

The Rotifera of Antony van Leeuwenhoek

BRIAN J. FORD

Science Unit, Mill Park House, 57 Westville Road, Cardiff, CF2 5DF

Introduction

THE ROTIFERS were amongst the first of the micro-organisms to be recorded by the pioneer microscopist Antony van Leeuwenhoek (in 1674 and 1676) and his vivid description of their survival whilst dessicated is an important portion of his letter sent to the Royal Society from Delft on 9 February 1702. He wrote that he had, on 25 August (presumably in 1701), found rotifers in the water trapped in a lead gutter on his house. They had been feeding on *Haematococcus*—in Leeuwenhoek's words: 'little round animalcules . . . whereof most had the outermost part of their bodies a pale green, and the middle of the body quite red'. He noted carefully that 'we see that these animalcules can lie so long in dry matter . . . and then on coming into water can swell out their bodies and swim off. Can there even now be people who still hang on to the ancient belief that living creatures are generated out of decay?' His clear description of the ring of cilia in the rotifera as: 'wheel-like or indented particles mov'd in a circle' (1713) well matches later findings. Most interesting of all are his studies of bdelloid rotifers dating from 1687, for in this case he sent to the Royal Society a sample of a dried algal mat similar in kind to the examples in which he had observed the organisms. The original specimens were found to be intact (Ford, 1981a) and the circumstances in which they were found have been documented (Ford, 1981b), as have the annotations on the packets in which the specimens were found (Ford, 1981c). The reconstitution of small fragments of this algal material from 1687 has now enabled some of the original rotifers to be provisionally isolated, and in one case identified with some certainty.

Leeuwenhoek's Descriptions

The letters in which Leeuwenhoek referred to the rotifera have been collated with the aid of the analytical index prepared by Cole (1938). Though some of these references are outline descriptions only, others go into considerable detail and some are accompanied by careful diagrams in the text of the original manuscript. Examples of these appear in the published versions of the letters (1703, 1705). A table in which Leeuwenhoek's investigations of rotifers are summarised is appended. Note that some of these are not available in a recent translation, as the definitive edition of the *Collected Letters of Antony van Leeuwenhoek* (q.v.) goes no further than the letter dated 10 July 1695 (published in 1969). The translation of the remaining letters is at present under way in the Netherlands.

Leeuwenhoek's first apparent reference to rotifers, according to Dobell

(1932) comes in his letter of 7 September 1674. It was in this crucial communication that he first recorded the discovery of microbial life (Ford, 1981b, 1982). He wrote:

'I found . . . some green streaks, spirally wound serpent-wise . . . and among these there were besides, very many little animalcules, whereof some were roundish, while others, a bit bigger, consisted of an oval. On these last I saw two little legs near the head, and two little fins at the hindmost end of the body.'

Leeuwenhoek seems to have passingly referred to rotifers again in his celebrated letter of 9 October 1676 [New Style] as 'very monstrous . . . and bigger animals' (Dobell, 1932, p. 121) but Dobell passes then to Leeuwenhoek's later letter of 28 June 1713 in which he speculates that the 'unbelievable motion . . . of their revolving toothed network' caused many little particles to be 'wafted towards the animalcule' until some of them, 'being borne into the middle of the revolving instrument, were used as food by the animalcule' (Dobell, 1932, p. 292). There are a number of other descriptions of these organisms, however, which are detailed and revealing, and which are only available in the early translations published by Hooke (1798, 1807) and in *Phil. Trans.* (see table).

The letter of 25 December 1702, published in *Phil. Trans.*, Vol. XXIII, p. 1304, in the next year, describes the vorticellid organisms which Leeuwenhoek 'liken'd to little Bells' and then continues with a description of sedentary rotifers (see Fig. 3):

'I observed . . . sheaths or cases fastened [to the roots of pondweed]. Out of the same sheath appear'd a little Creature, the forepart of whose body was roundish, as in x, z, y, and presently from the same Rotundity proceeded 2 little Wheels that had a swift Gyration, as in Fig. 8. a, b, c. The Limner* observing the Rotation of the Wheels, which always ran one and the same way, could not be satisfied with the sight, adding, O, that he could always see such a wonderful kind of a motion. These small Wheels were as thick beset with Teeth, like the Wheel of a Watch; and when these *Animalcula* had for some time exerted their circular motion they drew their Wheels into their Body, and their Body wholly into their Sheaths, and then soon after thrust them out again with the aforesaid motion.'

This is probably a reference to the rotifer *Limnias ceratophylli*, in which the mucilaginous sheath may be covered with adherent detritus (but is often translucent in clean water), and which is characterised by the possession of two lobes of cilia.

The next lengthy descriptions occur in the letter of 13 November 1703 published in *Phil. Trans.*, Vol. XXIV, pp. 1525, *et seq.* (see p. 366). Leeuwenhoek described how he collected a sample of clay earth 'about the bigness of a Crown piece' and took it home to examine it for micro-organisms, since he observed that he had seen some in the rotten wood of a Willow and in 'another rotten Plank that had lain in the open Air'. The organisms he had seen

*FOOTNOTE: The term *limner* = artist, painter; from the term *lumine*, 'to illuminate'. *Limnology*, the study of pond-life, is an unrelated term derived from the Greek *limne*, 'lake'.

Fig. 33.

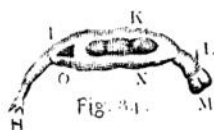


Fig. 34.

FIG. 1. These figures, to accompany the letter of 9 February 1702, appear in Hoole's plate XVI (vol II), and show two bdelloid forms. Though the remainder of this plate appears in the *Collected Letters* [plate XIV], these two figures are omitted.

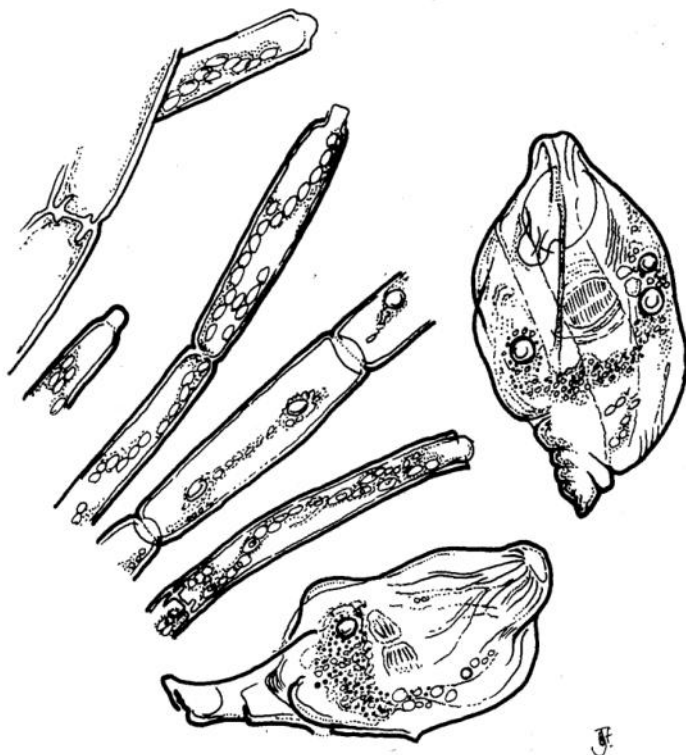


FIG. 2. Sketches by the author showing two bdelloid rotifers from the reconstituted material of specimen No. 8, a dried chlorophyte felt originally obtained from a barrel of well-water in Delft, and sent to the Royal Society by Leeuwenhoek on 17 October 1687. Note mastax (central) and orange-coloured food reserves which appear black in these drawings.

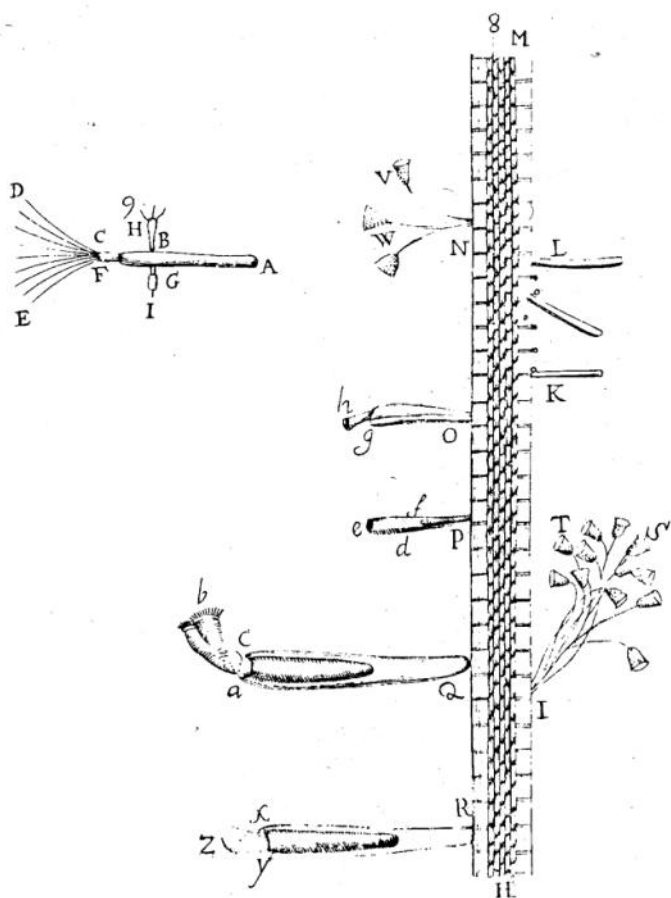


FIG. 3. Diagrams as published in *Phil. Trans.* XXIII: 1304 (1703) – facsimile in Dobell, C., *q.* Plate XXVIII, facing p. 277, showing *Hydra Vorticella* and a sheath-forming rotifer, provisional identified by the author as *Limnia ceratophylli*. Letter No. 149, 25 December 1702.

Y^eou may remember, that in my Letter of the 25th of Decemb., 1702. I affirm'd that the Animalcula, represented by Fig. 8. a. b. c. that were fastned to the small Roots of that Green stuff found on the top of the Water in our Ditches and little Canals, which we call Duck-weeds, had two small Wheels issuing out of their Bodies. A certain Curious Gentleman, that saw the Motion of these Wheels with great satisfaction, entreated me, that when I had an opportunity, I would once again show him this Wonderful Rotation.

FIG. 4. Opening passage of the letter No. 160, from *Phil. Trans.* XXIV: 1784, which refers to descriptions on Fig. 1. The letter, dated 14 November 1704, is not included in Dobell's biography

in these specimens were in his opinion 'some of those same *Animalcula* which are usually found in Water'.

He describes how he clipped away the excess grass, and mixed the earth with cool rainwater, previously boiled, in a glass tube 'about as wide as a Childs Finger'. His account continues thus:

This Water having stood several hours, and acquired a little more clearness, I saw two particular *Animalcula* that came very near in Figure to those that produce little *Wheels* out of their Bodies, only instead of such *Wheels* they protruded a Horny part out of their Body, which they sometimes drew in, and then thrust out again; there was also one *Animalculum* that put out two $\frac{1}{2}$ *Wheels*, and just by I perceived two other sorts of *Animalcula*, but immediately lost sight of them again; from whence I concluded, that so much Water was not natural to them, and therefore they were dead; and after that the Water had stood three days upon the Clay, I saw several *Animalcula* that were four times as long and as thick clinging to the sides of the Glas without any motion, tho they stirred about briskly at the first.

Leeuwenhoek then describes the occurrence of these organisms in dried material from gutters—an extension of his observations referred to in his letter of 9 February 1702, *supra*—in the following words:

'In the said small Particles of Water [produced in stormy weather] are conveyed the above-mentioned small *Animalcula* far up into the Land, and when the Ground becomes dry, they contract themselves into an oval Figure, and the Pores of their skin are so well clos'd, that they do not perspire at all, whereby they preserve themselves till it Rains, upon which they open their Bodies and enjoy the moisture. And thus, in my poor opinion, it happens that we find these *Animalcula* in every Meadow of our Country, none of which are very remote from the Sea or Water Canals.'

A lengthy discourse on the nature of the ciliary action of the rotifera occupies several pages of the letter dated 14 November 1704 in which Leeuwenhoek seems to describe *Rotaria rotatoria*, a frequent inhabitant of the water around duckweed, and *Philodina roseola*, a reddish rotifer typical of the population found in dried-up gutters reconstituted in the laboratory (and possibly the organism referred to in the Introduction, p. 362, *q.v.*). He writes:

'They had two distinct revolving *Wheels*, as they appear'd to others as well as myself; I have discover'd several *Animalcula* that thrust out two *Wheels* out of the fore part of the Body as they swim, or march on the sides of the Glass; one of which I have caus'd to be describ'd by Fig. 5 VWX. This sort of *Animalcula* I found in great numbers in the Gutter-water in Summer, which had stagnated some days.'

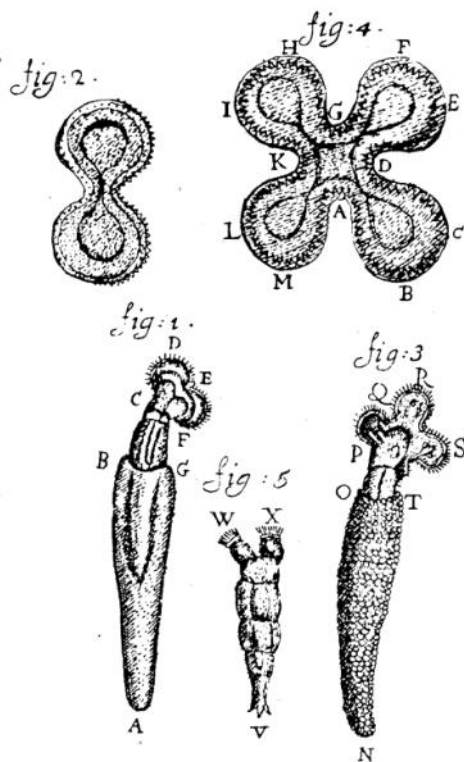


FIG. 5. The fine illustrations of rotifers, showing the velum structures (Figs. 2 & 4), accompany the letter No. 160 of 14 November 1704 (see also Fig. 2). Fig. 1 is possibly *Limnias ceratophylli*; Fig. 3 surely *Meliceria ringens* and Fig. 5 shows a typical bdelloid form of the kind observed in the Leeuwenhoek specimens sent to London. This form may represent *Philodina roseola*.

His account continues with a clear account of his successful reviving of rotifers that had lain 'near 21 months in the Paper', and it concludes with clear drawings of three rotifers (see above), which I provisionally identify as (Fig. 1) *Limnias ceratophylli*; (Fig. 3) *Meliceria ringens* and (Fig. 5), *Philodina roseola* referred to as the organism that had survived for nearly 21 months in the dried state.

Philodina and *Rotaria* are bdelloid, i.e., leech-like rotifers, a term connoting their characteristic means of locomotion across a solid surface. And it is this category of rotifers that Leeuwenhoek accurately described in his letter of 17 October 1687. This account has added interest in that it is accompanied by dried pond matter (Ford, 1981c, 1982) in which well-preserved rotifers are still visible.

LEEUEWENHOEK'S REFERENCES TO THE ROTIFERA

Letter Number ¹	Date	Published by
#6	7 Sept. 1674	<i>Phil. Trans.</i> , ix (108): 178 - 182 (1674). <i>Collected Letters</i> ² 1: 161 - 165. <i>Dobell</i> ³ 109 - 111, plate XVII.
[18b] ⁴	7 Nov. 1676	Referred to in Haaxman ⁵ (1875): 135, Snelleman ⁶ (1874 — in part only); a shorter copy of the previous letter. Published by Vandeveld and van Seters ⁷ .
#18	9 Oct. 1676	<i>Phil. Trans.</i> , xii (133): 821 - 831 (1677). <i>Collected Letters</i> 2: 91 et seq. <i>Dobell</i> , 117 - 166, plate XIX.
#59	17 Oct. 1687	Hartsoeker ⁸ p. 25 (1730). Hoole ⁹ 1: 218 - 220 (1798), 2: 31 - 32, 257 - 265 (1807). Vandevelde ¹⁰ , pp. 1031 - 1033 (1922). <i>Collected Letters</i> , VII: 95 - 97.
#144	9 Feb. 1702	Hoole, ii: 207 (1702). <i>Dobell</i> , 263 - 270.
#149	25 Dec. 1702	<i>Phil. Trans.</i> , xxiii: 1304, pl. 283. <i>Dobell</i> , 275 - 285, plates XXVIII, XXIX.
#152	13 Nov. 1703	<i>Phil. Trans.</i> , XXIV: 1522 (1704).
#160	14 Nov. 1704	<i>Phil. Trans.</i> , XXIV: 1784 - 1793, plate 295, (1705).
#VII	28 June 1713	<i>Phil. Trans.</i> , XXVIII: 160 (1714). <i>Dobell</i> , 291 - 294 (rotifers omitted).
#XXIX	5 Nov. 1716	Dutch ¹¹ and Latin ¹² versions only, extracts in <i>Dobell</i> : 297 - 298.

FOOTNOTES

1. After Cole, F. J. (1937). Leeuwenhoek's Zoological Researches, part 2, *Ann. Sci.*, II: 185 - 235, *vide* p. 228.
2. *Collected Letters of Antony van Leeuwenhoek* (1939 - present, publication continuing), Swets and Zeitlinger Ltd., Amsterdam.
3. Dobell, C. (1932). *Antony van Leeuwenhoek and his 'Little Animals'*, John Bale, Sons and Danielsson, London.
4. Numbered thus by Dobell, *supra*; note break in chronological sequence.
5. Haaxman, P. J. (1875). *Antony van Leeuwenhoek, de Ontdekker der Infusorien van Doesburgh*, Leiden.
6. Snellman, J. F. (1874). *Antony van Leeuwenhoek, Album der Natuur*: 375, Haarlem.

Contents Summary

A vague reference to organisms in water from Berkelse Mere: 'some were . . . an oval. On these last I saw two little legs near the head, and two little fins . . .'.

Summary in a letter to Constantijn Huygens and translated into French by his son Christiaan; it was not published until 1899, a different French summary being published in 1678. See previous entry, letter #6.

26 May 1676, 'divers creatures with tails [from rainwater]' attributed by Dobell to *Vorticella*, but probably rotifers since *Vorticella* does not occur in rainwater gutters, whereas rotifers do.

Describes green algal matter collected from a barrel of well-water and described in the present paper, and detailed accounts of rotifers from 'stone cisterns' in Delft.

Haematococcus and rotifers from a lead gutter are clearly described. The ability of rotifers to withstand desiccation is examined. Illustrated.

The rotary action of the rotiferan velum is noted: 'two little wheels that had a swift gyration . . . such a wonderful kind of motion'. Illustrated.

Brief descriptions. See text.

'Two small wheels . . . this Wonderful Rotation.'
Lengthy descriptions with excellent red-pencil drawings in the text, *q.v.*

Deduces the use of the ciliary velum in feeding, etc.

Descriptions of the resting behaviour of rotifers.

7. Vandevelde, A. J. J. and van Seters, W. H. (1925). Over eenige handschriften der Brieven van Antoni van Leeuwenhoek. *Versl. & Mededeel. Kon. Vlaamsche Acad.* 35 pp., Gent.
8. Hartsoeker, N. (1730). *Cours de Physique accompagné de plusieurs pièces*, La Haye.
9. Hoole, S. (1798, 1807). *The Select works of Antony van Leeuwenhoek*, 2 vols., London.
10. Vandevelde, A. J. J. (1922). De brieven 53 tot 75 van Antoni van Leeuwenhoek, *Versl. & Mededeel. Kon. Vlaamsche Acad.* 1019 - 1056, Gent.
11. Dutch editions, chiefly as *Ondervindingen en Beschouwingen* or *Ondervindigen en Ontdekkingen*, were published 1684 - 1713.
12. Many Latin editions were published, but see *Opera Omnia, seu Arcana Naturae, etc.*, Vols. I - IV, 1722, Lugduni Batavorum.

The Rotifer Specimens of 1687

Leeuwenhoek's account of 17 October 1697 is apparently the first in which he clearly described rotifers at some length. His description stated that they were six times as long as they were in thickness, with the abdomen tapering to a point. At the extremity of the abdomen were organs by which the organisms could attach themselves to glass, he wrote, and they swam by means of organs of motility at the front of the head. He observed that the particles suspended in water around the organisms showed a circular motion. His description of the alternative, bdelloid movements of these organisms is unambiguous:

'These Animals also had a second movement; for when they were unable to make any progress by swimming, they attached themselves to the glass by the organs at the front of the head; and then they drew their body up short, and having attached their abdomen to the glass, they detached the front of their body from the glass again, and then stuck, or stretched the same as long as they could, and then attached the same once more.'

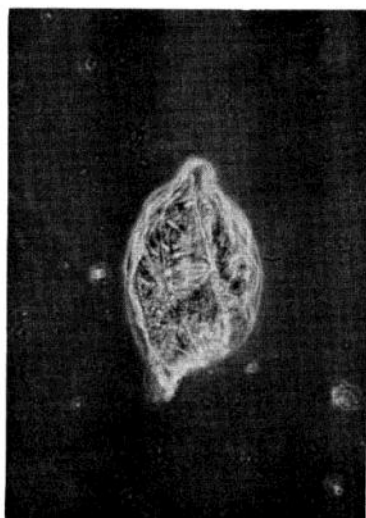
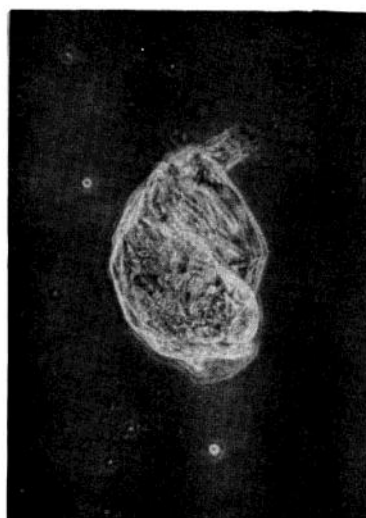
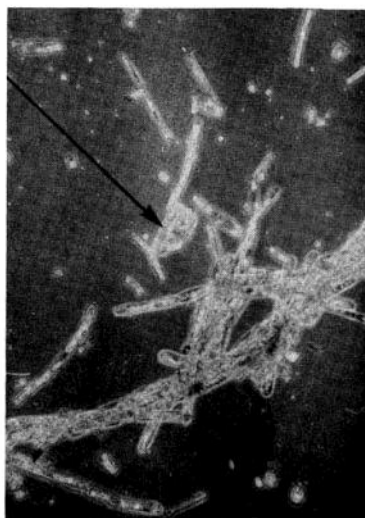
He analogised the movement to the looper caterpillars which we know as the Geometridae, an apt comparison (*Collected Letters*, Vol. VII, pp. 94 - 97). Although Leeuwenhoek's dried specimens included with this letter were intended to be examined for their component of 'green floating stuff', i.e., filamentous algae, it is intriguing that the material also contains some identifiable rotifers of exactly the kind Leeuwenhoek described. The algal material was reconstituted overnight with sterilised lake-water in order to facilitate the micrography and identification of the algal types present. By teasing the material, the dried remains were revealed by Leitz Phaco NPL fluotar phase microscopy. The rotifers were clearly identifiable as bdelloid types. The mastax structures were visible, together with coloured inclusions, presumably stored food reserves, with the appearance of reddish or orange oil droplets. In some cases these organisms were drawn from the slide, though some were also imaged for photomicrography in colour using Kodachrome 64 transparency film. Genus identification, on the evidence so far obtained, cannot usefully be attempted for most of the specimens observed (see Fig. 2):

PLATE 1. Low-power phase appearance of reconstituted chlorophyte filaments from Leeuwenhoek's specimens of 17 October 1687. Rotiferan resting-phase (arrowed) is visible near centre.

PLATE 2. Resting-stage bdelloid rotifer from Leeuwenhoek's dried algal material showing central ovoid mastax and rounded food-storage particle (right). Phase contrast. See also diagram p. 364.

PLATE 3. Bdelloid form in which gastric structure can be perceived. Note also pedal gland in partly extended extremity. Leitz dialux microscope, phase NPL optics.

PLATE 4. Partly extended configuration of this bdelloid rotifer reveals the rapid drying mentioned by Leeuwenhoek in his letter of 17 October 1687. Refractile [dark] mass (below centre) is presumptive ovarian/vitelline gland structure.



PLATES 1 - 4 show examples of rotifers found scattered amongst the algal filaments collected by Leeuwenhoek from a barrel of well-water in Delft and sent to the Royal Society in 1687. Plates 2 - 4 show individual rotifers teased clear of surrounding filamentous detritus. In each case the rotifer body is approximately 250 micrometers in length.



PLATE 5*. This finely-preserved rotifer from Leeuwenhoek's specimens of 17 October 1687 has been identified by the author as *Trichocerca cristata*. It is unique amongst the individuals in being provisionally identifiable to species level. The characteristic posterior cerci provide a distinctive appearance. Magnification $\times 450$. Leitz NPL phase.

However, one example of the characteristic rotifer *Trichocerca cristata* was observed, drawn, and photographed. This is a common species in the type of habitat from which Leeuwenhoek obtained the material, a barrel of well-water. The posterior stalk in this species is often as long as the body itself, and this appearance is unmistakable in the dessicated specimen found in Leeuwenhoek's dried algal material.

Further work is planned to identify the species from mastax structure, and perhaps to investigate the possibility—no matter how remote—that the organisms might be resuscitated.

Acknowledgements

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