Journal of the Marine Biological Association 14(1) 1926

Further Observations on Marine Ciliates Living in the Laboratory Tanks at Plymouth.

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With 28 Figures in the Text.

CONTENTS.

Trachelocerca phœnicopterus Cohn.

Always to be found in Drake's Island Tank.* Very abundant during the summer, but diminishing in number during the winter months. It has been described by O. Müller (**22**), Ehrenberg (**6**), Stein (**31**), Dujardin (**5**), Claparède and Lachmann (**3**), under various names, but their descriptions may be regarded as only of historic interest. The later observations of Gruber (**13**), Cohn (**4**), and Entz (**8**) are more detailed, and Lebedew (**17**) has given the fullest account of the animal. Kent (**16**), Bütschli (**1**), and Schewiakoff (**27**) have only short notices.

Trachelocerca is found in all the European seas, principally in the still water of bays and inlets, among decaying algæ.

It thrives in aquaria, so long as the saline concentration of the water does not vary too widely. Taking the salinity of Drake's Island Tank as $35^0/_{00}$, I have reduced it at intervals of six hours to $8^0/_{00}$ without affecting the animals; below $8^0/_{00}$ they begin to deteriorate, and at $7{\cdot}5^0/_{00}$ cytolysis sets in. They will not survive much increase of the normal salinity. Probably had the animals been allowed a longer time

* A large shallow tank standing in front of a south window in the Laboratory.

to adapt themselves to the reduced salinities they would have survived longer.

They feed freely on green algæ, flagellates, eggs of annelids, and Lebedew states that they can ingest even annelids themselves. Masses of ingested bacteria, in the form of small spherules, and thread-like masses, which stain readily with borax carmine may be seen distributed through the body plasma, particularly in the case of individuals taken from cultures containing decaying matter. Lebedew does not believe that Trachelocerca, like Vorticella, feeds on free-swimming bacteria, but entirely on masses collected in the scum on the cultures.

The general appearance (Fig. 1) and extraordinary contractility of Trachelocerca make it impossible to mistake it for any other Infusorian.

When lying quiet, the body appears oval or spindle-shaped, opaque, and tapering gradually anteriorly into a narrow neck, which is not so opaque as the body, and terminating in the cytostome. When the animal is extended the anterior end containing the cytostome is slightly enlarged.

The posterior end of the body is sometimes rounded, sometimes pointed, and generally forms a kind of tail ending in a sharp-pointed hook. The length of this tail is very variable, and Lebedew considers that there are two varieties of Trachelocerca, "tailed" and "tailless." In Plymouth the tailless variety is rare. In transverse section the body is round, oval or bent so as to form a furrow. When greatly extended it forms a flat ribband.

There is much included matter in the body plasma which Schewiakoff believed to consist of inorganic matter, such as calcium phosphate remaining from the digested food. Lebedew points out that after treatment with alcohol this included matter disappears, while the balance stains with different stains, and is probably of organic origin. He thinks, therefore, that it is the reserve material so often present in Protozoa. Vacuoles of various sizes are also present in the endoplasm.

When contracted the animal may measure only ·1 mm. in length, and when extended 1·5 mm. Van Beneden mentions having seen a specimen even 3 mm. long. I think this quite possible, as I have a specimen fixed in boiling sublimate, of 1·25 mm. length; and with the use even of boiling sublimate as a fixative, the animal's extraordinary power of sudden contraction is only slightly checked. Lebedew states that when swimming rapidly the animal can contract $\frac{1}{12}$ of its length in a flash.

When fully extended, and swimming rapidly Trachelocerca resembles a long, narrow rod, there being little appreciable difference of diameter throughout its length.

Trachelocerca is generally sluggish, and lies with the neck slightly extended, twisting it in different directions, and darting it forward and withdrawing it with great rapidity.

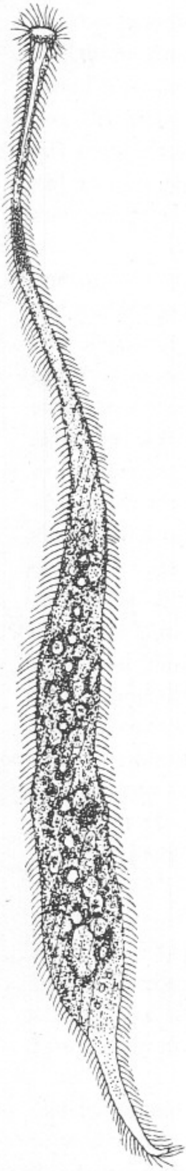

FIG. 1. *Trachelocerca phœnicopterus* in a state of ordinary extension. The 13 light spheres are nuclei.

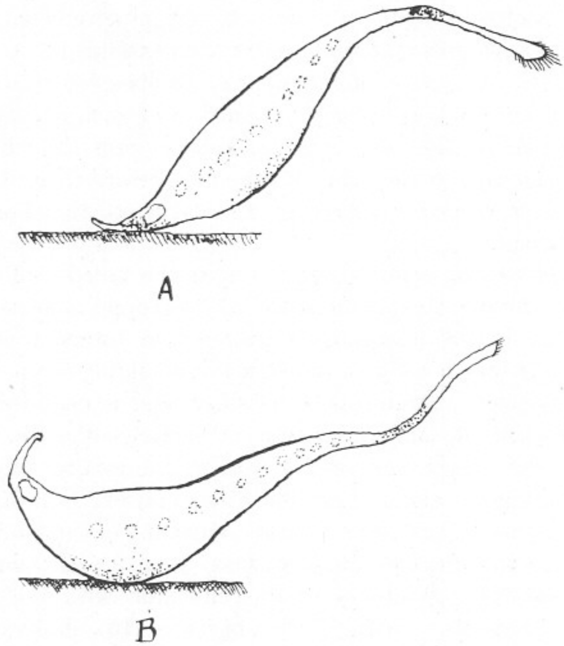

FIG. 2. *Trachelocerca phœnicopterus*, adherent to the surface on which it is lying.

A. Near tail end. B. At a point higher up the body.

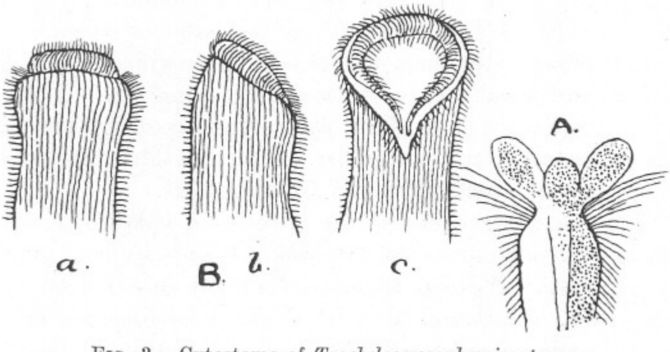

FIG. 3. Cytostome of *Trachelocerca phœnicopterus.*

B. After Lebedew. (a) Dorsal view. (b) Profile. (c) Ventral.
A. After Entz.

It adheres to the surface on which it is lying with considerable tenacity, and is often difficult to remove by the pipette (Fig. 2). On occasions it swims with great rapidity, and is then extended to a maximum length.

A peculiar crease or furrow may be observed running along the body. It is more or less strongly defined, and occupies various parts of, and positions on the body. Occasionally it runs the whole length from the anterior end to the tail. It was first described by Cohn (**4**). Entz (**8**), however, denied its existence, and suggested that Cohn's specimens were abnormal.

Lebedew observed it exclusively in the tailed forms. I have examined many Plymouth specimens and always found it present, except when the animal is at maximum extension, and forms a narrow ribband. It appears that it is due to a longitudinal folding of the body, so as to bring the opposite margins close together, and is possibly connected in some way with the animal's power of surface adhesion. Lebedew remarks that the presence of such a furrow (Längsfalte) might be expected on exconjugants along their line of separation, but that after careful examination he has never observed anything of the kind, nor do individuals having the crease show any signs of antecedent conjugation. He also suggests the possibility of its connexion with the power of adhesion, and compares it with C. Hamburger's (**15**) observations on *Trachelius ovum*, of what she calls a suction-cup (Saugknapf). Lebedew, however, always alludes to the posterior extremity as the point of adhesion. This is not exactly correct. Attachment is effected slightly above the extreme posterior end, generally at the point where the tail may be said to join the body. Often, however, it occurs much higher up, near the middle of the body, and in the tailless as well as the tailed variety. It may also be noticed that the crease does not extend to the extreme posterior end. Fig. 2, A and B, shows the two usual attachments.

In cultures Trachelocerca has the habit of collecting into masses, in which the individuals are closely intertwined. Lebedew thinks that syngamy usually takes place in this condition. I have not observed that such is the case. Possibly the presence of some favourite food causes the animals to crowd together. The same thing takes place in cultures of *Spirostomum ambiguum* and *Dileptus gigas*.

At the anterior end of the neck is the Cytostome. By reason of the rapid darting motions of the neck it is impossible to get a steady view of this organ. Although the animal is easily anæsthetised by 1% Eurythane solution, the marginal rim of the cytostome is always withdrawn. Observers consequently differ in their accounts of the structure. When the neck is extended the anterior end is slightly enlarged, and in the middle of this area is the cytostome, which is thus described by Entz (**8**). "The nearly central mouth-opening leads directly to a cytopharynx of somewhat remarkable size. Outside around the mouth lie four lobes arranged in a cross, and between them four somewhat smaller lobes. The lobes are of varying degrees of sharpness and sometimes disappear altogether" (Fig. 3A).

Schewiakoff's (**28**) description is similar.

Even if the margin of the cytostome is slightly lobular, which I think is the case, Entz's drawing is much exaggerated. Lebedew's description is as follows: "The anterior end of the body seen in profile is sharply truncated (Fig. 3B b). The mouth opening occupies the anterior end, and runs as a furrow of varying length on one side of the body. The side towards which the anterior end is truncated, and in which the mouth-opening is situated, may be, as with other Infusoria, called the ventral side. (Fig. 3B c of the present paper is a reproduction of Lebedew's figure.) A peculiar cytoplasmic ring surrounds the whole cytostome. This rim is striated, and carries a wreath of cilia. It can be protruded or withdrawn in varying degrees. In fixed specimens it is always withdrawn. It is in no sense a closed rim, but runs along the cytostome, and terminates lower down on the ventral side in two small angles (Kante)."

My own observations generally agree with those of Lebedew. The anterior end of the neck is obliquely truncated, and a rim with cilia longer than those on the rest of the body is apparent; but I am unable to say whether this rim terminates ventrally in two angles, or whether the two ends are joined.

Entz's figure certainly does not represent the fully extruded cytostome accurately; but I have observed that in fixed specimens the withdrawn margin is invariably lobular, and possibly Entz made his drawing from a fixed specimen.

I have never been able to make out the four smaller lobes he describes. It seems possible that the expanded rim when withdrawn would of necessity be divided into lobes so as to fit the reduced diameter of the neck.

Lebedew compares the cytostome of Trachelocerca with that of Dileptus as described by Schewiakoff (**27**), which it resembles, except that the rim of the cytostome runs anteriorly in Dileptus, and the reverse in Trachelocerca. Dileptus, moreover, has a cytopharynx, and striations which have been interpreted as supporting-rods, but which Schewiakoff suggests may be really the striation of the rim as in Trachelocerca.

The *cytopyge*, according to Lebedew, is situated at the posterior end, opening in tailless forms directly at the posterior end, but in tailed forms at the side.

The whole body is enveloped in a fairly thick, transparent and homogeneous pellicle. On the pellicle are rows of papillæ running longitudinally parallel to one another. The papillæ are close together and on each is a pretty long, very fine cilium. These cilia throughout the body are of the same length, but at the anterior and posterior ends, and on the cytostomial rim are rather longer. Each cilium rises from a basal corpuscle. These are easily seen in compressed and stained specimens. Fixation in boiling sublimate or Bouin Duboscq's solution, and staining with iron hæmatoxylin give good results.

When the animal is fully extended the margin of the pellicle is quite straight and smooth. As it contracts the margin becomes wrinkled, and these wrinkles appear as fine cross striæ on the body.

Lebedew describes the process of wrinkling as follows : " If the animal contracts slightly a number of fine cross striations appear on the pellicle (Fig. 5). With stronger contraction the outer surface arches itself outwards, between the rows of cilia, so that the cilia run in furrows along the body (Fig. 4). At the same time the cross striations become fewer in

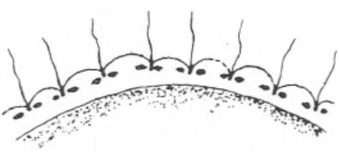

Fig. 4. Section of A form of *T. phœnicopterus*, showing the cilia arising between the wrinkles of the pellicle. Their basal corpuscles and sections of two myofibrillæ on either side of them are seen. After Lebedew.

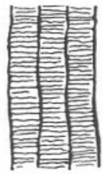

Fig. 5. Striations on pellicle of *T. phœnicopterus*, when animal is slightly contracted. After Lebedew

number, but much more strongly marked, so that the space between two rows of cilia resembles a column of small quadrangular figures, something like boxes, lying one above the other. (See Fig 6A, after Lebedew.) These columns appear to be individual, and lie between the muscle fibrillæ. If a fibrilla gets loose or destroyed the columns present an irregular or toothed outline." (See Fig. 6B, after Lebedew.)

I have noticed something of this appearance in compressed living specimens. Lebedew's drawings were made from specimens fixed in Picroacetic acid and crushed under the coverslip. My crushed and stained specimens do not appear so.

As might be expected from the extreme contractility of Trachelocerca, the myofibrillæ are well developed. They may be seen in whole preparations and in longitudinal and transverse sections. They run close and parallel to the lines of cilia, which are marked by the basal corpuscles (Fig. 7A). They stain more deeply than the surrounding plasma. They do not appear to run in canals as is the case with Stentor, Condylostoma and some other Infusorians.

The thickness of the fibrillæ varies, occasionally distinct nodosities are present. It is reasonable to conjecture that this is the result of contraction. In some cases Lebedew has seen fibrillæ of the rose-wreath form, and always in individuals closely contracted, and at points where the contraction was greatest (Fig. 7B).

Occasionally one or more rows of cilia may be unaccompanied by myofibrillæ, or a portion of a myofibrilla may be absent. Lebedew says that he has seen cases where all the myofibrillæ were absent. Lying on the opposite side of the basal corpuscles to the myofibrillæ above described, Lebedew states that he has seen another fibrilla (Fig 7B c). He conjectures that these may be either nerve-elements, " Neurophanea "

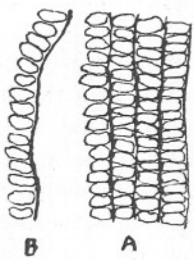

FIG. 6. (A) Appearance of pile of quadrangular figures produced by contraction of pellicle of *T. phœnicopterus;* (B) The same after loosening of a myofibrilla. After Lebedew.

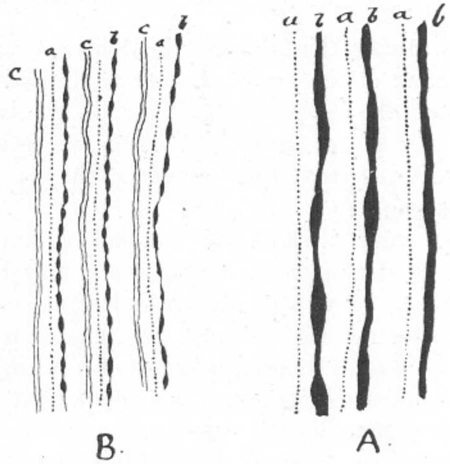

FIG. 7. (A) Sagittal section of *T. phœnicopterus*, showing (a) basal corpuscles of cilia, (b) myofibrillæ; (B) The same showing (a) basal corpuscles, (b) myofibrillæ in rose wreath form, (c) the fibrilla which does not stain so deeply. After Lebedew.

described by Neresheimer as occurring in Stentor, but denied by Schröder (**26**), or that they are true fibrillæ; in which case their number and distribution might be regarded as inconstant. I have failed to locate these fibrillæ in my preparations.

I have found no Trichocysts in the Plymouth Trachelocercæ, nor has Lebedew seen them in his individuals; but Schewiakoff states that he has observed them under the pellicle.

The contractile vacuole is rarely present. It lies at the posterior end, and functions very slowly. Lebedew says that it is not rare in the tailless variety, but absent in the tailed.

Previous to Lebedew's paper (**17**) accounts of the nucleus of Trachelocerca are scanty and contradictory. Entz describes it as single, oval, uniformly coarsely granular and lying about the middle of the body. Gruber, on the contrary, describes numerous small nuclei scattered irregularly through the body plasma, and opines that if a Trachelocerca does exist it must belong to a different species. Gruber found an animal with only one nucleus, and called it *Trachelocerca minor*. Lebedew has observed all three forms, and believes that he can prove them all to belong to one and the same species, and to be genetically related. He distinguishes them as follows :—

A. The form with a single nucleus.
B. With a number of nuclei arranged in one or two rows.
C. Those which according to Gruber have no nuclei, but in which nuclei are really present, but their structure very irregular.

Lebedew thinks that the diverse opinions regarding the nature and number of the nuclei arise from the fact that in any given sample of water the nuclear conditions of the animals therein are the same at any given period. He gives several examples in support of this theory derived from observations at Moscow, Sevastopol, Trieste, Rovigno, etc.

In Drake's Island Tank animals with a single or double row of nuclei are most abundant ; among them may be found a few with the single nucleus, or with nuclei of the irregular or indeterminate kind, C. For want of material Lebedew was unable to complete his observations on the A class. He gives a long and detailed account of the development of the multinucleate from the single nuclear form, which cannot be inserted here. Minchin (20) summarises his account as follows : " A simple instance of direct multiple division of a nucleus, in which apparently no centrioles are present has been described by Lebedew in Trachelocerca. In this case partitions are formed within the nucleus, between the grains and masses of chromatin, and finally the nucleus becomes segmented into a mulberry-like mass of daughter nuclei which separate from one another " (Figs. 8A and B).

In fixed and stained preparations of animals from Drake's Island Tank, I have been able to follow all the stages of nuclear multiplication described by Lebedew.

The nucleus lies generally dorsally, and Lebedew compares it to that of the Acinetæ (Dendrocometes), where chromatin is embedded in the nuclear stroma in the form of small granules. The number of nuclei observable is generally from 4 to 20, which may subsequently be increased to 50, or even 80, according to Lebedew.

As regards the nuclear division of the A form with one nucleus, Lebedew thinks that after the first division of the nucleus into two, the animal itself divides into two daughter products, each with a single nucleus,

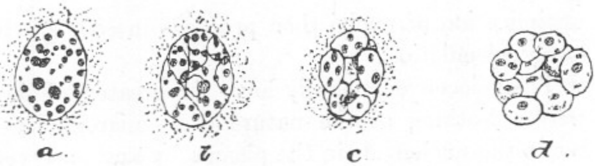

FIG. 8A. Four stages of direct multiple fission of nucleus.
(a) Nucleus of an A form animal. No differentiation visible.
(b, c, d). Stages resulting in the formation of a morula-like mass. After Lebedew.

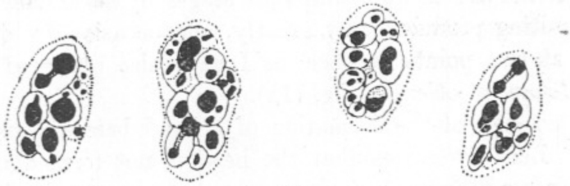

FIG. 8B. Nuclei from specimen fixed Bouin Duboscq solution stained Iron Hæmatoxylin × 630. This individual contained thirty nuclei.

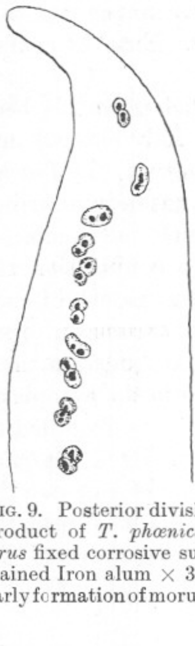

FIG. 9. Posterior division product of *T. phœnicopterus* fixed corrosive sub., stained Iron alum × 315, early formation of morulæ.

FIG. 10. *T. phœnicopterus* dividing from specimen with thirty nuclei. Fixed Bouin Duboscq solution, stained Iron hæmatox. × 315. More advanced than Fig. 9.

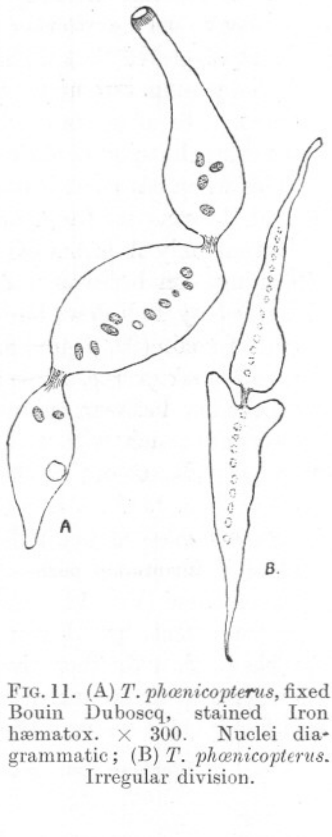

FIG. 11. (A) *T. phœnicopterus*, fixed Bouin Duboscq, stained Iron hæmatox. × 300. Nuclei diagrammatic; (B) *T. phœnicopterus*. Irregular division.

and that multiplication of nuclei then proceeds in each product. This, however, is only speculation.

The larger Trachelocercæ generally have the greater number of nuclei and conversely. Nothing of the nature of a micronucleus has been noticed either in the nucleus or in the plasma by any observer.

Division takes place very irregularly. The number, size, and condition of the nuclei do not appear to have any connexion with division of the animal itself. Figs. 9 and 10 represent products of two individuals in which the nuclei are in quite different stages of development. In size also the resulting products vary greatly, and occasionally division may take place at two points at once, as I have also observed in *Dileptus gigas* and *Holophrya oblonga* (Fig. 11A).

There is no sign of the formation of a head before division is fully completed. Lebedew states that the head is not formed until two or three hours after division.

Sometimes division is not so regular; the anterior end of the posterior product may project into one or two irregular processes, the point of rupture lying between them (Fig. 11B). Sometimes when the animal has been feeding, the body is swollen or constricted at points, and it is not easy to decide whether division is or is not commencing.

Entz suggested that division takes place within a cyst. Lebedew saw this happening, but under what he considered to be abnormal circumstances. He also saw and described the emergence of Trachelocerca from cysts, but points out that Entz's conclusion that Trachelocerca only divides when encysted is quite erroneous, having regard to the fact that B and C forms are frequently seen dividing normally. Entz, of course, held that only A forms existed.

Conjugation between multinucleate forms of Trachelocerca has been described by Lebedew, but in too great detail to be fully entered into here. Minchin (**20**, p. 449) has summarised them as follows: " In *Trachelocerca phœnicopterus*, a free living species, conjugation has been described by Lebedew between individuals containing many nuclei all similar in appearance, each with a large karyosome. Prior to conjugation the chromatin passes out of the karyosome into the nuclear cavity of each nucleus (Fig. 12A* B), and then divides into four. The chromatin forms a compact mass at one pole of each nucleus. During conjugation these masses of chromatin pass out of the nuclei, and lie free in the cytoplasm between them (Fig. 12, C–G); each such mass is now to be regarded as a micronucleus, and lies in a clear area, finally becoming a vesicular nucleus with a distinct alveolar structure; the old nuclei can now be considered as macronuclei. All the nuclei now collect in a mass near the middle of the body. The macronuclei ultimately degenerate; the

* Minchin's figure is reproduced in this paper under this number.

micronuclei multiply by fission, but ultimately, according to Lebedew, they all degenerate with the exception of one in each conjugant; the persistent micronucleus divides into two pronuclei which conjugate in the usual way; unfortunately the author's observations contain so many gaps that this statement cannot be considered established so decisively as could be desired. The exconjugants contain each a single synkaryon

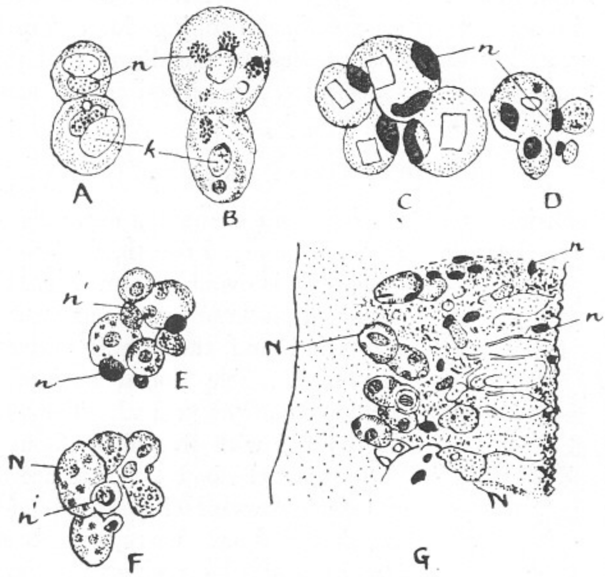

FIG. 12.

Formation of micronuclei in *T. phœnicopterus*. A, B: a nucleus has divided into two, and from the karyosome (k) of each daughter nucleus masses of chromatin are being given off into the nuclear cavity. C, D: the two nuclei of the preceding stage have divided again, to form a group of four, and the chromatin masses (n) have acquired a compact structure and are passing out of the nuclei to form the micronuclei. In C crystals are seen in the cavity of the old nuclei, probably a sign of degeneration. E, F: two groups of nuclei, both from the same specimen: the micronuclei given off from the old nuclei become surrounded by a vacuole (n^1 in F) and then acquire an alveolar structure (n^1 in E). G, portion of a preparation of the body of a conjugant, the wavy contour on the right being the surface of the body which is in contact with the other conjugant; numerous micronuclei (n) are seen, and also macronuclei, some of which still appear normal (N), others degenerating (N^1). Minchin, after Lebedew.

which divides by successive divisions into a number of nuclei not differentiated into micronuclei and macronuclei.

"The case of Trachelocerca, as it is described, furnishes an important clue to understanding the origin of the heterokaryote condition of Infusoria, from that found in other Protozoa. In this case, during the ordinary vegetative condition, the generative chromatin representing the micronucleus of other Infusoria, and the vegetative chromatin representing the macronucleus are contained in one and the same nucleus, and become separate only when syngamy is about to take place. The first sign of the separation is the formation of chromidia from the karyosome within the nucleus, resulting in the formation of a secondary nucleus which becomes separate, and which behaves exactly as an ordinary micronucleus; thus indicating a clear homology between the micronuclei of Infusoria and the secondary generative nuclei of Sarcodina. The production of numerous micronuclei in the conjugation of Trachelocerca is noteworthy, and would appear to favour the theory that primitively numerous gametes (swarm-spores) were produced in the conjugation of Infusoria."

Uronema marina Dujardin.

A small holotrichous ciliate very common among decaying algæ, and organic matter. Length, ·025 to ·04 mm. Breadth, ·015 to ·028 mm. The body is ovoid in form (Fig. 13); sometimes the anterior end is narrower than the posterior, and the lateral outline slightly flattened. The dorsal surface is more convex than the ventral. The whole body is covered with fine cilia, about half the breadth of the body. There are twelve to fourteen rows of cilia on the dorsal and ventral surfaces. There is no striation, but the lines of cilia may give the appearance of it. At the posterior end is a long bristle-like cilium which Schewiakoff (**28**) thinks is sensory. I have never observed anything in the animal's behaviour when the bristle is irritated to confirm this. Smith (**30**) also says that he could not agree with Schewiakoff's statement, as the animal lies quiet when the bristle is bent over to one side or the other. The body is colourless and elastic.

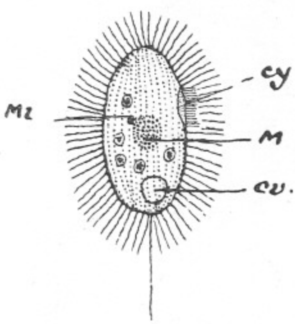

FIG. 13. *Uronema marina*. cy.: Cytostome. M.: Macronucleus. Mi.: Micronucleus. cv.: Contractile vacuole.

The cytostome is a pretty large oval opening in the upper half of the body on the ventral surface. Schewiakoff (**28**) says that the left margin of the cytostome carries a fairly large flapper-like (Klapperartig) undulatory membrane—that it is clearly striated, and appears as if it consisted of an agglutination of single cilia. On the right margin there are single cilia only. Smith's (**30**) description is similar to Schewiakoff's.

I observe that both margins are fringed with very fine cilia shorter than those of the body closely packed together, and that the cilia of either side when erected appear to form a striated undulating membrane, just as in the case of *Lembus elongatus*. Thus either margin may be said to carry an undulating membrane really resolvable under suitable magnification into very fine cilia. This is easily verifiable when the animal is lying perfectly quiescent with the cilia around the cytostome erected. The spherical macronucleus and a small spherical micronucleus close to it lie about the centre of the body. Smith (**30**) states that in a large percentage of cases, the macronucleus is found to be double, and thinks that this may be interpreted as a sign of precocious division long before division of the cytoplasm commences. I have not observed this peculiarity of the nucleus. The contractile vacuole lies at the posterior end, in front of the bristle.

The endoplasm is clear and contains vacuoles, and small refringent granules especially in the posterior part. Bacteria form the principal food of the animal. It moves rapidly, revolving on the longitudinal axis of the body.

The genus Uronema was founded by Dujardin (**5**), and *Uronema marina* has been described by him, by Cohn (**4**), Quennerstedt (**24**), Mereschkowsky (**19**), Smith (**30**), Kent, and by Gourret and Rœser (**12**) as *Cryptochilum nigricans*. Dujardin believed that the animal was mouthless, while Cohn recognised its position, but did not make out the so-called undulatory membrane, which Kent figures as sack-like. Uronema is probably identical with Maupas' Cryptochilum and Fabre-Domergue's Philaster.

Cyclidium glaucoma O. F. Müller.

A very small holotrichous ciliate resembling *Pleuronema chrysalis*. Found among putrid organic matter, decaying algæ, and in the film formed by bacteria and Zooglœa. Generally in company with Lembus, Uronema, Chaenea, etc. One of the commonest and most widely distributed ciliates. It seems to feed principally on Bacteria.

Length, ·018 to ·024 mm. Breadth, ·01 to ·016 mm.

The body is fairly elastic, but constant in shape and colourless.

In shape longish oval, or egg-shaped, and generally narrower at the extremities, but this is variable, and occasionally they are slightly flattened.

The dorsal surface is convex, the ventral flat, but hollowed out to form a peristomial area which occupies about two-thirds of the ventral area. In the anterior one-third of its length the peristome is narrower, and then widens out to form an area included by its borders, of which the left forms a deep curve while the right is flatter. It thus much resembles the peristome of *Pleuronema chrysalis*.

The body is clothed with long fine cilia, which when the animal is at rest appear stiff and bristle-like. They are spaced fairly widely apart, except at the anterior extremity, where they are more numerous and more close set. The cilia arise from small papillæ, which viewed together suggest striation. From the posterior end projects a very long pointed bristle-like cilium, which is characteristic of the genus (Figs. 15, 16).

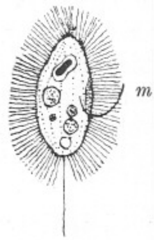

FIG. 14. *Cyclidium citrullus* after Möbius. × 480. m. The line formed by ends of cilia which he believed to be a bristle.

The pellicle is very thin and homogeneous, and difficult to make out. The endoplasm is transparent and slightly granular.

The orifice of the cytostome is very minute, and lies within the wide depression of the peristomial area. Schewiakoff (**28**) says that it is continued into a short, pipe-like cytopharynx, running dorsally towards the left. This I have not observed.

A long undulating membrane runs along the whole of the left peristome margin, turns round the end, and extends for a short distance up the right margin; but not so far as in Pleuronema, in which nearly one-third of the right margin is occupied by it.

The membrane thus forms a kind of bag round the posterior end of the peristome. This undulatory membrane consists of very fine cilia, and when the animal is lying in a suitable position its outline under

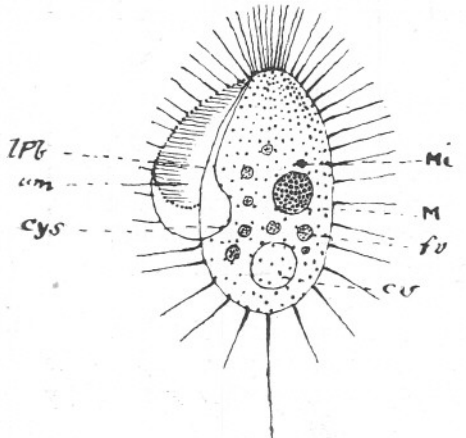

FIG. 15. *Cyclidium glaucoma.* Left side. um.: Undulating membrane formed by fine cilia. rPb., lPb.: Right and left peristomial borders. M.: Macronucleus. Mi.: Micronucleus. fv.: Food vacuoles. cv.: Contractile vacuole. cys.: Cytostome.

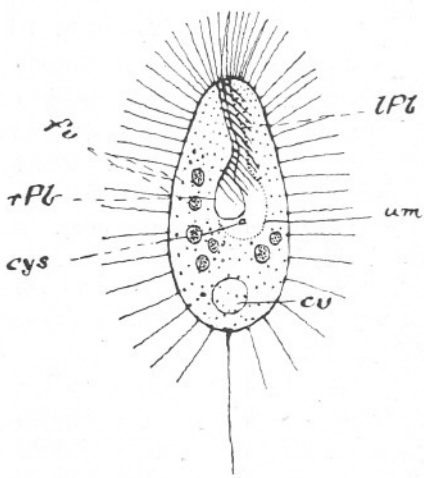

FIG. 16. *Cyclidium glaucoma.* Ventral view. Lettering the same as in Fig. 15.

high magnification shows as a line of dots, formed by the ends of the cilia, as in the case of other ciliates, *e.g. Lembus elongatus*. Under low magnifications the dots appear as a continuous line; and this led some of the earlier observers to describe it as a long flagellum or bristle. Möbius also (**21**) in describing a *C. citrullus* compares it to a long flagellum (Geissel) with its extremity bent towards the anterior end. Möbius' figure (reproduced here as Fig. 14) is an excellent representation of this appearance. Cohn (**4**) compares it to a stiff, hook-shaped bristle bent backwards, and correctly conjectures that it may be a sail made of agglutinated cilia. The membrane or rather the cilia composing it can be withdrawn wholly or partially within the peristomial area.

Along the right peristomial margin is a row of cilia equal in length to the body cilia, and directed obliquely towards the posterior end.

I have not seen the cytopyge. Schewiakoff (**28**) says that it opens on the ventral surface near the origin of the terminal bristle. The contractile vacuole lies close to it.

The macronucleus (Figs. 14, 15) lies near the middle of the body; it is spherical and finely granular. It is always accompanied by a small spherical micronucleus.

Cyclidium glaucoma has the habit of lying quite still, with all the cilia rigid and outspread, the contractile vacuole only continuing to pulsate. After a short interval, but long enough for observation, the animal disappears with a sudden jump, to be found again a short distance away. For this reason probably Fromentel and Dujardin gave it the specific name of *saltans*. The sudden motion appears to be effected by the terminal bristle which Gourret and Rœser (**11**) call the "Soie saltatrice."

Schewiakoff (**28**) describes another species of Cyclidium under the name *citrullus*, which appears to differ little from *glaucoma* except in size, and Gourret and Rœser state that at Marseilles they found two slightly different types of *glaucoma*: one in which the terminal bristle is not so highly developed and the cilia are shorter; and the other more elongated in shape, slightly rose-coloured, and with an exceptionally long terminal bristle.

Cyclidium glaucoma has been described by numerous authors: Schewiakoff (**28**), Müller (**22**), Ehrenberg (**6**), Claparède and Lachmann (**3**), Stein (**31**), Kent (**16**), Gourret and Rœser (**11**), Bütschli (**1**).

Schewiakoff (**28**) gives the following as synonymous with *C. glaucoma*:—

C. nigrescans and *C. saltans* Fromentel.
Pleuronema cyclidium Claparède and Lachmann.
Alyscum saltans Dujardin.
Euchelys nodulosa Dujardin.
Disticha hirsuta Fromentel.

Stein believed it to be a spore-product (Schwärmsprössling) of Chilodon.

Blepharostoma pigerrima (Cohn).

A very small holotrichous ciliate, abundant in decaying organic matter, in company with Lembus, Uronema, Chaenea, etc.

The body (Fig. 17A) is rather spindle-shaped, and varies in length from ·03 to ·06 mm. The length is rather more than twice the breadth, except when the animal is full of food (Fig. 17B) when it is almost spherical. The anterior extremity ends in a sharp slightly curved, beak-like pro-

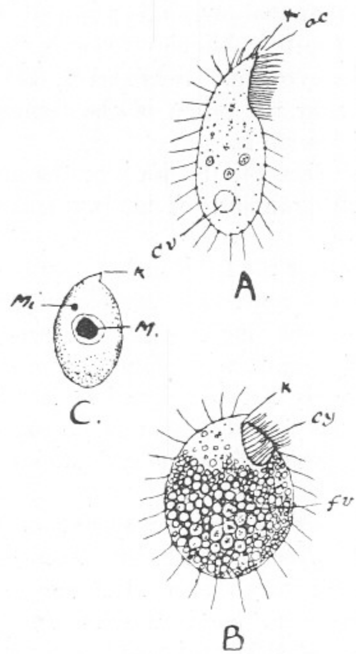

Fig. 17. *Blepharostoma pigerrima.*
A. In ordinary condition.
B. Distended with food.
C. Fixed and stained × 630.
k. : Beak. ac. : Anterior stiff cilia. cy. : Enlarged cytostome. cv. : Contractile vacuole. fv. : Food vacuoles. M. : Macronucleus. Mi. : Micronucleus.

jection. This point persists under all conditions even when the animal is greatly distended (Fig. 17B). It is not deformed in any degree after fixation, and appears to consist of a denser substance than the rest of the body plasma. It takes a bluish stain from picronigrosin, and probably contains Chitin.

The dorsal surface of the body is slightly convex and the ventral nearly flat. There is a deep hollow in the anterior third of one of the sides, and from the apex runs a peristomial groove for about one-third of the body length, terminating in the large oval cytostome. There is no cytopharynx. The margins of the peristomial groove carry cilia, which vibrate but slowly. Three or four of the anterior of these cilia are stouter than the others and resemble cirri. They maintain a slow, twitching motion, while the other cilia are still. The body cilia are fairly long, slightly less than half the breadth of the body, and disposed in about ten rows. They move stiffly. There is no terminal bristle and no surface striation. The endoplasm is clear with only a few refringent granules.

The body is not very contractile, but the posterior portion is extremely plastic, and can suffer great deformation, when the animal is moving about and feeding. While so doing it is quickly filled with food vacuoles and becomes nearly spherical. The anterior beak, however, is always visible, but the cytostome is forced upwards and forms a large opening nearly at the anterior extremity, and just below the beak.

The macronucleus is spherical (Fig. 17c), and lies just behind the mouth. A small spherical micronucleus lies near it.

The contractile vacuole is generally at the posterior end.

The animal moves slowly among decaying matter.

Blepharostoma pigerrima was described by Cohn (**4**), in 1866, as *Colpoda pigerrima*. In 1888 Gourret and Rœser (**12**) described as *Cryptochilum fusiforme* a new species which resembles the Plymouth ciliate in every particular except in the presence of a micronucleus. The persistence of the anterior beak after the enlargement of the posterior part of the body is referred to by them. Gourret and Rœser do not refer to Cohn's *Colpoda pigerrima*, although they debated whether their new species should be included in the genus *Colpoda*. The genus *Cryptochilum* was founded by Maupas in 1888, and Gourret and Rœser were doubtful at first whether to include the new species in it, having particular regard to the absence of the posterior bristle and of longitudinal striation, both of which are characteristic of Maupas' genus, *Cryptochilum*.

They finally decided that particular points of resemblance, such as the position of the peristomial groove and cytostome, the hollowing out of one of the lateral faces and the absence of a cytopharynx, overbalance the negative characters; more particularly as Maupas in his description of *Cryptochilum nigricans* remarks that striation is not always very clearly defined (la striation n'est pas toujours très nettement accusée).

The genus *Blepharostoma* was formed by Schewiakoff in 1893. I have not seen his work, but the generic description is given in *Nord. Plankton*, XIII, p. 64, as *Blepharostoma* Schewiak., 1893: "Very small, oval to spindle-shaped. Body covered with longitudinal rows of fairly long, close-packed cilia. Mouth opening large, oval. The whole border of mouth with the exception of the hindmost portion studded with long, strong cilia. Undulating membrane wanting. Nucleus central. Contractile vacuole terminal."

Holosticha rubra (Ehrenberg) var. flava.

A hypotrichous ciliate generally found in Drake's Island Tank. Abundant in the summer.

Body very flexible and elastic, but slightly contractile longitudinally. Length, ·18 to ·37 mm., and four or five times the breadth. The greatest width is about the middle of the body. The anterior end is narrowed and rounded, forming a kind of lobe, which is divided so as to form two lips of which the ventral one is transparent and projects slightly beyond the dorsal (Fig. 18 l). These two lips thus enclose a groove which is continued to right and left, and along it the anterior crown of cilia runs. The posterior extremity is wider than the anterior, but narrower than the

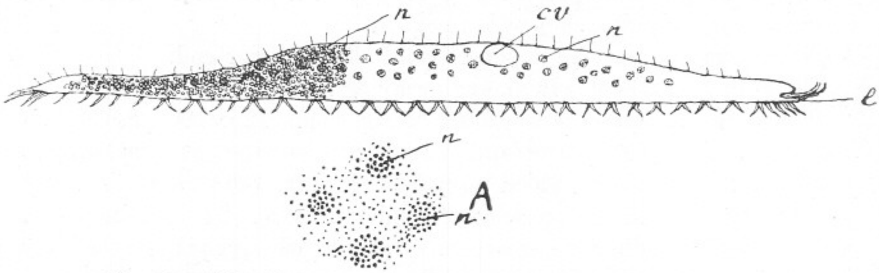

Fig. 18. *Holosticha rubra* var. *flava*, viewed from the right side. The posterior portion shows the closely pressed corpuscles.
A. Chromatin granules aggregating to form nuclei,
n. : Nuclei. l. : Clear under lip. cv. : Contractile vacuole.

middle body width. It is obtusely rounded, and rarely I have seen it prolonged into a tail-like appendage. The median region of the body is thicker than the anterior and posterior, so that the dorsal outline is convex (Fig. 19).

The ventral surface is generally flat, but the margins of the body can be contracted inwards, so that there is a ventral hollow. The dorsal surface is studded with very fine short cilia, placed a considerable distance apart. There is no sign of striation.

The colour is dusky yellow, and during 1925 I have not observed much variation in it. Sometimes dark-brown pigment masses lie near the base of the cirri, comparable to the red pigment in *Holosticha rubra*, but this is not usual. In the ectoplasm a number of very small spherules of equal size lie in direct contact with one another. These do not stain *intra vitam*, and require high magnification to make out.

There are four rows of ventral cirri. The two central rows start from the anterior end, and run the whole length of the body to the posterior end. The left (ventral) row begins at the point where the anterior row of cilia commences, and extends to the posterior end. The right (ventral) row, from about the middle of the peristomial right (ventral) margin to the posterior end. These cirri are fine, and all of the same size. There is a solitary cirrus, which lies on the left margin of the peristomial area.

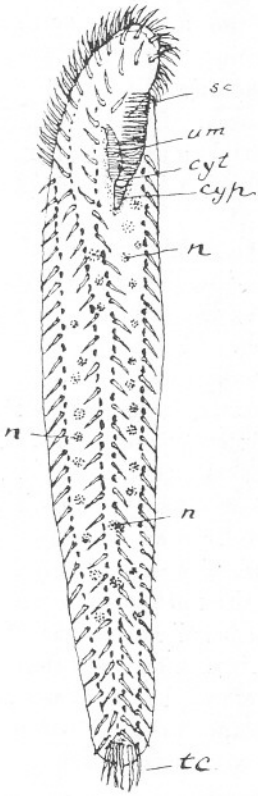

FIG. 19. *Holosticha rubra* var. *flava*, ventral view. cyt.: Cytostome. cyp.: Cytopharynx. um.: Undulating membrane. n.: Nuclei. tc.: Terminal cirri. sc.: Solitary cirrus.

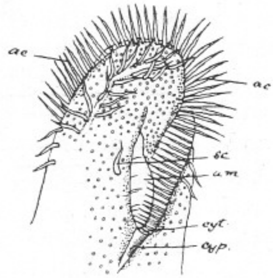

FIG. 20 Peristomial area of *Holosticha rubra* var. *flava* enlarged. ac.: Anterior stout cilia. sc.: Solitary cirrus. um.: Undulating membrane. cyt.: Cytostome. cyp.: Cytopharynx.

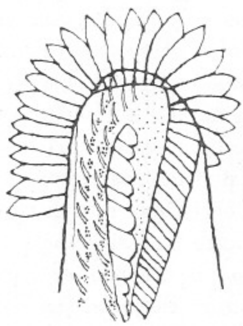

FIG. 21. Maupas' drawing of peristomial area of *Uroleptus Roscovianus*.

The cilia of the anterior crown start from a point within the anterior one-fifth of the body, on the left, and run round the anterior end following the groove between the dorsal and ventral lips, and terminate with the dorsal lobe.

There are six to eight cirri at the posterior end, which project about half their length beyond the extremity (Fig. 19).

The peristomial area (Fig. 20) occupies nearly the whole of the right (ventral) half of the anterior one-fifth of the body. It forms approximately an isosceles triangle with the base at the anterior end. At the posterior end is the cytostome, which is continued into a short cytopharynx, the walls of which are ciliated. The membrane covering the cytopharynx is very transparent, and its course very distinct.

A row of stout cilia or cirri run along the right (ventral) margin of the peristomial area. They are continuous with the cilia of the cytopharynx, and extend along the right margin until they meet the cilia of the anterior crown. It should be noted that viewing the animal ventrally they are based on the right margin of the peristomial area. The figures of Maupas, Entz, and Gourret and Rœser leave it doubtful from which margin they arise, but Wallengren's (**32**) admirable drawings of *Holosticha rubra* leave no doubt on this point.

There is a small vibratile membrane which readily breaks up into fine cilia, lying along the left peristomial margin just above the cytostome.

Holosticha flava affords a good example of the structure of cirri and membranes usually described as undulating. Under the coverslip the cirri and membranes may often be seen breaking down into their component cilia. It is, therefore, possible that the same species of ciliate may display cirri or membranes under different conditions. I have frequently observed cilia interposed among the peristomial cirri, and the undulating membrane in Holosticha is frequently very difficult to detect on account of its having broken down into exceedingly fine cilia.

Maupas, in his drawing of *Uroleptus Roscovianus*, probably identical with *Holosticha rubra* (Fig. 21), represents the anterior and peristomial margins as surrounded with large membranellæ. I have never seen such an extreme case in Holosticha, but, of course, it might occur if the synthesis of the cilia were extended. It seems, therefore, that the foundation of species on the possession of cirri or membranes in particular positions, should be adopted with caution, and only after examination of a very large number of specimens from different localities.

It may be mentioned here that immersion of the animal in 1% solution of Eurythane in sea-water much facilitates observation. The effect of the anæsthetic is almost immediate, and the animal is not damaged. I have used solution of cherry tree gum with good results. But the structure of the peristome is best observed when the animal is in sea-water under the coverslip, taking advantage of the comparatively short time between the retardation of the animal under the slip and its disintegration. The contractile vacuole generally appears about the middle of the body towards one side near the dorsal surface. In *Uroleptus Roscovianus* Maupas (**18**) describes two canals. I have observed neither these nor the cytopyge.

Nucleus. Staining *intra vitam* with congo-red or methyl-green, the nuclei appear as small spherical masses, distributed irregularly through the endoplasm. Fixed with sublimate or Bouin Duboscq's solution and stained with any of the ordinary stains, these masses are seen to be aggregates of small, deeply staining granules. These granules are scattered

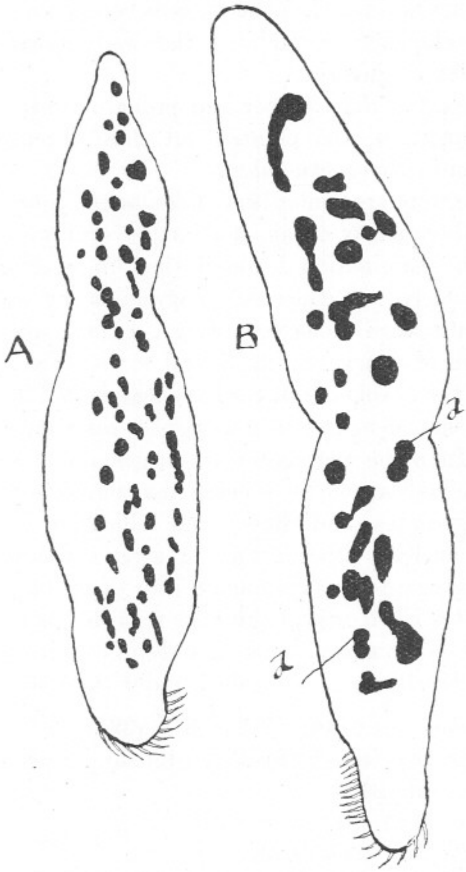

FIG. 22. Two views of *Holosticha rubra* var. *flava* in process of division.
A. Showing the numerous small nuclear aggregates.
B. Larger aggregates and smaller number. d. : Dumb-bell shaped masses formed by aggregation of two spheres.

throughout the endoplasm, and collect to form masses, according to Maupas ·003 to ·004 mm. diameter. Maupas (**18**) thinks that there is a homogeneous central substance round which the granules collect.

The existence of a micronucleus is doubtful. Gourret and Rœser (**12**) observe that there are two ovoid nuclei lying near together in the posterior part of the body; but that they are difficult to see, even after fixation by osmic acid and staining with aniline stains.

Entz (**8**) describes two well-developed nuclei and micronuclei—one lying at the posterior end of the peristome between the adoral band and the left body margin, and the other near the left margin of the body above the middle.

Gruber (**13**) maintained that the nucleus consists of granules scattered through the endoplasm, resembling the well-known disintegration of the nucleus after conjugation.

Entz (**8**) suggested that Gruber had probably only examined animals just after conjugation, and pointed out that Ehrenberg had observed two large nuclei in *Holosticha rubra*.

In 1911 there were great numbers of *Holosticha rubra* in Drake's Island Tank, and I subsequently obtained a further supply from dredgings, etc. On microscopic examination I found that in every case the nuclear matter was scattered or collected in granular masses of varying size, exactly as occurs with *Holosticha flava*. I have also examined many cases of division of which Fig. 22, A and B, are typical examples.

In each case the granular spheres have aggregated into larger masses—the dumb-bell-shaped figures in B evidently resulting from the union of two spheres. In B the aggregates are larger and fewer than in A, but in each case the nuclear matter is being distributed to the future products as separate aggregates, and there is no indication of the formation of a single large nucleus either before or after division. Probably after division the aggregates break up again into their component granules.

Holosticha rubra Ehrb. may, I think, be regarded as the type species and *Holosticha flava* as a variety, differing only in colour and possibly in size.

Holosticha rubra has been described under the following names:—

Holosticha rubra Kent (**16**), Wallengren (**32**).
Oxytricha rubra Ehrenberg (**6**), Dujardin (**5**), Fresenius (**9A**), Cohn (**4**), Quennerstedt (**24**).
Oxytricha flava Cohn (**4**).
Oxytricha flava var. *carnea* Cohn (**4**).
Holosticha flava Rees (**25**), Gruber (**14**), Kent (**16**), Fabre-Domergue (**9**), Smith (**30**).
Holosticha flavorubra Entz (**8**), Gourret and Rœser (**12**).
Uroleptus Roscovianus Maupas (**18**).

The only point in which these varieties differ is the colour, which is very variable. Maupas describes *Uroleptus Roscovianus* as rose-red; the specimens in Drake's Island Tank were more the colour of Paracarmine, and the scale runs through brick-red, reddish yellow, down to the ochreish yellow of the individuals which are now most abundant in the Tank.

HOLOSTICHA MULTINUCLEATA Maupas.

A hypotrichous ciliate found throughout the year in Drake's Island Tank, and abundant in the summer months (Fig. 23). It is described by Maupas (**18**), but his figures are not good representations of the Plymouth animal, because the anterior and peristomial cirri are aggregated into membranellæ, as is also the case with *Holosticha rubra* var. *flava*.

Wallengren (**32**) describes as *Holosticha multinucleata* var. *decolor* a variety which except in one or two minor points is identical with the Plymouth variety. His paper is in Swedish, but the figures are excellent.

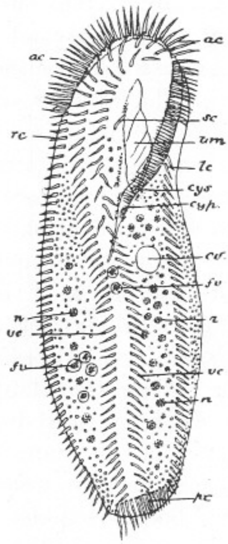

FIG. 23. *Holosticha multinucleata*, ventral view.

ac. : Anterior cirri. rc. : Right cirri. lc. : Left cirri. sc. : Solitary cirrus. vc. : Ventral cirri. pc. : Posterior cirri. cys. : Cytostome. cyp. : Cytopharynx. um. : Undulating membrane. fv. : Food vacuoles. vc. : Contractile vacuole. n. : Masses of aggregated nuclear material. The areas of closely packed yellow corpuscles are not shown.

His views are summarised in *Nord. Plankton,* XIII, 88, as follows: " Apart from certain variations in the arrangement of the rows of cirri, differs chiefly from the type form in the absence of pigment."

Holosticha multinucleata resembles *Holosticha flava* in many respects, differing principally in its general shape and proportions ; and is very easy to identify (Fig. 23).

It varies in length from ·120 mm. to ·270 mm., and occasionally reaches ·3 mm. The length is generally about three times, but occasionally only twice the breadth. Maupas states that the ratio is less in the larger, than in the smaller individuals, but my observations show that large and small vary indifferently. The body is not very contractile longitudinally, but is very elastic. The anterior extremity is boldly curved, and viewed dorsally appears as a lobe, turned towards the left. The posterior end is variable, sometimes forming a regular curve slightly less than the anterior, sometimes truncated, but never forming a tail. Occasionally it is wider than the anterior extremity. The right border of the body generally forms a long, fairly regular curve, while the left is more convex, especially in the middle region. These curves are, however, often broken, giving a more or less undulating outline. The ventral surface is flat; the dorsal arched, its highest point being about the middle of the body, and gradually flattens out towards each end. The ventral surface projects very slightly beyond the dorsal, and between them runs a groove which extends along either side, and along which runs the row of anterior cirri. The lower or ventral lip is, however, not transparent as in *Holosticha flava*. Maupas does not describe or figure this groove. It is shown in Wallengren's drawing.

The peristomial area resembles a large isosceles triangle with the base anterior, and occupies about one-third of the length of the body, and one-half of the width. I have frequently seen cases in which it occupied one-half the length. The left-hand border of the peristome carries a row of cirri, and the right a large, well-developed undulating membrane. Cross-striation is faintly visible, and it does not break up easily into its component cilia, although by constant flapping, its margin becomes frayed. It is easily removed entire by microdissection.

The cytostome is at the apex of the triangle forming the peristomial area, and is continued into a long narrow cytopharynx, which is ciliated.

In colour and structure the body resembles the Plymouth *Holosticha flava*, the former being greyish yellow, and the latter full of small spherical corpuscles of equal size, equally distributed through the body, but more closely packed in two areas equidistant from each other and from the right and left body margins. These areas are often nearly pure yellow in colour.

Maupas describes large irregular pigment granules, and other very small ones of brick-red colour. These very small granules he has seen arranged in five longitudinal rows on the dorsal surface.

The ventral cirri run in two rows from the anterior to the posterior end. Below the level of the mouth they curve slightly towards the left. They are all of the same dimensions, but Maupas states that in some of his specimens those of the left row just at the point where it commences to curve were longer than the others.

Posteriorly there is a row of transverse cirri directed obliquely from left to right. There are twelve or thirteen of them, and the longest project beyond the margin of the body. Maupas says that their ends are curved towards the right. This I have not seen.

The left-hand row of marginal cirri commences considerably above the cytostome, and lies well within the left body margin. The right commences at, or slightly above the point where the anterior vibratile cirri arise and runs to the posterior end, gradually approaching the body margin, so that the ends of many of the cirri are visible when the animal is viewed dorsally.

There is a solitary cirrus to the right of the right peristomial border. On the dorsal surface are fine short cilia as in *Holosticha flava*.

The contractile vacuole is situated slightly behind the cytostome, and

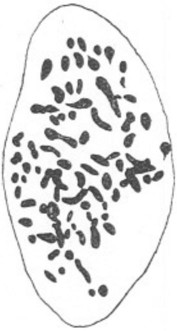

FIG. 24A.

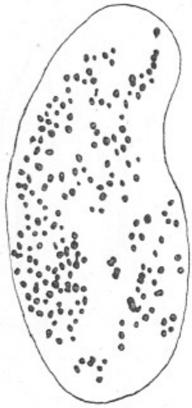

FIG. 24B.

Fixed and stained preparations of *Holosticha multinucleata*, × 240, showing aggregates of nuclear matter. Compare Figs. 22A and 22B.

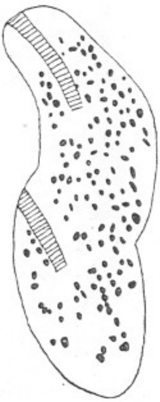

FIG. 25.

Holosticha multinucleata dividing from fixed and stained specimen × 240, showing irregular distribution of aggregates of nuclear matter to division products.

towards the left border. Maupas thinks that it lies in the dorsal wall, as in other Oxytrichids.

As regards the nucleus *H. multinucleata* resembles *H. flava*. The nuclear matter is distributed throughout the endoplasm in the form of small irregular spherical masses consisting of aggregated granules (Figs. 24A, 24B). They stain readily after fixation with Iron Hæmatoxylin, Hæmalum, Paracarmine, and Delafield's Hæmatoxylin. The figures show their similarity to those of *Holosticha rubra* var. *flava*.

Fig. 25 shows *H. multinucleata* dividing. The nuclear masses are distributed irregularly, as in *H. flava*.

I have not seen a micronucleus, nor any account of one by other observers. Its existence must be regarded as uncertain.

H. multinucleata is a restless ciliate, always creeping along the bottom and twisting among algæ, debris, etc. Occasionally it takes short flights, revolving on its longitudinal axis. It is very easy to examine in a 1% solution of Eurythane.

Lembus elongatus (Clap. and Lachmann).

A very small holotrichous ciliate, abundant in putrifying cultures in company with other species of Lembus, Uronema, Chaenea, etc.

The body (Fig. 26) somewhat resembles an elongated flask, which tapers from a little above the middle to form a narrow anterior portion, which sometimes inclines very slightly backward. Both anterior and posterior ends are rounded off.

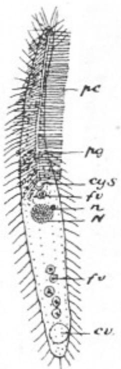

Fig. 26. *Lembus elongatus*. pc. : Cilia along one margin of peristomial groove erected pg. : Peristomial groove. cys.: Cytostome. N.: Macronucleus. n. : micronucleus. fv. : Food vacuole. cv. : Contractile vacuole.

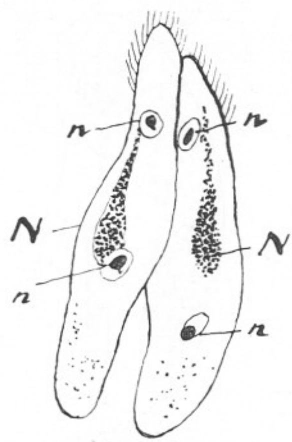

Fig. 27. *Lembus elongatus*. Conjugation from fixed and stained specimen × 630. N.: Macronucleus degenerating. n. : Micronuclei.

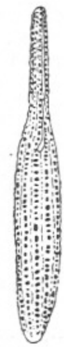

Fig. 28. *Lembus elongatus*. Stained *intra vitam* with orange-red.

It varies in length from about ·03 to ·13 mm., and in breadth at the widest part from ·01 to ·017 mm.

It is very elastic and flexible, but not markedly contractile. It hardly changes under fixation.

The endoplasm is exceedingly clear, and contains only a few refringent granules, principally confined to the anterior portion, and food vacuoles.

The body is clothed with about ten rows of fine flexible cilia, based on small papillæ, and thus appearing as faint lines of striation. There is no cross striation.

At the posterior end there is a fine bristle-like cilium, about twice as long as the body cilia.

The cytostome lies about the middle of the body, forming a shallow depression, communicating directly with the endoplasm. It is semicircular in shape, and its margins appear to be slightly thickened. I cannot make out the cytopharynx. Fabre-Domergue (**9**) states that there is a short tubular one, leading directly into the endoplasm. Gourret and Rœser (**11**), however, deny its presence.

From the cytostome a very narrow channel runs slightly obliquely to the anterior end. Both margins carry a row of exceedingly fine, closely set cilia rather longer than those of the body. These cilia can be erected so as to stand out rigidly, on either side of the channel or simultaneously. Under low magnification they appear like membranes, and have been described as such. Under an immersion objective they are resolved into the component cilia; the distal ends of the cilia appearing as a line of dots, owing to their vibration.

The views of observers on the cuticular striation and the structure of the peristome vary.

Cohn (**4**) states that the body surface is marked by clear, parallel, horizontal furrows.

Quennerstedt (**24**) believed that longitudinal striation existed, but that it was feeble, widely separated, and difficult to see. He was unable to detect any cross-striation, but pointed out that the appearance of the body outline, particularly at the posterior end, suggested it.

Fabre-Domergue (**9**) writes: "The tegument carries a system of longitudinal striation, and a system of transverse striation, which cross one another at right angles, and make the surface appear as if it were divided into small squares."

Similarly Gourret and Rœser (**11**) describe the striation.

Wallengren (**33**) made out only longitudinal striations, very faint, and widely separated. He considered that there is no transverse striation, but that under a low power an impression was conveyed that they did exist.

As regards the peristome, Cohn (**4**) writes that a mouth cleft extends from the anterior end to the second third of the body, and that from this a sail-like membrane can be more or less extended.

Kent and Rees (**16** and **25**) agree that the membrane consists of cilia, and Rees states that there are two such pseudomembranes, one along the left and the other along the right margin of the peristomial channel.

Quennerstedt (**24**) says that there is no real peristome; at the most a small narrow cleft is present; that Cohn's "mouthsail" is a finely striated undulating membrane stretching along one side over the oval mouth-opening. Later he adds that he observed another membrane, within Cohn's "mouthsail."

Fabre-Domergue (**9**) describes a finely striated undulating membrane.

Gourret and Rœser (**11**) describe such a membrane attached to the left margin of the peristome, and within this adoral membrane a row of finer cilia on the peristomial groove.

Wallengren (**33**) describes a well-developed undulating membrane running along the right margin of the peristome; this membrane is distinctly cross-striated. This membrane Wallengren believed to be a true membrane, and not a row of free aggregated cilia, since he never saw it resolved into its component cilia. Wallengren, however, noticed that when the membrane was erected, its free margin appeared as a line of dots. He thinks that the impression that there are two membranes, is due to a wrong interpretation of what is seen when the row of peristomial cilia is not erect. In this case the striated basal portion of the membrane would appear along one margin, and the gently undulating distal margin would appear to run along the left margin of the peristomial channel. When the membrane was erected, the illusion of there being two membranes would disappear. Of course, Wallengren's interpretation fails because he had never seen the membrane resolved into separate cilia, and reaggregated. Wallengren, however, admits that there is a slightly narrower undulating membrane along the right peristomial border, within the larger membrane, and that when the latter is extended, the inner membrane may be seen gently undulating. Probably what Wallengren saw was the lips of the cilia along the left margin moving gently. Had he waited he might have seen them erected so as to form the second membrane.

The contractile vacuole is at the posterior end of the body.

The macronucleus is situated about the middle of the body, spherical or ovoid in shape and of finely granular structure. It is accompanied by a small spherical micronucleus, also of granular structure. When the animal is about to divide, the micronucleus elongates and becomes constricted, and divides into two spherical portions which move apart to opposite poles of the macronucleus, meanwhile the macronucleus becomes constricted and divides, followed by the cytoplasm of the body. I am unable to decide whether the micronucleus divides mitotically or not. Some of my preparations suggest that it does so.

I have several times observed conjugation, in every case the process was in the same stage. The micronucleus had divided into two, and the macronucleus was breaking down. Probably conjugation follows the course observed in Paramœcium, where the micronucleus divides twice, giving four micronuclei in each conjugant. Of these three disappear, and the persisting one divides, forming two pronuclei. From the condition of the macronucleus (Fig. 27), which appears to be breaking down, the first division of the micronuclei is suggested.

Lembus elongatus can swim pretty swiftly, with an oscillating motion, describing a wide spiral round the direction of motion. It remains quiescent for long periods, erecting the cilia along the margins of the peristomial groove sometimes together, sometimes alternately, at the same time slowly revolving on its longitudinal axis.

Staining *intra vitam* with neutral red has a singular result. The whole body of the animal becomes covered with fairly regular figures arranged in longitudinal rows, giving the animal a resemblance to a painted vase (Fig. 28). The surface of the figures is raised like a blister above the surface of the body. Similar patterns arise when *Lembus sarcophagus* and *Lembus pusillus* are stained *intra vitam* with neutral red. Whatever be the nature of the substance that takes the stain it is destroyed by fixation—I have never observed a similar phenomenon, in any case of fixation and staining by usual reagents.

This ciliate has been described as *Lembus elongatus* by Kent (**16**) and Wallengen (**33**); as *Cyclidium elongatum* by Claparède and Lachmann (**3**) and Rees (**25**); as *Lembus retifer* by Cohn (**4**), Quennerstedt (**24**), Kent (**16**), Maupas (**18**), Entz (**8**), Gruber (**14**), Gourret and Rœser (**11**); as *Lembus striatus* by Fabre-Domergue (**9**); as *Lembus intermedius* by Gourret and Rœser (**11**); as *Lembus infusionum* by Calkins (**2**); and as *Proboscella vermina* by Kent (**16**).

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