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THE JOURNAL

OF THE

Quekett Microscopical Club.

On the Resolution of *Amphipleura pellucida*, etc., with a Dry Lens and Axial Illumination.

By A. A. Merlin, F.R.M.S.

(*Read November 16th*, 1900.)

Many members of our Club have been long familiar with the structure of *Amphipleura pellucida* as revealed by oil-immersion objectives of the highest class and aperture. The point to which I now beg to call your attention is the accomplishment of the resolution of normal specimens of this diatom by means of Zeiss's dry 4 mm. apochromat, and a $\frac{5}{6}$ths solid axial cone from Powell's adjustable apochromatic condenser.

I was led to attack the *A. pellucida* with the above specified optical arrangement through having remarked the great strength of the resolution yielded by some realgar-mounted specimens under the Zeiss 3 mm. of N.A. 1·4 and a solid axial cone of about N.A. 1·2 from an oil-immersion condenser. I must confess that the exact theoretical resolving limit of an object glass of N.A. ·95, as given in the table on page 85 of Carpenter's "The Microscope and its Revelations" (Seventh Edition, Edited by Dallinger, 1891), had at the time escaped my memory, otherwise it is extremely improbable that any such attempt would have been made.

It was found, however, that in actual practice the 4 mm., used in conjunction with a 27 compensating ocular, with which eyepiece the image remained perfectly sharp, would steadily show the fine transverse striae on realgar mounts, although the lineation was much fainter than that revealed by oil-immersion lenses of large aperture.

The resolution of valves in realgar having been accomplished, dry and balsamed specimens were next examined, and to my very considerable surprise, both proved resolvable with the 4 mm. and $\frac{5}{6}$ths axial cone. In balsam the striae appear as extremely faint, but clean, grey lines of great fineness. Although most faint and difficult, they have been held with perfect certainty for short intervals, slightly averted vision proving of material assistance in this instance.

In order to satisfy myself that the true striae are indeed rendered visible by the 4 mm., a valve has been first arranged to exhibit them under that lens, an oil-immersion being afterwards substituted, when the lines have been found to be identical, and of the same fineness and distance apart with both objectives, the only difference being in the strength of the resolution afforded by them.

The significance of the above results is at once apparent on turning to the aperture table, where we find that N.A. ·96 is given as the *limit* of resolution of the *A. pellucida*; hence it would appear that the Zeiss 4 mm. of N.A. · 95 (nominal), illuminated by a $\frac{5}{6}$ths solid axial cone, is in practice capable of revealing structure just within the theoretical resolving limit of a lens of N.A. ·96. and that this resolution is attainable not only in media of high refractive index, but also in balsam and with dry mounts.

Now the 4 mm., although its guaranteed minimum N.A. is only ·95, as a matter of fact is quite likely to possess an N.A. of ·96, or even one slightly in excess of this, so that theoretically, without any deduction for technical imperfections, it would be just capable of resolving the *A. pellucida*; but that this theoretical limit should be actually attained by a lens with strictly axial illumination, and on specimens mounted in media of both high and low refractive index, cannot but be regarded as a very extraordinary and interesting result, it having been hitherto considered that the transverse striae of the *A. pellucida* are in actual practice only just discoverable with dry achromatic lenses of N.A. 1·0, and that only on specimens mounted in a medium of about 2·4 refractive index when illuminated by oblique light in one azimuth along the valve.

Perhaps not the least interesting and satisfactory outcome of these observations is the indication that a dry lens is capable of working to its full theoretical capacity on balsam-mounted objects, the resolution only becoming more conspicuous in media of higher refractive index.

In addition to the *A. pellucida* many other forms have been recently studied with the 4 mm. and a $\frac{5}{6}$ths solid axial cone. The most difficult structural features have not been seen with a lesser cone, but I do not assert that they may not possibly be so resolved, although the results of my observations have strongly inclined me to the belief that, with axial illumination, structure just within the capacity of the lens employed can only be seen with a very large cone. It has appeared to me that closing down the cone, while greatly strengthening the contrast of the coarser, causes the finer detail to disappear altogether, and materially reduces the separating power of the objective. With reference to this matter the following experiment may prove interesting:—Arrange a Cherryfield *Navicula rhomboides*, mounted in a mixture of monobromide of naphthaline and balsam, under a good semi-apochromatic $\frac{1}{4}''$ of N.A. ·77, and 27 ocular, so that the valve shall lie longitudinally along and on the sharply focussed edge of the lamp flame. With slightly under $\frac{3}{4}$ cone the longitudinal striae will appear conspicuous throughout the entire length of the valve, while the closer transverse striae, although they may be seen to a certain extent, are far less satisfactorily defined, no thoroughly clear separation being apparent. Now replace the smaller by a $\frac{5}{6}$ths cone. The coarse strongly-defined longitudinal striae disappear, and at the first glance all structure may seem to have disappeared with them, but a little careful scrutiny will reveal the presence of a faint dotted resolution, the transverse divisions of which are as fully and cleanly shown as the longitudinal.

I am aware that the results dealt with in this paper cannot meet with general acceptance until they receive confirmation at abler hands than mine, nor indeed would it be desirable that they should be so accepted, involving as they do important theoretical considerations, until independent practical experience shall have placed their truth beyond doubt.

The subjoined notes on some of the forms lately examined with the 4 mm. may be of interest. A very large central solid cone has been invariably employed in conjunction with either Gifford's or the beautiful new acetate of copper screen.

Nitzschia curvula Sm. This diatom is mounted next to *Amphipleura pellucida* on Möller's dry "Probe-platte." Transverse striae close and delicate, but undoubtedly resolved.

Nitzschia sigmatella Grun. Möller's balsam type slide. Transverse striae extremely faint and difficult. A delicate object even with N.A. 1·3 and 1·4.

Nitzschia linearis and *N. obtusa* Sm. In balsam. The former very faintly resolved into transverse striae, the latter not so difficult. Dr. H. Van Heurck, in his "Synopsis des Diatomées," gives *N. linearis* as having 27 to 30 striae in 0·01 mm. (25·399 mm. = 1 inch), and *N. obtusa* 26 to 27 in 0·01 mm. *N. sigmatella* Grun., is given at 25 to 26 striae in 0·01 mm., but the specimen of this form on the type slide has much finer structure than *N. linearis* and *N. obtusa*.

Nitzschia sigmoidea Sm. Möller's dry "Probe-platte"—25½ to 26 striae in 0·01 mm. according to Van Heurck. This is remarkably easy with the 4 mm., the striae presenting a beaded appearance. They can be certainly seen with the 12 mm. apochromat of N.A. ·65, so do not probably, in this instance, exceed 55,000 to the inch. A specimen in balsam is also very easy with the 4 mm.

Nitzschia sigma Sm. Van Heurck gives 22 striae in 0·01 mm. Distinctly dotted in balsam, and very easy in mixed monobromide of naphthaline and balsam.

Grammatophora oceanica Ehrbg. = *G. subtilissima*. Möller's dry "Probe-platte." Resolved into transverse striae. Van

Heurck gives 30 striae in 0·01 mm. for the *G. oceanica* var. *indica* Grun., and 30 to 31 for the *G. oceanica* var. *novaezeelandiae* Grun. Some specimens of *G. subtilissima*, however, are finer, running at about 88,000 to the inch.

Navicula crassinervis. Striae 34 to 35 in 0·01 mm. according to Van Heurck. This has proved a most delicate object with the 4 mm., both dry and in realgar. With N.A. 1·3 and 1·4 realgar mounted valves are sharply resolved into dots, but the transverse striae have alone been seen with the dry lens.

Hyalodiscus subtilis. In a mixture of monobromide of naphthaline and balsam. Dotted structure on outer zone well seen, although faint and difficult near the edge of the disc. In balsam mounts the structure appears still fainter, but nevertheless may be traced nearly to the outer edge, where it runs at about 76,000 to the inch.

Surirella gemma Ehrbg. In realgar the beading has been seen beautifully defined with the valve arranged longitudinally on the sharply focussed edge of the lamp flame. Specimens mounted dry, in balsam, and in quinidine, have been also examined, but their complete resolution has proved a much more difficult matter.

Colletonema vulgare. Möller's balsam type slide. This has been most carefully studied with the 4 mm. The resolution is very faint, and requires particularly exact focal adjustment, but when once seen it can be held fairly steadily without any great difficulty. Dr. Van Heurck writes of this diatom, "Stries fines, délicates, les moyennes faiblement radiantes, les terminales parallèles, environ 34 en 1 c.d.m. ; les stries médianes plus fortes, plus écartées, 24 en 1 c.d.m. et plus radiantes."

Navicula major. Möller's balsam type slide. The full resolution of the structure of the bands on the hoop of this diatom is by no means easy, even with the Zeiss 3 mm. apochromat of N.A. 1·4. Notwithstanding this, the resolution is carried very far by the 4 mm., the striae appearing remarkably black, crisply defined, and well separated, their beaded nature being quite recognisable, although not so fully revealed as with the oil-immersion. On this specimen the striae alone are just visibly separated by the 12 mm. apochromat, $\frac{5}{6}$ths axial cone, and a Huyghenian eyepiece magnifying about 45 times, the 27 compensating ocular not proving sufficiently powerful for the purpose with this objective.

On the Specific Characters of *Asplanchna intermedia*, Hudson.

By Charles F. Rousselet, F.R.M.S.

(*Read November* 16*th*, 1900.)

Plate 1.

The object of this paper is to elucidate the differences which exist between *Asplanchna intermedia* and the closely allied species *Asplanchna brightwelli.*

Dr. Hudson, in the supplement to his monograph of the Rotifera (p. 12), writes that Mr. Gosse agreed with him in saying that he could not distinguish the female *A. intermedia* from that of *A. brightwelli.*

The reason of this, I think, is that in two essential points *A. brightwelli* has from the beginning been incorrectly described, and I suspect that the early observers had, without knowing it, sometimes the one and sometimes the other species under observation, and so mixed up the characters.

These two species are, however, readily distinguished from each other by the following three points, any one of which is sufficient for identification : (1) The shape of the jaws; (2) The number of flame-cells (vibratile tags); (3) The shape of the male.

The figure of the jaws of *A. brightwelli*, which Dr. Hudson has given on Pl. XII., Fig. 1, c, of his monograph, is unfortunately quite wrong, and has led to further errors. This figure has been reproduced from John Dalrymple's paper of 1849, evidently without being verified; and Mr. Dalrymple seems to have copied his figure from Mr. Brightwell's paper of 1848, or else Mr. Brightwell must have supplied him with two different species of *Asplanchna.* On comparing this figure with the jaws of *A. amphora*, it becomes evident that, when drawing these jaws, both Brightwell and Dalrymple must have chanced to have had a specimen of *A. amphora* under their microscopes, while their drawing of the male is undoubtedly that of *A. brightwelli.*

These various observations may have been made at different times, as Brightwell states that he found his animal several times during seven years. It is quite possible also that the two species were present in the pond simultaneously. In the "Supplement" in 1889 Dr. Hudson has given another and more correct figure of the jaws of *A. brightwelli* (Pl. XXXIII., Fig. 4), from his own observation. This figure is fairly correct, but the rami are a little more angular in shape, so that the space they inclose between them when closed is not so perfect an oval as there represented. In Fig. 3 of the accompanying Plate I now give an exact representation of these jaws as I have invariably found them ; this figure has been carefully drawn from a very fine photograph taken by Mr. M. Poser. It will be seen in particular that there is no tooth near the middle on the inner side, nor a hook-shaped prolongation on the outside at the base of the rami, as represented in Brightwell's and Dalrymple's figures ; but near the lower outer angle of the rami there arises a very small blunt projection, which can only be seen from a side view. At the tip there is really but a single point, and it is formed as represented in Fig. 3, C ; on crushing the jaws the thin chitinous ridge seen in side view (Fig. 3, B C) is bent over and simulates a second tooth. A tooth-like point, often seen near the tip of the ramus by focussing up or down, is a false appearance, being the outer edge of the broader part of the apex of the ramus. In a side view the rami are seen to be nearly as deep as they are broad. My view of their structure is that the chitinous material is bent at right angles throughout the length of the rami, forming an inverted "L" in cross section (⏋), which of course greatly adds to their strength. The chitin is very thin and the jaws are very light. This structure alone will account for the different appearances they present in front and side views, and will at the same time give the necessary strength these very delicate, but comparatively long, structures evidently possess. Attached to the outer edge of the ramus on each side there is a thin, delicate, curved chitinous rod, which was glimpsed by Dalrymple, and has been called the "secondary or reserve jaw." It arises a little below the middle from a small thin plate, which is fixed to the ramus by three or four delicate rods, one of which is longer, goes upwards, bifurcates, and is attached to two sides of the ramus. These "reserve jaws" remain, and are readily seen when the jaws have been dissolved out with caustic potash ; they open and close and move with the main jaws, but are too weak to be of any use in seizing prey or food. They were considered by Mr. Gosse as early as 1855 to represent the remnants of the mallei, which at first sight appear wholly wanting in all Asplanchnas. In this interpretation Mr.

Gosse was perfectly right, as I can now prove with the help of the jaws of *Dinops longipes* (*Asplanchna eupoda* Gosse), Fig. 6.

The jaws of *A. intermedia* are represented in Fig. 5, and it will be seen at once that they differ from those of *A. brightwelli* in shape and structure. Here also there is no tooth on the inner margin of the ramus, but on the outer side there is a large strong hook-shaped process for the attachment of muscles, and a little higher, another smaller process in the opposite direction. The basal part of each ramus is perforated by an oval aperture. The jaws are also much larger, though the animals are smaller than the other species. The secondary jaws (or the vestiges of the mallei, as I would call them) are present as usual, and the remainder of the structure follows that of the jaws of *A. brightwelli*.

For the purpose of comparison I here reproduce my figure of the jaws of *A. amphora*, Fig. 4 (also a nearly allied species), which differ again in shape and structure from both the preceding, particularly in having a tooth on the inner margin of each ramus, and a large hook-like process on the outer side.

With regard to the number of flame-cells, Dr. Hudson states that *A. brightwelli* has a number 'varying from about ten to twenty on each side. Dalrymple wrote in 1849 that it has "eight, twelve, or even twenty in number," but he draws only ten in his figure. My own observation is that *A. brightwelli* has invariably about ten flame-cells attached to a straight band, and *A. intermedia* about twenty. I believe the number to be quite constant in each species, but in counting, one or two of these very minute organs may be easily overlooked if badly placed. The above statements of Dr. Hudson and Dalrymple are further proof to me that they had, without knowing it, different species under observation at various times.

The third mark of distinction between *A. intermedia* and *brightwelli* is the male. In *A. brightwelli* the male is a humpless sac, widening posteriorly and quite correctly shown in Brightwell's, Dalrymple's, and Dr. Hudson's figures. In *A. intermedia* the male (Fig. 2) has two humps projecting laterally on the sides of the body, and the dorsal and ventral posterior corners also project somewhat at right angles to the lateral humps, thus greatly resembling the male of *A. amphora*, except that it is much smaller in size. The females of *A. intermedia* and *brightwelli* are saccate, humpless, and much alike in outer appearance, while the female of *A. amphora* has two lateral humps, which are very prominent in the young female, but become more or less merged into the body cavity of older animals.

In addition to the above characters, there are also specific differences in the winter eggs in the three species. The winter or ephippial egg of *A. brightwelli* has been described as covered with rounded, overlapping scales. There are no scales, however, the appearance of scales being produced by large globular transparent cells in the outer covering of the egg. In *A. brightwelli* the central yolk is yellow, and fills only one-half to two-thirds of the egg cavity, thus giving the appearance of a white cellular ring all round. The outer shell envelope consists of a mass of large and closely set globular, transparent, apparently empty cells of somewhat varying size. The size of a measured winter egg was 204 μ.

In *A. amphora* the yolk is whitish, fills the whole egg cavity; the outer shell envelope consists of numerous much smaller globular transparent cells, through which a finely dotted inner membrane can be seen. Size of egg, 170 μ.

In *A. intermedia* the whitish yolk fills about three-quarters of the egg cavity; the outer shell envelope is very thick, covered all over with very minute dots, which appear to be the outer openings of very fine tubes running through the egg-shell, for in optical transverse section numerous fine parallel lines can be seen in the substance of the egg-shell. On the surface there are a few scattered globular transparent cells, and the general appearance of this winter egg is quite different from the other two. The size of the egg from one of the smaller specimens from Hertford Heath is 136 μ.

It will be seen from what I have said that *A. intermedia* is really strangely intermediate in form and structure between *A. brightwelli* and *A. amphora*, and yet has characters of its own, by means of which it can readily be distinguished; it may possibly have been produced by a crossing of these two species, but the characters are certainly constant at present. I have found *A. intermedia* in various localities round London: Kew Gardens, the canal near Hanwell, Hertford Heath, etc., and also near Homburg, in Germany; but it is certainly not so common as *A. brightwelli*.

To recapitulate, the essential differences between the three species named in this paper are as follows:—

A. brightwelli has jaws without inner tooth or outer basal hook, as represented in Fig. 3. The female is saccate, humpless, and has about ten flame-cells on each side of the lateral canals, attached to a nearly straight band; the male also is saccate without humps.

A. intermedia has jaws without inner tooth, but with large outer basal hook, as represented in Fig. 5. The female is saccate, humpless, and has about twenty flame-cells on each side of the lateral canals, attached to a nearly straight band. The male has two lateral humps, as represented in Fig. 2. Both male and female are as a rule smaller than the two other species, whilst the jaws are markedly larger.

A. amphora has jaws with a large inner tooth and outer basal hook on each ramus, as represented in Fig. 4. The female is saccate, with two lateral humps more or less prominent, and has about forty flame-cells on each side of the lateral canals attached to a nearly straight band. The male has two prominent lateral humps, as represented in Fig. 1. Both male and female are as a rule larger than the two preceding species.

I possess preserved and mounted specimens of all these species, and also separately mounted slides of the jaws, which have been prepared by dissolving out with caustic potash. All these are exhibited under microscopes in the room.

The animal which M. de Guerne has called *Asplanchna girodi* is certainly *A. brightwelli*, and this new species would not have been made if at that time (1888) a correct figure of the jaws of *A. brightwelli* had existed.

In 1891, Dr. E. v. Daday published a Revision of the Species of *Asplanchna*: it is necessary to say that the figures of the jaws he gives, which are copied from different authors, are mostly quite wrong, and therefore misleading. No synonym or identification can be founded on these figures.

I add some measurements of the female, male, and jaws of these three species; from these it will be seen that *A. intermedia* is the smallest species of the three, but has much larger jaws than the other two. *A. brightwelli* varies a good deal in size in different localities.

I also add an unpublished figure of the jaws of *Dinops longipes*, a rare, Asplanchna-like animal with a foot, intestine and cloaca. These jaws are very peculiar and most instructive, as they are of the same type as those of *Asplanchna*, with the addition of a complete malleus. It will be readily seen that the structures called secondary or reserve jaws in *Asplanchna* are really the remnants of the mallei. *Dinops longipes* is the same animal as the one Mr. Gosse called *Asplanchna eupoda* (Supplement, Pl. XXXI., Fig 3), for in his original sketch-book, now deposited in the Library of the Royal Microscopical Society, there is a sketch of the characteristic jaws, which has not been reproduced in the published figure. Owing to the foot and the presence of an intestine it was removed to a new genus by Mr. G. Western, but its true name, according to the laws of precedence, should be *Dinops eupoda.* A figure and description of this animal will be found in Mr. Western's paper in this *Journal* for January 1891, p. 257. Measurements:—

Asplanchna brightwelli . . .	female . .	972 μ.
,, ,, . . .	jaws . .	117 μ.
,, ,, . . .	male . .	447 μ.
Another smaller specimen . .	female . .	681 μ.
,, ,, ,, . .	jaws . .	81·5 μ.
,, ,, ,, . .	male . .	313 μ.
Asplanchna amphora . . .	female . .	972 μ.
,, ,, . . .	jaws .	95 μ.
,, ,, ...	male . .	486 μ.
Asplanchna intermedia		
(from Hertford Heath) . .	female . .	583 μ.
,, ,, ...	jaws . .	104 μ.
A. intermedia	male . .	292 μ.
Another much larger specimen		
(from Germany) . . .	female . .	875 μ.
,, ,, ,, ,,	jaws . .	156 μ.
,, ,, ,, ,,	male . .	439 μ.

Description of Plate I.

Fig. 1. *Asplanchna amphora*, ♂, × 85 (drawn by Mr. Dixon-Nuttall).
,, 2. ,, *intermedia*, ♂, × 100 (drawn by Mr. Dixon-Nuttall).
,, 3*a*. ,, *brightwelli*, jaws, × 375
,, 3*b*. ,, ,, jaws, side view, × 375
,, 3*c*. ,, ,, side view of tip of ramus, × 1050
,, 4. ,, *amphora*, jaws, × 400
,, 5. ,, *intermedia*, jaws, × 275
,, 6*a*. *Dinops eupoda* (*longipes*), jaws, × 900
,, 6*b*. ,, ,, ,, side view of manubrium, × 900

The Origin of certain Colour Phenomena typically shown by *Actinocyclus Ralfsii.*

By J. Rheinberg, F.R.M.S.

(*Read December 12th*, 1900.)

At our meeting on June 15th last, Mr. Nelson gave us an interesting account of some peculiar colour effects shown by the diatom *Actinocyclus Ralfsii* (see *Journ. Q.M.C.*, Vol. 7, p. 377). Under my microscope this evening is a very fine slide showing a group of these diatoms, and it will be seen that the valves mostly show a beautiful blue or purple colour when viewed with a 1-inch objective; but some valves are pea-green, while others are golden-yellow, and in many the centre is of one colour with rings of other colours around it. Now the remarkable fact which Mr. Nelson pointed out is that these colours are only seen by transmitted light; with dark ground illumination, he told us, the diatom appears colourless, and this is exactly the reverse effect to that of other diatoms, such as species of *Pleurosigma*, *Hyalodiscus stelliger*, etc., which are colourless by transmitted light, but show colour on a dark ground owing to well-known diffraction phenomena. Further, Mr. Nelson told us that the colour was entirely controlled by the aperture of the objective, which must not be much greater than ·45 N.A.; for, viewed with any objective of larger aperture—for example, with an ordinary $\frac{1}{6}$-inch—the colours vanish. To quote Mr. Nelson's words (*l.c.*, p. 379): "The question, then, is: What is the cause of the colour in *Actinocyclus Ralfsii*? Obviously it cannot be a diffraction colour arising from the ordinary primary structure forming the 'rays,' which give the diatom its name, because, as we have seen above, when this structure is resolved the colour is still visible, and no colour arising from diffraction is visible when the diffractor itself is resolved. It cannot be due to pigment, for if it were it would remain visible when the aperture was increased beyond ·45 N.A. It cannot be caused by thin plates, because it would require reflected and not transmitted light to render it visible.* Polarisation and refraction seem quite out of the question; and as there is no other theory at hand the answer must for the present be left undetermined."

Now, after hearing this paper my peace of mind was disturbed. I am afraid I resemble in one respect certain animals which go a little mad when a patch of colour is dangled before them and they cannot make out what it is. At all events, I thought I would see if I could not track out what this monstrously irregular behaviour of *A. Ralfsii* was due to.

The first thing to do was to ascertain how and in what way the colour was formed. For this purpose it was found convenient to use a $\frac{1}{6}$-inch objective with a Davis shutter (*i.e.*, a small iris diaphragm) over it, by gradually closing which the clear transparent valves would don their coats of many colours. I had an idea that the difference in the colours of various valves might be due to the number of perforations in the silex, or the size of the perforations. That was soon shown to be incorrect, for with a 15-power eyepiece it could readily be seen that the only difference due to the closeness or size of the perforations was a slight alteration in the depth of the tint unaccompanied by any perceptible difference of colour. But it furnished a clue in a negative way, for it led to the observation that in the centre of the diatom there were usually a number of isolated and sometimes irregularly shaped perforations which coloured up exactly the same as in parts where the perforations were closely set; and finally, by very gradually and carefully closing the iris, it could be noticed that the colour first made its appearance within and around the edges of each perforation. Thus in a valve which would ultimately be blue, each perforation became bluish with purple-coloured edges. By further reducing the aperture of the iris the separate perforations would vanish, for simultaneously with a darkening of the colours they would join and run into the adjacent perforations and give rise to the typical coloured raylike appearance.

* Theoretically this is not quite right, because the colours of thin plates can be seen by transmitted light. Practically, however, it is perfectly correct, because these colours would be too faint at approximately perpendicular incidence of the light; moreover, diatoms are mostly too thick for the colours of thin plates to come in question.

Another thing wanting examination was the shape of these diatoms as a whole; and it turned out that, whilst a number were almost of even thickness, some appeared to be thin in the centre, with a bulging ring around it, as best seen in the photo which I will hand round, and which was taken by dark-ground illumination with oblique light.*

Another experiment tried was to see if perchance the diatoms polarised light in any way; but, as expected, they did not do so.

A fourth line of search was opened up by an examination of the spectra at the back of the objective, and this showed the remarkable fact that the diffracted beams did not appear as ordinary spectrum colours, but that they comprised all sorts of fancy tints—such as purple and chocolate; and, still more strange, the central or dioptric beam, which is ordinarily colourless, was distinctly coloured bluish in the case of the diatoms which would turn blue when the iris was closed, yellowish in those which would appear yellow, and so on. A further point was noted—viz., that the colour present in the dioptric beam appeared to be reduced or absent in the diffracted beams. This point has already been recorded by Dr. Johnstone Stoney, who, writing of *A. Ralfsii* in an appendix to "Modern Microscopy," by Messrs. Cross and Cole, p. 109, says: "It will be seen that most of the red is located in a ray of first lateral beams, with an equal defect of red in the central beam. Hence the blue colour seen when the image is formed by the central beam only." Strangely enough, Dr. Stoney only refers to this diatom in connection with diffraction colours, to which, as we have already seen, its distinctive phenomena are *not* due.

Lastly, I carefully noted in what way the colours of the diatoms themselves merged into one another, and the order was invariably the same. It appeared that a brownish yellow would merge into purple, purple into indigo, indigo into blue, blue into pale green, pale green into green-yellow, green-yellow into a canary-yellow; and this furnished a strong clue, for on turning up a table of Newton's colours of thin films the order of a part of the series corresponded almost precisely with the changes mentioned.

Of course it was not a question of thin films; for, as already

* Fig. 11 shows sections of *A. Ralfsii*, as near as I could ascertain from examination of a number of specimens mounted on edge and in different positions.

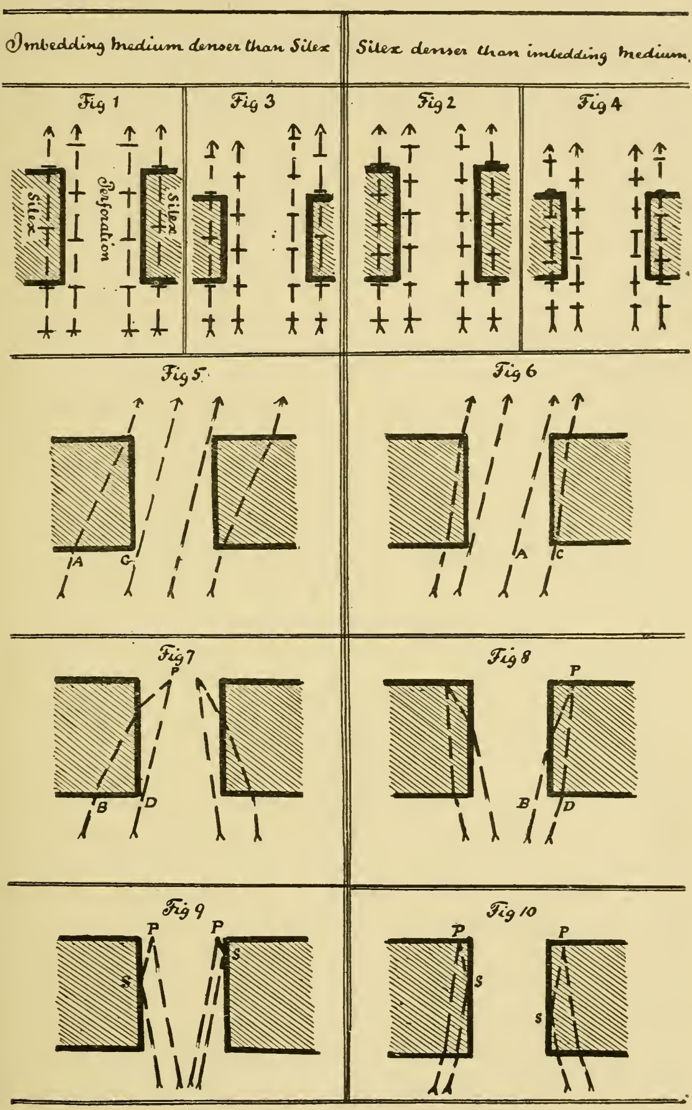
mentioned, the thickness of a diatom is usually greater than any films giving colours,* but the colours of the films are due to interference phenomena, whereby light of different wave-lengths becomes successively extinguished; and why should not the colours of *A. Ralfsii* be due to some such cause? And this suggestion gained in plausibility from the experiment of the coloured dioptric beam; for how could white light become coloured, except one of its component colours was extinguished, and how could it be extinguished, when the object was colourless and unpolarisable, except by interference?

To an interference effect, therefore, the phenomena had to be ascribed, and once that was settled, further matters began to arrange themselves beautifully. Firstly, there was evidently some connection with the thickness and shape of the diatom, for those which were apparently flat showed a more uniform tint than the others. Then, again, a gradual merging of a valve from purple to brown-yellow and yellow-green, corresponding with a gradual thinning down of the valve, would be accounted for by a successive extinction of green, indigo, and violet light.

It now remained to be ascertained exactly in what manner the interference arose, and that I think I can satisfactorily demonstrate.

First of all remember what diatoms, such as *Actinocyclus Ralfsii*, essentially are from an optical point of view. They are thin plates, maybe of uniform or of varying thickness, perforated by a number of small holes (secondary or other structure we will leave out of consideration, as not bearing on the points to be established). Now, in regard to the diffraction effects presented by diatoms, what has been the position taken up? Diffraction effects are always worked out on the supposition of an opaque body with openings, or of alternate opaque and clear lines; and in treating of the diffraction phenomena presented by diatoms, it has invariably been tacitly assumed that they behave like such an opaque body, as indeed in many cases they happen to do, because no other effects arise which complicate matters. But actually diatoms are not opaque:

* A film of silex to show colours of thin plates under conditions perfectly favourable for their production would have to be between about 5 and 40 millionths of an inch. I have ascertained by direct measurement that *Actinocyclus Ralfsii* is nearer 200 millionths of an inch.


Imbedding medium denser than Silex
Silex denser than imbedding medium.
Fig 1
Fig 3
Fig 2
Fig 4
Silex
Perforation
Silex
Fig 5
Fig 6
A
C
Fig 7
Fig 8
P
B
D
Fig 9
Fig 10
P
S

they are composed of a clear, siliceous, glassy material, and any light reaching them passes through their substance as well as through the perforations. And now see what happens when light impinges from a single point (supposed to be a good distance off, so that the light may be taken as parallel) on an *A. Ralfsii.*

Suppose Fig. 1 to show a small part of a valve with a perforation in it, and let the dotted lines with arrowheads represent light passing through the silex and through the perforation respectively. As the valve is usually not of so dense a substance as the medium in which it is embedded, and as we know that wave-lengths of light of any colour are longer in a rarer medium than in a denser one, or, to put it another way, more waves get squeezed into the same length of path in the denser medium, it may happen that for some particular wave-length the ray passing through the medium has just got half a wave-length ahead of the one passing through the silex. In the figure the transverse marks on the dotted lines represent wave-lengths, and the retardation of half a wave-length can be observed. This means that the crests of one set of waves arrive at the same time as the hollows of the waves of a neighbouring ray, and as the two rays have come from the *same* far-off point, they are in a condition to interfere and cancel one another completely according to the well-known law. Expressed more shortly, in the language of optics, the waves arrive with a half-phase difference and completely interfere.

Of course this complete interference has taken place for light of one particular wave-length only. Suppose it to be yellow light that has been stopped out in this way; then the white light in the vicinity of the perforation, being deprived of its yellow component, appears blue. If the perforations in the diatom were large, there would be a blue ring about their edges, but being so small the inner edges of the ring overlap and they appear blue altogether.

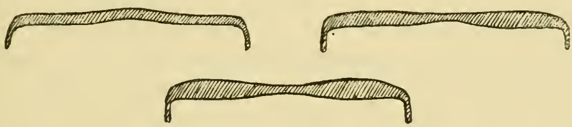
Fig. 2 shows how a similar result can come about if the diatoms are mounted in some medium less dense than the silex. Here the wave-lengths are shorter in the silex, and the diagram shows an acceleration of a half-wave-length on emergence.

Next consider a place where the diatom is thinner (*vide* Figs.

3 and 4). The same processes occur; but as the path of the rays is obviously shorter, the half-wave-length difference must be for light of some smaller wave-length. Consequently it is some other colour, for instance yellow-green, that gets stopped out, and the tint of the diatom will be purplish at this spot. And I have verified that, as the diatom is thicker or thinner in different parts, so are colours of longer or shorter wave-length extinguished; and of course their place is taken by light of just the complementary colour, the merging of one colour into another being, as mentioned, in accordance with the Newtonian series.

Now for some further proofs of the correctness of the above. So far, we have assumed that the light impinges on the diatoms almost perpendicularly; if it impinged on them obliquely, as shown in Figs. 5 and 6, the relative differences between the length of passages in balsam and in silex will change and consequently the colours ought to change—and so they do.

Fig 11



Again, if instead of using a comparatively narrow cone of light, we use a very wide one as compared with the objective, we get for each obliquity white light passed minus some different colour. If we were to sum up the light for, say, seven different slants, it would be: White minus violet; white minus indigo; white minus blue; white minus green; white minus yellow; white minus orange; white minus red; which is like saying 7 white minus 1 white, and this equals white: in other words, with a suitably large cone, the colour would disappear and the diatoms would appear white—and so they do.

This, again, is the explanation why with dark ground illumination these diatoms appear mostly white, but we can readily make them assume colour on a dark ground by narrowing the annular cone of light passing round the dark spot, as is easily verified.

The above explains the main colour-effects, but there are also some subsidiary ones that deserve notice. If the iris diaphragm above the objective be opened just, and only just, sufficiently to resolve the perforations, and a high eyepiece be used, it will be observed that surrounding each dot of the main colour there is a ring less marked of another colour. The cause of this in the case of light incident perpendicularly is that the perforations are not truly cylindrical, as diagrammatically figured, but that the silex is slightly convex or irregular, so that some rays pass through a greater thickness of silex than others. This is best explained by the action of rays impinging obliquely (Figs. 7 and 8) as with these the subsidiary colour effects must occur whether the perforation is truly cylindrical or not. On referring to Figs. 5 and 6 it will be noticed that any rays passing between A and C in a parallel direction must travel partly in silex and partly in the mounting-medium. The rays B in Figs 7 and 8 illustrate this. They meet the ray D, which started from the same point originally, in P, and there interfere according to the difference of phase in which they arrive. From the figures it is also apparent that each successive ray as we pass from A to C would traverse more of the medium and less of the silex, or *vice versa*, which means that we should get a rainbow-coloured ring. In practice, however, the rings appear of only one tint, owing firstly to the excessively narrow space to which the whole spectrum range is confined, secondly to the holes not being absolutely cylindrical, thirdly because rays impinging at several angles at the same time tend to counteract any pure colours,* and fourthly because we usually get a perfectly dark annulus in connection with them—which point I will refer to later on.

The total colour effect seen on *Actinocyclus Ralfsii*, viewed with a power not sufficient to resolve the perforations, is a blend of the main colour effect with the subsidiary ones plus an admixture of white light passing through the intercostal silex. The sparser the perforations per unit area, the greater the amount of intercostal silex, and the greater the amount of white light passing through it. So that a diatom with fewer per-

* It could be easily proved that the light impinging on the diatoms at various angles at the same time would tend to annul the colours of the rings to a far greater degree than it would affect the main colour produced by rays traversing the whole thickness of silex and medium respectively.

forations per unit area will appear of a paler tint than one where the perforations are more closely set.

All the peculiar colour effects of *A. Ralfsii* have now been explained, excepting two, which puzzled me exceedingly a long while. One of them was, that when the aperture of the objective much exceeded ·45 N.A. the diatom should appear colourless. Surely the colour that had been extinguished in the central or dioptric beam could not be added again by admission of light which the object itself had thrown up to the other parts of the objective. And the other thing was, why should the diffraction spectra assume "fancy" tints instead of the orthodox spectral colours?

It seemed at first that these two phenomena must hang together in some mutual connection, but that turned out to be a false scent, for the cause of the compound tints was found to be due to the unequal thickness of the diatoms in different parts. The consideration that some parts of the diatom would more or less refract the dioptric beam afforded sufficient explanation why the slant of refracted beams should vary accordingly, so that it might well happen that differently coloured portions of the diffraction fan proceeding from the differently situated points on the object might overlap, and then of course compound tints would be formed.

This point settled, the question of the diatoms being colourless with objectives of large N.A. became still more perplexing. At last the mystery was cleared up, and by the very selfsame reason that caused the interference effect with the dioptric beam; for when it was remembered that the diatom was *not* an *opaque* plate studded with holes, and that in the general effect of the diffraction, light which passed through the silex, and consequently was some fraction of a wave-length ahead of that passing through the balsam, would participate,—as soon as that was realised the whole difficulty vanished.

It became at once evident that for the different slants of the diffracted rays the light of any one colour would be enfeebled more or less. It must not be thought that the light must *necessarily* be of full intensity or completely extinguished because I have postulated this for the sake of illustration. There may be a quarter-phase retardation, or some other fraction, which would diminish the light without stopping it out altogether.

But without entering into the detail of the thing, which would be tedious, it could be worked out that if a certain colour is extinguished for the dioptric beam, then for the diffracted beams each other colour would be successively extinguished; and if that were so, irrespective of the appearance and tints of the diffraction spectra, it might be assumed that their total effect would be to produce a colour just the complementary to that given by the dioptric or central transmitted beam. For the whole of the diffracted beams ordinarily produce white light, and if we subtract all the colours except the one already subtracted from the dioptric beam, then just the complementary colour to that must appear. I made the experiment by stopping out the dioptric beam with a little black spot on a cover-glass placed over the objective. And the result corresponded with theory: the previously blue diatoms appeared yellow, the yellow ones blue, the green ones purple, etc. This change into the precisely complementary colours is one of the prettiest and most remarkable experiments one can make with these diatoms. One word more. In doing this it is assumed that only the diffraction fan of the first order is taken up by the objective. If parts of the diffraction spectra of the second order are present, they must be cut off, because they naturally alter the colours.

Summing up the cause of the colour phenomena of *A. Ralfsii*, we have now seen that they are due to an interference effect, that they depend upon the form of the diatom as a whole, on the thickness of the diatom, and on the relative density—*i.e.*, the refractive index of the silex and the medium in which the diatom is embedded.

It may be asked, Why should only *A. Ralfsii* present these phenomena, and not other diatoms as well? The answer is that besides *A. Ralfsii* and other, if not all, forms of the genus *Actinocyclus*, a great many other diatoms *do* show the same phenomena, but in a less degree. You have only to put an iris diaphragm above a $\frac{1}{2}$-inch or a 1-inch objective, and look at a miscellaneous set of diatoms, gradually closing the iris, and you will be surprised how many of them change colour, mostly turning to a sombre brown or chocolate or pale yellow hue. Several forms of *Navicula*, *Pleurosigma*, and *Grammatophora*, and many others, act in this way. In fact, it is a quite general principle, and the reason why it does not occur to a greater extent in these forms could, I doubt not, be readily worked out for each case, though I will not weary you with this now.*

There is only one other fact which I should like to draw your attention to, and, although it does not immediately bear on colour phenomena, it is a rather interesting matter, and I do not think it has been recorded.

The ways referred to in which interference effects are produced do not exhaust the number of possible ways in which an extinction of light may occur. Figs. 9 and 10 show another way. Here both the rays travel through the silex, and meet in the point P—the one ray having been reflected from the side of the wall at S. As is easily seen, both have travelled just the same length of path, but here comes the point to be noted. Whenever a wave is reflected it is well known that half a wave-length retardation occurs, and therefore when they meet at P the light is extinguished. Now this will occur irrespective of the colours of the light, and that seems to be the cause why a circular hole in a diatom is always surrounded by a little dark ring. The rings are easily seen on photographs of *A. Ralfsii.* The thickness of the little ring will depend on the thickness of the diatom and on the relative

* The reason why the phenomenon does not occur more frequently is even a simpler matter than appeared at the time the paper was read.

Calculations which I have since made, and can here only summarise, show that for diatoms mounted in any specific medium, a minimum and a maximum limit can be assigned for the production of any appreciable colour effect. A great many diatom valves are of a thickness below the necessary limit, or only slightly exceed it, and assume a pale yellow-brown tint (that being the first colour in the series) as, for instance, *Pleurosigma angulatum*, mounted *dry*. The limits vary with the *difference* in refractive index of the diatom silex and the medium in which it lies. The greater the difference, the smaller is the minimum limit for the occurrence of colour.

Taking diatom silex to have a refractive index of 1·43, as stated in Carpenter, the minimum limits would be roughly :—

In Air	24	millionths	of an	inch.
,, Monobromide of Naphthaline	44	,,	,,	,,
,, Styrax	66	,,	,,	,,
,, Canada Balsam . . .	111	,,	,,	,,

But if the refractive index of the diatom silex varies, so must these limits change, and I have found, by having, *A. Ralfsii* mounted in a medium of just 1·43, that it does vary considerably from this refractive index. Many other diatoms varied also from this, but none so markedly as *A. Ralfsii.* This therefore will also help to explain, on the theory indicated, why the interference effects are more accentuated than usual.

difference between the refractive index of the diatom and the substance in which it is embedded. The less the difference, the narrower will be the ring, because the critical angle becomes greater, and reflection at the side only occurs when the ray reaches it at a greater angle than that. If the medium be denser than the diatom, then the ring will be formed on the inner side of the perforation, as in Fig. 9; and if the diatom be denser than the medium it will be on the outer side, as in Fig. 10.

In conclusion, let me remark that a recognition of the possibility of interference effects, other than diffraction, occurring in microscopic objects is not in itself new, for it is mentioned in the well-known work on the Microscope by Naegeli and Schwendener.

Since this paper was written I find there is a specific name for the colour phenomena produced in the manner described. They are termed "*The Colours of Mixed Plates.*" According to Preston ("Theory of Light," p. 205) Dr. Thomas Young first discovered in 1802 that by interposing water or butter between two glass plates, so that globules of two different media were formed, coloured fringes or rings were produced by transmitted light. Other experimenters have used soap and water, white of egg, whipped cream, etc., for the production of the effect. I am not aware that the colours of mixed plates have ever been referred to except in connection with experiments such as these, but their production by the natural agency of diatoms like *A. Ralfsii* far surpasses their production by artificial means in brilliancy and regularity of effect—notably in the production of uniform colour over a comparatively large surface.

On *Diaschiza ventripes*.—A New Rotifer.

By F. R. Dixon-Nuttall, F.R.M.S.

(*Read January 18th*, 1901).

Plate 2. (Upper portion.)

Sp. Ch. *Body* almost cylindrical. *Lorica* normal Diaschiza-type.
Dorsal cleft narrow, straight. *Eye* cervical.
Foot ventral. *Toes* short, slightly decurved.

This little rotifer was found in large numbers in a pond in Knowsley Park, Lancashire, in water brought to me by my friend, the Rev. R. Freeman, throughout the autumn of 1900. From this pond more than a hundred species were determined on different occasions, omitting all the Bdelloida.

Included in the above hundred were *Furcularia eva* (one example); *Diglena clastopis*, *Coelopus cavia*, and *Stephanoceros eichornii* in great numbers; several *Pterodina bidentata*, *Cephalosiphon limnias*, etc. The *Diaschizae* found in this pond included *semiaperta*, *paeta*, *lacinulata*, *globata*, *ramphigera*, and *tenuior*.

Viewed laterally the body of *Diaschiza ventripes* is of equal height throughout, but the prone face and slightly concave ventral surface, together with the more convex dorsal outline, give it a rotund appearance. The posterior extremity does not taper slowly down to the foot, as in *D. ramphigera*, *tenuior*, etc., but ends in a clear sac-like projection over the base of the foot.

Viewed dorsally, the outline of the head is semicircular, of a diameter almost equal to that of the body at the neck, from which it is separated by a slight but well-marked constriction.

The width of the body gradually increases until two-thirds of its length, whence it tapers to the roundly truncate posterior extremity.

The lorica is transparent, consisting of the four flexible plates distinctive of the *Diaschizae.* The dorsal cleft is narrow, parallel-sided, widening a very little posteriorly. The other edges of the plates are curvilinear.

The eye is cervical and double, having the appearance of two eyes fused together, like that of *D. exigua.* It is placed on the lower part of a large brain.

The foot is short, quite *ventral,* and very much overhung by the posterior projection of the body, by which this species can be at once identified, and which has suggested the specific name. The toes are short, sharp, and slightly decurved. The usual setae on the foot common to all the *Diaschizae* are well marked.

In front of the corona there is a decided crater-like projection, which consists of the extended lips of the buccal orifice (the lower lip curves down), giving it the appearance of a bird's beak, as mentioned by Gosse in his description of *D. ramphigera* (" Supplement," p. 98). This feature is more or less developed in all the *Diaschizae*, and is not part of the trophi as suggested by him. All round the buccal orifice there is a ring of long setae, which are certainly tactile and most probably used to distinguish food from other matter.

The jaws are complex, apparently having two curved plates attached to the unci and rami, forming a hollow, which can be suddenly expanded, thus sucking in the food. This food often consists of diatoms longer than the width of the animal itself.

The small dorsal antenna is well marked at the centre of the circle of the head, above the large brain.

The lateral antennae are very small and carried far back in the lumbar region ; they end in a small bunch of long setae.

This is a rather slow and graceful rotifer, quite a contrast to the active and restless species like *D. semiaperta* and *paeta.* It obtains its food by grovelling in the flocculent matter on branches of the waterweeds, and only swims apparently when it requires a change of pasture.

Total length, $\frac{1}{200}$ (127 μ) ; toes alone, $\frac{1}{1100}$ (23 μ) ; greatest width, $\frac{1}{540}$ (47 μ). Habitat : Knowsley Park, Lancashire.

I append an attempt at a dichotomous scheme of the

Genus Diaschiza.

		Size about
A. Toes two-thirds length of body .	*D. valga*,	$\frac{1}{260}''$ (98 μ).
AA. Toes less than two-thirds length of body.		
B. Eye present.		
C. Eye cervical.		
D. Head large; body short, rapidly tapering .	*lacinulata*,	$\frac{1}{250}''$ (102 μ).
DD. Head not conspicuously large; body longer; gradually tapering.		
E. Foot ventral, Lorica projecting over foot.	*ventripes*,	$\frac{1}{200}''$ (127 μ).
EE. Foot not ventral, lorica not projecting.		
F. Large species, lips of buccal orifice very projecting . .	*ramphigera*,	$\frac{1}{130}''$ (195 μ).
FF. Small species, lips of buccal orifice not so prominent .	*exigua*,	$\frac{1}{300}''$ (85 μ).
CC. Eye frontal.		
G. Body long and large, laterally compressed .	*semiaperta*,	$\frac{1}{100}''$ (254 μ).
GG. Body not laterally compressed . . .		
H. Body almost spherical, small; toes slightly decurved . .	*globata*,	$\frac{1}{300}''$ (85 μ).
HH. Body gibbose, but of medium length; toes straight . . .	*sterea*,	$\frac{1}{170}''$ (150 μ).

BB. Eye absent.

K. Gastric glands often tinted; of even breadth throughout; toes upcurved . . *paeta*, Size about $\frac{1}{120}''$ (212 μ).

KK. Gastric glands never tinted; tapering slightly fore and aft; toes curved out at points . . . . *tenuior*, $\frac{1}{150}''$ (169 μ).

D. Hoodii, *cupha*, *acronata*, and *fretalis* are omitted, not having yet been met with.

Description of Plate 2. (Upper portion).

Fig. 1. *Diaschiza ventripes*, n. sp., lateral view × 980.
,, 2. ,, ,, dorsal view × 980.
,, 3. ,, ,, lateral view of jaws × 1300.

On a New Rotifer, *Cathypna ligona*.

By M. F. Dunlop.

(*Read January 18th*, 1901.)

Plate 2 (Lower portion).

The Island of Arran, in the Firth of Clyde, has again yielded a new species to the already large class of Rotifera. Last summer, in the month of July, when on a visit to Machrie on the west side of the Island, I came across, not much above the sea-level, an extensive peat moss in which were numerous pools thick with sphagnum. Taking specimens from several of the pools, I examined them microscopically from time to time, and, amongst several common moss-dwelling animals, observed a form which attracted my attention as something out of the usual. Of this form it was very difficult to get a clear view, as it lingered long on the moss leaves. After some time, however, one specimen swam out into an open space and disclosed a peculiarly-shaped appendage. Having no books of reference at hand, I was uncertain whether the specimen was new or only rare, so, carefully preserving the water and moss until my return home, I then searched for and obtained a few living specimens; but no similar form could be seen portrayed or described in any books in my possession. I therefore concluded that the form might be new, and set it down as belonging to the family Cathypnadae—genus *Cathypna*—in which view I was confirmed by Mr. Hood and Mr. Rousselet. It thus became necessary to make out the details of the animal's form.

At first, the peculiar appendage already referred to appeared to be a prolongation of the dorsal plate of the lorica; this did not harmonise with certain other appearances, and after considerable trouble I found that the appendage was a prolongation of the ventral plate beyond the termination of the dorsal plate. In the course of observing, great help was obtained from a little vorticella which adhered to an empty lorica, and which in swimming about dragged the lorica against obstructions here and there, causing it to be canted in all directions and affording various views which enabled a pretty good notion of the structure to be obtained in an easier manner than with the aid of a needle, however fine.

The *lorica* of the new species is somewhat depressed, thicker behind than in front, and consists of two plates apparently joined together by a flexible membrane which forms a sulcus or furrow both longitudinally and at the rear.

The *ventral plate* is broader and longer than the dorsal, and has a peculiar posterior prolongation or appendage slightly arched in the centre.

The *toes* are two, short and blade-shaped, with a slight trace of shouldering on their outer margins.

An idea of the form of the animal may probably be best obtained from a description of an empty lorica, viewed from above. The mental edge is slightly concave, and in width is about five-eighths of the whole length of the lorica. The lateral edge on either side gently and gradually swells out for about two-thirds of its length, when it curves inwardly, and then abruptly turns out for about one-eighth of its whole length, when a sinuous line slightly convex in the centre joins both sides. The occipital edge is convex. The lateral edges of the dorsal plate do not quite extend to the lateral edges of the ventral plate, which is increasingly broader posteriorly, and about the point where the outline of the ventral plate abruptly turns out, the dorsal plate is terminated by a nearly straight line. An inner lateral line on either side appears to indicate the inner edge of the inangulation. The internal anatomy is quite normal. The trophi have the mallei well developed. and I should say are virgate. I was unable satisfactorily to make out an eye or eyes. The foot projects through a squarish opening in the ventral plate, and when the animal is swimming the toes are trailed behind, but when feeding it poises on the toes, which are then mostly turned towards the head. The head when exserted is inclined downwards. The species is readily distinguished by the peculiarly-shaped appendage already referred to, and as the form suggests a spade-like appearance it is proposed to call it *Cathypna ligona* (L. *ligo*, a spade).

I am indebted to Mr. C. F. Rousselet for the following remarks on this new species. He says it "has close relatives. The nearest in shape, with a posterior square-shaped appendage, is *Monostyla lamellata*, found by Dr. Daday * in salt marshes in Hungary, and again found in Russia by A. Skorikow, who gave it a new name—*Monostyla appendiculata*; but this animal has a single toe and is a true *Monostyla*. Then, in 1892, Anderson and Shephard (Notes on Victorian Rotifers) described a new species under the name of *Distyla icththyoura*, but which is really a *Cathypna*, which has a smaller posterior appendage. About the same time in 1892 the same animal, or a slight variety of it, was described from America by C. H. Turner † under the name of *Cathypna leontina*, and in 1894 it was once more found in Finland by Dr. Levander, † and described as a new species under the name of *Cathypna appendiculata*."

I regret that, unfortunately, I was only able to mount one specimen, and that with its head retracted. I found a large number of empty loricae, which shows that the animal was fairly plentiful, and had I known earlier that it was new, I might have had several living specimens for observation. Mr. Dixon-Nuttall, however, has with his usual felicitous touch drawn a correct likeness of the mounted specimen which is reproduced in the accompanying plate.

I have to thank Mr. Dixon-Nuttall for his delineation, and also Mr. Rousselet and Mr. Hood for the aid they have given me.

* E. v. Daday. Beiträge zur Kenntniss der Microfauna der Natronwässer des Alföldes. Math. u. Naturw. Berichte aus Ungarn XI. 1893.

† C. H. Turner. Notes upon the Cladocera, Copepoda, Ostracoda, and Rotifera of Cincinnati. Bulletin Denison University VI. 1892.

‡ K. M. Levander. Materialen zur Kenntniss der Wasserfauna der Umgebung von Helsingfors. Acta Societatis pro Fauna et Flora Fennica XII. 1894.

The size of the lorica (exclusive of toes) is $\frac{1}{225}$ in. (112 μ), its width $\frac{1}{290}$ in. (88 μ.)

Description of Plate 2 (Lower portion).

Fig. 4. *Cathypna ligona*, n. sp., dorsal view, retracted, × 490.
,, 5. ,, ,, lateral view, × 490.
,, 6. ,, ,, transverse section about the middle, × 510.

The Stridulating Organs of Waterbugs (Rhynchota), especially of Corixidae.

By G. W. Kirkaldy, F.E.S.

Communicated by D. J. Scourfield, F.R.M.S.

(*Read January* 18*th*, 1901.)

Plates 3 and 4.

It has been known for many years that certain waterbugs possess the power of stridulating, that is to say, of making musical sounds through the interaction of specially developed portions of their chitinous integument.

The first notice of which I am aware, is that of Frisch (1) who, in 1740, noted that the common European broad waterbug (*Ilyocoris cimicoides*) produces a fiddling sound with its neck. In 1846 Robert Ball (2) recorded the fact that *Corixa striata* Curtis emitted a powerful sound, so loud as to be distinctly audible in an adjoining room through the closed door. These sounds, which were somewhat like those of a cricket, were given out while the insect was about two inches and a half under water. The observations were due, in the first place, to Miss M. Ball, in 1840, and were afterwards repeatedly verified by herself and Mr. Ball. It was also noted that the sounds were probably made by the male only. This incomplete discovery was recorded in the *Revue Zoologique* in 1846 (3), and somewhat amplified in the same year by Mr. Ball (4). In the last paper the following points were noticed: viz., the *Corixa* anchored itself by means of the middle pair of legs; "it then moved the fore-legs rapidly in front of its head and gave three brisk little chirps; very often after the chirps it made a noise something like grinding a knife, only *very much* fainter and softer; while doing so it moved its body rapidly from side to side, still keeping the hind legs stretched out." The sound may be heard at any time, but is very uncertain; the evening seems to be the favourite time, and from May till the middle of June. The apparent movement of the fore-legs across the striated "upper lip" is indicated as a probable source of the sound. It is unnecessary to do more than refer to similar notes by Redfern (5) and Bach (6). In 1874 Landois (7) described the "comb" on the anterior tarsus of the male in *Corixa* and its action (as he thought) on the last segment of the rostrum. In 1877 Swinton discussed (8) stridulation in waterbugs, being apparently ignorant of the previous literature except the notices of Frisch (1) and Ball (2). Swinton called attention to, and figured some minute limae on the mesonotum, which he considered acted with the overlapping pronotum to produce sounds. These limae were noted in *Ilyocoris cimicoides*, *Nepa cinerea* and *Corixa* spp., while in *Notonecta glauca* two obliquely striated bands were figured. These limae and bands, however, do not actually appear to exist, and the under surface of the pronotum does not seem to be sufficiently mutually modified. Later (1878 or the early "eighties"?) the same author (9) rediscussed the question. He does not appear to have investigated the subject very thoroughly, since he states, as a rule, that "in the Heteroptera both sexes stridulate," while a more careful examination of *Corixa* (one of the genera he discussed) would have convinced him of his error.

Schmidt-Schwedt (10) confirms Landois' statements, without being aware of their existence; while Bruyant (11), apparently ignorant of previous literature, except Schmidt-Schwedt's very brief note, records *Micronecta* (*Sigara* Bruyant) as a musical insect. Bruyant refers the production of the tone to the rapid movement of the bristly hairs of the anterior tarsus on the rostrum, and compares the monotonous, not at all metallic, stridulation to the sound produced by the teeth of a comb playing upon the edge of a thin plate. This stridulation is characteristic, and enabled Bruyant to rediscover the tiny bug at several places in the Auvergne. Almost contemporaneously Mrs. Thompson recorded (12) two distinct sounds in *Corixa* (male), and in the same year Carpenter (13) discussed the question, coming to the same conclusions that Landois had twenty years before. Various short notes followed in the *Irish Naturalist* for the ensuing year, and the subject was alluded to by Carpenter again (14 and 16), Miall (15), Sharp (17), etc., though no further facts were elicited. At the close of 1900 Handlirsch (18) summed up the greater part of the previous literature in a valuable paper, and confirmed Landois' account—considering also, however, that the remarkable "strigil," discovered by F. B. White in 1873 (6a), was a stridulating organ. Handlirsch extended his investigations to the allied genera *Cymatia* and *Micronecta*, and considered that possibly the long curiously shaped tarsal claw (in the males) in these genera had some connection with the production of the sounds.

In January 1901, unaware of Handlirsch's paper, I published a brief note (19), dealing principally with Carpenter's note (13), and expressing my belief that stridulation was caused by the movement of the anterior tarsi, not on the rostrum, but on a specially modified area (which I figured) of the *opposite* femora.

The purpose of the present memoir is to draw attention in Britain to this interesting subject, and thus ascertain how the stridulation is actually caused. Unfortunately, press of other work compels me to deal with it at present in a very incomplete manner.

One of the most remarkable facts, which is discussed somewhat in detail, is that the stridulatory organs in the genus *Corixa* are so diversely formed that it is possible to distinguish the various species (in the male sex), from an examination of those organs only. This is, I believe, unique up to the present among the *Rhynchota*.

An examination of the type of the genus *Corixa* (viz., *C. geoffroyi* Leach, which happens to be the largest and one of the commonest and most widely distributed of the palæarctic species), reveals a large number of regular and irregular spines and "teeth" on various parts of the bug. Many of the spines and bristly hairs are found in both sexes, but the "teeth" (presently to be described) and many of the spines are only found in the male sex. All observers have agreed in asserting that the sounds have not been heard from females.*

In *Corixa geoffroyi* (and indeed in all the British species of

* The remarkable sternal stridulatory areas found in almost all the great predaceous family of land-bugs (Reduviidae), except the aberrant sub-families Enicocephalinae and Nabinae are present in both sexes. In the common bed-bug (*Klinophilos lectularius*) only the female apparently possesses musical powers, while, on the contrary, in Corixidae, it is only the males.

Corixidae) the rostrum is very short and obscurely jointed in both sexes. It is strongly sculptured, having six parallel transverse keels, and two closely approximated longitudinal median keels. The apical margin is, according to Handlirsch, slightly roughened in the male, and it is on this part that the Austrian author believes the stridulation to be effected by the anterior tarsi. It is extremely difficult to observe accurately in the case of a minute insect inhabiting water, and at the same time very shy of observation, but I believe that I have observed the actual method of performance. The sexual difference in the structure of the rostrum is almost inappreciable to me, and moreover, the apex is thickly covered by stout bristly hairs, probably forming an effective bar against any overtures from the tarsi.

Also, the tarsal "comb" shows a remarkable degree of special modification in the male sex quite out of proportion to the feeble roughening of the supposed stridulatory area developed on the rostrum.*

The anterior pair of legs is extraordinarily modified in both sexes (Figs. 1 and 7). The femora are considerably thickened (Figs. 1*a* and 2), varyingly so according to the species, but almost always more so in the male than in the female, often very much more; the tibiae are very short and thick (Fig. 1*c*), and the tarsi are single-jointed, thickened, more or less knife- or spoon-shaped (Figs. 1*d* and 7*d*). In the females, the lower margin of the *pala* (as this thickened tarsus is called), is furnished with a number of long, bristly hairs, and a curved line of very short hairs of a somewhat similar texture runs across the interior surface. In the males, there is a similar, slightly shorter, row of long bristles, while the shorter row is noticeably longer than in the other sex. There is also on the inner surface, nearer to the upper margin, a row, varying in position, form, etc., according to the species (as does also the exact shape of the pala), of small, elongate or rounded chitinous "pegs" or "teeth," which Carpenter terms the "comb." These are the active agents in the stridulation—the "*stridulator*." On the inner surface of the femora (in the males only), near the base, is a specially modified area † of minute chitinous pegs,

* Handlirsch's figure of the rostrum is a little diagrammatic, since the internal edges of the two central keels are not really straight and contiguous along their entire extent, as he shows them.

† This area is also found in the female, but not nearly so highly modified.

arranged in regular rows. These are the passive agents, the "*stridulatory area.*" This area is diversely developed in various species, but is seen very distinctly in (*e.g.*) *Corixa geoffroyi* (Figs. 1*b* and 2*b*), and *C. striata.*

The stridulation, in my opinion, is performed as follows:—The "comb" of the *left* tarsus is drawn somewhat obliquely across the femur of the *right* leg, or vice versa. The fact that the face of *Corixa* is at an acute angle to the dorsal part of the head (the *vertex*), and its apical margin almost contiguous to the base of the anterior femora, has probably misled observers. The *stridulatory area* (as the femoral area may be termed), occurs in a highly developed state only in the males, and is present in the males of all the British species of *Corixa*, while it is feebly developed or absent in every female of that genus. In the closely allied genus *Cymatia*, there is no stridulatory area, nor is there a corresponding tarsal stridulator in either sex. In *Micronecta* I have not had sufficient fresh or alcoholic material for satisfactory investigation, but there does not appear to be any stridulatory area, and there are only bristly hairs on the tarsus. In the males of *Cymatia* and *Micronecta*, the anterior tarsus is terminated by a remarkably formed claw (Figs. 5 and 6). Handlirsch thinks that this may form some part of the musical instrument.

I feel assured that the principal method of stridulation in *Corixa geoffroyi* is that which I have just described, but there may well be other ways of producing recognisable sounds. The whole surface of a *Corixa* is so minutely and delicately sculptured and engraved, and the number and shape of chitinous bristles, pegs and spines scattered regularly and irregularly all over the body is so extraordinary, that one hesitates to pronounce positively on their value in this direction. It is quite conceivable that the long bristles on the palae in both sexes are employed to clean the strongly carinate face, or the "rastrated" * surface of the pronotum and elytra which obtains in many species, although the bristles are as well developed in the smooth-surfaced *C. geoffroyi* as in the deeply rastrated *C. sahlbergi.*

The evolution of the palar "stridulators" is not difficult to understand. A primitive form is found in *Micronecta*, where

* Striated like a file.

there are only short chitinous bristles (Fig. 6), scarcely differentiated from the other rows. Is *Micronecta* able to produce a sound with these comparatively soft, yielding bristles on the face or elsewhere, or does the strong apical claw come into play? In *Cymatia* (Fig. 5), a somewhat more primitive form of pala is seen. It is not known whether this genus stridulates. In *Corixa cavifrons*, a form of pala somewhat intermediate between *Cymatia* and other Corixas is found. The stridulator is also in a state of transition: the apical "pegs" being scarcely distinguishable from the bristles of *Micronecta*, while the basal ones are formed more as in the typical species* (Fig. 9).

Yet another suspected musical area is present, situated, at least as regards one of the components, on the abdomen. In the three genera discussed, the sexes are always very easily distinguished apart. Besides the shape and structure of the anterior legs,† the segments of the abdomen are very differently formed, both dorsally and ventrally. In the staid and conservative females these are regular and subparallel. In the males they are irregular, split and disordered (Fig. 34). On the upper surface, near the lateral margin of the sixth segment, is a remarkable organ, present only in the males of certain species of *Corixa* and *Micronecta*, discovered in 1873 by F. B. White (6*a*). It consists of a (variously shaped, according to the species) slightly convex, chitinous plate, attached to the abdominal segment by a short chitinous, apparently structureless, pedicle. This plate is formed of from 3 to 16 (according to species) rows of very closely set teeth—strongly resembling the teeth of a comb; the rows overlap more or less, and are very irregular in some species. This organ, which is situated on the left side of the abdomen in the typical subgenus of *Corixa* (*geoffroyi* and *affinis*), and on the right side in the other subgenera which possess it, was termed the "strigil," or "curry-comb" by its discoverer, and is considered by Handlirsch to be a stridulating organ. It does not seem possible that it could be employed under water—the only occasion when the sounds have been heard—as under these circumstances the

* The "pegs" vary in shape very considerably in the various species, but for examination a comparatively high power, such as "Zeiss F, is necessary, and I have not had sufficient leisure for this.

† In the males of *Corixa* and *Cymatia*, the face is more or less deeply excavated, while in the females it is either flattened (*Corixa cavifrons* and *Cymatia*) or convex. In *Micronecta* the face is convex in both sexes.

elytra are firmly adpressed to the abdomen to prevent the ingress of water, and moreover the folded lower wings completely cover over the strigil in this position. For the purpose of mating, these bugs often migrate to a neighbouring piece of water, and it is possible that during flight some of the spines on the posterior legs may be drawn across the strigil; otherwise the method of operation does not appear clear.

It has been remarked that the purpose of stridulation is not apparent, as no auditory organ has been observed in either sex, especially, of course, the female. Too much stress must not be laid on this, as no special auditory organs have been detected even in the Cicadidae. It is probable that the rhythmic sounds produced by the male Corixidae are transmitted through the water and perceived by the females by means of some of the numerous bristles scattered over the body. It has been suggested that the convex, hollow pronotum may serve as a sounding board, but there does not seem to be much in this hypothesis.

It will be evident, from a perusal of the foregoing, that there is an interesting field open during the next few months for observations as to the real nature and actual *modus operandi* of the stridulation in Corixidae.

I proceed now to briefly describe the palae, etc., of the various species.

Genus 1. **Micronecta** Kirkaldy.

(= *Sigara* in Saunders, Hemipt. Heteropt. Brit. Isl.)

Face convex in both sexes. Strigil present in the male. No stridular area. Palae subovate, terminated by a powerful knife-shaped claw in the male, stridulator composed of bristly hairs scarcely distinguishable from the other palar bristles. Palae elongate-cultrate in the female.

Species 1 (Fig. 6). *M. minutissima* (Linné).
Species 2. *M. scholtzi* (Scholtz).

Fig. 36 represents the strigil in *M. signoreti*, an African species, and is copied from Handlirsch's figure.

Genus 2. **Cymatia** Flor.

Face, excavated ♂, flattened ♀; strigil absent, no stridular area. Palae, ♂, elongate, subcylindric, terminated by a powerful curved claw; no stridulator. Palae, ♀, similar to ♂, but no strong curved claw.

Species 1. *C. coleoptrata* (Fabricius).

Species 2. *C. bonsdorffii* (Sahlberg). (Fig. 5).

The pala in *coleoptrata* is very similar to that of *bonsdorffii*, but very much smaller and a trifle broader.

Genus 3. **Corixa** Geoffroy.

Stridulator and stridular area present in ♂ (present also in ♀ but in a much less highly developed degree).

Palae, ♂, not terminated by strong flattened claw.

Subgenus 1. **Glaenocorisa** Thomson.

(= *Oreinocorixa* in Saunders, *l.c.*)

Face, excavated ♂, flattened ♀. Stridulator and stridular area present ♂. Strigil present.

Species 1. *C. cavifrons* Thomson (figs. 8–11).

Palae, ♂, subtriangular elongate, with a marginate concave enlargement on the upper margin near the base. Stridulator composed of nearly seventy teeth, ranging in form from short somewhat peg-top shaped ones at the base to long slender bristle-like ones near the apex, the transition being gradual.

Pala, ♀, subtriangular, elongate.

Subgenus 2. **Callicorixa** F. B. White.

Face, excavated ♂, convex ♀. Strigil absent. Stridulator and stridular area present ♂. Palae, ♀, cultrate.

Species 2. *C. praeusta* Fieber (figs. 12 and 13).

(= ? *sodalis* in Saund., *l.c.*, = ? *boldi* in Saund., *l.c.*)

The palae (♂) are "elongate, suddenly dilated at about half their length from the base, the dilated portion concave and bent forwards, apex subtruncate." There are two rows of pegs, one consisting of about twenty short suboval pegs rising from the base and running close to the lower margins, the other consisting of fifteen similarly-shaped ones along the upper margin nearer the apex.

Species 3. *C. caledonica* Kirkaldy.
(= *cognata* in Saunders, *l.c.*)

The only structural difference between this and *praeusta* that I can find is that the palae are not so suddenly dilated at the apex in the male, and there are only about nine pegs in the upper row, but this former character is a little variable in the latter species. Unfortunately, I have only been able to examine a single specimen.

Species 4. *C. concinna* Fieber (fig. 14).

Palae, ♂, simple, cultrate, with about 40 pegs, blunt and suboval basally, gradually elongating towards the apex.

SUBGENUS 3. **Arctocorisa** Wallengren.

Face as in *Callicorixa*. Strigil present on right side; stridulator and stridular area present ♂. Palae ♀, cultrate.
(= *Corixa* and *Glaenocorisa* in Saunders, *l.c.*, = *Basileocorixa* Kirkaldy, olim.)

Species 5. *C. nigrolineata* Fieber (fig. 18).
(= *fabricii* in Saunders, *l.c.*)

Palae, ♂, widely cultrate, broadest near the middle, one long row of pegs, the basal twenty of which are pegtop-shaped, the apical nine more elongate. They follow more or less the upper curve of the pala.

Nigrolineata and *fabricii* are certainly only unimportant colour-varieties of the same species.

Species 6. *C. saundersi* Kirkaldy, 1899 (Fig. 17.)

Palae cultrate, the upper margin arcuate, not produced backwards; base rather broader than the apex of tibia; one row of about twenty blunt, rounded pegs, the last six more elongate.

This very distinct little species is known only from four specimens (3 ♂♂ 1 ♀) collected in June 1873 at Chobham, Surrey, by Mr. Saunders. I visited the pond in which it was captured eleven times altogether during 1899 and 1900, many hours on each occasion; but although I examined every single *Corixa* of similar size captured, *saundersi* did not turn up again.

Species 7. *C. scotti* Douglas and Scott (Fig. 15).

Palae, ♂, shortly cultrate, widest near the base, the upper margin a little sinuate apically, rounded basally; one row of twenty-six suboval, blunt pegs, a little more elongate towards the apex.

Species 8. *C. fossarum* Leach (Fig. 16).

Palae, ♂, very like *scotti*, but much broader at the base; angulate supero-basally and produced a little backwards. One row of thirty-three pegs, those nearer the base short and suboval; elongate and pointed towards the apex.

Species 9. *C. venusta* Douglas and Scott (Fig. 19).

Palae, ♂, twice as long as broad, upper margin arcuate. One row of about eighteen blunt pegs from base almost to upper margin, subparallel with the lower margin, then two large acute teeth at an obtuse angle to the principal row; parallel to these two, but close to the upper margin near the apex, are seven small acute pegs.

Species 10. *C. semistriata* Fieber (Fig. 20).

Palae, ♂, short, widest near the base. Shorter and broader than in *C. venusta*; two rows, one arcuately sinuate, containing about twenty small blunt pegs, and another row of about six close to the apex.

Species 11. *C. limitata* Fieber (Fig. 21).

Palae, ♂, broad cultrate, rounded above, narrow at the base, widest about a third from the apex; two rows of pegs, the lower reaching from the base to about two-thirds of the palar length and consisting of twenty-six short, blunt pegs; the upper, close to the upper margin, for a third of its length from the apex, consisting of sixteen elongate acute pegs.

Species 12. *C. moesta* Fieber (Fig. 22).

Palae, ♂, upper and lower margins subparallel, slightly diverging apically, upper margin not arcuate, apical margin almost perpendicular; a single row of twenty teeth, rather blunt, closely following upper margin almost to the apex.

Species 13. *C. falleni* Fieber (Fig. 23).

Palae, ♂, subtriangular, upper margins very convex and broad near the base. One row of subelongate, acute pegs (about twenty-six in number) running oliquely from the base, and another row of six similar pegs near the upper margin at an obtuse angle to the lower row.

Species 14. *C. distincta* Fieber (Fig. 24).

Palae, ♂, cultrate. Two rows of rather small pegs, one of sixteen suboval running subparallel with the lower margin from the base about a third of the palar length, and another near the apex and the upper margin, consisting of ten acute pegs.

Species 15. *C. striata* auctt. (*nec* Linné) (Fig. 25).

Palae, ♂, shortly cultrate. Two rows of pegs, one of fourteen short, pointed pegs near the base, and one curved row of twenty-one suboval pegs nearer the apex and the upper margin.

Species 16. *C. linnei* Fieber (Fig. 27).

Palae, ♂, subparallel, slightly diverging towards the apex, which is subtruncate; one row of suboval pegs, following the superior margin, embracing twenty-one pegs.

Species 17. *C. sahlbergi* Fieber (Fig. 26).

Palae, ♂, much as in *linnei*, but more divergent apically. One row of twenty-one or twenty-two rounded pegs.

Species 18. *C. carinata* Sahlberg (Fig. 28).

Palae, ♂, cultrate, curved laterally. One row of about thirty-six pegs disposed as follows, starting from the base: fifteen or sixteen rather blunt, somewhat cramped together; one solitary blunt peg; five together (though farther from each other than the fifteen or sixteen are mutually distant); twelve or thirteen elongate, tapering, somewhat curved, continuing almost to the apex of the pala.

Species 19. *C. germari* Fieber (Fig. 29).
(= *C. carinata* in Saunders, *l.c.*, partly.)

Palae, ♂, very similar to *carinata*, but the form at the base seems a little different, and there appear to be about forty more uniform pegs. I have only one poor example, however, for examination. These two species (Nos. 18 and 19) have been placed by all modern authors in a separate subgenus from Nos. 5—17 and 20—22, on account of the pronotal keel being continuous and well marked. This, however, is a very insignificant character, and the two species are structurally indistinguishable subgenerically from *nigrolineata*, *striata*, *falleni*, etc.

Species 20. *C. lateralis* Leach (Fig. 30).
(= *hieroglyphica* in Saunders, *l.c.*)

Palae, ♂, cultrate. One row of twenty-eight pegtop-shaped pegs following the curve of the upper margin.

Species 21. *C. lugubris* Fieber (Fig. 31).

Palae, ♂, subcultrate, lower margin curved; one row of twenty-two pegtop-shaped pegs reaching from the base to $\frac{2}{3}$ of the palar length, and another consisting of eight elongate acute pegs near the apex on the upper margin.

Species 22. *C. selecta* Fieber (Fig. 32).
(= *lugubris* in Saunders, partly.)

Palae, ♂, subcultrate, subtruncate apically. One long curved row of twenty-eight pegs, the twenty-two basal being pegtop-shaped, the six apical elongate and acute.

Subgenus 4. **Corixa** in sp.
(= *Macrocorisa* in Saunders, *l.c.*)

Differs from *Arctocorisa* by having, *inter alia*, the strigil on the left-hand side.

Species 23. *C. affinis* Leach (Fig. 33).
(= *atomaria* in Saunders, *l.c.*)

Palae, ♂, long cultrate, obliquely rounded (subtruncate) apically; one row of about thirty-eight pegs reaching from near the base to the apex, following the upper margin; the basal eighteen are blunt, suboval, the apical ones are longer and more acute.

Species 24. *C. geoffroyi* Leach (Fig. 1—4, 7, 34 and 35).

Palae, ♂, subparallel, elongate, upper margin rounded close to the truncate apex. A single row of about thirty-two blunt suboval pegs, following the curve of the upper margin.

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EXPLANATION OF PLATES 3 AND 4.

In nearly all the figures of the palae, the long bristly hairs are not shown, the dotted line (*f* in Fig. 3) representing the points of insertion of one row. The figures have been drawn, in the

* Wrongly cited by Swinton as 1766. I have only seen the second edition ; the first edition is dated 1727.

first place, direct or under 1-inch or 2-inch objectives, except Fig 4, which was drawn under a Zeiss F.

FIG. 1. Anterior leg of *Corixa geoffroyi* Leach, ♂. *a*, femur; *b*, stridulatory area; *c*, tibia; *d*, tarsus (pala); *e*, comb; *f*, and *g*, two rows of bristly hairs.
,, 2. Femur of *Corixa geoffroyi* further enlarged.
,, 3. Pala of ,, ,,
,, 4. Tarsal "peg" (enlarged under Zeiss F).
,, 5. Pala, etc. of *Cymatia bonsdorffii* (Sahlberg), ♂.
,, 6. ,, *Micronecta minutissima* (Linné), ♂.
,, 7. ,, *Corixa geoffroyi* Leach, ♀.
,, 8—10. Pala *C. cavifrons* Thomson, ♂.
,, 11. Pala *C. cavifrons*, Thomson, ♀.
,, 12 and 13. Pala *C. praeusta* Fieber, ♂.
,, 14. Pala *C. concinna* Fieber, ♂.
,, 15. ,, *C. scotti* Douglas and Scott, ♂.
,, 16. ,, *C. fossarum* Leach, ♂.
,, 17. ,, *C. saundersi* Kirkaldy, ♂.
,, 18. ,, *C. nigrolineata* Fieber, ♂.
,, 19. ,, *C. venusta* Fieber, ♂.
,, 20. ,, *C. semistriata* Fieber, ♂.
,, 21. ,, *C. limitata* Fieber, ♂.
,, 22. ,, *C. moesta* Fieber, ♂.
,, 23. ,, *C. falleni* Fieber, ♂.
,, 24. ,, *C. distincta* Fieber, ♂.
,, 25. ,, *C. striata* auctt., ♂.
,, 26. ,, *C. sahlbergi* Fieber, ♂.
,, 27. ,, *C. linnei* Fieber, ♂.
,, 28. ,, *C. carinata* Sahlberg, ♂.
,, 29. ,, *C. germari* Fieber, ♂.
,, 30. ,, *C. lateralis* Leach, ♂.
,, 31. ,, *C. lugubris* Fieber, ♂.
,, 32. ,, *C. selecta* Fieber, ♂.
,, 33. ,, *C. affinis* Leach, ♂.
,, 34. Upper surface of abdomen of *C. geoffroyi* Leach, showing strigil.
,, 35. Strigil still further magnified (copied from Handlirsch).
,, 36. Strigil of *Micronecta signoreti* (Reuter), (copied from Handlirsch).

An Unrecorded Hydrachnid found in North Wales.

By Chas. D. Soar, F.R.M.S.

(*Read January 18th*, 1901.)

Plate 5.

The mite which I now bring before your notice was found in the upper tarn, Cwm-Glas, Snowdon, on September 6th, 1896, during an excursion for collecting purposes, by Mr. Scourfield and myself. Two males and two females were taken. When first found I took them to be *Pionacercus leuckarti* described by Piersig in 1894. But in September 1899 Dr. George, of Kirton-Lindsey, sent me a male and a female to examine which proved to be the true *Pionacercus leuckarti*; I then found out that mine was quite a different species. After spending some little time in making sure it had not been previously described, I decided to bring it before you as a new species of that genus.

Pionacercus is a genus which occupies an intermediate position between *Piona* and *Acercus*. It differs from *Piona* in that the males have the tarsi, or last segment of the fourth pair of legs, much modified, whereas in *Piona* it is the fourth segment which is peculiar in structure. The other characteristics are the same. It differs from the *Acercus* in having only three discs on each genital plate, while in *Acercus* there are a large number. Its other features show very little difference.

The characteristics of the genus *Pionacercus* are: Body-skin soft; eyes wide apart; claws to all feet; swimming hairs on legs; three discs on each side of the genital fissure; a small peg on the inner edge of the palpi near fifth segment; and the last segment of the fourth pair of legs much modified.

Piersig in his great work on water-mites (Deutschlands Hydrachniden) describes two species from Germany, *Pionacercus leuckarti* (Piersig), and *P. uncinatus* (Koenike). Both of these have been found in Great Britain and recorded in "Science Gossip" for 1900. Also one other described by Koch, *Pionacercus vatrax*. It is not in many genera that we can boast of more species than they can in Germany, but with the species here described we now have four as against two only known in Germany.

Description of Male. *Body.*—Length about 0·52 mm. Breadth about 0·40 mm., of a bright orange colour with brown marking on the dorsal surface. The general outline of the body is pear-shaped. This shape is not common with the Hydrachnids. *Acercus liliaceus* (Müller), is the nearest in form to this one, but it is not so pointed at the posterior extremity. The skin of the body is soft, but not so soft as we find it in *Diplodontus* and *Eylais*. It also appears much tougher at the apex than in the anterior portion. The eyes are wide apart and very distinct, being almost black, so that they show well on the orange-colour of the skin. There are two rows of glands on the dorsal surface. I have not found any hairs near these glands, but it is quite probable there are some, for they are nearly always found in that position on other mites.

Legs.—We find the usual eight legs with six segments to each. Length of first pair about 0·56 mm., these have very few bristles. The second pair show a few swimming hairs as well as bristles. The third pair, which are the shortest, being only about 0·53 mm. in length, are formed very much like the same pair in the male of *Curvipes*. This pair has a large number of swimming hairs on the fifth joint, the hook, or claws, on the tarsi being very small. The tarsi have very few hairs, but in *Pionacercus leuckarti* this segment has a great number. The fourth pair of legs are about 0·62 mm. in length; they are very strong and have a large number of hairs on the fourth and fifth segments. The sixth segment is of a very peculiar structure, being crozier-shaped, somewhat similar to the same segment in *Acercus*. It has nine strong teeth or setae arranged like the teeth of a comb on the inner curve of the foot. (In *Pionacercus leuckarti* there are only seven.) These teeth do not appear under the microscope to be always placed exactly in the same position on the inner curve of the foot, but I think the difference in the position can be ascribed to the twist which the foot may have derived from the pressure necessary for examination. In Fig. 3, for example, it will be seen that the three teeth nearest the body are placed more backward than the rest, but on the opposite foot of the same mite the teeth appear to be all in a gently curved line. There are two more of these setae near the end of the curve, and another on the clubbed portion of the foot, as shown in Fig. 3. These may answer the purpose of claws, but they do not appear sufficiently strong for that purpose.

Epimera.—These are in one piece covering the greater part of the ventral surface like a shield. This is hard and chitinous and is of the same colour as other parts of this mite, namely, an orange-yellow.

Palpi.—These are about 0·18 mm. in length, each composed of five segments of which the second and fourth are longer than the others. The fifth segment is like a finger. There is a small peg on the inner edge of the palpi (Fig. 4) springing from near the end of the fourth joint and slightly overlapping the fifth segment. This is the usual feature in all species of *Pionacercus* and *Piona.*

Description of Female. Oval in form. Length about 0·64 mm., breadth about 0·50 mm., same colour as male. The much larger size of the female as compared with the male will be seen by a glance at Figs. 2 and 5, which are both drawn to the same scale. The fourth pair of legs have the greatest number of swimming hairs. They show no trace of the peculiar modification of the terminal joint found in the male. The only difference between this animal and the female of *Pionacercus leuckarti* is that the epimera cover a larger portion of the ventral surface, and that the palpi are thicker and stronger.

On account of the somewhat unusual shape of the male I propose to call this species *Pionacercus pyriformis.*

Description of Plate 5.

Fig. 1.	*Pionacercus pyriformis*, n.sp.,	♂ ventral view × 80.
„ 2.	„ „	♂ dorsal view (body only) × 80.
„ 3.	„ „	♂ last joint of fourth pair of legs × 170.
„ 4.	„ „	♂ last two joints of palpus × 360.
„ 5.	„ „	♀ ventral view × 80.

The Ephippium of *Bosmina*.

By D. J. Scourfield, F.R.M.S.

(*Read January 18th*, 1901).

Plate 6.

The production of winter or resting eggs in the genus *Bosmina* has been referred to by various writers on the Entomostraca, but I do not think that any description of the egg's protective covering, which corresponds, of course, to the ephippium of the Daphnidae, has hitherto been published. As this structure exhibits one feature at least which distinguishes it from the homologous productions of all other forms of the Cladocera, it appears worth while to bring forward the present short paper on the subject.

If we examine the recently thrown-off resting egg of *Bosmina longirostris* enclosed in its protecting case (Fig. 1), we shall see at once that the latter is only a portion of the carapace of the mother. The particular part of the shell which has been utilised for the purpose evidently consists of the valves (as distinguished from the head-shield), with the exception of a rather large piece of their ventral margins. The ventral margins have not wholly disappeared, for the characteristic shell-spines at the posterior ventral angle are still present. At first sight it does not seem that the portion of the shell now enclosing the resting egg has been specially modified. The ordinary faint hexagonal markings on the surface of the valves are quite apparent, and the valves themselves are as transparent as when forming part of the coat of the living animal. Towards the back there is, it is true, a somewhat darker tinge than usual, but this is not very noticeable, and taken by itself would scarcely suggest special modification. Looking more closely at the structure, however, it will be seen that at the back—*i.e.*, along the line representing the dorsal margin of the original valves, there is a distinct increase in the thickness of the chitin, and, further, that there is a narrow, highly refractive band of chitin running somewhat obliquely across each valve from near the anterior dorsal angle to within a short distance of the posterior margin. It is the possession of these lateral thickened bands of chitin which distinguishes the ephippium of *Bosmina* from all homologous structures.

If one of the lateral bands of chitin be still further examined it will be seen that it probably represents a modified line of hexagonal areas, forming part of the shell sculpture of the unaltered valve. But all the cross partitions have been obliterated, and the edges of the band have been smoothed so as to show but little indication of the original polygonal arrangement. The extremely minute granulation or pitting of the areas enclosed by the shell markings has also disappeared, for the chitin of the band seems absolutely homogeneous (Fig. 5). In continuation of the band anteriorly, there is a slit in the valve which runs up to the anterior margin near the anterior dorsal angle. The edges of this slit are normally in contact, but may be easily separated by pressure. The slit seems to be produced by the falling out of a number of pieces of chitin (Fig. 6), exactly in the same way as I have described in the case of the line of separation along the ventral edge of the ephippium and round the valve-margins in *Leydigia acanthocercoides* (see "The Winter Egg of a Rare Water-Flea," *Journ. Q. M. C.*, Series 2, Vol. vii., p. 171). The pieces of chitin no doubt represent modified hexagonal areas of the original shell sculpture in the same line as the series which produce the lateral band. In connection with this it may be pointed out that the anterior end is often seen to be separated from the rest of the band by a transverse line (Fig. 1). At its posterior end the lateral chitinous band appears to end abruptly in the ordinary shell markings.

In *Bosmina longirostris* the lateral bands do not project very much beyond the surface of the shell, but in a species (Fig. 8) from Upper Lough Erne (probably *Bosmina lilljeborgi* Sars, although this is perhaps only a variety of *B. coregoni* Baird), very kindly sent to me by Mr. W. F. de V. Kane, the projection of the lateral bands is so pronounced that they deserve to be termed ridges (Fig. 9). The position of the bands in this case is also a little different to what it is in *B. longirostris*. As will be seen by a comparison of Fig. 8 with Figs. 1 and 4, there is a rather greater distance between the lateral bands and the back of the shell in *B. lilljeborgi* (?) than there is in *B. longirostris*; and more important still, the lower ends of bands approach very much nearer to the posterior ventral angle of the shell in the former than in the latter species. I may mention here that the lateral bands are not always so evenly curved as shown in the figures, but that they sometimes exhibit rather abrupt bends—as if in their formation the deposition of chitin had not followed one line of cells the whole way, but had changed from one series to another.

As regards the function of the lateral bands, I would suggest that, in addition to strengthening the ephippium, as they evidently do from their position almost directly over the egg, they may also help to keep the free edges of the valves more closely in contact than might otherwise be the case. Such a result would certainly follow if the ends of the bands, by their elasticity, possessed the power of pressing inwards and carrying the free margins of the valves with them. I do not know whether such a tendency exists, but it is at least very probable.

In addition to having the lateral bands very strongly marked, *B. lilljeborgi* (?) also shows the thickening along the back as a distinct ridge (Fig. 9). That the dorsal thickening is really in the form of a sharply defined band can, however, be also seen in *B. longirostris*, when views can be obtained either from the front (Fig. 3) or back (Fig. 2).

There is still one other point requiring elucidation, namely, How is it that the ventral portions of the valves become detached when the shell is to form an ephippium? By very careful scrutiny of a female carrying an ephippium and winter egg (Figs. 4 and 8), it can be demonstrated that there is a line of weakness, marked by a faint doubly-contoured line on each valve, already formed in the exact position where the anterior portion will break away. This line of weakness can be developed into a crack, at least for some portion of its length from the anterior end, by applying pressure. The edges of the crack are quite smooth. The line of weakness does not cross any of the ordinary shell markings on the valve, but, from the relation of the latter to one another on each side of the line, it is evident that a considerable amount of alteration of the original shell sculpture has taken place. The probability is that a line of hexagons has been suppressed or rather completely modified to form the line of weakness, and this view is borne out by the arrangement of the shell markings shown in Fig. 7, where we seem to have a very early stage of the process exhibited. The one long cell, which lies exactly where a portion of the line of weakness is always developed, has plainly been formed from the ordinary hexagonal markings, because its edges show the characteristic zigzag arrangement, and the crossbars are also just discernible, although almost obliterated. It is somewhat strange that in the specimen from which this was drawn there was no trace of any modification having commenced for the production of the lateral bands and slits. It looks as if the production of a line of weakness may be older in the history of the development of these ephippia than the formation of the lateral chitinous bands. This may very well be so, because among the Lynceidae, where there is in many cases scarcely any actual modification of the shell, there is almost invariably a line of weakness developed prior to the moulting of the ephippium.

Having now seen how it is that the ventral portions of the valves become so easily detached from the rest of the shell when an ephippium is formed, we may very well ask ourselves why this process should take place. As the phenomenon is so common among the Cladocera there must be some fundamental necessity for it. I think the answer to this question is undoubtedly to be found in the fact that in the vast majority of cases it would be quite impossible for the anterior margins of the valves to be brought into contact if the ventral, and especially the anterior ventral portions of the valves, owing to their very convex nature, remained in position. In other words, it would be impossible for the ephippium to form a closed covering for the egg.

In addition to the outer protective covering which has just been described, there are also some very delicate inner membranes which surround the egg, as indicated in Fig. 1. They most probably consist of the moulted inner layer of the shell valves, and, so far as can be seen, do not appear to have undergone any special alteration. The resting egg itself—there is never more than one in any ephippium—is very largely composed of small globules of a dull greenish oily material. At the edges it is slightly translucent, but elsewhere opaque. It can readily be distinguished from a "summer" or parthenogenetic egg by its rather larger size and general opacity. Of course it is enclosed in a special covering of its own, the egg-shell properly so called. In Fig. 3 a broken egg-shell is shown, inside its protecting ephippium, after the hatching out of the young *Bosmina.*

It will be apparent from the foregoing description that the ephippium of *Bosmina* much more nearly approaches the homologous structures found in the majority of the Lynceidae than it does those of the Daphnidae. It is, in fact, scarcely worthy of the name of an ephippium, as that word is commonly understood, but would be more correctly designated as a proto-ephippium, a term I have already employed for these less highly developed types of protective egg-coverings. But this question is not of much importance, and I have preferred to use the well-known word "ephippium" throughout this paper.

My observations on ephippia among the *Bosminidae* have been confined to the two species already referred to and *B. cornuta*, which agrees exactly with *B. longirostris*. It is much to be desired, therefore, that the investigations should be extended to other species, especially to some of the more remarkable forms, such as *B. gibbera*, *B. berolinensis*, etc. Although I have no doubt that all the species of the genus *Bosmina* will be found to produce ephippia of the type already described, it would be very interesting to learn something of the extent of the variations occurring in this respect in the genus. Still more interesting would it be if we could discover what kind of ephippium is formed by the peculiar *Bosminopsis deitersi* recorded by J. Richard from Argentina.

Explanation of Plate 6.

Fig. 1. Ephippium of *Bosmina longirostris*, side view × 150.
,, 2. ,, ,, ,, ,, dorsal view × 140.
,, 3. ,, ,, ,, ,, front view (somewhat flattened out of shape), × 140.
,, 4. *Bosmina longirostris*, carrying ephippium and winter egg, × 130.
,, 5. A portion of a lateral band of chitin, with adjacent shell-markings (ephippium of *B. longirostris*), showing how the areas enclosed by the latter are pitted, whilst the band is structureless, × 350.

Fig. 6. Upper portion of a lateral band (*B. longirostris*), showing the loose pieces of chitin at its anterior end, which apparently fall away and produce the slit found in this position in the ephippium, × 280.

,, 7. Portion of shell sculpture of a specimen of *B. longirostris*, showing probable early stage in the formation of the line of weakness between the ephippium and the ventral portions of the valves, × 180.

,, 8. *Bosmina lilljeborgi* (?), carrying ephippium and winter egg, × 90.

,, 9. *B. lilljeborgi* (?), view from above, showing the projecting lateral and dorsal bands of chitin, × 110.

NOTE.—The small letters have the same significance throughout, namely :—

d = Dorsal chitinous band of ephippium.

j = Junction line between head-shield and valves. This line is actually much fainter than represented in the figures.

l = Lateral chitinous band of ephippium.

m = Inner membranes surrounding winter egg.

s = Slit in valve proceeding from anterior end of lateral band to margin of ephippium.

w = Line of weakness separating the ventral portion of the valve from the part retained to form the ephippium. The line is doubly-contoured, but is much fainter than shown in the plate.

THE PRESIDENT'S ADDRESS.

By George Massee, F.L.S.

(*Delivered February 15th*, 1901.)

Next to the Phanerogams, or flowering plants, the Fungi constitute the most extensive group of plants known. Just over 50,000 species are already described, and every year this number is being augmented. We have in Great Britain 5,000 species of Fungi, which far exceeds in number that of all our other groups of native plants—Phanerogams, Filices, Muscinae, Algae, Lichens—added together.

As in every division of the animal and vegetable kingdoms, the primary groups are indicated by one or two prominent morphological features, which are supposed to indicate a common origin, whereas other and unimportant or secondary characters presented by the group are often very varied. In the Agaricineae, a family including some thousands of species, the common bond of union is the presence of gills or thin plates bearing the spores or reproductive bodies on their sides. The members of this group are popularly known as toadstools, with the exception of the edible species of our pastures, which is dignified by the name of mushroom. The mushroom-eating public flatter themselves that the only fungus they eat is the true mushroom (*Agaricus campestris*). This, however, is far from being the case. *Agaricus campestris* pure and simple is rarely if ever grown by cultivators, but in its place a variety of this species with a brownish more or less scaly cap, known scientifically as the variety *hortensis*. The horse mushroom (*Agaricus arvensis*) is often sold in the London markets as the true mushroom. However, all these are edible, even if lacking in taste and aroma. In this instance "ignorance is bliss."

The uses of Fungi are various. As food products, owing to fear of poisoning, with the exception of the kinds mentioned above, the numerous edible varieties growing in this country are mostly ignored, except by mycologists. The fungus popularly known as "blewits" or "bluecaps," however, is often offered for sale in Nottingham market. We have at least eighty different kinds of fungi perfectly safe and good to eat. Of these, forty kinds are common and widely distributed, the most abundant and one of the best being the "parasol mushroom" (*Lepiota procera*), one of the toadstool type, having a slender stem five to eight inches in length, and a flat brownish scaly cap six to nine inches across. The gills are persistently white. The Morels (*Morchella*) are amongst the best of edible fungi, and belong to a group of fungi that appear in the spring, when other kinds of edible fungi are absent. The species grow on the ground among grass, the stem is stout, and the cap or spore-bearing portion is globose or conical and marked on the outside with deep irregular depressions. In the Southern Hemisphere the counterparts of our Morels are parasites growing on trees. There is only one genus (*Cyttaria*), and the species, so far as is known, only grow on the different species of evergreen beech. These southern Morels are not uncommon in Chili and in Tasmania, and were in both countries eaten by the aborigines, as they are at present by their successors. Several species of fungi are eaten by squirrels. Slugs and snails are also partial to some kinds, the poisonous species of *Russula* being especial favourites.

Poisonous fungi do undoubtedly exist, but among the kinds that are at all likely to be collected for food poisonous kinds are not so common as generally supposed. Probably 90 per cent. of the deaths caused by poisonous fungi, both in this country and on the Continent, are due to eating the "death-cup" (*Amanita phalloides*), or its near relation *Amanita mappa*. Why these fungi should be collected for food is not quite clear. They certainly do not in the least resemble any species usually considered as good for eating—least of all the common mushroom; perhaps it is on account of their neat appearance, and the absence of anything suspicious in the way of smell or taste that they tempt the uninitiated.

In the majority of fungi the spores are diffused by wind, but in the most highly organised group (Phalloideae) the spores are distributed by insects, who, curiously enough, are attracted by colour, scent, and nectar-like food, exactly as in the case of those flowering plants where cross-fertilisation is effected by insects. The Phalloideae are most abundant in tropical regions. In Britain the group is represented by three species, two of which—the large stinkhorn (*Phallus impudicus*) and the smaller stinkhorn (*Mutinus caninus*)—are fairly common throughout the country, whereas the third, the latticed fungus (*Clathrus cancellatus*) is only met with on rare occasions in two or three southern counties. The smell in all species is very penetrating, and from the ordinary human standpoint intensely disgusting, although not objected to by flies and other insects, who pick up the scent and gravitate in great numbers towards its source, where they find a greenish dripping gluten, very sweet to the taste and containing the exceedingly minute spores imbedded in its substance. This mucus along with the contained spores is greedily eaten by the flies, and by this means the spores are distributed far and wide. In the most highly organised members of the Phalloideae, very varied and beautiful contrivances are present, serving as a platform for insects while partaking of their feast. These platforms are so arranged that the sweet mucus, trickling from the cap where it is produced, flows over their entire surface, thus affording standing room for more insects than if the mucus remained on the comparatively small cap.

In one species (*Dictyophora daemonum*) the fungus has a stout erect stalk four or five inches long, bearing at its tip the mucus and spore-producing cap. Springing from the stem just below the cap is a very beautiful network-structure fashioned like a lady's skirt or rather a crinoline, which widens out downwards and reaches almost to the ground. On to this crinoline the mucus spreads in every direction. In our latticed fungus the portion smeared with mucus is bright red, and resembles a hollow globe having a wall of network, the globe being about three inches in diameter. In other kinds variously branched coral-like appendages receive the mucus.

The subject of parasitic fungi is so extensive that an extended series of talks would be necessary to make clear even the broad outlines of the study, which embraces members belonging to every family of fungi, the individuals varying in size from the ephemeral microscopic mildews and rusts to the large woody structures, resembling inverted brackets, which grow upon and destroy forest trees. The following figures will give some idea of the enormous amount of injury done to the higher plants by parasitic fungi.

In Prussia, according to the Statistics Bureau, the loss on the crop of wheat, rye, and oats, caused by fungi during the year 1891, amounted to the sum of £20,628,147 sterling, or almost a third of the total value of the crops. In Australia the loss on the wheat harvest of 1890–91 due to rust was estimated at £2,500,000 sterling. In the United States the vineyards have suffered terribly from fungus pests. Up to the present time 30,000 acres of vines have been destroyed, causing a direct and indirect loss of 20,000,000 dollars.

These are not exceptional cases, but average illustrations of the disastrous effects produced by parasitic fungi on our cultivated crops. Until quite recently these epidemics were accepted with calm resignation, being considered as deserved visitations for wrong-doing. At the present day most civilised countries are establishing experiment stations for the purpose of studying these pests and devising means for checking their devastations. Great Britain is watching the result of these experiments with interest before plunging into the fray to any serious extent.

Note on a Remarkable Stigmatic Organ in the Nymph of *Ornithodoros megnini* (Duges).

By E. G. Wheler.

(*Read October 19th*, 1900.)

On August 27th last, Mr. A. E. Shipley, University Lecturer at Cambridge, sent me two specimens of the above species of Tick, one of which was slightly, and the other more fully distended. The latter was alive.

The letter which accompanied them stated that they had been taken by Dr. J. Christian Simpson out of the ear of an American visitor to Cambridge, who had spent some time camping out in Arizona during the early summer of this year. If, as the American thought, the ticks were acquired whilst on this expedition, they must have been in the external auditory meatus for many weeks. They gave rise to little or no inconvenience.

On my referring to Professor Neumann, of Toulouse, he at once identified them as *Ornithodoros* (or *Argas*) *megnini*. This form belongs to the Argasinae, but a careful examination showed a very remarkable difference from other members of that sub-family of the Ixodidae, and such as appears to be another instance of those extraordinary variations of type that have already made the study of these parasites unusually interesting.

The feature referred to consists of two protuberances placed in the position of stigmata, one on each side of the body. They are situated above, instead of behind the fourth pair of legs, and are therefore visible from the dorsal side of the tick. They are entirely different from the stigmal plates and peritremes usually present. The top is truncate and perforated with a large hole, through which, in the living specimen, was to be seen a pointed organ, projected and withdrawn at will with considerable rapidity (Figs. 1 and 2). This organ only partially filled up the orifice; it was furnished with three hairs at the end (Fig. 1), and in appearance was somewhat similar to the terminal joints of the palpi.

I am unable to satisfy myself as to its probable use. The presence of the tubercles, which from Neumann's description in his "Revision de la Famille des Ixodides" appears to be peculiar to the nymphal stage, may possibly be deemed sufficient to establish a new genus for this species. He had not, however, noticed the stigmatic organ contained within them.

The species has other peculiarities. Neumann mentions the unusual fact that the nymph attains dimensions at least as great as the mature female, and that it is in this state that it acquires the larger part of the reserves of blood which the latter utilises to form its eggs. He also states that so great a difference exists

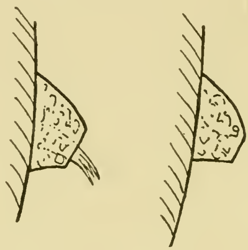


Fig. 1. Fig. 2.

between the two states as to have caused Dr. Marx to believe them to be separate species.

Descriptions of different stages of growth of this tick, with a brief reference to the stigmatic organ, are to be found in the "*Journal* of the New York Entomological Society" for 1893, pp. 49-52. It is well known in the States, and is mentioned as having infested the ears of children.

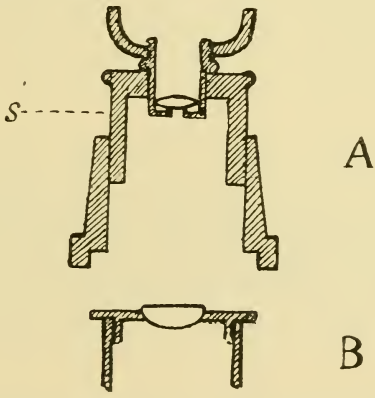
In general characteristics the species appears to be more nearly allied to *Argas* than to *Ornithodorus*; but it seems probable that it should be relegated to a separate genus, a contention that may be strengthened by the fact that the first joints of all the legs are almost entirely concealed beneath the cuticle of the body. But not having had an opportunity of examining an adult specimen, I should be sorry to express any definite opinion on the subject.

Note on a New Arrangement for viewing Diffraction Spectra.

By J. Rheinberg, F.R.M.S.

(*Read December* 21*st*, 1900.)

It is a matter of common knowledge that the diffraction spectra, which an object under the microscope gives rise to, may be observed by removing the eyepiece and looking down the tube.



A. Diffraction Spectra Ocular, which is arranged to fit on to the top of
B, the usual eyepiece.
The sliding collar *s* allows of adjustment to any power eyepiece.

But unless the eye is kept perfectly steady, which is difficult, they shift and change about. For this reason Dr. Johnstone Stoney, I believe, recommended looking at them through a pinhole near the eyepiece, a method which I followed for some time. This, though it does away with the shifting, reduces the light very much. It is also possible to view the spectra by screwing an objective into the lower end of the sliding draw-tube, with eyepiece in position at the upper end, and then focussing down on to the upper focal plane of the objective, but this is a cumbersome business. Latterly I have employed a method which is exceedingly convenient and efficient. The diffraction spectra, as is known, are not only formed in the focal plane of the objective, but are reformed just above the eyepiece, and may there be viewed by means of a lens. So I have mounted in a short tube the objective of one of the 7*s*. 6*d*. toy microscopes, which is in effect a lens of about a $\frac{1}{4}$ inch focus stopped down to an actual aperture of about 1 mm. The accompanying diagram will explain itself. The diffraction spectra ocular, as we may call it, when placed on the ordinary eyepiece of the microscope, on the cap of which it fits, shows the spectra splendidly, magnifying them at the same time. It gives plenty of light, and the spectra cannot shift. I can strongly recommend the arrangement to those who cultivate the useful habit of studying the spectra, *i.e.*, the optical effect produced by an object, as well as the object itself.

Note on the Occurrence of Larval Water-mites on various Aquatic Animals.

By Chas. D. Soar, F.R.M.S.

In a paper on Hydrachnidae, read on November 20th, 1896, (*Journ. Q.M.C.*, Vol. VI., p. 318), I mentioned that I wished to make myself familiar, as far as possible, with the larval forms of Water-mites, and by a systematic search amongst all kinds of pond-life to find out upon what creatures these larvae occurred, and if the same species was always parasitic on the same host. Since then I have collected and examined a great many aquatic insects, etc., but the results so far have been rather poor. They have, however, been considered sufficiently interesting to put on record.

One of the most common aquatic insects upon which to find the larvae of Hydrachnidae is *Corixa geoffroyi.* I have found a great number of these, and some of them I have succeeded in keeping alive long enough to allow the red globular water-mite larvae to drop off and become free-swimming. The latter always turned out to be nymphs of one of the species of the genus *Hydrachna.*

In September 1898, on the Norfolk Broads, I took a number of water-boatmen, *Notonecta glauca*, afflicted with the red globular parasites. I brought some of these home, but, although I kept one or two alive for a long while, I did not succeed in getting any of the larvae to arrive at the next stage. In the spring of 1899 I again paid a visit to the same neighbourhood, and succeeded in capturing some more water-boatmen. A number of these were brought home alive, as before, and this time I was successful in getting some of the red globules attached to the legs and body of the water-boatmen to become free-swimming in the nymph stage. These again all turned out to be a species of the genus *Hydrachna*. By comparing the size of the red larvae found on *Notonecta glauca* in the autumn of 1898 with those found on the same form at the same spot in the spring of 1899, I have come to the conclusion that the water-mite larvae remain attached to their hosts for a whole season—namely, from the summer of one year until the spring of the next—and the fact that those I found in the autumn did not undergo any alteration helps to strengthen this opinion.

I have further found two small yellow pear-shaped larval water-mites on the larval form of a gnat, and also one on an Ephemera larva, but I have been unable to rear them.

I have found also that the water-scorpion, *Nepa cinerea*, is a favourite host with some species. But I have not been able to keep any alive long enough to find out to what species of water-mite the larvae belong. In Epping Forest I took a specimen of *Ranatra*, literally covered with red water-mite parasites of all sizes. This I succeeded in keeping alive until ten specimens became free-swimming. They all turned out to be nymphs of *Hydrachna globosa* de Geer.

But the most curious find, perhaps, in this connection, has been a small fish from a pond on Earlswood Common with two larval forms of water-mites attached, which I take to belong to a species of *Arrenurus*. The accompanying figure ($\times$ 10) shows the position of the larvae on the fish, and it also illustrates the general appearance of water-mite larvae when in the parasitic stage on various aquatic creatures. I still have this interesting specimen in spirit with the red larvae attached.

In concluding this short note I may say that I shall feel much obliged if any of our members will kindly let me see any aquatic animals they may find having parasitic water-mite larvae attached to them.

Note on Some Portable Microscopes.

After considering the paragraph in the last Annual Report referring to the comparative paucity of exhibits at the "Gossip" meetings in recent years (see p. 105), it has seemed advisable to give a short description, accompanied by figures when available, of such instruments as have been expressly designed with a view of convenient and easy carriage; provided at the same time with thoroughly reliable focussing adjustments, and capable of taking a condenser or such other apparatus as might be required for the proper exhibition of the majority of objects.

Although perhaps unnecessary to those in constant touch with the products of the chief optical firms, the present note may be useful to others not so situated, and may also stimulate further efforts in this direction amongst those chiefly interested, whether makers or users.

On inquiry, which, however, is by no means presented as exhaustive, it is rather remarkable to find how comparatively few are the instruments regularly made and marketed for the purpose of portability; excluding, of course, as outside the view of this note, the various pocket or class microscopes intended to be passed from hand to hand—in other words, microscopes without firm stands.

Further, the chief existing forms have rarely in the first instance been provided for the use of the amateur microscopist. They were mostly designed for Army medical officers, and others concerned with the bacteriological investigation of tropical diseases, blood parasites and so forth, to whom lightness and small size of the necessary apparatus is of primary importance. If, however, they are suited to our requirements as well, their original purpose is of little concern.

It must be clearly understood that in drawing up the following brief descriptions we are entirely uninfluenced by any bias whatsoever as to the respective merits of the instruments themselves, and that we have not made any invidious selection amongst the firms producing them. We have taken simply what we could find, with the intention already set forth; and if any have been omitted it is that they either were not thought to come within the limits of this note, or that they were overlooked.

Taking them, then, in alphabetical order, the first that falls to be considered is Mr. C. Baker's "Diagnostic Microscope," a very compact little instrument, made at the suggestion of Surgeon-Major Ronald Ross for the use of officers in the I.M.S. for the diagnosis of malarial fever, etc. The annexed figure (Fig. 1) shows it as set up for use. It is provided with rack coarse and micrometer screw fine adjustment, sufficiently delicate to focus a $\frac{1}{12}$-in. oil-immersion objective. The draw tube extends to $5\frac{1}{2}$ in. (160 mm.), and the whole body can be drawn up through the bronzed jacket carrying the rack adjustment, so that powers as low as a 2-in. may be used, which is very convenient to naturalists and others who require, on occasion, low magnifications.

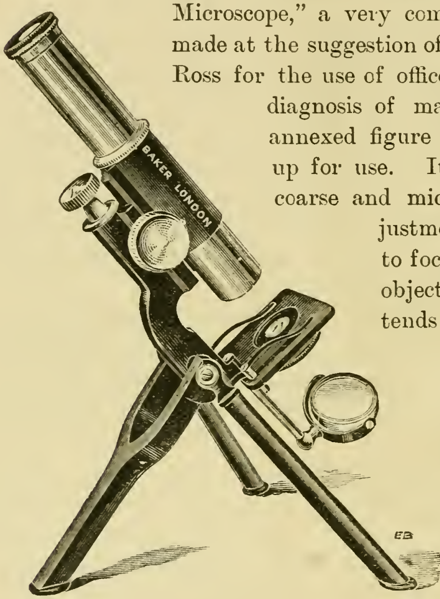


Fig. 1.

The chief dimensions of this instrument are as follows:—

Eyepiece gauge, R.M.S., No. 1	=	0·9173 in. or 23·3 mm.
Substage gauge	=	$1\frac{1}{12}$ in. or 27·5 mm.
Diameter of mirrors	=	$1\frac{1}{4}$ in. or 32 mm.

Size of stage, 2 in. (50 mm.) × $2\frac{3}{8}$ in. (60 mm.).
Spread of feet 7 × 7 in. = 180 mm.

The whole packs into a leather case, with handle or shoulder-strap, which holds three objectives and an extra eyepiece, measuring $10\frac{1}{2} \times 3\frac{1}{2} \times 3$ in. (270 × 90 × 75 mm.)

The stand alone in leather case costs £3 17s. 6*d*

A mechanical stage of a simple kind can be fitted if required, but this not only appreciably raises the cost, it also necessitates a somewhat larger case.

The well-known American optical firm, Messrs. Bausch & Lomb, of Rochester, N.Y., represented here by A. E. Staley & Co.,

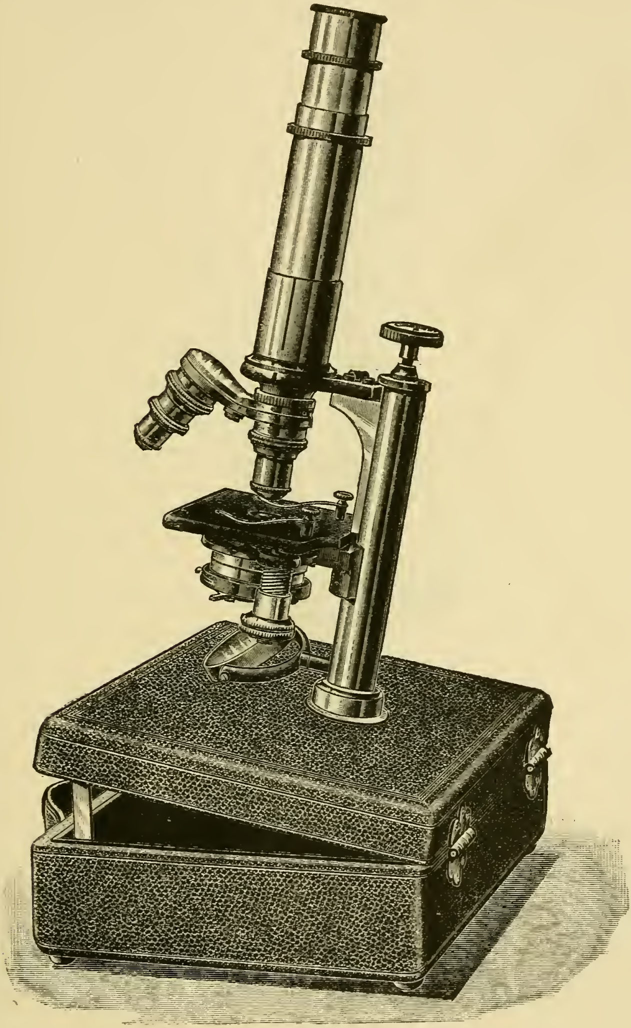


Fig. 2.

35, Aldermanbury, E.C., make a small portable microscope (Fig. 2 —one-third actual size), which recalls the instruments of a bygone time, in so far as in it the case forms the base for the stand, to which it is attached by a fly nut. Inclination is obtained by opening the lid, which is held in position by catches. As will be seen in the figure the coarse adjustment is by sliding tube, and

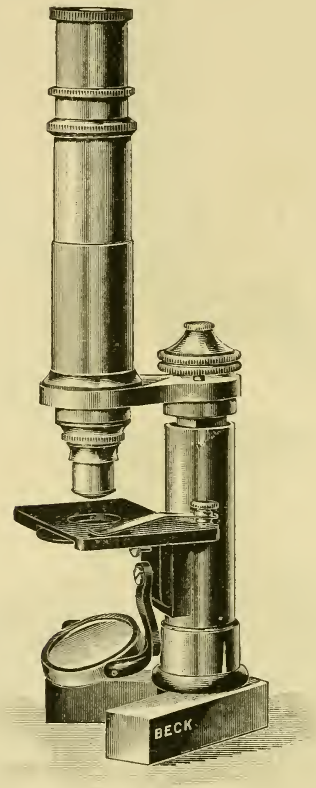


Fig. 3.

the fine is by micrometer screw acting on a vee slide in the pillar. The main tube has a draw, and the whole is arranged to pack within the case without detaching any of the accessories. A substage, focussing by screw, to take an Abbe condenser, as shown in the illustration, is attached to a side plate, which slips into a corresponding recess on the under side of the main stage.

The price, with 1 eyepiece and a $\frac{1}{6}$-in. objective, is £4 11*s.*

Adjustable substage, with Abbe condenser of N.A. 1·2, is £2 15*s.* extra.

Messrs. R. & J. Beck, Ltd., have a Portable Continental Model Microscope (Fig. 3), in which the base consists of two hinged sections, which fold together for packing, and in use open out in the form of a V. The focussing arrangements are by slide and micrometer screw, and a draw tube is provided. The stage, having below it

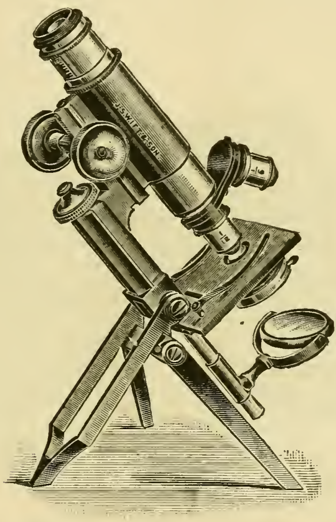


Fig. 4.

a rotating diaphragm, is rigidly held in position by a taper pin, just visible in the figure, which passes through a hole into the pillar of the instrument below the stage and above the mirror arm. When this pin is removed the stage may be rotated through an angle of 90°, so as to lie parallel with the body. The body tube is then withdrawn and pushed into the focussing jacket from below, while the mirror arm also swings out of the way for packing. The morocco case measures 8 × $2\frac{3}{4}$ × $2\frac{1}{2}$ in. Price of stand only in case, £4 3*s.*

Messrs. Beck also make their well-known "Star" Microscope, in portable form, with folding legs, at various prices from £4 upwards.

Mr. H. Crouch makes a small folding Microscope, fitting into a leather case 7 × 5 × $3\frac{1}{4}$ in.

Price with a $\frac{2}{3}$-in. and $\frac{1}{6}$-in. objectives and 2 eyepieces, £7 7*s.*

Messrs. Swift & Son's Improved Clinical Microscope (Figs. 4, 5) was also specially designed for bacteriologists attached to one or other of the services, whose duties in this connection often take them to remote districts, when a very compact equipment becomes an absolute necessity. As will be seen from the figures this is attainable to a remarkable degree by the open form given to the back leg of the tripod, and by the folding stage. It is furnished

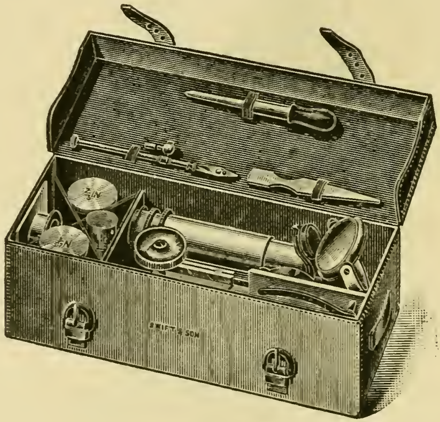


Fig. 5.

with rack coarse, and a special form of fine adjustment to work with any high magnification, while the outer body can be withdrawn sufficiently far to take a 5-in. objective if required. With draw-tube fully extended the body length is 8 in. or 200 mm. The eyepiece gauge is R.M.S. No. 2, viz., 1·04 in. = 26·416 mm.

The other dimensions are as follows:—

Height when closed down	...	$8\frac{1}{2}$ in.
Height from base to stage	...	$3\frac{1}{5}$ in.
Length when folded	...	$6\frac{1}{10}$ in.
Size of stage	...	$3\frac{1}{10} \times 2\frac{9}{10}$ in.
Diameter of mirrors	...	$1\frac{1}{2}$ in.
Spread of feet	...	$6\frac{1}{4} \times 6$ in.

The leather case measures $9 \times 3\frac{1}{4} \times 3$ in., will hold the apparatus as shown in Fig. 5, and is provided with handle or shoulder strap.

Weight of Microscope with eyepiece	2 lb. $6\frac{1}{2}$ oz.
Weight of case	15 oz.

The price of Microscope, 1 eyepiece and case, is £5.

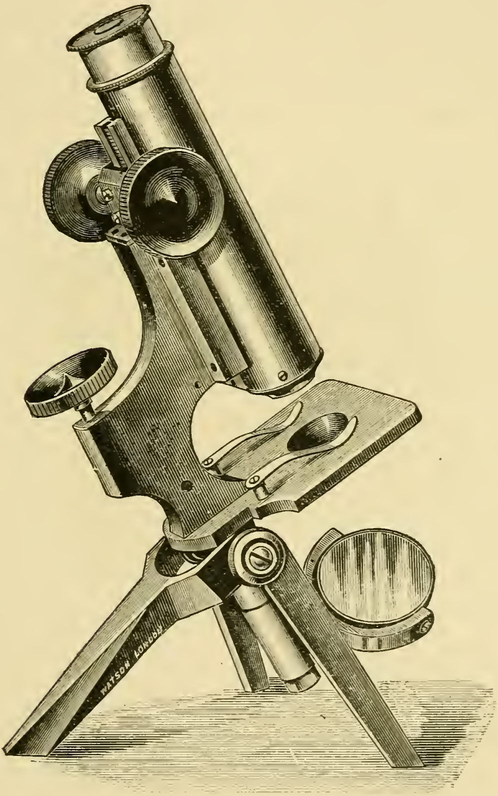


Fig. 6.

A mechanical stage can be fitted if desired, and the understage tube will take a full-size Abbe or other condenser; altogether a very charming and practical instrument.

Messrs. Watson & Sons' Portable Microscope is shown in the annexed figure (Fig. 6). The folding tripod has a spread of $5\frac{1}{2}$ in.

To pack in case the understage tube is removed, and also the mirror, when by unclamping a small lever the mirror stem and legs fold forward, close up under the stage. Coarse adjustment by rack and pinion, fine by Messrs. Watson's lever form of the usual pattern. Stage 3 in. × 3 in. The whole instrument when folded packs in a case measuring $8\frac{1}{4} \times 6 \times 3\frac{3}{4}$ in., with space for objectives and other apparatus.

Messrs. Watson supply these instruments with any size body to order, so that they may serve as companions, as it were, to larger stands. A rackwork substage with centring screws, and also a new form of mechanical stage can be adapted if required.

The price of this stand, with one eyepiece, is £5 5*s.*

Mahogany case, 15*s.*; substage, £2 2*s.*; mechanical stage, £3.

The firm also makes a Traveller's Microscope on a smaller scale, with folding tripod foot, sliding coarse and micrometer screw fine adjustment, and draw tube.

The price of this instrument is £2 2*s.*, without eyepiece. Mahogany or leather case, 10*s.*

NOTICES OF RECENT BOOKS.

THOMAS HENRY HUXLEY. A sketch of his life and work. By P. Chalmers Mitchell, M.A. 8 × $5\frac{1}{4}$ in., xvii + 297 pages, 6 plates. New York and London, 1900: G. P. Putnam's Sons. Price 5s.

Comparisons are odious, it is said. Nevertheless, we do not imagine that we shall hurt anybody's feelings when we say that Huxley was by far the most eminent of the many distinguished men who have held the office of President of the Quekett Microscopical Club. For this reason alone members of the Club should not fail to read this account of the life and work of the great fighter, who certainly did more than any other man to secure to scientific workers the perfect liberty they now enjoy of following the conclusions derived from their investigations, whithersoever they may lead. But, apart from this consideration, the book before us is well worthy of perusal, and it gives just about the amount of information which most people will require. For the general reader it is probably to be preferred to the "Life and Letters of Thomas Henry Huxley," by his son. It certainly gives one a much better idea of his relation to his contemporaries, and to the great problems which were being fought over during a large part of the second half of the nineteenth century, than can be obtained from his own correspondence, however interesting this may be.

The mainsprings of Huxley's remarkable power are well summed up by Mr. Mitchell as follows:—(1) "a faculty for the patient and assiduous observation of facts"; (2) "a swift power of discriminating between the essential and the accessory among facts"; (3) "the constructive ability to arrange these essentials in wide generalisations." Impelling and directing these faculties were two personal characteristics of immense importance, namely, "a driving force, which distinguishes the successful man from the muddler," and "a lofty and disinterested enthusiasm." These qualities were not only applied by Huxley to his biological work, but also to the problems of education, sociology, philosophy, and metaphysics.

As an example of one of the points mentioned above—namely, the extraordinary capacity of going straight to the essential features of every subject to which he turned his attention, we may venture perhaps to refer to Huxley's Presidential Address to the Q.M.C. in 1879 (*Journ. Q.M.C.* Ser. 1, Vol. v, pp. 250–5). That address contains, beyond question, some of the sanest things that have ever been said about "Microscopy," and it well deserves to be read again and again. D. J. S.

The Structure and Life-History of the Harlequin Fly (Chironomus). By L. C. Miall, F.R.S., and A. R. Hammond, F.L.S. 9 × $5\frac{5}{8}$ in., viii + 196 pages, 1 Plate, 129 figures in the text. Oxford, 1900: Clarendon Press. Price 7*s.* 6*d.*

It was an exceedingly good sign of the excellence and suggestiveness of Professor Miall's book on the "Natural History of Aquatic Insects," published in 1895, that all those who had the good fortune to read it came to the conclusion that it would be a capital thing if a greatly extended work on the same subject could be written. In a certain sense the book now under review is the response to that very real, if somewhat inarticulate, appeal for more.

Taking a single one of the insects dealt with in the earlier work (*Chironomus*), Professor Miall and Mr. Hammond have endeavoured to present us with a pretty full account of every phase of its life-history. Under the head of the "Larva of Chironomus," an elaborate description is given of the "bloodworm" so well known to all collectors of pond-life. The general structure, appendages, nervous, digestive and circulatory systems, organs of respiration, etc., are gone into in detail. Especially interesting are the remarks on wandering cells, on the peculiar cells known as oenocytes, and on the haemoglobin in the blood. The fly is dealt with in the same thorough-going way, special attention being paid in this case to the supposed auditory organs in the antennae, and to the sexual organs. The development of the pupa and the fly within the larva forms a very interesting chapter. It is pointed out that although *Chironomus* is less complex in its final stage than the blow-fly and other Muscidae, in its larval stage it is more complex. The transformation therefore from the larva to the perfect fly is more intelligible, the difference between these forms not being so great. On the whole *Chironomus* seems to be the best fitted of the well-known Dipterous types, for an elementary study of imaginal development. The final chapter of the book gives a succinct account of the embryonic development.

A large portion of the book is original, but the results of the labours of previous workers have been duly noticed. The authors do not claim to have written an exhaustive work on the subject, but they are certainly to be congratulated on having produced a treatise which will long remain a standard work of reference in connection with aquatic insects, and one which should serve as a model for a long series of similar studies on other forms. D. J. S.

TEXT-BOOK OF ZOOLOGY. Treated from a Biological Standpoint. By Dr. Otto Schmeil. Translated from the German by R. Rosenstock, M.A. Part III. Invertebrates. $9\frac{1}{4} \times 6\frac{1}{2}$ in., viii + 187 pages, numerous illustrations. London, 1900: A. & C. Black. Price 3*s*. 6*d*.

It has been the author's aim in this book to give much greater attention to biological details than is usually done in text-books of zoology. For this purpose a number of species representative of orders or sub-orders (or even families in some cases) have been selected for special treatment in regard to life-history, habitats, food, enemies, and such-like matters, while the other forms mentioned have been more summarily dealt with. Systematic and morphological details are necessarily, under the circumstances, to a large extent ignored. The insects receive the greatest amount of attention, about half the book being devoted to them, while on the other hand some groups of animals, such as Polyzoa, Rotatoria, Tardigrada, etc., have been omitted altogether, and the microscopic forms generally are very briefly dealt with. The net result is a book which can best be described as a cross between a "Natural History" and an ordinary zoological text-book. It should, however, be very valuable as a companion to a systematic work on zoology, especially as it contains a large number of excellent illustrations. D. J. S.

IN NATURE'S WORKSHOP. By Grant Allen. $7\frac{3}{8} \times 4\frac{3}{4}$ in., viii + 240 pages; 100 illustrations by Frederick Enock. London, 1901: George Newnes, Ltd. Price 3*s*. 6*d*.

Of the making of books intended to popularise the study of Natural History there is indeed no end, nor for that matter do we wish to see an end, though some of the samples we could very well spare. The present work, however, is a worthy representative of its class, and will certainly serve a useful purpose in directing the attention of many to the remarkable contrivances for defence and other purposes occurring in the organic world. It is quite impossible in a short review to give an adequate idea of the very varied character of the multitude of facts dealt with, but some notion of the scope of the book may be obtained, perhaps, by a reference to the titles of the eight principal sections. These are as follows:—"Sextons and Scavengers" (Burying Beetles and Scarabs); "False Pretences" (Devil's Coach-horse pretending to be a scorpion, etc.); "Plants that go to sleep"; "Masquerades and Disguises" (real and false Hornets, Bees, etc.); "Some Strange Nurseries" (Stickleback's nest, etc.); "Animal and Vegetable Hedgehogs" (Hedgehogs, Cacti, Sea-urchins, etc.); "The Day of the Canker-Worm" (the seventeen-year Cicada). Although it is not a book on microscopy, it is not at all a bad book for microscopists among others, and the excellent illustrations by Mr. Enock will certainly be viewed with pleasure by his very many friends among the members of the Q.M.C.—D. J. S.

HANDBOOK OF PRACTICAL BOTANY. By Dr. E. Strasburger. Translated and edited by W. Hillhouse, M.A. Fifth edition: re-written and enlarged. $8\frac{3}{4} \times 5\frac{1}{2}$ in., xxxii + 519 pages, 162 figures in the text. London, 1900: Swan Sonnenschein & Co. Price 10*s.* 6*d.*

To those who have given even a slight amount of attention to the study of Structural Botany at any time during the last fifteen years, "Strasburger's Practical Botany" will need no recommendation from us. They will have been forced to refer to it in some way or another, and to use the book is to learn to appreciate it. It may not be so well known to microscopists generally, however, that this book, apart from its excellence as a botanical text-book, is also one of the best introductions to practical microscopy that can be mentioned. It is crowded from beginning to end with all kinds of valuable hints as to the preparation and microscopical examination of vegetable structures, and it would scarcely be going too far to assert that any one who conscientiously followed the instructions given and verified the points referred to, would have obtained no inconsiderable portion of what we may term a liberal education in microscopy. And even those who have not the time nor inclination to work through the whole book would do well to carefully read the Introduction, Chapters I., II., III., XXI., and XXXII., and Appendices III. and IV.

In this new edition Prof. Hillhouse has almost entirely re-written the original text in order to bring the subject-matter as nearly as possible up to date, and he has also incorporated in the body of the work a large number of notes and hints suggested by his own experience as a teacher. The book is extremely well got up in every way, and will certainly maintain the high reputation which it has already earned. D. J. S.

Cours de Botanique. Anatomie; Physiologie; Classification; Applications Agricoles, Industrielles, Médicales; Morphologie Expérimentale; Géographie Botanique; Paléontologie; Historique. Par MM. Gaston Bonnier et Leclerc du Sablon. (9 × 5½ in.) Fascicule premier. Paris, 1901: Librairie Paul Dupont.

As may be gathered from the sub-titles, this is an ambitious work, which is intended to be issued in six fasciculi, forming, when completed, two 8vo volumes of about 2500 pages, illustrated with over 3000 figures in the text. The name of one of its authors at least—M. Gaston Bonnier, Editor of *Revue Générale de Botanique* and Professor at the Sorbonne, is obviously a considerable guarantee of the scientific value of any treatise on which it appears; and, judging by the first fasciculus (384 pp., 553 figs.), this is fully borne out in the present instance. This instalment deals with general principles, the vegetable cell, its organisation, evolution, reproduction and nutrition, followed by the descriptive morphology of the stem, leaves and root of Angiosperms, making use of a large series of types selected, whenever possible, amongst familiar plants. Space is to be devoted to the study of plant diseases, to geographical botany, to vegetable Palaeontology and also (a new feature) to experimental Morphology, or the influence of the surroundings on vegetable structure. As in most good French text-books, the diction is clear, luminous and expressive, while the figures are excellent and for the most part original. The subscription price for the whole work—viz., 25 fr. in advance—appears to be very moderate, and it should be noted that it is to be raised on completion, which is promised by 1903. Further instalments of this undertaking will be eagerly looked forward to. G. C. K.

THE MICROSCOPY OF THE MORE COMMONLY OCCURRING STARCHES. By Hugh Galt, M.B. $7\frac{3}{8} \times 4\frac{3}{4}$ in., 108 pages, 22 illustrations from photographs. London, 1900: Baillière & Co. Price 3*s.* 6*d.* net.

A comparative study of the starch grains of various plants is a very interesting and profitable one to all microscopists, and a good working knowledge of the subject is absolutely indispensable to those who, in the capacity of analysts, etc., have occasionally to report upon various unknown compounds submitted to them for examination. Under these circumstances it is somewhat surprising that there seems to be no book dealing with the starches in a thoroughly comprehensive way. Until such a work appears the present book, supplemented by W. Griffiths's little treatise published in 1892 on "The Principal Starches used as Food," for the sake of its photographs, will probably be helpful to many who are in want of a concise account of the microscopic appearances of the commoner starches.

The essential portion of the book consists of a series of short chapters, each of which is devoted to a description of the shape, size, markings, behaviour towards polarised light, etc., of a particular starch. Altogether the author treats of thirteen varieties—namely potato, rye, rice, oat, maize, pea, sago, tapioca, wheat, barley, Bermuda arrowroot, "tous-les-mois," and haricot bean starch. A synoptical table at the end of the book brings together the principal facts recorded in connection with each starch in a very useful way. One thing the author especially insists upon, and rightly so, namely, that the markings occurring on some starches are never so plain as they are shown in the figures in the text-books of botany, hygiene, etc. But on the other hand, we think he rather overstates the difficulty of seeing these lines. He says of potato starch, for instance, that "these lines are in all cases faint; indeed, to see them at all it is often necessary to reduce the aperture of the diaphragm of the microscope very considerably, or to use oblique light. . . . The lines are apparent chiefly in the larger ellipsoidal grains, but not in all of these, the smaller grains only occasionally showing any trace of such lines." With specimens freshly scraped from a potato and immediately examined in water there should be no trouble, however, in seeing the concentric lines with a $\frac{1}{6}''$ objective and a large axial cone of light from the condenser, and we have never yet under such conditions seen one of the larger grains without markings. Even the smaller grains, with the exception of the most minute, more often than not exhibit a few concentric lines. In dealing with wheat starch the author does not allude to the peculiar reticulated sculpturing of a part of the surface which a small percentage of the grains usually exhibit.

In regard to illustrations the author has been decidedly unfortunate. Compared with the direct prints from negatives contained in Mr. Griffiths's book already referred to, they are, to say the least, very poor. Whatever detail may have been shown on the original negatives has practically entirely disappeared in the half-tone reproductions. The difficulties of obtaining good photographs of some of the starches are no doubt very great, and we would suggest that the use of reagents producing a weak yellowish or brownish tinge might probably be employed with advantage to obtain the desired results. D. J. S.

Das Mikroskop im chemischen Laboratorium. Elementare Anleitung zu einfachen krystallographisch-optischen Untersuchungen. By Dr. F. Rinne. $10\frac{1}{2} \times 7\frac{1}{2}$ in., 74 pages, 202 figures in the text. Hanover, 1900: Jänecke Bros. Price 4 marks.

This book is intended to serve as an introduction to the study of the optical properties of crystals and the crystallographic investigation of natural and laboratory products by means of the mineralogical microscope. It is not written for would-be experts in crystallography, but for those who, like chemists, may wish to obtain, with a minimum of trouble, information concerning the form and optical peculiarities of the crystalline substances with which they have to deal. The author says—and the remark is probably even more to the point in this country than in Germany—that although such information is generally acknowledged by chemists to be of great value, the crystallographic method is very little used by them. They are probably prevented from taking up the subject by the notion that it involves the acquisition of a fairly exhaustive knowledge of that by no means easy branch of science, crystallography. Dr. Rinne points out, however, that the extreme refinements of determination used by the crystallographer are not necessary for the purposes of the chemist, and that much simpler methods are sufficient. These, and the principles underlying them, form the subject of the present work.

In the earlier sections the author deals with the geometrical and optical characteristics of crystals. Then follows a description of the microscope as fitted for the examination of crystalline substances. The greatest amount of space is, however, devoted to the methods of investigating the optical properties of crystals, including a very clear account of the nature and action of polarised light. In order to enable the most characteristic optical properties of crystals to be readily appreciated by those wishing to acquire this knowledge, the author has selected a series of fifteen sections of minerals which bring out all the principal facts. A further series of nine sections serve to illustrate the phenomena of circular polarisation, etc. These are issued by Messrs. Voigt & Hochgesang of Göttingen.

D. J. S.

Die Technik des modernen Mikroskopes. By Dr. W. Kaiser. Second edition. 10 × 7 in. Parts I. and II., 80 pages each; numerous illustrations in the text. Vienna, 1901: Moritz Perles. Price per Part, 2 crowns (= about 1*s.* 8*d.*).

This work on the microscope and its manipulation is to be issued in about five parts, and when complete it will undoubtedly form a very useful book on the subject. In the two parts before us the author deals with the optics of the microscope, the construction of objectives and eyepieces, the mechanical arrangements, selection and testing of a microscope, and commences to give some general hints as to microscopical manipulation. The special feature of the work is the large amount of attention paid to the microscopes and accessories produced by the Viennese firms of Reichert, Merker, and Ebeling. It is, in fact, one of the principal objects of the book to lay stress upon the progress which has been made in the last twenty years in the manufacture of microscopes and lenses in Austria—that is, in Vienna, for no firms producing microscopes of any repute exist outside the capital. The instruments of the German firms of Zeiss, Leitz, Hartnack, Seibert, and others are also discussed in pretty full detail, but the productions of other makers are practically ignored altogether. For those (and there should be many such) who wish to make themselves acquainted with the Continental point of view regarding the microscope, Dr. Kaiser's book will be very valuable.—D. J. S.

Handbuch der Seenkunde. Allgemeine Limnologie. By Dr. F. A. Forel. $8\frac{1}{2} \times 5\frac{1}{2}$ in., x + 249 pages, 1 plate, 16 figures in the text. Stuttgart, 1901 : J. Engelhorn. Price 7 marks.

The methodical study of lakes and the phenomena connected with them, constituting what is known as Limnology, has been actively pursued for the last three decades by an ever-increasing number of workers, both on the Continent and in America, but by none more zealously than Professor F. A. Forel, of the Lausanne University, the founder of this branch of science. Not only do we owe to him the first attempts to grapple in a comprehensive way with the many problems presented by lakes, but by his exhaustive monograph on Lake Geneva—" Le Léman "—the third volume of which is said to be now in the press, he has made a contribution to our knowledge of natural phenomena which it would be difficult to value too highly. A book by him, therefore, on " Lakes, and all About Them," as we may be allowed perhaps to paraphrase the title of the work under review, could not fail to be welcomed by the great number of persons interested in lakes, whether from the physical or biological standpoint. Microscopists who have been infected with lake fever will, at any rate, be extremely grateful to Professor Forel for bringing together so much information in such a convenient form. And in passing we may say that those who have not yet extended their collecting to lakes—*i.e.*, to lakes in the true sense, such as occur in the Lake District, North Wales, etc.—can form no conception of the fascinating character of the study of limnetic life, or of the superb means of recreation which it affords. In short, those who have never paid any attention to lakes have missed one of the things worth living for.

In his introduction, after explaining the scope of limnology, and defining what is meant by a lake, etc., Professor Forel discusses the causes which have contributed to the lively interest now being taken in "Seenkunde." He considers that there have been three principal factors at work. In the first place there has been a general deepening of the studies connected with lakes, owing largely to the influence of the rise and progress of Oceanography. Secondly, the individuality of lakes, the fact that every lake is a microcosmos in itself, has had a considerable influence, for it is evidently easier to get a true notion of the interactions of the various forces of nature in a lake than in the sea or in any particular district on dry land. The third factor has been the opening up of the depths of the lakes to investigation by the invention of all kinds of ingenious appliances, which has had all the attraction of the discovery of an entirely new province.

The author then proceeds to a consideration of the lake-basin, dealing with its origin, its gradual alteration in form, the regions into which it is divided, and a number of closely related topics. This forms the first of the two parts into which the book is divided.

The second part is concerned with the water of the lake, and the questions dealt with are very varied and important. For instance under the head of what may be called Hydromechanics, we have the pressure of the water, the alterations in level of the surface, the waves, currents, and so forth. An interesting account is given in this connection of the peculiar oscillations of level occurring in Lake Geneva, and some other lakes, known as "seiches." These remarkable movements, which apparently affect the whole body of water, are now known to be due to differences in the atmospheric pressure over different parts of the lake. The chemistry of the water, together with its thermal and optical peculiarities are next passed in review, and lastly there is a long chapter (80 pp.) on the biology of lakes. The last-named subject is necessarily, to us, the most important, and it is gratifying to see that the author has devoted so much space to it. Even as it is he has, of course, only been able to treat the subject in a general way, but the points dealt with, such as the characteristics of the littoral, abyssal and pelagic regions, the origin of lake faunas, the physiology of lacustrine organisms, the circulation of organic material in a lake, etc., are full of significance and should be carefully digested by all who desire to obtain a broad view of the life in a lake.

D. J. S.

PROCEEDINGS.

October 19th, 1900.—Ordinary Meeting.

George Massee, Esq., F.L.S., President, in the Chair.

The minutes of the meeting of June 15th, 1900, were read and confirmed.

Mr. Arthur Colls, Mr. Norman Warne, and Mr. G. H. D. Webb, were balloted for and duly elected members of the Club.

The Secretary said the members would hear with regret that they had lost several of their number by death since their last meeting, amongst whom, perhaps, the best known was Mr. J. D. Hardy, who had been a member since 1874. He was very seldom absent from their meetings, and generally had something to say upon most subjects which came before them. He had also devised several little contrivances for use with the microscope. Mr. Richard Smith was a well-known microscopist and inventor, and amongst other things invented the Hovis flour. His chief work was in connection with investigations on the germination of wheat, upon which subject he some time since published a book; he had been a member of the Club since 1892. Another member, whose death had been recently reported, was Mr. Edward George, who joined the Club in 1867, and was a very frequent attendant at its meetings; and finally Mr. G. Pearce, of Bournemouth.

The additions to the Library were announced, and the thanks of the meeting voted to the donors.

Messrs. Swift exhibited a roller mechanical stage fitted to their portable microscope shown at a previous meeting, and also a new low-power condenser for the same instrument, by means of which dark ground illumination could be got through a fairly thick zoophyte trough.

Mr. Karop said these additions had made this very useful microscope still more complete; the low-power condenser would he thought, be found specially valuable.

The President said they were indebted to Mr. Swift for bringing to their notice these new additions to his microscope; the condenser would, no doubt, prove a very great advantage to those who were studying living organisms.

The thanks of the Club were voted to Mr. Swift for his exhibit.

Mr. E. G. Wheler's notes on a "Remarkable Stigmatic Organ in the nymph of *Ornithodoros megnini*" and on "*Ixodes tenuirostris*" were read by Mr. R. T. Lewis, the former being illustrated by photographs taken by Mr. Wheler, and by the exhibition of one of the ticks referred to, and the latter by a mounted specimen shown under a microscope in the room.

Attention was also called to a tick sent up for exhibition by Mr. Wheler, and shown under the microscope by Mr. Lewis, which was remarkable as having scales in place of hairs; this creature was found on a zebra in East Africa, and had been named by Mr. R. I. Pocock—*Rhipicephalus marmorea.*

The President regretted that he knew very little about the creatures which had been described, but hoped some one more familiar with them would make some observations on the subject.

Mr. Karop said that insects getting into people's ears was not so very uncommon, and instanced a case in which an Italian organ grinder had come in distress to the hospital to have a number of ordinary bed bugs extracted from his ears. He asked if there were other instances known of this species of tick getting into human ears.

Mr. R. T. Lewis said that the tick in question had been found in the ears of children in America, and also in the ear of a prairie wolf. It was perhaps worth mentioning that certain species of ticks appeared to have special proclivities for attacking particular parts of an animal, and there were some in Natal which were extremely troublesome from their propensity to get into the ears of horses. He believed that a detailed account of the finding of the two ticks mentioned would shortly appear in the *Lancet.* The two photographs exhibited were of the dorsal and ventral aspects of the tick extracted from the left ear of the American gentleman referred to, and the tick exhibited in the room came from his right ear.

The thanks of the Society were unanimously voted to Mr. Wheler for his communications, and to Mr. Lewis for reading and illustrating the papers.

Mr. D. J. Scourfield read a paper on "The Swimming Peculiarities of *Daphnia* and its Allies, with an account of a new method of examining living Entomostraca, etc.," the subject being illustrated by blackboard diagrams.

The President was sure these investigations must have given great pleasure to the observer. As regarded cements for the purpose of sticking objects under water, he might mention that if they wished to germinate seeds under water, a drop of thick balsam was usually found sufficient for the purpose. He thought, however, that the descent of an organism in water by gravity would be observed to be quite different in the living state from what it was when dead. He had noticed particularly that this was the case with spermatozoids. In the cases mentioned it was quite possible, therefore, that there might be something more to be noted than the simple action of gravity.

Mr. Neville asked what was the special object of the antennae. Also, with reference to Cladocera, it seemed to him that there was a distinct gizzard, or a gizzard-like organ, similar to that found in some rotifers. Did they really possess this important organ?

Mr. Scourfield said the functions of the antennae were very important. Besides serving for locomotion, the animal in some cases was able to cling to weeds by means of a small hook on the end of one of the longer antennal setae; these hooks were a distinctive feature of *Simocephalus*. The appearance of the gizzard-like apparatus or mastax was really produced by the mandibles.

Mr. Karop asked if, in endeavouring to find a suitable cement, Mr. Scourfield had tried collodion; it was waterproof, and dried quickly. Gutta-percha tissue dissolved in chloroform also suggested itself as likely to be suitable for the purpose, as the chloroform evaporated very rapidly.

Mr. Scourfield said he found that nothing dissolved in benzole was of any use; he had not tried collodion.

The President thought this was a very interesting and suggestive paper, and one which showed them what had still to be done to complete their knowledge of these common organisms. The commonest things all presented problems for solution when they were cornered in this manner, and a paper like this put the points before them on which further investigation was desirable.

The Secretary said they had another paper on the agenda, "On the resolution of *Amphipleura pellucida*," by Mr. Merlin, which he thought, as the hour was advanced, it would be better to postpone until the next meeting.

Mr. Scourfield exhibited a camera lucida for use with the microscope, which was originally devised by Mr. Ashe, and had since been modified and improved. It was in action something like a Beale's neutral tint reflector, but could be used with the microscope inclined at any angle, and the second reflection got rid of the lateral inversion which was so troublesome a feature in drawings made with a Beale's reflector (see *Journ. Q.M.C.*, vol. vii., p. 413).

Mr. Rousselet said that when this camera lucida was originally brought forward, he made one for himself out of cardboard, only he substituted a piece of speculum metal for the silvered glass mirror, and in this way got rid of the double image.

The President thought that in common with all contrivances of this kind there would be some degree of distortion, and if there was any difference in the distortion at different angles, the tilting of the paper to correct this would be a very great inconvenience in drawing. Drawings made without regard to this were sure to be distorted, and in the case of very long objects the effect would be to considerably widen one end. So much so had this sometimes been the case that new species had actually been founded on the differences so produced.

Mr. Karop thought it was quite impossible to avoid distortion in drawings of this class unless they were made on a concave surface of proper curvature. He thought a much more reliable way was to make the drawing on paper ruled in squares, using ruled squares in the eyepiece; he found no difficulty in making drawings in this manner.

Mr. Scourfield also exhibited a remarkably compact mass of statoblasts of *Cristatella mucedo*, found at the Club's excursion to the East London Waterworks on October 6th. He said that these statoblasts had on that occasion been taken literally by the handful.

The Secretary, in making the announcements for the ensuing month, intimated that in consequence of some contemplated alterations in the North Room, it might be necessary for them in the course of a month or so to hold their meetings half an hour later than usual, whilst the work in question was going on; due notice would, however, be given of this.

November 16th, 1900.—Ordinary Meeting.

Dr. J. Tatham, Vice-President, in the Chair.

The minutes of the preceding meeting were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club :—Mr. J. F. Allcock, Mr. S. G. S. Dicker, Mr. S. E. Dowdy, Mr. C. W. Marshall, Mr. G. H. J. Rogers, Mr. B. J. Vernon, F.R.C.S.

The additions to the library since the last meeting were announced.

Mr. Merlin's paper "On the Resolution of *Amphipleura pellucida*, etc., with a Dry Lens and Axial Illumination," was, in the absence of the author, read by Dr. Spitta.

Dr. Spitta said that the paper just read was probably of even more interest for its surrounding considerations than for the actual facts contained in it. The explanation of the whole matter was, it appeared to him, *that the specimen used was coarsely marked*, as indeed some undoubtedly were. Before proceeding to show why he took this view, however, he begged members to understand that in making his remarks he did not wish to express any doubts as to the veracity of Mr. Merlin's statements. But he believed that what he had to say offered an explanation which had possibly escaped the author's attention.

To enable an object consisting of lines separated by minute intervals, or dots, or any small structures, to be seen, two conditions were absolutely necessary. First, that such objects should be sufficiently magnified for the eye to be capable of seeing them ; and secondly, that the N.A. of the objective should be high enough to render such objects sufficiently resolved ; for every one in the room was familiar with the fact that mere magnification without sufficient N.A., or "empty magnification," as Professor Abbe called it, was as useless as N.A. without the proper amount of magnification.

Now with regard to the first condition. It was supposed that $\frac{1}{250}$ inch represented the minimum distance that two objects, whether lines or dots, must be separated for the normal human eye to see and separate them distinctly at a distance of ten inches. No lines or dots closer than this could be recognised in their individuality. In other words, no matter what might be the real distance between any two dots or lines on a diatom they must, by optical means, be so rendered to the eye, when looking down the microscope, that they did not appear closer together than $\frac{1}{250}$ of an inch. It was more convenient for them to be magnified a little more, so as to be separated apparently by a greater interval, because in that case these whose eyes were not absolutely normal would see them better; but anyhow they must not apparently be separated by an interval of less than $\frac{1}{250}$ of an inch. The lines on *Amphipleura pellucida* were mostly about 100,000 to the inch, so to see them with the microscope the entire optical arrangement must result in magnifying at least 400 diameters, because $400 \times 250 = 100{,}000$. Now, how did the author obtain his magnification, and what was it? He used a $\frac{1}{6}$ in. objective and a 27 eyepiece. Well, that equalled a magnification of 1620, because the initial magnifying power of a $\frac{1}{6}$ in. was about 60, and $60 \times 27 = 1620$. He had, therefore, plenty of magnification. But what about the N.A.—the second condition?

Abbe's law, which was based on mathematical considerations admitting of no controversy, declared that, with the smallest possible beam of truly axial illumination, the number of lines to the inch capable of being resolved $= \lambda \times$ N.A. where λ is the number of wave-lengths to the inch of the light actually used. Putting this into actual figures, seeing that there are about 47,500 to the inch for *visual* light, it was found that $47{,}500 \times \cdot 95$ gave 45,125 lines to the inch as the theoretical limit—a long way off 100,000. In other words, the lines must not be closer than $\frac{1}{45125}$ of an inch. But with oblique light this formula was doubled and became $2\lambda \cdot 95$, or 90,250 to the inch, or $\frac{1}{90250}$ of an inch apart. It was evident, then, that Mr. Merlin could not have seen lines $\frac{1}{100000}$ or even $\frac{1}{90000}$ of an inch, apart without oblique light, using only a $\frac{5}{6}$ths cone of axial illumination; and this justifies the original remark that his specimen must have been a coarsely marked one. It was theoretically possible that the author might possess a photographic eye, so to speak: one that received impressions in the violet-blue ray as well as ordinary individuals did in the yellow-green or so-called "visual ray," but he had never heard of such a case.

As the formula already given applied to any ray, it should be possible to photograph on a plate what cannot be seen with the eye. The 100,000 lines to the inch could only be seen most faintly with the ·95 objective, but inasmuch as the wave-length of *photographic* light was about $\frac{1}{62500}$ of an inch, twice that × ·95 gave a photographic limit of a little over 100,000 lines to the inch His son, Dr. Harold Spitta, and himself had tried to do this. As they could not focus the lines on the ground glass screen of the camera, they had to make trial and error exposures, and failed several times, but at last succeeded in just showing the lines in the print exhibited. Dr. Spitta illustrated his remarks by diagrams, etc., drawn upon the board as he proceeded.

Mr. E. M. Nelson was sure that those present had listened to Mr. Merlin's interesting paper and to Dr. Spitta's remarks upon it, which had been placed so ably and concisely before them, with great pleasure. Mr. Merlin had spoken to him about the subject-matter of this paper before the holidays, which led him to make a few experiments of his own. Unfortunately his eyesight was not so good as it used to be, and he no longer possessed the same facility for picking up undiscovered new details; but Mr. Merlin's eyesight was exceptionally keen, and Mr. Merlin had, too, considerable experience with the telescope, which was probably as good if not better training for the eye than the microscope. The fact of his being unable to see any particular structure which Mr. Merlin had described in his paper would not, therefore, be evidence that Mr. Merlin was likely to have been mistaken in what he had seen. Before the vacation he had tried a $\frac{5}{6}$ths cone with the dry 4 mm. apochromat of ·95 N.A. with the $\frac{1}{2}$-inch wick of a paraffin lamp and an acetate of copper filter, but he was not able to effect any resolutions to anything like the extent Mr. Merlin had done. He next tried sunlight with a heliostat, but the heliostat proved untrustworthy and the sunlight fickle, so he was not able to push his experiments as far as he would have liked. He found, however, that with sunlight he could use a filter of much greater thickness, and then he was able to see some of the structures Mr. Merlin had mentioned. He hoped to be able to pursue this subject still further next summer.

There was another point—viz., that the Abbe diffraction theory did not fit in with all the observed phenomena bearing upon that branch of microscopy. It was highly probable that the large solid axial cone had a greater resolving power in it than was generally supposed. His experience showed him that 80,000 times the N.A. of the objective was the resolving limit in inches with this kind of illumination, but from what Mr. Merlin had said it was evident that a larger coefficient must be employed. The little beads in the lines on the hoop of a *Pinnularia major* were, so far as he knew, unresolvable by oblique light, but with the $\frac{5}{6}$ths solid axial cone he had been able to see them with the dry 4 mm. apochromat. Strange to say, this same object had in 1895 been a kind of minimum visible or crucial test for an apo. $\frac{1}{8}''$ of 1·43 N.A. !

It appeared, therefore, that the "minimum visible," the "crucial test," the "scarcely resolvable detail" of one year became the commonplace object at a subsequent period. This, Mr. Nelson said, had been his frequent experience during the quarter of a century he had been actively engaged in microscopical work.

Dr. Spitta said that seeing things with a direct solid cone was no doubt very much better and more to be relied upon than seeing them by oblique light. By means of a further diagram he showed that an object with large markings well seen by direct light appeared simply grey with oblique light. If the lens employed was a fine one and the lines were very fine they could be seen with oblique light, but if they were coarse they were lost sight of by virtue of their largeness.

Mr. J. M. Offord said that reference had been made to Mr. Merlin's eyesight. He could say that it was exceptionally good with the telescope, for when Mr. Merlin spent an evening with him and they were looking at the moon through his telescope, he found Mr. Merlin certainly saw minute details on the lunar surface which he himself had great difficulty in seeing even after they had been pointed out.

On the motion of the chairman hearty votes of thanks were accorded to Mr. Merlin for his paper, and to Dr. Spitta for reading and making his own valuable observations upon it.

Mr. C. F. Rousselet read a paper "On the specific characters of *Asplanchna intermedia*," which he illustrated by diagrams and by specimens exhibited under several microscopes.

Mr. Western said he looked upon this as a very valuable contribution to their knowledge of this genus, as there had always been great confusion as to these Asplanchnas. He had

had some correspondence with Dr. Hudson upon the subject, but was never able to get quite the information he wanted, because at the time he could never get sufficient specimens. He had no doubt found *A. intermedia*, and also *A. amphora*.

The Chairman said they could do no less than return their best thanks to Mr. Rousselet for this addition to his many very interesting communications. The thanks of the Club were then unanimously voted.

Announcements for the ensuing month were then made, and the meeting closed with the usual conversazione.

December 21st, 1900.—Ordinary Meeting.

A. D. Michael, Esq., F.L.S., Vice-President, in the Chair.

The minutes of the preceding meeting were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club: Mr. T. S. Beardsmore, Mr. William Campbell, Rev. Thomas Webster, and Rev. Henry Wadsworth.

The additions to the library were announced, and the thanks of the Club voted to the donors.

Mr. Karop called attention to a recent notice of the death of Mr. Samuel Highley, which had appeared in the newspapers. Like most press paragraphs, it was largely incorrect, and in referring to the deceased as "Dr." Samuel Highley it had certainly conferred a title upon him which he never possessed in life. It was, however, fitting that some notice should be taken of the death of one who was intimately connected with the Club in its early days, as one of its original members, and for some two years an active member of its Committee.

Mr. C. F. Rousselet said the members would no doubt recollect that some time ago Surgeon Gunson Thorpe described two new species of Rotifers from China. He had since found two species at Rangoon, which were the same as those previously found in the Yangtse Kiang. They were species of *Megalotrocha* which had not been exhibited before in England. He had much pleasure in showing them in the room that evening.

Mr. Rheinberg read a paper "On the Origin of certain Colour Phenomena typically shown by *Actinocyclus Ralfsii*," the subject being illustrated by diagrams explaining the author's idea as to the colours shown by the diatom *Actinocyclus Ralfsii* described by Mr. E. M. Nelson in his paper read before the Club on June 15th, 1900.

Mr. E. M. Nelson said he was extremely sorry that by dangling this colour before Mr. Rheinberg he had caused him such uneasiness; but he thought the members of the Club would all be glad that he did so, since it had been the means of bringing them a very excellent paper. His reason for mentioning the subject was that he had found this diatom to behave differently from other diatoms; but Mr. Rheinberg now told them that by putting a diaphragm over the objective other diatoms were also found to be coloured. The paper was obviously one which could not be fairly discussed without reading it; but he thought that when the thickness of the diatom was considered, together with the fact that diatom silex was so nearly the same as to its refractive index as Canada balsam, it was not at all easy to account for the effects seen. It seemed to him that the colours of diatoms differed from those of Newton's rings, and had a different origin. He should certainly try the experiment suggested, and he was glad Mr. Rheinberg had demonstrated that this colour existed in the case of other diatoms.

The Chairman said he was sure their thanks were due to Mr. Rheinberg for this paper, which was certainly one, as Mr. Nelson had said, which could only be discussed after reading it; indeed, he was not quite sure that he should feel able to discuss the questions raised even after reading it.

The thanks of the meeting were, on the motion of the Chairman, unanimously voted to Mr. Rheinberg for this communication.

Mr. Rheinberg said he should be very pleased to show any one the colours in other diatoms beside *Actinocyclus*, and, as already mentioned, he thought that the colour could not be due to diffraction. As regarded Newton's rings, he did not intend it to be understood that these phenomena were the same as those of Newton's rings, but rather that they were due to similar causes, as in this case the extinctions always recurred in the same order.

The Secretary reminded the members that at their next ordinary meeting it would be necessary to nominate members of the Committee for election at the annual meeting in February, and it would also be necessary to appoint some member to act as auditor on behalf of the Club.

January 18th, 1901.—Ordinary Meeting.

George Massee, Esq., F.L.S., President, in the Chair.

The minutes of the meeting of December 21st, 1900, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—Mr. T. A. Appleton, M.R.C.S., Mr. W. G. Campbell, Mr. A. H. W. Cleave, Mr. T. N. Cox, jun., Mr. T. J. Davis, Rev. R. Freeman, M.A., Mr. R. Paulson, Mr. P. E. Radley, F.R.M.S., Mr. J. Richardson, Mr. J. C. W. Shears, Mr. H. Sully, Mr. W. Wykes.

The donations to the Library were announced, and the thanks of the Club voted to the donors.

The Secretary reminded the members that their next meeting would be the Annual Meeting of the Club, at which the President and Officers for the ensuing year would be elected. He then read the list of nominations for officers, and asked the members present to nominate gentlemen to fill four vacancies on the Committee.

The following nominations were then made:—

Mr. Rheinberg, proposed by Mr. Curties, seconded by Mr. Dunning.

Mr. Soar, proposed by Mr. West, seconded by Mr. Bird.

Mr. E. T. Browne, proposed by Mr. Travis, seconded by Mr. Dineen.

Mr. Dadswell, proposed by Mr. Parsons, seconded by Mr. Soar.

Mr. J. M. Allen having been appointed Auditor on behalf of the Committee, the members were asked to elect another gentleman to act in that capacity with him.

Mr. W. J. Chapman was then proposed by Mr. Parsons, seconded by Mr. Taverner, and unanimously elected Auditor on behalf of the members.

Descriptions of two new Rotifers by Mr. F. R. Dixon-Nuttall and Mr. M. F. Dunlop were read by Mr. Scourfield.

Mr. Rousselet said that both the species described were exhibited under microscopes in the room that evening, and a specimen of one was presented to the cabinet of the Club.

Mr. Bryce thought that those who studied the Rotifera would be very much indebted to Mr. Dixon-Nuttall for his communication. He believed that the best work in this direction was only to be done by investigating a special group. Mr. Dixon-Nuttall had done this, and had supplied them with a very good key to the genus *Diaschiza.* Hudson and Gosse left the description of this genus in a very incomplete state, and though their work was of great value, it was by no means to be considered as final. He would strongly urge young students of the Rotifera to concentrate their attention upon one genus, as he felt sure that much more good would be done by this than by any amount of indiscriminate pond hunting.

The thanks of the Club were voted to the authors of these communications.

Mr. D. J. Scourfield read a paper by Mr. Kirkaldy, "On the Stridulating Organs of Water-bugs."

Mr. R. T. Lewis said he understood the writer of this paper to say that this was the only instance in which a genus was determined by reference to the stridulating organs. He thought, however, that there were some other examples in which these had been regarded as generic characters: the Pneumoridae for instance, were distinguished from other Orthoptera by the peculiar position of their organs of stridulation on the sides of the abdomen, with the counterpart on the femora of the third pair of legs.

Mr. Scourfield said that he did not think Mr. Kirkaldy wished it to be understood that the cases referred to in the paper were the first in which stridulating organs had been utilised for systematic purposes among insects generally, but simply that this was the first occasion upon which they had been so used in the group of the Rhynchota or Water-bugs.

The thanks of the Club were voted to the author of this paper and to Mr. Scourfield for reading it to the meeting.

Mr. D. J. Scourfield also read a paper on the Ephippium of *Bosmina.*

Mr. Karop asked if these ephippia and winter eggs were laid in the ordinary way, or if they were simply set free by the decomposition of the mother.

Mr. Scourfield said they were thrown off when the animals moulted, the mother surviving.

Mr. Soar read a paper on a new species of Water-mite, *Pionacercus pyriformis,* drawings of which were made upon the board in illustration.

The thanks of the Club were unanimously voted to Mr. Scourfield and Mr. Soar for their very interesting papers.

February 15th, 1901.—Annual Meeting.

George Massee, Esq., F.L.S., President, in the Chair.

The minutes of the meeting of January 18th were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—Mr. A. C. S. Bell, Mr. F. W. Eyre, Mr. F. W. Headley, Mr. L. E. Sexton, and Mr. W. Wesché.

The donations to the Library and Cabinet were announced, and the thanks of the Club unanimously voted to the donors.

Announcements of meetings, etc., for the ensuing month were then made, and the business of the Annual Meeting was proceeded with.

Mr. Johnson and Mr. Angus having been appointed by the President to act as scrutineers, the ballot for officers and committee for the ensuing year was taken. The following were subsequently declared by the President to be duly elected:—

President	George Massee, F.L.S.
Four Vice-Presidents	J. G. Waller, F.S.A. A. D. Michael, F.L.S., F.R.M.S. E. M. Nelson, F.R.M.S. The Rt. Hon. Sir Ford North, F.R.S.
Treasurer	H. Morland.
Secretary	G. C. Karop, M.R.C.S., F.R.M.S.
Foreign Secretary ...	C. Rousselet, F.R.M.S.
Reporter	R. T. Lewis, F.R.M.S.
Librarian	Alpheus Smith.
Curator	C. J. H. Sidwell, F.R.M.S.
Editor	D. J. Scourfield, F.R.M.S.
Four Members of Committee ...	E. T. Browne, B.A., F.R.M.S. E. Dadswell, F.R.M.S. C. D. Soar, F.R.M.S. J. Rheinberg, F.R.M.S.

The Secretary then read the thirty-fifth Annual Report.

The Treasurer presented the statement of accounts for the year 1900, and produced the balance sheet duly audited by Messrs. J. M. Allen and W. J. Chapman.

Mr. Hilton moved "that the Report and Balance Sheet now read be received and adopted." He thought these would be regarded as satisfactory, but would like to impress upon the members the necessity of increasing their numbers, so as to bring up the annual income from subscriptions to an amount sufficient to meet their general expenses without having, as their Treasurer had pointed out, to rely upon interest from investments and proceeds of advertisements to make up the deficiency. He also expressed a hope that more members would make an effort to attend and exhibit something of interest on the gossip nights.

The motion, having been seconded by Mr. Taverner, was put to the meeting by the President, and unanimously carried.

The President then gave the Annual Address—taking for his subject the general characters of the various classes of Fungi, which he illustrated by means of a large number of excellent lantern slides.

Mr. A. D. Michael, in moving "that the best thanks of the Society be given to the President for his admirable address," thought it was hardly necessary, after what they had heard and seen, for him to say much to commend this resolution to the members present; for when a man talked about something that he understood, and when in addition to this he had the resources of Kew Gardens at his command to provide him with materials in illustration, the result was sure to be something worth listening to. The members of the Club would doubtless agree with him that their thanks were very cordially due to the President on that occasion.

Mr. G. E. Mainland having seconded the motion, it was put to the meeting by Mr. Michael, and carried by acclamation.

The President thanked the members for the way in which they had listened to his remarks, and also for the cordial manner in which they had passed this vote of thanks. He only regretted that he appeared to be the only one in the Society who was at present interested in fungi, but he hoped that some one else would be found who would take the matter up. He could assure them that the study would prove most interesting, and he should be only too pleased to be allowed the opportunity of aiding any one who would take an interest in the subject.

A vote of thanks to the auditors and scrutineers was then proposed by Mr. Marshall, seconded by Mr. Neville, and unanimously carried.

Dr. Measures than moved "that the best thanks of the Club be given to the Officers and Committee for their work during the past year." He thought the general condition, as shown by the Report, would show how well their officers had done their part, and he was sure it must have afforded them great satisfaction to be able to lay such a statement before the members.

Mr. H. E. Freeman having seconded the motion, it was put to the meeting by the mover, and carried unanimously.

Mr. Morland, in responding for the officers of the Society, said they were very much obliged to the members for the very kind way in which their thanks had been given. It would of course be obvious that the work of a Society like the Quekett Club could not be carried out without a great deal of labour on the part of some one, but if they were encouraged by the appreciation of the members, he was sure their work would be a pleasure. They were only a small Society, with a very small subscription ; and therefore, if their expenses were to be met and their efficiency kept up, it was very desirable that they should obtain as many more members as possible—and of course members who would pay promptly.

Mr. Karop said he did not feel called upon to do more than second what Mr. Morland had said on behalf of the officers of the Club. As regarded himself, however, he might add that as he had been in office since 1883 he felt every year that a time was coming when it would be for the advantage of the Club that his work should be handed over to some younger and more energetic man to carry on. So long, however, as he retained the office he should always be pleased to do the best he could for the welfare of the Club.

OBJECTS EXHIBITED, WITH NOTES.

August 17th, 1900.

Mr. A. Earland: Sponges (Fresh-water) *Spongilla alba*, from Bombay, showing statoblasts in situ; (Hexactinellid) *Periphragella elisae*, from Japan, showing the "veil" of flesh spicules.

Mr. C. F. Rousselet: Mounted specimen of a very rare British Rotifer, *Notops clavulatus*, from Richmond Park.

October 5th, 1900.

Mr. C. Sidwell: Specimens, ♀♀, of *Scapholeberis mucronata* O. F. Müller, from Richmond Park, collected at Quekett excursion, September 29th, showing "ephippium" containing winter egg, also the modified setae on the flattened ventral margin, by which these animals cling to the surface film.

Mr. A. E. Hilton: Head of Sand Wasp, *Cerceris arenaria*, mounted without pressure, showing the organs of the mouth in their natural form and colour.

Mr. K. J. Marks: Epidermis of leaf of Mistletoe, showing stomata.

Mr. H. Morland: Frustules of *Rutilaria capitata* in chain, and side view of valve, from "Cementstein," Sendai, North Japan. As a rule the frustules fall asunder when treated with acids, leaving single valves of two opposite frustules still cohering by the centre connection.

October 19th, 1900.

Mr. R. T. Lewis: An undescribed species of Tick (*Ixodes*) found on a vole. Also Tick from Zebra, *Rhipicephalus marmoreus*, East Africa, remarkable for having scales instead of hairs.

Mr. A. E. Hilton: Leaf of a carnivorous plant, the Common Butterwort, *Pinguicula vulgaris*, showing the glandular hairs from which the adhesive fluid is exuded; mounted in glycerine.

NOVEMBER 16TH, 1900.

Mr. C. F. Rousselet: Three species of *Asplanchna*—viz., *A. amphora*, *A. brightwellii*, and *A. intermedia*, showing in each case the ♂, the ♀, and the jaws.

Mr. J. T. Holder: Kidney of Frog (bulk-stained borax carmine, and section-stained Ehrlich's haematoxylin), showing cortical and medullary portions, also the convoluted capillary blood-vessels (corpuscles of Malpighi).

DECEMBER 7TH, 1900.

Mr. A. J. French: Specimens of the rare male of *Bosmina longirostris*, also females with winter eggs, from Richmond Park. The antennules of the male, instead of being rigid, as in the female, are distinctly articulated to the head.

DECEMBER 21ST, 1900.

Mr. J. Rheinberg: Three exhibits showing the peculiar colour phenomena of *Actinocyclus Ralfsii*—(1) group of *A. Ralfsii* under a 1-inch objective, showing the distinctive colour phenomena by transmitted light; (2) *A. Ralfsii* under a $\frac{1}{6}$-inch objective by transmitted light; the diatom appears colourless, but by gradually closing the iris diaphragm *above* the objective the distinctive coloration shows itself, precisely as with the 1-inch objective; (3) *A. Ralfsii* under a $\frac{1}{6}$-inch objective by transmitted light; the diffraction spectra can be viewed by placing the small wooden arrangement (see p. 63) over the cap of the eyepiece: the direct central or dioptric beam is seen to be coloured.

JANUARY 4TH, 1901.

Mr. C. F. Rousselet: A young specimen of *Cristatella mucedo*, hatched from one of the statoblasts found at the Club's excursion to the East London Waterworks on October 6th last. A solid mass of these statoblasts, consisting of many thousands, was exhibited by Mr. Scourfield at the meeting on October 19th.

Mr. J. T. Holder: Section through snout of Foetal Rabbit showing nasal cavities, etc.

Mr. F. E. Filer: Longitudinal section through flower-bud of Spurge Laurel, *Daphne laureola*, showing ovule, etc.; and karyokinesis in cells in wall of ovary.

Mr. A. E. Hilton: Head of Wild Bee, *Andrena*, showing the organs of the mouth in their natural form and colour. Mounted in glycerine, without pressure.

Mr. J. B. Scriven: Two slides showing (1) Cephalic and thoracic ganglia of the Blow Fly. Pupa ten days old. The optic nerve shown, and also the cephalo-thoracic nerve joining the two ganglia. (2) Transverse section of cephalic ganglion of Blow Fly. Pupa five days old.

Mr. A. J. French: Mounted specimens of the largest British Daphnia, *D. magna* (= *D. schaefferi* Baird) ♂ and ♀; also an ephippial ♀ of the same species.

Mr. F. A. O'Donohoe: The suctorial ducts of the Blow Fly; to show these open channels clearly, all the subjacent tissue has been removed, and they are mounted without pressure in Canada balsam.

Mr. H. Morland: *Brightwellia elaborata*, Grev., from Oamaru deposit, New Zealand. Catalogued by Grove and Sturt in their Oamaru diatoms as *B. pulchra*, Grun., but Herr Grunow doubts if this form can be differentiated from *B. elaborata*. First found in the Barbadoes deposit in 1861, and Dr. Greville then notes that he could never find perfect forms, the edges of the valves being always broken, more or less. I myself have found it a very fragile form, but I have come across many perfect specimens.

January 18th, 1901.

Mr. J. Rheinberg: An arrangement for viewing the colours of thin films (Newton's Rings). By pressing together two pieces of plate glass, Newton's Rings are formed by the intervening film of air. By the device shown, the light is reflected from the right half of the ring system, and transmitted by the other half. Thus the reflected and transmitted colours are shown together in juxtaposition. In this way it is demonstrated that the sequence of colour is the same in both cases, but that the visible colours of the reflected series start half a wave-length before the others. The colours of the rings which are in juxtaposition are approximately complementary. The colours show the same sequence as those of the interference colours of *Actinocyclus Ralfsii* and other diatoms, which are due to an analogous principle known as "the colours of mixed plates." The rings shown are projected into the object plane by a 1-inch objective used as condenser, and magnified a few times by viewing with another 1-inch objective and B eyepiece.

Mr. A. E. Hilton: Head of Sand Wasp, *Miscus campestris*, showing the organs of the mouth in their natural form and colour. Mounted in glycerine, without pressure.

February 1st, 1901.

Mr. T. A. O'Donohoe: Three Proboscides of Flies; (1) the head and tongue of a House Fly with the lobes fully expanded, seen from the front. (2) The tongue of a Blow Fly shown with expanded lobes, but seen in profile; and (3) the tongue of a Blow Fly with its lobes closed and seen in profile. These were mounted without pressure in glycerine ten years ago, and are sufficiently transparent to show the bundles of *voluntary* muscles by which they perform their functions.

Mr. A. E. Hilton: Head of Thistle Bee, *Sphecodes*, showing the organs of the mouth in their natural form and colour. Mounted in glycerine.

Mr. A. Earland: Foraminifera, from Coral Mud, Timor Sea, N. of Australia, 50 fathoms. Many of the forms recently described by Mr. Millet in the *Journal R.M.S.* occur in this gathering.

Mr. H. Morland: Valves, frustule, and halved valve on edge of *Anthodiscus floreatus*, Gr. and St. From Oamaru, New Zealand. The halved valve shows the manner in which the sides of the valve and top are strengthened at their junction by bracket or corner-pieces.

Mr. J. B. Scriven: Two stages in the development of the ovary of the Blow Fly. (1) Pupa condition near maturity; ovum made up of imperfectly formed cells; (2) Ovary of imago; cells and nuclei distinct.

February 15th, 1901.

Mr. J. T. Holder: Vertical section through the snout of Foetal Rabbit showing developing jaw, nasal septum and olfactory capsules, tongue, upper and lower incisors, muscle with elongated nuclei, etc.

THIRTY-FIFTH ANNUAL REPORT.

Taking into consideration the circumstances of a very eventful period, your Committee is happy to present, on the whole, a favourable report to the Club.

During the year 1900, twenty-six new members were elected, a number slightly below the last decennial average ; seventeen have resigned, three were removed for non-payment of subscription, and seven have been lost by death. The total on the list up to December 31st last was 340.

Beyond the decease of actual members there has occurred another—to wit, Mr. Samuel Highley, who, although he had long ago severed all connection with the Club, was one of the original twelve enrolled. See "Early Memories of the Q.M.C.," by Dr. M. C. Cooke, *Journ. Q.M.C.*, Vol. VII., No. 45, Nov. 1899.

The attendances at the meetings have been fully maintained, whilst the matter submitted on the ordinary business nights was varied in character and of excellent quality.

The following is a list of the more important communications :—

Jan.	On some Australian Lacinulariae ...	Mr. Rousselet.
,,	On the Minute Structure of some Diatomaceae from Corica Bay	Mr. Merlin.
Feb.	The President's Address	Dr. Tatham.
Mar.	On the Tracheae of Insects, etc. ...	Mr. Merlin.
April.	Anatomy of *Dicranotaenia coronula* ...	Mr. Rosseter.
,,	Imitation of Polarisation Effects by Diffraction	Mr. Rheinberg.

May.	On some new British Fungi	Mr. Salmon.
June.	On *Actinocyclus Ralfsii*	Mr. Nelson.
,,	Contribution to Life-History of *Ixodes reduvius* L.	Mr. Lewis.
,,	On Structure in Bacillus of the Bubonic Plague	Mr. Merlin.
Oct.	On a Stigmatic Organ in *Ornithodorus megnini* and on *Ixodes tenuirostris* ...	Messrs. Lewis & Wheler.
,,	The Swimming Peculiarities of *Daphnia*, etc.	Mr. Scourfield.
Nov.	On Resolution of *A. pellucida* by Dry Lenses	Mr. Merlin.
,,	On *Asplanchna intermedia*	Mr. Rousselet.
Dec.	The Origin of a certain Class of Colour Phenomena typically shown by *Actinocyclus Ralfsii*	Mr. Rheinberg.

Some further short notes, descriptions of instruments or apparatus, and so forth, will be found in the Proceedings.

At the March meeting Mr. J. T. Holder gave an exhibition of a large number of photo-micrographs with the lantern, which, with the specimens themselves, were entirely his own work.

The Committee, on behalf of the Club, desires to thank the several authors of papers and exhibitors for their successful efforts in rendering the meetings both instructive and interesting.

There appears to be some falling off in the exhibition of objects on the gossip nights. This is a matter of regret to your Committee; and it may be permitted to point out that a slide which the owner regards as old or of little interest to himself may be quite the opposite to another, or shown in a different manner, and so on. Excellent portable microscopes, equal to any requirements, are now procurable, and it is to be hoped that members will put themselves to a little extra trouble for the general benefit and pleasure of all.

The following books, periodicals, and transactions of various societies, etc., have been added to the Library since the last Report:—

"British Moss Flora" (Dr. Braithwaite), part 20.
"The Mycetozoa" (Sir Edward Fry).
"Smithsonian Report for 1897."
"Protozoa of Lake Erie."
"American Hydroids," part 7.
"Fishes of North and Middle America."
"Synopsis of American Wasps" (Saussure).
"Index to the Foraminifera" (Sherborn).
"Catalogue of North American Diptera" (Osten Sacken).
"The Lucernaria" (W. J. Clark).
"Journal of the Royal Microscopical Society."
"Proceedings of the Royal Society."
"La Nuova Notarisia."
"American Botanical Gazette."
"Journal of Applied Microscopy."
"Proceedings of the Academy of Natural Science of Philadelphia."
"Proceedings of the Geologists' Association."
"British Annelids," part 2, Ray Society.
"Quarterly Journal of Microscopical Science."
"Annals and Magazine of Natural History."

The question of storage room, so often referred to, seems to be as far from solution as ever; but until some way out of the difficulty is found, it will be almost impossible for the Librarian to draw up a new Catalogue, which is greatly required, the latest list dating from 1883.

Although no important addition has recently been made to the Cabinet, the whole collection has been arranged and catalogued by the Curator, with the assistance of Mr. C. Turner and others. Having completed this somewhat irksome and lengthy task, Mr. Browne has found it necessary to resign the Curatorship, which he has held with conspicuous success for some six years. The Committee begs to tender him its warmest thanks for the services he has rendered to the Club during this period, and also to those gentlemen who were associated with him in his labours.

In nominating Mr. Sidwell for the office, the Committee has the fullest assurance that he will maintain the collections handed over in such good order by his predecessor.

It may be mentioned here that the specimens in the Cabinets now number about six thousand, but the retiring Curator reports that several groups in the animal kingdom are scarcely represented, and also that many of the anatomical preparations are of historical rather than scientific interest, having been made before the advent of the microtome and modern methods of staining. Here is an opportunity for such members as may possess the necessary material, appliances and skill, to fill up existing gaps or replace specimens which are no longer worth preservation.

The Journal has been issued with regularity, and the latest number completes Vol. VII. of the second series. Small, but noticeable improvements continue to be made by the Editor ; and the summary of contents of each part, with a list of the plates and illustrations, will greatly facilitate reference.

A careful scrutiny of the finances will show that, apart from the sale of the Journal and receipts accruing from advertisements therein, our expenditure is perilously near the amount of our receipts.

The fact must be faced, that, considering the very inadequate subscription, our membership is at present too small to be self-supporting, even if all pay—which unfortunately is not the case.

Active endeavour, therefore, should be made to remedy this state of things, and the enrolment of new paying members is of primary importance. The Committee proposes issuing a card setting forth the objects and advantages of the Club, which will be distributed as widely as possible, and existing members are earnestly desired to further this laudable effort by securing fresh adherents among their friends and acquaintances.*

The Committee desires to most cordially thank the officers of the Club for their services.

Finally, your Committee has every confidence in the vitality and continued prosperity of the Club, always provided that every individual member will consider it a duty to do all in his power to promote its welfare in the new century.

* The card referred to has now been issued. Copies may be obtained at any of the Club's meetings, or by post upon application to the Secretary.

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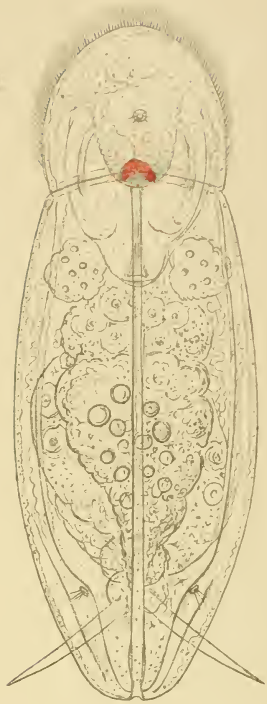

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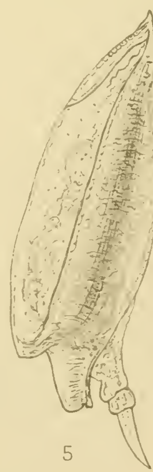

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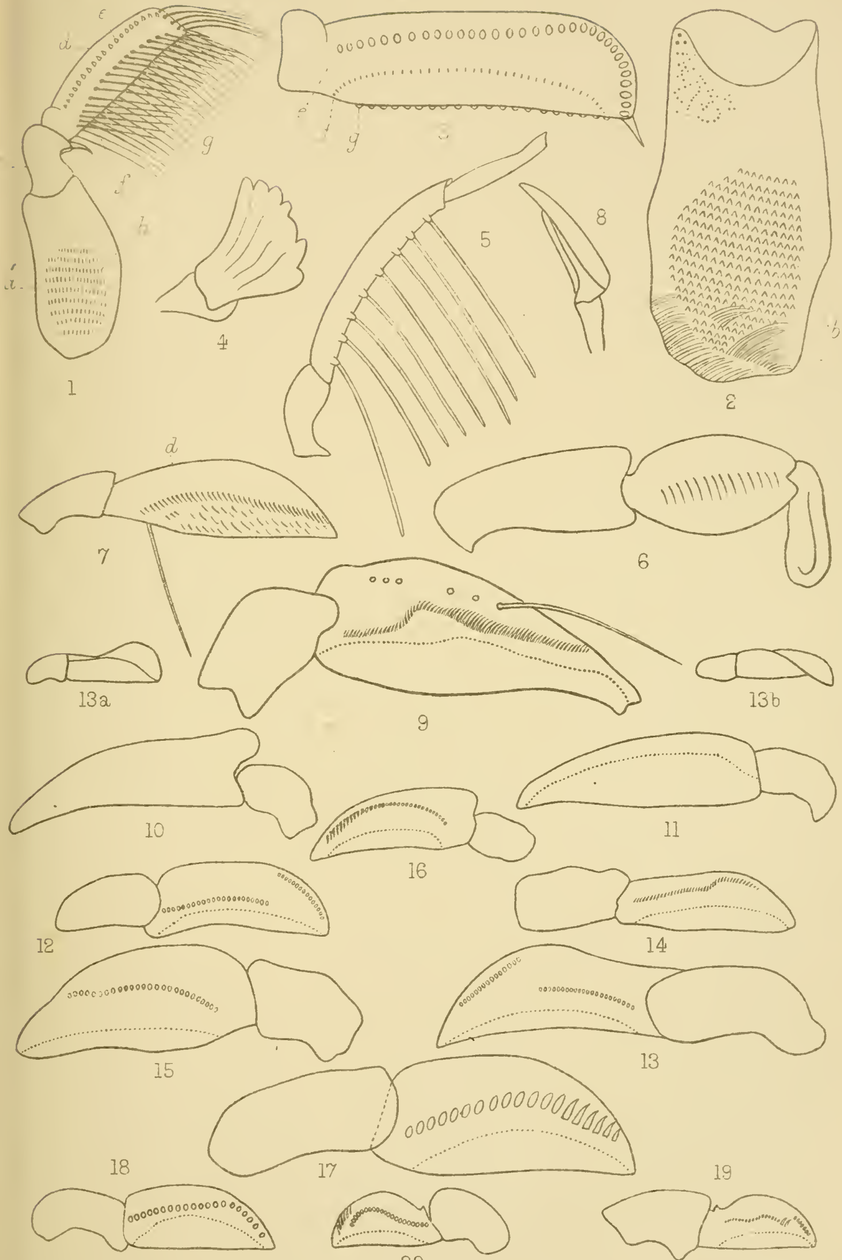
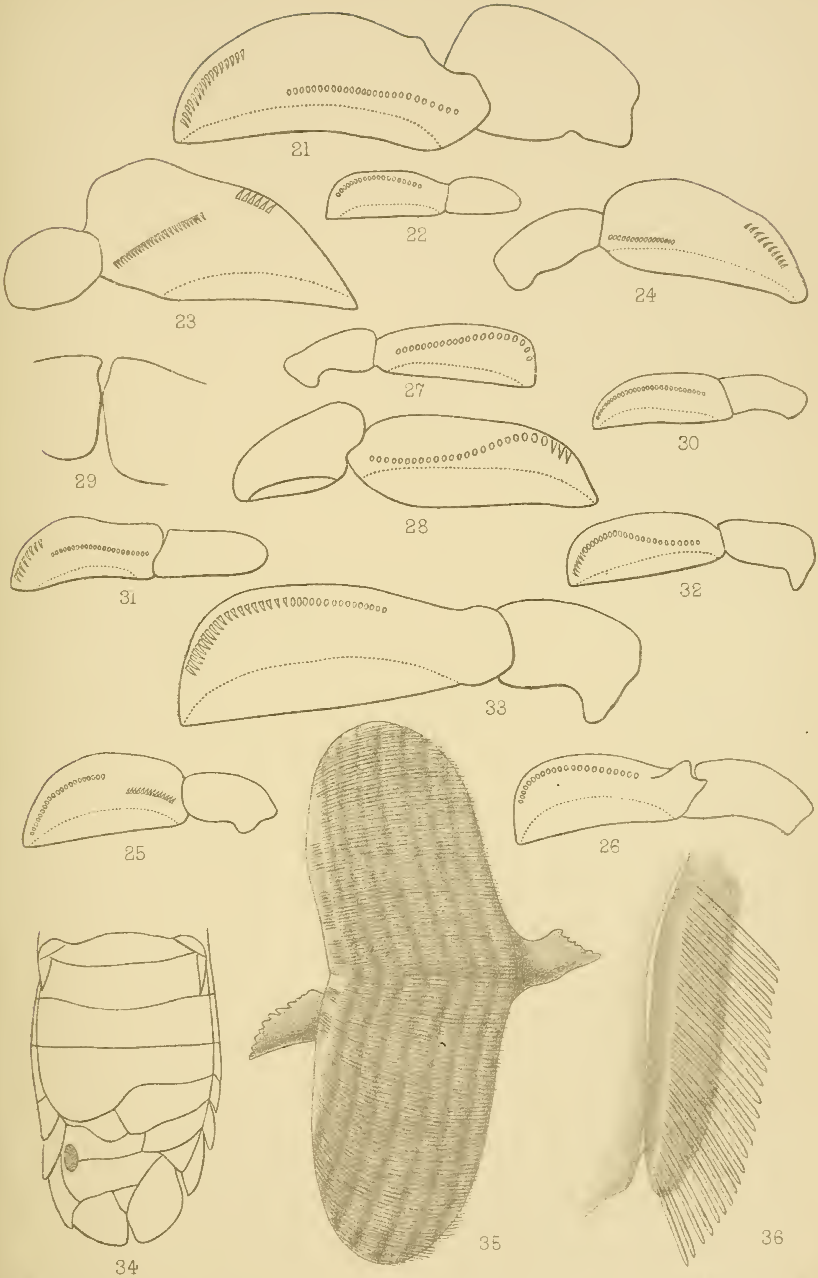
F.R.Dixon-Nuttall del. ad nat. West, Newman lith

Diaschiza ventripes n. sp.
Cathypna ligona n. sp.



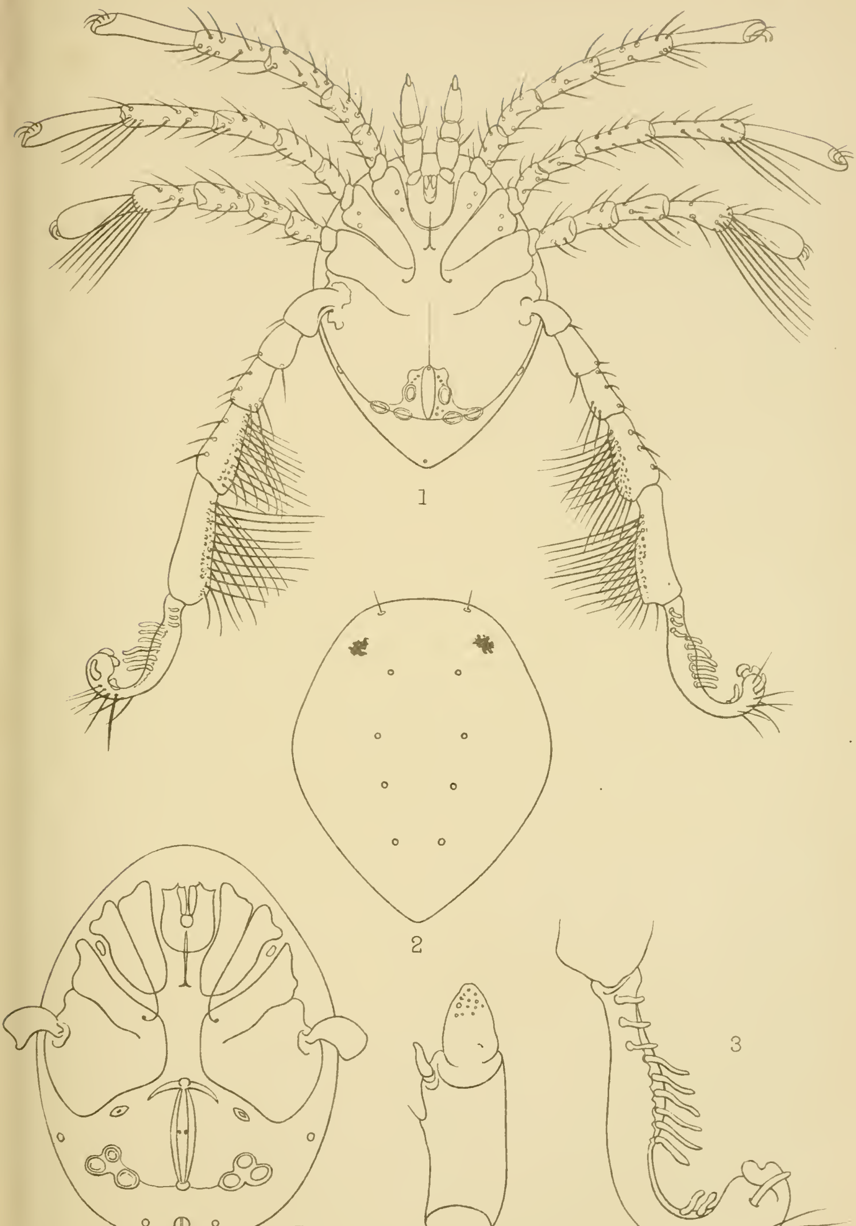
G.W.K. del. West, Newman lith.

Stridulating Organs of Aquatic Rhynchota.



G. W. K. del West, Newman lith.

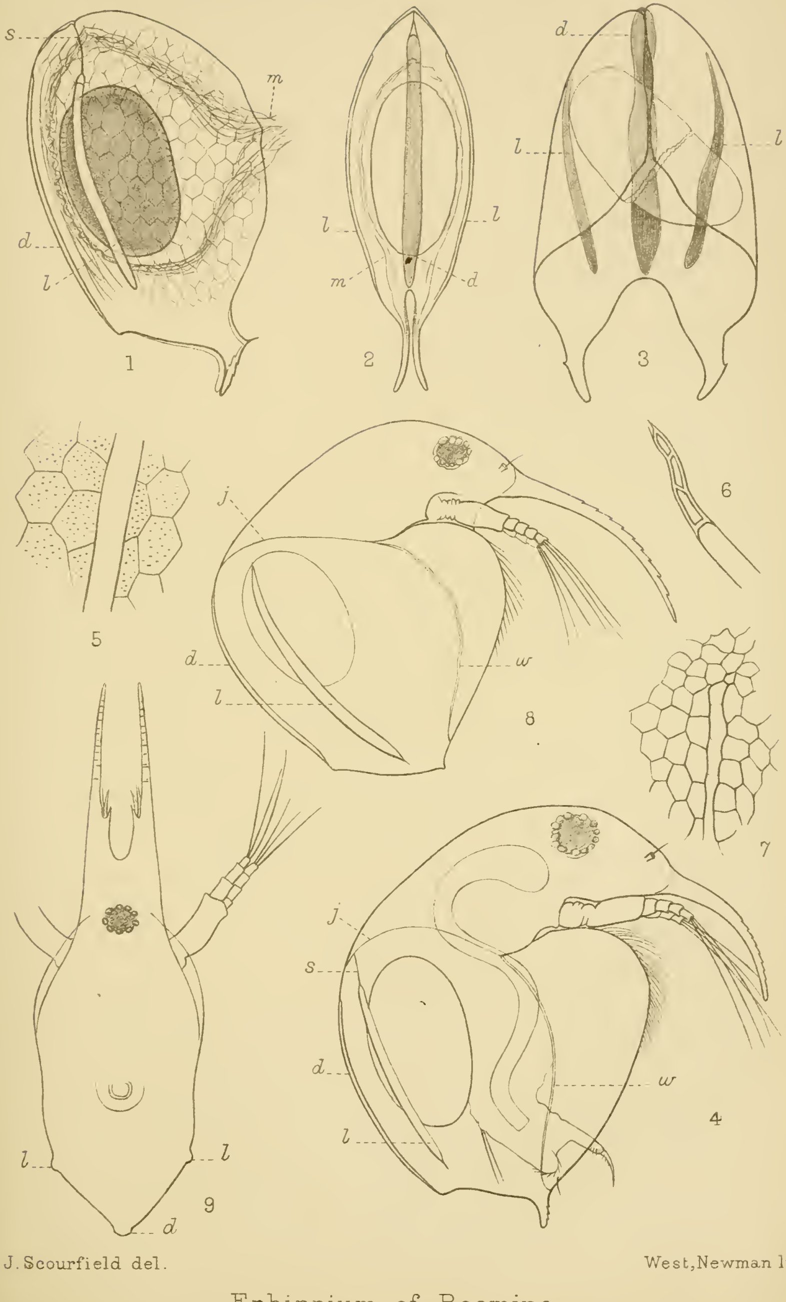
Stridulating Organs of Aquatic Rhynchota



Chas. D Soar del.

West, Newman lith.

Pionacercus pyriformis. n. sp.



D. J. Scourfield del. West, Newman lith.

Ephippium of Bosmina.

Images of Diatom Structure.

By W. Balfour Stokes.

(*Read April 19th*, 1901.)

The advantage of using a wide solid axial cone of illumination lies mainly in the blotting out of those perplexing and numerous interference effects so apparent when a narrow or oblique beam of light is employed.

With a wide cone, therefore, difficulties of interpretation are greatly reduced; but with many objects we may still have two images, from which we must select the true one. It is easier, however, to select from two than from a dozen.

A simple diatomic structure, for instance, if examined by means of a narrow or oblique beam of light, will present, at different focal positions, many images or effects, not one of which can be called trustworthy; but with a wide solid axial cone we obtain two images only, totally opposite in appearance and at different focal positions, but both of which are conceivably trustworthy representations of the only possible reality.

These two last images I will describe as follows:

		Silex.	*Edges and perforations.*
Upper focus	...	dark	bright.
Lower focus	...	bright	dark.

The upper image is usually known as the "white dot" image, diatom perforations appearing as white dots.

The lower image is known as the "black dot" image, diatom perforations appearing as black dots.

The question is: Which is the true image? A diversity of opinion seems to exist.

Most microscopists would, I think, select the "white dot" image, but Mr. Nelson prefers the "black dot," while Mr. Comber suggests that the true image should lie between the two.

The "white dot" image would be preferred by many because, with directly transmitted light, one naturally expects a perforation to appear brighter than the substance surrounding it; and I would point out that opaque materials present in this image the only appearance one would expect, viz. black.

Mr. Nelson preferred the "black dot" image because he was able to see fine differences and minute details in individual "black dots" of *Pleurosigma formosum*, which were quite invisible at any other focus.

I do not know Mr. Comber's reasons for regarding the true image to exist between the "black" and "white dot" images.

The true image, if it exists, must lie at the true focus. But if we divide our objective into zones, may not spherical aberration allow, within limits, a true focus to each zone?

Now, the conditions under which the "black" and "white dot" images are seen as separate and distinct entities are those in which the objective is divided into zones.

When an axial cone is used the objective is divided into two concentric zones, the central zone occupied mainly by directly transmitted light, the peripheral zone occupied only by indirectly transmitted (diffracted) light.

An annular cone (full cone and a central stop in the condenser) also divides the objective into two zones; but in this case the diffracted light occupies the central, the directly transmitted light the peripheral zone of the objective.

A "half-way" annular cone (a two-thirds cone with a central stop half the size of the diaphragm opening) divides the objective into three zones, of which the central and peripheral zones are occupied by diffracted light only, and the intermediate zone is occupied by direct light.

Examine an ordinary balsam-mounted diatom (not a *Pleurosigma*) by these three methods, and, when focussing down, you will find the positions of the "black dot" and "white dot" images to be as follows:

Axial cone	"white dot." "black dot."
Full annulus	"black dot." "white dot."
Two thirds annulus ...	"black dot." "white dot." "black dot."

There is, as the last method shows, an image for each zone of the objective, and on examining the results we see that apparently the " white dot " image is formed by the direct light, and the " black dot " is formed by diffracted light.

What would be the real effect of spherical aberration ? I have been told that most objectives are spherically under-corrected. If this be so, the foregoing suggestion is strongly supported : for one must bring an under-corrected objective nearer to the object in order to utilise the periphery of the lens. Compare this with our three previous experiments, and agreement will be found.

To return to our question : Which is the true image? Let us deal with Mr. Nelson's deductions from the examination of *Pleurosigma formosum*. This diatom differs from the majority of diatoms in this respect : When an axial cone is employed the "black dot" image is above the "white dot," the very reverse of what occurs with the great majority of diatoms. This, in my opinion, points to a difference or peculiarity in the structure of *P. formosum*.

I suggest that the perforations of this diatom are more or less silted up with foreign material. When the late Mr. C. Haughton Gill charged the minute perforations in diatom valves with opaque metallic sulphides, the " white dot " image of the perforations was changed to a " black dot " and the " black dot " to a " white dot " ; but no such changes took place in the appearances of *P. formosum*, the " black dot " image being merely intensified. Does not this point to the probability of the correctness of my suggestion—viz. that the perforations of this diatom were already filled up?

Again, the difficulty in getting an image of a " postage stamp " fracture through the perforations of this diatom was thought by Mr. T. F. Smith to be due to the existence of a layer of beaded structure, which would present the appearance of circles bulging outwards ; but I imagine that the clinging of any silting-up material to the broken-into openings would account satisfactorily for such appearances.

The minute appearances which Mr. Nelson discovered *within* the black dots of this diatom may be considered, not as pieces of silex or other material, but as irregular openings through the silted-up perforations. They are bright at the upper focus and dark at the lower focus when an axial cone is employed ; that is to say, they behave as do the images of ordinary diatomic perforations.

Pleurosigma formosum is either optically or structurally peculiar. I cannot imagine the former, so I suggest the latter. The possibility of the former would raise doubts as to whether the microscope were at all a reliable instrument; but my suggestion that *P. formosum* has its perforations silted up explains all former difficulties in the interpretation of the images of this diatom, and, besides, makes the exception confirm a method for the interpretation of such images as we are considering. And what is that method? It is a comparison of the relative positions and appearances of the images of unknown structures with those of the images of known structures.

For instance, assume the under-corrected objective and the axial cone, and we notice that clear diatomic perforations, fractures, grooves, etc., are bright at the upper focus and dark at the lower focus; while the silex, ribs and thickenings of silex especially, are dark at the upper focus and bright at the lower focus. You may have a peculiar line on a siliceous valve to interpret. According to the rule, if it be bright above and dark below, it is a fracture, groove, or tube; if it be dark above and bright below, it is a rib or other increase in thickness. I believe this rule to be applicable to all objects examined under these conditions.

But which, after all, is the true image? The answer must await a definition of a true image. If an image be only true when it has some macroscopic analogy, then only the "white dot" image is true. If, however, an image be true when it leads to a truthful interpretation of structure, then the "black dot" image is also true. Both images, in fact, agree in contour and detail with the object—that is, as far as aperture diffraction effects will permit.

The Black and White Dot Phenomenon.

By J. Rheinberg, F.R.M.S.

(*Read April 19th*, 1901).

The origin of the black and white dot phenomenon in diatoms, when the focus is adjusted to different shades, arises, I believe, primarily from the fact that the perforations in a diatom form approximately vertical partitions between two media differing in refractive index. Wherever two media of unlike refractive index form a vertical wall or boundary upon which a cone of light impinges from below, a solid area on both sides of the plane of partition is filled with darkness. This comes about as follows. A certain portion of the light which impinges on the partition from the side of the denser medium is not refracted through it; instead of this it is reflected, just as if the vertical wall were an ordinary mirror. The light which behaves in this way is that which reaches the plane of partition beyond the "critical angle." In consequence hereof darkness is brought about on the less dense side of the partition, in the space where the light has been unable to get through from the side of greater density. And darkness is also brought about on the denser side of the partition because throughout the whole of a certain solid space a direct and a reflected wave-stream, emanating from the same points of the light source, meet in opposite phase.

A few diagrams, drawn exactly according to the laws of refraction, will make the above explanations more clear. In Figs. 1-3 the diatom is denser than the imbedding medium; in 4-6 the imbedding medium has the higher refractive index; and the cases represented are—where light impinges on a diatom

(Figs. 1 and 4) at an angle less than the critical angle

(„ 2 and 5) at the critical angle;

(„ 3 and 6) at an angle greater than the critical angle.

In all these diagrams the closely shaded portion (when uncrossed by other lines) shows where no light has been able to get through, and it will be seen that no light reaches a space in the upper-surface plane of the diatom just at or near one of the edges of the vertical walls forming the partition.

It will further be observed in Figs. 1 and 2, and also in Figs. 4 and 5, that the rays which impinge on to one of the vertical partitions are thrown back upon themselves. A change of phase occurs where they are then reflected, and if we take any point where one of these rays meets one of the unreflected rays, we find the two have travelled the same length of path, and, being now in opposite phase, they cancel one another and produce

Fig 1

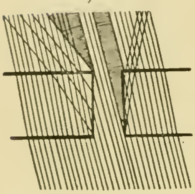


Fig 2

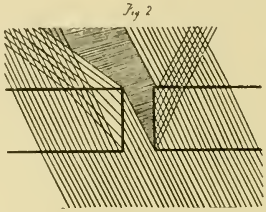


Fig 3

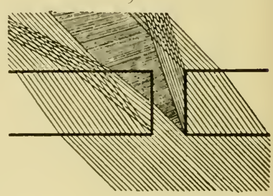


Fig 4

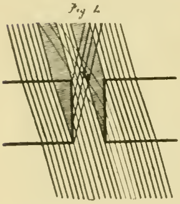


Fig 5

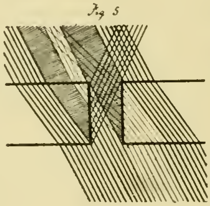
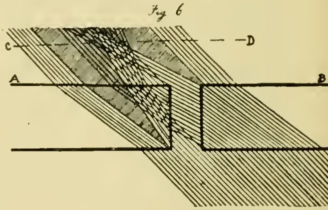


Fig 6



darkness. Thus darkness is formed in the surface plane of the diatom both sides of the partition, though due to different causes in the two cases.*

We have got, in fact, two bands of darkness, which issue upwards at an angle to each other from the horizontal plane in which the top of the vertical partition lies. In the case of

* To obtain the complete result of a cone of light impinging on the diatom, the three figures, 1, 2, and 3, or 4, 5, and 6, must be superposed. The relative amounts of light and darkness at various points on or above the surface plane of the diatom can in this way be estimated. Of course, where the rays are crossing each other in any place, great care must be taken to note whether one set has or has not suffered total reflection, because the change of phase accompanying this wholly alters the result.

a diatom which is studded with perforations, in other words with vertical partitions, we get an immense number of the bands parallel to each other in each of the two directions, forming a sort of trellis-work of light and darkness (Fig. 7). And as sections of trellis-work taken one below the other would show alternately light and dark spaces, so do the diatoms when the focus is adjusted to different planes. One great point must here be borne in mind. We cannot *really* see any plane of the diatom below that of its upper surface, although we may slightly rack down the objective. Imagine for a moment a perfectly free space below the upper surface of the diatom. Then if the objective were racked down we should simply see the state of light into which the rays proceeding upwards from the upper surface of the diatom would form themselves, if they were continued downwards as far as the plane on which the objective is focussed. And that is precisely what we see, although the diatom has not been removed. In like manner, if we rack the objective up so as to focus on a slightly higher plane than the surface of the diatom, we may still see markings, though they are fictitious and merely represent the result in that plane from the bands issuing from the actual surface of the diatom.

To fix our ideas, we might take Fig. 6 and cover up with a piece of white paper everything below the line A B. If now we prolonged all the rays above this line downwards, the resulting configuration would be quite different to the pattern covered up. And yet it is the former and not the latter which would correspond to the image observed in the microscope when racked down to focus below the plane of A B. And if racked up to focus on a plane above A B, as for example C D, light and darkness would be seen as indicated in Fig. 6 in the plane of C D, which varies greatly from the distribution of light and darkness in the plane A B.

This brings us to a very curious matter. Seeing that the only planes which can really be seen are the upper surface of the diatom or planes above it, it would seem natural that we should and ought to focus our objective on the upper surface plane exactly. But as a matter of fact my experiments so far have led to the conclusion that we focus slightly below that plane, and furthermore that the image we thereby get is actually a truer image of the surface plane than if we focussed exactly upon it. The reasons are that the black spots get more concentrated if the bands are prolonged slightly below the surface plane, and so become rather more distinct and sharp. Distinctness and sharpness is what the eye unconsciously makes for. At the surface plane the dark spots are larger than the perforations, because they form an outside as well as an inside ring; slightly lower down they overlap and do not cover an area quite so large, thereby conforming more nearly to the real diameter of the perforations.

This again is more simply explained by a diagram. Let Fig. 7 represent bands crossing each other at an angle. A reference to Figs. 1 and 2 will show that the position of the upper-surface plane of a diatom would be correctly shown by the line A B, and that *e g* and *f h* might be taken as the two walls which

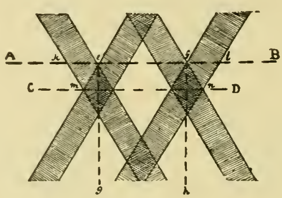


FIG. 7.

a vertical section of a perforation shows. But it is in the plane C D, slightly below A B, where the greatest overlapping and consequent concentration of darkness (or light) occurs, and which would appear most distinct. And the distance *m n* in this plane corresponds more nearly to the real size *e f* of the opening than does *k l* in the plane A B.*

It will already have been gathered from this paper that the black dot represents the best image. There is no doubt to my mind that this is in the great majority of cases correct. The statement is qualified, however; because from numerous diagrams which I have made following out the passage of the light through

* As a section of a perforation shows two walls, we have four bands issuing from each perforation; but the opposite walls of the perforations are mostly so close together that the bands overlap and appear as two only. For this reason the black dots have no white centre, as Fig. 7 might seem to show.

perforations, it appears that circumstances may occur where the surface of the perforation would be white.* It would necessitate certain special relationships between the depth and the breadth of the perforations. I have not worked this matter fully out yet.

Mr. Nelson pointed out in a paper a few years ago before the Bristol Naturalists' Society ("Proceedings," Vol. VIII., Part II., 1896-7) that the visibility of the black and white dot depends on the aperture of the objective, because the greater the aperture the easier it is to obtain a black dot, and that if the aperture is very small indeed only a white dot is obtainable. This admits of explanation on my theory. For as all the rays beyond the "critical angle" for the diatom and the medium in which it lies help to form the black dot, as soon as the aperture of the objective is cut down beyond a certain point, more and more of these rays get cut off, till at last we have the limiting case where the aperture is so small that practically only a parallel beam of light is allowed to pass upwards, and this light simply passes straight through the diatom perforations and the diatom silex, without any chance of reflection from the sides occurring at all, and therefore no black dot can come about.

It is instructive to note that different effects will be produced according to the different media in which the objects are mounted, since the critical angle for diatom silex and various media varies very greatly. The reason why, for example, *P. angulatum* with a $\frac{1}{6}$th objective can best be resolved in air, is dependent on this.

Another thing which helps to prove the theory is that the position which the black and white dots take up are not the same. Careful examination will show that the rows of white dots occupy intermediate positions to those which the black dots previously occupied. The explanation of this involves the action of cones of light on the perforations, and cannot readily be shown by diagrams.

Finally, I should like to say that it must not be imagined that my explanations pretend to anything else than to give a general idea of the cause of the phenomenon. I am fully aware of their incompleteness. For one thing, I have only dwelt upon the formation of the black dots, and not shown how by the super-

* This refers to ordinary illumination, and not to the special case mentioned below.

position of two wave-streams in the same direction the white dots become brighter than the diatom substance. I have spoken of trellis-work as if the light issued in parallel beams of equal intensity throughout, whereas actually cones of light of different intensities in different directions are formed. I have scarcely touched on the differences which ensue according to whether the diatom is imbedded in a medium of higher or less refractive index than itself, and what differences the spacing of the perforations, their thickness and their diameter, causes. All these things can be worked out easily enough, and I am hopeful that some interesting results as to the best mounting media will be obtained by pursuing the subject further.

The Laboulbeniaceae, a New Family of Fungi.

By George Massee, F.L.S.

(*Read May 17th*, 1901.)

It may be truly said that during the past twenty years, notwithstanding the very large amount of valuable work produced in the United States of America on botanical subjects generally, those portions dealing with the Fungi and Myxogastres are in many instances of an exceptionally high order of merit, and at the present day there are undoubtedly a greater number of mycologists resident in the United States than in any other country in the world. The reason for this is not far to seek; each of the numerous experiment stations under the direction of the Board of Agriculture requires that one member of its staff shall be an expert in the important science of vegetable pathology, and this of course implies not only a sound knowledge of mycology, but, in addition, the ability to conduct original research.

The object of this paper is to call attention to a very interesting group of fungi, for a knowledge of which we are almost entirely indebted to the researches of Dr. Roland Thaxter, Assistant Professor of Cryptogamic Botany at Harvard University, U.S.A.

Dr. Thaxter's pets, constituting collectively the family Laboulbeniaceae, are individually always minute, measuring, as a rule, less than one millimetre in length, and are remarkable in one respect—that of being external parasites on living insects of various orders, Coleoptera, more especially aquatic forms, being mostly victimised, although these parasites are not wanting on members of other groups of insects; they also occur sparingly on white ants and acarids. The general appearance of these fungi is described by Thaxter as follows. "When examined *in situ* on the host insect they appear in general like minute, usually dark-coloured or yellowish bristles or bushy hairs, projecting from its chitinous integument, either singly or in pairs, more commonly scattered, but often densely crowded over certain areas, on which they form a furry coating."

The members of the Laboulbeniaceae differ from other groups of fungi that are parasitic on insects, in not exercising any injurious influence on their host.

The members of the Laboulbeniaceae were first recognised as members of the vegetable kingdom by Robin, a Frenchman; but until Thaxter commenced his investigations only about half a dozen species were known, and these were imperfectly

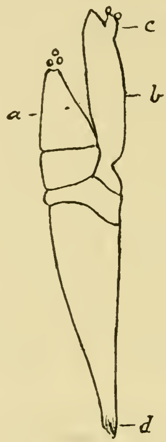


Fig. 1.

Camptomyces melanopus Thaxt. *a*. Antheridium with antherozoids escaping. *b*. Ascophore. *c*. Trichogyne with antherozoids attached. *d*. Point of attachment to host. Highly magnified. (After Thaxter)

understood. Thaxter's beautifully illustrated work on the group, entitled "Contributions towards a Monograph of the Laboulbeniaceae," forms Vol. XII. No. 3 of the "Memoirs of the American Academy of Arts and Sciences," 1896, and deals with the morphology, life-history, systematic arrangement, and geographical distribution of the species. The number of species described is 158, included among 30 genera; and at the present day these numbers are nearly doubled, and the author is at work on a complete monograph of the group. The variety of form and structure presented by these minute organisms is remarkable, but the point of greatest interest is the sexual mode of reproduction, which in all important features agrees with that met with in the Florideae or red sea-weeds. The female organ is furnished with a slender projecting thread, or trichogyne, to which the immotile antheridia are conveyed by water. After fertilisation is effected the carpogenic cell gives origin to asci, enclosing spores, as in other ascigerous fungi. A second point

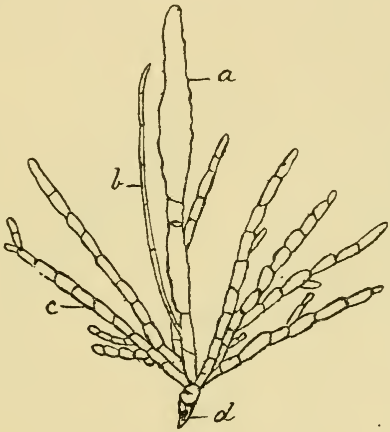


Fig. 2.

Compsomyces verticillatus Thaxt. *a*. Ascophore. *b*. Trichogyne. *c*. Antheridial branches. *d*. Point of attachment to host. Highly magnified. (After Thaxter).

of agreement between the Florideae and the Laboulbeniaceae is the very distinctly marked continuity of protoplasm between adjacent cells. This unbroken continuity of protoplasm is general throughout the vegetable kingdom, but is often very difficult to demonstrate, and is nowhere so conspicuous as in the two families enumerated above.

Some of the species of the Laboulbeniaceae bear male and female organs on the same individual, and in such instances self-fertilisation takes place. Others again are unisexual, and in such cases the spores produced by the female plant are held together in pairs by mucus. One of these spores gives origin to a male and the other to a female plant, and as the pairs of spores adhere together and grow up side by side, fertilisation is secured, which but for this remarkable arrangement would be somewhat uncertain, as the antheridia do not possess the power of locomotion in water, as is the case with the antherozoids of mosses, ferns, etc.

Dr. Thaxter has visited Europe twice for the purpose of examining the insects in European collections, as the fungi, being of a somewhat chitinous nature, retain all their important features after desiccation. His researches have shown that these minute fungi occur in every part of the world.

Notwithstanding the general abundance and cosmopolitan distribution of these beautiful little organisms, it is a regrettable fact that, up to the present, not a single species has been recorded as indigenous to Britain, and yet undoubtedly many species do in reality exist. This field of research offers an admirable opportunity for those who have not as yet settled down to the study of a specific group. The literature is in a concrete form, the illustrations numerous, and moreover the specimens retain all their features when mounted in glycerine. It is much to be desired that some member of the Quekett Club may be first in the field, so far as this country is concerned, in advancing the study of a group of organisms which appear destined to play so important a part in unravelling the sequence of life on our globe.

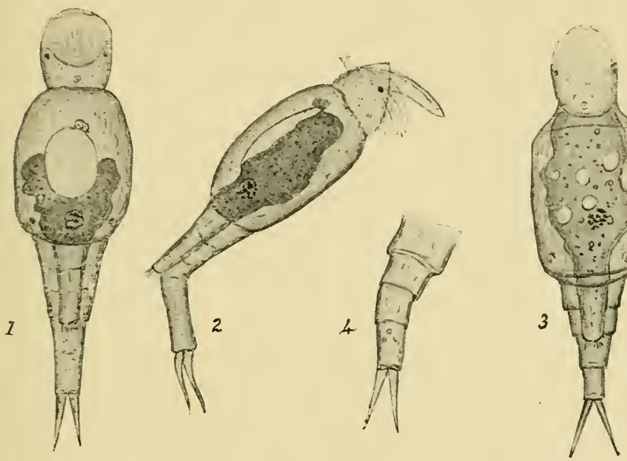
The accompanying figures represent characteristic species of this interesting group of fungi.

A New Male Rotifer (*Metopidia solidus*).

By Walter Wesché.

(*Read June* 21*st*, 1901).

Early in January of the current year I obtained some weed from a pond on Golder's Hill, Hampstead Heath, which I placed in tap water. On looking over the water several fully grown specimens of the rotifer *Metopidia solidus* were seen. The weed soon decayed, and, as it did so, great numbers of this species appeared; the mature form was constantly found, and with it several interesting immature forms. On Feb. 17th it was



Metopidia solidus.—Fig. 1. Dorsal view, ♂. Fig. 2. Lateral view, ♂. Fig. 3. Dorsal view, ♂ (another specimen). Fig. 4. Foot and toes of ♀.

my good fortune to find a male, and on the following evening two more were met with. Like all male rotifers that I am acquainted with, the specimen most carefully watched was exceedingly restless, and quick in movement, but after two hours' confinement in a live-box he obviously became moribund, and anchoring himself by the toes, he gave me an opportunity of more exactly observing him. The lower joint of the foot is mostly kept deflected, both in swimming and resting, and this renders it rather difficult to obtain an exact measurement, but I think $\frac{1}{225}$ inch (113 μ) may be accepted as fairly accurate. This is the extreme length of the fully extended rotifer.

The carapace cannot be said to be well defined. Although I was able in one case to see both an anterior and posterior edge, in another this could not be made out, and in no case had it the smoothness and symmetry that characterises the lorica of the female. It is rather dense, and has various oil globules and other matter obscuring its transparency; somewhat oblong in shape in one specimen, in another it was more rounded.

The foot was not unlike that of the female, and a careful examination shows homologies of structure, as there appear suggestions of segmentation on both joints; this was much more marked in one individual than in the others. The toes conform to the character of *Metopidia*, though they are pliable and sometimes take a well-defined curve which shows on the lateral view. The head is also quite characteristic of the genus. The "Cowl" or "Pick" on the front was well developed, two eyes were visible, and the cilia were long, and arranged on the same plan as in the female. The dorsal antenna was very well defined, and with the lateral antennae occupied approximately the same places as in the female, but the lateral were difficult to make out. Owing to the presence of oil globules, and the denseness of the lorica, the lateral canals of the vascular system were not visible.

In one specimen a transparent sack was seen in the dorsal region, which Mr. Rousselet pointed out to me was probably the remains of a digestive system. The penis is placed in the same position as in *Hydatina* and *Brachionus*—namely, at the end of the penultimate joint. This comparison will, however, only hold good as far as general appearance goes, as the foot will be seen in the third figure to be divided, like that of the female, into four segments. At the end of the second from the base is the ciliated orifice of the penis, while the fourth carries the toes; the joint in the middle of the foot is not so flexible in the female. The spermatozoa seemed contained in a small circular sac, which was apparently in the centre of a larger organ extending well into the middle of the body.

Before the male made its appearance several eggs were noticed, having the outer membrane quite smooth; but later the winter or resting egg was found, with the surface studded with short spines.

The Microstructure of Metals and Alloys.

By Sydney W. Smith, A.R.S.M.

Communicated by D. J. Scourfield, F.R.M.S.

(*Read June 21st*, 1901.)

Plate 7.

In offering these brief notes to those whose interest in microscopical work centres largely in biological science, the writer hopes that some slight assistance may be afforded to any who may wish to extend their work to the field of physical science, of which the subject of these remarks is one of the most striking branches, both in its novelty and in the practical utility of its results. It is impossible, however, to give here more than a general outline of the nature of the work.

The interest and importance attaching to the microscopical examination of metals and alloys depend on the fact that when a highly polished surface is etched by attack with suitable reagents and viewed by reflected light a certain "structure" is seen which will depend upon (1) the composition of the metal under examination, (2) the conditions under which it solidified, and (3) the treatment, either thermal or mechanical, which it has received subsequent to solidification. For example, it is well known that steel which has been slowly cooled from a bright red heat, or in other words has been annealed, has the properties of ductility and malleability to some considerable extent. If the same steel, however, instead of being allowed to cool slowly, is suddenly plunged into water, or "quenched," its properties of ductility and malleability entirely disappear and the material becomes quite brittle. Tempered steel is the compromise between these two states. Each, however, has a distinct and unmistakable microstructure (see Figs. 1, 2, and 3). This will be readily realised by those familiar with the somewhat analogous phenomena revealed by the study of rocks. For instance, the ultimate components of granite may give rise to bodies differing widely in physical properties, according to the conditions and rate of cooling of the original molten mass. Thus, complete crystallisation has occurred in a true granite, partial crystallisation in rhyolites and andesites which show crystals imbedded in a matrix of crystallites; while in the glassy lavas, such as obsidian, the rate of cooling has not been sufficiently slow to allow the formation of crystals to take place.

It may be presumed that the idea of crystallisation of minerals, either from a solution or from a molten mass, is familiar to all. In extending this to the case of metals, and in explanation of what follows, it may be well to consider briefly what happens during the solidification of a mass consisting of two metals, as being the simplest case of an alloy. Assuming that no segregation of the constituents into distinct layers of different specific gravity occurs, but that, as a whole, the mass remains homogeneous, then what happens is, in general, somewhat as follows:—Either one of the constituents first solidifies in the form of practically pure crystals or grains, or else the first portions to solidify consist of crystalline grains of a definite compound of the two constituents. These grains which are first to solidify remain, as a rule, distributed evenly through the mass. This may be followed by the solidification of a second compound of the two constituents, but, of course having a lower temperature of solidification. In this way solidification proceeds until the still molten material reaches a composition which for the particular pair of metals under consideration possesses the lowest "freezing" point, and then this, the so-called "eutectic" alloy, solidifies as a whole. This eutectic mixture or alloy usually possesses a characteristic banded structure common to alloys of all metals. Thus, if the composition chosen is that of the eutectic, then the whole mass will solidify at one temperature and will be made up entirely of eutectic, showing the characteristic banded or lamellar structure already referred to. The structure, then, of an alloy of two metals will, in general, show crystalline grains of a pure metal, or a compound of the two, set in a matrix of eutectic which has solidified round the grains (see Figs. 4, 5, and 6). The structure of the eutectic has been called "pearlitic," from the pearly appearance of the first observed eutectic—that of the iron-carbon alloy which is a characteristic constituent of annealed steel.

From the foregoing remarks it is easy to imagine how Sorby (to whom microscopy owes so much) was led from the study of the microstructures of crystals, minerals, and rocks to the structures of meteorites and then to those of iron and steel. It is to the latter that, up to the present, the greater portion of metallographic work has been devoted with the object of solving industrial problems connected with the use of steel for various purposes. The work is, however, rapidly spreading to the study of alloys of metals of every conceivable combination. It will be instructive, now, to consider briefly the technology of the subject.

Preparation of the Specimen for Examination.—It is usual, in commencing a systematic study of the alloys of two metals, to examine first the metal of the highest melting or "freezing" point, and then pass up the series by examining alloys each containing, say, 5 per cent. more of the second metal than the last, until finally pure metal is reached at the other end of the series. The preparation of these alloys is effected by merely melting the mixture together in a clay pot under a layer of powdered carbon, to prevent oxidation. By means of a hack-saw a portion is then cut off, of convenient size for polishing and subsequent mounting on the stage of the microscope. One face of the specimen is then filed up to give an even surface. This surface is further polished by rubbing on emery papers of gradually increasing fineness, the scratches produced by rubbing in one direction on one paper, being effaced by rubbing on the next in a direction at right angles to the last. After this treatment on four or five emery papers, a final brilliant polish is attained by rubbing with jewellers' rouge on cloth moistened with water stretched over a piece of board. The operation of polishing is in actual practice rendered less tedious by the use of mechanical arrangements for rotating wheels, on which the various emery papers are fastened.

Having obtained a well polished surface, free from scratches, it is necessary to reveal the structure of the metal by etching the surface, except in certain cases in which polishing alone reveals the structure. This surface etching is effected in various ways, according to the nature of the specimen dealt with. As a rule it is sufficient to dip the surface for a few seconds in dilute nitric acid, and then wash in water or methylated spirit, finally drying the surface by gently wiping with chamois leather moistened with benzole. In many cases strong acid is necessary, and it may even be necessary to heat the liquid before satisfactory etching is effected. The specimen is washed and examined as soon as the brightness of the surface is dulled. It may then be further etched, if, on examination, the structure is found to be imperfectly developed. Over-etching is to be avoided.

Other methods of treating the polished surface, in order to develop the structure, have been suggested from time to time. The "polish attack" of M. Osmond yields excellent results in examining sections of steel. The section is gently rubbed on damp parchment, fixed to a piece of planed wood and moistened with an infusion of liquorice root. A small amount of precipitated calcium sulphate is also placed on the parchment, and latterly M. Osmond advises the substitution of a 2-per-cent. solution of ammonium nitrate for the liquorice infusion. Another method by which the structure is developed, is by heating the specimen in air to a temperature below redness, by which means the different degree of oxidation of the constituents renders the structure apparent.

It should be mentioned that soft alloys, such as those of lead, which, on account of their low melting point, are easily prepared, are difficult to polish, since the softer constituents in polishing spread over and obliterate the harder portions. To avoid this, it has recently been suggested that the metal or alloy be poured or cast on to a sheet of mica which forms the bottom of a small mould. In this way a brilliant surface is obtained without polishing, and it is merely necessary to etch the surface and examine it.

Examination of the Specimen.—Owing, of course, to the opacity of the section, the metallographist is limited to oblique or vertical illumination in examining it. Otherwise, for ordinary purposes no special accessories are necessary for work on metals and alloys. The specimen, which may often be of irregular shape, is mounted on a glass slide with wax or some suitable material, care being taken that the polished surface is parallel to the slide. In examining specimens under low-power objectives, the Sorby-Beck reflector is largely used, although a cover-glass, supported at an angle of forty-five degrees between the objective and the surface, with a small black screen behind it, works well.

For high powers with which vertical illumination only is possible, the Beck illuminator, which is screwed between the objective and the microscope tube, works admirably, although it possesses the disadvantage of involving considerable loss of intensity by the passage of a large proportion of the light straight through without undergoing reflection.

Photographing the Structure.—In obtaining permanent records of the structures seen under the microscope, the usual methods of photo-micrography are adopted, the chief point on which a difference of opinion exists being the relative merits of the horizontal and vertical forms of enlarging camera. The question of illumination is of considerable importance. Wherever possible the arc light should be used, although good work can be accomplished with less brilliant illuminants, but these, of course, necessitate somewhat long exposures. The Welsbach lamp is very satisfactory, except that some difficulty may be experienced in getting rid of the "gratings" caused by the structure of the mantle. In any case the light is concentrated on the Beck illuminator (or its equivalent) by a condenser.

To those whose interest in this work may have been aroused, it may be said that the alloys of tin, lead, antimony, bismuth and zinc, offer ample scope for interesting work, and are, moreover, easy to make, on account of their comparatively low melting-points, while the study of steel under varying conditions of thermal and mechanical treatment opens up unlimited possibilities, although the various structures in this case are perhaps less striking, and are often only visible under high powers.

For further details respecting the application of the microscope to the study of metals and alloys, reference should be made to the various papers published in the "Philosophical Transactions of the Royal Society," by Sir William Roberts-Austen, M. Osmond, Ewing and Rosenhain, and others. Work on steel, which, as already mentioned, has received a large amount of attention, will be found in the Journals of the Iron and Steel Institute. An excellent quarterly publication, the *Metallographist*, devoted entirely to metallography, and containing reviews of all important work, is published by the Boston Testing Laboratories, U.S.A.

The following list contains some of the most important papers that have hitherto been published on this subject, and it may be useful to note that extracts of most of these will be found in the volumes of the *Metallographist* already referred to:—

SORBY, H. C. "Microstructure of Iron and Steel." *Journ. Iron and Steel Institute*, 1887, p. 255.

OSMOND, F. "Microscopic Metallography." *Trans. Amer. Inst. Mining Engineers*, vol. xxii., p. 243, 1893.

STEAD, J. E. "Microstructure of Metals." *Cleveland Inst. Engineers*, Feb. 1900.

ROBERTS-AUSTEN, W. C., and OSMOND, F. "On the Structure of Metals." *Phil. Trans. Royal Society*, 1896, vol. 187, pp. 417—432.

STEAD, J. E. "Microscopic Accessories." *Journ. Iron and Steel Inst.*, 1897, vol. i., p. 42.

STEAD, J. E. "Crystalline Structure of Iron and Steel." *Journ. Iron and Steel Inst.*, 1898, vol. i., p. 145.

SAUVEUR, A. "Relation between Structure and Thermal and Mechanical Treatment." *Journ. Iron and Steel Inst.*, 1899, vol. ii., p. 195.

EWING and ROSENHAIN. "Crystalline Structure of Metals." *Phil. Trans. Royal Society*, vol. 193, p. 353; vol. 195, p. 279.

CHARPY, M. G. "Etude microscopique des alliages métalliques." *Bulletin de la Société d'Encouragement pour l' Industrie Nationale*, March 1897.

DESCRIPTION OF PLATE 7.

FIG. 1. Steel (containing about 0·6 per cent. of carbon), which has been slowly cooled. Two main constituents: "Ferrite" (pure iron), white patches; and "Pearlite" (eutectic of iron and carbon), dark patches. The lamellar structure of the latter is not clearly shown under this magnification. × 110.

FIG. 2. Appearance of the specimen shown in Fig. 1 under a higher power. The lamellar structure of the "pearlite" is now very noticeable. × 750.

FIG. 3. Intercrossing needle-like (martensitic) structure of quenched (hardened) steel. The dark patches (troostite), are not always present. × 750.

FIG. 4. Lead-Bismuth alloy (cast on mica). White crystals imbedded in a matrix of eutectic. × 110.

FIG. 5. Gold-Lead alloy. Crystallites with their principal axes lying in two directions at right angles. × 110.

FIG. 6. Lead-Antimony alloy (cast on mica). White crystals imbedded in a matrix of eutectic. × 110.

Two-Speed Fine Adjustments.

By A. Ashe.

(*Read October* 18*th*, 1901.)

The introduction of wide-angled lenses has brought about, as an inevitable consequence, a great improvement in the construction of fine adjustments.

These improvements are still being made by leading opticians, and quite recently both Messrs. Zeiss and Reichert have brought out very novel forms—suited, of course, to the Continental type of instrument.

Up to the present, these firms, as well as others, have, with a single exception to be referred to later, apparently worked with only one object in view, and that is, the securing of an almost imperceptible movement of the focal point when the milled head is moved. Of course I do not include smoothness of motion, for without this as a foundation all labour spent in improving the design, or extending the usefulness of the adjustment, is thrown away.

Now, while it is true that oil-immersion objectives, when used, as they should be, in conjunction with wide-angled condensers, demand the utmost delicacy of motion obtainable, with regard to lenses of somewhat lower power and aperture this extreme slowness is not required to anything like the same degree; and when, as is often the case, the object under observation is of sensible thickness, covers a large area on the slide, and possesses numerous points at various depths, all of which it is necessary to rapidly examine, then the value of a comparatively quick fine adjustment will be realised.

Some will say that recourse can be had to the rack and pinion under such circumstances; but the rack, though quite capable of focussing a $\frac{1}{12}$-in. objective upon any particular point, is not adapted to the rapid following of focal planes and the tracing of their inter-relationships.

On the other hand, an ultra-slow adjustment involves in some work an enormous waste of time. This is especially noticeable in the examination of unprepared commercial products, where a large amount of material has to be gone over lest minute quantities of foreign ingredients, irregularly distributed throughout its mass, escape detection.

It becomes evident, therefore, that it is desirable for some workers to have a fine adjustment which, whilst on the one hand possessing the slowest and smoothest movement possible, is yet capable of giving a far more rapid motion when needed; and it should do this without requiring the removal of the hand from the milled head, or the performing of any operation whatever to bring the

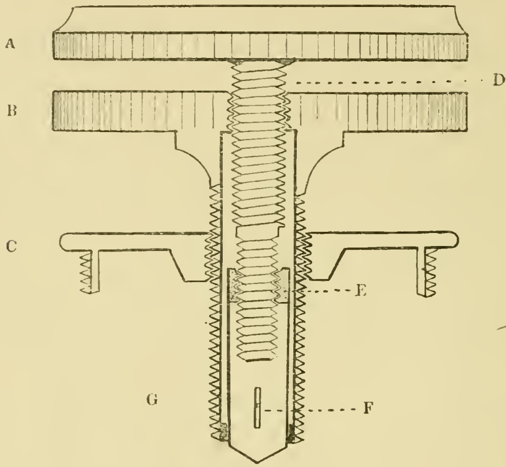


Fig. 1.

other speed into action, because any distraction of the mind caused by having to change the speeds will greatly reduce the utility of the adjustment.

Some years ago I designed an apparatus to fulfil the above requirements, and I intended to construct a model and show it to the members of the Club, but the want of accurate metal-working tools prevented this being done. The matter therefore remained in abeyance until our Editor—ever on the alert for anything which may interest the members—seeing my plans, persuaded me to take the matter up again.

The two-speed fine adjustment screw which I first designed is shown in the accompanying diagram (Fig. 1). It will be seen that it consisted of a hollow screw of comparatively coarse pitch (G), to which the lower milled head (B) was attached. This worked in the cap (C) on the top of the pillar, and formed the rapid movement. The slow movement was produced by a differential screw (D) passing through the first and inserted into the top of the rod (E) actuating the lever. The rod was prevented from rotating by a slot and pin (F). The differential screw was rotated by the upper milled head (A). When the upper head was rotated and the lower untouched, the slow motion obtained was derived from the action of the differential screw. If both were turned together, the resulting movement would be derived from the lower head only. This form of fine adjustment was designed for lever instruments in which efficiency is the chief consideration. Its action can easily be seen from an inspection of the figure. Its principal drawback is that it involves the use of a differential screw, and would require to be very accurately made.

It is, however, apparent that the same principle can be carried out in different ways, and that if a more simple form, without a differential screw, can be made which will suit instruments with direct-acting fine adjustments, especially those of the Continental type, the value of the adjustment will be greatly increased, and its field of usefulness proportionately extended. In many of these instruments the limb of the microscope is attached to a sleeve (C in Fig. 2), sliding up and down outside a prismatic bar (F), which is a fixed part of the stand. A micrometer screw (D), secured at its base to the top of the upright bar, is carried upwards through an aperture in the cap, and the milled head (A) is really a loose nut working upon this screw, whilst the cap, limb, tube, etc., are forced up into contact with the milled head by the action of a spring (G).

This very simple adjustment may, by a single addition, be converted into one having two rates of speed, it only being necessary to insert under the ordinary head (A, Fig. 2), a second head (B) attached to the hollow screw (E), working into the cap. The latter screw is made hollow, so that it may slide freely over the first screw (D).

The relative action of the two milled heads in this case is as follows: The upper head when turned to the right operates downwards, lowering the focus by depressing the sleeve (C) carrying the body of the microscope, and compressing the spring (G). The lower head (B) has, in this instance, simply the action of a washer placed between A and C.

A left-handed rotation of A, like the loosening of a nut, permits the expansion of the spring to force upwards both C and B, until stopped by A.

When on the contrary B is turned to the right, it screws itself into C, thereby tending to leave a space between A and B. But this space is at once taken up by the expansion of

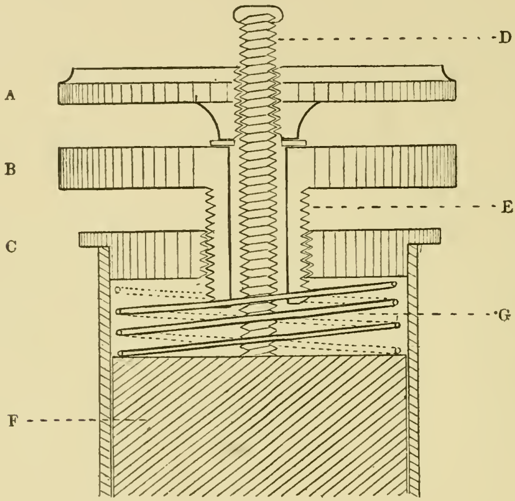


Fig. 2.

the spring, thereby raising the cap C together with B, and consequently the focus.

It will be clearly seen from the foregoing that although both screws are right-handed, the milled heads attached to them produce opposite motions in the adjustment, hence the simultaneous rotation of the two heads in the same direction will give the same effect as a differential screw, provided the screws are not of the same pitch.

In practice A might have 25 threads and B 27 to the inch. A single revolution of A would then correspond closely to a movement of the focus of one millimetre, whilst if both were turned together the movement would be reduced to $\frac{1}{337}$ inch. Of course other ratios may be given, but whatever they may be it is obvious that the central screw must be coarser than the outer, as otherwise a right- or left-handed rotation of A would not produce a motion in the same direction as that of A and B together.

It will be seen that, quite apart from the question of the two speeds, the foregoing design of fine adjustment has all the theoretical advantages of the differential screw, while, being simpler in construction, it ought to prove more satisfactory.

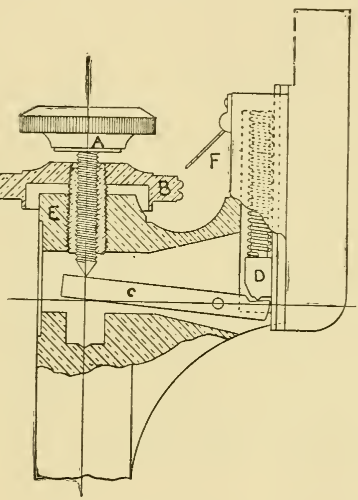


Fig. 3.

There is yet another common type of instrument in which the limb, actuated by a lever, moves in a slot cut in the pillar. To this microscope the adjustment just described cannot be applied, and as the differential screw is unnecessary for the purpose, I removed and substituted for it a fine micrometer screw, leaving the rest intact as in Fig. 1. Learning, however, that Messrs. R. and J. Beck were also making experiments with the same end in view, I placed myself in communication with them, with the result that they entered most readily into the subject; and I now wish to thank them most heartily for the trouble they have taken in making experiments to ensure success.

The form adopted by Messrs. Beck is seen in the accompanying illustration (Fig. 3).

It will be seen that the arrangement only differs from my design in having a strong, quick-moving screw (A) in the centre for the coarser adjustment, whilst in place of a central fine micrometer screw a thread is cut upon the exterior of a cylinder of large diameter attached to the milled head (B), thus reducing wear and tear to a vanishing point and adding greatly to its durability.

In this form the upper milled head controls the quick screw, which in practice proves to be a more convenient arrangement than does the converse.

I have frequently used this form of fine adjustment continuously for many hours, and can testify to its utility under such circumstances, not only by the saving of time effected, but also by the relief to the eye, brought about by the rapidity with which objects come into approximate focus.

The two-speed fine adjustment just referred to, and illustrated in Fig. 3, is of course essentially the same as that adopted by Reichert, in one of his latest instruments (see "The Microscope and its Revelations," 8th edition, pp. 210, 211), but as it was worked out quite independently, and was completed and manufactured before Reichert's instrument was heard of in England, it has been considered justifiable to include it in this paper.

In conclusion I wish to express my thanks to Mr. Scourfield for his help in bringing this matter forward.

Hydra and the Surface-Film of Water.

By D. J. Scourfield, F.R.M.S.

(*Read Oct. 18th*, 1901.)

Plate 8 (Upper Portion).

The fact that the different species of *Hydra*, although decidedly heavier than water, can maintain themselves for lengthened periods suspended from the surface film is well known to all observers of minute aquatic life, and various suppositions as to the means by which this peculiar phenomenon is brought about have been advanced from time to time. I do not think, however, that any of the explanations hitherto given have been satisfactory, although I believe, and shall try to show in the following remarks, that the action is very simple, being due, in fact, to the formation of minute capillary depressions in the surface-film by means of a water-repellent substance on the basal disc of the animal.

In investigating this subject the first thing to do is evidently to examine under the microscope the appearance which the animal presents when clinging to the surface-film. In passing it may not be superfluous to mention that if an animal cannot be induced of its own accord to attach itself to the surface-film in a vessel suitable for observation, such as a glass trough or a flat bottle, it is usually easy to make it do so, for all that is necessary is to take it out of the water, say with a hooked needle, and then gently lower it again into the water. It will almost invariably be found that by such procedure the *Hydra* will remain suspended, and the observer will not be long in incidentally noticing that it is practically always the basal disc which is attached to the surface and rarely any other part of the body.

Proceeding with the examination of the specimen clinging to the surface-film it will be seen that the basal disc, either wholly or in part, is in almost absolute contact with the surface. Sometimes it appears to be very slightly below the actual surface, but it is certainly never higher than the surface because the extreme limit of the ectodermal cells of the base can always be clearly seen.

Further scrutiny will often reveal the presence of minute strands and irregular masses of a gelatinous substance running from the basal disc to the surface film and spreading out considerably as they do so. The appearance described, which is shown in Fig. 1, produces at first the impression that the *Hydra* is stuck on to the underside of the surface-film by a transparent adhesive cement or mucilage. That there is such a substance normally present on the basal disc is of course highly probable from the fact that the animal can cling so tenaciously to weeds and to the sides of any vessel in which it is placed. Its presence can moreover be directly observed if the animal be examined in a live-box, so that a side view can be obtained of the basal disc. The gelatinous material can then sometimes, more especially in young specimens, be seen to be comparatively large in amount and almost symmetrical in outline, forming a kind of cap (see Fig. 2); but more often it is very irregular and not present in great quantity. The extreme tenacity of this substance can be proved by allowing the animal under observation to attach its basal disc either to the cover-glass or to the glass table, and then forcing it to alter its position by movements of the lid of the live-box. When the basal disc is at last shifted it will be seen that the gelatinous substance is pulled out into irregular streamers which eventually break, leaving a portion of the original mass adhering to the glass. Such a detached portion is shown in Fig. 3. The jelly-like material, although transparent, is not by any means homogeneous, but contains comparatively large globular and ovoid bodies, usually granular but sometimes structureless, and numerous smaller particles. This want of homogeneity seems to point to the conclusion that the adhesive substance, whatever its actual nature may be, is produced by the disintegration of the outer ends of the large ectodermal cells of the basal disc, and that it is not merely an exudation therefrom.

But, however sticky a substance may be, it is impossible to imagine that, merely because of its adhesiveness, it can suspend a weight against gravity from the surface-film. Such a supposition would push the analogy of the surface-film to an elastic membrane to the point of absurdity. There is only one way, I believe, by which a weight can be supported by the surface-film, and that is by the formation of capillary depressions.

This statement probably needs a little amplification to make it intelligible to those who are not familiar with the peculiar properties of the surface-film of water. Without going into all the details of the subject, it may be stated that there are two essential facts to be remembered in this connection. The first is that the surface of water is bent down below the normal horizontal level into little hollows, usually called capillary depressions, whenever water-repellent substances (*e.g.*, paraffin-wax, fat, etc.) are brought into contact with the surface, whether from above or below. Secondly, the surface-film bounding the capillary depression exerts an upward pull upon the object against which it is formed. A simple experiment, illustrated in Fig. 4, will make this clear. Take a portion of a lucifer match, and weight it at one end by driving in a pin. The weight must now be adjusted, by nipping off portions of the pin or cutting off pieces of the wood, as the case may be, until the match and pin together are slightly heavier than water. If now a small quantity of vaseline be placed upon the upper end of the wood, it will be found that when the match is brought up to the surface a capillary depression quite evident to the naked eye is formed round its top, owing to the water-repellent nature of the vaseline, and that the match and pin, although together heavier than water, will remain suspended as shown in the figure.

Exactly the same phenomena occur, I believe, when a *Hydra* is brought up from below to the surface, although they are not so easy to demonstrate. There is no doubt, however, that very minute capillary depressions are formed when a *Hydra* is attached to the surface-film, because if the surface of the water be examined with a pocket lens at a very oblique angle—that is, in such a way that the light from a lamp or window is largely reflected to the eye, the surface is seen to be broken exactly at the spot where the basal disc of the *Hydra* is situated. The reason why these depressions cannot be directly demonstrated when a *Hydra* clinging to the surface-film is examined from the side, as in Fig. 1, is, without doubt, due to their very minute size. Even in the experiment already described, where the capillary depression is readily noticeable from above, it will be found to be very faintly marked when viewed from the side. As regards the water-repellent nature of the mucilaginous material on the basal disc, I do not think there can be any reasonable doubt. I have repeatedly found, when manipulating a *Hydra* in a live-box, that when once the basal disc is brought into contact with the air it is with the greatest difficulty that the surface of the water can be made to leave the gelatinous material. In some cases the surface of the water only succeeds in getting away from the basal disc by pulling out long threads of the jelly, or by leaving an air-bubble entangled in the mass. Both these phenomena occurred in the case shown in Fig. 5. This last observation also explains a very remarkable appearance once noticed of a *Hydra* suspended in mid-water as shown in Fig. 6. I have no doubt that this was due to some of the water-repellent gelatinous substance remaining at the surface and producing the necessary capillary depressions, while it was at the same time connected with the basal disc by a very fine thread. In fact, by very careful examination with a pocket lens (the animal was not in a favourable position for observation under a microscope) I thought I could just discern such a thread, but it was exceedingly faint, as indicated.

The foregoing explanation of the means by which the attachment of *Hydra* to the surface-film is accomplished is, it will be noticed, essentially the same as that which I advanced some years ago in connection with the Entomostraca (see *Linnean Society's Journal—Zoology*, vol. xxv., 1894, pp. 1-19). The only difference, in fact, between the two cases is that, whereas in the Entomostraca the capillary depressions are produced, when formed at all, by the water-repellent nature of their chitinous coats, scales, or setae, in the present instance the capillary depressions are caused by the action of a specially formed water-repellent gelatinous substance on the basal disc.

In addition to *Hydra* there are many other examples of animals utilising the surface-film for support by means of gelatinous or mucilaginous substances, and if the explanation now brought forward is true in the former case it will in all probability be found to hold good in the latter also. Many molluscs in particular (including some which are not air-breathers and cannot therefore possibly be lighter than water) attach themselves directly to the surface-film, and some even suspend themselves from it by means of gelatinous threads.

As the subject of the relation of aquatic animals and plants to the surface-film, in spite of its attractiveness, is but little known, I will conclude with the following short list of the papers bearing on the question :—

BROCKMEIER, H. "Ueber Süsswassermollusken der Gegend von Plön." *Forschungsberichte aus der Biologischen Station zu Plön*, Theil 3, 1895, pp. 191—193.

HORNELL, J. "On Surface Tension as an aid to Locomotion among Marine Animals." *Journal of Marine Zoology and Microscopy*, No. 7, 1896, pp. 59—60.

MIALL, L. C. "Some Difficulties in the Life of Aquatic Insects." *Nature*, vol. 44, 1891, p. 457. "The Surface-film of Water and its relation to the Life of Plants and Animals." *Nature*, vol. 46, 1892, p. 7.

PLATEAU, F. "Observations sur l'Argyronète aquatique." *Bull. Acad. Sci. Bruxelles*, 1867, pp. 96—125.

SCOURFIELD, D. J. "Entomostraca and the Surface-film of Water." *Journal of the Linnean Society—Zoology*, vol. 25, 1894, pp. 1—19. "Note on *Scapholeberis mucronata* and the Surface-film of Water." *Journ. Quekett Micro. Club*, vol. 7, 1900, pp. 309—312.

EXPLANATION OF PLATE 8 (Upper Portion).

FIG. 1. Basal portion of *Hydra vulgaris* clinging to the surface-film of water. × 60.

FIG. 2. Basal disc of a young *Hydra viridis*, showing an almost symmetrical gelatinous cap.

FIG. 3. A detached portion of gelatinous material from the basal disc of *H. vulgaris*. × 200.

FIG. 4. Diagram to illustrate how a weighted match can be supported by the surface-film if tipped with vaseline.

FIG. 5. Gelatinous material from the basal disc of a *Hydra*, drawn out into a long thread by being attached to a large air-bubble in a live-box. A small bubble is entangled in the main mass of the jelly.

FIG. 6. A *Hydra vulgaris* suspended in the water at some distance below the surface-film. Probably supported by a very delicate thread, as indicated.

Triarthra brachiata, a New Species of Rotifer, and Remarks on the Spines of the *Triarthradae*.

By Charles F. Rousselet, F.R.M.S.

(*Read October* 18*th*, 1901.)

Plate 8 (Lower Portion).

The genus *Triarthra* contains three well-marked species, which are distinguished chiefly by the length of their skipping spines relative to the body. *Triarthra longiseta* has a small body (130—175 $\mu = \frac{1}{200}-\frac{1}{150}$ in. in size) and very long spines, twice to four times the length of the body. A very long-spined variety, which often occurs in very large lakes, has been called var. *limnetica* by Dr. Zacharias, but it seems to me the variation is too slight even for a variety. *Triarthra mystacina* has a larger and stouter body (204 $\mu = \frac{1}{125}$ in. in size), with spines $1\frac{1}{2}$ to $1\frac{3}{4}$ times the length of the body; whilst the third species, *Triarthra brevispina*, is very small (size 102 $\mu = \frac{1}{250}$ in.) and has very small, narrow spines, only about one-quarter the length of the body in size.

Two other species which have been named are undoubtedly synonyms: *T. cornuta* Weisse being the same as *brevispina*, and *T. terminalis* Plate seems to be *longiseta*.

For some years past I have occasionally come across a small *Triarthra* which is different from any of the above species. It is slightly smaller in length and less broad than *brevispina*, thus appearing more elongated in shape, and has longer spines, $\frac{5}{8}$ths to $\frac{3}{4}$ths the length of the body, and which are moreover very broad and arm-like at the base, as will be seen from fig. 7, Pl. 8. From this peculiarity I have named this new species *T. brachiata*. The broad bases of the spines appear to encompass the body at the shoulders, and seem hollow, but are not actuated by special muscles. When swimming the two lateral spines lie against the sides of the body, and the posterior spine is trailed behind; but when the head is retracted they all three spring out at right angles to the body—merely, as I think, by the pull exercised on the integument and by the pressure of the internal fluid. The posterior spine, it is then seen, is not quite terminal in position, but stands out on the ventral side a little above the base.

The shape of the body is cylindrical, slightly more than twice as long as broad, and truncate in front. The ciliary wreath is nearly circular, with a projecting lip on the ventral side. Two red eyes, set close together near the anterior surface of the head, are present. The rest of the anatomy is quite normal, and calls for no remark.

The male has not yet been seen, but a fertilised resting egg of characteristic *Triarthra* structure was seen, having a cellular annulus all round the longer axis (fig. 8).

Mr. F. R. Dixon-Nuttall has been good enough to draw fig. 7 for me from a mounted specimen, which, he thinks, is not so satisfactory as if he could have seen the living animal.

Size of body alone: 95 $\mu = \frac{1}{267}$ in., of spines 65 $\mu = \frac{1}{390}$ in., total length, including posterior spine: 156 $\mu = \frac{1}{164}$ in., found singly on Putney Common and in water received from the north of Ireland; rare.

A few remarks on the spines of *Triarthra* in general will not be out of place here. These more or less long, chitinous and stiff appendages have been called "skipping spines" by the various authors. I have not, however, observed that any real skipping or displacement is effected in these rotifers—such as undoubtedly takes place in *Polyarthra*—when the head is retracted and the spines fly out. These spines, it seems to me, are protective in quite a different way. I have often seen an *Asplanchna* trying to swallow *Triarthra longiseta* by suddenly dilating its pharynx and thus producing a sucking action, when *Triarthra* usually saves itself by promptly spreading out its long spines. Sometimes, however, the attack is renewed from an unexpected quarter, and occasionally *Asplanchna* succeeds in sucking in its victim, and *Triarthra* can then be seen in its enemy's stomach, with the long spines protruding through the oesophagus and mouth. *Triarthra* cannot therefore escape its enemies by flight, but rather by rendering itself unapproachable and impregnable, much in the same way as the porcupine and hedgehog, and it is evident that the longer the spines the greater is the protection they afford. It is ludicrous to see little *Triarthra brevispina*, with its tiny spines, act exactly like the long-spined species, though its small spines cannot be of much use when *Asplanchna* is the enemy.

The greatest enemy to all species of *Triarthra* is undoubtedly the surface-film of the water, for though these creatures live in the water, the surface of their bodies and spines is strongly water-repellent. The moment any of these animals touch the surface-film they adhere there so firmly that no efforts of theirs can disengage them, and they must perish. The same is the case with a good many other rotifers, particularly *Polyarthra*, *Anuraea longispina*, *Pedalion*, and *Mastigocerca*, and also with some Cladocera, such as *Bosmina*. Sometimes I collect very large numbers of *Triarthra longiseta* and *T. mystacina*, and after keeping these a few days in a small aquarium, the surface-film is covered by quite a layer of their dead bodies.

Explanation of Plate 8 (Lower Portion).

Fig. 7. *Triarthra brachiata*, n. sp. ♀, ventral view, × 370.
 „ 8. „ „ resting egg × 300.

Additional Note on Micro-Cements for Fluid Cells.

By Charles F. Rousselet, F.R.M.S.

In the note I published in this Journal in November 1898 (Vol. VII., pp. 93–97), I advocated for closing fluid mounts the use first of a coat of a mixture of damar and gold size, then four thin coats of pure gold size, followed by a finishing coat of Ward's brown cement at intervals of twenty-four hours.

Further experience has shown that the addition of this last coat is a mistake, as, by excluding the air, it prevents the oxidation, and consequently the hardening, of the gold size. The gold size therefore remains in a more or less semi-fluid state under the brown cement, which is not good. I find that pure shellac is not soluble in $2\frac{1}{2}$-per-cent. formalin, and I therefore now close fluid mounts as above, but with two coats of shellac between the damar and gold size, omitting the brown cement altogether, and hope this will prove satisfactory.

Note on a New Theory as to the Origin of Potato Tubers.

By George Massee, F.L.S.

(*Read April* 19*th*, 1901.)

Until quite recently it was generally supposed that potato tubers were included in the general scheme of evolution that resulted in the production of the potato plant, their function being that of reproducing the species in a vegetative or asexual manner. In this supposition, from the point of view of a Frenchman named Noel Bernard, we have been very much mistaken. According to this gentleman, the presence of tubers on a potato plant is quite accidental, and entirely depends on irritation of the tips of the subterranean branches occasioned by a minute fungus called *Fusarium Solani.* It is comforting to learn, however, that this particular fungus is so abundant in the soil that it is practically impossible for potato stems to escape the necessary irritation, which results in a tuber. To prove this theory the author planted sterilised potato tubers in sterilised quartz sand. In some instances no tubers were formed; this proved the truth of the theory, so says M. Bernard. In other cases a few tubers were formed, but according to the author these were due to the fungus having gained access to the roots in the sand. People generally will require stronger evidence before this romantic theory can be accepted. Many people have planted potatoes under conditions much more favourable than that of sterilised quartz sand, and yet have failed to secure a crop. *Fusarium Solani* is considered by vegetable pathologists as the fungus which causes one of the worst of diseases to which potatoes are subject; in fact, repeated experiments have proved this opinion to be correct.

Bernard's theory is not confined to the production of potato tubers only: he considers tubers generally as due to the influence of different species of fungi.

We sincerely trust the theory may prove to be true, and that M. Bernard may succeed in tickling up the underground portions of some common and hardy plant through the medium of an equally universal and energetic fungus, and that the result may be the production of a new edible tuber, equal to or better in quality than that of the potato. In this attempt he has our best wishes.

This idea of the formation of swellings on the roots of plants, due to the irritation of fungi or bacteria, is not altogether new, and in some instances is quite true, as in the case of the swellings on the roots of leguminous plants, and the roots of alder, etc.; but in these instances it is either a case of true parasitism, or of mutualism, where the plant benefits from a nutritive point of view. There is no clearly demonstrated case where vegetative reproductive bodies result from the action of an outside agent, fungus or otherwise.

Note on Red Rain Dust from Australia.

By G. C. Karop, M.R.C.S., F.R.M.S.

(*Read April 19th*, 1901.)

On March 20th of this year I received for examination from Captain C. J. Gray, F.R.G.S., a small sample of Red Rain Dust, collected by him in Melbourne, Victoria, on Dec. 28th, 1896.

The material was a cinnamon or brick-dust coloured powder in a very fine state of division. Under the microscope it was seen to consist almost entirely of extremely minute amorphous particles, sparsely intermixed with some larger aggregations of the same, which in xylol balsam and by transmitted light appeared of a dull orange tint.

On going over the preparations field by field, a few other inorganic inclusions and still fewer organic bodies were to be found—the latter consisting for the most part of diatomaceous fragments, but in one or two cases entire valves; broken sponge spicules, some very much eroded, and also some curved, hyaline objects, pointed at one end and possessing scattered, secondary blunt spines. The exact nature of these last is to me uncertain; they may be sponge spicules, but I rather incline to the idea that they are siliceous plant hairs.

The diatoms were generally too much fragmented for certain identification, a minute *Surirella* and a species of *Fragilaria* alone being entire. The central portion of what is clearly a *Stauroneis*, and bits of *Epithemia* valves were, however, distinguishable by their markings.

The dust itself is pretty certainly a ferruginous clay, and no effervescence or visible effect was produced by acids. The few inorganic inclusions are minute greenish grains of (?) chlorite or (?) glauconite; but these, of course, may be quite adventitious.

In the absence of any knowledge of the geological features of the Melbourne district it is obviously impossible for me to say whether the material examined is of local origin or not. In any case both it and its included remains are almost ubiquitous; the diatoms, etc., may have been rolled about for centuries or aeons. Reduced to impalpable powder by sun, rain, and wind, it has, perhaps, been borne aloft by some violent storm and travelled round the world; or, on the other hand, it may have been deposited by the first shower not very far from its birthplace.

The phenomenon, while hardly common, is yet not of very infrequent occurrence. This very year it has appeared in Southern Italy and other places, and, of course, given rise to numerous communications to the newspapers. The first really scientific exposition of the causes of this startling phenomenon, known to me at least, was Prof. C. G. Ehrenberg's work entitled "Passat Staub und Blut-Regen. Ein grosses organisches unsichtbares Wirken und Leben in der Atmosphaere. Mit 6 colorirten Kupfertafeln," published in the *Abh. Berliner Akad.*, Berlin, 1849, and other communications on the subject submitted to and published by the same Academy in 1862, and later.

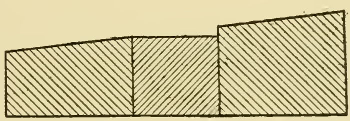
The two most common origins of so-called Blood-rain are, firstly as above—viz., extremely finely comminuted particles of red earth with various inclusions, raised by some tornado and carried, it may be, for immense distances from its place of birth; and, secondly, to the sometimes extraordinary development in a very short space of time of the lowly protophyte known as *Spherella* (*Protococcus*) *pluvialis*, which, besides its usual green, in certain peculiar and not very well ascertained conditions sometimes assumes a red colour, and was in this state formerly differentiated as *Haematococcus*. Either this and allied forms such as, for instance, the hardly separate one known as *S. nivalis*, causing "Red-snow," or *Bacillus prodigiosus*, or other chromogenous bacteria, and some of the *Palmellaceae*, as *P. cruenta*, occasionally appear with extreme suddenness, and among the unlearned give rise to no little alarm, and to dire prognostications of war, famine, and sudden death.

Note on Double-Image Discs and Complementary Interference Colours.

By J. Rheinberg, F.R.M.S.

(*Read April 19th*, 1901.)

Some years ago I was making experiments with multiple-colour illumination, using discs above the objective; and, in making one or two such discs out of coloured glass, Messrs. Zeiss, of Jena, observed a displacement of the image of the central portion of the colour disc relatively to that of the peripheral portion. They then made a double-image colour disc on purpose,



in the manner indicated by the diagram, which shows the same in section.

A prism-shaped disc of green glass had a central hole perforated in it, in which was inserted a smaller disc of red glass with plane parallel surfaces. Consequently the light passing through the prism-shaped part is shifted slightly as compared with that passing through the centre, and we get a separate image formed by each part. That formed by the central portion is an image the same as if the aperture of the objective were cut down to the same size. No fine detail would be seen with an objective of such small aperture, and the image becomes a so-called "dioptric" one. Provided the cone of light from the condenser does not exceed this small aperture, nearly all the light which passes through the prism-shaped portion of the disc will be light which is diffracted by the object, consequently the image formed by this part is a so-called diffraction image. I may mention that with a double-image disc this diffraction image is spurious, inasmuch as all fine periodic structure will be doubled owing to the absence of the dioptric beam as a component.

Now, it struck me that a double-image disc made in this manner, but of clear, uncoloured glass throughout, ought to further test and exemplify a point in the theory of interference colours—viz., that when the dioptric image of a diatom showed colour due to interference, the diffraction image of the first order should show the complementary colour. That was a point I tried to make out in my paper on the colours of *Actinocyclus Ralfsii* last December. (See *Journal Q. M. C.*, Vol. VIII., p. 13).

I have now had such a disc made, and the result, as you will see for yourselves by examining the slide of *Actinocyclus Ralfsii* under the microscope this evening, has fully borne out the anticipation. With these diatoms, which show such varied and vivid colouring, it is a very striking effect to see the two images of each diatom lying next to one another in precisely complementary tints.

A Further Note on *Ixodes reduvius* (Linn.).

By R. T. Lewis, F.R.M.S.

(*Read June* 21*st*, 1901.)

Members of the Club who were present at the meeting of June 15th, 1900, will probably remember that a paper was then read in which details were given of some observations which tended to show that impregnation in certain species of ticks was performed by means of the mouth organs of the males. Living specimens in copula in the manner described were exhibited in the room on that occasion, and the paper itself was published in November last, with a plate in illustration (see *Journ. Q. M. C.*, Vol. vii., p. 381, Pl. XXI.). Although there seemed a strong probability that the inference drawn from these observations was correct, it was admitted that the one conclusive proof—namely, the fact of the transference of spermatozoa—was missing, and that until this was demonstrated it would be unwise to affirm that what had been seen was the actual method of impregnation, although a good case had been made out for supposing it to be so. It is therefore a matter of great satisfaction to be able to announce that Mr. Wheler has now settled this question beyond doubt. Writing to me under date of May 18th, 1901, he says:

"I am sure it will interest you to hear that I believe I have been able to prove beyond doubt the accuracy of your views on the sexual intercourse of *Ixodes reduvius* by the mouth organs, as communicated to the *Quekett Microscopical Club Journal* in November last.

"I was examining some of these ticks for another purpose, when I accidentally found the spermatozoa of the male. These were easily obtained by severing the capitulum from the body, and the spermatozoa were plentiful in the tissues which were pressed out by crushing the body on a cover glass. I found no spermatozoa in a number of females taken from diseased sheep which I examined.

"Yesterday I took three fasting females (these are sure to be virgins) and three males on rushes. They soon paired in the bottle. After about an hour I killed one pair with chloroform, and examined the female without result, though the spermatozoa were as usual present in the male. A second pair separated spontaneously after a couple of hours. In this case plenty of spermatozoa were present in the female. There seems no doubt that I had separated the first pair prematurely. The third pair were still attached after eighteen hours. I send you the two slides showing the spermatozoa taken from the male and female respectively for comparison.

"I have recently found a pair of *I. hexagonus* attached in a similar manner. This is the third species that has been noticed to employ the mouth organs when in copula."

I have brought to the meeting this evening two slides mounted by Mr. Wheler, showing the spermatozoa obtained from the male and the female ticks in the second case mentioned in his letter, and have placed the last-named under a microscope on the table for the inspection of those members who may be interested in the subject. A similar slide having been sent to Professor Neumann at Toulouse, he writes as follows : " Your preparation of spermatozoa of *Ixodes reduvius* conforms to those which Pagenstecher has figured in his 'Beiträge zur Anatomie der Milben H. 2.'"

In further reference to the subject it may also be of interest to mention that I have lately been favoured with a copy of a letter addressed by Mr. Henry Tryon, the Naturalist of the Agricultural Department at Brisbane, to Mr. P. R. Gordon, the Chief Inspector of Stock in Queensland, from whom he had received a reprint of the paper already referred to. In this letter Mr. Tryon points out that the special labial processes which were described and figured in the plate illustrating the paper were discovered by Dr. H. A. Pagenstecher in 1861" (*l.c.*, Taf. I., fig. 2*a*), who said that he had found behind each last and largest lateral hook two anomalous forms which, according to his judgment, appeared to be coarse blunt hooks. Mr. Tryon remarks, therefore, that, "although it thus appears that Mr. Lewis has not been the first to discover their existence, he has been the first to discover their nature." It is perhaps also worth noting that Pagenstecher's observation was made in the case of *Ixodes ricinus*, and not on *I. reduvius*, as described in my paper; which shows at least that these organs are not confined to one species.

Note on a New Description of Forceps for Holding Cover Glasses.

By T. J. Davis.

(*Read June 21st*, 1901.)

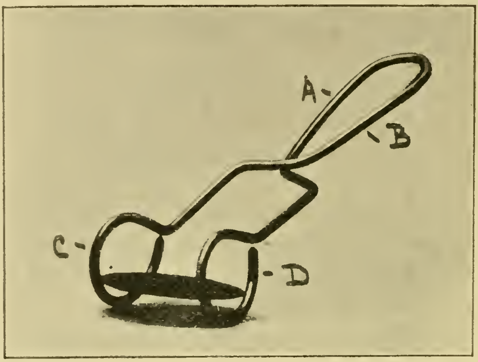
From experience with the various kinds of forceps for holding cover glasses whilst staining and decolorising in bacteriological work, I have come to the conclusion that for several reasons none of these are altogether satisfactory.

Taking the "Cornet" forceps, for instance, these are out of all proportion to the fragile glasses, inasmuch as the metal may, and does, receive too great an amount of heat, which is transmitted to the cover glass; again, when the Carbol stain is applied, capillary attraction takes place, and this causes the stain to run on to the underside of the cover glass and drop off, which is highly objectionable.

Other forceps of a lighter construction as sold by opticians are also objectionable, inasmuch as they need to have compression maintained during the whole process of manipulation, and this is most tiring to the finger and thumb owing to the length of time this may take; again, the swan-bill points set up a capillary attraction as in the former case; and finally, these forceps being made of steel, the acid used in decolorising rapidly eats away the metal, and quickly renders them worthless.

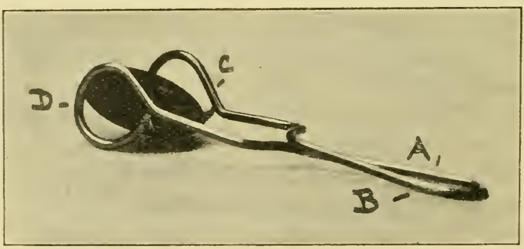
Owing to the above experience, I have made what I consider a better instrument, and respectfully submit the same to the members of the Club. It will be seen from the accompanying illustrations, that when A and B are compressed, C and D open to receive the cover glass, which is then held in position by slight pressure on four points of C and D. The staining, decolorising and double staining is carried through while the cover glass is in this position, and when completed A and B are again compressed, and the cover glass drops out on to blotting paper, which soaks up the superfluous liquid.

The material employed in making the forceps is dental alloy as used by dentists, and it has been selected for this purpose because it has the required amount of elasticity, and is not



damaged by diluted acids—say, 30 per cent. nitric acid, as is the case with steel.

By the peculiar construction of this instrument it will also be seen that the cover glass can be turned over or set aside temporarily, remaining comparatively free from dust, and without touching anything.



This instrument has been used by me for over twelve months, and I have been so satisfied with its performance that it is a pleasure for me to introduce the same, in hope that others may derive the same benefit from it as I have done.

Note on the Method of Feeding of Phyllopods and Cladocera.

By Marcus Hartog, M.A., D.Sc.

(*Communicated June 21st*, 1901.)

In the course of some hatching experiments with *Apus* and *Branchipus* I incidentally noticed that they fed lying on their backs, the swing of the appendages producing a backward current of the water down either side, while the inmost lobes ("gnathobasites" of Lankester) sent an upstream along the median line to the mouth. The food consisted of the floating materials in the water, and was swallowed by the combined movements of the mandibles and the peristaltic action of the gullet. The two mandibles work so that the one has greater play than the other, carrying the suspended matters past it right into the gullet.

It is interesting to compare this with the more complex arrangements of Cladocera. To study these in *Daphnia*, etc., we require a good magnification by a low-angle lens, such as the B ($\frac{1}{2}$ in.) and C ($\frac{1}{4}$ in.) of Zeiss; and the animal must lie in a cell, preferably uncovered, deep enough to allow it free play. Here the thoracic appendages cause a flow of water into the shell through the angles on either side between the valves and the beaked head, and immediately past the anterior antennae, which are thus in the very best position, as sense organs, for perceiving any change in the properties of the indraught. The stream flows backwards between the valves in the space traversed by the limbs proper and their pectinate plates. Into the gill-cavities, between the valves and the outer side of the limbs, no formed particles can be seen to pass, as the pectinate plates on the limbs, which make them so efficient in producing the current, are equally efficient as sieves or filters. The solid particles in suspension as they pass back drift into the angle where the hinder end of the body bends abruptly down. Here they are turned forward into a reverse eddy, forwards, under and along the median line of the body, till they reach the oral region behind the labrum, where the play of the mandibles, like that of *Apus*, sends them into the gullet to be swallowed. If the solids in the water be in excess, the accumulation against the labrum is too large to be dealt with in this way; and the hinder end of the body, armed as it is with two strong spines, is, as it were, scraped along the median groove, and turned sharply downwards and backwards at the end of the stroke, so as to scoop away the clogging mass and expel it from the shell. I may note that by adding carmine to the water we can see that the food passes freely from the gut proper into the pyloric caeca, which are therefore not merely secreting organs.

They may often be seen feeding in this way when resting by the back of the head against a weed or the wall of the vessel. A large sensory nerve ends here, and possibly the end organ may secrete matter viscid enough to fix the animal, so long as it does not execute vigorous swimming movements. This "dorsal organ" (or rather "nuchal organ") is especially well developed in *Sida*.

While the general rhythm of the bulk of the limbs of crustacea is backwards, their bases and their epipodial appendages tend to work in the reverse direction. This is especially visible in the last gill of *Daphnia*, and is notably the case with the gills, etc., of the Decapoda, the highest group.

The Nauplius larva of *Cyclops* has a so-called "masticatory hook" at the base of its second pair of appendages, which works into the pharynx just in the same way as do the mandibles of *Apus* or *Daphnia*.

Note on the "Fred. P. Pullar Memorial Prizes."

Through the generosity of Sir John Murray, K.C.B., the General Committee of the Marine Biological Association of the West of Scotland have been enabled to offer the following prizes, to be called the Fred. P. Pullar Memorial Prizes. They are instituted in memory of the late Fred. P. Pullar, who was associated with Sir John Murray in the Bathymetrical Survey of the Scottish Fresh Water Lochs (see *Geographical Journal*, April 1900, and March 1901), who took much interest in the Millport Marine Station, and who lost his life in the unfortunate ice accident on Airthrey Loch, Bridge of Allan, on February 15th last.

I.—A prize of £50 for a paper on the Seasonal Distribution and Development of Pelagic Algae in the Waters of the Clyde Sea Area.

II.—A prize of £50 for a paper on the Reproduction, Development, and Distribution in the Clyde Sea Area of the Genera Nyctiphanes and Boreophausia (Crustacea Schizopoda).

III.—A prize of £50 for a paper on the Formation and Distribution of Glauconite in the deposits of the Clyde Sea Area and the adjacent seas of Scotland.

These prizes are open to investigators from any part of the world who conduct observations in the several subjects at the Millport Marine Station, and who produce, at any time before January 1st, 1905, papers which, in the opinion of a Committee of three scientific men, to be nominated by the Committee of the Association and by Sir John Murray, shall be deemed of sufficient value to merit publication. Those proposing to work for any one of these prizes should make known their intention to the Secretary of the Association (John A. Todd, Esq., 190, West George Street, Glasgow) in order that the necessary arrangements may be made.

The offer of the above-mentioned prizes marks an important departure in the study of marine biology in Scotland, and it should at least do much to still further increase the good work done at the well-known Millport Station in the Firth of Clyde. It is sincerely to be hoped, in the interests of science, that quite a number of competitors may be induced to enter for each of the prizes.

It may not be out of place here to call attention to the very interesting little "Handbook of the Marine Station, Keppel Pier, Millport," which has quite recently been issued by the Marine Biological Association of the West of Scotland. It is designed to give a brief account of the history and present position of the Station, and to indicate some of the lines along which the work of the Station may be expected to develop in the near future. It contains an excellent portrait of the late Dr. David Robertson—"The Cumbrae Naturalist"—together with views and plans of the Station buildings and boats.

NOTICES OF RECENT BOOKS.

The Microscope and its Revelations. By the late William B. Carpenter, C.B., M.D., LL.D., F.R.S. Eighth Edition, revised by the Rev. W. H. Dallinger, D.Sc., D.C.L., LL.D., F.R.S., $8\frac{3}{4} \times 5\frac{1}{2}$ in., xx + 1181 pages, 22 plates, 817 figures in the text. London, 1901: J. and A. Churchill. Price 28*s*.

If the microscopist were compelled to limit himself to a single book on microscopical matters, the selected work should, of course, be Dallinger's "Carpenter." This has been true any time this last ten years—that is, since the publication of the seventh edition; and now that this new edition has appeared, it will remain true, we firmly believe, for at least another decade. This is not because of the infallible accuracy or superlative excellence of every part of the book, but because, as a whole, it contains such a mass of valuable information, both theoretical and practical, upon such a variety of topics, that it is impossible to imagine that there can exist any worker with the microscope who could not learn something to his advantage from its pages.

It would be extremely difficult in a short notice to attempt to give even a general outline of the contents of such a heavily freighted book as "Carpenter" has now become. Fortunately this is scarcely necessary, because the present issue follows exactly upon the lines of the widely-known seventh edition. It will be sufficient, therefore, if a few of the additions and alterations only are referred to.

As might have been anticipated, the chapter which has received the greatest amount of revision is the extremely important one dealing with the history and development of the microscope. In the earlier part of this chapter several new figures of old microscopes have been introduced, notably one by Bonannus (1691), showing a sub-stage compound condenser with focussing arrangements. We notice also that Dr. Dallinger has now added the weight of his own testimony to that of Mr. Mayall that the famous lenticular piece of rock crystal from

Sargon's Palace at Nimroud could never have been intended for use as a lens. As regards typical modern microscopes, we find that practically all the important patterns of quite recent construction have been included; although to make room for these, many of the descriptions and figures of instruments in the former edition have been omitted. Such gaiety as the book possessed has certainly been decreased in this way, for we can no longer turn to it for a quiet chuckle over the delightful pictures of radial and swinging sub-stage microscopes attempting to stand on their heads, wagging their tails, and performing other clever but useless tricks.

In the chapter devoted to accessory apparatus there are several new features. Nelson's camera lucida, for instance, is fully described, though we fail to find any mention of Ashe's form, which carries out the same idea in a more useful way. New condensers, including Powell and Lealand's apochromatic form with Nelson's correction collar, necessarily receive considerable attention; and space has also been found for a short account of the rings and brushes shown by certain minerals under polarised light, and for a description of Gifford's F-line screen.

The section on the preparation and mounting of objects has been very much improved—largely rewritten, in fact—but that on collection remains unaltered. This seems rather a pity, when it is remembered what important advances have been made in the methods of collecting plankton alone. It is curious, too, that no mention is made of the material almost invariably employed nowadays in the construction of nets—namely, silk-gauze.

The second half of the book, commencing with Chapter VIII., and treating mainly of the minute forms of plant and animal life and other microscopic structures, has not been materially altered, so far as we can see. The main changes are those in connection with the Bacteria, which have been illustrated by two new plates, and the application of the microscope to geological investigation. An appendix has also been added to Chapter XIII. on Rousselet's method of preparing Rotifers. We are not unmindful of the very large amount of most valuable information contained in this portion of the book, but we cannot help suspecting that some of the statements would have been somewhat modified, and possibly also expanded, if they had been submitted to specialists. This is probably what will have to be done in the future, for "Carpenter" now appears to us to have reached its utmost limit as a one-volume work. In any future edition a process of reproduction by fission will have to take place, and the "Microscope" and the "Revelations" will have to be issued in two volumes, which should of course be obtainable separately if desired.

The present edition is printed on much better paper than the last, with the result that the letterpress and the figures in the text are much clearer than before, and the general appearance of the book is now everything that can be desired. D. J. S.

Das Tierreich. Eine Zusammenstellung und Kennzeichnung der rezenten Tierformen, $10\frac{1}{4} \times 6\frac{3}{4}$ in. Berlin : Friedländer & Sohn.

Lieferung 3. Oribatidae, by A. D. Michael, xii + 93 pages, 15 figures in the text. 1898. Price 6·80 marks.

Lieferung 7. Demodicidae and Sarcoptidae. By G. Canestrini and P. Kramer, xvi + 193 pages, 31 figures in the text. 1899. Price 12 marks.

Lieferung 13. Hydrachnidae and Halacaridae. By R. Piersig and H. Lohmann, xviii + 336 pages, 87 figures in the text. 1901. Price 21 marks.

Five years ago the German Zoological Society commenced the truly colossal task of issuing a complete descriptive summary of all the known species of animals. Since that time there have appeared sixteen instalments, and nothing but praise can be bestowed upon the editors and authors alike for the excellent way in which the work has been carried out. The parts which we now have before us deal with various kinds of "mites"—beetle-mites, bee-mites, bird-mites, itch-mites, cheese-mites, water-mites, etc.—and it is the barest truth to say that they are absolutely indispensable to those who make the slightest pretension to acquaintance with these little creatures.

We do not propose to consider in detail each of the parts mentioned above; but it may nevertheless be useful to some microscopists if, in addition to calling attention to these epoch-making books, we give a few notes on the part dealing with the Hydrachnidae. This has been compiled by Dr. R. Piersig, whose name alone is a sufficient index of its value. The amount of research necessary to produce the work must have been enormous. Every author who has written on this division of the Acarina for the last hundred and fifty years is quoted and referred to. According to Dr. Piersig, the family Hydrachnidae now reaches fifty-eight genera, and upwards of six hundred species. In addition to the detailed descriptions of these, keys are given for the rapid identification of both genera and species, and any one who has once tried to construct a key to a number of species will realise the immense amount of work such an undertaking entails, especially when it is stated that one genus alone, *Arrhenurus*, contains seventy-nine species.

Among the changes introduced by this work we notice that there are three genera in which an alteration has been made in the usually accepted spelling. *Eylais* is now *Eulais*, *Krendowskia* is now *Krendowskija*, and *Arrenurus* is now *Arrhenurus*. There are also some very important alterations in the generic names: *Sperchonopsis* is now *Pseudosperchon*, and *Piona* is now *Laminipes*. We hope this latter name will be final, for this is the third alteration since 1835. *Cochleophorus*, a sub-genus of *Atax*, has been altered back to *Neumania*, the name given by Lebert in 1879. *Acercus* has also been altered back to *Tiphys*, Koch, 1835. But perhaps the most important change is that the genus *Curvipes* has been altered to *Piona*. We may surely hope that this has now found a resting-place. It is a genus containing a large number of species which were at one time described under the name of *Nesaea*, but Koenike in 1891 introduced the name *Curvipes*, and this was accepted by most writers. Now we are taken back to *Piona*, Koch's name for a portion of this genus.

Such radical changes are very troublesome, but most of them will in all probability be final. And as the work is a digest of all the information, so far as species go, that exists in the numerous scattered papers and books by writers of all nationalities, it is evidently one that no student of the Water-mites can do without.

C. D. S.

Life by the Sea-Shore. An Introduction to Natural History. By Marion Newbigin, D.Sc., $7\frac{1}{2} \times 5$ in., vii + 344 pages, 93 figures in the text. London, 1901: Swan Sonnenschein and Co. Price 3*s*. 6*d*. net.

The natural history of the sea-shore has already formed the subject of a very large number of publications; but, owing to the fascinating character of shore-hunting and the almost inexhaustible variety of the material to be dealt with, there always seems to be room for yet another book. At any rate the present work can safely claim to have justified its appearance for it is an exceedingly well written and, as far as it goes, a very accurate account of the majority of the commoner animals found between tide-marks, and it can very well serve, as suggested by the sub-title, as an introduction to natural history. The essentially microscopic forms—the Protozoa—are not dealt with, but naturally many very minute forms, such as some of the Hydrozoa, Bristle-worms, larval Crustacea, Nudibranchs, and Tunicates receive some attention. The Nudibranchs or Sea-slugs have a chapter all to themselves, and they fully deserve it, although they are usually dismissed with a very short notice. One characteristic feature of the book is that at the end of each chapter keys or tables are given to assist the rapid identification of the species mentioned therein. And in connection with the selection of the species, it has been the author's aim to make the descriptions sufficiently detailed to ensure the identification of actual specimens, and not to refer to a large number of animals merely by name. The first two chapters and the last are devoted to the consideration of some general points connected with the study of the littoral fauna, such as the general characteristics of shore animals, the methods to be employed in their collection and study, and their distribution and relationships. A remark in the second chapter, to the effect that the shore naturalist should interest himself in the animals he finds if he cannot find those in which he is interested, might well be taken to heart by others than rock-pool hunters. It might even be meditated upon by those who, during pond-dipping excursions, pass hasty judgments upon various ponds, to the effect that this one is no good because there are no rare Rotifers in it, or the other is useless because it only contains "common" water-fleas, and so on.

Altogether Miss Newbigin is to be congratulated upon the freshness with which she has treated a well-worn subject, and our only regret is that a rather larger number of illustrations could not have been sandwiched into such admirable text. D. J. S.

Lehrbuch der technischen Mikroskopie. By Dr. T. F. Hanausek. 10 by $6\frac{1}{2}$ in., x + 456 pages, 256 figures in the text. Stuttgart, 1901: Ferdinand Enke. Price 14·40 marks.

There is every indication that the employment of the microscope for all kinds of technical purposes is rapidly assuming more and more importance, and the issue of a text-book on technical microscopy therefore, by such an expert as Dr. Hanausek of Vienna, will certainly meet with approval. The work before us is somewhat ambitious, in that it claims to cover the whole field of technical microscopy Although we may well be sceptical on this point, looking to the almost inexhaustible variety of the questions connected with commerce and the arts which are decided wholly or partially by the microscope, the book is undoubtedtly a most comprehensive one. And not only does it range over a wide area, but the subjects touched upon are, for the most part, treated in sufficient detail to make the book really serviceable to the practical man, which, we need hardly say, is by no means always the case with text-books.

Of the varied contents it is not easy to give a brief summary, but it may be pointed out that by far the greatest amount of space is devoted to vegetable substances such as starches, cotton, flax, hemp, jute, woods, barks, roots, leaves, fruits and seeds. The animal fibres (wool, hair and silk) and bone, ivory, horn, etc., are, of course, also considered, though more briefly, and there is a final chapter upon micro-chemical analysis. Two extremely instructive sections are concerned with the microscopical examination of paper and textile fabrics. The author has also drawn upon his own experience as a technical microscopical referee to include a number of interesting examples of actual problems which have occurred in practice. For instance, a particular sample of potato starch was found by the manufacturer to be unavailable for the preparation of dextrine. When the starch was examined microscopically, the grains were seen to have undergone considerable alteration, evidently produced by the solvent action of a ferment, and the explanation of this was that in all probability there had been used in the production of this starch potatoes which had commenced to sprout. Again, in a case of incendiarism, where a man suspected of the crime was found to have in his possession a piece of cord apparently similar to that discovered to have been used to set fire to the building, it was conclusively shown that the two pieces were not really the same, as one of them consisted of two strands of hemp and one of jute, while the other was wholly of hemp. Many other examples are given, but the two quoted will serve as specimens.

Taking all the features of the book into consideration, not forgetting the many excellent figures and the abundant references to the literature of the subject, we have no hesitation in recommending the work to all those who have to, or would like to, use their microscopes either constantly or occasionally for technical ends.

The issue of a translation of the work would, we have reason to believe, be much appreciated in this country. D. J. S.

Die mikroskopische Analyse der Drogenpulver. Ein Atlas für Apotheker, Drogisten und Studierende der Pharmacie. By Dr. Ludwig Koch. $11\frac{1}{2}$ by $8\frac{1}{2}$ in. Vol. I., 168 pages, 14 plates. Leipzig, 1901: Gebrüder Borntraeger. Price 12 marks.

It is not so very long ago that the "chemist and druggist" powdered many of his drugs directly from the raw material, and he was then able to judge pretty accurately of their quality. But now he can often only obtain them in a powdered state; with the result that, although he is still responsible for their purity, he has no check upon the wholesale dealer, unless he can tell from the microscopical characters whether the powders sold to him are what they pretend to be or not. It is with a view to provide him with an absolutely reliable guide in this matter that Professor Koch, of the University of Heidelberg, has planned the present elaborate work. The first volume has been completed (it was issued in three instalments), and it deals with the barks, or more correctly "rinds," and woods used as drugs, according to the German "Arzneibuch."

The volume opens with a general description of the methods suitable for the investigation of powdered drugs, such as the preparation of the slides for examination, the different liquids to be added and the reagents to be used, and the points to be specially noted when the object is actually under the microscope.

Coming next to the special part of the work, the author treats of the "rinds" and woods used as drugs from two points of view: namely, (1) their general constitution, including a discussion of the anatomical elements, such as bast-fibres, stone-cells, cork tissue, phelloderm, etc., and (2) the appearance of the powders under the microscope. Naturally, it is the latter subject which receives the greatest amount of attention, and the facts are brought forward in a very methodical and painstaking way. They are, moreover, illustrated by a number of carefully prepared lithographic plates, which should lighten the task of the analyst very considerably; although, as Professor Koch points out, it must not be expected that either the text or the figures can be used in a purely mechanical way for purposes of identification. Individual judgment and common sense, combined with a general knowledge of the subject and much patience, must also be brought into play if the microscopical analysis of "drug powders" is to be successful.

In succeeding instalments the microscopical characters of powdered drugs from other sources, as stems, roots, leaves, etc., will be considered; and, if demanded, descriptions will also be given of drugs not alluded to in the "Arzneibuch." Should the whole work be carried out in the same style and with the same care as this first volume, there is no doubt that it will long remain the "first" book on the subject in a higher sense than that of the mere priority of publication which it claims.—D. J. S.

Leitfaden zu mikroskopisch-pharmakognostischen Übungen für Studierende und zum Selbstunterricht. By Dr. J. Moeller. $9\frac{1}{2} \times 6\frac{1}{2}$ in., viii + 336 pages, 409 figures in the text. Vienna, 1901: Alfred Hölder. Price 8 marks.

This is yet another book belonging to the same category as the two preceding works, and occupying a position somewhere between them. Like Professor Koch's book, it is intended mainly for those who have to deal with pharmaceutical substances, but it covers much more ground in that it treats of the microstructure of nearly all the drugs in general use, and also of many substances used for food or in various manufactures. On the other hand, it is not intended to be such a general work as Hanausek's "Lehrbuch der technischen Mikroskopie."

The endeavour of the author has been to arrange the matter in such a way that the student is led step by step from the comparatively simple and more easily investigated structures, to those of greater and greater complexity. It is, therefore, only natural that, after the inevitable "Allgemeiner Theil" on the microscope and its use, we should be introduced to those vegetable substances usually met with in the form of powder, such as Lycopodium, Lupulin, Kamala, and the starches. Then follow the fibres and fibre-like structures, both animal and vegetable, leaves and flowers, seeds and fruits, woods and barks, and finally the underground vegetable productions and a few miscellaneous things such as galls, etc. Particular attention is directed to the commoner forms of adulteration in cases where this is prevalent. There can be no doubt but what this book will be of the greatest assistance to those interested in any way in the subjects with which it deals, and its illustrations make it quite a useful book of reference for the student of structural botany. It is, in fact, the most copiously illustrated publication of its kind that we have seen for a long time: four hundred and nine figures, and nearly all of considerable size and excellent quality, to three hundred and thirty-six pages.—D. J. S.

Anleitung zum Gebrauch des Polarisationsmikroskops. By Dr. E. Weinschenk. 9 × $5\frac{5}{8}$ in., vi + 123 pages, 100 figures in the text. Freiburg-i.-B., 1901: B. Herder. Price 3 marks.

The methods employed in the use of the polarising microscope, or as it is more usually called in this country the mineralogical or petrological microscope, are very rarely given in any detail in books dealing with microscopical manipulation. This is the more remarkable because this form of instrument is not limited in its usefulness merely to the examination of thin sections of rocks and minerals, but is, or might be, of the greatest importance to many workers in other fields, and especially to chemists and analysts. The explanation is very probably to be found in the fact that the subject has become too extensive for satisfactory treatment except in a special work. Such a work we now have before us. It has been written by Dr. Weinschenk, Professor of Petrography at Munich, and, whilst without any pretence to be considered exhaustive, it seems to contain all that is necessary for a good working knowledge of the subject.

A general account of the polarising microscope, including notes on various types of instruments by Seibert, Nachet, and Voigt & Hochgesang, forms the first section of the book, and following this a few pages are devoted to various adjustments of the stage, crossed wires, and Nicol prisms, after which the author passes to the examination of crystals with ordinary light. But the essential parts of the treatise are contained in the two following sections, dealing with observations made with the help of parallel and converging polarised light. We are here introduced to the optical properties of crystals, the interference colours which they exhibit, the methods of determining the direction, degree, and relative speed of vibration of the two rays produced by doubly refracting bodies, and also, of course, to the peculiarities of the appearances of the "rings and brushes" of crystals. The numerous pieces of subsidiary apparatus employed for various purposes in connection with this part of the subject, such as the various forms of stauroscope, the quarter-undulation plate, the mica wedge, the quartz wedge, etc., are either discussed in the text or referred to in special notes. The final section concerns the peculiar twinning which occurs in many cases, and to some optical anomalies. In a short appendix some of the wonderfully improved forms of goniometer now in use are alluded to, and also apparatus for the heating and delineation of crystals.

The book, it must be remembered, is not a treatise on petrology or crystallography, but simply what its title states it to be—an introduction to the use of the polarising microscope—and as such it appears to be an exceedingly useful and compact little work.

D. J. S.

PROCEEDINGS.

March 15th, 1901.—Ordinary Meeting.

J. G. Waller, Esq., F.S.A., Vice-President, in the Chair.

The minutes of the Annual Meeting, held on February 15th, were read and confirmed. Mr. Leslie H. Winn was balloted for and elected a member of the Club.

The additions to the Library and Cabinet were announced, and the thanks of the Club voted to the Donors.

The Secretary, referring to the recommendation of the Committee in the Annual Report, said a card had been drawn up and printed, describing the objects and advantages of the Club, for the use of members in endeavouring to extend the membership of the Club. A supply was placed on the table, and it was hoped that the members would make use of them. He regretted that the agenda that evening was absolutely a blank. The only paper available was held over, as the gentleman who wished to discuss the matter was unable to be present that evening. Mr. Curties had, however, kindly brought up some interesting objects which were on the tables, and he invited discussion upon them. As he and the Committee had been engaged until the commencement of the meeting, they had not been able to do more than glance at the objects.

There was one point, however, that struck him in the slide of Desmids. He should like to know if the object had been stained, and if so how? Was the endochrome or the envelope stained?

Mr. Curties replied that the object was stained, but he did not know by what process.

Mr. Morland, referring to the slide of Limestone showing sections of foraminifera, thought it was a pity more interest was not taken in Rock sections, which were generally considered merely pretty "show" objects. The structure of rocks, as shown by the polariscope and otherwise, was a most interesting study, and he recommended members who wanted a subject to take it up. The section of Limestone on the table was a fine section, and well cut. He had made a good many sections from Jutland Slate showing sections of Diatoms, *Coscinodiscus* and other forms, in different planes. It was evident that these diatoms had been deposited in very quiet water, as all were lying on their flat side, and horizontal sections of the rock showed the circular form and vertical sections the transverse section of the diatoms.

Mr. Stokes inquired if the secondary structure could be traced.

Mr. Morland replied that it could not, but the shape of the cells could be seen most distinctly, and the eye-spot was marked in the interior by small tubes, which were cut straight across in the section.

A hearty vote of thanks to Mr. Curties was passed.

The meeting closed with the usual conversazione.

April 19th, 1901.—Ordinary Meeting.

George Massee, Esq., President, in the chair.

The minutes of the meeting of March 15th, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—Mr. W. H. Browne, Mr. Walter C. Railton, Mr. Rowland R. Robbins.

The additions to the Library were announced.

The Secretary said that they had also received from Mr. James Mottram a very valuable addition to their Cabinet. It would be remembered that about two years ago Mr. Nelson presented the Club with a hundred slides of diatoms from the Hamilton-Smith collection. Mr. Mottram, hearing of this, said that he would at a future date present the remainder, and this he had now done; so that the Club was in possession of the whole series of four hundred slides, all of which were in excellent condition, and would be available for the use of the members as soon as Mr. Sidwell had time to arrange them. The Committee had already passed a formal vote of thanks to Mr. Mottram, but he had not the slightest doubt that every member of the Club would like to join in this.

The thanks of the meeting were then unanimously voted to Mr. Mottram for his donation, and also to the donors of the various additions to the Library.

Mr. W B. Stokes read a paper on "Images of Diatom Structure," the subject being illustrated by diagrams drawn upon the blackboard.

Mr. J. Rheinberg followed with a paper on the same subject, entitled "The Black and White Dot Phenomenon," in which the effects described by Mr. Stokes were explained to be the results of entirely different causes.

Mr. Stokes, replying to a portion of Mr. Rheinberg's remarks, pointed out that it was the late Mr. Haughton Gill who filled up the perforations in the diatoms with solid matter, and it was then found that the "black dot" of these diatoms did not occupy the same plane as before. What he was trying to show was that these appearances followed some general rule, and that if they changed the zones of the objective so that the refracted light and the reflected light changed places, the position of the dots was altered. If three zones were used, then they had three images. He thought that the trellis-work system referred to by Mr. Rheinberg would produce an almost indefinite effect, not following any rule.

Mr. Rheinberg said he perfectly agreed with Mr. Stokes that these things followed a certain rule, but he did not think it had anything to do with the objective, because when using an apochromatic he could get one and even two images above the focal plane, and nearly always two below. His reference to trellis-work was merely by way of crude analogy. There was, of course, no true trellis-work in the structure, but there was such an amount of overlapping that it was not possible to get a distinct image of what was underneath. They were not only in this case dealing with the rays mentioned, but they had a number of others still more oblique crossing each other in all directions and causing irregular effects.

On the motion of the President, a hearty vote of thanks was given to Mr. Stokes and Mr. Rheinberg for their respective communications.

The President read a note on the so-called origin of Potato-tubers as propounded by Bernard in the *Comptes Rendus*, which, but for the fact that it appeared in such a high-class scientific journal, he should have thought must surely have been a huge joke.

Mr. Karop contributed a note on "Red Rain Dust from Australia," which had been collected by Captain C. J. Gray and sent to him for examination. This did not appear greatly to differ from other samples, which were found to consist of a vast number of different bodies in a finely powdered condition raised to great heights by wind-storms and carried about by atmospheric currents until they were brought down by the rain. The subject was investigated very thoroughly by Prof. Ehrenberg, who published many papers relating to it.

Mr. Earland said that Mr. Mottram had sent him some red rain dust also from Melbourne. He was given to understand that its origin had been traced to a district in the middle of Australia, and that it always came with a north wind.

Mr. Karop thought it probable that both lots were from the same source. Some of Ehrenberg's samples, however, were taken as much as a hundred miles out at sea.

Notices of meetings and excursions for the ensuing month were then given, and the proceedings terminated with the usual conversazione.

May 17th, 1901.—Ordinary Meeting.

George Massee, Esq., President, in the Chair.

The minutes of the meeting of April 19th, 1901, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—G. P. Deeley, H. Gladding, S. Harvey, T. G. Kingsford, Hon. T. Kirkman, E. H. Lund, J. P. Miles, A. E. Mitchell, G. A. Pedley, M.R.C.S., D. Powell, M.A., A. Reynell, E. H. Rundle, W. Selman, A. G. Soutter, O. Whiting, L. M. Wilde, and W. F. G. Winter.

The donations to the Library and Cabinet were announced.

The Secretary called special attention to a donation of slides from Mr. Rousselet, which brought up the collection of mounted Rotifers in the Cabinet of the Club to a total of 242 slides. He also reminded the members that the Club possessed two albums for the portraits of those who were good enough to contribute them. These albums were upon the table, and formed a very interesting collection, especially as reminiscences of many of the early members, who had since been removed by death.

The President said he was sure the members of the Club would feel very greatly indebted to Mr. Rousselet for this further donation of slides of Rotifers, for nothing could be more useful to those who were interested in such organisms than to have a good type collection available, to which they could have access when they wanted to identify species which they found. He therefore moved that their special thanks be given to Mr. Rousselet for this valuable contribution to their Cabinet.

The motion being put from the Chair, was carried by acclamation.

The President then gave an interesting account of the group of fungi known as the Laboulbeniaceae—the subject being well illustrated by coloured diagrams and by drawings on the board.

Mr. J. G. Waller, who occupied the chair *pro tem.*, moved a vote of thanks to the President for the very able and interesting description of a group of vegetable organisms belonging to a class with which he was so well acquainted, the subject being one of which he was so perfect a master. The thanks of the meeting were then unanimously voted to the President for his communication.

Mr. Karop said that this group had been known for a number of years, but some forms had been found in Australia growing upon caterpillars and attaining a length of several inches. He should like to ask if these were the same, or did they belong to a separate group?

Mr. Massee said that they belonged, broadly speaking, to the same division of fungi, but they were really *Cordiceps*, which were similar in structure but without any sexual reproduction whatever. They were commonly parasitic on insects, and the downy substance sometimes found on insects in the chrysalis state was the conidial form of *Cordiceps*. The sexual mode of reproduction was the distinctive feature of the Laboulbeniaceae.

He thanked the members of the Club for the way in which they had received his description of the group, and hoped that some of them would be able to discover these forms in England. He did not think there should be the slightest difficulty in doing this, and should quite expect that any one who set himself to this work would find some on water-boatmen or other aquatic insects in the course of an hour.

Mr. Karop read an article on the "Wonders of the Microscope," extracted from *Answers*, the absurdity of the many inaccuracies in which caused considerable amusement.

Announcements of meetings and excursions for the ensuing month were then made, and the proceedings closed with the usual conversazione.

June 21st, 1901.—Ordinary Meeting.

J. G. Waller, Esq., Vice-President, in the Chair.

The minutes of the meeting of May 17th, 1901, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—Mr. George Buttifant, Mr. Ernest Cecil Goulton, Mr. E. A. Rickomartz, Mr. H. R. Robertson, Mr. E. H. Tyrrell, Mr. Bernard Smith.

The list of donations to the Club since the last meeting was read, and the thanks of the members were voted to the donors; attention being specially called to a bound collection of his various papers on microscopical subjects presented to the Library by Mr. E. M. Nelson.

Mr. R. T. Lewis read a further note with reference to *Ixodes reduvius*, as a sequel to his paper read at the meeting of the Club in June 1900, and printed in the *Journal* for November last. A slide of the spermatozoa, mounted by Mr. Wheler, was exhibited in illustration.

The thanks of the meeting were voted to Mr. Lewis for his communication.

Mr. T. J. Davis exhibited and described a useful form of clip for holding cover-glasses in bacteriological work.

The Chairman thought this would be found a very useful invention; it was simple in construction and very handy for the purpose.

Mr. Karop said that Mr. Davis had mentioned the objections to the use of the ordinary forceps, which every one must have had experience of who had used them for the purpose. When he was doing work of this kind he used to find that the ends of the steel forceps very soon got corroded, and he made some horn points to protect them. These answered the purpose very well, but of course they were easily destroyed if too much heat was applied. It was, however, a very easy matter to renew them; but the forceps were not self-holding, like those of Mr. Davis.

Mr. John Shephard exhibited and described a new species of *Brachionus* from the colony of Victoria. He said that microscopy in Victoria was chiefly carried on by members of the Field Naturalists' Society of Victoria, which had a membership at the present time of about two hundred. Amongst them were men who had done much to describe the fauna and flora of Australia, which in some parts were being so greatly injured by indiscriminate hunting that it had been found necessary to protect many of the animals—such as the ornithorhyncus and even the kangaroo—by legislative enactments. These measures, though not completely successful, had done something towards checking the waste. The collecting of Rotifera was done chiefly in the neighbourhood of Melbourne, and all had been collected within twenty miles of the city; so that it might be said that the Rotifera of the colony were almost as yet untouched. The attention they had given to the subject had already revealed some new species, and amongst these some unique and remarkable forms. One of these, which he showed that evening—*Lacinularia striolata*—was, when found, usually present in very large numbers, each colony being formed by a kind of swarming after the manner of bees. The eggs were of two kinds—resting, and those which hatched out at once. Those which hatched immediately sent out the young ones to gather together, and they then formed a quantity of mucus, which after a short time surrounded them. After a time they arranged themselves with their toes towards the centre, and then they poured out mucus in one direction, which eventually formed a peduncle, and the colony was thus found to consist of individuals all of the same age. *Lacinularia pedunculata* was another species whose habits were similar to those of the one previously named; but in this case the young took their places in the colony immediately they hatched out. He had another specimen, which, however, had not yet been described; this was a species of *Brachionus* with a very remarkable lorica. Another remarkable creature which he had brought for exhibition was a *Lepidurus*, one of the largest of the Entomostraca, which was allied to *Apus*, but differed from it because of the presence of a curious leaf-shaped process. These creatures were remarkable for the extreme rapidity with which they were developed from the eggs. In the district where they were found the ground was during part of the year extremely dry and the soil a fine alluvium; but when the rains came, in April or May, the water remained in the small pools which were formed, and in a month these were all full of *Lepidurus*. Another specimen was a *Branchipus*, a small crustacean whose development was equally rapid. The so-called "winter egg" was with them really a summer egg, protecting the race from destruction during the drought and heat of summer, but beginning to develop in the course of a few days after the rains had begun. He had found these animals in the same place during several successive years in a district which was always completely dried up during the summer.

Mr. Karop said the *Lepidurus* was certainly a very fine animal of its kind—almost as large, in fact, as a young King-Crab. He asked how long it would take to attain that size, and also what it fed upon?

Mr. Shephard said it would develop to the size of the specimen exhibited in the course of five or six weeks; but *Apus* would develop in a much shorter time, and could be found within a fortnight. *Lepidurus* mostly fed upon decaying vegetable matter.

Mr. Karop thought it did great credit to its diet.

Professor Marcus M. Hartog said that the very interesting observations of Mr. Shephard suggested that he should give his own experiences of the raising of *Apus* and *Branchipus* from mud kindly sent to him by Herr Poppe, of Bremen, over twenty years ago, when he was working at Crustacea. He found that the *same* mud would give a succession of broods in successive years if dried off between times—proving clearly that different eggs attain the power of germination under similar conditions at different times. Doubtless, from the inadequate size of the containing vessel, he never succeeded in rearing the young to their full size, though some that he showed at the Royal Microscopical Society were, to the best of his recollection, at least $\frac{1}{4}''$ in length. He had tried to find some more mud of the same sort, but had never succeeded. He hoped Mr. Shephard might be able to send him some. Professor Hartog then gave an interesting account of the mode of feeding in the case of *Apus* and *Daphnia* (see *ante*, p. 157).

Mr. Shephard said he should be very pleased to send some mud to Professor Hartog, but he could not guarantee that it would produce Entomostraca. He had usually kept the mud in an open vessel out of doors, but found it best to bring it indoors during the very dry weather.

On the motion of the Chairman very hearty votes of thanks were then passed to Mr. Shephard and to Professor Hartog for their communications.

Mr. W. Wesché read a paper on a new male rotifer found at Golder's Hill, which he referred to *Metopidia solidus.*

Mr. Rousselet said it was satisfactory to know that they were becoming acquainted with the males of so many species ; but the male of *Philodina* had not yet been found.

Mr. Karop said he had received a very excellent paper on "The Microstructure of Metals and Alloys," by Mr. Sydney W. Smith, A.R.S.M., which would be taken as read and be printed in the *Journal.*

Mr. Karop said that the meeting of that evening was the last ordinary meeting of the session, but the members could meet as in former years on the usual nights, which would be considered as "gossip nights." He thought all the members would agree with him that the session now closing had been a very pleasant and instructive one; he certainly thought that the meeting of that evening had been a very good one, reminding him of the Quekett of the past. He wished the members a very pleasant vacation, and hoped when they met again in October they would hear what some of them had been doing.

The meeting then terminated with the usual conversazione.

OBJECTS EXHIBITED, WITH NOTES.

March 1st, 1901.

Mr. A. J. French: Lips on proboscis of Blow-Fly, showing triple rows of teeth. Stained with Carmalum, and mounted in Glycerine Jelly.

Mr. J. B. Scriven: Testicle of Blow-Fly, showing also part of the *vas efferens.*

Mr. H. Morland: *Aulacodiscus Rattrayii* G. and St., from Oamaru deposit, New Zealand. Each valve shows two processes only, although this species may be found with from two to four processes.

Mr. A. E. Hilton: Head of Parasitic Bee (*Nomada*), showing the organs of the mouth in their natural form and colour; mounted in Glycerine.

Mr. H. E. Freeman: A new species of Tick, *Haemaphysalis bispinosa* Neumann, from an Indian goatherd, with original drawing from nature by Tuffen West.

Mr. A. Earland: A new British species of Foraminifera, *Storthosphaera compressa* Pearcy, from shallow water in the Clyde Estuary (near Ailsa Craig, 26–35 fathoms), figured and described in Proceedings of Millport Biological Station for 1900. *Points of interest*: (1) The shallowness of the sea in which it occurs, the genus to which it belongs being a very deep water type. (2) There is no visible external aperture for the extrusion of the sarcode, which must therefore find its way between the fine interstices of the arenaceous wall. It is probable that in such cases the living foram obtains its nutriment by digesting food outside the shell, only the products of digestion being conveyed by the sarcode to the interior of the test. (3) In the interior of the test there is no attempt at the fine arrangement of sand-grains which characterises the exterior. This may be seen by the specimen cut open to show the internal cavity.

March 15th, 1901.

Mr. C. Lees Curties: Six exhibits of Diatoms, etc. *Isthmia nervosa* on Alga; *Heliopelta* and *Biddulphia*, mounted as opaque objects; *Diatoma hiemale*, stained, showing endochrome; Desmids (*Euastrum*) stained; and section of limestone showing Foraminifera.

Mr. A. W. Dennis: Crystals of Sodium tartrate, shown with polarised light.

Mr. C. Rousselet: A flagellate Infusorian (*Mallomonas plosslii*), covered with long setae.

Mr. A. Earland: Foraminifera (*Buliminae* and *Cassidulinae*) from Gulf of St. Lawrence, 100 fathoms. Many of the forams in this gathering have their chambers entirely filled with pyrites deposited after the death of the animals. The commencement of this process may be observed in the central specimens of *B. ovata*, where crystals of pyrites have begun to form in the sutures.

Mr. W. R. Traviss: Louse of Cat, *Trichodestes subrostratus.* Found on cat at Eastbourne; supposed to be the first discovered in England.

Mr. A. E. Hilton: Gizzard of Flea, *Pulex irritans*, showing the muscular structure.

Mr. K. J. Marks: *Stephanoceros eichornii*, and *Dinocharis pocillum*, taken from under ice, February 24th, 1901, at Church End, Finchley.

April 19th, 1901.

Mr. C. Turner: *Cristatella mucedo*, hatched from the statoblasts taken on the Club's excursion to the East London Waterworks in the autumn of 1900.

Mr. K. J. Marks: A colony of *Stentor polymorphus*, colourless variety, showing a common mucilaginous basis built up through excretion.

Mr. J. Rheinberg: Exhibit illustrating Complementary Interference Colours. *Actinocyclus Ralfsii*, shown by means of a double-image disc (see *ante*, p. 151) of clear glass, which is placed over the objective. A dioptric and a diffraction image are formed of the same object side by side. Where the colours due to interference are formed in the dioptric image, the complementary colours will be formed in the diffraction image.

May 3rd, 1901.

Mr. A. E. Hilton: Nematohelminthes (Thread-worms), showing the genital and anal pores.

Mr. T. N. Cox (jun.): Leaf of *Anacharis alsinastrum*, a North American plant, now naturalised in this country, showing circulation of sap, especially near the midrib.

Mr. W. R. Traviss: The "Blood Rain" Plant. Found in a tank at Camden Town.

Mr. H. Morland: Two slides of lobes of proboscides of Blow-Fly, *Calliphora erythrocephala*, and Yellow Dung-Fly, *Scatophaga stercoraria*, prepared to show the so-called "teeth." Presented to the cabinet by Mr. W. H. Harris, Cardiff.

The "teeth" arise from modifications of the basal plates of the pseudo-tracheae. In the Blow-Fly they consist of three distinct superimposed rows, the thin free ends being slightly in advance of the immediately preceding row. The primary, or superficial, row consists of eleven to twelve strap-shaped organs, the margins of which are recurved for a considerable portion of their length, giving the appearance of a split tube, with the fracture slightly opened. The intermediary row consists of fewer "teeth" than the primary set, and is built up on a different plan, the base of each "tooth" arising from two distinct points on the right and left of the two adjacent pseudo-tracheae, and becoming fused together towards the free end. All the "teeth" are cleft into a V-shaped form at their extremities. In the case of the Dung-Fly the "teeth" are formidable organs, and the basal portion is considerably thickened.

Mr. T. A. O'Donohoe: An adult Acarus and four young ones found on a sun-flower. When captured the mother was carrying its young on its back.

Mr. A. Earland: Globigerina Ooze, from 1290 fathoms (about $1\frac{1}{2}$ miles), Indian Ocean, showing *Globigerina aequilateralis*, etc., imbedded. One specimen has the outer whorl of chambers removed, and exhibits the spinous armature on the surface of the early chambers. All the pelagic Globigerinae are covered with similar spines, but they are of such a delicate nature as to be dissolved by the carbonic acid in solution in the sea-water during the long process of sinking to the bottom after the death of the animals.

May 17th, 1901.

Mr. R. T. Lewis: Black currant mites, *Phytoptus ribes*, which of late years have done serious damage to the fruit crops in England.

Mr. J. T. Holder: Ephemera larva under dark ground illumination. The branchial plates are covered with Vorticella. The circulation of blood under the eye is very noticeable.

Mr. C. F. Rousselet: Mounted specimen of *Brachionus militaris* from China.

Mr. C. Turner: Head of Whirligig Beetle, *Gyrinus natator*, showing the two pairs of compound eyes.

Mr. A. Earland: "Red Rain," which fell at Melbourne, Australia, on December 27th, 1896. Contains disintegrated siliceous and mineral fragments, diatoms, etc., believed to be derived from the Central Australian Desert, where the particles are lifted up into the higher regions of the atmosphere by the agency of "dust-devils," or vortex storms.

Mr. J. Rheinberg: Section of Echinus spine, shown under low-power colour illumination.

Mr. H. E. Freeman: Ova of *Myobia* on male organ of Lesser Short-eared Bat. The Rev. C. R. N. Burrows discovered two species of *Myobia* on various bats. One of these, *M. chiropteralis*, was described by Mr. Michael in the Club's *Journal*, Vol. II., Series 2, p. 1. The present species has not been named or described, so far as Mr. Burrows is aware, and he has named it *M. immunda*. It differs from *M. chiropteralis* in being short, flat, much smaller, and colourless. The latter is much longer, stouter, with long flat hairs, and body slightly yellow when mature. The two species are found on the same bat, but *M. immunda* is always found on or near the genital organs, hence the name, which literally means unclean or filthy. In this respect it resembles the human parasite, *Phthirius inguinalis*. On account of its minute size and delicate structure it is extremely difficult to capture and examine in the living state. Specimens of the two sexes of both species are shown; also *Myobia* from the Mouse and Mole for comparison.

June 7th, 1901.

Mr. J. B. Scriven: Nerve entering a transversely cut muscle in the maggot of the Blow-Fly.

Mr. A. E. Hilton: Eggs of House-Fly, *in situ*, as found on decayed vegetable matter.

Mr. J. T. Holder: Vertical section through head of foetal Rabbit, showing eye, etc.

June 21st, 1901.

Mr. A. E. Hilton: Spinnerets of Garden Spider, *Araneus diadematus*, mounted in Glycerine without pressure.

Mr. J. Shephard: Rotifers and Phyllopods from Victoria Australia. A new *Brachionus*; colonies of *Lacinularia pedunculata*, *L. reticulata* and *L. striolata*; *Branchipus australiensis*; and *Lepidurus* sp.

Mr. R. T. Lewis: Spermatozoa taken from the female *Ixodes reduvius* immediately after copulation in the manner described in the *Q.M.C. Journal* for November, 1900.

Mr. A. Earland: *Orbulina universa* d'Orbigny, laid open to show the internal *Globigerina* shell. *Orbulina* appears to be only a life stage in the history of *Globigerina*, though they are usually placed in separate genera. Rhumbler's theory is that the *Globigerina* builds the investing spherical chamber to protect the delicately spinous shell against injury, and that the internal shell, being then useless, is gradually absorbed. Only about 2 per cent. of the *Orbulina* shells contain traces of a *Globigerina* inside.

July 5th, 1901.

Mr. A. E. Hilton: Female organs of Garden Spider, *Araneus diadematus* (see Blackwall's "British Spiders," Plate XXVI., fig. 258, *d*, *e*, and *f*). Mounted in Glycerine.

Mr. J. B. Scriven: End organ of sensory nerve of the Blow-Fly. The nerve is supplying a hair, and can be traced for a considerable distance under the skin of the abdomen.

Mr. A. Merlin: Mitosis in *Ascaris megalocephala*, showing divided nucleus (the two daughter nuclei are preparing for further division), asters, centrospheres, spindle, equatorial plate, and chromosomes. Leitz, No. 5 objective, N.A. ·77.

July 19th, 1901.

Mr. J. B. Scriven: Origin of sensory nerve from cephalic ganglion in the Blow-Fly.

Mr. A. Merlin: *Filaria nocturna* in human lung. Under a Leitz No. 5 objective ($\frac{1}{4}$ in.) N.A. ·77 and No. 4 ocular. Illuminated by a solid axial cone giving a working ratio of ·83 and working aperture of ·64.

Mr. T. A. O'Donohoe: Blood taken from the heart of a goose which had been killed a few days. It contains several kinds of bacilli and micrococci; stained with Eosin and Methylen-blue.

August 2nd, 1901.

Mr. A. Merlin: Flagellated Cholera Bacillus, stained by Loeffler's method. Flagella plainly visible under a No. 5 Leitz objective ($\frac{1}{4}$ in.) N.A. ·77, and Zeiss 18 compensating ocular. Illuminated by a solid axial cone giving a working ratio of ·83, and working aperture ·64.

Mr. A. Dennis: *Stemonitis fusca*, a mycetozoon from North Wales.

Mr. W. Wesché: Hooked process on the mandible of the Worker Bee (*Apis mellifica*), figured and described in *Knowledge*, in 1894, by the exhibitor.

Mr. W. Wesché: Stomach of Earwig, *Forficula auricularia*, ♀, containing undigested food consisting of a number of mutilated aphides, proving that this insect is in some degree beneficial.

August 16th, 1901.

Mr. G. H. Rogers: A small Planarian worm (? *Mesostomum*) with numerous light brown egg-capsules or resting-eggs.

Mr. D. J. Scourfield: Preserved specimens of *Holopedium gibberum* from Loch Vennachar. This very remarkable Entomostracan surrounds itself with a ball of hyaline jelly. It occurs in many of the Scotch lochs, and also in several of the lakes of the Lake District, but otherwise it is very rare in the British Isles.

Mr. A. Merlin: Transverse section of spinal cord of Cat, cervical region, showing nerve fibres.

September 6th, 1901.

Mr. W. Wesché: *Stephanops lamellaris*. These little Rotifers have been living since July on Anacharis.

Mr. K. J. Marks : Living specimens of *Pedalion mirum*, taken in one of the ponds on Hampstead Heath.

Mr. M. W. Liston : A thin portion of the secondary (green) cortex of *Rhamnus frangula* (the berry-bearing alder), just below the epidermis, showing "continuity of protoplasm" between the cells, the walls of which have been dissolved away with sulphuric acid.

Mr. A. E. Hilton : A fresh-water alga, *Batrachospermum vagum*, showing filaments with dense whorls of ramifying branchlets—mounted in formalin.

Mr. T. G. Kingsford : Portion of leaf of *Sphagnum* (bog moss), showing large empty cells with spiral fibres and communicating apertures. Stained.

Mr. D. J. Scourfield : An "Ephippium" of *Daphnia magna*. The ephippium is a protective covering for the winter or resting eggs, and is formed by a modification of the shell of the mother. In all the true Daphnias there are two eggs in each ephippium as in this case; but in the closely allied genera, *Ceriodaphnia*, *Simocephalus* and *Scapholeberis*, there is never more than one egg in each ephippium.

Mr. A. Merlin : "Madura Foot," a fungoid disease which attacks the natives of India.

September 20th, 1901.

Mr. G. H. J. Rogers : A small colony of *Cristatella mucedo* surrounding the stem of an aquatic plant. The reddish body seen in the centre of the colony is probably a statoblast in an early stage of development.

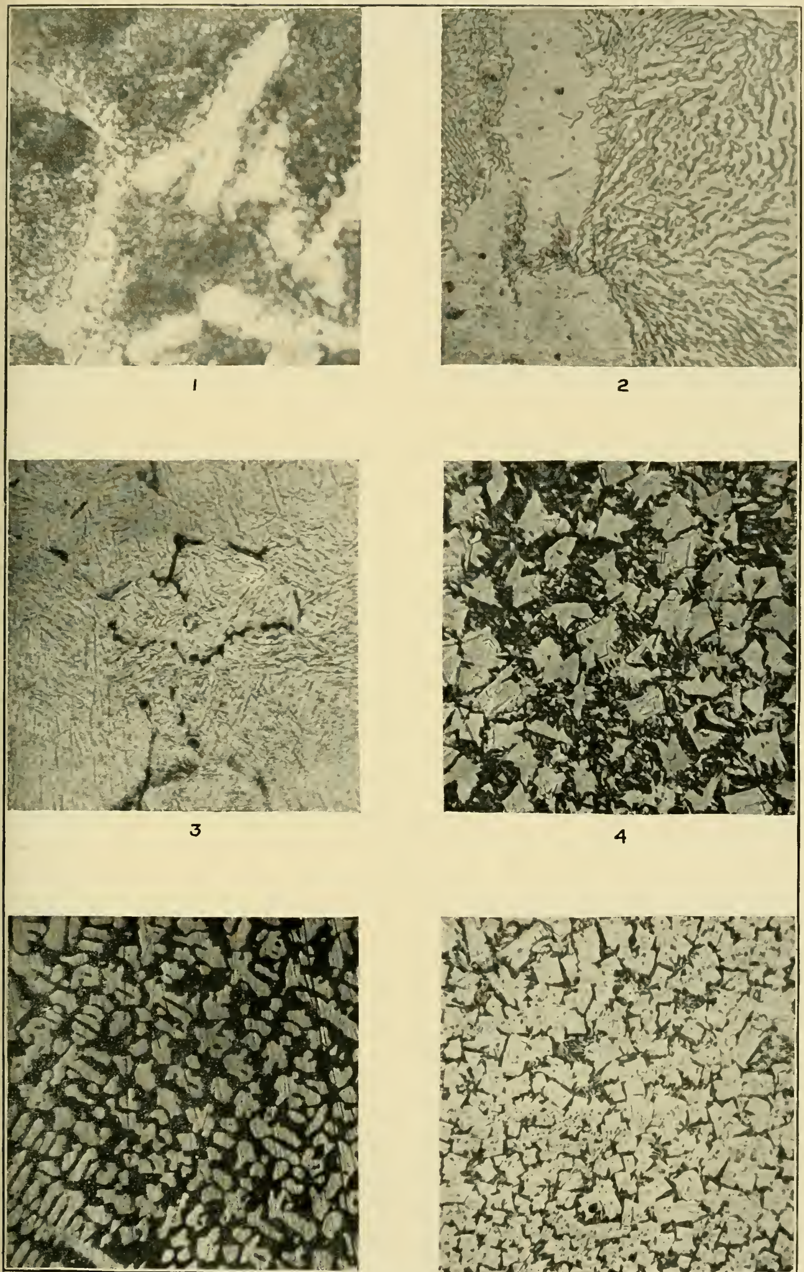
Mr. T. A. O'Donohoe : One of the Poduridae, *Seira buskii*. This species is easily recognised by its ovate or leaf-like scales, on which the "notes of exclamation" are very long, extending sometimes half the length of the scale. The scales are also shown.

Mr. C. F. Rousselet: Mounted specimens of *Lacinularia socialis*, male and female.

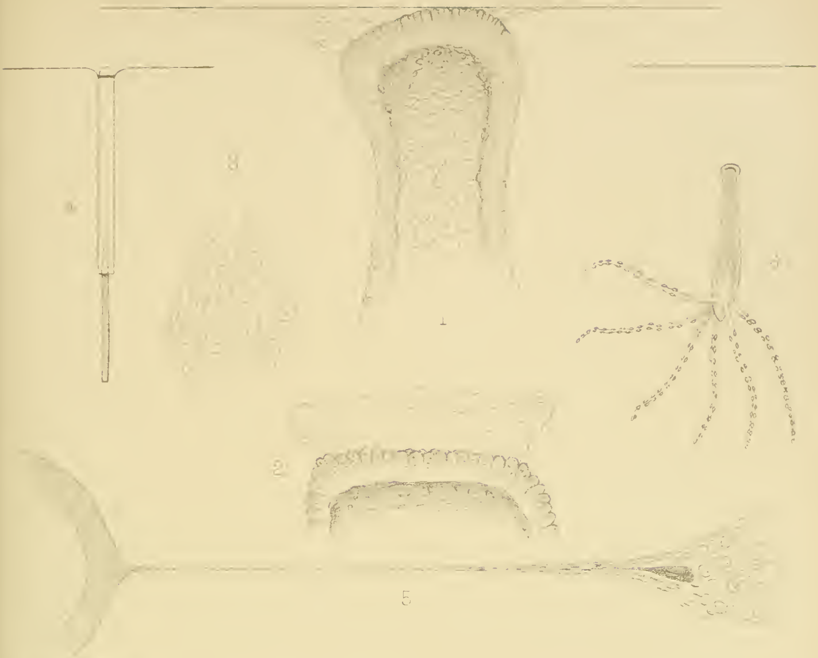
Mr. T. G. Kingsford: Proboscis of female gnat, showing lancets.

Mr. D. J. Scourfield: *Sida crystallina*, taken at the Club's excursion to the East London Waterworks. A very interesting feature of this species is the complex gland at the back of the head by which the animal attaches itself, usually head downwards, to weeds, etc.

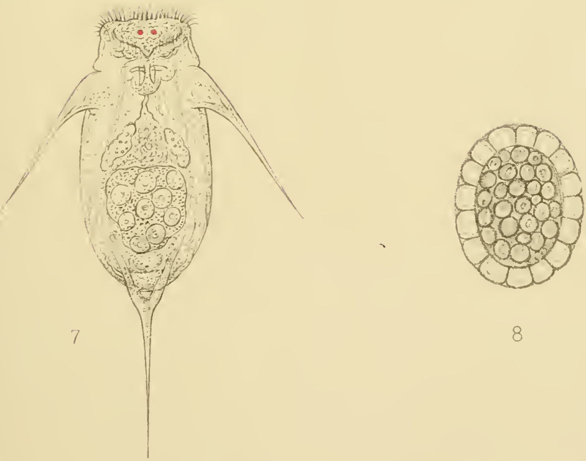
Mr. L. O. Grocock: Oogonia and antheridia of *Chara*, the antheridia showing the cells in which the spermatozoids are developed.



Microstructure of Metals and Alloys.



Hydra & the Surface-Film.



F. R. Dixon-Nuttall and C. F. Rousselet del. ad nat. West, Newman lith.

Triarthra brachiata n.sp.

On the Spermatozoön of the Rat.

By A. A. Merlin, F.R.M.S.

(*Taken as read November 15th,* 1901.)

A few years ago, in microscoping difficult objects, the *modus operandi* frequently consisted in first examining the specimen, say, under a $\frac{1}{4}$-in. or $\frac{1}{8}$-in. objective, and of then substituting a $\frac{1}{25}$ in. or $\frac{1}{50}$ in. of probably little higher numerical aperture than the lens previously employed. If no new detail was perceived under the $\frac{1}{50}$ in. it was taken for granted, as a matter of course, that none existed, and the structure was confidently described as homogeneous. It is now, of course, well known that mere magnifying power *per se* without a corresponding increase of the numerical aperture is of little avail; and we can no longer feel confident that because no structure is discernible with an oil-immersion lens of N.A. 1·4, capable of yielding a useful magnification of 1500, or at most 2000 diameters, that therefore none exists. On the contrary, it hardly seems logical to suppose that the numerous highly complex and imperfectly understood processes just observable under our highest powers and most perfectly corrected objectives are not preceded by, and dependent on, still minuter changes utterly beyond their grasp.

In consequence of the formerly prevalent opinion that structure unresolvable by the old $\frac{1}{50}$-in. and $\frac{1}{80}$-in. objectives, as then used, must be altogether non-existent, the spermatozoa, originally discovered by Leeuwenhoek about 1677, were by most considered to consist of absolutely structureless and undifferentiated protoplasm, the existence of a proper cell wall even being called in question. Under such conditions it seems difficult to understand how these wonderful bodies were supposed to accomplish their function save by a purely chemical process. In 1865, however, Schweigger-Seidel and La Valette St. George were considered to have proved that the spermatozoön consists of a complete cell made up of nucleus and cytoplasm, and there can be little doubt but that this view is the correct one.

In the ninth edition of Carpenter's "Human Physiology," published in 1881, the following description of these interesting organisms is found (p. 870): "The human spermatozoön consists of a small flattened discoid 'head' 5 μ in length and 1–2 μ in thickness, an intermediate portion 6 μ in length, from which proceeds a long filiform 'tail,' gradually tapering to the finest point, of 50 μ in length. The whole is perfectly transparent, and nothing that can be termed 'structure' can be satisfactorily distinguished within it."

The view widely held at the present time, which will be found explained at length in Dr. Wilson's extremely interesting work on "The Cell"* (2nd edition, 1900), is that the human and animal spermatozoön consists of four parts—*i.e.* (1) the nucleus, forming the main portion of the head; (2) the *acrosome*, an apical body lying at the front end of the head; (3) the middle or connecting piece, a cytoplasmic body lying behind the head and giving attachment to the tail, from which it is not always distinctly marked off; and (4) the tail or flagellum, which consists of a fibrillated axial filament surrounded by a cytoplasmic envelope sometimes bearing on one side a fin-like undulating membrane. Towards the tip of the flagellum the envelope is said to suddenly disappear, or to become very thin, leaving a short end-piece, which by some authors is considered to consist of the naked axial filament.

* "The Cell in Development and Inheritance," by Edmund B. Wilson, Ph.D. Second edition, pp. 135-7.

The nucleus and middle-piece are believed to play the most important part in fertilising the ovum, the latter being considered to be the fertilising element *par excellence*, since it is supposed to contain or to be itself a metamorphosed centrosome, which, when introduced into the egg, stimulates division (Wilson). The invariable truth of this latter point, however, may be open to doubt, as in a photograph annexed to a paper "On the Human Spermatozoön,"* read by Mr. Edward M. Nelson before the Quekett Microscopical Club on November 21st, 1890, a tail, middle-piece, and cup are clearly shown, from which the "head" or "spore" has fallen, while in another photograph a "spore" is depicted without a cup. This observation appears to be in opposition to the theory that in every case the head and middle-piece of the spermatozoön together enter the ovum, the tail alone being carried off by the formation of the vitelline membrane, and that the sperm aster is always developed around the material of the middle-piece. That the sperm aster is developed round this material in the case of the sea-urchin *Toxopneustes variegatus* seems, however, to be proved by the photographs published in Dr. Wilson's "Atlas of the Fertilisation and Karyokinesis of the Ovum" (1895).

The spermatozoön of the rat is thus described in Schäfer's "Essentials of Histology" (2nd edition, 1887): "The head is long, and is recurved anteriorly; it is set obliquely on the middle-piece, which is also of considerable extent, and has a closely wound spiral filament encircling it in its whole length." (H. H. Brown).

Having spent a considerable time in the examination of an exceedingly fine stained preparation of rat spermatozoa in my possession, with objectives of the very highest class and optical excellence, employed under such conditions as insure the most critical results, I venture to claim that the head of this spermatozoön does show something strongly resembling an organised

* *Journal Q.M.C.*, Ser. II., Vol. IV., p. 264, and Plate 18, Figs. 2 and 3.

structure, which I have endeavoured to represent in the annexed drawing, Fig. 1, made with a power of 2300 diameters (reduced to 1650), obtained by means of a Zeiss' $\frac{1}{8}$ apochromat of N.A. 1·426 and 27 compensating ocular.

In the "head" the points noted and figured are :

1. A strongly stained portion of the endoplasm extending from the fore to the middle part of the "head," situated close to the concave under surface, and completely embedded in, and

Fig. 1.

surrounded by, the gelatinous and homogeneous substance or ectoplasm which constitutes the forward part. This endoplasm exhibits near its tip an exceedingly small notch, or barb, which is extremely difficult to define satisfactorily, and is indeed not certainly visible in all specimens, although it has been traced in a considerable number. A second and much more easily definable notch exists a little farther from the tip, which not only cuts into the endoplasm, but extends through the ectoplasm to the convex upper edge of the organism.

2. Further, towards the posterior end of the "head" a band of deeply stained endoplasm branches off and passes diagonally across to the convex edge, along which it extends for a considerable distance, as figured. The whole of this portion of the endoplasm is not usually as distinctly definable or so well marked as that previously described.

3. Still nearer the posterior end a broad diagonal band stretches from the concave to the convex edge, in parts of which indications of differentiated structure have been strongly suspected.

4. A deeply stained, triangular-shaped mass of endoplasm where the middle-piece joins the head.

5. Two external notches on the under concave edge, that nearest the tip being less frequently well marked than the other.

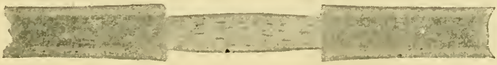


Fig. 2.

Figure 2 represents the appearance of a portion of the tail with a considerable length of core exposed. This core has been subjected to a most careful and critical examination, and has been found to exhibit indications of a longitudinal striation, as if built up of many extremely minute fibres. It slightly bulges half way along its exposed length, as though freed from the constricting influence of its sheath. The tail and middle-piece appear mottled; but this effect may be due to the core seen through the sheath. I have endeavoured to faithfully represent the appearance in the figure. The spiral fibre running round the middle-piece has not been seen, possibly owing to the method of preparation not being favourable to the demonstration of this feature.

When observing this organism under the best conditions, with a fine aprochromatic objective of N.A. 1·426 and a large solid axial cone from an oil-immersion condenser, one is strongly impressed with the conviction that what is seen is merely a partial resolution of really existing organised structure, which increase of aperture would more fully reveal.

It has been pointed out by biologists that protoplasm is frequently so much affected by the staining and fixing reagents employed as to coagulate, and give rise to false structural appearances. This may be the case in some instances, but it has yet to be shown that definite features of the kind figured in connection with this paper can be thus constantly and recurrently reproduced. The likelihood of a merely chemical action being responsible for the production of such decidedly structural effects would seem to be very remote indeed; otherwise little reliance would be placed by many on much of the beautiful and elaborate work which has been accomplished in recent times in connection with the mitotic division of the cell.

On the Critical Employment of the Microscope for Ordinary Working Purposes.

By A. A. Merlin, F.R.M.S.

(*Read November 15th*, 1901.)

As a microscopist of over twenty years' experience, I trust that it may not be considered presumptuous on my part to offer a few remarks on the subject of "critical" microscopy, in the hope that they may be of some interest to the younger members of our Club. An apology is perhaps the more necessary in view of the fact that the opening chapters of the last two editions of "Carpenter" contain a most lucid and admirable exposition of the whole principles of microscopical manipulation, and explain at length the conditions under which the best results are alone attainable. Now, as this work is in the hands of the great majority of British microscopists, by whom its authoritative character is generally admitted, one would naturally infer that its students would endeavour to carry out its clearly-explained precepts by applying them to their own several branches of inquiry, and that once having done so, they would not fail to appreciate the enormous advantage of such critical methods of research as compared with the happy-go-lucky, rough-and-ready systems still so zealously inculcated in many medical schools.

But whatever the reason may be, it is sufficiently evident to the observant visitor at microscopical exhibitions and *soirées* that a large number of the specimens there shown, although most beautifully and carefully prepared and mounted by their exhibitors, are optically arranged with a total disregard of the rudimentary elements of critical microscopy, notwithstanding the fact that the instruments and accessories actually employed could be easily utilised so as to afford far more satisfactory results. The following causes should perhaps be reckoned amongst those principally responsible for the existence of this state of things.

(1) The considerable training and practice required to enable the eye to fully grasp the points of difference between a critical and non-critical diffraction image, or to appreciate the delicately faint, but true, rendering of all the visible features in the former case, as compared with the misleading and unreliable, although well-marked and obtrusive, diffraction outlines and effects invariably associated with the latter.

(2) The strong prejudice evinced by many workers in favour of an evenly-lighted "full moon" field in place of the sharply-focussed image of the light source. It is true that with a low-power substage condenser the focussed image of the lamp flame can be made to fill the entire field, but the rough-and-ready worker finds it much simpler to secure this result by lowering or raising his condenser.

(3) Carelessness and apathy regarding microscopical manipulation; it being considered that the labour requisite for the acquirement of even an elementary knowledge of the subject would be a mere waste of time on the part of a naturalist or kindred worker.

(4) A conscientious objection to the critical large cone image on theoretical grounds; for, according to the Abbe dictum, "Strictly similar images cannot be expected, except with a *central* illumination with a narrow incident pencil, because this is the necessary condition for the possible admission of the whole of the diffracted light." *

I will ask your indulgence to here examine each of these points in detail.

With regard to the first, nothing but practice and patient work will enable the microscopist to perceive in a delicate object all the minute faintly-outlined features just within the resolving power of the objective employed, and revealed by it under the action of a solid $\frac{5}{6}$ths or even $\frac{6}{7}$ths axial cone from a well-corrected

* Carpenter's "The Microscope," 8th edition, page 75.

aplanatic substage condenser. It is true that under such conditions diffraction effects are conspicuously absent, the picture of a translucent object, such as a diatom, exhibiting almost as little contrast as would a perforated plate of clear glass held at arm's length between the eye and a bright background. But, although the resultant image is pale, the delineating and defining power of a good lens thus used is such, that in the case of a 4-mm. apochromat of measured N.A. ·985, employed in conjunction with a copper acetate screen, the transverse striae of a balsam mounted *Amphipleura pellucida*, running at about 94,000 to the inch, have been certainly seen and held for short intervals, 95,446 lines per inch being, according to Abbe, the theoretical separating limit for N.A. ·99 with oblique white light. When the illuminating cone was cut down so as to afford a working aperture of much under ·821, no true resolution could be distinguished. The effect of stopping out a small central portion of the large cone was also tried, the valve being then found to exhibit a smudgy corrugated appearance, but no cleanly-separated striation. Thus it would seem that the complete large solid cone is practically absolutely essential to the formation of a true image of an object possessing fine structure, or at least of the nearest possible approximation to such that the N.A. of the objective employed will allow. It must not be thought that this maximum resolution was attained or is attainable by merely screwing a fairly good objective on to the nosepiece of any microscope stand provided with a condenser capable of yielding a large aplanatic cone. Other most important conditions are essential to success. In the first place, Mr. Nelson, the originator of critical microscopy, many years ago found it necessary, in order to properly appreciate the faint details of images produced by means of a large illuminating cone, to work in a well-darkened room. Daylight must be excluded, and the microscope lamp should be provided with the well-known metal chimney, into the front of which a glass slip is inserted. An additional small, well-shaded lamp is admissible when required for sketching or reference purposes, and will prove useful for reading the stage finder. In the second place, it will be found most advantageous in very difficult observations, after the preparation has been arranged on the stage, and all optical adjustments carefully made, to completely rest the eye for an interval of from five to ten minutes before searching for faint detail. Frequent rests of this kind should also be taken in the course of all observational work. Thirdly, it should be remembered that the eye itself is an optical instrument which varies much in its capacity at different times. In my own case I find that from about an hour after lunch to 6 or 7 p.m. is decidedly the best period, but the evening hours can also be usefully employed. The morning is to me individually the most unfavourable part of the day for observational purposes, my eyes then becoming quickly and easily fatigued. It may well be, however, that the experience of others will differ in this respect, but each observer will probably find that his best work can only be accomplished during some certain hours of the day or evening.

But probably the easiest means by which the beginner will be enabled to most speedily convince himself of the advantages of critical microscopy for ordinary working purposes, lie in the proper employment of a good 1-in. or $\frac{2}{3}$-in. objective of about N.A. ·30. Experiments with such a lens will be the more likely to prove instructive, as it has been over and over again asserted that, however necessary critical images may be when the higher magnifications are in question, the rough-and-ready method is quite satisfactory for low-power general work. To absolutely disprove the truth of this so frequently reiterated statement, you have only to place a common entomological object, such as the proboscis, wing, or leg of a fly, or other similar preparation, under, say, a cheap Leitz No. 3 objective ($\frac{2}{3}$-in.) of N.A. ·28, and sharply focus on the selected specimen the image of the edge of the lamp flame, using a low-power achromatic sub-stage condenser. Having done this, carefully examine the appearance of the smaller features of the object: (*a*) with the condenser diaphragm quite open, thus giving a full cone, *i.e.*, when the eyepiece is removed the back of the objective appears evenly illuminated over its entire area ; (*b*) with the diaphragm a little closed so as to illuminate $\frac{5}{6}$ths of the central portion of the back lens of the objective, leaving a narrow dark outer annulus ; (*c*) with the diaphragm successively more and more closed up, so as to light respectively about $\frac{2}{3}$, $\frac{1}{2}$, $\frac{1}{4}$, and $\frac{1}{8}$th of the central part of the back lens. Then, on the same object, carefully observe the effect of lowering or raising the substage condenser beyond its focal point, an all too common expedient for obtaining an evenly-lighted field. In these experiments it will be advisable to use some simple form of light modifier, such as a piece of signal-green glass, and a rather high eyepiece may be employed with advantage in order to render differences in the quality of the various images more prominently visible. It should also be borne in mind, and experimentally verified, that when the back lens of the objective is nearly filled with light, it is extremely sensitive to any alteration of tube length or cover-glass thickness, a very slight increase or decrease of the former being sufficient to make or mar the sharpness of the resultant picture, while any oversight in making this adjustment will inevitably cause it to appear veiled and milky, even with a first-class apochromatic objective. Indeed, the better the lens employed, the more sensitive it will be found in this respect. If the beginner will only examine a number of miscellaneous objects under the above specified conditions, there can be but little doubt that his conversion to critical microscopy, even for low-power every-day purposes, will be speedy.

Passing on to the second cause of the avoidance of critical methods of research by general observers, especially such as habitually employ low amplifications—*i.e.*, their strong predilection for an entirely illuminated "full-moon" field—it should be realised that if this condition be considered a *sine qua non*, there are several ways of easily obtaining it without putting the sub-stage condenser out of focus; *that* method will not be thought desirable by any one who has tried the experiments recommended above. Neither is the expedient of placing an auxiliary condenser in front of the lamp flame to be altogether commended, although a properly arranged and focussed aplanatic "bull's-eye" thus used is, in skilful hands, capable of affording good (but not strictly critical) results when compared to the images obtainable with an out-of-focus sub-stage condenser. The proper and easy way to obtain perfectly critical representations of objects viewed under a $1\frac{1}{2}$-in. or 1-in. objective, with the whole field fully illuminated, is to employ a very low power achromatic condenser, affording a sufficiently large aplanatic cone for the purpose. This maximum aperture need not exceed ·3 for the 1-in., and may be, of course, considerably less for the $1\frac{1}{2}$-in.; but as it will be frequently found advantageous to utilise such an appliance with a $\frac{1}{2}$-in., especially in photomicrography, it should be capable of yielding a solid cone of N.A. ·5. Now, it is a remarkable fact that no cheap very-low-power achromatic condenser of the kind above indicated is at present on the market, so that clearly no great demand for it exists, although there must be hundreds of earnest investigators to whom it would prove a boon could they once realise the advantages derivable from it. As a makeshift it will be found, however, that one of the ordinary triplet combination loups magnifying 6 times, when mounted in a suitable fitting and provided with an iris diaphragm, will answer well for 2-in. to $1\frac{1}{2}$-in. objectives, affording a large image of the light source, and practically filling the field when the broad part of the lamp flame is focussed. The Zeiss Abbe achromatic condenser with top lens removed gives even better results; and I would especially call attention to the modified semi-apochromatic form recently introduced by Baker, which, without the front lens, has a power of $\frac{8}{10}$-in., and an *aplanatic* N.A. of ·5, thus rendering it available for use with a wide-angled $\frac{1}{2}$-in. apochromat, while with the top lens *in situ*, it may be satisfactorily employed with the higher powers, being then a $\frac{4}{10}$-in. of aplanatic N.A. ·9; but in this latter respect the high power dry and oil-immersion condensers of all our leading opticians now leave little to be desired.

Regarding the third point—*i.e.*, the apparent carelessness and lack of interest in all optical matters evinced by many naturalists—it is difficult to believe that such men, most of whom will put themselves to infinite pains in the collection, careful preparation, and preservation of their specimens, could fail to be equally fastidious and painstaking with respect to the manner in which they exhibited to themselves and others the fruit of their hard work, toil none the less taxing because it happens to be entirely a labour of love, without thought of gain, were they once convinced that any practical advantage might be derivable in their own particular branches of research by a little more careful attention to optical principles. In some instances these workers may be deterred from any attempt to grapple with the subject by the mistaken idea that considerable study of an intricate nature in a, to them, uncongenial field is requisite, or that the cost of a proper instrumental outfit to secure optical results of a high order is quite beyond their means. If I should happily succeed in convincing one such person of the utter fallacy of these notions, that practically no study of optical principles of a dry-as-dust nature is requisite in order to secure absolutely critical results, and that the outfit necessary for the great majority of purposes is inexpensive, and is probably already in the hands of most, I shall feel that I have not trespassed on your patience or claimed your indulgence in vain.

For the attainment of a strictly critical image the only essentials are:—

(*a*) That the source of light (preferably the edge of a lamp flame) be sharply and centrally focussed on to the object by means of a sub-stage condenser of suitable aplanatic aperture, the microscope being either pointed directly to the illuminant, or, if the angle at which the instrument must be inclined to effect this should from any cause prove inconvenient, the plain mirror may be requisitioned to reflect the light into the condenser. Any light source which does not lend itself to being sharply focussed on the object, such as the incandescent electric lamp, should be avoided.

(*b*) That the aperture of the substage condenser diaphragm be at least large enough to illuminate three-quarters of the diameter of the back lens of the objective employed.

(*c*) That the microscope tube length be such as to exactly compensate for variations in the thickness of the cover glass, this correction being readily effected by pulling out or sliding in the draw-tube, and noting the varying clearness of the image. The best point is easily determinable when a large illuminating cone is used.

With due attention to these three requisites good results are invariably attainable.

As to the instrument and indispensable accessories, it need only be remarked that our opticians now construct admirable small microscope stands, provided with good fine adjustments, at a cost of from £4 to £6; that the semi-apochromatic Leitz objectives are both cheap and most satisfactory in their performance when used in conjunction with very large illuminating cones, and that an aplanatic substage condenser is procurable at a trifling outlay. With such an outfit, costing in all not more than £10, results of an exceedingly high order, with low and medium magnifications, are readily attainable, the most massive and rigid stands of the Powell No. 1 type, and apochromatic objectives, being only absolutely necessary in the most difficult branches of research, and when the best attainable photomicrographs are in question.

Now we come to the fourth point, and have to consider the opponents of large-cone critical images on theoretical grounds, *i.e.*, those who think with Abbe that central illumination with a narrow incident pencil, the perfectly logical corollary drawn by him from his diffraction theory of microscopical vision, is the necessary condition for the attainment of an image strictly similar to the object, or at least the nearest possible approach thereto capable of being afforded by the objective employed. Now there is one infallible proof to which all theories, however profound or ingenious they may be, or however much we may admire the labours of their authors, have always, sooner or later, to submit, and by which they must inevitably stand or fall: and that is, *observed fact.* When a new and brilliant theory on any philosophical subject is first promulgated by some eminent scientist, it is the tendency of self-elected disciples, exponents, and admirers to permit themselves to be carried away by their enthusiasm, and to go to lengths in defending and expounding the new tenets that their author would be perhaps the first to deprecate. Forgetting the lessons of the past, that few indeed are the theories which have withstood the test of time unscathed, they from the outset regard matters not from a strictly impartial, but from a purely partisan standpoint, and, while eagerly calling attention to and exaggerating the significance of such observations as may appear to them at the moment to favour their views, they, on the other hand, heatedly call in question and throw doubt upon those which tend to the contrary, often without patient inquiry or experiment. It has been said that even a bad theory is better than none at all, and this is undoubtedly true in so far as it paves the way for that calm, philosophical discussion from which we may hope to eventually attain some nearer approach to the truth, as distinct from controversy and personal recrimination, which can only serve to retard progress.

The object of the following remarks is not to discuss the truth of the diffraction theory, except in so far as its doctrines are opposed to critical large-cone illumination, and advocate in its place the employment of narrow incident pencils. To such as wish to examine the general question of its soundness, I would earnestly recommend the perusal of Mr. J. W. Gordon's recent brilliant paper on the whole subject.*

I am aware that many supporters of the diffraction theory, being not only theoretical but experienced and skilled practical microscopists, have now tacitly admitted the value of large-cone illumination, without apparently realising the wide gulf that such an admission has opened between their views and those of the author of the theory. In this connection it is instructive to notice that the deductions contained in the clear summary of the diffraction theory in the seventh edition of "Carpenter," published in 1891, which is peculiarly authoritative and weighty as having been submitted to Professor Abbe himself, and as having obtained his cordial endorsement, together with the expression of his greatest satisfaction at seeing his "views represented in the book so extensively and intensively," † have not been in any way modified in the eighth edition, published ten years later. This, taken in conjunction with the significant fact that the best substage condenser constructed by the firm of Zeiss for use with the highest powers still only affords a maximum aplanatic cone of N.A. ·65, clearly indicates that, whatever admissions or changes of front his self-constituted supporters and defenders may have thought fit to make, Professor Abbe himself continues to unwaveringly maintain that strictly similar images are alone to be expected with the central narrow incident pencil, this being the necessary condition for the admission of the whole of the diffracted light. What more logical conclusion could be possibly reached on the hypothesis that microscopical vision is *sui generis*, and that "the images of minute objects are not delineated microscopically by means of the ordinary laws of refraction; they are not dioptrical results, but depend entirely on the laws of diffraction"? ‡ Undoubtedly, on any such assumptions as these, it is reasonable to maintain that the nearest possible approach to truth in the rendering of minute structure will be only attained

* "An Examination of the Abbe Diffraction Theory of the Microscope." *Journal* R.M.S., 1901, page 353.

† Preface to Carpenter's "The Microscope," 7th edition, p. viii.

‡ Carpenter's "The Microscope," 8th edition, p. 62.

with a narrow central illuminating pencil, for we can all easily satisfy ourselves by experiment that the strongest and most marked diffraction images and effects are thus obtainable. As we increase the diameter of the illuminating pencil we can experimentally observe that the picture rapidly becomes worse and worse from a diffractive point of view until, when we reach a $\frac{5}{6}$ths or $\frac{6}{7}$ths cone, no certain diffraction effects are discernible. In the case of a delicate object possessing fine structure we have an image greatly lacking contrast, and exhibiting no broad diffraction edges, in which we may glimpse points just within the theoretical grasp of the objective, the difficulty of holding these for any length of time strongly reminding a telescopist of his fleeting glimpses of planetary detail just visible under the most favourable atmospheric conditions. This is precisely the contrary of what we should expect to see according to the deductions from the diffraction theory summarised in "Carpenter," for these would make us feel confident that in the instance of the *A. pellucida* the central narrow incident pencil should produce the most truthful picture, and one more nearly approximating to the ultimate structure in exactness, than would be the case with a large pencil. But we have observationally found that with N.A. ·985 and a large $\frac{5}{6}$ths or $\frac{6}{7}$ths cone, with light passed through a copper acetate screen, the striae, running at about 94,000 to the inch, are discernible and clearly separated, while they are absolutely invisible with a much narrower pencil. Now the Abbe limit of resolution for N.A. ·99 being 95,446 lines to the inch with oblique white light (Line E), and 103,458 with blue light (Line F), therefore, if this observation is correct, we may feel confident that it is not the narrow, but the very large axial cone, which affords the maximum resolution, and the nearest possible approach to the complete rendering of the object that the aperture of the objective will permit.

This conclusion is of paramount importance to the non-theoretical practical worker, for it is only on the supposition that the large cone affords a critical or true image, that he can place reliance on the objective reality of any minute features that happen to be visible in his instrument. He knows, of course, that the ultimate structure is probably so minute as to utterly elude the grasp of his lenses; but the supremely vital point in practical work is to feel assured that what *is* visible should, so far as it goes, be a true rendering of existent structure. The diffraction theory, while teaching that the central narrow incident pencil can alone be expected to yield strictly similar images, holds out but poor assurances of their reliability to the investigator, for we are told that "minute structural details are not imaged by the microscope geometrically or dioptrically, and cannot be interpreted as *images of material forms*, but only as *signs* of material differences of composition of the particles composing the object, so that nothing more can be safely inferred from the image as presented to the eye than the presence in the object of such structural peculiarities as will produce the specific diffraction phenomena on which the images depend."* Judging from practical observation, many of us will cordially endorse the truth of this inference when non-critical, narrow-cone images are concerned. Every optically careless rough-and-ready microscopist would therefore do well to bear in mind the danger he incurs should he even inadvertently employ such methods, as in consequence he will probably eventually discover that the conclusions he has reached after years of patient microscopical research are untrustworthy, having been vitiated through the lack of a little manipulative skill, which might have been quickly and easily acquired; for with small-cone diffraction images no ordinary non-mathematical observer is fairly entitled to hold or express an opinion regarding the interpretation of what he sees, because, in order to understand its real significance, he must remove the eyepiece and examine the diffraction spectra at the back of the objective, and from these he must mathematically compute the structure by which they have been produced, remembering that the ideal picture resultant from his calculations will only prove a completely true representation of the object in the event of *all* its diffraction spectra having been admitted by the objective. Only imagine an animated discussion on some keenly-controverted point in the internal organisation of a minute saprophyte or infusorian conducted on such a basis! Even where simple diatomic structures are concerned, no more impressive demonstration of the hopelessness of correct computations of the kind is to be found than in the well-known examples of Dr. Eichhorn's calculation of the structure

* Carpenter's "The Microscope," 8th edition, p. 72.

deducible from the six spectra of the *P. angulatum.* According to Dr. Eichhorn's diagram,* we should see with our widest-angled lenses a hexagonal structure with intercostals, the spectra being ranged *opposite* to the *sides* of the hexagons, and that this was considered to be the nearest possible approach to the true structure attainable with our present optical means is shown by Dr. Zeiss' narrow pencil photograph of this diatom × 4900, reproduced in "Carpenter," in which intercostals are visible. It is now known that with a real hexagonal arrangement of the kind indicated in Dr. Eichhorn's diagram, easily observable with a 1-in. in the *Triceratium favus*, the six spectra of the first order are *not arranged opposite the sides of the hexagons,* as shown by Eichhorn, but *opposite to their angles.* If such a mistake could arise and remain so long uncorrected and unexplained in Professor Abbe's deliberately-selected specimen of a computation of a comparatively simple regular formation, the probability of error when dealing with more elaborate irregular structures need not be dwelt upon.

Having touched on the four causes which, I believe, may be fairly taken as principally militating against the general adoption of critical methods by ordinary workers, and, it is hoped, having shown how easy it is for each individual microscopist to practically test their efficacy and trustworthiness for himself, in conclusion I venture to call your attention to a few points connected with the "glass and brass" department, which seem to have been hitherto overlooked by those whom they would more especially benefit.

The first of these relates to a new form of Huyghenian eyepiece computed by Mr. Nelson. I have had one of these oculars, made by Messrs. Powell and Lealand, magnifying 12 times, in constant use for the past two years, and have tested it on a large variety of low and high power, dry and oil-immersion apochromatic, semi-apochromatic, and old achromatic objectives. Be the explanation what it may, I have found that with *all* these so differently corrected objectives, with one exception only, it has proved itself decidedly superior to both the compensating and Huyghenian forms, the image appearing more crisply defined, and diatomic "dots" and structures exhibiting markedly

* Carpenter's "The Microscope," 7th and 8th editions, p. 71.

increased blackness; the only lens tried with which no actual improvement was noticeable being the 3-mm. ($\frac{1}{8}$-in.) Zeiss apochromat of N.A. 1·425, and even in this instance it proved almost a "tie," only an extremely slight advantage appearing to rest with the compensating ocular. This fact is of great importance to the microscopist of limited means, for the new eyepiece, being simpler, should be less expensive than the complicated cemented forms, and a set of two (one × 24 having been lately computed) would be amply sufficient for the general worker, and could be equally advantageously employed for different kinds of objectives as yielding the best yet attained results with them all. The construction of this eyepiece is open to all opticians, the full formula having been published.*

The next point relates to an objective of the utmost general utility, manufactured by Zeiss for some years past, but not catalogued by that firm, owing apparently to the small existing demand for it. It is a 36-mm. ($1\frac{1}{2}$-in.) semi-apochromat of the highest class. A recently-purchased specimen of this lens in my possession has a measured N.A. of ·21, and the perfection of its corrections is such that it has even visually rivalled in performance an expensive fluorite apochromat of the same power, while its superiority to ordinary $1\frac{1}{2}$-in. objectives is unmistakable. One would suppose this to be quite an ideal lens for the naturalist and hundreds of other kindred low-power workers, especially as it is not costly.† Yet, although it has been procurable for upwards of three years, the consecutive number borne by my own objective, obtained a few months ago, is only 20!

Lastly, I would emphasise the desirableness of employing mounting slips of one definite thickness for both low and high power objects, as the beautiful aplanatic sub-stage condensers now procurable from our opticians are sensitive to any pronounced differences in the thickness of the glass they work through, and will not afford large unbroken solid cones when used under unsuitable conditions. On trial it will be found that most modern dry condensers possess ample working distance and perform most perfectly through moderately thick slips; these should consequently be accorded the preference by the preparers

* Carpenter's "The Microscope," 8th edition, p. 377.

† Its price is 35s.

of all objects except those likely to require the use of an oil-immersion condenser, in which case a slightly thinner slip might be preferable.

In concluding these remarks, addressed to the younger and more inexperienced members of our Club, I need hardly explain that they are made in no carping spirit, nor with a desire to arrogate to myself a claim to speak with any authority beyond that of a working microscopist of some experience, who has paid considerable attention to the subject of microscopical manipulation, and has formed certain opinions based on practical observation.

The Apertometer and its Use, with a Description of Two Simple Forms of the Instrument.

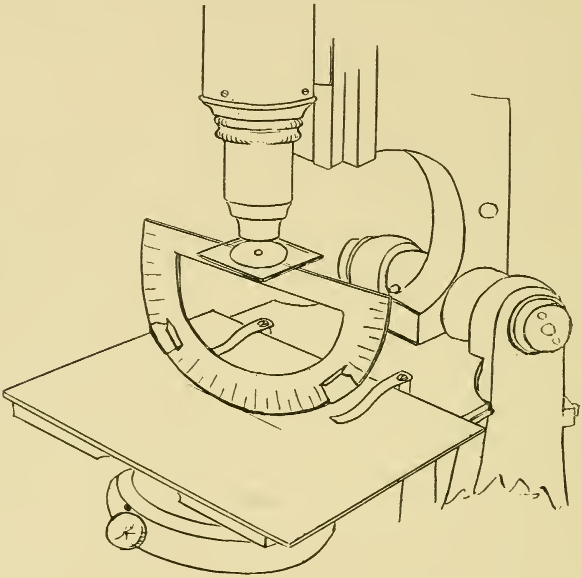
By H. F. Angus.

(*Read December 20th*, 1901.)

The Apertometer, on account of its high price and supposed limited range of usefulness, is perhaps the last piece of apparatus which the average worker would consider necessary, and few possess such an instrument; yet the apertometer is capable of giving information which cannot be obtained in any other way—information which materially assists in bringing out the utmost capabilities of the optical combination used, and of elucidating a great number of those problems which are constantly presenting themselves to the earnest student, without a clear understanding of which the intelligent use of the microscope is impossible.

These two objections, however—viz., high price and limited range of usefulness—need no longer deter those who prefer scientific methods of using a scientific instrument to the rough-and-ready, and therefore inefficient procedure usually in vogue, if only immersion lenses are left out of consideration. Of apertometers of limited range there are two patterns to which I wish to draw your attention: one, which we will call the protractor apertometer, capable of measuring the aperture of any dry lens; the other, the substage-scale apertometer, useful only for dry objectives of medium aperture, its range of efficiency varying somewhat with the aplanatic aperture of the condenser with which it is used. The former should not cost more than a quarter of the price of the cheapest of those at present on the market, and the latter can be obtained for a few shillings, thus disposing of the first objection. Before considering the second it would, perhaps, be well to give a detailed description of these two pieces of apparatus and their use.

The Protractor apertometer, as will be seen from the figure, consists essentially of an ordinary semicircular protractor mounted on a base, and supplied with two pointers, easily



adjustable to indicate any angle, and an object placed at the centre on which to focus the objective under examination. In practice, a silvered cover-glass mounted on a piece of glass the thickness of an ordinary slip, with an aperture of about 1 mm., is found the best object on which to focus. The objective is focussed in the usual manner on the edge of the aperture in the silvered surface ; the protractor is then moved slightly, so that the edge on which the focus was obtained moves out of the field, and the aperture becomes coincident with the optic axis of the microscope; then, on removing the eyepiece and looking down the tube, the whole of that part of the protractor which the objective takes in will be found to be visible, and the pointers can be adjusted so as to touch the opposite edges of the field, the reading indicated being the aperture required. Except with very low powers, however, the image of the protractor seen when looking down the tube is so small that some difficulty will be experienced in adjusting the pointers. To obviate this the draw-tube can be converted into an auxiliary microscope, thus magnifying the original image. This is effected by replacing the eyepiece and screwing into the lower end a very low-power objective, such as the posterior half of a 2-in. objective (the most suitable power varies somewhat with the available tube-length of the microscope). Care should be taken, when unscrewing and replacing the draw-tube, that the focus of the objective under examination is not altered in any way; and, when the auxiliary microscope is in position, any requisite focussing should of course be effected by sliding the draw-tube in or out as the case may be, not by altering the body-tube of the microscope.

Having in this way obtained a reading of the actual angle embraced by the objective, it can be converted to N.A., either by reference to some table such as that given in Dallinger's "Carpenter," or to a table of sines. With care, and with suitable illumination, N.A. 0·95 can be read with this instrument.

The Substage-scale apertometer was suggested to me by Mr. F. J. Cheshire, of the Birkbeck Institute, and consists essentially of a glass disc, of such diameter that it can be dropped into the stop-carrier of the condenser with which it is used, ruled with equidistant lines (a millimetre scale will be found as suitable as any). To use this piece of apparatus it is first necessary to find the value of the scale when used with any given condenser. This is effected by means of an objective of known aperture in the following manner: the condenser and objective having been focussed on an object, the disc is inserted below the condenser, the eyepiece removed, and the number of divisions of the scale visible in the field duly noted. As in the case of the Protractor apertometer, it will usually be necessary to magnify the image so obtained in order to read the scale with accuracy. When set up in this manner, the scale will appear sharply defined right up to the edge of the field, provided that the aperture of the lens measured does not exceed the aplanatic aperture of the condenser. Let us take as our objective of known aperture a $\frac{1}{2}$-in. of N.A. 0·34, and as our condenser the Abbe chromatic pattern N.A. 1·20 (this is the total aperture, the aplanatic aperture is of course very much less, approximately N.A. 0·50). Then, proceeding as above, we shall find that $8\frac{1}{2}$ divisions are visible in the field, and that consequently 1 mm. of the scale with this condenser has a value of N.A. 0·04; if now we take another objective, say a $\frac{3}{4}$-in., and find 5 divisions visible in the field, then we know that the aperture of the lens under examination is N.A. 0·20. It is, of course, obvious that the value of the scale varies with the power of the condenser with which it is used.

Having described the two instruments and the method of using them, thus disposing of the first objection to an apertometer, viz., its high price, we will now turn our attention to the supposed limited application of such an instrument. I shall confine my remarks to dark-ground illumination, but other applications will no doubt occur to the practical microscopist.

In the first place let me define exactly those conditions under which a good dark-ground illumination can be obtained. These rules were formulated by the aid of the instrument (substage-scale apertometer) just described, and are capable of verification by any one possessing a similar instrument.

(1) The aperture of the objective employed must not exceed $\frac{1}{4}$, or at the most $\frac{1}{3}$, of the total aperture of the condenser.

(2) A good dark-ground illumination can be obtained with high powers, if stopped down in accordance with the above rule.

(3) The size of the stop used in the condenser should be accurately determined for exactly those conditions under which it will be used, the difference of a millimetre in the diameter either way affecting the result, either as regards illumination of object or blackness of field.

(4) The correct diameter of stop for any given combination of objective, condenser, etc., can be calculated on the basis of the actual aperture of the iris, which cuts down the condenser to that point where it just fills the back lens of the objective and no more (the eyepiece is removed to determine this point).

(5) The diameter of the actual aperture of the iris (when the condition set forth in Rule 4 is fulfilled), plus a fractional part, which varies inversely with the perfection of the correction of the condenser, will be the diameter of the stop required: the fractional part to be added must be found experimentally for each type of condenser, but when found is a constant for all stops used with any given condenser. For instance, with the Abbe chromatic condenser N.A. 1·20, one-half must be added—that is to say, if the actual iris aperture which just fills the back lens of an objective is 8 mm., then the stop must be 12 mm. in diameter; if 10 mm., then 15 mm. would be the diameter of the stop required.

To apply these rules in practice a substage-scale apertometer will be found of constant use. For instance, it is required to cut down an objective $\frac{1}{4}$-in., of say N.A. 0·45, so as to give a good dark-ground illumination with an Abbe chromatic condenser N.A. 1·20: the value of the millimetre divisions of the disc are with this condenser, as we have already found, N.A. 0·04; then we must insert a stop behind the objective of such size that it will limit the field seen at the back of the objective without the eyepiece to 8 mm., that is N.A. 0·32 (Rule 1).

Having cut down the objective to a suitable aperture, it is necessary to determine the size of the substage stop; this can be done without the disc by picking up the microscope and measuring the iris aperture with a pair of dividers, but it can be more conveniently done with the disc, as, owing to the scale being in practically the same plane as the iris, a direct reading can be taken, not only of the N.A. of the objective, but also of the iris aperture; the reading in this case is 8 mm., consequently a 12 mm. stop will be required.

To take another instance, an objective $\frac{3}{4}$-in. of N.A. 0·20 combined with an Abbe chromatic condenser of N.A. 1·20 with the front lens removed, gives a field of 12 mm., and it will be found that an 18 mm. stop gives the best possible result.

Instances might be multiplied; but I think that, although the above does not pretend to be exhaustive, enough has been said to show the utility of an apertometer for this work. In conclusion, I may say that black paper discs carefully centred on discs of glass cut to the size of the stop carrier are quite efficient, at any rate for experimental work: a set of stops so determined could afterwards be made in metal if desired, the various discs being made interchangeable on a skeleton stop carrying a central pin.

On *Diglena rostrata*: a New Rotifer.

By F. R. Dixon-Nuttall, F.R.M.S., and Rev. R. Freeman, M.A.

(*Read December 20th*, 1901.)

Plate 9.

Specific Characters	*Body:* long, thin; dorsum, slightly arched; venter, flat. *Face:* long, prone, with a long projecting hook. *Eyes:* two, red, frontal. *Foot:* thin, cylindrical. *Toes:* long, blade-shaped.

Towards the end of April, 1901, we found this graceful *Diglena* in water taken from the large lake in Knowsley Park, Lancashire, which at once struck us as being a new species, both on account of its hyaline appearance, and also on account of the long projecting prow-like beak. From this latter feature we decided to name it rostrata, after "rostrum," the beak or prow of a boat.

The skin is soft and very transparent, but apart from the two folds in the neck, and the parts posterior to the lumbar fold, the animal is not given to contortion, so that its general outline remains constant.

Viewed laterally, the dorsum is slightly arched towards the lumbar regions, but hardly sufficiently so to destroy the graceful outline. It rounds rapidly to a lumbar fold, and thence tapers to the cloaca.

Viewed dorsally, the body is almost cylindrical, but slightly fusiform, tapering to the width of the foot at the lumbar fold.

The foot is cylindrical, with a slight tail-like projection, carrying no seta, as in *D. uncinata*. The toes are long, cylindrical, slightly decurved and outcurved, and carried wide apart when viewed dorsally.

The head is produced into a long hooked beak, which, with two red eyes situated just beneath its base, is the most striking feature of this rotifer, and can be easily observed under low-power objectives. The face is prone, elongated, and well covered with long vibratile cilia. The two red eye-spots, which, under high power, are slightly reniform, are simple, and not composed of a cluster of red pigment, as in *D. clastopis*.

The jaws are not of the usual savage type of the *Diglenae*. The manubria are thin rods; the unci are more like curved plates than sharp hooks as in many other *Diglenae*. The fulcrum is short and thin; the rami widen out triangularly at the base.

The dorsal and lateral antennae are well marked and in the usual position. The brain is long and clear. The gastric glands are large and clear, and easy of observation.

The whole animal is particularly hyaline, none of the specimens observed contained any brown food-matter, as is invariably the case in *D. clastopis*. The ovary, contractile vesicle, and other organs are normal.

We are strongly of opinion that this rotifer finds its food upon the *roots* of water weeds, because we never found a single example without deep dredging.

On those occasions when we dredged deeply we always found it. On other occasions, in the very same spot and at the same time when water and weeds were gathered from the surface, not a single specimen was found.

When disturbed from the roots of the weeds it is restless, swims gracefully, and buries itself rapidly in any flocculent matter it can find.

It is far from common, and we seldom obtained more than a few out of a large gathering, though the water was carefully examined for it; but by visiting its special locality several times we have been able to secure numerous specimens, and to subject it to careful and repeated examination.

Total length, $\frac{1}{106}$ in. (240 μ); toes alone, $\frac{1}{475}$ in. (53 μ); width of body, $\frac{1}{550}$ in. (46 μ). Habitat: The large lake, Knowsley Park, Lancashire.

Explanation of Plate 9.

Fig. 1. *Diglenda rostrata*, side view × 475.
,, 2. ,, ,, dorsal view × 475.
,, 3. ,, ,, jaws.

The Ephippia of the Lynceid Entomostraca

By D. J. Scourfield, F.R.M.S.

(*Read December 20th*, 1901.)

Plates 10, 11 and 12.

For some years past I have been making observations, as opportunity offered, on the protective coverings of the winter or resting eggs of the Cladocera, known in their more highly developed forms as "ephippia." I have already in two papers read before this Club brought forward some of the facts ascertained—see "The Winter Egg of a Rare Water-Flea" (10) * and "The Ephippium of Bosmina" (11)—and it was my intention to wait until I had sufficient material for a paper on ephippia in general before writing anything further on the subject. As, however, I have not as yet been able to do much with the ephippia of the Daphnidae and nothing at all with those of the Lyncodaphnidae, while on the other hand I have now collected a fair amount of information on the ephippia of a large proportion of the genera of the Lynceidae, it seemed advisable to put together my notes on this family rather than wait for an indefinite period until I should have been in a position to deal in a suitable manner with the ephippia of the whole of the Order Cladocera. There is also some further justification for this course to be found in the fact that the Lynceid ephippia are not nearly so well known as those of the Daphnidae, and they seem, therefore, to call more urgently for consideration.

It is somewhat surprising, indeed, that a greater amount of attention has not hitherto been paid to the simple types of ephippia found among the Lynceidae. The explanation is no doubt due to several causes, the chief of which are probably the comparative rarity of the occurrence of these structures, their small size, and the somewhat mistaken notion held by students of the Cladocera that the ephippia of this family are practically unmodified carapaces and not specially prepared receptacles intended for the protection of the winter eggs.

* The figures in brackets refer to the number in the list of literature appended to this paper.

In my paper on the Winter egg of *Leydigia acanthocercoides* (10) I referred to the principal sources of our knowledge of the ephippia of the Lynceidae, but it will probably be useful if the same information is repeated here, together with a few additional references to the literature of the subject—which is, as already hinted, very meagre.

The first allusion to ephippia and winter eggs among species of the Lynceidae, so far as I have been able to discover, is made by Jurine in his classic work "Histoire des Monocles" (2), published in 1820. He only refers specifically to *Chydorus sphaericus*, the development of which he figures on Plate 16 from the egg, "jusqu'au moment où se forme la selle," etc. In figs. 3 *f* and 3 *g* on the Plate mentioned he shows an ephippial female seen from the back and from the side, and in 3 *h* a moulted ephippium with its egg. Generalising apparently from this particular case, he says, when considering the characters of the group to which *Chydorus* belongs: "Ces petits monocles nous offrent encore une autre particularité. La selle qui couvre leur dos ne contient jamais qu'une seule boule, laquelle est placée au milieu de cette pellicule noire et y fait saillie." He goes on, however, to admit that perhaps in the larger species, normally carrying numerous eggs, the statement just quoted might not hold good.

The next reference to ephippia of Lynceidae that I have seen is to be found in a very elaborate paper by Schödler (7), published in 1846, on *Acanthocercus rigidus* (=*Acantholeberis curvirostris*). It is stated that in this species, and also in the Lynceidae, the whole of the valves, which moreover are said not to suffer any noticeable alteration, are usually employed to retain the winter eggs. The whole "Eierpacketchen" is thrown off at the next moult, and attached to plants or to the walls of the vessel containing the animals. It is also incidentally noted that the number of eggs in the ephippium of *Eurycercus lamellatus* (the only Lynceid mentioned by name) varies from two to ten. Many years later (1863) Schödler issued another paper (8) in which he refers to the winter eggs and rudimentary ephippia of *Eurycercus lamellatus*, *Peratacantha truncata*, and *Chydorus sphaericus*, and he again notices that these Lynceid ephippia are often attached to plants, etc., as in the case of *Acantholeberis*.

In passing, it may be remarked that Baird, in his "Natural History of the British Entomostraca" (1), published in 1850, quotes Jurine as to the occurrence of ephippia in the Lynceidae, but states that he himself had never seen such structures in this family.

Nothing further appears to have been done on this subject until Kurz, in 1874, published his "Dodekas neuer Cladoceren" (3), in which he definitely recorded the existence of winter eggs in about sixteen species of Lynceids. He roundly declares that a true ephippium is produced by the majority of the Lynceidae. His descriptions are almost invariably very short, but he gives a fairly long account of the ephippial female of *Chydorus sphaericus*, and he also notices the fact that the ephippia are attached to some solid body, such as the glass sides of the aquarium.

Weismann was at this time also working diligently at the Cladocera, and among the numerous observations mentioned in the "Beiträge zur Naturgeschichte der Daphnoiden" (12) he refers to the winter eggs and ephippia of seven species of Lynceidae. He seems to have been the first who paid any close attention to the moulted ephippium, for he remarks that the ventral margin of the valves separate from the thicker and darker part of the shell, so that only this modified portion is left as a covering for the egg, and he states that the process is evidently a step in the direction of the typical ephippium formation as found in the Daphnidae.

In two of his papers on exotic Entomostraca—from Australia (5) and South America (6)—Sars has given figures and descriptions of the ephippial females of various species of Lynceids, but has not specially alluded to the ephippia in their detached condition.

The recent beautiful work on Swedish Cladocera by Lilljeborg (4) refers to the occurrence of winter eggs and the darkening of the shell in ephippial females of many species of Lynceidae, including some cases which had not previously been recorded, but it does not add anything to our knowledge of the structure of Lynceid ephippia.

To the foregoing account of the work that has so far been done on this subject may be added that in an article on *Chydorus sphaericus*, published in 1898 (9), the author of the present paper made some observations on the ephippium of that species, and in a subsequent paper gave a detailed description of the ephippium of *Leydigia acanthocercoides* (10).

Having now considered the small literature connected with Lynceid ephippia, attention may be turned to the more essential object of this paper, which is, to describe and figure as fully as possible the ephippia of numerous species, in order that some idea may be obtained of their general characteristics and of the range of their principal variations. I propose, therefore, to commence at once with the description of the ephippia, or ephippial females, of those species I have actually examined, taking them as far as possible in the order in which they are arranged by Lilljeborg (4).

Eurycercus lamellatus (O. F. Müller).

The ephippial female of this giant Lynceid exhibits a well-defined area of a deep reddish-brown colour extending nearly three-quarters of the distance across the valves from the dorsal margin. The exact shape and position of the darkened area can best be understood by a reference to Fig. 1. The ordinary shell markings, a very faint irregularly hexagonal meshwork, seem to be increased in strength over the darkened area—at least they are quite evident in the specimens of ephippial females kindly sent to me by Professor Sars from Finmark—whereas in our British specimens of the ordinary female the hexagonal markings are rarely if ever present. A considerable thickening of the substance of the shell has also probably taken place, and the structure of the chitin is no longer homogeneous, but contains a large number of exceedingly minute pits or cavities. Along the dorsal line of the shell the chitin is clearly seen to be much increased in thickness. This is indicated in the figure by the double line along the back.

But the most remarkable fact about the ephippium of *Eurycercus lamellatus*, and one which is probably quite characteristic of the genus, if not of this species, is that it is designed to contain a large number of winter eggs. Schödler records from two to ten, Weismann says up to eight, and I have seen as many as thirteen in one of the ephippial females sent by Professor Sars. With one possible exception, to be referred to later in connection with *Camptocercus rectirostris*, every other Lynceid ephippium contains but a single winter egg. I have not been able to obtain moulted ephippia of this species, but from the drawing given by Weismann (12, Taf. vii., Fig. 10), reproduced in Fig. 2, it will be seen that a large part of the ventral portions of the valves break away from the ephippium in a manner which we shall find to occur again and again as we proceed. Whether there are any special inner membranes surrounding the eggs, as in most, if not all, other Lynceid ephippia, I do not know, but it is at least very probable.

Camptocercus rectirostris Schödler.

I have been able to examine the moulted ephippium of this species on several occasions; and as, owing to its thinness and transparency, it is a particularly favourable object for investigation, and moreover seems to bring out many of the essential features of a Lynceid ephippium, it will be well to devote some extra care to its examination. The ephippium is shown in Fig. 3, and it will be seen at once that it consists of the moulted shell, minus a rather considerable portion of the ventral region. If we commence by looking at the four edges of the ephippium, we notice that the dorsal and posterior margins are of exactly the same contour as seen in the shell of the ordinary female of this species; but while the latter is unmodified, the dorsal margin is very considerably thickened by a deposit of clear homogeneous chitin. We shall find that this increase in the thickness of the chitin along the back is probably a universal characteristic of Lynceid ephippia, and I further believe it is a feature common to all ephippia. The anterior edge is formed by the line of junction between the head-shield and the valves, as may readily be proved by comparison with an ordinary moulted shell. The little upturned cusp at the dorsal end of the anterior edge is very characteristic, and may prove to be peculiar to the genus *Camptocercus*, although it is faintly foreshadowed in *Acroperus*. The ventral margin of the ephippium, unlike the others, is somewhat jagged in appearance. It runs approximately parallel to the dorsal line for the greater part of its length, but posteriorly it turns towards and eventually cuts the original ventral margin of the shell just above the posterior ventral angle, thus leaving a small piece of the old shell margin intact. This feature is exactly similar to what is found in the ephippium of *Bosmina* (see 11), and it will be seen, as we proceed, to be of very common occurrence among the Lynceid ephippia. Careful examination of the ventral edge of the ephippium will show that, from the anterior edge to within a short distance of its posterior termination, there is a narrow border of finely pitted chitin. The origin of this will be seen presently. The surface of the ephippium shows the characteristic longitudinal stripes and also the fine intermediate "scratchings" present in the ordinary shell; and these markings do not seem to be in any way modified in this species, except that where the ephippium is darkest, *i.e.* just over the egg, the long parallel lines show a slight tendency to be rather better defined than usual. As regards the darkening of the shell, which may be very intense, even making the ephippium appear almost black to the naked eye, it must be pointed out that it is really limited to a comparatively small oval area, the situation of which will be seen indicated in Fig. 4. The chitin of this dark brown area does not, however, appear to be altered in structure, as is so often the case in other ephippia.

So far only the outside of the ephippium has been dealt with. We can now turn our attention to the interior; and here it will be found that the solitary egg is not simply lodged in the case just described, but is surrounded by a sheath of exceedingly delicate crumpled membranes. These do not touch the egg, at least not as seen from the side, but stand off at some distance, as figured. They undoubtedly represent the moulted inner lining of the valves, just as the external part of the ephippium is evidently the exuviated outer coat. It is not intended in this paper to specially consider the winter eggs contained in the ephippia, but it may be noticed in passing that the single egg* in this species is rather longer in proportion to its width than that of any

* Weismann (12) says that there may be two winter eggs in *Camptocercus macrurus*, and he gives a figure of an ephippial female with two such eggs (Taf. vii., Fig. 9). Whether this really represents a difference between the species of the genus or not is uncertain. Professor Sars informs me that he has never seen more than one winter egg in any Lynceid except *Eurycercus*; and this has been my experience.

other we shall have to deal with. Like most other winter eggs it is of a dirty greenish colour, for the most part quite opaque, but with faintly translucent edges.

Having now considered the detached ephippium, it will be found very instructive to examine the shell of a living ephippial female, especially with a view to discover if any trace of the future ventral margin of the ephippium can be seen. As a matter of fact, with critical illumination from a substage condenser, and, say, a good $\frac{1}{6}$-in. objective, an exceedingly delicate line, composed of what appear to be a row of somewhat lozenge-shaped cells, can be made out running across the ordinary shell markings in the exact position where the ventral portions of the valves will eventually break away from the rest to form the ephippium (Fig. 4). The line cannot be traced all the way to the ventral margin of the shell, as it becomes very vague for some distance before reaching that point. Under a $\frac{1}{12}$-in oil-immersion this line of weakness is seen to consist of a band of chitin free from the ordinary "scratches" of the shell, but exhibiting numerous minute "pits," and having along its centre a string of loosely connected pieces of chitin. It is by the falling asunder of these that the ventral portions of the valves become so easily detached from the ephippium; and as they occupy only the middle portion of the band above mentioned, there is a border of pitted chitin left along the ventral margin of the ephippium, as already noticed. One curious fact deserves mention in this connection: namely, that where the line of weakness crosses the ordinary shell markings, the latter, and also the tiny intermediate scratches, turn aside from their ordinary paths in such a way as to bring themselves more or less parallel with the newly formed line. (See Fig. 5.)

It should be mentioned that it is impossible to demonstrate the line of weakness just described in preserved specimens of ephippial females. It is necessary to have living animals for this purpose; and even then, rough and ready methods of examination will not suffice to make out the structure satisfactorily.

Camptocercus similis Sars.

Through the kindness of Professor Sars I have been enabled to examine ephippial females of this South American species.

A representation of one is given in Fig. 6, and it will be seen that there is a very general resemblance to *C. rectirostris* in all points, except that the longitudinal markings of the shell become in this species developed into very prominent ridges in the centre of the darkened area, *i.e.*, just over the spot where the egg will be eventually lodged. Each of these ridges can be traced into one of the ordinary shell lines both anteriorly and posteriorly. In front view the projecting ridges can be seen to be somewhat crenulated. In the preserved specimens at my disposal it was impossible to trace out the lines of separation of the ephippium from the rest of the shell, but this does not in the least prove that they do not exist, and I have no doubt that the ephippium of this species very closely resembles that of *C. rectirostris* in outline and all other characters except the prominent ridges.

Acroperus harpae Baird.

Much of what was said about the ephippium of *C. rectirostris* applies also to this species. There is the same thickening of the chitin at the back (see Fig. 7), the same slightly ragged ventral margin terminating at some distance in front of the posterior ventral angle of the shell, and the shell markings are not perceptibly altered. Of course the general outline differs somewhat from *C. rectirostris*, being necessarily conditioned by the normal shape of the shell in the species; but the most noticeable difference in this respect is that the anterior dorsal cusp, which forms such a striking feature of the ephippium of *C. rectirostris*, is extremely small. The darkening of the shell is not so deep as in *Camptocercus*, but on the other hand it spreads nearly uniformly from the back over a large part of the ephippium, instead of being confined to an oval patch just over the egg. The inner membranes around the egg are much more developed than in *C. rectirostris*, forming, in fact, a quite distinct capsule. That this capsule is really an efficient second line of defence for the egg may be inferred from the fact that, in ephippia which have been moulted for some time, the space between the valves of the ephippium and the capsule may be seen to contain various tiny living organisms such as diatoms, bacteria, etc., while the space within the capsule is quite free from such invaders. The same fact will be brought out in another way when dealing with *Chydorus sphaericus*. That the crumpled membranes forming the capsule are produced by a special modification of the inner lining of the shell valves is evident from an examination of the back of an ephippial female, which shows a very great development of the inner layer of skin, as indicated in Fig. 8. This figure also shows the great increase in the thickness of the chitin at the back of the shell.

In living specimens of the ephippial female of *A. harpae* a line of weakness very similar to that already referred to in connection with *C. rectirostris* can, with care, be traced, and under a high power it can be shown to consist of a row of cells, or rather pieces of chitin, which are only loosely joined to the rest of the shell and to one another.

Alonopsis ambigua Lilljeborg.

I am indebted to Professor Sars for ephippial females and moulted ephippia of this species, the particular specimens sent coming originally from Algeria. The ephippium is shown in Fig. 9, and it will be noticed that quite a third of the ventral portion of the shell has been detached. A line of weakness is evidently formed in this case before the moulting of the ephippium, for there are still to be seen a few of the loosely-connected pieces of chitin along the ragged ventral margin. The outer shell structure is not modified, for the excessively fine longitudinal striae on the surface are still to be seen on the ephippium, but there is the usual thickening of the shell along the dorsal margin. Within the outer shell, however, there is a dense mass of chitinised cellular material occupying a quite definite area, and closely investing the egg. This material, which seems to serve as "packing" for the egg, is composed mainly of cells of various sizes (Fig. 10), the larger ones for the most part being along the back, while just over the egg itself the cellular nature of the material seems to change into a mass of minute fibres felted together. The "packing" can be seen in the ephippial female in the process of being produced from the inner lining of the carapace, and no doubt it is homologous to the delicate membranes seen in *Camptocercus*, and to the membranous capsule in *Acroperus*.

The appearance of this ephippium is, if we confine our attention to the portion occupied by the "packing," strikingly similar to that of the Daphnid *Simocephalus vetulus*, but the cellular "packing," although giving this ephippium such a decidedly

Daphnidan appearance, is not, I believe, homologous to the definite prismatic cell structure—the "Schwimmgürtel" of Weismann—found in the more typical ephippia of the higher family.

Euryalona occidentalis Sars.

Preserved specimens of the ephippial female of this interesting form have been sent to me by Professor Sars, who raised this species from dried mud collected at Ipiranga, in Brazil. The shell in this case (Fig. 11) is very evidently modified, for at the first glance it is seen that the back, instead of being evenly curved as in the ordinary female (see "Fresh-water Entomostraca of South America" (6), Plate 12, Fig. 1), is produced in the middle into a blunt angle. The thickening of the chitin from just above this angle to the posterior dorsal corner is also well marked, and there is a small, but very evident, darkened area of a deep brown colour near the centre of the valves, though nearer the back than the ventral margin. When the animal is viewed from the front these darkened areas are seen to project very considerably, thus showing that they will form a special chamber to contain the resting egg. No line of weakness could be made out; but this, as already stated, does not preclude the possibility of its existence. Judging from the apparent extra development of the inner layer of the carapace, I should think that when the ephippium is thrown off the egg becomes surrounded by very evident membranes.

Alona affinis (Leydig).

The ephippial female of this species, some examples of which I have been able to examine through the kindness of Prof. Sars, shows a very strongly marked thickening of the chitin at the back, and a very considerable darkening of the dorsal and central parts of the shell (see Fig. 12). The dorsal thickening is rather peculiar, in that it comes to an end a long way before the posterior dorsal angle is reached. Over the darkened area the structure of the chitin is somewhat altered, being full of little pits, and the coarse shell markings are also somewhat indefinite, but the excessively fine longitudinal striae are still present everywhere over the shell. With some care a chain of specially developed cells, forming a line of weakness between the ephippium and the ventral portions of the valves, and also the line of junction between the head-shield and the valves, can be made out in the positions indicated in the figure. The posterior end of the former line turns off in the direction of the ventral margin of the shell, not very far after reaching the middle of the valve—seeming to indicate that a very considerable portion of the original shell margins will be permanently attached to the ephippium. It is possible that this is correlated in some way with the stopping short of the dorsal thickening already alluded to. The inner lining of the carapace can be seen to be much increased and thrown into curious folds, showing that provision is being made for the special protection of the egg by investing membranes.

Alona tenuicaudis Sars.

In one respect the ephippium of this species is unique, so far as my experience goes, for it consists of the whole shell of the animal, with the exception, of course, of the head-shield (see Fig. 13). There is no sign of any tendency for the ventral to break away from the middle and dorsal parts of the valves. The shell markings are also normal, but the back shows the usual chitinous thickening seen in ephippia, and there is a certain amount of darkening extending from the back well over the egg. This ephippium also presents us with another illustration of the remarkable development of the inner lining of the shell. It will be seen from the drawing that the egg is embedded in a great mass of irregular cellular tissue, almost exactly similar in structure to that found in *Alonopsis ambigua*, already described. This "packing" fills up a large portion of the shell, and even projects from between the anterior margins. For the most part it is very irregular, but at the back it appears to be composed of rather long prismatic cells, the walls of which exhibit fine striations, as shown in Fig. 14. I had the opportunity on one occasion of isolating an ephippial female of this species in which the winter egg was already extruded, but otherwise showed no sign of ephippial modification except a faint darkening of the shell. The next day, however, the cellular structures within the shell were quite evident, and could be plainly seen to be produced by the inner layer of the skin. The cell-walls were still colourless (they are darkened and chitinous in the moulted ephippium), while the interspaces were filled with granular matter. At the back the inner layer of the skin could be seen to be swelling out to a considerable thickness, though still quite soft and pliable. The ephippium, when thrown off, was exactly similar to the one figured. One fact in connection with the moulting of this ephippium may be worth recording. It was attached so firmly to the bottom of the glass tube in which the experiment had been made, that I could not move it with a little brush, but had to take a hooked needle and tear it away forcibly. The adhesion of Lynceid ephippia to the sides of the vessels in which Entomostraca are kept is not at all an uncommon phenomenon, and it has already been referred to, but this was the most tenacious attachment that I have observed. I believe that the mass of threads and cellular matter protruding from the anterior part of the ephippium is the means by which the attachment takes place.

Alona costata Sars.

The ephippium of this species, before the ventral portions of the valves have become quite detached, is shown in Fig. 15. There is very little alteration of the shell, the surface-markings remaining as in the ordinary female, but there is a considerable amount of darkening over the egg and in the dorsal region generally. The chitin of the back is thickened as usual, and is of a dark yellowish-brown colour. Surrounding the egg there is a copious supply of exuviated membranes, but their arrangement is very irregular, although they probably form a closed inner case. Some of the membranous material may project beyond the shell, as indicated. I have not been able to examine a living ephippial female, but from the appearance of the edges of the crack between the ephippium and the ventral parts of the shell, there can be no doubt that a line of weakness is formed before the moulting of the ephippium takes place. In the figure little imperfectly connected pieces of chitin can be seen still adhering to a part of one edge of the crack, showing that much the same formation takes place in this species as in *Camptocercus rectirostris* and *Acroperus harpae*. When the ventral portions of the valves become detached they break off abruptly a little way in front of the posterior ventral angle, in the position indicated by the dotted line.

Alona rectangula Sars.

This is one of the smallest species of the genus, and its ephippium is correspondingly minute, never much exceeding $\frac{1}{90}$ in., and being sometimes rather less. It exhibits several interesting features. In the first place, the whole of the ventral third of the shell splits away from the remaining portion, the line of separation being continued straight to the posterior margin, and not running off to meet the ventral margin, as is usually the case (see Fig. 16). In the drawing the ephippium is shown with the ventral parts of the valves still attached. These and other ephippia, as already seen in the case of *A. costata*, are very often found in this condition, but they are also found without the ventral parts of the original shell. It probably depends to some extent upon the usage to which they have been subjected after being thrown off by the animal.

Another peculiarity is to be found in the elaboration of the inner membranes surrounding the egg into a delicate cellular "packing," not so well marked nor so copious as in *Alonopsis ambigua* and *Alona tenuicaudis*, but apparently representing a step in the same direction. The coarser structure is fairly well shown in Fig. 16, where it will be seen that, closely investing the egg and extending from the back almost to the other three edges of the ephippium, there is a mass of irregularly polyhedral cells having somewhat ragged margins. In each of these larger cells there are a great many smaller ones, the irregular edges of which, seen in optical section, produce the impression of a cavity filled with fine spider lines (see Fig. 17). This ephippium is very dark brown, almost black, in colour, and the darkening occupies approximately the same area as the "packing." The dorsal margin is thickened as usual, and the line of weakness is produced by the formation of a special chain of loosely adhering chitinous plates, as may be inferred from the few still attached in their places to the edges of the crack. The ordinary shell markings do not appear to be appreciably modified. After the moulting of an ephippium, the back of the animal shows a little crumpling, reminding us of what we find in such a marked degree in the Daphnidae after the throwing off of an ephippium.

Leydigiopsis curvirostris Sars.

This species has been hatched from dried mud from São Paulo, in Brazil, by Professor Sars, who kindly sent me some ephippial females for examination. There is no alteration in outline, but the valves are seen at once to be much darkened over nearly the whole of the dorsal half of the shell, and the chitin at the back is much thickened. The surface of the shell is everywhere covered with extremely closely-set striae similar to what is found in *Alona affinis* and *Leydigia acanthocercoides*, and these fine lines are not modified in any way in the ephippial females. In passing it may be pointed out that, although Professor Sars does not mention these fine striae in his description of the species (6), they undoubtedly exist, but can only be properly seen with the most careful illumination, and high magnification. Under these conditions they can be resolved into rows of tiny dots (black or white according to the focus), almost comparable in delicacy to diatom markings. There is no other shell sculpture. I was able in this instance, even with the preserved specimens at my disposal, to demonstrate a line of weakness running obliquely across the shell striae in the direction of the ventral margin, but I could not make out its real nature quite satisfactorily. In one or two places, however, distinct cells or pieces of chitin could be seen, and upon these there were no striae. The ephippium when moulted would most probably be very similar in outline to that of *Alona costata*, and in confirmation of this Professor Sars notes that the single egg becomes covered with a *part* of the moulted carapace. In the central and darkest part of the shell there is a fairly evident reticulated structure consisting of hexagonal cells of rather large size, apparently containing masses of fibrous material. These are probably connected with some special development of the inner layer of the carapace, such as we have seen to take place in other cases.

Leydigia acanthocercoides (Fischer).

A detailed description of the ephippium of this species has been given in a special paper (10), and it will therefore be sufficient for our present purpose if the main features only are referred to. Side and front views are given in Figs. 18 and 19, and from these it will be seen that it is provided with two enormous hooklike processes which are evidently the darkened, and possibly thickened, margins of the original shell. So far as known at present, this is a feature that is unique among Lynceid or any other ephippia, the nearest approach to such an arrangement being found in *Daphnia magna* (for a few remarks on which species see the paper just referred to). The portion of the original shell forming the actual ephippium is smaller, comparatively, than in the case of any other Lynceid, and it is approximately semicircular in outline. The dorsal margin is strongly chitinised, and the whole ephippium is much darkened, and probably also thickened. The shell markings, consisting of parallel longitudinal stripes with extremely fine striae between them, are not obliterated, but are somewhat altered, as if by irregular deposits of chitin.

The ephippium and its hooked processes become detached from the rest of the valves by the falling away of a special line of loosely connected pieces of chitin developed, before moulting takes place, along the ventral margin of the ephippium and completely round the free margins of the shell (Fig. 20). Within the outer case, and completely surrounding the egg, there is an abundant development of cellular tissue, forming a kind of "packing," similar, in some respects, to what occurs in *Alonopsis ambigua* and *Alona tenuicaudis*. Some of this may project from between the ventral edges of the ephippium, as shown in the figure. Altogether this ephippium is one of the most peculiar, and possibly also the most highly evolved, of all the Lynceid ephippia.

Dr. Vosseler has given a figure of the ephippium of this, or an allied species, in Lampert's "Das Leben der Binnengewässer," 1899, p. 257, but without a detailed description.

Graptoleberis testudinaria (Fischer).

My drawing of the ephippium of this species, Fig. 21, was made in 1892, before I had given any special attention to this subject. It shows, however, that, while there is no evident alteration of the shell sculpture, the chitin is thickened at the back; that a rather small part of the ventral margin of the shell becomes detached, and that there are probably some inner membranes surrounding the egg. The ephippium was a little darkened, as is commonly the case; and I noted that the keel of the shell did not seem so evident as usual in this species, indicating, perhaps, that there may be some modification in this respect.

Alonella rostrata (Koch).

Figure 22 represents the ephippium of this species. It is very much darkened, especially towards the back, but the surface shell sculpture is not appreciably modified, and the dorsal margin is but very little thickened—at least, it does not show such a clear line of chitin as is usually the case. Over the darkened area the chitin is minutely pitted. The ventral margin is bounded by a line of loosely connected pieces of chitin, which have apparently been produced independently of the ordinary shell markings, and it cuts the old ventral edge of the shell just in front of the posterior ventral angle. I have not been able to satisfactorily demonstrate the existence of this line of special cells in the ephippial female before moulting, but I think, from what we have seen in other cases, that we may assume it to exist. The inner membranes enclosing the egg are very delicate, and cannot be traced with certainty in all cases completely round the egg. They sometimes project from the posterior part of the ephippium. I have, at times, seen many of these ephippia attached to the sides of the bottle in which the species has been kept.

Alonella excisa (Fischer).

This is one of the very minute ephippia, scarcely exceeding $\frac{1}{100}$ in. in length. It is very much darkened, but otherwise the shell does not show much modification, for it is but very slightly thickened at the back, and the ordinary surface reticulations, with their characteristic secondary markings, are practically the same as in the ordinary female (see Fig. 23). I do not know whether the line of separation between the ephippium and the ventral parts of the shell is entirely produced by a line of loosely connected cells or not, for the ephippial female has not been examined, and in the ephippium the ventral margin is remarkably sharp and regular, only showing posteriorly a ragged edge. The line meets the original ventral margin of the shell just in front of the posterior ventral angle. There is a great mass of membranous material of a delicate character surrounding the egg, which may even protrude from both the anterior and posterior ends of the ephippium. In one specimen, which I rolled about in the live-box so as to open the valves and expose the egg, the membranes seemed to be still attached posteriorly to the inner surface of the shell. As in the case of the foregoing species, I have observed many of these ephippia attached to the sides of a glass jar in which the animals were contained.

Alonella diaphana (King).

Professor Sars obtained ephippial females among the specimens of this species raised by him from dried mud from Argentina, some of which he forwarded to me for examination. A sketch of one of these is given in Fig. 24, and it will be seen that, in contrast to the two previous species of *Alonella*, a considerable amount of structural modification of the shell has taken place. The dorsal outline has been slightly angulated as compared with that of the parthenogenetic female [for a figure of the latter see (5) Pl. 5, Fig. 5], there is a very great amount of thickening of the dorsal margin, and the shell markings have been very much increased in intensity over the darkened area—so much so, in fact, as to produce the appearance of a series of strong wavy longitudinal lines in the dorsal region. The markings just over the egg itself are hexagonal, and possibly this is the real structure everywhere, but it is not very plain in other parts of the shell. The chitin over the darkened area is minutely pitted. No line of weakness could be discovered in these preserved specimens, and, owing to the opacity of the shell, it was not possible to make out whether the inner lining was undergoing modification or not.

Alonella karua (King).

Some ephippial females and moulted ephippia of this species, from Itatiba in Brazil, have been received from Professor Sars. The ephippium, with the ventral margins of the shell not wholly separated, is shown in Fig. 25. It consists of a large part of the shell, which is very considerably darkened, and thickened at the back. The chitin of the shell over the darkened area is minutely pitted, while the surface markings (longitudinal lines) are obscured, although not quite obliterated. A line of weakness is formed which runs out to meet the ventral shell margin just in front of the little teeth at the posterior ventral angle. The most striking feature about this ephippium, however, and one reminding us in some respects of *Alonopsis ambigua* and *Alona tenuicaudis*, is the excessive development of the inner membrane into a mass of chitinous cellular "packing" over a sharply defined area. The cellular character of this material is not everywhere apparent, and true membranes exist in addition to the irregular spongy tissue.

Peratacantha truncata (O. F. Müller).

With this species we reach the first of a type of ephippium which may be termed the Pleuroxus-Chydorus type, the main feature of which is that the dorsal margin, instead of being nearly as long as the total length of the ephippium, is considerably shorter than this, being perhaps not more than half, or even less. The anterior margin also joins the dorsal margin at an angle considerably greater than a right angle, whereas, in all the ephippia hitherto examined, the angle has not differed much from a right angle. These two points, which are of course mutually related, are determined by the great backward extension of the head-shield typically shown in the genera *Pleuroxus* and *Chydorus*, though it does not by any means follow that all the species at present included in those genera exhibit these characteristics. In Fig. 26 a drawing is given of an ephippium of *Peratacantha truncata*, with the ventral margins of the valves still attached posteriorly. The ephippium is much darkened, and the dorsal thickening very strong, but the shell markings, always rather vague, do not seem to be much altered. The line of weakness, which can be easily seen in the living ephippial female, is marked by a double or triple row of imperfectly connected pieces of chitin, as indicated in Fig. 26, and more highly magnified in Fig. 27. It reaches the ventral shell margin a little way in front of the posterior ventral angle. The inner membranes, which are much wrinkled and folded, form a capsule round the egg, which is probably entire, but appears rather indefinite posteriorly. The shape of the egg seems characteristic in this species. It is always about as shown in Fig. 26—that is, the broader end is placed anteriorly, and is somewhat obliquely flattened. Weismann also shows it thus (12, Taf. vii., Fig. 11 B).

This species is a very good example of the way in which some Lynceids attach their ephippia to the sides of the vessels in which they are kept. In a collection from Richmond Park, made in November, 1898, I counted, after a few days, no less than sixty of these bodies adhering to the sides of a small glass jar.

Pleuroxus laevis Sars.

The ephippium of this species, shown in Fig. 28, is of almost exactly the same shape as that of *Peratacantha truncata*, and resembles the latter closely in nearly all other respects. The ordinary shell sculpture, consisting of very faint polygonal markings, is present all over the ephippium, but the chitin is minutely pitted. The line of weakness is formed in very much the same way as in *P. truncata*, but there do not seem to be so many loose pieces of chitin developed. The inner membranes are delicate and very confused, and cannot be said to make any approach to a definite capsule, although they do probably form a closed sheath for the egg.

Pleuroxus trigonellus (O. F. Müller).

I have not seen the ephippium of this form for many years, and my very rough sketch of it is not suitable for reproduction. It shows, however, that the general outline is closely similar to the two foregoing species, and that the dorsal margin is considerably thickened. I noted that the shell was darkened as usual, especially over the egg.

Pleuroxus uncinatus Baird.

A sketch of the ephippium of this species made some years ago indicates that it is very much the same as those of the other Pleuroxids already referred to, although the dorsal margin seems somewhat longer in proportion, and the new ventral margin does not cut the ventral edge of the shell so far back. The hexagonal shell sculpture is the same as in the ordinary female, and the egg is protected by inner membranes, but no notes were made as to their exact nature.

Dunhevedia sp.

In some material kindly sent to me by Mr. F. E. Allum, of Perth, Western Australia, from "Herdsman's Lake," near that city, I found an ephippium which undoubtedly belongs to a species of *Dunhevedia.* It is shown in Fig. 29. The greater part of the ephippium (the area, in fact, within the dotted line) is very dark brown, and the chitin is minutely pitted, but there is no evident shell sculpture. The dorsal margin is well thickened, the anterior margin has a rather wavy outline, and the ventral line of weakness, instead of running out to meet the ventral edge of the shell, is carried back to the middle of the posterior margin. The egg is comparatively very large, and it is completely surrounded by irregularly disposed membranes. Viewed from the top or front, the ephippium is seen to bulge considerably over the egg (Fig. 30).

Chydorus sphaericus (O. F. Müller).

The ephippium of this common little Lynceid is shown in Fig. 31. It will be noticed that the dorsal margin is much reduced in length, but it is very much thickened and highly refractive. The ventral margin consists for a considerable distance of the old shell margin, owing to the line of separation between the ephippium and the anterior ventral portions of the valves not running back much beyond the blunt angulation in the middle of the ventral edge of the shell. The new edges are bordered by minute elongated pieces of chitin loosely connected together, showing that a special line of weakness is developed before the moulting of the ephippium. The shell is somewhat darkened, but the hexagonal markings remain as in the parthenogenetic female. Around the egg are a series of irregularly folded and crumpled delicate membranes, and it was proved that these really form a closed envelope by the fact that when an egg was crushed the contents were confined within a definite area, and could only be squeezed out beyond the limiting membrane by severe pressure. It is not usual in this species to find the anterior ventral portions of the shell still connected with the ephippium, but in the specimen figured they were so attached, and looked somewhat as if they might serve the purpose of rudimentary hooks. A front view presented the appearance shown in Fig. 32.

I have already given an account of some observations made on the repeated formation and moulting of ephippia by isolated specimens of this species (9), but it will be useful to refer to the subject again. Two females with resting eggs in the ovaries, and having outlines like that shown in Fig. 34 (*i.e.*, with the evenly arched dorsal contour broken posteriorly by a straight line), were selected for observation. In three days both had moulted, and appeared as in Fig. 33—*i.e.*, as ephippial females. After another three days both had moulted again, and appeared as at first, but the resting eggs had not been extruded from the ovaries and the ephippia were empty. Exactly the same processes were repeated a second time in two consecutive periods of three days each, after which no change was observed for some time, and the observations were suspended. It is possible that the inability of the animals to place eggs in the ephippia was due to the absence of a male.

This is another of the species in which I have actually seen the ephippia attached in numbers to the sides of a glass jar in which the animals had been kept.

Chydorus barroisi (Richard).

The ephippial female of this species, some examples of which, from Itatiba in Brazil, have been sent to me by Professor Sars, differs considerably in shape from the ordinary female, for the back, instead of being evenly rounded, is flattened in the anterior half and distinctly angulated near the middle (Fig. 35). The dorsal thickening is strong, and much longer, comparatively, than in other species of the genus. The darkening of the shell, too, is somewhat peculiar. It consists of large reddish-brown hexagonal spots in addition to a general deepening of colour, producing a very characteristic appearance. The shell sculpture, normally minute hexagonal markings, is apparently modified over the darkened area to agree with the much larger hexagonal arrangement of the coloration; and the chitin of the darkened area is minutely pitted. The nature of the inner membranes could not be made out, nor could a line of weakness be traced in these preserved specimens.

Chydorus eurynotus Sars.

The ephippium of this species from São Paulo, kindly sent to me by Professor Sars, is very similar to that of *C. sphaericus*, except that the ventral margins of the valves break away entirely, right down to the posterior ventral angle. The line of separation is marked by a row of minute, loosely connected chitinous plates. The shell is not very much darkened, and the dorsal thickening is not so strong as in *C. sphaericus*, although somewhat longer. There are hexagonal, but very indefinite markings over the surface, and the chitin is minutely pitted. Surrounding the egg are some very delicate inner membranes. The female, after throwing off an ephippium, has the back deformed in almost exactly the same way as *C. sphaericus*.

From the foregoing details regarding the ephippia of what may probably be regarded as a fairly representative collection of genera and species of the Lynceidae, we can now formulate the general characteristics of these productions in the family with some approach to certainty. The chief of these are, I think, as follows.

(1) The ephippium is, as a rule, composed of a large portion of the original shell.

In the great majority of cases the ephippium is about three-fourths of the area of the old shell, and the portion detached does not include the whole of the ventral margin. In this the ephippia of the Lynceidae agree with those of the Bosminidae (see 11), but are in sharp contrast to the ephippia of the Daphnidae, in which no part of the ventral or even posterior shell margins is ever used in the production of the ephippium. In a few cases of Lynceid ephippia (*e.g.*, *Alonopsis ambigua*, *Alona rectangula*) only from two-thirds to a half of the shell is utilised, the detached portion including the whole of the ventral and a part of the posterior margin, and in one case (*Leydigia acanthocercoides*) the ephippium is actually cut out of the old shell without including any portion of the ventral or posterior margins (except in the form of special hooks) just as in the Daphnidae. On the other hand, there is one species at least (*Alona tenuicaudis*) which utilises the whole of its shell as an ephippium.

(2) The dorsal margin of the ephippium is always specially strengthened by a more or less copious deposit of chitin.

In most cases the chitin appears, when viewed from the side, as a clear, highly refractive band; but in a few species (*e.g.*, *Alonella rostrata*, *A. excisa*) the extra thickening is not very marked, although it no doubt exists. This feature of the thickening of the chitin along the back is found also in ephippia other than those of the Lynceidae, and may be quite general. In the Bosminidae, however, it appears to be confined to a definite narrow band, while in the Lynceidae, and apparently also in the Daphnidae and Lyncodaphnidae, there seems to be a general thickening of the chitin over the dorsal part of the shell.

(3) The anterior margin is formed by the ordinary line of junction between the head-shield and the valves.

This is probably true in the case of all ephippia, and in some instances it gives quite a characteristic appearance to the ephippium—*e.g.*, *Camptocercus rectirostris*, *Dunhevedia*, and species of *Pleuroxus* and *Chydorus*.

(4) The line of separation between the ventral portions of the valves to be detached and the ephippium is traced out, at least anteriorly, before the ephippium is thrown off, and it appears to be always due to the special formation of a row or rows of easily separated pieces of chitin, of variable but usually minute size.

The consequence of this is that a Lynceid ephippium usually has a somewhat jagged ventral margin, due to the falling away or otherwise of the little pieces of chitin referred to. In this respect it differs from an ephippium of a *Bosmina*, in which the edges of the crack always seem to be quite smooth.

The object to be attained by the separation of the ventral parts of the valves is, without doubt, the formation of a nearly closed receptacle for the egg. It is evident that if the ventral margins, and especially the strongly vaulted anterior portions of them, remained in position, the anterior edges of the valves could not come together, and there would also usually be an opening between the middle parts of the ventral margins, owing to the normal structure of the Lynceid shell. It is interesting to note that in the only instance where the whole shell is used as an ephippium (*Alona tenuicaudis*) the egg is embedded in a great mass of chitinous spongy tissue—although this is, to be sure, not the only case in which the latter provision occurs.

(5) The chitin of the valves of the ephippium is always more or less darkened and probably thickened, but as a rule it is not much modified, except that the ordinary shell sculpture becomes at times intensified, and a minutely pitted structure is often developed.

In a great number of species it is quite easy to trace the normal shell markings, both coarse and fine if present, over the ephippium, and in no case do we find such a radical alteration of the outer shell structure as is seen in the more highly evolved ephippia of the Daphnidae, nor has any instance been observed of an approach to the formation of an oblique lateral band of chitin such as occurs in the Bosminidae. In some cases there seems to be a decided tendency for the shell to swell out into a more or less pronounced boss just over the egg, but this may be due in part simply to the closing of the valves over the egg.

(6) Between the outer valves of the ephippium and the egg there are always certain membranes or cellular tissue present, forming probably in most cases a perfectly closed inner covering for the egg.

The nature of the inner membranes, etc., varies very much indeed. In many, perhaps the majority of cases, the egg is surrounded by extremely delicate membranes representing the unmodified, or nearly unmodified, inner lining of the carapace, which is, of course, normally moulted in the same way as the outer highly chitinised shell. In other cases a certain amount of increase in the substance of the membranes has occurred, and even a rudimentary cellular structure developed (*e.g. Alona rectangula*), while in not a few species (*e.g. Alonopsis ambigua, Alona tenuicaudis, Leydigia acanthocercoides, Alonella karua*), a very elaborate cellular spongy "packing," more or less completely filling up the whole space between the outer coat of the ephippium and the egg, has been produced. So far as I am aware, this latter development is peculiar to the Lynceidae, and it seems as highly specialised a feature in its own way as the chitinous inner shell found in the ephippia of *Daphnia magna* and its nearest relatives.

(7) The ephippium contains but one resting egg, except in the single genus *Eurycercus*, where numerous eggs occur.

The genus *Eurycercus* is so peculiar, both in regard to structure and the great size to which its representatives attain, that it is scarcely surprising to find a well-marked distinction in one point at least in connection with its ephippia and resting eggs. The only other case in which more than a single resting egg has been recorded is *Camptocercus macrurus*, which, according to Weismann, (12), sometimes, but not always, has two such eggs. In view of the evidence now available in favour of the universal adherence to the principle of one ephippium, one egg, in the sub-family Lynceina, it is certainly desirable that this species should be re-examined in order to ascertain whether the production of two winter eggs can be considered in the slightest degree normal.

As regards the interesting question of the probable course of evolution among the ephippia of the Lynceidae, we are unfortunately not in a position to say very much with certainty. Nevertheless, everything seems to point to the fact that ephippia have developed out of the very simple process of depositing the resting egg or eggs in the unmodified moulted shell, the delicate inner lining of which would also, no doubt, gather round the egg, being prevented from leaving the outer case by the egg itself. It will be evident, from what has been said above, that there is not a single case known at present which approaches anywhere near this imaginary primitive condition. Even in *Alona tenuicaudis*, where the whole shell is used as an ephippium, there is a darkening and thickening of the valves dorsally, while, more important still, there is a highly evolved "packing" produced as a further protection for the egg. And in the least specialised of the remaining ephippia there is always, in addition to a certain amount of darkening and thickening, a special line of weakness formed with the object of allowing the anterior ventral portions of the valves to be detached. In the more highly specialised forms we find a rather greater amount of thickening and darkening, a larger portion, or the whole, of the ventral margin detached, and some increase or other modification of the inner membrane; whilst in the most highly specialised form of all, *Leydigia acanthocercoides*, the same modifications become still more marked, with the additional feature of hooklike appendages, so that we get an ephippium which, in certain respects, is more elaborately formed than many of those of the Daphnidae. As, however, none of these Lynceid ephippia possess any trace of the peculiar prismatic cell structure of the outer coat found in the ephippia of all the Daphnidae and some Lyncodaphnidae, we can still regard them as forming, together with those of the Bosminidae, a distinct, and, on the whole, a lower type, to which the term "proto-ephippium" may be applied, as proposed in the article on *Chydorus sphaericus* (9). The use of a special word is, perhaps, hardly necessary in ordinary circumstances, and I have preferred to use the well-known word "ephippium" throughout this paper.

It might be thought strange if, in a paper dealing with ephippia, no mention were made as to the most likely times to find such objects; so I will devote a few words to this subject, trusting that it may induce collectors of pond-life to be on the look-out for these peculiar productions. In this country—and the same is probably approximately true for the whole of the north temperate zone—ephippia are produced most abundantly, and by the greatest number of species, in the autumn and early winter (latter end of September to the early part of December), the maximum production being reached in October and November. In addition to this main period of development there is always another in late spring, with its maximum in May, which only seems to affect the individuals living in pools and little ponds liable to dry up in the summer. It may sometimes happen that ephippia are formed at other seasons of the year. I have myself seen an ephippial female of *Chydorus sphaericus* as early as February, but there is no doubt that the two periods mentioned are the best times to search for these productions.

Before concluding this account of the Lynceid ephippia, I would like to draw attention to the fact that a detailed study of these bodies is not only interesting from a morphological point of view, but will, without doubt, turn out to be very valuable to the systematist. It must have been observed during the course of this paper, that in many cases the different genera are characterised by well-marked types of ephippia, and that even species of the same genus may vary very considerably in this respect. The most striking case, perhaps, is that of the genus *Alona*, in which, out of four species described, we have at least three distinct types of ephippia. In *Alona tenuicaudis* the whole shell is used, and the egg is embedded in "packing"; in *A. costata* (and perhaps also in *A. affinis*) the anterior ventral portions of the valves are detached, and the egg is surrounded by simple membranes; and in *A. rectangula* the whole ventral third of the valves is thrown off, and the egg is enclosed in a delicate cellular tissue. Other instances of these marked differences within a single genus are to be found in *Camptocercus*, *Alonella*, and *Chydorus*. In fact, the more closely the ephippia are studied, the more clearly it is seen that we have in them valuable auxiliary specific characters. But it cannot be too strongly insisted upon that it is, as a rule, only in the moulted ephippium that all the peculiarities, especially the course taken by the line of weakness and the character of the inner membranes, can be properly made out. It is not enough to describe the ephippial females. This should, of course, be done where possible, but it would be rendering still greater service to the study of the Cladocera if the thrown-off ephippia could also be described wherever possible.

It now only remains for me to express my warmest thanks to Professor G. O. Sars for his great kindness in sending me so many important examples of ephippia and ephippial females. I only hope that I have dealt with the material so generously placed at my disposal in a way which will at least be found to throw a little fresh light on the subject, and have the effect of stimulating others to take up and continue the work.

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Explanation of Plates 10, 11, and 12.

(Note.—The ephippia have not been shaded, in order to show the shell sculpture and inner membranes more clearly.)

Plate 10.

Fig. 1. *Eurycercus lamellatus*, ephippial ♀. × 18.
,, 2. ,, ,, ephippium. After Weismann.
,, 3. *Camptocercus rectirostris*, ephippium. × 60.
,, 4. ,, ,, ephippial ♀. × 50.
,, 5. ,, ,, anterior end of line of weakness between ephippium and ventral portion of shell. × 250.

FIG. 6. *Camptocercus similis*, ephippial ♀. × 70.
„ 7. *Acroperus harpae*, ephippium. × 60.
„ 8. „ „ part of the back of an ephippial female, showing thickening of chitin and modification of inner layer.
„ 9. *Alonopsis ambigua*, ephippium. × 70.
„ 10. „ „ a portion of the "packing" surrounding the egg. × 400.
„ 11. *Euryalona occidentalis*, ephippial ♀. × 40.
„ 12. *Alona affinis*, ephippial ♀. × 60.

PLATE 11.

„ 13. *Alona tenuicaudis*, ephippium. × 90.
„ 14. „ „ part of the back of an ephippium, showing the modification of the inner layer of the shell. × 250.
„ 15. *Alona costata*, ephippium. × 110.
„ 16. *Alona rectangula*, ephippium. × 150.
„ 17. „ „ a portion of the cellular tissue surrounding the egg. × 450.
„ 18. *Leydigia acanthocercoides*, ephippium. × 70.
„ 19. „ „ „ (front view). × 30.
„ 20. „ „ anterior end of line of weakness. × 150.
„ 21. *Graptoleberis testudinaria*, ephippium. × 100.
„ 22. *Alonella rostrata*, ephippium. × 180.

PLATE 12.

„ 23. *Alonella excisa*, ephippium. × 130.
„ 24. *Alonella diaphana*, ephippial ♀. × 60.
„ 25. *Alonella karua*, ephippium. × 140.
„ 26. *Peratacantha truncata*, ephippium. × 100.
„ 27. „ „ a portion of the line of weakness.
„ 28. *Pleuroxus laevis*, ephippium. × 100.
„ 29. *Dunhevedia* sp., ephippium. (The dotted line shows the limit of the darkened area). × 110.
„ 30. „ „ (view from anterior end). × 80
„ 31. *Chydorus sphaericus*, ephippium. (The retention of the anterior ventral portions of the shell, as shown in the figure, is unusual in this species). × 130.
„ 32. „ „ „ (front view). × 100.
„ 33. „ „ ephippial ♀. × 60.
„ 34. „ „ post-ephippial ♀. × 60.
„ 35. *Chydorus barroisi*, ephippial ♀. × 140.

Modifications of the Legs in some Dipterous Flies.

By W. Wesché, F.R.M.S.

(*Read January 17th*, 1902.)

Plates 13 and 14.

This may perhaps be thought a subject more fitted for a society devoted to Entomology than to Microscopy, but as the structures I am about to bring under notice are all microscopic, I plead their small size as justification for submitting them to the Quekett Club.

To compensate for the absence of nerves in the chitinous covering of insects, many hairs and bristles are present, which are placed in sockets, and no doubt convey some kind of sensation when touched or excited, as they have a connection with the nervous system. Their number, size, and arrangement vary in an infinite degree in the different families and species.

When on the legs, delicate hairs are used for three purposes: (1) As brushes to keep the antennae, and the hairs on the body, head, and eyes, clean and sensitive. Such an arrangement is found on the fore tarsi of the larger house-fly, *Musca domestica*; * (2) As pads, as in *Platichirus*, which I shall refer to later on; (3) As floats, as in *Dolichopus*, where the tomentum, or down, on the tarsi is so fine, that it holds the air and enables the insect to glide on the surface-film of water.

In other cases the hair is stronger, and is modified into bristles,

* A similar brush is found on the fore tarsi of the hive bee (*Apis mellifica*), and of most of the Hymenoptera. So important to these insects is the care of the antennae, that, in addition to this brush, special cavities have been hollowed out of the first fore tarsi, which are fitted with an arrangement of stiff hairs in the shape of semicircular combs, through which the antennae are drawn. (See Cheshire on the Hive Bee.)

spurs, and strong spines, for the better holding of prey or mate. I will give first a few examples of legs modified to hold prey.

Passing over the forelegs of *Bibio* and *Dilophus*, which may be seen figured in many books, I may remark that, as they are to be found in both sexes, they are probably used as offensive weapons. I have figured the middle leg of *Tachydromia arrogans* (Curtis), of the family *Empidae* (Fig. 1). Not only are the hairs in this species modified into sharp spines, but the femur is thickened, probably to contain a strong muscle, and the tibia has its end hardened and pointed, and is used to pierce the body of the victim, while the toothed femur and tibia grasp the wings and thorax.

Belonging to the same family is *Hybos femoratus*. In this species it is the hind leg which has been modified (Fig. 2); the tibia is not toothed or sharpened, but the first tarsus and femur are strongly armed.

There is doubt as to the use of the adaptations in the two following examples. The hind legs of *Ascia podagrica* (Fig. 3) are of the same type as the two preceding species, but the habits of the flies are totally dissimilar. *Ascia* is a genus of the Syrphus flies, better known as Hawk or Hover flies: they are pollen feeders. Many genera have in both sexes the hind femur enlarged and studded with strong teeth or spines. I have seen the contents of the stomachs of a number of species, and have always found pollen only.

The strong hooks on the end of the tibiae of the hind legs of *Sphaerocera subsaltans* are also difficult to explain, but they are probably offensive weapons. The tarsi are also much modified, and the two upper are furnished with pads of soft hair (Fig. 9).

We now come to those adaptations which are to be found only in the male, and are known as "secondary sexual characters."

The middle legs of *Campsicnemus curvipes* are most elaborate in detail (Fig. 4). The shapes of the femora, tibiae, and first tarsi have all been altered to enable the limbs to obtain a firmer hold of the abdomen of the female. Many strong hairs and spines have been arranged on the depressions and grouped for the same purpose. *Campsicnemus* is a genus of the family *Dolichopidae*, the males of which have a very largely developed hypopygium. The whole organ is turned under the end of the abdomen, and its extremity consists of about twenty knife-like hooks (*Dolichopus aeneus* and *Poecilobothrus nobilitatus* are good examples). So remarkable and highly specialised is this organ that Cuvier figured it in the *Journal de Physique*. As an example of the economy of nature, it may be noted that the males of those genera possessing this organ have simple legs not differing from those of the females. In *Campsicnemus* the hypopygium is without the hooked process, but the middle legs are elaborately modified in compensation. The flies belonging to this family are predaceous, feeding on minute worms and gasteropods, and have developed the faculty of gliding on water to enable them to get at their prey. Some species are found in our gardens, where they probably do good by killing the newly-hatched snails.

Platychirus is another genus of the Hover flies, and has in the males the tarsi and tibiae of the forelegs much flattened and covered with pads of soft hair (Fig. 5). The female is by this contrivance more firmly held.

It needs a trained eye to distinguish *Hydrotea dentipes* from the house-flies. All the males of this genus (family *Anthomyidae*) have a tooth or teeth on the fore femora and a modification of the hairs and setae (Fig. 6).

Sepsis cynipsea is a very small and graceful fly, often found in our gardens. It is the commonest species of the family, and, in common with three others, has a small dark spot on the tip of the wing. The males have a curious tubercle, and teeth on the femora and tibiae of the foreleg (Fig. 7). Both sexes are furnished with brushes of hair on the fore tarsi to keep the eyes and antennae clean. In *Borborus nitidus* we find a fresh departure; the chitin of the femur has been drawn out into the curious hook illustrated in Fig 8. This is on the hind leg. All the setae and spines previously figured grow out of sockets, and are obviously modified hairs, but this is part of the femur. The female has also a "secondary sexual character" which is comparatively rare. "The small second spur of the hind tibiae is twisted and angular, and catches on the hook of the male" (Walker).

Limosina sylvatica is also of the same family (*Borboridae*). In this species the middle legs are highly modified. The arrangement of spines and the alterations in the shape of the limb may be compared with the middle leg of *Campsicnemus* (Fig. 10). We here see, in two distantly-related species, the identical causes, working on parallel lines to approximately the same results.

We now come to a case in which the limbs have been strikingly modified, but from obscure causes. Speaking of the Crane-fly, *Tipula oleracea* (the familiar "daddy longlegs"), Dr. Sharp, in the "Cambridge Natural History," says, "It is impossible to assign any reason of utility for the extreme length of the legs of crane-flies: they break off with extreme ease, and the insect appears to get on perfectly well without them." I do not think the problem here presented is of such difficulty as that of the use of the hind legs of some of the *Syrphidae.* The eggs of crane-flies are laid on grassland, and the larvae, as is well known, do injury to the roots. It is conceivable that the extreme length of limb is useful to the insect in making its way through short herbage. Such being the case, we would expect the male to develop longer limbs than the female, as that would be of advantage in finding and catching her, and in transmitting that characteristic to his offspring. We find that males frequently have longer limbs than females—a fact which, if not proving, at all events suggests, that length of limb has been brought about by the law of "survival of the fittest." An analogous case is the eye, which is often larger in the males than in the females of *Diptera.* It may therefore be conceded, on this evidence, that length of limb is useful. It is obvious that much increase in weight in an insect creeping from grass-blade to grass-blade would not be of service, therefore the increase of length was not accompanied by an increase of strength. It is further conceivable that the frequent loss of limbs would produce a race which would bear that loss with a certain amount of immunity. The hardy male or female who could lose a joint or so without succumbing would have a better chance of transmitting that hardihood to his or her offspring. It has been suggested that the length of limb would be of service as a balance when flying, by counteracting the weight of the long abdomen. That being so, though the crane-fly does not use his wings as much as his legs, it would further aid the increase of the length of the legs. Darwin says that the males of *Tipulae* frequently fight for possession of the female. This, however, throws little or no light on what I have discussed.

We have noticed legs used as organs of locomotion; as arms in grasping or holding prey or mate; as brushes in cleaning the body and head, and probably as balancers when flying. There yet remains a fifth use: the plumed gnats (*Chironomus*) use the front legs as feelers, and some of the ordinary gnats (*Culicidae*) have a habit of holding up the hind legs for the same purpose. As these last three genera are so well known, and present little modification other than that of length and tenuity, I have not figured them. What I have figured may be considered as, in some measure, types of their genera or families, but there remain large numbers of forms equally, if not more, interesting.

In conclusion, I may be excused for pointing out that the subject of microscopical entomological structure has been much neglected for many years. Naturalists are satisfied with making collections, and the establishment of a new species seems to be the summit of ambition. Personally I feel equally, if not more grateful to that individual who proves a species to be but a variety, or a stage in the life-history of a species.

There must come a day when further new species will be exceedingly difficult to find, and then the pendulum may swing the other way, and we shall have more study of life-history and of minute structure. Both in the bugs and flies, *Hemiptera* and *Diptera*, there is ample room for original microscopical work of the most interesting nature, and our studies of life-history will be greatly assisted, and have a peculiar pleasure, if we bring to that study a good knowledge of the microscopical structure of the insects under observation.

Since writing this, Lord Avebury has asked the question, "What is Natural History?" and answered it in so apposite a manner that I cannot resist adding the weight of his great authority to what I have said.

"What is Natural History? The collection of many kinds of animals or plants, the arrangement of specimens in cases, or of insects or dried plants in drawers, is merely a provision of suitable material for study.

"On the other hand, to study their structure, to understand their relations to one another, to watch their habits, to ascertain their dependence on, and relation to, the forces of Nature, to realise what the world appears to them—*this is*, as it appears to me at least, the true interest of Natural History, and may give us a clue to senses and perceptions of which at present we have no conception."

Explanation of Plates 13 and 14.

Plate 13.

Fig. 1. Middle leg of *Tachydromia arrogans* (Curtis).
" 2. Hind leg of *Hybos femoratus.*
" 3. Hind leg of *Ascia podagrica.*
" 4. Middle leg of *Campsicnemus curvipes.*

Plate 14.

Fig. 5. Fore leg of *Platychirus albimanus.*
" 6. Fore leg of *Hydrotea dentipes.*
" 7. Fore leg of *Sepsis cynipsea.*
" 8. Hind leg of *Borborus nitidus.*
" 9. Hind leg of *Sphaerocera subsaltans.*
" 10. Middle leg of *Limosina sylvatica.*

Ecpolus papillosus, n. sp. An unrecorded Hydrachnid found in Britain.

By Chas. D. Soar, F.R.M.S.

(*Read January* 17*th*, 1902.)

Plate 15.

Towards the end of 1901 Mr. Taverner found in the New River a mite he was unable to recognise. This was sent to me to identify, but I was unable to do so, as the specimen was quite unlike any mite I had previously seen. I made drawings of it, and looked through all the figures I have of water mites, but the only one I could find at all near it was Koenike's *Ecpolus tuberatus*, described and figured in his Hydrachnidae of Madagascar and Nossi Bé. (Abhandl. der Senckenbergischen Naturf. Gesellschaft, Band XXI., p. 368, Figs. 73–79.) But it was quite different in structure, so that it could not be the same species, even if belonging to the same genus, of which I had doubts. After I had finished my drawings, I sent tracings of them to Dr. Koenike, of Bremen. He replied to my letter saying that the animal was quite unknown to him, but he thought it belonged to the genus *Ecpolus*. There seems no doubt, therefore, that the mite under consideration is new to science, and as my friend Mr. Taverner has asked me to name and figure it, I propose to call it *Ecpolus papillosus* on account of its exaggerated papillae on the dorsal and ventral surfaces. So far only the female has been found.

The following are the details as to size and specific characteristics:—Body, about 0·63 mm. in length and 0·46 mm. in breadth, of a pale orange colour. The skin is chitinous, but not so hard and brittle as we find in Arrhenurus. The whole surface is covered with fine papillae, but it has also a large number of projections or exaggerated papillae, which project from the body as much as 0·04 mm. to 0·05 mm. These are very conspicuous, and all have a hair growing from near the base. There are more of these towards the posterior margin of *Ecpolus papillosus* than on other parts of the body. In *Ecpolus tuberatus* the projections are mostly round the margin of the body, the central portions of the dorsal surface being entirely free from them.

The legs (first, 0·40 mm.; second, 0·53 mm.; third, 0·56 mm.) and epimera exhibit nothing uncommon, being very much the same as we find in *Piona* and some other genera.

The genital plates are quite different to those of Koenike's *Ecpolus tuberatus.* In the latter the genital discs are free on the surface skin, but in this mite the genital discs are on special plates (see fig. 3), and they stand up in relief.

I hope during this coming season that Mr. Taverner, or some other member of the Club, may be so fortunate as to find some more specimens, including the male.

Explanation of Plate 15.

Fig. 1.	*Ecpolus papillosus*, n. sp. ♀,		Dorsal surface, × 64.
,, 2.	,,	,,	Ventral surface, × 64.
,, 3.	,,	,,	Genital area, × 158.
,, 4.	,,	,,	Tarsus of first leg, × 190.

THE PRESIDENT'S ADDRESS.

Coprophilous, or Dung Fungi (Résumé).

By George Massee, F.L.S.

(*Delivered February* 21*st*, 1902.)

To those in quest of new fields of research, the very interesting fungi growing on the dung of various animals may be recommended as affording ample material, whether viewed from the systematic or biological standpoint. Research in this direction, carried on at intervals during one year, has added just over fifty species to the British Fungus Flora, and the field is by no means exhausted; whereas, from the biological side of the question, which is undoubtedly the most fascinating, it may be truly said that almost everything yet remains to be done. As many of these fungi are readily cultivated, the means of adding to our knowledge as to why many forms assume such grotesque shapes, are furnished with such remarkable-looking appendages, or provided with such bright colours, should tempt some from amongst those who are desirous of entering a comparatively new field of investigation.

It is just possible that the special matrix on which the subjects of our remarks elect to grow might prove a bar to this special branch of study; this, however, is purely a matter of sentiment, and should not stand in the way. A piece of horsedung about the size of a cricket-ball, kept moist and covered with a bell-jar, may be kept under observation for months, and will yield rich crops of probably not less than thirty or forty different species. From such a stock-in-hand, material of some kind is always in good condition for examination at any spare moment; and, furthermore, where the investigation of the life-history of a species is undertaken, the above simple method never fails to supply an abundance of material in every stage of development.

Fungi growing on dung do not belong especially to any one particular section,—in fact, representatives of almost every order of fungi occur on this substratum. The one feature in common is that the species occurring on dung are among the simplest and most primitive in structure and organisation of their respective families.

The habit of growing on dung is in many cases an acquired one, as proved by the fact that representatives of many groups of fungi found on dung at the present day existed long before the advent of warm-blooded, herbivorous animals, on the dung of which most coprophilous fungi occur. The reason for this will be explained later on.

Statistics given elsewhere * show that out of the 757 species of fungi known to grow on dung, 708 kinds occur on the dung of herbivorous animals, 45 species on that of the carnivora, and 4 on dung of reptiles. Seventy-four different fungi have been recorded as occurring on rabbit dung.

Many kinds of fungi met with not unfrequently on dung grow also on many other substances, more especially on decaying vegetable matter; and such species are usually dependent on wind for the diffusion of their spores, which are consequently minute and dry, usually forming a powdery mass at maturity.

On the other hand, many fungi belonging to the group technically known as the Discomycetes, and belonging to such genera as *Ascobolus*, *Saccobolus*, *Ryparobius*, *Thelebolus*, etc., also several forms of the Phycomycetes, as *Pilobolus*, and certain species of *Mucor*, occur, so far as is at present known, only on dung.

Such fungi, notwithstanding the entire absence of affinity from a systematic standpoint, all agree in the common feature of having their spores more or less enveloped in a subgelatinous or viscid substance, by which they are bound together, thus precluding the possibility of diffusion by means of wind, and necessitating some other special arrangement for securing their being deposited on the matrix suitable for their germination and development.

A second common feature of agreement among such fungi is

* "Researches on Coprophilous Fungi," Geo. Massee and E. S. Salmon: "Annals of Botany," 1891, p. 313.

that their spores, when mature, are ejected with some force to a distance, not individually, but the entire mass of spores produced in an ascus or sporangium.

Now, if we imagine the dung of some herbivorous animal deposited in a pasture, and in due time becoming covered with fungi, it follows that when the mature spore masses are ejected, many such alight on the surrounding herbage. The mucilage accompanying the spores sets firmly, and becomes insoluble in water when exposed to the air; thus the tiny spore-masses remain firmly attached to the grass until it is eaten by some animal, when the spores commence to germinate in the alimentary canal, are then

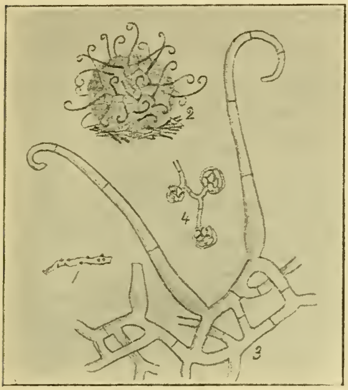


Fig. I.

Fig. II.

deposited along with the dung, and afterwards continue their development, until finally the spores are shed on the grass, to be again swallowed by some animal.

By this remarkable modification and adaptation to a narrow set of conditions, these tiny, but beautiful, fungi are dispersed. These tiny spore-masses have been found on dead grass in the neighbourhood of heaps of dung in the spring, having been deposited the previous season. Such spores germinate readily on being passed through the body of an animal, and it is probably due to such spore-laden grass being eaten by herbivorous animals in the early spring, that the first crop of fungi occurring on the dung is secured.

Finally, as would be expected from what has been already said, such spore-laden grass in the form of hay would also aid in the dispersion of characteristic dung-borne fungi; and the shipment of such forage in large quantities from one part of the world to another will be very likely to secure a wide geographical range for such organisms.

The mucilage accompanying the spores assumes various forms in different species. In the primitive condition it is simply mixed up with the spores, comparable to a quantity of peas stirred up in thick gum-water. In other instances the entire surface of each spore is surrounded by a thick layer of mucilage, which shows up as a hyaline, strongly refringent border under the microscope. In others, again, the surrounding envelope of mucus is prolonged at one or both ends of the spore, into one or more long, tail-like appendages.

When a fresh piece of dung is placed under the conditions described above, the sequence of growth of fungi is as follows:—

First come members of the Phycomycetes, the first being almost invariably *Pilaira anomala*, closely followed by various species of *Mucor*, and such beautiful forms as *Chaetostylum*, *Circinella* and *Pilobolus*. A distinct sexual mode of reproduction, in addition to an asexual or conidial stage, often occurs in the members of this group, which are yet in touch with their ancestors the Algae.

Next appear members of the group called Hyphomycetes, popularly known as moulds; and exceedingly beautiful objects many of them are, resembling miniature forests, each branch of the tree bearing one, or several conidia arranged in a chain. Many forms included in this group, at one time considered as good species, have recently been proved to be the conidial condition of the Discomycetes or Pyrenomycetes.

Following the Hyphomycetes appear the Discomycetes, recognised by the spore-bearing portion of the fungus being more or less cup-shaped, or in some species flattened or plane. In some species the cup or disc is quite smooth, in others more or less hairy outside; in others, again, the edge of the cup or disc is furnished with a fringe of hairs. Brilliant colours characterise the members of this family—vermilion, red, green, salmon-colour, and bright yellow, being the prevailing tints.

The spores, which are produced in asci, or mother-cells, usually eight spores in each ascus, are also often coloured. In the genus *Ascobolus* the spores are at first clear green, changing to a brilliant amethyst or violet, and finally dark brown and opaque.

The spores of many fungi that grow only on dung, and require to pass through the alimentary canal of an animal to induce germination, have a coloured cell-wall, and are very resistent to the action of acids and alkalies. This structure probably serves to protect the spores in their passage through the alimentary canal.

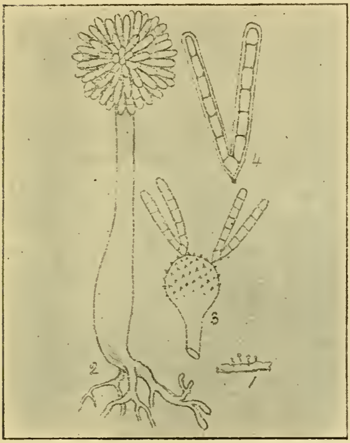


Fig. III.

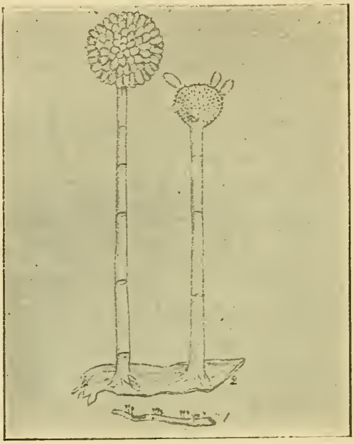


Fig. IV.

The last in the sequence to appear are members of the Pyrenomycetes. These agree with the Discomycetes in having the spores produced in asci, but differ in having the asci completely enclosed in a special structure called the perithecium, which is furnished at the apex with a minute aperture through which the spores are ejected when mature. The opening or mouth is often situated in the centre of a little nipple-like swelling at the apex of the perithecium, or in some instances occupies the apex of a more or less elongated beak, as in Fig. VI.

The perithecia are usually blackish or dingy olive, smooth, scurfy, or more or less clothed with soft down, or with pointed bristles, which are sometimes hooked or variously curved and twisted. The exact use of these hooked hairs is not determined, but the fact that the numerous minute creatures so abundant on dung may frequently be seen trudging along with a load of one or more perithecia adhering to them by the curved and elastic hairs, suggests the idea that these appendages may play some part in the distribution of these minute fungi, after the fashion served by the curved spines of many fruits—as species of *Lappa*, *Galium*, *Circaea*, etc.

All species of Pyrenomycetes that grow on dung have the

Fig. V.

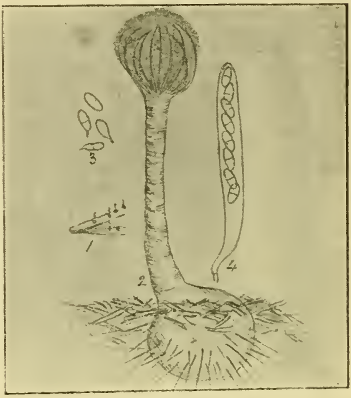


Fig. VI.

spores enveloped in mucus, and it is in this group that the mucus so frequently, in addition to forming a continuous layer surrounding the spore, forms the curious tail-like appendages at one or both ends of the spore.

When the perithecium of a fungus belonging to the present group is crushed in water, and not allowed to come in contact with the air, the mucous appendages are somewhat difficult to detect, and are moreover soluble, commencing to swell at once and soon disappearing. This difficulty can be overcome by the addition of a little methylene blue stain to which a trace of formalin has been added, when the mucus assumes a clear blue colour, and retains its original form for some time.

Description of the Figures.

I. *Myrotrichum uncinatus*, Schröter. A member of the Gymnoascaceae, the simplest in organisation of ascigerous fungi. 1, Plants, natural size. 2, Plant enlarged. 3, Portion of the irregular peripheral network bearing two projecting hooked appendages, highly magnified. 4, Ascigerous hypha bearing three asci, each containing 8 spores, highly magnified.

II. *Ascobolus immersus*, Pers. A typical dung fungus belonging to the Discomycetes. 1, Fungus, natural size, on rabbit dung. 2, Surface view of fungus, slightly magnified. 3, Section of fungus, showing the mature asci or mother-cells containing the spores, projecting above the surface of the body of the fungus, slightly magnified. 4, An ascus containing 8 spores, highly magnified.

III. *Syncephalis intermedia*, Van Tiegh. One of the Phycomycetes. 1, Plants natural size. 2, A plant, highly magnified. 3, Head of a plant with most of the spores removed in order to show their mode of origin from minute spicules on the swollen apex of the stalk, highly magnified. 4, A single spore, highly magnified.

IV. *Oedocephalum glomerulosum*, Sacc. One of the Hyphomycetes. 1, Plants, natural size. 2, The same, highly magnified. The right-hand specimen has most of the conidia removed to show their mode of attachment to minute spines covering the globose apex of the stem.

V. *Magnusia nitida*, Mass. & Salm. One of the Perisporiae. 1, Fungus growing on fragments of dead grass, natural size. 2, A perithecium or fruit of the fungus, showing the numerous slender curved appendages; highly magnified. 3, Ascus containing eight spores, highly magnified.

VI. *Spumatoria longicollis,* Mass & Salm. A member of the Pyrenomycetes, hitherto met with only on dung. 1, Plants, natural size. 2, A single plant, highly magnified; the perithecium or globose portion containing the spores is more or less immersed in the matrix; the neck, up which the spores have to pass to escape, protrudes. Conidia (3) are first produced; these when mature pass up the long neck, and being mixed with mucus, form a sticky ball at the apex, being held in position by bristles. Afterwards spores produced in asci develop in the perithecium, and eventually form a glairy ball at the apex. The masses of conidia and spores are eventually diffused by rain or eaten by minute animals, mites, podurae, etc.

Note on the Black and White Dot.

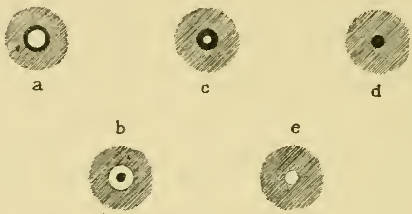
By Edward M. Nelson, F.R.M.S.

(*Read December* 20*th*, 1901.)

Two valuable papers upon this subject have appeared in the last number of our Journal; in presenting a third one for your kind consideration I must, by way of apology, briefly explain that, however puerile and insignificant this subject as indicated by its title may seem, yet nevertheless any theory of microscopic vision, however well enunciated and proved, must be held to be incomplete unless it yields an explanation of these phenomena.

The description of the black and white dot which Mr. Stokes in his excellent article has only given in general terms, might lead those who are not perfectly familiar with the phenomena to form wrong conclusions, unless it is clearly pointed out what meaning the words are intended to convey. The statement that at the upper focus the silex is dark and the perforations bright, and at the lower focus the silex is bright and the perforations dark, might give one the idea that the image was like a tessellated pavement consisting of black and white tiles, where a change from the upper to the lower focus would be represented by taking up the black tiles and relaying with white, and the white ones with black. This, however, would be an entirely wrong conception of the images. Let us see exactly what the appearances are like by an examination of a coarse diatom, say a *Navicula lyra*, in balsam under a dry $\frac{1}{6}$-in. objective with a $\frac{3}{4}$ cone illumination. At the upper focus we shall find the "lyra," or clear part of the diatom, has a brightness just about equal to that of the field outside the diatom, while the perforations are many shades brighter than the field; then, at the lower focus, we have the "lyra" portion perhaps one shade or half a shade brighter than the field, while the perforations are only a shade or two removed from blackness. So that while the alteration in the brightness of the silex amounts to a single shade or half a shade, the brightness of the perforations varies from many shades brighter than the field to nearly blackness. When making these experiments it is of the utmost importance that the silex be contrasted with the field, and not with the perforations; for the silex looks ever so much brighter than the black dots, and ever so much darker than the white dots, but the change in the brightness of the silex when contrasted with the field, which under such slight focal alterations as we are speaking about undergoes practically no alteration, is quite small.

Now, if while the objective and illumination remain the same, we change the diatom for one more finely marked, we shall find that at the lower focus the perforations are not so black; and if a still finer one be examined it may not be possible to see the black dot appearance at all, but only the white. So,



then, it is obvious that, for some reason or other, this white and black dot appearance depends upon a ratio of the aperture of the objective to the fineness or minuteness of the perforation. Again, if we select a diatom with bolder perforations than the *N. lyra*—say, for example, our old friend *Actinocyclus Ralfsii*—we shall find that with the same objective and illumination the perforations have a bright dot (Fig. a) in the centre of the black dot; this will be all the more marked if we use an oil immersion of 1·43 N.A., and the full aperture of a dry condenser. At the upper or white-dot focus we have the complementary picture of a black dot in the centre of a white one (b). This bright dot (a) is the image of the back lens of the substage condenser, and on focussing up the condenser, so that the image of the edge of the flame is out of focus in the field, we shall find the image of the edge of the flame appearing in the perforations of the diatom instead of the bright disc at (a). A smaller-sized perforation will give an image like (c), and the *N. lyra* type the well-known images like (d) and (e). This illustrates precisely what Mr. Stokes calls "edges and perforations," (a) showing a large perforation with a black edge, (c) a smaller one, and at (d) the edges have met. There is no doubt that Mr. Stokes is right in assigning to spherical aberration an important function, for in those cases where there is a white dot both above and below the black dot, the upper or lower white dot can be made the stronger or weaker, or both made alike, by means of screw-collar or tube-length adjustments.

Some experiments lately made have given me reason to believe that the upper black dots which Mr. Stokes observed when he employed annular illumination must have been images of the stop at the back of the condenser; if the arm holding this stop be carefully turned aside so as not to disturb the focus in the very least, it will be found that they occupy precisely the position of the focus for the ordinary white dots.

We must all be in agreement with Mr. Stokes' conclusions, but this new experiment shows that some other demonstration is needed than that of a stop at the back of the condenser, for the purpose of illustrating the effect of spherical aberration on the image. The whole question is a most difficult one, and fresh complications are always turning up, for in one of Mr. Morland's slides of *Pleurosigma angulatum* examples of that diatom show both white above, and black below, and others black above, and white below, the diatoms facing the same way up.

In another slide of *P. angulatum* mounted in dense medium, the valves being all the same way up, show white above, and black below, which is also the appearance when the valves are mounted dry on cover. A narrow crack in a valve, mounted dry on cover, is black when the dots are white, but in a medium it is, as Mr. Stokes points out, white when the dots are white. I have lately seen a balsam-mounted slide which has a *P. formosum* and *P. rhombeum* both giving white above, and black below, but on the *P. rhombeum* there is a dark patch in which this order is reversed. (These patches are by some authorities called gum, and by others air.) It is important to note that the black dot in the patch is at precisely the same focal plane as the white dot on the rest of the valve. In general a balsam mounted *P. formosum* has the white dot below, a curious anomaly pointed out by Mr. Stokes, but the finding of an example where the reverse was the case caused me, a few days ago, no little astonishment. So far as I am able to measure it accurately, the distance between the black and white dot is pretty constant at 3λ. It should be borne in mind that silex has a smaller refractive index than balsam, so a sphere of silex in balsam would act as a negative lens.

Passing on to Mr. Rheinberg's carefully worked-out papers, we are brought at once face to face with a single point which, if it is a fact, seemed to me to offer a fatal objection to his whole argument. If, for example, the white dot occupies the precise position of the black dot, and *vice versa*, then there is an end to the trellis-work theory. Now I have made, both long ago, and also since reading this paper, most careful experiments, and can come to no other conclusion than that these white and black, or black and white dots, as the case may be, are exactly superimposed on one another. Critical examination of the six dots surrounding a single blocked-up dot on, say, a *P. angulatum*, will probably convince any observer that they change their appearances without altering their positions, thus proving the superposition of the black and white dots. This is an experiment easily performed, because the six dots round the black spot are arranged in a hexagon, and whether a side or an angle of the hexagon faces a particular direction of the field can be most readily seen. For example, if with the white dot a side of the hexagon faces the upper side of the field, but with the black dot an angle, then the black dots have shifted over to the inter-costals, but if, on the other hand, there is no change in the orientation of the hexagon, when the dots are changed by focal adjustment, then the black dots must be precisely superimposed on the white. Under these circumstances it would seem that Mr. Rheinberg's most ingenious and very carefully worked-out theory cannot be regarded as an explanation of the phenomena in question.

Note on Hanging-Drop Cultivation.

By G. C. Karop, M.R.C.S., F.R.M.S.

(*Read March 21st*, 1902.)

In the course of his most interesting Presidential Address on Coprophilous Fungi, Mr. Massee several times referred to cultivation of the spores of this group by the method of the 'hanging-drop.' He appeared to take it for granted that this method was well-known to his audience at large; and although it certainly is so to some, I am pretty confident that among the continual influx of new members, many of whom are comparatively 'prentice hands at microscopic biology, there are not a few practically unacquainted with this simple and easy device for studying the growth and development of the lower organisms, particularly algae and fungi. For such alone the following brief description of the affair and its handling may be useful—the more so as it is not to be found in the more elementary text-books, so far as I know. The idea is to put any of these organisms in such a position, immersed in a fluid suitable for their nutrition, that they may be examined for either comparatively long or intermittent periods, with any required magnification, without being disturbed, and without risk of desiccation. In such conditions, if properly chosen to meet any given case, development can be followed out uninterruptedly up to a certain point, and a very large amount of valuable information gained at first hand on growth, nuclear changes, spore formation and so forth, instead of merely taking book statements and their ten-times-borrowed *clichés* for immutable truth.

While there are several ways of contriving a 'hanging-drop,' for the purpose of this note I shall confine myself to the form I have individually found the most convenient, and which can be made by any one.

The materials required are of the simplest: some good stout millboard or strawboard as used by bookbinders, 3 × 1 slips, 1-in.

square covers, a soup plate and bell-glass to fit it, white blotting-paper, and a strip or two of perforated zinc complete the outfit. Cut the millboard into pieces 1 in. square, and punch out the centres with a $\frac{3}{4}$ or $\frac{5}{8}$ gun-wad punch. Take a strip of perforated zinc about $6 \times 2\frac{1}{2}$ in., and bend down 1 in. of the longer diameter at both ends to a right angle, thus making a table or support for the slides to rest upon while in the moist chamber formed by the soup plate and bell-glass.

We will now suppose some subject is ready for study; and to take the one suggested by the President's Address, let it be the spores of a fungus. The first proceeding is to thoroughly soak one or more of the punched squares of millboard in water; and to do this without resolving the material into its constituent layers, the pieces should be put between two bits of glass lightly weighted on the top and immersed for some hours. If a shallow drop only is required, take one of the squares, if a deep one two or more, and having squeezed out any excess of water place it, or two superimposed, in the centre of a 3×1 slip. Now take a cover, and ring a very thin smear of soft paraffin or vaseline just a shade smaller than the aperture in the millboard. In a clean capsule put a little of the nutrient fluid employed,* and stir in the spores, mixing thoroughly; now plant a moderately convex drop of this in the centre of the ring with a glass rod or dropper, and invert carefully over the perforation in the millboard; there is now a 'hanging drop' on the underside of the cover. Place three or four layers of blotting-paper on the bottom of the soup plate with sufficient water to saturate them, on these the zinc support, on this the slide with the hanging drop, and over all the bell-glass. Note the time, and examine at some fixed intervals, drawing all visible changes. On removal from the moist chamber any condensation on the cover may be removed by snips of blotting-paper, fixing it at one corner to prevent displacement; and during a prolonged examination under the microscope it may be necessary to moisten the millboard with a camel-hair brush dipped in water, to make up the loss by evaporation.

In this elementary note I have not troubled about sterilisation,

* For Coprophilous Fungi the best medium, I believe, is an infusion of the dung on which they ordinarily grow. For some organisms, as Saccharomyces, etc., Cohn's or Pasteur's fluids are used, and for the "germination" of pollen a 1-per-cent. cane-sugar solution is recommended.

temperature, the influence of light and other refinements which must be observed in some cases if success in cultivation is to be attained; but the more advanced student will find full information in the larger treatises on Physiological Botany, monographs and special papers.

Note on Certain Minute Structure observed in some Forms of *Triceratium*.

By A. A. Merlin, F.R.M.S.

(*Read March 21st*, 1902.)

A variety of *Triceratium parallelum* from the Oamaru deposit, resembling the ordinary form in size, shape and general appearance, but not identical in detail, has been found to possess a delicate lacework structure apparently covering the whole of the silex composing the upper surface of the valve, and extending to and closely surrounding the primaries. Subsequently a similar but even finer network was observed on the outer surface of a typical *Triceratium parallelum*. This is an excessively faint and difficult object, and is close to the limit of visibility with a fine Zeiss 3-mm. apochromat of N A. 1·426, illuminated by the full cone of Powell's dry adjustable apochromatic condenser. Later, signs of the existence of an identical network were noticed on a *Triceratium glandiferum* Grun, which could only be resolved and held for brief intervals, after long rests to the eye in the dark, by the employment of the 1·426 objective and a solid axial cone of about N.A. 1·3 from Watson's oil-immersion condenser. I believe this to be the most faint and evasive of all the diatomic structures I have observed, but possibly certain other valves of this species may prove easier than the specimen referred to.

From the indications, there can be but little doubt that the appearances seen in the above-mentioned forms represent really existent structure on the upper surface of the silex, and are due to no ghostly diffraction effects.

All the specimens alluded to were mounted in styrax.

A Plea for a New "Williamson."

By Arthur Earland.

Of all branches of microscopy there is probably none more neglected by what we may call the casual worker than the Foraminifera. The reason is not far to seek. Most microscopists are primarily attracted by subjects which have a literature readily accessible to the beginner. The enthusiasm of such a beginner who asks, "In what book shall I find figures and descriptions of our British Foraminifera?" is not unreasonably damped by the reply, "There is no work which contains what you require."

The fact does little credit to either British rhizopodists or British publishers, but the fact remains. It is now nearly half a century since the Ray Society published Williamson's "Monograph on the Recent Foraminifera of Great Britain." From that day to this it has had no successor, and though the classification and nomenclature are more or less obsolete, it still remains the base upon which the student of British Foraminifera must build up his studies.

The widely felt need for a new work on the subject is best expressed by the fact that Williamson figured and described some ninety varieties only, while at the present day there cannot be far short of three hundred varieties recognised as British. For the remaining two hundred the student must refer to a score or more of isolated papers, scattered through the transactions of various societies, many of them provincial or foreign, and all but inaccessible to the average microscopist.

It is true that the admirable report on the Foraminifera of the *Challenger* Expedition contains figures of most British Foraminifera; but the cost of this great work renders it unattainable to all but a few students, and, moreover, the figures being drawn from exotic or deep-sea specimens are more or less unrecognisable when compared with British types.

In the *Journal of the Royal Microscopical Society* for December, 1887, the late H. B. Brady published a "Synopsis of British Recent Foraminifera," giving a complete list of the varieties recognised at that date, some 260 in all, with full references to authorities, etc. But there are neither illustrations nor descriptions of the forms, and for these reasons the paper, though invaluable to the advanced student, is almost useless to a beginner, who naturally shrinks from consulting such a mass of authorities at the start.

It has become almost a recognised axiom that nothing stimulates research or popularises a subject so much as the publication of a good text-book. Take the instance of the Mycetozoa. Ten years ago the average microscopist hardly knew of their existence. Yet the publication of well illustrated books on the subject by Lister, Massee, Fry, and others, has within a few years raised the group to one of popular interest. I believe that similar results would follow the publication of a good Handbook on British Foraminifera. The time for its production seems particularly ripe, for during the last few years there has been a pause in the flow of papers on the subject, and very few new varieties have been added to the list of our Fauna.

Probably it would be a difficult matter at the present day to find a society willing to undertake the publication of such a work, though it falls within the scope of the Ray Society's scheme. The question therefore arises whether such a work could be brought out commercially with any hope of success. I believe that modern reproductive processes would enable this to be done, and that the publisher of a new "Williamson," revised and brought up to date, would have no reason to regret his venture.

The range of such a work can hardly be discussed here, but the essential features in my opinion should include—

(1) A figure or figures of every recognised British variety *drawn from British specimens*, with brief but sufficient description of its characters.

(2) A Bibliography, complete so far as British Foraminifera are concerned, and also including the most important works of reference on Foraminifera generally.

(3) An introductory chapter of the most ample character which should include a *précis* of the systematic history of the group, and a full account of the life history so far as we know it at present. This chapter should be brought right up to date, so as to include the researches and methods of Lister, Rhumbler, and other modern investigators. This part of the work I should be inclined to regard as of supreme importance, for there is no recent volume on the subject,* and the collection of these facts, which now lie scattered through the pages of the scientific journals of many countries, would in itself earn the gratitude of all English rhizopodists.

* Since this note was written Messrs. Longmans, Green & Co. have published Mr. Chapman's book, "The Foraminifera: an Introduction to the Study of the Protozoa." This excellent work, which is reviewed elsewhere, contains a good, but all too brief account of recent researches, and of the systematic history of the group. Its appearance does not in the least degree affect the question of the need for a new "Williamson."

NOTICES OF RECENT BOOKS.

The Protozoa. By Gary N. Calkins, Ph.D. 9 × $6\frac{1}{4}$ in., xvi + 347 pages, 153 figures in the text. London, 1901 : Macmillan & Co. Price 12*s.* 6*d.* net.

It is with genuine pleasure that we call attention to this carefully written and well illustrated book. Prepared by the Instructor in Zoology of the Columbia University, and forming vol. vi. of the now widely known Columbia University Biological Series, it is without doubt one of the most useful general surveys of the unicellular animals that has appeared for a long time.

In the introductory chapter the author rapidly reviews the early history of the study of the Protozoa, and then passes on to the modern views as to their classification and the ever-recurring question of the boundary between animals and plants. In regard to this latter point it may be of interest to note that the author gives his sanction to the inclusion of *Volvox*, *Gonium*, *Pandorina*, etc., among the Protozoa. A general sketch of the morphology, including a consideration of the endoplasm, ectoplasm, nucleus, etc., and of the physiology and economic aspects of the Protozoa is next given, and this prepares the way for a consideration of each of the four modern divisions of the Protozoa, namely, the Sarcodina, Mastigophora, Sporozoa, and Infusoria.

Each of these has a chapter to itself and is treated in the same way. Thus, after dealing with the characters peculiar to each group, such as the pseudopodia and shells and tests of the Sarcodina, the flagella of the Mastigophora and so on, attention is given to the nucleus, the nutrition, reproduction, and inter-relationships of each, together with a condensed statement of the classification. These chapters are all very instructive reading, but special mention may be made of that on the Sporozoa because of the increased importance which has lately been given to these parasitic forms in connection with the malaria organism.

The remaining portion of the book consists of three chapters devoted respectively to the sexual phenomena, the special morphology of the nucleus, and some physiological problems of the Protozoa. In the first of these the phenomena of conjugation are considered under four heads, which may represent stages in the evolution of sexual reproduction. There is the union, first of exactly similar adult cells, then of individuals only differing somewhat in size, thirdly of reduced individuals (swarm spores), and lastly of specialised individuals (spermatozoa and eggs). The chapter on the morphology of the nucleus is a very valuable one, as it contains an extremely good account of the facts brought to light by the foremost recent investigators. The general conclusion is that the nucleus itself and also the mitotic figures in the Protozoa are much less complex than in the higher animals and plants. The physiological problems dealt with in the last chapter are intra-cellular digestion, respiration, secretion and excretion, and irritability, the last named leading to an interesting discussion of the question as to the real nature of the apparently conscious activities of the Protozoa.

Appended to each chapter are short bibliographies on the subjects dealt with, and at the end of the volume there is a long list of books and papers, to most of which reference has been made in the text. There is a double index: the first of authors, with an indication of the subjects mentioned in connection with their names, and the second of subjects. The illustrations are exceptionally good for a text-book, a large number of them being original, and most of the others being copies from recent papers.

Apart from its value as a storehouse of facts, the book will, we believe, have a stimulating effect in the direction of encouraging original research. The limits of our present knowledge in numerous cases are so clearly brought out that the student can scarcely fail to see the many possible openings for investigation. To take a single instance (p. 127), it seems that, in the Choanoflagellata (collared monads), it is by no means certain whether the mouth is within the collar (as maintained by Saville Kent and others), or not. Here, then, is a piece of work which certainly ought to be taken in hand at once. The beautiful, though excessively minute, animals referred to are easily obtained, for one can hardly examine a *Daphnia*, *Cyclops*, or other aquatic creature, to say nothing of the water-weeds, without finding numerous specimens. And after getting the material to work upon, all that is necessary in this case is the skilled use of the highest powers with the best possible illumination, and a little care in supplying the animals with some harmless colouring-matter as food. It is really quite remarkable, when there is so much valuable work to be done, that so many expert microscopists, with the finest lenses and apparatus at their disposal, should be content to gaze for ever at mounted diatom valves and other "test objects." Probably it is that they do not know what wants doing. Such a book as the present should give them plenty of choice of subject, and we therefore heartily recommend it, not only to students of all branches of the Protozoa, but also to the amateur high-power microscopist who wants to use his skill upon something that will yield results of real value to biological science. D. J. S.

British Tyroglyphidae. By A. D. Michael, F.L.S., F.Z.S., F.R.M.S., etc. Vol. I. $8\frac{3}{4} \times 5\frac{3}{4}$ in., xiii + 291 pages, 22 plates. London, 1901 : Ray Society.

This handsome work, which cannot fail to add greatly to the already world-wide reputation of our distinguished Vice-President, is one which will doubtless prove of the greatest service to all who are interested in the studies of the Acarina, concerning which the available literature has hitherto been somewhat scattered and imperfect, as well as being—with the exception of Mr. Michael's own papers in the Journals of the R.M.S., Q.M.C., and the Linnean and Zoological Societies—the production of foreign writers. In the volume before us, and in that which is to follow, British species are alone dealt with; but the distribution of these minute creatures is so universal that perhaps not many genera will escape mention. The introductory chapter will probably be the one of most interest to the general reader, describing as it does, in popular language, the general characters and habits of this innumerable family of mites, their distribution and size, and their importance to man from the mischief they frequently do to his property. Surprise, however, will no doubt be expressed at the statement that, although found in all climes in such myriads, the number of known genera does not much exceed fifteen, whilst the number of species is probably less than seventy. Chapter II. gives an interesting *résumé* of the literature of the subject, from the work of Dugès in 1834 to that of Wasmann in 1897. Chapters III. and IV. deal with the classifications of the Acarina and Tyroglyphidae respectively, which have from time to time been proposed by different writers, each in turn being critically examined by the author. Chapter V. will undoubtedly prove of greater interest to the microscopist, treating as it does, in the course of some eighty pages, of the external and internal anatomy of these minute creatures, and being illustrated by about thirty figures drawn with extreme care under various magnifying powers up to × 800. Chapter VI., which concludes the first part of the book, is devoted to a description of the development and immature stages, the eggs, larvae and nymphs being severally considered, and a detailed record given of observations made during many successful attempts to rear *Histiogaster entomophagus* from the nymphal to the adult form. The hypopial stage, as being considered biologically the most interesting feature in the life-history of the Tyroglyphidae, has naturally come in for a large share of the author's attention, and in the course of thirty pages he has not only given us an excellent account of what others have written on the subject, but has largely supplemented this by relating the conclusions arrived at as the result of his own personal observations. In the last hundred pages, which constitute Part II., Mr. Michael commences a systematic and exhaustive description of genera and species, beginning with the single species of his own genus *Lentungula*. Four species of *Histiostoma* are next considered, and an account of nine species of *Glycyphagus* brings the present volume to a close, minute details being given as to the structure, life-history and habitat of each, whilst references to the numerous figures given in illustration enable the reader to intelligently follow the descriptions.

Of the plates, 22 in number, comprising in all 240 figures, it is hardly possible to speak too highly: the whole of these have been prepared from Mr. Michael's own drawings from the objects themselves; and to any one acquainted with his exceptional skill both as an observer and a draughtsman, it will only be necessary to say that the illustrations in this, his latest published work, fully sustain his previous reputation. The way in which these very beautiful drawings have been reproduced and printed leaves little to be desired. The letter-press is also remarkably clear, and so free from typographical errors that Méguin for Mégnin on page 4 is almost the only slip at present noticed. R. T. L.

The Microscope. An Introduction to Microscopic Methods and to Histology. By Prof. S. H. Gage. Eighth Edition; $9\frac{1}{4} \times$ 6 in., vi + 299 pages, 230 figs., and a table of natural sines. Ithaca, N.Y., 1901: Comstock Publishing Co. Price $1.50.

This, the latest edition of Prof. Gage's well-known work, is kept thoroughly abreast of modern ideas, and is an excellent text-book, particularly for those going in for a laboratory course, but, at the same time, containing a great deal of information required by the general microscopist. The optical principles are concisely and intelligently stated; the use of most, if not all, really necessary appliances for observation and preparation are well, though briefly, described and figured, while photo-micrography, projection, fixing, embedding, section-cutting, staining and mounting, receive adequate treatment within the limits and purpose of the work. A very useful bibliography and list of periodicals relating to the microscope and microscopical work is appended. G. C. K.

Practical Histology. By J. N. Langley, M.A., Sc.D., F.R.S. $7\frac{1}{4} \times 5$ in., viii + 340 pages, 3 figures. London, 1901: Macmillan & Co. Price 6*s*.

This manual is an eminently practical work for the professional or serious student who is working under the personal supervision of a teacher in the class-room. For the mere microscopist with a leaning towards vertebrate histology as a recreation it will be of more limited use, for the directions are severely technical, even though they are succinct and to the point in the last degree ; the presence of an expert to direct and advise is taken for granted, and, moreover, there are practically no illustrations. But for *class purposes* there could hardly be a better guide, and it contains all the latest tried methods for demonstrating the various tissues, both in the fresh and preserved state. Besides the general and particular directions in the text for the examination of each tissue system, a number of appendices treat of methods of hardening, staining, and so forth, with the formulae of the various fluids and reagents in detail ; the treatment of living tissues with methylene blue ; the gold process for nerve-endings, etc. There is a preliminary chapter on the use of the microscope, and this is the only weak point in the book. It goes far to show that the intelligent use of the microscope is almost a neglected factor in the average laboratory class, for the whole subject is dismissed in seven pages. In order to justify this somewhat severe criticism, we give verbatim the directions for using a condenser : "Sub-stage condenser. If the microscope has a sub-stage condenser, raise this so that its upper surface is level with the stage when using a high power ; when using a low power, lower the condenser till it is the same distance below the specimen as the object-glass is above it." The whole of this brief chapter is, of course, only a *précis* of the oral directions given to a class on its first day of meeting, and it might well be omitted in a future edition without detriment to what is otherwise a very excellent work. G. C. K.

Cours de Botanique. Par MM. Gaston Bonnier et Leclerc du Sablon. 9 × 5½ in. Tome premier, fascicule II (1er partie), pp. 385—576, figs. 554—950. Paris, 1901 : Paul Dupont.

A notice of the first part of this elaborate work was given in this Journal for April 1901, No. 48, and it is sufficient to say now that the second fasciculus fully maintains the high character of its predecessor. It deals chiefly with the root, a comparison of the root, stem, and leaf, and the structure of the inflorescence. Both matter and illustrations are worthy of high praise.

G. C. K.

THE FORAMINIFERA. An Introduction to the Study of the Protozoa. *By* Frederick Chapman, A.L.S., F.R.M.S. 9 × 6 in., 15 + 354 pages. Frontispiece, 14 plates, and 42 figures in the text. London, 1902: Longmans, Green & Co. Price 9*s.* net.

This excellent book, well printed and illustrated, and by a writer with a deservedly high reputation on the subject, should supply a long-felt want, and tend to increase the number of microscopists interested in the subject. Not every student can obtain ready access to the classical monographs of Carpenter, Williamson, or Brady; and the recent literature of the subject, scattered in half a dozen languages through the publications of scientific societies, is, in Mr. Chapman's own words, "outside the scope of the general student's reading."

The author has essayed, and we think with success, to bridge this gap, and to lay before the general student a volume which, in addition to a review of the life-history and distribution of the group, also includes a brief description of all the generic and the principal sub-generic types.

Such a book falls naturally into distinct sections. The first of these, consisting of five chapters, is devoted to the life-history, shell structure, and schemes of classification. The account of the life-history and reproduction of the animal is up to date and good, so far as it goes; but only fourteen pages are allotted to it, and the value of the book would have been much increased if this subject had been treated at greater length. The observations on the structure of the shell are of great interest. Recent researches, confirmed by Mr. Chapman's own experiments, tend to show that the porcellanous or imperforate shell, which has long been regarded as Aragonite, must be considered as "an intermediate mineral condition in which the organic element is intimately mixed with the mineral, and probably corresponding with the new mineral species Conchite." The geological evidence seems to support this view.

The second division of the book relates to the Classification of the Foraminifera under Brady's system, which in the author's opinion is still the best available, in spite of several defects. Mr. Chapman gives a brief but sufficient description of each genus or important sub-genus, and illustrates it with a further description and illustration of one or more typical species. The illustrations, though somewhat rough, are on the whole good and sufficient for their purpose. Among the least satisfactory are the figures of *Lagena marginata*, W. & B. (Plate X., Fig. F, which would pass equally well for *Biloculina depressa* d'Orb. var. *murrhyna*, Schwager) and of *Polytrema miniaceum*, Linné (Plate XII. Fig. Q.)

More exception may be taken to some of the types selected by the author. In such a book it would have seemed desirable that the types selected should, as far as possible, belong to species of abundant and wide-spread distribution. This is not always the case. Thus the two examples selected in illustration of the cosmopolitan genus *Haplophragmium* are both fossil forms, and of restricted distribution even as fossils. The genus *Cassidulina*, again, is illustrated, by a species (*C. calabra*, Seguenza) which is of extremely rare and local distribution in both the recent and fossil states.

The final section of the book is devoted to a review of the geological history of the group, which has been largely extended of late years, and to a considerable extent by the researches of Mr. Chapman himself. The theory that the earliest forams were of an arenaceous type has, like so many other theories, found no confirmation in the geological record; for the earliest known arenaceous forms date no farther back than the Silurian (Wenlock Series), while various Lower Cambrian rocks have yielded representatives of no less than four out of the six families of perforate Foraminifera, all of genera existing at the present day. The group may therefore be regarded as firmly established even at that early period. What the ancestors of these ancient though varied types may have been we shall probably never know. Probably the author's surmise is correct, that they are the descendants of unknown forms, which being either wholly devoid of a shell, or having only a thin chitinous investment, have escaped fossilisation.

The volume concludes with an excellent chapter on methods of collection and preparation, and with a selected bibliography of nearly two hundred of the most valuable books and papers dealing with the group. A. E.

PROCEEDINGS.

October 18th, 1901.—Ordinary Meeting.

J. G. Waller, Esq., F.S.A., Vice-President, in the Chair.

The minutes of the preceding meeting were read and confirmed.

Mr. Charles J. Jones and Mr. Harry Moore were balloted for and duly elected members of the Club.

The donations and additions to the Library and Cabinet were announced, and the thanks of the Club unanimously voted to the donors.

The Secretary said that some bottles of material sent by Mr. C. J. Pound from Queensland for distribution had been handed to Messrs. Rousselet and Scourfield for examination and report.

Mr. Ashe's paper on "Two-speed Fine Adjustments" was read by Mr. Scourfield, and illustrated by drawings on the blackboard. The thanks of the meeting were voted to the author and the reader.

Mr. D. J. Scourfield read a paper on "*Hydra* and the Surface-film of Water," illustrated by blackboard drawings.

Mr. Morland said the properties of the surface-film of water were very often seen when one wanted to clean a single diatom, which would often rest on the top instead of in the water. The strength of the surface-film was also well seen when a needle was carefully laid upon it. The needle was of course much heavier than water, and yet it would rest on the surface, which could be seen to be depressed by it.

Mr. Karop thought the chief point of interest in this paper lay in the description of the gelatinous suspensory filaments, which, so far as he knew, had not been observed before in *Hydra*, although similar strands of gelatine were known to be given off by some other creatures. For instance, the movements of some of the Gregarines, formerly inexplicable, have been shown by Cheviakoff to be due to a secretion of filaments of this nature; but here, of course, the question of the surface-film does not arise.

Mr. Rousselet read a paper on "*Triarthra brachiata*," a new species of Rotifer which had been found on Putney Common, and had also been sent to him from the North of Ireland, concluding with some remarks on the spines of the *Triarthradae* in general, and the relation of these rotifers to the surface-film. The paper was illustrated by drawings and by specimens exhibited under the microscope.

Mr. Scourfield said he could confirm the observation as to the adhesion of these rotifers to the surface-film of water, but would like to ask if Mr. Rousselet had ever seen them suspended from it in such a way as to suggest that they were deliberately making use of the surface-film for support.

Mr. Rousselet said he had not seen this in the case of the rotifers just described, but he had, he thought, seen *Philodina* suspended in this way.

A hearty vote of thanks to Mr. Rousselet for his paper was unanimously carried.

Mr. Karop said they had another paper on the agenda by Mr. Merlin "On the Spermatozoön of the Rat." This was no doubt a very excellent piece of work, which he thought it would be a pity to read at that hour; it was therefore proposed to defer it to the next meeting.

The proceedings then terminated with the usual conversazione.

November 15th, 1901.—Ordinary Meeting.

J. G. Waller, Esq., F.S.A., Vice-President, in the Chair.

The minutes of the meeting of October 18th, 1901, were read and confirmed. The following gentlemen were balloted for and duly elected members of the Club:—Mr. Charles R. Drewitt, Mr. Wilberforce E. Hazell, Mr. William R. Martin, Mr. Alfred J. Mullens, and Mr. Charles J. T. Smith.

The donations to the Club were announced, and the thanks of the Club were voted to the donors, especially to Dr. Dallinger for his valuable and useful gift of a copy of the eighth edition of "The Microscope and its Revelations"; and to Mr. Scourfield for his donation of seventeen slides of British Fresh-water Entomostraca, which would form a useful addition to the type collections in the Society's Cabinet.

Mr. Karop said it would be remembered that at their last meeting he mentioned that they had a paper "On the Spermatozoön of the Rat," sent by Mr. Merlin, but in consequence of the other matters before the meeting, there was not time to read it, and it was therefore agreed that it should stand over until the present meeting. Since then, however, they had received another paper from Mr. Merlin, and the Council had decided that, as the second paper was upon a subject of more general interest than the former one, the first should be taken as read and published in the *Journal*, and the second should be read at the present meeting.

Mr. Merlin's paper "On the Critical Employment of the Microscope for ordinary Working Purposes" was then read by Mr. Karop.

Mr. W. B. Stokes said he was sure that all who had heard this paper must have been greatly interested by it, for it was not only, as the author suggested, likely to be useful to the youngsters amongst them, but would also, no doubt, be profitable to many of the more advanced microscopists. Mr. Merlin had mentioned the advantage of a darkened room and of resting the eyes, and he could himself say that he had often been able to see much more after having rested his eyes for a time. As regarded long and short tubes, they often saw even in that room objectives which had been made to work on short tubes put upon long-tube microscopes, and of course it was impossible to get the best results in that way. Then, as to correcting for thickness of cover-glass by lengthening or shortening the tube, he had found that as tubes were usually made it was not possible to get a sufficient range of distance, seeing that anything between 4 in. and 11 in. might be wanted. He had listened to this paper with a great deal of interest; the subject was one which was of much practical importance, and he hoped it would not be allowed to drop.

On the motion of the Chairman a very hearty vote of thanks was accorded to Mr. Merlin for his paper, and to Mr. Karop for reading it.

The announcements of meetings for the ensuing month were then made, and the meeting terminated with the usual conversazione.

December 20th, 1901.—Ordinary Meeting.

The Rt. Hon. Sir Ford North, F.R.S., Vice-President, in the Chair.

The minutes of the meeting of November 15th, 1901, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—Mr. Thomas Craig, F.R.M.S., Mr. Frederick H. Hicks, Mr. Howard E. Hurrell, Lieut-Col. Thomas Lamb.

The donations to the Library were announced, and the thanks of the Club unanimously voted to the donors.

Mr. Angus being called upon to explain some apertometers which he exhibited in the room, said that perhaps the apertometer best known to most persons present, at least by name, was that of Professor Abbe. Few amateurs were, however, acquainted with it, as its application was limited, and it was expensive. He had therefore brought with him and placed upon the table some simpler forms, which could be made for very little indeed. The first was merely a protractor, mounted on edge with a piece of silvered cover-glass, in which, with a low-power object-glass, a good view could be obtained of the protractor. Two points marked off would indicate the angle, but they could also get this by using a small pencil of light. This very simple contrivance of course showed the angle of the objective, and not the numerical aperture. Another method shown was by placing a disc of glass, with a millimetre scale ruled upon it, in the carrier of an Abbe condenser. On putting this into position, by proper adjustment of the draw-tube, and with an objective from $\frac{1}{2}$ in. to 2 in., a very good view could be obtained of the millimetre scale. To determine the value of this it was, however, necessary to get an objective of known aperture for comparison. This contrivance was also limited in its application, but he wanted to explain the usefulness of these apertometers in determining the kind of stop to be used in obtaining dark ground illumination. To get the best possible results, the stop in the sub-stage must have a definite relation to the apertometer measurement of the angle of the lens. He thought it was not sufficiently realised that the size of the stop to be used varied under different conditions—tube length, trough, and other things would affect it, but it was only by measuring and working out these conditions that what was the true relation between them could be ascertained.

Mr. Karop was sure the Club was very much indebted to Mr. Angus for the exhibition of these examples, and for his explanation of them, and he expressed a hope that this communication might be put into a form in which it could appear in the *Journal* with diagrams in illustration. Some time ago it was proposed to get an Abbe apertometer for the use of the Club, but it was thought that as very few members would be likely to use it the expense could very well be spared. As regarded stops, various contrivances had been recommended, but he thought sticking a piece of paper on the condenser was not at all satisfactory : it was almost impossible to get a true centring, and it got out of shape ; he therefore strongly recommended that stops should be made of thin sheet-metal.

The Chairman said they had heard Mr. Angus's useful and instructive paper with great pleasure, and he had no doubt they would desire not only to thank him for the explanations which he had given them in language which all could understand, but would join with Mr. Karop in expressing a hope that he would have them put into the *Journal.*

The thanks of the meeting were unanimously voted to Mr. Angus for his communication.

Mr. Karop called attention to a microtome by Reichert which had been brought to the meeting for exhibition by Mr. Curties. It was at first sight an instrument which could only be regarded with some apprehension, but on closer inspection it certainly appeared to be a very marvellous and beautiful piece of mechanism.

The Chairman did not know if any one had examined this microtome before the meeting, so as to be able to explain its working : it certainly looked a rather formidable instrument.

Mr. C. L. Curties said that, although this microtome was not really new, he believed it had not been shown before at a meeting of the Club, and he had therefore thought the members might be interested in seeing it. Since it was first brought out there had been a few alterations made in it. The block which held the razor was arranged with a slot, so that any position of the blade could be obtained; there was also an arrangement by means of which it could be tilted into any required position. The uses of the various adjustments to the working portions were then briefly explained, and the thanks of the meeting voted to Mr. Curties for bringing this instrument for exhibition.

Mr. F. R. Dixon-Nuttall and the Rev. R. Freeman's joint paper on "*Diglena rostrata*, a new Rotifer," found at Knowsley Park, Lancashire, was read by Mr. Rousselet, who also exhibited a mounted specimen of the species in the room.

The Chairman presumed, from what Mr. Rousselet had told them, that not many persons in the room had seen this animal in the flesh. Possibly, however, they would have future opportunities of doing so, since Knowsley Park, named as its habitat, was not likely to be destroyed. He moved that the thanks of the Club be given to Messrs. Dixon-Nuttall and Freeman for the addition they had made to their knowledge that evening. The motion was carried unanimously.

Mr. D. J. Scourfield read a further paper on the winter eggs of Entomostraca, entitled "The Ephippia of the Lynceid Entomostraca," illustrating the subject by drawings on the board.

The Chairman regretted that he was unable to make any useful remarks upon the subject of the paper, which it was impossible to hear without feeling impressed with the knowledge of how much there was yet to be known about everything, and how little opportunity they had of learning it. He understood that Mr. Scourfield had now given them three papers upon this subject, and he thought he might venture to make a prophecy that they would yet have a fourth or even a fifth paper upon it, and he certainly hoped that his prediction would be fulfilled. He was sure that all present would join in thanking Mr. Scourfield for what he had told them that night. This was carried unanimously.

Mr. Nelson's paper, "On the Black and White Dot" question, was read by Mr. Karop—in the absence of the author, whose state of health at the time unfortunately prevented him from being at the meeting.

Mr. Stokes thought that if they examined a very simple structure about which they had no doubt, the explanation was easy to give; but when they examined a diatom, the structure of which they were not so sure about, the explanation became more difficult. It was well known that in the case of a regular structure they got the black and white dots, but it would also be found that the same effects were produced in the same way on the edge of a piece of silex, whether there were any perforations or not. They were very thankful to Mr. Nelson for his remarks, because his experience in these matters was very much greater than that of any one he knew.

Mr. Rheinberg said he should not be so rash as to make off-hand any criticism on Mr. Nelson's paper, because it was well known that Mr. Nelson's opinions were only given after so much study that it must be assumed they were well grounded. It was said that the perforations in diatoms acted as lenses, and that an image was formed of anything through them. He thought, however, that in diatom structure they got tubes which were filled with a substance of the same kind as the surrounding medium, and he could not tell how these tubes could produce an image. It had not been suggested that the holes were in any way lens-shaped. In *Actinocyclus Ralfsii* the perforations were large, and the larger the perforations the larger they found the dots. If the perforations did give an image of the stop in the condenser it still seemed to him to want some sort of explanation how this came about, and if so, how was it that they got three or four images by focussing lower and lower. He had a number of slides mounted in about eight different media, and the result was that the black and white dots altered very considerably according to the media. The main point, however, was in what way these perforations through the diatoms could produce images.

Mr. Stokes said that a very simple experiment would show how perforations could and did act as lenses. They had only to make a small pin-hole in a piece of tin-foil, and it would be found that this was quite competent to produce an image; and it was, of course, well known that a pin-hole had been used for photography, and very good results had been obtained.

The Chairman was quite sure that all who had heard Mr. Nelson's paper would join in expressing their thanks to him for it, and would regret that illness was the cause of his absence.

The thanks of the meeting were unanimously voted to Mr. Nelson for his communication.

Mr. Karop reminded the members that at their next ordinary meeting they would be asked to nominate persons to fill vacancies upon the Council, and also to elect an auditor of the accounts for the past year, in preparation for the Annual Meeting of the Club, which would take place on February 21st.

January 17th, 1902.—Ordinary Meeting.

J. G. Waller, Esq., F.S.A., Vice-President, in the Chair.

The minutes of the preceding meeting were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club: Mr. L. R. Gleason, Mr. S. H. Heaney, and Rev. H. A. Soames, M.A., F.L.S.

The additions to the Library and Cabinet of the Club were announced, and the thanks of the Club unanimously voted to the donors.

The Secretary reminded the members that, as the next meeting would be their anniversary, at which it would be necessary to elect Officers and members of Council for the ensuing year, nominations must be made at the present meeting. He then read the following nominations for Officers made by the Committee:—

As President, Mr. G. Massee.

As Vice-Presidents, Messrs. Waller, Nelson, Michael, and Sir Ford North.

Other officers as before.

The Auditor appointed by the Committee on their behalf was Mr. J. M. Allen.

The members were then invited to nominate five gentlemen for election on the Committee to fill vacancies caused by the retirement of Messrs. Western, Earland, Allen, Harris, and Ingpen, all of whom were eligible for re-election except Mr. Ingpen, who had removed from the neighbourhood of London and would be unable to attend.

Mr. Western said that he should much prefer not being called upon to serve again, as his health was uncertain, and would probably interfere with his attendance.

The following nominations were then made :—

Mr. G. T. Harris,	proposed by	Mr. Swift,	seconded by	Mr. Muiron.
Mr. A. Earland,	,,	Mr. Traviss,	,,	Mr. Marks.
Mr. J. M. Allen,	,,	Mr. Mainland,	,,	Mr. Freeman.
Mr. A. E. Hilton,	,,	Mr. Parsons,	,,	Mr. Lloyd.
Mr. Bryce,	,,	Mr. Scourfield	,,	Mr. Wesché.

As Auditor on behalf of the members of the Club, Mr. Chapman was proposed by Mr. Neville, seconded by Mr. Parsons, and unanimously elected.

Mr. Wesché read a paper on "Modifications of the Legs in some Dipterous Flies," which he illustrated by drawings on the board, and also by mounted specimens shown under microscopes and by drawings laid upon the table. A collection of the insects referred to was also exhibited.

Mr. Karop said it was very refreshing to find there were a few observers, like the author of the paper just read, who endeavoured to learn some of the functions fulfilled by these singular spines and hairs, instead of trying to make their number and arrangement fit some scheme of specific distinction only. Dr. Scriven had shown a whole series of those organs at successive "gossip" meetings, and had demonstrated their close connection with peculiar nerve terminals, which in some cases were comparable with the "end-organs" of vertebrates. It seemed far more rational to try and discover the use of certain insect structures than to make merely a so-called "collection," because, with few and rare exceptions, no private *general* collections were of any value except to the owner, whereas accurate observations when communicated became the common property of naturalists.

The thanks of the Society were unanimously voted to Mr. Wesché for his paper.

Mr. Wesché said he should like, before they passed on to another subject, to express his obligation to Messrs. Baker for lending the microscopes upon the tables, which had rendered it possible to exhibit so many specimens in illustration of his paper.

A paper by Mr. C. D. Soar, "On *Ecpolus papillosus*, an unrecorded Hydrachnid found in Britain," was read by Mr. Scourfield.

Mr. Karop remarked that it was very curious to note again how very far apart closely allied and apparently rare species were sometimes found—in this case in the New River and in Madagascar.

The thanks of the meeting were voted to Mr. Soar for his communication, and to Mr. Scourfield for reading it.

Notices for the ensuing month were then made, and the meeting terminated with the usual conversazione.

February 21st, 1902.—Annual Meeting.

George Massee, Esq., F.L.S., President, in the Chair.

The minutes of the previous meeting were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—Mr. T. J. Edwards, Mr. J. Halsey, Mr. A. H. Macdonald, Mr. W. Radcliffe, Mr. H. W. Shepherd, Mr. E. Wyatt.

The additions to the Library were announced, and the Secretary said that one of these deserved special attention. It had been represented to the Committee that Dr. Lilljeborg's "Cladocera Sueciae," a most elaborate work with eighty-seven beautiful plates, would be a very desirable acquisition and of the greatest assistance to students of the Entomostraca. Unfortunately, works of this size and character were necessarily costly, and the Committee hardly felt justified in incurring the outlay. One of their number, who, however, desired to be anonymous, had most generously presented not only the book itself, as issued, but the very handsome and substantial binding in which it now appeared. A very cordial vote of thanks to the donor of this valuable and useful gift was moved from the chair and carried by acclamation.

The meetings for the ensuing month were then announced, and the special business of the Annual General Meeting proceeded with.

The President appointed Mr. Neville and Mr. West scrutineers, and ballot was taken for President, Vice-Presidents, Officers, and five members of Committee. On receiving their return, the President declared that the names on the printed list had all been unanimously elected.

President . . .	George Massee, F.L.S.
Four Vice-Presidents .	J. G. Waller, F.S.A. A. D. Michael, F.L.S., F.R.M.S. E. M. Nelson, F.R.M.S. The Rt. Hon. Sir Ford North, F.R.S.
Treasurer . . .	H. Morland.
Secretary . . .	G. C. Karop, M.R.C.S., F.R.M.S.
Foreign Secretary . .	C. Rousselet, F.R.M.S.
Reporter . . .	R. T. Lewis, F.R.M.S.
Librarian . . .	Alpheus Smith.
Curator . . .	C. J. Sidwell, F.R.M.S.
Editor	D. J. Scourfield, F.R.M.S.
Five Members of Committee . . .	J. Mason Allen, F.R.M.S. D. Bryce. A. Earland. G. T. Harris. A. E. Hilton.

The Secretary then read the Thirty-sixth Annual Report.

The Treasurer presented his statement of accounts and balance sheet for the year 1901, duly audited.

Mr. Taverner moved the adoption of the Report and Accounts, which was seconded by Mr. French and carried unanimously.

The President having requested Mr. Waller to take the Chair, then gave his annual address, in which he described some of the leading features of the Coprophilous Fungi, the minute species found on horse-dung and other animal excreta, tracing the principal characteristics of several typical forms, and illustrating his remarks with a series of large coloured drawings.

Mr. Waller proposed a hearty vote of thanks to the President for his admirable address. It was most delightful to hear one who was a perfect master of his subject, as the President was Mr. Allen seconded the vote, which was carried with acclamation.

The President, in reply, said the greatest gratification to him would be for at least one student to take up the subject and give it a trial. He would be pleased to assist any one who would do so as far as he possibly could. He was perhaps a little biassed, but he thought there was nothing to equal it.

Mr. Neville inquired if there was any way of preserving these objects.

The President said it was possible to preserve these fungi, but there was a lot of detail to be explained, and he would, if desired, devote part of an evening to clearing up points requiring attention, and give the methods adopted, and the whole routine.

Mr. Wesché proposed a vote of thanks to the Auditors and Scrutineers; seconded by Mr. Marks, and carried.

Mr. Woodley proposed a vote of thanks to the Committee and Officers for their services during the year; seconded by Mr. T. J. Smith, and carried.

The Secretary, on behalf of the Officers, said they were all very pleased to do their best for the Club, and gratified to know their efforts were appreciated by their fellow-members. He had held his own post now for about nineteen years, and probably it would be better to obtain the services of a younger and more energetic man; but so long as he felt that he retained their confidence, and the Club's interests did not suffer, he should be most happy to continue in office.

Mr. Morland said it was a pleasure to assist the Club, which was a sort of co-operative society. When they looked at the balance-sheet, and saw the amount spent on the Journal, the rent of the room and so forth, they must admit that even now they really got 20*s.* in the £. If they *all* co-operated it would, he thought, be something like 30*s.* in the £. One way of doing this would be to pay their subscriptions as quickly as possible.

OBJECTS EXHIBITED, WITH NOTES.

October 4th, 1901.

Mr. T. N. Cox: Three slides of *Pinna* Shell, under polarised light. (1) Transverse section, *P. pectinata*; (2) Longitudinal section, *P. rudis*; (3) Prisms.

Mr. J. T. Holder: Two transverse sections of Caterpillar, showing (1) legs, etc.; (2) the vegetable matter that has been devoured (double stained).

Mr. D. J. Scourfield: A living specimen of *Hydra vulgaris*, stained with a weak solution of methylene blue. The stain seems to be taken up by a number of ovoid granules within the cells.

Mr. T. A. O'Donohoe: The teeth or scrapers of the Blow-Fly, and another fly (species not known). Those of the blow-fly are all bifurcate, and are in three rows on each side of the gullet, whereas those of the other fly form four rows, in the anterior one of which the teeth are not bifurcate, but quite round at the ends.

Mr. A. E. Hilton: Bladderwort (*Utricularia*), showing bladders containing entrapped aquatic animalcules; mounted in formalin.

October 18th, 1901.

Mr. A. E. Hilton: Tail of Fantail Fly, *Dolichopus nobilitatus*, showing the male reproductive organ. Male and female specimens also exhibited.

Mr. A. Earland: Trifurcate siliceous spicules of Sponge, *Corticium kittoni*, from Colon, Central America. Described in *Ann. and Mag. Nat. Hist.* 4 S., vol. XIV., p. 253.

Messrs. R. and J. Beck: *Pleurosigma angulatum*, under $\frac{1}{12}$-in. oil-imm. objective, with No. 4 eyepiece. Microscope fitted with Ashe's two-speed fine adjustment. (See *ante*, pp. 135-6.)

Mr. C. F. Rousselet: Mounted specimen of *Triarthra brachiata*, a new species of Rotifer. (See *ante*, pp. 143-5.)

Mr. R. T. Lewis: Curious sense-organ at the extremity of the palpi of the female mosquito, *Anopheles maculipennis* (sp. ?). This is absent in the case of the common gnat (*Culex pipiens*), but a similar organ is found on the palpi of the Ticks in all stages. It is retractile and capable of independent motion, and is conjectured to be the means by which the exact position of blood-vessels is ascertained.

November 1st, 1901.

Mr. T. N. Cox: Filamentous Alga, *Spirogyra*, showing spiral band-like chromatophores.

Mr. A. J. French: A fresh-water Alga, *Draparnaldia glomerata*, mounted in weak formalin.

Mr. A. E. Hilton: Sporangia of a Mycetozoan, *Badhamia foliicola* (Lister), before and after the dispersion of the spores. *In situ* on withered blade of grass.

Mr. J. B. Scriven: Sensory nerve end-organs in the Blow-Fly. A trachea passes through one of them, possibly forming an organ of hearing.

Mr. C. F. Rousselet: *Ploesoma hudsoni*, a Rotifer from America.

Mr. H. Morland: *Hemiaulus polycystinorum*. About the commonest form found in the Springfield (Barbados) Polycystinous deposit; showing front and side views.

November 15th, 1901.

Mr. A. E. Hilton: Head of Fantail Fly, *Dolichopus nobilitatus*, showing the brilliant eyes. Mounted in formalin.

December 6th, 1901.

Mr. T. G. Kingsford: Pith of Sunflower by reflected light, showing the colours of thin plates.

Mr. K. J. Marks: Vertical section of leaf of *Ficus elastica*, showing cystolith in cell wall. Stained borax carmine.

Mr. H. E. Freeman: Living specimen of *Canthocamptus staphylinus* Jurine (*C. minutus* of Baird's "Nat. Hist. of British Entomostraca"). The peculiar spermatophore is typical of the species.

Mr. H. Morland: *Triceratium sentum*, O. Witt, showing front and side views of valves. From Simbirsk deposit, Russia.

Mr. F. E. Filer: Root of Onion, showing karyokinesis. Stained with safranin and gentian violet. Fixed in Flemming's fluid (chromic, osmic, and acetic acids).

Mr. T. N. Cox: Eye of Water Beetle, *Dytiscus*, with sections of same.

Mr. C. F. Rousselet: *Daphnia kahlbergensis*, from Russia. Varieties of this very hyaline species have been found in this country, but are not common. The remarkably tall head is the most noticeable feature.

Mr. A. Earland: Hexactinellid Sponge, *Euplectella suberea*, from Japan, showing the "hexasters," or flower spicules, *in situ*. These spicules are extremely delicate, and rarely found in such a perfect state as those shown.

Mr. A. E. Hilton: *Diatomite*, from the Kieselguhr Mines, Toome Bridge, Co. Antrim, containing various diatoms and also spicules of sponges.

Mr. J. B. Scriven: Large nerve-cells in the sensory nerve-endings of the Blow-Fly. These cells have multiple nuclei.

December 20th, 1901.

Mr. E. C. Goulton: *Demodex folliculorum*, from hair follicles of dog. Mounted in distilled water.

Mr. A. Earland: Parasite of Sparrow, *Dermaleichus chelopus* (Acarina, Sarcoptidae). The lobster-like claws are only found in the male.

Mr. K. J. Marks: Tangential section of *Tilia Europaea*, showing fibro-vascular bundles and sphaeraphides in the cell cavity. Stained acid green and borax carmine.

Mr. H. F. Angus: Five exhibits to illustrate the determination of the aperture of dry lenses by means of (1) a protractor, and (2) a millimetre scale in the stop carrier of Abbe condenser, also the useful application of the results obtained for the production of the best possible dark ground illumination. (See *ante*, p. 209.)

Mr. W. Wesché: Mouth parts of *Hilara matrona* ("fisherman's curse"), a predaceous fly of the Empidae family (Diptera).

January 3rd, 1902.

Mr. K. J. Marks: *Brachionus quadratus*, Rousselet. The lorica is covered with polygonal areolations. The foot is remarkable, having the false joints of a *Noteus* and the transverse wrinkled structure of a *Brachionus*. The toes are unusually long and retractile, like a *Philodina*.

Mr. T. G. Kingsford: Section through external ear of Cat, showing cartilage, fibrous tissue, and hair follicles.

Mr. W. Wesché: *Notholca longispina*, ♀ with egg, from Leg of Mutton Pond, Hampstead Heath.

Mr. A. Downs: *Synura uvella*. Spheroidal colony, composed of flagellate animalcules. No pigment specks are present in this variety. From a pond near Bath, beneath the ice.

Mr. L. O. Grocock: Transverse section through thallus of lichen, showing the algal " gonids " and fungal hyphae.

Mr. W. J. Winter: A mounted specimen of the Rotifer *Notops brachionus*.

Mr. H. Morland: Triceratia from Oamaru. Showing various forms of *Triceratium*, which are very frequent in this deposit.

Mr. J. B. Scriven: Sensory nerve in the sheath of the proboscis of *Tipula*. It partly encircles the sheath and supplies one large hair and many small ones.

January 17th, 1902.

Mr. H. Taverner: A new Water Mite, *Ecpolus papillosus*. Described by Mr. Soar. Found in the New River. (See *ante*, p. 251).

Mr. W. Wesché: Twelve exhibits in illustration of his paper on "Modifications of the Legs in some Dipterous Flies" (see *ante*, p. 245). Species shown: *Tachydromia arrogans*, ♀; *Hybos femoratus*, ♀; *Ascia podagrica*, ♂; *Campsicnemus curvipes*, ♂; *Platychirus albimanus*, ♂; *Hydrotea dentipes*, ♂; *Sepsis cynipsea*, ♂; *Sphaerocera subsaltans*, ♀; *Limosina sylvatica*, ♂; *Tipula oleracea*, ♂; *Dolichopus griseipennis*, ♂. Microscopes lent by Messrs. Baker.

February 7th, 1902.

Mr. W. R. Traviss: Model of a church window in selenite, containing upwards of eighty separate pieces. Made by Mr. J. Swift more than forty years ago. Shown with polarised light.

Mr. D. J. Scourfield: *Limnosida frontosa*. A very rare Entomostracon from Finland. This species has so far only been found in Norway, Sweden, and Finland. The projecting eye and the notched posterior margin of the shell are very characteristic.

Mr. H. Morland: *Triceratium rugosum* Gr. & St., from the Oamaru deposit, N.Z., showing "front" and "side" views of valves, also difference in shape of the "upper" and "lower" valves of frustule as observed by Herr Grunow, of Vienna.

Mr. K. J. Marks: *Protococcus viridis*. Spherical, unicellular plants, primarily filled with chlorophyll, which sometimes changes to a reddish colour. Multiplication by repeated bi-partition of the cells, as shown. Mounted in acetate of copper solution.

Mr. J. B. Scriven: Compound eye of Blow-Fly. True corneae in front, shaped like watchglasses. The lens is situated at the bottom of the pseudocone, which represents the aqueous chamber in the higher animals.

THIRTY-SIXTH ANNUAL REPORT.

In presenting the usual Report at the Annual Meeting your Committee is again enabled to give a good account of the Club's position.

The number of new members elected during the past twelve months—viz., 55—is considerably above the average, and a very gratifying response to the appeal made by the Committee in the previous Report.

On the other hand, seven have been lost by death, twenty-seven have resigned, and four were removed for non-payment of subscription, leaving a membership, up to December 31st last, of 352.

The attendance at the meetings has been most satisfactory, and the papers or other communications submitted at the business nights good both in quality and quantity. A larger number of specimens than has been the case for a long time have been exhibited at the "gossip" meetings, frequently accompanied by instructive and interesting illustrative notes. The Club is to be congratulated on the active enthusiasm which has prevailed, and produced such excellent results.

The following is a list of the chief communications read at the meetings:—

Jan	On *Diaschiza ventripes*, n. sp. .	Mr. Dixon-Nuttall.
,,	On *Cathypna ligona*, n. sp. . .	Mr. Dunlop.
,,	The Stridulating Organs of Water-bugs (Rhynchota) especially of Corixidae	Mr. Kirkaldy.
,,	An unrecorded Hydrachnid found in North Wales . . .	Mr. Soar.
,,	The Ephippium of *Bosmina* . .	Mr. Scourfield.
Feb.	The President's Address . .	Mr. Massee.
April.	Images of Diatom structure .	Mr. Stokes.
,	Black and White Dot Phenomenon	Mr. Rheinberg.

May.	The Laboulbeniaceae . . .	Mr. Massee.
June.	On *Metopidia solidus*, ♂ . .	Mr. Wesché.
,,	Micro-structure of metals and alloys	Mr. Smith.
Oct.	Two-speed fine adjustments . .	Mr. Ashe.
,,	*Hydra* and the surface-film of water	Mr. Scourfield.
,,	On *Triarthra brachiata*, n. sp. .	Mr. Rousselet.
Nov.	The Spermatozoön of the Rat .	Mr. Merlin.
,,	The critical employment of the microscope for ordinary working purposes	Mr. Merlin.
Dec.	Two simple Apertometers . .	Mr. Angus.
,,	On *Diglena rostrata*, n. sp. . .	Messrs. Dixon Nuttall and Freeman.
,,	The Ephippia of the Lynceid Entomostraca	Mr. Scourfield.
,,	The Black and White Dot . .	Mr. Nelson.

Besides these a number of short "Notes" on various subjects will be found in the Journal.

The following books, periodicals, and transactions of various societies have been added to the Library during the year :—

"The Microscope and its Revelations." 8th edition, edited by Dr. Dallinger.

"The Microscope." 8th edition. Professor S. H. Gage.

E. M. Nelson's "Contributions to the Royal Microscopical Society, and the Quekett Microscopical Club, 1886-90."

"Smithsonian Reports, 1898 and 1899."

"Journal of the Royal Microscopical Society."

"Proceedings of the Royal Society."

"Journal of Applied Microscopy."

"Proceedings of the Academy of Natural Science of Philadelphia."

"Proceedings of the Geologists' Association."

"Missouri Botanical Garden, 1901."

"American Botanical Gazette."

"La Nuova Notarisia."

"Quarterly Journal of Microscopical Science."

"Annals and Magazine of Natural History."

"Larvae of British Butterflies and Moths," Vol. 9, Ray Society.
"British Coccidae," Vol. 1, Ray Society.
"British Tyroglyphidae, Vol. 1, Ray Society.
"Nova Acta Kaiser. Leopold-Carol. Akad." Bdə. 77-8.
Various other Transactions, etc.

Dr. Lilljeborg's "Cladocera Sueciae," an elaborate work on Entomostraca, containing some 80 plates, was most kindly presented by a member who desires to be anonymous. The best thanks of the Club are due, and hereby offered, to this gentleman for his valuable gift; also to Dr. Dallinger for a copy of the 8th edition of "Carpenter," and the other donors. A "Card Catalogue" of the books is being prepared by the Librarian, who hopes to complete it before very long.

The Cabinet has received the most assiduous attention from the Curator, who reports that over 1,000 slides have been issued during the year. A classified catalogue of the zoological specimens, some 1800 in number, has been drawn up, and this the Committee considered advisable to print. As, however, it is double the size of any of the previous lists, the selling price has been fixed at one shilling, which only just covers the cost. Being based on the lines of modern classification, it should be useful to many beyond the mere purpose of showing what specimens are actually in the Club's possession at the moment; and your Committee trust that an extensive sale of this catalogue will justify the rather large outlay upon it. Some slight alteration has been made in the conditions of loan of specimens, and this is printed inside the cover of the new list. Altogether 412 slides have been added to the collection since the last report, the most noteworthy being Mr. Mottram's munificent donation of 300 "Hamilton Smith" diatoms, and a further set of 54 slides of "type" Rotifers from Mr. Rousselet. The complete list is as follows: Mr. Dennis (6), Mr. W. Harris (2), Mr. Miles (5), Mr. Mottram (300), Mr. Nelson (1), Mr. Pound (4), Mr. Rousselet (54), Mr. Scourfield (18), Mr. Sidwell (16), Mr. Wesché (6). Mr. Sidwell wishes it to be made known that anatomical sections prepared by modern methods, and slides illustrating pond life, are amongst the chief desiderata.

The Journal itself is the best testimony to the care and ability bestowed upon it by the Editor. Comparison with some of the earlier numbers will show the marked advance that has been made in paper, typography and illustration, as well as in arrangement of matter, and at present the Journal may be said to be fully worthy of the Club in every respect.

The Excursions in the past year have been better attended, and some interesting captures made; but there are two difficulties to be met, and if possible overcome, in connection with these affairs. The first is the want of a larger number of specialists for groups of organisms which, at present, are passed over, so far as systematic work is concerned. The second is the need of fresh collecting grounds within a reasonable distance of town. Any assistance in the former case, and suggestions as to the latter, will be very welcome and greatly appreciated by the Excursions' Committee.

The Finances, as will be seen from the Balance-sheet, are in a healthy condition, in spite of an increase in some of the items of expenditure, the balance in hand at the end of the year being some £25 in excess of the previous one. This is entirely due to the energy of the Treasurer in collecting the subscriptions, and there are, at present, but few outstanding arrears.

The Committee desires to express its thanks to the officers, collectively and individually, for their efficient services.

Taking a general survey of the past year, and recognising the efforts made in all directions to uphold and extend the utility of the Club, your Committee sees no reason to doubt its continued prosperity in the future, so long as this spirit of lively interest endures, and the cordial co-operation of the great body of members on its behalf is maintained; provided always that every care be taken to keep its numbers undiminished and its financial stability secure.

THE TREASURER IN ACCOUNT WITH THE QUEKETT MICROSCOPICAL CLUB

For the Year ending December 31st, 1901.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance from 1900	141	0	5	By Rent of Rooms and Bookcases	54	12	0
„ Subscriptions received during 1901	192	10	0	„ Expenses of Journal	120	0	9
„ Dividends on Investments	8	18	6	„ Postage	6	17	9
„ Sales of Journals	16	5	6	„ Printing and Stationery	9	16	3
„ Sales of Reprints	0	7	5	„ Attendance	6	0	0
„ Sales of Catalogues	1	17	1	„ Petty Expenses	2	17	4
„ Receipts for Advertisements	17	0	6	„ Books, etc., purchased	11	9	6
				„ Balance in hand	166	5	10
	£377	19	5		£377	19	5

Investments.

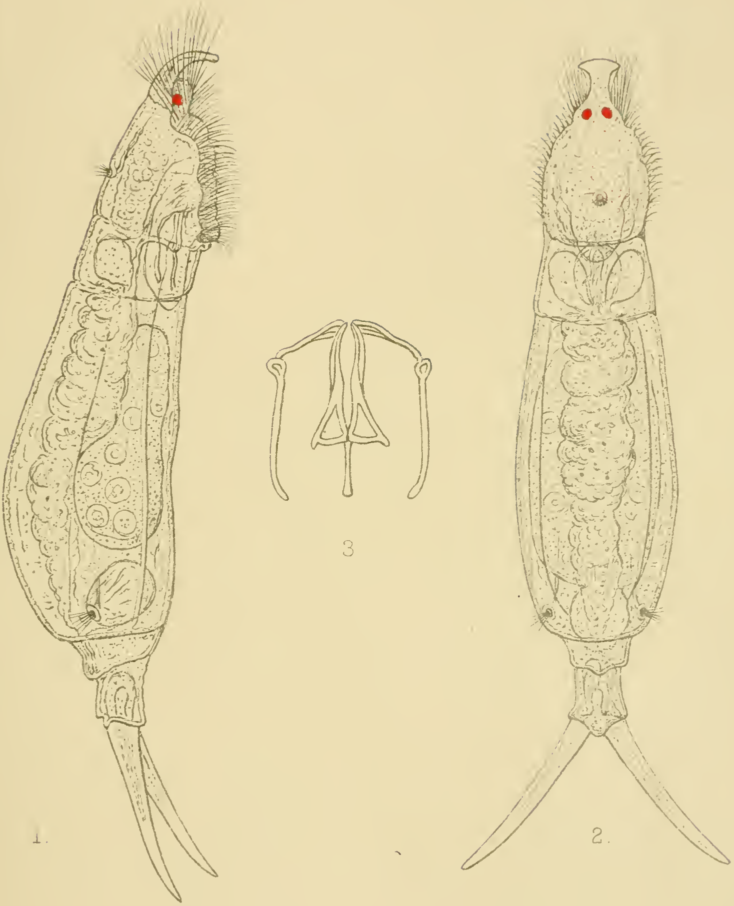
	£	s.	d.
$2\frac{3}{4}$ per cent. Consols	200	0	0
$2\frac{1}{2}$ per cent. Metropolitan Stock	49	5	2
$2\frac{1}{2}$ per cent. Annuities, 1905	100	0	0
	£349	5	2

We have examined the above statement of Income and Expenditure, and compared the same with the Vouchers in the possession of the Treasurer, and have verified the investments at the Bank of England, and find the same correct.

January 24th, 1902.

H. MORLAND, *Hon. Treasurer*,

J. MASON ALLEN, W. INGRAM CHAPMAN, } *Auditors.*

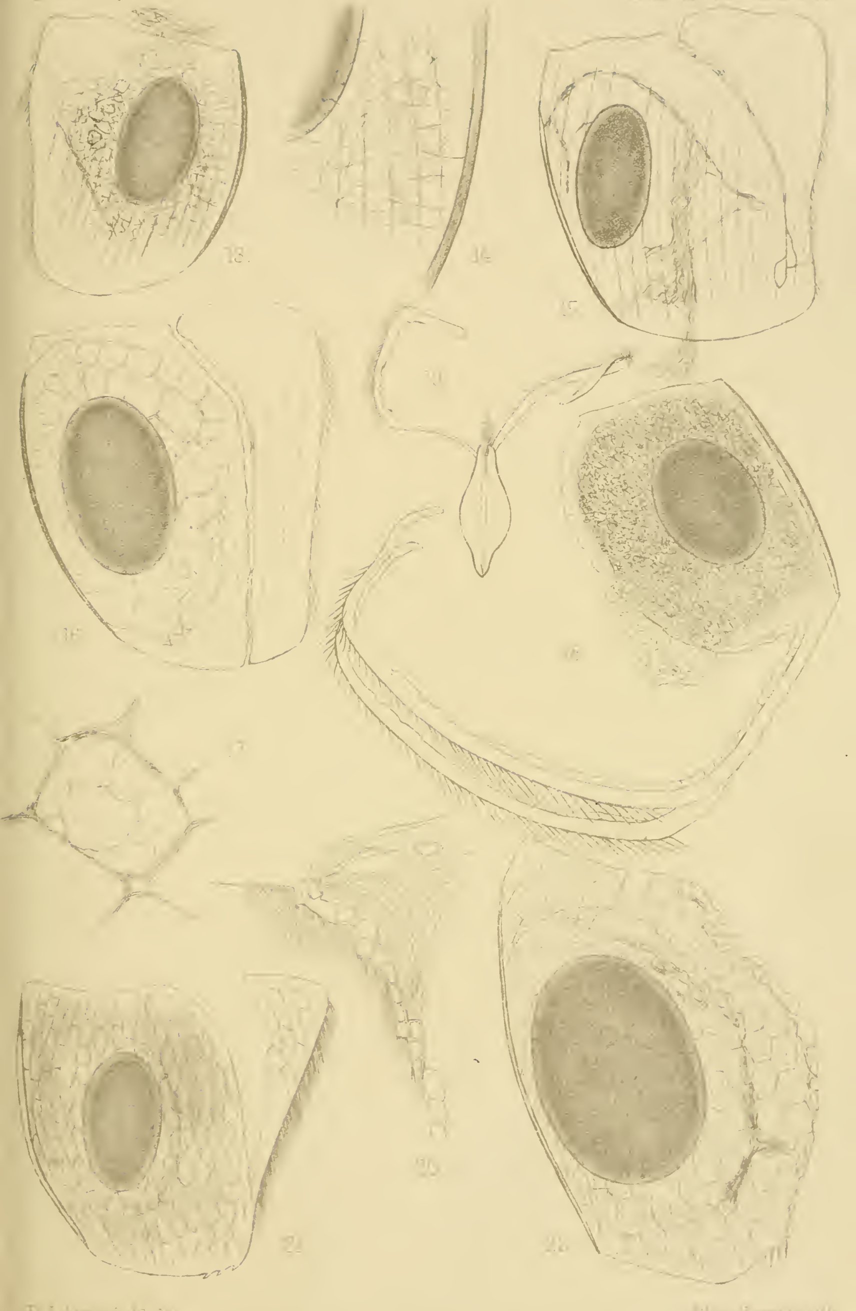


F.R. Dixon-Nuttall del. ad nat. West, Newman lith.

Diglena rostrata. n. sp.

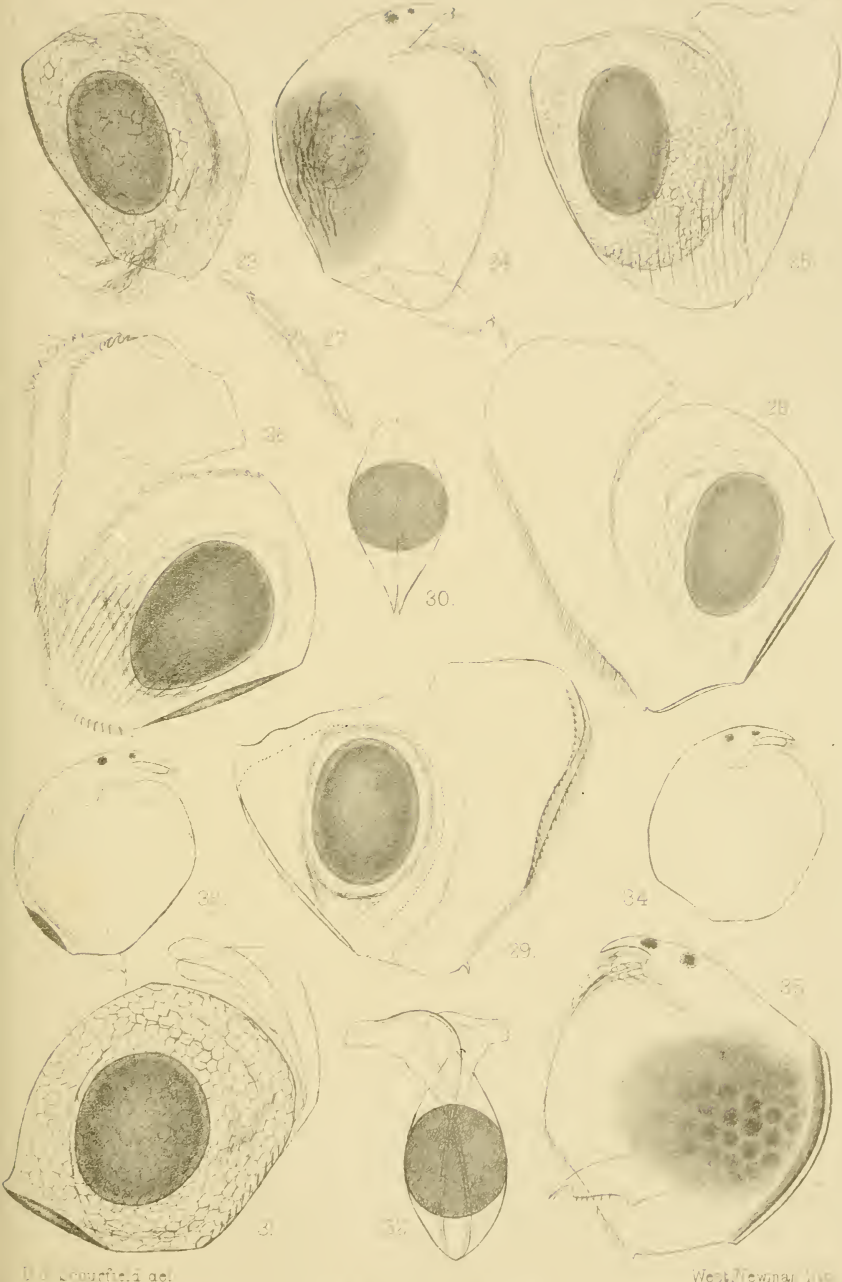
D. J. Scourfield del. West, Newman lith

Ephippia of Lynceid Entomostraca



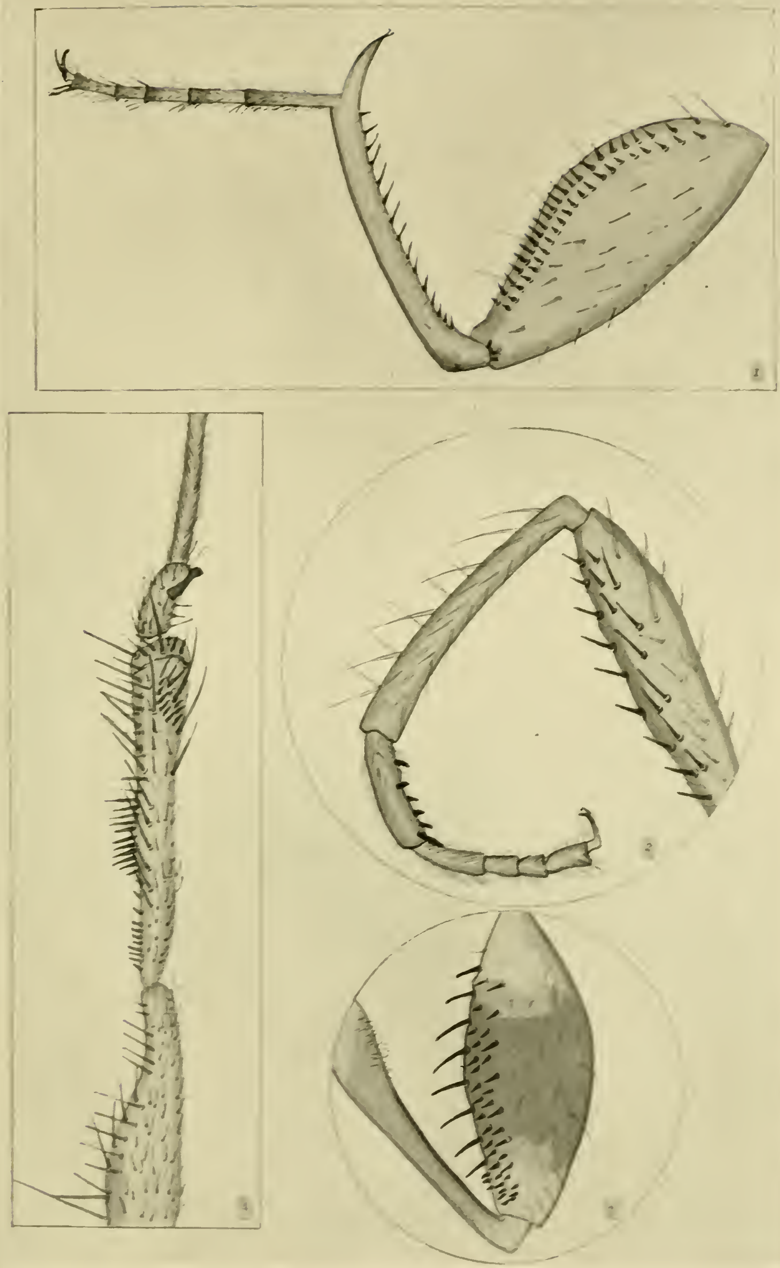
D. J. Scourfield del. West, Newman lith.

Ephippia of Lynceid Entomostraca



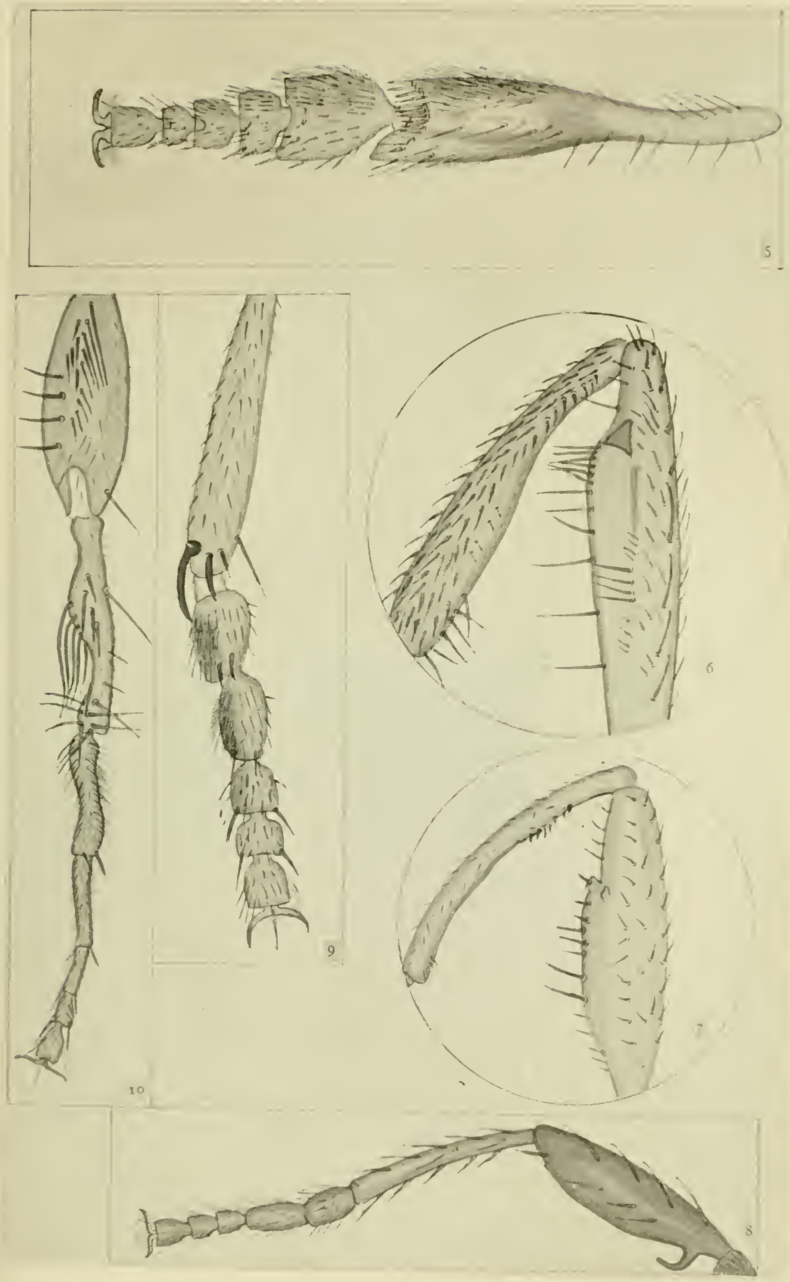
D. J. Scourfield del. West, Newman lith.

Ephippia of Lynceid Entomostraca



W. Wesche del.

LEGS OF DIPTERA.



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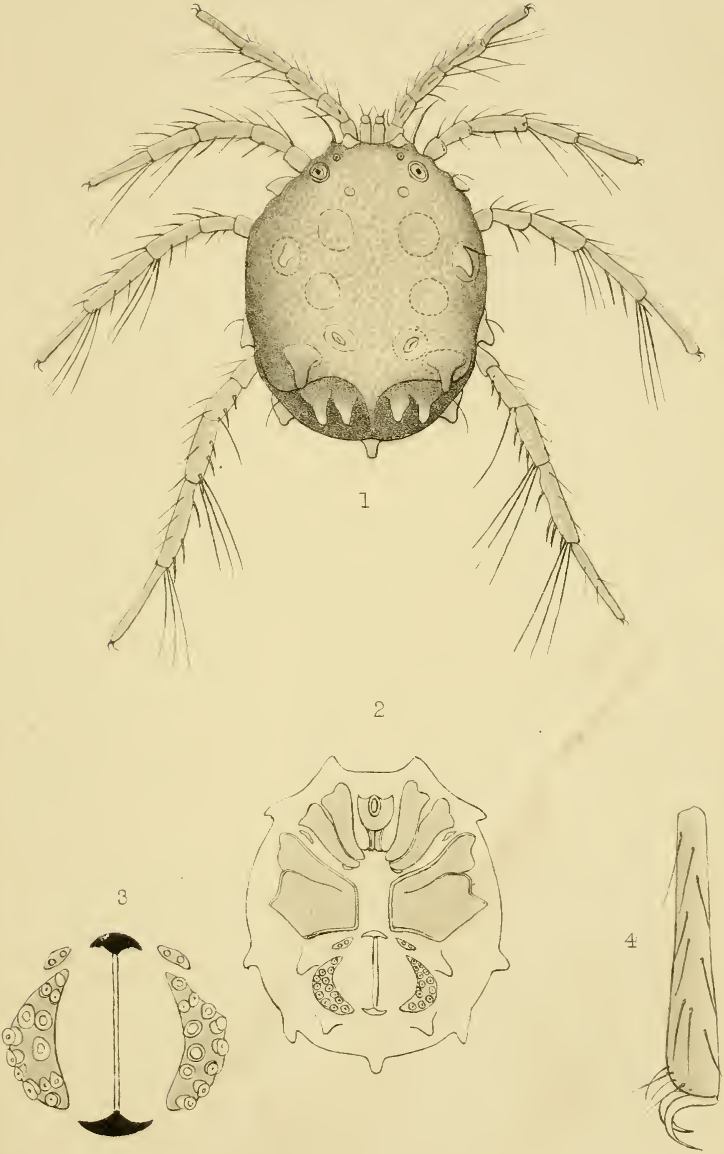


Chas. D. Soar del, West, Newman lith.

Ecpolus papillosus. n. sp.

The Black and White Dot Phenomenon.

By J. Rheinberg, F.R.M.S.

(*Read March* 21*st*, 1902.)

You will, I am sure, agree that, however trivial a matter may appear to be on the face of it, if it has a direct bearing upon more important general problems, it is worth threshing out and clearing up.

Mr. Nelson in his excellent article, read at our meeting last December (*ante*, p. 261), tells us that the black and white dot phenomenon is such a matter, and this is my excuse for asking your kind indulgence for another communication on the subject.

I am, moreover, anxious to acknowledge certain valid criticisms passed upon my paper of April last (*ante*, p. 113), and to modify the views then put forward in some respects.

In the first place, further experiments show that it is erroneous to suppose that a cone of light impinging on a vertical wall of silex forms a dark area on *both* sides of the partition. It appears that, in conformity with the ordinary laws of geometrical optics,* the dark area is only formed on one side, viz., that of the denser medium, and that on the side of the rarer medium, on the contrary, there is an equivalent space where the light is doubled in brightness.

Secondly, I have to admit an error of observation, since, as Mr. Nelson pointed out, the black and white dot are coincident in position. It is not quite such an easy matter to determine as it would seem; in fact, I find that a very able writer on microscopic optics has also stated that those images shift; yet I

* An error has crept in on p. 113 (7 lines from bottom of the page) in describing the diagrams on p. 114. This ought to be read as follows. "The cases represented are when light impinges on a *vertical partition* of a diatom—

Figs. 1 and 4 at an angle *greater than* the critical angle,
Figs. 2 and 5 at the critical angle,
Figs. 3 and 6 at an angle *less than* the critical angle."

am quite satisfied now that Mr. Nelson's view is the correct one, and that the appearance of shifting arises from a curious optical illusion to which I will refer a little later.

Then Mr. Stokes' observation, that, since isolated objects (such as bacteria) and edges also show the effects in question, they cannot be due to bands or cones arising from periodic structure, certainly merits attention, and makes it necessary to explain that, according to my view, the bands or cones arising from a

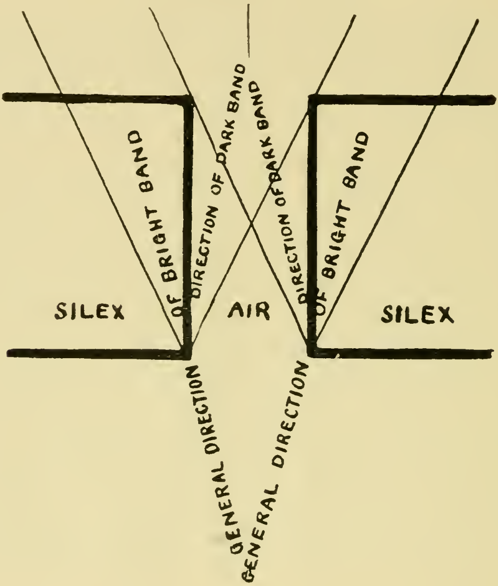


Fig. 1.

single cylindrical perforation in a diatom are by themselves competent to give two images, viz., one chief image, and one above or below. Since, as above stated, a dark area is only formed on one side of a partition, a vertical section of a perforation would show us *two* more or less expanding bands of darkness diverging from each other, and two similarly shaped bands of extra brightness likewise diverging from each other. Apparently it is where these bands cross respectively that we get the maximum black and white dot effect. Fig. 1, a mere diagram, gives a general indication of what occurs. I believe that in the case of such single perforations or isolated objects, more than two definite images can never be obtained, whilst in the case of periodic structure under suitable conditions some supplementary images—always very hazy—are obtainable, which are due to the crossing of bands from elements which are separated from one another. In the case of a single edge without any adjacent perforation in the structures, I have never been able to obtain more than two, and often only one image, having any pretension to sharp definition.

Now, let us see what is the general position of the question.

We have the following theories to choose from: That the chief and immediate causes of the appearances are—

(1) Spherical aberration by reason of the objective acting in zones, each zone having its own focus within certain limits.

(2) A stenopaic, or pin-hole effect.

(3) Crossing of bands, arising from diffraction (Dr. Johnston Stoney on Microscopic Vision, *Philosophical Journal*, May, 1896, pp. 514-16.)

(4) Crossing of bands (or rather cones) formed by reason of the difference of refractive indices of the media, in accordance with the ordinary laws of total reflection beyond the critical angle.

So far as I know the above comprise all the theories brought forward, and indeed it would be difficult to suggest any further one.

Let us, therefore, take them one by one.

(1) The spherical aberration of any objective is easily measurable, and is, under given conditions, a fixed quantity. We should, therefore, expect, when using the same objective with an almost full cone of light on diatoms mounted in the same medium, without altering tube length, that the distances between the black and white dots were the same. But what we do find is that these distances are very variable. The distance between the black dot and upper white dot in some styrax-mounted specimens of *Navicula lyra* was about 6 μ (μ = 1 micron = $\frac{1}{1000}$ millimetre) in *Stauroneis phoenicenteron* 3 μ; in *Actinocyclus Ralfsii* it was in different specimens $4\frac{1}{2}$, $7\frac{1}{2}$, and 9 μ.

Another point to observe is that the spherical aberration of an objective usually shows at its worst when narrow cones of light are employed, whilst the black and white dot effect is most marked with wide cones of light.

So that I think we may dismiss spherical aberration as the primary and direct cause, and regard the changes in the image which tube length, etc., cause as subsidiary.

(2) With regard to pin-hole effects, it is only necessary to observe that pin-hole images have no fixed focus, and the images do not alternate in light and dark. If the object be a bright point the image will always be bright.

(3) We have to examine whether bands caused by diffraction are the direct cause, and I think I can show you by simple geometry that this is not the case.

Mr. Nelson finds that the distance between the black and white dot in dry-mounted specimens of *Pleurosigma angulatum* is pretty constant at 3 λ, with which my own measurements agree. We also know that the perforations of *P. angulatum* are about 1 λ apart, and that the angle between the dioptric and first diffracted beams is about 60°.

We will therefore draw lines diverging 60° from points A. B. C. (fig. 2), and consider the distance A to B or B to C to be 1 λ. Now the distance between B and B^1 would represent the distance between the white and black dot, and it will be seen *that it is less than* the distance from A to B or 1 λ, whereas to accord with fact it should be about three times as great.

I have calculated corresponding results in the case of one or two other diatoms.

We see, therefore, that diffraction cannot be considered as the *direct* cause of the black and white dots, notwithstanding the part which diffracted light plays in every optical image.

(4) Failing any other theory we are thrown back upon what, for shortness, I may call my "critical angle" explanation, and we will briefly pass over the pros and cons, beginning with the latter.

(*a*) Objection has been taken to my comparison with trellis-work. It has been said that, since the position of the dot at the various foci is the same, this is fatal to the argument.

Let me admit at once that the comparison with trellis-work is probably too loose, seeing that we are not dealing with simple bands of light and darkness crossing in one direction only, but with cone-shaped figures crossing in many directions. And it is perhaps not quite apt to call the few bands arising from a single perforation, and which, as mentioned earlier, suffice for the production of the chief image and one above or below, a " trellis-work."

But apart from these secondary considerations, I do not think the non-shifting of the position of the dots disproves the theory, and for this reason :

The black dot is invariably surrounded by a space brighter than

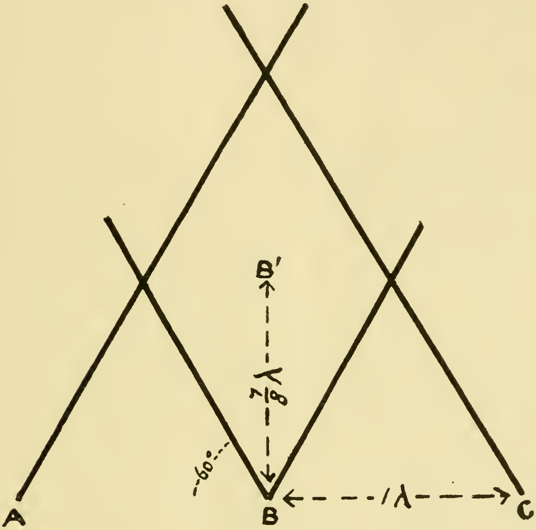


Fig. 2.

the clear part of the diatom, whilst the white dot is invariably surrounded by a darker space than the clear part of the diatom.* The photograph and enlargements which I am passing round will show you this. So that in changing from the black to the white dot focus, the darkness forming the dot does actually shift sideways, and now appears as darkness between two dots.

This lateral shifting of the darkness is readily observable, and gives rise to the optical illusion that the dots themselves shift in position.

* By the clear part of the diatom is meant a part of the silex comparatively free from perforations, which, as Mr. Nelson states, approximates to the brightness of the field.

Theoretical considerations also teach us that when the dark dots give place to white dots, there must be an equivalent amount of darkness spaced between them. It follows the law of distribution of energy, which tells us that we cannot destroy any of the light, we can merely rearrange it in other ways.

In most high-power photographs of fine diatom structures, as well as in visual observations, the extra bright space surrounding a dark space, or *vice versâ*, can be seen or detected.*

(*b*) A second objection which has been suggested is that we are scarcely justified in applying the ordinary laws of geometric optics to such small structures, the dimensions of which may be counted by one or two wave lengths, or even fractions of a wave length of light.

This objection assumes a sort of *sui generis* difference between the phenomena of the large and the small, and it may well be pointed out that the whole tendency of microscopic optics at present seems to be to break down such barriers. The fact is, all optical appearances are necessarily complex, and due to various causes. We cannot absolutely isolate one cause and eliminate all the others. What does happen is that, whilst all the causes are always at work, when the conditions are varied, one cause becomes more prominent than another, and may overpower the result of the others. Diffraction furnishes one of the chief examples of this. It is ever present in an optical image. Its effects gain or lose prominence according to size of structure, angular aperture, and other reasons. Under certain conditions it greatly disturbs a correct appreciation of the image, overpowering the concomitant effects due to refraction, reflection, etc. I have already pointed to some reasons why diffraction cannot be the direct cause of the black and white dot appearances. Unless, therefore, some new and unknown law is causing the effects, for which we have no evidence whatever, we are left with those causes which we do know are at work, and of which the laws are well known.

(*c*) It is interesting to note that both the black and white dot appearances with light and dark areas respectively are well shown in photographs of the very finest secondary structure in

* Care must be taken that the light is not too strong, because the eye is considerably less sensitive to differences of brightness, as compared to the field, in a very strong light than in a light of moderate intensity.

the perforated membranes of diatoms. This shows that another disturbing factor which is often present is not the primary cause. I refer to the fact that in viewing a diatom valve we are frequently looking upon what is practically a double layer, one on top of the other, with perforations facing each other, so that the optical appearance resulting from the lower layer might upset or modify those due to the upper layer. But this objectionable influence is to a great extent done away with, in viewing the perforated membranes within the coarser perforations, since, so far as I am able to ascertain, there is only a single layer of this secondary structure.

Summing up the points in favour of the critical angle explanation, we find—

(*a*) It will explain the appearances without recourse to other than the most ordinary and generally established optical laws.

(*b*) It accounts for the fact that wide-angled objectives will show the results better than narrow-angled ones; similarly it shows why wide cones are more favourable than narrow ones for the production of the appearances.

(*c*) It allows for the alteration of appearances due to spherical aberration, tube length, etc. It can also be shown to harmonise with those changes at different foci caused by diffraction.

(*d*) It accounts for the appearances of edges of a transparent object, and of transparent isolated objects, as bacilli, etc.*

(*e*) The dimensions of the perforations, particularly the relation of depth to width, account in the simplest way for the fact that sometimes the white dot is seen above and the black below, sometimes *vice versâ*. It is simply a matter of an extra reflection at the wall.

(*f*) Different dimensions of the perforations explain the varying vertical distances between the black and white dots seen in different diatoms on the same slide.

(*g*) Lastly, the existence of patches on a diatom showing reverse order of the black and white dot can be accounted for by the difference of refractive index of the gum or other medium in which that portion of the diatom forming the patch is immersed.

* In non-transparent edges and objects, somewhat similar results may be obtained, more especially with narrow cones, which have their origin entirely in diffraction. In transparent objects and wide cones of light, the change in appearance due to the latter cause is minimised.

All things considered, and notwithstanding that, owing to imperfect data, it is sometimes difficult to assign the exact cause of the appearances presented by any special case, I think you will admit that there are very substantial grounds for assuming the

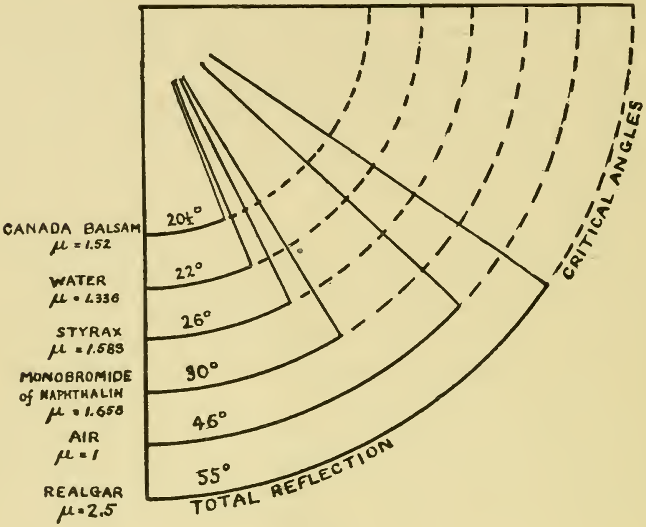


Fig. 3.

Variations of Critical Angles and of the Amounts of Light totally reflected, according to the medium in which the diatom is mounted. The Refractive Index (μ) of the diatom silex is taken as 1·43.

black and white dot phenomenon to be simply due to differences of refractive index of the transparent media. The measure of these differences is the critical angle, or angle of total reflection, and how much this varies for diatoms mounted in the usual media is seen in the accompanying figure (Fig. 3).

On *Cymbalopora bulloides* (d'Orbigny) and its internal structures.

By Arthur Earland.

(*Read April* 18*th*, 1902.)

Plate 16.

A little more than a year ago Mr. E. H. Matthews, of Yorke Town, South Australia, forwarded me some small packets of Foraminiferous material which he had himself collected in bygone years at various places round the shores of the Yorke Peninsula in South Australia. They yielded many very interesting forms, some of which deserve further notice; but my present object is to draw your attention to one particular gathering which in its way was quite unique.

This was a very tiny packet containing only a few grains of material, and labelled "Query Foram, Corny Point, 1880." On examination it proved to be what I had never seen or heard of before—a pure gathering of a single species, and that a species of far from frequent occurrence—viz., *Cymbalopora bulloides*, d'Orbigny.

I was so much struck with the singular nature of this gathering that I at once wrote to Mr. Matthews, asking him for any information respecting the form and the conditions under which it had been found, though after a lapse of twenty years I did not expect to receive any very definite information. Fortunately, however, the unusual nature of the gathering had been impressed upon him at the time, and he replied as follows :—

"Now as to your queries : I was wondering if I had included the Corny Point gathering amongst those I had sent you; to me it is one of the strangest of my finds. In November, 1880, I went as far as Warooka (fourteen miles west of Yorke Town) by mail, and was there met by horses and trap for the remaining thirty miles of the journey. It was a warm, still night in our early spring, very dark—one could hear, but not see, the kangaroos as they broke across the track. I arrived at my friend Barclay's at about 1.30 a.m. He lived about a quarter of a mile from the beach; and as we drove along I could hear what I took to be the surf breaking on rocks, and promised myself good sport. Too tired and excited to sleep, I got up at about 5 a.m. and strolled across to the water's edge, and found in place of rocks a long strip of sandy beach with a broken roll tumbling in on the sand. Strolled along for a few miles, then back to breakfast, and then down again for a stroll in the other direction. By this time (8 a.m.) the tide was beginning to ebb, and I found along the ripple edge what I took at first to be seaweed spore, got my glass out and found it to be this foram. I had nothing on me to collect with as I was only prospecting; but searched the cliff, and ultimately found a piece of cuttlefish bone, and by scraping this out I gathered about a teaspoonful, and could have got pints. In places it was four or five inches wide, and extended for quite a quarter of a mile. I did not trouble about taking a quantity, as I merely took this to show my friend B., who was out hay-making. He had never seen it before, but thought it common; so I took it up to the house, and went down the following morning prepared to gather a quantity, but from that day to this have never seen a sign of it. Have been down to Barclay's several times at about the same time of the year, and at different seasons, but have never seen this form again. It taught me a lesson, and I have now always something at hand to collect in, as I have several times since seen the same sort of thing with shells. One year (about nine years ago) our beautiful *Chïone lamellata* came up in hundreds. I secured for friends two hundred and forty living specimens in one trip; since then I have had solitary ones, and some seasons not even that. Another time an *Akera* came ashore in such enormous quantities that the beach literally stank, and you could have loaded a dray. No more since.

"Corny Point is the extreme west south-west point of Hardwicke Bay, a deep horseshoe-shaped indentation on the west shore of the Yorke peninsula. The bay extends for about eighty miles, and is more or less sandy along the whole length and shallow, the five-fathom line ranging about one and a half miles from the beach; in fact, I do not think any part of the bay exceeds seven fathoms. The bottom in patches is densely covered with a growth of sponges and seaweed, with muddy ooze containing *Lima* and other mollusca.

"At the time of my first visit to Mr. Barclay's the weather had been very fine for days—light winds from the north-east and very little sea on."

So much for Mr. Matthews' recollections of the gathering, which are sufficient to prove that the occurrence of this deposit was altogether abnormal.

I will now give you in some detail what we already know about this singular foram, and subsequently describe some new features in its structure which I have lately made out. *C. bulloides* was first described and figured in 1839 by d'Orbigny under the name of *Rosalina bulloides*, d'Orb. (A). The genus *Rosalina* contained a number of heterogeneous forms which have long since been separated into different genera. D'Orbigny's description of the form is as follows:—

"Shell a globular spiral, perforated, reddish, convex above and below; spire bluntly convex, with four distinct coils; chambers scale-like, the last one much swollen. Diameter, $\frac{1}{3}$ mm. . . . Perforations very marked, especially those on the lower side of the last chamber, each of which is surrounded by a little collar. . . . Chambers five in each convolution, convex, the last chamber partly covering all the others, and looking like a large transparent ball, obscuring $\frac{5}{6}$ths of the under surface. We have not been able to discover any opening. Perhaps none exists, or it may be hidden underneath.

"Colour very pale red, most marked at the apex of the spire. The last chamber nearly white."

The genus *Cymbalopora* was instituted by Hagenow in 1850 for some fossils occurring in the chalk of Maestricht, and Carpenter assigned d'Orbigny's specimens to this genus (B). Carpenter in his description of the species writes: "The whole of the base is occupied by a single large chamber, the wall of which, instead of being furnished with its normal aperture, is perforated by numerous large 'orbuline' lipped pores."

For some reason or other, probably owing to its restricted distribution, the species did not receive any further notice until 1880, when Professor Moebius published his monograph on the Foraminifera of the Island of Mauritius (C). He described and illustrated the form with some minuteness, pointing out details of structure hitherto unnoticed, which, in his opinion, necessitated the separation of the species from its congeners, and its removal into a new sub-genus, for which he proposed the name *Tretomphalus*. His description of the species, which I will quote in full, is as follows :—

Tretomphalus bulloides d'Orb.

(From τρητὸς pierced, and ὀμφαλὸς navel, or boss of a shield.)

"The shell consists of sharply curved concavo-convex chambers, which are spirally arranged in three coils. The chambers of the last convolution are much more voluminous than the preceding ones. The final chamber especially is very large, and at the base* studded with hemispherical perforated bosses,† and in the plane of the bosses is furnished with a tube projecting into its interior. The greater part of the final chamber is, like all the rest of the chambers, covered with fine 'pore canals.' These have a diameter of ·004 mm. The diameter of the bosses amounts to ·014 mm., the diameter of their perforations to ·008 mm. The whole shell has a length of ·265 mm. and a breadth of ·20—·22 mm.

D'Orbigny described these remarkable forams under the name *Rosalina bulloides* in "For. Cuba," 1839. He did not know of the existence of the tube in the last chamber.

W. B. Carpenter placed *R. bulloides* d'Orb. in the genus *Cymbalopora* (Hagenow). The characteristic features of this genus are as follows: The chambers have their principal opening directed into a deep oral depression, and they possess side openings as well as a principal opening. These peculiarities are entirely wanting in *Rosalina bulloides*, for its chambers communicate with one another through wide openings. I therefore consider it desirable to institute a new genus for these forms, which in my opinion have the following distinctive features :—

Shell spirally coiled without umbilical depression.‡ At the distal end of the final chamber are perforated bosses, the rest of the shell has the usual pseudopodial perforations. A tube projects into the interior of the final chamber from the plane of the perforated bosses.

* Literally "at the opposite pole to the primordial chamber."

† These are the "numerous large 'orbuline' lipped pores" of Carpenter.

‡ Lit. mouth-navel.

The genus *Tretomphalus* is related to *Discorbina*. The acquisition of the perforated bosses in addition to the customary pseudopodial perforations speaks for itself as a strongly marked advance on the Discorbina type. The internal tube opening points to the simple Entosolenia type."

Brady devotes a considerable space to *Cymbalopora bulloides* in his report on the Foraminifera of the *Challenger* expedition (D), and as his description summarises all that was known of the species at this time, I will quote its more important parts. He writes: "The salient feature of *C. bulloides* is the large inflated chamber which forms the base of the shell, and constitutes the greater part of its entire bulk. In its earlier stage the test is Rotaliform, the superior side convex, the inferior concave; the segments are arranged in about three convolutions, and but for a certain irregularity in the disposition of the later whorls, it might in this condition be mistaken for one of the weaker modifications of *Discorbina*. The inferior side of the Rotaliform shell has an umbilical depression, round which the segments are arranged, and into which they open, and the intervals between the chambers form radiating fissures. In all these points the initial test resembles the typical *C. poeyi*, but the general contour is more outspread and the umbilical recess remains open, not being covered by a shelly flap, as is usual with the latter species. The peripheral margin of the Rotaliform test forms the line of attachment of the large balloon-like chamber which envelops the whole of the inferior side. The distal face of the "balloon" is decked with a number of large, Orbuline pores, the margins of which have generally a slight rim or border. Moebius has pointed out that one of the pores near the centre of the disc is furnished with a short tube, projecting into the cavity of the chamber, and suggests that this constitutes the general aperture of the test. The existence of this Entosolenian orifice had been overlooked by previous writers, but I am able to confirm the observations of Moebius in every particular, having seldom failed to trace it, except in occasional very small specimens. It often cannot be detected externally, but sometimes it is situated in a little dimple or depression . . . and it may nearly always be distinguished in balsam mounted specimens, when examined by transmitted light. The test attains a diameter of $\frac{1}{45}$ inch or more.

C. bulloides has long been known as a bottom foraminifer . . .

but on the *Challenger* cruise it was frequently taken in the townets at the surface of the sea, always in shallow areas, and in the immediate neighbourhood of coral reefs. It is somewhat remarkable in connection with the surface specimens, that the same gathering invariably furnished shells of two distinct sizes, some of them being of the normal adult dimensions, while a large number were comparatively minute, their individual diameter being scarcely half that of their associates. The large shells appeared to be empty, and of intermediate specimens there were few or none. The repeated observation of these facts has led Mr. Murray to question whether *C. bulloides* is under all circumstances a pelagic Foraminifer, or whether it is not more probable that it may only be the breeding stage of a bottom form. ("In every specimen taken from the surface which I examined, the shell was filled with minute monadiform bodies." J. M.)

Goes, in his "Reticularian Rhizopods of the Caribbean Sea" (E), and also in his report on the "For. of the U.S. Fish Comm. Steamer, *Albatross*" (F), considers *C. bulloides* to be only a "singular form of a modified *Discorbina*. The pores of various sizes on the last segment should not be regarded as a mark of generic or of specific distinction. If this globular chamber is detached, the rest will hardly be distinguished from *D. rosacea*."

Goes suggested that d'Orbigny's name *Rosalina* should be revived for forms referred to *Cymbalopora*, Hagenow's figures being of doubtful nature; but this would only lead to more confusion.

Agassiz, in his "Three Cruises of the *Blake*" (G), and Egger, in his "Foraminifera of the Gazelle" (H), also refer to and figure this foram, but neither add anything to our knowledge of the subject.

The latest notice on the subject of this form is contained in the recently published work of Mr. F. Chapman, "The Foraminifera" (I). He writes of *C. bulloides*: "The chief difference in this form is the large inflated chamber which is developed from the inferior surface of the test of an ordinary Cymbalopora of the variety *squamosa*.

"This pelagic modification is particularly interesting on account of the frequent occurrence of embryonic shells living within the balloon-like chamber, and which are liberated through an entosolenian orifice."

No authorities or references are quoted for this latter statement—an unfortunate omission. In their absence we must suppose that Sir John Murray's record of the occurrence of the monadiform bodies in the balloon chamber is alluded to, though the substitution of "embryonic shells" for "microspores," which the monadiform bodies doubtless were, seems unjustifiable.

It will thus be seen that since d'Orbigny first described *C. bulloides* in 1839, two additions only have been made to our knowledge. Moebius discovered the tube leading into the interior of the balloon, and Murray the constant presence of monadiform bodies or microspores in the sarcode of the balloon chamber. It will also be seen that all the writers who have described the form speak of the balloon as a single enlarged chamber. As a matter of fact this final inflated portion of the shell is double, and consists of two chambers, one within the other, and having no connection with each other. This is clearly shown in the specimens exhibited on the table, in which I have entirely removed the whole of the outer covering (the "balloon" of Brady), leaving the inner chamber, which I propose to call the "float" chamber, quite perfect and intact.

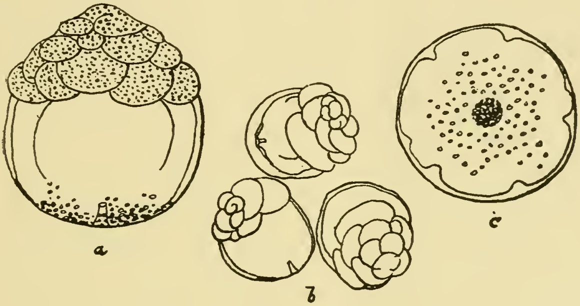
This inner or "float" chamber is a very singular feature, and I believe quite unique in its structure and delicacy. It occupies nearly the whole of the interior of the balloon, in which it hangs suspended, but is not attached to the inner surface of the balloon in any way. It is attached to the lower surface of the upper or spiral shell, but it has no direct connection with these upper chambers, the only opening into its interior consisting of the small tube in the centre of its base, discovered by Moebius. This tube is not in any way connected with the external or balloon chamber, the inner surface of the base of the balloon being perfectly smooth except for the large "orbuline" pores.

In shape the "float" chamber varies considerably in different specimens. In Mr. Matthews' specimens, and in most small shells, it is almost perfectly globular, and exhibits none of those constrictions of the surface which are characteristic of the "float" chamber in large and mature shells. These constrictions, which start from the point of attachment of the "float" chamber, are often so deep and marked as to give a distinctly lobate appearance, so that the "float" chamber bears some resemblance to a tomato or to a bag of wet sand tightly bunched together at the top.

The walls of the "float" chamber are of calcite of the most delicate transparency and thinness, more like the film of a soap bubble than any rhizopod shell, and it is quite devoid of all perforations except the tube already alluded to. Now this is a very extraordinary feature, and I think quite unique. Hitherto the calcite shell has been regarded as essentially and typically perforate, and the aragonite (or conchite, according to Chapman) shell essentially imperforate. But here we have a typically and coarsely perforated foram possessing an internal chamber at variance with what has been considered the essential feature of its group. Such a radical departure must have an adequate reason to account for it, but what that reason may be is not very apparent. It is, however, permissible to put forward a theory to account for its presence, and in my opinion this inner chamber is neither a breeding chamber nor a body chamber, but a "float." No specimens which I have examined show any trace of sarcode on the interior surface, which is invariably smooth and shiny; while the exterior surface, in common with the walls of the balloon chamber, are frequently covered with patches of dried sarcode. The absence of perforations would be a valuable feature in a chamber designed to hold air or gas; but, on the other hand, if the "float" were to contain sarcode, the contents would be practically isolated from the remainder of the animal, which could hardly be beneficial.

What purpose is served by the tube? Possibly the animal has the power of increasing or depleting the supply of gas in the chamber so as to modify its specific gravity, and so travel from the bottom to the surface and *vice versâ*.

It is not easy to understand how such a striking feature, and one by no means difficult to detect, can have been overlooked by such careful and skilled observers as Moebius and Brady, to mention only those who have written of the form in detail. There is no doubt that both of these writers were ignorant of its existence, for they both mention specifically that the final balloon chamber is single. Yet they must both have been within a hair's breadth of detecting its presence, for there are distinct though faint indications of its presence in their illustrations of the form. The figures in Moebius' work, drawn by himself, include one (Pl. X., fig. 9) showing an idealised optical section of the test. The lobulated surface of the "float" chamber is faintly indicated by the shading. The feature is more plainly marked in the outline woodcut upon p. 639 of Brady's *Challenger* monograph, which was probably drawn by Hollick from a sketch by Brady. The depressions between the lobes of the "float" chamber are shown by lines in all the figures, notably in figure C, which shows the form in optical section as seen from the base. From the nature of the drawings, however, and from the entire absence of any reference to the presence of an internal chamber, there can be no doubt that Brady entirely misunderstood the meaning of the markings which he saw, and it is probable that he regarded these markings as thickenings of the balloon wall.



Cymbalopora (*Tretomphalus*) *bulloides.*

a. Large surface-specimen; *b.* small (young ?) specimens from the same gathering; *c.* distal face of the balloon-like chamber, showing the entosolenian orifice, seated in a slight depression.

(Reduced from Brady's report on the Foraminifera of the *Challenger* Expedition.)

I have been aware of the existence of this inner chamber for at least ten or twelve years, but never having made any special study of the form until I received Mr. Matthews' material, I was misled by the woodcut in the *Challenger* report into the belief that it was a well-known feature of the species.

There is another feature in connection with this singular form which does not seem to have received the attention which it deserves. I refer to the existence of two distinct varieties which may be described as the Discorbine and the Acervuline forms. In the Discorbine form the early chambers are regularly spiral, and, apart from the final balloon, are indistinguishable from specimens of the allied genus *Discorbina* (*D. rosacea*, d'Orb.). In the Acervuline variety the shell also starts spirally, but the Discorbine portion is extremely small and almost buried beneath an accumulation of scale-like chambers, which are more or less irregularly arranged. D'Orbigny figures a regularly Discorbine specimen, as also does Moebius. Brady mentions the occurrence of specimens of two different sizes in the same gathering, without intermediate specimens between the two, and his figures show that the small specimens were Discorbine, and the large ones Acervuline. This accords fairly well with my own observations. The small variety appears to be invariably Discorbine; at any rate I have never met with a small Acervuline specimen. The large variety is almost invariably Acervuline, but there are exceptions. I have met with at least two specimens of the large variety in which the early chambers are entirely and regularly Discorbine and so largely developed that the balloon is entirely hidden when the spiral portion is uppermost. Perhaps the two forms are Megalospheric and Microspheric.

Mr. Matthews' specimens from Corny Point are all of the small or Discorbine variety, and have the reddish-brown colour which appears to be characteristic of the small form, as it frequently is of its ally *Discorbina*. They agree generally with the characteristics of the species; but, so far as I have been able to see at present, none of the specimens have a tube opening into the inner "float" chamber. The "balloons" are more or less filled with dark, dried sarcode, rendering observation somewhat difficult, so that it is possible that there may be a simple basal orifice instead of a tube opening. This seems the more probable from the fact that balsam penetrated pretty readily. The tube is not, however, invariably present, for I have often failed to detect it. When present it differs very much in size and diameter, so that it is very probable that a simple basal perforation may frequently take its place.

I have left to the last the discussion of the circumstances under which this remarkable gathering of Mr. Matthews was made, because it presents several points of great difficulty. *Cymbalopora bulloides* has hitherto been regarded as a purely tropical form, and one of by no means frequent occurrence. As a rule isolated specimens only are to be found in individual gatherings, and even in the *Challenger* dredging, Station 185, off

Raine Island, 155 fathoms, in which it is more abundant than I have elsewhere found it, it is by no means common. The limits of its distribution, according to Brady, are Bermuda and Mauritius—say, 32° north and 20° south of the Equator. Corny Point is on the south shore of Australia, about 35° south latitude, an extension of 15°, or 900 miles beyond its previous record. Again, the specimens, according to Mr. Matthews' note, must temporarily have existed in countless millions, judging from the area of beach which they discoloured.

Now, Corny Point is on the southern shore at the opening of Spencer Gulf, which is almost a small land-locked sea running due north and south. It faces north, from which direction the wind had been blowing for some days. It seems evident, therefore, that the sudden appearance of *Cymbalopora bulloides* in such enormous numbers was due to the stranding of a shoal of pelagic specimens driven ashore by the winds and currents. I have examined a number of gatherings from various localities on the shore of Spencer Gulf and the neighbouring St. Vincent's Gulf, but have never met with a single specimen elsewhere in the neighbourhood. The dominant genus in the locality, as elsewhere on the South Australian coast, is *Discorbina*, which abounds almost to the exclusion of other types, and attains very large dimensions.

The explanation of this pelagic shoal in my opinion is intimately connected with a very thorny question—that of the relationship existing between the so-called "genera" of Foraminifera. It has been more or less accepted by all rhizopodists that true specific features are almost non-existent in the Foraminifera. Of course for systematic purposes it is convenient and even necessary to fix upon certain features for specific types; but there can be no doubt that they are more or less artificial, and that environment exercises a modifying influence upon form to an extent unparalleled in higher forms of life. It therefore seems to me very probable that *Cymbalopora*, so far from being a distinct genus, is only a life stage of the closely allied *Discorbina*. Not necessarily a life stage of constant or invariable occurrence, but perhaps a sexual form assumed at intervals and under favourable conditions for the regeneration of a type impaired by constantly repeated asexual reproduction.

The monadiform bodies observed by Murray in small pelagic specimens, which, judging from Brady's figures, closely resembled Mr. Matthews' specimens, were probably microspores. They might be discharged through the "orbuline" pores at the base of the balloon, or more probably by the rupture and dissolution of the balloon chamber. This would not necessarily imply the decease of the parent shell, which might continue its existence and growth, the regularly Discorbine specimens as *Discorbina rosacea*, d'Orb., the Acervuline specimens as *Cymbalopora poeyi*, d'Orb., a form of abundant occurrence in all tropical waters, and differing from *C. bulloides* in but little except the absence of a balloon chamber.

The question, however, is altogether unanswerable except as the result of prolonged experiment with living specimens, and I therefore put it forward with some diffidence, but in the hope that some Australian microscopist, more favourably situated than myself, may have an opportunity of studying and confirming it.

In conclusion, I have again to express my thanks to my friend, Mr. A. J. French, for the excellent drawings which he has made in illustration of my paper. I also desire to acknowledge the kindness of Sir John Murray, to whom I am indebted for the supply of material from the *Challenger* station at Raine Island, from which I have worked out most of my details. Sir John Murray has also done me the courtesy of reading this paper in manuscript.

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I.—Chapman, F. "The Foraminifera." London, 1902, p. 217.

Explanation of Plate 16 (*Cymbalopora bulloides*).

Fig. 1. Side view of "Acervuline" specimen from Raine Island, part of the outer "balloon" chamber removed, to show the inner "float" chamber with its basal entosolenian tube. The lobulated pleats of the "float" chamber, and its attachment to the Acervuline chambers, are also shown. The outer "balloon" is also attached to the lower Acervuline chambers, but does not touch the "float" at any point.

Fig. 2. The same specimen viewed from the underside or base. The "balloon" is seen partly enveloping the "float." Where a part of the "balloon" has been removed, the Acervuline chambers can be seen projecting beneath the "float."

Fig. 3. A large bottom specimen of the "Discorbine" type from Raine Island, viewed from the top. The balloon chamber is entirely hidden by the spreading Discorbine chambers.

Fig. 4. The same specimen viewed from the side.

Fig. 5. Bottom specimen from Raine Island, showing the early "Discorbine," or spiral chambers passing into the "Acervuline" type. The "balloon" projects slightly beyond the Acervuline chambers, and has been partly removed to show the lobulated "float" chamber viewed from the top.

Fig. 6. Side view of "Acervuline" specimen. Both "float" and "balloon" chambers, and also one of the Acervuline chambers, have been laid open to show the method of attachment to the Acervuline chambers.

(All the figures are drawn to a magnification of 65 diameters.)

Observations on Male Rotifers.

By W. Wesché, F.R.M.S.

(*Read April* 18*th*, 1902.)

Plates 17 and 18.

The males have only been seen in about 20 per cent. of the known species of Rotifers. As they are comparatively so rare, their appearance is always a matter of interest, both from a morphological and a biological point of view.

It is well known that the large majority of those observed are without digestive organs, but there are two, *Proales werneckii*, and *Rhinops vitraea*, which are fully equipped with mastax and stomach, and several others with the same organs have been seen, but no drawings or descriptions are yet published. It is probable that the two named will not be as exceptional as was at first thought.

Members of the Quekett Club may recall with pride that it was at one of our excursions that the first male Rotifer with digestive organs was discovered by Mr. Rousselet.

Males are difficult to observe for several reasons. 1. Their size in many cases is very minute. 2. Their movement is very quick. 3. Their appearance is in some cases very dissimilar to that of the female, several being more like infusoria than Rotifers.

Every collector has his own methods of observation. Personally I find a flat open trough on the horizontal stage of the microscope the most convenient. This, examined with a power of an inch, enables me to see the smaller animals on a fairly large field, and when I see an organism darting quickly about, I suspect a male Rotifer. Though males move at a great speed, they usually swim in a straight line, and to or from the light. They are thus brought up by the side of the trough and this is generally a favourable moment for their capture with the pipette, and transference to a compressorium for examination under higher powers.

There is also another method of securing males, namely, to watch for a female with the male egg. This is a comparatively rare production, and is more circular in shape and smaller in size than the female egg. When such a female Rotifer has been secured, it can then be isolated in a live-box. In doing this it will be necessary to give plenty of water, and see that the channel round the edge is moist. To make assurance doubly sure, the live-box may be placed under a bell-glass with some wet blotting paper, or the hanging drop method, described in Mr. Karop's useful and interesting paper which was read in March (see *ante*, p. 265), might be resorted to. This isolation is not a very severe trial of patience, as usually twenty-four hours is sufficient to hatch out the male Rotifer.

It is well known that Rotifers are parthenogenetic, and that fecundation by the male is only necessary when the resting egg is to be laid.*

Maupas made some experiments,† and satisfied himself that he could artificially bring about the production of male eggs by

* The parthenogenetic egg has a smooth surface, and has much the same appearance in all the species. The opposite is the case in the resting egg. Thus:

In *Hydatina* it is covered with hairs;

In *Rhinops* a distinct morulation is seen, and the membrane has short spined tubercles;

In *Triarthra brevispina* it is markedly morulated;

In *Metopidia solidus* it is covered with short spines;

In *Callidina plena* it is sub-oblong in shape with a domed swelling at the opposite extremities. This is given as a "resting" or "winter egg" ("winterei") because of its close resemblance to those recorded by Dr. Janson. Mr. Bryce, whose opinion carries very great weight, maintains that it is not proved that "resting eggs" occur among any of the Bdelloid Rotifera.

† "Comptes Rendus, Ac. Sci.," 1890, p. 310.

raising the temperature of the water in which the Rotifers were living to that of summer heat, 20° C = 79 F. The male made its appearance, fertilised the female, which laid the resting egg, capable of surviving in the dried-up mud of the pond, and in that condition waiting for a rainy day. But as males are often found under ice, and indeed at all seasons of the year, the theory that it is only the heat of summer which gives rise to males is untenable.

In Mr. Rousselet's list of male Rotifers published in the *Journal* of the R.M.S. there are 63 species that have been figured and described by their discoverers.* In addition to these there is a further list of 31 species that have been noted, but of which no description or figure has been published. I am now able to figure and describe three species from this second list, as well as a new mastaxed male, several specimens of which were seen by Mr. K. J. Marks and myself, but whose species we were unable to determine, though it seems fairly probable that it belongs to the Notommatadae.

The first male I have to refer to is that of *Triarthra longiseta* Ehr. It is minute, variable in size, generally inclining to be globose in form. The head is well defined, and its limits are marked by several folds of skin. The body is broad and stout. The foot is well separated from the body, without toes, but with two short setae on the orifice of the penis which goes down to the extremity of the foot. The setae are like those in *Synchaeta*, composed of a number of fine hairs. There is a large brain with a conspicuous sub-circular eye-spot.

Four powerful muscles are attached to the brain and cilia. The cilia are long and fairly strong. The dorsal antenna is connected with the brain by a flexible tube.

The lateral antennae are well marked, and have the usual tapering gland, noticeable in the female. There is no trace whatever of a digestive system. The lateral canals are well marked and the contractile vesicle large. The skin is thick but flexible. A

* Journ. R. Micr. Soc., 1897, pp. 4—9.

large spermatheca tapers down to the end of the foot, which practically forms the penis. Several of the specimens seen were rather granular in appearance, but one was exquisitely hyaline, and I was able very clearly to see the spermatozoa moving about inside the spermatheca, and to obtain a measurement of a spermatozoon, namely, $\frac{1}{1285}'' = 20\mu$.

Size $\frac{1}{273}'' - \frac{1}{360}'' = 90\mu - 70\mu$.

Habitat, pond at Neasden on private ground, February 7th and 8th, 1902.

This form is interesting as it enables us to make some comparisons with the males of allied genera. It may not be superfluous to state that *Triarthra longiseta* ♀ is one of those highly modified Rotifers which have the faculty of jerking themselves through the water by means of more or less lengthy spines. It is impossible to generalise or to formulate a law from the small amount of information available, but, judging by *Polyarthra* and *Pedalion*, it seems a rule that where the female is highly elaborated and provided with leaping spines and setae, the structure of the male is simple and has a tendency towards degeneration.

The comparatively unimportant part played by the male in rotatorial life is shown by the fact that he is quite unprovided with protective appliances, or with any of those numberless contrivances so common in insects and known as secondary sexual characters.

It is evident from the following facts, namely, that some males are supplied with digestive organs, that others have rudiments of glands and stomach, while others, like the animal just described, have lost all traces of such structures, that we have a process of degeneration going on under our eyes, and that possibly all males may ultimately degrade to the low stage represented by the male of *Polyarthra*, an amorphous body, ciliated at two extremities and provided with no structure except a spermatheca. Going even further, the male may disappear altogether, which would explain the fact that no male has been found in the Philodinadae.

A resting egg has, however, been seen, and I have myself observed one in the moss Rotifer, *Callidina plena* Bryce.*

The subject is full of uncertainty and complexity, but we might have here a very rare "reversion to an original type." If that were so, it would only be at long intervals that a male would be seen, and that male would be of the lowest type, indistinguishable from an infusorian without the most careful examination.

We now come to the second male on my list *Notommata naias* Ehr. I found this male as far back as January, 1894.

The general shape is fusiform, with a slight tendency to angularity. The head is well separated from the body, which is long in proportion to its breadth and distinctly annulated. The foot is long with four annulations. The toes are identical with those of the female, each furnished with a big gland which extends into the body some distance beyond the orifice of the penis. The cilia are moderately long, with several indistinct setae. The brain is large, and retracted by two powerful bifurcate muscles. The eye is very large, dark red, standing out from the brain (as in ♀), and there is a slight constriction where it joins the brain. The dorsal antenna seemed placed very much forward on the brain, but was not distinct. The lateral antennae were quite clear, and on the lower part of the body. Below the brain was a granular mass, and adjoining were some nebulous glands which seem to be the remains of the digestive organs. The vascular system was distinct, but no contractile vesicle could be seen. The spermatheca was very large, extending well into the middle of the body.

Size $\frac{1}{120}'' = 212\mu$.

Habitat, pond at Neasden. Seen in January, 1894, and March, 1902.

The third male is that of *Notops hyptopus* Ehr. (The generic name *Notops* is now altered to *Gastropus* by Dr. Weber.) The male has much the same shape as the female, *i.e.*, a rather globular sack. The head is defined by folds of skin which can

* See, however, note, p 324.

be traced on the surface. The body is globose, with a tough skin, which it requires some imagination to describe as a lorica. There is a fold of skin on the dorsum. Strictly speaking the foot is absent, but its place is occupied by the penis. The cilia are very long and filiform. The brain is exceedingly large, and comes down in an elongated mass from the front. At its lower extremity a very large reddish-black granular mass seems to concentrate into a dark red eye on the ventral side. Four powerful muscles are attached to the brain and cilia. The antennae are as in the female. There are some minute glands below the orifice of the penis on the ventral side. A curious circular gland, connected with the brain by a long muscle, may have some relation to the contractile vesicle. The penis, which is rather long, is ciliated and kept retracted. On pressure being applied it was protruded through an opening which corresponds with the orifice of the foot in the female. I was able to see the spermatozoa individually in the spermatheca.

Size $\frac{1}{200}'' = 127\ \mu$.

Habitat, pond at Neasden, March 29th, 1902.

I will now give a description of the mastaxed male, which also came out of this very prolific pond. The general shape is fusiform. The animals seen were singularly hyaline, and both Mr. Marks, who had two individuals under observation, and myself had the greatest difficulty in making out detail. As I said before the whole type is that of a *Notommata*. The constriction of the integument which defines the head was decided. The body is annulated—four constrictions were noted.

The foot is long, without annulations. The toes are much the same shape as in *N. naias*; the toe glands, the ends towards the front, when viewed laterally, appear bluntly pointed. The cilia are long and fine. The brain is very large, white, and opaque.

There is no eye. The antennae were not made out. The mastax is fairly large and well forward under the brain. Owing to the very muscular and dense structure, the details of the trophi could not be seen. This difficulty was rendered quite insuperable by the animal continually snapping and protruding the mastax, so that the trophi were not quiet for a fraction of a second. The oesophagus was moderately long, and the stomach seemed composed of a number of circular organs, in each of which was a dark pellet. The lower end of the stomach was hidden by the spermatheca. The lateral canals were clearly seen, but no contractile vesicle. The spermatheca was so crowded with spermatozoa that only the circular heads of the latter could be made out. The penis had a ciliated orifice. This opening was situated lower down the foot than usual. The size was large, $\frac{1}{163}'' = 156\ \mu$.

Habitat, pond at Neasden, February 7th, 1902.

Most male Rotifers, as might be expected from their peculiar organisation, are peaceable and inoffensive in disposition. I am sorry to find an exception to the rule in the animal under notice. Mr. Marks had two of this species under observation, and had the following experience, which I give in his own words :—

"On the 8th February, 1902, I was observing some Floscules, and noticed two male Rotifers, similar to that seen at Mr. Wesché's on the previous evening. I was not able to press either of them sufficiently in the live-box to fix them for accurate observation. They were colourless; had a mastax, small stomach, lateral canals with several tags. One of them attacked a Floscule, which retreated at once, but the aggressor fixed his mastax to the setae and several times nearly managed to pull the head of the Floscule out of the tube, but was unable to effect his purpose, though he tried for at least five minutes. His movements were very lively. He measured $\frac{1}{160}'' = 158\mu$. There were many Rotifers almost similar in appearance to *N. naias* in the same water."

My notes state that the water contained some *Notommata collaris*, which may possibly be the Rotifer alluded to by Mr. Marks, but I have no evidence, morphological or otherwise, to establish a relationship between the animals.

It has been pointed out to me that the nomenclature of this Rotifer is impossible till the female has been found, and consequently the publication of its observation is premature. To this I demur on several grounds. 1. The animal has a mastax and stomach, and this is so rare as to be remarkable. 2. The size is so large that an inexperienced observer might easily mistake it for a female, and the record would be of use in putting him right. 3. The habits are very peculiar, similar actions never having been hitherto recorded in the male.

Explanation of Plates.

Plate 17.

Fig. 1 *a.* *Triarthra longiseta* ♂, lateral view × 600.
,, 1 *b.* ,, ,, ♂, dorsal view × 600.
,, 2 *a.* *Notommata naias* ♂, dorsal view × 420.
,, 2 *b.* ,, ,, ♂, lateral view × 420.

Plate 18.

,, 3. *Notops* (Ehr.) / *Gastropus* (Weber) } *hyptopus* ♂, lateral view × 350.
,, 4 *a.* New male, dorsal view × 600.
,, 4 *b.* ,, ,, lateral view × 600.
,, 5. Resting eggs of various species.
a. *Hydatina senta.* *b.* *Rhinops vitraea.*
c. *Triarthra brevispina.* *d.* *Metopidia solidus.*
e. *Callidina plena* ?

Simple Methods of Focometry and Apertometry.

By Frederic J. Cheshire.

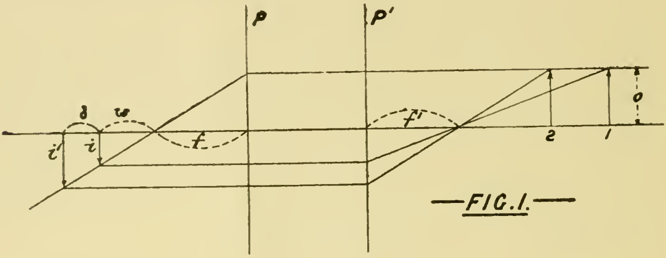
(*Read May 16th*, 1902.)

In presenting the following simple methods of microscopical focometry and apertometry to your notice, I would, in the first place, observe that they are the outcome of considerable experience and numerous experiments extending over the last two or three years. I may claim for them then, I hope, that they are something more than mere paper methods; in fact, I am sanguine enough to think that, so far as the subject of apertometry is concerned, I shall be able to present to you a very simple and inexpensive method by which any one can, with care, determine and compare the N.A's of dry objectives to a degree of accuracy quite sufficient for all practical purposes.

Focometry.

Some of the methods to be subsequently described for determining N.A. necessitate a careful preliminary determination of the focal lengths of objectives and condensers. These I find, in practice, are best found by using the microscope as a simplified but less accurate modification of the focometer invented by Abbe, and described in the *Journal Roy. Mic. Soc.*, 1892. This modification, which does not appear to be known to microscopists to the extent that its merits deserve, I first saw described in a publication some three or four years ago; but unfortunately I have lost the reference, and am therefore unable to do the author the justice of mentioning his name.

Abbe's focometer is based upon the fact that if an image of an object is produced by a lens system, first in one plane normal to the axis, and then in another, the focal length of the system is equal to the distance between these two image-planes divided by the difference of the magnifications.* Fig. 1 is a diagram which represents the production of an image of an object by an optical system with principal planes P and P^1. The object of length o is first supposed to be at (1), giving an image i, and is then supposed to be moved to (2) to give an image i^1 in a plane at a distance δ from the first image-plane; f and f^1 equal the focal lengths of the system, and ω the distance between the principal focus of the image-space and the first image-plane. Two rays are drawn as usual from a terminal point of the object—one parallel to the axis to the second principal plane P, and then through the second principal focus; and the other through the first principal focus to the first principal plane P^1, and then parallel to the axis.



—FIG. I.—

When the object is at (1) the magnification—

$$M = \frac{i}{o} = \frac{\omega}{f} \qquad \dots \qquad \dots \qquad (1)$$

and when at (2) the magnification—

$$M_1 = \frac{i_1}{o} = \frac{\omega + \delta}{f} \dots \qquad \dots \qquad (2)$$

Deducting equation (1) from (2)—

$$M_1 - M = \frac{\omega + \delta - \omega}{f} = \frac{\delta}{f}$$

Whence $$f = \frac{\delta}{M_1 - M} \qquad \dots \qquad \dots \qquad (3)$$

Using the microscope, then, the magnifying power of the objective is first determined with the draw-tube pushed in. This may be done by placing a sheet of ground glass on the top of the

* Actually, in Abbe's focometer, it is the distance between two object planes that is measured, but this obviously does not affect the principle involved.

draw-tube, from which the eyepiece has been withdrawn, and then focussing and measuring the image of a stage micrometer scale upon it. It may also be done with an ordinary negative micrometer eyepiece, provided the field lens of it be first removed. The best method, however, is to have a hand-magnifier, such as Zeiss' ($\times$ 10), mounted as an eyepiece, with the usual eyepiece scale in its focal plane. The magnification having been determined for the short tube by one of these methods, the draw-tube is then pulled out to its full extent, and the magnification again found. Let the short-tube magnification equal M, and the long-tube magnification equal M_1, and let δ equal the distance in millimetres (or inches) through which the draw-tube has been pulled out, then the focal length f, from what has been already shown, is obtained from equation (3) above.

It should be noted that this result is independent of any interval which may occur between the principal points of the objective, and also of the distance through which the objective is moved to focus the image in the second plane. In the case of an immersion lens, as is evident from the diagram, it is the back or upper focal length that is determined, not the lower.

The method may be employed for finding the focal length of an ordinary Huygenian eyepiece by fitting the nose of the microscope with a short tube, or adapter, in which the eyepiece can be pushed to be used as an objective, with the eye-lens directed to the micrometer on the stage. A condenser may in a similar way be fitted to the microscope, and have its focal length determined. It is advisable to stop down eyepieces and condensers before making these measurements, in order to get a well-defined image of the divisions of the stage micrometer scale.

Determination of the Focal and Principal Points of Objectives, Eyepieces, etc.—Fit the body of the microscope with an eyepiece and low-power objective in the usual way, and then, after removing the optical part of the sub-stage condenser, screw the objective under examination into an adapter-ring fitting the stop-ring of the condenser; or let it rest approximately in the axis of the instrument on a 3×1 slip on the stage of the microscope. The *plane* mirror should then be manipulated to direct light from a distant object (brickwork, say, on the opposite side of the road) along the axis of the microscope. If the objective is placed with its anterior lens uppermost, *i.e.*, in such a position that light passes through it in the opposite direction to that in which it passes when in ordinary use, an aerial image of the distant object will be formed at its lower* principal focus. The microscope body should then be adjusted to focus this image in exactly the same way as an ordinary object is focussed. Then, having noted the position of the body of the microscope, rack it down until the dust on the first lens surface is in focus. The distance racked down, which is best determined by means of a scale carried by the body, is equal, of course, to the distance between the principal focus and the first lens surface. The objective should now be reversed, so that the light passes through it in the opposite direction, and the experiment repeated to determine the position of the upper principal focus with respect to the outer surface of the posterior lens of the objective. In Huygenian eyepieces the lower, and in high-power objectives in general the upper principal focus is virtual, *i.e.*, parallel incident rays do not converge to a point outside the optical system, but they *appear* to diverge from a point within it. Experimentally, however, the only difference is that the microscope body must be racked up, and not down, to focus the dust upon the lens surface after focussing the image of the distant object.

Having determined the positions of the focal points of an objective, etc., of known focal length, the positions of the principal points can be readily determined by setting off the focal length along the axis, from each focal point in turn, in the opposite direction to that in which light must pass through the objective to produce an image at the focal point from which the measurement is made.

Optical Tube-length.—Instead of determining the positions of the focal and principal planes with respect to the lens surfaces, it is generally more convenient, in the case of objectives, to do so with respect to the face of the flange which butts against the nose of the microscope body. This can be done by focussing in succession the picture in the upper focal plane and the face of the flange, and measuring the necessary body displacement. The

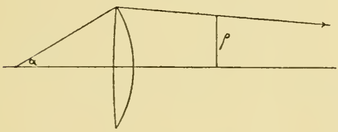
* Throughout this paper the two foci of condensers, objectives, and eyepieces are distinguished by the words "upper" and "lower," which have reference to the positions occupied by the foci in a microscope in ordinary use.

positions of the focal and principal planes of an eyepiece can be similarly determined with respect to the flange of the eye-lens, which rests upon the top of the draw-tube. If, then, the mechanical tube-length L is known, the distance d of the upper focal plane of the objective below, say, the flange, and the distance d^1 of the lower focal plane of the eyepiece below the flange of the eye-lens, it is obvious that the optical tube-length, *i.e.*, the distance between the upper principal focus of the objective and the lower principal focus of the eyepiece, must be equal to $L + d - d^1$.

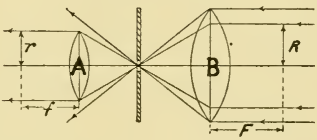
Apertometry.

The methods of apertometry which I am about to describe are based upon the use of a condenser scale, in the way, I believe, first suggested by myself, and very briefly described by Mr. Angus in the last number of this *Journal* (*ante*, p. 211). I have

—FIG. 2.—



—FIG. 3.—



during the last few months been working at the method with a view of determining its limitations, and the precautions to be observed to ensure the most accurate results. To understand and appreciate these, it will be necessary for us to consider for a moment the theory of the method.

In the case of an aplanatic microscope objective (Fig. 2), let α equal the semi-angle of the maximum cone of light which it can take up from an object in a medium of refractive index μ, and let ρ equal the radius of the disc of light in the upper focal plane. By a well-known equation, if f equal the back or upper focal length, the numerical aperture is obtained from

$$\text{N.A.} = \mu \sin \alpha = \frac{\rho}{f}$$

Now let us consider two such lens systems A and B (Fig. 3), with a common focal plane and parallel incident light. Further, let us suppose that each system is spherically corrected for light converging to the common focal point. The system B is shown transmitting a cone of light of greater N.A. than the system A can take up. The effective and equivalent semi-apertures are R and r respectively, and for these the N.A's must obviously be equal, thus:—

$$\frac{r}{f} = \frac{R}{F}$$

$$\text{or } \frac{R}{r} = \frac{F}{f} = \text{a constant.}$$

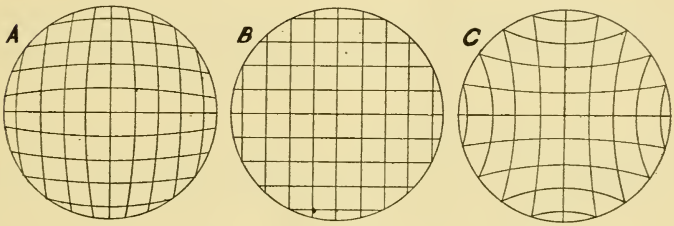
In other words, any ray passing through the system will pass through the outer or posterior focal planes at distances from the axis having a constant ratio. It follows from this, that, if by means of a stop in the common focal plane the image-forming rays are restricted to those which upon incidence are practically parallel to the axis, a number of equidistant parallel lines, such as a scale, in one posterior focal plane will be projected as equidistant parallel lines—*i.e.*, orthoscopically—in the other. Now let us suppose that F is known, and that a scale is placed in the focal plane R. Then to determine the N.A. of the lens A, it would only be necessary to examine in its focal plane r the image of the scale at R, and to read off the length projected, say 2R, as a diameter of the disc of light seen. Since the N.A. of the lens $A = \frac{r}{f} = \frac{R}{F}$, it could thus be obtained by dividing the length 2R by twice the focal length F.

Now, given a sub-stage condenser spherically corrected for its principal focus, it is obvious that this method could be carried out practically by placing a scale of length *accurately* in the lower focal plane, which should be that of the stop-ring,* and projecting it into the upper focal plane of an objective. Unfortunately, however, those condensers (achromatic) in which this correction is best made have a virtual lower focus, at which it is therefore impossible, physically, to place a scale. It is a remarkable and fortunate fact, however, that by adjustment of the axial distance between the condenser and the objective, Abbe's two-lens chromatic condenser can in general be made

* This is important, because otherwise the magnification would vary with the axial distance between the objective and condenser.

to give a sufficiently orthoscopic image of an object placed in its lower focal plane, which in this form is outside the lens system, and therefore accessible. The following experiment can be made to show this: Take a disc of wire gauze of about 30 to the inch, and place it in the stop-ring of the condenser. Screw an objective, say $\frac{1}{6}$ inch, on to the nose of the microscope, and drop a stop with a hole in it of about $\frac{1}{10}$ inch in diameter into a low-power eyepiece. Then rack up the condenser until it practically touches the objective. Upon now examining, with a hand-magnifier, the image of the gauze in the eye-ring (that disc of light just above the eyepiece), it will probably be found to have slight barrel-shaped distortion, A, Fig. 4.

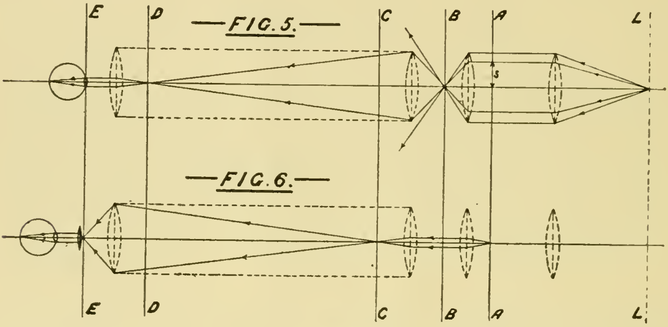
—FIG. 4.—



If now the condenser is racked carefully down, the lines first become straight (B), and then pass into waist-shaped distortion (C, Fig. 4).

The rectilinear or orthoscopic image B can be obtained in this way with all dry objectives that I have been able to test. Its attainment with the object gauze at the lower principal focus of the condenser is a necessary preliminary to a trustworthy determination of an N.A. by the condenser-scale method, now to be described. Let us, for the sake of simplicity, represent the optical elements of a compound microscope—the bull's-eye, sub-stage condenser, objective, and eyepiece—conventionally by a single lens each (Figs. 5 and 6). A-A is the lower focal plane of the condenser and the plane of the stop-ring; B-B, the object plane and the lower focal plane of the objective; C-C, the upper focal plane of the objective; D-D, the lower focal plane of the eyepiece; E-E, the plane of the eye-ring, and approximately the upper focal plane of the eyepiece; and L-L, the plane of the light source. Fig. 5 shows the path of the light rays, by which the retinal image of the axial point of an object on the stage is formed; and Fig. 6 similarly shows the path of the light rays proceeding from the axial point of the scale in the condenser, and the eye-ring being examined with a hand-magnifier.

Now, since the condenser has a greater N.A. than the objective, it follows that the cone of light transmitted by the condenser is more than sufficient to fill the objective, *i.e.*, an outer annulus of the condenser opening is non-effective. The effective opening, so far as the objective is concerned, is limited to that diameter S,*



which transmits the maximum cone the objective can take up, and the N.A. of this cone is equal to the working N.A. of the condenser, that is, the diameter S divided by twice the focal length of the condenser.

Now the length S is projected into the upper principal focal plane of the objective, and also into the plane of the eye-ring, in either of which it may be read off. The first method of reading off this length S, I will distinguish as the back-focus method, and the second as the eye-ring method. In the back-focus method the length S may be read off by fitting the lower end of the draw-tube with a low-power objective, to make, with the eyepiece, an auxiliary microscope. In the eye-ring

* In Fig. 5, *S* is shown as a radius in error.

method the length can be read off directly and simply with a powerful hand-magnifier, such as a × 16. Whichever method is, however, adopted, it is of the utmost importance that the apex of the cone of light entering the objective should be sharply defined, for reasons fully set out by Abbe in his paper on Apertometry published in the *Journal Roy. Mic. Soc.*, 1880. This may be done in the back-focus method by fitting the auxiliary objective with a small stop, just within its back-focus, as is done by Zeiss in the objective he supplies for use with the apertometer. In the eye-ring method it can be done in a more simple, but not less effective way, by dropping a small stop of a diameter of about 3 mm. into the eyepiece, so as to be at the principal focus of the eye-lens. In whichever position the stop is placed its projected image functions as the stop shown in Fig. 3. By both methods the determination is very much facilitated by completely filling the objective with light. This can easily be done, even when using Abbe's chromatic condenser, by using as a source of light either (1) the sky, or (2) a strongly illuminated sheet of ground glass at the principal focus of the bull's-eye.

Calibration of the Condenser Scale.—In whatever way the length of the condenser scale projected is found, a determination of the N.A.-equivalent of 1 mm. of that scale should have been previously made. This may be done by one of the three following methods:—

I. Use an objective of known N.A. to project the condenser scale in the way, and with the precautions already described. The length S divided into the known N.A. gives the N.A.-equivalent to be found.

II. Rest a cover-glass on the top lens of the condenser. Lower an immersion lens, with oil between as usual, on to the cover-glass. Adjust for the critical image of the gauze with the fine adjustment. Under these conditions a thin layer of air is left between the cover-glass and the condenser, the N.A. of which is thus cut down to 1·0. The N.A.-equivalent to be found must therefore equal the reciprocal of the length S.

III. Find the focal length f of the condenser in the way described in the first part of this paper. Then, since at any time the working N.A. of the condenser is equal to $\frac{S}{2f}$, it follows that the N.A.-equivalent of the scale is equal to the reciprocal of twice the focal length.

The first method is probably the best, especially if several objectives of known N.A. are available, so that a mean value of the N.A.-equivalent can be obtained.

Now the eye-ring method requires the minimum amount of auxiliary apparatus and on the whole probably gives the most reliable results; it is therefore to be preferred. In practice, then, the N.A. of an objective should be determined as follows:—

(1) Use as a light source the sky, or an illuminated sheet of ground glass, at the principal focus of the bull's-eye, *i.e.*, in place of the ordinary flame.

(2) Screw on the objective to be tested, insert the wire-gauze disc in the stop-ring, and the stop in the low-power eyepiece.

(3) Rack up the condenser until it practically touches the objective; then, whilst viewing the eye-ring with a hand-magnifier, rack back the condenser to the *furthest* point at which the gauze is orthoscopically projected, *i.e.*, to the point at which the image is about to show waist-shaped distortion.

(4) Replace the gauze by the condenser scale and read off the length S projected.

(5) Mutiply the length S by the N.A.-equivalent of the scale to obtain the N.A. of the objective.

To determine whether this condenser-scale method is equally reliable throughout the range of the N.A's of dry objectives, five objectives were taken, ranging in N.A. from 0·26 to 0·90. The N.A. of each was first determined by Abbe's apertometer in the usual way. An Abbe's chromatic condenser, of a focal length of 13·4 mm., as determined by the method described in the early part of this paper, was then taken, and a $\frac{1}{2}$ mm. scale carefully adjusted in its lower focal plane. The length S of this scale projected into the upper focal plane of each objective was then determined. This length for each lens was then divided into the corresponding N.A. to obtain the N.A.-equivalent of 1 mm. of the scale S. The *average* value (0·038) of the N.A.-equivalent thus found was then multiplied by the length S to obtain figures for comparison with those obtained by the apertometer. The results are given in the above order in the first five columns of the following table :—

Objective.	N.A. (by Abbe's Apertometer).	Length S mm.	$\frac{\text{N.A.}}{\text{S.}}$	S × N.A.-equivalent of Scale (0·038).	$\frac{\text{S}}{2 \times 13{\cdot}4.}$
1	0·26	6·9	·0377	0·26	0·26
2	0·46	12·2	·0377	0·46	0·46
3	0·80	20·7	·0386	0·79	0·77
4	0·90	23·7	·0380	0·90	0·88
5	0·90	23·8	·0378	0·90	0·89

Finally, in the last column the results obtained by dividing the length S by twice the focal length of the condenser are given. It will be remembered that this method does not necessitate the calibration of the condenser scale, and is therefore the simplest.

For the ready determination of N.A.s by the method I have described, I would suggest the use of a glass disc fitting the stop-ring and ruled in $\frac{1}{2}$ mm. or I mm. squares on its upper surface and ground on its lower. Such a disc, in addition to its use as a scale, would also serve the purpose of the wire gauze, and render unnecessary the special precautions as to lighting.

A condenser, having been calibrated, should be marked with the result. For example, the one used in the above experiments would be marked "1 mm. = 0·038 N.A."

In conclusion, allow me to say a word as to the limitations of the methods I have described. For general applicability and accuracy throughout the whole range of N.A., that simple and beautiful instrument—Abbe's apertometer—must stand unrivalled. It represents, in my humble opinion, the *ne plus ultra* of apertometers, but it is, unfortunately, expensive, and must be so. There is, however, a large class of microscopists, whose objectives are practically confined to dry ones, who would, I venture to think, be glad to be able to compare and determine the N.A's of their objectives, and to satisfy themselves that they are what they profess to be. To that class my paper is addressed.

My thanks are due to Mr. Curties and Mr. Angus for their courtesy in placing at my disposal apparatus necessary for my experiments. To a late pupil of mine, Mr. Hailes, I am under obligation for the careful drawing of the various diagrams.

The Preparation of Serial Sections of Insects, based upon Experiments with the Blow-fly.

By Brigade-Surgeon J. B. Scriven.

(*Read June 20th*, 1902.)

As many members of the Quekett Club have asked me about the mode of setting up the preparations I have exhibited from time to time at our meetings, I have thought it worth while to write a short paper on the subject. The matter, however, has been so well treated by Dr. Benjamin Thompson Lowne in his interesting book on "The Anatomy and Morphology of the Blow-fly," * that it will only be necessary for me to touch upon certain points, in which further experience has opened up new knowledge, or suggested improvements on former methods. Dr. Lowne himself was aware of certain defects in his plan of operations; more especially he lamented the immense amount of labour and time they involved, and he implied that future observers would do well to try and simplify them. This object has to some extent been attained in the methods I am now about to describe. Let us consider—

1. *Certain preliminary measures.*—An insect is most conveniently killed by chloroform. The proceedings immediately afterwards differ a little, according to the stage of its existence. A maggot should be boiled for five minutes in water,† and then dropped into methylated spirit. After twenty-four hours in this, it should be cut through, or a slice taken off with a sharp razor, in the direction in which thin sections are to be made. It should then be put into absolute alcohol (to be changed every twenty-four hours) for at least three days. Boiling drives out the air effectually from the maggot, and coagulates its albumen.

A pupa should likewise be boiled, but slowly: for rapid boiling sometimes bursts the shell and spoils the contained nymph. Boiling, however, does not remove the air so thoroughly as in the

* Pp. 93-8 and 347-50.
† Lowne, p. 94.

larva. The pupa also should now be put into methylated spirit, and, if it be five days or more old, a small opening may be made in the shell after about four hours, and it may be again put into the same medium.

Next day the shell can be removed, and a slice taken off the nymph, which should now, as in the case of the maggot, be put into absolute alcohol for three days.

If the pupa is younger, and the shell adherent so that it cannot be separated, the whole may be cut through after twenty-four hours in the methylated spirit, and then dropped into absolute alcohol.

The imago (which ought to be a newly-hatched one) should not be boiled, but at once put into methylated spirit. In twenty-four hours it also may be cut through, and dropped into absolute alcohol. As soon as this has been done, the nymph, or imago, should have its air exhausted by an air-pump or exhausting syringe; otherwise cavities may remain, even after imbedding.*

2. *Imbedding.*—If the specimen is to be stained on the slide, it is now ready for imbedding; if to be stained in bulk, this is the time for it, and it must be dehydrated again afterwards. In either case, when the hardening has been sufficiently carried out, it should be placed in about one fluid drachm of absolute alcohol in a small capsule on the water oven, and heated to the melting point of the imbedding medium, which ought to be kept liquid on the same oven. The specimen may then be transferred direct to the melted medium with an ordinary lifter. No intermediate process, such as soaking in ether, chloroform, or cedar oil, is necessary or desirable. It must be kept in the melted material till bubbles of spirit, if there be any, have ceased to rise: an hour may be enough, but $2\frac{1}{2}$ hours is a safer time. Often no bubbles are visible from first to last.

As an imbedding medium pure paraffin has found most favour with microtomists. Professor Bolles Lee says it is better than "any of the many mixtures with wax and the like that used to be recommended."† Its tendency, however, to form vacuoles in cooling is to my mind a great objection, as these often injure greatly

* Dr. Lowne says that latterly he has not used the exhausting syringe ("Anatomy and Morphology of the Blowfly," p. 350).

† "Microtomists' Vade Mecum," 5th edition, p. 115.

the delicate tissue of the fly. For this reason, a few years ago, I set myself to inquire whether some as yet untried combination might not be more satisfactory. I found that a compound, such as had been used by many before me, of paraffin (melting point 45° C.) 60 grains and white wax 30 grains was a good basis to build upon. This mixture alone, though it did not form vacuoles, had a tendency to crack on cooling; but the addition of exceedingly small quantities of certain other materials quite prevented this. Thus, one or two minims of a weak solution of caoutchouc was perfectly effectual. Three grains of camphor produced the same result. For most of the preparations I have exhibited here, the mixture of paraffin, wax, and caoutchouc, has been employed, being the more easily prepared.

The melting point of both these mixtures is 48° C. I always cooled them slowly, simply putting the containing capsules on a wooden table at the temperature of the laboratory, which I generally kept at about 16° C., and I never found them form vacuoles. My object was to get a good medium, suitable for cutting at this temperature; and for a long time I felt fairly satisfied. Nevertheless I could not help observing that sometimes the imbedded insect was too hard, causing the sections to tear in cutting; so I reduced the quantity of wax and added a little creasote, and my most recent specimens, which are much better than my earlier ones, have been imbedded in a material of which the following is the composition :—

Paraffin (45° C.)	80 grains.
White wax	10 ,,
Anhydrous creasote	2 minims.
Solution of caoutchouc in pure benzol (1 gr. to 5 fl. drachms)	2 ,,

This combination has all the advantages of those mentioned above, without the drawback of being too hard, and its melting point is 3° lower, viz., 45° C.

3. *Stretching, Fixing, and Mounting.*—My sections, which are all made with the Cambridge rocking microtome, lose about $\frac{1}{8}$ of the width of the block, from which they are cut, in consequence of wrinkles or compression from the impact of the knife. Professor Lee has told us how to obliterate the wrinkles and restore the

width by means of warm water,* as well as how to combine this process with the use of Mayer's albumen and glycerine; and I find that sections of the fly can thus be very successfully dealt with.

A still greater improvement on the old methods, however, as he further shows, is not only to stretch, but also to fix the sections by means of warm water on a clean slide, without any adhesive material. This also is applicable to the fly; in fact, it is so much better than Mayer's plan, that I think the latter may be discarded altogether; for the adhesion is much stronger on the clean side, if the proceeding be conducted with sufficient care, always understanding that the sections are good, *i.e.*, not torn or injured, as by cutting with an insufficiently sharp knife.

To carry out the process successfully, it is necessary to be very particular about the cleanliness of the slides, as Professor Lee points out. Nevertheless I have not found it worth while to follow him to the letter, and have never rejected a slide because a line of water, or the breath, would not lie evenly upon it. Few slides, it appears to me, come up to this ideal condition. The temperature of the water used ought not to exceed 17° C. below the melting point of the ribbon laid upon it: anything above this is dangerous to its integrity. I cover the whole slide with cold water, which is much easier than making a line of water, as Professor Lee recommends. I then lay the piece of ribbon upon it, or two pieces side by side, and put the slide on the top of the water oven under a glass shade, not completely preventing communication with the air of the room. There I leave it in the horizontal position,† and do not touch it (except it be to keep the ribbon in place with a camel-hair brush) till the water has evaporated and the whole thing is dry, which occupies about $2\frac{1}{2}$ hours. Any attempt to remove superfluous water with a brush, or to drain it away, as by setting the slide on end, seems to me to diminish the strength of the adhesion. Professor Lee says that tap-water is better than distilled: it leaves a little deposit of chalk about the edges of the ribbon, (not under the sections), which can be removed at a later period under water, partly with

* "Microtomists' Vade Mecum," 5th edition, pp. 113 and 140 *sqq*. See also Carpenter's "The Microscope and its Revelations," 8th edition, by the Rev. Dr. Dallinger, pp. 501, 502.

† Much trouble may be saved by using a spirit level.

the finger, and partly with a fine piece of stick like a lucifer-match cut to a chisel edge. When the slide and ribbon are perfectly dry, the imbedding material may be melted, and dissolved away while hot, by a rapid flooding with benzoline,* which in its turn can be washed off just as quickly with absolute alcohol. If the specimen has been stained in bulk, oil of cloves should now be applied, as recommended by Dr. Lowne, the slide set on end to drain for six hours, and the mounting completed with Canada balsam. Sections, to be stained on the slide with Ehrlich's logwood, have to undergo seven more processes than those stained in bulk, and the risk is proportionally increased.

After they have been washed with alcohol to remove the benzoline, they have (1) to be washed with methylated spirit; (2) to be stained; (3) to be plunged into acidulated water; (4) to be placed in running tap-water for thirty minutes. Then they must be brought back to the dehydrated condition, for which purpose we use (5) proof spirit; (6) pure methylated spirit; (7) absolute alcohol. After this the oil of cloves may be applied, and the mounting completed in the same way as for specimens stained in bulk.

Of the above seven processes, the second, third and fourth are the most dangerous to the sections, though damage can generally be avoided if adhesion be firm; and with good sections it usually is so firm, that a second staining, after the running water process, may be practised with safety.

It will be found, on comparing the methods recommended in this paper, with those described by Dr. Lowne in his book (pp. 93 to 98), that time and labour are saved and risk of failure diminished.

Thus (1) the preparation of the specimen by soaking in chloroform or other agent is done away with altogether; (2) the time required for imbedding is reduced from "twenty-four hours or longer" to a much shorter period, commonly to about 2½ hours, and this object is effected at the temperature of 45° C. instead of 54° (130° Fahr.); (3) the removal of the imbedding material from the slide, by soaking in turpentine for "from one to twenty-hours," is replaced by a rapid flooding while hot with benzoline; (4) the removal of the turpentine by immersion in methylated

* This has been used by other microtomists, but is objected to by Dr. Lowne on account of its inflammability (p. 350).

spirit for "ten minutes," is replaced by an almost instantaneous flooding with absolute alcohol to remove the benzoline; (5) air cavities in the specimen are avoided by using the exhauster; (6) the danger of vacuoles is eliminated; (7) the use of an adhesive material and of No. 4 bath *before* staining * is rendered unnecessary; (8) wrinkles are obliterated.

Against these obvious gains must be put the time, amounting to about $2\frac{1}{2}$ hours, spent in stretching and fixing. Still, considerable benefit remains in the shortening of the aggregate time occupied by all the proceedings, in the larger percentage of success, and the more satisfactory results.

* The object of using Dr. Lowne's No. 4 bath at this stage of the proceedings was to prevent the staining of the adhesive material.

Note on a Method of using Abbe's Apertometer.

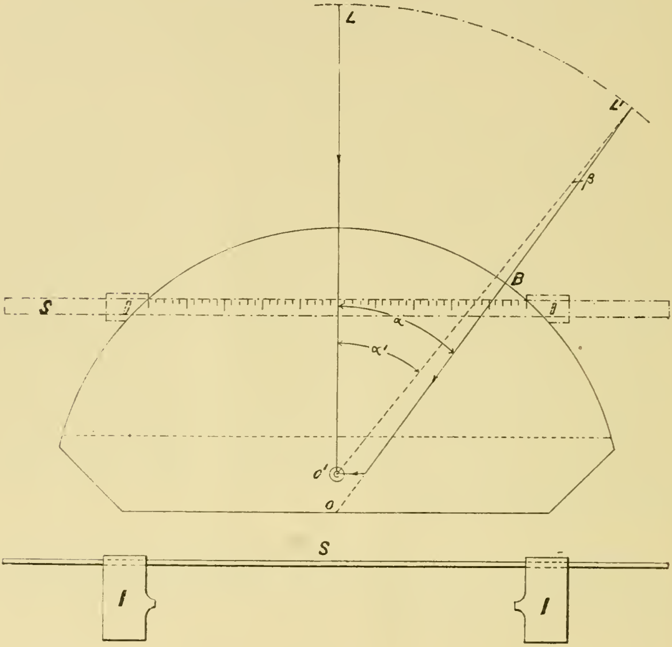
By Frederic J. Cheshire.

(*Read May 16th*, 1902.)

On pp. 395–6 of the 8th edition of "The Microscope," by Carpenter-Dallinger, a method of using Abbe's apertometer is described, which consists in placing it upon the graduated rotating stage of a microscope, and using as an indicator the edge of a fixed lamp flame. The stage is rotated to bring the indicator from the centre to the edge of the field, and the N.A is calculated from the angle through which the stage is rotated, upon the supposition that it is equal to the semi-angle of the maximum cone of light in the glass which the objective can take up. This method, however, if employed without certain precautions being taken, is subject to an error, which under certain conditions becomes serious.

Let the figure show a plan of the apertometer in use in the way described. Let L be the lamp and D its distance from the centre O′ of the focussing disc.

Now the centre of the circular edge of the apertometer is not the centre of the focussing disc, but a point O midway along the back edge. Suppose that the objective, being tested, can take up the cone of light from the glass, the semi-angle of which is α, the limiting ray then must pass along the line OB, making an angle α with the line OL, before striking the inclined reflecting edge of the apertometer. Now about O′ describe a circle with a radius D intersecting the line OB produced at L′, and draw O′L′. In rotating the apertometer about an axis passing through the point O′, *i.e.*, about the optical axis of the microscope, the flame at L will be seen until light from it passes along the line OB, that is, until the point L′ coincides with L. From the figure it is obvious that this will be the case when the apertometer has been turned through the angle α', which is equal to the true aperture angle α plus the small angle β. The angle read off on the stage, therefore, will always be in *excess* of the true angle by the angle β.



Now $\sin \beta = \dfrac{d \sin \alpha}{D}$ ... ... (1)

Where d equals the length OO′.

Since the real numerical aperture (N.A.) equals $\mu \sin \alpha$, and the found (N.A.[1]) equals $\mu \sin (\alpha + \beta)$.

$$\frac{\text{N.A.}^1}{\text{N.A.}} = \frac{\sin(\alpha + \beta)}{\sin \alpha} = \frac{\sin \alpha \cos \beta + \cos \alpha \sin \beta}{\sin \alpha}$$

$$= \cos \beta + \sin \beta \frac{\cos \alpha}{\sin \alpha} \quad \dots \quad \dots \quad (2)$$

Since the angle β never exceeds a few degrees $\cos\beta = 1$ to a first approximation, and from (1) $\sin\beta = \frac{d \sin a}{D}$, thus finally:—

$$\text{N.A.}^1 = \text{N.A.} + \text{N.A.}\frac{d \cos a}{D}$$

$$= \text{N.A.} + \frac{\mu\, d \cos a \sin a}{D} \quad \ldots \quad (3)$$

The determined N.A. is thus always in excess of the true N.A. by the quantity represented by the last term of equation (3). This quantity for a given lamp distance becomes a maximum when $a = 45°$, that is for N.A's just over unity. In the limiting case, when D is as small as possible (a fixed indicator on the stage, say), and a also is small, the error may amount to more than 10 per cent. With a lamp a foot away the error in general is not more than from 1 to 2 per cent., but it increases rapidly as D is diminished, and diminishes slowly as D is increased.

The various attempts that have been made from time to time to improve upon Abbe's apertometer, or his method of using it, have not met with such success as to encourage further efforts in the same direction, but it may be pointed out that the auxiliary objective and stop may be dispensed with by dropping a stop of about 3 mm. diameter into a low-power eyepiece—the lower the better—and examining the image of the circular edge of the apertometer disc in the eye-ring by means of a powerful hand magnifier. This method has the further advantage that it does away with the necessity for withdrawing the draw-tube to screw in the objective after focussing. Further, an ungraduated apertometer disc * may be substituted for the usual graduated one by mounting the two indicators, 1,1, to slide on a scale S † and using it as shown in broken lines to measure the chord of the maximum aperture angle. Now the N.A. to be determined is equal to $\mu \sin a$, where a is half the angle subtended by the chord. Therefore $\sin a$ equals the chord divided by twice the radius of the disc, thus the

$$\text{N.A.} = \text{Chord} \times \frac{\mu}{2 \times \text{radius of disc}}$$

$$= \text{Chord} \times \text{a Constant.}$$

* Zeiss, cost 25*s.*

† Brown & Sharpe, 100 mm. divided into fifths, cost 1*s.* 10*d.*

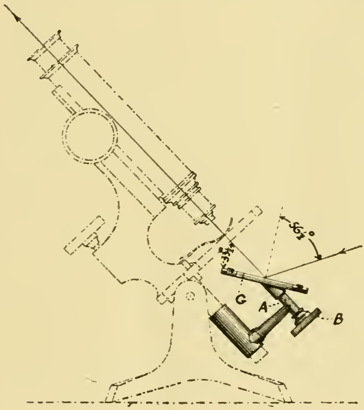
Knowing the radius of the disc in millimetres and the refractive index of the glass, it is then only necessary to divide the latter by twice the former to obtain the N.A. equivalent of one millimetre of chord. Thus a disc in my possession has a radius of 46·2 mm. and a refractive index of 1·62. Consequently 1 mm. of chord is equivalent to N.A. 0·0175. In any determination with this disc, therefore, I simply adjust the indicators on the scale until they are just seen simultaneously on opposite edges of the field, and then multiply the distance between them by 0·0175 to get the N.A. of the objective being tested. If these discs supplied by Zeiss are made to a standard radius and refractive index, as they probably are, there is no reason why the indicators should not slide on a scale graduated to give the N.A. direct without the necessity for multiplication by a constant.

Note on a simple form of Reflecting Polariser.

By Frederic J. Cheshire.

(*Read May 16th*, 1902.)

When light is incident upon a plane crown-glass surface, the reflected beam contains the maximum proportion of polarised light when the angle of incidence is about $56\frac{1}{2}°$. A slip of



ground glass G, about $1\frac{1}{4} \times 2\frac{1}{2}$ inches, with a coat of Aspinall's black enamel on its back and ground side, is mounted, therefore, at an inclination of $33\frac{1}{2}°$ on a short spindle A in the axis of the microscope, which can be rotated by a milled head B. The polariser is mounted on the tailpiece in the same way as the usual mirror. By this construction it is obvious that, however the spindle A may be rotated to bring the lamp flame or other light source into view, any light that passes along the axis after reflection must be fully polarised without any adjustment for the polarising angle. The analyser must of course be capable of independent rotation. This is simply and efficiently effected by screwing it into the bottom of the draw-tube, in which position it does not limit the field of view, as is the case when mounted in the eyepiece. The light incident upon the slip G should preferably be made parallel with the usual bull's-eye.

The single reflecting surface gives quite sufficient light for low powers. If more is required for high powers, it can readily be obtained by temporarily fixing with wax a large cover-glass on the top of the slip G.

The advantages of this simple form may be summarised as follows:—It gives, practically, an unlimited field even for the examination of stauroscopic figures in the back of the objective. It is readily fixed below and with the condenser. The position of the plane of polarisation of the incident light is obvious. The cost of the reflector is small as compared with that of a Nicol of fair size.

NOTE ON *CHAETOMIUM BOSTRYCHOIDES*, ZOPF.

BY GEORGE MASSEE, F.L.S.

(*Read May* 16*th*, 1902.)

THIS beautiful little fungus was discovered in Germany several years ago, growing on rabbit dung; last year it occurred in England on the same substratum, and quite recently it has been received from Calcutta, where it occurred on the dung of a fruit-eating bird. The genus *Chaetomium* belongs to the Sphaeriaceae, or ascigerous fungi, and, as the name denotes, the component species are ornamented with external hairs, which are often much branched or curled in various apparently fantastic ways; but when these minute organisms are carefully studied, it is seen that the branching or twisting of the hairs serve some important function in the economy of the species. In the fungus under consideration the perithecium, or outer protective wall enclosing the spores, is egg-shaped, about 1 mm. high, and in the early stage is everywhere covered with short, dark-coloured, bristle-like rigid hairs. During this stage the spores are maturing, and are eventually expelled through a small opening at the tip of the perithecium as a compact black mass, bound together by a mucilaginous substance.

Now, simultaneous with this expulsion of the mass of mature spores, a specialised set of hairs grow up round the opening at the tip of the perithecium. Each hair is straight and rigid for some distance at its base, but the apical portion is twisted into a dense corkscrew-like coil, one portion of the coil turning to the left, the other portion to the right, the two coils being separated by a short straight portion, as in the tendrils of the vine.

The ejected spore-mass is at first deposited on these closely-coiled hairs, which are hygroscopic, and, under certain conditions, slowly uncoil or expand, thus elevating the spore-mass, which is either eaten by minute mites, etc., or scattered by rain; in either case the dispersal of the spores is effected.

In the most widely distributed British species, *C. elatum* Kze., the hairs forming the apical tuft are straight, very long, and branched in a dichotomous manner, whereas in *C. murorum* Corda, the hairs are curved throughout their length, forming a semicircle curving away from the mouth of the perithecium.

Many species grow on damp straw or decaying plant stems, others are exceedingly abundant on damp paper; in fact, to procure a crop of *C. elatum* it is only necessary to keep blotting-paper damp for two or three weeks, and the fungus will be almost certain to appear.

Mutual Help in Microscopical Work.

In spite of the papers and discussions at the ordinary meetings of the Club and the friendly conversation of the "gossip" nights, it seems that there are still a considerable number of our members who do not know exactly to whom to apply to get information on the different branches of microscopical work. To remedy this as far as possible, it has been suggested that lists should be published from time to time of those members specially interested in particular subdivisions of microscopical research who would be willing to help beginners in various ways. Of course there never has been any doubt of the readiness of members to help one another—such mutual assistance and encouragement having always been a special feature of the Quekett Club. But it is believed that greater benefit would accrue, both to the advanced worker and to the beginner, if the names of those able to give advice on special subjects were brought more prominently before their fellow-members, and especially before those who have but recently joined the Club.

The following list is, therefore, a preliminary attempt in the direction indicated. It is necessarily a very incomplete statement of the Club's special workers, even with regard to the groups mentioned, which, it will be seen, do not by any means cover the whole field of microscopical work. Its publication should, however, induce many other members to come forward with offers of help, so that when the next list is issued it may more accurately represent the sum total of the club's activity. The Editor will be very pleased to hear from any members willing to put down their names in this way, and to receive any suggestions in connection with this subject. It will be understood that the members offering their services on special subjects do not necessarily claim to be experts, although some, no doubt, may with excellent reason be so regarded. In any case, whether experts or not, they would still desire to be considered as students, having a little start, perhaps, of many of their fellow-members in their own particular grooves, but, nevertheless, having infinitely more to learn than they have to teach.

Subject.	Name of Member.
Diatomaceae	H. Morland.
Micro-Algae (including Desmids)	A. L. Still.
Fungi, Myxomycetes	G. Massee.
Bacteria	L. R. Gleason. A. L. Still.
General Vegetable Histology	R. Paulson.
Rhizopoda (Fresh-water)	D. J. Scourfield.
Foraminifera, Radiolaria	A. Earland.
Gastrotricha (Hairy-back Animalcules), Rotifera	C. F. Rousselet.
„ (Bdelloida)	D. Bryce.
Tardigrada (Water-bears)	D. J. Scourfield.
Acarina—General, „ Oribatidae, „ Tyroglyphidae	A. D. Michael.
„ Ixodidae	R. T. Lewis.
„ Hydrachnidae	C. D. Soar.
Araneina (Spiders)	F. P. Smith.
Entomostraca (Fresh-water)	D. J. Scourfield. C. J. H. Sidwell.

Subject.	Name of Member.
Aquatic Insects	F. Enock.
Diptera	W. Wesché.
Petrology	H. S. Martin.
Microscopical Optics (including testing and critical manipulation of the Microscope)	J. Rheinberg. W. B. Stokes. F. Cheshire.
Technical Microscopy (*i.e.*, the microscopical study of animal, vegetable, and mineral substances for industrial purposes)	A. Ashe.

Generally speaking the members mentioned above cannot undertake to enter into correspondence on the subjects to which their names are attached, but they will be most happy to give any assistance in their power, to those requiring it, at the meetings of the Club. And in this connection the following suggestions may be made to those wishing for information :—

(1) Bring up specimens to the meetings for exhibition and identification whenever possible. It is quite a mistake for a member to hesitate about bringing objects for exhibition because he does not know precisely what they are; in fact, that should be one of the best of reasons for bringing them. It may safely be affirmed that at least as much general benefit will be derived from following this course as from the exhibition of the specialist's choicest rarities.

(2) If, for one reason or another, specimens cannot be exhibited, drawings or photographs of the objects about which information is wanted should be brought up. The fact that the drawings may be crude should not deter members from bringing them to the meetings. A rough sketch, if made direct from the object, is very often quite sufficient for purposes of identification, and

may possibly bring out points of real value little suspected by the draughtsman.

(3) Notes regarding the enemies, food, swimming peculiarities and habits generally of microscopic organisms, based on direct personal observation, will always be welcomed, and should therefore be brought up for informal discussion. The same is also true with regard to personal experiences in the manipulation of both the microscope and objects, and the preservation and mounting of the latter.

(4) Microscopical apparatus of every description, especially if the result of a member's own thought and work, should, whenever practicable, be brought to the meetings for inspection. It often happens that an apparently quite simple device, carried out in the most rough and ready manner, embodies some important, and perhaps but little understood principle, or possesses a much wider range of usefulness than imagined by the designer. In any case, the suggestions and criticisms evoked by the exhibition of such apparatus are sure to lead to beneficial results.

NOTICES OF RECENT BOOKS.

Traité de Bactériologie pure et appliquée à la Médicine et à l'Hygiène. By P. Miquel and R. Cambier. 11 × 7½ in. xv. + 1,059 pages. 224 figures (many coloured) in the text. Paris, 1902: C. Naud. Price 45 francs.

This is one of those "monumental" works, in the best sense of the term, which it is almost hopeless to review in anything approaching an adequate manner. The authors, who are respectively the director and sub-director of the Bacteriological Laboratory at Paris, have indeed co-operated to some purpose in the production of this book, and they have rendered an immense service to all students of bacteriology by the careful way in which they have brought together and arranged the enormous number of facts relating to the subject, and especially by their very full treatment of bacteriology in relation to hygiene.

Starting with the morphology of bacteria, and such facts as are known about their polymorphism and internal structure, we are led, in the course of the first of the four parts into which the book is divided, to the consideration of their biological activities, their reactions to various physical and chemical agents, their artificial culture, and the cultivation media. Three chapters are also appended to this part dealing with experiments upon animals, the preparation of bacteria as microscopic objects, and microscopical manipulation.

The second and third parts, devoted to detailed accounts of the various pathogenetic, fermentation, and colour-producing bacteria, are exceedingly well done, and necessarily occupy a very large amount of space. In the case of the better known forms, such as the bacilli of tuberculosis, of anthrax, of diphtheria, etc., the very large amount of information is collected under various headings—such as habitat, etiology, morphology, methods of cultivating and staining, toxic properties, experimental inoculation, etc., so that we almost get a series of little monographs embodied in the general work. This portion of the text is also enlivened by many dainty little figures in colour, which may or may not be useful for purposes of identification, but which, at any rate, give a certain attractiveness to the book.

In the fourth part, dealing with the applications of bacteriology to hygiene, the authors give us a very excellent presentation of the methods of bacteriological analysis of the air, of water, and of the soil, together with two important chapters on the purification of sewage and potable water, and on disinfectants.

As becomes an important work of this character, the paper and printing are all that can be desired, and there is a very full index. No general bibliography is included, but numerous references to papers on special points are given as foot-notes on nearly every page. Considered as a whole, and remembering the youthfulness of bacteriology, we should say that it would be difficult to find any single book which would give a better idea of the tremendous pace at which science has been advancing in the last two or three decades than the work now under notice. D. J. S.

European Fungus Flora—Agaricaceae. By George Massee, F.L.S. 7½ + 5in., vi. + 274 pages (no illustrations). London, 1902: Duckworth & Co. Price 6*s.* net.

Those who have collected the larger fungi at annual forays with mycological experts will readily admit the force of the author's remarks in the preface on the significance of the term species. In the field, and elsewhere, when a fungus is brought for verification, a few qualifying remarks are often made on some exceptional local condition, so that the amateur, by reason of drought or of an unusually wet and cold season, comes to doubt the identity of a specimen that he imagined he knew perfectly well.

A book that will enable one to seize on a few essential characters is a valuable addition to our list of fungus floras. The present work, as one gathers from the title, is a European

Fungus Flora limited to the Agaricaceae, the author holding that, by including the genera common to European countries, the false impressions that often arise from a familiarity with the fungi of one country only, may be removed.

The chief aim of this book is to give the most important characters of each species as presented by pileus, gills, stem, and spores respectively. On putting the book to a practical test one is convinced of the utility of the method employed, for a great saving of time is at once evident. It is not a book for the beginner. From twenty to twenty-four species are often diagnosed on a couple of pages, but for all this, the printing is quite clear, and the lines belonging to each description are perfectly distinct. One cannot speak equally well of the paper and binding. A book constantly needed for reference surely requires an extra strong binding. The addition to the cost might be considerable, but those putting the book to practical use would certainly appreciate a more durable cover.

The work includes descriptions of 2,750 European species, of which 1,553 are British. Those not recorded as British are indicated by a bracket. The index is singularly well prepared. Objection might be raised to the absence of plates of any kind, but as they cannot be included without greatly increasing the bulk and cost, it is perhaps advisable not to add them. In the bibliography Mr. Massee gives the necessary information respecting the best published illustrations of British and other fungi.

To one who is already interested and wishes to work seriously at the Agaricaceae, this book will prove of great assistance, for the perspicacity of the short descriptions will often save him from wading through an amount of unnecessary detail. R. P.

Manipulation of the Microscope. By Edward Bausch. Fourth Edition. $6\frac{1}{2} \times 4\frac{1}{2}$ in. vii. + 214 pages, about 70 figures in the text. Rochester, N.Y., 1901 : Bausch and Lomb Optical Co. Price (in England), 3*s*. 6*d*.

This little book, which has now reached the fourth edition, possesses many excellent features and should certainly be more widely known in this country than has hitherto been the case. While essentially a book for beginners and written in simple language, it is not by any means of the milk-and-watery type often considered good enough for microscopical babes, for it undoubtedly covers a very large portion of the wide field of microscopical manipulation, and does not ignore such subjects as numerical aperture and its determination, under- and over-correction of objectives, centering and focussing of the condenser, etc. About the only serious omission we have noticed is that no mention is made of the use of screens, etc., for the production of monochromatic light for microscopical purposes. The earlier sections of the work deal with the optical properties of lenses, simple and compound microscopes, objectives and eyepieces. The methods of working with the microscope, illumination with the sub-stage condenser, and the drawing of objects next claim attention; and lastly, there are some useful hints upon the selection and care of a microscope. Nearly every page shows evidence of the practical acquaintance of the author with the subject in hand, and although possibly some experienced workers would take exception to a statement here and there as to the best means of obtaining certain results, there can be no question that, on the whole, we have in the work before us a very reliable introduction to the correct handling of a microscope. D. J. S.

First Steps in Photo-Micrography. By F. Martin Duncan, F.R.H.S. 7 × $4\frac{3}{4}$ in., 104 pages, 17 figures. London: 1902, Hazell, Watson and Viney. Price 1s. net.

It was a good idea of the publishers to include a little work on Photo-micrography in their series of cheap handbooks known as "The Amateur Photographer's Library." It is sincerely to be hoped that the subject will thus be brought before a much wider public than if the book had been issued without such a connecting link to other works on photography.

Mr. Duncan, in his endeavour to interest those who have not yet taken up the photography of minute objects, very wisely insists in the first place upon the fact that there is considerable scope for genuine photo-micrographic work without the use of a microscope, and even without microscopic objectives. To be sure, this is only true for very low power work, but the point is well worth remembering. In dealing with medium and high power photo-micrography, the author gives simple directions for setting up the microscope and camera which will no doubt be helpful to those approaching the subject for the first time, but the beginner will, of course, not go very far before feeling the need of something more than the "First Steps" in these matters. Incidentally Mr. Duncan strongly recommends acetylene gas as an illuminant for high power work, as he considers it to be in several respects superior to lime light. The second half of the book deals with developing and printing, the preparation of objects, and stereo-photo-micrography. The latter is a branch of photo-micrography which it is certainly well to call attention to, but it seems rather a pity that such subjects as developing of negatives and mounting of objects should have been included when the space could have been so much more profitably devoted to the main purpose of the book. D. J. S.

Manuel Pratique de Bactériologie, Parasitologie, Urologie, Anatomie Pathologique. By Dr. Petit and G. Borne, $7\frac{1}{2} \times 4\frac{3}{4}$ in. 235 pages, 47 figures in the text. Paris, 1902: C. Naud. Price 3 francs.

Although written expressly for the use of candidates for the French doctor's degree, this book should also, if its limitations are borne in mind, prove useful to many who require a condensed account of the principal facts concerning the somewhat wide range of subjects with which it deals. In the first of the four principal divisions of the work, the authors review the general methods of bacteriological research, and give short descriptions of some of the best known disease-producing bacteria, such as those of cholera, typhoid, anthrax, etc. The animal and vegetable parasites found constantly or occasionally in or on the human body are next very briefly dealt with, and then, under the heading of "Urologie," a fairly exhaustive account is given of the methods of examination of urine and also of blood, pus, etc. The concluding section is devoted to the technique of post-mortem investigation and the chief facts concerning pathological anatomy. As is often the case with text-books avowedly written for examination purposes, the facts are given in a somewhat abrupt and disconnected style, and are indeed probably intended rather as a series of systematised notes, to be supplemented by class teaching, than as a logical treatise on the subjects dealt with. From this point of view the book may certainly be commended, although the illustrations are rather poor and not very helpful. D. J. S.

METALLOGRAPHY.—An introduction to the study of the structure of metals, chiefly by the aid of the microscope. By Arthur H. Hiorns. $7 \times 4\frac{3}{4}$ in. xiv. + 158 pages. 96 half-tone figures on 32 plates. London, 1902: Macmillan & Co. Price 6*s*.

The study of the internal structure of metals and alloys by means of the microscope was begun by Dr. Sorby as long ago as the year 1864, when he examined some specimens of steel in Sheffield. The seed which he sowed, however, did not germinate for many years, and little was done, either by himself or by others, until about the year 1885. Since that time the labours of Martens, Osmond, Wedding, Charpy, Roberts-Austen, Stead, Arnold, Sauveur, and many others have elevated metallography into a new branch of science. Numerous researches have been carried out and their results communicated to various learned societies. A periodical, the "Metallographist," devoted entirely to the chronicle of the work that is being done on the subject, has been in existence for over four years, and engineers and metallurgists are becoming more and more alive to the importance of following the development of the science. Already metallography is being taught as a separate subject in some of the universities and technical schools. Yet, wonderful to relate, no text book on the subject in the English language existed before the publication of the work under review. The papers and articles on which Mr. Hiorns has based his book are scattered and highly specialised, and the acquirement of a general elementary knowledge of the subject has been a difficult matter for the student. Teachers have been seriously handicapped in their efforts, and last, but not least, original investigators have had no book of reference to aid them in their researches.

The appearance of this work is therefore particularly well timed, and it will be eagerly examined by many who will be anxious to know how far it will suit them. It may be said at once that they will have no right to be disappointed by what they find.

Mr. Hiorns has collected a large number of the more important results which have been obtained recently, and has given a capital summary of them which is surprisingly complete considering the moderate size of the book. The introduction, which contains some account of the history of the subject and some general considerations upon it, is perhaps the least satisfactory chapter. The working directions, however, for preparing pieces of metal for examination and for photographing them, are sufficient for the purpose.

The greater part of the book is devoted to the metals which are most important in industrial work, that is, to iron and steel in the first place, and to the alloys of copper in the second. It has long been known that the appearance of the fractured surface of steel may be misleading and give little clue to the nature of the specimen. It is necessary to make a clean cut with a saw through the metal, to polish the surface with several emery papers in succession, each one of finer grain than the last, and to finish with the finest rouge spread on broadcloth and wetted thoroughly. The polished surface is then etched by acids or by rubbing with a solution of ammonium nitrate or liquorice, and mounted for examination with the microscope.

It can then be seen that metals generally consist of large, irregular crystalline grains, each composed of a large number of secondary crystals arranged with some regularity. The primary grains vary enormously in size, and may be as much as an inch in diameter. The secondary crystals in steel, however, are exceedingly minute, and may require a magnification of a thousand diameters to be resolved. As the examination must be by reflected light, special means of illumination must be used, and it is now customary with the highest powers to use a beam from a powerful arc-lamp, which falls vertically on the surface of the metal and is reflected through the microscope. Under these conditions hardened steel is readily distinguishable from annealed or even tempered specimens, and it is possible to distinguish all the variations of thermal treatment to which the metal has been subjected. This is of great value to the engineer, and the "pathology" of injured specimens has become one of the chief means of testing material which has shown signs of failure. All this is clearly set forth and the photographic illustrations throughout the book are beautifully reproduced on special paper. In future editions, no doubt, Mr. Hiorns will be able to extend and complete his work, but, taking it as it stands now, he deserves the thanks of his fellow-workers for the useful aid which he has given them.

T. K. R.

PROCEEDINGS.

March 21st, 1902.—Ordinary Meeting.

A. D. Michael, Esq., F.L.S., Vice-President, in the Chair.

The minutes of the preceding meeting were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—Mr. J. W. Barker, Mr. R. Newnham-Catt, Rev. S. Firman, Mr. F. G. Brook-Fox, Mr. G. Gale, Mr. J. L. Gribbin, Mr. H. J. Quilter, Mr. C. H. Rushton, and Mr. F. B. Taylor.

The additions to the Library and Cabinet were announced, and the thanks of the Club unanimously voted to the donors.

Mr. Karop said the members would remember that at the last meeting of the Club it was announced that the new catalogue of the zoological objects in the Cabinet was in the press. This was now ready, and was available for any members desiring to obtain a copy. It was also intimated that the price of the catalogue would have to be raised to 1*s.* in consequence of its great increase in size. It had been very carefully compiled, and the Committee hoped that it would have a sufficiently large sale to recoup them for the considerable cost of production.

Messrs. Watson exhibited and described a new two-speed fine adjustment for the microscope, in which the quicker motion was obtained by the simple device of attaching a milled head, or rather spindle, of small diameter to the same axis as the ordinary fine adjustment. They also exhibited a useful mechanical stage fitted to the " Fram " microscope.

Mr. Scourfield thought that the two-speed arrangement exhibited was open to serious objection, for the method of twirling a small milled head between the finger and thumb did not allow of that delicate command over the adjustment which was absolutely essential for careful focussing; and it also threw an immense amount of extra work on the micrometer screw.

The Chairman said it appeared to him to be rather a novel and probably convenient addition, as the twirling of the small spindle provided a kind of intermediate adjustment between the ordinary coarse and fine adjustments.

Mr. Swift said he had always understood that the small milled top of the conical fine adjustment head in Continental microscopes was for the purpose of obtaining a rapid motion, exactly in the same way as the two-speed adjustment now exhibited.

The thanks of the meeting were voted to Messrs. Watson for their exhibits.

Mr. Rheinberg read a further paper on "The Black and White Dot Phenomenon," which he regarded as due to the differences of refractive index of the transparent diatom silex and of the medium in which the object was mounted. The argument was supported by reference to diagrams on the board showing the ratio between the angles of total reflection of different mounting media.

Mr. Stokes said he regarded this as a very interesting subject, and could fully appreciate the amount of work which Mr. Rheinberg had devoted to it; but he was hardly able to follow some of the conclusions given in the paper. He was not able to imagine that a diatom was perforated with holes having a depth greater than the breadth. With regard to diffraction, it was useless to deny that this had an overwhelming part in microscopical vision, or that the diffraction effects which were noted in coarse objects were different from those in the case of fine objects. He thought that diffraction of aperture, which was a telescope theory, was something of the same kind, and that a star disc showed very similar effects, for both had rings which to some extent limited the disc and formed a limit of resolution, and the appearance of the white dot of a very fine perforation was very much like the appearance of a star disc. As regarded the markings of *Pleurosigma angulatum*, his work convinced him that these diatoms were altogether peculiar, because they seemed to act in a manner quite different from all others. For this reason a great deal of work had been given to them, and they had given rise to more illuminators than anything else. He should be very pleased to read this paper when it appeared in the *Journal*.

Mr. Rheinberg said that he thought Mr. Stokes was mistaken as to the depth and breadth of the holes in diatoms, and that he would find the depth in many of them was certainly greater than the breadth. He had himself made a number of experiments by the method of "interference colours," which he described some time ago at the Club,* and had found in *P. angulatum* that the depth exceeded the width. There were means of ascertaining this which left no doubt upon the matter. Mr. Stokes had referred to diffraction effects as being overwhelming. They were of course always present, and their influence had been fully recognised in his paper, but they were limited in the cases under consideration to a very small area. As regarded the aperture of the objective, it seemed rather like straying away from the subject to bring this in, because it was always there under any circumstances, and the effect due to this was a very small amount. As regarded comparing the hole in a diatom to a star disc as seen through a telescope, he thought this was a somewhat far-fetched comparison, because in the one case they were throwing light upon the object, and it depended upon the way in which the light was thrown what the effect would be; whereas in the case of a star they had a self-luminous object, which was an unalterable condition of things. *Pleurosigma angulatum* was chosen because its perforations were so very regular, and were just a wave length apart; but they could trace the effects very much better with something more irregular and where they could separate one thing from another.

The thanks of the meeting were voted to Mr. Rheinberg for his paper.

A note by Mr. Merlin "On certain minute structure observed in some forms of *Triceratium*" was, in the absence of the author, read by Mr. Karop: and the thanks of the Club were voted to Mr Merlin for his communication and to Mr. Karop for reading it.

Mr. Karop read a paper on "Hanging-drop Cultivation," a matter which had been referred to by the President in the course of his annual address, and might not be well understood, at least by some of those who were only beginners in microscopy.

Mr. Bryce said he should like to congratulate Mr. Karop upon his choice of a subject, and also upon the way in which he had dealt with it. Papers of this kind were just what they wanted

* "The Origin of certain Colour Phenomena typically shown by *Actinocyclus Ralfsii*" (*ante*, p. 13).

in a Club like theirs, and he hoped they would have some more of the same kind.

The President was sure that all would unite in a vote of thanks to Mr. Karop for the very plain and practical directions he had given them as to what was now regarded as one of the best methods of investigation, though one which was perhaps not generally known to young microscopists.

The thanks of the meeting were unanimously voted to Mr. Karop for his paper.

Notices of meetings, etc., for the ensuing month were then given, and the proceedings terminated with the usual conversazione.

April 18th, 1902.—Ordinary Meeting.

The Rt. Hon. Sir Ford North, F.R.S., Vice-President, in the Chair.

The minutes of the meeting of March 21st, 1902, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—Mr. John Cumming and Mr. Walter Imboden.

The donations to the Library were announced, and the thanks of the Club voted to the donors.

Mr. Hill, for Messrs. R. and J. Beck, exhibited some rulings on glass which had been made by Mr. Grayson, of Melbourne, and brought over to this country by Mr. Wedeles, who, being present at the meeting, was asked to say something about the specimens.

Mr. Wedeles said that, though he had never seen the rulings done, he had seen the machine by which they were produced, and this was actuated by glass wedges which moved the cover-glass. The diamond was fixed in a small carriage, and the great difficulty experienced in making these rulings was in getting a suitable fragment of diamond for the purpose. Owing to Mr. Grayson being entirely occupied with other work, the matter had been in abeyance for the last three years; but he believed it would now be taken up again. Ruling up to a fineness of 90,000 to the inch had been quite successful, but those at 100,000 and 120,000 had been less so, partly owing to the diamond and partly to the glass. Mr. Grayson was now trying to find a splinter of diamond which would rule these finer markings perfectly, as the machine itself was quite equal to doing it. The great distinctness with which the lines were seen was due to the manner in which they were mounted. The earlier specimens were mounted dry; but as this was not satisfactory, Mr. Grayson had sought for some medium which would render them more distinct and permanent, and he had now mounted them in a realgar having a refractive index of 2·5, and though this had a tendency to crack after about three years, it was the best that had yet been found. The result was described by Mr. Nelson as being the most perfect of the kind which had yet been produced. If the difficulty as to the diamond could be overcome, he hoped to be able to send over some much finer examples than those now shown.

The Chairman said that those who had the opportunity of seeing these rulings would agree as to the wonderful precision with which they had been produced. It was said that seeing was believing, but in this case they must hear also before they could believe what they saw, for without the explanation given no one would believe it possible to rule lines so numerous in so small a fraction of an inch. Their thanks were due to Mr. Wedeles, not only for bringing these slides for them to see, and for what he had told them, but also for promising to send them some further examples later on. He hoped he would let Mr. Grayson know how greatly his work had been appreciated.

In reply to Mr. Karop, Mr. Wedeles further mentioned that the diamond points were obtained by breaking a diamond with a hammer: also that the lines were not filled in with plumbago or other substance, but that their blackness was due to the high refractive index of the realgar.

Mr. Earland read a paper on "*Cymbalopora bulloides* d'Orbigny," one of the Foraminifera. The paper was illustrated by diagrams and specimens.

The President, in inviting remarks upon the subject of the paper, regretted that he could not himself discuss it, as he was only one of those who were walking round the outside of the subject; but they were interested in what they heard and saw, and he was sure would give their thanks to Mr. Earland for giving them the fruits of his investigations.

Mr. W. Wesché read a paper on "Male Rotifers."

Mr. Rousselet said it was satisfactory to know that during the last few years many of the male rotifers had been discovered, and were being described and figured, so that they could be identified more readily in future. They were generally much smaller, and not much like the females, and had consequently been much overlooked. One of those described in the paper, however, was curious as being a male of which no female form was known.

Mr. Bryce said that every writer on the subject had placed on record a statement that no males were known amongst the Bdelloid Rotifera. Workers among the Rotifera were so far at a disadvantage that they were unable to refer to fossil records for testimony as to the past history of the group, and each observer had to draw his own conclusions from the facts which came under his own observation. For his part he was not prepared to say that no males existed among the Bdelloid Rotifera, but he had never been able to find one, and he was inclined to believe that if they ever had existed, their services had long ago been dispensed with. Mr. Wesché's suggestion that the males had disappeared as a result of degeneration was a possible explanation of their absence, and one new to the speaker. As regarded the resting eggs, Mr. Wesché thought that he had found such belonging to a Bdelloid Rotifer, *Callidina plena*, but it must be remembered that three things were necessary before they could say that what was found was really a "resting egg." It must be proved that the species in question laid two distinct forms of egg; that one of these took a very much longer time than the other to mature and produce the young animal; and that the resting egg was that one of the two forms which required the most time for its development. Notwithstanding Dr. Janson's statements, any reported appearance of a "resting egg" among the Bdelloid Rotifera must be very carefully confirmed before it could be accepted as an absolute fact.

The Chairman was sure that all would join in thanking those who had contributed to their knowledge on this subject. He thought also they should particularly thank Mr. Wesché for giving them in a short compass at that hour of the evening the general purport of a paper which he said would take a considerable time to read through.

The thanks of the Club were then cordially voted to the readers of the papers and to those who had spoken upon them.

Notices of meetings and excursions for the ensuing month were then made, and the proceedings terminated with the usual conversazione.

May 16th, 1902.—Ordinary Meeting.

George Massee, Esq., F.L.S., President, in the Chair.

The minutes of the meeting of April 18th, 1902, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—Mr. Edward J. Eedle, M.R.C.S., L.R.C.P.; Mr. Charles F. Knight, M.D.; Rev. Thomas J. Nevill, Mr. George Tilling, and Mr. William Vicarey.

The donations and additions to the Library were announced, and the thanks of the Club unanimously voted to the respective donors.

Mr. Karop called special attention to the new part of Dr. Braithwaite's "British Moss Flora," which was beautifully illustrated and equal to any which had preceded it. This was Part XXI. of this work, which now needed only two more parts to finish it.

Mr. F. J. Cheshire read a paper on "Simple Methods of Focometry and Apertometry," which he illustrated by numerous diagrams and formulae on the black board, and by examples of the experiments referred to, shown under microscopes lent for the purpose by Messrs. Baker.

Mr. Cheshire read further short papers on a method of using Abbe's apertometer, and on a simple form of reflecting polariser for the microscope, exhibited in the room.

The President regretted that the subject was one upon which he felt compelled to say absolutely nothing; but he was quite sure, from the attention given to the subject which had been put before them with such great lucidity by Mr. Cheshire, that the members of the Club had thoroughly appreciated its value.

Mr. Stokes thought this paper was a great acquisition to the Society, and he personally felt very grateful to Mr. Cheshire for bringing it before them. The formulae, he believed, were new, and were certainly likely to be very useful. He had seen Professor Thompson's focometer, which was a very elaborate and also a very expensive appliance, the cost running nearly to three figures, and therefore quite beyond the reach of most microscopists. Simple methods like those described in this paper were therefore a great acquisition, especially as they were shown to be so reliable as to their accuracy. It was a very important thing to determine numerical aperture, because it gave them the limit of the resolving power of an objective. He thanked Mr. Cheshire for this paper, which he was sure would be read with very great pleasure and profit when it appeared in the *Journal*.

Mr. Rheinberg thought the methods described would be very useful to those who desired to obtain for themselves results which they could rely upon as being accurate, because at the present day they saw so many things and heard so many methods proposed that they sometimes did not know where they were. A great advantage of these methods was that many of the experiments described could be carried out by any one without any apparatus whatever. It was curious to note that the method described of measuring the focal length of a lens occurred to Mr. Nelson also at the same time as to Mr. Cheshire, and was described in the last number of the *R.M.S. Journal.* He wished to ask Mr. Cheshire as to the particular adjustment necessary to obtain the very curious figures which he had described, and what would produce the oblique form of the straight rod as shown.

Mr. Cheshire said that in describing his method of apertometry the one thing he would insist upon was that it insured results equal to Zeiss's. It must be remembered, however, that it could not be used with an achromatic condenser, because it was a necessity of the case that the scale must be put at the back-focal plane of the condenser, and in the achromatic form they could not get at this point. As an illustration of the usefulness of being able to easily test objectives, he might say that, seeing a description of a lens in a maker's catalogue which was said to have an N.A. of ·55, he tested two of them, and found they were really ·48 and ·47 only; but on calling attention to it he was told that this was a misprint—they really were ·48. On another occasion he met with two lenses, a $\frac{1}{10}$ in. of ·7 and a $\frac{1}{12}$ in. of ·95; but on testing these he found both to be really ·9; and if he had to choose between these he should certainly select the former, especially as it was priced at 15*s.* less. To see the effects he had mentioned it was only necessary to rack up the condenser close to the objective, and then as it was racked down again it would produce all the series as described. If the stops were removed, and the wire was put under and moved across the field, the effects he had referred to would be produced.

The President said this paper was one the merits of which could only be fully appreciated by reading it through in the *Journal* more than once. Nevertheless it was one of extreme interest to listen to, and their hearty thanks were due to Mr. Cheshire.

The thanks of the Club were unanimously voted to Mr. Cheshire for his papers.

The President read a note on *Chaetomium bostrycoides*, a species of coprophilous fungus, which he illustrated by coloured diagrams showing the development and maturing of the spores as seen by the microscope, the fungus itself being barely visible to the naked eye.

The thanks of the meeting were unanimously voted to the President for his interesting communication.

Announcements were then made of meetings and excursions for the ensuing month, and the proceedings terminated with the usual conversazione.

June 20th, 1902.—Ordinary Meeting.

George Massee, Esq., F.L.S., President, in the Chair.

The minutes of the meeting of May 16th, 1902, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—Mr. Alfred Fullard, Mr. Frederick P. Lawson, Mr. T. A. G. Margary, and Mr. Robert H. Thomas.

The Secretary read a brief memoir of Mr. J. W. Groves, F.L.S., whose death had occurred since the last meeting of the Club. Mr. Groves had belonged to the Club since 1868, and had been a member of the Committee and a Vice-President, and was well known to the older members.

The donations to the Library and Cabinet, including a slide of volcanic dust from Barbados from Mr. Ashe, were announced; also a small packet of volcanic dust from La Soufrière, St. Vincent, sent for distribution by Mr. H. Epps. The thanks of the Club were voted to the donors.

Mr. Karop called attention to a statement made in Mr. Cornish's book, "The Naturalist on the Thames," concerning the Bladderwort, which is known to entrap Entomostraca, Rotifers, etc., by means of its bladders. Mr. Cornish refers to these plants as being busily engaged in catching small *tadpoles* by the tails and holding them until they died; but as the bladders were usually $\frac{1}{10}$ in. in size, and in the largest species not more than $\frac{1}{5}$ in., it was rather difficult to understand how they could manage to hold such active creatures as tadpoles.

The President thought that, as every one was familiar with the Bladderwort, it would be interesting to hear any opinions from those who had made observations upon it. The delicate filaments referred to were generally branched hairs covered with some viscid secretion which was not affected by water; but whether this was sufficiently adhesive to hold a tadpole by the tail, he should like to hear. It might perhaps be possible if the tadpole was unwell, and only had strength to wriggle feebly. He thought their thanks were due to Mr. Karop for bringing the question before them; for, although such statements as had been referred to might appear rather ridiculous, there might, after all, be a substratum of truth which it would be well to get at if possible.

Mr. J. B. Scriven's paper on "The Preparation of Serial Sections of Insects, based upon Experiments with the Blowfly," was read by the Secretary.

Mr. Karop said that Dr. Scriven's success in preparing sections of this kind was so great that it was very interesting and useful to have a detailed description of his methods. Years ago, when Professor Lowne was engaged on his work on the Blowfly, he remembered the difficulty caused by a want of adhesion between the insect's chitin and the imbedding mass, and Dr. Scriven's idea of incorporating a small quantity of very dilute rubber solution to overcome this was a distinct advance. Given an absolutely reliable imbedding medium, properly employed, the next essential for successful section-cutting was a perfect edge to the razor, for the least roughness here would be sure to tear and dislocate the sections. The really good razor sharpener seemed to be born, and not made; at least, most of the razors returned by the professional were unsatisfactory. Many years back he had come across a "wrinkle" in Behren's "Hilfsbuch," where it is attributed to Hugo von Mohl, which had answered very well indeed. It was to finally polish the razor edge on a strip of plate-glass with finely-powdered "Vienna lime" and water. This material, which he believed was a variety of dolomite, could be obtained from the importers of watchmakers' requirements in Soho or Clerkenwell. Quite recently some similar material, incorporated with a soapy base, was sold as "Buttercup Polish," and used on the smooth side of an ordinary razor-strop. This gave a polished edge to the blade, which was absolutely necessary for success. The rest was a matter of personal practice.

The President thought there was the right ring about this paper, and the hints it contained would be of service to all who were in the habit of cutting sections. As regarded the Cambridge rocking microtome, he found that this developed more electricity than any other, and the effect of this was very troublesome. After a while this did not happen for some reason, but at first so much electricity was developed that the ribbon was simply blown to pieces. One great use of serial sections of such things, for instance, as hyphae, was that by making drawings of these on a number of pieces of paper the thing could be built up and a model produced, which was a far more valuable method than any other for understanding the structure of any object under examination. The method described by Dr. Scriven appeared to be a very excellent one, and when it became a matter of importance to trace out a particular organ, the method by serial sections was the only true way of doing it.

Mr. Morland said he remembered that many years ago Mr. Newton made a number of sections of the brain of the cockroach in the way mentioned by the President, and cut them out in thin plates of wood, which, when put together, formed a model of the brain. (See *Journal Q.M.C.*, Ser. I., Vol. V., p. 150.)

Mr. Wesché said he had seen many of Dr. Scriven's sections, and they were certainly remarkably clear. Every organ could be traced right through.

The President said he was sure the members would desire to give a very hearty vote of thanks to Dr. Scriven for his very valuable paper, and to couple with this their thanks to Mr. Karop for so kindly reading it, and for having further illustrated the subject by giving them some of the results of his own experience.

The thanks of the Club were unanimously voted accordingly.

The notices for the month were then mentioned, but it was announced that the ordinary meetings of the Club would, as usual, be suspended until the third Friday in October. The ordinary meeting-nights meanwhile would be utilised as gossip-nights.

OBJECTS EXHIBITED, WITH NOTES.

March 7th, 1902.

Mr. J. T. Holder: Small Intestine of Cat, showing outer longitudinal and inner circular muscular coat, areolar coat, sub-mucous coat, mucous membrane pervaded with crypts of Lieberkühn lined with columnar epithelium, and villi covered with columnar epithelium.

Mr. T. G. Kingsford: Cyclosis as seen in the cells of *Spirogyra.* The moving particles are excessively minute, and occur just under the cell wall.

Mr. A. Earland: *Frondicularia archiaciana* Brady. A foram from Torres Straits, 155 fathoms. An extremely rare form in the recent state, but common in Cretaceous times.

Mr. A. E. Hilton: Head of Wasp, *Vespa vulgaris*, mounted in glycerine, without pressure; showing the organs of the mouth in their natural form and colour.

Mr. K. J. Marks: *Rhinops vitrea* Hudson, found in a pond at Hampstead in very large numbers; the water contained no other rotifers.

Mr. W. Winter: Malarial parasite in section of brain.

Mr. H. Morland: *Pseudo-Rutilaria monile*, Gr. and St., "side" view of valves and "front" view of two cohering valves of two opposite frustules from the Oamaru Deposit, New Zealand. In nearly all cases the cells on one side of the centre cell exceed in number by one those on the opposite side.

Mr. J. B. Scriven: (1) Two lateral terminal scales of the ovipositor of the Blow-fly, transverse section. (2) All three terminal scales in longitudinal section.

Mr. E. Larmer: Eyes of Spider, *Salticus tardigradus*, mounted without pressure in glycerine jelly, showing natural colours and internal structure.

March 21st, 1902.

Mr. W. R. Traviss: Ova of Frog, showing movements of embryos.

Mr. A. E. Hilton: First Leg of Honey Bee, *Apis mellifica* (worker), showing the semicircular comb used in cleaning the antennae.

Mr. H. E. Freeman: Phosphorescent Entomostraca from the Indian Ocean. The singular position of the eyes, in the centre of the body, and the long and delicate antennae are specially noticeable.

Mr. C. Rousselet; Living specimens of *Stentor polymorphus*, forming globular and irregular colonies.

Mr. J. T. Holder: Large Intestine of Cat, showing simple tubular glands similar to the crypts of Lieberkühn found in the small intestine. Many goblet or mucus secreting cells can be seen.

April 4th, 1902.

Mr. J. B. Scriven: Transverse section of ovipositor of Female Blow-fly. The smaller lumen of the rectum is on the dorsal side of the vagina. The ovipositor consists of four somites, which fold up like a telescope, the largest and most anterior receiving all the others.

Mr. M. W. Liston: *Rhamnus frangula*, Alder Buckthorn. Longitudinal section, from the green cortex just beneath the epidermis, to show cells connected by threads of protoplasm. Fixed with strong H_2SO_4, and stained by watery solution of aniline blue.

Mr. T. A. O'Donohoe: Transverse section of ordinary developed photographic film, showing the granules of silver, like micrococci, embedded in the gelatine. The film is about $\frac{1}{600}$ in. thick.

Mr. W. Wesché: Teeth on the proboscis of *Stomoxys calcitrans*, a British Dipterous Blood-sucking Fly, nearly related to the Tsetse fly of Africa.

Mr. W. Winter: Section of brain showing malarial parasite in capillaries.

Mr. K. J. Marks: Male of *Hydatina senta* Ehrenberg. This male Rotifer has been described by Ehrenberg under the name of *Enteroplaea hydatina*, as he was not aware of its sex. Its internal structure is like *Asplanchna priodonta* ♂.

Mr. G. T. Harris: *Chirocephalus diaphanus*. A fresh-water Entomostracon (Phyllopod) taken in the New Forest last year. This form is very rare in this country; in fact, it was supposed to be extinct. Lantern slide from photograph of individual taken in fluid.

Mr. H. Morland: *Gomphonema acuminatum* var. *coronata*, from Crane Pond, Mass., U.S.A., showing frustule and valves. Found also in several other New England fresh-water deposits.

Mr. A. E. Hilton: Section of Inflorescence of the Common Fig, *Ficus carica*, showing pistillate flowers containing ovules.

April 18th, 1902.

Mr. C. J. H. Sidwell: Transverse section of developing Radicle of Barley, *Hordeum vulgare*, showing the disposition of the cells to form the plerome, periblem, root-cap, etc. Stained borax-carmine.

Mr. A. Earland: *Cymbalopora bulloides* d'Orb. Typical bottom specimens from *Challenger* Station 185, and small surface specimens from a shore gathering at Corny Point, Hardwicke Bay, South Australia, showing arrangement of chambers, balloon, float, and tube.

Mr. D. J. Scourfield: *Peratacantha truncata*, a representative of the Entomostracan family Lynceidae. The curious teeth on the anterior ventral shell-margin seem to be enlarged basal portions of the ordinary fringing hairs, and may possibly be used for scraping surfaces of weeds, etc., and so securing small diatoms for food. The use of the teeth on the posterior shell-margin is quite unknown.

Messrs. R. and J. Beck: Examples of H. J. Grayson's fine rulings on glass, 50, 55, and 60 thousand to the inch.

May 2nd, 1902.

Mr. H. Morland: *Entopyla Australis* Ehr., from deposit at San Redondo, California, showing "front" and "side" views of valves, also difference between the upper and lower valves.

Mr. D. J. Scourfield: Living specimens of *Diaptomus vulgaris* ♂ and ♀, collected at the Club's Excursion to Richmond Park. This finely-coloured species is not very common in this country. It is intermediate between the well-known *D. castor* and the very common *D. gracilis*, but nearer the latter.

Mr. C. F. Rousselet: *Brachionus quadratus*, with spiny resting egg.

Mr. C. Lees Curties: Pollen grain of Evening Primrose, emitting tube.

Mr. W. Wesché: *Limnias ceratophylli*, a tube-building Rotifer. The smaller tubes are built on the parent's tube. From Dollis Hill, N.W.

May 16th, 1902.

Mr. K. J. Marks: Transverse section of stem of *Cyperus longus* Linn. (or "Galingale"), showing the indiscriminate manner in which the fibro-vascular bundles run through the fundamental tissue, essentially characteristic of the Monocotyledons. Several bundles pass from the stem to each leaf.

Mr. A. Earland: Siliceous Tetractinellid Sponge Spicules from anchor mud, Grenada, West Indies, ex. S.S. *Roddam*. Abundant in anchor mud of this locality. Figured in Bowerbank as "Spicules of an unknown Sponge." I have found similar spicules in muds from many tropical localities. $\frac{2}{3}$-in. objective and Lieberkühn.

Mr. A. Earland: Scoriae and Volcanic Ash from Vesuvius. Dredged in Bay of Naples, 100 fathoms.

Mr. A. E. Hilton: Head of Hairy Bee, *Dasypoda hirtipes*. Mounted in glycerine, without pressure, showing the organs of the mouth in their natural form and colour.

Mr. J. W. Barker: Spiral crystallisation under polarised light with selenite. Film of gum-water solution of copper and magnesium sulphates, 3 to 1, crystallised at 24° C.

Mr. F. J. Cheshire: Four exhibits in illustration of his paper and notes—(1) Calibration of condenser-scale with immersion objective; (2) Curious images produced by zonal aberration; (3) Images of wire gauze in back focal plane in objective; (4) Reflecting polariser.

June 6th, 1902.

Mr. T. A. O'Donohoe: Transverse sections of a Lippmann's colour photograph of the red and blue parts of the spectrum, showing the laminae formed by the action of light on the silver in the film.

Mr. F. J. Cheshire: New method of using Abbe's Apertometer. Graduated disc replaced by ungraduated one, and chord measured instead of arc. (See *ante*, p. 349).

Mr. J. W. Barker: Stauroscopic figures with crossed micas---using a reflecting polariser and monochromatic (sodium) light.

Mr. J. B. Scriven: Nymph of Blow-fly nearly mature. Tripolar end-organ of sensory nerve. From each angle extends a nervous expansion, the protoplasm of which is obviously continuous with that of the end-organ. The large cells have double nuclei.

Mr. K. J. Marks: *Philodina macrostyla* Ehr. If this Rotifer be put into clean water, it drops its floccose covering. Gosse observed a specimen covered with "tubercles," and was led to create a new species, *P. tuberculata*; but in one of his last notes says, "*P. tuberculata* has *no* tubercles." Found in *Sphagnum* at Quekett excursion to Chingford, May 24th, 1902.

Mr. T. G. Kingsford: *Hydrometra stagnorum*, showing great elongation of head peculiar to this insect. (See article in the May number of "Knowledge," by E. A. Butler.).

Mr. A. E. Hilton: Ova of Black Goby, or Rock Fish, *Gobius nigra*, showing sacs containing embryos with conspicuous eyes.

Mr. D. J. Scourfield: *Simocephalus serrulatus*. There are three known British species of this genus of Entomostraca, two of which, *S. vetulus* and *S. exspinosus*, are very common. The species exhibited is very rare, only having been found in three or four localities. It is easily recognised by the sharply-pointed head, with little teeth at the point, and the large blunt process in the position occupied by the shell-spine in *Daphnia*. From the lake in Kew Gardens.

June 20th, 1902.

Mr. W. Wesché: Mouth parts of *Hydrotea occulta*, ♂, showing the newly-discovered palpi described at the R.M.S. on the 18th inst.

Mr. T. A. O'Donohoe: Blood of Newt, showing karyokinesis (?) in a red corpuscle.

Mr. A. Earland: *Dilophus* sp. A Dipterous insect, with double eye on each side of head. The curvature and sizes of lenses differ.

July 4th, 1902.

Mr. T. A. O'Donohoe: Blood of child, showing many white corpuscles with nuclei stained blue. Method of preparation: Spread thinly on slide; fix in saturated solution of corrosive sublimate; wash thoroughly; stain in eosin; immerse for three or four seconds in solution of caustic soda, 1 in 10,000; stain in methylene blue; wash, dry thoroughly, and mount in Canada balsam; use a No. 1 cover-glass gently pressed down for examination by immersion lens.

Mr. A. Earland: Ninety-six typical species of Foraminifera to illustrate the principal genera of Brady's classification. "Bryce Scott" type slide, with air-tight sliding cover-glass.

Mr. J. B. Scriven: Nymph of Blow-fly (female nearly mature). Vertical sections. Eight slides to illustrate paper read on June 20th, 1902. The specimen was first stained in bulk with eosin and carmine, and finally on the slide with Ehrlich's logwood. It was transferred direct from absolute alcohol to the imbedding medium. The sections were cut with the Cambridge rocking microtome, eight teeth of the regulating wheel being used, so that they are (theoretically) $\frac{1}{5000}$ in. thick. They were afterwards stretched and fixed on clean slides with warm water, without any adhesive material.

Mr. H. Morland: *Amphiprora ornata* Bailey. From old furnace pond, Hamburg, Sussex County, New Jersey, U.S.A. A fresh-water form not yet recorded in the British Isles. A delicate membranous form, with twisted keel on face of valve, strongly constricted in centre, and undulated pleated hoop on frustule.

July 18th, 1902.

Mr. K. J. Marks: Tangential longitudinal section of *Pinus sylvestris*, showing prosenchymatous wood cells (tracheides) with bordered pits and medullary rays.

Mr. A. Earland: Fragments of an unknown organism, probably a new genus of Foraminifera, showing *selective instinct* in a highly advanced degree. The fragments shown are evidently parts of a tubular shell, built up entirely of broken sponge spicules neatly cemented together side by side with the fine mud cement characteristic of some Astrorhizidae. Instances of selective instinct in shell-building are well known in several genera of Foraminifera, but the construction is in all cases more or less haphazard. In these specimens, however, care has been taken to select broken spicules of approximately equal size, and to build them up in such a manner that, like the bricks in a wall, the various courses shall not lie in the same line. From Atlantic, off S.W. Ireland. Depth unknown.

AUGUST 1ST, 1902.

Mr. H. Morland: *Amphitetras elegans* Grev., from fossil deposit at San Redondo Beach, South California, showing valves and frustule.

Mr. A. Earland: Types of adventitious shell structure of varying degrees of refinement in Foraminifera. Genera: *Haplophragmium*, *Trochammina*, *Reophax*, *Textularia*, *Hormosina*.

Mr. K. J. Marks: *Salpina macracantha* Gosse, from pond near Neasden.

AUGUST 15TH, 1902.

Mr. T. G. Kingsford: Living specimens of young Marine Mussels, showing action of gills.

Mr. A. Earland: Head of cysticercus of the Hare, showing hooklets.

Mr. T. N. Cox: Sugar of Milk, shown with polarised light.

SEPTEMBER 5TH, 1902.

Mr. C. Turner: Legs of *Gyrinus natator*, showing the paddle expanded and shut as in the act of swimming.

Mr. C. J. H. Sidwell: Tongue of Crane Fly, *Tipula oleracea*, viewed from below. The "pseudo-tracheae" are deep-channelled folds kept open by incomplete rings, which differ from those in the Blow-fly in being perfectly plain, instead of alternately forked at either end. Two main channels on each side start from the base of the mouth and take a sinuous course over the bladder-like membrane; from these a number of similar smaller channels diverge at right angles, covering the whole surface, and forming a fine strainer, through which the fluid element passes on its way to the mouth. There are practically no mandibles, the only traces of these organs being a pair of small, chitinous, hook-like thickenings in the integument at the base of the lobes.

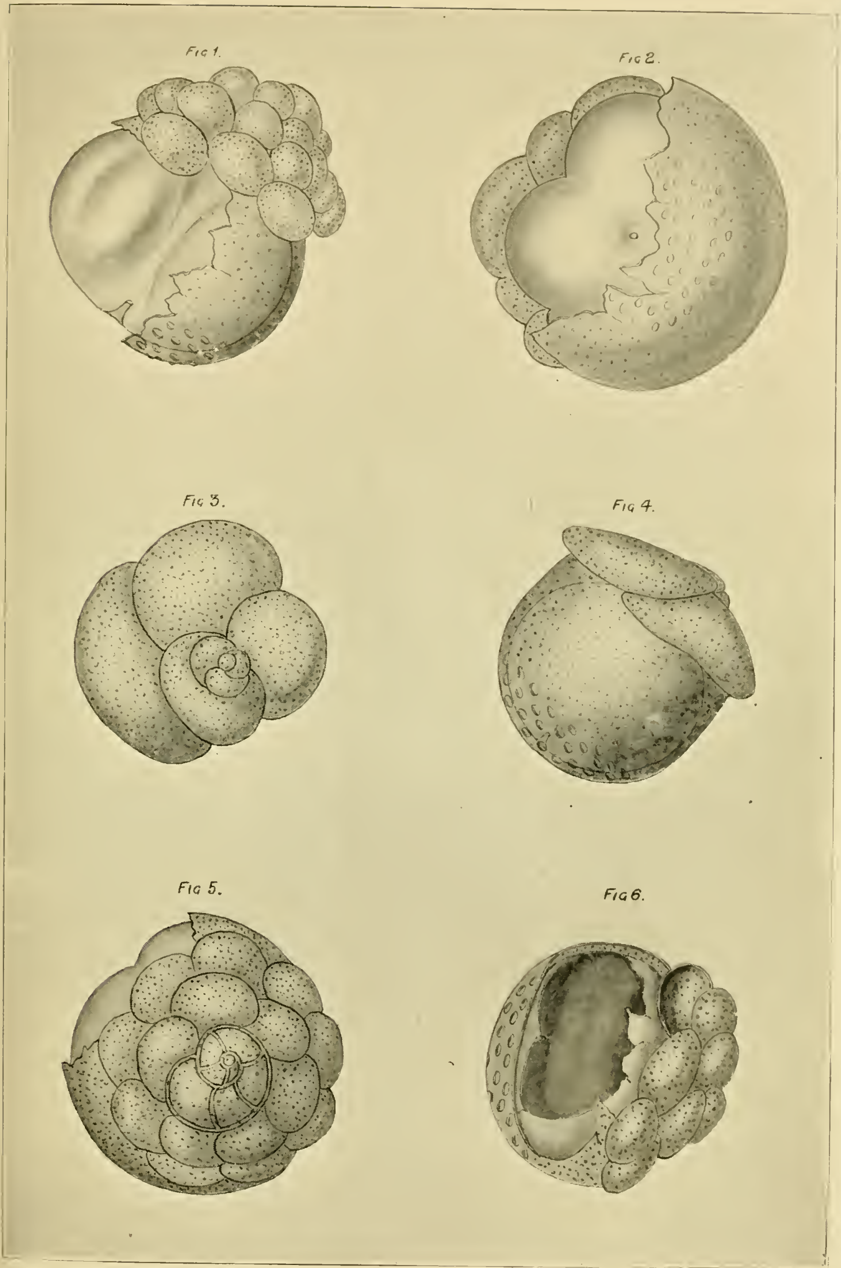
September 19th, 1902.

Mr. H. S. Martin: Longitudinal section (radial) of *Pinus sylvestris* (Scotch Fir), showing bordered pits.

Mr. C. F. Rousselet: Mounted specimen of the Rotifer, *Notops brachionus.*

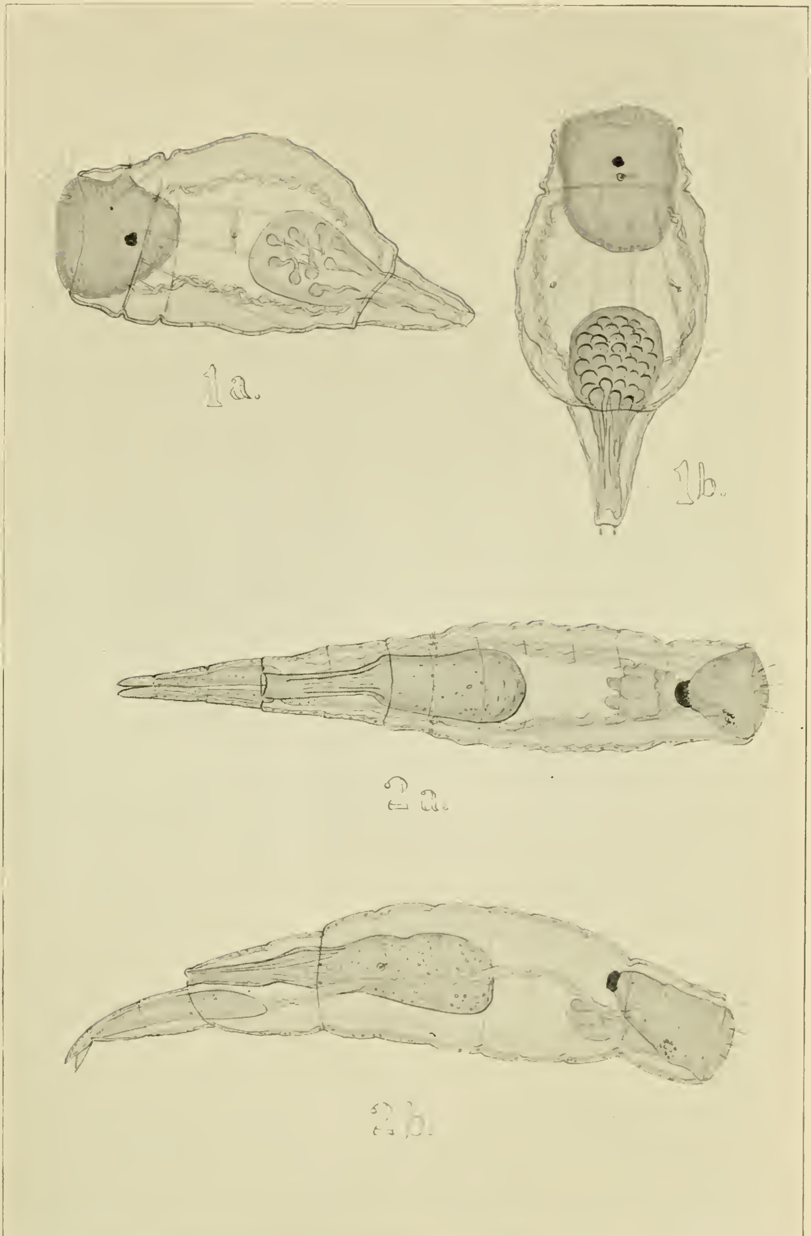
Mr. J. T. Holder: Testis of Frog, showing spermatozoa.

Mr. T. G. Kingsford: A Mite, known as the "Cotswold Bug," and found in great quantities in the Cotswold Hills. Attacks most animals, including man, burying itself in the skin after the manner of the Harvest Bug. Colour, when living, a brilliant orange.



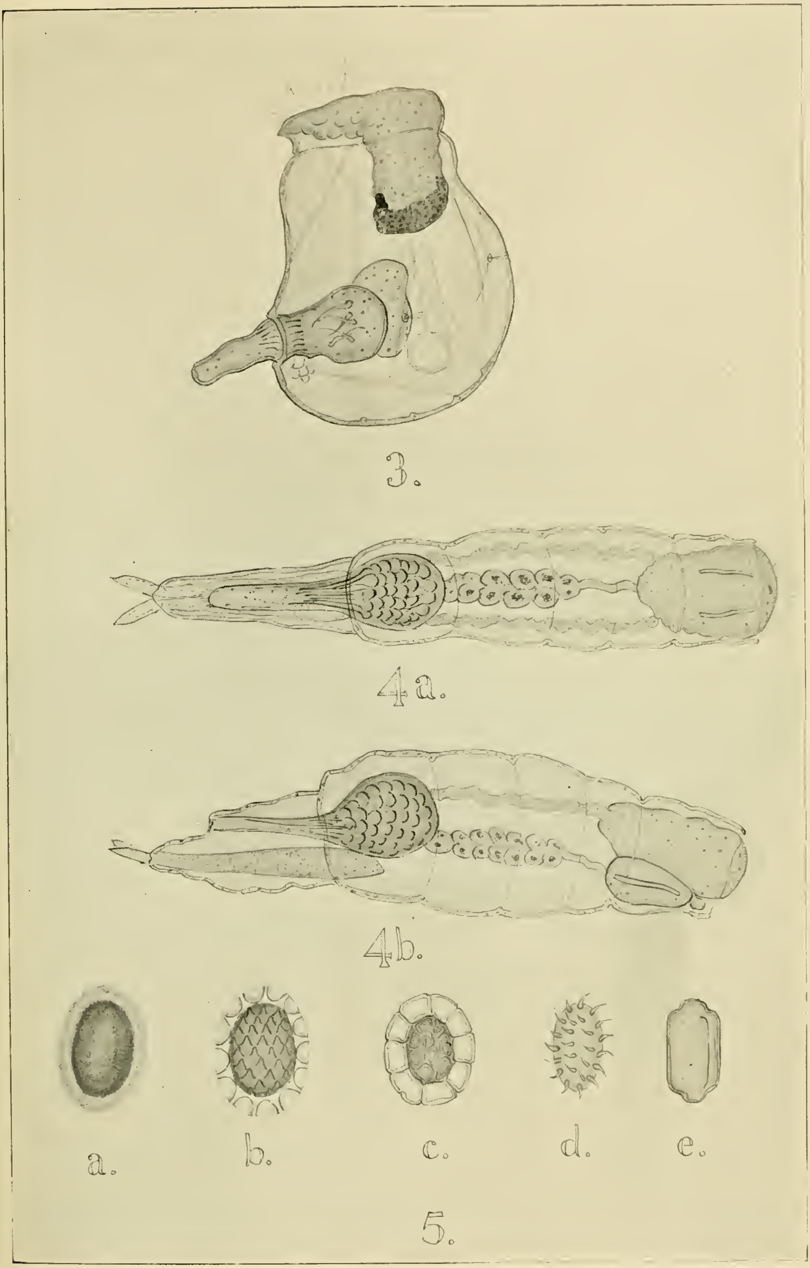
A. J. French, del ad nat.

Cymbalopora bulloides (d'Orbigny).



W. WESCHÉ, del.

MALE ROTIFERS.



W. WESCHÉ, del.

MALE ROTIFERS AND RESTING EGGS.

The Dentition of the Diptera.

By W. H. Harris.

(*Read October 17th*, 1902.)

Plate 19.

It is scarcely a subject of common knowledge that many species of Diptera indigenous to Great Britain possess organs which, for the purpose of the insects, perform the function of teeth. Flies do not, indeed, bite in the sense we ordinarily understand the expression, but nevertheless special organs are present in the flexible lobes of the haustellate mouths of very many species which perform the function of teeth, enabling the insects to add a little finely-divided solid material to the pabulum upon which they feed.

No doubt the members of this Club possess the knowledge that certain species of Diptera are thus provided with teeth, but probably even they are not aware of the wide distribution of these structures in the extensive family Muscidae. Further, they may not be aware that the various forms these organs assume, their number and method of arrangement, supply an almost unlimited field for investigation, which if systematically conducted could not fail to prove interesting, and possibly of scientific value in cases where a study of the life-history and habits of these insects is undertaken.

The subject is by no means a new one, but, as far as I am aware, it has not engaged the attention of many workers in this country. My attention was first directed to it by some correspondence which appeared in the pages of *Science Gossip* in the year 1876, and in the years 1884—1887 I contributed a series of short articles to that periodical upon the structure of the teeth of some fifteen species of Diptera.*

As the seasons have come round I have continued the investigations, with the result that a tolerably large collection of interesting objects has now been accumulated, and a certain modicum of knowledge obtained.

Preliminary to a critical examination of the dental organs, it is both interesting and instructive to observe the action of a fly during the act of feeding. The following method has been attended with tolerable success. Dissolve a small piece of clear gum arabic in a saturated solution of sugar and water, apply a small quantity of this mixture to the inside surface of the glass cover of a live box, and set aside to thoroughly harden.

The blow-fly may be usefully employed for the experiment, its mouth being typical of the majority of species. Enclose the fly within the live-box, and it will quickly be found that the prepared repast meets with approval, for the margins of the lobes of the labium will be closely applied to the food, the central part of the mouth will assume a concave form, and very quickly a drop of saliva will be emitted, so as to occupy the central part of the concavity. A rapid vibratory motion of the lobes, in a direction at right angles to the median line of the mouth, will be the predominant feature—this action being very pronounced in the posterior part of the mouth—and a steady stream of fluid will flow towards the oral cavity; this may be observed by small particles of the dislodged food floating upon the surface of the current.

At frequent intervals the lobes will be fully expanded for three or four times in rapid succession. It is assumed the teeth are then brought into operation; but as the movements are so quickly performed it is impossible to speak with absolute certainty from observation of the actual contact of the organs with the food.

In all books on Entomology to which I have hitherto had access it has been stated that the pseudo-tracheae are channels for the conveyance of liquid food, and this statement is generally accepted as fully proved. It may therefore be considered rank presumption on my part to state that since I have paid some

* *Science Gossip*, xx., 1884, xxi., 1885, xxii., 1886, and xxiii., 1887.

attention to the dental organs, and watched the actions of the living insects while partaking of food, my faith in the absolute correctness of the statement has been shaken. That these channels are capable of conveying liquids goes without saying, but I am sceptical as to this being the only, or even primary, use for which these organs were designed. I can recommend this subject as a special study to any one in search of employment, fully believing that there is much to be learned respecting these, so-called, suctorial channels.

It is impossible, within the limits of this paper, to do more than glance at some of the leading features of the subject; accordingly a few examples of typical groups of teeth have been selected for description and illustration. Before, however, proceeding to their consideration I may be permitted to make a few preliminary remarks of a general character.

The dental organs of flies are arranged in two nearly, if not absolutely, symmetrical groups, occupying a somewhat central position near the median line of the lobes of the proboscis. Each lobe contains one group of teeth. The groups of teeth may consist of one, two, three, or four distinct rows of organs, which, for convenience of description, may be divided into two distinct sections. Those mouths which have the organs arranged in two single symmetrical rows may be referred to as simple, while those which have two or more such rows in each lobe may be termed compound. When the rows of teeth are thus duplicated, they form compact and somewhat complex groups.

By far the larger number of species of flies possess their dental organs arranged on the compound system; but although this is the case, it must not be hastily assumed that they present a monotonous similarity. Many slight changes occur which the practised eye soon detects, and which relieve them from this accusation; for instance, the number of individual teeth in each row may vary considerably: they may be long or short, slender or robust; they may be of uniform breadth throughout their entire length, or they may be broad at the base with narrow free ends, or these latter distinctions may be exactly reversed. Then again the free ends of the teeth are subject to variation of form: they may be bi- or tridentate. Some of the teeth may bear from one to four small denticles between the large lateral points, thus giving the organs so furnished a pectinated appearance; or one denticle may be considerably enlarged, while the corresponding one is dwarfed.

Among certain species of Diptera, however, as already mentioned, the teeth are contained in a single row in each lobe of the proboscis, and it is among such that the variety of forms of these organs reach their fullest development. From the simple bidentate strap-like form found in the blow-fly, they attain by slight modifications the highest specialised type, and in such approach in form, and probably usefulness, similar organs to be found in some of the lower vertebrates.

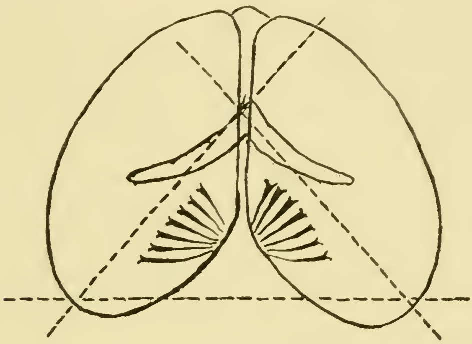
It is probable that the compound groups of teeth render the insects an additional service by guarding the entrance to the mouth from the intrusion of solid particles too large for the use or comfort of the insects. By the approximation of the two groups of organs a perfect screen is obtained through which the liquid food can be filtered before absorption, and particles of solid material firmly lodged between the teeth are of frequent occurrence.

Another fact of some interest may be mentioned. The pseudo-tracheae are very largely developed both in size and number in the mouths of all flies hitherto met with whose teeth are of the compound type. With the development of the dental organs there is a decline in size and number of the pseudo-tracheae until they finally disappear from the mouths of those insects whose teeth attain the highest state of development. Their absence, however, is compensated for by the introduction of certain modifications and additional organs, doubtless of equal value to the insects under the altered habits which their dental organs appear to indicate.

As some of our members are already interested in the subject of this paper, and I desire, if possible, to enlist recruits, I may be permitted to give a brief outline of the method of dissection and preparation of the objects which has given the best results.

Having killed the fly, sever the lobes from the trunk of the proboscis just at the junction of these parts. Spread the lobes apart upon an ordinary glass slip, taking particular care to have that side uppermost which we were observing in the living animal; place a thin cover-glass upon the object, and apply sufficient concentrated carbolic acid to immerse the lobes. At first the object will appear clouded and indistinct, but as the acid penetrates it will become beautifully transparent, and the dissection may be completed in the liquid.

In order to do this make three clean cuts in the direction of the lines indicated in the accompanying figure. Separate the uppermost membrane, which contains the object sought, from the one resting on the glass slip, which may now be discarded, and with a fine hair brush free the object from all internal organs, and finally mount in Canada balsam. It will be found that a small quantity of the acid is miscible with the balsam without decreasing the transparency of the latter, and that, for



hard parts of insects, no better or more expeditious method could be desired.

We will now proceed to consider a few typical examples of the teeth of flies:—

Figures 1 and 2, Plate 19, represent moieties of the dental organs of the Blow-fly, *Calliophora erythrocephala*, and *Polietes lardaria* respectively, both typical of the compound group. The teeth comprising the primary set in the first-named species may be described as bidentate rods, having a U-shaped section for about two-thirds of their length; the remaining third becomes flattened and solid at the free end. There are usually ten or eleven such organs in each half of the mouth. Each organ of the secondary set of teeth arises from two plates at the base of the pseudo-tracheae. With a graceful curve the two parts of each tooth approach each other, and at a short distance from their free ends become fused together, terminating in the form of a V.

The organs in the second row in the illustration number eight, in the third row they are reduced to four; thus each lobe is furnished with twenty-three organs. The complete set possessed by the fly which furnished this object consisted of forty-six bidentate teeth.

Figure 2, *Polietes lardaria*, furnishes a more robust development. The stout, primary teeth have lost their V-shaped terminations, indicating the service they have rendered the creature. This group was furnished by a fly taken in late autumn; recently emerged specimens possess the fully-formed teeth.

Figures 3 and 4 are examples of the compound type, comprising four rows. Many of the teeth in the subsidiary rows are beset with very minute projections situate between the two lateral denticles. In Figure 3, *Mydaea urbana*, the primary teeth are tridentate; but in Figure 4, *Spilogaster sp.* ?, they are bidentate.

Figure 5, *Morellia hortorum*. This fly furnishes a compound mouth consisting of two rows. The teeth of the primary row at their free ends are very narrow and tridentate. The basal portions are conspicuously enlarged, and the lateral margins are deeply incurved. The teeth of the subsidiary row are few in number and inconspicuous.

The illustration is an excellent example of a perfect dissection, showing the entire group of teeth furnished by this fly.

Figure 6, *Musca domestica*. The number of teeth possessed by this species is subject to considerable variation; the normal number is five, but individuals may be found having as few as three, or as many as seven. But, whatever be their number, the teeth are always characterised by saw-like edges.

Figure 7, *Hydrotaea irritans*. This fly is a common pest in the country, and needs no seeking. Each lobe has seven teeth; they are long, stoutly and firmly constructed, and considerably curved (see diagram p. 396, No. 1). Their free ends are tridentate; the two lateral points, however, are very minute, the central one is prominent. All are exceedingly sharp, rigid, and liable to fracture. They appear to be absolutely solid throughout, and in this respect differ from those of all other known species.

Figures 8, 9, and 10 represent the dental organs of species of

Scatophaga. Figure 8, *S. calida*, displays the entire group of mouth-organs in this insect. The position of the large tooth and the uniform size of the remainder should be contrasted with Figure 9, *S. stercoraria*, the common dung-fly. The teeth are more unequal in size than those of the first-named species. The large tooth has become the third member of the group, which peculiarity is still further exemplified by Figure 10, *S. scybalaria* (?) in which species it occupies a central position. The lateral view is shown in the diagram (No. 2).

These are interesting examples of slight modifications existing in different species of the same genus. Systematic investigation would probably reveal similar minor variations occurring in other genera.

Figure 11, *Caricea tigrina*. The dental organs differ entirely from any of the preceding species. Each lobe contains four cuspidate teeth of unequal size, somewhat triangular, or bayonet-shaped, in transverse section. The basal portions are expanded, and light in colour, indicating their point of attachment; their free ends are dark, dense, and liable to fracture.

The posterior and anterior parts of the mouth are furnished with four groups of strong setae; these probably aid the creature in the capture of its prey by entanglement.

Figure 12, *Caenosia sexnotata*. This bears a strong family likeness to the last-described species, to which it is probably closely related, but slight modifications occur which may be briefly referred to. The teeth are more uniform in size, and less triangular in transverse section, the basal portion differs in form, and when a lateral view is obtained it is seen to be deflected at a considerable angle; the upper portion presents great curvature, and finally the groups of setae are somewhat different in size, shape, and density. A view of the lateral aspect of these teeth is given in the diagram (No. 4).

Figure 13, *Schaenomyza litorella*, a marine species, widely distributed, but rare. The mouth of this insect contains eight powerful, tricuspidate teeth, well shown in the illustration. The anterior and posterior portions of the mouth have groups of setae less dense than in Figure 11. The lateral aspect of the tooth is given in the diagram (No. 3).

Figure 14, *Stomoxys calcitrans*. The greatest of domestic pests, a fruitful source of bad language, and an ambassador of Beelzebub. Each lobe contains five rather short, stout, bidentate teeth, which on their conical portions are beset with very fine serrations. Diagram (No. 5). All traces of pseudo-tracheae have disappeared; their positions, however, are occupied by long, lance-like organs. Behind each tooth are curiously-paired organs, the use of which is problematical.

The foregoing examples have been selected, not without due consideration, as illustrating the chief point it has been the object of my paper to refer to. An examination of the objects in my cabinet would disclose many connecting links, but as all the species have not been identified I have refrained from introducing them.

To briefly recapitulate, I have attempted to show that the dental organs of Diptera may be divided into two groups, the

Lateral aspect of teeth of:—
1. *Hydrotaea irritans.* 3. *Schaenomyza litorella.*
2. *Scatophaga stercoraria.* 4. *Caenosia sexnotata.*
5. *Stomoxys calcitrans.*

compound and the simple. The former contain from two to four rows of teeth, developed on different lines; the simple contain organs more highly differentiated, and approaching in form the lower orders of vertebrate types. With the development of the teeth there has throughout been a gradual diminution of pseudo-tracheae, both in size and number, until they disappear entirely.

It may be asked whether extended investigations would be merely an interesting occupation—an amusement for an idle curiosity—or whether any scientific value could be derived from them. I fear I am unable at present to offer a definite opinion that would be quite satisfactory. I may, however, say that, so far as my researches have been carried, the dental organs of flies appear to supply a fairly constant additional set of specific characters. Among the vertebrates these organs are certainly regarded as characteristic. I therefore see no reason why the Diptera should be excluded; but much has yet to be done before this question can be satisfactorily answered.

In a monograph by the late Dr. R. H. Meade, of Bradford, on the British species of the Flesh-fly, *Sarcophaga*, published in the *Entomologist's Monthly Magazine*, February, 1876, page 217, he remarks as follows: "The majority of these flies are so much alike, that it is impossible to distinguish the separate species from each other by mere differences of colour and design; and the greater number of authors having chiefly relied upon these points, very few of the species described by them can be determined with certainty."

It was my privilege to have the advantage of this gentleman's experience in the matter of identification, he having become interested in the subject I was engaged with; and in a letter I received from him he made the suggestion that investigation as to the value of the teeth as reliable specific characters would probably prove valuable. His lamented death has been an irreparable loss to me, and has so far prevented any progress in this direction. It is almost superfluous to remark that assistance in this particular portion of the subject would be welcomed, for the labour of many hours could often be dispensed with if specimens could be submitted to an expert for specific determination.

Note.—In the discussion which followed the reading of the above paper, the question was raised by one of the members whether these organs could really be called teeth. Without wishing to enter into a discussion on this point, I may refer those who may still have any doubt upon the matter to the monograph on the Blow-fly, by Dr. Lòwne, in which the simple, strap-like organs of that insect are by him denominated teeth.

What is a tooth? Referring to "Cassell's Encyclopaedic Dictionary," vol. vii., page 128, under the word "tooth," the following definition is given: "Any projection resembling or corresponding to the teeth of an animal in shape, position, or office. A small narrow projecting piece, usually one of a set."

All these particulars are conformed to by certain Diptera, and, subject to the limitations I have set upon their use in the previous portion of my paper, I feel perfectly justified in adhering to the use of the word "teeth."—W. H. H.

Explanation of Plate 19.

Teeth of Flies.

Fig. 1. *Calliophora erythrocephala*, × 40.
,, 2. *Polietes lardaria*, × 65.
,, 3. *Mydaea urbana*, × 40.
,, 4. *Spilogaster sp.*, × 65.
,, 5. *Morellia hortorum*, × 40.
,, 6. *Musca domestica*, × 100.
,, 7. *Hydrotaea irritans*, × 40.
,, 8. *Scatophaga calida*, × 40.
,, 9. ,, *stercoraria*, × 65.
,, 10. ,, *scybalaria ?* × 65.
,, 11. *Caricea tigrina*, × 65.
,, 12. *Caenosia sexnotata*, × 140.
,, 13. *Schaenomyza litorella*, × 140.
,, 14. *Stomoxys calcitrans*, × 140.

[In illustration of this paper Mr. Harris has very kindly presented to the club a number of excellent preparations of the teeth of Flies. These may be borrowed in the usual way upon application to the Hon. Curator.—Ed.]

On the Anatomy of *Drepanidotaenia tenuirostris*.

By T. B. Rosseter, F.R.M.S.

(*Read October* 17*th*, 1902.)

Plate 20.

Rudolphi attributes the discovery of this tape-worm to Bremser, who found it parasitic in the intestine of *Mergus serrator L.* (red-breasted merganser) in Vienna, and who placed a type specimen in the museum of that city. Rudolphi also found it parasitic in *Mergus albellus L.* (seamew) at Berlin.* He describes it thus: "*Caput* subrotundum parvum; *rostellum* gracile versus apicem obtusum increscens; inerme. *Collum* mediocre." Like Bremser, Rudolphi also placed a type specimen in the Berlin Museum.

Dujardin, in his "Histoire Naturelle des Helminthes," 1845, p. 610, merely quotes Rudolphi in connection with this helminth, but throws out the suggestion of the possibility of the rostellum of the Bremser-Rudolphi specimen having become deprived of its hooks accidentally.

Krabbe of Copenhagen examined the specimen which Rudolphi had placed in the Berlin Museum, and describes the worm as being 100 mm. long. He also carefully examined the scolex with its rostellum, and discovered that Rudolphi was in error in saying that this was "*inerme*," as he, Krabbe, found that the rostellum possessed a crown of "10 hooks," the same as his own specimen did which he took from *Anas marila* in Jutland. Krabbe figures these hooks together with the rostellum in his work

* Rudolphi, "Carol. Asm. Entozoorum Synopsis." Berolini, 1819. Pt. 1, p. 156, sec. 44; and pt. 2, p. 509 sec. 44.

"Bidrag til Kundskab om Fuglenes Baendelorme," and states that they have a mean measurement of 0·020 mm. long. Krabbe's specimen was 250 mm. long, and the proglottides, or segments, 1·5 mm. broad.

Von Siebold, Bavaria, took it from *Mergus merganser L.* (Goosander); this specimen was but 120 mm. long and 1·5 mm. broad.

The genital organs were entirely overlooked by all those naturalists who, from Bremser up to Krabbe, had found this worm in the intestine of various aquatic birds, and even the latter is very brief in his description of these organs; he merely says, "Aperturae genitalium secundae. Longit penis 0·019 mm., latit 0·008 mm. Hamuli embryonalis longit 0·007 mm."

This cursory description of Krabbe's is not even accompanied by a sketch of the male organs of generation, and neither they nor the female organs have ever been studied until the author of this memoir undertook, as in the case of *Dicranotaenia coronula*, the task of not only studying and describing the male and female organs, but likewise illustrating them for the benefit of present and future helminthologists who might undertake to continue the work on the anatomy of those tape-worms which make the *Anatidae* their final host. It is' evident from Krabbe's brief description that the proglottides from which he drew his conclusions, so far as the male genital organs and the hooks of the oncosphere are concerned, were uterine segments; the genital organs, both male and female, were in a state of absorption and much obscured by the formed uterus.

Much doubt seems to have surrounded this particular specimen. Rudolphi was inclined to think that it was identical with *T. trilineata* of Batsch. Froelich thought that *T. trilineata* was identical with *T. longirostris* Rudolphi, and catalogued it as such; whilst Dujardin came to the conclusion that *T. trilineata* was simply a variety of Rudolphi's *T. sinuosa*. Krabbe simplifies the matter by dropping *T. trilineata* altogether out of his catalogue and description of Avian tape-worms. I agree with him, and think he was perfectly correct in so doing, more especially when we take into consideration how much depends, in defining the species, on the formation, contour, size and number of the hooks on the rostellum. The hooks of all three of these species—viz. *tenuirostris*, *longirostris*, and *sinuosa* (I have a specimen of each species in my cabinet)—have so many discrepancies and are so dissimilar in respect to contour, formation, and size, that one has no difficulty in defining and diagnosing either of these species by the hooks of the rostellum.

The tape-worm from which I have made the following observations is one I had produced by infecting ducks (*Anas boschas dom.*) with cysticercoids. It was 39·400 mm. long ; was composed of about 400 proglottides or segments, which gradually widen from 0·084 mm. to 1·5 mm.—which is their extreme breadth, from each lateral border—in the uterine segments. It will thus be seen that this specimen, although a mature worm, falls far short of that of the Bremser-Rudolphi specimen, and is but $\frac{1}{6}$th of that of Krabbe. It was not what we call a virgin worm, because it had already shed a portion of its strobila, which was composed wholly of uterine segments. I have others in my collection, which I took from the intestine of the same duck, in various stages of growth, from the scolex, with its immature collum, the result of late experimental feeding, to that which I have selected for the production of this paper.

Description of the Worm.

The head or scolex is subglobose, 0·27 mm. wide and 0·135 mm. long. From the crown springs a long attenuated retractile rostellum approximately 0·112 mm. long and 0·023 mm. in diameter; it is terminated by a bulbous rostrum, around which are arranged ten sickle-shaped hooks 23 μ long. At the base of the rostellum, deeply sunk in the middle of the scolex, is a muscular pyriform bulb or root (see *Journ. Q. M. C.*, Ser. 2, vol. vi., No. 41., pp. 397–405, Pl. XVIII., Figs. 9–11), which sends a series of retractor muscle fibres to the rostrum. These muscle fibres invert the rostrum, together with the hooks down the rostellum, like the inverted finger of a glove, leaving a circular orifice at its proximal end. Not that the rostellum is cylindrical or tubular, as was supposed by Dujardin (following Rudolphi, who says "Rostellum cylindricum"), in the case of *T. sinuosa* and *T. trilineata* *; but the external cuticle folds inwards in the act of inversion. There are four strong muscular suckers placed equidistantly round the subglobose scolex.

The neck is short and narrow. It varies in different specimens, and segmentation commences quite perceptibly a short distance from the scolex.

In a mature worm which, like the one under consideration, had shed its uterine proglottides, the "anlage" or commencing formation of the reproductive organs does not occur until the 182–200th segment from the scolex is reached, or about 5·737 mm. down the strobila, and where the segments have a mean width of 0·304 mm. The proglottides elongate themselves proportionally as the organs of generation develop. The usual sequence of development common to the *Taenidae* is pursued, and a gradual wasting of the genital organs ensues when the act of coition has taken place and the receptaculum filled with sperm. The act of fructification usually takes place when the 300th segment is reached, or about 22·413 mm. from the scolex. The act of absorption is slow, and at the point where my specimen broke off—viz. the 400th segment—the proximal testes still existed, but in an attenuated form; and the afferent and efferent ducts had been entirely absorbed.

Description of the Genital Organs.

The genital cloaca is situated on the dextro-lateral margin of the proglottis near its posterior end. It is an elongated narrow cavity, and forms one of the lateral serrations. The genital pores are unilateral, and although distinct from each other, are enclosed in one matrix.

* "Histoire des Helminthes," pp. 573–574.

Male Genital Organs.

The male genital sinus is anterior to that of the female. There are three testicular sacs, situated proximally, medially, and distally, and they lie in the dorsal portion of the segment (Fig. 1, *a.b.c.*) The median is the largest of the three, being 0·101 by 0·083 mm., and is 0·020 mm. larger than the other two. In contour it is somewhat pyriform, whilst the other two are subglobular. They do not all three lie in the same plane, the proximal testis being more dorsally situated than the other two. They are quite distinct from each other—that is to say, the proximal and median testis each send off a distinct undulating vas efferens, which effects a junction with the vas deferens; whilst the ductus efferens of the distal testis goes to form the vas deferens (Fig. 1, *d*). The vas deferens swells out and forms a long vesicula seminalis, the proximal portion of which resolves itself into a cirrus pouch.

The vesicula seminalis (Fig. 1, *v.s.*) occupies in a sexually mature segment one half of the whole width of the proglottis; its widest diameter is 0·044 mm. Both its proximal and distal ends are drawn out into a narrow neck. The neck at the proximal end forms the cirrus pouch (Fig. 1, *c.p.*), and this again swells out into a large contractile globe, to which I have given the name of the globulous cirrus chamber or cup (Fig. 2), the interior of which is covered with minute spines. When the cirrus is everted for the purpose of coition, the cup also elongates itself until it becomes a long ampulla-shaped organ. It elongates itself to the extent of 0·03 mm., whilst its orifice is 0·01 to 0·02 mm. (Fig. 3). The cirrus is a short smooth hollow rod 0·034 mm. long, with a diameter of 0·003 to 0·007 mm., varying in different segments. The neck at the distal end of the vesicula seminalis receives the afferent ducts of the prostate glands.

The prostate glands in this instance are duplex, and they are situated anteriorly and posteriorly on either side of the large vesicula seminalis (Fig. 1, *a.p.g.*, *p.p.g.*, and Fig. 4). As will be seen on reference to Fig. 1, they are two elongated glands whose efferent ducts make a junction independently of each other with the vas deferens. They have individually a length of 0·145 mm. and a width of 0·057 mm. At no period of their development have these glands any semblance of cells; they have a waxy homogeneous appearance, and both haematoxylin and picro-carmine stain them very faintly.

The Female Organs.

The female genital sinus is situated posteriorly to that of the male. The vagina (Fig. 6) is ampulliform. It is encircled by a series of muscles and enveloped in a segregated mass of cellular tissue which gives it a flocculent appearance. It is 0·4 mm. in length, and has a median diameter of 0·017 mm. Its interior in the proximal third, which is really the vulva, is spinous, and has a transverse diameter of 0·013 mm., which contracts in impregnated specimens to a minimum of 0·003 mm. At its distal end it narrows and forms the vaginal canal. In stained transverse sections the vulva is seen to be composed of a series of minute radiating muscle fibres, which no doubt cause it to contract at the time of coition. The vaginal canal (Fig. 5, *v.c.*), on its exit from the vagina, runs for a short distance ventrally to the vesicula seminalis and then hangs down semicircularly in the proglottis. In its proximal portion it is somewhat attenuated, dilates itself in the median third, but before making a junction with the receptaculum, it again becomes narrow and also sinuous.

The receptaculum seminis (Fig. 5, *r.s.*) is a continuation of the vaginal canal swollen into a large subglobular sac, and when distended with spermatozoa, after coition, has a diameter of 0·186 by 0·192 mm. It is situated ventrally in the distal anterior third of the proglottis, the distal end of the vesicula seminalis overlapping it dorsally. Its efferent duct, which forms the fructifying canal, makes its exit on the ventral side, and goes obliquely down the proglottis to the shell gland. The canal has a diameter of 0·002 mm.

The ovaries (Fig. 5, *a.o.* and *p.o.*) are a pair of fan-like organs situated medio-ventrally and in some respects similar to those of *Dicranotaenia coronula*. The observations made on these glands, and the conclusions drawn as the result of those observations—read before the Quekett Club in my paper on the generative organs of *Dicranotaenia coronula* on April 20th, 1900—apply also to those of the present helminth. The ovarian ducts have a diameter of 0·003 mm., becoming reduced at their junction with the fructifying canal. The porose ovary has a length of 0·185 mm., and the aporose 0·169. The latter is narrower and more compressed than the former.

The shell gland (Fig. 5, *s.g.*) is situated medio-ventrally on the posterior border of the segment between the two ovaries. It is a reniform gland 0·089 mm. long, and its apical axis 0·04 mm. The secretive cells of this gland and those of the ovaries both readily take, and are deeply stained by haematoxylin.

The yelk gland (Figs. 5 and 7) is unique in its character; in fact, it may be looked upon as a distinctive characteristic of this species of tape-worm, for instead of being situated as it usually is in other species (viz. medio-ventrally between the ovaries and posterior to the shell gland), in this case it lies in the median line of the proximal third of the proglottis close under the vesicula seminalis and dorsal to the vaginal canal. It is a long club-shaped gland 0·086 mm. long and 0·03 mm. wide. The efferent duct is a long tortuous canal, and makes a junction with, and empties the secreted yelk into, the shell gland. This is demonstrable in those segments in which the organs of generation, having fulfilled their mission, are gradually wasting away, and they contain not only exhausted and partially exhausted yelk glands, exhibiting their cuticular structure, but likewise those yelk glands whose secretive substance has passed into a thick, tough, cheesy, and in some cases a brittle, condition (Fig. 7). In such the efferent duct, losing its support in the surrounding tissue, which has become transformed into the already forming uterus, breaks up into pieces, thus exposing the coagulated secretion within the duct. This gland is the last organ of generation to form within the proglottis, commencing its evolution from the cellular tissue of the segment about 22·600 mm. from the scolex.

I regret that, owing to my specimen being deficient below the 400th segment, as above mentioned, I am unable to give any account of the structure of either the uterine canal or uterus and oncospheres.

Explanation of Plate 20.

Drepanidotaenia tenuirostris.

Fig. 1. Male organs, × 155.
c.p., Cirrus pouch; *v.s.*, vesicula seminalis; *a.p.g.*, anterior prostate gland; *p.p.g.*, posterior prostate gland; *a.*, proximal; *b.*, median; *c.*, distal testes, with their ducts, *d.*

Fig. 2. Globulous cirrus chamber or cup, × 350; *c.*, cirrus.

Fig. 3. Cirrus cup, elongated with protruded cirrus, *c.*, × 350.

Fig. 4. The prostate glands detached, × 155.

Fig. 5. Female organs, × 155.
v., vulva; *vg.*, vagina; *v.c.*, vaginal canal; *a.o.*, anterior ovary; *p.o.*, posterior ovary, with their ducts; *s.g.*, shell gland; *y.g.*, yelk gland; *f.c.*, fructifying canal; *r.s.*, receptaculum seminis.

Fig. 6. Vagina, × 1400; *m.r.*, muscular rings.

Fig. 7. Cheesy formation of yelk gland, × 350.

Fig. 8. Worm, natural size.

On *Zoothamnium geniculatum*, a New Infusorian.

By William Ayrton.

(*Read December* 19*th*, 1902.)

Plate 21.

In the summer of 1899 I first observed this distinctive tree-like colony-stock of the Vorticella tribe, attached to weeds growing in the river Waveney, near Beccles, Suffolk. On one occasion, in November or December of 1899, I brought some specimens to a meeting of the Quekett Club, and the opinion was then expressed that it was *Zoothamnium arbuscula* or a form closely allied to it. Further study and observation have brought to light very distinctive features, which make it evident that we have to deal with a new and undescribed species.

There are four genera of the *Vorticellidae* forming compound tree-like colony-stocks—namely, *Opercularia*, *Epistylis*, *Carchesium* and *Zoothamnium.* In the first two the pedicle and branches, or zoodendrium, are rigid and uncontractile. In *Carchesium* the zoodendrium is contractile, but the central muscular fibrilla is disconnected, and each zooid or group of zooids is able to contract separately. In *Zoothamnium* the muscular band is continuous throughout, so that when a single zooid contracts, all the others follow suit, and there is a complete contraction of the whole colony-stock.

Seen with the naked eye or pocket-lens, the whole colony of *Zoothamnium geniculatum* appears very similar in size and shape to that of *Zoothamnium arbuscula*, though anyone well acquainted with both species will easily discern a difference in the fern-like fronds and mode of contraction.

The chief difference from other species, and peculiarity, is in the main stalk or pedicle. This can be divided into three regions; the upper part is flexible, and contracted by the internal muscular thread into a more or less spiral form, while the two lower parts are perfectly stiff, but connected by a highly flexible knee-joint (Figs. 4 and 7). In contraction this knee-joint is the most remarkable and obvious feature, and has suggested the specific name. At the summit the pedicle divides horizontally or obliquely into from five to nine fern-like fronds, with bipinnate or alternate branching secondary stalks, which are again subdivided as represented in Figs. 2, 3, and 8. The nodes are close together, and two or three smaller branchlets usually spring from the underside of each node. In *Zoothamnium arbuscula* the secondary stalks of the fronds are fine, smooth, and elongate, while in *Zoothamnium geniculatum* they are stout, short, and knotty (Fig. 8). All the ultimate branchlets and zooids are situated on the under side of the frond, and the current in the water, produced by the total action of the cilia, runs from below the tree upwards and through the branches.

The zooids are of two shapes and sizes. The very numerous smaller zooids are conical-campanulate and of the usual Vorticella structure (Fig. 3). The larger reproductive zooids are four times as large when fully grown, spherical in shape, pellucid, with a very small ciliated cup at the apex, and contain a large crescentic nucleus of a bluish colour in their interior; they are always few in numbers and attached to the underside of the main rib of the fronds (Fig. 6).

Attached to the branches I have noticed parasitic Vorticellae with slender spiral stalks, resembling *Vorticella campanulata*, $\frac{1}{470}$ in. in size, living among the zooids of *Zoothamnium geniculatum.* A Rotifer also—probably *Proales petromyzon*—is found living and laying its eggs on the branches, and feeding on the zooids.

The muscular fibre is continuous throughout all the branches, and at the summit of the main pedicle the various threads run together to form a stout muscular band (Fig. 5), which runs down the stem to a point some little distance above the knee; from this point the band becomes very transparent, as if only the sheath of the muscular thread were continued, and just below the knee it is attached to the side of the pedicle (Fig. 7). The muscular thread therefore does not run down to the base of the pedicle, as is the case in *Zoothamnium arbuscula.* In structure the internal muscular fibrilla consists of a cord with fine transverse striations encased within a delicate hyaline sheath, which itself is very finely striated longitudinally.

The size of the whole adult zoodendrium is $\frac{1}{6}$ in. in height and equally wide across the crown. The longest diameter of the small zooids is $\frac{1}{440}$ in. long and $\frac{1}{750}$ in. wide. The large spheroidal zooids vary in size from $\frac{1}{200}$ in. to $\frac{1}{110}$ in. in diameter.

The whole colony-stock of this infusorian presents the appearance of a most beautiful living miniature tree in which the small zooids represent the leaves and the large reproductive zooids the fruit, and it is quite visible to the naked eye.

The only habitat known so far is in the river Waveney, above Beccles, in fresh water, where it is to be found attached to submerged weeds, sometimes in fair abundance, during the summer months and even up to December; but even there it disappears sometimes for several years, and it must therefore be considered a rare species.

I have worked the other Norfolk rivers and broads for some years, but have never been able to find it elsewhere. Should any member of our Club discover it in any other locality, I shall be pleased to be informed of it.

Explanation of Plate 21.

Zoothamnium geniculatum, n. sp.*

Fig. 1. Adult colony-stock, × 15.
,, 2. Enlarged frond, × 30.
,, 3. Group of four zooids, × 200.
,, 4. Colony in act of contraction, × 15.
,, 5. Apex of pedicle showing branching, × 200.
,, 6. Reproductive zooid, × 50.
,, 7. The knee in contraction, × 30.
,, 8. Muscular fibre and branching of frond, × 200.

* By an oversight, the name on the Plate has been printed *Z. geniculata*.

The Male Organs of the Flies *Scatophaga lutaria* and *S. stercoraria*.

By W. Wesché, F.R.M.S.

(*Read January* 16*th*, 1903.)

Plate 22.

The two species *S. lutaria* and *S. stercoraria* are common; they are related to our smaller house-fly, *Homalomyia canicularis*, but they are predaceous and modified in an interesting manner, having longer and more setose legs, stronger wings, and more highly developed teeth.

The genitalia of the male in most of the Muscidae are difficult to make out, but in these species, on account of their fair size, their habits, and the larger development of the parts, a little trouble will enable the student to get a clear idea of the armature.

A dissection of the parts in the cockroach (*Blatta orientalis*) gives a little help in the study of these flies, and may be briefly referred to. Professor Huxley says* that only numerous figures can make intelligible the position and form of the number of hooks and plates that form these genitalia, "and that though they are of the same nature as the female gonapophyses, they are not their exact homologues." But he does not give the figures or any terminology.

An interesting text and complete figures will be found in Miall and Denny's work.† But in the matter of terminology there is but little to make use of. However, in Mr. Theobald's volume on British Flies,‡ a scheme is given which seems of value; it is applied to the family of the *Mycetophilidae*, taking as a type the genus *Phronia*. The genitalia in this family are of a different character from those usually found in Diptera, and need

* "Anatomy of Invertebrated Animals," p. 350, 1877 edition.

† "The Cockroach," Miall & Denny.

‡ "British Flies," Theobald, p. 126.

special study, as they appear on a cursory examination to resemble the ovipositor, and indeed may easily be taken for that organ. However, they will be found to homologise, as they consist of a number of plates and processes arranged round a central male organ. These make a total of nine parts, and consist of two lower plates (*laminae basales*), two upper plates (*laminae superiores*), two outer hooks or claspers (*forcipes inferiores*), two inner claspers (*forcipes superiores*), and a central penis, which is called the *appendix interna*, or *adminiculum*. These are homologised with the same number of parts in the ovipositor. Compared with *Blatta*, the genitalia of *Scatophaga* are simple, and correspond in several points with the arrangement of those found in the *Mycetophilidae*.

The males in *Scatophaga* are variable in size, some being smaller, and others, contrary to the general rule, larger than the female. In mating the female is seized with a sudden spring (when killing prey or feeding are favourite occasions), and forcibly held, though sometimes fiercely struggling. We see here the cause of the variability in size—superior strength is of obvious advantage to the male, as well as the complicated mechanism we are about to examine. Most, if not all, insects which mate on the wing are provided with hooks or claspers for holding the female. In Diptera this is very well marked in the gnats (*Culicidae*) and the fantailed flies (*Dolichopidae*). *Scatophaga* is well provided in this respect, as, without counting the testes, or any of the internal tubes or glands, and the lever figured, as No. 7, the male genital armature consists of no less than ten separate pieces with distinct functions. This also omits a series of setose processes which line the anterior edge of the cavity of the hypopygium, but which are absent in some species.

Four paired organs are found: viz.—(1) two plates, which probably correspond with the podical plates of Huxley, and are so thickly haired that possibly they may be of sensory use (Fig. 3). (2) Two outer hooks, with setae on the edges; I have noticed these organs holding the abdomen of the female (Fig. 4). (3) Two small palpi with apical bristles are within the cavity of the hypopygium (Fig. 5). (4) Close to these palpi are two smaller hooks (Fig. 2). Behind the hooks is the penis, which probably forms a continuation of the ejaculatory apparatus, and is a complicated piece of mechanism (Fig. 8). Behind the penis is a curious club-shaped hook (Fig. 9), which varies exceedingly in shape in the different species.

The terminology given above can be applied to the outer plates, which appear to correspond with the *forcipes inferiores*, while the outer claspers are the *forcipes superiores*. The palpi and inner claspers are only appendages of the *appendix interna* or *adminiculum*. The other parts—the *laminae basales* and *laminae superiores*—are difficult to identify.

To find a corresponding part to the club-shaped hook we must turn to *Blatta*, where there is a similar process in apposition to the penis; in this insect it is called the "titillator."*

The organs in *Scatophaga* are shown diagrammatically in Fig. 1, and a lateral view, with the outer plates and claspers removed, is given in Fig. 8. The hook (Fig. 9) is posterior to the penis. On the anterior edge of the cavity of the hypopygium are the two spiny processes shown in Fig. 1. They perhaps may be homologues of the *laminae superiores*.

The spermatozoa are contained in two chitinous sacs, provided with an intricate ramification of nerves, and leading by two long tubes (*vasa deferentia*) to the ejaculatory organ.

These parts are those found in *S. lutaria*. The general plan of those belonging to *S. stercoraria* is similar, but varies in detail. The larger hooks (Fig. 4) differ in shape, the palpi (Fig. 5) are shorter and more bristly, and the inner hooks (Fig. 2) have rounded blunt ends. The penis is shaped differently, and is shown (Fig. 6) drawn to about the same scale as Figs. 2, 3, 4, and 5. The shapes of the two organs are very dissimilar. *S. stercoraria* has two minute hooks on the upper part of the penis, and the accompanying posterior hook is fused at the base and exceedingly modified in shape. The most striking variation is the presence of an organ of spatulated shape, which I have failed to find in *S. lutaria* (Fig. 7). This part has much the same appearance in *Lucilla cornicina* and *Palloptera ustulata*, but in *Nemopoda cylindrica* it is much elongated. It appears to be a lever or apodeme, to which powerful muscles are attached.

Professor A. Berlese † has studied the copulation of the house-fly

* "The Cockroach," Miall & Denny.

† "Riv. Patol. Vegetale," ix. (1902), pp. 345–56.

(*Musca domestica*), and has succeeded in obtaining sections of the insects *in copula*. By this means he proves the remarkable fact, hitherto unsuspected, that the male, after seizing the female, is *passive*. It is the ovipositor that is forced into the cavity of the hypopygium, and its soft parts fit into and round the complicated armature of the male. This applies to *Scatophaga* as well; but with families where the females have long jointed horny ovipositors, this observation of Professor Berlese's does not apply, and we find a different type of genitalia in the male. In the Lonchaeid (*Toxeneura muliebris*) the claspers are more like palpi, there are no inner hooks, and the penis is modified into a long ciliated ribbon. In other genera of the same family this ribbon has a chitinous bulbous head, with an organ which appears to correspond with Fig. 9 (*Palloptera ustulata*). In the Trypetid, (*Acidia heraclei*), the ribbon is not ciliated, and ends in a bulb with complicated internal parts.

Speaking generally, in those families in Diptera where the female has a type of ovipositor approximating to that in *Musca*, the arrangement of genitalia in the male will be found to homologise fairly well with that in *Scatophaga*.

The characteristic specific modifications under discussion are the means by which the sterility between allied forms, so necessary for the preservation of distinct species, is obtained. Judging from *S. stercoraria* and *S. lutaria*, besides others that I have observed, these modifications will be found to be most pronounced in the penis, the other differences being matters of detail.

By microscopic comparison I am able to prove that Mr. G. H. Verrall * is right in relegating the species *Scatophaga merdaria* to the list of varieties. I am unable to separate my preparations of *S. stercoraria* and *S. merdaria*, as the bleaching process they have gone through has removed all the colour, which appears to be the only characteristic difference, the genitalia and other parts being quite identical.

Returning to the subject of sterility between species of insects, I think this is mostly brought about by mechanical means, such as obtain in *L. stercoraria* and *S. lutaria*. It is obvious that sterility must be in a more or less degree a character of species, for if a modification were to appear beneficial to an individual, unless there came with it either an accidental isolation of the

* "A List of British Diptera," 1901.

descendants of that individual, such as might be brought about by an exceptional mortality of the unmodified relatives, or that with the modification occurred a correlated alteration in the genitalia (and these parts are without doubt exceedingly variable), the favourable modification would be swamped before it had time to establish itself. Lord Tennyson, speaking of Nature, says: *

> "That I considering everywhere
> Her secret meaning in her deeds,
> And finding that of fifty seeds
> She often brings but one to bear."

Fifty, as applied to species, would be an economy wholly different from Nature's methods. For one modification that has established itself as a species, an enormous number, only to be guessed at by a calculation of the laws of chance, have appeared and disappeared.

In the case of those flies that lay their eggs in the tissues of leaves or plants, and have developed a horny ovipositor for this purpose, a character is found that, first occurring in the female, has gradually modified the other sex, and finally produced such very specialised genitalia as those of *Palloptera ustulata*—an exceedingly complicated process of evolution. Here, from the very nature of the case, the variation would have less danger of being "swamped," and probably this circumstance has had an important influence on the successful establishment of these very pronounced characters. However, the families whose females bear a horny ovipositor are few in number compared with the ordinary type. Four families with 135 species are given in Mr. Verrall's list of British Diptera, a list which catalogues over three thousand species.

To study genitalia it will be necessary to dissect under the microscope. A freshly killed insect is best; but old dry specimens are not altogether useless, as by soaking them for about two hours in a 10 per cent. solution of caustic potash, followed by an hour in water, the soft parts expand and the chitin ceases to be brittle.

A compressorium or a live box is useful after the organs have been "teased" apart, which must be done in water contained in a watchglass or shallow cell. Add a drop of glycerine, compress, and examine with powers of about $\frac{1}{3}$rd and $\frac{1}{6}$th inch. An interesting

* "In Memoriam," lv.

slide for study can be made by arranging the parts symmetrically on a slip, after having, in addition to the already mentioned preparation, washed away the glycerine, and kept them in acetic acid for twenty-four hours, followed by one hour in water. Fix each part in its place by the minutest possible drop of white of egg (albumen), heat on a hot plate, dehydrating and adding turpentine, and finally balsam and cover-glass—the chief point being never to let the dissection get dry, or air will get into the cavities.

Explanation of Plate 22.

Fig. 1. Diagram of the male organs of *Scatophaga lutaria*, showing the relative position of the various parts as seen from the ventral side of the insect. (*a*) Outer plate or *forceps inferior*. (*b*) Outer clasper or *forceps superior*. (*c*) Inner hook. (*d*) Palpus. (*e*) Penis, *appendix interna*, or *adminiculum*. (*f*) Anterior spiny processes (*laminae superiores*?)

,, 2. Inner, smaller hook, × 120.

,, 3. Plate, × 120.

,, 4. Exterior, larger hook, × 120.

,, 5. Inner palpus, × 120.

,, 6. Penis of *S. stercoraria*, × 110.

,, 7. Internal organ of *S. stercoraria*, × 125.

,, 8. Dissection of the genitalia of *S. lutaria* seen laterally, the outer plates and hooks having been removed, × 78.

,, 9. Club-shaped hook in *S. lutaria*, × 120.

Some Points in the Structure and Life-History of Diatoms.

By F. R. Rowley, F.R.M.S.

Communicated by D. J. Scourfield, F.R.M.S.

(*Read January* 16*th*, 1903.)

Plate 23.

In "*Natural Science*" for December, 1898, pp. 406-416, I gave a somewhat full account of the movement of Diatoms and the structure of the frustules in two forms, viz., *Pinnularia major* and *Surirella calcarata*, based upon Robert Lauterborn's "Untersuchungen über Bau, Kernteilung und Bewegung der Diatomeen."* The interesting sections dealing with the protoplasm and its inclusions, the nucleus, the centrosome, and the phenomena attending nuclear and cell division, were left untouched owing to lack of space, but I propose in the present paper to partly supply this deficiency. Although several years have elapsed since the publication of Lauterborn's work, there are doubtless many who have not had an opportunity of becoming acquainted with his researches, and may, therefore, be glad to avail themselves of the present abstract.

It was in the summer of 1891 that Lauterborn first commenced to work at the Diatomaceae, in order to discover, if possible, the relation of the centrosome, discovered by Bütschli in *Surirella calcarata*, to the dividing nucleus.

On the approach of winter, when the species just mentioned became increasingly scarce, he extended his observations to other and more easily procurable forms, such as *Nitzschia*, *Pleurosigma*, *Pinnularia*, *Navicula*, etc., obtaining in all cases most interesting results.

* Engelmann, Leipzig, 1896.

In proceeding first of all to deal with the protoplasm and its inclusions, it is hardly necessary to mention that, in Diatoms, the living protoplasmic material is shut in between two valves, one of which fits over the other like the lid upon a pillbox. These valves are encrusted with silica, and when all the organic parts are removed by suitable treatment, we get the Diatom in the familiar guise of the ordinary cabinet specimen.

The inner structure of Diatoms was first efficiently studied by Pfitzer a little more than thirty years ago. During this interval our knowledge of the structure and life of the cell has undergone an entirely unexpected extension and deepening. Features which are of primary interest in Cytology, such as the structure of protoplasm, the construction of the resting nucleus, and especially the karyokinetic process, had scarcely been studied in the Diatomaceae, and therefore challenged enquiry first of all.

With regard to the arrangement of the protoplasm in the interior of the cell, Lauterborn was able to confirm in the main Pfitzer's results. In studying inclusions in the protoplasm, special attention was paid to the so-called "red granules" ("roten Körnchen") first discovered by Bütschli, with the result that many bodies previously regarded simply as oil drops were shown to belong to that category.

A very interesting section of Lauterborn's paper is that dealing with the minute structure of the protoplasm. Bütschli had previously pointed out that *Surirella* was admirably adapted for the study of living protoplasm, and Lauterborn extended his researches to other forms with great success. Under comparatively low powers the protoplasm of Diatoms appears simply finely granular, as described by the earlier observers, but with the aid of the best lenses and under favourable conditions—particularly in cases where the layer of protoplasm is thin and as free as possible from embedded granules—it is often possible to recognise a distinctly reticulated structure, and this, it should be remembered, not merely in preserved material, but in the living cell substance. It may be observed, for instance, in the small masses of protoplasm which occupy the extremities of the frustule in *Pinnularia* *oblonga* (Fig. 1, *p*.). They exhibit a fine and even reticulation with a clearly-defined alveolar border where the protoplasm is in contact with the valves and skirts the cavity of the vacuole.

In *Surirella*, at the commencement of nuclear division, Lauterborn noted the presence of closely-crowded delicate fibrillae radiating from the centrosome and prolonged through the various protoplasmic processes into the most remote

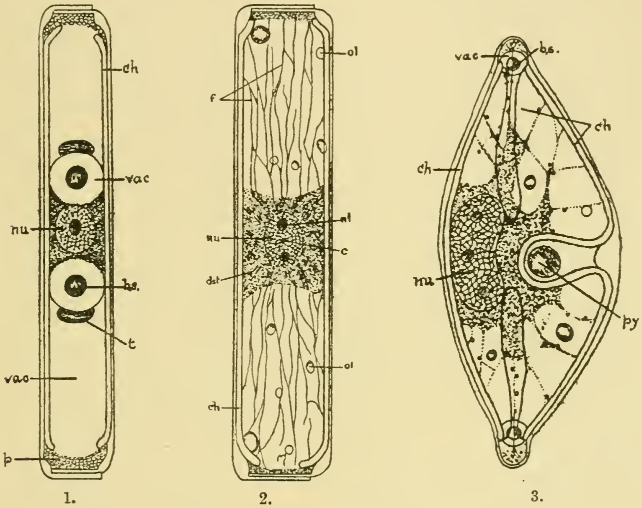


FIG. 1. *Pinnularia oblonga* (resting stage). Lateral view showing Bütschli's spherules *b.s.*, chromatophore *ch*, nucleus *nu*, terminal masses of protoplasm *p*, cap-like bodies *t*, and vacuoles *vac*. (After Lauterborn.)

FIG. 2. *Pinnularia major*. Lateral view showing centrosome *c*, chromatophore *ch*, paired rods, "doppelstäbchen" *dst*, protoplasmic fibrils *f*, nucleus *nu*, nucleolus *nl*, and oil drops *ol*. (After Lauterborn.)

FIG. 3. *Cymbella cuspidata*. Surface view. Lettering as in Fig. 1 and *py* = pyrenoid. (After Lauterborn.)

regions of the cell (Fig. 6), but these he regarded as being in reality the walls of radiating cellular compartments, and not simple thread-like structures as might at first be imagined. A similar structure was also noticed in certain parts of the protoplasm in resting examples of *Surirella calcarata*. The prolongations of the central mass towards the periphery of the cell exhibited a very beautiful longitudinal striation, while the protoplasmic processes occupying the transverse canals mentioned in my previous paper appeared to consist of five or six long rows of cellular compartments.

Another interesting feature is the presence of short paired rod-like bodies in the central protoplasm of such *Pinnulariae* as *P. viridis*, *major*, and *nobilis* (Fig. 2, *dst*). These rods ("Doppelstäbchen") are connected with a plexus of anastomosing fibrils situated between the chromatophore and the cell membrane (Fig. 2, *f*). At the commencement of mitosis these rods and fibrils exhibit a radial arrangement with respect to the nucleus.

An irregular anastomosing system of fibrils occurring between the cell wall and chromatophore has also been observed in *Surirella* (Fig. 4, *f*), but bodies corresponding to the paired rods in *Pinnularia* have not been observed when the nucleus is in the resting condition, though they appear in considerable numbers when the central mass of protoplasm moves towards the broad end of the cell in the initial stage of division. In many cases, these little rods are placed parallel to the fibrillae which radiate from the centrosome and poles of the spindle into the surrounding protoplasm.

If the fibrillar plexus in either of the forms described above be observed carefully, it will be noticed that individual fibrils possess the power of independent movement, sometimes twisting in a lively fashion or moving in an oscillatory manner. Under unfavourable conditions, as when confined for some time under a cover-glass with consequent lack of oxygen, they swell up and lose their identity in a vast number of small refractive globules. It is difficult to fix these elements of the cell satisfactorily; the most perfect preservation of form and arrangement being obtained by using chromo-aceto-osmic acid, or sublimate, as a fixative.

Lauterborn points out that these protoplasmic fibrils are not confined to the Diatomaceae, but appear to have an extensive distribution in plant cells. Similar structures have been observed by Berthold in *Bryopsis*, and by Frank Schwarz in a large-celled

Spirogyra, whilst the last-named author has also figured and described intracellular fibrils in *Mnium undulatum* which exhibit a delicately-beaded structure, are generally arranged parallel to the long axis of the cell, and contain minute oscillatory granules.

Most prominent amongst the cell contents in the Diatomaceae are the chromatophores, structures which are invariably present. Their colour is, in most cases, a beautiful golden brown (more rarely olive green), due to the fact that the chlorophyll of the endochrome plates is mixed with a brown colouring-matter, the so-called diatomin.

To attempt any description of the various forms of chromatophores in different genera of Diatoms would extend this paper beyond permissible limits, but certain other less prominent cell inclusions must be briefly noticed.

The bodies known as Pyrenoids were first discovered in the Diatomaceae by Fr. Schmitz, first of all in marine forms, and subsequently in many freshwater genera, though it should not be forgotten that Pfitzer had previously described and figured, in *Cymbella* and *Gomphonema*, definitely-formed bodies which correspond, in part at any rate, to the structures subsequently designated pyrenoids by Schmitz.

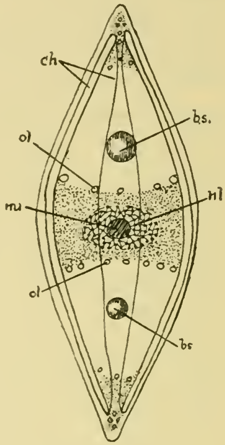
The fresh-water Diatoms in which the latter observer detected these bodies belonged to the genera *Frustulia*, *Colletonema*, *Cymbella*, *Encyonema*, *Brebissonia*, *Anomoeoneis* and *Gomphonema*. Lauterborn's observations extended only to *Cymbella* and *Surirella*.

Cymbella cuspidata possesses a single large pyrenoid occupying a depression in the chromatophore on the most convex side of the Diatom (Fig. 3, *py*). It may be stained with safranin and other aniline dyes, but it is unaffected by Delafield's haematoxylin in material fixed with chromo-aceto-osmic acid.

The pyrenoids in *Surirella calcarata* are numerous, and lie embedded in the lobular extensions of the chromatophores, usually one pyrenoid to each lobe (Fig. 4, *py*). During life they appear as bright rounded spots, not particularly sharply differentiated from their surroundings, but become for a time much more prominent, owing to the contraction of the chromatophores, if the frustule is damaged, appearing then as sharply-defined, spindle-shaped corpuscles. In Diatoms prepared by Henneguy's method for showing the centrosome, the pyrenoids, stained a beautiful red by the safranin, stand out in marked contrast to the pale substance of the chromatophore.

Oil drops often occur in considerable numbers in the interior of the cell (Figs. 2 and 5, *ol*), especially in Diatoms cultivated for some time with an insufficient supply of oxygen, as observed by Lüders. Under these circumstances they appear in the form

4.



5.

FIG. 4.—Portion of lobed chromatophores *ch.l.* of *Surirella calcarata*, showing positions of the pyrenoids *py*. Above the chromatophores is a network of protoplasmic fibrils, which exhibit oscillatory movements in the living diatom. (After Lauterborn.)

FIG. 5.—*Navicula cuspidata*. Surface view showing Bütschli's spherules *b.s.*, chromatophore *ch*, nucleus *nu*, nucleolus *nl*, and oil drops *ol*. (After Lauterborn.)

of several large, not always spherical, droplets, which may be easily recognised by their solubility in sulphuric ether and blackening with osmic acid. In addition to these undoubtedly fatty globules, other structures occur in the interior of many Diatoms, which, though optically very similar, differ in being insoluble in alcohol and ether, in their behaviour when treated with osmic acid, and especially by their marked staining capacity.

These inclusions, formerly regarded as fatty in nature, are the so-called red granules (roten Körnchen) of Bütschli, and merit a somewhat detailed consideration.

We owe to Bütschli the differentiation of these spherules from oil globules, and the recognition of the property they possess of taking an intense red-violet stain with Delafield's haematoxylin, as also of staining, *intra vitam*, with methylene blue. He noted their wide distribution in Bacteria, Cyanophyceae, Filamentous Algae, and Flagellata, as well as in certain Diatoms, and at one time considered them to be nearly related to the chromatin granules of the nucleus, but Lauterborn's researches did not lend support to this view.

A noticeable feature in connection with these Bütschli's spherules is their very characteristic distribution in certain Diatoms, often affording, indeed, good specific characters. Lauterborn's descriptions are too detailed for reproduction here, but one or two of the most interesting examples may be briefly mentioned.

Thus, in *Navicula cuspidata*, there are two of these spherules, usually measuring from 6—9μ in diameter, and placed one on either side of the median protoplasmic bridge containing the nucleus (Fig. 5, *b.s*). *Pinnularia oblonga* agrees in the number and positions of the spherules, but each of them is surrounded by a conspicuous vacuole bearing on the side turned towards the extremity of the cell a crescentic, cup-like body of a grey colour, which, unlike the spherules, stains neither with haematoxylin nor with methylene blue (Fig. 1, *t*). These appendages vary in size, and are frequently vacuolated. They are absent in *Cymbella cuspidata*, which possesses two spherules (each surrounded by a vacuole) placed at the extremities of the cell (Fig. 3, *b.s*).

In *Surirella calcarata* and *S. splendida* Lauterborn notes the presence of numerous small granular bodies exhibiting active movements. They appear to be generally distributed over the surface of the protoplasm, and may be watched gliding here and there, now coming to rest for a short time, then suddenly starting into activity again. The general direction of movement would seem to be from the middle of the cell towards the periphery, and then back again towards the nucleus, though there is considerable irregularity in the movements of individual granules. Careful observations suggest that the cause of these movements must be sought for in the granules themselves, and not, as might be supposed, in streaming movements of the protoplasm.

Lauterborn details at considerable length the behaviour of Bütschli's spherules towards reagents. In a concluding recapitulation he defines them as vesicles filled with a tolerably strongly refracting viscid substance, and mentions as marked characteristics of the external envelope its capacity for actively taking up methylene blue during the life of the cell, and the readiness with which it may be stained by Delafield's haematoxylin.

The part played by these bodies in the economy of the cell is left an open question, but a study of the changes which they undergo during nuclear and cell division suggests that they may contribute in some way to the formation of protoplasm.

As previously mentioned, the occurrence of such spherules is not confined to the Diatomaceae. Bütschli has recorded his "roten Körnchen" in Cyanophyceae, in the green and colourless plasma of Flagellata, and in the Algae *Stigeoclonium* and *Chantransia*. Lauterborn also notes the occasional occurrence of granules staining deeply with haematoxylin and methylene blue in the Desmidiaceae (*Closterium ? sp.*), as well as in certain Rhizopods (*Amoeba villosa*, *Arcella vulgaris*, and *Gromia mutabilis*).

The space at my disposal will not permit me to attempt anything like a complete abstract of Lauterborn's observations on nuclear and cell division in the Diatomaceae. The whole subject is elaborately treated, and the illustrations bear eloquent testimony to the excellence of the lenses employed, and the patient care with which the drawings were executed. As an example of the results obtainable by careful and persistent observation, I will conclude by describing the various stages of mitosis in *Surirella calcarata*, which affords special facilities for tracing the various phases of division in the living cell. Lauterborn states that this species may stand as a model for other forms in the matter of cell division, so that, by giving his observations in this particular case, I shall at the same time be broadly summarising the conditions existing in the other Diatoms of which he treats, such as *Nitzschia sigmoidea*, *Pinnularia major*, *viridis*, and *oblonga*, *Pleurosigma attenuatum*, and *Navicula amphisbaena*.

The first sign that *Surirella* is about to undergo division is afforded by the frustule, the valves of which move apart from one another to a perceptible extent, so that the whole Diatom becomes obviously broader. At the same time the chromatophores begin to lose their normal contour little by little, and the processes which usually occupy the transverse canals in each valve are gradually retracted, so that the latter are eventually left quite unoccupied. The centrosome, which in the resting cell lies in the hollow of the kidney-shaped nucleus, gradually moves outwards and becomes the centre of a system of radiating lines traversing the cytoplasm in all directions, as mentioned earlier in this paper. There is as yet no perceptible alteration in the nucleus, which exhibits the normal arrangement of a network of fibrils composed of a substance called linin, in the interstices of which are scattered numerous granules of the deeply staining substance called chromatin, or nuclein.

It is at this stage that a small, pale, spherical body makes its appearance in the immediate vicinity of the centrosome, from which, according to Lauterborn, it is without doubt derived by a process akin to budding. This insignificant particle is of great interest, representing as it does a structure as yet undeveloped, but destined, as the so-called "central spindle," to play a most important part in the division of the nucleus.

A little later and we see the nucleus involved in the oncoming change. Its reticulum begins, if one may use such an expression, to shake itself out, so that the whole texture becomes looser, but the most marked feature is the commencing arrangement of the chromatin granules to form single strands looking like strings of beads, a condition first observable at the periphery of the nucleus, from whence it spreads inwards towards the centre. The rudimentary central spindle has also moved away from the centrosome towards the surface of the nucleus, and has increased markedly in size. In fact, at this stage it closely resembles one of the nucleoli which are still clearly visible (Fig. 6, *c.s.*). So much alike, indeed, are these two cell constituents, that if the origin of the spindle had not been observed it might have been looked upon as a nucleolus which had migrated from the interior of the nucleus.

The changes in the interior of the nucleus are accompanied by an alteration in its outward form, which becomes more or less ellipsoidal instead of kidney-shaped. At the same time the rearrangement of the chromatin elements has advanced a step further. The moniliform rows of granules have now commenced to fuse together, forming twisted threads. A collection of granules as yet practically unaffected remains in the centre of the nucleus, but the nucleoli are disappearing. According to Lauterborn, they probably contribute in some way to the formation of the changing nuclear network. Lying obliquely midway between nucleus and centrosome is the developing spindle, somewhat boat-shaped when seen in optical section.

As we shall see more clearly a little later, the entire protoplasmic contents of the Diatom cell commence to move towards the broadest end of the frustule at the beginning of division, the whole process strongly suggesting that the centrosome is exerting an attractive influence upon the various cell contents, and is the agent which determines the direction of movement.

It is at this point that we notice the appearance in the cytoplasm of the little rod-like bodies ("Doppelstäbchen") previously mentioned. We now arrive at the completion of what is known as the spireme stage. The chromatic network of the nucleus consists of many twisted threads, appearing in optical section as scattered dots. The central spindle which we left as a circular plate-like body is now rapidly developing. Its two surfaces begin to recede from one another and the intervening space exhibits a very delicate striation. At the upper extremity of the spindle, on each side, two dark masses stand out clearly which are destined to form the new centrosomes, one for each of the daughter cells. The original centrosome, after decreasing in size, suddenly vanishes, and it has not yet been satisfactorily ascertained whether it is dissolved, so to speak, in the cytoplasm of the cell, or whether it is merged in the substance of the two growing centrosomes.

The next phase in the process of division is marked by the entry of the central spindle into the substance of the nucleus, where it lies at first somewhat obliquely (Fig. 7, *c.s.*). At this stage, also, the chromatic substance of the nucleus has split up into separate pieces—the chromosomes (*chr.*)—most of which have become loop-like. Not only so, but each chromosome about this time splits lengthwise into two similar halves, and the first step is thus taken towards the equal distribution of the chromatin between the daughter cells which it is the object of cell division to accomplish.

A little later the central spindle takes up a position in the middle of the nucleus, and at right angles to a line drawn through the Diatom from end to end. Its curved extremities (the poles of the spindle) are connected by numerous extremely delicate threads (the interzonal fibres), which pass uninterruptedly from pole to pole. The chromosomes, though not at first arranged in any particular way, show an increasing tendency to collect around the equator of the spindle (Fig. 8).

Lauterborn states that it is impossible to follow individual chromosomes in their migration towards the equator of the spindle, *intra vitam*, owing to the indistinctness of their contours, so that stained preparations are necessary for the study of the process; but so soon as they have arrived at their destination, and are grouped together in a ring-like mass, this equatorial ring, as well as the central spindle itself, stand out with extraordinary distinctness. The mitotic figure when viewed endways at this stage shows a clear, approximately circular central space occupied by the interzonal fibres, around which the chromosomes are grouped in a radiating fashion.

Perhaps the most striking feature in connection with this "Stadium des Muttersterns" is the way in which the chromosomes appear for a time to almost entirely lose their individuality, visually speaking, since only one or two can be seen faintly outlined in the uniform greyish mass (Fig. 9). The nucleus is said to remain for nearly an hour in this condition, which is probably the reason why this stage is more frequently met with than any other, and, during the interval, the two halves of each of the chromosome loops are separated from one another, and arranged in readiness for distribution to the two daughter nuclei. The two centrosomes are visible as pale spherical bodies lying close to the polar surfaces of the spindle.

The division of the nucleus is heralded by a change in the shape of the equatorial ring, whose polar surfaces, where in contact with the central spindle, are drawn out in the direction of the poles. The divided chromosomes are now finally parted by a line of division at right angles to the axis of the spindle, and the two halves begin to recede from one another.

The nuclei having arrived at the poles of the spindle, a noticeable feature is the appearance of two large masses between the nuclei and their respective centrosomes (Fig. 10, *sp*). According to Lauterborn these are really the polar ends of the spindle separated from the more central portion by constriction, due to the diminution in size of the central aperture in each chromosome ring.

Up to this point the interzonal fibres have been very sharply and clearly defined, but with the first appearance of a line of division in the cytoplasm, they assume a wavy aspect with a slight thickening in the equatorial part. Shortly afterwards complete partition of the cell contents takes place (Fig. 11), and the fibres then vanish entirely, perhaps passing through the central aperture of the chromosome ring into the remnant of the polar end of the spindle. The nucleus viewed endways at this stage exhibits a slit-like central aperture in place of the approximately circular one noticed in the equatorial ring.

Division of the cell is now to all intents and purposes complete, and the nuclei have only to undergo a process of reconstruction as they pass into the resting condition. At first they are curved in shape, with their concave surfaces turned towards the broad end of the cell near to which they are still lying (Fig. 12). The chromatin is now present in a granular condition, the central cleft being surrounded by a dense zone, from whence fibrils, studded with darkly-stained granules, pass at regular intervals towards the surface of the nucleus. As the nuclei retreat from the broad end towards the centre of the cell, they again turn through an angle of 90°, so that their convex surfaces face the new cell wall in each case. Nucleoli appear in the central space which is now rapidly filling up, and the centrosome shows a connection with the nucleus by radiating lines. No trace of the polar ends of the spindle now remains, and Lauterborn suggests that they may possibly have passed into the substance of the centrosomes.

Each daughter nucleus occupies, of course, one valve of the parent frustule, but the commencing formation of a new valve for each daughter cell may now be noticed, including the first appearance of the transverse canals (Fig. 13). A little later the nucleus and centrosome will exhibit a change of position, so that the convexity of the now kidney-shaped nucleus will once more be turned towards the broad end of the cell.

The various changes thus briefly described are estimated to occupy about five to five and a half hours from start to finish, but the unnatural conditions which prevail when the organism is subjected to examination under a cover-glass must be taken into consideration, and it is probable that under natural conditions the work of division is performed in a much shorter time.

It is by no means an easy matter to find dividing nuclei. The beautiful series of figures of *Surirella* given by Lauterborn represent the work of two summers. Weeks would sometimes pass without any result, although hundreds of specimens might be examined, but this apparent scarcity might possibly be due to the time of day when observations were carried on. Dividing cells were relatively most abundant in the morning hours, and thus it may be that in Diatoms—as in *Spirogyra* and *Ceratium*—division usually takes place during the night.

Castracane's view—that division was the exception, not the rule, and that Diatoms usually multiplied by a process of spore formation—found no support in Lauterborn's work. Although thousands of examples passed under his notice from first to last, not the slightest trace of any such process was ever detected, but some hundreds of dividing cells were observed and studied.

Explanation of Plate 23.

Nuclear and cell division in *Surirella calcarata.*

Fig. 6. First stage. Centrosome surrounded by astral rays, central spindle approaching nucleus, and changed appearance of the chromatophores, including the withdrawal of their processes from the "transverse canals."

Fig. 7. Entry of spindle into the nucleus.

Fig. 8. Formation of equatorial ring.

Fig. 9. Completion of the equatorial ring.

Fig. 10. Division of the chromosomata.

Fig. 11. Division of cell contents. One daughter nucleus shown.

Fig. 12. Daughter nucleus undergoing reconstruction.

Fig. 13. Later stage. Commencing formation of a new valve for each daughter cell.

c. centrosome.
c.g. chromatin granules.
ch. chromatophore.
chr. chromosomes.
c.s. central spindle.
d.n. daughter nucleus.
e.r. equatorial ring.
iz.f. interzonal fibres.
l.c. longitudinal canal.
nl. nucleolus.
nu. nucleus.
sp. polar end of spindle.
tr.c. transverse canal.

All figures after Lauterborn.

Synopsis of the known Species of British Fresh-water Entomostraca.

Part I. Cladocera.

By D. J. Scourfield, F.R.M.S.

(*Read January 16th*, 1903.)

Plate 24.

Now that we have such an excellent and authoritative work on the Cladocera as Lilljeborg's "Cladocera Sueciae,"* it seems desirable that a list of the known British species should be drawn up, so that those interested in these creatures may have some guide (1) to the species described and figured therein which have been found here, and (2) to the very few forms that are known to be British, but are not referred to by Lilljeborg.

In the case of the latter species short descriptions and figures will be given, thus supplementing the work of Lilljeborg, so far as is necessary for our purpose, and putting into the hands of those possessing, or having access to, the "Cladocera Sueciae" a complete synopsis of the Cladoceran fauna of the British Isles as known at present.

This arrangement is, to be sure, not to be compared with the issue of a good monograph on our British species; but there is this advantage about it, that British students, by having to constantly refer to the "Cladocera Sueciae," will be kept on the watch for some of the species recorded as Swedish that have not so far been taken in this country.

It is not considered necessary to give descriptions of the species to be found in the "Cladocera Sueciae," or even keys for their identification, as this has been so well done in the book referred to. An attempt will, however, be made to indicate the synonyms under which the species have been recorded in different works on British Entomostraca. In the case of the rarer species the

* "Cladocera Sueciae oder Beiträge zur Kenntniss der in Schweden lebenden Krebsthiere von der Ordnung der Branchiopoden und der Unterordnung der Cladoceren." By Wilhelm Lilljeborg. Upsala, 1900.

localities from which they have been obtained will also be given, and the general distribution of all the species, so far as known, will be shown in tabular form.

Of the ninety-six species recorded from Sweden, we have, it will be seen, only seventy-five, thus showing that there is a considerable amount of work yet to be done even in the matter of discovering species "new to Britain," although we can never expect, of course, to find all the Swedish species in the British Isles, as some of them are typically Arctic forms. On the other hand, we have, in addition to the seventy-five species just mentioned, six which are not given by Lilljeborg as Swedish, thus bringing up the British total to eighty-one. The number of species recorded by Lilljeborg is much smaller than it would have been if he had followed the example of some other authors in regard to the validity of certain so-called species; but I believe he is quite right, as a rule, in putting together again many of the forms that have been dignified with specific names. We necessarily have many of these varieties in this country, and some of them will be duly noticed.

It is intended, in a subsequent paper, or series of papers, to extend this summary of the known British fresh-water species to the other Orders of Entomostraca, and I shall be glad to receive any information as to supposed new British species, or any records of distribution.

CLADOCERA.

Sididae.

Sida Straus.

S. crystallina (O. F. Müller).

A very widely distributed species though somewhat sporadic in its occurrence.

Diaphanosoma Fischer.

D. brachyurum (Liévin).

Daphnella Wingii Baird (in part) (1).*

Daphnella brachyura Beck (3), Pratt (18), Scott (20, 21, 23).

Diaphanosoma brandtianum Scourfield (29).

A fairly common form in clear water all over the British Isles.

* The numbers in brackets refer to the list of literature at the end of the paper.

D. leuchtenbergianum Fischer.

Daphnella Wingii Baird (in part) (1).

It is very doubtful whether this is distinct from the foregoing species. Our usual *Diaphanosoma* certainly seems to be *D. brachyurum*, but I have occasionally seen specimens in the Lake District and in North Wales which would probably come under *D. leuchtenbergianum*, and Mr. W. F. de V. Kane tells me he has seen this form in several localities in Ireland. Baird's figures (1 Tab. XIV.) seem to represent this species rather than *D. brachyurum* if we may judge by the great length of the second antennae.

Latona Straus.

L. setifera (O. F. Müller).

Not yet seen in Ireland or south-east and middle of England.

Holopedidae.

Holopedium Zaddach.

H. gibberum Zaddach.

Not yet seen in the south, east, and middle of England or in Wales. Mr. Kane has taken specimens at Ballinahinch, Connemara, which is so far the only record from Ireland.

Daphnidae.

Daphnia O. F. Müller.

D. magna Straus.

D. schaefferi Baird (1).

A rather rare species, but distributed all over England. Not yet recorded from Scotland, Ireland, or Wales.

D. atkinsoni Baird.

Dactylura pubescens Brady (5).

I have carefully examined specimens of *D. pubescens* kindly sent to me by Prof. G. S. Brady, and I believe they should be referred to *D. atkinsoni*. The only difference I can find is that the post-abdomen tapers evenly to the claws, whereas in the figures given by Lilljeborg there is a slight but distinct truncation just before the claws are reached. The characteristic flattening of the head above the eye certainly occurs in *D. pubescens*, and the number of teeth on the post-abdomen is 11 or 12, not about 25 as stated by Brady. The latter number was probably obtained by counting some of the little setae which clothe the sides and lower margin of the post-abdomen. The accompanying drawings were made from one of Professor Brady's specimens (see Pl. 24, Figs. 1, 2, 3, and 4).

Only found in one locality, namely, in a roadside pond near Staithes, Yorkshire.

D. psittacea Baird (1).

The species described by Baird as *D. psittacea* has never again been certainly seen by any collector of British Entomostraca, but a form thought to be the same, and called by this name has been found occasionally on the Continent. Lilljeborg figures and describes this, although he does not record it as Swedish. From Baird's figure, I should have thought that *D. psittacea* was the same as *D. atkinsoni*, if both had not been described by Baird himself.

D. pulex (De Geer).

We have many varieties of this common species, some of which have been recorded by Prof. Brady and others under the names of *D. schoedleri*, *D. brevispina*, *D. hamata*, *D. obtusa*, and *D. propinqua*. I am rather inclined to think that at least *D. obtusa* (including *D. propinqua*) should be regarded as a good species.

D. longispina O. F. Müller.

D. pulex var. *longispina* Baird (1).

Several varieties of this species have been placed on record by Brady (5).

D. hyalina Leydig.

? *D. jardinii* Baird (2).*

D. lacustris, *D. galeata*, *D. hyalina* Brady (5), Scourfield (25, 29).

D. jardinii Brady (4), Scott (20).

Four subspecies are recognised by Lilljeborg, and three of

* As it seems impossible to decide whether Baird's *D. jardinii* was a pointed-headed form of *D. hyalina* or *D. cucullata*, it will probably be better to drop the earlier name altogether, as is done by Lilljeborg.

these we certainly have in this country, viz., *D. hyalina* s. str., *D. lacustris* Sars, and *D. galeata* Sars. The fourth, *D. pellucida* P. E. Müller, probably occurs also, but is certainly not common.

If all these forms can be grouped together as one species, I do not see quite clearly how they can be kept apart from *D. longispina*, which does not seem to differ so much from some of them as they do from one another.

With regard to the distribution of the variety *galeata* it may be mentioned that the form occurring in Epping Forest and the south-east of England generally is not the typical *galeata* such as occurs in the north of England, Scotland, and Ireland, but the smaller form referred to by Lilljeborg as approaching *D. cucullata*.

D. cucullata Sars.

?*D. jardinii* Baird (2).*

D. bairdii Forrest (8).

Hyalodaphnia jardinii and *H. kahlbergensis* Brady (5).

D. jardinii Hodgson (10).

Scapholeberis Schoedler.

S. mucronata (O. F. Müller).

Daphnia mucronata Baird (1), Brady (4).

Both the *cornuta* and the typical forms occur, often associated together, but the latter does not appear so early in the year as the former.

Simocephalus † Schoedler.

S. vetulus (O. F. Müller).

Daphnia vetula Baird (1) Brady (4).

One of the commonest of the British Cladocera.

S. exspinosus (Koch) (? De Geer).

Daphnia vetula Baird (in part) (1).

A fairly common species in the south and east of England, but not yet recorded from the north or from Scotland.

* See note on previous page.

† In a paper in the "Annals and Mag. Nat. Hist." for April 1903, Canon Norman proposes the name *Simosa* for this genus, as *Simocephalus* was previously used for a genus of snakes.

S. serrulatus (Koch).

I have only had this species from the following localities; Richmond Park, Kew Gardens, Ditch between Kew and Richmond, and Newborough, Anglesey. My friend Mr. C. J. H. Sidwell has also found it at Hanwell. It does not seem to have been recorded by any other writer in this country.

Ceriodaphnia Dana.

C. reticulata Jurine.

Daphnia reticulata Baird (1), ? Brady (4).

There exist at least three varieties of this species in this country: namely, the typical form; a form with enormously extended fornices—the var. *serrata* of Sars and Lilljeborg; and a very small form, probably *C. kurzii* Stingelin.

C. megalops Sars.

Daphnia reticulata Baird (in part) (1) Tab. VII. fig. 5.

Moderately common in the south and east of England, but apparently rare in the north. Only one record from Scotland, namely, Loch of Park, Aberdeen (Scott 22), and one or two from Ireland. Not seen in North Wales.

C. quadrangula (O. F. Müller).

C. pulchella Scourfield (28) Creighton (6).

This is a common species in the lakes of the north of England, North Wales, Scotland, and Ireland, but has only been seen once or twice in the south and east of England, its place being taken apparently by the next species.

C. pulchella Sars.

C. quadrangula Scourfield (25, 26, 29), Hodgson (10).

The distribution of this species seems to be exactly opposite to the foregoing, as it is common in the south and east of England, rare in the north, and has not been certainly identified in either Wales or Scotland.

C. affinis Lilljeborg.

C. scitula Scourfield (29), Sprague (33).

There is some doubt whether this species is really *C. scitula*

Herrick. It is, however, certainly *C. affinis* Lilljeborg, and the latter name has therefore been adopted. It is a rare British species, the only localities known to me being Higham Park, Essex; Potter Heigham, Norfolk; and Penicuik, Midlothian, where it was found by Dr. and Miss Sprague (33).

C. laticaudata P. E. Müller.

Daphnia rotunda Baird (in part) (1).

C. rotunda Scourfield (26, 29), Scott (20), Hodgson (10).

All the specimens that I have seen belonging to the "rotunda" group have been of this form. It seems rather a pity that the name *C. rotunda* cannot be used for it rather than for the following.

C. rotunda G. O. Sars (? Straus).

Daphnia rotunda Baird (in part) (1).

I do not know of any certain recent records of this form, but Baird's fig. 4*a*, Tab. X., perhaps represents this species.

Moina Baird.

M. rectirostris (Leydig).

A comparatively rare species, even in England, and not yet recorded from Scotland, Ireland, or Wales. It occurs only in small, shallow ponds and puddles with very turbid water.

M. brachiata (Jurine).

Baird (1) recorded this from a pond at Blackheath, but I have never seen specimens nor heard of them being taken, and cannot therefore give an illustration of the species, notwithstanding the fact that it is not to be found in the "Cladocera Sueciae." It does not differ very much, apparently, from the foregoing species, but the ephippium is stated to contain two eggs instead of one.

M. bánffyi Daday.

This is another species not recorded in the "Cladocera Sueciæ." Its chief characteristics are:—Head without indentation, more or less hairy, especially at the back (the valves are also hairy, but not so noticeably); shell-markings very similar to *Simocephalus*; antennules covered with scale-like markings and hispid; second antennae very large and densely hairy; post-abdomen of the usual *Moina* type with about nine teeth, the first or bifid tooth being scarcely longer than the pointed setose teeth; terminal claws without special "combs," but with strongly marked lateral setae. Length about $\frac{1}{20}$ inch. (See Figs. 5, 6, 7, and 8.)

Daday's Latin description in his "Crustacea Clad. Faunae Hungaricae" (Budapest, 1888) is short, but seems certainly to refer to our species. His two figures (Tab. III., 1 and 2) are apparently rather diagrammatic.

I found this species as long ago as 1893 in a little roadside pond on Lord Tennyson's estate at Farringford, Isle of Wight, but it has not hitherto been referred to in any publication.

Bosminidae.

Bosmina Baird.

B. longirostris (O. F. Müller).

This is a common species in the south and east of England—where, in fact, it is the only species of the genus to be found. In the north of England, North Wales, Scotland, and Ireland it does not seem to be so common, its place being probably taken by *B. obtusirostris*. The variety *cornuta* occurs frequently, sometimes alone and sometimes associated with the typical form. Some of the other varieties mentioned by Lilljeborg certainly occur, but I have no separate records of them.

B. obtusirostris Sars.

B. longispina Norman & Brady (17) (in part), Scourfield (28), Scott (20), Creighton (6, 7), and several other authors.

It is somewhat doubtful whether this ought to be separated from *B. longispina*, but it will probably be as well to follow Lilljeborg in regarding it as distinct from the extremely long-spined form. In one or other of its numerous varieties it occurs over a large part of the British Isles, but has never been seen in the south and east of England, and only doubtfully in the Midlands.

B. longicornis Schoedler.

Mr. W. F. de V. Kane informs me that he has taken this species in the Boyne Canal, and I have seen specimens from Lough Melvin which approached this very closely.

B. longispina Leydig.

B. longispina Norman & Brady (17) (in part), and many other authors.

This species, as limited by Lilljeborg, is not very common. I have taken very fine examples in Loch Morar.

B. mixta Lilljeborg.

B. lilljeborgii Scourfield (31).

Only seen in Lough Erne, where it was discovered by Mr. W. F. de V. Kane (15). It does not differ very much from the following, and it is very doubtful whether it ought to be regarded as a distinct species.

B. coregoni Baird (2).

Baird first found this species in Lochmaben Castle Loch, in Dumfriesshire, where it has been taken more recently by Canon Norman. It has also quite recently been found in the north of Scotland by Mr. James Murray, of the Lake Survey. Hodgson records it from Ellesmere (11), and Mr. Kane has taken a few examples (verified by Lilljeborg) in Upper Lough Erne.

LYNCODAPHNIDAE.

Ilyocryptus Sars.

I. sordidus (Liévin).

Acantholeberis sordidus Norman (16).

A moderately common species, but it must be sought for by collecting the sediment from the bottom of ponds, etc.

I. agilis Kurz.

I first recorded this from the Victoria regia Tank at the Royal Botanic Gardens, Regent's Park (27). Since then I have taken it in Rollesby and Barton Broads, Norfolk, the Basingstoke canal at Weybridge, and in one of the tanks in the lily-house at Kew Gardens (32). Quite recently Mr. R. Gurney has also found it in Barton Broad.

I. acutifrons Sars.

This is a new record for the British Isles. It was discovered by Mr. James Murray in material taken last September from Loch Meide, in Sutherland, and has also been seen by him in a collection from Loch Shin in the same county.

Macrothrix Baird.

M. laticornis (Jurine).

A pretty widely distributed but not very common species.

M. rosea (Jurine).

Only hitherto recorded from Lochmaben Loch in Scotland, and from three or four Loughs in Connemara, Ireland (see 17). Canon Norman has, however, also obtained specimens from Ebbesborne, near Salisbury.

M. hirsuticornis Norman & Brady (17).

A rare species. Only known from Ashburn, near Sunderland (17); Connaught Water, in Epping Forest (29); Loch of Beiton, Shetland (23); and pools on King's Links, Aberdeen (22).

Lathonura Lilljeborg.

L. rectirostris (O. F. Müller).

Daphnarella longisetata Rousselet (19).

A rare species. I have seen it on three or four occasions in the south and east of England, also in North Wales, and it has been recorded from Scotland and Ireland. It has not been seen, however, in the north of England so far as I am aware.

Streblocerus Sars.

S. serricaudatus (Fischer).

S. minutus T. Scott (20, 21 A).

The smallest of the Lyncodaphnids. Not yet seen in the south and east of England.

Drepanothrix Sars.

D. dentata (Eurén).

D. hamata Norman & Brady (17); Brady (4); Creighton (6).

A widely distributed but not very common species. The only record I have for it in the south-east of England is from Fleet, in Hampshire.

Acantholeberis Lilljeborg.

A curvirostris (O. F. Müller).

This is by no means a common species, but may usually be expected in pools and shallow waters on moors and bogs. The only record I have of it in the south-east of England is from a pond at St. George's Hill, near Weybridge.

Lynceidae.*

Eurycercus Baird.

E. lamellatus (O. F. Müller).

* According to the Rev. T. R. R. Stebbing this ought to be Chydoridae. See his paper on *Lynceus* and the *Lynceidae* in the "Zoologist," March, 1902, pp. 101–106.

Camptocercus Baird.

C. rectirostris Schoedler.

C. macrurus Baird (1); Norman & Brady (17); Scourfield (26, 28); Scott (20, 21 A).

There seems no doubt that the form referred to by Baird, Norman & Brady, etc., as *C. macrurus* is really *C. rectirostris*, and not *C. macrurus* as defined by Lilljeborg.

It cannot be called a very common species. Not yet recorded from Ireland

C. lilljeborgii Schoedler.

I took this species in Norfolk (in the channel leading from Stalham to Barton Broad) in 1898. It is now recorded as British for the first time.

Acroperus Baird.

A. harpae Baird.

Lynceus harpae Norman & Brady (17).

The variety previously recorded by me (29) is not at all uncommon, but I am doubtful whether it represents a permanently distinct race.

A. angustatus Sars.

This I found in company with *Camptocercus lilljeborgii.* It also is now recorded for the first time as British.

Alonopsis Sars.

A. elongata Sars.

Lynceus elongatus Norman & Brady (17).

A common species in the north of England, North Wales, Scotland, and some parts of Ireland, but I have never yet taken a specimen in the south and east of England.

Alona* Baird (= **Lynceus** Lilljeborg).

A. quadrangularis (O. F. Müller).

Alona quadrangularis Baird (in part) (1).

Lynceus quadrangularis Norman & Brady (in part) (17), Hodgson (10).

* I have preferred to retain the name *Alona,* as it appears uncertain whether *Lynceus* can be properly used for these creatures. See the Rev. T. R. R. Stebbing's paper already mentioned.

A. affinis Leydig.

Alona quadrangularis Baird (in part) (1).

Lynceus quadrangularis Norman & Brady (in part) (17).

This seems almost if not quite as common as the foregoing species, and often occurs with it.

A. tenuicaudis Sars.

Lynceus tenuicaudis Norman & Brady (17), Hodgson (10).

A rather rare species, but well distributed.

A. costata Sars.

Lynceus costatus Norman & Brady (17), Hodgson (10).

A. guttata Sars.

Lynceus guttatus Norman & Brady (17), Hodgson (10).

A. intermedia Sars.

A. neglecta T. Scott (20, 23). First described in (23) Part I.

This species has only been found in Scotland, where apparently it is not at all uncommon.

A. rectangula Sars.

A. intermedia Scourfield (25, 26), Scott (20).

Lynceus intermedius Hodgson (10).

Probably a moderately common species all over the British Isles, but often overlooked owing to its small size.

A. elegans Kurz.

I am indebted to Canon Norman for specimens of this pretty little species. As it is not to be found in the "Cladocera Sueciae," sketches are given of the shell (fig. 13), showing the very characteristic close striation (there are about sixty striae on each valve), and of the post-abdomen (fig. 14). The teeth on the latter are not all simple, as stated by Kurz, but some are compound. Length about $\frac{1}{45}$ inch. Roadside pond near Staithes, Yorkshire. It has not been previously recorded as British.

A. rustica T. Scott (23 Part I.).

This seems to be distinct from any of the species given in the "Cladocera Sueciae." It is mainly characterised by its post-abdomen, of which a drawing is given in fig. 10. It will be seen that the inferior angle is very much produced, although well rounded, and that the teeth on the dorsal edge are robust and very widely separated. The whole animal, which is about $\frac{1}{50}$ inch in length, is shown in fig. 9. The shell may be either faintly striped or ornamented with rows of dots. On the whole, the species seems intermediate between *A. guttata* and *A. costata*. It is widely distributed in the British Isles, but very rare in the south and east of England.

A. rostrata (Koch).

Lynceus rostratus Norman & Brady (17), Hodgson (10).
Alonella rostrata Scourfield (26, 29), Sprague (33).

A rather rare species even in the south and east of England, where it is commoner than elsewhere in the British Isles. Not yet seen in North Wales.

Leptorhynchus* Herrick.

L. falcatus (Sars).

Lynceus falcatus Norman & Brady (17).
Harporhynchus falcatus Scott (20), Hodgson (10).

Apparently more common in Scotland and the north of England than elsewhere in the British Isles. The only place in the south-east of England where I have found it is Fleet Pond, in Hampshire. It has not been recorded from Wales or Ireland.

Leydigia Kurz.

L. quadrangularis (Leydig).

Lynceus acanthocercoides Norman & Brady (17) (probably).
Leydigia acanthocercoides Scourfield (26, 28).

Probably not a very rare form, but often overlooked owing to its habit of living on the bottom.

L. acanthocercoides (Fischer).

I have taken specimens of this species from Barton Broad, Norfolk; Snaresbrook (Eagle Pond), Essex; and Richmond Park, Surrey (30). Mr. Kane has found it in Upper Lough Erne and Killyhoman, Ireland. These are the only localities known to me.

* Canon Norman, in the paper already referred to (page 367), proposes *Rhynchotalona* as the name of this genus, both *Leptorhynchus* and *Harporhynchus* having been previously used in zoology.

Graptoleberis Sars.

G. testudinaria (Fischer).

Lynceus testudinarius Norman & Brady (17).

Alonella Sars.

A. excisa (Fischer).

Lynceus exiguus Norman & Brady (17) (probably).

A. exigua Scott (20, 21, 21A, 23), Sprague (33), Hodgson (10).

This is the commonest of the genus in this country.

A. exigua (Lilljeborg).

? *Lynceus exiguus* Norman & Brady (17) (in part).

This seems to be a very rare British species. I have only seen it once—from the Water-lily pond in Kew Gardens last year (32)—and I know of no other certain records. Mr. T. Scott's records of *A. exigua* really refer to *A. excisa*. See his remarks in (20) Part IX., p. 201.

A. nana (Baird).

Acroperus nanus Baird (1).

Lynceus nanus Norman & Brady (17).

A pretty common and widely distributed species. It is the smallest Entomostracon known at present.

Peratacantha Baird.

P. truncata (O. F. Müller).

Peracantha truncata Baird, etc.

Lynceus truncatus Norman & Brady (17).

Pleuroxus Baird.

P. laevis Sars.

Lynceus laevis Norman & Brady (17).

P. trigonellus (O. F. Müller).

Lynceus trigonellus Norman & Brady (17).

P. uncinatus Baird.

Lynceus uncinatus Norman & Brady (17).

P. aduncus (Jurine).

I believe this has hitherto been included under *P. trigonellus* by most writers on British Entomostraca, but it is a good species, and probably not uncommon.

Chydorus Leach.

C. globosus Baird.

Lynceus globosus Norman & Brady (17).

A rather rare species, but widely distributed.

C. ovalis Kurz.

C. latus Scourfield (28, 29), Scott (20).

C. latus Sars.

Mr. T. Scott has recorded some forms of *Chydorus* which he thinks belong to this species rather than to *C. ovalis*, and Mr. Kane has also found it in Lisdoonvarna Lake, co. Clare.

C. sphaericus (O. F. Müller).

Lynceus sphaericus Norman & Brady (17).

The commonest and most widely distributed of all the Cladocera. There are several varieties, but none of much importance except, perhaps, *coelatus* [= *C. sphaericus* var. *favosa* Brady (4)].

C. barbatus (Brady).

Lynceus barbatus Brady (4).

I cannot make this agree with any of the species recorded by Lilljeborg, although it is evidently close to *C. piger*. Its chief characteristics are: Ventral shell-margin densely fringed with long plumose setae, posterior margin well rounded but extremely short; shell-sculpture consisting of ill-defined hexagons giving rise to the appearance of stripes, or rows of dots; antennules with two olfactory setae at some distance from the other seven; antennae with only seven swimming setae; post-abdomen with 9–10 long straight teeth followed by a line of fine hairs along the whole length of the anus. Length about $\frac{1}{60}$ inch. (See Figs. 11 and 12.)

In the south and east of England I have only seen it from Fleet in Hampshire, but it is not uncommon in the Lake District and in Scotland. It has also been seen in Wales and Ireland, and it occurs on the Continent, as I have collected specimens in the Achen See in the Tyrol.

Monospilus Sars.

M. dispar Sars.

M. tenuirostris Norman & Brady (17), Hodgson (10).

A rare species. Not yet seen in Wales.

Anchistropus Sars.

A. emarginatus Sars.

One of the rarest of all the British Cladocera. It was found by Mr. D. Robertson in 1863 in the Paisley Canal near Glasgow (see 17). It was not seen again, so far as I can ascertain, until Mr. Kane two or three years ago took a few specimens in Lough Erne. In 1901 my friend Mr. C. J. H. Sidwell found two or three specimens in one of the reservoirs of the East London Waterworks at Walthamstow, and last year I took a single specimen (ephippial female) from the same place.

Polyphemidae.

Polyphemus O. F. Müller.

P. pediculus (Linn.).

Bythotrephes Leydig.

B. longimanus Leydig.

B. cederstromii Beck (3).

This has never been seen anywhere in the south and east of England, but usually occurs, though never in large numbers, in the lakes of the Lake District, North Wales, Scotland, and Ireland.

B. cederstroemii Schoedler.

B. borealis Kane (13).

Mr. W. F. de V. Kane found this in Lough Erne, where it occurs pretty abundantly. It has not hitherto been noticed elsewhere in the British Isles.

LEPTODORIDAE.

Leptodora Lilljeborg.

L. kindtii (Focke).

L. hyalina Graham (9), Beck (3), Scott (20, etc.), Scourfield (20), and all authors who have mentioned it.

Not uncommon in lakes and large reservoirs. In the south and east of England it has only been found, so far as I am aware, by Mr. C. F. Rousselet, who on two separate occasions took a few specimens in the Regent's Canal at Regent's Park, London. Whether they normally live in this locality, or are simply brought from a distance by the water passing through the canal, has not been determined.

An attempt has been made in the following table to show at a glance the distribution of the British fresh-water Cladocera, so far as this can be ascertained from the records to which I have had access. A few words of explanation will probably be necessary to make it quite clear.

(1) The table is so arranged that the total known species for England, Wales, Ireland, and Scotland respectively are to be found in the four columns commencing with "Total England."

(2) England has been divided into three great divisions—South and East, Midland, and North—and the totals of these appear in three adjoining columns. By "South and East" is to be understood all the country lying to the south-east of a line joining the Wash and the south-west corner of Hampshire. "North" comprises the six northern counties, and "Midland" the country between "South and East" and "North." The south-west is not alluded to because no records of any extent are known for that part of England. It should also be mentioned that the available records for the Midlands are not nearly so complete as for the South and East, and North of England, and they are, moreover, almost entirely confined to the districts around Birmingham and Leicester. For the former district I am indebted to Mr. Hodgson's list (10), and

for the latter to information kindly furnished to me by Mr. J. H. Garnar.

(3) The special lists under "South and East" England are from Epping Forest (comprising the whole of the existing forest and a margin on either side extending to the rivers Lea and Roding); Richmond Park district, including Kew Gardens; and the Norfolk Broads district. These three have been given in detail because they have been more systematically worked than any other districts in the south-east. The Epping Forest and Richmond districts also form two diametrically opposite areas with regard to London, being situated to the north-east and south-west of the metropolis respectively, and the characters of their Entomostracan faunas offer some curious points of difference.

(4) The "Lake District" has been given separately under the North of England, because it is a very interesting and well-defined area, and I have had some opportunity of personally working at its Entomostracan fauna. The records of Brady, Beck, and Pratt have, of course, also been consulted.

(5) The records from Wales are from the northern half only, including Anglesey. I have myself collected all the species mentioned, though I am indebted to Professor G. S. Brady for material from several localities.

(6) For the records from Ireland I am indebted to Creighton's lists (6, 7), a note by Hodgson (12), papers by Kane (13, 14, 15), and my own examination of a few samples of material, together with much valuable information supplied to me direct by Mr. Kane.

(7) Scotland has been divided into three great divisions—a southern, or "Lowland" (all the country south of a line joining the Firths of Tay and Clyde), a middle, or "Highland" (all the country north of the Lowlands as far as Ross and Cromarty), and an extreme northern division (Sutherland and Caithness, together with the Orkney and Shetland Islands). For records of Entomostraca from all parts of Scotland Mr. T. Scott's papers are a mine of information, and they have been used almost exclusively for these lists. Some additional information has been obtained, however, from Dr. and Miss Sprague's list, and from my own observations in the Trossachs, Loch Rannoch, and Loch Morar districts.

DISTRIBUTION OF BRITISH FRESH-WATER CLADOCERA.

Species.	England.								Wales.	Ireland.	Scotland.			
	South and East.					North.								
	Epping For.	Richmond.	Norfolk Bds.	Total S. and E.	Midland.	Total N.	Lake Dist.	Total England.			Total Scotland.	"Lowlands."	"Highlands."	Extreme North.
Sididae.														
Sida crystallina	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Diaphanosoma brachyurum	×	×	×	×	×	×	×	×	×	×	×	×	×	×
,, *leuchtenbergianum*	...	...	...	...	...	×	×	×	×	×	...	...	...	...
Latona setifera	...	...	...	...	...	×	×	×	×	...	×	...	×	×
Holopedidae.														
Holopedium gibberum.	...	...	...	...	...	×	×	×	...	×	×	×	×	...
Daphnidae.														
Daphnia magna	×	×	×	×	×	×	...	×	...	...	...	...	...	...
,, *atkinsoni*	...	...	...	...	...	×	...	×	...	...	...	...	...	...
,, *psittacea*	...	...	...	×	...	...	...	×	...	...	...	...	...	...
,, *pulex*	×	×	×	×	×	×	?	×	×	×	×	×	×	?
,, ,, *obtusa*	×	...	×	×	×	×	...	×	...	×	×	×	?	...
,, *longispina*	×	×	×	×	×	×	×	×	×	×	×	×	×	×
,, *hyalina s. str.*	×	×	...	×	×	...	...	×	×	...	×	×	...	...
,, ,, *pellucida*	...	...	...	...	...	...	...	...	...	...	×	?	?	...
,, ,, *lacustris*	×	×	×	×	×	×	×	×	?	×	×	×	×	×
,, ,, *galeata*	×	...	...	×	×	×	×	×	...	×	×	×	×	×
,, *cucullata*	×	...	×	×	×	×	×	×	...	×	×	×	...	...
,, ,, *kahlbergensis*	...	...	...	×	×	...	...	×	...	×	×	×	×	...
Scapholeberis mucronata	×	×	×	×	×	×	×	×	...	×	×	×	×	×
Simocephalus vetulus	×	×	×	×	×	×	×	×	×	×	×	×	×	...
,, *exspinosus*	×	×	×	...	×	...	...	×	×	×	...	...	...	...
,, *serrulatus*	...	×	...	×	...	...	...	×	×	...	...	...	...	...
Ceriodaphnia reticulata	×	×	×	×	×	×	×	×	×	×	×	×	×	...
,, ,, *serrata*	×	...	×	×	...	...	...	×	...	...	...	...	...	...
,, ,, *kurzii*	×	...	×	×	...	...	...	×	...	...	...	...	...	...
,, *megalops*	×	×	×	×	×	×	...	×	...	×	×	...	×	...
,, *quadrangula*	...	...	×	×	...	×	×	×	×	×	×	×	×	×
,, *pulchella*	×	×	×	×	×	×	×	×	...	×	...	...	...	...
,, *affinis*	×	...	×	×	...	...	...	×	...	...	×	×	...	...
,, *laticaudata*	×	...	×	×	×	...	...	×	...	×	×	×	×	...
,, *rotunda*	...	...	...	?	...	...	...	×	...	...	...	...	...	...
Moina rectirostris	×	...	×	×	×	×	...	×	...	...	...	...	...	...
,, *brachiata*	...	...	...	×	...	...	...	×	...	...	...	...	...	...
,, *bánffyi*	...	...	...	×	...	...	...	×	...	...	...	...	...	...
Bosminidae.														
Bosmina longirostris	×	×	×	×	×	×	×	×	×	×	×	×	×	...
,, ,, *cornuta*	×	×	×	×	...	×	×	×	×	...	×	×	...	...

DISTRIBUTION OF BRITISH FRESH-WATER CLADOCERA.

Species.	England.								Wales.	Ireland.	Scotland.			
	South and East.					North								
	Epping For.	Richmond.	Norfolk Bds.	Total S. and E.	Midland.	Total N.	Lake Dist.	Total England.			Total Scotland.	"Lowlands."	"Highlands."	Extreme North.
BOSMINIDAE—*continued.*														
Bosmina obtusirostris	...	...	...	...	?	×	×	×	×	×	×	×	×	×
" *longicornis*	...	...	...	...	...	...	...	...	...	×	?	...	?	...
" *longispina*	...	...	...	...	...	...	...	...	...	×	×	...	×	...
" *mixta*	...	...	...	...	...	...	...	...	...	×	...	...	...	...
" *coregoni*	...	...	...	...	×	...	...	×	...	×	×	×	...	×
LYNCODAPHNIDAE.														
Ilyocryptus sordidus	×	×	×	×	×	×	×	×	×	×	×	×	×	×
" *agilis*	...	×	×	×	...	...	...	×	...	...	...	...	..	...
" *acutifrons*	...	...	...	...	...	...	...	...	...	...	×	...	...	×
Macrothrix laticornis	×	×	...	×	×	×	...	×	...	×	×	×	...	...
" *rosea*	...	...	...	...	...	...	...	×	...	×	×	×	...	...
" *hirsuticornis*	×	...	...	×	...	×	...	×	...	...	×	...	×	×
Lathonura rectirostris	...	×	×	×	×	...	...	×	×	×	×	×	×	...
Streblocerus serricaudatus	...	...	...	...	...	×	×	×	×	×	×	×	×	...
Drepanothrix dentata	...	...	...	×	×	×	×	×	×	×	×	×	×	×
Acantholeberis curvirostris	...	...	...	×	...	×	×	×	×	×	×	×	×	×
LYNCEIDAE.														
Eurycercus lamellatus	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Camptocercus rectirostris	×	×	×	×	×	×	×	×	×	...	×	×	×	×
" *lilljeborgii*	...	...	×	×	...	...	...	×	...	...	...	...	...	...
Acroperus harpae	×	×	×	×	×	×	×	×	×	×	×	×	×	×
" *angustatus*	...	...	×	×	...	...	...	×	...	...	...	...	...	...
Alonopsis elongata	...	...	...	...	...	×	×	×	×	×	×	×	×	×
Alona quadrangularis	×	×	×	×	×	×	×	×	×	×	×	×	×	×
" *affinis*	×	×	×	×	×	×	×	×	×	×	×	×	×	×
" *tenuicaudis*	×	...	×	×	×	×	...	×	×	×	×	×	×	...
" *costata*	×	...	×	×	...	×	×	×	...	×	×	×	×	...
" *guttata*	×	×	×	×	...	×	×	×	×	×	×	×	×	×
" *intermedia*	...	...	...	...	...	...	...	...	...	...	×	×	×	×
" *rectangula*	×	×	×	×	...	×	×	×	×	×	×	×	×	×
" *elegans*	...	...	...	...	...	×	...	×	...	...	...	...	...	...
" *rustica*	×	...	...	×	...	×	×	×	×	×	×	×	×	×
" *rostrata*	×	×	×	×	×	×	...	×	...	×	×	×	...	...
Leptorhynchus falcatus	...	...	...	×	...	×	×	×	...	...	×	×	×	×
Leydigia quadrangularis	×	...	...	×	×	×	...	×	×	...	×	×	×	...
" *acanthocercoides*	×	×	×	×	...	...	...	×	...	×	...	...	...	...
Graptoleberis testudinaria	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Alonella excisa	×	×	×	×	...	×	×	×	×	×	×	×	×	×
" *exigua*	...	×	...	×	...	?	?	×	...	...	...	...	...	...
" *nana*	×	×	×	×	×	×	×	×	×	×	×	×	×	×

DISTRIBUTION OF BRITISH FRESH-WATER CLADOCERA.

Species.	England: South and East: Epping For.	Richmond	Norfolk Bds.	Total S. and E.	Midland.	North: Total N.	Lake Dist.	Total England.	Wales.	Ireland.	Scotland: Total Scotland.	"Lowlands."	"Highlands."	Extreme North.
Lynceidae—*continued.*														
Peratacantha truncata	×	×	×	×	×	×	×	×	×	×	×	×	×	...
Pleuroxus laevis	×	×	×	×	...	×	×	×	...	×	×	×	×	...
" *trigonellus*	×	×	×	×	×	×	...	×	×	×	×	×	×	×
" *uncinatus*	×	×	×	×	×	×	×	×	...	×	×	×	×	...
" *aduncus*	×	×	...	×	...	...	...	×	...	×	...	...	...	...
Chydorus globosus	×	×	×	×	×	×	×	×	×	×	×	×	×	×
" *ovalis*	×	...	×	×	...	×	×	×	×	×	×	×	×	×
" *latus*	...	...	...	...	...	...	...	...	...	×	×	?	?	...
" *sphaericus*	×	×	×	×	×	×	×	×	×	×	×	×	×	×
" " *coelatus*	×	...	...	×	...	×	×	×	×	×	×	×	×	...
" *barbatus*	...	...	...	×	...	×	×	×	×	×	×	×	×	×
Monospilus dispar	×	...	...	×	...	×	...	×	...	×	×	×	×	...
Anchistropus emarginatus	×	...	...	×	...	...	...	×	...	×	×	×	...	...
Polyphemidae.														
Polyphemus pediculus	...	×	×	×	×	×	×	×	×	×	×	×	×	×
Bythotrephes longimanus	...	...	...	...	...	×	×	×	×	×	×	×	×	...
" *cederstroemii*	...	...	...	...	...	...	...	...	...	×	...	...	...	...
Leptodoridae.														
Leptodora kindtii	...	...	...	?	×	×	×	×	×	×	×	×	×	...

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EXPLANATION OF PLATE 24.

Fig. 1. *Daphnia atkinsoni* Baird (= *Dactylura pubescens* Brady), ♀. Outline sketch from side, × 20.
,, 2. ,, ,, Post-abdomen, × 45.
,, 3. ,, ,, Terminal claw.
,, 4. ,, ,, Rostrum and antennule.
,, 5. *Moina bánffyi*, Daday, ♀. × 45.
,, 6. ,, ,, Antennule, × 250.
,, 7. ,, ,, Post-abdomen, × 180.
,, 8. ,, ,, Hooked spines on margin of shell near posterior dorsal angle.
,, 9. *Alona rustica*, T. Scott. ♀, × 100.
,, 10. ,, ,, Post-abdomen, × 300.
,, 11. *Chydorus barbatus*, G. S. Brady, ♀, × 140.
,, 12. ,, ,, Post-abdomen, × 400.
,, 13. *Alona elegans*, Kurz. ♀, × 55.
,, 14. ,, ,, Post-abdomen, × 275.

THE PRESIDENT'S ADDRESS.

Fermentation and Putrefaction.

By George Massee, F.L.S., V.M.H.

(*Delivered February 20th*, 1903.)

The scientific knowledge as to the true nature of fermentation and putrefaction is of recent date, and much of this knowledge is due to the brilliant discoveries of Pasteur, the celebrated French scientist. On the other hand, various theories concerning these phenomena have been advanced from time to time, some of which are of very ancient date. Aristotle states that, through the agency of heat, one living being may originate from the corruption of another. Then again, in the fourth book of Virgil's "Georgics," occurs the well-known account of the bees produced from the putrefying carcase of a bull. Many other, sometimes repulsive, accounts are forthcoming in various works up to the end of the eighteenth century.

Even at the present day, although all are agreed as to fundamental laws on the matter, various definitions are forthcoming, depending on the point of view taken on the subject. Gautier's definition of fermentation is as follows: "Fermentation occurs when an organic compound undergoes changes of composition, under the influence of a nitrogenous organic body called a ferment. The ferment acts in small quantities, and furnishes nothing to the substance being fermented."

During the limited time at disposal the subject will be discussed as follows. Fermentation will be confined to a brief review of the work done by the yeasts, or *Saccharomyces*, characterised more especially by the formation of carbonic dioxide (carbonic acid gas) and alcohol; putrefaction, or decomposition of organic or inorganic bodies by bacteria, with liberation of free nitrogen or ammonia.

It is important to bear in mind that the substances enumerated above as characteristic of the activity of yeasts and bacteria respectively, are by no means the only bodies liberated during fermentation or putrefaction. The very varied smells and tastes produced during these processes testify otherwise.

The yeasts are true fungi, originally included in the genus *Saccharomyces*, and were at one time considered as representing one of the simplest phases of plant life, owing to their minute size and apparent absence of differentiation. Recently, however, thanks to improved microscopes, reagents, and stains, the presence of nuclei has been demonstrated, and a sexual mode of reproduction observed. All yeasts are unicellular organisms, the average size being about 10 μ long. The commonest mode of reproduction is unisexual, and known as budding. When yeast is placed in a saccharine solution kept at a suitable temperature, the yeast cells rapidly increase in size, and when a given stage is reached, one or more minute bulges appear on the surface of the parent cell. These bulges increase in size, and eventually become free, each in turn adding to the number of plants present. By this rapid method of reproduction, a quantity of suitable liquid, containing only a very few yeast cells, soon becomes thick and turbid, due to the rapid increase in numbers of yeast cells. During this active period of growth, a brisk effervescence, due to the liberation of carbonic acid, is going on, and proper examination reveals the presence of a certain amount of alcohol in the liquid; both substances being by-products resulting from the dissociation of the sugar by the yeast plant.

A second mode of reproduction is by the formation of endospores, or spores formed within a yeast cell. This form of reproduction occurs when the yeast is placed under conditions where very little food is available.

A third mode of reproduction, of a sexual nature, has quite recently been observed in some of the yeasts. This method is known as conjugation, and consists in the blending of the nuclei of two morphologically similar cells, as met with in the Zygomycetes, or Mucors, fungi much more highly differentiated than the yeasts. Probably the latter are not so truly primitive as their present structure might lead us to believe, but rather represent degraded forms of higher types.

All yeasts require oxygen for the performance of their vital functions. Certain kinds obtain this gas directly from the atmosphere, with which they must necessarily be in contact when growing; such yeasts are described as aerobic. Others again, called anaerobic, do not obtain their oxygen from the atmosphere, but by the decomposition of compounds containing this element; such yeasts can pursue their course of life in an atmosphere devoid of oxygen.

Much more is known respecting the yeasts from a scientific standpoint, on account of their importance in the brewing industry, than would otherwise be the case. The fact that the revenue benefits to the annual amount of over £32,000,000, directly and indirectly connected with this industry, of which over £13,000,000 is derived from beer, gives some idea of the enormous amount of capital at stake in this country alone, and depending entirely on the utilisation of a by-product—alcohol—furnished by the yeast plant. The enormous amount of carbonic acid liberated during the process of brewing escapes into the atmosphere, where it is used by plants.

In the process of brewing it was the custom at one time, when the wort was ready for fermenting, to leave it exposed and trust to the yeasts always floating in the air settling on it and setting up fermentation. This was succeeded by the practice of placing a certain amount of yeast, obtained from the previous brew, into the wort. *Saccharomyces cerevisiae* is the species used in brewing beer, and Professor Hansen, a Danish botanist, has shown that this species has given origin, during its utilisation by man, to many distinct races, each of which behaves differently in the fermenting vat. Some races produce sparkling beer, others produce a strong head, property of brightening quickly, and resisting turbidity, and thus suitable for export beer, etc. The practical outcome of this discovery is that at the present day, in many of the large breweries, especially on the Continent, perfectly pure cultures of the particular yeast giving the desired result are used for brewing.

In bygone times, and even in the present day in country districts, a ginger-deer plant constitutes one of the heirlooms transmitted from generation to generation, and used for the purpose of manufacturing home-made ginger-beer. In appearance the ginger-beer plant is not inviting; somewhat resembling thin sago pudding, with a slimy feel, and slipping between the fingers when crushed in the hand. This remarkable "plant" consists of a mixture of two distinct organisms, the one being a yeast —*Saccharomyces pyriformis*, the other a bacterium—*Bacillus vermiformis*. The occurrence of these two organisms, neither of which alone can produce ginger-beer, is considered by Professor Marshall Ward as affording an instance of true symbiosis. When the ginger-beer plant is placed in water containing crushed ginger, sugar, and a little tartaric acid, and kept at the proper temperature, the yeast first commences work on the sugar, setting up fermentation, the bacteria remaining, for the time being, encased in a glairy sheath. After the yeast has been active for some time, certain by-products, the result of its activity, check its progress, and would soon put a stop to further fermentation. At this stage, however, the bacteria emerge from their respective sheaths, and rapidly consume the by-products which retard the activity of the yeast, and by the mutual aid exercised between these two organisms, the work of fermentation or the manufacture of ginger-beer proceeds uninterruptedly.

The exact position of the Bacteria, or Schizomycetes, is as yet a matter of speculation, being considered by some as nearest to the fungi, and by others as presenting affinities with the Algae. The fact is, some of the organisms included in the Schizomycetes are algal-like and others fungal-like.

All agree in the extreme simplicity of their morphological characters: the marked changes in form and habit depending on environment and other factors; and on their exceedingly minute size, even compared with the yeasts.

Reproduction takes place by fission, or the separation into two equal portions of an individual, each half, on assuming the size of its parent, undergoing a similar division. A second mode of reproduction is by the production of endospores within the cell or body of an individual.

Under favourable conditions, reproduction by fission, the most usual method, takes place in a very short time. In the cholera comma-bacillus twenty minutes is occupied in this process, hence in a single day a progeny of sixteen hundred trillions would result. This quantity of bacteria would contain about one hundred tons of solid residue.

Some bacteria are characterised by the production of brilliant colours, forming patches of blood-red, pink, green, yellow, etc., on cooked meat, cheese, bread, and other organic substances. Others again are strongly fluorescent.

Smells agreeable or otherwise often result from the activity of these organisms in promoting the decomposition or putrefaction of organic matter, but, as already stated, a characteristic feature of the group is the liberation of free nitrogen or ammonia.

Bacteria, like yeasts, are either aerobic or anaerobic, and in addition respond to the stimulus of certain substances in solution, which do not necessarily serve as food. The influence thus exercised is termed Chemotaxis. When substances such as peptone, potassic chloride, asparagin, etc., attract bacteria, the Chemotaxis is positive, and negative when repelled, as by free acids or alkalies, alcohol, etc. The innumerable ills of man and beast attributed to "germs" must be passed over in silence, and the brief period of time remaining at our disposal devoted to a sketch of the direct or indirect influence of bacteria on plant life.

The final decomposition of various substances present in the soil, or intentionally placed there for the purpose of forming manure or plant food, was until recently attributed entirely to chemical activity. The disintegration of such varied bodies as manure, urine, gas-lime, green crops ploughed into the land, etc., are now definitely known to be due to innumerable bacteria present in the soil, and invariably resulting in the liberation, along with other substances, of free nitrogen and ammonia.

The free nitrogen escapes directly into the atmosphere, where some of it is used up by bacteria, in a manner to be described further on.

The ammonia is immediately attacked by the so-called nitrifying bacteria. These organisms are divided into two groups, representing a division of labour in the production of nitrates. First come the nitrite bacteria, which convert the ammonia into nitrous acid; this acid is then converted by the nitrate bacteria into nitric acid, which eventually combines with a base to form a nitric salt. It is from such soluble nitric salts formed by bacteria that all green plants except the Leguminosae obtain their nitrogen by absorbing the dissolved salt through the roots. Nitrate of soda and nitrate of ammonia are examples of such salts.

Saltpetre or nitre—nitrate of potash—whether produced naturally, as in India and South America, or artificially in saltpetre works, depends on the presence of bacteria. For the production of this substance the presence of decomposing animal matter and carbonate of potassium are necessary. The bacteria first liberate ammonia from the animal matter, this is by stages converted into nitric acid, which in turn takes the place of the carbonic acid in the carbonate of potash, and saltpetre, or nitrate of potash, results. The nitre bacterium is one of the smallest of bacteria known, and is the only organism known that can assimilate carbonic acid in darkness.

It has been known from very early times that leguminous plants, peas, beans, tares, etc., added nitrogen to the soil in which they grew; whereas all other plants impoverished the soil of this important element of plant food. This property of leguminous plants is now known to be due to bacteria living in the roots. These bacteria are present in the soil, and when peas or beans are growing, the delicate root-hairs liberate a certain amount of asparagin, by which the bacteria are chemotactically attracted. The tips of the root-hairs then become partly dissolved, and allow the bacteria to penetrate their interior, from whence they pass in a glairy stream into the thicker roots, and, increasing rapidly in numbers, form the well-known nodules, or warts, present on the roots of leguminous plants.

During the first period of existence in the root, the bacteria are provided with an ample supply of food by the host-plant, in the form of soluble carbohydrates, etc. After a time the bacteria present in the nodules of the roots begin to absorb free nitrogen, which accumulates in the nodules to the extent of six to seven per cent. as time goes on. When the plant is in bloom, the bacteria, which hitherto have been liberally supplied with food as already stated, are now victimised by the plant, which secretes certain enzymes that practically dissolve the bacteria, and their store of nitrogen is appropriated by the plant, and mostly transferred into its own seeds.

When this period is reached, the nodules on the roots gradually decay, and a few of the bacteria that have escaped destruction pass into the soil, where they remain until opportunity offers for entering the root of some leguminous plant.

Plant diseases caused by bacteria, fortunately, are not numerous; nevertheless, there are some undoubted cases where very destructive epidemics are to be attributed to the agency of these minute organisms. Amongst the most serious may be mentioned a potato disease which has done widespread injury in the United States, and has recently also been observed in this country. The leaves are first attacked, the disease being spread by insects alternately visiting diseased and healthy plants. By degrees the bacteria travel down the vessels of the stem, their progress being indicated by dark brown streaks, and in the end reach the tubers, which first show a zone of brown discoloration a little distance within the skin. Finally the affected tuber decays, and the bacteria remain in the soil until another crop of potatoes are grown, when the attack is resumed.

Hyacinths and tomatoes are also liable to injury from the attacks of bacteria.

Note on the Occurrence of Living Hydrachnid Larvae in the Stomach of a Trout.

By C. D. Soar, F.R.M.S.

(*Read January 16th*, 1903.)

On May 11th, 1902, in the course of the investigations carried out by the "Lake Survey" under Sir John Murray, a trout was taken from Loch Rannoch, in the stomach of which Dr. T. N. Johnston found living larvae of Hydrachnids. They were very lively and in great abundance, and when the contents of the stomach were put into saucers of water, the mites swarmed to the side towards the light, and were easily caught with the pipette. No dead specimens were seen. Some of these mites were afterwards killed in a preservative solution and kindly forwarded to me through Mr. Scourfield for examination. Permission was also kindly given by Sir John Murray and Dr. Johnston to publish any note on them I thought fit in the pages of our Journal.

Now it is very well known that nearly all the larvae of water-mites pass one stage of their existence as parasites on some other form of aquatic life. They have been found on insects out of the water, but only on such insects as have passed a part of their lives in an aquatic state, such as gnats, dragon-flies, etc. Severa species of *Atax* are found in fresh-water mussels. Other mites have been found on *Dytiscus*, *Corixa*, *Notonecta*, *Nepa*, *Ranatra*, and other insects. Carl Thon has found them parasitic on fresh water snails. Krendowskij has found the larvae of *Arrhenurus* on the wings of a dragon-fly. Water-mite larvae have also been found attached to small fish (see note in this Journal, *ante*, p. 65). But I believe this is the first time that larval forms of a Hydrachnid have been found living in the stomach of a fish.

I have carefully examined and drawn the larvae, but I am not at present in a position to say to what species they belong, although they seem to me to be very close to the larval forms of *Neumania*, a sub-genus of *Atax*. I sent some of the mites to Dr. Koenike, of Bremen, thinking that perhaps he had seen this particular larva, and that he might be able to give me its name. Dr. Koenike does not know it, however, but thinks that it is a stage in the development of a "thick-skinned fresh-water mite (*Arrhenurus ?*)" and bases his opinion on the presence of a distinct dorsal plate.

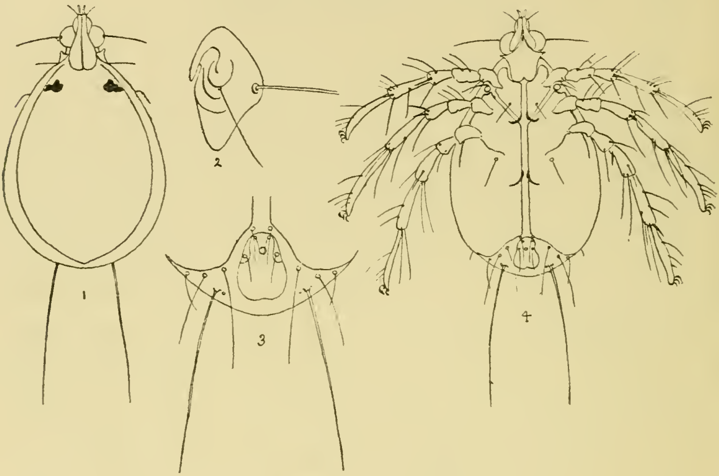


Fig. 1.—Dorsal surface.
Fig. 2.—Palpus.
Fig. 3.—Posterior ventral surface.
Fig. 4.—Ventral surface.

But whatever its specific name may be, it is no doubt the larval form of a fresh-water mite, and I think it advisable to publish this note in order that collectors may be put on the look-out for other larval forms in the stomachs of trout and other fishes.

Length of larva 0·42 mm.

Note on the Phototropism of *Daphnia*.

By G. W. Kirkaldy.

(*Read March* 20*th*, 1903.)

H. Schouteden has recently published the results of some interesting observations on the action of light upon *Daphnia* *; the subject has always been somewhat controverted, owing partly to some little difference in method of research, partly also doubtless to the different points of view of the observers, and possibly to the different behaviour of different species.

Whilst collecting Daphnias, Schouteden was struck by the variations noted in their vertical distribution at different times, these variations being apparently in direct relation with meteorological conditions. A clear day and bright sun discovered at the surface of the water only a few Daphnias compared with those gathered in the depths; on the other hand, with a sun obscured, a notable increase in their number in the upper strata was at once discernible, and it was the same at the close of the day after sunset. During Whitsuntide, 1902, the days were constantly overcast, and it was observed that a large part of the Daphnias were at the surface, though if, as was often the case, a strong rain or hail fell, the crustaceans regained the lower strata of the water.

In the cases where the majority of the Daphnias remained near the bottom, with a bright sun, it was noted that there was a much larger proportion of young individuals in the surface-catch than in the others; it seemed that the young Daphnias had a tendency to stay in the upper strata of the water, even when the older ones—recognised by their opaque white colour—preferred to remain far away. These observations were confirmed in the laboratory. The Daphnias were placed in a wooden rectangular receptacle, of which the two long vertical sides were of sheets of thin glass, 50 centimetres long, 20 centimetres high, and leaving between them a space of 3 centimetres; all the wood was painted black, outside and within. This apparatus was placed in a wooden case, open at both ends, and occupied its entire width. To graduate the light, a prism was used, of gelatine darkened by a solution of Chinese ink. Great care was taken to prevent the ingress of any other exterior light.

Schouteden summarises his results as follows: *Daphnia magna*,

* "Le Phototropisme de *Daphnia magna* Straus (Crust.)," 1902. *Ann. Soc. Entom. Belgique*, xlvi., pp. 352-62.

exposed to the action of light and able to choose between different intensities, is at first positively phototropic—that is to say, it goes towards the zone of greater light; then—as regards the adults—it gains the zone of less illumination. As to the young individuals, they appear to have tendencies less precise; nevertheless, the positive reactionis maintained in a very great number of cases.

Schouteden finds in previous literature confirmations of these facts. Zschokke, Bruyant, and Francé note that during the day the plankton, which consists, of course, very largely of Entomostraca such as *Daphnia*, etc., retires a certain distance from the surface, to return at night, and the circumstance that the captures made at the surface during the day are mostly young individuals is also confirmed. These authors, however, seem to attribute such variations, at least in great part, to thermic phenomena; this is denied, as an ultimate factor, by Schouteden. The Belgian zoologist has apparently overlooked the researches of Lubbock, summarised by him in 1891,* upon which considerable light is now thrown.

Lubbock placed a number of Daphnias in a shallow wooden trough, divided by cross-partitions of glass, so that the parts illumined by different coloured rays of a spectrum could be isolated; the partitions were then removed so that the Daphnias could circulate freely. After this they were exposed to the light for ten minutes, and then the glass partitions were inserted and the Daphnias in each division counted. Lubbock concludes that, while Daphnias prefer light to darkness, there is a certain maximum of brilliancy beyond which the light becomes inconveniently bright to them, and that they can distinguish between light of different wave-lengths. He supposes that it would be impossible to prove that they actually perceive colours; but to suggest that the rays of various wave-lengths produce on their eyes a different impression from that of colour, would be to propose an entirely novel hypothesis. He thinks that he has shown that they do distinguish between rays of different wave-lengths, and prefer those which to our eyes appear green and yellow.

Schouteden promises further experiments, which will be awaited with interest.

* "On the Senses, Instincts, and Intelligence of Animals, with special reference to Insects." Edition 3. (*International Science Series*, Vol. LXV., pp. 211-31). These experiments were made on *Daphnia*, confirming previous observations upon ants.

NOTICES OF RECENT BOOKS.

Modern Microscopy. By M. I. Cross and M. J. Cole. 3rd edit. Demy 8vo. pp. xvi + 292 ; 76 illustrations. London, 1903 : Baillière. Price 4*s*. net.

The new edition of this work well sustains the reputation its predecessors acquired as an excellent introduction to general microscopy ; moreover, it has been increased by some 110 pages. The first part, by Mr. Cross, dealing with the instrument and its accessories, remains much the same as before, except that some few obsolete types are omitted and some newer ones introduced. The second part, by Mr. Cole, has been thoroughly revised and brought up to date, and remains one of the very best guides to the preparation, staining, and mounting of microscopic objects extant in a limited compass. An entirely new and useful section has been introduced in this edition on "Microtomes : their Choice and Use," by Mr. G. West, of the Botanical Laboratory, Edinburgh. This should be of great assistance to the beginner, who is most frequently bewildered by the multiplicity of these indispensable instruments. He will find here practical directions as to the suitability of the various types to different classes of work, the methods of embedding and cutting, from the simplest to the most elaborate ; in fact, all the information a comparatively brief exposition can be expected to afford. As was said of the previous edition, it is a work that can be cordially recommended.

G. C. K.

Practical Photo-Micrography. By Andrew Pringle, F.R.M.S., etc. Third Edition. $8\frac{3}{4} \times 5\frac{1}{2}$ in., 179 pages, 34 figures in the text. London, 1902 : Iliffe & Sons. Price 3*s*. 6*d*. net.

The publication of the third edition of this well-known work is a welcome addition to the literature of Photo-Micrography. Many of the chapters in the present issue have been extended, whilst nearly all have been brought up to date by the introduction of new matter.

In the section devoted to cameras, there is a good illustrated description of a vertical camera for photographing moving objects which may require the stage of the microscope to be kept in a horizontal position. To a time or instantaneous shutter is adapted a telescopic arrangement for the purpose of watching the object under examination until the desired moment for taking it arrives.

The chapters relating to objectives, condensers, illumination, and the actual procedure for making a negative, are all carefully written, and contain much useful information. Very little, however, is said of the use and advantages of light filters or monochromatic illumination, whilst the reader of page 95 might infer that the vertical illuminator is obsolete, the fact being that it is now rapidly attaining to an important position amongst accessories, for by means of it alone can the microscope be applied to the examination of the physical structure of metals and their alloys—a subject, by the way, which is completely ignored in this book.

A good account is given of chromatic plates, the circumstances under which they should be employed, and the precautions to be observed in order to obtain successful results ; but an opportunity has been missed of giving a description of the methods of photographing objects in their natural colours, especially the Sanger-Shepherd and Lumière processes, by which such beautiful results are now obtained, and which are destined in the future to play an important part in the photography of microscopic objects.

A favourable recommendation is given to printing-papers of the " Velox " type, which, on account of their remarkably smooth surface, are especially suitable for rendering the fine details required in microscopic work.

" As an imperfect preparation will never yield a perfect photograph," the author devotes the last chapter to giving an outline of the methods which he has found best for the production of good physiological or pathological preparations, also for embedding, section cutting, and making cover-glass preparations.

A price list and a good index conclude this excellent and clearly-written book, in which the aim of the author to give practical instruction rather than theoretical information has certainly been attained.

A. A.

Elementary Photo-Micrography. By Walter Bagshaw. $7 \times 4\frac{3}{4}$ in., 68 pages, 11 figures in the text, 12 on 6 plates. London, 1902: Iliffe & Sons. Price 1*s*. net.

In the preface to this little work the author clearly states that it is not written for experts, but for beginners only, and he certainly succeeds in showing that excellent results may be obtained by means of very simple apparatus. Among other things of this kind he gives directions for the construction of a plain, though efficient, base-board on which to mount the camera and microscope.

It is, however, impossible to treat the subject of this book in an adequate manner within the compass of sixty-eight pages, twenty-six of which are devoted to the consideration of purely photographic matters, such as developers, printing processes, etc., and necessarily many little details of manipulation which would be found helpful even by beginners are left out. The use of the substage condenser, for instance, is only casually alluded to. Still, so far as he does go, the author treats his subject in an interesting manner; and as the plates are excellently reproduced, Mr. Bagshaw's little book may excite an interest in some of his readers, and if it leads them on to the serious study of more advanced works, it will have fulfilled its purpose.

A. A.

The Natural History of Aquatic Insects. By Prof. L. C. Miall, F.R.S. Second Edition; $7 \times 4\frac{1}{2}$ in., xi + 395 pages, 116 figures in the text. London, 1903: Macmillan & Co. Price 3*s*. 6*d*.

It seems somewhat surprising that of the many who devote themselves to the study of various kinds of insects such a small proportion should pay attention to the aquatic forms. Until the appearance of the first edition of this book, eight years ago, there was some excuse for this state of affairs, as there was no handy book dealing in anything approaching an adequate manner with these creatures. But with Prof. Miall as a guide there should now be no difficulty in getting a good grounding in the subject, and it is much to be hoped that the issue of this second and cheaper edition will give an additional fillip to the interest taken in aquatic entomology. The book can certainly be strongly recommended, and not only to insect lovers, but to all who collect "pond-life" in any shape or form. It is an exceedingly useful book of reference on the special subject of which it treats, and a careful perusal of the Introduction, dealing with various problems of aquatic existence, and urging the claims of "live Natural History," will be found to open up many avenues for possible original work in connection with many kinds of minute aquatic life. Without going into detail it would obviously be difficult to give a good idea of the many different kinds of insects dealt with, but it may be useful to state that the general plan of the book is to devote a chapter to each of the principal groups to which aquatic insects belong—Water-beetles, Dipterous larvae, Caddis-worms, May-flies, etc.—thus systematically going over the whole of the ground, though necessarily not dealing with all the known species. D. J. S.

Subject List of Works on General Science, Physics, Sound, Music, Light, Microscopy, and Philosophical Instruments in the Library of the Patent Office. $6\frac{3}{8} \times 4\frac{1}{8}$ in., 183 pages. London, 1903: Patent Office. Price 6*d*.

The free library of the Patent Office in Southampton Buildings, Chancery Lane, is undoubtedly well known to many members of the Quekett Club, but it certainly deserves to be known to a still larger number. Probably in no other public library can one see so many books on microscopy and allied subjects all brought together in such a nice quiet little alcove. The absence of all fuss in getting out books—readers, in most cases, simply having to help themselves to any book on the shelves—is also a very valuable feature, as it saves an immense amount of time; and now that this little catalogue has been issued, the usefulness of the library to microscopists should be still further increased. The works contained in the library dealing with microscopy are for the most part grouped under that heading in the catalogue, but a few others are to be found under Polarisation, Photomicrography, Medical Microscopy, etc. As indicated by the title, many other subjects, more or less closely connected with microscopy, are referred to in this list, and it may not be out of place to remark that, in addition to the microscopical periodicals mentioned, the library contains a fair number devoted to Natural History pure and simple, such as the "Annals and Magazine of Natural History," "The Midland Naturalist," "The Proceedings of the Zoological Society," etc. Why these should be in a Patent Office library is not quite evident, but the microscopist who is also interested in biological matters need not inquire too closely into that question.

D. J. S.

The Common Basis of the Theories of Microscopic Vision treated without the aid of Mathematical Formulae. By Julius Rheinberg, F.R.M.S. 9 × 6 in., 35 pages, 35 figures in the text. Leipzig, 1902: S. Hirzel. London: Williams & Norgate. Price 1*s.* 6*d.*

A student of general optics, upon turning his attention to microscopical problems, as treated by microscopists, is usually struck by two facts. He cannot but be impressed, in the first place, by the large number of important optical problems, which are practically peculiar to the microscope, and of which the discussion is practically confined to microscopists. Secondly, a perusal of the literature of the subject leads to the conclusion that many writers have specialised too soon. While treating, it may be with ability, the most recondite and difficult problems, they are continually going astray and wasting their energies in consequence of their imperfect knowledge and appreciation of the fundamental principles of the science. For instance, in a paper by a microscopist of deserved repute, it has been seriously contended that a plane mirror brought converging (*sic*) skylight to a focus in the same way that a concave mirror brought parallel light to a focus! Much otherwise useful work has thus undoubtedly been minimised in value. The latter consideration applies with peculiar force to much that has been written and said on the subject of microscopical vision. Ambitious work has been marred by an imperfect comprehension of the sine-law! Mr. Rheinberg's brochure should therefore be received with pleasure and read with profit by students of microscopical optics. It is not ambitious in its aim—it does not profess to do more than present the simple facts of interference and diffraction in an experimental and non-mathematical form. This is done with characteristic care and thoroughness. It commences with an explanation of Huygen's principle of wave-motion, and then passes on to consider the diffraction produced by a simple slit, and a lens imaging a point source. In the case of diffraction gratings, the effects of two and then three slits are first discussed, then the cumulative effects of many, in a very ingenious way. Finally, converging illuminating cones are considered.

An error occurs in Figures 2 and 10. The wave-fronts are shown as having the signs of their curvatures changed in passing through the *substance* of the lenses. A slight slip also occurs on p. 6, where it is stated that the intensity of light varies as the square of the amplitude of vibration, but in the next sentence it is stated that the superposition of two vibrations in the same phase, and presumably of the same amplitude, gives rise to light of *double* intensity. The intensity of light under these circumstances would, of course, be *quadrupled*. F. J. C.

KNOWLEDGE, 1902. $11\frac{1}{2} \times 9$ in., 288 pages, 12 plates and many figures in the text. London: "Knowledge" Office, 326, High Holborn. Price 8*s.* 6*d.*

We have much pleasure in calling the attention of those who do not happen to take in this excellent scientific monthly, to the efforts which its editors are now making to cater for the wants of microscopists. As is probably well known, "Knowledge" was founded by the late Richard Proctor, and his bias towards Astronomy is reflected in the paper to the present day, although other subjects are by no means neglected, and the whole range of science, from the infinitely great to the infinitely little, seems to be comprised in its scope. During the past year a large number of interesting points in connection with microscopy have been dealt with in the special section conducted by Mr. M. I. Cross, and there have been in addition a number of useful articles on microscopical subjects, such as Collecting and Preparing Foraminifera, by Mr. A. Earland; Preserving and Mounting Rotifers, by Mr. C. F. Rousselet; The Linking

Hooks on the Wings of Insects, by Mr. E. A. Butler; The Sea-spiders, by the Rev. T. R. R. Stebbing, etc. It is announced that a still larger amount of space is this year to be devoted to things microscopical, and we hope this decision will be amply justified by a considerable increase in the number of both contributors and subscribers.

D. J. S.

PROCEEDINGS.

October 17th, 1902.—Ordinary Meeting.

J. G. Waller, Esq., F.S.A., Vice-President, in the Chair.

The minutes of the ordinary meeting of June 20th, 1902, were read and confirmed.

The donations to the Library were announced, and the thanks of the Club voted to the donors.

A paper was read by Mr. W. H. Harris on "The Dentition of the Diptera," illustrated by a large number of photographs shown upon the screen.

Mr. Hilton inquired if there was any good ground for regarding the organs described as teeth. He thought they might be very useful as a means of classification; but had they ever been observed in such action as to justify the name of teeth? They might also be very useful to the insect for screening its food, as suggested; but this in itself would not constitute them teeth.

Mr. Wesché expressed his admiration of the illustrations shown, but thought that most of the facts had been already published in "Science Gossip." He inquired if Mr. Harris found that the teeth communicated with the main trachea and were used for sucking.

Mr. Harris said he thought that this was not so.

Mr. Wesché said he was sure that the sucking had nothing whatever to do with the teeth, which were placed in the middle of the labellae. It was stated by Professor Packard that the teeth were used for scratching, and that the edges and backs of books were sometimes damaged by means of them. As to the teeth being used in killing prey, he thought that that was a mistaken idea. The hypopharynx, the lancet, under the labrum, was used for that purpose. Mr. Harris seemed to be under the impression that the pseudo-tracheae were the only organs of suction; and as to the homology of these organs he had said nothing. Later observations went to show that the mandibles were embedded in the upper part of the labium, and it was just possible that these so-called teeth might be excrescences on the mandibles; but it was at least certain that whenever teeth were found on the mandibles they were always part of the mandibles, and it was more probable that these might be part of the second pair of mandibles, the maxillae.

Mr. Neville said he should like to express his thanks to Mr. Harris for his paper; for although the subject might have been dealt with in "Science Gossip," he had never had it brought so clearly before him as it had been that evening. The structures referred to were perhaps not to be regarded as teeth, but rather as triturating organs; but he should like to ask Mr. Harris what he considered they were derived from, and also when they were of a very strong nature, did he consider them characters of carnivorous insects?

Mr. Harris said he could not answer all these questions; it was a subject which required a great deal of study. He was not sure whether all the insects with strong teeth were carnivorous, but certainly some of them were—*e.g.*, *Sarcophaga.* As regarded the slides which he had used in illustration of his paper, he could only say they were all new, and he had never shown them before.

The Chairman moved a hearty vote of thanks to Mr. Harris for his paper, which was carried unanimously.

The Secretary said he had received a contribution from their old friend Mr. Rosseter on his favourite subject, the tape-worms. As this was, however, a purely morphological paper, dealing with the anatomy of *Drepanidotaenia tenuirostris*, it would hardly be of general interest to the meeting at that hour, and it was proposed that it be taken as read. It was a very excellent paper on the matters dealt with, and would appear in the Journal in due course.

A vote of thanks to Mr. Rosseter for his communication was unanimously carried.

The proceedings then closed with the usual conversazione.

November 21st, 1902.—Ordinary Meeting.

The Right Hon. Sir Ford North, F.R.S., etc., Vice-President, in the Chair.

The minutes of the meeting of October 17th, 1902, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club :—Mr. G. H. Cressey, Mr. W. Fuller, Mr. F. W. Heal, Mr. W. H. Langton, Mr. E. Leonard, Mr. M. Roberts, Mr. R. Z. Sanderson, Mr. B. F. T. Tryon, and Mr. F. Worthington.

The additions to the Library were announced, and the thanks of the Club voted to the donors.

Mr. Swift exhibited a microscope fitted with a new form of slow-motion fine adjustment—the "Ariston"—controlled by two levers, both of which were isolated from the main fitting of the movement. In further explanation of the construction of this arrangement a sectional model was also exhibited.

Mr. Karop said they were very much obliged to Mr. Swift for bringing this ingenious adaptation of the lever principle to show them ; it was a very nice way of getting a long lever, and he thought it was likely to be a lasting arrangement.

Mr. Stokes thought it was very much like a model introduced some time ago by Leitz, which he called the English model.

The thanks of the meeting were, on the motion of the Chairman, unanimously voted to Mr. Swift for his exhibit and explanation.

Mr. E. Turner then gave an extremely interesting demonstration of the Lumière process of colour photography. He commenced by remarking that it had for many years been the ambition of photographers to be able to produce photographs in the natural colours of the objects depicted. Clerk-Maxwell and others had made early attempts to achieve this, and some prints exhibiting some colour were made in 1894 ; but Mr. Sanger Shepherd had, by applying theory to practice, lately achieved some very marvellous results, and so much had been done since 1890 that things which were then thought to be impossible were now rendered so simple as to be within the reach of all. The differences between the process of Lumière and those which preceded it were briefly explained, great emphasis being laid upon the importance of keeping to one process, it being of little use to employ a set of screens of one kind with plates which had been prepared for another. The screen and the plate must be adjusted to each other in order to produce any really good result. Coarse objects might be done in the former way, but for the reproduction of any delicate tints strict attention must be given to the relation between the screens and the plates. The negatives were not taken upon the ordinary films, but upon thin plates of mica, which were coated with gelatine, treated with bichromate of potash, and also with bromide of silver, the object of which was to enable the photographer to see what he had done. The image was formed on the bichromate-gelatine in from five to ten minutes; the plate was then put into hot water, which washed away all those portions of the gelatine which had not been acted upon by the light. The prints were then stained in the primary tints, and on being superposed, the result was a picture in the complete colours of the original object. Some care was of course required in staining, so that one colour did not overpower the others; but if the print was found to be too strongly stained, it could be easily washed out in a weak solution of glue, and if not stained enough it could as easily be returned to the staining bath for as long as might be necessary. Mica had a very great advantage over celluloid in being perfectly clear, so that the light passed through the three films as easily as through one, whilst the thinnest celluloid always intercepted some light; then the mica films, being thinner, could be laid closer together than celluloid. Mica had the further very great advantage that it was not injured by heat, which would completely destroy any film of celluloid. The best guide in developing was to note any white object in the picture, and if this was found to be correct, all the colours would be correct also.

The subject was then illustrated by a number of slides shown on the screen: the first, taken from a well-known coloured picture, was shown separately on the red, the green, and the blue films, which, when placed together, combined to form a picture of great brilliancy and beauty, with perfect fidelity to the original. Other slides of flowers, china, etc., were followed by microscopic objects, such as blood-corpuscles, stained sections, and bacteria, some of which had been taken by Mr. L. R. Gleason, who had only quite recently turned his attention to the subject.

In reply to Mr. Morland, Mr. Turner said that the three films were simply placed in contact, no medium such as balsam being used to cement them together.

The Chairman said he was sure all would join in thanking Mr. Turner most heartily for coming there and giving them such an interesting and beautiful exhibition. Some of those present were about as old as photography, and could recollect the earliest attempts, such as the Daguerreotype, when it took about a quarter of an hour to get a person into position, another quarter of an hour for the exposure, and yet another to find out if there was anything on the plate. From that time onward it had continued to be a succession of surprises. From the first there were people who began to think that colours might some day be photographed, but others said it was impossible. A few said they were sure it could be done, but a legion said it could not; and it was by the persistent exertions of those who did not believe in impossibilities, and who had striven to overcome what were said to be insuperable difficulties, that the results they had seen that evening had been attained. When, however, they saw what were called the best results, they should not say these were the best which were possible, because photography had gone on improving, and things that were put forward at one time as the best attainable had been soon left very far behind. Everyone who had been present must have been struck by the great advances shown them that evening. When the first three pictures were put on the screen, neither of them looked anything very attractive; but when they were put on together the result was marvellous. He hoped that those who were giving their attention to the subject would go on until something even better still was arrived at.

The thanks of the meeting were then unanimously voted to Mr. Turner for his communication.

Mr. R. T. Lewis read a short note "On an Undescribed Species of Chelifer," illustrating the subject by the exhibition of a specimen under the microscope, and by a coloured drawing which he proposed ultimately to place in the MS. book on Chelifers, compiled by Dr. M. C. Cooke, and now in the library of the Club.

The thanks of the Club were voted to Mr. Lewis for his remarks and exhibits.

The proceedings then terminated with the usual conversazione.

December 19th, 1902.—Ordinary Meeting.

J. G. Waller, Esq., F.S.A., Vice-President, in the Chair.

The minutes of the meeting of November 21st, 1902, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club :—Mr. G. S. Barton, Mr. W. H. Bawtree, Mr. H. S. Partridge, Mr. H. M. Sayers, Mr. W. B. Stamp, and Rev. C. Zimmermann.

The donations to the Library were announced, and the thanks of the Club were voted to the donors.

A paper by Mr. Ayrton, "On *Zoothamnium geniculatum*, a New Infusorian found in the River Waveney, near Beccles," was read by Mr. Rousselet, and was illustrated by drawings.

Mr. Scourfield inquired if the species described did not come very close to something illustrated in Saville-Kent's Manual of the Infusoria ?

Mr. Rousselet said there was nothing in Saville-Kent's book like it, but it was nearer to *Z. arbuscula* than to the other species.

Mr. Karop asked if anything was known as to its mode of reproduction.

Mr. Rousselet thought that as in allied species it was probable that one individual broke away from the rest, and having attached itself somewhere, divided again and again, until a whole colony was produced.

Mr. Hilton inquired if it would be possible to reproduce in the Journal the very beautiful drawing with which this paper was illustrated.

Mr. Karop said they had found some difficulty in the production of successful prints in white upon a black ground, it being rarely that any of the processes now employed gave quite satisfactory results; but efforts would certainly be made to reproduce Mr. Ayrton's drawing in the Journal.

The thanks of the meeting were unanimously voted to the author of the paper, and to Mr. Rousselet for reading it in his absence.

Mr. Karop reminded the members that at the next Ordinary Meeting of the Club they would be asked to nominate some of their number to fill vacancies on the Committee—to be elected at the Annual Meeting in February; an auditor would also have to be elected on behalf of the members.

There being no other paper on the agenda, the proceedings terminated with the usual conversazione.

January 16th, 1903.—Ordinary Meeting.

George Massee, Esq., F.L.S., President, in the Chair.

The minutes of the meeting of December 19th, 1902, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—Mr. J. Bawcombe, Mr. C. L. Curties, junr., Lieut. G. Damant, R.N., Mr. H. E. Ebbage, Rev. W. H. Gordon, Mr. H. O. Green, and Mr. W. O. Walker.

The donations to the Library were announced, and the thanks of the Club voted to the donors.

The Secretary, having reminded the members that their next ordinary meeting would be their anniversary, when Members of Committee and Officers for the ensuing year would have to be elected, read the list of nominations by the Committee for President, Vice-Presidents, and Officers, and invited the members to nominate five gentlemen to fill vacancies on the Committee. The following nominations were then made:—

Mr. Vezey,	proposed by	Mr. Marshall,	seconded by	Mr. Traviss.
Mr. Stokes,	,, ,,	Mr. O'Donohoe,	,, ,,	Mr. Smith.
Mr. Turner,	,, ,,	Mr. Neville,	,, ,,	Mr. Fuller.
Mr. Wesché,	,, ,,	Mr. Curties,	,, ,,	Mr. Marks.
Mr. Hughes,	,, ,,	Mr. Parsons,	,, ,,	Mr. West.

The Committee having appointed Mr. J. M. Allen to act as Auditor on their behalf, the members were asked to elect some other member to act for them in the matter.

Mr. Hicks was thereupon proposed by Mr. MacKenzie, seconded by Mr. O'Donohoe, and unanimously elected.

Mr. Wesché read a paper "On the Male Organs of the Flies *Scatophaga lutaria* and *S. stercoraria*."

The President said this was a subject which he knew nothing about; but he could not fail to notice the grip of the subject possessed by the writer of the paper, and he hoped that it would be discussed by those present who were acquainted with it.

Mr. Hammond said that many years ago he happened to make some little studies of various insects, and amongst them *Scatophaga lutaria.* He had brought to the meeting, for the inspection of those who were interested in the subject, a series of drawings, in which the ejaculatory organ was shown, and in one sketch the other parts could be easily recognised. The same parts had also been studied in *Blatta.* The study of these things was very interesting, the mechanical complexity and finish of the organs being very striking.

In *Tipula oleracea* a different state of things existed, the penis being very long, and having at its base a beautiful arrangement for controlling the emission of the spermatozoa.

Mr. Karop recommended this study to any members who had not yet taken it up as being extremely interesting, as he himself had found when working at the subject with Mr. Lowne in preparation for his book. His recollection of the penis in *Tipula* was that it was perforated. He recommended a careful examination of Mr. Hammond's drawings, which were beautifully executed, aud would prove very instructive.

Mr. Hammond, in further explanation of his remarks, drew a diagram on the board to illustrate the arrangement which existed for the purpose of contracting or closing the orifice of the ejaculatory duct.

On the motion of the President, a very hearty vote of thanks was passed to Mr. Wesché for his paper.

Mr. Scourfield said they had received a paper from Mr. Rowley, entitled "Some Points in the Structure and Life-History of Diatoms," and he gave a *résumé* of its contents.

Mr. Wesché asked if the method by which diatoms moved had really been discovered.

The President said this was a question not easily answered with certainty, as various reasons had been assigned, and the question appeared to have been lately reopened.

Mr. Scourfield said there was now an idea that it was due to the projection of an extremely hyaline substance from the central node of the diatom. He thought that recent investigations such as those of Lauterborn appeared to indicate that they were on the right track towards the discovery of the cause of diatom movement.

Mr. Morland said that the emission of a hyaline substance was mentioned some time ago by Professor Hamilton Smith, who observed it in the case of some diatoms mounted in a medium, which showed the hyaline substance very clearly along the raphe.

Mr. Earland asked why it had not been possible for this substance to be stained and shown if it really existed?

Mr. Scourfield said he thought it was probably due to the fact that workers had hitherto taken very little trouble to investigate the living diatom, nearly all their efforts having been concentrated on the shapes and markings of the "cleaned" frustules.

Mr. Karop said that this question of the emission of a hyaline substance by diatoms went back as far as Ehrenberg, and, though much had been written on both sides, he was not at all convinced that there was conclusive evidence that anything of the sort existed. In defence of Ehrenberg it should, however, be said that he did his work with lenses of a most inferior description. As they knew, he bought a microscope for 10 thalers, and they might form some idea of the quality of an instrument at that price in his time.

Mr. Scourfield presented the first part, dealing with Cladocera, of a paper entitled "A Synopsis of the Known Species of British Fresh-water Entomostraca," proposing to follow up the subject if possible by papers on other groups later on. Professor W. Lilljeborg has recently recorded about ninety-six species of Cladocera as having been found in Sweden, and his work, "Cladocera Sueciae," will no doubt form the basis for most subsequent work on the subject. Of the ninety-six Swedish species we have in this country, as far as is known at present, about seventy-five, but we also have five or six other species not yet found in Sweden.

Mr. Soar read a note "On the Occurrence of Living Hydrachnid Larvae in the Stomach of a Trout," and, in reply to a member, he said he considered them to be true internal parasites.

The President, in moving a vote of thanks to the authors of these papers, expressed a hope that Mr. Scourfield would be able to follow up his communication with a series, which could not fail to be useful. Mr. Soar's paper had brought before them something both interesting and instructive. He thought papers of this kind which stimulated enquiry were always of value.

February 20th, 1903.—Annual Meeting.

George Massee, Esq., F.L.S., President, in the Chair.

The minutes of the meeting of January 16th, 1903, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club:—Mr. T. E. Clarke, Mr. H. H. Gant, Mr. W. D. Hall, Mr. F. J. Kent, Mr. E. W. Klingler, Mr. C. F. Pitcher, Mr. E. R. Turner.

The donations to the Library and Cabinet were announced, and the thanks of the Club were unanimously voted to the donors.

Mr. Karop said he had received a letter intimating that Mr. Andrew's Cabinets of Objects were for disposal, and could be seen on application.

Mr. Morland said it was unusual to read any communications at an Annual Meeting, but he wished to say that he had received a letter from Mr. E. E. Green, of Ceylon, with reference to the catching of Tadpoles by *Utricularia.* He then read from the letter as follows:—"In the last number of the *Journal* (for November, 1902) I see that doubt is thrown on Mr. Cornish's statement that tadpoles are caught by the bladders of *Utricularia* (*vide* p. 378). I have no experience of the English species of *Utricularia*; but it may be of interest to note that a small aquatic species of this plant in Ceylon can catch and hold young fish in the way described. I have had experience of this fact in my own aquarium, in which I had a species of *Utricularia* bearing bladders scarce $\frac{1}{16}$th of an inch in longest diameter. On several occasions I observed young fish (about one inch in length) caught and firmly held by their tails in these little traps."

The President having appointed Messrs. Freeman and O'Donohoe to act as Scrutineers, the ballot for Officers and five Members of the Committee was proceeded with. It was subsequently reported that the following had been unanimously elected :—

President . . .	George Massee, F.L.S.
Four Vice-Presidents .	J. G. Waller, F.S.A. A. D. Michael, F.L.S., F.R.M.S. E. M. Nelson, F.R.M.S. The Rt. Hon. Sir Ford North, F.R.S..
Treasurer . . .	H. Morland.
Secretaries . . .	G. C. Karop, M.R.C.S., F.R.M.S. A. Earland.
Foreign Secretary . .	C. Rousselet, F.R.M.S.
Reporter . . .	R. T. Lewis, F.R.M.S.
Librarian . . .	Alpheus Smith.
Curator . . .	C. J. H. Sidwell, F.R.M.S.
Editor	D. J. Scourfield, F.R.M.S.
Five Members of Committee . . .	J. J. Vezey, F.R.M.S. W. B. Stokes. C. Turner. W. Wesché, F.R.M.S. F. Hughes.

The Thirty-seventh Annual Report of the Club was then read by the Secretary.

The Statement of Accounts and audited Balance-sheet for the year 1902 was read by the Treasurer.

Mr. Hilton moved that the Report and Balance-sheet be received and adopted. He thought this motion needed no support from him, as all present must have regarded it as very satisfactory. There were only two points which required their serious attention, namely, to get some more discussion at their meetings, and to do all they could to increase the membership.

Mr. Soar having seconded the motion, it was put to the meeting by the President and unanimously carried.

The President then gave his Annual Address, taking as his subject "Fermentation and Putrefaction," and illustrating it with a number of coloured diagrams of various fungi which were concerned in bringing about these processes.

Mr. J. G. Waller, who had occupied the Chair *pro tem.*, said he had a very pleasant task to perform in asking them to pass a very hearty vote of thanks to the President for his address and for the treat he had given them that evening.

Mr. Hughes having seconded this, it was put to the meeting and carried unanimously.

Mr. Taverner proposed, and Mr. Scourfield seconded, a vote of thanks to the Auditors and Scrutineers, which was also put and duly carried.

Mr. Wesché then moved that the best thanks of the Club be presented to the Officers and Committee for their services during the past year. He was quite sure that this proposal would be heartily responded to, for they all felt how much they were indebted to these gentlemen for their kindness and courtesy, and for the able way in which the affairs of the Club had been conducted.

Mr. K. J. Marks seconded this proposal, which was put to the meeting and carried unanimously.

Mr. Morland expressed his thanks for the kind way in which this vote of thanks had been proposed and received. He did not want to say that the work they did was very onerous, but at the same time it was sometimes felt as a tie, though he was quite sure he could say on behalf of his colleagues that it was done cheerfully and to the best of their ability.

Mr. Karop said he was equally obliged with Mr. Morland for the kind expressions which had been used. Mr. Smith and Mr. Lewis were their oldest officers, and certainly Mr. Smith deserved any vote of thanks which they might have to bestow. For his own part he could only say again that he was very much obliged.

The President said that he felt that he must thank the members, not only for their vote, but also for the kind way in which they had shown their consideration in tolerating his shortcomings. He was only sorry that he had not been present more often, and that he had not been able to join in some of their excursions, but he hoped to be more fortunate during the coming season.

OBJECTS EXHIBITED, WITH NOTES.

October 3rd, 1902.

Mr. W. H. Langton: Proboscis of House-fly, showing openings in pseudo-tracheae.

Mr. K. J. Marks: *Callidina tetraodon* Ehr. In Sphagnum, from a valley near Gorey, Jersey. The head has two frontal prominences, and the toes are modified into a tube-like process, ending in a perforated disc; this occurs only in a few forms.

Mr. D. Bryce: *Callidina aculeata* Milne. Described in 1886 from specimens found in Scotland. Rare spinous form living in moss. Lately found at Dunmow, Hendon, and Hollingbourne, Kent.

Mr. D. J. Scourfield: *Notodromas monacha*, from Osterley Park. An Entomostracon (*Ostracod*), having the power of clinging to the surface-film of water. Note the straight ventral margin which is applied to the surface-film, and the dark coloration of the ventral parts of the valves.

Mr. A. E. Hilton: Pollen of *Gaillardia*, showing the oval granules studded with spikelets.

Mr. H. Morland: *Aulacodiscus orientalis*, from the Fiji Islands, showing the cellules radiating from the centre, and arranged concentrically round the same, causing them, where crowded, to be somewhat quadrangular and never polygonal. First described by Dr. Greville about thirty-nine years ago.

Mr. H. F. Angus: An inexpensive apertometer, made by a member of the Club, with which an objective listed as N.A. 0·65 was found to be only N.A. 0·64, this being afterwards confirmed on a Zeiss apertometer.

October 17th, 1902.

Mr. A. E. Hilton: Head of Six-Spotted Burnet Moth, *Zygaena filipendulae*, showing eyes, tongue, and antennae. Mounted in glycerine.

Mr. C. F. Rousselet: A new Synchaeta, *S. bicornis* Rous., a brackish-water species, from Lake Ponchartrain, near New Orleans, U.S.A.; found by Mr. J. C. Smith, of New Orleans. The species is characterised by two little fleshy horns on the dorso-lateral sides of the body, just below the auricles; one cervical and two frontal eyes.

Mr. W. Wesché: Extremity of labium of the tsetse fly, *Glossina morsitans*, showing teeth.

November 7th, 1902.

Mr. D. Bryce: *Monostyla arcuata* Bryce. Interesting chiefly as one of the few Rotifera (outside the order of Bdelloida), which seem to exclusively inhabit moss. Closely related to *Monostyla cornuta*, but obviously differing in the strongly excised anterior margins of both dorsal and ventral plates of lorica, and in its rather smaller size and lighter appearance.

Mr. C. D. Soar: Larvae of some Hydrachnid (genus and species uncertain) found living in the stomach of a trout caught in Loch Rannoch. (See p. 461).

Mr. H. Morland: *Triceratium lineatum* Grev., from Oamaru, N.Z.; "front" and "side" views of valves, showing the depth of the furrows on face of valve.

Mr. C. J. H. Sidwell: Dental organs on proboscis of a Fly, *Spilogaster sp.* The "teeth" are in four rows, the primary being V-shaped at the apex, and the other three rows denticulated. In the common Blow-fly there are only three rows of "teeth," which are superimposed, the free ends being slightly in advance of the preceding row. Original slide as described by Mr. W. H. Harris in the paper read at last meeting of the Club.

Mr. T. N. Cox: Section of stem of Lime Tree cut obliquely through the junction of a branch with the stem, and showing pith with cells containing starch granules, raphides, etc., medullary rays, two years' growth of wood, the half-formed third year's woody tissue, cambium, cuticle, and many other interesting features.

NOVEMBER 21st, 1902.

Mr. C. F. Rousselet: Mounted specimen of the Polyzoan *Cristatella mucedo*, showing tentacles and cilia fully expanded.

Mr. L. R. Gleason: Transverse section through root of sensory hair of Cat's Whisker. Shown for comparison with the photomicrograph in colours by Lumière's process.

DECEMBER 5th, 1902.

Mr. A. W. Dennis: Fructification of Filmy Fern, *Hymenophyllum tunbridgense*, showing toothed involucre, which is perhaps the most easily recognisable distinction between this and the closely allied *H. unilaterale*.

Mr. W. H. Langton. Head of *Tipula* mounted in balsam without pressure.

Mr. H. Morland: *Triceratium morlandii* Grove and Sturt, from Oamuru deposit, N.Z., showing frustule and valves. First described in the Quekett Club Journal, January, 1887.

Mr. A. E. Hilton: Fructification of Alga from North Sea, *Polysiphonia byssoides*, showing ovate capsules (ceramidia), furnished with terminal pores, and containing pear-shaped spores.

Mr. T. N. Cox: Section of Rhubarb, *Rheum palmatum*, showing stellate crystals. Polarised.

Mr. A. Earland: Hexactinellid Sponge, *Hyalonema reflexum*, from Japan. In the Hexactinellida the spicules typically consist of a system of three equal axes intersecting at right angles, and variations in this type are due to unequal development of branching, or the suppression of some of the rays. The typical spicule in this form is a pentact (= 5-rayed) pinulus (= little pine tree), a pinulus being a ray bearing oblique lateral teeth.

Mr. C. J. H. Sidwell: Bladderwort, *Utricularia minor*, taken from the Long Water, Hampton Court, Quekett Microscopical Club Excursion, September 6th, 1902. The opening of the bladder is fringed with peculiar tapering bristles, and is closed with a pair of lips. From the upper lip hangs a thin, transparent, obliquely-placed valve, forming a trap-door, and allowing Entomostraca, Insect larvae, Infusoria, and other similar organisms to enter, either in search of food, or fleeing from pursuit. The captured organisms perish, the products of the decomposition of their bodies being absorbed by the cross-shaped cells which line the whole inner surface of the bladder.

Mr. L. R. Gleason: Latex of *Ficus elastica*, mounted wet, showing the "Brownian" movement.

Mr. A. L. Still: An ascomycetous mould, *Eurotium aspergillus-glaucus*, showing very early stages of the primordium of the ascocarp. Stained by Hoffmann's blue, dissolved in the 60 per cent. glycerine of the mount.

Mr. W. J. Winter: Section of fossil fern from coal-bed, showing polarisation with *one* prism, selenite and mica film.

JANUARY 2nd, 1903.

Mr. W. Wesché: A "springtail," *Podura aquatica*, one of many found on duckweed in pond at Hampstead. Specimen kept in cell with damp blotting-paper for preceding fourteen days.

Mr. H. Morland: Section of Hälleflinta, *Petro-silex*, from Sweden, containing amongst its constituents quartz, in which there are cavities with moving bubbles.

Mr. H. J. Quilter: Microscope by C. Chevalier, date about 1830.

Mr. K. J. Marks: *Melicerta tubicolaria* Ehr. The only Melicerta that does not make pellets, although it has a pellet cup. Born in the trough.

Mr. A. L. Still: The Black Currant Mite, from characteristic swollen bud.

Mr. T. G. Kingsford: Diatoms, etc., found in a sample of non-conducting material used for covering steam boilers. The diatoms can be seen mixed with numerous fibres of asbestos.

Mr. A. Earland: Section of Flint containing various organisms, such as Foraminifera, Sponges, Echinoderms, etc.

January 16th, 1903.

Mr. J. T. Holder: Transverse sections of intestinal villi (Kitten), showing columnar epithelium, basement membrane, goblet cells, etc. Stained: (*a*) Ehrlich's acid haematoxylin and eosin; (*b*) Benda's iron haematoxylin and acid fuchsin; (*c*) safranin.

February 6th, 1903.

Mr. W. Wesché: A "springtail," *Degeeria sp.* Common under damp leaves.

Mr. F. P. Smith: Foraminifera, etc., from Turkey sponges. The material is prepared by first shaking the sponge dust with water in a bottle for a minute, then emptying into a basin of water, and removing the shells which collect round the edge with a camel-hair brush.

Mr. A. E. Hilton: Dog Parasite, *Haematopinus piliferus*, found on dogs out of condition.

Mr. T. N. Cox: Pollen tubes in stigma of Evening Primrose.

Mr. A. Earland: Typical Siliceous Sponge Spicules, illustrating the range and variety of form.

February 20th, 1903.

Mr. C. F. Rousselet: *Brachionus falcatus*, Zach. This Rotifer was first described by Dr. O. Zacharias in the *Plöner Forschungsberichte* for 1898. It was obtained by him from two ponds near Oppeln and Breslau. The specimens exhibited have been sent by Mr. Hlava from Bohemia. This species is characterised by two long posterior spines and two very long intermediate anterior horns.

Mr. H. Taverner: Earwig with wings spread out to show their delicate structure and iridescent tints.

THIRTY-SEVENTH ANNUAL REPORT.

Your Committee is once more in a position to give a satisfactory account of the Club's affairs during the past year.

Forty-four members were elected, a number which, although below that of the previous year, is still well above the average. Fifteen were lost by resignation or removal and seven by death, amongst whom were Professor J. W. Groves, F.L.S., an early member and former vice-president; Mr. F. W. Andrew, who joined the Club in the year of its foundation, and was a constant exhibitor at the gossip nights; Viscount Gort, and Mr. H. V. Shaw. The total number on the books on December 31st was three hundred and seventy.

The meetings have been as well attended as ever, and the papers and other communications not wanting in quality or variety; but the Committee has noticed some falling off in the amount of discussion given to the subjects brought forward. This is most probably due to diffidence merely, but, nevertheless, it is to be regretted for several reasons. Questions and remarks frequently bring out additional information, and are generally appreciated by the writer of a paper; whereas if his effort is received without comment he may think he has written above or below his audience, or, at least, has failed to excite their interest.

The following is a list of the chief communications read at the meetings:—

January .	Modifications of the Legs in some Dipterous Flies . . .	Mr. Wesché.
,, .	On *Ecpolus papillosus* n. sp. . .	Mr. Soar.
February .	President's Address on Coprophilous Fungi	Mr. Massee.

March . .	The Black and White Dot Phenomenon	Mr. Rheinberg.
„ . .	Minute Structure in *Triceratium* .	Mr. Merlin.
„ . .	Hanging-drop Cultivation . .	Mr. Karop.
April . .	On *Cymbalopora bulloides* . .	Mr. Earland.
„ . .	On Male Rotifers	Mr. Wesché.
May . .	Simple Methods of Focometry and Apertometry	Mr. Cheshire.
„ . .	On a Method of using Abbe's Apertometer	„
„ . .	On a Reflecting Polariser . .	„
„ . .	On *Chaetomium bostrychoides*. .	Mr. Massee.
June . .	The Preparation of Serial Sections of Insects	Mr. Scriven.
October .	The Dentition of the Diptera .	Mr. W. Harris
„ . .	Anatomy of *Drepanidotaenia tenuirostris*	Mr. Rosseter.
November.	On a Supposed New Species of Chelifer	Mr. Lewis.
December.	On *Zoothamnium geniculatum* n. sp.	Mr. Ayrton.

At the November meeting Mr. E. R. Turner gave a very interesting description of Lumière's process of three-colour photography and its application to the microscope, with an exhibition of pictures on the screen. The Committee begs to thank this gentleman and the members who have communicated their investigations to the Club.

The following books, periodicals, and transactions of learned societies have been added to the Library during the year:—

Dr. Braithwaite's "British Moss Flora" (Part 21).
Crookshank's "Text-Book of Bacteriology."
Baird's "Entomostraca."
Cooke's "Rust, Smut, and Mildew."
Martin's "Microscopic Objects."
"Smithsonian Annual Report."
"Missouri Botanical Garden."

"Transactions of the American Microscopical Society, 1901."

Stark's "British Mosses."

"American Botanical Gazette."

"Journal of Applied Microscopy."

"Proceedings of the Academy of Natural Science of Philadelphia."

"Journal of the Royal Microscopical Society."

"Proceedings of the Royal Society."

"Proceedings of the Geologists' Association."

"Rivista di Patologia Vegetale."

"La Nuova Notarisia."

"Quarterly Journal of Microscopical Science."

"Annals and Magazine of Natural History."

"The Microtomist's Vade Mecum" (5th edition).

Various Transactions and Proceedings.

The Journal has been issued with the usual regularity, and fully maintains the reputation it has acquired under its present management. A new feature has been added, at the Editor's suggestion, with the intention of increasing the utility of the Club, particularly to its more recently joined members. It is a list of the names of those willing to give advice and assistance in such subjects as they have individually made a special study; and it is to be hoped that this fresh attempt to further the purpose for which the Quekett Club was primarily founded will meet with success. It is proposed to issue this list from time to time, and the Editor will gladly receive any aid or support in the matter.

The specimens in the Club's cabinets have required and received considerable attention from the Curator, who reports an increasing demand for the slides in his charge, as is evinced by the fact that over one thousand seven hundred have been lent out during the past twelve months. A small number of preparations, some twenty-five only, have been presented since the last report, and donations of good zoological and botanical sections, as well as specimens of pond-life, will be very welcome. In order to fill certain gaps in the collections, the Committee has authorised the expenditure of a portion of the sum realised by the sale of catalogues in purchasing specimens. This, of course, will not go very far, and the Club must, as heretofore, chiefly rely on the generosity of members for the proper maintenance of its cabinets.

The excursions of the past year were well attended, the average being the highest since 1893. Osterley Park, which was courteously put at the disposal of the Club for the afternoon of September 20th by the Earl of Jersey, attracted a considerable gathering of members, and the thanks of the Club are due to his lordship for his kindness in permitting the excursion and providing a guide to the various ponds. Many interesting captures have been made on several occasions, and it may be hoped that some notice of these will be brought before the Club in due course.

The finances do not call for any extended reference, although one or two items of expenditure are somewhat increased in comparison with the previous year. The excess is mainly, if not entirely, due to printing the catalogue of zoological specimens and to bookbinding, and neither outlay is likely to be re-incurred for some time to the same extent. The subscriptions collected also show a diminution of about £10, but this is explained by the pleasant fact that there are very few outstanding arrears. On the other hand, the receipts from advertisements are rather more, while the sale of Journals is slightly less. Taken as a whole, then, the financial position is unchanged, the balance remaining practically the same as in the previous report.

The Committee desires to express its thanks to the officers for their individual and collective services, on which the efficiency of the Club so largely depends.

In conclusion, your Committee is convinced of the continued prosperity of the Club so long as the bulk of its members give it their hearty support. With its very inadequate subscription and absence of any entrance fee, the necessity of securing as large a membership as possible is sufficiently obvious, and this should be the first concern of every one interested in the welfare and maintenance of the Quekett Club.

THE TREASURER IN ACCOUNT WITH THE QUEKETT MICROSCOPICAL CLUB

For the Year ending December 31st, 1902.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance from 1901	166	5	10	By Rent of Rooms and Bookcases	54	12	0
„ Subscriptions received during 1902 ...	183	10	3	„ Expenses of Journal	120	7	7
„ Dividends on Investments	8	17	10	„ Postage	6	4	2
„ Sales of Journals	14	8	8	„ Printing and Stationery	6	11	11
„ Sales of Reprints	0	6	3	„ Attendance	6	0	0
„ Sales of Catalogues	3	3	2	„ Petty Expenses	5	11	1
„ Receipts for Advertisements	22	16	11	„ Books, Catalogues, etc.	31	17	4
				„ Balance in hand	168	4	10
	£399	8	11		£399	8	11

Investments.

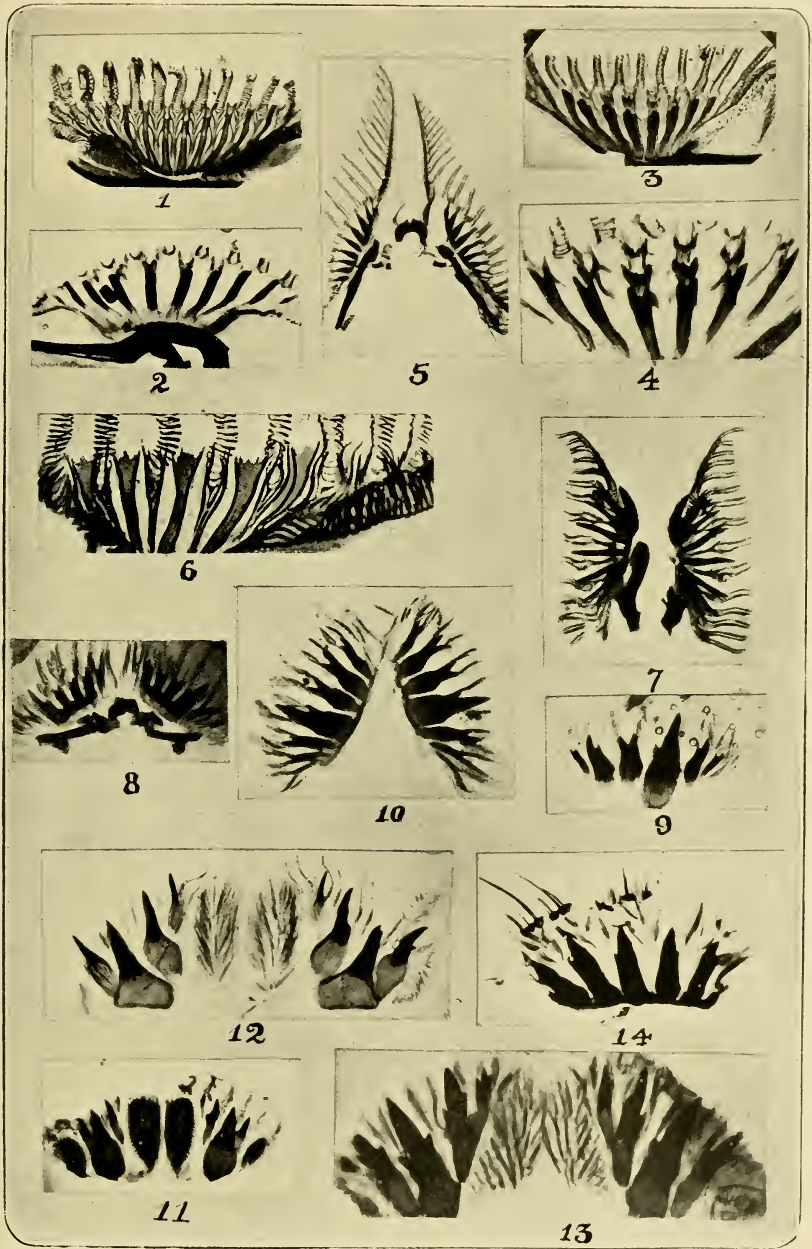
	£	s.	d.
$2\frac{3}{4}$ per cent. Consols	200	0	0
$2\frac{1}{2}$ per cent. Metropolitan Stock	49	5	2
$2\frac{1}{2}$ per cent. Annuties 1905	100	0	0
	£349	5	2

We have examined the above statement of Income and Expenditure, and compared the same with the Vouchers in the possession of the Treasurer, and have verified the investments at the Bank of England, and find the same correct.

January 29*th*, 1903.

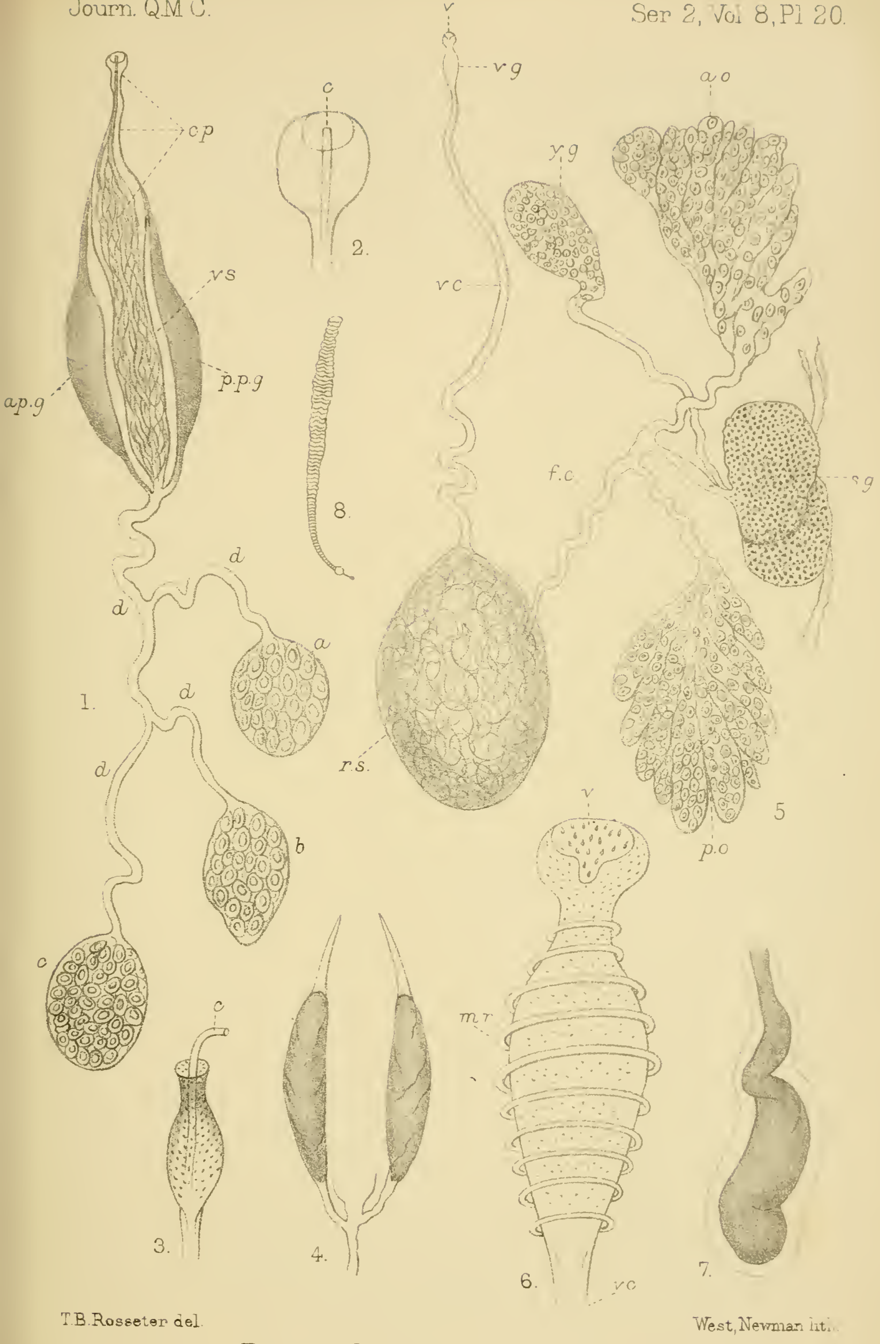
H. MORLAND, *Hon. Treasurer*.

J. MASON ALLEN, } *Auditors*.
FREDK. H. HICKS, }



W. H. Harris, Photo.

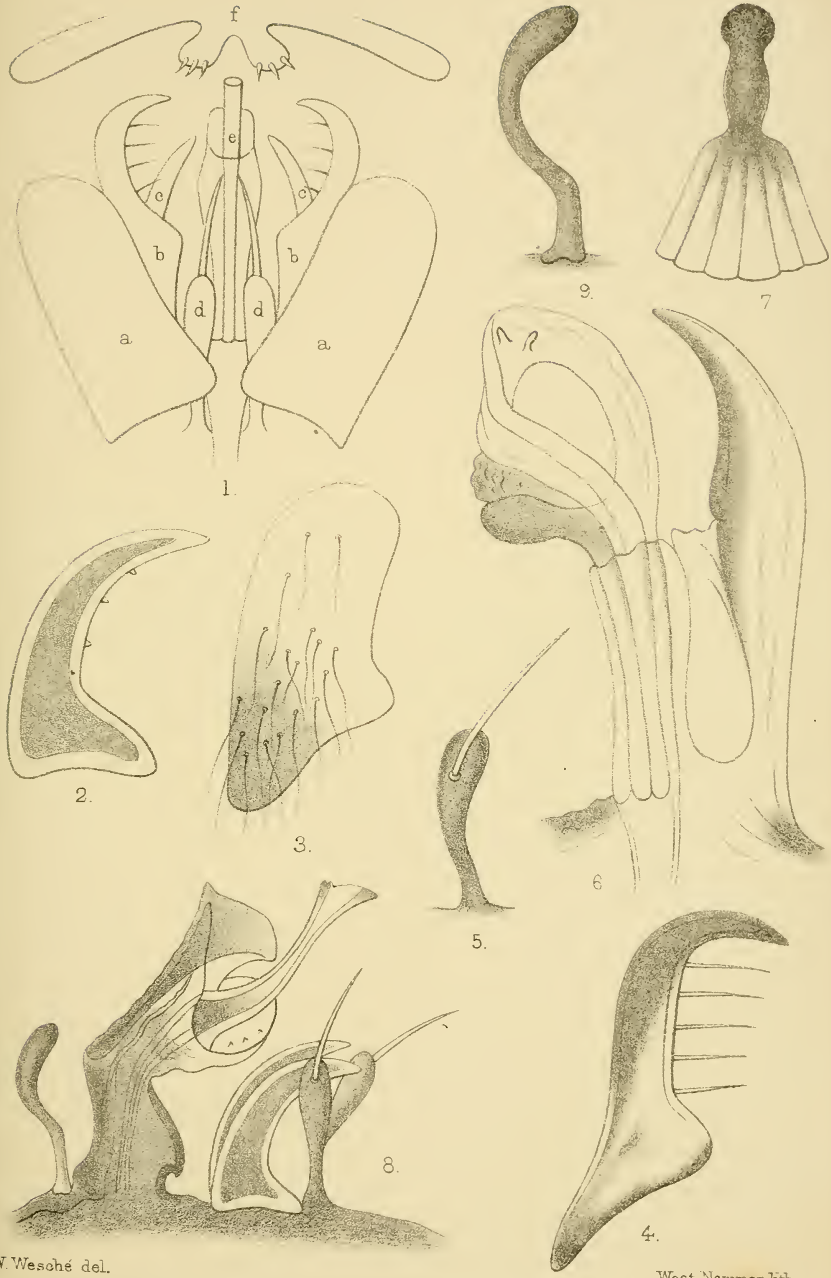
Teeth of Flies.



T.B. Rosseter del. West, Newman lith.

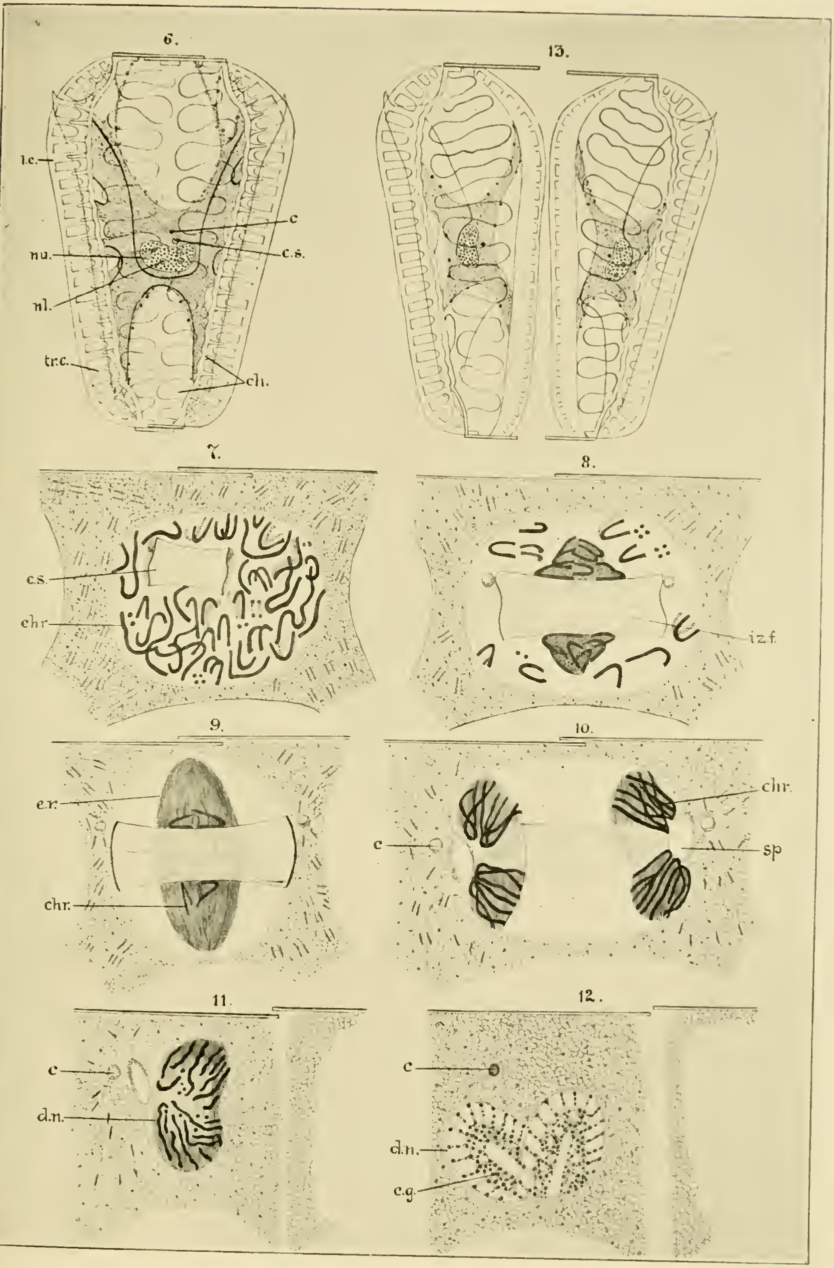
Drepanidotaenia tenuirostris

Zoothamnium geniculata. n. sp.

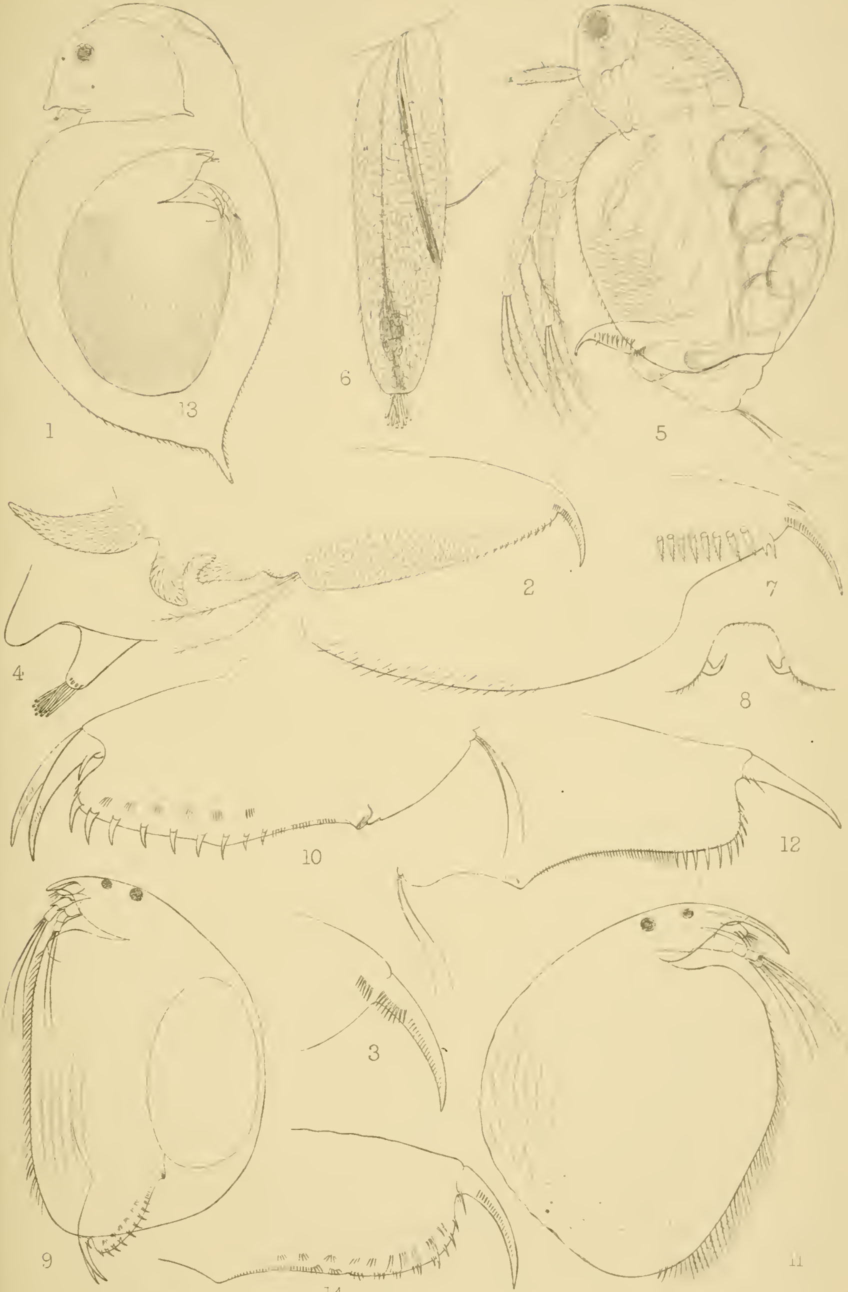


W. Wesché del. West, Newman lith.

Male Organs of Flies. (Scatophaga.)



Surirella calcarata.
(Cell Division.)



D.J. Scourfield del. West, Newman lith.

British Cladocera.

On an undescribed Species of *Chelifer*.

By R. T. Lewis, F.R.M.S.

(*Read November 21st*, 1902.)

Plate 25.

On October 25th, 1867, a paper was read at the Ordinary Meeting of the Quekett Microscopical Club, by the late Mr. S. J. McIntire, "On Pseudoscorpiones," living specimens of which were exhibited in illustration of the subject. The paper was printed in the first number of the Journal of the Club, but unfortunately was not illustrated. Dr. M. C. Cooke at the same meeting gave a list of all the recorded species, particulars as to which he subsequently embodied in a manuscript book now in the library of the Club; and at the second soirée of the Club, on March 13th, 1868, Mr. McIntire exhibited some living Chelifers. So far as I remember these are the only occasions on which these creatures have figured at our meetings.

In November 1869 an illustrated paper, also from the pen of Mr. McIntire, appeared in "Science Gossip," in which he described several species of *Chelifer* and the allied genus *Obisium*. I remember being much interested in these, and that I kept some under observation for a considerable time, feeding them upon mites and podurae, but failing to add very much to what was already known of their life history.

During 1890, a correspondent in Natal sent me a small consignment of insects, and amongst the débris at the bottom of the box I found a dried Chelifer, which proving a fine object under the binocular microscope, I mounted in a cell for future observation. Other subjects of greater interest diverted attention, and the specimen remained undisturbed in my cabinet until quite recently, when, having found another, which was sent from the same place and in the same way, I was greatly struck by the beautiful manner in which its whole surface was sculptured, and I endeavoured to get it identified. A reference to Dr. Cooke's book, before mentioned, did not afford the information required, although amongst the fifty-four species therein described seven are stated to be African. An enquiry at the Natural History Museum seemed more promising; there were about a dozen specimens of the same creature in their collection, all of which were labelled as having come from Natal, but neither had any name assigned, and Mr. Pocock, the curator of the Arachnida Department, was of opinion that, though known, it had never yet been either named or described. Assuming this to be so, he asked me to take the matter up, offering to place the museum examples at my disposal for the purpose, my own having been mounted unset, and having the feet curled up underneath and embedded in gum. I therefore arranged to spend an afternoon in the Arachnida room, and as an exhaustive search in the literature on the subject in the Museum library throws no further light on the question, I have completed my description, and have great pleasure in adding this, together with the drawings now exhibited, to the very valuable compilation of Dr. Cooke in our own reference library.

This Chelifer is of a bright red colour. Body ovate, much narrowed in front and semi-circular behind. Length, ·125 inch; greatest breadth, ·105 inch. Abdomen divided into twelve segments, of which eleven are sculptured on the dorsal side with circular depressions, each having a raised central spot; a longitudinal median depression becomes apparent at the fourth segment, and is increasingly well marked thence to the posterior extremity. The first three joints of the palpi are thickly studded with sub-conical elevations or tubercles, each bearing a short stiff hair on the anterior side a little below the apex. The fourth joint comprises the powerful forceps, the upper and immovable jaw of which is hollowed near the incurved tip, whilst the lower jaw is of equal length but somewhat less curved; both are fringed with stiff hairs, and are admirably adapted for firmly holding an insect by its leg without risk of cutting it through. The anterior portion of the cephalo-thorax, immediately above the eyes, is furnished with a row of six or seven spiny hairs. Eyes two. Palpi four-jointed: first, ·02 inch long × ·0175 inch at greatest breadth; second, ·05 inch long × ·02 inch at greatest breadth; third, ·04 inch long × ·0225 inch at greatest breadth,—these three studded with subconical tubercles; fourth, forceps ·06 inch long × ·0275 inch at widest part, without tubercles, but covered with fine flexible hairs. Legs: first joint shortest; second (femur) longest; third (tibia) and fourth (tarsus) of equal length. Claws two. Margin of abdomen of female crenulated by one semicircular process at each segment except the last. Margin of abdomen in male, first three segments and the last same as in the female, fourth to eleventh segments inclusive terminating in a strong recurved hook-like process.

It is proposed to name this species *Chelifer sculpturatus.*

Explanation of Plate 25.

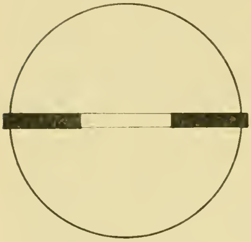
Fig. 1. *Chelifer sculpturatus* n. sp., ♀, dorsal aspect × 15.
„ 2. „ „ „ ♂, „ „ × 15.
„ 3. „ „ „ Forceps, lateral aspect × 15.

Pocket Magnifiers.

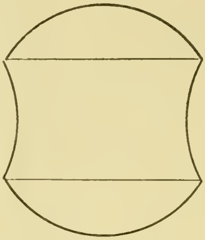
By G. C. Karop, F.R.M.S.

(*Read March 20th*, 1903.)

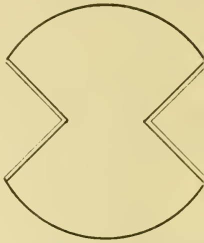
Messrs. Swift have put into my hands for exhibition a pocket-lens which, although possibly not of absolutely novel construction, appears to embody certain very useful features not hitherto, to my knowledge, at least, combined in quite the same way or in precisely the same form as in the instrument now shown. When examining and testing, to some limited extent, the performance of this magnifier in order to be able to say something about its merits, it occurred to me that it might not be unprofitable to myself, and perhaps to a few others if communicated, to look up some of the very numerous devices invented for simple microscopes, or used secondarily as pocket-lenses. Of the equi-convex lens, long the only magnifier and still largely employed, there is little or nothing to be said, except that it is cheap and efficient enough for rough purposes. Its great aberration, both spherical and chromatic (unless its curves are kept very flat and therefore its power low), is, however, a serious drawback, and one necessarily inherent in all single lenses, although a plano-convex has less aberration, and an inequi-convex with curves of 6 : 1 (in glass of refractive index 1·5) is known as a "lens of least aberration." Nevertheless, such is our ignorance or indifference, or perhaps it is merely an expression of the innate and unconscious human hostility to change, that I suppose more than one half of us have, at one time or another, gone about with one, two, or three equi-convex lenses in our pockets, mounted in horn, and most probably made of inferior glass and not worked to an edge. One of the first to attempt an improvement of the simple lens was Dr. Wollaston ("Philosophical Transactions," 1812), who combined two deep plano-convexes by the plane surfaces, with a perforated disc or diaphragm of metal in between. The diaphragm, having a very narrow opening, one-fifth of the focal length, greatly diminished the spherical aberration (the light also); and from the oblique rays, like the central, meeting the surface at a right angle in practically whichever way the lens be held, it was called a "periscopic." Brewster, however, pointed out that to make it really efficient the interval between the lenses should be filled by some substance, such as balsam, nearly approaching the refractive index of the glass. Somewhat later, Brewster conceived the idea of arriving at the same end more easily and effectually by grinding a shallow, subcylindrical groove round the equator of a glass sphere, and so doing away with both cement and diaphragm. It is doubtful, however, whether, except in simplicity of construction, this was any very great advance on Wollaston's lens, as, although two surfaces of refraction were eliminated, the amount



Wollaston (1812)



Brewster.

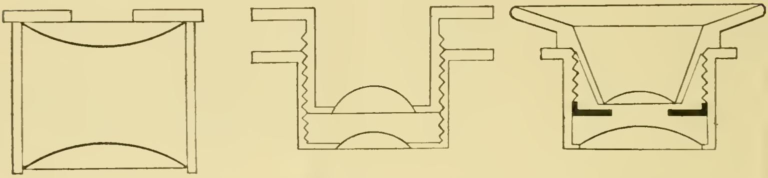


Coddington (1830).

of marginal error was but little reduced by the shallowness of the groove at first employed. Coddington ("Philosophical Transactions," 1830) proposed that the groove should be made both deeper and of angular form, and this proved so much more advantageous that it held its ground as a pocket magnifier until the advent of the achromatic and aplanatic triplet of Steinheil, and is still, I suppose, a purchasable article. This lens was also made with a narrow channel instead of an angular groove, which, of course, answers equally well. From its form, resembling two truncated cones, apex to apex, it was called a "coneopside," or, as it also has a likeness to the eye of certain birds, "a bird's-eye lens"; but Coddington's name has always been associated with it, and in my humble opinion very properly, as it is a distinct improvement on Brewster's original idea. Its chief drawback is shortness of focus, and this defect is still greater in the so-called "Stanhope" lens, which at one time was sold as a cheap, and bad, substitute for the Coddington. This consisted of a short glass cylinder having two unequal curvatures worked at its ends, and so calculated that, the greater being held next the eye, objects lying on the lesser were in focus. The inferior curvature was provided to avoid distortion of the field, but in the cheapest and worst form, known as a Stanhoscope, and sold by hawkers in the street, it is more or less a plane, and useless except as a toy.

Next we come to combinations of two or more lenses, superposed with a view of partially balancing their individual aberrations, which, however, in a more or less unscientific manner, had been in use long before. Divini ("Philosophical Transactions," 1668) combined two plano-convexes with their curves in apposition, and Joblot two biconvexes, and also planos fitted in a sliding tube, so as to obtain varying magnifications. Adams, according to Harting, who gives a figure, made plano doublets in a fixed mount, as also did Frauenhofer in later times, and this construction is not to be despised. As a boy I possessed one made by an optician in Leipzig, and prized it greatly for many years, until one day it was borrowed by a barrister to examine a signature on some deed, and, like the little kitten in the poem, "ne'er was seen again."

Euler was, I believe, the first (in 1764) to work out the theoretical curves for a true optical doublet, which consisted of a biconvex and a meniscus, the distance between them varying according to the focus; but I rather think this was intended for telescopes, and it seems doubtful if any were ever made. The elder Herschel took up the matter again in 1821, and worked out formulae for several doublet combinations. One is the same as Euler's, except that the convex surfaces are in contact, and the focus therefore unalterable; another consists of two plano-convexes of unequal curvature, with foci as 1 : 2·3, also in contact as in Divini's; and a third of a crossed lens of least aberration, 6 : 1, combined with a plano-convex whose focus is to the former as 2·6 : 1. This last is still used, and gives excellent results; indeed, the instrument before you is based on a modification of it, the plano having a much smaller radius of curvature. It should be said, however, that these doublets of Herschel were not intended for low-power hand magnifiers, but as objectives, and the difficulty of constructing relatively high powers with the calculated curvatures proved, at that time, insuperable, and they appear to have been abandoned. It was to Wollaston, again, in 1829, that opticians were indebted for a doublet, which, simple as it was in conception (merely a Huygenian ocular reversed), yet, on account of its components being adjustable to one another, effected a sensible correction of the aberration. But the relative distance apart of the lenses and their respective foci as fixed by Wollaston—viz., focus of lower lens to upper as 1 : 3, distance of plane surfaces 1·4 to 1·5 of the focus of smaller lens—were found by Pritchard to be capable of variation with advantage, and he also introduced a diaphragm between them, which still more improved their performance. Chevalier went a step further. His doublets, like Wollaston's, consist of two plano-convexes, but of equal foci, though of unequal diameter, the one next the eye being much the smaller. This allows the lenses to be brought



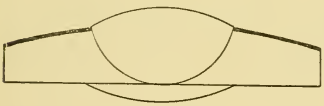
Adams. Wollaston (1829). Chevalier.

close together, and to pass more light; moreover, the working distance is also increased. If correctly spaced and centred, these doublets perform extremely well, and many here will doubtless remember the exhibition by one of our members not long ago of a fine Chevalier microscope furnished with a set of them. Triplet combinations were also made, Holland's form ("Transactions of Society of Arts," 1832) being, perhaps, the best known. It was formed of three plano-convexes, the two lower in contact, with a diaphragm between them and the upper and larger lens. By this time, however, the introduction of flint and crown combinations, in which the aberrations were greatly reduced and the aperture largely increased, gave a great impetus to the compound microscope, and caused the simple to be comparatively neglected. A notable improvement was later, however, made by Chevalier, who superposed an achromatised concave over his doublet, which gave a longer working distance, although it diminished the size of the field. This convenient device appears to have been overlooked until it was re-invented by Bruecke years afterwards, and it is now used for dissecting and other purposes.

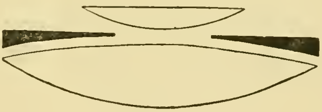
Plössl, according to Harting, was the first to construct magnifiers, in the limited sense, with achromatised lenses, though he does not give their composition. At the present day the triple cemented combinations known as "Steinheil" lenses, a thick biconvex centre and a meniscus at each end, have practically supplanted all the earlier forms; when well made, these are undoubtedly of great excellence, and for certain purposes unsurpassed.

The celebrated Dutch naturalist Leeuwenhoek appears to have been the first to construct a reflector microscope, a concave speculum with a lens in the centre (Letter to the Royal Society of London, January 1689). But it was Lieberkühn who brought this form of instrument into prominence, about 1738. In its primitive pattern it was applicable to any number of small opaque objects, being furnished with a stage forceps adjustable to its focus. The later, and, from pictures at least, better known instruments, however, had the considerable drawback of being restricted to a single object—one microscope, one specimen—beautiful as these may have been.

It is rather singular that some similar type of reflecting magnifier, which possesses obvious advantages to the field naturalist,



Nelson.



Swift.

should not have survived, but until recently I cannot call to mind anything of the kind. Some two or three years ago, Mr. Nelson turned his attention to this hiatus in our modern equipment, and devised a very ingenious reflecting magnifier of somewhat peculiar construction. It consists of a thick inequi-convex let into a plano-convex, the curved surface of which is silvered, and on its lower plane surface a plano-convex, of about the same size as the biconvex, is cemented. When held towards the light the silvered surface reflects and concentrates the rays upon the object held in the focus of the combination. Mr. Nelson's "mirror loup" is made by Messrs. Watson. This brings me to the instrument which was the *primum mobile* of this, I fear, discursive note, and which has much the same intention as the one just mentioned, but carried out in rather a simpler and less expensive manner. It is, in fact, a modified Herschelian doublet made up of a lower inequi-convex 6 : 1 lens and an upper plano-convex of smaller size, just sufficiently spaced to admit a thin, polished metal reflector-diaphragm between them. The sizes and focal lengths of the lenses are approximately as follows :

Inequi-convex :	diameter,	1·3 ;	focus, 2·1,	in inches	or parts.
Plano-convex :	„	·65 ;	„ 1·75	„	„
Focus of combination :	„	1·95 ;		„	„

But of course, all these can be varied in relative proportion if required. The three elements are mounted separately, just as in an ordinary triple magnifier, so that, although it is calculated to act as a "system," either lens may be used by itself, with or without the speculum. This arrangement should prove very convenient to the naturalist in the examination of small flowers, floral organs, insects, etc., and it will be found to perform very well indeed on such-like objects in the open, for which purposes it was chiefly intended. It is probable that by artificial light, unless skilfully managed, it will be less satisfactory, the illumination being generally either too much or too little; but I think this "reflector doublet" is likely to meet with the general approval of the genuine outdoor worker, if it can be made and sold at a reasonable price.

Further Observations on Male Rotifers.

By K. I. Marks, F.R.M.S., and W. Wesché, F.R.M.S.

(*Read April* 17*th*, 1903.)

Plate 26.

We are now able to add to the list of male rotifers two species which have not been previously observed, *Brachionus quadratus* Rous. and *Anuraea brevispina* Gosse, and to furnish particulars of another, *Pterodina patina* Ehr., a very well known and common species, the male of which has been recorded, but not figured or described.

The males of two of these species were obtained from a pond adjoining Willesden Lane, which, if one may judge from the trees growing on its banks, must be of very considerable age. During the last twelve months this pond has invariably yielded *B. quadratus* in considerable quantities. Several males were seen swimming in company with the females, but to prove their identity a female with four male eggs was isolated, and the drawings now submitted were made from the males hatched out from these eggs in the course of the following night. This male has been observed to spin a thread from the toes, and anchor himself by it, an action seen also in the male of *B. angularis*. In all the known males of *Brachionus* there is present an organ the explanation of which is a matter of considerable difficulty. It consists of a mass of blackish granules enclosed, in some instances at least, in a separate membrane, and situated on the dorsal side immediately above the sperm-sac. This mass not only differs in appearance in different species, but is very variable in shape in individuals of the same species, whilst it occasionally appears broken up, a portion being seen in another part of the body. It has therefore no value as a specific character. Gosse * noticed this granular mass in all

* *Phil. Trans.*, vol. 147, 1856, p. 324.

the males of *Brachionus* with which he was acquainted, and also in the males of some species of *Floscularia*, *Lacinularia*, and *Stephanoceros*. He also saw it in females, and did not consider it an exclusively male character. In *B. pala* he saw traces of a vesicle containing the black mass, which observation we are enabled to endorse by our experience of *B. quadratus*, wherein the mass of granules was enclosed in a distinct membrane. Dr. Leydig considered the granules to be urinary concretions ("Harnconcremete") analogous to the chalky fluid which is discharged by many insects after their evolution from pupae. In *B. quadratus* the granules are in constant agitation, reminding one of the cyclosis seen at the ends of some Desmids—*Closterium*, for example.

The spermatozoa have a different movement. Intermixed with them in the sperm-sac were a number of circular masses of protoplasm, with a few granules at the sides. The spermatozoa differ from those figured in this Journal, November, 1902, Pl. 17. They are angular in shape, and have no bulb at either extremity; but one end is thick, swelling to a blunt point, situated at about one-third from the end. The other end is acutely pointed. Some were seen outside the body, and from these measurements were obtained and drawings made. The length of these spermatozoa was $\frac{1}{1620}$th inch ($= 15\,\mu$) (Fig. 1, *c*).

The males of the Brachionidae are very similar in appearance, but some have marked characters that make them easy of identification; *B. pala*, for instance, has a distinctly triangular eye, and the dorsal antenna is situated at some distance behind the head. In addition, the body contains numerous oil globules which are usually absent in other species.

Several females of *B. quadratus* were seen with resting eggs (Fig. 1, *d*). Mr. Rousselet informs us that these are very uncommon, and as their production is generally thought to depend on fecundation by the male—*i.e.* they are not parthenogenetic eggs—their extreme rarity is easily explained.

The granular mass alluded to was not present in the other male rotifers we describe. In some water from a pond at Neasden were many females of the small loricated free swimmers—*Anuraea brevispina* Gosse; *A. aculeata* with fairly long spines, yet not so long as we have sometimes seen them;

and some specimens that we should describe as very short *A. aculeata* or long *A. brevispina.* Several of the *A. brevispina* females carried eggs; but one which particularly attracted the attention of Mr. Wesché, had two, which appeared rather smaller than the ordinary egg. This female was isolated, and twenty-four hours later was seen with the lower egg-shell empty, and the male figured (Fig. 2) was seen swimming. On the next day a dipping from the same water contained another male, which was identical with that hatched out, and Mr. Wesché was thus enabled to say with certainty that it was also the male of *A. brevispina.*

Dr. Plate gives a description of the male of *A. aculeata* Ehr., but no figure. As he never succeeded in fixing this animal, his observations are necessarily incomplete, but we gather from his remarks that it presents no striking character to differentiate it from *A. brevispina*; indeed, most observers are of opinion that *A. brevispina* Gosse, *A. aculeata* Ehr., *A. tecta* Gosse, and *A. curvicornis* Ehr. are all varieties of one species. Although this view would seem to be confirmed as regards *A. brevispina* and *A. aculeata* by our finding them in company together with intermediate specimens, we have thought it desirable to describe the male now found as the male of *A. brevispina*, it having been hatched from an egg carried by a female of that form. It is possible that a more complete examination than has yet been made of the male of a typical *A. aculeata* may reveal some reliable distinction at present unsuspected.

A very strong superficial likeness exists between the male of *A. brevispina* and the male of *Triarthra longiseta*; but examination with high powers dispels this. *Tr. longiseta* has no lorica or chitinous case to the foot, but has glands to the lateral antennae, which are very well marked. The points on which they agree are the general shape, the eye, the absence of toes, and the setae upon the extremity of the foot. This likeness in the males suggests a common parentage, although that very important organ, the mastax, differs considerably in the females of these two species.

The male of *Pterodina patina* Ehr. has several points of interest. Like the female, it has two frontal eyes, and the antennae are situated in the same places; but its appearance otherwise is quite dissimilar. It is vermiform in shape, and swims somewhat after the manner of a *Notommata*; indeed, it was at first thought to be a young *Proales petromyzon.* A lateral view enabled one observer to obtain a glimpse of some membranes situated on the ventral side of the brain, which are probably the remains of a digestive system.

BRACHIONUS QUADRATUS *Rous.* ♂, Fig. 1.

Stoutly fusiform in shape, a lateral view shows the head and foot curved downwards when swimming free.

Head, inclined to be globular, a little variable in shape; the constriction of the neck also varies with position. The head is capable of retraction within the body.

Body, cylindrical, stout, has marks of the edge of the carapace, as in *Diaschiza.* A fold of skin is sometimes seen in dorsal view.

Foot, stout, short, and wrinkled, tapering from body and retractile.

Toes, minute, triangular; sometimes a thread is spun from their extremities.

Cilia, long.

Brain, large, three-lobed on the front. Sometimes oval glands seem to form part of it, in dorsal view.

Eye, rather nebulous, not well defined, faintly red, and variable in shape.

Antennae: dorsal, well forward on the head; lateral, low down on sides of body, as in the female, with long setae. There is no digestive system nor even remains visible.

A vascular system is present, but the lateral canals are difficult to make out. Mr. Marks observed two flame-cells on each side of the lateral canals. There are well-marked glands to toes.

Generative system: a very large sperm-sac tapering from the centre of the body cavity to the middle of the foot. It is constricted as it passes through the end of the body, by which means the spermatozoa seem contained; but it is impossible to make out the nature of the ejaculatory apparatus, on account of its minute size. A dark granular mass contained in a vesicle shows above the testis in dorsal view.

Size, $\frac{1}{200}$th to $\frac{1}{180}$th inch (127 μ—141 μ).

Habitat, pond in Willesden Lane, March 8th and 21st, 1903.

Resting eggs were seen carried by several females, and two were noticed at the bottom of the trough. They were dark in colour, granular, and covered with short blunt spines.

Size, $\frac{1}{180}$th inch ($= 141\ \mu$).

ANURAEA BREVISPINA *Gosse* ♂, Fig. 2.

The shape of this minute rotifer is inclined to be truncate, but globular, not so broad as it is long, and the body, unlike that of the female, in a foot, ends usually somewhat pendant.

Head, stout, with a chitinous covering on the dorsal side, well marked in lateral view; this folds up and encloses the head when the animal retracts the cilia. There is a deep constriction at the neck.

Body, enclosed in a carapace which has openings on the dorsum and sides, so that it appears to be enclosed in three more or less arched plates; in the specimens seen there was a conspicuous oil globule.

The foot has a chitinous sheath, down which the passage from the sperm-sac passes, so that it may be said to take the place of the penis. At the extremity are two hyaline threads, as in *Triarthra longiseta*.

Toes, none.

Cilia, fairly long.

Brain, large, occupying all the head and part of the body.

Eye, large, bright red, circular in dorsal view, narrow in lateral view, nearer the ventral than the dorsal side.

Antennae, very minute on head and sides of carapace. No digestive system. No glands made out, but the animal appears to spin a thread from foot.

Vascular system very indistinct. No contractile vesicle made out.

Generative system, a large pouch containing spermatozoa and other bodies, which may be seen in movement in the interior. This pouch narrows to a long neck, which is worked up and down the foot, and is capable of protrusion from its extremity.

Size, $\frac{1}{300}$th inch ($= 84\ \mu$).

Habitat, pond at Neasden, April 2nd, 1903.

PTERODINA PATINA *Ehr.* ♂, Fig. 3.

Seen laterally, rather vermiform in shape, resembling a young *Proales petromyzon*. Dorsally, somewhat broad, but having no approximation to the plate shape of the female.

Head, rather short, without quasi-auricles as in female; constriction of neck not well marked.

Body, rather broad, but fairly long; edge of carapace visible laterally, and two folds on the posterior sides when viewed dorsally. The two muscles, so prominent in the female and used to retract the head, are present and well marked, and best seen on the dorsal view.

Foot, short, stout, retractile, with a gland at the extremity.

Toes, none.

Cilia, moderately long.

Brain, large, occupying all the head and sending a long process to the dorsal antennae.

Eyes, two, red and well marked.

Antennae, all three in the centre of the body, almost in a line.

Setae, very fine and difficult to make out.

Digestive system, represented by a hyaline membrane, appearing to be in an atrophied condition.

Vascular system, faint; no contractile vesicle seen.

Generative system, very large; spermatozoa massed in testis; orifice of penis slightly ciliated and situated half down the dorsal side of the foot; no granular masses, as in *Brachionus*.

Size, $\frac{1}{200}$th to $\frac{1}{187}$th inch ($=127$ to $135\ \mu$).

Habitat, pond in Willesden Lane, May 12th, 1902.

The scarcity of males and the difficulty of observing them is well put by W. T. Calman,* who states that a period of no less than a hundred and thirty years elapsed between the discovery of the female and the identification of the male of *Stephanoceros eichhornii*. But difficulties do not end with the finding of the male, as its extraordinary activity has produced a curious diversity of observations on the actual sexual act. It has been observed in various ways. Gosse satisfied himself that he had seen a momentary coïtus at the cloaca.† Dr. Weber had a similar experience.‡ Dr. L. Plate had arrived at different conclusions, having seen the male of *Hydatina senta* attach itself

* *Natural Science*, vol. 13, July, 1898, p. 43.

† *Phil. Trans.*, vol. 147, 1856, p. 317.

‡ "Notes sur quelques mâles de Rotateurs," *Rev. Suisse de Zoologie*, vol. 5, 1897, p. 98.

to the female at various points, thus confirming what had been stated by Dr. F. Cohn.* Plate calls it *hypodermic impregnation.*† We separately repeated Gosse's experiment, but with *B. pala* instead of *B. rubens.* We saw a male swim round a female in the manner described by Gosse, but saw nothing we could describe as coïtus. But Mr. Marks saw on seven occasions the foot introduced into the anterior cavity of the lorica, and remain attached for periods of over a minute. A similar action was independently seen in one instance by Mr. Wesché, but the female was moribund, if not dead. On the other hand, Mr. Wesché has a note of having seen the coïtus of *B. angularis* in December, 1901. Connection was made at the tail orifice (cloaca), and the male and female remained together for approximately a minute. When they separated, a thread was seen to proceed from the toe of the male and connect the two animals. Dr. Plate concluded from his observations that "uninterrupted parthenogenesis prevailed among the Rotifera, and that the male was a vestigial and superfluous sex, and that the abortive attempts at impregnation were an atavistic phenomenon without significance in the life history of the species." ‡

Certainly our observations tend to confirm Dr. Plate's, but with the great diversity in the organisation of males it would be quite premature to conclude that an observation which only affected two or three species bore on the whole order. On the other hand, E. Maupas claims to have proved that the production of the resting egg depends on fertilisation by the male, which quite upsets Dr. Plate's generalisation. §

Dr. R. Lauterborn came to the conclusion that the appearance of the male, and consequent production of the resting egg, is "normally recurrent in the life cycle of each species, after a certain definite number of parthenogenetic generations." He further notes, and our observations quite bear him out, "that

* "Ueber die Fortpflanzung der Rotatorien," *Zeitsch. f. Wiss. Zool.*, vii., p. 431, 1856.

† "Beiträge zur Naturgeschichte der Rotatorien," *Jena. Zeitsch. f. Naturw.*, xix., p. 63, 1885.

‡ "Beiträge zur Naturgeschichte der Rotatorien," *Jena. Zeitsch. f. Naturw.*, xix., p. 37, 1885.

§ "Comptes rendus," Ac. Sci., 1890, p. 310.

when any species was becoming predominant by rapid parthenogenetic multiplication, the appearance of the sexual period might be looked for." *

After considering the various theories, we are inclined to think that the hypothesis advanced in the paper previously alluded to † is still a reasonable explanation of the curious phenomenon of the male of the Rotifera. Briefly recapitulated, it is this. The male is gradually disappearing, and the stages of this process can be seen in the various families and species, beginning with those which possess a digestive apparatus, through those that are highly organised, but have no digestive apparatus, to the lowly organised *Polyarthra* and *Pedalion*, and ending with the Bdelloida, in which sub-order no male has been seen, and in which it is supposed they have ceased to exercise any function.

As this interesting problem is still in an unsolved state, it is highly desirable that the male should be studied in as many species as possible, and its habits carefully noted.

Explanation of Plate 26.

Fig. 1. *Brachionus quadratus*, Rous., ♂, dorsal view, fully extended.
- *a.* Lateral view.
- *b.* Dorsal view, retracted.
- *c.* Spermatozoa.
- *d.* Resting egg.

,, 2. *Anurea brevispina*, Gosse, ♂, lateral view.
- *a.* Dorsal view.

,, 3. *Pterodina patina*, Ehr., ♂, lateral view.
- *a.* Dorsal view, retracted.
- *b.* Dorsal view, fully extended.

* *Biol. Centralblatt* 18, 1898, p. 173.

† "Observations on male Rotifers," W. Wesché, *Journ. Quek. Micro. Club*, Ser. 2, vol. 8, pp. 326, 327.

Remarks on the Emission of Musical Notes and on the Hovering Habit of *Eristalis tenax*.

By W. H. Harris.

(*Read April 17th*, 1903)

Among the Diptera common to Great Britain there is one family, the Syrphidae, some species of which offer to even the most superficial observer two very distinct and remarkable peculiarities —namely, their ability to emit musical notes, and their hawk-like or hovering propensity.

In the "Introduction to Entomology" by Kirby and Spence there are some remarks as to the manner in which the former of these actions is performed by certain species of flies, but with regard to the latter, no attempt is made to explain by what means they accomplish this feat, nor have I ever been successful in my endeavours to discover any literature on the subject.

Thrown back on my own resources, I have attempted to investigate for myself, and the following remarks are the outcome of adopting this course.

Emission of Musical Notes.

With regard to the emission of sound, I must be permitted to make an extract from the work quoted, showing the nature of the investigations made by several old observers whose names are deservedly held in great respect, some of which are exceedingly curious and others scarcely worth repeating.

De Geer, whose observations seem to have been made upon aphidivorous flies, appears to have proved that "the sounds were produced by the friction of the root or base of the wings against the sides of the cavity in which they are inserted. To be confirmed of this, he affirms, the observer has nothing to do but to hold each wing with the finger and thumb, and stretching them out, taking care not to hurt the animal, in opposite directions, thus to prevent their motion—and immediately all sound will cease. For further satisfaction he made the following experiment. He first cut off the wings of one of these flies very near the base; but finding that it still continued to buzz as before, he thought that the winglets and poisers, which he remarked were in a constant vibration, might occasion the sound. Upon this, cutting both off, he examined the mutilated fly with a microscope, and found that the remaining fragments of the wings were in constant motion all the time that the buzzing continued; but that upon pulling them up by the roots all sound ceased."

Shelver conducted similar experiments, and these go to prove, "with respect to the insects that he examined," that "the winglets are more particularly concerned with the buzzing. Upon cutting off the wings of a fly—but he does not state that he pulled them up by the roots—he found the sound continued. He next cut off the poisers; the buzzing went on. This experiment was repeated eighteen times with the same result. Lastly, when he took off the winglets, either wholly or partially, the buzzing ceased. This, however, if correct, can only be a cause of this noise in the insects that have winglets. Numbers have them not. He next therefore cut off the poisers of a crane fly (*Tipula crocata*) and found that it buzzed when it moved the wing. He cut off half the latter, yet still the sound continued; but when he had cut off the whole of these organs the sound entirely ceased."

The only remark that need be made on the experiments of these two observers is, that probably they were made upon different species of flies, and that it is highly probable that the sounds are produced by different methods among the innumerable species of flies that are capable of producing them.

"Dr. Burmeister, however, was led by his experiments to a different conclusion. Finding that the buzz of a large fly (*Eristalis tenax*) still continued after the winglets, the poisers, and even the wings had been quite cut off except their very stumps (only in this last case the sound was somewhat weaker and higher), he conceived that the spiracles lying between the meso- and meta-thorax must be the instruments of sound, which accordingly he found to cease entirely when they were stopped with gum, though while the wings were in vibration.

"Pursuing his researches, he extracted one of these spiracles, and opening it carefully, found its posterior and inner lip, which is directed towards the commencement of the trachea, to be expanded into a small crescent-shaped plate, upon which are nine parallel very delicate horny laminae, the central one being largest, while those on each side became gradually smaller and lower; and it is, he is persuaded, in consequence of the air being forcibly driven out of the trachea and touching these laminae that they are made to vibrate and sound precisely in the same way with the glottis of the larynx."

The quotation need not be prolonged; we are, I imagine, on firm ground as to the point of origin of the sound produced by *Eristalis tenax.* I think, however, that it will be capable of being demonstrated that Dr. Burmeister was not strictly accurate in his description of the musical organ, unless the theory of evolution has been exemplified by this fly in a most remarkable manner since his observations were made.

In order to do this to the satisfaction of the members of our Club, I have sent six slides of dissections of the parts to be dealt with in these remarks; if they are thought worthy of a place in the cabinet of the Club, I shall be pleased to have them placed where they may possibly be more useful than remaining in mine almost unnoticed.

The first slide contains the anterior and posterior thoracic spiracles, also three of the organs from the abdomen; they are mounted without pressure, and arranged to give an external view of the parts. There are also two portions of the exquisite arborescent fringe which guards the aperture, mounted under pressure to admit of higher power being employed for their examination. It will be observed that each posterior stigma is entirely surrounded with the fringe of appendages. In this respect they differ from the corresponding organs in others flies that I have examined. There is nothing especially remarkable about the anterior spiracle, consequently it will disappear from subsequent remarks on slides.

The second slide contains two posterior thoracic spiracles, taken from different flies—thus they may be regarded as tests for any difference in those organs; they are mounted to give an internal view, without pressure, in order that their normal form may be preserved. A wonderful and very beautiful addition is displayed, to which I now desire to direct your attention.

I have already quoted Dr. Burmeister's description of the internal aspect of the musical organ, but for convenience will repeat it: "*A small crescent-shaped plate, upon which are nine parallel very delicate horny laminae.*" Do our flies of the present century appear to confirm this statement? I think they do not. What we really find I will endeavour to explain. In so doing I trust I may not commit myself to any statement incapable of demonstration, for an error once started travels far, and in nautical circles it is a well-known fact that a stern chase is the longest to engage in.

What really exists is, I think, as follows. There are two crescent-shaped rods, composed of chitin, joined together by a ligament, thus forming a bow with elongated arms, the ends of which appear to be quite free; in outline they almost complete an oval figure—a small space at the extremities of the arms alone prevents the use of the term. A large bundle of muscles is connected with the ligament, which, when contracted, cause the two crescent-shaped rods to be deflected, turning the arms towards each other; when the pressure is relaxed they return to their normal position. The rods support very delicate and pliant membranes, which are folded or pleated in a very complicated and extraordinary manner; the free edges of the pleats are considerably enlarged, and present a margin of considerable extent packed away in the smallest possible space. There are from twenty-three to twenty-five such pleats in the entire organ, which they almost completely surround.

Slide number three carries the dissection a stage further. It contains one almost complete set of folds—unfortunately a few are missing, but for our purpose this is immaterial—also one-half of another set. They are mounted under pressure, and consequently are somewhat distorted, but this has had the advantage of displaying in one nearly entire organ both sides of the pleats, for which purpose the additional half was originally mounted; moreover, a higher power objective may be usefully employed for the examination. It will be observed that at least three-fourths of the pleated membrane extends above the crescent-shaped rods, consequently any movement of the latter must cause the free ends of the pleats to be considerably deflected.

During the process of dissection I have satisfied myself that the free edges of the pleats may be caused to almost, if not completely, approach each other, by operating the ligament as it would doubtless be done by the muscles in the lifetime of the insect.

The fourth slide contains two portions of a membrane which entirely closes the internal part of the spiracle; the smaller portion shows its expanded condition, the larger fragment its contracted appearance; it is an expansion of the tracheal system and in the living insect forms a perfect air-chamber. If the second slide is examined carefully fragments of this membrane may be observed still adhering thereto; the larger portion, however, has necessarily been removed in order to display the folded membranes.

The opinion I have arrived at is briefly as follows. The air-chamber is kept constantly inflated by the movements of the fly. When the insect requires to produce the musical sound, it has simply to bring the free edges of the pleats close together, and to expel air with sufficient force to set them in vibration. The force employed to do this is derived from the large bundles of muscles which almost completely fill the cavity of the thorax, among which the finer ramifications of the tracheal system are abundantly distributed. The air contained in these would be driven forward very gradually into the air-chamber, and thus replace the quantity discharged to produce the note. Probably when the note is long sustained some of the numerous sclerites may assist the operation by reducing the cavity of the thorax.

If this explanation is correct it is self-evident that no constant vibration of either wings, poisers, scales, or even rapid motion of the legs is necessary, one long-sustained, slow, steady movement alone being sufficient to produce the musical note.

If the movements of the fly are restrained without injury to the insect—as for successful experiment it should be—it can be caused to give forth its musical note. To accomplish this you need only use the net in which you capture the insect; gently but firmly compress it until visible movement ceases. The sense of touch will convey the unmistakable impression that some organs are in a state of rapid vibration. With the cessation of the note the vibration discontinues, and thus, I submit, corroborative evidence in support of the explanation given is supplied.

It only remains to point out the differences disclosed by these dissections from Dr. Burmeister's description. They are four in number, viz.:

(1) There are two rods, or plates if you prefer the term, and not one.

(2) That the folded membrane occupies both sides of the stigma; not one side only as implied.

(3) That there are from twenty-three to twenty-five pleats or folds in each vocal organ, and not nine as distinctly stated.

(4) That it is a very delicate and pliable membrane that is thus folded, and not "horny laminae" as described.

Hovering.

I approach the subject of hovering with great trepidation, for I must candidly admit that I know nothing about it. For the life of me I could not state in correct terms the mechanical theories of either flight or hovering. In my perplexity I sought the aid of a friend who really knows a thing or two, but from him no assistance could I obtain. He, however, consoled me with the assurance that my complete ignorance of the subject was in reality my special qualification for dealing with it, as possessing such vacuity I must be free from prejudice, and that therefore I was the proper person to discourse upon this very interesting subject. This was comforting, but scarcely reassuring; at any rate, it appeared to be "up-to-date."

While at the seaside last summer I was seated near the edge of a cliff, the face of which was nearly vertical. A moderately strong but steady breeze was blowing, and poised above me at an altitude of from seventy to eighty feet was a sea-gull. With the aid of my glass I watched this bird for half an hour, but no movement of its outspread wings could I perceive, save alone, occasionally, a slight change of inclination, which enabled the bird to regain its original position, from which it would be quietly drifted inland by the current of air in which it floated. I walked away half a mile, occasionally turning to look at the bird; returned, and again sat down for a while, and finally left it still poised. It seemed a perfect illustration of the story told by an American traveller with regard to one district he had visited where everything was petrified—the trees, the beasts, even the birds were still suspended in the air over that district. On the expression of a doubt as to the latter statement, he calmly assured his audience that in that region even gravity was petrified. But this is a digression.

On reflection I found that the sea-gull gave me no more assistance than had my unfeathered friend. Let us think for a moment. The wind, striking the almost vertical face of the cliff, is deflected upward with considerable velocity; as this force diminishes it again resumes its original course and passes inland. In this upward current the gull, with its outspread wings, as readily attained its equilibrium as a cork does in water. One of the opposing forces was external and independent, and therefore not quite to be compared with a hovering fly, which has to create and control opposing forces.

We all know that the gossamer spider has the ability to emit filaments of web which, by the aid of its legs, it subsequently gathers into a flocculent mass, and thus constructs an aerial chariot capable of sustaining and transporting it on the zephyrs of autumn for considerable distances. Here the support is the direct product of the spider, but there is no permanent connection between them; the conveyance once made lasts as long as it is required, without further expenditure of labour, whereas the hovering fly has to be constantly expending energy in order to maintain its position in the air.

Now, we may ask, can we discover anything in connection with *Eristalis tenax*—and for that matter other hovering flies also—that would probably assist it to maintain its equilibrium? Are any organs more highly developed than similar parts in flies that cannot hover? Is it provided with auxiliary organs absent in the case of non-hovering species?

An affirmative answer can, I think, be given to each of these questions.

In the following descriptions I shall adopt the modern terms "alulets or scales," the equivalents of "winglets" of the old authorities.

The fifth slide contains portions of the membranes which constitute the two alulets or scales; these are formed by the folding of the parts upon themselves; the deep depression in the margin indicates the point where the fold occurs; they are of unequal size. The scales are spread apart, the better to display the remarkable appendages which border their free margins.

The fringing appendages are of two distinct kinds, and will well repay very careful examination. Those which border the smaller scale appear at first sight like simple flat plates; but if examined carefully, they will be found to be hollow, or tubular, organs. A central tube passes either completely through, or stops short of the free ends—which, I have been unable to determine, as some appear to favour one view, others the reverse. Probably they are subject to wear, but until a further supply of insects can be obtained this must remain an open question.

The basal portions of these organs can, I think, be traced for some distance within the margin of the scale, and in this respect appear to differ from those of the larger scale now to be referred to.

The appendages of the larger scale, unlike those of the smaller, are of true dermal origin; they arise from and are continuous with small elevations which border the organ. They consist of a central shaft, which for some little distance from the base gives off numerous short branches; these in turn divide and give rise to from two to six very long tapering branches, entire throughout their length; collectively they produce the effect of an exquisite fringe. They are at their maximum length in the centre of the scale, decreasing somewhat on either side.

If a perfect fly is examined there will be found, near the part where the membranes are folded to form the two scales, a curious organ to which I now desire to draw attention. I have never seen any allusion to it in any books that I have had access to. To this organ I attribute the property which enables the fly to accomplish the feat of hovering, and I propose to call it, provisionally, the "plume."

The sixth slide contains an isolated plume. This consists of two parts—*viz.*, a strong chitinous basal part, and a membranous hollow expansion which gives rise to innumerable long hairs; it presents a beautiful feathery appearance, and from its size would appear capable of presenting considerable resistance to the passage of air. The whole organ can be extended at right angles to the thorax; in this position it is free from the alulets, or it may be compressed against the side of the fly, and probably withdrawn under shelter of the scales. It is attached to one of the small sclerites which so freely abound near the base of the wings and are so difficult to understand.

I regard the appendages of the four alulets and the two feathery plumes as essential, and sufficient to enable the fly to maintain its apparently motionless position in the air. It is highly probable that the plumes move rhythmically with the wings, being alternately extended and withdrawn; but I have never been able to devise a plan to assure myself of this. The struggles of a fly under restraint may, and probably do, differ from those it makes in its natural state of freedom, and it is so very easy to fall into error. I must, therefore, leave this an open question, resting satisfied for the present with the little I have done towards the elucidation of two very interesting subjects.

Two new Bdelloida commensal in the branchial cavities of *Telphusa fluviatilis*, Lmk.

By Sebastiano Piovanelli.

(*Read June 19th*, 1903.)

While examining the branchial cavities of the common Italian fresh-water crab, *Telphusa fluviatilis*, I found two forms of Bdelloid Rotifera commensal therein and not referable to described species, one having distinctive characters of such importance that I propose to place it in a new genus.

Mr. Bryce has very generously aided me with valuable information and advice in compiling the following descriptions. The observations on which these descriptions are based have been made in Professor Decio Vinciguerra's laboratory in the R. Stazione di Piscicoltura, Museo Agrario, Rome, and under his guidance and supervision.

Callidina cancrophila, n. sp.

Slender and parallel-sided, 426—530 μ in length. Skin smooth, with dorsal and lateral longitudinal folds. Colour greenish grey. Width of corona, 67 μ, scarcely more than collar; of neck, 53 μ. Rami formula, 2/2; length, 27 μ; maximum width of each ramus, 11 μ. Antenna rather flattened antero-posteriorly, about 16 μ long. On the first cervical, at each side of the antenna, a small boss of thickened hypodermis, which extends down each side of the segment in a slight and decreasing ridge. A rather prominently angular lateral outline is presented by the anal segment. The first foot segment, though smaller, presents, from dorsal or ventral view, a similar appearance, but the angularity is due to a deep thickening of the hypodermis, which increases to a boss dorsally. Foot of four joints, 93 μ long. Spurs stout and strong, pointed, with distinct heel; outside edge boldly convex, slightly angular at about one-third from tip; inner edge below heel nearly straight or slightly concave. They are somewhat rigidly attached and their pose is characteristic, as they are widely divergent, and rather erect relatively to the foot axis. Length, 25 μ; interstice, 4 μ, convex. Toes three, rather stout.

Commensal in the branchial cavities of *Telphusa fluviatilis*, Lmk.

Anomopus, a new genus of the Family **Philodinadae.**

Gen. Ch.—Eyeless. Rostral lamellae present. Foot long, terminated by perforated adhesive disc. Spurs very small. Foot-glands built up of longitudinal series of cells, ducts not enclosed in a capsule.

A. TELPHUSAE, n. sp.

A smooth, elongated, flexible form, with dorsal and lateral longitudinal folds. Average length of adults, 600μ; one exceptionally large individual, 738μ. Corona very wide, 120μ; width of collar, 100μ; of narrowest neck joint, 62μ. Sulcus shallow, about 41μ wide. Upper lip arched towards mouth, extending almost to the level of the discs, and sloping gently on each side down to a slight median notch or groove. Antenna stout, terminated by short setae, narrowed near base, resting on a flange; length, 21μ. Rami formula, $1 + {}^1/{}^1 + 1$; length, 29μ; maximum width of each ramus, 12μ. Foot very characteristic, of five joints, slender, very long, 132μ, the second joint rather the longest and having a ring-like thickening of the hypodermis about its middle. The narrow and elongate anal and preanal segments increase the apparent length of the foot. Spurs wide apart (interstice, 21μ), apparently perforate, rounded, almost pimple or nipple-shaped, with a slight basal constriction, externally about 3μ long, but having the appearance of being prolonged for several times their own length within the foot joint, which extends some way below them. Adhesive disc circular, 19μ diameter, pierced by numerous minute (less than 1μ diameter) perforations.

Only one series of large cells (length of largest, 35μ; diameter of nuclei, 7μ) is clearly discernible as constituting each foot-gland, which extends some way above the anus into the trunk.

This species is frequently attacked externally by a saprophytic Cladothrix, which is sometimes in isolated hairs on the skin sometimes in tufts, and sometimes forms a furry coating.

Commensal in the branchial cavities of *Telphusa fluviatilis* Lmk.

On two New Species of *Philodina*.

By David Bryce.

(*Read June* 19*th*, 1903.)

Plate 27.

Although a few of the species belonging to the genus *Philodina* can be readily identified by means of their pronounced and obvious peculiarities of structure, the majority, forming what may be called the central group, agree somewhat closely in all the more important or salient details, and can only be recognised with any approach to certainty by attention to points which, to the uninitiated, may seem to be exceedingly trivial. In the closely related genus *Callidina*, with its much greater array of species, the difficulty of identification is greatly lessened by its wide range of variation, and one is able to rely with confidence upon characters afforded by the proportions of the corona, by the form of the upper lip, by the number of teeth, by the treatment of the food, and by the structure of the various parts of the foot.

In the central group of the genus *Philodina* there is comparatively little variation in any of these details, with the exception of those processes upon the penultimate foot segment known as the spurs. In the form, length, distance apart, and direction of these processes there is considerable, although perhaps not very conspicuous, variation. So far as I have been able to judge, the individual variation, or that which obtains among the individuals of one species, is extremely slight, whilst the specific variation (*i.e.* as between the different species) is sufficiently characteristic and remarkably constant. I have come therefore to rely mainly upon this character in the determination of specimens otherwise of doubtful identity. But while the spurs are thus useful for systematic purposes, the foot as a whole is itself interesting as the highest development found among Bdelloid Rotifera of that portion of the body. Those who are interested in these animals will remember that, by some unexplained error, Hudson and Gosse laid down as one of the characteristics of the order Bdelloida that the toes were three in number. It is now well known that in the genus *Philodina* the toes seem to be invariably four, whilst in the genus *Callidina*, as at present constituted, there are species with four toes, others with three, and some without any.

As I am not aware of the existence of any figures which clearly show the plan on which the four toes are arranged in the typical Philodina foot, I have introduced into the accompanying plate a slightly diagrammatic outline of the hinder portion of the foot of *Philodina roseola*, drawn from an individual under compression sufficient to force out the foot to the fullest extent.

It is clear from their descriptions that Hudson and Gosse regarded the foot of a Philodina as including all the segments behind that sudden diminution of the width of the body so conspicuous in *Philodina citrina* or *P. megalotrocha.* Inasmuch, however, as this diminution, apparently marking off the foot from the central body or trunk, is scarcely noticeable in some species, and in others does not occur at the corresponding segment of the body, this view of the foot limits does not commend itself as reliable or advantageous for comparison. Later writers have therefore unanimously agreed to regard the foot, throughout all the genera of the Bdelloida, as comprising only those segments which are subsequent to the anus. In the genus *Philodina* there are usually four of these segments, but in *P. roseola* and *P. erythropthalma* there are five, and in *P. commensalis*, I believe, six. In the two former species the upper part of the foot consists of three segments of nearly equal length. In those other species which have a foot of four segments in all, the first segment is usually much longer than the second. It would seem, therefore, that the extra segment has been evolved by the division of this usually long first segment into two shorter segments. In either case the penultimate segment bears the spurs—two dorsal processes whose function, as I believe, is simply to act as mere supports to the foot when the animal is feeding, and as buffers to lessen the shock of the recoil when the animal, in alarm, contracts itself violently upon its affixed foot-base.

It has been stated that the spurs are perforate, but I have not in any species been able to detect any trace of perforation, or of capability, by the exudation of mucus or otherwise, to attach the spurs, or to lay hold by them in any way of the surface they may touch. Their bases are undoubtedly hollow, but their apices appear to me to be solid and imperforate. They are usually stiff, but may occasionally be observed to bend when under temporary strain.

When the foot is fully protruded, as in the specimen sketched, it is seen that the penultimate segment extends a little way below the bases of the spurs. A few species which usually feed while extended to their greatest length, habitually show this lower portion of the segment. In species which adopt a more or less squatting position when feeding, it is rarely exposed.

The terminal segment is furnished with two pairs of toes, the dorsal and the terminal. The dorsal toes are usually much smaller than the terminal, and are placed at some distance above them. When in their natural position they stand out from the foot surface nearly parallel to each other (not strongly divergent, as shown in sketch, and as caused by pressure of cover-glass). Although it is clear, when the foot is thus protruded straight out behind the body, that these two toes are on the dorsal side, this position is rarely seen when the animal is free, and does not occur in the ordinary course of locomotion, but only when it desires to creep backwards, as sometimes happens. In the act of creeping forwards, when the body has been extended to its utmost, and hold has been taken with the tip of the rostrum or anterior extremity, the foot is released and the body, partly contracting in telescopic fashion, partly arching like the caterpillar of a geometer moth, is drawn up towards the rostrum. At the moment when the foot has been brought forward as far as possible and seems to be on the point of being set down, the terminal segment, until now concealed, is shot forward below the animal, the terminal toes are applied and become affixed, and almost simultaneously, by the telescopic action of the foot parts, the dorsal toes arrive and attach themselves behind the others, while the spurs take a position immediately at the rear of all the toes, which are at once invaginated, their tips remaining affixed. By the bending of the foot forwards underneath the body, the dorsally placed toes are brought into use as well as the terminal. The latter pair are stout, of moderate length, and of two joints, the distal being telescopically retractile within the proximal.

Each pair of toes is capable of independent motion, and must therefore be provided with distinct muscles and controlling nerves. All four toes are broadly truncate, and their tips are pierced with several pores, from which ducts pass upwards through the foot to the cells which form the foot-glands. These glands are each built up of a series of large nucleate cells extending from a little way above the spurs as far as or, in some cases, even beyond the anus. The mucus secreted by them passes down the ducts, and is exuded through the pores in the tips of the toes.

In the three-toed species of *Rotifer* and *Callidina* the central toe is dorsal, the external toes terminal; but there is practically no interval between their bases, and their movements are usually simultaneous.

The two new species whose descriptions are appended resemble each other in several particulars. Both are rather below the usual size of Philodinae, and both usually adopt a squatting position when feeding. In each case the eyes are frequently indefinable, and when visible are small and round. The spurs are so nearly alike that, while they absolutely distinguish these two species from all others described, they do not afford reliable distinction between the one species and the other. Fortunately, however, the two forms are readily recognised by the skin, which in *P. rugosa* is rough and more or less opaque, and in *P. nemoralis* is smooth and transparent.

Philodina nemoralis, n. sp.

Sp. Ch.—Rather small for the genus. Skin smooth. Dental formula, 2/2. Foot of four joints; spurs short, slender, acute, and separated by an interstice nearly as wide as their length.

Central portion of upper lip bounded by ridge-like folds of skin. Eyes small and round.

This form might easily be passed over as merely an immature or small variety of *P. citrina*, but it differs distinctly and sufficiently from that species in the above noted characters of the spurs and of the upper lip. It occurs usually in mosses growing on or near damp ground, but is also to be taken in Sphagnum and in mossy pools. The alimentary regions are sometimes colourless, more often yellowish-red, occasionally of a faint green tint. Although in most cases the length does not exceed 285 μ when extended, yet in some localities it seems to attain decidedly larger proportions.

Its general form is scarcely so robust as usual among those Philodinae which have a four-jointed foot. The corona is moderately wide, 45 to 55 μ, the pedicels separated by a sulcus of average width and depth. The upper lip has its central portion bounded at each side by a ridge-like fold of skin which invests the bases of the pedicels on the inner and dorsal sides. The collar has a breadth of 38 to 44 μ, and is always distinctly greater than the neck, 29 to 32 μ. The dorsal antenna is of fair length, and each trochal disk possesses a seta or pencil of setae arising from a slight central prominence.

The mastax and internal organs generally, so far as made out, present no peculiarities. The rami are about 16 μ long, and have each two distinct transverse bars, and occasionally a fainter bar indicated more or less plainly. The lumen of the stomach is slender and lined with cilia. In dorsal view the eyes are small and round and of the usual red colour. When the animal is feeding, the rather short and slender foot is generally concealed beneath the posterior segments of the trunk. The spurs are from 4 to 6 μ long, and the interstice between them is about 4 μ wide. They are usually held at a slightly divergent angle, and may occasionally be seen to be bent abruptly, as though not absolutely stiff. The four toes are in two pairs, the dorsal pair smaller than the terminal, as usual.

I found this interesting species first near the Cuckoo Pits in Epping Forest in 1893, and in later years in other localities in Essex and also near Folkestone. I have received it also from Forstmeister Bilfinger, of Stuttgart, from Mr. Lord of Rawtenstall, and from Mr. James Murray, who has sent it from various Scottish localities, including Loch Vennachar and Ben Nevis.

In confinement it is unusually hardy, and will live for months in a fraction of a drop of water in a suitable cell. Like a few other Bdelloid species, it is, under such circumstances, subject at times to what must be looked upon as a pathological condition of the gastric glands. These organs usually include in their substance a small number of minute, clear spaces or vacuoles. In this abnormal or diseased condition one (or more) of the glands has some of the vacuoles so greatly enlarged that the whole gland is like one large, clear vesicle, and in some cases is swollen much beyond its customary size. Strange to say, this condition of the glands does not appear to seriously affect the health of the individuals attacked, or, at all events, to lead to their rapid decease. When the disease shows itself, it generally affects most of the individuals in the cell.

Where *P. nemoralis* occurs, it is usually in fair numbers, and it is certainly a widely distributed species, not uncommon in its own group of habitats, but easily overlooked.

Philodina rugosa, n. sp.

Sp. Ch.—Small, rather stout. Skin of trunk shagreened; skin-folds prominent; ridges roughened, transversely wrinkled, or minutely sinuate. Rami 18 μ long; formula 3/3. Spurs short, moderately slender; bases separated by rather wide interstice. Eyes small and round.

I have much pleasure in giving to this species the name suggested for it by Forstmeister L. Bilfinger, who gave me in 1894 some particulars of the form now described as the type. Two years later I found a couple of specimens in moss collected in Spitsbergen by Dr. J. W. Gregory on the occasion of Sir Martin Conway's expedition to that island. With the exception that they were smaller, these specimens agreed well with the particulars of those found by my correspondent near Stuttgart.

The minutely sinuous and prominent ridges of the skin-folds of the trunk give this form a very distinctive appearance. The skin is somewhat opaque and of a greyish-brown colour. The body is seldom seen extended, as the animal is extremely sluggish in its habits. When feeding, it invariably conceals its foot beneath the hinder part of the body—a habit which gives it an additional appearance of stoutness. The corona (45 μ) is little wider than the collar (40 μ). The sulcus between the pedicels is only moderately wide, and the central portion of the upper lip is slightly concave. In dorsal view the eyes are small and round. The rather short and stout foot has spurs 6 μ long, scarcely so slender or so acute as those of *P. nemoralis*, and the interstice between them is nearly equal to their length. The Stuttgart examples measured 270 μ; those from Spitsbergen only about 230 μ. My figure represents one of the latter.

I include in this species two fairly well-marked varieties. The first of these, *coriacea*, is a rather larger form, and differs from the type in the lesser prominence of the lateral series of skin-folds, the obliteration of the dorsal series, and the absence of the sinuous and roughened ridges so conspicuous in typical examples. The skin of the trunk is profusely shagreened, reddish-brown, and rather opaque. The spurs in this variety are about 9 μ long, and the interstice between their bases is slightly convex, with a distinct central notch. A series of specimens were found in liverworts taken from a tree near Sandling Junction, Kent, in 1896.

The other variety—*callosa*—was really met with before the others, one or two specimens having been found in moss brought to me by my niece from Baden in 1893. These specimens, like others since examined, showed no trace of eyes, and were therefore judged to belong to the genus *Callidina*. I detected the eyes, however, in some specimens found at Slindon, Sussex, in 1895. In more recent years I have had this form from Edge Hill, Warwickshire, Norton's Heath, Essex, and from Hollingbourne, Kent, nearly always in liverworts. Mr. James Murray has found it not only in the same plants, but also in the open water of a Scottish loch. This variety would thus seem to be the most widely distributed in this country, but I have rarely met with more than one or two individuals at a time.

It is nearly intermediate between the typical *rugosa* and the variety *coriacea*. In general style it resembles the latter; but the skin-folds are faintly ridged and transversely wrinkled, and the skin less distinctly shagreened. The colour is pale yellowish-red or faintly greenish. In size it resembles the type form, and probably frequently escapes detection for that reason, and because of its timid and sluggish nature. In some specimens the skin is slightly viscid.

Explanation of Plate 27.

Fig. 1. *Philodina nemoralis*, n. sp., dorsal view, feeding. × 480.
„ 1*a*. „ „ foot more extended. × 480.
„ 2. *Philodina rugosa*, n. sp., dorsal view, feeding. × 480.
„ 3. *P. rugosa*, n. sp., variety *coriacea*, dorsal view, feeding. × 480.
„ 3*a*. „ „ „ foot extended.
„ 4. *P. roseola*, lower part of foot (under compression). × 800.

Synopsis of the known Species of British Fresh-water Entomostraca.

Part II. Copepoda.

By D. J. Scourfield, F.R.M.S.

(*Read June 19th*, 1903.)

The first part of this paper, published in April last, was concerned with the animals belonging to the Cladocera. It is now proposed to deal on somewhat similar lines with the species of British Fresh-water Entomostraca comprised in the Order Copepoda. There will thus be left for consideration in a subsequent part only the Ostracoda, and a few species belonging to the Branchiura and Phyllopoda.* As before, the principal synonyms by which the species are referred to in works on British Entomostraca will be given, and the distribution of the free-swimming forms will be shown in a table similar to that prepared for the Cladocera.

Unfortunately, there is no one book dealing with the fresh-water Copepoda so completely as the "Cladocera Sueciae" does with the Cladocera. The beautiful work of O. Schmeil, "Deutschlands freilebende Süsswasser-Copepoden" (44)† contains, however, the majority of the forms found in the British Isles, and will be followed as far as possible, though supplemented occasionally by other papers, more especially by Lilljeborg's two recent publications, " Synopsis specierum . . . Cyclopis" (40) for the species of *Cyclops*, and " Synopsis specierum . . . Harpacticidarum" (41) for the Harpacticids.

* As two species of Cladocera new to Britain, *Ophryoxus gracilis* and *Scapholeberis aurita*, and several further records of rare species have been obtained since the publication of Part I., a paragraph will also have to be appended dealing with these forms.

† The numbers in brackets refer to the list of literature printed partly at the end of the present and partly at the end of the previous instalment of this paper.

COPEPODA.

Centropagidae.

Diaptomus Westwood.

D. castor (Jurine) [Schmeil (44), Brady (36)].*

A widely distributed but not very common species. Not yet seen in Wales, and only hitherto recorded from three localities in Scotland (*see* T. Scott, 22). Mr. James Murray has, however, recently found it also at Nerston Quarry, near Glasgow.

D. gracilis Sars. [Schmeil (44), Brady (36)].

D. castor Baird (in part) (1), Brady (in part) (35).

D. westwoodii Lubbock (42).

One of the very commonest of the British Entomostraca.

The "*graciloides*" form, whether a good species or not, has never been definitely recorded as British, notwithstanding the remarks on the subject by Brady (36).

D. vulgaris Schmeil [Schmeil (44) = *D. coeruleus*].

Only found as yet in the south and east of England.

D. wierzejskii Richard [Schmeil (44); Brady (36) = *D. serricornis*].

D. serricornis Brady (36), Scott (20, 23).

This seems to be characteristic of the extreme north of Scotland, although it occurs also in the "Highland" region. It is the only species found in the Shetland Islands, if we except a single record of *D. castor* (23).

D. hircus Brady [Brady (36)].

This species may be peculiar to the British Isles—at least, no foreign localities are given by Schmeil in "Das Tierreich" (45). It is closely allied to the foregoing, but the female has two setae instead of one on the thirteenth joint of the first antennae, and a distinctly two-jointed inner branch to the fifth pair of feet, while the male has a "ploughshare-shaped process" with "an obscurely fimbriated free margin" on the last joint but two of the right antenna instead of a strongly serrated appendage.

A variety, in which the process on the male right antenna simply bears a pointed tooth, is widely distributed in Scotland and also occurs in Ireland. Specimens of what seems to me to be this variety, collected by Mr. Kane in Lough Mask, are regarded by Canon Norman as *D. laticeps* Sars.

* The references within square brackets, following the name of a species, indicate where figures and descriptions of the same may be found.

D. bacillifer Koelbel [Brady (36)].

Only noted by Brady (36) from Loch Earn, Perthshire, so far as I am aware. As the adult male was not seen, the record is not so satisfactory as it might be.

D. laciniatus Lilljeborg [Schmeil (44) "Nachtrag"; T. & A. Scott (54)].

Confined to Scotland apparently, and a rare species even there. Mr. J. Hewitt tells me, however, that it occurs pretty constantly in Lewis.

D. sanctipatricii Brady [Brady (36)].

If this is really distinct from *D. laciniatus*, it seems to be peculiar to the British fauna. It has only been found as yet by Professor Brady in Connemara (36).

Eurytemora Giesbrecht.

E. velox (Lilljeborg) [Schmeil (44) = *E. lacinulata*; Brady (36) = *E. clausii*].

Temora velox Brady (35).
E. clausii Brady (36), Scott (20, 46, 47).
E. lacinulata Scourfield (29).

Usually occurring in or near brackish water, but also thriving in absolutely fresh water far inland, as at Higham Park, Essex, the East London Waterworks reservoirs, little loch above Rutherglen (47), etc.

E. affinis (Poppe) [Schmeil (44), Brady (36)].

Rarely, if ever, found far away from brackish water influence.

CYCLOPIDAE.

Cyclops O. F. Müller.

C. strenuus Fischer [Schmeil (44), Brady (36)].

C. brevicaudatus and *C. clausii* Lubbock (42).
C. strenuus and *C. pulchellus* Brady (35).
C. strenuus, *C. abyssorum*, and *C. vicinus* Brady (36).
C. ewarti Brady (36), Scott (20, 46).

Lilljeborg (40) admits no less than five variations of the *strenuus* type to rank as species—viz., *C. strenuus*, *C. scutifer*, *C. kolensis*, *C. miniatus*, and *C. vicinus*; but it is doubtful whether these can all be maintained. We certainly have some of these forms in this country, but no separate records exist except for "*vicinus*." The *C. ewarti* Brady is almost certainly an immature stage of this species.

C. leuckarti Claus [Schmeil (44); Brady (36) = *C. scourfieldi*].
C. scourfieldi Brady (36), Scourfield (26).

C. oithonoides Sars [Schmeil (44); Brady (36) = *C. scourfieldi* var.].
C. scourfieldi var. Brady (36), Scourfield (26).

The variety "*hyalinus*," admitted by Lilljeborg (40) as a distinct species, occurs as well as the typical form.

Not yet found in Scotland.

C. dybowskii Lande [Schmeil (44)].

According to Lilljeborg (40) this ought to be known as *C. crassus* Fischer.

C. bicuspidatus Claus [Schmeil (44); Brady (36) = *C. thomasi*].

The variety "*lubbockii*" Brady [= *C. insignis* Brady (35, 36)], with fourteen-jointed antennae, is only found in or near brackish water.

C. languidus Sars [Schmeil (44)].

C. languidoides Lilljeborg [Lilljeborg (40)].

This has been found recently by Mr. Robert Gurney in the "Broads" district, but has not hitherto been recorded. It is very closely related to the following species.

C. nanus Sars.

Prof. Sars has very kindly examined specimens for me, and says they unquestionably belong to the *C. nanus* described in his "Oversigt" in 1863. As no figures of this species appear to have yet been published, illustrations of a few details will, if possible, be issued with the next part of this paper.

Recorded by T. Scott from two or three places in Scotland (20). I have also taken it in Scotland, and I believe also near London; Dr. and Miss Sprague inform me that they have seen it in the Lake District.

C. vernalis Fischer [Schmeil (44)].
? *C. elongatus* Brady (36).

The *C. kaufmanni* of Brady's "Monograph" and "Revision" (35, 36) is probably the immature male of this species, but young males of *C. viridis*, etc., are very similar.

C. bisetosus Rehberg [Schmeil (44); Brady (36) = *C. bicuspidatus*.]

C. viridis (Jurine) [Schmeil (44); Brady (36)].
C. gigas Brady (35).

Lilljeborg (40) regards *C. viridis* and *C. gigas* as distinct species, but I often find specimens combining the characters of both.

The variety which I have referred to as "*brevicornis*," under the mistaken impression that it was *C. brevicornis* Claus, may, however, really be a good species. It is always distinguished by its smaller size, its pelagic habit, and the absence of setae on the inner edges of the caudal rami. It has only been seen in the south-east of England.

C. diaphanus Fischer [Schmeil (44)].

C. longicaudatus Brady (36).

Apparently a very rare species. Brady (36) only mentions it from one locality, Ebbesborne, near Salisbury, and I have taken it on Mousehold Heath, Norwich. No further records are known.

C. bicolor Sars [Schmeil (44)].

C. rubellus Lilljeborg [Lilljeborg (40)].

Miss B. Sprague (55) has lately put this on record as a British species. I have found it also in the same locality (Lake District), and Mr. Robert Gurney informs me that he has found it in the "Broads" district.

C. varicans Sars [Schmeil (44)].

C. fuscus (Jurine) [Schmeil (44)].

C. quadricornis var. *c.* Baird (1). *C. coronatus* Lubbock (42).
C. signatus Brady (35) and in part (36), Scourfield (26).

C. bistriatus Koch [Schmeil (44) = *C. albidus* var. *distinctus*; Lilljeborg (40) = *C. distinctus*].

As I have already stated (29), I believe that this form must be referred to Koch's *C. bistriatus* (39). The vexed question as to whether it is a good species or a hybrid between *C. fuscus* and *C. albidus* has not yet been settled so far as I am aware. It has only hitherto been found in the south and east of England.

C. albidus (Jurine) [Schmeil (44)].

C. tenuicornis Lubbock (42), Brady (35), Scourfield (26).
C. signatus Brady (36) in part.

C. serrulatus Fischer [Schmeil (44), Brady (35, 36)].

This extremely common species has long been recognised as exhibiting considerable variation, and Lilljeborg (40) has proposed to divide it into three distinct species—viz. *C. serrulatus* in the strict sense, *C. macruroides*, and *C. varius*, the latter being further subdivided into the three new varieties, *speratus*, *proximus*, and *brachyurus*. Naturally no sufficient records yet exist to show how these forms are distributed in this country, but from my own experience it seems that *C. varius* is much commoner than either of the other two. My doubtful record of *C. macrurus*, from Wanstead Park (26), was most probably a male of *C. macruroides*. Whether all these subdivisions of the old *C. serrulatus* are really permanently differentiated forms or not seems to require further investigation.

C. macrurus Sars [Schmeil (44), Brady (36)].

A rather rare species, and not yet found in Ireland or Wales.

C. prasinus (Jurine) [Schmeil (44), Brady (36) = *C. magnoctavus*].

C. magnoctavus Brady (36).

A widely distributed species, and sometimes occurring in great numbers, but on the whole by no means common.

C. affinis Sars [Schmeil (44), Brady (36)].

C. phaleratus Koch [Schmeil (44), Brady (36)].

C. canthocarpoides Lubbock (42).

C. fimbriatus Fischer [Schmeil (44), Brady (36)].

C. crassicornis Brady (35).

The variety "*poppei*" (*see* Schmeil, 44) also occurs in this country, but I have only found it once, many years ago, at Hackney Marsh.

C. aequoreus Fischer [Brady (35)].

This ought not, perhaps, to be included in a list of fresh-water Copepoda; for although it does not occur in the sea, it is never found far away from the influence of salt water. It seems to occur in marshes and dykes near the sea all round our coasts.

Harpacticidae.

Canthocamptus Westwood.

C. minutus (O. F. Müller) [Schmeil (44) and Lilljeborg (41) = *C. staphylinus*].

C. minutus Baird (1), Brady (35), Scourfield (26).

C. staphylinus Scourfield (28, 29), Scott (20, 49).

The views of Canon Norman as to the correct name for this (and the following species) are given by T. Scott (49), pp. 195-6. In a letter recently received, Canon Norman also calls my attention to the fact that Jurine himself quotes Müller's *Cyclops minutus* as a synonym for his own *Monoculus staphylinus*.

C. lucidulus Rehberg [Schmeil (44) and Lilljeborg (41) = *C. minutus*].

C. minutus Claus; Scott (20, 49, 52), Scourfield (28, 29).

C. horridus Fischer [Schmeil (44) = *C. northumbricus*; Lilljeborg (41)].

C. northumbricus Brady (35), Scott (46), Scourfield (29).

C. gracilis Sars [Lilljeborg (41).]

C. inornatus Scott (20, Part VII.).

C. trispinosus Brady [Schmeil (44), Lilljeborg (41)].

Not uncommon in the south and east of England, but not yet seen in Scotland, Ireland, or Wales.

C. hirticornis T. Scott [Lilljeborg (41) = *C. megalops*; Scott (20, Part V.)].

C. subsalsus Brady (37).

More usually found in situations within the influence of brackish water, but also occasionally in perfectly fresh water.

C. palustris Brady [Brady (35)].

This species is scarcely a fresh-water form in the strictest sense, as it seems to be confined to water containing at least a slight trace of salt. Messrs. T. & A. Scott (51) have recorded a variety which they have named *C. palustris* var. *elongatus*.

C. schmeilii Mrázek [Lilljeborg (41), T. & A. Scott (52)].

Peculiar to Scotland so far as shown by our records.

C. bidens Schmeil [Schmeil (44)].

I only know of one British locality for this species—namely, the Water-Lily Pond, Kew Gardens, where I found it in May, 1902 (32).

C. crassus Sars [Schmeil (44), Lilljeborg (41)].

Attheyella spinosa Brady (35), Scott (46).

C. pygmaeus Sars [Schmeil (44), Lilljeborg (41)].

C. cryptorum Brady (34).

Attheyella cryptorum Brady (35), Scott (46).

One of our commonest Copepods, but it must usually be sought for by washing wet mosses and dense masses of vegetation.

C. zschokkei Schmeil [Schmeil (44)].

Attheyella propinqua T. Scott (20, Part III.).

C. rhaeticus Schmeil [T. & A. Scott (51) = *Attheyella MacAndrewae*].
Attheyella MacAndrewae T. & A. Scott (51), T. Scott (20).
C. MacAndrewae Scourfield (28).

C. duthiei T. & A. Scott [Lilljeborg (41), T. & A. Scott (53)].
Only recorded from Shetland and Loch Leven, Kinross.

C. cuspidatus Schmeil [Scott (20, Part VII.)].
Found in several localities in the middle and north of Scotland, but as yet nowhere else in the British Isles.

Nitocra Boeck.

N. hibernica (Brady) [Schmeil (44), Lilljeborg (41)].
Canthocamptus hibernicus Brady (35).
Found in several localities in the south and east of England, also two in Ireland, but not recorded from any other part of the country.

Moraria T. & A. Scott.

M. brevipes Sars [Mrázek (43) and Schmeil (44) = *Ophiocamptus sarsii*; Lilljeborg (41)].
M. anderson-smithi T. & A. Scott (50), T. Scott (20), Scourfield (29).
Apparently not uncommon in Scotland; also seen in one or two places in the south and east of England, but not elsewhere.

M. mrázeki T. Scott (49) [Mrázek (43) and T. Scott (20, Part V.) = *Ophiocamptus brevipes*].
Ophiocamptus brevipes and *Moraria brevipes* T. Scott (20).
Recorded from several places in Scotland. I believe I have also seen it in North Wales, but know of no other localities.

M. poppei (Mrázek) [Mrázek (43) = *Ophiocamptus poppei*; Scott (20, Part VII)].
A rare species only recorded from three stations in Scotland (*see* 49).

Maraenobiotus Mrázek.

M. vejdovskyi Mrázek [Mrázek (43), T. & A. Scott (53)].
As in the case of *Moraria poppei*, this has only been taken from three localities in Scotland (*see* 49).

Belisarius Maupas.

B. viguieri Maupas [Mrázek (43) = *Phyllognathopus paludosus*].

This has only been obtained in this country from the Royal Botanic Gardens, Regent's Park, London, and Kew Gardens, where I find it almost constantly in the cups formed by the leaves of Bromeliaceous plants. On one occasion at Kew I also found it in the pitchers of one of the Pitcher-plants. Apart from its peculiar habitat, it is a very remarkable species in other ways. For instance, it is quite blind, it does not carry its eggs in an ovisac, but apparently allows them to drop to the bottom, and it possesses a special vibrating organ in the region of the shell-gland which is quite unique so far as our present knowledge of the crustacea goes.

In all my specimens, the caudal furca in the adult female differs somewhat from Mrázek's figure, but I can find no other point of difference. I hope to issue a drawing of the species with Part III. of this synopsis.

In the foregoing enumeration of free-swimming Copepoda only a few forms have been admitted which can be considered as belonging rather to brackish than to fresh water. These are *Eurytemora affinis* Poppe, *Cyclops bicuspidatus* var. *lubbockii* Brady, *Cyclops aequoreus* Fischer, *Canthocamptus palustris* Brady, and perhaps *C. hirticornis* T. Scott. There are, however, quite a number of other species which occur in brackish water, the most important of which it may be useful to enumerate here without going into further details. Most of them are to be found figured and described in Brady's monograph of the British Copepoda (35).

Acartia longiremis Lilljeborg.
Ectinosoma curticorne Boeck.
Tachidius discipes Giesbrecht (= *T. brevicornis* O.F.M.).
Tachidius littoralis Poppe.
Delavalia palustris Brady.
Mesochra lilljeborgii Boeck.
„ *robertsoni* Brady.
Laophonte similis Claus.
Laophonte littorale T. & A. Scott.
„ *mohammed* Blanchard & Richard.
Cletodes tenuiremis T. Scott (= *Itunella subsalsa* Brady).
Nannopus palustris Brady.
Platychelipes littoralis Brady.
Dactylopus tisboides Claus.
Harpacticus fulvus Fischer.

Parasitic Copepoda.

Caligus O. F. Müller.

C. rapax M. Edwards [Baird (1)].

Recorded by Baird (1) from Lough Neagh, where it was taken on trout and pollan (*Coregonus pollan*).

C. curtus O. F. Müller [Baird (1) = *C. mülleri*].

Also from the pollan in Lough Neagh.

It is very doubtful whether the two foregoing species ought to be included in a list of fresh-water Copepoda, in spite of Baird's records from L. Neagh. They seem to be distinctly marine forms.

Lepeophtheirus v. Nordmann.

L. stromii Baird [Baird (1)].

Found on salmon and salmon-trout.

Lernaeopoda Blainville.

L. salmonea (Gisler) [Baird (1)].

Taken on the gills of the salmon.

Lernaeocera Blainville.

L. cyprinacea (L.) [Baird (1)].

Occurs on carp, bream, and roach.

Achtheres v. Nordmann.

A. percarum v. Nordmann.

I have seen specimens from a trout caught in Loch Rannoch.

Thersites Pagenstecher.

T. gasterostei Pagenstecher [Scott (48)].

Recorded by T. Scott (22) from Barra, R. Forth, and Aberdeen. It occurs on the inside of the gill-covers of the three-spined Stickleback (*Gasterosteus aculeatus*).

The following table, showing the distribution of the free-swimming forms of British fresh-water Copepoda, has been prepared in similar form to that adopted in Part I. for the Cladocera. The column devoted to "Midland England" has been omitted, however, as it was impossible to obtain sufficient records for this district.

DISTRIBUTION OF BRITISH FRESH-WATER COPEPODA.

Species.	England.							Wales.	Ireland.	Scotland.			
	South and East.				North								
	Epping For.	Richmond.	Norfolk Bds.	Total S. and E.	Total N.	Lake Dist.	Total England.			Total Scotland.	"Lowlands."	"Highlands."	Extreme North.
CENTROPAGIDAE.													
Diaptomus castor	×	...	×	×	×	...	×	...	×	×	×	×	×
" *gracilis*	×	×	×	×	×	×	×	×	×	×	×	×	×
" *vulgaris*	×	×	×	×	...	...	×	...	...	...	...	...	...
" *wierzejskii*	...	...	...	...	...	...	...	...	...	×	...	×	×
" *hircus*	...	...	...	...	×	×	×	×	×	×	} ×	×	×
" " *var.*	...	...	...	...	...	...	...	...	×	×			
" *bacillifer*	...	...	...	...	...	...	...	...	...	×	...	×	...
" *laciniatus*	...	...	...	...	...	...	...	...	...	×	×	×	...
" *sanctipatricii*	...	...	...	...	...	...	...	...	×	...	...	...	...
Eurytemora velox	×	×	×	×	×	...	×	×	...	×	×	...	...
" *affinis*	...	×	×	×	×	...	×	...	...	×	×	...	...
CYCLOPIDAE.													
Cyclops strenuus	×	...	×	×	×	×	×	×	×	×	×	×	×
" " *vicinus*	×	×	×	×	×	×	×	...	...	×	×	×	...
" *leuckarti*	×	×	×	×	×	×	×	...	×	×	×	×	...
" *oithonoides*	×	×	?	×	...	...	×	×	×	...	...	...	...
" " *hyalinus*	×	?	×	×	...	...	×	...	...	...	...	...	...
" *dybowskii*	×	...	×	×	×	×	×	...	...	×	?	×	...
" *bicuspidatus*	×	...	×	×	×	×	×	...	×	×	×	×	×
" " *lubbockii*	...	...	...	×	×	...	×	×	...	×	×	...	...
" *languidus*	×	...	×	×	×	×	×	×	...	×	×	×	...
" *languidoides*	...	...	×	×	...	...	×	...	...	...	...	...	...
" *nanus*	...	...	...	×	×	×	×	...	...	×	×	×	...
" *vernalis*	×	...	×	×	×	×	×	×	...	×	×	×	×
" *bisetosus*	×	...	×	×	×	...	×	×	...	×	×	×	...
" *viridis*	×	×	×	×	×	×	×	×	×	×	×	×	×
" " *var.*	×	×	...	×	...	...	×	...	...	...	...	...	...
" *diaphanus*	...	...	...	×	...	...	×	...	...	...	...	...	...
" *bicolor*	×	×	×	×	×	×	×	×	...	×	...	×	...
" *rubellus*	...	...	×	×	×	×	×	...	...	...	...	...	...
" *varicans*	×	..	×	×	×	×	×	...	...	×	...	×	...
" *fuscus*	×	×	×	×	×	×	×	×	×	×	×	×	×
" *bistriatus*	×	×	×	×	...	...	×	...	...	...	...	...	...
" *albidus*	×	×	×	×	×	×	×	×	×	×	×	×	×
" *serrulatus s. str.* }													
" " *varius* }	×	×	×	×	×	×	×	×	×	×	×	×	×
" " *macruroides* }													
" *macrurus*	...	...	×	×	×	×	×	...	...	×	×	×	...
" *prasinus*	×	×	×	×	×	×	×	×	×	×	×	×	...
" *affinis*	×	...	×	×	×	×	×	×	...	×	×	×	×

DISTRIBUTION OF BRITISH FRESH-WATER COPEPODA.

Species.	England.									Scotland.			
	South and East.				North								
	Epping For.	Richmond.	Norfolk Bds.	Total S. and E.	Total N.	Lake Dist.	Total England.	Wales.	Ireland.	Total Scotland.	"Lowlands."	"Highlands."	Extreme North.
CYCLOPIDAE—*continued.*													
Cyclops phaleratus	×	...	×	×	×	...	×	...	×	×	×	×	...
" *fimbriatus*	×	...	×	×	×	×	×	×	×	×	×	×	×
" " *poppei*	...	...	...	×	...	...	×	...	...	...	...	...	...
" *aequoreus*	...	...	×	×	×	...	×	×	×	×	×	?	×
HARPACTICIDAE.													
Canthocamptus minutus	×	×	×	×	×	×	×	×	×	×	×	×	×
" *lucidulus* (=*minutus, Claus*)	×	×	×	×	×	×	×	×	...	×	×	×	×
" *horridus*	×	...	...	×	×	×	×	...	...	×	×	×	...
" *gracilis*	...	×	×	×	×	...	×	...	...	×	×	×	...
" *trispinosus*	×	×	×	×	...	...	×	...	...	...	...	...	...
" *hirticornis*	...	...	×	×	...	...	×	×	...	×	×	×	×
" *palustris*	...	...	×	×	...	...	×	...	...	×	×	×	×
" *schmeilii*	...	...	...	...	...	...	...	...	...	×	×	×	...
" *bidens*	...	×	...	×	...	...	×	...	...	...	...	...	...
" *crassus*	×	×	×	×	×	...	×	×	...	×	×	×	×
" *pygmaeus*	×	...	×	×	×	×	×	×	...	×	×	×	×
" *zschokkei*	×	...	×	×	×	×	×	×	...	×	×	×	×
" *rhaeticus*	...	...	...	...	×	...	×	×	...	×	...	×	...
" *duthiei*	...	...	...	...	...	...	...	...	...	×	×	...	×
" *cuspidatus*	...	...	...	...	...	...	...	...	...	×	...	×	×
Nitocra hibernica	×	×	×	×	...	...	×	...	×	...	...	...	...
Moraria brevipes	×	...	?	×	...	...	×	...	...	×	×	×	×
" *mrázeki*	...	...	...	...	...	...	...	?	...	×	×	×	...
" *poppei*	...	...	...	...	...	...	...	...	...	×	×	×	...
Maraenobiotus vejdovskyi	...	...	...	...	...	...	...	...	...	×	×	×	...
Belisarius viguieri	...	×	...	×	...	...	×	...	...	...	...	...	...

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The Photography of Cavities in Minerals, and the Determination of the Condensation Points of the Enclosed Gases.

By A. Ashe.

(*Read June 19th*, 1903.)

Plate 28.

Through the kindness of Mr. Traviss I have been afforded an opportunity of examining a specimen of topaz in which occurred some exceptionally large cavities enclosing apparently liquid carbonic acid gas.

As the slide presented points of great interest, photographs were taken in the usual manner with a horizontal microscope, using a 1½-inch objective and No. 2 ocular, the illumination being by means of an oil lamp, except in the case of three instantaneous views, when limelight was employed in conjunction with a rapid shutter. The photograph No. 1 is that of a cavity which at a temperature of 34° F. is filled to the extent of one-third of its volume with condensed carbonic acid. When the temperature of the liquid was raised to 60° or 70° F., no perceptible increase in its volume was apparent—in fact, within this range of temperature it followed the ordinary laws of expansion of liquids when under the influence of heat; but as it approached 82° F., it expanded at a rapid rate until at 84° F. it filled the entire volume of the cavity (see photograph No. 2).

On cooling the liquid quickly, an interesting phenomenon took place. At a particular temperature a number of rapidly moving bubbles were generated in the liquid, and for a moment there was an appearance of ebullition too quick for the eye to follow.

An attempt was therefore made to obtain some instantaneous photographs of the liquid in this effervescing condition, and the photographs Nos. 3, 4, and 5 were secured by employing lime-light as an illuminant, together with an instantaneous shutter attached to the camera.

In order that the shutter might be released at the right moment, a "vertical illuminator," of the cover-glass pattern, was placed over the ocular, which thereby deflected a small portion of the light to the side of the microscope, whilst the greater portion of it passed on through the glass into the camera. By this simple means the field of view could be observed and the photograph taken at any desired moment.

No. 3 shows the appearance produced when the slide was quickly cooled and the liquid was in a state of violent effervescence.

No. 4 is the same, but was taken when the action had nearly ceased; and as the cavity was placed in a different position, the form of the vacuum bubble is seen to greater advantage. The effects of surface tension may be noticed in this photograph by the little drops of liquid which linger for an appreciable time on the surface of the condensed portion.

No. 5 is similar to No. 3, but is slightly enlarged. In a few cavities the condensation took place more gradually, and gave the appearance of falling raindrops rather than of ebullition. This difference in their behaviour seemed to be due entirely to the ratio of the volume of the enclosed liquid when cool to the volume of the cavity it occupied.

When this ratio was high, the liquid contracted from a large bulk to a small one with great violence; but when, on the contrary, the ratio was low, the contraction being less, it proceeded more evenly, and produced the appearance of falling rain.

In order to determine with accuracy the precise temperature at which these effects took place, an apparatus was employed of which the following description, together with the photographs given, will render its use apparent in similar work.

The first requisite in an apparatus of this kind is that the temperature may be made to fall at a very low and even rate, and this is best attained by enclosing the mineral in a relatively enormous mass of water and allowing the whole to cool spontaneously—a requirement which is met by the arrangement shown, in which

(A) is a lamp.

(B) a glass globe holding about 1,500 c.c. of recently boiled distilled water.

(C) a thermometer graduated to one-tenth of a degree.

(D) a perforated cork to hold the thermometer in any required position.

(E) the slide which should be in close contact with the mercurial bulb of the thermometer.

(F) a flat piece of glass which must be "oiled on" to the globe at the point of contact.

(G) a low-power objective which forms a telescopic image of the slide at the point H.

(M) a microscope with which to observe the image H.

To use this apparatus the flask is filled with water at a temperature of 85° to 86° F.

The microscope and lamp are placed at opposite sides of the globe and as nearly as possible in a line passing through its centre. The flat piece of glass is then oiled on and secured in its position at right angles to this line.

Under these conditions the definition of an object in the centre of the globe will be sufficiently good to enable the cavities to be satisfactorily examined. The thermometer is then lowered into its place as close to the object as is possible.

The object of employing such a large bulk of water is to prevent the lowering of the temperature proceeding too rapidly, thereby enabling the thermometer and slide to approximate to each other's temperature, and to compensate in some measure for the different rates at which different bodies radiate heat into their cooler surroundings.

In practice a fall of one-tenth of a degree F. per minute should not be exceeded, and as this very gradual and uniform change of temperature is so necessary, it follows that the reverse operation of raising the temperature by means of a lamp placed beneath the globe gives fallacious results; for however carefully done, the thermometer cannot quickly respond to the temperature of the mixed currents of hot and cold water which are inevitably produced, but by following the method here recommended repeated tests will always give the same results, the only drawback being the length of time required to make and verify an observation.

Explanation of Plate 28.

Fig. 1. A cavity in Topaz containing:
a. The vacuum above the condensed liquid B.
b. The condensed liquid showing its volume at temperatures between 34° F. and 70° F.

,, 2. The same at 84° F., showing the increase in volume of the liquid and the disappearance of the vacuum.

,, 3. Is taken at the condensation point, when the liquid was in a state of effervescence.
a. Mixture of gas and liquid.
b. Liquid collecting at the bottom of the cavity.

,, 4. Shows the termination of the condensation, and at—
a. Several little drops supported by surface tension on the liquid.
b. The condensed liquid.

,, 5. This photograph is taken at a similar point of condensation to that in Fig. 3, and it may be noticed that the drops in their fall from the top of the cavity increase considerably in size.

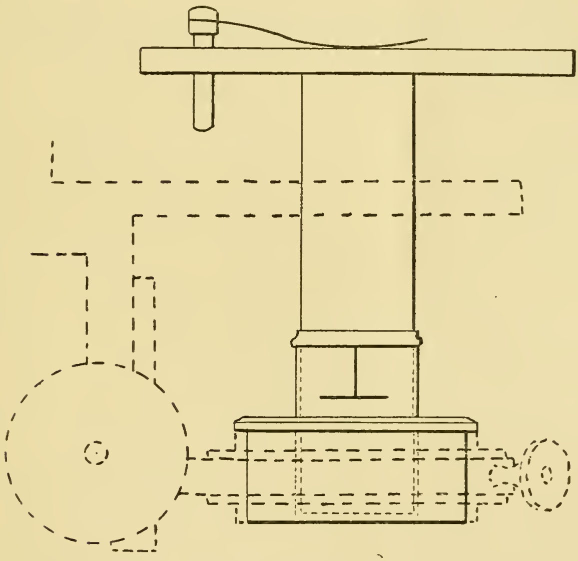
,, 6. Apparatus for observing the condensation points of gases contained in mineral cavities.

Note on a Metallurgical Stage.

By W. B. Stokes.

(*Read March 20th*, 1903.)

The appliance exhibited may be said to effect a temporary conversion of any microscope possessing a focussing substage into a stand suited to the needs of metallurgists.



When using the "vertical illuminator," it is found that a change of object often involves a considerable change in the illumination, but by giving the stage a focussing movement the lighting arrangements remain undisturbed. In stands specially made for metallurgists, this extra movement is provided; the aim of the present accessory is to supply this movement to an ordinary microscope. Taking advantage of the substage movement, it is evident that we only require a stage plate fixed to a stem, which fits into a substage adapter in such a way that the stem passes through the ordinary stage aperture. (See the accompanying diagram.)

The present form, which has been made by Messrs. Swift & Son, though simple, is capable of any necessary elaboration. For instance, as it is seldom that metal sections have their upper surfaces parallel to the stage, a levelling carrier must be employed. This may take the shape of a plate, through which pass three screws with milled heads at equidistant tapped holes near the edge; then the carrier will be a tripod with legs of variable length by which the section may be placed with its surface at right angles to the optic axis and moved about in that position. If the microscope be inclined, large bowed spring clips must be attached to the lower face of the carrier to curl round the edge of the focussing stage and press against its lower surface.

Note on a Method of taking Internal Casts of Foraminifera.

By H. J. Quilter.

(*Read May 15th*, 1903.)

It may be of interest to some to know that very fair internal casts of some, at least, of the Foraminifera can be taken in paraffin wax.

The idea of taking these casts was first suggested in a conversation which I had with Mr. Earland about a year ago, and soon after, the first casts were made by dropping the shells into melted paraffin wax, in which they were left for a short time, then picking them out and rolling them on a slip of glass just warm enough to melt the wax. This method was on the whole unsatisfactory, as although perfect casts were obtained, they were too fragile to bear much handling. This was due to the fact that a large part of the wax inside the shell ran out again, leaving the casts hollow. Then casts in bees-wax, in resin, in Canada balsam, and in various compounds were tried, but none of these gave such good results, or were as easy to manipulate as paraffin wax. It was realised that a solid cast was necessary in order to obtain the necessary strength and tenacity, and, after prolonged experiment, I have succeeded in obtaining perfect specimens by the following method.

The shells, having been cleaned by boiling in caustic potash, in order to remove all trace of sarcode from the tubuli, are first soaked in benzole. This extracts most of the air, and prepares the surface of the shell for the wax. They are then transferred to melted paraffin wax (the higher the melting point the better), and the wax is then heated and cooled several times, the object being to expel air. After all air-bubbles have disappeared from the shells, a 3in. × 1in. glass slip is cleaned, and a little of the wax in which the shells are soaking is put in its centre, and the slide heated on a warm stage, and maintained at a temperature sufficiently high to keep the wax in a fluid state. The shells should now be transferred to the wax on this slide, and arranged so that there is a clear space round each. The slide is then allowed to cool; when the wax is quite hard, a camel's-hair pencil, cut square across so as to make a stiff brush, is dipped in benzole, and the shells are well brushed with this until the wax above and around them has been removed. Care must be taken that the brush does not retain too much benzole, or the casts will be spoiled. They are then well washed with a camel's-hair brush and soap and water; after this treatment they should be quite clean, and remain attached to the slide by a small pellet of wax. The slip with the shells attached is now put into a beaker, and sufficient water poured in to cover them; hydrochloric acid is then added until brisk effervescence takes place. The slip is left in this as long as any gas is given off; it is then taken out, washed in clean water, and left in a cool place to dry; when quite dry it is ready for mounting.

Sometimes during the treatment with acid and water the shells or casts float off the slip, and must then, when all the shell has been dissolved, be picked out one at a time, dried, and remounted on the slip with Canada balsam or gum.

Little trouble will be experienced when taking casts of the larger forms, but with the smaller ones it is different, as these will be found to become detached from the slide towards the end of the treatment with the benzole and brush; but as a rule, when this happens, the outsides of the shells are clean enough, and they can then be transferred to the acid and water, and afterwards treated as before described.

Note on some Insects sent from Queensland by Mr. C. J. Pound, F.R.M.S.

By R. T. Lewis, F.R.M.S.

(*Read June 19th*, 1903.)

At the meeting of the Quekett Club in May, three bottles containing insects in spirit were handed to me by Mr. Rousselet, with a request that I would examine the contents and report if they contained anything of interest to the Club, as they had been sent from Queensland by Mr. C. J. Pound.

The smallest bottle contained two crab spiders and a silken ovisac containing a number of eggs, which from their condition appeared to have been recently laid when transferred to the spirit, as they contained no sign of embryo, and neither they nor the spiders appeared to be of microscopic interest.

The second bottle was labelled, "Insects found on dried cow's-hide," and contained about a dozen larvae in various stages of growth, all of the same species and obviously those of some kind of beetle. The structure of their mandibles indicated that these were likely to be very effective upon dry animal tissues, and the resemblance to the mouth organs of the larvae of a small beetle which I found some time ago actively engaged in destroying a leather hand-bag was at once remarked. It does not seem possible to identify the species in question from an examination of the larvae, but I have mounted a specimen for the collection of the Club, which may some day be of use for purpose of comparison.

The third bottle was much larger, and contained a number of lepidopterous larvae in various stages, some lepidopterous pupae of four different species, and a very perfect specimen of a common Australian species of Phasmidae, apparently a *Podacanthus*; but as this measures about three inches in the body, it can hardly be regarded as microscopic. Its original colour has no doubt been discharged by the spirit, and its complete saturation rendered it rather difficult to set in a very satisfactory manner. Of the pupae in this bottle, the most interesting were some which were suspended by the posterior extremity from the under-sides of some leaves, a noticeable feature being a row of brilliant spots of golden metallic lustre round the abdomen, and four similar but larger tubercles upon the head. Whether these were the same species as the larvae, it is not possible to determine; but as one of the number had the appearance of being almost mature, I ventured to carefully remove the investing pupa case, and was rewarded by finding inside a butterfly so perfectly formed that it must have been within a few hours of emergence when put into the spirit. The wings were as usual very short, but on setting them out, the pattern upon them was quite distinct, although the wings were less than one-third of their ultimate length. It is well known that after emergence from the pupa case a butterfly usually rests for a time upon some upright object, and that during this period the wings are lengthened out to their full size, and after the complete adhesion of the upper and under surfaces the membranes become dry and hard, and the insect is then ready to take flight. An examination of the wing at this time shows it to be perfectly covered with scales, each row overlapping that below it, like the tiles on a roof, and it has sometimes been a little difficult to understand how this arrangement came about, seeing that the area of the wings when fully extended was at least six to nine times greater than on their first emergence. There is no doubt nothing new in the observation, but it was a source of great interest to me to have in this instance an opportunity of seeing exactly how the scales were arranged on the pupal wing. They were at once seen to be perfectly formed, but all standing on end, and packed closely together like so many tiles standing on edge and in contact, and it was obvious that the extension of the membrane to which their lower extremities were attached would have the double effect of separating the rows and causing them to incline in the direction of the line of tension, until, when this had reached its limit, they would lie horizontally in contact and overlapping, just as would happen if the tiles on edge were separated from each other by three-fourths of their length and were then laid flat in the same direction. The pattern and coloration upon the unextended wings are quite perfect, forming a pattern in miniature of what the ultimate markings would be. The present stretch of the wings being about one and a half inches, this object also is of more than microscopic size, and any attempt to mount it in a cell would render examination troublesome and unsatisfactory.

NOTICES OF RECENT BOOKS.

Faune Rhizopodique du Bassin du Léman. By Dr. Eugène Penard. $12\frac{1}{2} \times 9\frac{1}{4}$ in., 714 pages, numerous figures in the text. Geneva, 1902: H. Kündig. Price, 56 francs.

One of the most curious facts about the pursuit of microscopy is the almost utter neglect, by both amateurs and professed biologists alike, of several important groups of microscopical organisms. There are cases, no doubt, where there is some excuse for this, owing it may be to the difficulty of the study or to the fact that the literature of the subject is very scattered and written in a perfect babel of foreign tongues. In the case of the fresh-water Rhizopods, however, this neglect is rather difficult to understand. The creatures are by no means rare, they are easily examined, and many of them are among the most beautiful of the smaller microscopic objects. In addition to this, we possess in Leidy's "Fresh-water Rhizopods of North America" a text-book of the highest class, with the most beautiful illustrations.

Leidy's book, however, was published in 1879, and even for that time the author took perhaps an unnecessarily conservative view as to the validity of many of the species; at any rate, it seems certain that some of the forms grouped together under a single name by Leidy are as much entitled to specific rank as any of those admitted by him as good species without question. A considerable amount of additional knowledge has also been obtained since Leidy wrote, and those few who were interested in the subject were beginning to think that a supplementary book would be very useful. Such a book has now appeared, for Dr. Penard's work is much more than a mere catalogue of the forms found in Lake Geneva and its immediate neighbourhood: it is really a monograph on the whole group (exclusive of the Heliozoa, which are to be dealt with, we understand, in a separate treatise), for, in addition to detailed accounts of all the species recorded for the district under consideration, the author gives figures and descriptions of the known species that have not so far been taken there. At first sight we are rather inclined to think that Dr. Penard has gone a little too far perhaps in the splitting up of species, but in all cases he backs up his opinion with weighty arguments drawn from his own careful observations.

While not aspiring to rank with Leidy so far as illustrations go, the book contains useful figures of all the species, and at the end (p. 702) there is a very interesting full-page illustration showing one species of every genus drawn to a uniform scale of three hundred diameters. Included in the book are a series of valuable "Notes" on such subjects as the methods of collection and study of Fresh-water Rhizopods, their shells, protoplasm, nuclei, parasites, geographical distribution, reproduction, vitality, and even psychology. There is also a good list of the literature of the subject. We heartily congratulate Dr. Penard on the appearance of this most useful book, and we hope it will be the means of stirring up renewed interest in a group of organisms which deserves very much more consideration than it usually receives.

D. J. S.

The Rôle of Diffusion and Osmotic Pressure in Plants. By B. E. Livingston. $9 \times 5\frac{3}{4}$ in., xiii. + 149 pp. Decennial Publications of the University of Chicago, Second Series, Vol. VIII. Chicago, 1903: University Press. Price, $1.50 net.

This volume consists of two distinct parts. The first, under the head "Physical Conditions," deals with elementary physical facts and theories relating to the subjects treated of in the second part, and might well serve as an introduction to a work on physical chemistry. The matter is clearly expressed, but the reader who lacks the knowledge which this part gives cannot be the same as he who would be interested in the subsequent pages. Should the student of osmotic pressure be required to pay for an elementary part which he will not need? The writer states in the preface: "It has been difficult for the student of physiology, who is not at the same time versed in physical chemistry, to obtain the information required for the prosecution of the work in this field." He must have overlooked some of the excellent and inexpensive works on chemistry; for example, "Modern Chemistry," published in England (London 1900), by William Ramsay, D.Sc., 1*s.* Such a book gives, in a very few pages, almost all that is contained in Part I. of this work.

The second part contains a general review of diffusion and osmotic pressure in plants in their biological aspect, and will prove a valuable addition to the library of the student of this subject. The bibliography is full, and appears as footnotes to the various pages. The *raison d'être* of this portion is, to quote the author, "the presentation of the promising and unpromising points for further research"; and this is kept well in view, for the difficulties are not passed over as though they were non-existent. A concise account is given of what has been done, and of the difficulties that still remain to be overcome.

One naturally turns to the question of the ascent of the transpiration current in tall trees, the solution of which has baffled so many investigators, and finds the author concluding that "just how the sap is raised in trees is not known." The chapters of this part are: Turgidity; Absorption and Transmission of Water; Absorption and Transmission of Solutes; and, The Influence of the Osmotic Pressure of the Surrounding Medium upon Organisms.

The type is clear, and the binding good. A few uncorrected errors, pp. 52, 72, and 93, suggest haste as the work passed through the press.

R. P.

THE MICROSCOPICAL EXAMINATION OF FOODS AND DRUGS. By H. G. Greenish, F.I.C., F.L.S. $9\frac{1}{2} \times 6$ in., xxiv. + 321 pages, 168 figures in the text. London, 1903: J. & A. Churchill. Price 10*s.* 6*d.* net.

The appearance of this work by Professor Greenish will be very welcome to analysts and others in this country who may be called upon to examine powdered drugs and similar pharmaceutical preparations, for, although much has been already written on the subject, the information is so scattered through the pages of scientific and technical journals that it is rarely available when wanted.

German workers, on the other hand, are well provided with literature on the subject, as may be gathered from the fact that in 1901 no less than three similar and notable books were reviewed in this Journal—viz., Hanausek's "Lehrbuch der Technischen Mikroskopie," Koch's "Die Mikroskopische Analyse der Drogenpulver," and Moeller's "Leitfaden zu Mikroskopisch-Pharmakognostischen Übungen" (see Vol. VIII., pp. 166—169).

The author, therefore, who has made full use of the above and other publications, has written this book with the view of describing the best methods of examining and recognising those vegetable tissues most commonly met with, especially those that are sold in a powdered or disintegrated state, the identification of which is made a special feature of this work.

This volume is divided into twelve sections, treating respectively of starches, hairs and fibres, spores and glands, ergot, woods, stems, leaves, bark, seeds, fruits, rhizomes, roots, together with an appendix devoted to reagents and their reactions.

Each of these sections is prefaced by an introduction to its particular subject, and is followed by a description of the most suitable methods of preparing the material, the various tissues to be observed, the important points to be noticed in connection with them, and the chemical reactions by which they are distinguished. Examples are then given of specimens from common drugs, both in the state in which they occur in commerce, and also after being ground into a fine powder.

The student is thus trained to work in a systematic manner, and is taught to recognise a material which cannot be subjected to the usual operation of section cutting, and of which it is consequently difficult to perceive the structural relationship of its component parts. This latter point is an important feature of the book, having hitherto been so much neglected by writers in this country.

The whole work is in every way a practical one, and it is desirable that in a future edition its usefulness may be extended by the inclusion of a still greater number of materials frequently met with.

A. A.

Lehrbuch der Mikrophotographie. By Dr. Carl Kaiserling. 8 × $5\frac{1}{2}$ in., viii. + 179 pages, 54 figures in the text. Berlin, 1903: Gustav Schmidt. Price 4 marks.

Unlike most books on photo-micrography, this work of Dr. Kaiserling commences with a rather lengthy description of the principal methods of projection. The author thinks, and not without reason, that the general principles of photo-micrographical technique can be most simply explained, if the elements of successful lantern enlargement are clearly understood. Not only are the simpler forms of projection apparatus alluded to, but also the complicated epidiascopes of Zeiss and others. The consideration of these leads naturally to the use of low-power objectives, such as the Zeiss planars, and then to the use of the microscope itself for projection purposes or photography. Very careful instructions are given as to the actual methods of procedure in taking photographs with the microscope, both in the horizontal and vertical positions, and such little practised branches of photo-micrography as micro-spectroscopy, micro-stereoscopy, and the production of photographs with polarised light, are by no means forgotten.

The pieces of apparatus described and figured are practically confined to the beautiful but expensive instruments of Zeiss. Dr. Kaiserling does not, however, wish his readers to suppose that only with these can good results be obtained. Nor, on the other hand, does he lead them to imagine that the possession of the most perfect apparatus is necessarily followed by the production of superior negatives. As he pertinently remarks, scientific photography is no mere trade, but an occupation demanding individual consideration, individual experiment, and persistent application. The photo-micrographer must, in fact, learn to think for himself, and not rely too much on rules laid down by others.

So far as we can see there is not much that is essential in connection with photo-micrography, the production of lantern slides (in natural colours as well as in monochrome), and projection, that is overlooked by the author. The methods of the metallographist are not mentioned, it is true; but this is a very special subject, and its omission will not detract from the great value of the book for the majority of those who take photographs with the microscope.

D. J. S.

Minute Marvels of Nature. By John J. Ward. $8\frac{1}{2} \times 5\frac{1}{2}$ in., xxiv. + 272 pages, 184 figures in the text and frontispiece. London, 1903: Isbister & Co. Price 7*s.* 6*d.*

This very attractive-looking book consists mainly of a series of articles on various microscopical subjects, which have been previously published in *Good Words* and other magazines. The author does not, of course, pretend to illustrate, or even indicate, a tithe of the vast numbers of types of microscopical structure existing in Nature; but he has certainly succeeded in putting, in exceedingly clear and simple form, a considerable amount of reliable information on the subjects actually dealt with. The first four chapters are devoted to vegetable structures, starting with the minute unicellular Algae and passing upwards to the microscopic details of higher forms of plant-life. Chapter V. treats of animal-plants and sea-weeds, and the remaining chapters deal either exclusively or in part with insects from various points of view.

With regard to the illustrations, we do not think that they are a great success. The exclusive use of photographs of the objects referred to, whilst a most praiseworthy ideal, demands that the photographs should be exceptionally good, and the method of reproduction such as to do at least a moderate amount of justice to their finer details. In the book before us, however, the half-tone illustrations scarcely fulfil the latter condition, nor do many of the photographs themselves appear to have been selected because of their exceptional technical merit. Nevertheless, the book will undoubtedly prove useful to a beginner, and may certainly be recommended to the notice of those who are in search of a novelty in the form of a gift-book on microscopy. D. J. S.

PROCEEDINGS.

March 20th, 1903.—Ordinary Meeting.

The Right Hon. Sir Ford North, F.R.S., Vice-President, in the Chair.

The minutes of the annual meeting of February 20th were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club: Mr. Thomas H. Casebourne, Mr. Edward W. Nelson, Mr. Robert A. Rolfe.

The additions to the Library and Cabinet were announced, and the thanks of the meeting given to the donors.

Mr. Stokes exhibited and described a form of stage which was made to fit into the sub-stage of an ordinary microscope, thus rendering it available for metallurgical purposes. It was explained that metallurgical microscopes were provided with a vertical movement of the stage. The supplementary stage exhibited could be fitted into the sub-stage and moved with it. He thought it would supply a want by enabling an ordinary instrument to do what could previously be only obtained by a microscope of special construction.

The Chairman thought they had in this contrivance what might prove a very valuable improvement, and anything which would make one instrument answer the purpose of two could hardly fail to be of advantage.

The thanks of the meeting were voted to Mr. Stokes for his exhibit.

Mr. Kirkaldy's note "On the Phototropism of Daphnia" was read by Mr. Scourfield, who said he could confirm the observations as to the daily movements of plankton recorded in the paper. When he and Mr. Sidwell were collecting Entomostraca in the Lake District a year or two ago, they made a special point one day of testing the vertical movement of the pelagic organisms in Windermere. During the day the surface waters, to a depth of two or three feet, only yielded a small species of *Bosmina* and young forms of other Entomostraca, together with some rotifers; whereas at deeper levels numerous individuals of such comparatively large forms as *Leptodora*, *Bythotrephes*, *Daphnia*, *Diaptomus*, *Cyclops*, etc., were obtained. Going out in the boat again about 10 p.m., they found that they could then get quite near the surface, just the same sort of collection as they had obtained earlier in the day from much greater depths.

Mr. Earland said this phenomenon was very common in respect to marine life. It was found that the tow-net brought up very little in the day, whereas at night it was crammed. He thought, however, the cause was more a question of heat than of light.

Mr. Scourfield regarded this as a very promising field for research, and hoped some who were interested in the subject would take it up.

Mr. Bryce said he had often noticed that in a glass vessel rotifers always gathered towards the side which was nearest to the light.

Mr. Wesché said he had found the same thing, and that sunny days were the best for catching rotifers.

Mr. Still presumed that the effect of the light upon these creatures was produced through the medium of their eyes, and it might be inferred that the difference produced in the case of rotifers and Daphnia might be due to the difference in their eyes.

The Chairman said their thanks were due both to the writer of the paper and to Mr. Scourfield for reading it and telling them of his experiences upon Windermere. He suggested that next time he should continue his researches beyond midnight, as he might then ascertain at what hour the old ones went to bed.

Mr. Karop read a paper on "Pocket Magnifiers," in the course of which he described, and illustrated by diagrams, the various forms which had been devised for the purpose.

Mr. E. M. Nelson said Mr. Karop had incidentally mentioned that the Lieberkühn original microscopes had been lost, but he was glad to be able to say that they were still existent. It was Leeuwenhoek's which were lost. Lieberkühn's were left to the Royal College of Surgeons, and were still intact, and he recently had the pleasure of seeing them there.

The Chairman, in moving a vote of thanks to Mr. Karop for his paper, said it was worth noting that even with such simple instruments as those which had been described very important and interesting work had been done; and if only our knowledge had increased in proportion to the advances made in the construction of microscopes, it was difficult to imagine what might have been the result.

The thanks of the meeting were unanimously voted to Mr. Karop for his paper.

Notices of meetings and excursions for the ensuing month were then made, and the proceedings terminated with the usual conversazione.

April 17th, 1903.—Ordinary Meeting.

J. G. Waller, Esq., F.S.A., Vice-President, in the Chair.

The minutes of the meeting of March 20th, 1903, were read and confirmed.

Mr. Ralph Henry Grey, Mr. Henry Williams, and Mr. Walter Bagshaw were balloted for and duly elected members of the Club.

The donations to the Library and Cabinet were announced, and the thanks of the Club voted to the donors.

A paper by Messrs. Marks and Wesché, entitled "Further Observations on Male Rotifers," was read by Mr. Wesché, and drawings of the species described were exhibited in illustration.

Mr. Rousselet said that male rotifers were not so rare as was formerly supposed. Females could often be found carrying male eggs, and if these were isolated for twenty-four hours, the males could be easily obtained. The resting eggs of *Brachionus quadratus* were, however, very rare. They could always be identified by the spines being few in number and very short and stout. He had often seen the males attach themselves to the females at any part, but whether this constituted a coïtus he could not say.

A vote of thanks to the authors of the paper was unanimously passed.

A paper by Mr. Harris, on the emission of musical notes by the Drone Fly (*Eristalis tenax*), and on its hovering habit, was read by the Secretary, six slides and some photographs of the specimens being exhibited in illustration.

Mr. Wesché thought the Club was to be congratulated on acquiring the slides which Mr. Harris had so kindly presented. It was well known, however, that the sound referred to was produced not by the wings, but by the spiracles.

A vote of thanks was then unanimously voted to Mr. Harris for his paper.

On the motion of the Chairman a vote of thanks was also given to Mr. Curties for the loan of microscopes under which were shown the slides presented by Mr. Harris.

Notices of meetings, etc., for the ensuing month were then given out, and the proceedings terminated with the usual conversazione.

May 15th, 1903.—Ordinary Meeting.

J. G. Waller, Esq., F.S.A., Vice-President, in the Chair.

The minutes of the meeting of April 17th, 1903, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club: Mr. George H. Gabb, Lieutenant-Colonel G. L. Tupman, and Mr. A. H. W. Cleave.

The additions to the Library were announced, and the thanks of the Club voted to the donors.

Mr. C. L. Curties said he had brought for exhibition an apparatus made upon the lines of Dr. Spitta's method of obtaining pure monochromatic light. It consisted of a Nernst lamp, with an aplanatic condenser, and a grating fitted upon a prism so as to give a direct beam of light to the microscope and a moderate-sized spectrum sufficient to fill the whole field of a $\frac{1}{2}$-inch objective with one colour only. He had hoped to be able to exhibit this in action, so that members might see what could be done with monochromatic light obtained in this way. Unfortunately, however, through some defect in the lamp, he was unable to show this, but hoped to be able to do so on a future occasion.

Mr. H. J. Quilter read a note "On a Method of Taking Internal Casts of Foraminifera."

Mr. Earland congratulated the author upon the remarkable success which he had achieved, and expressed his belief that the process would be one of great value to the student. Natural casts had been very largely used in the study of structure by Carpenter and others; but natural casts were often not available, and they were also very delicate and difficult objects to prepare, and seldom as perfect as the specimens exhibited by Mr. Quilter. But these natural infiltrations or casts were much more enduring than the calcareous shells of the forams, and were found in a more or less perfect state in many strata from which the actual Foraminifera had entirely disappeared. The earliest recorded Foraminifera were those of the Lower Cambrian clays of Russia and the Lower Cambrian sandstones of Shropshire, and these were all glauconitic casts, and showed a considerable diversity of form, even at this very ancient period. Similar glauconitic casts were being formed at the present time on the sea bottom round many of the Continental areas; but the chemistry of their formation was not clearly understood. He hoped that Mr. Quilter would continue his experiments, and endeavour to obtain a mineral infiltration, as this would be an improvement on wax casts.

Mr. W. J. Stokes said that the perforations in diatoms had been demonstrated by means of infiltrating them with mercury and silver salts, and suggested that similar methods might prove successful with Foraminifera.

Mr. Morland said he had with him a slide of diatoms which had been filled up in this manner, the only fault being that they generally got so much filled up that the detail was quite blotted out—because when the salt was added to the solution the precipitate came down in such a quantity that the diatoms were quite obliterated. Mr. Haughton Gill read a paper on the subject some years ago, which was published in the R.M.S. Journal.

Mr. Earland did not think this process was at all likely to be of use in the matter, because in the case of diatoms they were filling up perforations with a fine precipitate, and not obtaining, nor desiring to obtain, solid casts.

Mr. Wesché said he knew very little about Foraminifera, but it seemed to him to be a triumph to be able to ascertain what the minute inhabitants of these shells had been like. He had been exceedingly interested in the account given of the process, and heartily congratulated Mr. Quilter upon his success in the matter.

The thanks of the Club were cordially voted to Mr. Quilter for his very interesting communication.

Notices of meetings, etc., for the ensuing month were then given, and the proceedings terminated with the usual conversazione.

June 19th, 1903.—Ordinary Meeting.

J. G. Waller, Esq., F.S.A., Vice-President, in the Chair.

The minutes of the meeting of May 15th, 1903, were read and confirmed.

The following gentlemen were balloted for and duly elected members of the Club: Mr. W. Coxhead, Mr. S. C. E. Piovanelli, and Mr. H. B. Eisenberg.

The donations to the Club's Library were announced, and the thanks of the meeting voted to the donors.

Mr. Langton exhibited a small portable microscope which he had designed recently, the various parts of which could be easily detached and carried in the pocket without inconvenience. Although described as a tripod, it rested on four legs, and the focussing was managed by a sliding tube, this method being considered to be sufficiently fine for use with a $\frac{1}{4}$-inch objective; the mirror could be removed from below the stage and fixed above it when required to act as a side illuminator for opaque objects. When put together, this little instrument stood upon a small tray of the proper size to take the feet, and in this position it was found to be remarkably rigid.

Mr. Karop thought it would be advisable to add a small fine adjustment to this microscope, if it was intended to use a $\frac{1}{4}$-inch objective; for though it might be possible to focus it with care by the sliding tube, this sometimes had an inconvenient way of slipping. He thought this addition would not greatly increase the price, and would be a great advantage. The tray on which this microscope was mounted reminded him of a suggestion made some time ago as to the convenience of placing both the microscope and lamp upon a Japanese tray, which could then be passed round a table without disturbing the adjustment of the light.

Mr. Piovanelli's paper, describing two parasitic rotifers found on the common fresh-water crab of Italy, was read by Mr. Bryce. The rotifers were exhibited under microscopes in the room, and living specimens of the species of crab from which they had been taken were passed round for inspection.

Mr. Bryce also read a description of two new species of Philodinae.

The thanks of the meeting were cordially voted to Mr. Piovanelli and to Mr. Bryce for their communications.

Mr. Cheshire read a paper "On Abbe's Test of Aplanatism, and a simple Apertometer derived therefrom," * in the course of which he described various methods of examining the back focal plane of an objective, and demonstrated the method now proposed by exhibiting the arrangement on the table.

Mr. Hilton enquired if the diagram which it was proposed to issue with the next number of the Journal would be large enough to be of use for the purpose described.

Mr. Cheshire said it would be large enough to answer for the whole series of dry objectives in common use.

The thanks of the meeting were unanimously voted to Mr. Cheshire for his paper.

Mr. R. T. Lewis read a short note describing the contents of three bottles of entomological specimens which had been sent to the Club from Queensland by their fellow member Mr. C. J. Pound.

Mr. Scourfield gave a *resumé* of a paper he had written in continuation of the series which was to form a synopsis of the British Fresh-water Entomostraca.

Mr. Scourfield also read a paper by Mr. Ashe on some instantaneous photographs of the curious appearance of ebullition which seemed to take place in the cavities of topaz, a diagram in illustration being drawn upon the board, and the photographs also exhibited.

The thanks of the meeting were voted to Mr. Scourfield and Mr. Ashe, and the ordinary meetings were then adjourned to October 16th.

* This paper has been unavoidably held over, but will be published in the next number of the Journal.

OBJECTS EXHIBITED, WITH NOTES.

March 6th, 1903.

Mr. H. Morland: *Trinacria grunowii*, from deposit at Simbirsk, Russia, showing "front" and "side" views of valve.

Mr. K. I. Marks: Transverse section of young stem of *Clematis japonica*, showing open collateral fibro-vascular bundles, the number of the same being few, as it is a leaf climber.

Mr. A. L. Still: *Plumularia pinnata.* Killed with cocaine and osmic acid. Stained with carmine. Mounted in balsam, 1896.

Mr. H. J. Quilter: Foraminifera from the London clay. Taken from Hampstead Heath Tube station.

Mr. F. E. Filer: Mitosis in endosperm of *Fritillaria imperialis.*

Mr. A. Downs: *Spirillum rugula*, a bacterium common in bog water.

Mr. A. E. Hilton: Head of House Gnat, *Culex pipiens*, showing plumed antennae, labium, and palpi. Mounted in glycerine, without pressure.

March 20th, 1903.

Mr. A. L. Still: Portion of a twelve-months'-old culture (on French plum) of *Eurotium aspergillus-glaucus*, showing a few heads of gonidia and numerous ripe ascocarps. The contained ascospores are still capable of fairly rapid germination.

Mr. A. Downs: *Hydra viridis*, showing the testes and the active spermatozoa.

April 3rd, 1903.

Mr. H. Morland: *Pyxilla americana*, from Sendai "cementstein,' Japan, showing how the opposing frustules cohere to each other.

Mr. W. Wesché: A flea, *Ceratosyllus jubatus* ♂, parasitic on bat. Mounted, without pressure, on cover-glass to show both sides. The antennae, which in the *Pulicidae* are usually in cavities, are well shown.

Mr. A. L. Still: A gymnoblastic hydroid, *Coryne fruticosa.* Stained with carmine.

Mr. J. Dick: *Arachnoidiscus ornatus, in situ*, on coralline from Mauritius.

Mr. A. Earland: Typical foraminifera from S.W. Ireland. Dredged in forty fathoms.

April 17th, 1903.

Mr. W. H. Harris: Six slides of the Drone-Fly, *Eristalis tenax*, showing: (1) External view of anterior thoracic spiracle; (2) internal view of posterior thoracic spiracle, with the folded membrane (the musical organ) in its natural position; (3) the musical organ, with the folded membrane, the chitinous rods, and the arborescent appendages; (4) expanded and contracted conditions of portions of the membrane which closes the air chamber internally; (5) portions of alulets, or scales, with two kinds of appendages; (6) the plume, or auxiliary organ.

Mr. C. F. Rousselet: *Asplanchna brightwellii*, with a parasitic fungus growing in the body cavity.

Mr. K. I. Marks: *Floscularia cornuta* Dobie, ♂ and ♀, with *Oecistes intermedius* Davis on the same weed in large numbers; from Willesden Green.

Mr. T. N. Cox: Section of a coal plant. Part of a large *Lepidodendron*, an extinct genus of *Lycopodiaceae* containing about forty species.

Mr. J. T. Holder: Transverse section of finger of human foetus (about seven months), showing nail, etc.

Mr. A. E. Hilton: Third leg of Hairy Bee, *Dasypoda hirtipes.* Mounted in glycerine.

May 1st, 1903.

Mr. W. H. Langton: Head and proboscis of Five-spotted Burnet Moth, showing the large compound eyes and the junction of the two halves of haustellum, or proboscis, at the point of connection with the head.

Mr. G. S. Barton: Four slides showing: (1) "Bovine" tubercle bacilli, isolated from cow's lung; (2) tuberculous milk, from a case of advanced "tubercular mastitis"; (3) gonococcus pus; (4) anthrax (commonly called wool-sorters' disease) from spleen of guinea-pig, inoculated from pus taken from malignant pustule.

May 1st, 1903.

Mr. T. N. Cox: *Asellus aquaticus* (Water Hog-Louse). An Isopod crustacean. Common in stagnant ponds. Showing circulation of the blood in all parts of the body.

Mr. A. E. Hilton: Transverse section of bark of willow, *Salix Russelliana.* This bark yields salicin, an alkaloid used in the adulteration of sulphate of quinine. Shown with polarised light.

Mr. W. Wesché: Two dissections of posterior thoracic spiracle of *Eristalis tenax*, L., from Jersey, showing Burmeister's plates: (1) The female shows the plates as 11-9 in number; (2) the male, as 12-12 in number. The discovery of this organ by Burmeister was announced in 1836. The plates are also present in *E. arbustorum*, L., but very faint; apparently eight in number.

Mr. H. Morland: *Triceratium forresterii*, Tempère. Possibly a variety of *T. plano-concavum*, J. Br. A very rare form found in "cementstein," from Sendai, North Japan. Figured and described in vol. i. of "Le Diatomiste," Pl. I., fig. 2, p. 5, from William's Bluff deposit, Oamaru. Also an abnormal form of *Coscinodiscus Oculus-Iridis*, and the typical form of *Aulacodiscus nigricans*, Temp. and Brun, both the latter being from Sendai, North Japan.

May 15th, 1903.

Mr. A. Earland: Artificial casts (internal) of foraminifera in paraffin wax, showing the exact shape of the sarcode body of the animal. Made by Mr. Quilter.

Mr. W. R. Traviss: Common paste eels, *Anguillula* sp., not in contact with cover-glass, showing the peculiar rhythmic undulations performed in unison by many individuals.

Mr. A. E. Hilton: Male organ of the Loosestrife Bee, *Macropis labiata.* Mounted in glycerine, without pressure.

June 5th, 1903.

Mr. H. E. Freeman: Living specimens of Podurae and Chelifers. (1) *Tomocerus plumbeus* (?); (2) *Lepidocyrtus curvicollis*, with young and eggs; (3) *Orchesella cincta*, a scaleless species common in gardens; (4) *Chelifer latreillei*. Found in chaff and stable *débris*.

Mr. H. Morland: *Biddulphia calamus*, Tempère and Brun, a somewhat scarce form from the "cementstein," Sendai, North Japan.

Mr. F. A. Parsons: Polycystinae from Springfield deposit. Cleaned with rain water without the use of acid, resulting in more perfect specimens being obtained.

Mr. A. E. Hilton: Parasite of emu: (Order *Mallophaga* ?.) Male, female, and larva shown.

Mr. J. T. Holder: Vertical sections through entire head of foetal rabbit, showing internal ear, etc. Stained with Ehrlich's haematoxylin and eosin.

Mr. H. J. Quilter: Fossil radiolaria and diatoms from the London clay.

Mr. K. I. Marks: Head of larva of a species of may-fly, *Ephemeridae*. Although the imagos are so short lived, these insects pass a long period in the larval and pupal states. They are notable for numerous moults or castings of the skin, sometimes as many as twenty.

Mr. W. Wesché: Larva of the beetle, *Meloë proscarabeus*. The egg is laid in depressions on heaths, commons, etc. The larva does not feed when hatched, but attaches itself to some hairy insect. If the latter happens to be one of those wild bees which prepare a pollen food for their young, the larva establishes itself in the nest, devouring an egg. This food causes it to grow vigorously. It then loses its legs, and assumes an appearance similar to the hymenopterous larvae, in which state it is fed by the bees. Found in Kent.

June 19th, 1903.

Mr. A. E. Hilton: *Nycteribia hopei* ♀. Parasite of Indian Fruit-Bat or Fox-Bat, *Pteropus*, commonly called the Flying Fox.

Mr. H. E. Freeman: Plumed mites, *Glyciphagus plumiger* (alive and mounted in fluid). These minute but most beautiful creatures are found in stable refuse, husks of chaff, etc., in company with many other mites and creeping things more interesting than beautiful. The Chelifers (also shown alive) come from the same sources, but in drier places.

Mr. H. E. Freeman: *Atropine.* This substance, on crystallising, manifests a strong antipathy to air bubbles. Solid particles are quickly surrounded by the advancing wave of crystallisation; but if an air bubble is encountered, a point is thrown out to push it away, and often a second and a third point will attack the bubble and carry it forward a considerable distance. The slide shown was prepared by the Rev. C. R. N. Burrows, who called attention to the curious action just noted.

Mr. K. I. Marks: A gathering from the "Moat" Church, Finchley, containing the following Rotifera: *Euchlanis dilatata*, *Oecistes intermedius*, *Colurus bicuspidatus*, *Stephanoceros eichhornii*, *Rotifer vulgaris*, *Rotifer tardus*, *Dinocharis pocillum*, *Diaschiza lacinulata*, *Stephanops lamellaris*, *Anuraea curvicornis*, and *Pompholyx complanata*.

Mr. J. T. Holder: Section through entire eye of foetal guinea-pig, showing cornea, sclerotic and choroid coats, retina, lens, iris, etc. Note transition of epithelium into lens fibres.

Mr. F. J. Cheshire: Methods of, and apparatus for, examining the upper focal plane of microscope objectives: (1) Eye alone, or better, a stop on the draw-tube instead of an eye-piece; (2) A low-power objective in the lower end of the draw-tube with a stop approximately in its upper focal plane; (3) Zeiss's axial-image eye-piece (optically equivalent to the second method); (4) Eye-ring method. A stop is placed in a low-power eye-piece (preferably 50 mm.), and the eye-ring is examined with a magnifier × 16 or × 20.

Mr. D. Bryce, on behalf of Signor Piovanelli of Rome: Living specimens of *Telphusa fluviatilis*, the common fresh-water crab of Italy. Also living examples of *Callidina cancrophila* and *Anomopus telphusae*, two new species found parasitic within the branchial cavities of this crab by Signor Piovanelli. (See his paper, read at this meeting, p. 521.)

Mr. D. Bryce: *Philodina nemoralis* n. sp. (See paper, p. 523.)

JULY 3rd, 1903.

Mr. C. F. Rousselet: *Asplanchna amphora*, ♂ and ♀, and *Notops brachionus*, from Hertford Heath.

Mr. K. I. Marks: *Anomopus telphusae*, Piovanelli. (Paper by Signor Piovanelli on the discovery of this species, read by Mr. Bryce at the last Quekett meeting.)

Mr. J. T. Holder: Pus, fixed fresh with absolute alcohol, 5 cc., and mercuric chloride, 1 gram. Stained methylene blue.

JULY 17th, 1903.

Mr. F. H. Hicks: *Amphipleura pellucida*, resolved into lines with Wenham half-button condenser. Mounted in realgar. Obj., $\frac{1}{12}''$ imm., 1·25 N.A.

Mr. A. Earland: Insect dissection without pressure, pyloric valve of Ground Beetle, *Colymbetes* sp.

Mr. A. H. W. Cleave: *Moina rectirostris*, a rather rare entomostracon, found only in little turbid ponds. The characteristic lateral teeth on the tail deserve special notice.

AUGUST 7th, 1903.

Mr. A. E. Hilton: Vertical section of ear of leper, double stained. When magnified 1,000 diameters, and photographed in colours by the "Sanger-Shepherd" process, the "Bacilli Leprae" show red blotches, purple blobs, and red rodlets of the apparent length of about $\frac{1}{20}$th of an inch.

Mr. C. F. Rousselet: *Polyarthra euryptera* and *Brachionus dorcas*, from Putney Heath.

Mr. T. N. Cox: Fruit of cotton grass, *Eriophorum* sp., a genus of plants of the order *Cyperaceae*, growing on boggy moors. From Inverness.

AUGUST 21st, 1903.

Mr. D. J. Scourfield: *Ophryoxus gracilis*, Sars, an entomostracon belonging to the family *Lyncodaphnidae* of the order *Cladocera*. Found in Loch Ness. An addition to the British fauna. This form has only hitherto been found in Norway, Sweden, Finland, and North America.

Mr. A. Earland: A tick, caught under bark in Cassiobury Park, Watford. Mounted in glycerine, without pressure.

Mr. T. G. Kingsford: Head of flea, *Pulex irritans*, showing mouth-organs, etc. Mounted in glycerine, without pressure.

September 4th, 1903.

Mr. T. N. Cox: Leaf of *Deutzia* (? species), showing stellate hairs. The leaves of another species (*D. scabra*) are so rough with siliceous hairs that they are used by joiners in Japan for polishing wood.

Mr. A. E. Hilton: The hornwort, *Ceratophyllum submersum*, showing fructification.

Mr. A. W. Dennis: Prothallia of Royal Fern, *Osmunda*. The spores producing these prothallia were sown five weeks ago.

Mr. A. J. French: *Batrachospermum moniliforme*, from a shallow pond near Leytonstone. Preserved in 2½ per cent. formalin.

Mr. H. S. Martin: Section of rhyolite, a volcanic rock showing "flow structure." From Yellowstone Park, U.S.A.

September 18th, 1903.

Mr. W. Wesché: Larva of *Psychoda* sp. The genus *Psychoda* belongs to a small group allied to the gnats. The species shown is very close to *P. phalaenoides*, but is probably distinct. This larva is very rarely met with, though the flies are common. It anchors itself to the surface film by the setae on the tail.

Mr. A. Earland: Section of marine limestone, Miocene strata, Gozo, Malta. Chiefly composed of remains of a calcareous alga, *Halimeda*. Foraminifera few in number.

Mr. A. E. Hilton: Desmids, diatoms, algae, amoeba, etc., from Millwood Tarn, Dalton-in-Furness.

Mr. H. S. Martin: Section of pitchstone (glassy volcanic rock) from Isle of Arran, Scotland, showing arborescent grouping of the crystallites.

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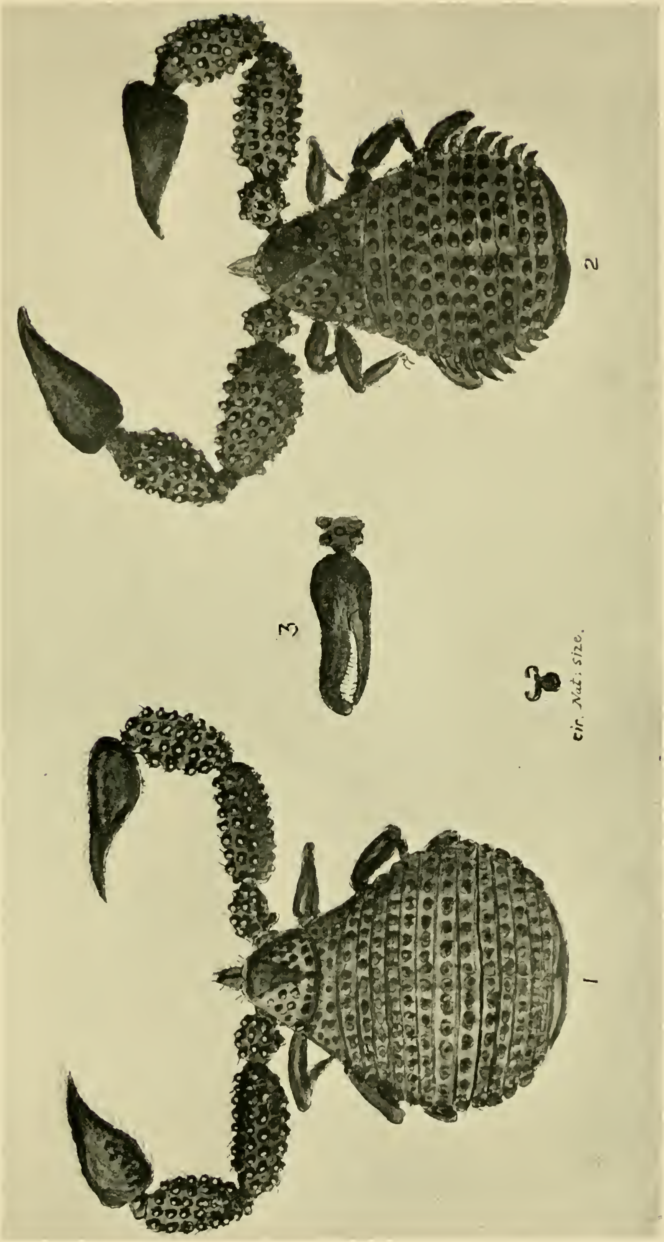
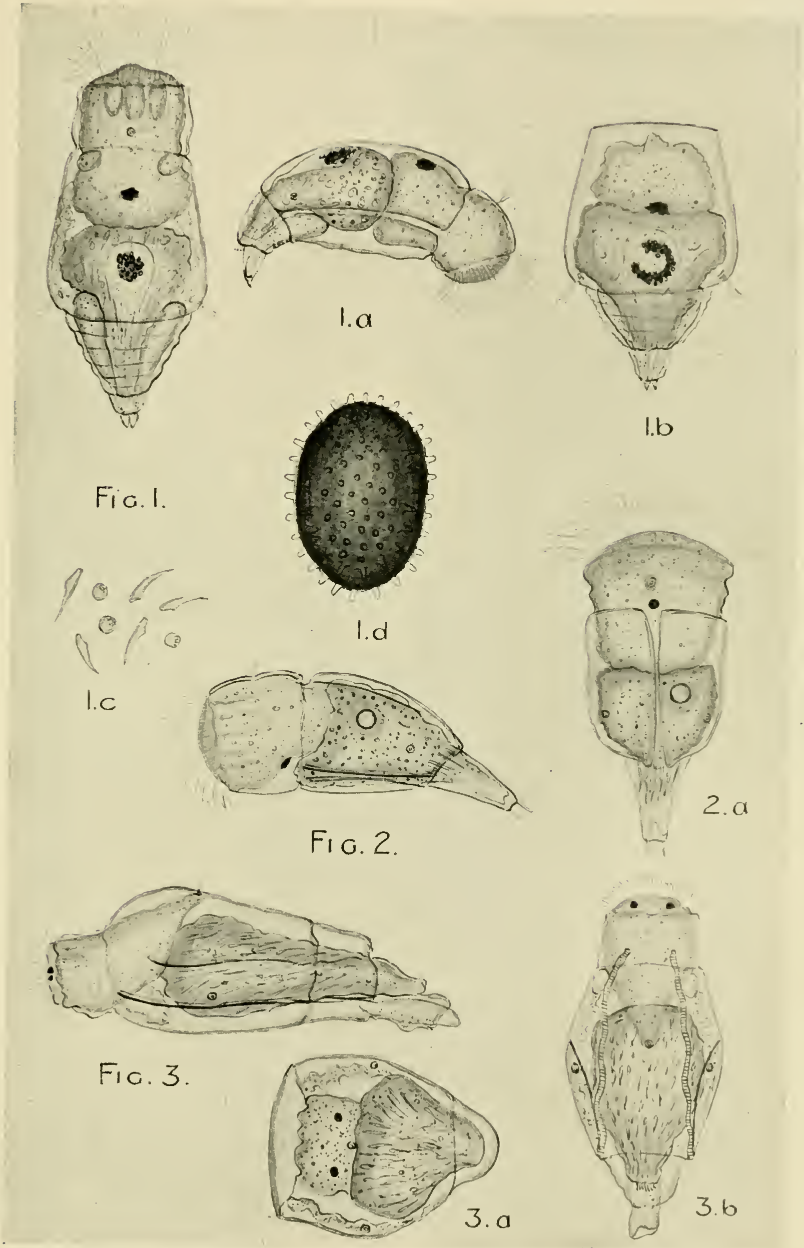


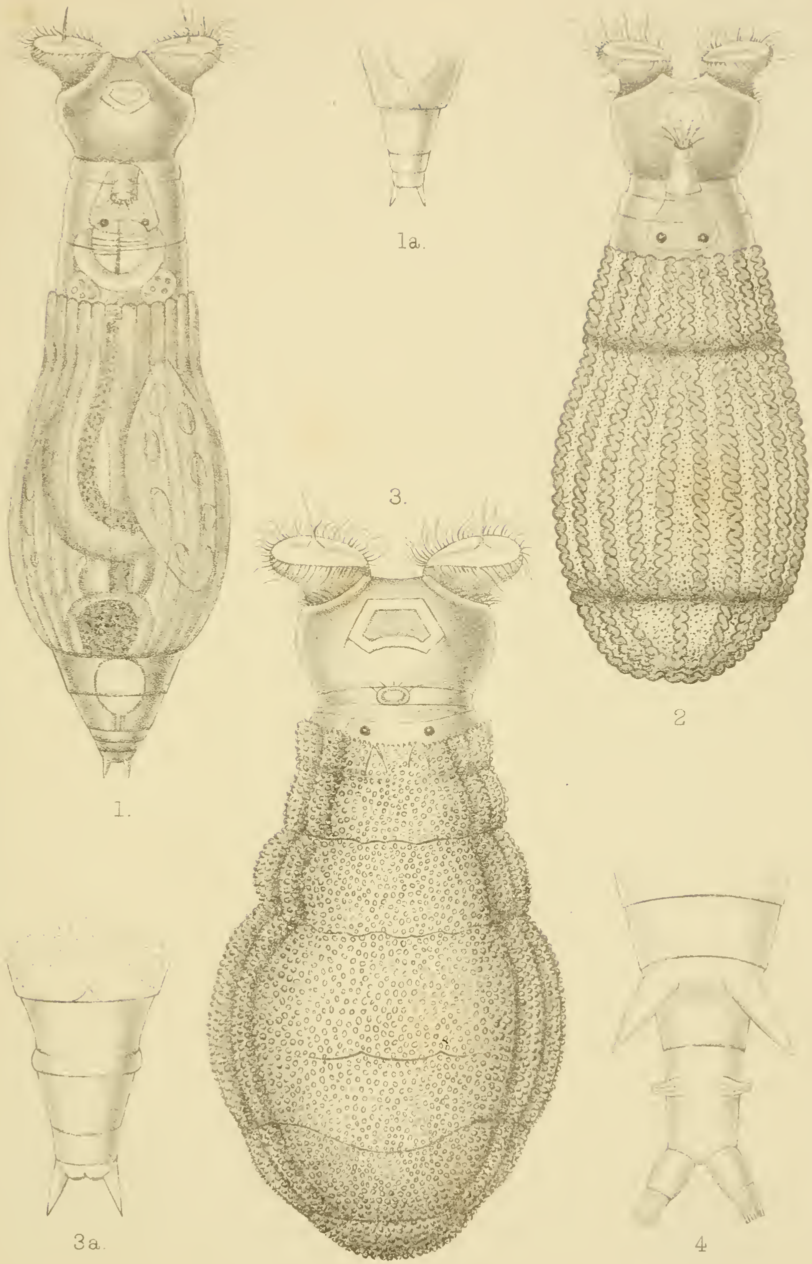
R. T. Lewis, del.

Chelifer sculpturatus. n. sp.



W. Wesché, del ad nat.

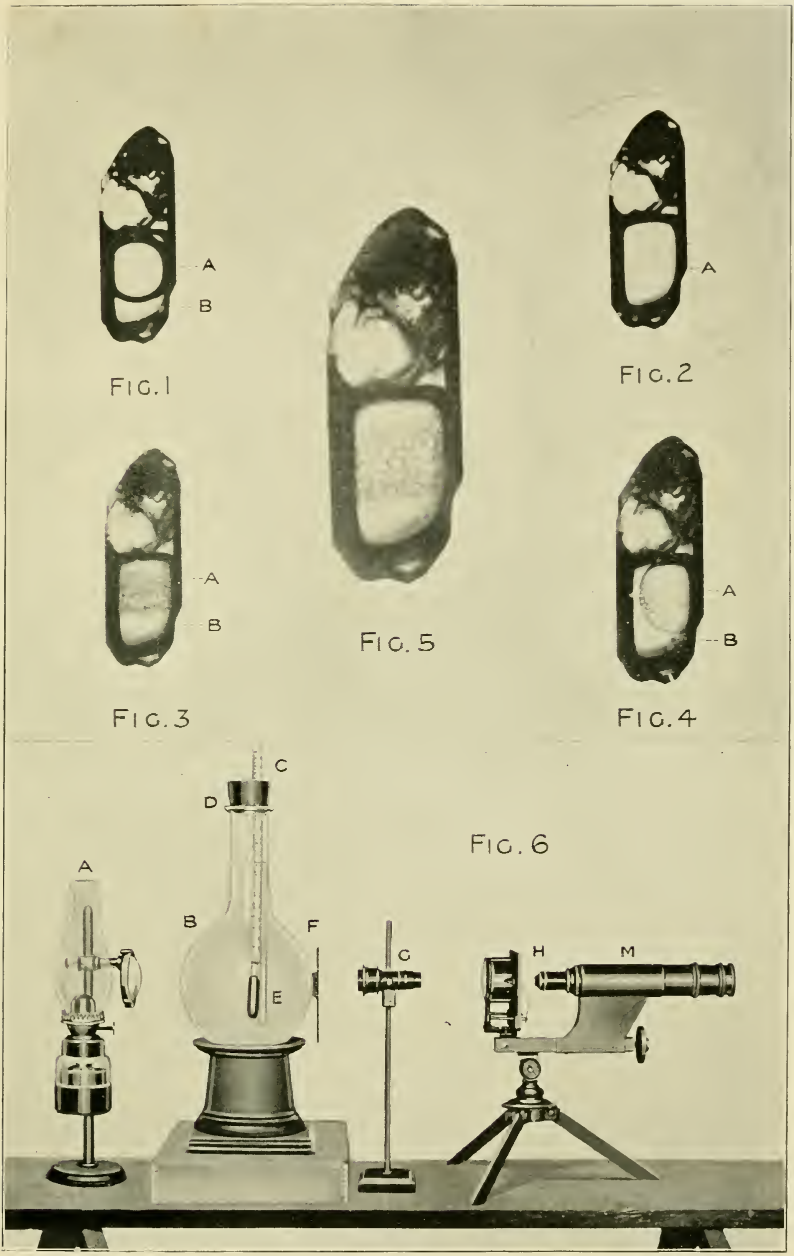
Male Rotifers.



).Bryce del.ad nat.

West, Newman lith.

New Philodinae.



A. Ashe, Photo.

Cavities in Minerals.

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EDITED BY
D. J. SCOURFIELD, F.R.M.S.

(It will be understood that the Authors alone are responsible for the views and opinions expressed in their papers.)

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MEETINGS

OF THE

QUEKETT MICROSCOPICAL CLUB,

FOR 1901-1902, AT

20, Hanover Square, W.,

ON THE

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This CLUB was established in 1865 for the purpose of affording to experienced Microscopists, as well as to Students, regular and frequent opportunities of discussing those special subjects in which they are mutually interested, and also for promoting Field Excursions to the well-known collecting districts around the Metropolis.

No Entrance Fee. Annual Subscription, 10*s*., dating from January 1st.

The ORDINARY MEETINGS are held on the *Third* Friday in each Month, except July, August, and September. Business commences at 8 o'clock.

The meetings on the *First* Friday in each month, and on the *Third* Friday in July, August, and September, are for conversation and for the exhibition of objects, from 7 to 9.30 p.m.

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* The ANNUAL GENERAL MEETING will be held on the Third Friday in February of each year, at 8 o'clock, for the Election of Officers and other Business.