus *D. constricta* may be glabrous or provided with from one to six horns on its test.

More stable and seldom showing so much variation are the modifications of the tests themselves, such as the internal pockets and depressions characterising the tests of such species as *Nebela equicalceus*, *N. martiali*,

and *N. bigibbosa*, which seldom depart from the type, whilst the large protrusions forming horns or extensions externally on the tests of such species as *Difflugia oblonga*, *D. acuminata*, and *Nebela bipes*, often show great variability in form and size; such variation is frequently found in a single locality, but is usually greater when collections from different localities are compared, and is more marked still when the specimens come from different continents.

Varietal and specific names have frequently been assigned to apparently distinct varieties which subsequent investigation has shown to be connected with each other by an unbroken series of slight modifications; these names, although perhaps not strictly justifiable, may still in many cases be useful or even necessary to an accurate tabulation of local variations.

A consideration of the methods by which Rhizopod tests are constructed may afford a clue to an explanation of the difference in the potentiality of variation in these different structures, since we find that those portions or elements which are secreted involuntarily are more stable in form and position than those appendages which are either placed in position or built up by the animal voluntarily, as we may perhaps say, by means of its pseudopodia; but further observations of tests in process of construction are much to be desired.

A feature which is usually reliable for specific discrimination is the form of the aperture of the test and the nature of its border or margin. Usually these are very constant for each species; among the *Euglyphæ*, for instance, it is possible to identify nearly every species if only a single aperture scale is available; on the other hand, although the *Arcellæ* all have circular apertures, the same species in perhaps the same locality will provide tests with singly- and doubly-invaginated apertures, which may be either plainly circular or crenated; this variability in the *Arcellæ* is not common in Europe, but is frequently met with in North America.

Tests with lobed apertures, such as those of *Difflugia corona*, *D. oviformis*, and *D. lobostoma*, show a considerable variation in the shape or number of the lobes, but are nearly always symmetrical.

Considering the manner in which Rhizopoda construct their tests, the bi-lateral symmetry they nearly always possess is very remarkable. Attention however may be directed to one departure from this in the case of curved tests, belonging to species which usually possess them straight, found occasionally in very restricted habitats; one such, *Difflugia acuminata* var. *curvata* Cash, is described in Volume I, and the writer found in a pond in Long Island, U.S.A.,* two species of *Nebela* and a *Quadrulella* thus modified, and in Georgia, U.S.A., a curved species of *Arcella* occurs.

Reproduction in the Rhizopoda usually entails and at certain stages may entirely consist of either multiple or simple binary division. In the latter case the test, if it is membranous or chitinous, may also divide, a process which nearly always takes place in a longitudinal direction; the more substantial tests, such as those of the *Difflugiæ* and *Nebelæ*, do not divide. In Volume III, Plate LIII, fig. 4, is an illustration of the division of a test of *Diaphoropodon mobile*, and Plate LVII, fig. 4, depicts what appears to be the commencement of division in a transverse direction of a test of *Amphitrema flavum*.

In some genera or species the tests are protected by a more or less thick covering of very fine hair-like cils which appear to be secreted from the interior through fine pores, as for instance *Diaphoropodon mobile*, *Nebela barbata*, and species of *Cochliopodium*; and from Sierra Leone a species of *Difflugia* has been recorded bearing fine spines; even one or two amœboid species are thickly covered with very fine cils which disappear and re-appear as the plasma flows, and must therefore be protrusions of the plasma itself, e. g. *Amœba pilosa*.

* *v.* 'Journ. Linn. Soc., Zool.' vol. xxxii, pp. 136, 142.

Propagation and Development.

The adequate treatment of propagation and development in each of the various genera is beyond the scope of a systematic work such as the present, even if it were possible in the present state of our knowledge of the subject, but in only a very few species has the embryology been worked out, and perhaps not exhaustively even in some of these. In the Amœbina especially are details of life-history lacking, and it is to be hoped that competent observers willing and able to devote the necessary time will be found to carry out further investigations.

English readers will find most of the information which is available on the biology of the Sarcodina in the works of Calkins, Ray Lankester, and Minchin, especially in the latter's 'Introduction to the study of the Protozoa,' 1912; also in the Cambridge Natural History.

Order I. AMŒBINA.

Family 1. Lobosa.

1. **Amœba fluida** Gruber.

(Plate LVIII, fig. 1.)

Amœba fluida
Gruber in Zeits. wiss. Zool. XLI, 2 (1884), pp. 219–220, pl. xv, f. 49.
Penard Faune Rhiz. Léman (1902), pp. 42–44, 6 figs.; Sarcodinés in Cat. Invert. Suisse (1905), p. 13.
Hopkinson in Irish Natur. 1910 (Jan.), p. 2.
Brown in Naturalist, 1910 (Feb.), p. 91; in Brit. Assoc. Handb. Sheffield (1910, Aug.), p. 501.
Wailes in Jrn. Linn. Soc., Zool. XXXII (1912), p. 123.

Body ovoid with rounded outlines, more or less yellowish in colour, the expansions of the plasma lobular or wave-like; the plasma finely and densely granular, the granules being in continual motion both vibratory and circulating; nucleus single, colourless, containing a granular nucleole and usually several vacuoles; one to three contractile vesicles usually present.

Length 50–80 μ or more.

Habitat.—Ponds and aquatic vegetation.

England.—W. Yorkshire*; Derbyshire (*Brown*).
Ireland.—Killough, Co. Wicklow (*Hopkinson*).

The constant vibratory movements of the numerous granules in the plasma and the circulation of the plasma as a whole are striking features in this species. Progression takes place by wave-like expansions which usually occur in rapid succession. The nucleus and the yellowish colour of the plasma due to large numbers of minute, coloured grains, are characteristic.

* N., E., and W. Yorkshire signify the North, East, and West Ridings.

Gruber first found this species in sea-water; it has been recorded from Switzerland by Penard, and it occurs in the United States.

2. **Amœba granulosa** Gruber.

(Vol. I, Plate I, fig. 3; Pl. III, fig. 2.)

Amœba proteus
LEIDY (pars), Freshw. Rhiz. N. Amer. (1879), p. 35, pl. i, f. 9.
Amœba granulosa
GRUBER in Zeits. wiss. Zool. XLI, 2 (1884), p. 218, pl. xv, f. 46.
PENARD Faune Rhiz. Léman (1902), pp. 46–47, 3 figs., in Proc. R. Soc. Edinb. xxv, 8 (1905), pp. 595, 598; Sarcodinés in Cat. Invert. Suisse (1905), p. 14.
Amœba proteus var. *granulosa*
CASH Brit. Freshw. Rhiz. I (1905), pp. 47–48, pl. i, f. 3; pl. iii, f. 2.
WAILES in Jrn. Linn. Soc., Zool. XXXII (1913), p. 202.

Body attaining a considerable size, the plasma of a dark colour due to large numbers of fine included granules, sometimes also containing green bodies but seldom other inclusions; the form usually elongate with few or no lateral, lobose processes; nucleus large, single, spherical, granular; contractile vesicles one or sometimes two in number.

Length up to 400 μ or 500 μ, seldom less than 100 μ.

Habitat.—Ponds, ditches, etc. Not common.

This species is adequately represented by Cash in Vol. I, Plate I, fig. 3, and Pl. III, fig. 2, the latter figure being the form perhaps most often seen; its dark colour, usually large size, and the rapid streaming of the fine granules with which the plasma is crowded render it conspicuous and easily recognized.

The spherical nucleus also serves to distinguish it from *A. proteus*, which has an ovoid one; Penard states that many of the small granules under a high magnification can be recognized as small bicuspid crystals.

When moving, the hinder part is usually terminated by a tufted or mulberry-shaped extremity, as stated by Cash.

3. **Amœba vespertilio** Penard.

(Plate LVIII, fig. 2; Pl. LIX, figs. 1–3.)

Amœba proteus
LEIDY (*pars*) Freshw. Rhiz. N. Amer. (1879), p. 48, pl. iv, ff. 22–24.
Amœba vespertilio
PENARD in Rev. Suisse Zool. IX (1901), p. 237; Faune Rhiz. Léman (1902), pp. 92–95, 7 figs.; Sarcodinés in Cat. Invert. Suisse (1905), p. 22.
BROWN in Naturalist, 1910, p. 91; in Jrn. Linn. Soc., Zool. XXX (1910), p. 361.
WAILES & PENARD in Proc. R. Irish Acad. XXXI, LXV (1911), p. 14.
WAILES in Naturalist, 1913, p. 145; in Jrn. Linn. Soc., Zool. XXXII (1912), p. 123.

Body usually ovoid or elongated without any caudal appendage; pseudopodia conical, comparatively short, connected at the base by web-like expansions of the ectoplasm; plasma colourless, containing numerous granules and food-particles; nucleus single, spherical, containing a single large nucleole; contractile vesicles from one to three in number; numerous small vacuoles also often present.

Length 60–100 μ.

Habitat.—Ponds and submerged vegetation. Common.

ENGLAND.—Cumberland, Westmorland, Lancashire, and Yorkshire (*Brown*); Shropshire.

SCOTLAND.—Ayrshire and Wigtonshire (*Brown*).

IRELAND.—Achill Isl., Clare Isl., Inishturk, Mayo.

The character of the pseudopodia usually serves to distinguish this species with facility, their palmate appearance resembling a bat's wing or the webbed foot of a bird; rarely, longer and attenuated pseudopodia are formed, but when the animal begins to move they resume their characteristic aspect.

4. **Amœba verrucosa** var. **papyracea** (Penard) var. nov.

(Plate LVIII, fig. 3.)

Amœba verrucosa
EHRENBERG (pars) Infus. (1838), p. 126, pl. viii, f. xi (3).

Amœba terricola
GREEFF (pars) in Arch. mikr. Anat. II (1866), pp. 302–317, pl. xvii, ff. 2–8; pl. xviii, f. 10.
Amœba papyracea
PENARD in Arch. Protist. VI (1905), pp. 191–201, ff. 8, 14; *op. cit.* XXVII (1909), p. 266; XXVIII (1912), pp. 82–83.
GROSSE-ALLERMANN in Arch. Protist. XVII, 2 (1909), pp. 206, 216, pl. xi, ff. 7, 8.
BROWN in Brit. Assoc. Handb. Sheffield (1910), p. 500; in Naturalist, 1910, p. 91.

Similar to the type but larger.

Length up to 350 μ when extended; diameter 160–190 μ in a globular state.

Habitat.—Mosses.

ENGLAND.—Eccleshall, Yorkshire (*Brown*).

The *A. verrucosa* group (comprising *A. verrucosa*, *A. fibrillosa*, *A. alba*, and *A. sphæronucleolus*) is characterized by the possession of a firm outer pellicle which enables the animals to resist desiccation and to survive the dry periods so apt to occur in the mosses which they inhabit. *A. verrucosa* and this variety are further distinguished by the possession of a nucleus ovoid in shape, and that of var. *papyracea* is usually provided with a layer of larger granules within the periphery than in the type. *A. verrucosa* measures about 90–100 μ in diameter when at rest and rarely reaches 250 μ in length when in movement. Grosse-Allermann (1909) and Penard should be consulted for a detailed study of this group of Amœbæ.

5. **Amœba alba** Greeff.

(Plate LIX, fig. 4.)

Amœba alba
GREEFF in Biol. Centralbl. XI (1891). p. 640.
PENARD Faune Rhiz. Léman (1902), pp. 123–125, 2 figs.; in Arch. Protist. VI (1905), pp. 203–204; Sarcodinés in Cat. Invert. Suisse (1905), p. 24.
WAILES & PENARD in Proc. R. Irish Acad. XXXI, LXV (1911), p. 65.

Plasma colourless, finely granular except near the periphery, contained in a fine pellicle; nuclei numerous, spherical or sub-spherical, containing numerous

nucleoles; contractile vesicle voluminous; pseudopodia broad and short, usually somewhat angular in outline.

Length up to 300 μ or 400 μ; nuclei about 10 μ in diameter.

Habitat.—Damp moss. Rare.

Ireland.—Clare Island, Mayo.

The nuclei may be very numerous, the number, according to Penard, sometimes reaching several hundreds; the nucleoli are distinct and scattered, they may number twenty but are usually about eight or ten.

The plasma usually has few inclusions, the remains of ingested rotifers and a parasitic bacillus have been observed; the contractile vesicle is exceptionally large and its diameter may equal one quarter of the length of the organism.

This species and *A. fibrillosa* Greeff together with *A. verrucosa* Ehrenb. (*A. terricola* Greeff) form a group the members of which are often found in moss that is liable to desiccation, and it may be to this circumstance that the unusually firm outer covering with which they are all provided is due. Whether it is a true pellicle or only a hardening of the ectoplasm has been much discussed, and for a summary of the various opinions the reader is referred to Penard,* who after weighing the evidence comes to the conclusion that these species possess a true, although very fine, pellicle.

Specimens of *A. verrucosa* in a dried state sent through the post from Dr. Penard in Geneva to the author in America all revived after a few hours in fresh water.

The three species have characteristic nuclei; those of *A. fibrillosa* are spherical and contain a single centrally-placed nucleole, whilst *A. verrucosa* has a single nucleus which is ovoid and contains numerous nucleoles.

* 'Faune Rhiz. du Léman,' pp. 105–121.

Order II. CONCHULINA.

Family 1. Arcellida.

§ A. *Arcellinæ.*

1. Arcella vulgaris var. **hemisphærica** (Perty) var. nov.

(Plate LIX, fig. 5, and fig. 161 in text.)

Arcella hemispherica

Perty Kenntn. kleinst. Lebensf. (1852), p. 186, pl. ix, f. 5.
Penard in Mém. Soc. Genève, XXXI, 2 (1890), p. 153, pl. v. ff. 93–95; in Rev. Suisse Zool. IX (1901), p. 237; Faune Rhiz. Léman (1902), p. 400, 4 figs.; in Proc. R. Soc. Edinb. XXV, 8 (1905), pp. 593, 596; Sarcodinés in Cat. Invert. Suisse (1905), pp. 78–79.
Godet in Bull. Soc. Neuchâtel. XXVIII (1899), p. 78.
Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), p. 65.
Wailes in Jrn. Linn. Soc. Zool. XXXII (1912), pp. 123, 130.

Test smaller than in the type, nearly hemispherical in side view, the basal diaphragm forming nearly a right angle with the circular dome as seen in vertical section; the base concave with a central circular

Fig. 161.—*Arcella vulgaris* var. *hemisphærica*. Side view. × 250. (After Cash.)

orifice usually everted; plasma, nuclei, and contractile vesicles as in the type.

Diameter of test usually 40 μ to 50 μ, sometimes less.

Habitat.—Ponds and ditches. Generally distributed.

Described by Perty under a specific name, this variety is included in Vol. I, p. 120, by Cash among the synonyms of *A. vulgaris*, but it seems to deserve at least varietal rank.

2. **Arcella catinus** Penard.

(Figs. 162 and 163.)

Arcella vulgaris
LEIDY (pars) Freshw. Rhiz. N. Amer. (1879), p. 171, pl. xxviii, ff. 6, 7.
Arcella catinus
PENARD in Mém. Soc. Genève, XXXI (1890), pp. 154–155, pl. v, f. 87.
LAGERHEIM in Geol. Fören. Stockholm Förh. XXIII (1901), p. 507.
BROWN in Ann. Scott. Nat. Hist. 1911, p. 228; in Naturalist, 1912, p. 180; in Scott. Natur. 1913, pp. 186, 206.
WAILES & PENARD in Proc. R. Irish Acad. XXXI, LXV (1911), pp. 14, 20.
WAILES in Scott. Natur. 1912, p. 60.
PLAYFAIR in Proc. Linn. Soc. N. S. Wales, XLII, 4 (1918), p. 640, pl. xxxiv, f. 12.
Arcella artocrea
PENARD Faune Rhiz. Léman (1902), pp. 404–406, 5 figs.; Sarcodinés in Cat. Invert. Suisse (1905), p. 80. (Non *Arcella artocrea* Leidy, 1879.)
Arcella vulgaris var. *compressa*
CASH Brit. Freshw. Rhiz. I. (1905), pp. 138–139, f. 28.
WAILES in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 123, 131.

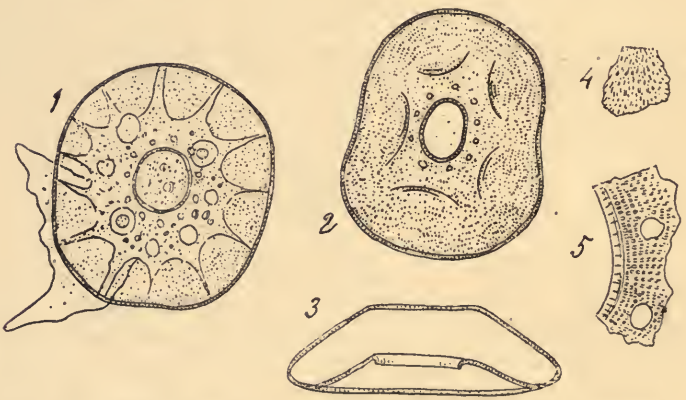

FIG. 162.—*Arcella catinus*. 1, upper view; 2, oral view; 3, side view in outline. × 280. 4, Usual appearance of the surface of the test; 5, part of the test near the aperture, with two pores. × 1000. (After Penard.)

This is the same as *A. vulgaris* var. *compressa* Cash described in Vol. I; it may we think be legitimately considered an autonomous species. In the British

Isles it is somewhat rare, although it is sometimes numerous in the localities where it does occur.

Cash in his description and figure has omitted the pores which surround the oral aperture and are usually about twelve in number.

It is quite distinct from *A. artocrea* Leidy, although Penard referred it to that species in his ‘ Faune Rhiz. du Léman ’ (1902) thinking it might be a European

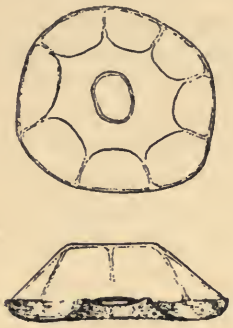

Fig. 163.—*Arcella catinus.* Upper and lateral views. × 260. (After Cash.)

form of it, but *A. catinus* in its typical form, as drawn by Leidy (Pl. xxviii, figs. 6 and 7) and Cash, is not uncommon in America.

3. **Arcella arenaria** Greeff.

(Plate LVIII, figs. 4 and 5.)

Arcella arenaria

Greeff in Arch. mikr. Anat. II (1866), p. 330, pl. xviii, f. 16; in Sitzb. Ges. Marburg, 1888, pp. 106–107.

Lagerheim in Geol. Fören. Stockholm Förh. XXXIII (1901), p. 507.

Levander in Acta Soc. Fauna Fenn. XX (1901), p. 7.

Penard Faune Rhiz. Léman (1902), pp. 406–408, 3 figs.; in Arch. Protist. IX (1903), p. 258; Sarcodinés in Cat. Invert. Suisse (1905), pp. 79–80; in Deux expéd. Antarct. françaises (1911), pp. 4, 5.

Averintzeff in Trudui S.-Peterb. Obshch. XXXVI, II (1906), pp. 159–160.

Schouteden in Ann. Biol. lacustre, I, 3 (1906), pp. 335–336.

Brown in Naturalist, 1910, p. 93; in Brit. Assoc. Handb. Sheffield, (1910), p. 500; in Scott. Natur. 1912, p. 112; *op. cit.* 1913, p. 146.

Daday in Sitzb. Akad. Wien, CXIX, I (1910), p. 575.

Cockerell in Univ. Colorado Stud. VIII, 4 (1911), p. 241.

Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), pp. 9, 14, 21.
Wailes in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 123, 129, 155; (1913), p. 212; in Naturalist, 1913, p. 146.
Heinis in Mém. Soc. Neuchâtel, V (1914), pp. 677, 679, 693, 696.

Arcella microstoma
Penard in Mém. Soc. Genève, XXXI (1890), p. 154, pl. v, ff. 75–77; in Amer. Natur. XXV (1891), pp. 1071, 1074.
Lagerheim in Geol. Fören. Stockholm Förh. XXIII (1901), p. 507.
Levander in Acta Soc. Fauna Fenn. XX, v (1901), p. 7.

Arcella aureola
Maggi in Rend. R. Ist. Lomb. (2) XXI (1888), p. 310, pl., f. 4.

Test brown, of medium size, discoid, the base dish-shaped with a sharply-defined upper edge from within which arises a low convex crown; aperture circular, invaginated, about one-fifth of the diameter of the test in width, usually provided with a small external lip; plasma grey, granular; nuclei two in number, each containing a central nucleole; contractile vesicles numerous; pseudopodia lobular with irregularly-indented borders, rarely displayed.

Diameter 60–80 μ, or more; height about one third the diameter.

Habitat.—Mosses. Generally distributed.

England.—Cumberland and Westmorland (*Brown*); N. & W. Yorkshire (*Brown*); Nottinghamshire; Rutlandshire; Bedfordshire; Hertfordshire; Oxfordshire; Cornwall.

Scotland—Perthshire, Bass Rock, and Wigtonshire (*Brown*).

Ireland.—Castlebar and Clare Island, Mayo; Inishbofin, Galway.

4. **Arcella polypora** Penard.

(Plate LVIII, figs. 6 and 7.)

Arcella polypora
Penard in Mém. Soc. Genève, XXXI, i, ii (1890), p. 156, pl. vi, ff. 2–9; in Rev. Suisse Zool. IX (1901), p. 237; Faune Rhiz. Léman (1902), pp. 408–410, 2 figs.; Sarcodinés in Cat. Invert. Suisse (1905), pp. 80–81.
Wailes in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 123, 204, 210.

Test large, pale brown in colour, discoid with acute

basal angles; crown evenly convex; base concave; aperture circular, about one-third the diameter of the test in width, surrounded by a ring of small circular markings; plasma colourless, granular; nuclei small, from 6 to 20 in number, each with a large central nucleole; contractile vesicles numerous; pseudopodia digitate.

Diameter 100–200 μ; aperture 0·3 to 0·4 of the diameter; height one-fourth to one-third the diameter.

Habitat.—Sphagnum and aquatic vegetation.

England.—N. Yorkshire; Shropshire; Buckinghamshire.

Ireland.—Clare Island, Mayo.

Those *Arcellæ* which have disc-shaped tests form a small group comprising four species which, except *A. discoides*, are distinguished from all other members of the genus by possessing more than two nuclei; *A. discoides* has also by some observers been recorded as multinuclear, but it is probable that in these cases a process of division was in progress, or perhaps *A. polypera* was under observation. The following table shows the approximate sizes and mutual relationship of the members of this group; in all of them the height of the test may vary from one-third to one-fourth or less of the diameter.

	Diameter.	Aperture.	No. of nuclei.
A. discoides Ehrenb.	80–150 μ	0·3 of the diameter	2 normally
A. polypera Penard	100–200 μ	0·3–0·4 „	6–20
A. megastoma Penard	190–365 μ	0·4–0·55 „	40–200
A. curvata Wailes	120–135 μ	0·4 „	4–5

Genus 15 a. **PYXIDICULA** Ehrenberg, 1834.

Frustulia (pars) Agardh in Flora (Bot. Zeit.), X, 2 (1827), p. 627.

Cymbella (pars) Agardh Consp. crit. Diatom. (1830), p. 11.

Frustulia (*Cyclotella*) Kuetzing in Linnea, 1833, p. 535.

Gallionella? (*Pyxidicula*) Ehrenberg in Abh. Akad. Berlin, 1833 (1834), p. 265.

Pyxidicula Ehrenberg in Abh. Akad. Berlin, 1835 (1836), p. 173; Infus. (1838), p. 165 (genus first defined by him).
Cyclotella Kuetzing Bacill. oder Diatom. (1844), p. 50.
Arcella (pars) Carter in Ann. Nat. Hist. (3) XIII (1864), p. 61.

Test discoid or patelliform, more or less rigid, punctate in appearance, transparent; the oral aperture circular, large, being either the full diameter of the test or somewhat contracted by an inward extension of it; plasma and pseudopodia similar to those of the genus *Arcella;* nucleus usually single; contractile vesicles one or more.

Only a few species are included in this genus. *P. patens* Clap. & Lachm. is discoid and has a short funnel-shaped rim attached to the inner side of the inverted edge of the test which is about 40 μ in diameter. Three species have been recorded from the British Isles.

Synopsis of the British Species.

Test very small, discoid, circular, with inverted aperture. (1) *P. operculata.*
Test rather larger, discoid, with bifurcated margin. (2) *P. invisitata.*
Test much larger, patelliform, with external border. (3) *P. cymbalum.*

1. **Pyxidicula operculata** (Agardh) Ehrenberg.

(Figs. 164–166.)

Frustulia operculata
Agardh in Flora (Bot. Zeit.), X, 2 (1827), p. 627.
Cymbella operculata
Agardh Consp. crit. Diatom. (1830), p. 11.
Frustulia (Cyclotella) operculata
Kuetzing in Linnea, 1833, pp. 535–537, pl. xiii, f. 1; Synops. Diatom. (1834), p. 7, pl. vii, f. i.
Gallionella? (Pyxidicula) operculata
Ehrenberg in Abh. Akad. Berlin, 1833 (1834), p. 265.
Pyxidicula operculata
Ehrenberg in Abh. Akad. Berlin, 1835 (1836), p. 173; Infus. (1838), p. 165, pl. x, f. 1; Mikrogeol. (1854), pl. xvi, I, f. 46 *a, b.*

Pritchard Hist. Infus. [ed. 2.] (1841), p. 198, pl. ii, f. 127; [ed. 3.] (1852), p. 433, pl. ii, f. 127.
Bailey in Amer. Jrn. Sci. Art, XLII (1842), p. 88, pl. ii, ff. 1, 1a.
Brightwell Fauna Infus. E. Norfolk (1848), p. 36, pl. x, ff. 10–12.
Hertwig & Lesser in Arch. mikr. Anat. X (1874), Suppl. pp. 103–105.
Archer in Qrt. Jrn. Micr. Sci. (2) XVII (1877), p. 110; in Proc. Dublin Micr. Club, III, 2 (1878), p. 228.
Blochmann Mikr. Thierw. Süsswass. (1886), p. 11; ed. 2 (1895), p. 15.
Penard in Rev. Suisse Zool. IX (1901), p. 238; Faune Rhiz. Léman (1902), pp. 413–414, 3 figs.; Sarcodinés in Cat. Invert. Suisse (1905), pp. 81-82.
Averintzeff in Trudui S.-Peterb. Obshch. XXXI, II (1906), pp. 144–145.
Schouteden in Ann. Biol. lacustre, I, 3 (1906), p. 333, f. 4.
Doflein in Sitzb. Ges. Morph. München, XXXIII, 3 (1908), pp. 116–117, f. 1 (7 figs.).
Wailes & Penard in Proc. R. Irish Acad. XXXI, LXV (1911), p. 19.

Cyclotella operculata

? Brebisson Consid. Diatom. (1838), p. 20.
Kuetzing Bacill. oder Diatom. (1844), p. 50, pl. i, f. 1; ed. 2 (1865), p. 50, pl. i, f. 1.
Meneghini in Atti Impl. Inst. Venuto, V (1846), pp. 88, 90; (transl. in) Bot. and Physiol. Memoirs (1846), pp. 385, 387. (Ray Soc.) 8°. London.
Perty Kenntn. kleinst. Lebensf. (1852), p. 200.

Arcella patens

Carter in Ann. Nat. Hist. (13), XIII (1864), pp. 61–62, pl. ii, f. 15. (*Non* Claparède & Lachmann Études Inf. et Rhiz. (1859).

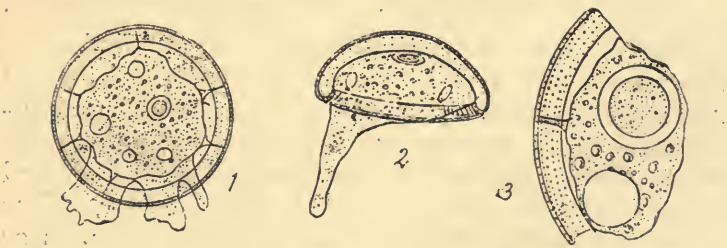

Fig. 164.—*Pyxidicula operculata*: 1, upper view; 2, side view. × 1200. 3, part of the test. × 4800. (After Penard.)

Test discoid, circular, with narrow inverted margin forming a large circular orifice; formed of smooth, transparent, chitinous material finely punctate, becoming darker or nearly brown with age; plasma clear, granular, nearly filling the test to which it is attached by numerous epipodes; nucleus single, spherical, containing a large central nucleole; contractile vesicles usually numerous; pseudopodia short, lobose or digitate.

Diameter of test about 20 μ, height about one half the diameter.

Habitat.—Aquatic vegetation. Rare.

England.—Norfolk (*Brightwell*); Hampstead ponds, Middlesex (*Pritchard*).

Ireland.—Clare Island, Caher Island, and mainland, Mayo.

This species was for many years considered to be a diatom. It will be seen from the synonymy that it was first described by Agardh as a *Frustulia*, and then placed by him in the genus *Cymbella*, to which it has but little nearer resemblance. By Kuetzing it was referred to *Cyclotella*, to which, had it been a diatom, it would have been most nearly allied. He first

Fig. 165.—*Pyxidicula operculata*: *a*, vertical view; *b*, upper detached part; *c*, lower detached part. × 750. (After Brightwell.)

considered that to be a sub-genus of *Frustulia*, but afterwards followed Brébisson in treating it as an autonomous genus. Ehrenberg then placed it doubtfully under his new genus *Galionella*, suggesting the name *Pyxidicula*, and soon afterwards described and figured it in his great work 'Die Infusionsthiere' as *Pyxidicula operculata*, under which name it stands as the type-species of its genus.

Meneghini, in his synopsis of Kuetzing's 'Bacillarien oder Diatomeen,' after giving a diagnosis of *Pyxidicula*, remarks*: "It is really surprising that although Agardh, Kuetzing, Ehrenberg, and Brébisson have described and figured the *Cymbella* or *Frustulia operculata* as the type of this genus, and corresponding perfectly with the foregoing generic character, Kuetzing himself, without acquainting us with the

* Quoted from the translation of his "Sulla animalité delle Diatomee" published by the Ray Society in 'Botanical and Physiological Memoirs.'

mistakes of others, nor his own, should now form the type of the preceding genus [*Cyclotella*] from this same species, prescribing the name at first proposed but altering the sense; and at the same time should describe, as a new species of *Pyxidicula*, the *P. operculata* of Bailey, which seems either identical with that of Ehrenberg or very similar to it and to that so described and figured by the authors named above." He adds his opinion that the specimens of Brébisson and Leonardi in his possession belong to *Cyclotella* and not to *Pyxidicula*. It is evident that he believed *Pyxidicula operculata* to be the correct name for this species, and, had he not been merely annotating

FIG. 166.—*Pyxidicula operculata*: *a*, vertical view; *b*, side view, showing furrow by which the test separates, *c*, showing a transparent globular body; *d*, a detached half. × 550. (After Pritchard.)

Kuetzing's memoir, 'Die kieselschaligen Bacillarien oder Diatomeen,' he would have adopted that name.

By all the above-named and some other writers—Pritchard, Brightwell, and Perty—this creature was considered to be a diatom. It was first determined to be a rhizopod by Carter, who found it in the island of Bombay, but he wrongly referred his specimens to the *Arcella patens* of Claparède and Lachmann. He says that it is very like Ehrenberg's *Pyxidicula operculata*, placed by him amongst the Diatomeæ. This appears to be his reason for rejecting it as a *Pyxidicula*, and he adds that he thinks "much alliance will be found to exist between the Rhizopoda and the Diatomaceæ." It was the opinion of Meneghini and some other naturalists that the diatoms were animals, and by Ehrenberg not only the diatoms but also the

desmids were believed to be so and were grouped together by him as the Bacillaria, a name now restricted to a genus of marine Diatomaceæ.

While Carter was the first to transfer this minute creature from the Diatomaceæ to the Rhizopoda, Hertwig and Lesser were the first to place it in the Rhizopoda under its right name, determining it to be the same species as the *Arcella patens* of Carter but not of Claparède and Lachmann.

It was first recorded as a British species, with several other freshwater microscopic forms of life, including Heliozoa and other Rhizopoda, by Brightwell (1848), and a few years later it was so recorded by Pritchard (1852), but, as both these authors placed it under the Algæ, it was overlooked when the first volume of this work was prepared. Doubtless owing to its minute size it has since been overlooked in the British Isles until it was discovered in the west of Ireland, nearly sixty years later than the previous record, and enumerated in the tables in the Clare Island Report of Wailes and Penard (1911).

The figures after Brightwell and Pritchard, which are slightly enlarged from their coloured drawings, must not be taken as accurate representations of this species. They are merely introduced to show how some of the early naturalists misinterpreted the structure of the test. Penard's observation (see p. 24) may explain them. The figures in Brightwell's work, which were drawn by his daughter, evidently from the life, give more detail than any previously published. It is doubtful whether Pritchard's figures are original, as similar ones had before appeared.

2. **Pyxidicula invisitata** Averintzeff.

(Plate LIX, figs. 6–9.)

Pyxidicula invisitata

Averintzeff in Trudui S.-Peterb. Obshch. XXXI, II (1906), pp. 145–146, pl. v, ff. 61–64.

Schouteden in Ann. Biol. lacustre, I, 3 (1906), p. 333.

Brown in Jrn. R. Micr. Soc. 1918, p. 171, pl., ff. 1–4.

Test discoid, often flattened on the dome, open below, thin, chitinous, varying in colour from light yellow to brown, the margin often colourless, punctate with radial striations at the margin; the open or ventral side of the test provided with a circular ring attached at a distance equal to its breadth from the edge of the test, thus contracting the aperture; plasma greyish in colour, granular, containing numerous green bodies and brown food-particles; nucleus single; contractile vesicle prominent, usually single.

Diameter of test 25 μ to 50 μ, usually about 40 μ.

Habitat.— Wet moss and moorland pools.

England.—Cumberland, Westmorland, and Derbyshire (*Brown*).

Scotland.—Inverness-shire, Elginshire, Ross-shire, Argyllshire, and Perthshire (*Brown*),.

The test in section shows a thickening near the margin where the marginal flanges join; in some cases they curve towards one another, whilst in others the inner one projects inwards, thus contracting the aperture of the test.

It is probably common but is easily overlooked. The nucleus is usually indistinct, but Averintzeff figures it with a prominent, dark, central nucleole.

The double marginal flange and its smaller size distinguish this species from *P. cymbalum* Penard.

3. **Pyxidicula cymbalum** Penard.

(Fig. 167.)

Pyxidicula cymbalum
Penard Faune Rhiz. Léman (1902), pp. 417–418, 4 figs.
Edmondson in Ward & Whittle's Fresh-water Biology (1918), p. 222, f. 292.

Test moderately large, patelliform, chitinous, brown in colour, punctate and furnished with a diaphanous external margin or border; nucleus single; contractile vacuole single; pseudopodia not observed.

Dimensions, 85 μ to 90 μ in diameter.

Habitat.—Wet moss and sphagnum.

England.—Westmorland and Derbyshire (*Brown*).
Scotland.—Argyllshire (*Brown*).

Its larger size distinguishes this species from other members of the genus; the large open side which serves as the aperture is devoid of any constriction, but is furnished externally with a border of lighter colour, faintly punctate and much thinner than the body part of the test; occasionally tests are found from which the border is missing.

The brown colour of the tests becomes darker with age, and the punctate appearance under a high magnification is seen to be due to its areolar structure of small plates in closely set series; the base usually lies in one plane, but is sometimes found waved.

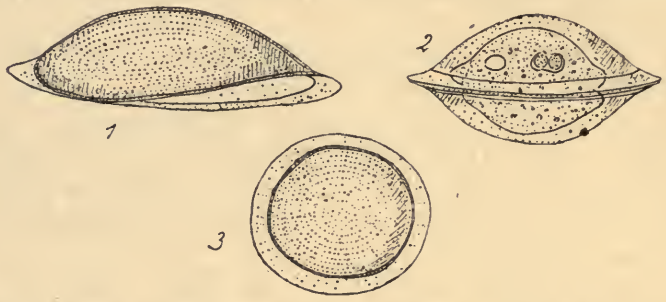

Fig. 167.—*Pyxidicula cymbalum*. 1, side view. × 500. 2, two individuals in conjugation. × 380. 3, upper view. × 270. (After Penard.)

Penard observed living individuals only in pairs, either in conjunction or division apparently, the single tests being all empty.

15 b. **MICROCORYCIA** Cockerell, 1911.

Corycia Dujardin in Ann. Sci. Nat. (3) XVIII (1852), p. 241. (Pre-occupied in Lepidoptera, 1816.)
Amphizonella (pars) Greeff in Arch. mikr. Anat. II (1866), pp. 329–330.
Microcorycia Cockerell in Zool. Anzeig. XXXVIII (1911), p. 137.

Test composed of a flexible membrane, discoid or approximately hemispherical in form, with a fine, diaphanous continuation or fringe around the periphery, capable of being folded together or completely closed by the drawing together of the free borders; the crown of the test smooth or furnished with excrescences; the plasma not entirely filling the test; nuclei one or two in number; pseudopodia lobular or digitate.

The description of this genus as *Corycia* by Dujardin is far from explicit and is unaccompanied by any drawing; we have followed Penard in identifying it with *Amphizonella flava* Greeff and not with *Pamphagus mutabilis* Bailey (*Lecythium mutabile*), as suggested by Leidy.

Synopsis of the British Species.

Test 80–100 μ (or more) in diameter; crown of test smooth or sparsely covered with small adherent grains. (1) *M. flava.*

Test minute, 24–30 μ in diameter. (2) *M. radiata.*

1. **Microcorycia flava** (Greeff) Cockerell.

(Plate LVIII, figs. 11–13.)

Amphizonella flava

Greeff in Arch. mikr. Anat. II (1866), pp. 329–330, pl. xviii, f. 19 *a*, *b*.

Archer in Qrt. Jrn. Micr. Sci. (2) XI (1871), pp. 130–131, 134–135.

Maggi in Rend. R. Ist. Lomb. (2) X (1877), pp 309, 315–324, pl. ii, ff. 1–6, 8, 11, 12.

Corycia dujardini

Gagliardi in Qrt. Jrn. Micr. Sci. (2) XI (1871), p. 80.

Corycia flava

Penard Faune Rhiz. Léman (1902), pp. 173–177, 9 figs.; in Arch. Protist. II (1903), p. 254; *op. cit.* XVII (1909), pp. 259–?60; Sarcodinés in Cat. Invert. Suisse (1905), p. 31.

Averintzeff in Trudui S.-Peterb. Obshch. XXXVI, II (1906), pp. 142–143.

Schouteden in Ann. Biol. lacustre, I, 3 (1906), pp. 232–233.

Brown in Naturalist, 1910, p. 92; in Brit. Assoc. Handb. Sheffield (1910), p. 500.

Wailes & Penard in Proc. R. Irish Acad. XXXI, LXV (1911), pp. 9, 15, 23.

Wailes in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 123, 131; *loc. cit.* (1913), pp. 212–214.

Heinis in Mém. Soc. Neuchâtel, V (1914), pp. 677, 681, 696.

Microcorycia flava

Cockerell in Zool. Anzeig. XXXVIII (1911), p. 137.

Test discoid, formed of a yellowish-brown, homogeneous, flexible membrane, the crown convex, the periphery prolonged into a diaphanous membrane capable of completely closing in the base of the test; the crown usually sparsely covered with small adherent foreign particles; plasma partly filling the test, the ectosarc colourless and limpid, the endosarc containing numerous minute yellow-brown granules; nuclei two in number, usually placed close together; contractile vacuoles variable in number; pseudopodia few, short, lobular or broadly digitate.

Diameter 80–100 μ or more; young and immature individuals may be as small as 20 μ in diameter.

Habitat.—Mosses.

England.—Westmorland (*Brown*); N. and W. Yorkshire (*Brown*); Bedfordshire; Shropshire; Isle of Wight; Cornwall; Isles of Scilly.

Wales.—Anglesey.

Ireland.—Clare Island and Inishturk, Mayo; Inishbofin, Galway.

The synonymy of this species seems inextricably mixed; Cash, following Archer, refers *Amphizonella flava* Greeff to *Pseudochlamys patella* Clap. & Lachm. (Vol. I, p. 129); Penard, whose name for this species is now generally adopted, points out ('Archiv f. Protist.,' Vol. XVII, p. 260) that the earlier writers in many cases gave insufficient descriptions and often no drawings of the species described; also that *Corycia* [*Microcorycia*] *flava* when young or immature closely resembles the adult *Pseudochlamys patella* and both species possess tests capable of taking a variety of shapes. The plasma however is very distinct in the two species. *M. flava* usually lives only in the drier mosses, such as grow on trees, walls, and rocks, and also in those growing on the ground. From such situations the tests are liable to be carried into ponds where *Pseudochlamys patella* is usually found.

2. **Microcorycia radiata** (Brown) Hopkinson.

(Plate LX, figs. 1–4.)

Corycia radiata
Brown in Scot. Natur. 1912, p. 109, pl. v, ff. 1–4.

Test small, sac-like, composed of a transparent and colourless chitinoid pellicle, bordered by a very thin, flexible, transparent membrane; the crown of the test furnished at the margin with two concentric, circular ridges and also seven or eight radial ones; plasma not completely filling the test, greyish, granular; nucleus single, containing a central nucleole; contractile vacuoles one or more; pseudopodia not observed.

Diameter 25–30 μ.

Habitat.—Mosses.

England. — Westmorland, Lancashire, Yorkshire, Derbyshire, and Surrey (*Brown*).

Scotland.—Bass Rock, Isle of May, and Wigtonshire (*Brown*).

The above description and figures are taken from those of J. M. Brown. Penard reports the occurrence of this species near Geneva (private letter).

Genus 15 c. **PARMULINA** Penard, 1902.

Parmulina Penard Faune Rhiz. Léman (1902), pp. 206–207; and (amended) in Arch. Protist. XVII (1909), p. 286.

Animal amœba-like but invested with an ovoid test of chitinous membrane covered with foreign particles; aperture uncovered but capable of being closed; plasma similar to that of an *Amœba*, containing a single nucleus and one or more contractile vesicles.

This genus is very closely allied to *Diplochlamys* and somewhat similar to *Microcorycia*. As first described by Penard in 1902, the test of *P. cyathus* was defined as hemispherical, but in 1909 the description was

amended, the author having found that the individuals from which his previous observations had been drawn assumed the hemispherical form owing to their ill health due to the conditions under which they had been examined. Another species, *P. obtecta* (Gruber) Penard, awaits further investigation.

1. **Parmulina cyathus** Penard.

(Plate LXI, figs. 5 and 6, and figs. 168 and 169 in text.)

Parmulina cyathus

Penard Faune Rhiz. Léman (1902), pp. 207–208, 6 figs; Sarcodinés in Cat. Invert. Suisse (1905), p. 37; in Arch. Protist. XVII (1909), p. 286.

Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), pp. 9, 18.

Heinis in Mém. Soc. Neuchâtel, V (1914), pp. 678, 691, 695, 696.

Edmondson in Ward & Whittle's Fresh-water Biology (1918), p. 221, f. 285.

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Figs. 168 and 169.—*Parmulina cyathus.* Fig. 168, side view. × 650. Fig. 169, oral view. × 750. (After Penard.)

Test small, composed of a thick, homogeneous, chitinous, flexible membrane; ovoid in face view, semicircular in side view; transverse section ovoid with incurved lip; the outer surface thickly covered with extraneous particles; aperture appearing as a long parallel slit when the test is folded together, but elliptical or circular when the test is expanded; plasma Amœba-like, colourless, granular, containing food-particles and excretory granules; nucleus single, containing a single nucleole; one or more contractile vesicles usually present; pseudopodia not observed.

Length 40–55 μ.

Habitat.—Mosses.

Scotland.—Perthshire (*Brown*).

Ireland.—Louisburgh and Achill Island, Mayo (*Penard*).

The test is of a greyish or yellowish colour and too opaque for the plasma to be clearly visible in the living animal. No pseudopodia have been observed, but the plasma often protrudes in a lobular form.

Genus 16 a. **CAPSELLINA** Penard, 1909.

Capsellina Penard in Arch. Protist. XVII (1909), p. 290.

Body enclosed in a hyaline, ovoid, membranous sac, with or without a second outer testaceous covering; aperture single, terminal, linear; nucleus single, placed posteriorly; one or more contractile vesicles; pseudopodia filose. Multiplication takes place by division.

Only two species belonging to this genus have been described; *C. bryorum* Penard has in addition to the inner membranous sac a dark brown outer test similar in shape, composed of a membrane covered with fine silicious or chitinous particles; it is 35–45 μ in length. *C. timida* Brown has no outer envelope and is the only species recorded, so far, from the British Isles.

Multiplication in *C. bryorum* takes place by binary fission accompanied by the longitudinal division of the envelopes.

1. **Capsellina timida** Brown.

(Plate LVIII, fig. 8; Pl. LIX, figs. 10–14.)

Capsellina timida
Brown in Jrn. Linn. Soc., Zool. XXXII (1911), pp. 80–82, pl. ix, ff. 9–13; in Scott. Natur. 1912, pp. 112, 113; in Naturalist, 1912, p. 181.

Test small, ovoid, membranous, hyaline; longitudinal section oval; transverse section elliptical; aper-

ture terminal, linear, invaginated, elastic; plasma colourless, granular, containing numerous oil-like globules and food-particles, usually filling the test; nucleus single, containing a central nucleole and placed posteriorly; contractile vacuoles numerous; pseudopodia single, filose.

Length 34 μ; breadth 25 μ; thickness 16–17 μ.

Habitat.—Mosses.

England.—Cumberland; Eccleshall, Yorkshire; and Derbyshire (*Brown*).

Scotland.—St. Kilda (*Brown*).

Ireland.—Clare Island, Mayo.

In this species, as with the majority of those inhabiting the drier mosses, the pseudopodia are very rarely displayed; in the instances observed by Brown only a single filose pseudopodium was emitted, of a peculiar tapering character. The pseudopodia of *C. bryorum* have not been observed. The method of multiplication in *C. timida* is not known; the aperture is linear, bordered by sharply incurved lips, and unless seen exactly at right angles it shows as two intersecting curved lines; the lips are usually tightly closed, but that they are capable of distension is evident from the presence in the plasma of large food-particles and even diatoms. At Eccleshall near Sheffield it was found in moss on walls and on a water-trough; on Clare Island and St. Kilda in damp moss on the ground.

Genus 16 b. **DIPLOCHLAMYS** Greeff.

Diplochlamys Greeff in Sitzb. Ges. nat. Marburg, III (1888), p. 104.

Amœba (pars) Penard in Mém. Soc. Genève, XXXI, 1, II (1890), pp. 192–193.

Test hemispherical or cup-shaped, flexible, formed of an inner and outer envelope; the inner envelope consisting of a hyaline membranous sac closely in-

vesting the animal and provided with an elastic aperture; the outer envelope consisting of loosely-aggregated particles of silicious, earthy, or vegetable materials, the aperture large, partially or completely closed by the inner membrane; plasma clear, granular, containing various inclusions consisting usually of food-particles, excretory granules, and occasionally crystals; nuclei varying in number from one to one hundred or more; contractile vesicles usually present; pseudopodia few, short, digitate or pointed. Multiplication takes place by division.

For a detailed account of this genus, Penard ('Archiv. f. Protist.,' 1909) should be consulted; five species are described, three of which have been recorded from Great Britain. *D. fragilis* Penard and *D. gruberi* Penard have not, up till now, been recorded.

Synopsis of the British Species.

Test cup-shaped, dark grey in colour; nuclei varying from one to twenty in number. (1) *D. leidyi.*

Test approximately hemispherical, about 45 μ in diameter; nucleus single, 7·5–10 μ in diameter. (2) *D. timida.*

Test approximately hemispherical, about 100 μ in diameter; nuclei usually over 100 in number and 3·5 μ in diameter. (3) *D. vestita.*

1. **Diplochlamys leidyi** Greeff.

(*D. fragilis*, Plate LX, fig. 5.)

Diplochlamys leidyi

Greeff in Sitzb. Ges. nat. Marburg, III (1888), pp. 104–106.

Averintzeff in Trudui S.-Peterb. Obshch. XXXVI, II (1906), p. 165.

Schouteden in Ann. Biol. lacustre, I, 3 (1906), p. 338.

Penard in Arch. Protist. XVII, 2 (1909), pp. 270–272, 274, 275; in Brit. Antarct. Exped. I, Biology, 6 (1911), pp. 220, 232.

Wailes & Penard in Proc. R. Irish Acad. XXXI, LXV (1911), pp. 9, 16.

Test hemispherical or cup-shaped, dark grey in colour, the exterior covered with fine silicious grains and earthy particles; the inner membrane clearly

defined and projecting beyond the outer aperture; plasma and pseudopodia normal; nuclei one to twenty in number.

Diameter 90–100 μ (probably).

Habitat.—Mosses.

England.—Westmorland (*Brown*).
Ireland.—Clare Island, Mayo (*Penard*).

Unfortunately Greeff gives no dimensions or illustrations of this species, but it is apparently only by the smaller number of nuclei which it possesses that it is distinguishable from *D. fragilis* Penard, the latter having from 30 to 40, each about 6 μ in diameter. The tests of the two species being similar, it is only possible to distinguish between them when living individuals are under observation.

The individual found by Penard on Clare Island was only doubtfully identified, but it was not *D. fragilis;* no drawing was made of it, so it is not possible to give an illustration in this work.

2. **Diplochlamys timida** Penard.

(Plate LX, fig. 6, and figs. 170 and 171 in text.)

Diplochlamys timida
Penard in Arch. Protist. XVII, 2 (1909), pp. 275–279, 7 figs.; in Brit. Antarct. Exped. I, Biol. 6 (1911), p. 232; in Deux expéd. Antarct. françaises (1911), pp. 4, 7–8.
Heinis in Mém. Soc. Neuchâtel, V (1914), pp. 676, 683, 694, 696.
Edmondson in Ward & Whittle's Fresh-water Biology (1918), p. 221, f. 284.
Diplophrys (male pro *Diplochlamys*) *timida*
Brown in Ann. Scott. Nat. Hist. 1911, pp. 230, 231; in Scott. Natur. 1913, p. 209.

Test small, sub-spherical, semitransparent, greyish-yellow in colour, becoming darker with age; outer envelope thickly encrusted with amorphous particles of organic origin; inner membrane hyaline, supple, deeply invaginated around the aperture; plasma clear, bluish-grey in colour, containing food-particles and granules of excretion; nucleus single, containing a

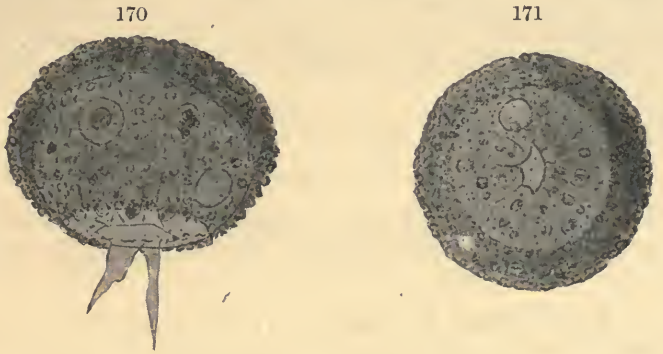
single nucleole; one to three contractile vesicles usually present; pseudopodia one or two in number, broad at the base, pointed.

Diameter 40–59 μ, usually 45–50 μ; nucleus 7·5–10 μ in diameter (*Penard*).

Habitat.—Mosses.

Scotland.—Ross-shire, and Portpatrick, Wigtonshire (*Brown*).

The above is the sole British record of this species, the absence of others being largely due, no doubt, to



Figs. 170 and 171.—*Diplochlamys timida.* Fig. 170, side view. Fig. 171, oral view. × 750. (After Penard.)

its habitat being in the drier mosses found on trees, walls, etc., these spots having been largely neglected in favour of situations in which the Rhizopod fauna is more plentiful and varied.

3. **Diplochlamys vestita** Penard.

(Plate LX, fig. 7.)

Amœba vestita
Penard in Mém. Soc. Genève, XXXI, i, ii (1890), pp. 192–193, pl. xi, ff. 64–73.
Diplochlamys vestita
Penard in Arch. Protist. XVII, 2 (1909), pp. 279–282, 5 figs.; in Deux expéd. Antarct. françaises (1911), pp. 4, 7.
Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), pp. 9, 16.
Heinis in Mém. Soc. Neuchâtel, V (1914), pp. 678, 683, 694, 696.

Test spheroidal in form, flattened on the ventral side, of a dark-grey colour with black markings; the outer envelope formed of small globular masses of organic matter mixed with silicious particles; the inner membrane extremely fine; aperture normally circular but capable of assuming various forms or becoming linear; plasma clear, colourless, granular, containing food-particles, starch-grains, granules of excretion, and occasionally a few rectangular crystals; nuclei small, about 100 in number, each containing a single nucleole; several contractile vesicles usually present; pseudopodia conical, wide at the base with pointed extremities, one or two in number, rarely displayed.

Diameter 75–130 μ, usually about 100 μ. Nuclei 3–5 μ in diameter.

Habitat.—Mosses, dry and submerged.

Ireland.—Achill Island, Mayo (*Penard*).

In submerged mosses a large form is found about 190–200 μ in diameter, occasionally attaining to 400 μ.

1. **Centropyxis aculeata** var. **discoides** Penard.

(Plate LXI, figs. 1 and 2.)

Centropyxis aculeata var. *discoides*
Penard Faune Rhiz. Léman (1902), pp. 305–306, 7 figs.; Sarcodinés in Cat. Invert. Suisse (1905), p. 59.
Daday in Zool. Jahrb., Syst. XXV (1907), 2, p. 249.
Wailes in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 123, 128; (1913), p. 212.

Test circular, discoid, larger and more compressed than in the type, either brown and chitinous or grey and covered with silicious grains and plates, with or without spines, which if present are few in number; aperture less eccentric than in the type; nucleus single, large, granular; plasma and pseudopodia as in the type.

Diameter 150–300 μ; thickness about one-quarter the diameter; aperture about one-third the diameter.

Habitat.—Aquatic vegetation.

England.—Isle of Man; Westmorland! (*Brown*); N. Yorkshire; Derbyshire (*Brown*); Bedfordshire.

Wales.—North Wales.

Scotland.—Outer Hebrides; Dumfries.

Ireland.—Donegal; Clare Island and Mainland, Mayo; Kerry.

The brown chitinous tests with 2 to 4 spines are perhaps less common in Britain than the grey silicious ones; the latter are very rarely provided with spines. In Gormire Lake, Yorks, these are numerous, whilst in the sphagnum swamp at Pilmoor, Yorks, the brown tests are found. The spines when present are never placed far apart, being distributed over one-third or less of the periphery.

Living animals are very scarce and active ones are hardly ever seen.

2. **Centropyxis arcelloides** Penard.

(Plate LXI, figs. 3 and 4.)

Centropyxis arcelloides

Penard Faune Rhiz. Léman (1902), pp. 309–310, 4 figs.; Sarcodinés in Cat. Invert. Suisse (1905), p. 60.

Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), pp. 9. 15.

Wailes in Jrn. Linn. Soc., Zool. XXXII (1912), p. 156; (1913), p. 212.

Edmondson in Ward & Whittle's Fresh-water Biology (1918),p. 221, f. 286.

Test of medium size, usually brown in colour, hemispherical with rounded basal angle, composed of a chitinous membrane covered with small silicious plates; aperture large, placed centrally in the base, slightly invaginated; plasma grey, granular; nucleus large, spherical, containing numerous minute nucleoles; numerous vacuoles usually present; pseudopodia not observed.

Diameter 80–110 μ; height about three-fifths the diameter; aperture about half the diameter.

Habitat.—Mosses and sphagnum.

England.—Isle of Man; N. Yorkshire; Cambridgeshire; Bedfordshire; Shropshire; Buckinghamshire; Somersetshire; Devonshire.

Wales.—Anglesey.

Scotland.—Orkney Islands; Dumfries.

Ireland.—Inishbofin, Galway; Clare Isl., Achill Isl., and Caher Isl., Mayo; Kerry.

The hemispherical test, with the large, slightly-invaginated aperture, serve to identify this species with ease. The internal prolongation of the membrane around the aperture towards the crown, usually present in members of this genus, is entirely wanting.

Although not uncommon, only a few individuals have been observed in a living state and none with their pseudopodia extended.

§ B. *Difflugin*æ.

1. **Difflugia oblonga** var. **tenuis** Penard.

(Plate LXI, fig. 8.)

Difflugia pyriformis var. *tenuis*
Penard in Mém. Soc. Genève, XXXI, i, 11 (1890), p. 138, pl. iii, ff. 47–49.
Difflugia oblonga var. *tenuis*
Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), pp. 16, 34.

Test similar to that of the type in form, but smaller and usually transparent; fundus frequently angular; plasma and pseudopodia normal.

Length 40–60 μ; diameter 20–35 μ.

Habitat.—Aquatic vegetation.

Ireland.—Achill Island and Louisburgh, Mayo (*Penard*).

Penard (1890) describes the occurrence, on the fundus of the tests of this variety, of small rod-like parasites, but they appear to have been merely accidental.

2. **Difflugia oblonga** var. **bryophila** Penard.

(Plate LXI, fig. 9.)

Difflugia pyriformis var. *bryophila*
Penard Faune Rhiz. Léman (1902), pp. 221–222, f. 7; Sarcodinés in Cat. Invert. Suisse (1905), p. 40.
Difflugia oblonga var. *bryophila*
Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1902), pp. 16, 34.

Test of medium size, brownish in colour, elongate with hemispherical fundus whence the sides taper towards the aperture in nearly straight lines; plasma as in the type; nucleus containing several greenish nucleoles; pseudopodia normal.

Length 90–130 μ; breadth 40–60 μ; aperture 20–30 μ.

Habitat.—Mosses and sphagnum.

England. — N. Yorkshire; Shropshire; Buckinghamshire.

Ireland.—The islands off Clew Bay and Mayo (*Penard*); Inishbofin, Galway; Cahirciveen, Kerry.

In shape very like var. *lacustris* but smaller and of a brownish colour; the neck also is without any large adherent grains.

3. **Difflugia rubescens** Penard.

(Plate LX, figs. 10 and 11.)

Difflugia pyriformis
Leidy (pars) Freshw. Rhiz. N. Amer. (1879), p. 103, pl. x, ff. 22, 24, 25.
Difflugia rubescens
Penard in Amer. Natur. XXV (1891), pp. 1072, 1075–1076; in Rev. Suisse Zool. IX (1901), p. 237; Faune Rhiz. Léman (1902), pp. 227–229, 4 figs.; Sarcodinés in Cat. Invert. Suisse (1905), pp. 41–42.
Averintzeff in Trudui S.-Peterb. Obshch. XXXVI, ii (1906), pp. 195–196.
Schouteden in Ann. Biol. lacustre, I, 3 (1906), pp. 343, 346.
Cockerell in Univ. Colorado Stud. VI, 4 (1909), p. 306; *op. cit.* VIII, 4 (1911), p. 240.
Brown in Brit. Assoc. Handb. Sheffield (1910), pp. 500, 501; in Jrn. Linn. Soc., Zool. XXX (1910), pp. 361, 363; in Naturalist, 1910, p. 92; *op. cit.* 1912, p. 181; 1913, p. 206.
Wailes & Penard in Proc. R. Irish Acad. XXXVI, lxv (1911), pp. 9, 16, 34–35.
Wailes in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 124, 127.

Test of medium size, pyriform, not compressed, yellowish in colour, formed of a flexible chitinous membrane encrusted with foreign particles and diatom-frustules; aperture circular, usually bordered by an incurved crenulate margin; plasma partially filling the test, colourless but containing numerous granules of a brick-red colour; nucleus single, containing a single nucleole; a single contractile vesicle usually present; pseudopodia few, not long, digitate, simple or forked.

Length 66–105 μ; diameter 42–70 μ; aperture 16–30 μ.

Habitat.—Aquatic vegetation.

England.—Isle of Man; Cumberland; Westmorland! and Lancashire (*Brown*); N. & W. Yorkshire; Sheffield District (*Brown*); Derbyshire (*Brown*); Isle of Wight; Devonshire; Cornwall.

Wales.—North Wales.

Scotland.—Kircudbrightshire and Wigtonshire (*Brown*).

Ireland.—Mayo and the islands off Clew Bay; Inishbofin, Galway; Limerick; Kerry.

The animal is very frequently found encysted, in a spherical form; when it is active the plasma is attached to the fundus of the test by several epipodes by means of which it can, when alarmed, retreat rapidly into its test. The pseudopodia are usually one or two in number and the circulation of the plasma carries many of the red globules for some distance into them.

The test even when empty is easily recognized, and the internal crenulation of the aperture is usually well defined and quite characteristic; the neck is occasionally slightly constricted.

In localities where it occurs it is usually abundant; it is found on the Continent of Europe and in North America.

4. **Difflugia manicata** Penard.

(Plate LXI, fig. 10.)

Difflugia manicata

Penard Faune Rhiz. Léman (1902), pp. 226–227, 5 figs.; Sarcodinés in Cat. Invert. Suisse (1905), p. 41.

Averintzeff in Trudui S.-Peterb. Obshch. XXXVI, II (1906), p. 207.

Schouteden in Ann. Biol. lacustre, I, 3 (1906), pp. 344, 347.

Zschokke in Arch. Hydrobiol. II, 1 (1906), p. 3.

Wailes & Penard in Proc. R. Irish Acad. XXXI, LXV (1911), p. 16.

Wailes in Scott. Nat. Hist. 1912, p. 60; in Naturalist, 1913, pp. 145, 146.

Test small, ovoid, not compressed, yellow or brown in colour, comparatively smooth; aperture small, circular, usually with a border of large quartz-grains; plasma pale-blue in colour enclosing starch-grains and occasionally a few Zoochlorella-cells; nucleus of medium size, bluish, with a central nucleole; pseudopodia not numerous, digitate or rarely branched.

Length 60–80 μ; diameter two-thirds the length; aperture half the diameter.

Habitat.—Aquatic vegetation.

England.—N. Yorkshire.

Scotland.—Outer Hebrides.

Ireland.—Mayo and the islands off Clew Bay (*Penard*).

The brown colour and smooth test are characteristic features of this species; it is not of common occurrence.

5. **Difflugia labiosa** Wailes.

(Plate LXI, fig. 11.)

Difflugia amphora

Penard in Rev. Suisse Zool. IX (1901), p. 237; Faune Rhiz. Léman (1902), pp. 289–292, 8 figs.; Sarcodinés Grand Lacs (1905), pp. 26–28, 111; Sarcodinés in Cat. Invert. Suisse (1905), p. 56. (Non *Difflugia amphora* Ehrenberg, 1872; Leidy, 1874; Averintzeff, 1906; nec *D. urceolata* var. *amphora* Leidy, 1879.)

Test large, ovoid, not compressed, formed of variously-sized quartz-grains; the fundus may vary from hemispherical to conical, the anterior part of test

truncate ; aperture hexagonal or lobed, of medium size, bordered by an expanded lip with a wavy periphery ; the neck very short with the base recessed into the body of the test; plasma normal, containing Zoochlorella-cells in symbiotic relationship, also frequently oil-like globules; nucleus single, large, granular; one or more contractile vesicles usually present; pseudopodia numerous, digitate, simple or branched.

Length 150–275 μ (*Penard*).

Habitat.—Aquatic vegetation and ooze of lakes and ponds.

Wales.—Anglesey.

This species as described by Penard (1902) has a well-characterised test and appears to be quite distinct from *D. amphora* Leidy (1874), which was afterwards recorded as *D. urceolata* var. *amphora* Leidy (1879) and includes forms which belong to *D. amphoralis* Hopkinson (1908); from all these *D. labiosa* is distinguished by the recess around the base of the neck of the test, and the wavy collar following the undulations of the polygonal aperture.

In Great Britain it is rare, being only recorded from a single locality, and of the following dimensions :— length 265 μ ; greatest diameter 160 μ ; aperture 65 μ. (Collected by H. E. Forrest from N.W. Anglesey.)

6. **Difflugia olliformis** Lagerheim.

(Plate LX, figs. 8 and 9.)

Difflugia olliformis
Lagerheim in Geol. Fören. Stockholm Förh. XXIII (1901), pp. 512–513, ff. 1–5.
Zacharias in Forschb. Plon, X (1903), pp. 286–287, pl. i, f. 20.
Averintzeff in Trudui S.-Peterb. Obshch. XXXI, II (1906), p. 213.
Schouteden in Ann. Biol. lacustre, I (1906), p. 348.
Wailes in Jrn. Linn. Soc., Zool. XXXII (1913), p. 206, pl. xv, f. 12.
Difflugia subæqualis ?
Wailes in Scott. Natur. 1912, p. 63 ; in Naturalist, 1913, pp. 145–146.

Test of moderate size, broadly ellipsoidal, truncate; of a yellowish-brown or grey colour, chitinous, sparsely

covered with variously-shaped small silicious grains; aperture large, circular, with a narrow collar; plasma normal; pseudopodia few, long, digitate.

Length 50–84 μ; breadth 44–80 μ; diameter of collar 30–50 μ. (*Lagerheim*—length 59–70 μ; diameter 44–68 μ.)

Habitat.—Aquatic vegetation.

England.—Pilmoor and Gormire, Yorkshire.

Wales.—Bodelwyddan, N. Wales.

Scotland.—Orkney Islands; Outer Hebrides.

In addition to tests of average size, a small variety occurs at Pilmoor, about 30 μ in length, similar to the small form illustrated by Lagerheim (figs. 4, 5).

The test is very similar to that of *D. subæqualis* Penard, but is distinguished from it by the comparatively smaller aperture which causes the length to be slightly greater than the breadth of the test; it is also much more variable in size. The dimensions of *D. subæqualis* are, length 80–82 μ; breadth about 88 μ (Penard, 'Revue Suisse de Zoologie,' vol. xviii (1910), p. 933).

Difflugia tuberculata var. **minor** Wailes.

(Plate LXI, figs. 12 and 13.)

Difflugia tuberculata var. *minor*
Wailes in Jrn. Linn. Soc., Zool. XXXII (1912), p. 124.

Test of medium size, pyriform, not compressed, composed of variously-sized quartz-grains with an occasional admixture of diatom-frustules; aperture small, approximately hexagonal, bordered by a projecting lip; plasma and pseudopodia as in the type.

Length 74–100 μ; diameter 52–90 μ; aperture 23–25 μ.

Habitat.—Ponds and aquatic vegetation.

England.—Windermere, Westmorland; Pilmoor, Yorkshire.

The typical *D. tuberculata* is characterized by the

ovoid form of the test and the polygonal (usually hexagonal) aperture; the surface of the test may or may not be mamillated; the aperture may be plain or lipped; the test varies in length from 108 μ to 160 μ and is about one-tenth less in diameter than in length.

In var. *minor* (the "petite varieté" of Penard) the test is not mamillated and the aperture is invariably lipped; the length of the test is from one-tenth to one-third greater than the diameter; the aperture, usually more or less hexagonal, may be four- or five-sided or even somewhat lobed, this appearance being caused by the occasional convexity of its sides.

If it were not for the fact that Penard has found intermediate forms this variety might be taken for an autonomous species.

The elongated form of test with a diameter about three-quarters of the length is that usually met with.

It also occurs on the Continent of Europe, in the Eastern United States (often plentifully), and in India.

8. **Difflugia constricta** var. **spinifera** Playfair.

(Fig. 172.)

Echinopyxis aculeata (Ehrenb. sp.)
CARTER in Ann. Nat. Hist. (1) XIII (1864), p. 29, pl. i, f. 8.
Difflugia marsupiformis
WALLICH in Ann. Nat. Hist. XIII (1864), p. 241, pl. xvi, f. 5.
Difflugia constricta
LEIDY (pars) Freshw. Rhiz. N. Amer. (1879), pl. xviii, figs. 45–57.
CASH (pars) Brit. Freshw. Rhiz. II (1909), pl. xix, f. 17, and f. 69 in text.
Difflugia constricta var. *spinifera*
PLAYFAIR in Proc. Linn. Soc. N.S. Wales. XLII, 4 (1918), p. 647, pl. xxxvi, f. 6.

The variety thus named is the spined form of *D. constricta* as illustrated by Cash in Vol. II, fig. 69, p. 58, and Pl. XIX, fig. 17. Many spined forms occur which (as stated, *loc. cit.* p. 57) are indistinguishable from *Centropyxis aculeata* (Ehrenb.) Stein; on the other hand spineless forms of this species, *C. aculeata*

var. *ecornis* (Ehrenb.) Leidy, are often similar to the accepted type of *D. constricta*.

In both species the test is chitinous and more or less covered with extraneous particles; if these consist of closely-set grains of sand or silicious plates entirely hiding the chitinous membrane and giving a grey colour to the test, it is identified with *D. constricta*; when however the adherent matter is more or less scattered, leaving parts of the chitinous membrane exposed, and the test is of a brown or yellowish colour, it is usually identified with *Centropyxis aculeata*.

Unfortunately living occupants of tests are not

Fig. 172.—*Difflugia constricta* var. *spinifera*. × 320. (After Cash.)

common, and active individuals are very rarely seen under the microscope, so that frequent comparison of the pseudopodia and movements of the various forms cannot be made, and the opacity of the tests prevents observation of the living plasma and its inclusions.

Observers such as Wallich, Leidy, Penard, and Cash, amongst others, have all expressed their inability to clearly differentiate certain forms of the two species, which it would certainly appear advisable to include under one name, indicating the various forms as varieties or formæ.

Tests occur from which may be formed a graduated series varying in shape from *Helix*-like to *Arcella*-like, the former usually conforming to the *D. constricta* type, the latter to *C. aculeata*; spines may or may not be present on any of them, but are more usual and more numerous on the latter.

Wallich in 1864 gave the name *Difflugia marsupiformis* to the spined forms of this species and the name *D. cassis* to the small and usually spineless forms; since then, however, both forms have usually been grouped together under the name *D. constricta* (Ehrenb.) Leidy.

In the Clare Island Survey report Penard* has the following note:—"In reality these two Rhizopoda (*Difflugia constricta* and *Centropyxis aculeata*) are practically inseparable; and in my opinion it would be better to transfer *Difflugia constricta* at once to the genus *Centropyxis*, which, by its peculiar shape and the special disposition of the peristome, etc., is removed from all the *Difflugiæ*."

Genus 18 a. **BULLINULA** Penard, 1911.

Bulinella Penard in Jrn. R. Micr. Soc. 1907, pp. 274, 278. (pre-occupied in Mollusca, 1891.)
Bullinula Penard in Brit. Antarct. Exped. I, Biol., 6 (1911), p. 226.

Test smooth, ellipsoidal, flattened on one face, formed of silicious plates cemented upon a thin pellicle; the flattened face pierced by an elongated narrow slit constituting a peristome with a smooth inferior lip and an overhanging superior lip; nucleus single; pseudopodia digitate or spatulate, simple or branched.

The genus contains only one species, *B. indica* Penard, which is widely distributed throughout the world but does not usually occur very numerously. As in the genus *Plagiopyxis*, the aperture is often difficult to detect and the opacity of the test prevents observation of the plasma. The name *Bulinella*, being occupied in another Phylum, was altered to *Bullinula*.

* Wailes & Penard in 'Proc. Roy. Irish Acad.' Clare Isl. Survey, Pt. 65 (1911), p. 22, note.

1. **Bullinula indica** Penard.

(Plate LVIII, figs. 9 and 10.)

Bulinella indica

Penard in Jrn. R. Micr. Soc. 1907, pp. 274–277, pl. xiv, ff. 1–4.

Bullinula indica

Penard in Brit. Antarct. Exped. I, Biol., 6 (1911), pp. 225–226; in Rev. Suisse Zool. XX, 1 (1912), pp. 1–9, pl. i, ff. 1–5.

Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), pp. 9, 15, 22, pl. i, f. 1.

Wailes in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 123, 131; (1913), pp. 211, 212, 214; in Scott. Natur. 1912 (Mar.); in Naturalist, 1913, p. 146; in Murray's Nat. Hist. Bolivia and Peru (1913), pp. 32, 33.

Heinis in Mém. Soc. Neuchâtel, V (1914), pp. 677, 680.

Edmondson in Ward & Whittle's Fresh-water Biology (1918), p. 225, f. 309.

Test ellipsoidal, dark brown in colour, flattened or concave on the ventral or buccal face, composed of a thin covering of small silicious grains and plates cemented upon a brown chitinous pellicle; aperture long, arcuate, narrow, with the inner lip prolonged and incurved, the outer lip usually furnished with a row of pores; plasma clear, limpid, containing numerous minute granules, pale-coloured grains, and food-particles of a vegetable nature; nucleus single, spherical, granular, containing a large central nucleole; contractile vesicle probably absent, being replaced by one or more vacuoles; pseudopodia numerous, digitate, simple or lobed, sometimes spatulate.

Greater diameter 120–250 μ, but in the British Isles usually 140–180 μ; length of aperture equal to about half the greater diameter of the test; pores on outer lip 2–3 μ in diameter.

Habitat.—Mosses and sphagnum.

England.—N. and W. Yorkshire; Cambridgeshire; Oxfordshire; Devonshire; Cornwall.

Wales.—North Wales.

Scotland.—Dumfries; ? loc. (*Murray*).

Ireland.—Clare Island, Mayo.

Owing to the dark colour and opacity of the test, the plasma cannot be seen in a living state, and active individuals have only been observed by Penard, who

succeeded in doing so only after long-continued observation ('Revue Suisse Zool.' 1912). When mounted in balsam the tests do not become any less opaque, and only by carefully breaking them up can their structure be ascertained.

The aperture requires careful orientation of the test to see it clearly; the pores bordering its upper lip vary in number and in their disposition, and occasionally cannot be distinguished.

Genus 18 b. **PLAGIOPYXIS** Penard.

Plagiopyxis Penard in Rev. Suisse Zool. XVIII, 4 (1910), p. 936.

Test of medium size, sub-circular in dorsal view, ovoid in side view; aperture linear, lunate, the inner lip short or continued for a considerable distance internally nearly parallel to the curvature of the test; plasma grey, granular; nucleus single; a single vacuole usually present.

Two species are included in this genus, *P. callida* and *P. labiata* Penard; the former is very similar in form but smaller than *Bullinula indica;* it also has affinities with *Trigonopyxis* (*Difflugia*) *arcula*. In none of these species have the pseudopodia been observed, except on one or two occasions by Penard. There is no British record of *P. labiata*, whose test is similar to that of *P. callida* but with a wider aperture and no prolongation of the inner lip—some forms of it approach varieties of *Difflugia constricta* so closely that Penard has doubts as to whether it should not rather be considered as a form or variety of that species.

1. **Plagiopyxis callida** Penard.
(Plate LXI, fig. 7).

Plagiopyxis callida
Penard in Rev. Suisse Zool. XVIII, 4 (1910), pp. 936–940, pl. viii, ff. 8–10; in Brit. Antarct. Exped. I, Biol., 6 (1911), pp. 250–251.
Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), pp. 9, 18, 51, pl. vi, f. 30 *a*, *b*.

Wailes in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 123, 131, 159; (1913), p. 212.
Edmondson in Ward & Whittle's Fresh-water Biology (1918), p. 226, f. 310.

Test of medium size; grey, yellowish or brown in colour; ovoid with ventral side flattened or concave and pierced by a linear, lunate aperture, the inner lip of which is continued nearly parallel to the side of the test for two-thirds of the distance to the crown; plasma limpid, grey in colour, containing numerous small, pale, spherical granules and occasionally food-particles of vegetable origin; nucleus large, spherical, with numerous minute nucleoles; a single vacuole occasionally present; pseudopodia numerous, radiating, short, broad, pointed or palmate, very rarely observed.

Diameter 55–135 μ, but usually 90–110 μ.

Habitat.—Mosses.

England.—Cumberland, Westmorland, and Lancashire (*Brown*); N. Yorkshire; Shropshire; Buckinghamshire; Cornwall; Isles of Scilly.

Scotland.—Elginshire (*Brown*).

Ireland.—Clare Island and Inishturk, Mayo; Inishbofin, Galway.

This is a widely distributed and often numerously represented species; the test is dark and opaque. This, together with its narrowness, often renders the aperture very difficult to locate. The pseudopodia are so rarely observed that only once has their appearance been recorded, a result achieved by Penard after lengthy observations. The geographical range is extensive, records extending to both the Northern and Southern Hemispheres.

Genus 18 c. **CUCURBITELLA** Penard, 1912.

Difflugia (pars) Leidy Fresh. Rhiz. N. Amer. (1879), p. 114.
Cucurbitella Penard Faune Rhiz. Léman (1902), pp. 310–311.

Test ovoid, not compressed, formed of variously-shaped silicious grains; aperture terminal, circular,

irregularly serrated and surrounded by a four-lobed annular collar; plasma grey, granular, containing Zoochlorella-cells living in symbiotic relationship; nucleus single, large; one or more contractile vesicles usually present; pseudopodia numerous, digitate.

The genus contains only one species, the test of which in general appearance and characteristics resembles that of a *Difflugia*, but the collar around the aperture at once distinguishes it.

There are in reality two apertures to the test, the outer one four-lobed and the inner and smaller one with irregular edges.

1. **Cucurbitella mespiliformis** Penard.

(Plate LX, figs. 12 and 13.)

Difflugia lobostoma
LEIDY (pars) Freshw. Rhiz. N. Amer. (1879), p. 114, pl. xv, f. 7.
Cucurbitella mespiliformis
PENARD in Rev. Suisse Zool. IX (1901), p. 237; Faune Rhiz. Léman (1902), pp. 311–314, 6 figs.; Sarcodinés in Cat. Invert. Suisse (1905), pp. 60–61.
AVERINTZEFF in Trudui S.-Peterb. Obshch. XXXVI, II (1906), pp. 176–177.
SCHOUTEDEN in Ann. Biol. lacustre, I, 3 (1906), p. 340.
WAILES in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 124, 133; in Naturalist, 1913, p. 146.

Test ovoid, moderately large, dark grey in colour, composed of variously-shaped silicious grains and plates; aperture terminal, small, irregularly serrated, surrounded by a three- or four-lobed annular collar; plasma grey, granular, containing Zoochlorella-cells living in symbiotic relationship; nucleus large, usually containing a large central nucleole which may occasionally be divided; one or more contractile vesicles usually present; pseudopodia numerous, short, digitate.

Length 116–140 μ; diameter 80–105 μ; inner aperture 15–16 μ in diameter; outer aperture 23–33 μ across the widest part; collar 43–50 μ in diameter.

Habitat.—The ooze of ponds and aquatic vegetation.

ENGLAND.—Husthwaite near York.

The only British record is from a pond, where it was found in the mud when the water was nearly dried up; in numerous previous gatherings from the aquatic vegetation it had not occurred. The collar or peristome, although usually four-lobed, is occasionally three-lobed, and Leidy represents such a test on Pl. xv, fig. 7. In the United States individuals as small as 97 μ in length occur. Owing to the opacity of the test it is not possible to examine the plasma in the living animal.

1. **Pontigulasia rhumbleri** Hopkinson.

(Plate LXIII, figs. 1 and 2.)

Pontigulasia compressa
RHUMBLER in Zeits. wiss. Zool. LXI (1895), p. 105, pl. iv, f. 13 *a*, *b*.
PENARD Faune Rhiz. Léman (1902), pp. 316–317, 3 figs.; Sarcodinés in Cat. Invert. Suisse (1905), p. 61.
AVERINTZEFF in Trudui S.-Peterb. Obshch. XXXI, II (1906), pp. 169–170.
SCHOUTEDEN in Ann. Biol. lacustre, I (1906), 3, pp. 338, 339.
(Non *Pontigulasia compressa* Carter, 1864.)
Pontigulasia rhumbleri
HOPKINSON in Cash's Brit. Freshw. Rhiz. II (1909), p. 162 (see also p. 64).

Test pyriform, compressed, formed of a chitinous pellicle covered with diatom-frustules with a small proportion of silicious grains; aperture elliptical or sub-circular without any definite neck or constriction of the test; internal diaphragm ribbon-shaped, widening towards the ends, placed centrally a short distance within the aperture and attached to the broader sides of the test; plasma partly filling the test; nucleus single, placed near the fundus; pseudopodia lobose, long, numerous.

Length 130 μ to 140 μ; greatest breadth about three-quarters of the length; thickness about half the breadth.

Habitat.—Sphagnum and aquatic vegetation in shallow water.

ENGLAND.—Cumberland (*Brown*).

The form of the internal diaphragm, which is situated centrally, leaving an opening on either side, distinguishes this species from *P. compressa* (Carter) Cash which has the diaphragm stretching across the whole width of the neck of the test, with an orifice on one side only; instances occur in which the tests of the latter have no obvious external features to mark the neck and indicate the form of the diaphragm; in these cases it may be necessary to immerse the tests in oil-of-cloves or canada balsam to enable the structure of the diaphragm to be clearly seen and their identity established. To this occasional external similarity of the two species the paucity of records of *P. rhumbleri* in the British Isles may be due.

The form of the test distinguishes it from *P. elisa* which has a similar type of diaphragm.

Rhumbler's name of *P. compressa* is preoccupied by the species so named by Carter in 1864, described on p. 62 of Vol. II, and the present name is suggested on p. 162 of the same volume.

Genus 23. **CRYPTODIFFLUGIA** Penard, 1890.

Cryptodifflugia Penard in Mém. Soc. Genève, XXXI, i, ii (1890), p. 168.

In Vol. II one species belonging to this genus, *C. oviformis* Penard, is described by Cash; since then three other species have been recorded from the British Isles.

All the members of the genus are remarkably shy and seldom display their pseudopodia whilst under observation.

The following description of the life-cycle in this genus from the observations by Prandtl* is given by Minchin†:—

* Prandtl, H., "Der Entwicklungskreis von Allogromia sp.," 'Archiv für Protistenkunde,' IX, p. 1 (1907).

† Minchin, E. A., 'Introd. to the Study of the Protozoa.' London, 1912.

"In this form also the organism, at the time of gamete-formation, quits its shell and penetrates into some other Protozoan organism, such as *Amœba proteus*, in the body of which it becomes parasitic and goes through the process of gamete-formation. The nucleus breaks up into chromidia, from which secondary nuclei are formed, producing a multinucleate plasmodium which multiplies by plasmotomy until the host is full of them. Ultimately the plasmodia break up into uninucleate cells, the gametes, which are set free and copulate. The zygote becomes a flagellated *Bodo*-like organism, with two flagella, one directed forward, the other backward as a trailing flagellum; it feeds and multiplies in this form for several generations in the free state, but ultimately it loses its flagella, becomes amœboid, forms a shell, and develops into an adult *Cryptodifflugia*. Noteworthy in this development are the alternation of generations between the flagellated and the amœboid phase, as in *Pseudospora*, and the parasitism in the gamete-forming phases; if, however, the *Cryptodifflugia* does not succeed in finding a suitable host, the gamete-formation may take place in the free state."

As only one species (*C. oviformis*) belonging to this genus has been described by Cash, and three other species are now recorded, a synopsis of the genus is here given:

Section A. Test smooth, usually compressed.

Test oviform, slightly compressed; aperture circular, terminal. (1) *C. oviformis.*

Test oviform, much compressed; aperture elliptical, terminal. (2) *C. compressa.*

Test elongate, slightly compressed; aperture circular, oblique. (3) *C. eboracensis.*

Section B. Test usually with adherent foreign particles.

Test pyriform, not compressed; aperture circular, terminal, enlarged. (4) *C. sacculus.*

1. **Cryptodifflugia oviformis** Penard.

(See Vol. II, pp. 79–80, fig. 78.)

2. **Cryptodifflugia compressa** Penard.

(Plate LX, figs. 14–16.)

Cryptodifflugia compressa

Penard Faune Rhiz. Léman (1902), p. 428, 3 figs.; Sarcodinés in Cat. Invert. Suisse (1905), pp. 82–83.

Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), pp. 9, 15, 23, p. i, f. 2.

Wailes in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 124, 133; in Naturalist, 1913, p. 146.

Playfair in Proc. Linn. Soc. N. S. Wales, XLII, 4 (1918), p. 656, pl. xxxviii, f. 9.

Test small, ovoid, yellowish-brown in colour, transparent, homogeneous, compressed; transverse section elliptical; aperture terminal, elliptical, with a short neck; plasma clear, colourless, slightly granular; nucleus single, placed posteriorly, containing a small central nucleole; one or two contractile vesicles usually present; pseudopodia few, not long, pointed or digitate.

Length 17–20 μ; breadth 14–18 μ; thickness 8–10 μ; aperture 5–6 μ by 1·5–3 μ; nucleus about 2 μ in diameter.

Habitat.—Sphagnum and aquatic vegetation.

England.—Cumberland (*Brown*); Lendall, Westmorland; N. Yorkshire; Shropshire; Buckinghamshire; Chillenden, Kent; Isle of Wight.

Ireland.—Belclare, Clare Island, and Caher Island, Mayo.

Not a common species, and usually occurring in association with *C. oviformis*, a much more abundant and generally-distributed species from which the greatly-compressed test and elliptical aperture distinguish it. The pseudopodia are very rarely displayed, the plasma being more often seen protruding from the aperture as a small lobular

expansion. It is not improbable that *Hyalosphenia inconspicua* G. S. West may represent this species (Vol. II, p. 84).

3. **Cryptodifflugia eboracensis** Wailes.

(Plate LXII, figs. 1 and 2.)

Cryptodifflugia eboracensis
Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), pp. 8, 15, 24, pl. i, f. 3.
Brown in Naturalist, 1912 (Oct.), p, 181.
Wailes in Jrn. Linn. Soc., Zool. XXXII (1912, Dec.), pp. 124, 133; in Naturalist, 1913, p. 146.

Test small, yellow-brown in colour, transparent, smooth, homogeneous, elongated, moderately compressed; aperture circular, oblique, without collar or invagination; plasma colourless, granular; nucleus single, containing a central nucleole; one or two contractile vesicles usually present; pseudopodia few, short, pointed or digitate.

Length 24–28 μ; breadth 15–17 μ; thickness 10–15 μ; aperture 4–7 μ in diameter; nucleus 5 μ in diameter.

Habitat.—Sphagnum.

England.—Westmorland; Goathland, Bransdale, and Bolton, Yorkshire; Derbyshire (*Brown*); Bedfordshire; Shropshire; Isle of Wight.

Wales.—N. Wales.

Scotland.—Argyllshire (*Brown*).

Ireland.—Clare Island, Inishturk, Caher Island, and mainland, Mayo; Inishbofin, Galway.

The form of the test is similar to that of *Trinema enchelys*, but otherwise it has the characteristics of the genus *Cryptodifflugia*. The species occurs in the Eastern United States and Alaska.

As with the other members of this genus the animal is very shy, and only on one or two occasions have the pseudopodia been observed, and even then they may not have been fully extended.

Although never abundant it is not uncommon in the localities where it occurs.

4. **Cryptodifflugia sacculus** Penard.

(Plate LX, fig. 17.)

Cryptodifflugia sacculus

PENARD Faune Rhiz. Léman (1902), pp. 429–430, 6 figs.; Sarcodinés in Cat. Invert. Suisse (1905), p. 83.

WAILES & PENARD in Proc. R. Irish Acad. XXXI, LXV (1911), pp. 9, 16, 25, pl. i, f. 5 *a*.

WAILES in Naturalist, 1913, p. 146.

Test small, pyriform, not compressed, hyaline or yellowish in colour, composed of a homogeneous, chitinous, transparent membrane usually covered with adherent foreign particles and sometimes diatoms; aperture circular, terminal, usually enlarged; plasma colourless, granular; nucleus single with a central nucleole; one or two contractile vesicles usually present; pseudopodia few in number, of moderate length, pointed.

Length 20–30 μ; diameter 15–22 μ; aperture 6–12 μ.

Habitat.—Aquatic vegetation.

ENGLAND.—Lindal, Westmorland; Pilmoor and Gormire, N. Yorkshire; New Forest, Hants; Grimspound, Devon; Lizard, Cornwall.

SCOTLAND.—Shetland Isles; Outer Hebrides; Scourie, Sutherland.

IRELAND.—Clare Island, Mayo; Oughterard, Galway.

Most of the above records are from material collected by W. West. Clare Island and Pilmoor each provided a single individual with a smooth colourless test and unenlarged aperture; the plasma appeared normal. The test of this species resembles small forms of that of *Pseudodifflugia fascicularis*, but the aperture of the latter is usually more thickly encrusted with foreign particles.

§ C. *Nebelinæ.*

1. **Hyalosphenia ovalis** Wailes.

(Plate LXII, figs. 3 and 4.)

Hyalosphenia ovalis
Wailes in Scott. Natur. 1912, pp. 61, 64, fig. 1.

Test large, pyriform, of a yellow colour, compressed; in broad view the crown semicircular, the sides converging in slightly concave lines to the aperture; the crown perforated with from two to twelve pores with beaded internal orifices; the test in narrow side view elliptical, truncate, and notched at the aperture; the crown and anterior portions of the sides of the test furnished with a wide rounded keel; test in transverse section elliptical; aperture elliptical, straight in broad view, slightly notched in narrow view; plasma clear, colourless, containing numerous granules and food-particles; nucleus large, placed posteriorly, containing several nucleoles; one or two contractile vesicles usually present; pseudopodia few, digitate.

Length 153–177 μ; breadth 130–140 μ; aperture 50–55 μ; thickness about half the breadth, or less.

Habitat.—Sphagnum.

Scotland.—Dumfries.

Ireland.—Cahirciveen, Kerry.

From *H. papilio* this species is distinguished by its much larger size and the keel-like ridge around the borders of the test; the number of pores in the crown is also usually greater, and the thickening of the test around their inner openings is also characteristic. The test is always pyriform in broad view, whilst the test of *H. papilio* is only occasionally so.

It appears to be rare, for its large size precludes it from being easily overlooked.

1. **Nebela bigibbosa** Penard.

(Plate LXII, figs. 5 and 6.)

Nebela bigibbosa

Penard in Mém. Soc. Genève, XXXI, i, II (1890), pp. 161–162, pl. vi. ff. 85–97; Faune Rhiz. Léman (1902), pp. 575–576, f. 7; in Arch, Protist. II (1903), pp. 259–260, f. 7; in Rev. Suisse Zool. XIII. 3 (1905), pp. 600–602, pl. xiii, ff. 16–19; Sarcodinés in Cat. Invert. Suisse (1905), p. 70; in Brit. Antarct. Exped. I, Biol., 6 (1911), p. 240.

Blochmann Mikr. Thierw. Süsswass. ed. 2 (1895), p. 17.

Averintzeff in Trudui S.-Peterb. Obshch. XXXI, II (1906), pp. 237–238.

Schouteden in Ann. Biol. lacustre, I (1906), pp. 353, 356.

Wailes & Penard in Proc. R. Irish Acad. XXXI, LXV (1911), pp. 9, 10, 17, 44, pl. v, f. 3.

Brown in Jrn. Linn. Soc., Zool. XXXII (1911), p. 80; in Ann. Scott. Nat. Hist. 1911, pp. 230, 231; *op. cit.* 1912, p. 112; in Scott. Natur. 1913, p. 209.

Edmundson in Univ. Colorado Stud. IX (1912), p. 68.

Test large, pyriform, compressed, yellowish in colour, composed of circular, oval, or elongated plates; the crown in broad view semicircular, each side, at about one-third of the length from the aperture, furnished with a pair of pores situated in depressions and connected by an internal tube; test in narrow side view elliptical, truncate at the aperture, with a small pore, just anterior to the internal tube, in the margin at each side; aperture elliptical, convex in broad view, notched in narrow view, and furnished with an external lip; nucleus not large, containing several nucleoles; plasma and pseudopodia normal.

Length 135–170 μ; breadth 87–110 μ; thickness 50–55 μ; aperture 34–45 μ.

Habitat.—Ground mosses.

England.—Lodore, Cumberland, and Lancashire (*Brown*).

Wales.—Moel Siabod, N. Wales, at 2,500 feet (collected by *J. Hopkinson*).

Scotland.—Glen Eagles, Perthshire, and St. Kilda (*Brown*).

Ireland.—Castlebar, Clare Island, and Inishturk, Mayo.

Three other species of *Nebela*, viz. *N. martiali*, *N. certesi*, and *N. murrayi*, are characterized by the two pairs of orifices in depressions in the sides of the tests and the tubes connecting each pair. The two last-mentioned species have been recorded from the Southern Hemisphere only; *N. bigibbosa* from the Northern Hemisphere only, where it usually occurs in elevated situations.

2. **Nebela griseola** Penard.

(Plate LXI, figs. 14–16.)

Nebela griseola
PENARD in Brit. Antarct. Expéd. I, Biol., 6 (1911), pp. 244–245, pl. xxiii, f. 8.
WAILES & PENARD in Proc. R. Irish Acad. XXXI, LXV (1911), pp. 9, 18, 47–48, pl. v, f. 25 *a–g*.
WAILES in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 125, 138.

Test small, pyriform, slightly compressed, composed of variously-shaped plates and silicious grains; aperture usually circular and bordered by a prominent collar, semicircular in section; plasma clear, colourless, containing starch-grains and food-particles, also occasionally reserve materials; nucleus small, placed centrally, containing numerous small nucleoles; one or two contractile vesicles usually present.

Length 80–87 μ; breadth 52–60 μ; thickness 45–55 μ; aperture 18–23 μ; collar 27–32 μ in diameter; nucleus 12 μ dia.

Habitat.—Sphagnum and mosses.

IRELAND.—Achill Island and Clare Island, Mayo.

The resemblance to *N. tenella* is somewhat close, but this species is distinguished by the slighter compression of its test, larger aperture, and (usually) larger size. The ratio of the transverse axes in *N. tenella* is from 4 : 3 to 2 : 1, in *N. griseola* it is 5 : 4. The only other species of *Nebela* with a similar collar around the aperture is *N. cratera* Wailes, in which the test is not compressed and is 120–140 μ in length.

3. **Nebela lageniformis** var. **minor** Wailes.

(Plate LXII, figs. 7 and 8.)

Nebela lageniformis
WAILES (pars) in Proc. R. Irish Acad. XXXI, LXV (1911), p. 18, pl. v, f. 28 *a*, *b*.
Nebela tubulata
PENARD (pars) in Proc. R. Irish Acad. XXXI, LXV (1911), p. 50.
Nebela lageniformis var. *minor*
WAILES in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 157–158; in Naturalist, 1913, p. 147.

Test similar to that of the type but smaller; plasma and pseudopodia as in the type.

Length 75–100 μ.

Habitat.—Sphagnum.

ENGLAND.—N. Yorkshire; Bedfordshire.

IRELAND.—Clare Island, Inishturk, Caher Island, and Castlebar, Mayo.

Australia (*Penard*). Seychelles (*Wailes*).

The typical *N. lageniformis* is usually 110–130 μ in length, although in New Zealand it reaches a length of 160 μ (*Penard*); small forms 85–100 μ are not uncommon in some localities and are easily recognized, but the smallest individuals closely approach *N. tubulata* Brown in size and general proportions but always possess the characteristic torulose neck. On the other hand individuals of *N. tubulata* are found in which the neck is slightly but distinctly torulose, and when these measure about 75 μ in length it is often difficult to decide to which species they belong.

4. **Nebela tubulata** Brown.

(Plate LXII, fig. 9.)

Nebela sp. (*barbata—collaris*)
LEIDY Freshw. Rhiz. N. Amer. (1879), p. 160, pl. xxiv, f. 18.
Nebela barbata
CASH (pars) Brit. Freshw. Rhiz. II (1909), pl. xxvii, ff. 5, 6.
Nebela militaris var. *tubulata*
BROWN in Jrn. Linn. Soc., Zool. XXX (1910), pp. 361, 365, pl. l, ff. 9, 10.

Nebela tubulata

Brown in Jrn. Linn. Soc., Zool. XXXII (1911), p. 79; in Scott. Natur. 1911, p. 229; *op. cit.* 1912. p. 122; *op. cit.* 1913, p. 186.

Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), pp. 9, 18, 49–50, pl. v, f. 27.

Wailes in Scott. Natur. 1912, p. 61; in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 125, 127, 140, 159; in Naturalist, 1913, p. 147.

Test small, yellowish-brown in colour, flask-shaped, compressed, composed of circular and oval plates; test in broad view oval, terminating in a long, slender, usually parallel neck; aperture elliptical, rounded in broad side view, notched in narrow view and bordered by a thickened lip; plasma clear, colourless, containing food-particles and occasionally green algæ cells; nucleus not large, containing several nucleoles; pseudopodia not observed.

Length 55–74 μ; breadth 28–48 μ; aperture 10–15 μ; thickness about two-thirds the breadth; length of neck one-third to one-half the total length of test.

Habitat.—Sphagnum.

England.—Cumberland, Westmorland, and Lancashire (*Brown*); N. & W. Yorkshire; Derbyshire (*Brown*); Bedfordshire; Isle of Wight; Devonshire.

Wales.—North Wales.

Scotland —Dumfries; The Outer Hebrides; Perthshire; St. Kilda and Wigtonshire (*Brown*).

Ireland.—Mayo and the Islands off Clew Bay; Inishbofin, Galway; Kerry.

The typical form of this species with the parallel neck is easily recognized, but there is a distinct and well-marked tendency for the neck to assume a torulose form, in which case it has the appearance of a small form of *N. lageniformis*, although usually less in size than var. *minor* of that species; in Ireland and the Seychelles both of these species occur in association, but in New York State only *N. tubulata* was found, and in several localities in South America only *N. lageniformis* of normal size; this was also the case in Colorado, U.S.A., where the var. *minor* of that species occurs, but *N. tubulata* has not been recorded.

There is some similarity between *N. tubulata* and small forms of *N. barbata*, which are occasionally found about 80 μ in length, especially if these are seen in oil-of-cloves or in canada balsam, as in these media the fine cils which cover the tests are invisible; but its tapering neck and less compression of the test serve to distinguish them even if the cils are overlooked.

5. **Nebela scotica** Brown.

(Plate LXI, fig. 17; Pl. LXIII, figs. 3–7.)

Nebela scotica
Brown in Jrn. Linn. Soc., Zool. XXXII (1911), pp. 79–80, pl. ix, ff. 5–8; in Scott. Natur. 1913, p. 207.
Nebela dentistoma var. *lageniformis*
Playfair in Proc. Linn. Soc. N. S. Wales, XLII, 4 (1918), p. 659, pl. xxxix, f. 5.

Test of medium size, grey in colour, pyriform, moderately compressed, the short neck terminating in a broadly-elliptical aperture; the surface of the test usually smooth but occasionally irregular, composed of transparent colourless scales of various shapes, occasionally imbricated; plasma and pseudopodia normal.

Length 78–82 μ; breadth 57–59 μ; aperture 18–19 μ; thickness 40 μ.

Habitat.—Sphagnum.

England.—Westmorland (*Brown*).
Scotland.—Ben Ledi, Perthshire (*Brown*).

It is questionable if it would not be more appropriate to record this species as a form or variety of *N. dentistoma* Penard, as in the case of a very similar American form, *N. dentistoma* var. *lacustris* Wailes,* which is 140–200 μ in length but of similar form and proportions. *N. dentistoma* is remarkable for its polymorphic tendencies, the test varying in form from elongate-ovoid to nearly circular, in this latter case being often similar to *N. acolla* Cash.

* 'Journ. Linn. Soc., Zool.' vol. xxii, p. 137 (1912).

Since the above was written Playfair has described under the name of *Nebela dentistoma* var. *lageniformis* an Australian form which evidently belongs to this species, but is somewhat larger, being 126 μ in length.

6. **Nebela vitræa** var. **sphagni** Wailes.

(Vol. II, Plate XXVIII, figs. 14–17.)

Nebela vitræa
PENARD (pars) Faune Rhiz. Léman (1902), pp. 372, 374, f. 6.
CASH Brit. Freshw. Rhiz. II (1909), pp. 121–122, pl. xxviii, ff. 14–17.
WAILES & PENARD in Proc. R. Irish Acad. XXXI, LXV (1911), pp. 18, 50–51, 60, 61.
Nebela vitræa var. *sphagni*
WAILES in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 125, 141.

This variety is the *Nebela vitræa* described by Cash in Vol. II. It is a sphagnum-inhabiting species, much smaller than the large deep-water form described by Penard, which is 170 μ to 200 μ in length; in America this large form is found in sphagnum, attaining nearly 300 μ in length, but its test is somewhat different in structure from that of the Swiss type.

N. vitræa var. *sphagni* usually measures from 80 μ to 100 μ in length, but may vary between 66 μ and 120 μ, and is very similar in size to *N. dentistoma*, with which species it is frequently associated in the British Isles. The test differs from that of the type by not being composed of regularly-arranged plates or scales the interstices between which are mostly covered by small overlapping plates; the aperture of the test also is bordered by proportionally smaller and more numerous grains of irregular shape, which in the type are usually only from seven to ten in number.

In Switzerland the large species is recorded only as occurring in deep water and var. *sphagni* from one or two localities, and even there it is rare; but in America the two are found in association amongst sphagnum and aquatic vegetation in shallow water.

Both in America and Switzerland a medium-sized

variety differing only from the type in its smaller size occurs, and may be distinguished as *N. vitræa* var. *minor* as suggested by Penard; it is about 140 μ to 150 μ in length: it has not yet been recorded from the British Isles and is rare in Switzerland, but at Lakehurst in New Jersey it is the dominant type.

1. **Quadrulella symmetrica** var. **irregularis** Penard.

(Fig. 173.)

Quadrulla symmetrica var. *irregularis*
PENARD in Amer. Natur. XXV (1891), p. 1073; Faune Rhiz. Léman (1902), p. 378; Proc. R. Soc. Edinb. XXV, 8 (1905), pp. 595, 597.
CASH Brit. Freshw. Rhiz. II (1909), p. 132.
WAILES & PENARD in Proc. R. Irish Acad. XXXI, LXV (1911), p. 142, pl. vi, f. 31.
WAILES in Jrn. Linn. Soc., Zool. XXXII (1912), p. 142, pl. xii, f. 20.

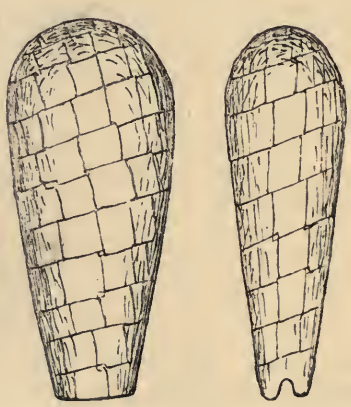


FIG. 173.—*Quadrulella symmetrica* var. *irregularis*. × 250.

Test larger than in the type, moderately compressed, the fundus, in broad side view, hemispherical with the sides tapering in nearly straight lines to the aperture; the aperture devoid of lips and without any constriction of the neck; plasma and pseudopodia as in the type.

Length 130 μ to 160 μ; breadth 55 μ to 60 μ; aperture in greatest width 23 μ to 30 μ.

Habitat.—Sphagnum.

England.—Goathland, N. Yorkshire.
Scotland.—Loch Ness (*Penard*).
Ireland.—Inishbofin, Galway.

The typical *Q. symmetrica* varies considerably in form, the outline in broad view ranging from a somewhat wide pyriform shape with convex sides to an elongated form with slightly concave sides; the var. *irregularis* resembles the latter in shape, but the sides are nearly or quite straight and the size is considerably larger.

It is not common, and records of its occurrence are so far restricted to the British Isles and the United States of America, where Penard first found it in the Rocky Mountains (10,000 ft.) and where it also occurs in the Eastern States.

It has been suggested that the genus *Quadrula* (*Quadrulella*) rightly belongs to the genus *Nebela*, and this opinion has recently received further support by the discovery in North and South America and in the Tropics of intermediate forms which have been recorded under the names of *Nebela tropica* Wailes and *Nebela scutellata* Wailes.

1. **Heleopera sordida** Penard.

(Plate LXII, figs. 10 and 11.)

Heleopera sordida
Penard in Rev. Suisse Zool. XVIII, 4 (1910), pp. 931–932, pl. viii, ff. 2, 3; in Brit. Antarct. Exped. I, Biol., 6 (1911), p. 236.
Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), p. 17.
Wailes in Scott. Natur. 1912, p. 61; in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 125, 143, 156; *loc. cit.* (1913), p. 213; in Naturalist, 1913, p. 146.

Test small, of a yellow colour, chitinous, ovoid, compressed, smooth except for a few adherent particles on the fundus which consist of silicious and vegetable matter; aperture wide, in side view notched or with the lips closed together; plasma clear and colourless, the anterior portion granular; nucleus large, granular,

containing several small nucleoles, placed posteriorly; pseudopodia few in number, digitate, simple.

Length 60–70 μ; breadth 45–55 μ; aperture 20–25 μ; nucleus about 15 μ in diameter.

Habitat.—Sphagnum.

England.—N. Yorkshire; Bedfordshire; Shropshire; Buckinghamshire; Isle of Wight; Somersetshire; Cornwall.

Wales.—N. Wales.

Scotland.—Outer Hebrides.

Ireland.—Mayo and the islands off Clew Bay; Inishbofin, Galway.

The only other species of *Heleopera* resembling this is *H. sphagni* var. *lævis* Wailes ('Journ. Linn. Soc.,' Zool., vol. xxxii (1912), p. 143), which however usually exceeds it in size, has a smoother fundus, and is of a characteristic yellow colour; the test also has a peculiar reticulated structure (v. Leidy, 1879, Pl. xxvi).

H. sordida is also peculiar among the species of the genus in having vegetable débris attached to the fundus; this is easily confirmed by immersing the test in a chlor-zinc-iodine solution which stains vegetable tissue a dark red; also when the tests are mounted in canada balsam the vegetable particles usually appear black.

It is a widely distributed species and occurs on the Continent of Europe, in North and South America, Australasia, and the Seychelles.

Genus 27 a. **AVERINTZIA*** Schouteden, 1906.

Heleopera (pars) Penard Faune Rhiz. Léman (1902), pp. 390–393.

Awerinzewia Schouteden in Ann. Biol. lacustre, I, 1 (1906), p. 357.

* This alteration in spelling from the German form of *Awerinzewia* seems to be the nearest approximation to the transliteration into English, with generic form of termination, of the Russian characters in the name of the distinguished biologist in whose honour this genus was founded, and is in accordance with Latin orthography, which the German form is not.

Test similar to that of *Heleopera* but having a small elliptical aperture.

The walls of the test around the aperture are considerably thickened but taper very gradually to normal. This portion of the test is quite characteristic and at once distinguishes it from the test of any species of *Heleopera*, the only genus with which it is likely to be confused.

This genus contains only one species, *A. cyclostoma* (*Heleopera cyclostoma* Penard). No characteristics of the genus are given by its author.

1. **Averintzia cyclostoma** (Penard) Schouteden.

(Plate LXII, figs. 12 and 13.)

Heleopera cyclostoma
Penard Faune Rhiz. Léman (1902), pp. 390–393, 6 figs.
Awerinzewia cyclostoma
Schouteden in Ann. Biol. lacustre, I, 3 (1906), p. 357.
Penard in Brit. Antarctic Exped. 1907–9, I, 6 (1911), p. 225.
Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv (1911), pp. 9, 15, 22.
Wailes in Jrn. Linn. Soc., Zool. XXXII (1912), pp. 125, 143, 156; (1913), pp. 211, 213.
Heinis in Mém. Soc. Neuchâtel, V (1914), pp. 677, 680, 693, 696.
Edmondson in Ward & Whipple's Fresh-water Biology (1918), p. 227, f. 317.

Test of moderate size, broadly ovoid, compressed, composed of various-sized quartz-grains cemented in a chitinous material of a dark violet colour; surface of test smooth except at the crown where a few adherent grains may occasionally be present; test in narrow side view elongate-oval; transverse section elliptical; aperture small, terminal, elliptical, bordered internally by a thickening of the walls of the test; nucleus single, large, granular; pseudopodia not observed.

Length 135–180 μ; breadth about three-quarters the length; thickness three-fifths to two-thirds the breadth; nucleus 33 μ dia. (*Penard*).

Habitat.—Sphagnum and aquatic vegetation.

England.—Lancashire (*Brown*).

Ireland.—Clare Island, Mayo; Inishbofin, Galway.

Greatly resembling *Heleopera petricola* var. *amethystea* Penard in appearance, this species is distinguished from that variety by its usually larger size and small elliptical aperture; the test is also characterized by more or less numerous opaque white plates of various shapes incorporated in it. Owing to its opacity little can be distinguished of the animal itself, which is seldom found and then usually in a state of encystment. Although rare it is widely distributed and has been recorded from the Continent of Europe, North and South America, and the Seychelles.

§ D. *Pseudonebelinæ.*

1. **Cochliopodium obscurum** Penard.

(Plate LXII, fig. 14; Pl. LXIII, figs. 8 and 9.)

Cochliopodium obscurum

Penard in Mém. Soc. Genève, XXXI, i, ii (1890), p. 135, pl. iii, ff. 26–29; in Rev. Suisse Zool. IX (1901), p. 237; Faune Rhiz. Léman (1902), pp. 203–206, 6 figs.; Sarcodinés in Cat. Invert. Suisse (1905), p. 35.

Averintzeff in Trudui S.-Peterb. Obshch. XXXVI, ii (1906), pp. 140–141.

Schouteden in Ann. Biol. lacustre, I, 3 (1906), pp. 331, 332.

Wailes & Penard in Proc. R. Irish Acad. XXXI, lxv(1911), p. 15.

Animal covered with a hyaline, elastic membrane, of hemispherical shape when extended with the periphery expanded into a disc-like form, but capable of being closely folded up; the central portion of the membrane thickly covered with adherent rounded particles; plasma clear, colourless, granular, usually containing a number of small yellow particles; nucleus single, containing a single large nucleole; contractile vesicle large, single; pseudopodia varying from spatulate to pointed.

Diameter, when contracted 25–30 μ, when expanded about 50 μ.

Habitat.—Aquatic vegetation.

Ireland.—Clare Island, Mayo (*Penard*).

The particles covering the central portion of the membrane are so closely set that the plasma is quite hidden from view; although their general appearance is quite dark, Penard found that isolated particles were bright and colourless or of a pale yellow.

The pseudopodia are somewhat similar to those of *C. bilimbosum*. From other members of the genus *C. obscurum* is distinguished by the numerous adherent particles on the test. It should however be remembered that the genus includes species of very diverse characteristics.

2. **Cochliopodium granulatum** Penard.

(Plate LXIII, figs. 10 and 11, and figs. 174 and 175 in text.)

Cochliopodium granulatum

Penard in Mém. Soc. Genève, XXXI (1890), pp. 134–135, pl. iii, ff. 23–25; in Arch. Sci. Nat. (3) XXVI (1891), pp. 138–139; in Rev. Suisse Zool. VII (1899), pp. 22–23, pl. ii, ff. 4–5; *op. cit.* IX, p. 138; Fanne Rhiz. Léman (1902), pp. 194–196, 6 figs.; Sarcodinés Grands Lacs (1905), pp. 11–13, 2 figs.; Sarcodinés in Cat. Invert. Suisse (1905), p. 34.

Averintzeff in Trudui S.-Peterb. Obshch. XXXI, ii (1906), pp. 139–140.

Schouteden in Ann. Biol. lacustre, I (1906), pp. 331, 332.

Brown in Jrn. Linn. Soc., Zool. XXXII (1911), pp. 77–78, pl. ix, ff. 1, 2.

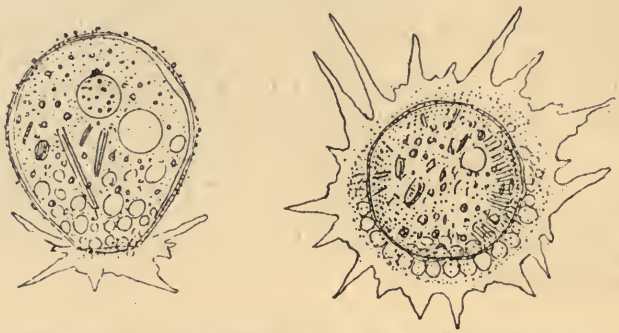
Test of medium size, not compressed, of variable form, hyaline or yellowish in colour, consisting of a thin flexible membrane usually sparsely covered with extraneous grains; aperture terminal, flexible; plasma usually filling the test, grey in colour, granular, containing numerous vacuoles with sometimes ingested diatom-frustules; nucleus single, spherical or subspherical, granular, containing numerous small nucleoles, placed posteriorly; contractile vacuoles one or

two in number; pseudopodia spatulate or pointed, often voluminous.

Diameter of body 70 μ to 90 μ.

Habitat.—Among aquatic vegetation in shallow water.

England.—Warwickshire ? (*Brown*).*



Figs. 174 and 175.—*Cochliopodium granulatum.* Fig. 174, side view. × 310. Fig. 175, upper view. × 250. (After Penard.)

The test, although very flexible, is firm and sufficiently elastic to retain its shape when the plasma, as occasionally happens, does not entirely fill it; when viewed in transverse section its thickness is denoted by the double contour-line and its structure is indicated by the numerous transverse striations which probably represent the margins of small discs or pellets incorporated in it as is the case with most of the other members of the genus.

The anterior portion of the plasma is usually crowded with vacuoles, many of them of large size; when the aperture is completely closed these serve to indicate which is the buccal extremity.

* From a gathering by Bolton in the neighbourhood of Birmingham.

INDEX

OF SPECIES, ETC., NAMED OR DESCRIBED IN VOL. IV.*

Synonyms in italics.

* The figures in heavy type indicate the pages on which they are described; in light type, synonyms and incidental references.

FIG. 176.—*Pyxidicula operculata.* × 800. (After Ehrenberg, 1856.)

ERRATA AND CORRIGENDA.

Vol. I.

PAGE

54, line 2 from bottom, *after* Zool. *insert* VII.

61, line 2, *for* spherical nucleus *read* ovoid nucleus.

129. *Pseudochlamys.* Cockerell has discovered that this name is pre-occupied and has suggested *Microchlamys* (Zool. Anzeig. vol. xxxviii, p. 136, 1911); but Greeff's name *Amphizonella* (1866) has priority and our species should be *Amphizonella patella* (Clap. & Lachm.) Hopk.

133. *Echinopyxis hemispherica* Barnard. This is a form which occurs in America and is described under the name of *Centropyxis aculeata* var. *hemispherica* (Barnard) Wailes in Jrn. Linn. Soc. XXXII (1913).

Vol. II.

5, line 19, *for* Guerne *read* De Guerne.

19, „ 3 from bottom, *for* 1842 *read* 1841.

32, „ 6 of synonymy, *for* Schroteden *read* Schouteden.

62, last line of synonymy, *for* (1905) *read* (1895).

114, lines 2 and 3, *omit* The latter *to* examples.

127–128. *Nebela triangulata* var. *bicornis* G. S. West, should be *Nebela bipes* (Carter) Murray.

136, line 6, for *Heliopera* read *Heleopera.*

passim, for Edmonston *read* Edmondson.

Vol. III.

73, line 16, *for* III *read* XXX.

144. Synonymy of *Diplophrys*, line 4, *for* 265 *read* 159.

145, add to synonymy: *Cystophrys haeckeliana* Archer in Qrt. Jrn. Micr. Sci. (n. s.) IX (1869), p. 259, pl. xvii, ff. 1 and 2.

147, lines 5 and 6, *from* which *to* globules *read* which also measure about 4 μ in diameter but contain red or carmine oil-like globules.

„ line 8, *for* Pl. XX, fig. 3) *read* Pl. xvii, fig. 3).

149, line 10, *for* Pl. XVI *read* Pl. XVII.

passim, for Tarr *read* De Tarr.

EXPLANATIONS OF THE PLATES.

Plate 58

PLATE LVIII.

FIGS.

1. *Amœba fluida* Gruber. (p. 8) Active individual. × 400.
2. *A. vespertilio* Penard. (p. 10) Small active individual. × 400.
3. *A. verrucosa* var. *papyracea* Penard. (p. 10) Active individual. × 200.

4, 5. *Arcella arenaria* Greeff. (p. 15) Fig. 4.—Side view of empty test. Fig. 5.—View of active individual from above. × 500.

6, 7. *A. polypera* Penard. (p. 16) Fig. 6.—Side view of empty test. Fig. 7.—View of active individual from above. × 300.

8. *Capsellina timida* Brown. (p. 29) Longitudinal view of active individual. × 700. After Brown.

9, 10. *Bullinula indica* Penard. (p. 45) Fig. 9.—Side view of test. Fig. 10.—Oral view of test. × 200.

11–13. *Microcorycia flava* (Greeff) Cockerell. (p. 25) Fig. 11.—Oral view of individual with extended test and partially closed aperture. Fig. 12.—Side view of test showing the membrane by means of which the aperture can be closed. Fig. 13.—Oral view of test partially folded together. × 350.

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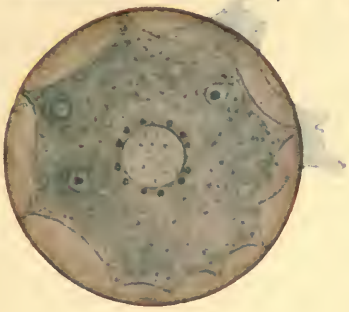

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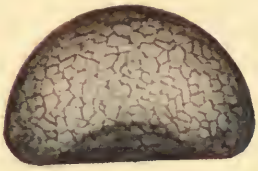

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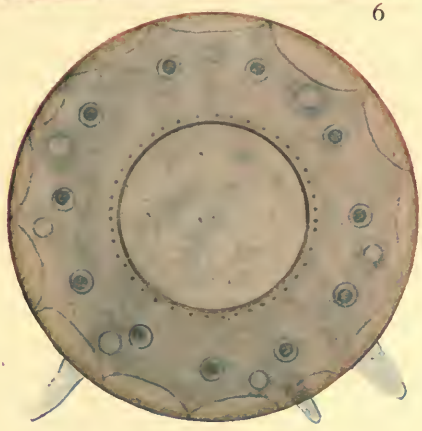

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Plate 59

PLATE LIX.

FIGS.

1–3. *Amœba vespertilio* Penard. (p. 10) Active individuals. × 400.

4. *A. alba* Greeff. (p. 11) Active individual. × 150.

5. *Arcella vulgaris* var. *hemisphærica* (Perty) Wailes. (p. 13) View of empty test as seen in section. × 750.

6–9. *Pyxidicula invisitata* Averintzeff. (p. 22) Fig. 6.—View of living individual seen from above. *fl.*, bifurcated margin of test. *p.v.*, pulsating vesicle. Fig. 7.—Sectional view of empty test. Figs. 8 and 9.—Different forma of the marginal flange. × 1000. After Brown.

10–14. *Capsellina timida* Brown. (p. 29) Fig. 10.—Active individual. × 700. Fig. 11.—Living individual. × 700. Fig. 12.—Enlarged view of oral extremity. × 1000. Fig. 13.—Individual with lips of aperture open. × 350. Fig. 14.—Encysted individual. × 500. After Brown.

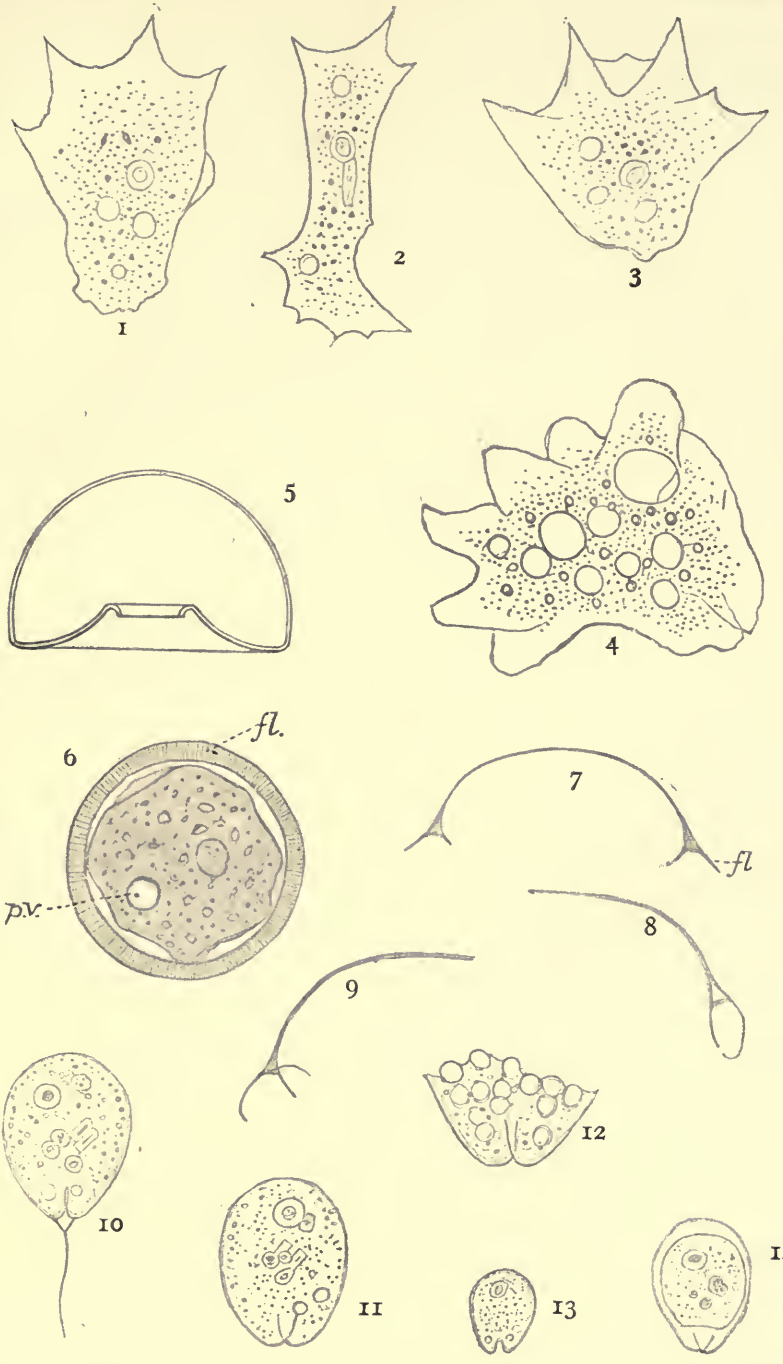
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Plate 60

PLATE LX.

FIGS.

1–4. *Microgromia radiata* (Brown) Hopk. (p. 27) Figs. 1 and 2.—Longitudinal views of active individuals. Fig. 3.—Longitudinal view with the aperture closed. Fig. 4.—Oral view of test with the aperture closed. × 700. After Brown.

5. *Diplochlamys fragilis* Penard. (To represent *D. leidyi* Greeff, p. 31) Side view of living individual, the aperture closed by the diaphanous membrane. × 400.

6. *D. timida* Penard. (p. 32) View of active individual. × 400. After Penard.

7. *D. vestita* Penard. (p. 33) Oral view of living individual, the aperture closed by the diaphanous membrane. × 400.

8, 9. *Difflugia olliformis* Lagerheim. (p. 40) Side and oral views of empty test. × 300.

10, 11. *D. rubescens* Penard. (p. 37) Fig. 10.—Side view of active individual. Fig. 11.—Oral view of empty test. × 300.

12, 13. *Cucurbitella mespiliformis* Penard. (p. 48) Oral and side views of living individual; Husthwaite, Yorkshire. × 300.

14–16. *Cryptodifflugia compressa* Penard. (p. 52) Broad, narrow, and oral views. × 800.

17. *C. sacculus* Penard. (p. 54) Side view of active individual. × 800.


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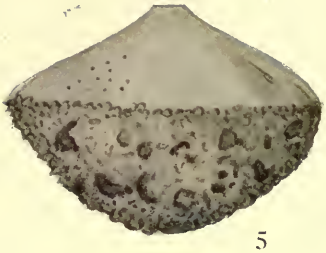
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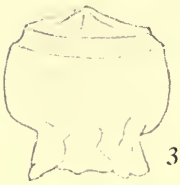
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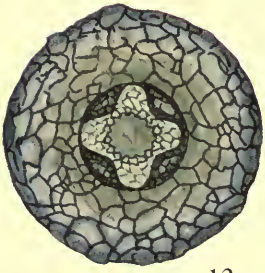
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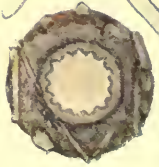
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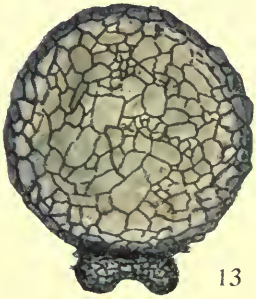
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Plate 61

PLATE LXI.

FIGS.

1, 2. *Centropyxis aculeata* var. *discoides* Penard. (p. 34) Oral and side views of empty test. × 200.

3, 4. *C. arcelloides* Penard. (p. 35) Oral and side views of empty test. × 300.

5, 6. *Parmulina cyathus* Penard. (p. 28) Side and oral views of living individual. × 400.

7. *Plagiopyxis callida* Penard. (p. 46) Oral view of test. × 300.

8. *Difflugia oblonga* var. *tenuis* Penard. (p. 36) Side view of active individual. × 400.

9. *D. oblonga* var. *bryophila* Penard. (p. 37) Side view of empty test. × 400.

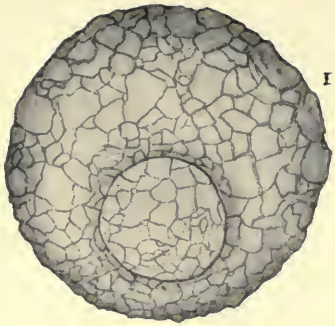
10. *D. manicata* Penard. (p. 39) Side view of active individual. × 400.

11. *D. labiosa* Wailes. (p. 39) Side view of test, from Anglesey. × 200.

12, 13. *D. tuberculata* var. *minor* Wailes. (p. 41) Side and oral views of active individual. × 400.

14–16. *Nebela griseola* Penard. (p. 57) Oral, and broad and narrow side views, of empty test. × 400.

17. *N. scotica* Brown. (p. 60) Broad side view of empty test. × 400.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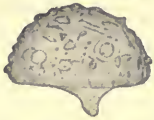
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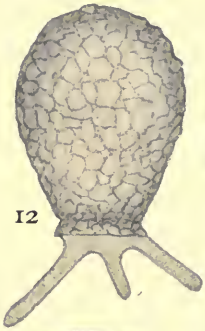
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Plate 62

PLATE LXII.

FIGS.

1, 2. *Cryptodifflugia eboracensis* Wailes. (p. 53) Side and oral views of active individual. × 1200.

3, 4. *Hyalosphenia ovalis* Wailes. (p. 55) Broad and narrow side views of active individual. × 300.

5, 6. *Nebela bigibbosa* Penard. (p. 56) Broad and narrow side views of empty test. × 300.

7, 8. *N. lageniformis* var. *minor* Wailes. (p. 58) Broad side view of empty test. × 400.

9. *N. tubulata* Brown. (p. 58) Broad side view of empty test. × 400.

10, 11. *Heleopera sordida* Penard. (p. 63) Broad and narrow side views of living individual. × 400.

12, 13. *Averintzia cyclostoma* (Penard) Schouteden. (p. 65) Broad side view and oral view of empty test. × 240.

14. *Cochliopodium obscurum* Penard. (p. 66) Active individual. × 700. After Penard.

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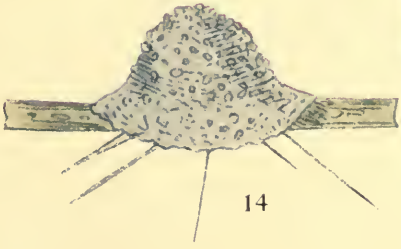

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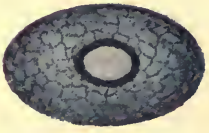

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Plate 63

PLATE LXIII.

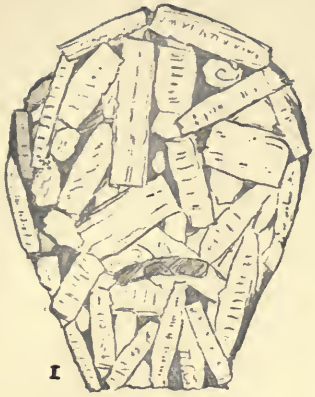
FIGS.

1, 2. *Pontigulasia rhumbleri* Hopk. (p. 49) Fig. 1.—Broad side view of test, the transverse diaphragm discernible about one-third the length of the test above the aperture and measuring 35 μ in width where it is attached to the walls. Fig. 2.—Oral view, showing the diaphragm narrowing in its central portion. × 350.

3–7. *Nebela scotica* Brown. (p. 60) Fig. 3.—Broad view of active individual. × 400. Fig. 4.—Broad view of encysted animal. × 400. Figs. 5–7.—Enlarged views of portions of test (fig. 5 at the aperture). After Brown.

8, 9. *Cochliopodium obscurum* Penard. (p. 66) Side views of two active individuals. × 700.

10, 11. *C. granulatum* Penard. (p. 67) Side and vertical views of active individual. × 300.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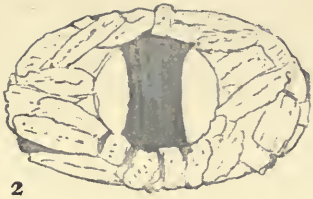
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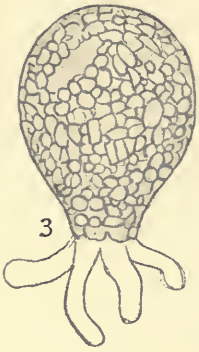
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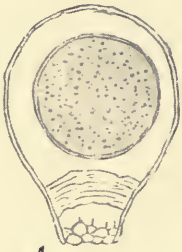
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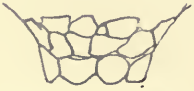
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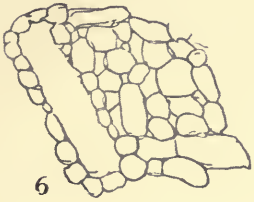
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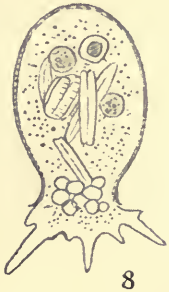
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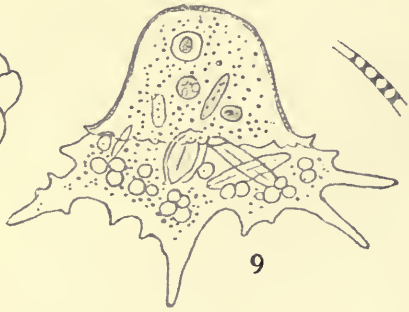
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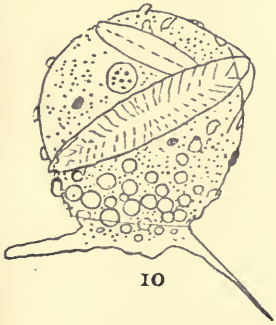
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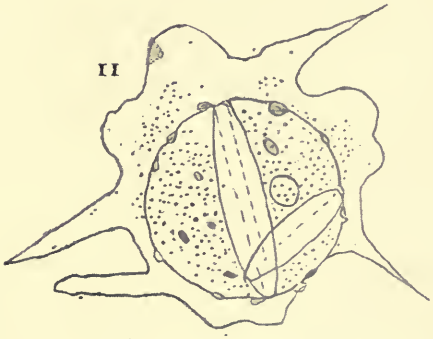
11

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The following is merely a list of works (books and papers) referred to in Vols. I–IV of the present Monograph. The entries are extracted from a Bibliography which is now about four times the length of this, and will, in all probability, be considerably added to.

The pages, plates, and text-figures enumerated are those of the complete papers, whether they deal entirely with the Freshwater Rhizopoda or only in part. The pages in which are references to them, and the plates and text-figures illustrating them, are not separately enumerated, as is done in the writer's 'Bibliography of the Tunicata,' for all such references are given in the synonymies; nor are abstracts, notices, or reviews of original papers or books, as in that work; for it is only intended to give titles of papers, which are not given in the synonymies of genera and species, and fuller titles of the books with their place of publication, etc. This has considerably shortened the list. A few papers referred to which treat almost entirely of the Heliozoa are not entered; they will be found in the Bibliography of the Heliozoa in the next volume.

The three following paragraphs, quoted from the above-named work, apply also to this Bibliography.

"With an alphabetical arrangement of the names of authors, the sequence of their works is chronological so far as could be ascertained. When more than one in the same year it is alphabetical under the first word in the title, except when

they have appeared in the same journal, in which case the sequence is that in which they are printed."

"The principal divisions of a work, mostly called volumes or the equivalent if in a foreign language, are . . numbered in large Roman capitals unaccompanied by vol., tome, or Band, etc.; separately paged parts similarly in small Roman capitals, and parts not separately paged in Arabic type. . . . A series is indicated in parentheses preceding the volume."

"The number of pages, etc., of independent publications is only given when it is so small that they may be considered pamphlets."

This, it may be added, is also given when the work treats exclusively or nearly so of the Freshwater Rhizopoda.

In confining this Bibliography to works made use of in the preparation of the synonymies there is one disadvantage. In few cases the whole and in some cases only a few out of many of an author's works on the Freshwater Rhizopoda can be given; an inadequate idea of their number may therefore be formed. This is particularly the case with the works of Greeff, Gruber, Maggi, and especially with those of Penard, who is by far our greatest authority and most prolific writer on the Freshwater Rhizopoda and Heliozoa. Should the complete Bibliography ever be published this defect will be remedied.

JOHN HOPKINSON.

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* For synonyms and occasional references to genera and species the index to each separate volume should be consulted.

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98. The British Freshwater Rhizopoda and Heliozoa. By James Cash and G. H. Wailes, assisted by John Hopkinson. Vol. III. The Rhizopoda, Part III. By G. H. Wailes. xxiv + 156 + 52 pp., 25 plates (xxxiii–lvii), and frontispiece. 8vo. 1915.

For the Seventy-second Year, 1917.

99. The Principles of Plant-Teratology. By W. C. Worsdell. Vol. I. xxix + 270 + 50 pp., 25 plates. 8vo. 1915.

For the Seventy-third Year, 1916.

100. The British Marine Annelids. By W. C. McIntosh. Vol. III. Part II.—Plates. viii + 48 pp., 24 plates Folio. 1915.

101. The Principles of Plant-Teratology. By W. C. Worsdell. Vol. II. xvi + 296 + 56 pp., 28 plates (xxvi–liii). 8vo. 1916.

In Course of Publication.

The British Freshwater Rhizopoda and Heliozoa. By the late James Cash and G. H. Wailes. (Vol. V, Heliozoa, will complete the work.)

The British Charophyta. By James Groves and Canon Bullock-Webster. (Vol. I in the press ; Vol. II will complete the work.)

The British Marine Annelids. By Prof. W. C. McIntosh.

The British Desmidiaceæ. By W. and G. S. West.

Preparing for Publication.

The British Apterygota. By J. M. Brown.

The British Centipedes and Millepedes. By W. M. Webb.

The British Diatomaceæ. By George West.

The British Earthworms. By the Rev. Hilderic Friend.

The British Ixodoidea. By W. F. Cooper and L. E. Robinson.

The British Orthoptera. By W. J. Lucas.

The British Trematoda. By Dr. William Nicoll.

Dec. 1918.

ADDITIONS AND CORRECTIONS

TO

LIST OF THE RAY SOCIETY.

Add : 1918.

Berens, A. A., M.A.; 50 *Eaton Square,* S.W. 1.
India, Zoological Survey of; *Calcutta.*
Williamson William, 79 *Morningside Drive, Edinburgh.*

Remove :

Bagshaw, W.; *Moorfield, Birkenshaw, Bradford.*
Börgeson, Dr. E.; *Botanic Library, Copenhagen.* (Resigned.)
Friend, Rev. Hilderic; *Solihull, Birmingham.* (Resigned.)
Norman, Rev. Canon, M.A., D.C.L., F.R.S.; *Berkhamsted.* (Died.)

Add : 1919.

Barrett, Miss Dorothea E.; *The Homestead, Berkhamsted.*
Boycott, Arthur Edwin, M.A., M.D., B.Sc., F.R.S., Pres. Herts Nat. Hist. Soc.; 17 *Loom Lane, Radlett, Herts.*
Clemence, Walter, F.R.M.S., M.I.Mech.E.; *Park Terrace, Nottingham.*
Coward, Thomas Alfred, F.Z.S., F.E.S.; *Brentwood, Grange Road, Bowdon, Altrincham.*
Duncan, Francis Martin, F.R.M.S., F.R.P.S.; 71 *St. Leonard's Road, East Sheen,* S.W. 14.
Edwards, Stanley, F.L.S., F.Z.S., F.E.S.; 15 *St. German's Place, Blackheath,* S.E. 3.
Frazer, Wilson Ray, F.E.S.; 6 *College Gardens, Dulwich,* S.E. 21.
Maxwell, Edward Kelly, B.A., F.E.S.; *H.M. Patent Office, Southampton Buildings, Holborn,* W.C. 2.
South London Entomological and Natural History Society; *Hibernia Chambers, London Bridge,* S.E. 1.
Turner, H. J., F.E.S.; 98 *Drakefield Road, New Cross,* S.E. 14.

Remove :

Bristol Municipal Public Libraries. (Resigned.)
Godman, F. DuCane, D.C.L., F.R.S.; 45 *Pont Street,* S.W., and *South Lodge, Horsham.* (Died.)

Change of Address :

Sprague, M.A., LL.D., F.R.S.E.; (to) *West Holme, Woldingham, Surrey.*
Wadsworth, R. V. B.; (to) *Kenach, Beacon Hill, Rednal, Birmingham.*

March, 1919.