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Faunistic and Taxonomic Studies on Ciliates (Protozoa, Ciliophora) from Clean Rivers in Bavaria (Germany), with Descriptions of New Species and Ecological Notes

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With 20 Figures and 13 Tables

Key words: Ecology, Protozoa, River Ciliates, Saprobic System, Taxonomy

Summary

156 ciliate species were identified in 22 samples from 4 clean streams (Illach, Eger, Röslau, Zinnbach) in Bavaria, Germany. With few exceptions, e.g. *Urotricha synuraphaga*, all occurred in low or very low numbers, as is typical for clean waters. Most samples also contained few species, possibly due to methodological and/or food shortcomings. Only 3 new species were found; however, about 30 taxa were not identified, and some of these could have been new species too. Many of the species found were indicators for mesosaprobic or polysaprobic conditions although the rivers did not receive easily degradable (anthropogenic) organic wastes. Very likely, these species developed in respective microhabitats, e.g., around decaying insect larvae. Thus, it is crucial that, in evaluating water quality with the saprobic system, abundances of the indicator species are taken into account; protozoan species occurring in low or very low numbers should usually either be excluded from the analysis or at least weighted less heavily than numerous ones. Fifteen species were investigated in detail using live observation, silver impregnation, scanning electron microscopy, and morphometry: *Lacrymaria olor*, *L. granulifera* nov. spec., *L. robusta* stat. nov., *Monilicaryon monilatus*, *Trachelius ovum*, *Prorodon armatides* nov. comb., nov. nom., *Pseudochilodonopsis polyvacuolata*, *Gastronauta clatratus*, *Holophrya seyrli* nov. spec., *Urotricha synuraphaga*, *Platynematum sociale*, *Gastrostyla minima*, *Hackenbergia langae* nov. gen., nov. spec., *Pseudochlamydonella rheophila*, *Rostrophrya camerounensis*. *Monilicaryon monilatus* lacks short, oblique preoral kineties. Thus, a new genus, *Pseudomonilicaryon* nov. gen., is established for dileptids having a moniliform or vermiform macronucleus and a normal dileptid oral infraciliature. The new genus *Hackenbergia* belongs to the colpodid family Pseudochlamydonellidae and is characterized by highly reduced oral structures. The morphogenesis of *Gastrostyla minima* is described. This genus develops the ventral cirral row in the manner characteristic of the Amphisiellidae. Accordingly, *Gastrostyla* does not belong to the Oxytrichidae, as previously assumed, but to the Amphisiellidae.

Introduction

Ciliates from running waters have been extensively studied because they are excellent bioindicators for the amount of easily degradable organic matter and the oxygen regime (for reviews, see FOISSNER et al. 1991, 1992a, 1994, 1995, SCHÖNBORN 1992, SLÁDEČEK 1973). The mesosaprobic and polysaprobic zones were even characterized by specific ciliate communities (FOISSNER et al. 1995, ŠRÁMEK-HUŠEK 1958). However, literature on ciliates from clean streams and rivers is scarce and highly scattered, very likely because ciliates are often sparse under such conditions and thus difficult to study (FOISSNER et al. 1994, 1995). The most comprehensive investigations were performed by PÄTSCH (1974) and JUTRCZENKI (1982), who studied the periphytic ciliate communities on exposed slides in some clean streams near Bonn, Germany.

FOISSNER et al. (1995) suggested the existence of a specific oligosaprobic ciliate community composed of small and very small, algae and/or bacteria feeding cyrtophorids (e.g., *Pseudochilodonopsis polyvacuolata*, *Chlamydonella* spp.), small and medium-sized colpodids (e.g., *Kreyella* spp., *Pseudochlamydonella rheophila*, *Rostrophrya* spp.), small prostomatids (e.g., *Urotricha synuraphaga*), and medium-sized hypotrichs (e.g., *Diaxonella trimarginata*). This is supported by the present investigations, although data are still too incomplete for a definite conclusion. Very likely, many ciliates which prefer or are restricted to clean running waters have been not yet discovered. This is apparent from the few detailed studies performed, all describing new species or species of uncertain affinity: *Pseudochilodonopsis polyvacuolata* FOISSNER & DIDIER, 1981 from a clean stream in France; *Trochilioides* sp. PÄTSCH, 1974 and *Pseudochlamydonella*

rheophila BUITKAMP, SONG & WILBERT, 1989 from clean streams in Germany; *Idiocolpoda pelobia* FOISSNER, 1993 from an ephemeral stream in Hawaii; and *Hackenbergia langae* and *Holophrya seyrli* described in this paper.

There is thus an urgent need for detailed and comprehensive studies of ciliates from clean streams and rivers. The present paper is just a glimpse of a biotope which very likely holds a lot of surprises.

Materials and Methods

1. Area description

Four mountain streams were investigated in Bavaria, Germany. The Illach river originates at the north foothills of the Ammergebirge, E10°55′ N47°43′, in about 900 m NN. It is a richly structured, submontane, third-order tributary flowing into the Lech river about 5 km north of the village of Lechbruck; small areas are regulated. The Ammergebirge is a calcareous massif belonging to the headland of the Tyrolean Central Alps. The drainage basin (60.45 km^2) of the Illach is primarily spruce forest and pasture land. There is some eutrophication by nutrients from the pastures and a small sewage plant, but no or only slight anthropogenic pollution with degradable organic matter.

The Eger, Röslau, and Zinnbach are very small streams (Table 2) and represent a series of increasing anthropogenic acidification (FOISSNER 1994). They are in the Fichtelgebirge, E12° N50°, whose highest elevation is 1053 m NN. The mountains are composed of young, base-poor granites containing comparatively high amounts of silicic acid. The spring of the Eger stream is situated in an area rich in phyllites, quartzites, and grey wackes; that of the Röslau stream in granitoid gneiss; that of the Zinnbach stream in granite. The Röslau and the Zinnbach are first and second-order tributaries, respectively, to the Eger which flows into the River Elbe (PONGRATZ 1991). The drainage basin is primarily spruce forest. However, the region was almost completely deforested between 1920 and 1940 and used for agriculture and stock-farming; the Eger and Röslau streams were used for fish farming. Depositions of H^+, SO_4^{2-} – S, and NO_3^- – N amount to 2 – 3.8, 53 – 73, and 11 – 13 kg/ha.a, respectively.

2. Study sites and physicochemical characteristics (Tables 1, 2)

Four sites were selected between the spring and mouth region of the Illach river. However, a detailed site description and separate listing of their ciliate communities are beyond the (primarily taxonomic) scope of the paper. The physicochemical data show low variation between spring and mouth and over the year (Table 1). The river bed is about 5 m wide and consists of fine and coarse gravel mixed with some sand; maximum water depth is about 1 m, flow velocity is between 0.5 and 1 m/s. Most gravel is covered by diatoms and other micro-algae, including small patches of filamentous cyanobacteria. Foliage from deciduous trees and shrubs skirting the river accumulates in the lentic zones.

In the Eger, Röslau, and Zinnbach all samples were taken close downstream (up to 2.5 km) from the springs, ahead of any anthropogenic pollution and regulation. See Table 2 for some main physicochemical data.

Table 1. Physicochemical characteristics from the Illach river (kindly supplied by B. HÖCKER, Bayerisches Landesamt für Wasserwirtschaft). Extreme values are shown from 12 monthly measurements during the year 1995 at 10 sites between the spring and mouth.

Parameter	Min	Max	Mean
Low flow (m^3)	–	–	0.205
Mean flow (m^3)	–	–	0.909
High flow (m^3)	–	–	24.9
pH	7.8	8.4	
Temperature (°C)	4.0	13.0	
Conductivity (µS/cm)	300	470	
Dissolved oxygen (mg/l)	9.2	13.3	
Oxygen saturation (%)	91.0	112.0	
BOD_5 (mg/l)	0.0	2.2	1.2
NH_4 – N (mg/l)		<0.1	
NO_3 – N (mg/l)	2.5	7.0	
PO_{4total} – P (mg/l)	0.001	0.08	

Table 2. Physicochemical characteristics from the Eger, Röslau, and Zinnbach stream (from FOISSNER 1994). The data are averages from about 80 measurements each during the years 1983 – 1990. Extreme values in brackets.

Parameter	Streams		
	Eger (episodically acidified)	Röslau (periodically acidified)	Zinnbach (permanently acidified)
Mean flow (m^3)	0.031	0.103 (0.01 – 0.4)	0.008 (0 – 0.025)
pH	6.0 (4.4 – 7)	5.2 (3.9 – 6.6)	4.1 (3.4 – 4.9)
Conductivity (µS/cm)	53	49 (22 – 78)	87 (40 – 140)
TOC (mg/l)	2.3	4.6 (2 – 12)	4.4 (2.2 – 9.8)
NO_3^--N (mg/l)	0.73	0.69 (0.2 – 3)	1.4 (0.2 – 4.8)
SO_4^{2-} (mg/l)	5.4	15.0 (7 – 30)	25.9 (13 – 43)
Cl^- (mg/l)	8.3	2.4	3.0
Al_{tot} (mg/l)	0.21 (up to 1.3)	0.91 (0.1 – 2.1)	2.1 (0.6 – 3.8)

Eger: Samples were taken about 1 km downstream from the spring, where the river bed was 0.5 – 1 m wide and strongly shaded, mainly by spruces. The water was about 20 cm deep and had a velocity of about 0.8 m/s. The run-off was thus estimated to be 20 and 40 l/s, respectively, on the two sampling occasions. The water was slightly brownish by humic materials, clear and had a delicious, sweetish taste. The river bed consisted of sand and coarse gravel, the surface of which was brownish and partially covered by liverworts. H_2S developed in the large, compact banks of spruce needles which accumulated in the lentic stream zones.

The Eger is episodically acidified. The pH is circumneutral during dry weather periods and decreases down to 4.4 after heavy rains and snow thaw. Sulfate, TOC and aluminium concentrations are distinctly lower than in the Röslau and Zinnbach streams. The comparatively slight acidification of the Eger is very likely caused by the flat drainage basin which enables prolonged contact of the rainwater with the surface soil and the rocky bed. Furthermore, the minerals in the spring region have a slightly higher buffer capacity than those found in the spring regions of the Röslau and Zinnbach streams.

Röslau: Samples were taken about 2.5 km downstream from the spring, where the river bed was 1.5 – 2 m wide and strongly shaded by spruces. Remnants of an old regulation were recognizable. The water was about 20 cm deep and had a velocity of about 0.8 m/s. The run-off was thus estimated to be 150 – 200 l/s, respectively, on the two sampling occasions. The water was slightly brownish by humic materials and clear. The river bed consisted of sand and stones which were partially covered by green filamentous algae (in spring) and liverworts. The lentic river zones were partially occupied by banks of spruce needles, while most of the fine sand was covered with a golden layer of *Synura* sp. and diatoms.

The Röslau is periodically acidified, i.e. the pH decreases in rainy and thaw periods to 3.9 and never approaches circumneutral conditions. Likewise, sulfate and aluminium concentrations show distinct fluctuations.

Zinnbach: Samples were taken about 500 m downstream from the spring, where the river bed was 0.2 – 0.4 m wide and strongly shaded by spruces. The water was about 5 cm deep and had a velocity of about 0.4 m/s. The run-off was thus estimated to be less than 10 l/s on both sampling occasions. The water was colourless, clear and tasty. The river bed consisted of sand and some gravel which was brownish and partially covered with liverworts. Some H_2S developed in the compact banks of the spruce needles which accumulated in the lentic stream zones.

The Zinnbach is permanently acidified, i.e. the pH is always below 5. It also has higher concentrations of nitrate, sulfate and aluminium than the Eger and Röslau streams. The rather high level of organic carbon indicates that the spring is fed from a flat aquifer.

3. Sampling

Sixteen samples were analyzed from the Illach river in spring and autumn 1995. One sample each was collected from the Eger, Röslau, and Zinnbach stream in spring and autumn 1992. Direct (natural substrate) sampling was used because a comparative study showed that it was more effective than foam and litter bag sampling (FOISSNER et al. 1992b). Briefly, sampling was directed at the more obviously definable substrate types, and collecting procedures were varied slightly to obtain samples reflecting the variety of substrates (e.g., logs, twigs, rocks, mosses, algal masses, mud, debris, leaves). An effort was made to collect each different type of substrate at each station and to collect from comparable substrates at all sites. Three samples were hereby obtained at each station and date: (1) logs, twigs, and mosses; (2) algal masses, mud, debris, detritus, litter and fine gravel; (3) Aufwuchs brushed off stones and coarse gravel. Samples were stored in a cooling box while transported to the Salzburg laboratory and investigated on the day of sampling.

4. Determination of the number and kinds of species, nomenclature

In the laboratory, coverslips (40 × 24 mm) were placed on the water surface of each sample for 30 – 60 min. This is a simple and highly effective method for collecting most of the vagile and sessile Aufwuchs species (FOISSNER et al. 1991). After the coverslips had been inspected, some drops of the sediment were investigated for bottom dwellers.

Most species were determined in vivo using bright field and interference contrast microscopy. Difficult taxa were subjected to routine taxonomic procedures (see below). Identification and nomenclature followed the guides by FOISSNER et al. (1991, 1992a, 1994, 1995) and specific literature cited in the species descriptions.

5. Similarity analysis

Similarity between the ciliate communities of the streams investigated was calculated with the DICE (1945) index, which is comparatively robust against different sample sizes (WOLDA 1981). For comparison, the index proposed by SØRENSEN (1948) was used. The similarity values obtained were summarized by clustering using the UPGMA (unweighted group mean, average distance criteria; SNEATH & SOKAL 1973) algorithms of the CLUSTAN program.

6. Taxonomic (cytological) methods

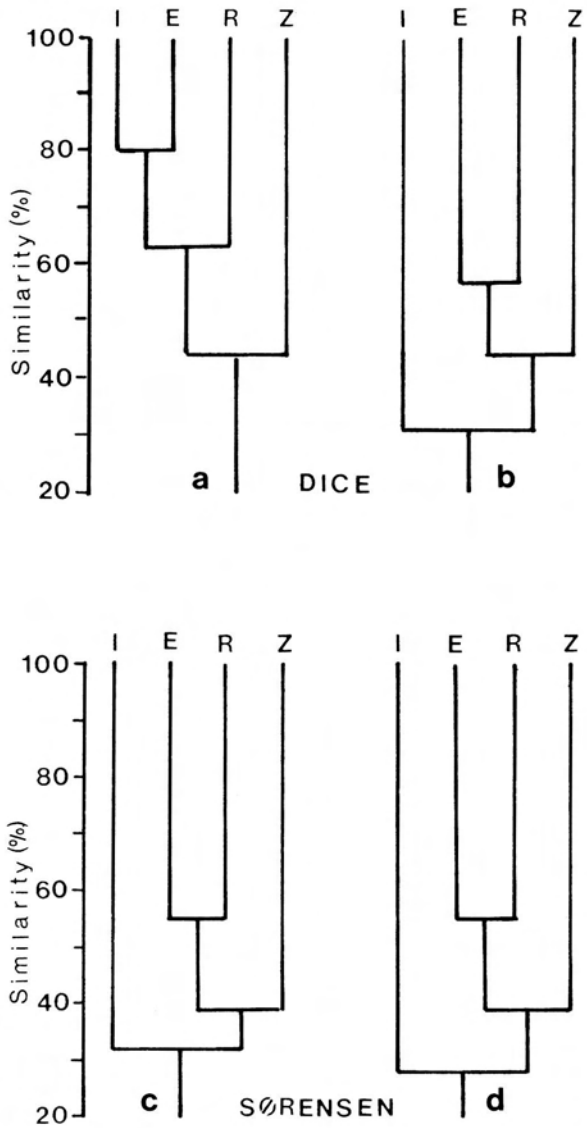
The species described were studied in vivo using a high-power oil immersion objective and interference contrast. The ciliary pattern (infraciliature) was revealed by various silver impregnation techniques, preferable protargol, all described in detail by FOISSNER (1991). The descriptions are based either on fresh field material or on specimens from raw cultures set up in petri-dishes with some crushed wheat grains to stimulate growth of bacteria and other natural food organisms.

Counts and measurements on silvered specimens were performed at a magnification of X 1000. In vivo measurements were conducted at a magnification of X 40 – 1000. Although these provide only rough estimates it is worth giving such data as specimens usually shrink in preparations or contract during fixation. Standard deviation and coefficient of variation were calculated according to statistics textbooks. Illustrations of live specimens are based on free-hand sketches and video tape records, those of impregnated cells were made with a camera lucida. All figures are orientated with the anterior end of the organism directed to the top of page.

Results and Discussion

1. Ecological notes

Community structures: A total of 156 ciliate species were identified in the 22 samples investigated; 125 of these occurred in the Illach river and 80 in the streams of the Fichtelgebirge (Table 3). With few exceptions, viz. *Urotricha synuraphaga*, *Stylonychia mytilus*, *Pseudochilodonopsis algivora*, *Lembadion lucens*, *Stentor igneus*, *Trithigmostoma srameki*, *Holosticha pullaster*, *Chlamydonellopsis polonica*, *Litonotus alpestris*, *L. cygnus*, *Trochilia minuta*, *Placus luciae* and *Vorticella campanula*, which were abundant especially in the Illach river, all had low or very low abundances, as is typical for clean waters. Unfortunately, reliable, systematic studies about the number of ciliate species in rivers of different size and organic pollution are lacking. Thus, it is difficult to interpret the present data, but I suppose that most differences in species richness were caused by the different number of samples investigated and/or the highly different size of the streams (see mean flows, Tables 1, 2). However, the total number of species and especially the number of species per sample were frequently rather low, as is typical for clean, oligosaprobic waters (FOISSNER et al. 1994, JUTRCZENKI 1982, PÄTSCH 1974). This became obvious by a comparison with a mesosaprobic river, where 209 ciliate species were identified in 37 samples (FOISSNER et al. 1992b), and the mean number of species per sample was twice as high as in the streams from the Fichtelgebirge (Table 4). It is not known whether the low species number of ciliates in oligosaprobic waters is caused by methodological shortcomings or the result of environmental factors. Certainly, abundances of organisms are usually low in clean waters due to the limited nutrients. Thus, rare species have a lower chance of being sampled and a higher probability of being overlooked in the samples. On the other hand, one cannot exclude that, in general, fewer species are present and/or excysted (active) in clean waters due to the limited food resources.



Figs. 1a–d. Clusters of DICE and SØRENSEN similarity indices for the ciliate communities investigated. See text for detailed explanation. **a, c:** All samples. **b, d:** Two samples each from all streams. E = Eger stream, I = Illach river, R = Röslau stream, Z = Zinnbach stream.

Only 3 out of the 156 species identified were new to science (Table 3). However, about 30 taxa were not determined, mainly because few specimens were found, making determination too difficult and time-consuming. Very likely, some of these unidentified taxa were new species too.

Thirty-seven (24%) out of the 156 species identified have been reliably recorded from terrestrial habitats (mosses, litter, mineral soil; FOISSNER 1987). This rather high percentage of soil species, including even some obligate fungal feeders (e.g. *Pseudoplatyophrya nana*), is understandable because litter and mosses were included in the sample design and these small streams had intensive contact with the surrounding soil (cp. FOISSNER et al. 1992b). Furthermore, about 30% of the soil ciliates known occur in both limnetic and terrestrial habitats (FOISSNER 1987).

The similarity analysis was of course impaired by the very different sample and stream sizes. Thus, two different indices were tested and a second pair of clusters was calculated using, like in the streams from the Fichtelgebirge, only two samples (one from spring and one from autumn) from the Illach river (Figs. 1b, d). In spite of these problems, a rather constant pattern was obtained with the Illach river and the Zinnbach stream being distinctly separated from the Eger and Röslau streams (Figs. 1b–d). Only the DICE-index grouped the Illach and Eger together when all samples were included in the

Table 3. Ciliate species found in four clean (oligosaprobic) streams (Illach, Eger, Röslau, Zinnbach) of Bavaria. + = found, − = not found.

Species	Illach[1])	Eger[2])	Röslau[2])	Zinnbach[2])
Acineria incurvata DUJARDIN, 1841	+	−	−	−
Acineria uncinata TUCOLESCO, 1962*	−	−	+	−
Alinostoma burkli BLATTERER & FOISSNER, 1990	+	−	−	−
Amphileptus pleurosigma (STOKES, 1884) FOISSNER, 1984	+	−	−	−
Amphileptus procerus (PENARD, 1922) SONG & WILBERT, 1989	+	−	−	−
Amphileptus punctatus (KAHL, 1926) FOISSNER, 1984	+	−	−	−
Aspidisca cicada (MUELLER, 1786) CLAPARÈDE & LACHMANN, 1858	+	−	−	−
Aspidisca lynceus (MÜLLER, 1773) EHRENBERG, 1830	+	+	+	+
Aspidisca turrita (EHRENBERG, 1831) CLAPARÈDE & LACHMANN, 1858	−	−	−	+
Balanonema sapropelica FOISSNER, 1976	−	−	−	+
Blepharisma hyalinum PERTY, 1849*	+	−	−	−
Bryometopus pseudochilodon KAHL, 1932*	−	−	−	+
Calyptotricha lanuginosa (PENARD, 1922) WILBERT & FOISSNER, 1980	+	+	−	−
Carchesium polypinum (LINNAEUS,1758) EHRENBERG, 1830	+	+	−	−
Chaenea stricta (DUJARDIN, 1841) FOISSNER et al., 1995	+	−	−	−
Chilodonella uncinata (EHRENBERG, 1838) STRAND, 1928*	+	+	+	−
Chilodontopsis depressa (PERTY, 1852) BLOCHMANN, 1895	+	+	−	−
Chlamydonella alpestris FOISSNER, 1979	+	+	+	−
Chlamydonella minuta PÄTSCH, 1974	−	+	−	−
Chlamydonella rostrata (VUXANOVICI, 1963) SONG & WILBERT, 1989	+	+	−	−
Chlamydonellopsis plurivacuolata BLATTERER & FOISSNER, 1990	+	−	−	−
Chlamydonellopsis polonica FOISSNER et al., 1981	+	−	−	−
Cinetochilum margaritaceum (EHRENBERG, 1831) PERTY, 1849*	+	+	+	−
Coleps nolandi KAHL, 1930	+	−	−	−
Colpidium colpoda (LOSANA, 1829) STEIN, 1860	+	−	−	−
Colpoda inflata (STOKES, 1884) KAHL, 1931*	−	+	+	−
Colpoda steinii MAUPAS, 1883*	−	+	−	−
Ctedoctema acanthocryptum STOKES, 1884	+	+	+	+
Cyclidium glaucoma MUELLER, 1773*	+	+	+	+
Cyclidium heptatrichum SCHEWIAKOFF, 1893	+	−	−	−
Cyclidium muscicola KAHL, 1931*	−	+	−	−
Cyrtohymena citrina (BERGER & FOISSNER, 1987) FOISSNER, 1989*	+	−	−	−
Cyrtolophosis mucicola STOKES, 1885*	−	−	+	−
Dexiostoma campylum (STOKES, 1886) JANKOWSKI, 1967	+	−	+	−
Dexiotricha tranquilla (KAHL, 1926) AUGUSTIN & FOISSNER, 1989	+	−	−	−
Drepanomonas sphagni KAHL, 1931*	−	−	−	+
Enchelyodon farctus CLAPARÈDE & LACHMANN, 1859	+	−	−	−
Enchelys gasterosteus KAHL, 1926	+	−	+	−
Epistylis entzii STILLER, 1935	+	−	−	−
Euplotes affinis (DUJARDIN, 1841) KAHL, 1932	+	−	−	−
Euplotes moebiusi KAHL, 1932	+	−	−	−
Euplotes patella (MUELLER, 1773) EHRENBERG, 1831	+	−	−	−
Frontonia angusta KAHL, 1931	+	−	−	−
Fuscheria lacustris SONG & WILBERT, 1989	+	+	+	−
Gastronauta clatratus DEROUX, 1976	+	−	−	−
Gastronauta membranaceus BUETSCHLI, 1889	−	−	−	+
Gastrostyla minima HEMBERGER, 1985*	−	−	+	+
Glaucoma scintillans EHRENBERG, 1830	+	+	+	−
Gonostomum affine (STEIN, 1859) STERKI, 1878*	+	−	−	−
Hackenbergia langae n.g., n.sp.	+	−	−	−
Halteria grandinella (MUELLER, 1773) DUJARDIN, 1841*	−	+	+	−
Holophrya discolor EHRENBERG, 1833	+	−	−	−
Holophrya teres (EHRENBERG, 1833) FOISSNER et al., 1994	+	−	−	−
Holophrya seyrli n.sp.	−	−	+	+

Table 3. continued

Species	Illach [1])	Eger [2])	Röslau [2])	Zinnbach [2])
Holosticha monilata KAHL, 1928	+	+	–	–
Holosticha multistilata KAHL, 1928	+	–	–	+
Holosticha pullaster (MUELLER, 1773) FOISSNER et al., 1991	+	–	–	–
Kahlilembus attenuatus (SMITH, 1897) FOISSNER et al., 1994*	+	–	–	–
Keronopsis wetzeli WENZEL, 1953*	–	–	+	–
Kreyella minuta FOISSNER, 1979	+	+	+	+
Kreyella muscicola KAHL, 1931*	–	–	–	+
Lacrymaria filiformis MASKELL, 1886	+	–	–	–
Lacrymaria granulifera n.sp.	+	–	–	–
Lacrymaria olor (MUELLER, 1786) BORY DE SAINT-VINCENT, 1824	+	–	–	+
Lacrymaria robusta VUXANOVICI, 1959	–	+	–	+
Lacrymaria vaginifera SONG & WILBERT, 1989	+	+	+	–
Lembadion bullinum (MUELLER, 1786) PERTY, 1849	+	–	–	+
Lembadion lucens (MASKELL, 1887) KAHL, 1931	+	–	+	–
Leptopharynx costatus MERMOD, 1914*	+	+	–	+
Litonotus alpestris FOISSNER, 1978	+	–	+	–
Litonotus crystallinus (VUXANOVICI, 1960) FOISSNER et al., 1995	+	–	–	–
Litonotus cygnus (MUELLER, 1773) FOISSNER et al., 1995	+	–	–	–
Litonotus fusidens (KAHL, 1926) FOISSNER et al., 1995	+	–	–	–
Litonotus lamella (MUELLER, 1773) FOISSNER et al., 1995	+	–	–	–
Litonotus varsaviensis (WRZEŚNIOWSKI, 1866) WRZEŚNIOWSKI, 1870	+	+	+	–
Loxodes striatus (ENGELMANN, 1862) PENARD, 1917	+	–	–	–
Loxophyllum meleagris (MUELLER, 1773) DUJARDIN, 1841	+	+	–	–
Mesodinium acarus STEIN, 1867	+	–	–	–
Metopus es (MÜLLER, 1776) LAUTERBORN, 1916	–	–	–	+
Microthorax pusillus ENGELMANN, 1862	–	–	+	+
Microthorax simplex FOISSNER, 1985	–	–	–	+
Monilicaryon monilatus (STOKES, 1886) JANKOWSKI, 1967	+	–	–	–
Nassula citrea KAHL, 1931	+	–	–	–
Nassula picta GREEFF, 1888	+	–	–	–
Nassulopsis elegans (EHRENBERG, 1833) FOISSNER et al., 1994	+	–	–	–
Nivaliella plana FOISSNER, 1980*	–	+	–	–
Odontochlamys alpestris FOISSNER, 1981*	+	–	+	–
Ovalorhabdos sapropelicus FOISSNER, 1984	+	–	–	–
Oxytricha haematoplasma BLATTERER & FOISSNER, 1990	+	–	–	–
Oxytricha setigera STOKES, 1891*	+	–	–	–
Oxytricha similis ENGELMANN, 1862	+	–	–	–
Paracolpidium truncatum (STOKES, 1885) GANNER & FOISSNER, 1989	+	–	+	–
Paraenchelys spiralis FOISSNER, 1983	+	–	–	–
Paramecium aurelia-complex	–	–	–	+
Paramecium bursaria (EHRENBERG, 1831) FOCKE, 1836	+	–	+	–
Paramecium caudatum EHRENBERG, 1833	+	–	–	–
Paramecium putrinum CLAPARÈDE & LACHMANN, 1859	+	+	+	–
Philasterides armatus (KAHL, 1926) KAHL, 1931	+	–	–	–
Placus luciae (KAHL, 1926) KAHL, 1930	+	+	+	–
Plagiocampa rouxi KAHL, 1926*	+	+	+	+
Platynematum sociale (PENARD, 1922) FOISSNER et al., 1994*	–	–	+	+
Platyophrya macrostoma FOISSNER, 1980*	–	+	–	–
Platyophrya vorax KAHL, 1926*	+	+	+	+
Prorodon armatides (KAHL, 1930) nov. comb., nov. nom.	–	–	–	+
Pseudochilodonopsis algivora (KAHL, 1931) FOISSNER, 1979	+	+	–	–
Pseudochilodonopsis caudata (PERTY, 1852) BLATTERER & FOISSNER, 1990	+	–	–	–
Pseudochilodonopsis fluviatilis FOISSNER, 1988	+	–	+	+
Pseudochilodonopsis mutabilis FOISSNER, 1981*	+	+	–	–
Pseudochilodonopsis polyvacuolata FOISSNER & DIDIER, 1981*	+	+	+	–

Table 3. continued

Species	Illach [1])	Eger [2])	Röslau [2])	Zinnbach [2])
Pseudochlamydonella rheophila BUITKAMP et al., 1989	+	+	–	–
Pseudoplatyophrya nana (KAHL, 1926) FOISSNER, 1980*	–	+	–	+
Rostrophrya camerounensis (NJINE, 1979) FOISSNER, 1993	+	–	–	–
Sathrophilus hovassei GROLIERE, 1975	–	+	+	+
Sathrophilus muscorum (KAHL, 1931) CORLISS, 1960*	–	–	+	+
Spirostomum minus ROUX, 1901	–	–	+	–
Stammeridium kahli (WENZEL, 1953) WENZEL, 1969*	–	–	–	+
Stentor igneus EHRENBERG, 1838	+	–	–	–
Stentor muelleri EHRENBERG, 1831	+	–	–	–
Stentor multiformis (MUELLER, 1786) EHRENBERG, 1838	+	–	–	–
Stentor roeselii EHRENBERG, 1835	+	–	–	–
Sterkiella histriomuscorum (FOISSNER et al., 1991) FOISSNER et al., 1991*	+	+	–	–
Stichotricha aculeata WRZEŚNIOWSKI, 1866	+	–	–	–
Strobilidium caudatum (FROMENTEL, 1876) FOISSNER, 1987	+	+	+	–
Strombidium rehwaldi PETZ & FOISSNER, 1992	+	–	–	–
Stylonychia mytilus-complex*	+	–	–	–
Stylonychia pustulata (MUELLER, 1786) EHRENBERG, 1835	+	–	–	–
Tachysoma pellionellum (MUELLER, 1773) BORROR, 1972	+	+	+	+
Tetrahymena corlissi THOMPSON, 1955	+	+	–	+
Tetrahymena pyriformis-complex	+	+	–	–
Thigmogaster oppositevacuolatus AUGUSTIN & FOISSNER, 1989	+	–	–	–
Tintinnidium semiciliatum (STERKI, 1879) KENT, 1881	+	–	–	–
Trachelius ovum (EHRENBERG, 1831) EHRENBERG, 1838	+	+	–	–
Trachelophyllum apiculatum (PERTY, 1852) CLAPARÈDE & LACHMANN, 1859*	+	+	–	–
Trithigmostoma cucullulus (MUELLER, 1786) JANKOWSKI, 1967	+	–	–	–
Trithigmostoma srameki FOISSNER, 1988	+	–	–	–
Trithigmostoma steini (BLOCHMANN, 1895) FOISSNER, 1988	+	–	–	–
Trochilia minuta (ROUX, 1899) KAHL, 1931	+	–	–	–
Trochilioides fimbriatus FOISSNER, 1984	+	–	–	–
Uroleptus gallina (MUELLER, 1786) FOISSNER et al., 1991	+	–	–	–
Uroleptus musculus (KAHL, 1932) FOISSNER et al., 1991	+	–	–	–
Uroleptus piscis (MUELLER, 1773) EHRENBERG, 1831	+	–	–	+
Uronema nigricans (MUELLER, 1786) FLORENTIN, 1901	+	–	–	–
Urosomoida agiliformis FOISSNER, 1982*	+	+	+	–
Urostyla grandis EHRENBERG, 1830	+	–	–	–
Urotricha agilis (STOKES, 1886) KAHL, 1930	+	–	–	–
Urotricha armata KAHL, 1927	+	–	–	–
Urotricha farcta CLAPARÈDE & LACHMANN, 1859	+	–	+	–
Urotricha globosa SCHEWIAKOFF, 1892	+	–	–	–
Urotricha ovata KAHL, 1926	+	–	–	–
Urotricha synuraphaga KAHL, 1927	–	+	+	+
Vorticella aquadulcis-complex*	+	–	–	–
Vorticella campanula EHRENBERG, 1831	+	+	–	–
Vorticella citrina MUELLER, 1773	+	–	–	–
Vorticella convallaria-complex*	+	+	+	+
Vorticella picta (EHRENBERG, 1831) EHRENBERG, 1838	+	–	–	–
Zosterodasys transversa (KAHL, 1928) FOISSNER et al., 1994	+	–	–	–
Number of taxa identified	125	47	42	35
Approximate number of unidentified taxa	16	10	5	5

[1]) Sixteen samples were analyzed from 4 different sites in spring and autumn 1995.
[2]) One sample each was analyzed in spring and autumn 1992.
* Reliably recorded also from terrestrial habitats (mosses, litter, mineral soil).

Table 4. Number of ciliate species per sample in the rivers investigated.

River	Illach [1])	Eger	Röslau	Zinnbach	Amper [2])
Species number	34, 40, 43, 45 25, 32, 27, 28 50, 32, 30, 50 20, 37, 36, 20	28, 37	20, 32	20, 27	48, 75, 45, 67, 62, 46, 47, 49, 38, 56, 42, 56, 52, 77
Mean ($\bar{x}$)	34.3	32.5	26.0	23.5	54.3

[1]) Note that the last 8 values are not from composite (see method section) but from choriotope (litter, moss, stones) samples.
[2]) From FOISSNER et al. (1992b).

analysis (Fig. 1a). The distinctiveness of the Illach river was probably caused by the spatial distance to the other streams, while that of the Zinnbach could have been caused by its high acidity. However, it could not be excluded that the separation was simply an effect of its small size (see mean flow, Table 2).

Saprobiological considerations: The saprobic system evaluates water quality and, more specifically, organic pollution by indicator species (CURDS 1992, FOISSNER et al. 1994, SLÁDEČEK 1973). Four main zones of pollution and self-purification are distinguished: polysaprobity (very heavily polluted), a-mesosaprobity (heavily polluted), b-mesosaprobity (moderately polluted), and oligosaprobity (clean or very slightly polluted). Ciliates play a major role in the saprobic system because many of them meet one of its central theorems, viz. that the organisms are uniquely dependent, within relatively narrow limits, on the chemical composition of the water for their distribution and development (CURDS 1992, FOISSNER et al. 1994, 1995, LIEBMANN 1951, SLÁDEČEK 1973).

The present findings seemingly contradict the above statements because many mesosaprobic and even polysaprobic species were found although the rivers were clean and did not receive easily degradable (anthropogenic) organic wastes. However, with few exceptions (see above), all species occurred in low or very low numbers. Very likely, the mesosaprobic and polysaprobic species developed in respective microhabitats which occur in most waters, e.g., around decaying insect larvae and rotting litter accumulations. Thus, it is crucial that, in evaluating water quality with the saprobic system, abundances of the indicator species are taken into account. As concerns ciliates and other single celled organisms, those species which occur in higher numbers should be more heavily weighted than those occurring in low or very low numbers because these often develop in microhabitats not representative for the whole system (for more detailed discussion, see BLATTERER 1995, FOISSNER 1996a, FOISSNER et al. 1994, LIEBMANN 1951, SLÁDEČEK 1973).

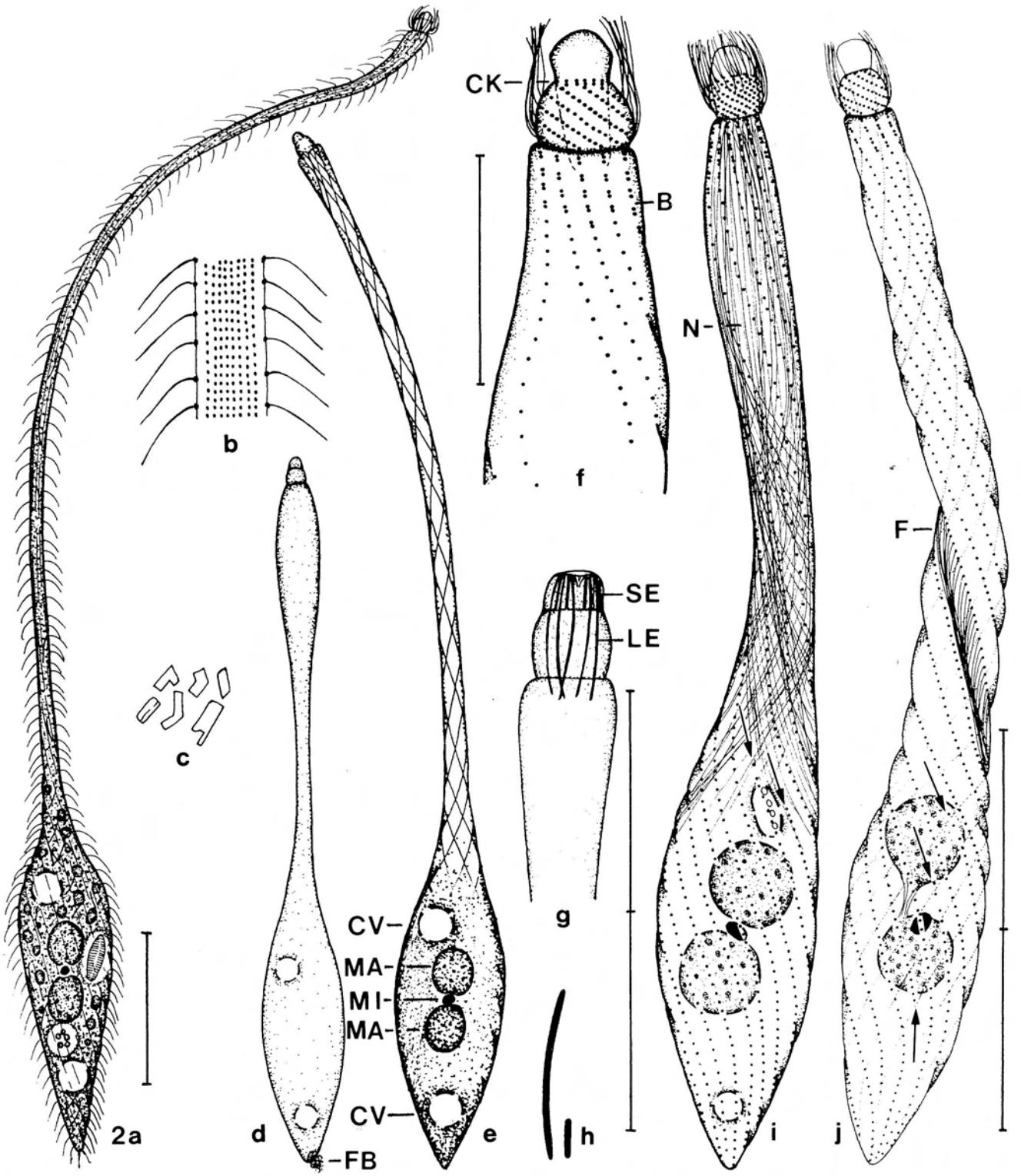
2. Description of new and insufficiently known species

Morphometric data shown in Tables 5–13 are repeated in this section only as needed for clarity. All observations are from field material or raw cultures, i.e. not from clones. Thus, it remains possible that similar, but different, species were mixed, although this is unlikely because I excluded all specimens which deviated in at least one prominent character. Certainly, this can generate some bias in the data if used too uncritically. However, I usually exclude only such specimens which have, e.g., a different nuclear structure (very likely often postconjugates), a distinctly deviating ciliary pattern (very likely often injured, regenerating or malformed specimens), or an unusually small size (very likely often degenerating, just excysted or divided specimens). The inclusion of such individuals, which might sometimes belong to another species, would artificially increase variability.

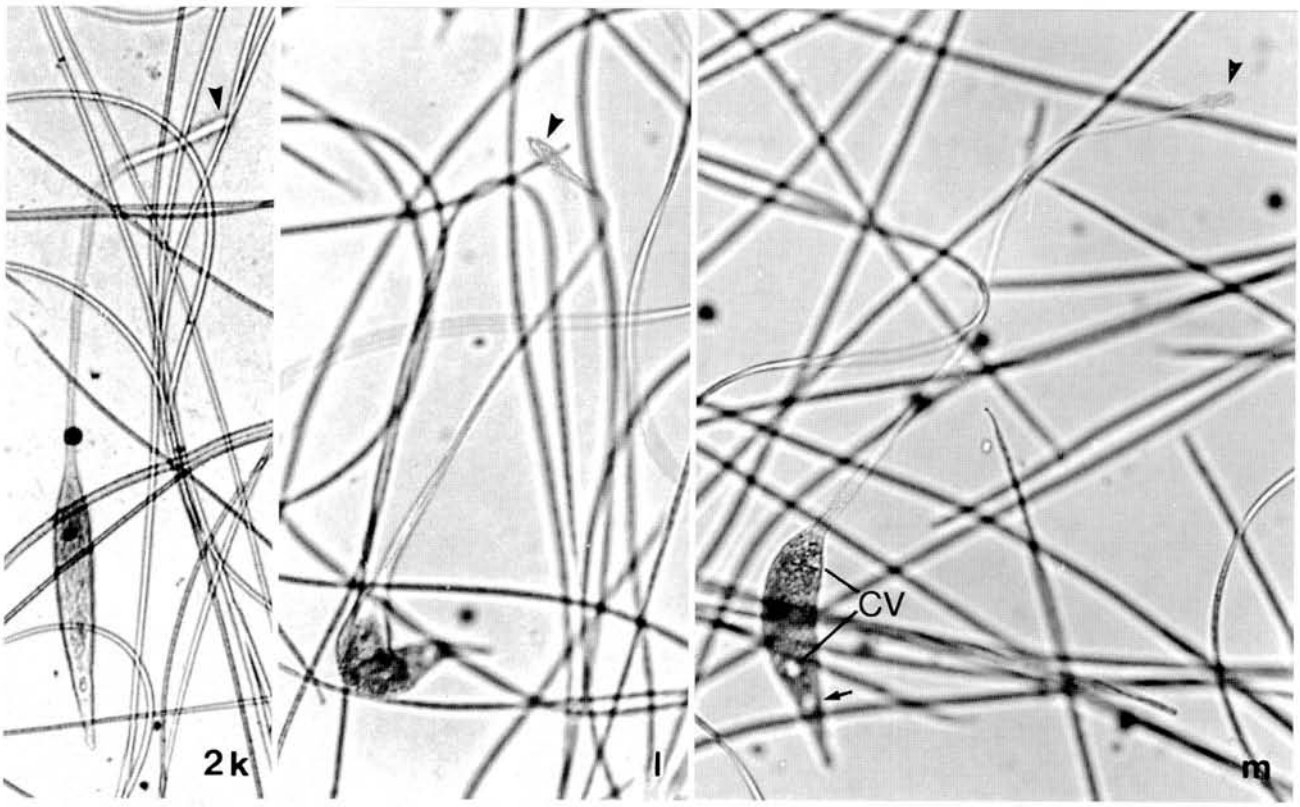
Family Lacrymariidae FROMENTEL, 1876

- *Lacrymaria olor* (MÜLLER, 1786) BORY DE SAINT-VINCENT, 1824 (Figs. 2a–t, 3a–h, Table 5)

1786 *Vibrio olor* MÜLLER, Animalcula Infusoria: 75.
1824 *Lacrimatoria olor* MÜLLER – BORY DE SAINT-VINCENT, Encyclopédie méthodique: 479.
1830 *Lacrymaria olor* – EHRENBERG, Abh. dt. Akad. Wiss. Berl., year 1830: 42 (emendation of genus name).
1838 *Trachelocerca olor* (MÜLLER, 1786) – EHRENBERG, Infusionsthierchen: 342 (revision).
1922 *Lacrymaria olor* (MÜLLER) EHRENB. (1838) – PENARD, Études Infusoires: 43 (redescription).
1930 *Lacrymaria (Vibrio) olor* O.F. MÜLLER, 1776 – KAHL, Tierwelt Dtl., 18: 93 (revision).
1970 *Lacrymaria olor* (O.F.M. 1786) – BOHATIER, Protistologica, 6: 331 (misidentification).
1972 *Lacrymaria olor* (O.F.M. 1786) – KINK, Acta Protozool., 10: 205 (misidentification).



Figs. 2a–j. *Lacrymaria olor* from life (a–e, g, h) and after protargol impregnation (f, i, j). **a:** Extended specimen. **b:** Surface view of cortex showing rows of minute granules between ciliary rows. **c:** Cytoplasmic crystals. **d:** Contracted specimen with bulbous neck and emerging fecal ball. **e:** Slightly contracted specimen with neck cross-furrowed by ciliary rows. **f:** Infraciliature of anterior body portion. **g, h:** Anterior body portion with long (12 μm) and short (2.5 μm) head extrusomes. **i, j:** Total views of infraciliature. Arrows mark shortened kineties. B = brush, CK = circumoral kinety, CV = contractile vacuoles, F = fibres, FB = fecal ball, LE = long extrusomes, MA = macronuclear nodules, MI = micronucleus, N = nematodesmata, SE = short extrusomes. Scale bars 10 μm (Fig. 2f) and 50 μm (Figs. 2a, i, j).



Figs. 2k—m. *Lacrymaria olor*, bright field micrographs of live specimens searching for food between filamentous cyanobacteria. Arrowheads mark head of *Lacrymaria*, arrow marks almost empty and thus bright food vacuole. **k:** Slightly contracted specimen. **l, m:** Almost fully extended specimens. Note long, versatile, filiform neck having about same diameter as filamentous cyanobacteria.

1974 *Lacrymaria olor* (O.F. MÜLLER) — PÄTSCH, Arb. Inst. landwirt. Zool. Bienenkd., 1: 13 (misidentification ?).

1986 *Lacrymaria olor* (O.F. MÜLLER, 1788) — DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 146 (misidentification).

1989 *Lacrymaria olor* (MÜLLER, 1788) — SONG & WILBERT, Lauterbornia, 3: 40 (morphometry).

1995 *Lacrymaria olor* (MÜLLER, 1786) BORY DE SAINT-VINCENT, 1824 — FOISSNER, BERGER, BLATTERER & KOHMANN, Taxonom. ökol. Rev. Cili. Saprobiensyst., IV: 163 (revision).

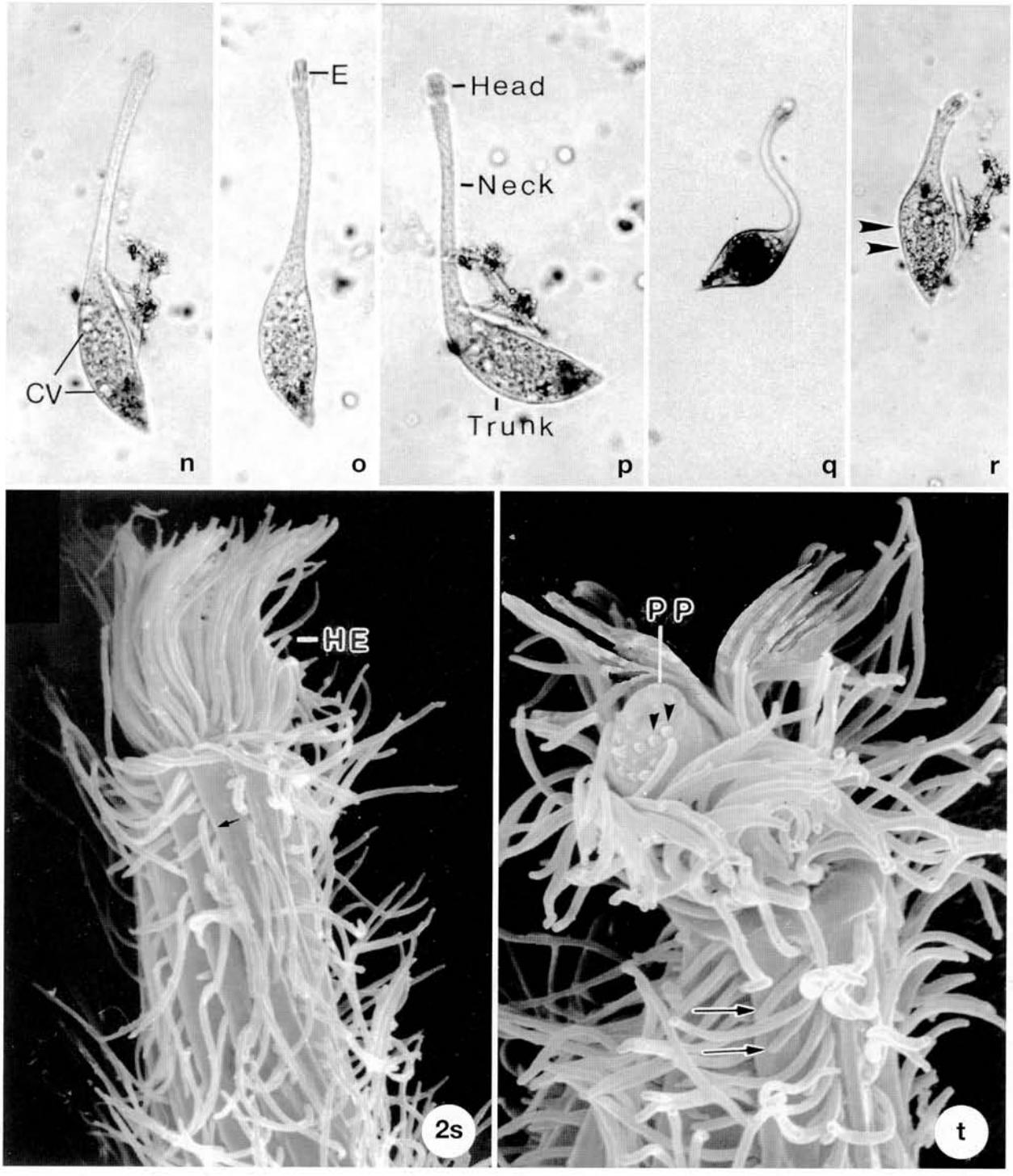
Improved diagnosis: In vivo 300—500 × 20—30 µm, body with distinct head, neck, and trunk, highly contractile. Two slightly ellipsoidal macronuclear nodules and single micronucleus in between. Two contractile vacuoles. Extrusomes terete, large type 10—12 µm long, small type 2—3 µm long. 14 ciliary rows on average.

Nomenclature: *Lacrimatoria* is the original spelling of the genus name (BORY DE SAINT-VINCENT 1824). However, EHRENBERG's emendation, *Lacrymaria*, prevailed in the later literature and was also approved by the first reviser (KAHL 1930). Thus, *Lacrymaria* should be recognized as the valid spelling (CORLISS 1979, FOISSNER & FOISSNER 1988b). *Lacrymaria olor*, type of the genus, has a senior synonym, *Brachionus proteus* PALLAS. However, this name has never been used in the later literature and thus should be abandoned.

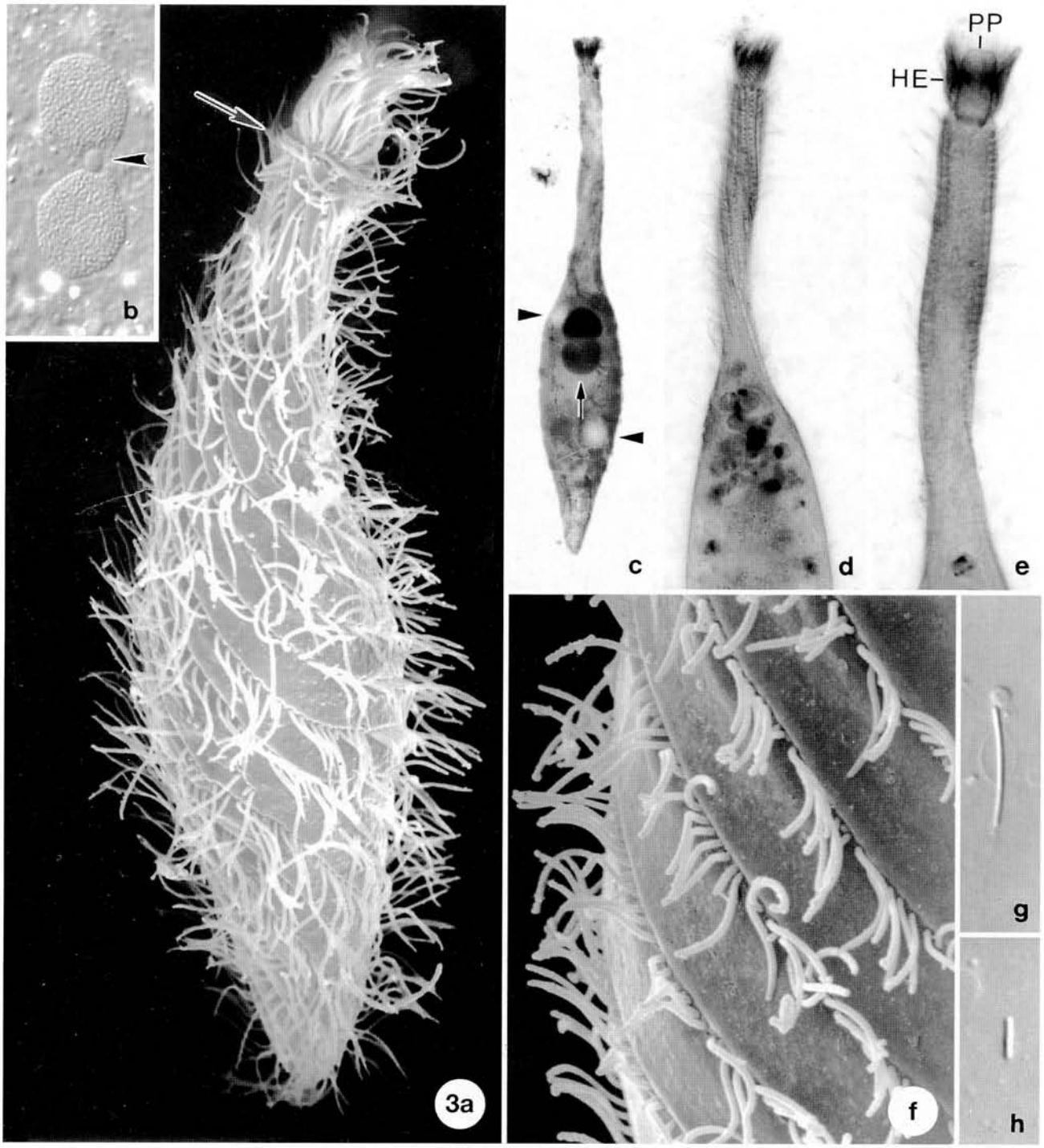
Type material: No type material from *L. olor* has been mentioned in the literature. Thus, I declare the population from Austria as neotype and deposit two slides with protargol-impregnated specimens in the Oberösterreichische Landesmuseum in Linz (LI), Austria. Relevant specimens are marked by a black ink circle on the cover glass.

Description of Austrian population: *L. olor* occurred in the Illach river and the Zinnbach stream (Table 3). The population described here, was found in October 1989 in an acidic moorland pond (Frankinger Moor, E 12° N 48°03′) in Upper Austria.

Size in vivo about 300—500 × 20—30 µm, fully extended specimens up to 1200 µm long according to PENARD (1922). Trunk about 100 µm long, fusiform to slightly clavate, posteriorly narrowed to obtuse tip. Neck filiform, very hyaline and conspicuously cross-furrowed by ciliary rows, highly versatile and contractile, up to four times as long



Figs. 2n—t. *Lacrymaria olor* from life (n—r) and in the scanning electron microscope (s, t). **n—q:** Rather strongly contracted, swimming specimens. **r:** Fully contracted specimen swimming backward. Arrowheads mark macronuclear nodules in centre of trunk. **s, t:** Ciliature of anterior body portion. Each of the 6—10 ciliary rows commences with 4—5 paired cilia (dikinetids) of which the posterior ones are shortened (= dorsal brush, arrows). The circumoral kinety, which extends around the anterior end of the head, is covered by the cilia of the densely ciliated head. Each oblique head kinety consists of about 15 cilia. Arrowheads in Fig. 2t mark discharging extrusomes, very likely toxicysts. CV = contractile vacuoles, E = extrusomes, HE = head, PP = pharyngeal plug (oral bulge).



Figs. 3a–h. *Lacrymaria olor* from life (b, g, h), after protargol impregnation (c–e), and in the scanning electron microscope (a, f). **a, f:** Ciliature and cortex of a contracted specimen. Note spiral arrangement of ciliary rows, which extend in flat furrows. Arrow marks anterior end of neck which bears the densely ciliated head. **b:** The nuclear apparatus consists of two finely granulated macronuclear nodules and a single micronucleus (arrowhead) in between. **c–e:** Macronuclear nodules (arrow), contractile vacuoles (arrowheads), and ciliature of head and neck. **g, h:** Curved long (10–12 µm) and straight short (2–3 µm) extrusome shown at same scale. Both types, very likely toxicysts, occur in pharyngeal plug and cytoplasm. HE = head, PP = pharyngeal plug (oral bulge).

Table 5. Morphometric characteristics from *Lacrymaria granulifera* (1st line), *L. olor* (2nd line) and *L. robusta* (3rd line)[1]).

Character	$\bar{x}$	M	SD	$SD_{\bar{x}}$	CV	Min	Max	n
Body, length	181.1	186.0	37.0	7.9	20.4	114	228	22
	151.7	148.0	23.8	5.2	15.7	118	220	21
	91.3	88.0	17.5	4.0	19.1	63	142	19
Body, width	31.8	30.0	5.7	1.2	18.0	21	45	22
	17.1	17.0	2.5	0.5	14.4	15	24	21
	14.4	14.0	1.6	0.4	11.2	12	17	19
Pharyngeal plug plus head, length	10.7	10.5	1.4	0.3	12.8	9	13	21
	9.0	9.0	0.7	0.2	7.4	7	11	15
	7.6	8.0	0.7	0.2	9.1	6	9	19
Pharyngeal plug, length	3.5	3.0	0.7	0.2	20.8	3	5	21
	4.4	4.5	0.2	0.1	5.6	4	5	15
	3.6	4.0	0.6	0.2	18.1	3	5	19
Macronuclear nodule, length	15.6	16.0	3.2	0.7	20.5	9	22	21
	10.7	11.0	1.6	0.4	15.0	9	14	19
	18.0	18.0	1.7	0.4	9.7	16	22	19
Macronuclear nodule, width	12.4	12.0	2.5	0.5	19.8	8	16	21
	8.9	9.0	1.3	0.3	14.2	8	11	19
	6.4	6.0	1.4	0.3	21.7	5	9	19
Micronucleus, length	4.8	4.5	0.7	0.3	14.0	4	6	5
	2.4	2.2	0.6	0.2	24.5	2	4	18
	2.2	2.0	0.3	0.1	13.7	2	3	19
Micronucleus, width	3.9	4.0	0.8	0.4	21.1	3	5	5
	1.7	1.5	0.4	0.1	24.0	1	3	18
	1.9	2.0	0.5	0.1	27.2	1	3	19
Macronuclear nodules, number	2.0	2.0	0.0	0.0	0.0	2	2	20
	2.0	2.0	0.0	0.0	0.0	2	2	19
	1.0	1.0	0.0	0.0	0.0	1	1	19
Micronuclei, number	1.0	1.0	0.0	0.0	0.0	1	1	6
	1.0	1.0	0.0	0.0	0.0	1	1	19
	1.0	1.0	0.0	0.0	0.0	1	1	19
Somatic kineties, number	16.1	16.0	1.3	0.3	8.0	14	19	19
	14.1	14.0	1.1	0.2	7.5	13	16	19
	9.0	9.0	0.5	0.1	5.3	8	11	23
Kinetids in 15 µm of a somatic kinety in centre of trunk	19.1	19.0	2.4	0.6	12.7	16	24	18
	15.5	15.5	2.9	0.7	18.9	11	25	19
	14.2	15.0	1.6	0.4	10.9	11	18	19

[1]) Data based on protargol-impregnated and mounted morphostatic specimens from field. Measurements in µm. CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of specimens investigated, SD – standard deviation, $SD_{\bar{x}}$ – standard deviation of arithmetic mean, $\bar{x}$ – arithmetic mean.

as trunk, distal end claviform and thus distinctly set off from barrel-shaped head and dome-shaped pharyngeal plug (Figs. 2a, e, k–m). Highly contractile and flexible, contracted specimens fusiform and with neck frequently more or less distinctly inflated (Figs. 2d, n–r, 3a, c–e). Nuclear apparatus in centre of trunk, macronuclear nodules globular to slightly ellipsoidal, in vivo about 15 × 12 µm, with many small nucleoli; micronucleus invariably between macronuclear nodules, in vivo about 3.2 × 2.5 µm (Figs. 2a, e, i, j, r, 3b, c). One contractile vacuole each near anterior and posterior end of trunk, both with about 4 excretory pores each (Figs. 2a, d, e, i, m, n, 3c). Cytopyge at posterior body end, egestion vacuoles about 10 µm across, often containing orange-coloured fat droplets (Fig. 2d). Two types of rod-shaped extrusomes, very likely toxicysts, in head and cytoplasm (Figs. 2g, h, o, t, 3g, h): long type slightly curved and 10–12 × 0.5 µm in size; short type straight and 2–3 × 0.5 µm in size, difficult to recognize

because of its minuteness. Cortex colourless, slightly furrowed by somatic kineties; cortical granules about 0.6×0.4 µm, colourless, arranged in about 8 rows each between ciliary rows of trunk (Figs. 2b, 3f). Cytoplasm with many fat globules 1–5 µm across and some 2–3 µm sized, colourless crystals (Figs. 2a, c, n–r). Feeds on ciliates (*Strobilidium caudatum*) and diatoms (*Achnanthes* sp.). Swims very fast and serpentinous, usually, however, *L. olor* crawls between organic debris and/or filamentous bacteria frequently extending and contracting the long, versatile neck (Figs. 2k–m).

Cilia about 8 µm long, rather narrowly spaced, arranged in 13–16 ($\bar{x}$ 14, Table 5; SONG & WILBERT 1989) right-spiralling rows, 3–5 of which commence on trunk only, number of ciliary rows thus higher on trunk than on the neck; rarely, 1–2 kineties shortened on trunk, i.e. commencing at anterior end of neck and terminating in trunk region (Figs. 2i, j, 3a). All neck kineties commence with 4–5 dikinetids, the anterior basal bodies of which bear a normal cilium, whereas the posterior basal bodies have an about 4 µm long bristle (Figs. 2f, s, t). Postciliary microtubule ribbons conspicuous, form plate-like layer between ciliary rows (Figs. 2j). Head kineties distinctly oblique and narrowly spaced, composed of about 15 cilia each. Circumoral kinety at anterior end of head kineties, composed of about 12 rather loosely spaced, vertically oriented dikinetids associated with fine but very long nematodesmata extending to anterior portion of trunk (Figs. 2f, i, j, s, t, 3a, c–e).

Ecology: The huge amount of faunistic and autecological data available on *L. olor* has been reviewed by FOISSNER et al. (1995). Unfortunately, many data very likely refer to other, similar species, as evident from the misidentifications discussed in the following paragraph. *Lacrymaria olor* occurs in running and stagnant waters and prefers beta-mesosaprobic, benthic habitats. Peak abundances often occur in autumn (FOISSNER et al. 1995).

Comparison with previous descriptions and related species: Although widespread and frequent, *L. olor* is insufficiently known because most authors confused it with other species. Typical examples are the redescriptions by PENARD (1922) and KAHL (1930), who mixed *L. olor* with similar species having only a single macronucleus and contractile vacuole. BOHATIER (1970) and KINK (1972) also identified as *L. olor* a species with a single ellipsoidal macronucleus and a single, subterminal contractile vacuole. DRAGESCO & DRAGESCO-KERNÉIS (1986) obviously confused *L. olor* with *L. granulifera*. Thus, I based the identification on the remarks by PENARD (1922) and KAHL (1930) that *L. olor usually* has two macronuclear nodules, two contractile vacuoles, and a long, highly contractile neck. The first characters were, understandably, not mentioned in the original description and the redescription by EHRENBERG (1838). However, both emphasized the long, contractile neck, which is indeed highly characteristic for *L. olor*, but occurs also in some other large species of the genus, e.g. in *L. granulifera*. Thus, a detailed redescription and neo-typification, as provided above, were necessary.

Lacrymaria olor is easily confused with *L. granulifera* (see below), *L. filiformis* MASKELL (redescribed in FOISSNER 1983), and *L. vaginifera* SONG & WILBERT, 1989, the latter, however, having a single, ellipsoidal macronucleus and a single, subterminal contractile vacuole.

- *Lacrymaria granulifera* nov. spec. (Figs. 4a–s, Table 5)

Diagnosis: In vivo about $450–650 \times 40–70$ µm, body with distinct head, neck and trunk, highly contractile. Two slightly ellipsoidal macronuclear nodules and a single micronucleus in between. Two contractile vacuoles. Extrusomes terete, large type about 12 µm long, small type about 2 µm long. Single, conspicuous row of special cortical granules right of each somatic kinety. 16 ciliary rows on average.

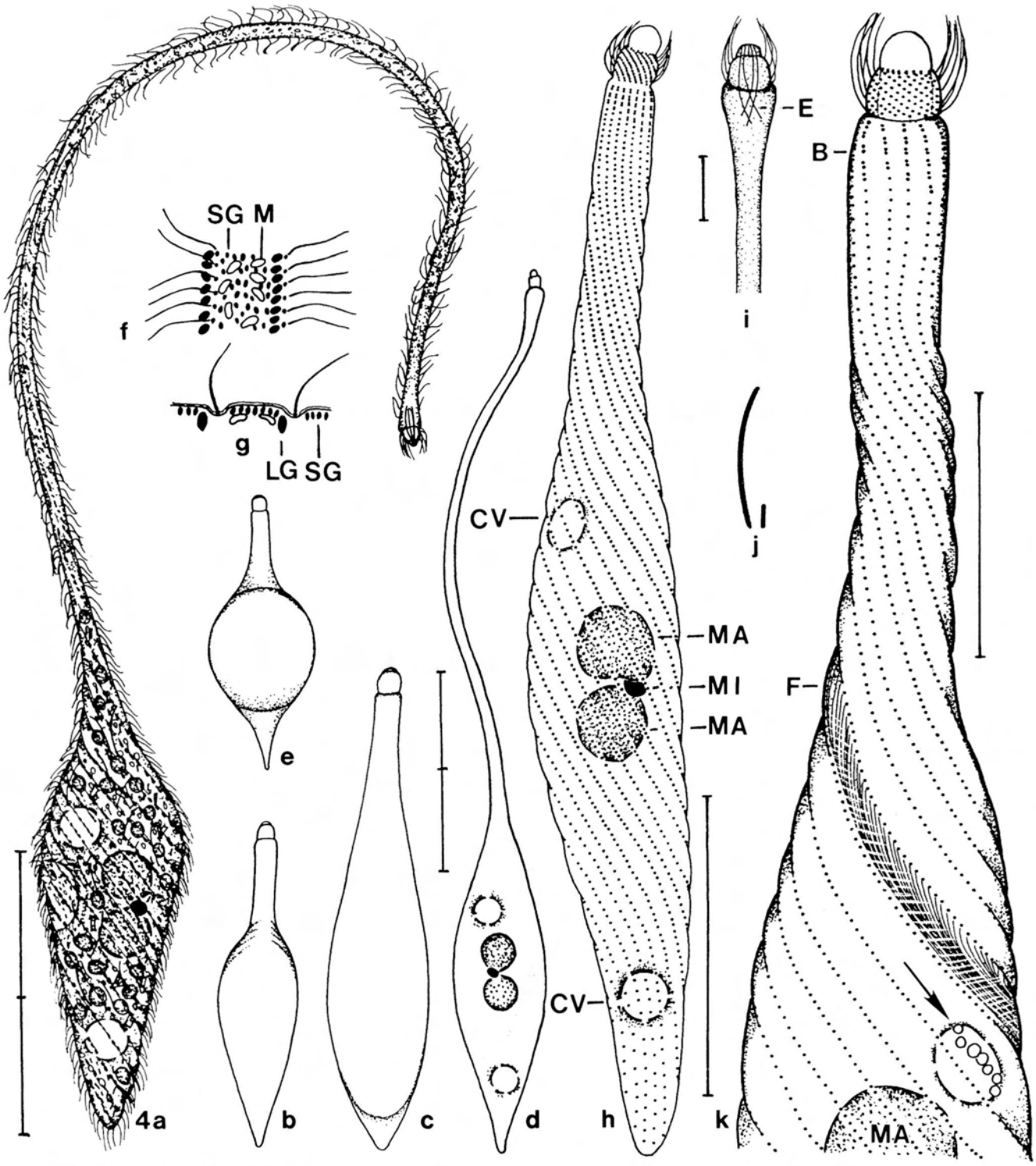
Type location: Amper river in Bavaria (Germany) near town Fürstenfeldbruck, E 11°15′ N 48°10′.

Etymology: *granulifera* because of the conspicuous granules along the ciliary rows.

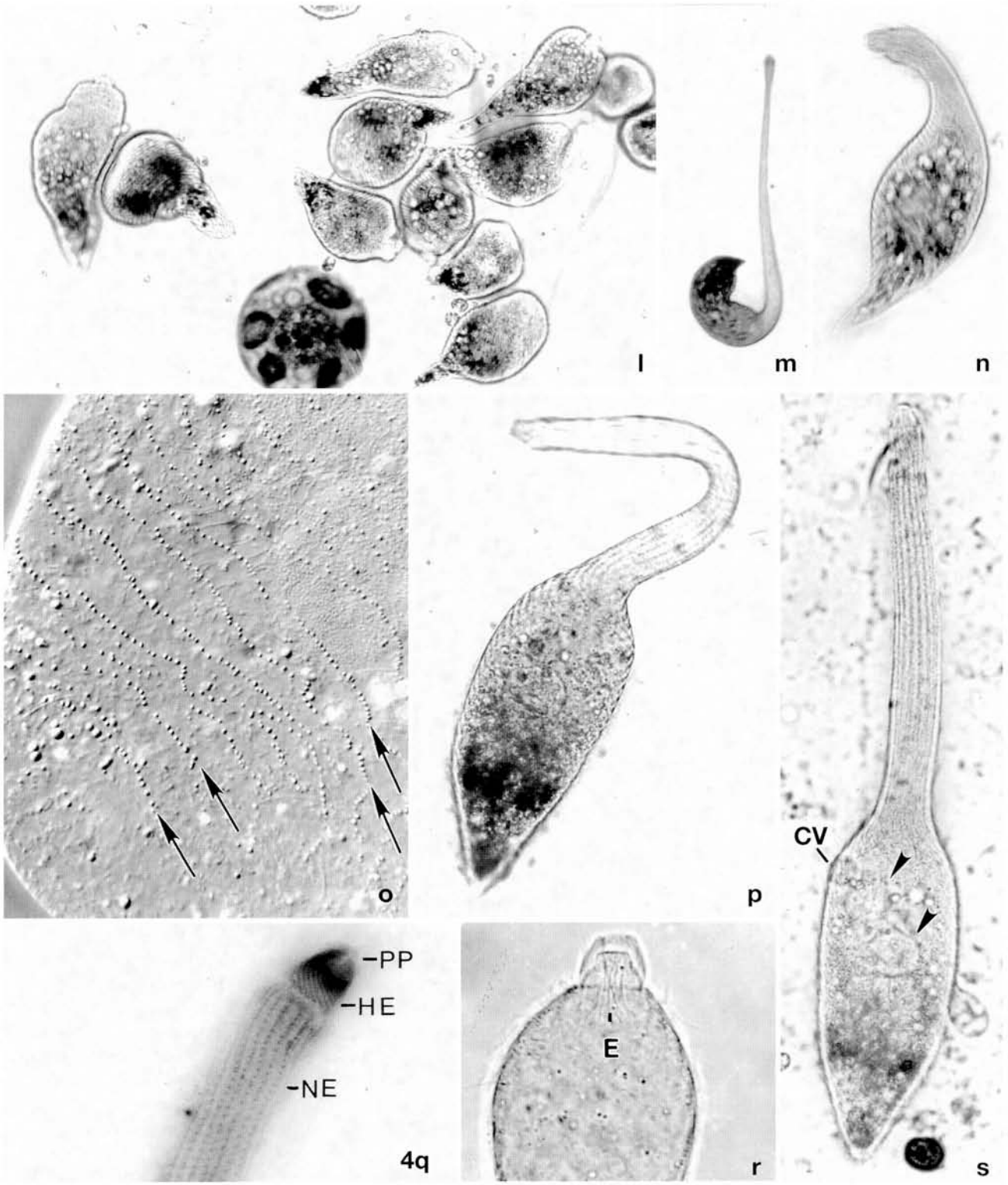
Type specimens: One holotype and two syntypes as three slides with protargol-impregnated specimens have been deposited in the Oberösterreichische Landesmuseum in Linz (LI), Austria. Relevant specimens are marked by a black ink circle on the cover glass.

Description: I discovered this new species in October 1988 in the Amper river, which is thus type location; later, I found it also in the Illach river. All observations refer to the Amper population.

Trunk in vivo $80–150 \times 40–70$ µm, fusiform or slightly conical, posterior portion narrowed to obtuse tip. Neck highly versatile and contractile, about three to four times as long as trunk, 5–7 µm across when fully extended, distal end club-shaped and thus distinctly set off from cylindroid head and dome-shaped pharyngeal plug (Figs. 4a, d, i, m, p, s). Highly contractile and metabolic, contracted specimens 100–200 µm long, club-shaped (Figs. 4b, l, p), pyriform (Figs. 4c, l), fusiform (Figs. 4h, n), or with bulbous central portion (Fig. 4e). Nuclear apparatus in centre of trunk, micronucleus invariably between macronuclear nodules (Figs. 4a, d, h, s). One contractile vacuole each near anterior and posterior end of trunk, both with about 7 excretory pores each (Figs. 4a, d, h, k, s). Two types of rod-shaped extrusomes, very likely toxicysts, in head and cytoplasm: long type slightly curved and 12–13 µm long; short type straight and 2–3 µm long, difficult to recognize because of its minuteness (Figs. 4i, j, r). Cortex colourless, distinctly striated not by somatic kineties but by granule rows, one each extending along right margin of somatic kineties; granules compact and highly refractile, about 2.5×2 µm in size, distinctly larger than minute (<0.5 µm) cortical granules forming narrowly spaced rows between



Figs. 4a–k. *Lacrymaria granulifera* from life (a–g, i, j) and after protargol impregnation (h, k). **a, d:** Extended, swimming specimens. Note distinct cortical striation caused by large cortical granules (Fig. 2f). **b, c, e:** Contracted specimens. **f, g:** Surface and transverse view of cortex. Large cortical granules form a conspicuous row right of each kinety; rows of small granules and pale, ellipsoidal mitochondria are found between ciliary rows. **h, k:** Infraciliature, total view and anterior body portion at higher magnification. Arrow marks pores of anterior contractile vacuole. **i:** Anterior end at high magnification. **j:** Large (13 μm) and small (2 μm) head extrusomes, drawn to scale. B = brush, CV = contractile vacuoles, E = extrusomes, F = fibres, LG = large cortical granules, M = mitochondria, MA = macronuclear nodules, MI = micronucleus, SG = small cortical granules. Scale bar division 10 μm (Fig. 4i) and 50 μm (Figs. 4a, d, h, k).



Figs. 4l–s. *Lacrymaria granulifera* from life (l–p, r, s) and after protargol impregnation (q). Figures 4p, r, s kindly supplied by H. BLATTERER. Note distinct cortical striation in all specimens caused by a row of large, bright cortical granules right of each ciliary row (cp. Figs. 4f, o). **l:** Cluster of contracted specimens. **m, p, s:** Extending specimens. Note blunt shape as compared with *L. olor* (Figs. 2k–q). **n:** Contracted specimen. **o:** Heavily squeezed specimen showing rows (arrows) of bright, large cortical granules right of somatic kineties. **q, r:** Infraciliature and extrusomes in anterior body portion. CV = contractile vacuole, E = extrusomes, HE = head, NE = neck, PP = pharyngeal plug.

somatic kineties (Figs. 4f, g, o). Cytoplasm colourless, contains few to many fat globules up to 8 µm across and some 2–5 µm sized crystals, as in *L. olor*. Swims rather fast and serpentinous, however, often several individuals attach trunk on slide, possibly by some slimy substance, forming conspicuous aggregates (Fig. 4l).

Somatic and oral infraciliature as in other members of genus but more dense as, e.g. in *L. olor*, because of the higher number of ciliary rows (cp. Figs. 2f–j, 4h, k, q). Cilia about 8 µm long, arranged in right-spiralling rows, all kineties unshortened and commencing with 3–7 dikinetids, possibly having only anterior basal bodies ciliated. Circumoral kinety composed of dikinetids, associated with long nematodesmata, as in *L. olor*. Postciliary microtubule ribbons conspicuous (Fig. 4k, q).

Ecology: *L. granulifera* is widespread in slightly polluted, eutrophic streams. However, it is less frequent than *L. olor*, with which it is often associated.

Comparison with related species: *L. granulifera* is very similar to *L. olor*, differing from that species mainly by the large granules along the ciliary rows. The granule rows cause a distinct striation of the cortex easily recognizable and separating *L. granulifera* from *L. olor* even at low magnification (Figs. 4a, f, l, o, p, s). In fact, it was this distinct striation which gave me the first indication that the population under investigation was not *L. olor*. However, there are also other, minor differences between *L. granulifera* and *L. olor*, the latter usually being slightly smaller and having fewer somatic kineties, 3–6 of which are shortened (Table 5); thus, *L. olor* has more ciliary rows on the trunk than on the neck.

Very likely, *L. granulifera* has been frequently confused with *L. olor*, for instance by DRAGESCO & DRAGESCO-KERNÉIS (1986), whose figures perfectly match my observations. KAHL (1930) also distinguished two varieties in "normal" populations of *L. olor*, viz. a blunt (possibly *L. granulifera*) and a slender (*L. olor*) form.

- *Lacrymaria robusta* VUXANOVICI, 1959 stat. nov. (Figs. 5a–g, Table 5)

1959 *Lacrymaria acuta* KAHL var. *robusta* n. var. VUXANOVICI, Studii Cerc. Biol., 11: 313.

Improved diagnosis: In vivo about 100–150 µm long, body with distinct head, neck and trunk, fairly contractile. Macronucleus ellipsoidal with distinct groove containing micronucleus. Two contractile vacuoles. Extrusomes terete, large type about 12 µm long, small type about 4 µm long. Nine somatic kineties on average.

Nomenclature: VUXANOVICI's variety is treated as subspecies, according to article 45(g) of the ICZN (1985). Furthermore, it is raised to species rank, with VUXANOVICI as author [article 50(c)(i) of the ICZN], because size, number of contractile vacuoles and habitat indicate that it has little in common with the marine *L. acuta* KAHL, 1933, which is 300–400 µm long and has only a single, subterminal contractile vacuole.

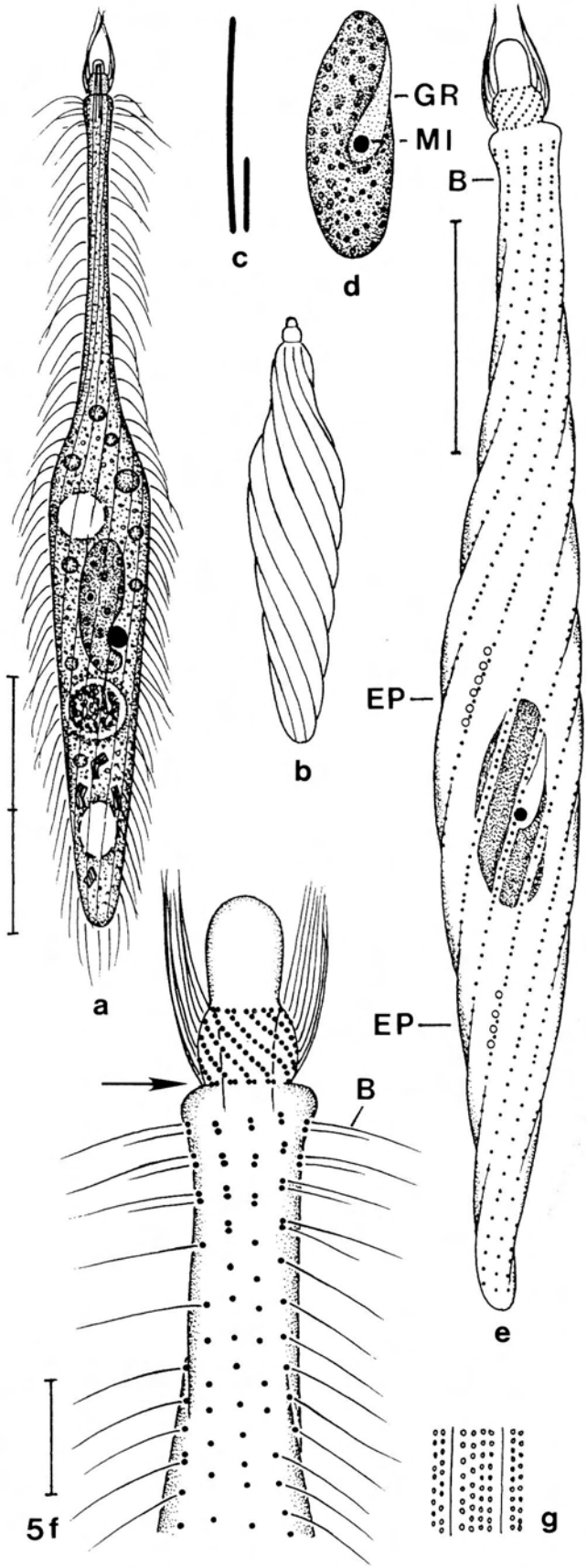
Type material: No type material from *L. robusta* has been mentioned in the literature. Thus, I declare the population from the Eger stream as neotype and deposit two slides with protargol-impregnated specimens in the Oberösterreichische Landesmuseum in Linz (LI), Austria. Relevant specimens are marked by a black ink circle on the cover glass.

Description of Bavarian population: Trunk in vivo 50–70 × 25–30 µm, distinctly clavate with posterior end narrowed to obtuse tip. Neck about as long as trunk, cylindroid, 3–5 µm across when fully extended, distal end club-shaped and thus distinctly set off from barrel-shaped head and cylindroid pharyngeal plug (Fig. 5a, f). Moderately contractile, i.e. about 50% of body length, contracted specimens fusiform (Fig. 5b). Nuclear apparatus in centre of trunk, macronucleus distinctly ellipsoidal (3:1), contains many small nucleoli; micronucleus lenticular, in conspicuous, oblong groove of macronucleus (Figs. 5a, d, e). Anterior contractile vacuole near anterior end of trunk, posterior contractile vacuole distinctly subterminal, both with about 5 excretory pores each (Figs. 5a, e). Two types of rod-shaped extrusomes, very likely toxicysts, in head and cytoplasm: long type straight to very slightly curved and about 12 µm long, short type straight and about 4 µm long (Fig. 5c). Cortex colourless, slightly furrowed by ciliary rows, contains numerous rows of minute (< 0.5 µm) granules, possibly mucocysts (Fig. 5g). Cytoplasm with fat globules and some 3–4 µm sized crystals mainly around posterior contractile vacuole. Feeds on small ciliates, one specimen contained an almost intact *Urotricha synuraphaga*. Swims very fast contracting more rarely and less distinctly than *L. olor*; thus, protargol slides contain almost fully extended specimens (Fig. 5e).

Somatic and oral infraciliature very similar to other members of genus (Figs. 5e, f). Cilia about 10 µm long, arranged in 9, very rarely 8 or 11 right-spiralling, bipolar rows each commencing with 3–4 ciliated dikinetids whose posterior cilia are shortened to about 5 µm long bristles. A loose row of dikinetids at *both* ends of head kineties, anterior dikinetids, forming circumoral kinety, associated with short, inconspicuous nematodesmata (Fig. 5f).

Ecology: VUXANOVICI (1959) discovered a rich population of *L. robusta* in Lake Herăstăru, Rumania. I found low numbers in the Eger and Zinnbach streams, also indicating that *L. robusta* prefers clean water.

Comparison with original description and related species: For discussion of species status, see paragraph on nomenclature above. The original description of *L. robusta* is not very detailed. However, all characters mentioned (size, shape, number and location of contractile vacuoles, macronucleus) match my specimens. Thus, the identification is very likely correct. *Lacrymaria robusta* is easily confused with *L. filiformis* MASKELL (single posterior contractile



vacuole only; FOISSNER 1983) and *L. oblonga* VUXANOVICI, 1962 (length only 70 µm, neck distinctly shorter than ellipsoidal trunk).

Family Tracheliidae EHRENBERG, 1838

- Genera *Monilicaryon* JANKOWSKI, 1967 stat. nov. and *Pseudomonilicaryon* nov. gen.

Improved diagnosis of *Monilicaryon:* Tracheliidae with moniliform macronucleus and a somatic (perioral) kinety each along right and left side of circumoral kinety. Oblique preoral kineties lacking.

Remarks: *Monilicaryon monilatus* is unique among the known Tracheliidae by the lack of preoral kineties, i.e. of short, oblique ciliary rows along the left side of the circumoral kinety (cp. next species, *Trachelius ovum*). However, the circumoral kinety of *M. monilatus* is accompanied on both sides by a somatic (perioral) kinety, whereas other tracheliids have a somatic kinety only on the right side (Fig. 7; FOISSNER et al. 1995).

JANKOWSKI (1967) split *Dileptus* into 3 subgenera using the macronuclear configuration (dispersed, moniliform, two pieces with micronucleus in between) as sole character. Unfortunately, the same macronuclear configuration very likely evolved independently in several dileptids. Thus, I suggest the lack of preoral kineties as main character of *Monilicaryon*, the type species of which is *M. monilatus*. The lack of preoral kineties is an extraordinary feature, i.e. a perfect genus character. Thus, I raise *Monilicaryon* from subgenus to genus rank. Other species with moniliform macronucleus, e.g. *Dileptus gracilis* KAHL, 1931 (redescribed in FOISSNER 1989), have a normal oral infraciliature and thus need to be transferred to a new genus, *Pseudomonilicaryon* nov. gen., which I diagnose as follows: Tracheliidae with moniliform or vermiform macronucleus and short, oblique preoral kineties. Type species: *Dileptus gracilis* KAHL, 1931 (*Pseudomonilicaryon gracilis* nov. comb.).

Figs. 5a–g. *Lacrymaria robusta* from life (a–c, g) and after protargol impregnation (d–f). **a, b:** Extended and contracted specimen. **c:** Large (12 µm) and small (4 µm) head extrusomes, drawn to scale. **d:** Nuclear apparatus of specimen shown in Fig. 5e. **e:** Infraciliature, total view. **f:** Head and neck infraciliature at high magnification. Note that *L. robusta* has a row of dikinetids each at anterior and posterior (arrow) end of head. **g:** Surface view showing rows of minute cortical granules between ciliary rows. B = brush, EP = excretory pores of contractile vacuoles, GR = groove, MI = micronucleus. Scale bar division 5 µm (Fig. 5f) and 20 µm (Figs. 5a, e).

Table 6. Morphometric characteristics from *Monilicaryon monilatus* (upper line) and *Trachelius ovum* (lower line)[1]).

Character	$\bar{x}$	M	SD	$SD_{\bar{x}}$	CV	Min	Max	n
Body, length in vivo	526.0	475.0	217.2	68.7	41.3	320	950	10
	–	–	–	–	–	–	–	–
Body, width in vivo	61.3	57.5	13.1	6.6	21.5	50	80	4
	–	–	–	–	–	–	–	–
Body, length	389.3	378.0	85.0	20.0	21.8	258	534	18
	188.3	200.0	34.9	10.1	18.5	115	230	12
Body, width	66.2	63.5	12.8	3.2	19.3	53	105	16
	112.7	112.5	13.3	3.8	11.8	85	130	12
Anterior end to pharyngeal	85.4	82.0	27.7	7.7	32.5	48	150	12
opening, distance	73.5	79.0	17.5	5.1	23.8	40	100	12
Macronuclear nodules, number	21.8	22.0	5.8	1.4	20.7	14	29	17
	2.0	2.0	0.0	0.0	0.0	2	2	12
Macronuclear nodules, length (*M. moni.*)	13.3	13.5	2.3	0.5	17.2	9	17	18
or length of macronuclear figure (*T. ovum*)	76.5	75.0	12.4	3.6	16.2	50	95	12
Macronuclear nodules, maximum width	8.4	9.0	1.4	0.4	16.3	6	10	18
	20.9	20.0	2.6	0.7	12.3	18	25	12
Micronuclei, number	18.0	17.5	4.8	1.4	26.4	11	26	11
	4.0	4.5	1.2	0.4	31.2	2	5	10
Micronuclei, diameter	2.5	2.3	0.4	0.1	17.0	1.5	3	17
	3.4	3.0	–	–	–	3	4	12
Pharyngeal opening, diameter	15.8	16.0	2.1	0.5	13.5	12	20	16
	17.0	17.0	2.4	0.7	14.0	13	20	12
Somatic kineties in mid-body, number	51.8	50.0	5.3	1.3	10.2	40	60	17
	101.7	100.0	11.7	4.8	11.5	90	120	6

[1]) Data based, if not stated otherwise, on protargol-impregnated and mounted morphostatic specimens from field. Measurements in µm. CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of specimens investigated, SD – standard deviation, $SD_{\bar{x}}$ – standard deviation of arithmetic mean, $\bar{x}$ – arithmetic mean.

- *Monilicaryon monilatus* (STOKES, 1886) JANKOWSKI, 1967 (Figs. 6a–u, Table 6)

1886 *Amphileptus monilatus* STOKES, Ann. Mag. nat. Hist., 17: 102.

1905 *Dileptus monilatus* STOKES – CONN, Bull. Conn. St. geol. nat. Hist. Survey, 2: 46 (combining author).

1931 *Dileptus monilatus* (STOKES, 1886) – KAHL, Tierwelt Dtl., 21: 205 (partim).

1953 *Dileptus monilatus* (STOKES, 1886) – JONES & BEERS, J. Elisha Mitchell scient. Soc., 69: 42 (misidentification ?).

1959 *Dileptus monilatus* (STOKES, 1886) – VUXANOVICI, Studii Cerc. Biol., 11: 328 (misidentification).

1962 *Dileptus monilatus* (STOKES, 1886) – DINGFELDER, Arch. Protistenk., 105: 557 (misidentification).

1963 *Dileptus monilatus* (STOKES, 1886) – DRAGESCO, Bull. biol. Fr. Belg., 97: 109.

1967 *Monilicaryon monilatus* (STOKES, 1886) – JANKOWSKI, Mat. V. Conf. Mold., p. 36.

1994 *Dileptus monilatus* (STOKES, 1886) – SONG, Acta zootax. sin., 19: 388 (misidentification).

1995 *Monilicaryon monilatus* (STOKES, 1886) JANKOWSKI, 1967 – FOISSNER, BERGER, BLATTERER & KOHMANN, Taxonom. ökol. Rev. Cili. Saprobiensyst., IV: 199.

Improved diagnosis: In vivo usually about 400–700 × 50–60 µm. Slenderly fusiform, proboscis indistinctly set off from cylindroid trunk and conspicuously short, i.e. 1/4 to 1/6 of body length. An average of 22 macronuclear nodules in single, straight chain. Many contractile vacuoles in dorsal side of proboscis and trunk. Two types of extrusomes, large type 6–9 µm long and thorn-shaped, small type terete and 2–3 µm long. 50 somatic kineties on average. Usually 1 brush kinety in midline of dorsal side of proboscis.

Type material: Only SONG (1994) deposited protargol-impregnated slides of *D. monilatus* in the College of Fisheries, Ocean University of Qingdao, China. However, the population he studied very likely belongs to another species. Thus, and because SONG did not neotypify his population, I declare my population from the Amper river in Germany as neotype and deposite four slides with protargol-impregnated specimens in the Oberösterreichi-

sche Landesmuseum in Linz (LI), Austria. Relevant specimens are marked by a black ink circle on the cover glass.

Description of Bavarian population: *M. monilatus* occurred in the Illach river (Table 3). However, the population described here, was found in January 1989 in the Amper river in Bavaria (see FOISSNER et al. 1992b for site description). Another population, studied mainly for the extrusomes, was found in the Ager river in Upper Austria.

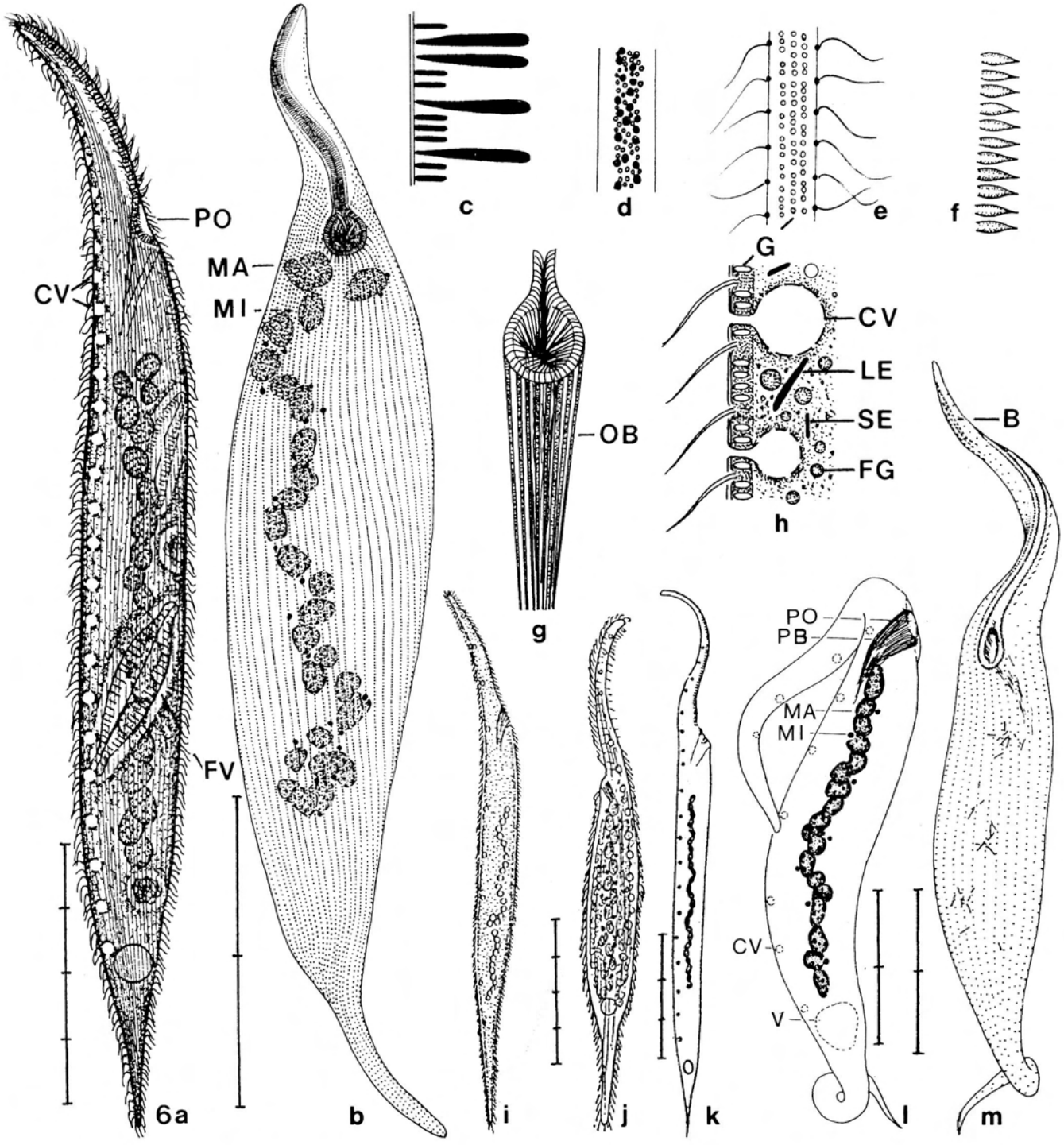
Size in vivo about $300-1000 \times 50-80$ µm (Table 6), smallest individuals were possibly injured; brownish at low magnification ($X < 100$) due to cytoplasmic inclusions and cortical mucocysts. Slightly contractile and very flexible, often spirally twisted along main body axis and/or curved loop-like (Fig. 6t). Slenderly fusiform, proboscis and tail indistinctly set off from cylindroid trunk (Figs. 6a, q, r). Proboscis slightly flattened laterally and curved dorsally, versatile, conspicuously short, i.e. 1/4 to 1/6 of body length (Figs. 6a, b, q, r, Table 6), very fragile; thus, mutilated and regenerating specimens occur frequently. Posterior end slightly to distinctly elongated, tail 1/6 to 1/8 of body length. Macronucleus in trunk, surrounded by slightly argyrophilic capsule, moniliform, individual nodules globular to ellipsoidal, occasionally dumb-bell shaped, with many small nucleoli. Micronuclei globular, attached to macronuclear nodules but outside of capsule (Figs. 6a, b, r, u). About 20–40 contractile vacuoles, each with single excretory pore, in dorsal side of proboscis and trunk (Figs. 6a, o–q). Two types of extrusomes, very likely toxicysts, in oral bulge of proboscis and in cytoplasm (Figs. 6c, d, h, s): large type $6-9 \times 1$ µm and thorn- to cartride-shaped, small type $2-3 \times 0.5$ µm and rod-shaped. Cortex gelatinous and conspicuously thick, i.e. about 2 µm, between each two ciliary rows about 3 rows of bright, $1.5-2 \times 1$ µm sized cortical granules, very likely mucocysts (Figs. 6e, h). Cytoplasm densely granulated, usually with several large food vacuoles containing ciliates, rotifers, and (possibly from ingested ciliates) diatoms (*Nitzschia palea*, *N. sigmoidea*, *Synedra ulna*, *Cymbella* sp., *Rhoicosphenia curvata*). Moves slowly and serpentinously between organic debris.

Cilia 8–10 µm long, narrowly spaced, arranged in about 50 longitudinal rows (Table 6); about 1/5 of kineties commence ventrally beneath pharyngeal opening, about 2/3 commence prepharyngeally near oral bulge and end subterminally at base of tail. Prepharyngeal kineties do not abut to circumoral ciliature, leaving blank rather wide field at both sides of proboscis (Fig. 6n). First somatic kinety right and left of pharyngeal opening elongated, i.e. extend as perioral kineties along circumoral kinety to tip of proboscis (Fig. 6n). Dorsal brush basically composed of single row of narrowly spaced dikinetids having tongue-shaped cilia, extends in midline of dorsal side of proboscis, interrupted by pores of contractile vacuoles (Figs. 6f, o); rarely, up to 4 dorsal brush kineties occur in distal region of proboscis (Fig. 6p).

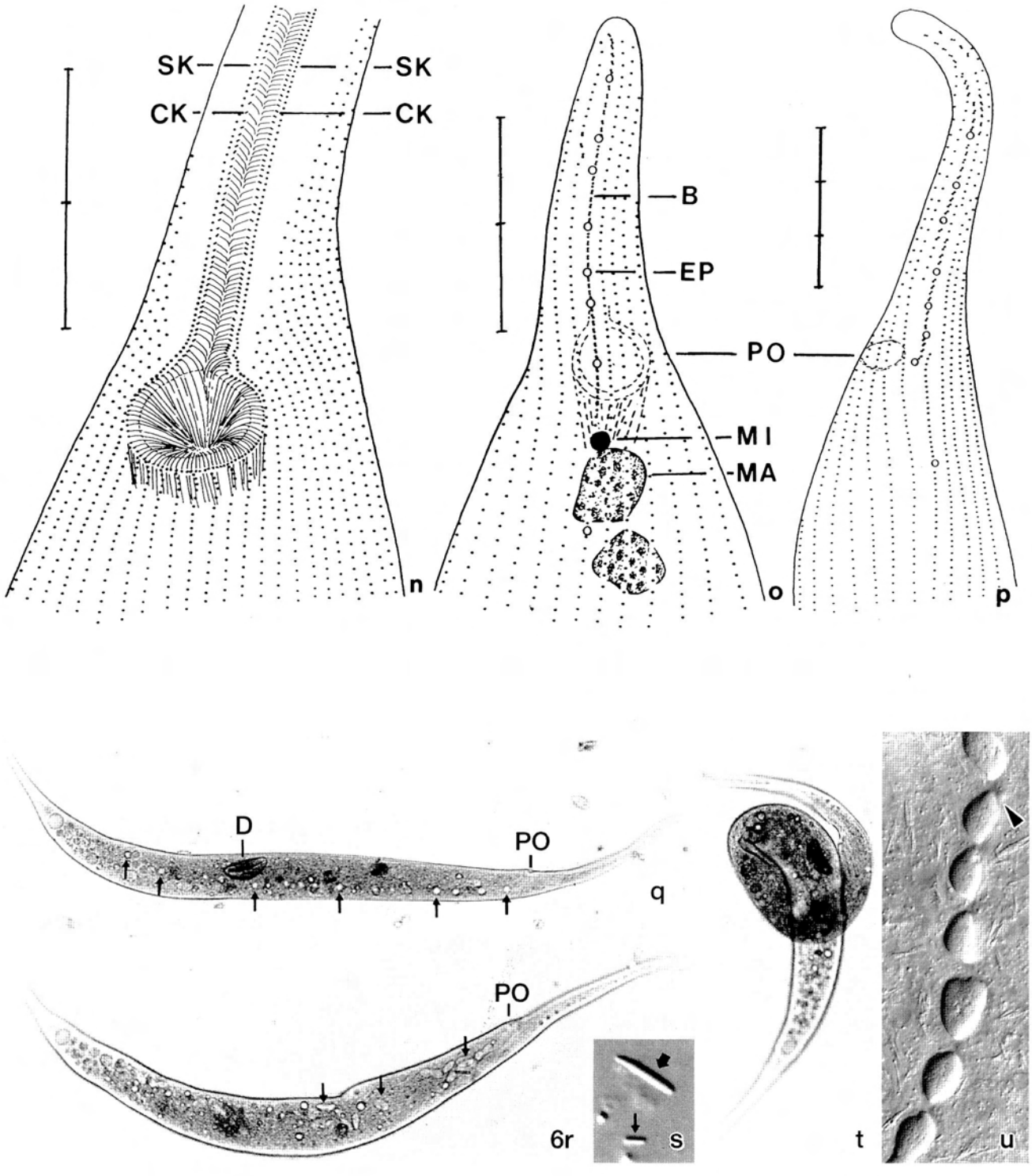
Pharyngeal funnel conspicuous, circular, consists of an inner and an outer basket (Figs. 6a, g, n): outer basket composed of many about 130×2 µm sized rods, inner basket made of many about 100 µm long fibres, very likely transverse microtubule ribbons originating from circumoral kinetids. Circumoral kinety composed of monokinetids around pharyngeal opening, and of oblique dikinetids on proboscis; kinetids associated with conspicuous fibres extending to centre of oral bulge and pharyngeal opening forming inner pharyngeal basket, as mentioned above (Figs. 6b, n). Circumoral cilia about 10 µm long, narrowly spaced and thus forming distinct mane along ventral side of proboscis.

Ecology: The rather voluminous faunistic and ecological literature on *M. monilatus* has been reviewed by FOISSNER et al. (1995). Unfortunately, many data very likely refer to other, similar species, as evident from the misidentifications discussed in the following paragraph. *Monilicaryon monilatus* prefers beta-mesosaprobic, benthic habitats of slowly running and stagnant waters. Often found near and in traps of certain caddis-flies, possibly searching for food. Usually, *M. monilatus* is rare, peak abundances occur in summer.

Comparison with previous descriptions: My observations match the original description very well. Thus, I do not hesitate to declare my population as neotype of *Dileptus monilatus* (STOKES, 1886). The most important character of *M. monilatus*, apart from its special oral infraciliature (see genus discussion above), is the extraordinarily short proboscis, as mentioned also by STOKES (1886): "The anterior trunk-like portion forms one-fourth of the entire length of the body" (Fig. 6i). All redescriptions, possibly except that of DRAGESCO (1963, Fig. 6k; but see DRAGESCO & DRAGESCO-KERNÉIS 1986), show specimens with a much longer proboscis. JONES & BEERS (1953), for instance, definitely state: "The proboscis of *D. monilatus* varies from one-third to one-half as long as the trunk in our specimens". The same applies to the species studied by KAHL (1931; Fig. 6j) and SONG (1994; proportion of body length to proboscis length 2.6–3.1; Figs. 6l, m). Thus, the populations studied by KAHL (1931), JONES & BEERS (1953), DINGFELDER (1962) and SONG (1994) very likely belong to *Dileptus kahli*, a species erected by ŠRÁMEK-HUŠEK (1957) for *D. monilatus* as figured in KAHL (1931). The *D. monilatus* of VUXANOVICI (1959) has symbiotic green algae and is thus very likely also another species. Unfortunately, another important character of dileptids, viz. in vivo shape and size of the extrusomes, has been almost completely ignored by previous authors, even recent ones like JONES & BEERS (1953) and SONG (1994), who depict only stained extrusomes, which is useless because they often become heavily altered by the fixation and staining procedures.



Figs. 6a–m. *Monilicaryon monilatus* from life (a, c–k) and after protargol impregnation (b, l, m). **a:** Right lateral view of typical, well-fed specimen. **b:** Infraciliature of ventral side. Note short proboscis. **c, d:** Optical section and surface view of proboscis showing long and short extrusomes. **e, h:** Surface view and optical section of dorsal cortex. **f:** Dorsal bristles. **g:** Pharyngeal basket. **i, j, k:** *Dileptus monilatus* from STOKES (1886), KAHL (1931) and DRAGESCO (1963). **l, m:** Nuclear apparatus and infraciliature of *D. monilatus* from SONG (1994). B = dorsal brush, CV = contractile vacuoles, FG = fat globule, FV = food vacuole, G = cortical granules, LE = long extrusomes, MA = macronuclear nodules, MI = micronuclei, OB = outer pharyngeal basket, PB = pharyngeal basket, PO = pharyngeal opening, SE = short extrusomes, V = vacuole. Scale bar division 50 μm.



Figs. 6n–u. *Monilicaryon monilatus* from life (q–u) and after protargol impregnation (n–p). **n:** Ventral view of oral infraciliature. Note lack of preoral kineties. **o, p:** Dorsal views of proboscis infraciliature. Dotted lines show pharyngeal opening (PO) on ventral side. **q, r, t:** Gliding specimens. Note short proboscis. Arrows in Fig. 6q mark contractile vacuoles, those in Fig. 6r denote macronuclear nodules. **s:** Long (thick arrow) and short (thin arrow) extrusome from oral bulge (cp. Fig. 6c). **u:** Part of macronucleus which consists of many nodules. Arrowhead marks a micronucleus. B = dorsal brush, CK = circumoral kinety, D = ingested diatom, EP = excretory pore of contractile vacuole, MA = macronuclear nodule, MI = micronuclei, PO = pharyngeal opening, SK = somatic (perioral) kinety. Scale bar division 20 μm.

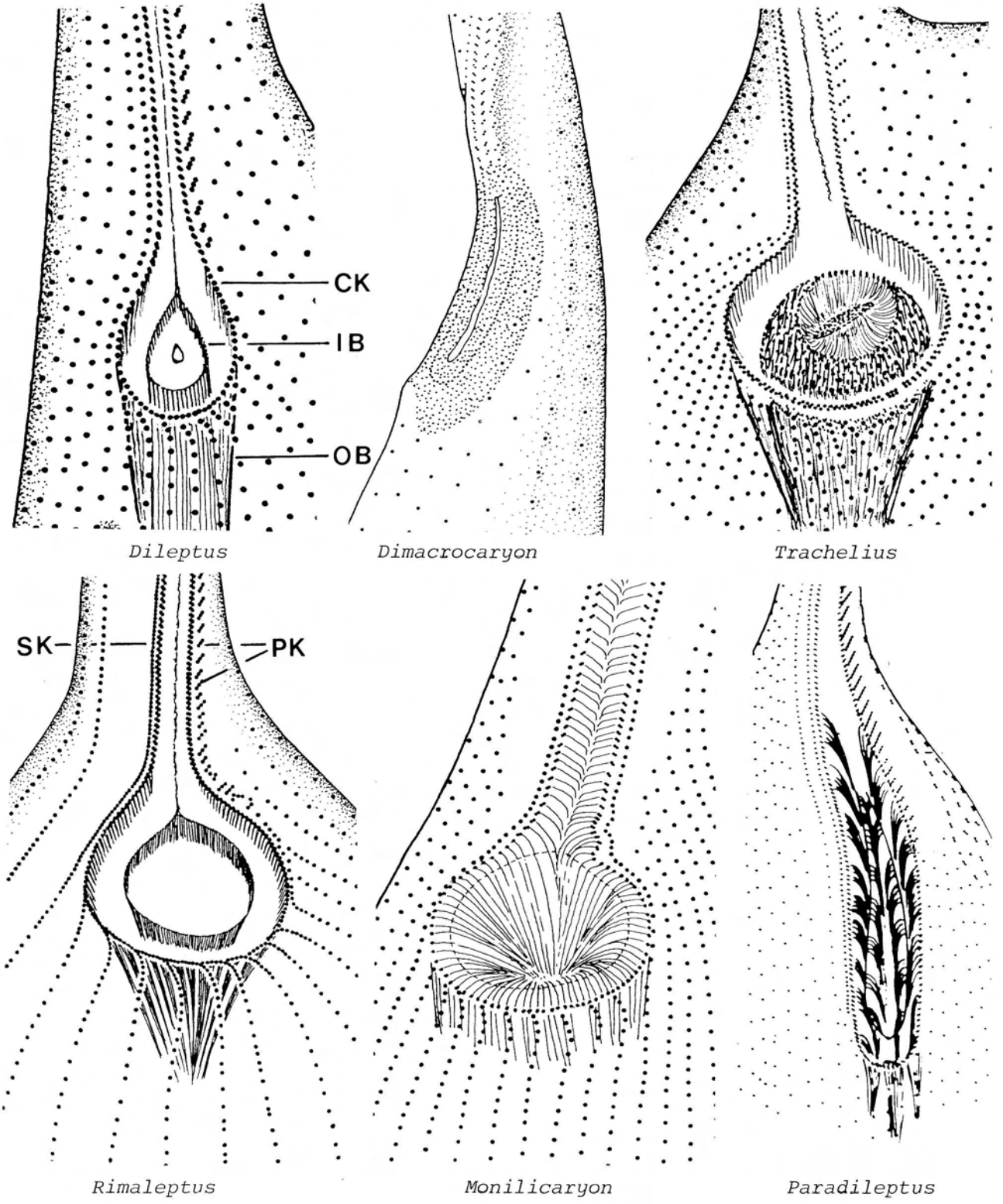


Fig. 7. Oral infraciliature of tracheliids after protargol impregnation (from FOISSNER 1984, 1995 and PACKROFF & WILBERT 1991). Note that *Dimacrocaryon* lacks a pharyngeal basket and *Monilicaryon* lacks preoral kineties. *Trachelius* has a strongly developed, club-shaped inner basket. See text for further explanation. CK = circumoral kinety, IB = inner pharyngeal basket, OB = outer pharyngeal basket, PK = preoral kineties, SK = somatic (perioral) kinety.

• Genus *Trachelius* SCHRANK, 1803

Improved diagnosis: Tracheliidae with many short preoral kineties and ventrolateral fossa (pit) containing and surrounded by a specialized infraciliature. Inner pharyngeal basket strongly developed, club-shaped, consists of innumerable fine fibres. Circumoral kinety composed of dikinetids throughout.

Remarks: The detailed organization of *Trachelius* is still insufficiently known, although the type species, *T. ovum*, has been redescribed several times (DRAGESCO & DRAGESCO-KERNÉIS 1986, HAMBURGER 1903, PENARD 1922, SONG & WILBERT, 1989). All figures of the infraciliature are too schematized and incorrect in some details, e.g., in the angle the right lateral somatic kineties abut to the circumoral kinety.

My reinvestigation shows that the somatic and oral infraciliature of *Trachelius* basically agrees with those in other members of the family. It has, however, at least two unique features, viz. the ventrolateral fossa, where the ciliature is specialized, and the inner pharyngeal basket, which is strongly developed and consists of innumerable fine fibres forming a conspicuous, club-shaped structure lacking in all other genera of the family (Fig. 7). Furthermore, the slides show clearly that the circumoral kinety of *Trachelius* is composed of dikinetids throughout, while most (all?) other genera, at least *Dileptus*, *Rimaleptus* and *Monilicaryon*, have it composed of oralized somatic monokinetids in that part which surrounds the pharyngeal opening (Fig. 7; FOISSNER & FOISSNER 1988a).

• *Trachelius ovum* (EHRENBERG, 1831) EHRENBERG, 1838 (Figs. 8a–q, Table 6)

1831 *Ophryocerca ovum* EHRENBERG, Abh. dt. Akad. Wiss. Berl., year 1831: 112.
1838 *Trachelius ovum* (EHRENBERG, 1831) – EHRENBERG, Infusionsthierchen: 323.
1903 *Trachelius ovum* – HAMBURGER, Arch. Protistenk., 2: 445.
1922 *Trachelius ovum* EHRENBERG, 1838 – PENARD, Études Infusoires: 80.
1931 *Trachelius ovum* EHRENBERG, 1831 – KAHL, Tierwelt Dtl., 21: 210.
1986 *Trachelius ovum* (EHRENBERG, 1831) – DRAGESCO & DRAGESCO-KERNÉIS, Faune tropicale, 26: 167.
1989 *Trachelius ovum* EHRENBERG, 1831 – SONG & WILBERT, Lauterbornia, 3: 43.
1995 *Trachelius ovum* (EHRENBERG, 1831) EHRENBERG, 1838 – FOISSNER, BERGER, BLATTERER & KOHMANN, Taxonom. Ökol. Rev. Cili. Saprobiensyst., IV: 208.

Type material: No type material from *T. ovum* has been mentioned in the literature. Thus, I declare the population from Germany as neotype and deposit four slides with protargol-impregnated specimens in the Oberösterreichische Landesmuseum in Linz (LI), Austria. Relevant specimens are marked by a black ink circle on the cover glass.

Description of Bavarian population: The redescription is confined to the infraciliature because the life aspect of *T. ovum* has been described in great detail by HAMBURGER (1903), KAHL (1931) and PENARD (1922). *Trachelius ovum* has a complicated nomenclature and synonymy discussed briefly by FOISSNER et al. (1995).

All ciliary rows extend longitudinally from the circumoral kinety to posterior body end and are rather loosely ciliated, those commencing at pharyngeal part of circumoral kinety more densely ciliated in anterior portion. Ciliature

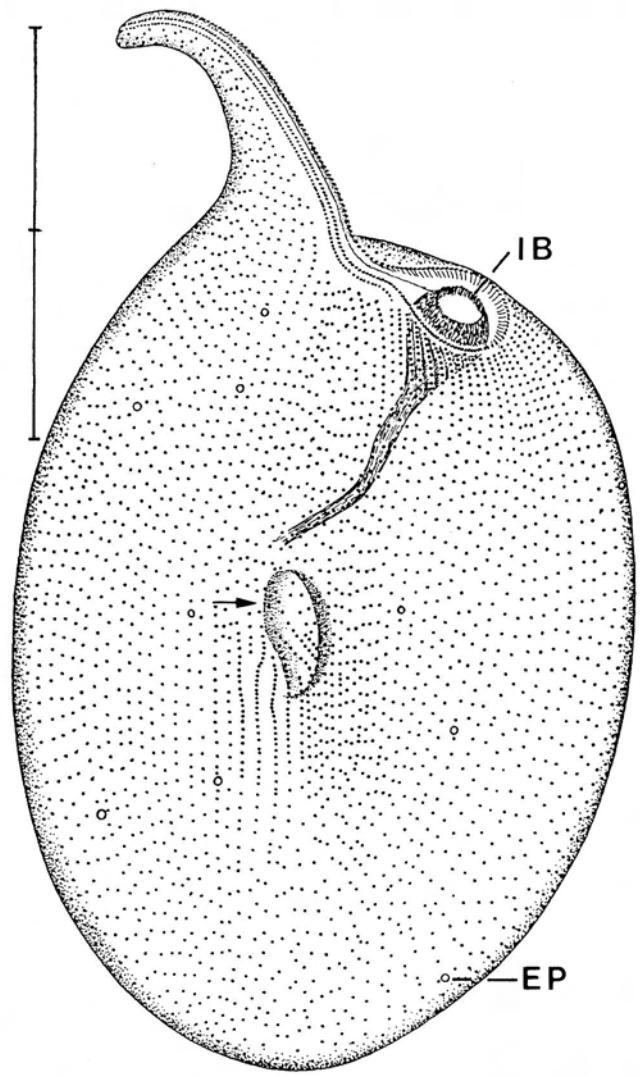
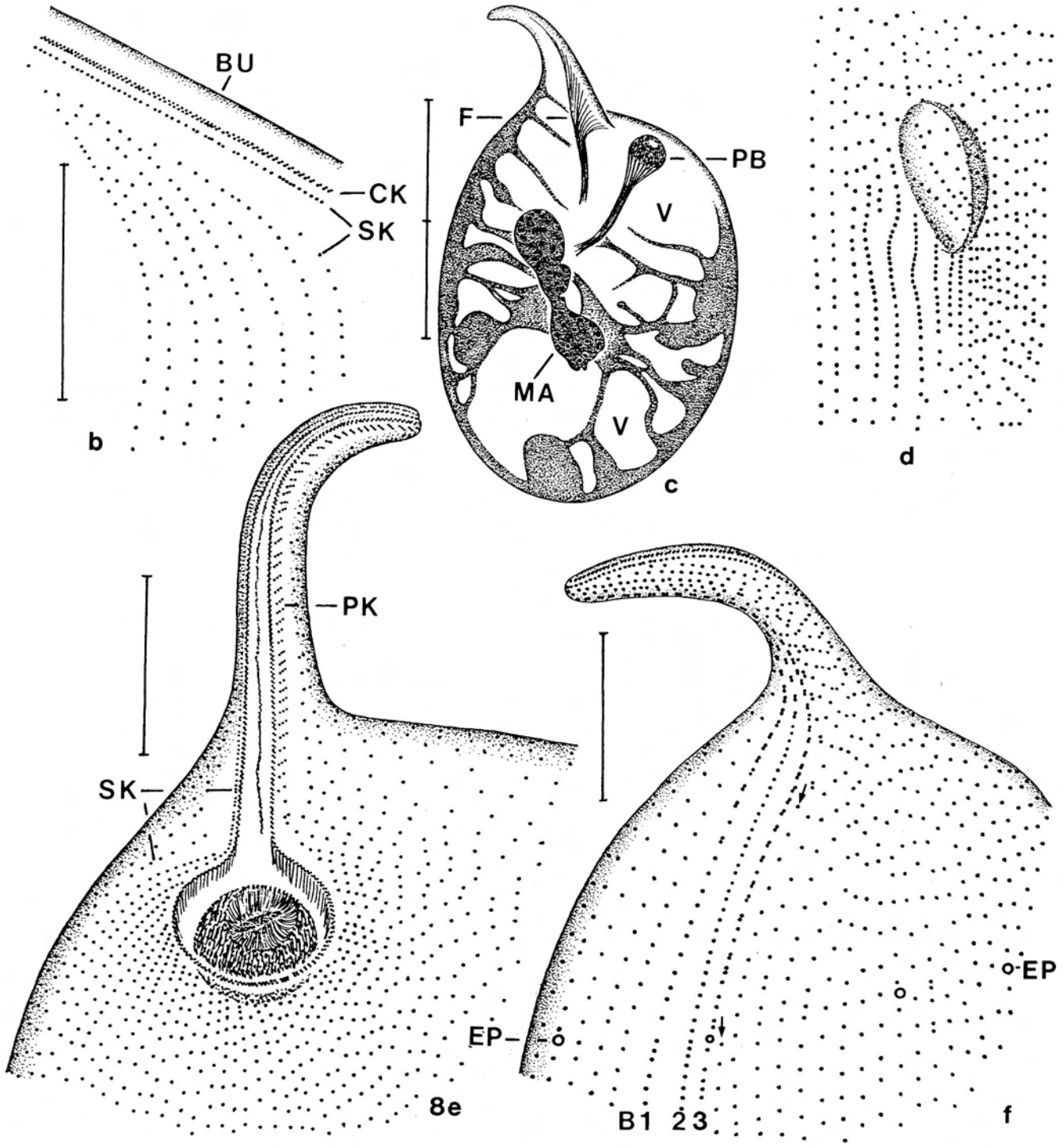
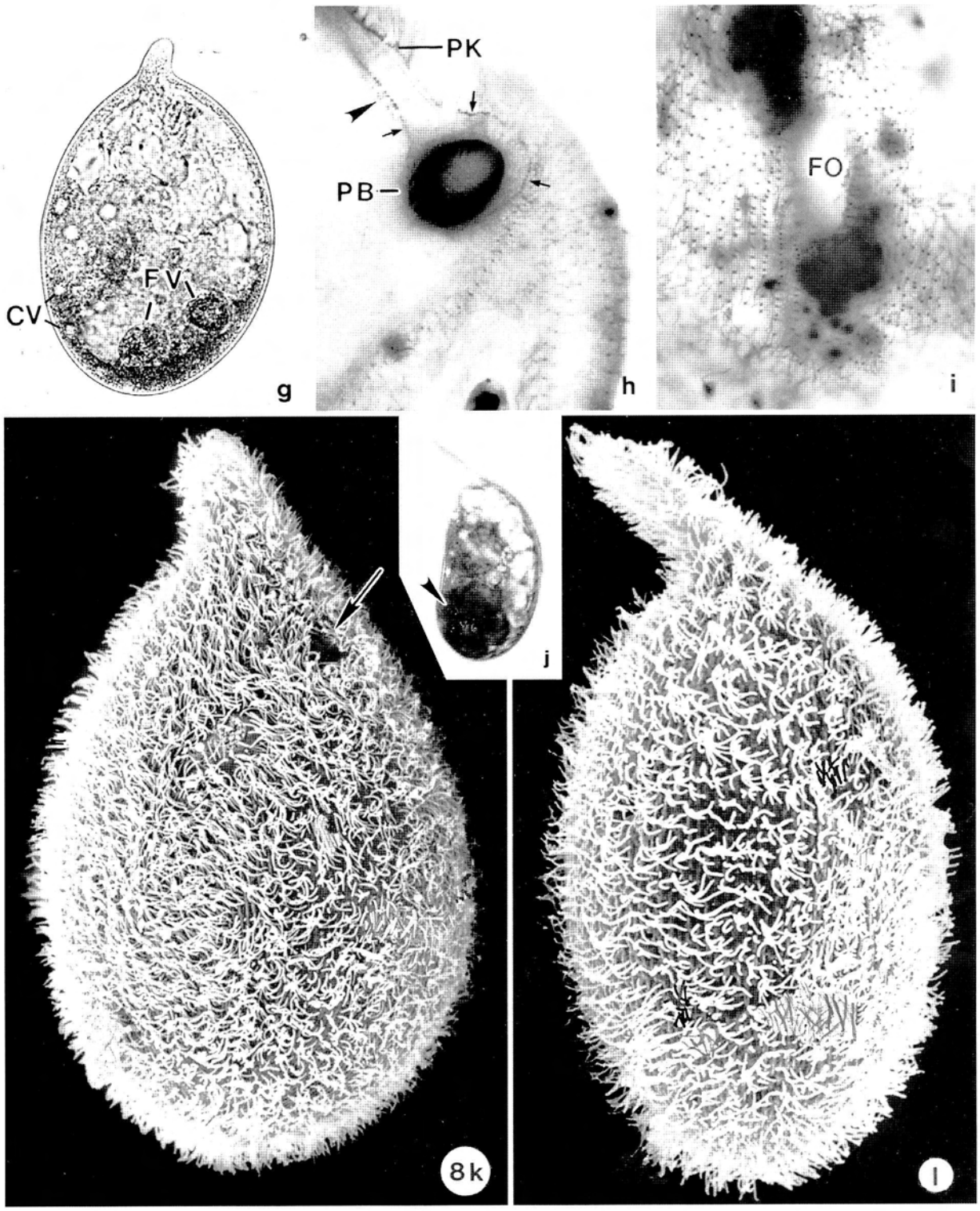


Fig. 8a. *Trachelius ovum*, ventrolateral view of infraciliature after protargol impregnation. Arrow marks fossa (cp. Fig. 6d). EP = excretory pore of a contractile vacuole, IB = inner pharyngeal basket. Scale bar division 50 µm.



Figs. 8b—f. *Trachelius ovum*, somatic and oral infraciliature after protargol impregnation. **b:** Right lateral proboscis area. **c:** General organization. Note strongly vacuolated cytoplasm and club-shaped inner pharyngeal basket. **d:** Fossa of specimen shown in Fig. 8a at high magnification. **e, f:** Anterior ventral and dorsal side. Arrows mark somatic kineties abutting to left side of brush. B1, 2, 3 = dorsal brush kineties, BU = oral bulge, CK = circumoral kinety, EP = excretory pore of contractile vacuoles, F = fibres originating from circumoral kinety, MA = macronucleus, PB = pharyngeal basket, PK = preoral kineties, SK = somatic kineties, V = vacuoles. Scale bar division 20 µm (Figs. 8b, e, f) and 50 µm (Fig. 8c).



Figs. 8g—l. *Trachelius ovum* from life (g, j), after protargol impregnation (h, i) and in the scanning electron microscope (k, l). **g:** Slightly squeezed specimen with very short proboscis. **h:** Oral infraciliature. Arrows denote circumoral kinety, arrowhead marks perioral (somatic) kinety. **i:** Right lateral infraciliature with fossa. **j:** Typical, swimming specimen. Note strongly vacuolated cytoplasm, short triangular proboscis, and large food vacuole (arrowhead). **k, l:** Ventrolateral and right lateral views. Arrow marks pharyngeal opening. Note that the fossa is not recognizable. CV = contractile vacuoles, FO = fossa, FV = food vacuoles, PB = pharyngeal basket, PK = preoral kineties.

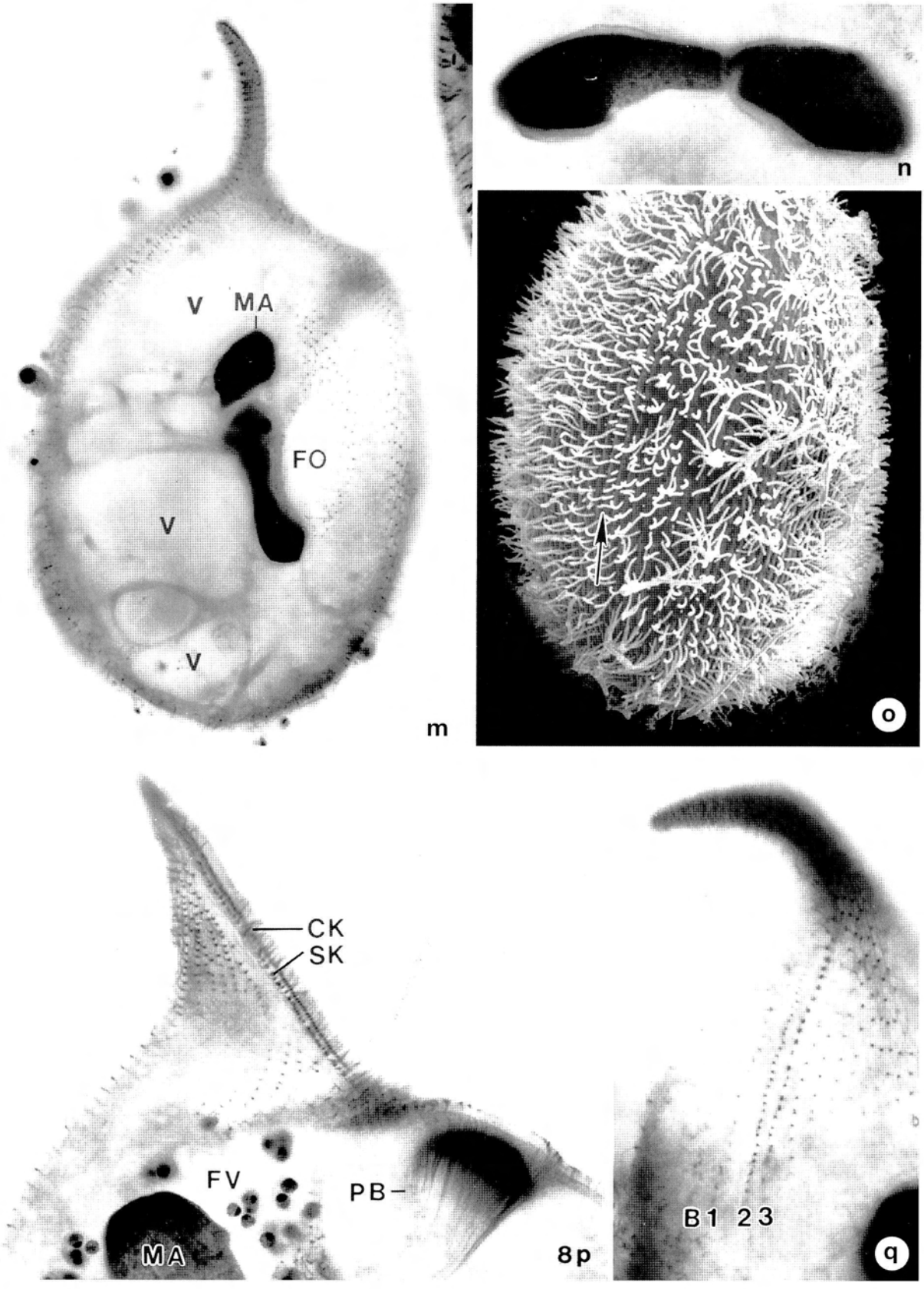


Figure explanation, see following page.

also condensed ventrolaterally in mid-body around posterior margin of fossa, some kineties end at fossa margin, while others extend to its bottom and proceed terminally (Figs. 8a, d, i, m). Right lateral ciliary rows abut to circumoral kinety of proboscis at obtuse angles (~140°), whereas those of left side abut at almost right angles; one right lateral ciliary row unshortened and extending as perioral kinety along circumoral kinety to distal end of proboscis (Figs. 8b, e, p). Some kineties abut to left side of dorsal brush, forming an inconspicuous secant system (Fig. 8f). Dorsal brush 3 to 4-rowed, extends on dorsal surface of proboscis and on anterior third of trunk, composed of short (~4 μm), paired cilia, middle row shorter than right and left row, left row extends near posterior end of body, however, not with paired but with single bristles (Figs. 8f, o, q), fourth (leftmost) row (if present) inconspicuous, composed of alternating mono- and dikinetids (Fig. 8f).

Circumoral kinety composed of dikinetids throughout, at right accompanied by a somatic (perioral) ciliary row, at left by many short, oblique preoral kineties each composed of 2–3 basal bodies. Pharyngeal opening circular, outer basket inconspicuous, composed of fine rods in single layer, inner basket very conspicuous, obliquely directed to cell centre, club-shaped, composed of innumerable fine fibres (Figs. 8a–c, e, h, k, p).

Ecology: The voluminous faunistic and ecological literature on *T. ovum* has been thouroughly reviewed by FOISSNER et al. (1995). *Trachelius ovum* occurs worldwide in the periphyton, benthos, and plankton of mesosaprobic running and stagnant waters, peak abundances have been observed during the cold half of the year. Usually, *T. ovum* is found near colonial peritrichs, especially *Carchesium polypinum*, its preferred food. When feeding, *T. ovum* attaches to the stalk of the prey by its ventrolateral pit (HAMBURGER 1903).

Family Prorodontidae KENT, 1881

- Genus *Prorodon* EHRENBERG, 1833

For nomenclature, see FOISSNER et al. (1994). Formerly, species as described and discussed here were assigned to the genus *Pseudoprorodon* BLOCHMAN, 1895, a junior objective synonym of *Prorodon* EHRENBERG, 1833.

Prorodon is still poorly known, possibly because most or all species are difficult to impregnate with silver due to the thick, gelatinous cortex. Two detailed reports are available. GROLIÈRE (1977) redescribed *P. niveus* EHRENBERG, 1833, type of the genus. However, I agree with SONG & WILBERT (1989) that GROLIERE's figures show another species because the brosse is distinctly different from that described by KAHL (1930). SONG & WILBERT (1989) provided an excellent redescription of *P. emmae* (BERGH, 1896) FOISSNER et al., 1994, showing for the first time the extraordinary brosse of *Prorodon*: many rows composed of alternating dikinetids and monokinetids. This is confirmed by my observations on *P. armatides*, described below.

Very likely, *Prorodon* is polyphyletic. However, splitting should await a detailed redescription of the type species, *P. niveus*. JANKOWSKI (1973) sorted out *P. lieberkuehni* as a separate genus, *Myriokaryon*, but without sufficient evidence.

I agree with SONG & WILBERT (1989) that *Prorodon* belongs to the haptorid gymnostomatids which contain two genera, *Pleuroplites* FOISSNER, 1988 and *Foissnerides* SONG & WILBERT, 1989, having the same peculiar brosse structure as *Prorodon*. Possibly, *Prorodon* and *Foissnerides* should be united in the family Prorodontidae KENT, 1881. *Pleuroplites* has been referred to a separate family, Pleuroplitidae FOISSNER, 1996, due to the extraordinary location of the extrusomes in a single subapical bundle.

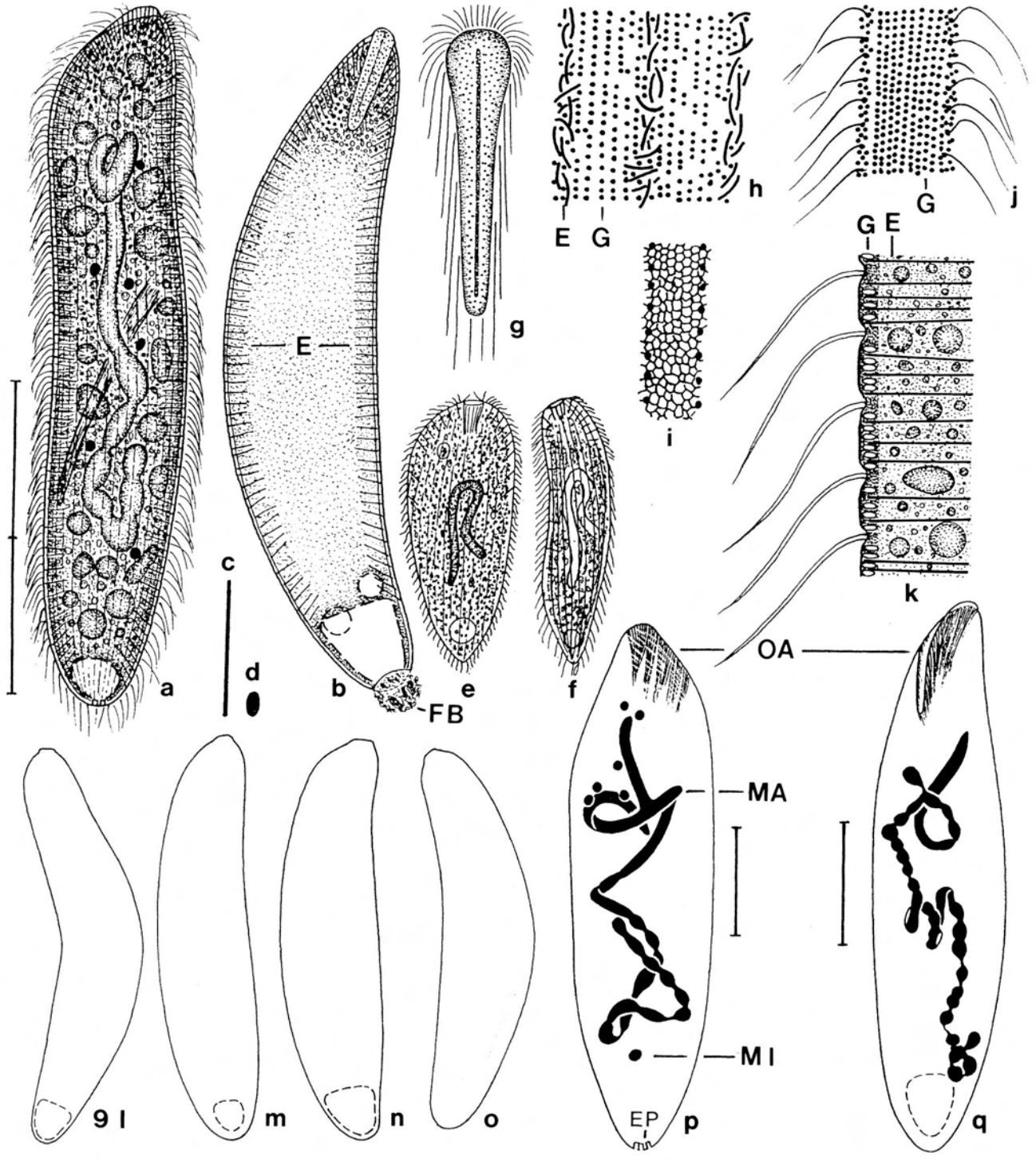
- *Prorodon armatides* nov. comb., nov. nom. (Figs. 9a–t, 10a–l, Table 7)

1930 *Pseudoprorodon armatus* KAHL, Tierwelt Dtl., 18: 70.

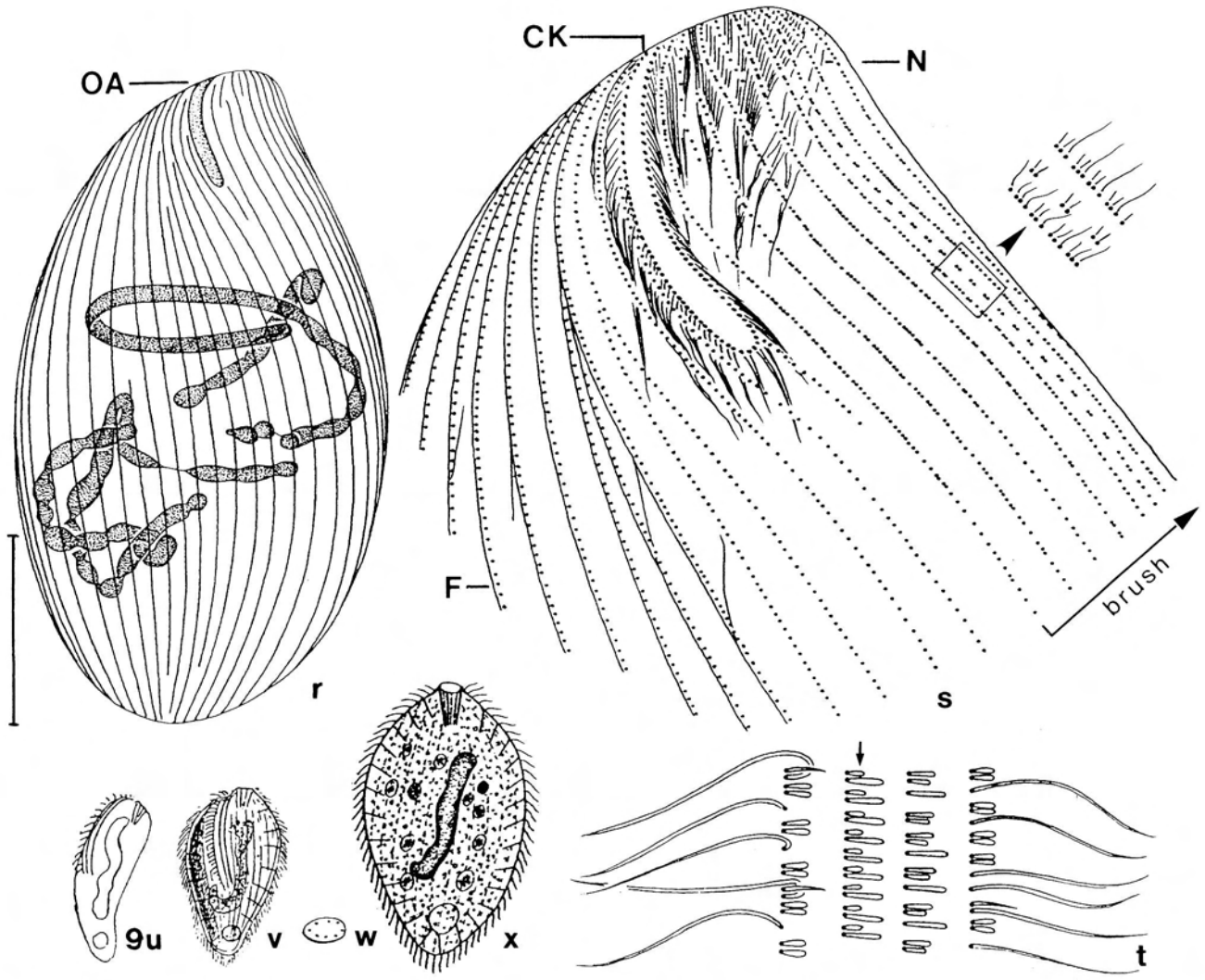
Improved diagnosis: Length in vivo 100–300 μm, slenderly to broadly cylindrical. Macronucleus filiform. Single contractile vacuole in posterior end. Extrusomes about 7 × 0.2 μm, terete, within oral bulge and perpendicularly attached to somatic cortex forming about 20 bipolar stripes. About 40 ciliary rows, half of them differentiated to complicated brosse in anterior half of left and dorsal quarter of cell. Oral bulge key-hole shaped, about 40 μm long.

Nomenclature: KAHL's species must be transferred to *Prorodon* because *Pseudoprorodon* is a junior objective synonym (FOISSNER et al. 1994): *Prorodon armatus* (KAHL, 1930) nov. comb. Unfortunately, then it becomes a junior homonym of *Prorodon armatus* CLAPARÈDE & LACHMANN, 1859. Thus, *P. armatus* (KAHL, 1930) has to be re-named: *Prorodon armatides* nov. nom.

Figs. 8m–q. *Trachelius ovum* after protargol impregnation (m, n, p, q) and in the scanning electron microscope (o). **m:** General view, focused to fossa level. **n:** The macronucleus is invariably dumb-bell shaped. **o:** Dorsal view. Arrow marks brush kinety 3 (cp. Fig. 8q) which extends almost to posterior body end with unpaired, short bristles. **p:** Right lateral view of oral infraciliature. **q:** Infraciliature of anterior dorsal side. B1, 2, 3 = dorsal brush kineties, CK = circumoral kinety, FO = fossa, FV = food vacuole, MA = macronucleus, PB = pharyngeal basket, SK = somatic (perioral) kinety extending along circumoral kinety, V = vacuoles.



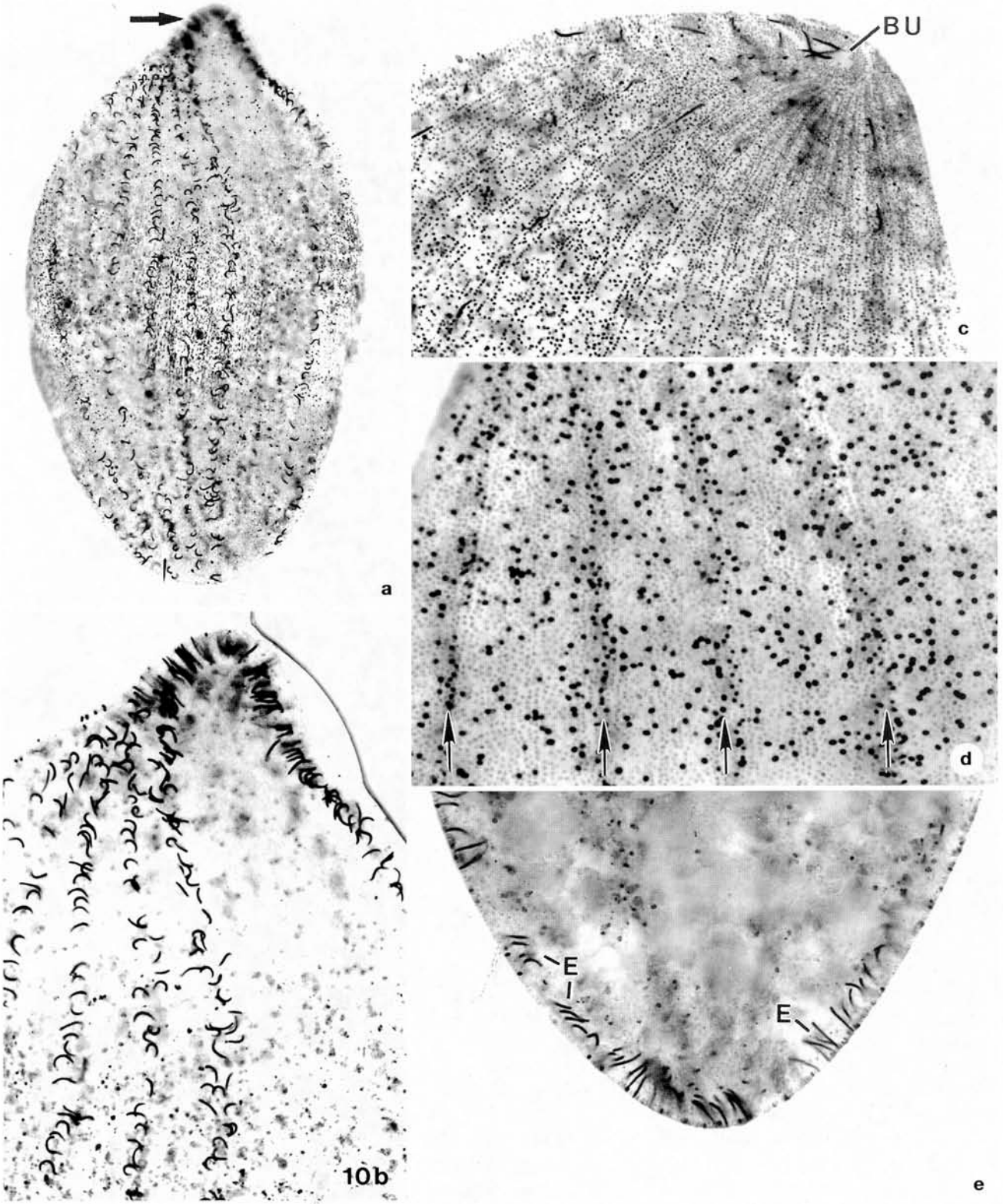
Figs. 9a–q. *Prorodon armatides* from life (a–g, j–o) and after silver carbonate (h), CHATTON-LWOFF silver nitrate (i) and protargol (p, q) impregnation. **a, b:** Left lateral and ventral view of same specimen, video tape records. **c:** Extrusome, 7 µm. **d:** Cortical granule, 0.8 × 0.4 µm. **e, f:** *P. armatides* from CHORIK (1968) and KAHL (1930), 135 µm and 110 µm. **g:** Frontal view of oral bulge. **h, j:** Surface views of cortex showing extrusomes and rows of granules between kineties. **i:** Silverline system. **k:** Optical section of cell periphery. Note thick, gelatinous cortex containing innumerable granules. **l–o:** Shape variants, video tape records. **p, q:** Nuclear apparatus and location of oral apparatus. E = extrusomes, EP = excretory pores of contractile vacuole, FB = fecal ball, G = cortical granules, MA = macronucleus, MI = micronucelus, OA = oral apparatus. Scale bar division 50 µm.



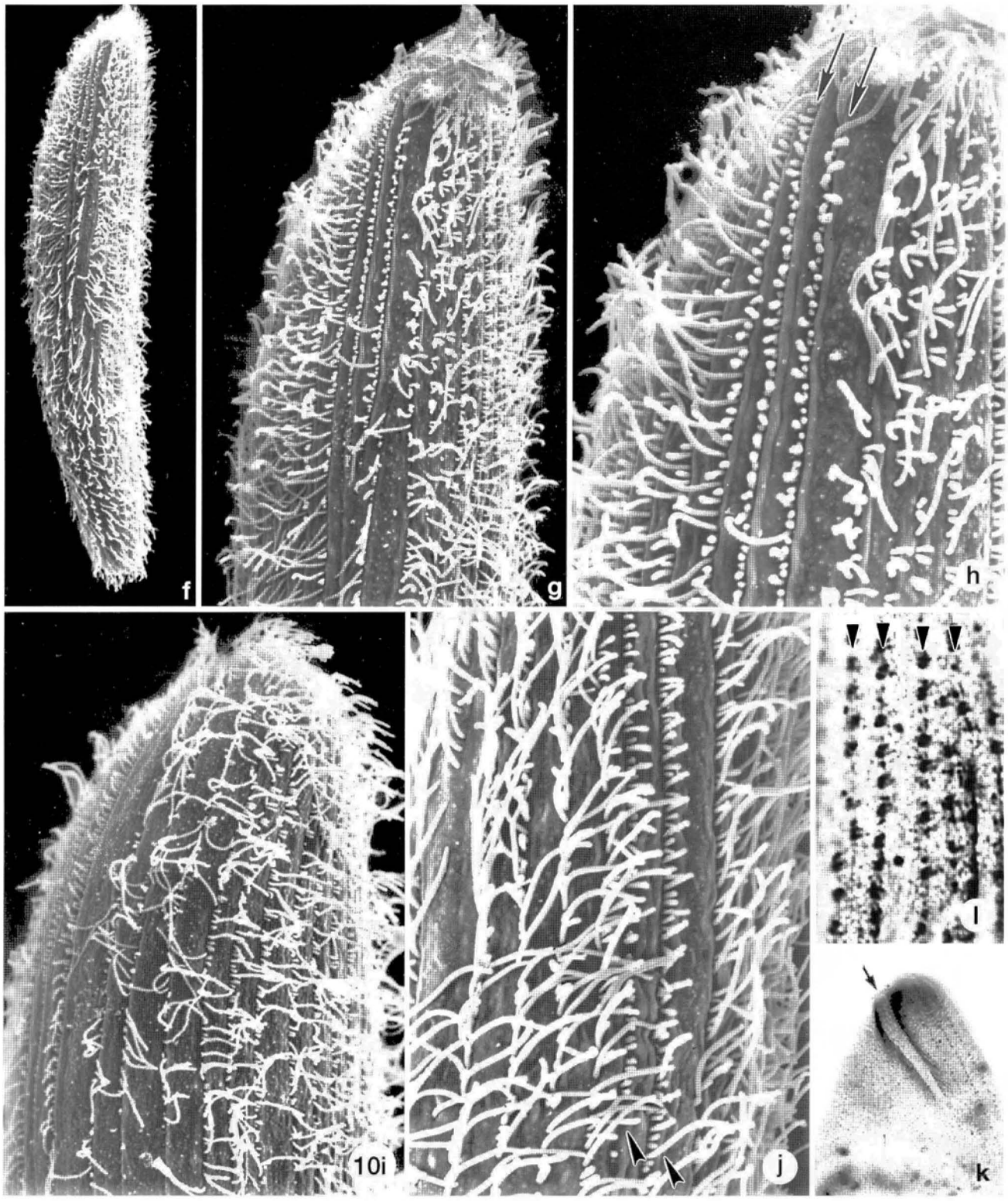
Figs. 9r–x. *Prorodon armatides* (r–t) and *P. sulcatus* (u–x) from life (t–x) and after protargol impregnation (r, s). **r, s:** Somatic and oral infraciliature of ventral side. Figure 9s is a higher magnification of the oral area of the specimen shown in Fig. 9r. **t:** Central portion of brosse. Arrow marks central brosse row; cilia drawn to scale, longest ones about 10 µm. **u–w:** Lateral and dorsal view, and oral opening; length 80 µm (from KAHL, 1930). **x:** General view, length 100 µm (from CHORIK 1968). CK = circumoral kinety, F = fibres, N = nematodesmata, OA = oral apparatus. Scale bar 50 µm.

Type material: No type material of *P. armatides* has been mentioned in the literature. Thus, I declare the population from the Zinnbach stream as neotype and deposit three slides with silver nitrate and protargol-impregnated specimens in the Oberösterreichische Landesmuseum in Linz (LI), Austria. Relevant specimens are marked by a black ink circle on the cover glass.

Description of Bavarian population: Size of field specimens in vivo about 200–300 × 50–80 µm, in three weeks old raw cultures distinctly smaller, viz. 120–200 µm (Table 7). Slenderly to broadly cylindrical, unflattened, prepared specimens sometimes fusiform, thus possibly slightly contracting during fixation. Oral region slightly asymmetric, i.e. straight at dorsal side and obliquely flattened ventrally (Figs. 9a, b, l–p, 10f). Macronucleus long, tortuous, filiform in anterior portion, nodular to moniliform in posterior; fragmented in 2–3 long pieces in about one third of specimens. Many micronuclei, about 5 µm across, along macronucleus (Figs. 9a, p, q). Contractile vacuole in posterior body end, surrounded by small adventitial vacuoles, 2–4 closely spaced excretory pores in centre of posterior pole, where food remnants are defecated (Figs. 9b, p). Cortex about 1.2 µm thick, gelatinous, contains innumerable 0.8 × 0.4 µm sized, bright granules arranged in closely spaced, longitudinal rows (Figs. 9j, k); granules, possibly mucocysts, brown to black stained and partially lacking after silver carbonate impregnation, indicating that they can be extruded (Figs. 9h,



Figs. 10a—e. *Prorodon armatides*, extrusomes and cortical granules after silver carbonate impregnation. **a, b:** The extrusomes form a dense bundle in the oral bulge (arrow) and about 20 narrow stripes extending whole body length. **c:** Arrangement of cortical granules. **d:** Cortical granules at high magnification. Note negatively stained, very small silverline meshes (cp. Fig. 9i). Arrows mark extrusome rows (cp. Fig. 10b). **e:** Posterior body end focused to centre showing extrusomes extending perpendicularly into cytoplasm. BU = oral bulge.



Figs. 10f—l. *Prorodon armatides* in the scanning electron microscope (f—j) and after silver nitrate (l) and protargol (k) impregnation. **f—h:** Dorsal views of same specimen. The two central rows of the dorsal brush (arrows) have short, paired cilia, while in the neighbouring rows normal somatic cilia alternate with paired bristles. **i, j:** Dorsal views of two other specimens. Arrowheads mark central rows of dorsal brush. **k:** Anterior end with oral opening (arrow) lined by nematodesmata. **l:** The silverline system consists of very narrow meshes. Arrowheads mark somatic kineties.

Table 7. Morphometric characteristics from *Prorodon armatides*[1]).

Character	Method[2])	$\bar{x}$	M	SD	$SD_{\bar{x}}$	CV	Min	Max	n
Body, length[3])	P	196.8	200.9	30.4	8.1	15.4	145	250	14
Body, width[3])	P	73.8	71.0	13.5	3.6	18.3	57	100	14
Distance anterior end to proximal end of circumoral kinety[3])	P	36.2	37.5	6.1	1.6	16.8	30	45	14
Macronucleus, width[3])	P	6.1	6.0	0.8	0.2	12.6	5	7	14
Body, length[4])	CL	137.7	135.0	16.6	4.4	12.0	120	180	14
Body, width[4])	CL	47.2	47.0	6.1	1.6	12.9	36	57	14
Somatic kineties, number[4])	CL	38.4	39.5	3.0	0.8	7.8	34	43	14
Excretory pores, number[4])	CL	2.4	2.0	–	–	–	2	4	14

[1]) Preparations were rather poor, morphometry is thus incomplete. Measurements in μm. CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of specimens investigated, SD – standard deviation, $SD_{\bar{x}}$ – standard deviation of arithmetic mean, $\bar{x}$ – arithmetic mean.
[2]) P – protargol impregnation, CL – CHATTON-LWOFF silver nitrate impregnation.
[3]) Specimens from field.
[4]) Specimens from about 3 weeks old raw culture.

10a–d). Oral and somatic extrusomes, very likely toxicysts, of same size and shape, terete, very fine, about 7×0.2 μm, arranged in conspicuous circumpharyngeal bundle and in about 20 narrow stripes extending whole body length, extend perpendicularly into cytoplasm, become black and curved after silver carbonate impregnation, decreasing in length to 4–5 μm (Figs. 9a–c, h, k, 10a, b, e); protargol does not stain attached extrusomes but many similar structures, possibly juvenile and/or developing extrusomes scattered throughout cell. Cytoplasm colourless, oral area brownish at low magnification (≤ X 100) due to accumulation of 0.2 μm sized, bright granules (Figs. 9a, b); field specimens usually contain many 4–20 μm sized globular and irregular fat droplets and one or two curved inclusions up to 100 μm long (Figs. 9a, k). Moves slowly and like a turbellarian worm.

Silverline system reticulate throughout, even in brosse region, meshes about 0.5 μm across, forming more or less distinct longitudinal rows (Figs. 9i, 10l); occasionally negatively stained by silver carbonate (Fig. 10d).

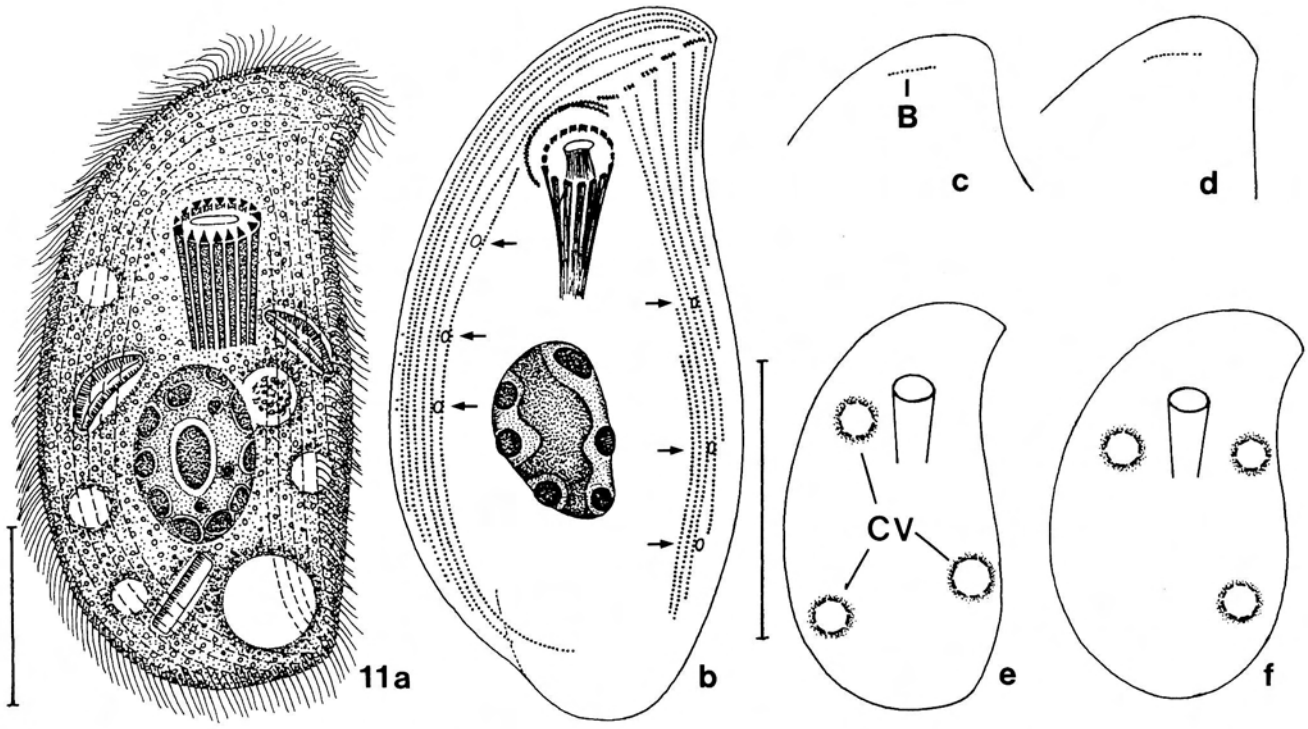
Ciliary rows bipolar, lateral ones abut at steep angle to circumoral kinety, some rows shortened anteriorly and/or posteriorly at irregular interval, composed of monokinetids, except in anterior left lateral and dorsal quarter where about 20 rows differentiate highly complex brosse. Right of ciliary rows sharply impregnated fibre having oblique, irregularly distributed left and right lateral branches (Figs. 9r, s). No caudal cilia. Brosse with one central row consisting of paired basal bodies having about 0.7 μm (anterior cilium) to 1.5 μm (posterior cilium) long, distally slightly inflated bristles. Left of central row single kinety composed of dikinetids (anterior cilium about 1.2 μm long, posterior about 0.9 μm) rather regularly alternating with monokinetids having about 1.5 μm long bristles. Right and left of these two rows about 10 kineties each composed of dikinetids (cilia about 1 μm long and distally slightly inflated) rather regularly alternating with monokinetids having normal somatic cilia about 10 μm long (Figs. 9s, t, 10f–j).

Oral apparatus on obliquely flattened anterior end of cell, oral bulge and circumoral kinety key-hole shaped, about 40 μm long (Figs. 9a, b, g, p, q); oral bulge distinct only near dorsal side of cell, ventrally gradually flattening and merging into body proper; circumoral kinety, possibly composed of dikinetids, ciliated, give rise to distinct bundles of nematodesmata (Figs. 9p–s, 10k).

Occurrence and ecology: KAHL (1930) discovered *P. armatides* near Hamburg (Germany) among *Utricularia* leaves, i.e. very likely in a clean pond. Later, CHORIK (1968) recorded it from ponds in Moldavia. I found *P. armatides* together with many other ciliates in the ferric mud deposited in some lentic sites of the heavily acidic Zinnbach stream (Tabs. 2, 3). It reproduced slowly for some weeks in culture dishes containing part of the natural biocoenosis whose development was stimulated by adding some crushed wheat grains.

Identification: My population matches the original description in body and macronucleus shape and the highly characteristic arrangement of the extrusomes (Figs. 9a, f). Thus, the identification is very likely correct. The only difference concerns size, viz. 100–130 μm according to KAHL (1930) and CHORIK (1968), up to 300 μm in my population. However, my specimens showed great size variation (Table 7), indicating that it is an ambiguous character insufficient for separating the two populations at species level.

Pseudoprorodon sulcatus KAHL, 1927 might be an (older) synonym of *P. armatides*. It differs from that species in body size (length 40–70 μm), length of extrusomes (12 μm) and blunter body shape (Figs. 9u–x).



Figs. 11a–f. *Pseudochilodonopsis polyvacuolata* from life (a, e, f) and after protargol impregnation (b–d). **a:** Ventral view of French type population (from FOISSNER & DIDIER 1981). **b–d:** Infraciliature of ventral and dorsal side of German (Röslau stream) population. Arrows mark excretory pore of contractile vacuoles. **e:** Arrangement of contractile vacuoles in a specimen from the Amper river in Germany. **f:** Arrangement of contractile vacuoles in a specimen from the Enns river in Austria. B = dorsal brush, CV = contractile vacuoles. Scale bar 20 µm.

Order Cyrtophorida FAURÉ-FREMIET in CORLISS, 1956

- *Pseudochilodonopsis polyvacuolata* FOISSNER & DIDIER, 1981 (Figs. 11a–f)

1981 *Pseudochilodonopsis polyvacuolata* FOISSNER & DIDIER, Annls Stn limnol. Besse, 15: 258.

Material: A voucher slide with one protargol-impregnated specimen has been deposited in the Oberösterreichische Landesmuseum in Linz (LI), Austria.

Supplementary observations: *P. polyvacuolata* differs from its congeners by the increased number of contractile vacuoles (3–6 vs. 2), preoral kineties (5–6 vs. 4), and somatic kineties in the right ciliary field (6–8 vs. 5). Since the original description, I have found several small populations of this species in clean rivers of Austria and Germany. A few specimens from the Röslau stream were especially well impregnated, even showing the pore of the contractile vacuoles (Fig. 11b). They match the type population very well, but have fewer (10–15 vs. 20) cilia in the dorsal brush. The number of contractile vacuoles is highly variable within and between populations, but there are at least three (Figs. 11b, e, f). *Pseudochilodonopsis polyvacuolata* occurs also in soil. A population from the litter of a deciduous forest in lower Austria (Baumgarten; see FOISSNER et al. 1985) had the same number and arrangement of the contractile vacuoles as the specimens from the Röslau stream (Fig. 11b).

- *Gastronauta clatratus* DEROUX, 1976 (Figs. 12a–c, Table 8)

1976 *Gastronauta clatratus* DEROUX, Protistologica, 12: 494.

1982 *Gastronauta clatratus* DEROUX – JUTRCZENKI, Decheniana, 135: 107.

1986 *Gastronauta clatratus* DEROUX, 1976 – WILBERT, Acta Protozool., 25: 382.

1989 *Gastronauta clatratus* DEROUX, 1976 – SONG & WILBERT, Lauterbornia, 3: 97.

Material: Two voucher slides with protargol-impregnated specimens from the Illach river have been deposited in the Oberösterreichische Landesmuseum in Linz (LI), Austria.

Supplementary observations: The taxonomic status of this species is not yet clear because DEROUX probably overlooked the posterior dorsal brush 3 (JUTRCZENKI 1982) and the type population probably has 4 contractile vacuoles (DEROUX, pers. comm.). Furthermore, the type

Table 8. Morphometric characteristics from *Gastronauta clatratus*[1]).

Character	$\bar{x}$	M	SD	$SD_{\bar{x}}$	CV	Min	Max	n
Body, length	59.2	64.0	7.6	2.0	12.8	47	64	14
Body, width	29.6	30.0	3.4	0.9	11.5	23	34	14
Anterior end to circumoral kinety, distance	19.1	20.0	1.3	0.3	7.0	17	21	14
Anterior end to macronucleus, distance	31.5	32.0	3.2	0.9	10.3	26	36	14
Anterior end to brush 1, distance	4.2	4.0	0.6	0.1	13.7	3	5	14
Anterior end to brush 2, distance	12.7	13.0	1.9	0.5	15.6	10	15	14
Anterior end to brush 3, distance	50.5	51.0	6.7	1.8	13.4	41	60	14
Macronuclei, number	1.0	1.0	0.0	0.0	0.0	0	0	14
Macronucleus, length	16.6	17.0	2.5	0.7	15.2	13	21	14
Macronucleus, width	11.2	11.0	2.1	0.6	18.2	8	15	14
Micronuclei, number	1.0	1.0	0.0	0.0	0.0	1	1	14
Micronucleus, length	3.6	4.0	0.6	0.2	16.5	3	5	14
Micronucleus, width	3.2	3.0	0.3	0.1	10.0	3	4	14
Contractile vacuole pores, number	2.0	2.0	0.0	0.0	0.0	2	2	14
Somatic postoral kineties, number	19.9	20.0	1.0	0.3	5.0	19	23	14
Preoral somatic kineties, total number	11.7	12.0	0.6	0.2	5.2	11	13	14
Shortened preoral kineties, number	8.7	9.0	0.6	0.2	7.0	8	10	14
Preoral vertical kinety fragments, number	3.1	3.0	–	–	–	3	4	14
Circumoral kineties, number	1.0	1.0	0.0	0.0	0.0	1	1	14
Oral slit, length	19.7	20.0	1.3	0.3	6.4	17	22	14
Oral slit, width	2.8	3.0	0.5	0.1	19.2	2	4	14
Dorsal brush, number of groups	3.0	3.0	0.0	0.0	0.0	3	3	14
Dorsal brush 1, number of kinetids	8.5	8.0	1.1	0.3	12.5	7	11	14
Dorsal brush 2, number of kinetids	9.3	9.0	1.6	0.4	17.2	7	12	13
Dorsal brush 3, number of kinetids	8.2	8.0	0.9	0.3	11.3	7	10	13

[1]) Data based on protargol-impregnated and mounted morphostatic specimens from field. Measurements in μm. CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of specimens investigated, SD – standard deviation, $SD_{\bar{x}}$ – standard deviation of arithmetic mean, $\bar{x}$ – arithmetic mean.

population obviously has a brush kinety at the anterior left margin (DEROUX 1976, Figs. 8a–c), which is lacking not only in my specimens but also in those observed by JUTRCZENKI (1982), WILBERT (1986) and SONG & WILBERT (1989). WILBERT (1986) very likely figured brush kinety 2 on the wrong margin. Thus, a reinvestigation of DEROUX's and WILBERT's type slides is necessary. In the meantime, I consider JUTRCZENKI (1982) as authoritative redescription.

A complete redescription of *G. clatratus* is not necessary because my observations largely agree with those of DEROUX (1976), WILBERT (1986), SONG & WILBERT (1989), and especially JUTRCZENKI (1982). Thus, I provide only some accurate figures (Figs. 12a–c) and a detailed morphometry from the population found in the Illach river (Table 8). All other authors did not provide morphometrics. Accordingly, a detailed comparison is impossible. However, the number of somatic and preoral kineties of my population is very near to those figured by the authors cited in the synonymy list. Only JUTRCZENKI (1982) figured the small patch of 4 basal bodies between the uppermost preoral, vertical kinety fragment and the end of the rightmost somatic kineties (Figs. 12a, c, arrows).

Family Holophryidae PERTY, 1852

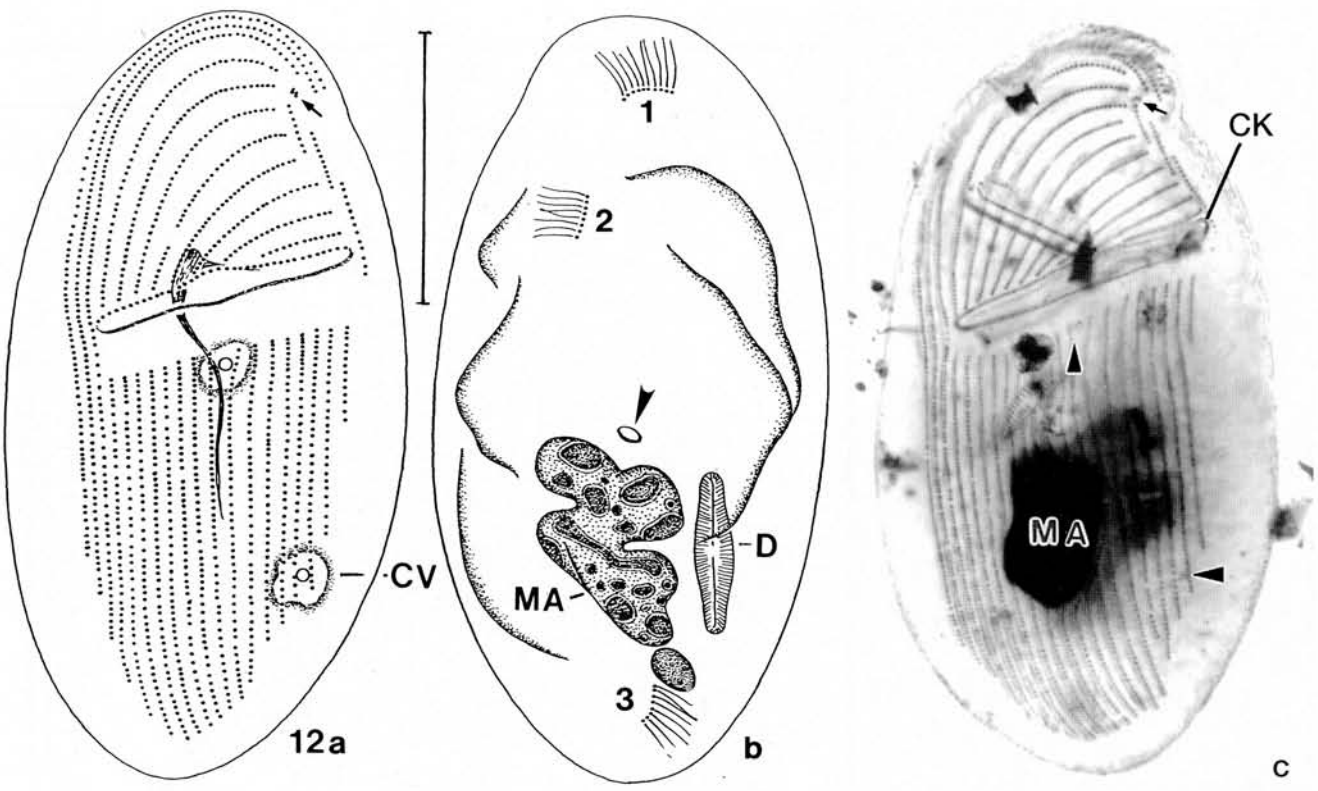
- *Holophrya seyrli* nov. spec. (Figs. 13a–z, 14a–g, Table 9)

Diagnosis: In vivo 70–120 × 40–70 μm, prolate ellipsoidal. Macronucleus slightly ellipsoidal, in theronts with large, central nucleolus. Extrusomes about 10 × 0.3 μm, terete, attached to pellicle, extend into cytoplasm. 43 ciliary rows and about 30 pharyngeal rods on average. Brosse enklitoloph-dexiotrop, consists of 3 rows extending in anterior fifth of cell.

Type location: Zinnbach stream in Bavaria (Germany), E12° N50°.

Dedication: I dedicate this new species to Mr FRITZ SEYRL, librarian at the Studienbibliothek in Linz, as a small token of appreciation for his invaluable help over many years in locating and procuring difficult literature.

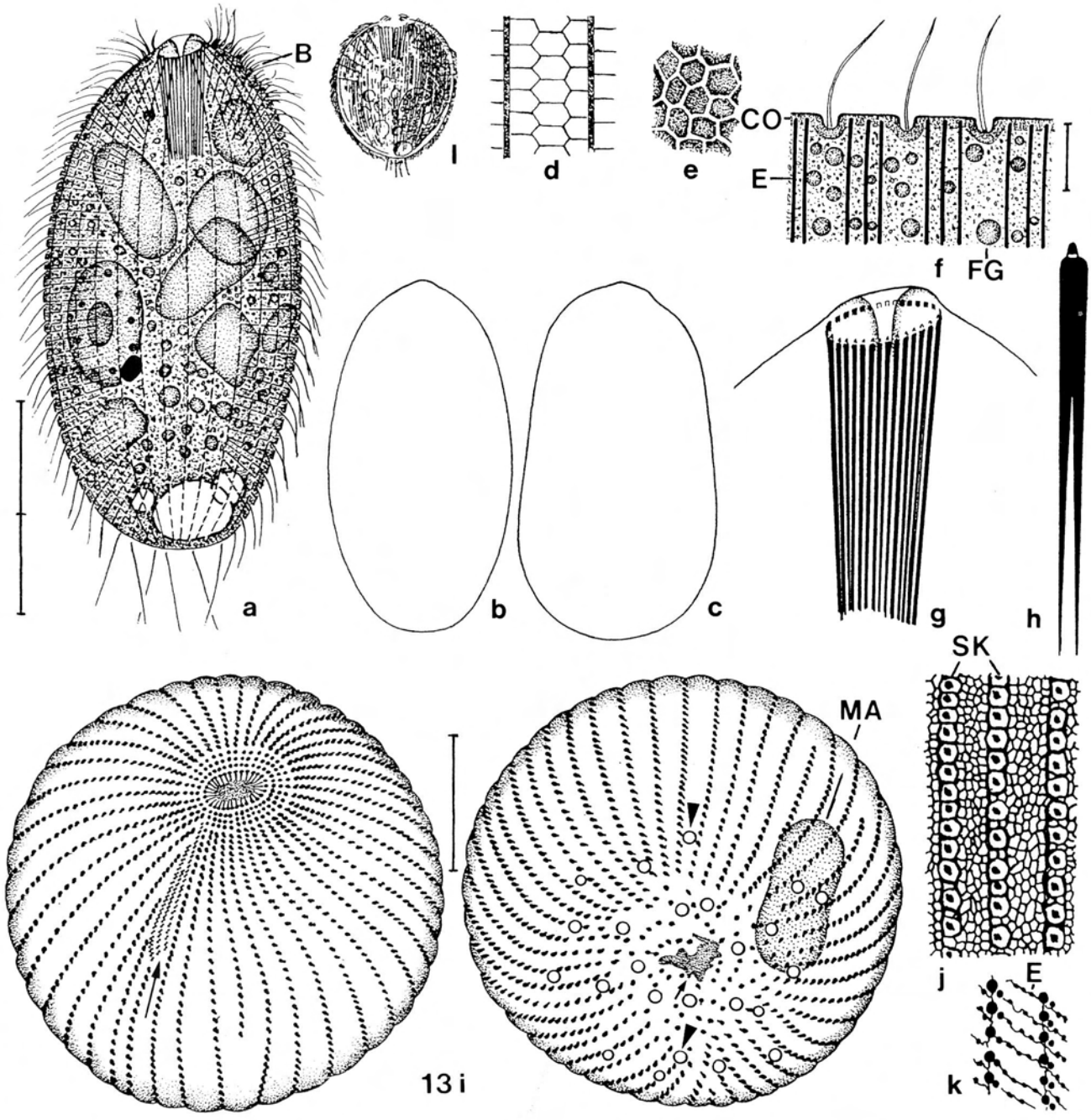
Type specimens: One holotype and one syntype as two slides of silver nitrate (CHATTON-LWOFF technique)-impregnated cells have been deposited in the Oberösterreichische Landesmuseum in Linz (LI), Austria. Relevant specimens are marked by a black ink circle on the cover glass.



Figs. 12a–c. *Gastronauta clatratus* after protargol impregnation. **a, c:** Infraciliature of ventral side. Arrows mark patch of 4 basal bodies between uppermost vertical kinety and anterior end of rightmost somatic kineties. Arrowheads in Fig. 12c mark excretory pore of contractile vacuoles. **b:** Infraciliature of dorsal side. Numbers designate dorsal brush kineties. Arrowhead marks pore of unknown function. CV = contractile vacuole, CK = circumoral kinety, D = ingested diatom, MA = macronucleus. Scale bar 20 μm.

Description: Usually about 80×60 μm, acontractile. Prolate ellipsoidal, rarely slightly oviform or pyriform, anterior region inconspicuously flattened, both ends broadly rounded, anterior pole with minute papilla at pharyngeal aperture (Figs. 13a–c, n, o, r). Macronucleus in mid-body, in vivo about $20-25 \times 15-20$ μm, contains large central nucleolus and many minute nucleoli in theronts; micronucleus about 4×3 μm, attached to macronucleus (Figs. 13a, i, p). Contractile vacuole in posterior end, surrounded by some small adventitial vacuoles, many excretory pores irregularly distributed in pole area; cytopyge in centre of posterior pole, appears as lobbed patch in silver nitrate-impregnated specimens (Figs. 13a, i). Cortex about 1 μm thick, compact, distinctly furrowed by ciliary rows (Fig. 13f, 14a), with hexagonal alveoli (Fig. 13d) and complicated, uninterrupted microfibrillar network sometimes clearly impregnated with silver nitrate (Figs. 13k, 14e, f) and silver carbonate (Figs. 13v, 14g). Extrusomes terete, about 10×0.3 μm, i.e. long but very fine and thus easily overlooked, slightly curved, loosely arranged between ciliary rows, extend perpendicularly into cytoplasm, do not stain with methylgreen-pyronin but occasionally with silver carbonate (Figs. 13a, f, q, 14b); mucocysts neither recognizable in vivo nor after methylgreen-pyronin and silver staining. Cytoplasm colourless, trophonts dark at low magnification ($\leq$ X 100) due to many food vacuoles and innumerable 3–7 μm sized fat globules (Figs. 13a, f, n, o). If small and medium-sized ciliates (e.g. *Colpidium colpoda*) and wheat starch were offered as food concomitantly, the latter was preferred. Moves slowly by rotation about main body axis. Divides in cysts.

Cilia in vivo about 8 μm long, originate from deep pits, arranged in bipolar rows left of minute subpellicular ridge recognizable in vivo (Figs. 13f, i, r–t, 14c) and, after demembranation, also in scanning electron microscope (Fig. 14d). Each ciliary row commences with three pairs of ciliated basal bodies (dikinetids) having single parasomal sac at right producing distinct triads; dikinetidal girdle usually rather distinctly set off from somatic kineties by small gap, forms conspicuous bunch of cilia around oral aperture (Figs. 13i, m, r, t, w, y); some ciliary rows shortened anteriorly and/or posteriorly at irregular interval, 6–7 rows abut at right side of brosse in steep angles, distance slightly decreased between first abutting kinety and kinety beneath brosse (Figs. 13i, m, t, x). Ciliature loosen and irregular in posterior pole region where some inconspicuous, 15–20 μm long caudal cilia originate



Figs. 13a–l. *Holophrya seyrli* from life (a–d, f–h), after methylgreen-pyronin staining (e) and CHATTON-LWOFF silver nitrate impregnation (i–k). **a, b:** Typical specimen from lateral and dorsal, video tape records. The cytoplasm is packed with starch grains and small fat globules. **c:** Pyriform shape variant, video tape record. **d:** Surface view of cortex showing pellicular alveoli and ridges right of ciliary rows. **e:** Negatively stained microfibrillar network (cp. Fig. 13j). **f:** Transverse view showing long, fine extrusomes anchored in thick, compact cortex. **g:** The pharyngeal basket is slightly retracted in non-feeding specimens. **f:** Pharyngeal rod at high magnification. **i:** Oblique anterior and posterior polar view of somatic and oral infraciliature. Arrows mark brosse, respectively, cytopyge; arrowheads mark some of the many pores of the contractile vacuole. For details see Figs. 13m, w, x. **j:** Microfibrillar network. **k:** Silverline system (very likely only partially impregnated). **l:** *Prorodon armatus*, length 100 µm (from KAHL 1930). B = brosse, CO = cortex, E = extrusomes, FG = fat globules, MA = macronucleus, SK = somatic kineties. Scale bar division 5 µm (Fig. 13f) and 20 µm (Figs. 13a, i).

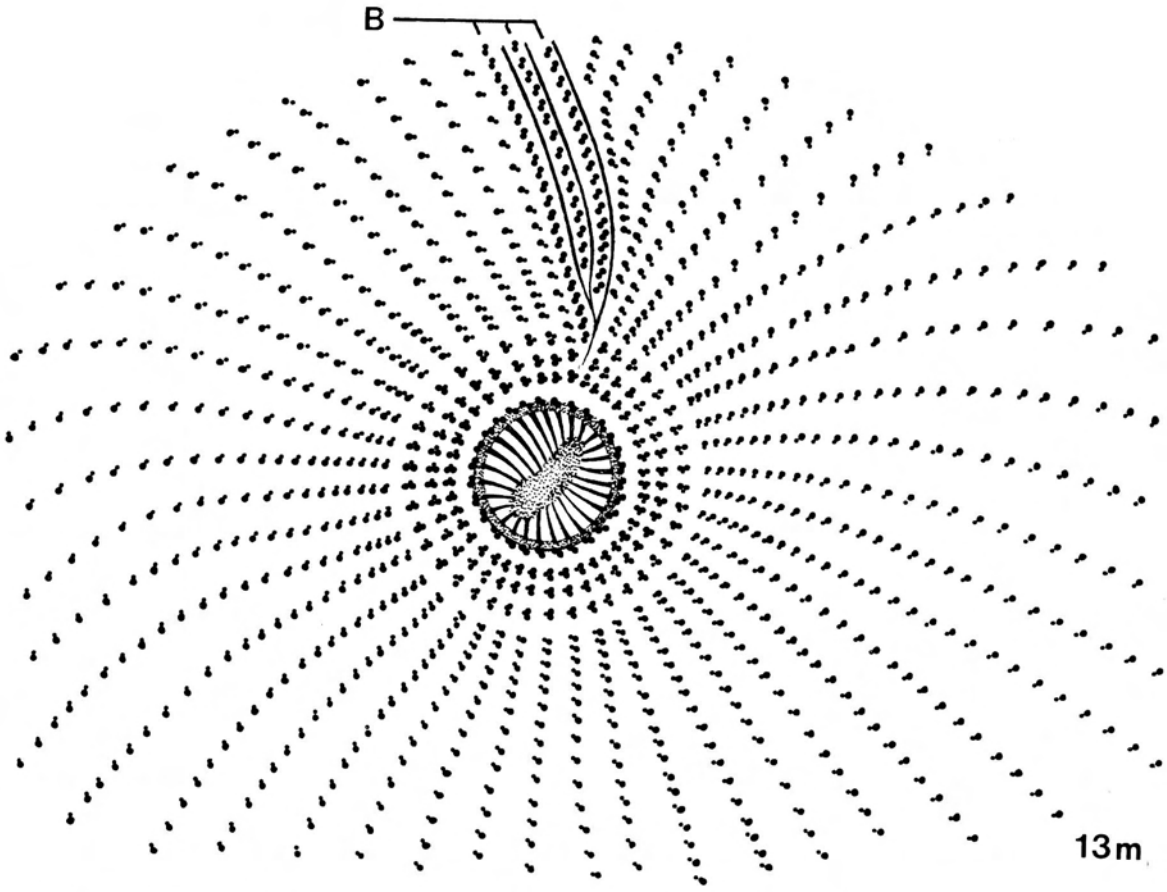


Fig. 13m. *Holophrya seyrli*, anterior polar view. Combined drawing from scanning electron microscopic observations and silver stained specimens. See text and Fig. 13w for explanation. B = brosse.

(Figs. 13i, s). One parasomal sac right of each basal body, sacs larger than basal bodies in silver nitrate preparations, smaller after silver carbonate impregnation.

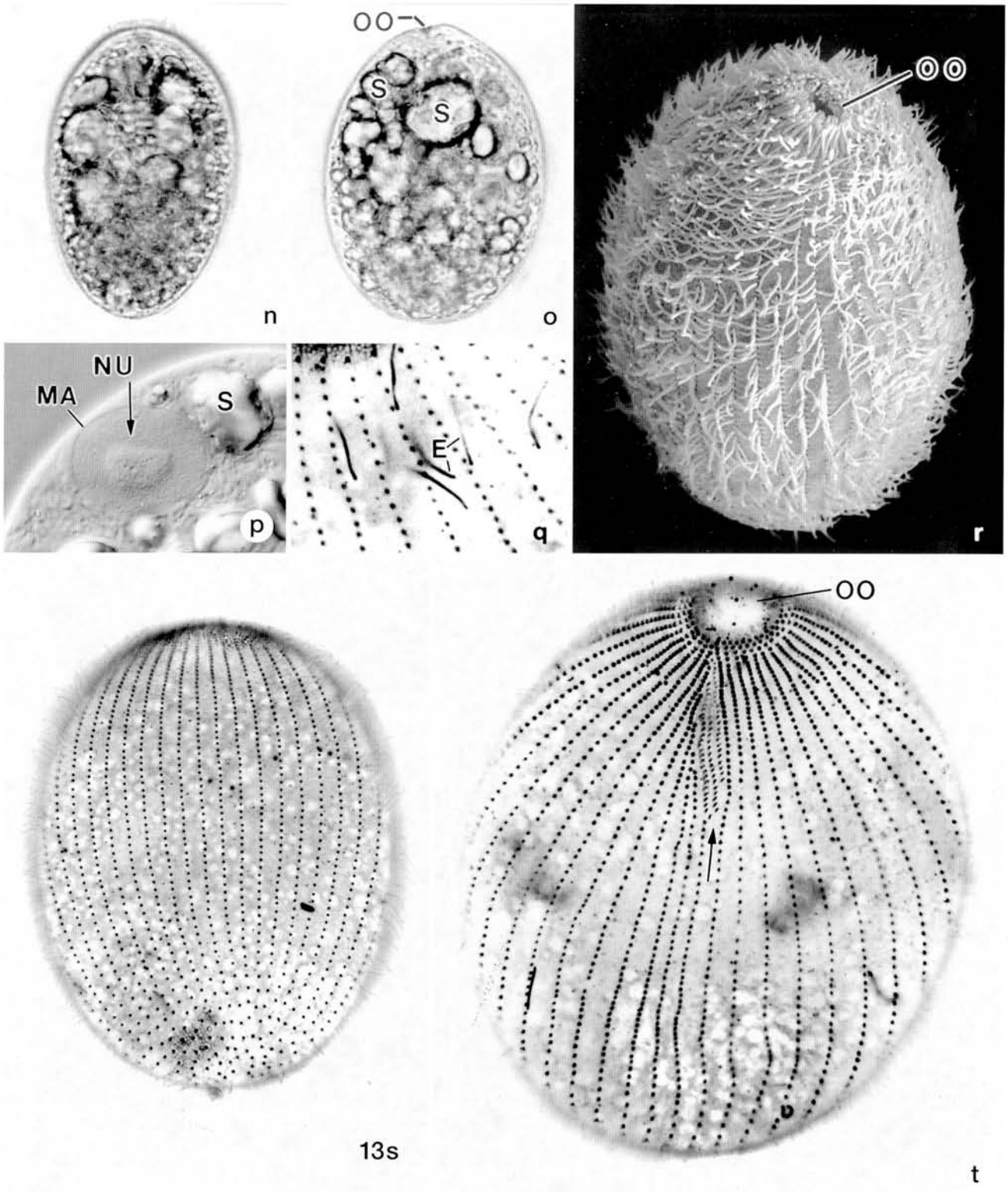
Oral aperture circular to slightly elliptical, obliquely truncate and slightly out of anterior pole centre, inner margin surrounded by about 1 µm thick microtubule ribbon sometimes deeply stained with silver carbonate (Figs. 13a, c, i, m, o, w). Pharyngeal basket slightly retracted in non-feeding specimens, lined by distinctly striated membrane, consists of about 30 firm rods originating from obliquely orientated circumoral dikinetids; rods with small apical tooth and bifurcate posterior half (Figs. 13g, h, m, u, w). Brosse (adoral organelles) enklitoloph-dexiotrop, consists of 3 oblique kineties extending in anterior fifth of cell; kineties in rather deep grooves separated by distinct ridges from each other and from neighbouring somatic kineties, consist of narrowly spaced, oblique dikinetids which very likely have only one basal body ciliated with an about 3 µm long bristle, right and middle kinety slightly shortened anteriorly, left row posteriorly (Figs. 13a, i, t, v, x, z).

Ecology: *H. seyrli* occurred together with many other ciliates in the ferric mud deposited in some lentic sites of the heavily acidic Zinnbach stream (Table 3). It reproduced in culture dishes containing part of the natural biocoenosis, whose development was stimulated by adding some crushed wheat grains. As mentioned above, *H. seyrli* preferred wheat starch.

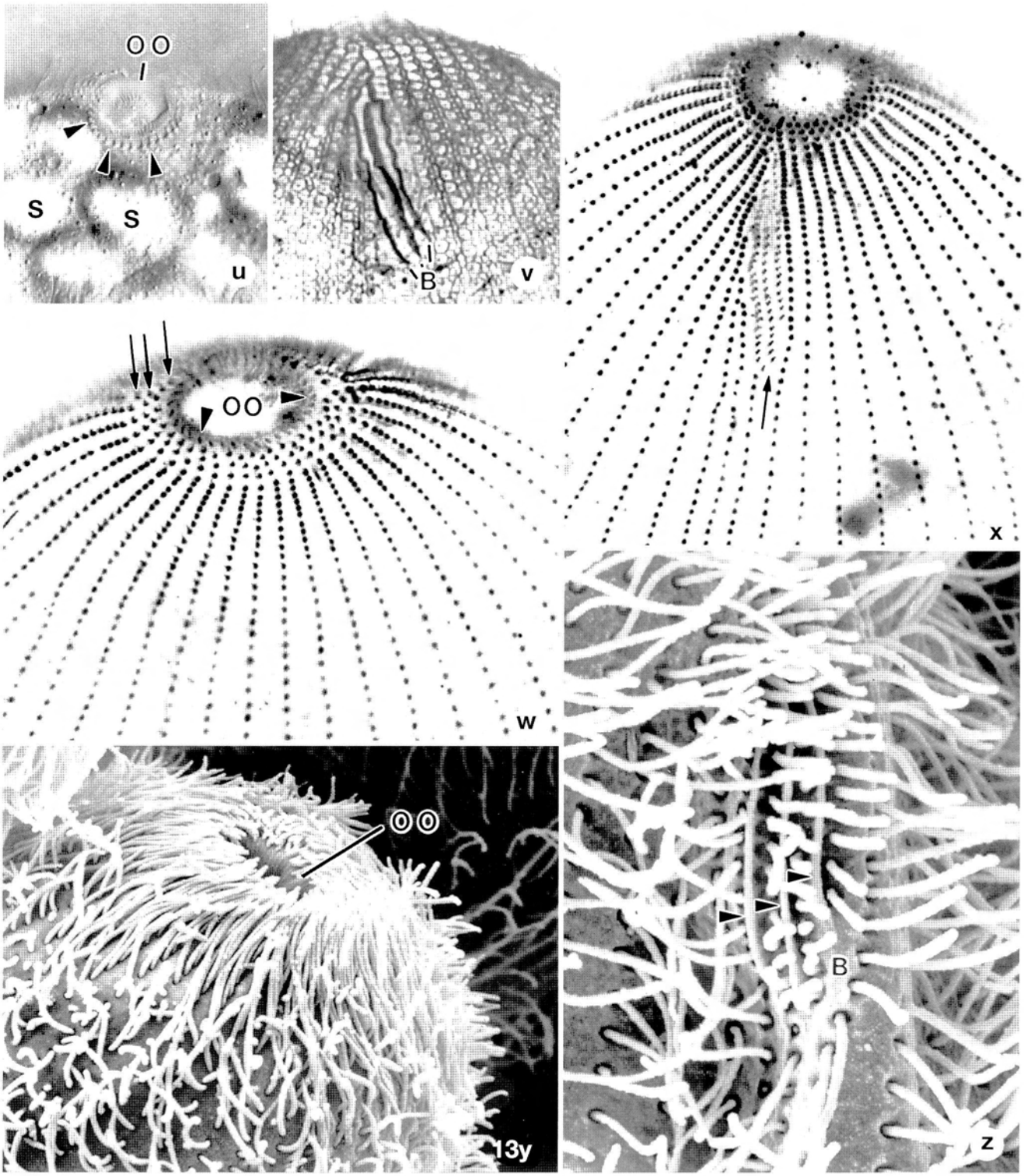
Comparison with related species: *Holophrya* and *Prorodon* have a complicated nomenclatural history disentangled by FOISSNER et al. (1994). Formerly, *H. seyrli* would have been classified with *Prorodon*.

Many *Holophrya* species have been described. They can be classified into several groups, depending on brosse structure (HILLER & BARDELE 1988), body size, and number of ciliary rows. *Holophrya seyrli* has an enklitoloph-dexiotrop brosse, is smaller than 150 µm, and has less than 60 ciliary rows. Only species with similar characters will be compared.

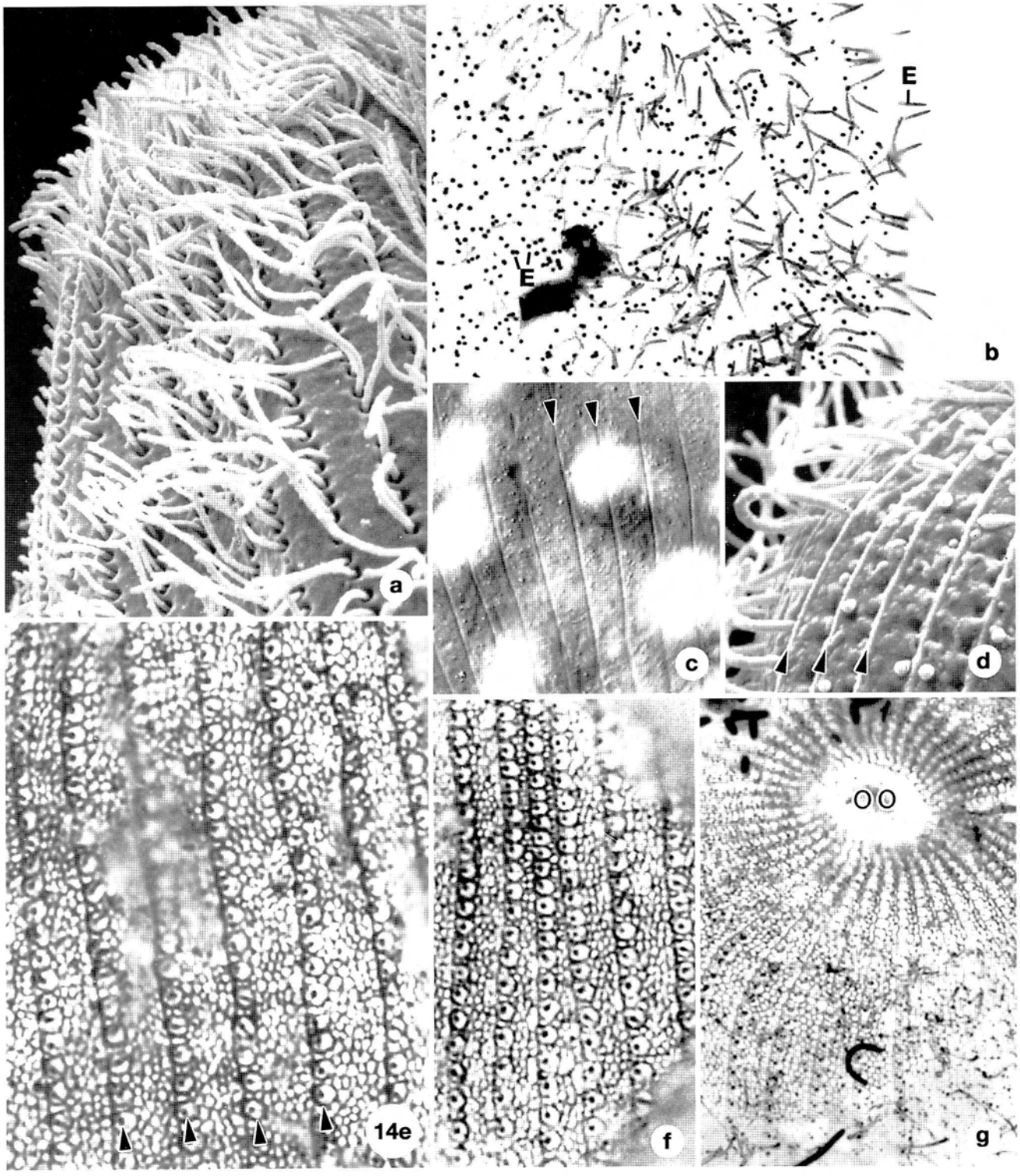
Holophrya seyrli is most similar to *H. discolor* EHRENBERG and its synonyms (FOISSNER 1983, FOISSNER et al. 1994). The sole significant difference concerns the extrusomes which are 10 µm long, fine rods in *H. seyrli* contrasting the 2–3 µm long, fusiform structures (possibly mucocysts) found in *H. discolor* (FOISSNER et al. 1994).



Figs. 13n–t. *Holophrya seyrli* from life (n–p), in the scanning electron microscope (r), and after silver carbonate impregnation (q, s, t). **n, o, r:** Well-fed specimens containing many starch grains. **p:** Macronucleus. **q:** Extrusomes and somatic infraciliature. **s, t:** Somatic and oral infraciliature of dorsal and ventral side. Arrow marks brosse. E = extrusomes, MA = macronucleus, NU = nucleolus, OO = oral opening, S = starch grains.



Figs. 13u–z. *Holophrya seyrli* from life (u), after silver carbonate impregnation (v–x), and in the scanning electron microscope (y, z). **u, y:** Anterior end showing pharyngeal opening surrounded by very narrowly spaced cilia. Arrowheads mark pharyngeal rods. **v:** Anterior ventral region showing microfibrillar network and brosse ridges. **w:** Anterior polar view showing three circles (arrows) of specialized basal bodies (dikinetids) around pharyngeal opening. Arrowheads mark pharyngeal rods at outer margin of a darkly stained microfibrillar ring (cp. Fig. 13m). **x, z:** Anterior ventral views showing brosse ridges (arrowheads; cp. Fig. 13v) and brosse (arrow) composed of closely spaced, oblique dikinetids. Only one of the basal bodies of the dikinetids has a short bristle. B = brosse, OO = pharyngeal opening, S = starch grains.



Figs. 14a–g. *Holophrya seyrli* from life (c), after silver carbonate (b, g) and CHATTON-LWOFF silver nitrate (e, f) impregnation, and in the scanning electron microscope (a, d). **a:** Somatic cortex showing cilia emerging from deep pits. **b:** Resting and partially discharged extrusomes. **c, d:** Flat ridges (arrowheads) extend right of the ciliary rows. **e–g:** The microfibrillar network is continuous over the cell and very similar after silver nitrate (e, f) and silver carbonate (g) impregnation. Arrowheads mark ciliary rows, individual basal bodies are surrounded by a ring-shaped mesh of the microfibrillar network. E = extrusomes, OO = oral opening.

Table 9. Morphometric characteristics from *Holophrya seyrli*[1]).

Character	$\bar{x}$	M	SD	$SD_{\bar{x}}$	CV	Min	Max	n
Body, length	85.3	84	14.0	3.7	16.4	66	108	14
Body, width	59.6	61	9.4	2.5	15.8	44	75	14
Anterior end to macronucleus, distance	30.9	29	11.9	3.2	38.5	12	55	14
Anterior end to brosse end, distance	17.4	17	4.0	1.1	22.9	12	25	14
Pharyngeal basket, length	25.2	25	4.2	1.1	16.6	20	30	14
Pharyngeal basket, width	8.6	9	1.1	0.3	12.7	7	10	14
Macronucleus, length	15.7	16	3.5	0.9	22.1	10	22	14
Macronucleus, width	13.6	13	3.1	0.8	22.5	10	19	14
Micronucleus, length	3.6	4	0.5	0.1	13.6	3	4	14
Micronucleus, width	3.4	3	0.5	0.1	14.8	3	4	14
Macronuclei, number	1.0	1	0.0	0.0	0.0	1	1	14
Micronuclei, number	1.0	1	0.0	0.0	0.0	1	1	14
Somatic kineties, number	43.0	43	2.2	0.6	5.2	39	46	14
Kinetids in a dorsal kinety, number	52.9	53	11.7	3.1	22.2	35	75	14
Brosse kineties, number	3.0	3	0.0	0.0	0.0	3	3	14

[1]) Data based on CHATTON-LWOFF silver nitrate-impregnated and mounted morphostatic specimens from well-fed cultures. Measurements in µm. CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of specimens investigated, SD – standard deviation, $SD_{\bar{x}}$ – standard deviation of arithmetic mean, $\bar{x}$ – arithmetic mean.

Holophrya ovum EHRENBERG, type of genus, matches *H. seyrli* in size and shape of the extrusomes but possesses symbiotic green algae, a distinctly higher number of ciliary rows (52–80, $\bar{x}$ 66 vs. 39–46, $\bar{x}$ 43), and mucocysts (FOISSNER et al. 1994).

Prorodon armatus CLAPARÈDE & LACHMANN, 1859 matches *H. seyrli* in size (about 100 µm) and extrusomes: „Ces trichocystes sont fort longs dans la région polaire antérieure, mais ils vont en diminuant rapidement de longueur à mesure qu'on s'éloigne du pôle". However, CLAPARÈDE & LACHMANN's figure shows that the trichocysts are only about 4 µm long and rather thick. Furthermore, *P. armatus* has a large, prolate ellipsoidal pharyngeal opening, dissimilar to that found in *H. seyrli*. The population provisionally identified as *P. armatus* by KAHL (1930) is more similar to my specimens, although I have never seen globular cells like those drawn by KAHL (Fig. 131).

Prorodon nucleolatus PENARD, 1930 in KAHL, 1930 has, like *H. seyrli*, long, fine extrusomes which, however, are bundled. Furthermore, *P. nucleolatus* is slightly larger than *H. seyrli* (120–160 µm vs. 70–120 µm) and has fusiform mucocysts and 135 ciliary rows (DRAGESCO 1966).

Prorodon trichocystus DRAGESCO has, like *H. seyrli*, long, fine extrusomes. However, it is slightly larger (120–160 µm vs. 70–120 µm) and has distinct, fusiform mucocysts and about 70 ciliary rows (DRAGESCO 1960).

Note added in proof: Four supposed *H. discolor* populations studied since then had, like *H. seyrli*, long, fine body extrusomes, suggesting that *H. seyrli* is either very common or synonymous with *H. discolor*.

Family Plagiocampidae KAHL, 1926

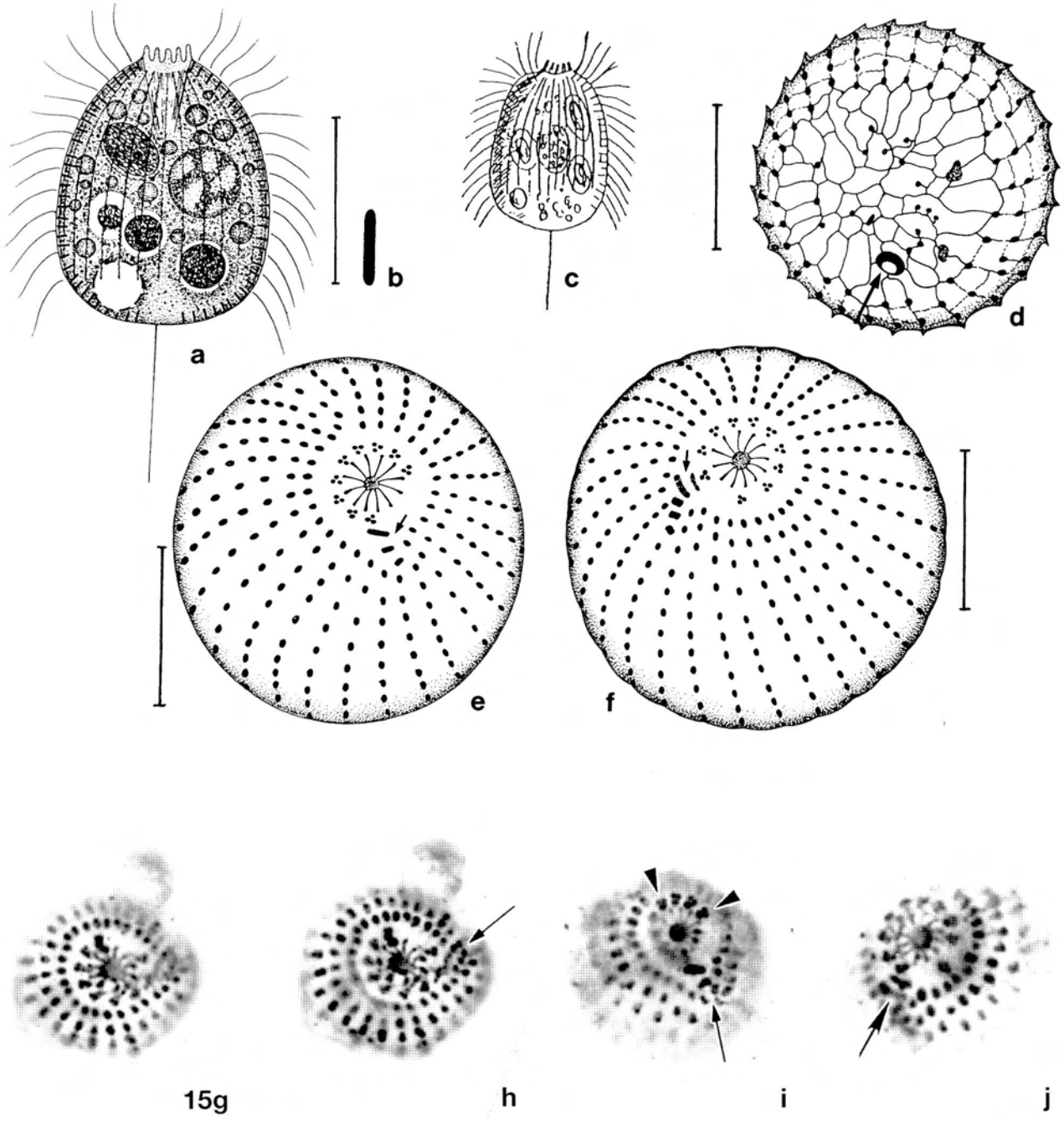
- *Urotricha synuraphaga* KAHL, 1927 (Figs. 15a–j, Table 10)

1927 *Urotricha synuraphaga* KAHL, Arch, Protistenk., 60: 64.

Type material: No type material of *U. synuraphaga* has been mentioned in the literature. Thus, I declare the population from the Röslau stream as neotype and deposit two slides with silver nitrate (CHATTON-LWOFF technique)-impregnated specimens in the Oberösterreichische Landesmuseum in Linz (LI), Austria. Relevant specimens are marked by a black ink circle on the cover glass.

Redescription: In vivo 25–40 × 20–30 µm. Broadly oviform, posterior body portion rounded with central area slightly truncate, especially in starving specimens (Fig. 15a); dorsoventrally slightly to distinctly flattened, prepared specimens, however, almost circular (Table 10). Macronucleus globular, in cell centre. Contractile vacuole in posterior end with single excretory pore at brosse side distinctly out of pole centre (Figs. 15a, d). Cortex with sharp ridges along ciliary rows (Fig. 15d). Extrusomes narrowly spaced, rod-shaped with rounded ends, 1.5 µm long (Figs. 15a, b). Cytoplasm colourless, well-nourished specimens packed with bright fat globules, 1–3 µm across, and many 5–8 µm sized food vacuoles containing single cells of *Synura* sp. Swims very fast by rotation about main body axis, but does not jump, as also emphasized by KAHL (1927).

Ciliary rows extend about 80% of body length, evenly spaced, 2–3 rows abut to right side of brosse, composed of monokinetids throughout, dikinetid at anterior end of



Figs. 15a–j. *Urotricha synuraphaga* from life (a–c) and after CHATTON-LWOFF silver nitrate impregnation (d–j). **a:** Typical specimen with many golden-brown food vacuoles containing ingested *Synura* sp. **b:** Extrusome, length 1.5 µm. **c:** Type figure from KAHL (1927). **d:** Posterior polar view. Arrow marks excretory pore of contractile vacuole. **e, f:** Anterior polar views. Arrows mark brosse left of which some circumoral kinetids are lacking. **g–j:** Anterior polar views showing oral and somatic infraciliature. Arrows mark brosse left of which 1–2 circumoral kinetids (arrowheads) are lacking. The circumoral kinety is composed of conspicuous, triangular kinetids each comprising 3 distinct granules (arrowheads).

Table 10. Morphometric characteristics from *Urotricha synuraphaga*[1]).

Character	$\bar{x}$	M	SD	$SD_{\bar{x}}$	CV	Min	Max	n
Body, length	29.4	30.0	2.3	0.6	7.7	25	33	15
Body, lateral width	23.9	24.0	1.5	0.4	6.1	21	26	15
Body, dorsoventral width	22.7	23.0	1.5	0.4	6.8	20	25	15
Anterior end to end of somatic kineties	24.1	25.0	2.7	0.7	11.4	17	27	15
Somatic kineties, number	29.0	29.0	1.1	0.3	3.7	27	31	15
Cilia in a dorsal kinety, number	12.9	13.0	1.6	0.4	12.6	10	16	15
Circumoral kinetids, number	9.0	9.0	1.0	0.3	11.1	7	10	15
Brosse kinety 1, length	1.8	1.5	0.5	0.1	27.1	1	2.5	15
Brosse kinety 2, length	1.4	1.5	0.4	0.1	25.1	1	2	15
Brosse kinety 3, length	1.2	1.0	0.3	0.1	27.5	1	2	13
Brosse kinety 4, length	1.0	1.0	0.3	0.1	28.9	0.5	1.5	7

[1]) Data based on CHATTON-LWOFF silver nitrate-impregnated and mounted morphostatic specimens from field. Measurements in µm. CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of specimens investigated, SD – standard deviation, $SD_{\bar{x}}$ – standard deviation of arithmetic mean, $\bar{x}$ – arithmetic mean.

kineties, found in many congeners, lacking or at least not recognizable (Figs. 15e–j). Silverline system rather irregularly reticulate in posterior pole region with meshes gradually narrowing to pole centre, many granules in and at silverlines, basal body of caudal cilium thus not clearly recognizable (Fig. 15d).

Oral opening in centre of anterior pole, pharyngeal basket indistinct, oral flaps about 2 µm long, 1–2 flaps lacking left of brosse, circumoral kinety thus open ventrally. Circumoral kinetids composed of three granules each forming distinct triangles, inner granule slightly smaller than outer granules; distinct fibres extend from circumoral triangles to centre of oral basket. Brosse composed of 3–4 kineties arranged one behind the other, first kinety in barren area between circumoral kinety and anterior end of somatic kineties (Figs. 15a, e–j).

Occurrence and ecology: KAHL (1927) discovered *U. synuraphaga* in a clean spring pool near Hamburg, Germany. He emphasized that it fed exclusively on single cells of *Synura*. This matches my observations. I found *U. synuraphaga* in lentic zones of several streams in Bavaria (Germany), about 1 km below the stream springs (Table 3). It was especially abundant in a lentic site of the Röslau stream, where the sand was covered with a golden layer of *Synura* sp. and some diatoms.

Comparison with original description and related species: My morphological and ecological data perfectly match the brief description by KAHL (1927; Fig. 15c). Thus, there is no doubt about the identification.

The somatic and oral infraciliature of *U. synuraphaga* highly resembles that of small congeners, like *U. furcata* (FOISSNER et al. 1994), *U. farcta* (DRAGESCO et al. 1974) and *U. ristoi* KRAINER, 1995, especially in having the anterior brosse kinety in the barren area between circumoral kinety and somatic ciliature. The interruption of the circumoral kinety in the brosse area is, like the special diet, a unique feature of *U. synuraphaga*. The interruption is highly reminescent of the genera *Plagiocampa* and *Chilophrya*, which, however, have the brosse kineties arranged side by side (FOISSNER 1978, 1984).

Family Cinetochilidae PERTY, 1852

- Genus *Platynematum* FOISSNER, BERGER & KOHMANN, 1994

Improved diagnosis: Small to medium-sized (length 30–60 µm) Cinetochilidae with minute cavity containing single caudal cilium at posterior end. Oral apparatus in anterior body third, paroral membrane restricted to curved right margin of buccal cavity, 3 elongate adoral membranelles, right end of membranelle 1 slightly curved. Contractile vacuole subterminally on ventral side.

Type species: *Uronema sociale* PENARD, 1922 (subsequent designation by FOISSNER et al. 1994).

Remarks: For nomenclature, see FOISSNER et al. (1994). Briefly, the genus had to be re-established due to the lack of a type species. *Platynematum* is very similar to *Sathrophilus* CORLISS, 1960, at least as that genus is understood today (FOISSNER et al., 1994, GROLIÈRE 1975), the main difference being the posterior cavity surrounded by minute processes. However, synonymization should await further studies on related species, especially a reinvestigation of *S. agitatus*, the type species. KAHL's (1931) diagnosis of *Platynematum* (very small to small, i.e. 30–60 µm, ellipsoidal and dorsoventrally flattened; 1 prominent caudal cilium; contractile vacuole terminal, right; mouth at right margin, small, elliptical, with straight or slightly curved left margin bearing outer membrane; ventral ciliary rows horseshoe shaped, extend around upper mouth margin and notch anterior body margin) is vague and does not separate

it distinctly from *Sathrophilus* (very small to small, usually distinctly flattened and with elongated caudal cilium; mouth in anterior quarter to third, at left margin of cell in flattened species, bears outer membrane at both sides forming pocket-like structure; with preoral suture or minute, ciliated keel).

- *Platynematum sociale* (PENARD, 1922) FOISSNER, BERGER & KOHMANN, 1994 (Figs. 16a–q, Table 11)

1922 *Uronema sociale* PENARD, Études Infusoires: 112.
1931 *Platynema (Uronema) sociale* (PENARD, 1922) – KAHL, Tierwelt Dtl., 21: 346.
1935 *Platynematum* nom. n. – KAHL, Tierwelt Dtl., 30: 833.
1994 *Platynematum sociale* (PENARD, 1922) nov. comb. – FOISSNER, BERGER & KOHMANN, Taxonom. ökol. Rev. Cili. Saprobiensyst., III: 256.

Improved diagnosis: In vivo 25–50 × 15–30 µm, ellipsoidal, flattened up to 3:1. Nuclear apparatus in posterior dorsal third of cell. 14 somatic kineties slightly shortened anteriorly and posteriorly, commence with two dikinetids each, except for 3 postoral kineties and first ciliary row right of oral apparatus, which has 5–8 narrowly spaced monokinetids forming membrane-like structure right of anterior end of paroral membrane.

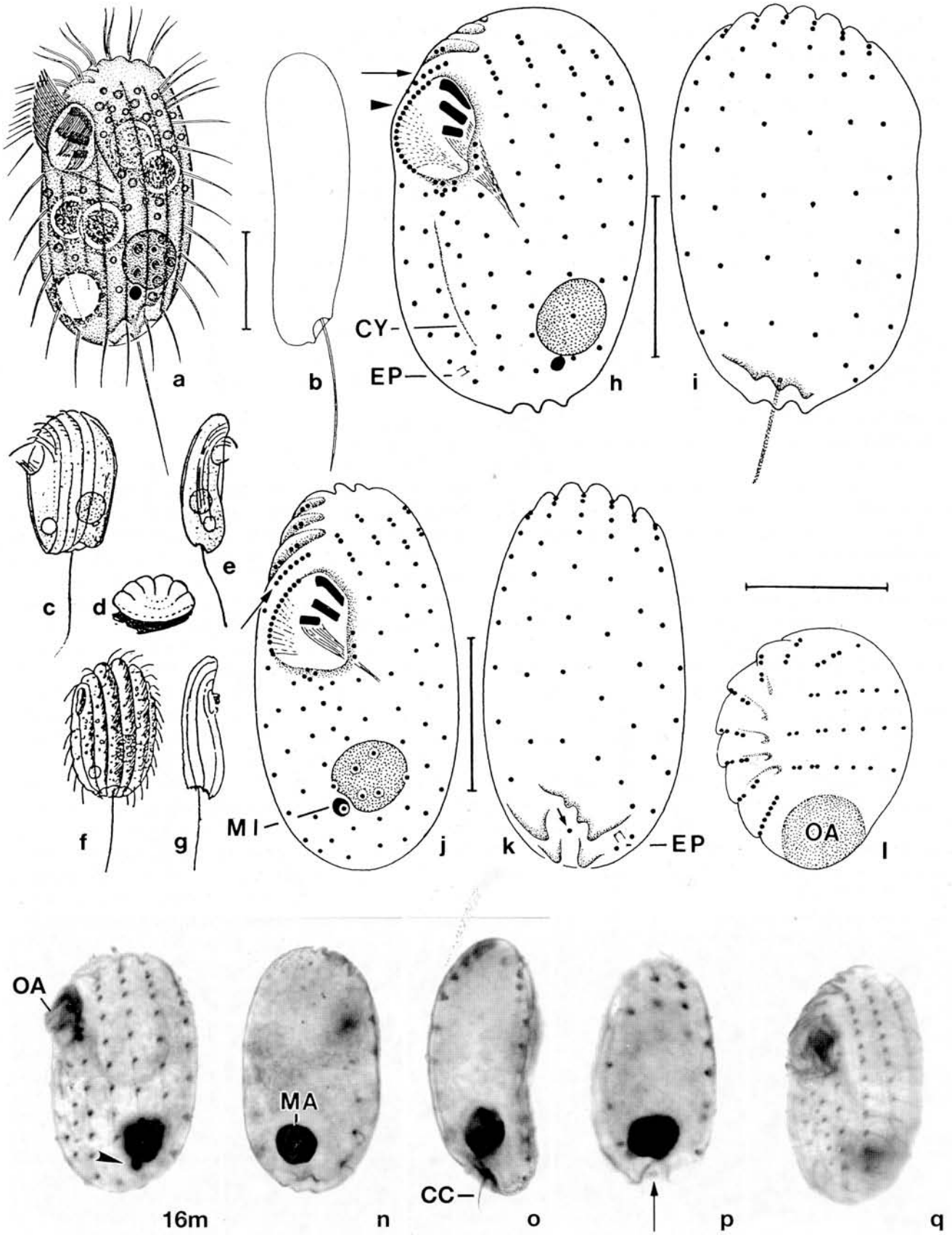
Type material: No type material of *P. sociale* has been mentioned in the literature. Thus, I declare the population from the Zinnbach stream as neotype and deposit two slides with protargol-impregnated specimens in the Oberösterreichische Landesmuseum in Linz (LI), Austria. Relevant specimens are marked by a black ink circle on the cover glass.

Description of Bavarian population: In vivo about 25–35 × 15–20 µm, shape very constant, regular ellipsoidal with both ends broadly rounded; distinctly (2:1) flattened laterally, some specimens leaf-like, i.e. flattened about 3:1, slightly curved in ventral and dorsal view (Figs. 16a, b, m, o). Right anterior end conspicuously serrated by ciliary rows, dorsal posterior region with about 3 µm deep cavity containing obliquely spread caudal cilium at least half as long as body; cavity surrounded by 4–7 minute processes formed by posterior ends of furrows containing ciliary rows (Figs. 16a, b, h–k, n–p). Macronucleus invariably in posterior third near dorsal side of cell, slightly ellipsoidal, with many small nucleoli. Micronucleus globular, in minute indentation of macronucleus (Figs. 16a, h, j, m, n). Contractile vacuole in posterior end with single, faintly impregnated excretory pore on ventral side between or at ends of first and second kinety right of paroral membrane (Figs. 16a, h, k). Cortex bright, inflexible, distinctly furrowed by ciliary rows; no extrusomes recognizable in live or protargol-impregnated specimens. Cytoplasm colourless, contains some about 5 µm sized food vacuoles with bacterial residues and, mainly in anterior half, numerous fat globules, about 1 µm

Table 11. Morphometric characteristics from *Platynematum sociale*[1]).

Character	$\bar{x}$	M	SD	$SD_{\bar{x}}$	CV	Min	Max	n
Body, length	27.1	27	2.3	0.5	8.3	24	32	19
Body, width	16.4	16	1.9	0.4	11.4	13	21	19
Anterior end to oral apparatus, distance	5.0	5	0.9	0.2	18.9	3	7	19
Anterior end to proximal end of oral apparatus, distance	11.7	12	1.3	0.3	11.1	9	15	19
Anterior end to macronucleus, distance	18.3	18	1.8	0.4	9.6	16	22	19
Paroral membrane, length	5.8	6	0.6	0.1	10.4	5	7	19
Macronucleus, length	5.4	6	0.7	0.2	12.8	4	7	19
Macronucleus, width	4.8	5	0.7	0.2	14.9	4	6	19
Micronucleus, largest diameter	1.5	1.5	0.2	0.1	16.1	1	2	19
Macronuclei, number	1.0	1	0.0	0.0	0.0	1	1	19
Micronuclei, number	1.0	1	0.0	0.0	0.0	1	1	19
Somatic kineties, total number	14.0	14	0.0	0.0	0.0	14	14	19
Postoral kineties, number	3.0	3	0.0	0.0	0.0	3	3	19
Kinetids, number in 2nd kinety right of paroral membrane[2])	9.9	10	1.0	0.2	10.0	8	12	19
Kinetids, number in middle kinety of left side[2])	11.3	11	1.1	0.3	9.7	9	13	19
Kinetids, number in pseudomembrane at anterior end of first kinety right of paroral membrane	6.7	7	1.1	0.3	15.8	5	8	19
Posterior processes, number	5.9	6	0.6	0.1	9.6	4	7	19

[1]) Data based on protargol-impregnated and mounted morphostatic specimens from field. Measurements in µm. CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of specimens investigated, SD – standard deviation, $SD_{\bar{x}}$ – standard deviation of arithmetic mean, $\bar{x}$ – arithmetic mean.
[2]) Paired basal bodies counted as single kinetid.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across, giving cells brownish colour at low magnification ($\leq$ X 100). Movement without peculiarities, usually crawling on organic debris.

Cilia in vivo about 6 µm long, loosely spaced, on left side arranged in slightly oblique, on right and dorsal surface in straight rows. Number of ciliary rows very constant (14; Table 11), commence subapically with two ciliated dikinetids each, except for 3 postoral kineties and first kinety right of oral apparatus, which has 5–8 narrowly spaced, ciliated monokinetids forming membrane-like structure right of anterior end of paroral membrane. Anterior pole area (frontal plate) conspicuous, barren, reniform, posterior pole area also barren but smaller than frontal plate, roundish (Figs. 16h–q).

Oral apparatus subapical at right margin of cell. Buccal aperture roughly triangular, buccal cavity rather large but flat. Adoral membranelles in anterior left half of buccal cavity, obliquely arranged, decrease in size from anterior to posterior. Paroral membrane composed of narrowly spaced cilia forming slightly curved row, restricted to right margin of buccal aperture, i.e. does not extend along its posterior margin where 4–8 irregularly arranged basal bodies reside to form the scutica. Pharyngeal fibres inconspicuous, most originate from paroral membrane and membranelle 3 (Figs. 16a, h, j, m, q).

Occurrence and ecology: See FOISSNER et al. (1994) for a detailed review. Briefly, *P. sociale* has been recorded mainly from the bottom and periphyton of stagnant and running freshwaters in Europe, North America, and Central America; rarely, it has been found in plankton, brackish water, activated sludge, and soil. *Platynematum sociale* prefers, according to the literature data, sapropelic habitats without hydrogen sulfide, although it did not reproduce in my jars when the samples become putrid.

Identification and comparison with related species: My observations agree well with those of PENARD (1922; Figs. 16c–e) and KAHL (1931; Figs. 16f, g). Thus, there is no doubt about the identification. Two other freshwater species are known (KAHL 1931). *Platynematum solivagum* (KAHL, 1926) has the caudal cilium located not in a cavity but on a minute process; otherwise, it is very similar to *P. sociale*. *Platynematum mirum* (PENARD, 1922) has distinct, fusiform trichocysts and the contractile vacuole near the dorsal side, indicating that it belongs to another genus.

Platynematum sociale is easily confused with *Sathrophilus muscorum* (KAHL, 1931), which, however, prefers terrestrial habitats and lacks the posterior cavity (for review, see FOISSNER et al. 1994). In fact, WILBERT (1986) redescribed *P. sociale* as *S. muscorum*, as indicated by the minute processes at the posterior end. Furthermore, *P. sociale* is easily confused with *Cinetochilum margaritaceum*, a very common species having a similar size and shape as well as a notch at the posterior end (for review, see FOISSNER et al. 1994). However, *C. margaritaceum* has the oral apparatus in the posterior body half and the contractile vacuole near the dorsal side, just above the posterior notch. Thus, it can be separated from *P. sociale* even at low magnification.

Family Amphisiellidae JANKOWSKI, 1979

- *Gastrostyla minima* HEMBERGER, 1985
  (Figs. 17a–u, Table 12)

Material: Eight voucher slides with morphostatic and dividing protargol-impregnated cells, each marked by a black ink circle on the cover glass, have been deposited in the Oberösterreichische Landesmuseum in Linz (LI), Austria.

Improved diagnosis: Size in vivo about 70–150 × 25–50 µm. 2 macronuclear nodules. Cortical granules in narrowly spaced rows, in vivo not recognizable but deeply stained with methylgreen-pyronin and silver nitrate. On average 32 adoral membranelles, 32 right and left marginal cirri, 5 transverse cirri near posterior end, and 13 cirri in median cirral row. 6 dorsal kineties with 1 caudal cirrus each associated to kineties 1, 2, 4.

Identification: In evaluating the status of the German population one main character, the cortical granules, unfortunately cannot be used because they are not recognizable in live and protargol-impregnated specimens. Among the *Gastrostyla* species with two macronuclear nodules, one is known to have distinct cortical granules, namely *G. pulchra* (PEREJASLAWZEWA, 1886) KAHL, 1932. However, *G. pulchra* is a large (length 150–300 µm), marine species with the transverse cirri almost in mid-body (PEREJASLAWZEWA 1886, BORROR 1963, BURKOVSKY 1970).

Figs. 16a–q. *Platynematum sociale* from life (a–g) and after protargol impregnation (h–q). **a, b:** Left lateral and dorsal view of typical specimen. **c–e:** Left lateral, frontal, and ventral view of type population, length 33–41 µm (from PENARD 1922). **f, g:** Left lateral and ventral view, length 40 µm (from KAHL 1931). **h, i:** Infraciliature of left and right side. Arrow marks pseudomembrane at anterior end of first ciliary row right of oral apparatus; arrowhead denotes paroral membrane. Note paired cilia (cp. Fig. 16a) at anterior end of somatic kineties. **j, k:** Infraciliature of ventral and dorsal side. Arrow in (j) marks pseudomembrane at anterior end of first kinety right of oral apparatus; arrow in (k) denotes basal body of caudal cilium. **l:** Anterior polar view. **m-q:** Infraciliature of left, right, ventral, dorsal, and left side. Arrow marks basal body of caudal cilium, arrowhead denotes micronucleus. Note minute processes surrounding posterior cavity. CC = caudal cilium, CY = cytopyge, EP = excretory pore of contractile vacuole, MA = macronucleus, MI = micronucleus, OA = oral apparatus. Scale bars 10 µm.

Table 12. Morphometric characteristics from *Gastrostyla minima*[1]).

Character	$\bar{x}$	M	SD	$SD_{\bar{x}}$	CV	Min	Max	n
Body, length	75.5	72	9.3	2.4	12.4	62	97	15
Body, width	29.4	30	4.1	1.1	13.8	22	37	15
Anterior end to proximal end of adoral zone of membranelles, distance	26.5	26	2.2	0.6	8.2	23	31	15
Anterior end to posterior end of median cirral row, distance	42.1	41	5.1	1.3	12.0	37	55	15
Posterior end to distalmost transverse cirrus, distance	9.4	9	2.5	0.6	26.0	7	16	15
Distance between macronuclear nodules	6.7	6	2.0	0.5	30.4	3	10	15
Macronucleus, length	13.4	13	2.6	0.7	19.3	9	19	15
Macronucleus, width	8.1	8	0.9	0.2	11.3	6	10	15
Micronucleus, length	3.6	4	0.5	0.1	13.0	3	5	15
Micronucleus, width	3.2	3	0.2	0.1	7.3	3	4	15
Adoral membranelles, number	32.2	32	2.0	0.5	6.6	29	37	15
Right marginal cirri, number	32.2	33	3.9	1.0	12.0	25	39	15
Left marginal cirri, number	31.7	32	2.1	0.5	6.6	28	34	15
Anterior (enlarged) frontal cirri, number[2])	4.1	4	–	–	–	4	5	15
Buccal cirri, number	1.0	1	0.0	0.0	0.0	1	1	15
Cirri in ventral row, number	12.4	13	1.9	0.5	15.2	9	15	15
Pretransverse ventral cirri, number	2.0	2	0.0	0.0	0.0	2	2	15
Transverse cirri, number[2])	5.1	5	–	–	–	5	6	15
Caudal cirri, number[3])	2.9	3	–	–	–	2	3	15
Dorsal kineties, number	6.0	6	0.0	0.0	0.0	6	6	15
Macronuclei, number	2.0	2	0.0	0.0	0.0	2	2	15
Micronuclei, number[2])	2.1	2	–	–	–	2	3	15

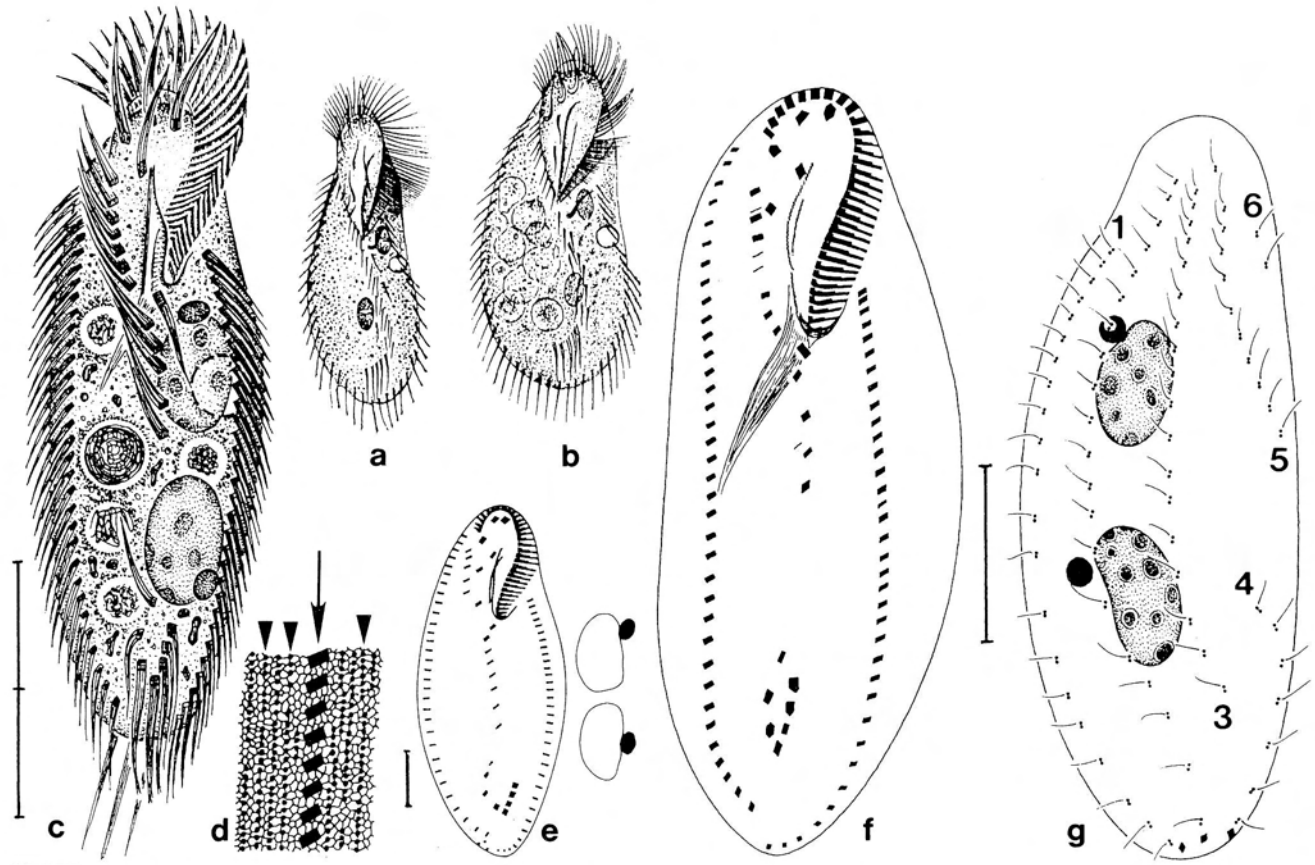
[1]) Data based on protargol-impregnated and mounted morphostatic specimens from field. Measurements in µm. CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of specimens investigated, SD – standard deviation, $SD_{\bar{x}}$ – standard deviation of arithmetic mean, $\bar{x}$ – arithmetic mean.
[2]) Higher value found in 1 out of 15 specimens investigated.
[3]) Two cirri in 2 out of 15 specimens investigated.

The infraciliature of the German specimens is most similar to that of *G. minima* HEMBERGER, 1985, a freshwater species from Peru, both in pattern and morphometry (Figs. 17e, f). Thus, the identification is very likely correct although the Peruvian specimens are slightly larger (120–145 × 45–60 µm) and HEMBERGER (1985) did not mention cortical granules. However, HEMBERGER (1985) used WILBERT's protargol method, where specimens sometimes become rather inflated, and studied only specimens impregnated with protargol, which does not stain the cortical granules.

BERGER (in FOISSNER et al. 1991) synonymized *G. minima* HEMBERGER, 1985 with *G. mystacea* (STEIN, 1859) STERKI, 1878, a medium-sized (length 120–170 µm) freshwater species discovered by STEIN (1859) in pools heavily polluted by liquid manure. Furthermore, *G. mystacea* has at least 20 cirri in the median cirral row, which extends to the distinctly subterminally located transverse cirri (Figs. 17a, b). Admittedly, these differences are not very prominent but sufficient to maintain both forms as distinct species, at least at the present state of knowledge. In fact, the numerous ventral cirri of *G. mystacea* are so prominent that KAHL (1932) and BORROR (1972) transferred it to the genus *Holosticha*.

I have data from another species found in soils of the USA and the Galapagos Islands. These populations lack cortical granules, which would match HEMBERGER's description of *G. minima*, but have only 3–4 cirri in the postperistomial portion of the median cirral row, which is dissimilar to *G. minima*. Obviously, this species is

Figs. 17a–m: *Gastrostyla mystacea* (a, b) and *G. minima* (c–m) from life (a–c), after CHATTON-LWOFF silver nitrate impregnation (d, i–m), protargol impregnation (e–g), and in the scanning electron microscope (h). **a, b:** Ventral views, length 120–170 µm (from STEIN 1859). **c, h:** Ventral views. **d, i–m:** Cortical granule rows (arrowheads) and silverline system of ventral (d, i, k–m) and dorsal (j) side. Arrows mark cirral rows. **e:** Ventral infraciliature and nuclear apparatus of Peruvian type population (from HEMBERGER 1985). **f, g:** Infraciliature of ventral and dorsal side of Bavarian population. Numbers denote dorsal kineties. Scale bar division 20 µm.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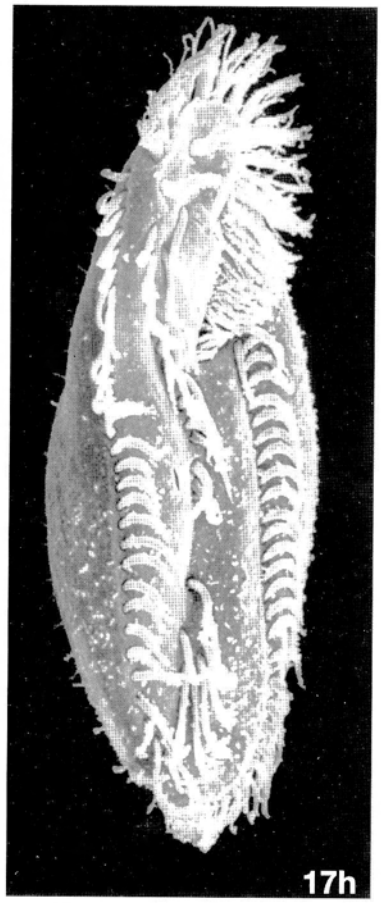
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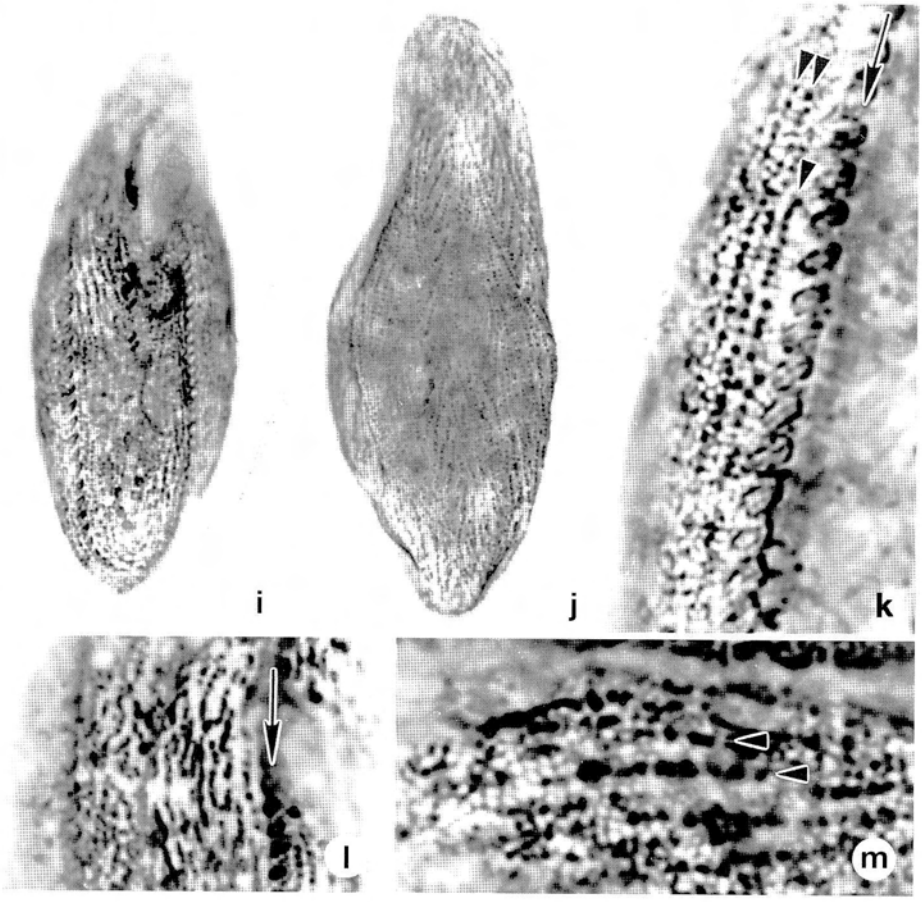
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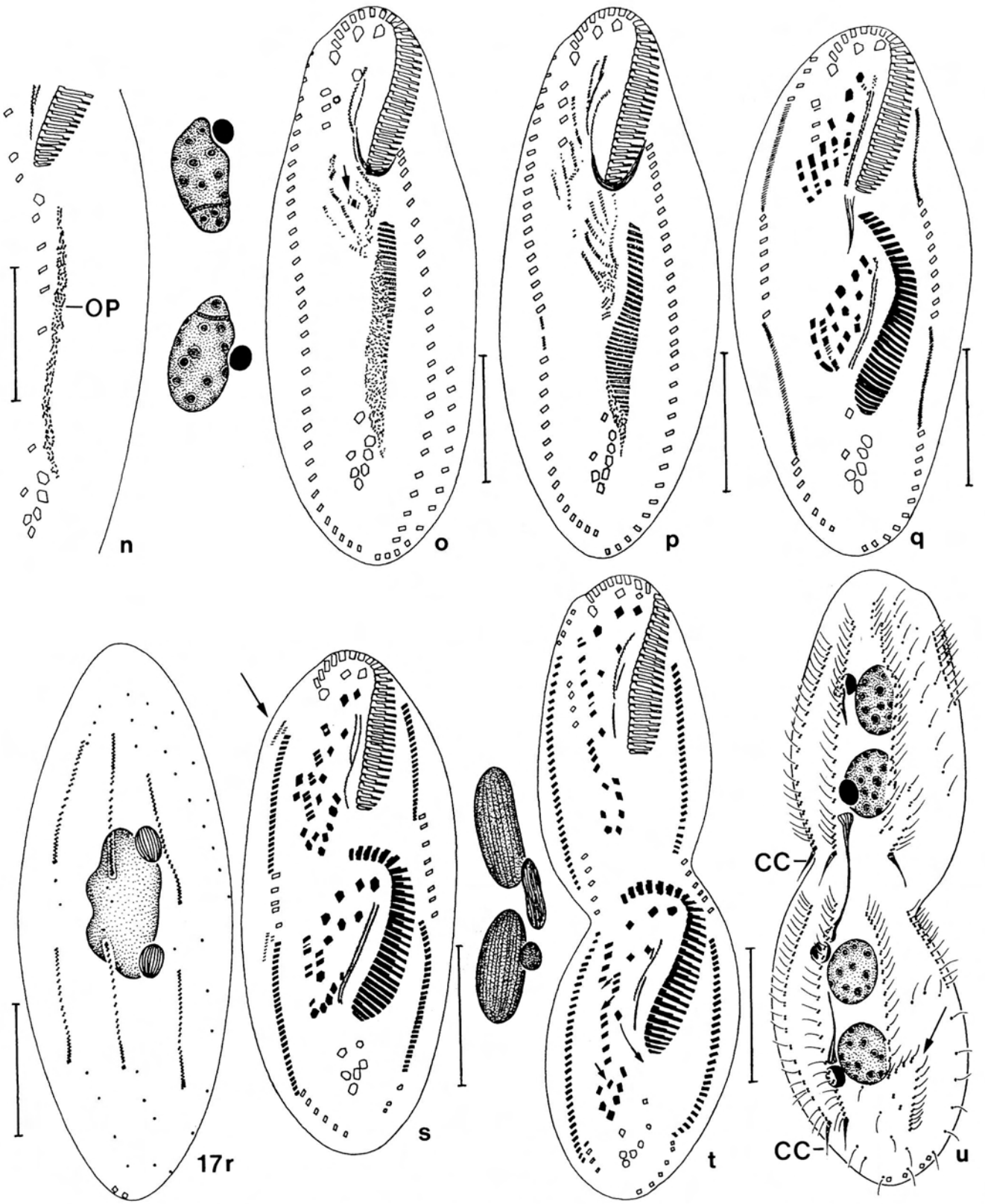


Figs. 17n–u. Protargol impregnated dividers of *Gastrostyla minima*. Parental structures shown by contour, newly formed shaded black. See text for detailed explanation. Arrow in (o) marks disintegrating postperistomial cirrus; arrow in (s) denotes dorsomarginal kineties; arrows in (t) show movements of median cirral row fragments and postperistomial cirrus; arrow in (u) marks separation of dorsal kinety 4 from kinety 3 (cp. Fig. 17g). CC = caudal cirri, OP = oral primordium. Scale bars 20 μm.

between the descriptions by HEMBERGER and the present paper. Considering the very similar ventral cirral pattern and that HEMBERGER (1982, 1985) originally found *G. minima* in freshwater, I prefer to assume that HEMBERGER overlooked the cortical granules and thus identify the Röslau population as *G. minima*.

HEMBERGER's description of *G. minima* is brief and lacks live observation and detailed morphometry. Thus, I provide a complete redescription.

Description of Bavarian population (Figs. 17a–m, Table 12): Size in vivo about 70–120 × 25–40 µm. Prolate ellipsoidal, length: wide ratio about 3:1, left side more distinctly convex than right, both ends evenly rounded, flattened laterally up to 2:1, rather flexible (Figs. 17a, h, i). Macronuclear nodules ellipsoidal (1.5:1), rather close ($\bar{x}$ = 6 µm) together in middle third of body to left of midline; nucleoli scattered, globular. Micronuclei slightly ellipsoidal, conspicuous because rather large and compact, one each attached to macronuclear nodules in variable position. Contractile vacuole pre-equatorial at left body margin. Cortex colourless, contains narrowly meshed silverline system (Figs. 17d, k–m). Cortical granules in narrowly spaced short and long rows on ventral and dorsal side, do not stain with protargol but contrast as whitish, punctate lines with dark brown pellicle in overimpregnated specimens; granules colourless, about 1 µm across, not recognizable in live specimens, even with interference contrast, but stained dark blue with methylgreen-pyronin and brown with silver nitrate (Figs. 17d, k–m). Cytoplasm colourless, contains some 1–4 µm long yellowish crystals and food vacuoles 5–10 µm across. Feeds on bacteria, diatoms and *Euglena* sp. Movement moderately rapid, scrabbling amongst debris.

Cirral pattern very constant, number rather variable (Table 12). Anterior frontal cirri about 17 µm long, transverse and caudal cirri about 20 µm long, marginal and ventral cirri about 14 µm long. Marginal rows open at posterior end, gap occupied by caudal cirri right of cell midline, right row ends subterminally, left extends to midline of posterior end, posteriormost marginal cirri distinctly reduced in size, especially in left row. Median cirral row slightly sigmoid, extends about half body length in midline of ventral surface, frequently some cirri strongly reduced in size and/or slightly out of line; postperistomial cirrus slightly enlarged and distinctly left of median cirral row closely beneath peristomial vertex. Transverse cirri close together, rather distant from but projecting above posterior end (Figs. 17c, f, h, Table 12). Dorsal cilia in vivo about 4 µm long, arranged in 6 rows which originate as follows: row 1 slightly shortened anteriorly, associated with right caudal cirrus, originates by within-row-proliferation (Figs. 17g, r, u); row 2 extends whole body length, associated with middle caudal cirrus, originates by within-row-proliferation (Figs. 17g, r); row 3 distinctly shortened posteriorly, originates by within-row-proliferation (Figs. 17g, r); row 4 curved, commences subequatorially, associated with left caudal cirrus, separates (fragmentates) from row 3 in late dividers (Figs. 17g, u); row 5 extends in anterior body half only, originates near or from right marginal row (Figs. 17g, s); row 6 near anterior end of cell, consists of 2–4 dikinetids only, originates, like row 5, near or from right marginal row (Figs. 17g, s).

Oral apparatus and adoral zone of membranelles of usual structure and size, occupy about 36% of body length. Buccal cavity rather narrow and flat, posterior right half covered by hyaline lip. Paroral and endoral membrane slightly curved, distinctly shifted in parallel, posterior end of paroral thus optically intersects endoral in mid-region. Pharyngeal fibres distinct (Figs. 17c, f, h).

Occurrence and ecology: HEMBERGER (1985) discovered *G. minima* in freshwater in Peru, later he found it also in soil from this region. I found *G. minima* in the Röslau and Zinnbach streams. It survived and reproduced for some days in the sampling jars.

Morphogenesis (Figs. 17n–u): Ontogenesis commences with the development of an oral primordium close to the left of the median cirral row. Five cells were found, all looking like that shown in Fig. 17n, indicating that basal body proliferation occurs simultaneously in a long, narrow area between the proximal buccal vertex and the uppermost transverse cirrus. Next, six cirral anlagen each develop in the proter and opisthe (Figs. 17o, p). The anlagen of the proter originate from the anterior end of the paroral membrane, the buccal cirrus, the cirrus left of the median cirral row, and from the posterior cirri of the upper half of the median cirral row. The anlagen of the opisthe originate from the postperistomial cirrus, the oral primordium, and the postperistomial portion of the median cirral row, whose cirri are completely incorporated into the oral primordium and the cirral streaks. In middle and late dividers (Figs. 17q, s), cirri segregate within the anlagen; those of the three right streaks arrange obliquely and one behind the other, forming the „amphisiellid median cirral row" (EIGNER & FOISSNER 1994). The postperistomial cirrus segregates from anlage 4, which slips between the anlagen 5 and 6 in late dividers (Fig. 17t). The leftmost anterior frontal cirrus originates from the paroral membrane which is, as the endoral, renewed during morphogenesis. The marginal cirral rows and the nuclear apparatus develop in the usual amphisiellid manner. See species description for ontogenesis of dorsal infraciliature.

Systematic position of *Gastrostyla*: The morphogenesis of *G. minima* is rather similar to that of *G. steinii* as described by HEMBERGER (1982), indicating congenerity. There is only one conspicuous difference, viz. the postperistomial portion of the median cirral row, which is almost inactive in *G. steinii* and very active in *G. minima*, which incorporates all postperistomial cirri in the oral anlage and/or cirral streaks (Figs. 17n–p).

Gastrostyla has long been considered as belonging to the Oxytrichidae (BORROR 1972, KAHL 1932, TUFFRAU & FLEURY 1994). Only recently, EIGNER & FOISSNER (1994) recognized that the ventral cirral row of *Gastrostyla* originates in the manner characteristic of the Amphisiellidae. This is fully confirmed by the present investigations. However, the dorsal infraciliature of *Gastrostyla* develops as, e.g., in *Oxytricha granulifera* FOISSNER & ADAM, 1983, indicating either convergent evolution or a common ancestor from which both the Oxytrichidae and Amphisiellidae originated.

Class Colpodea SMALL & LYNN, 1981

Colpodids mainly inhabit terrestrial biotopes (FOISSNER 1993a). However, the present and other recent studies (FOISSNER 1993b, 1994, OLMO & TELLÉZ 1996) indicate that our knowledge is incomplete and biased. Very likely, many new genera and species wait to be discovered in freshwaters, especially in clean, mossy streams and rivers. Possibly, species like *Pseudochlamydonella rheophila*, *Kreyella minuta*, and *Hackenbergia langae* form the core of an oligosaprobic ciliate indicator community.

- *Hackenbergia* nov. gen.

Diagnosis: Very small Pseudochlamydonellidae with oral aperture in middle third of right side, close to left of midline. Right side with several almost circular kineties, left with single, short kinety only. Cytopharynx inconspicuous, funnel-shaped, extends to dorsal side and curves back to oral cavity. Adoral organelles (left oral ciliary field) lacking or reduced to inconspicuous vestiges.

Type species: *Hackenbergia langae* nov. spec.

Dedication: I dedicate this new genus to Mr ANDREAS HACKENBERG as a small token of appreciation for the excellent work he did over years in producing, as publisher's reader, the European Journal of Protistology. The genus has feminine gender, according to article 30 (b) of the ICZN (1985).

Comparison with related genera: *Hackenbergia* differs from *Pseudochlamydonella* BUITKAMP, SONG & WILBERT, 1989, the sole other genus in the family, mainly by the lack of brick-shaped adoral organelles at the left margin of the oral aperture. The lack is stated with certainty because some specimens were excellently impregnated (Figs. 18d, j). There are a few ciliated dikinetids near the right posterior margin of the pharyngeal aperture which might be remnants of adoral organelles. Note that BUITKAMP et al. (1989) overlooked the adoral organelles in *Pseudochlamydonella*, as has been proven by a subsequent reinvestigation of the type slides and of another population of the type species, *P. rheophila* (FOISSNER 1993a; see also brief redescription below). A second, minor difference concerns the somatic kineties, which are bow-shaped in *Pseudochlamydonella* and almost circular in *Hackenbergia*.

- *Hackenbergia langae* nov. spec. (Figs. 18a–j, Table 13)

Diagnosis: In vivo about 30 × 20 µm, broadly ellipsoidal and distinctly flattened laterally. Contractile vacuole and excretory pore close beneath oral aperture. 9 ciliary rows: 5 right of oral apparatus, 3 postoral, 1 subapically on left side.

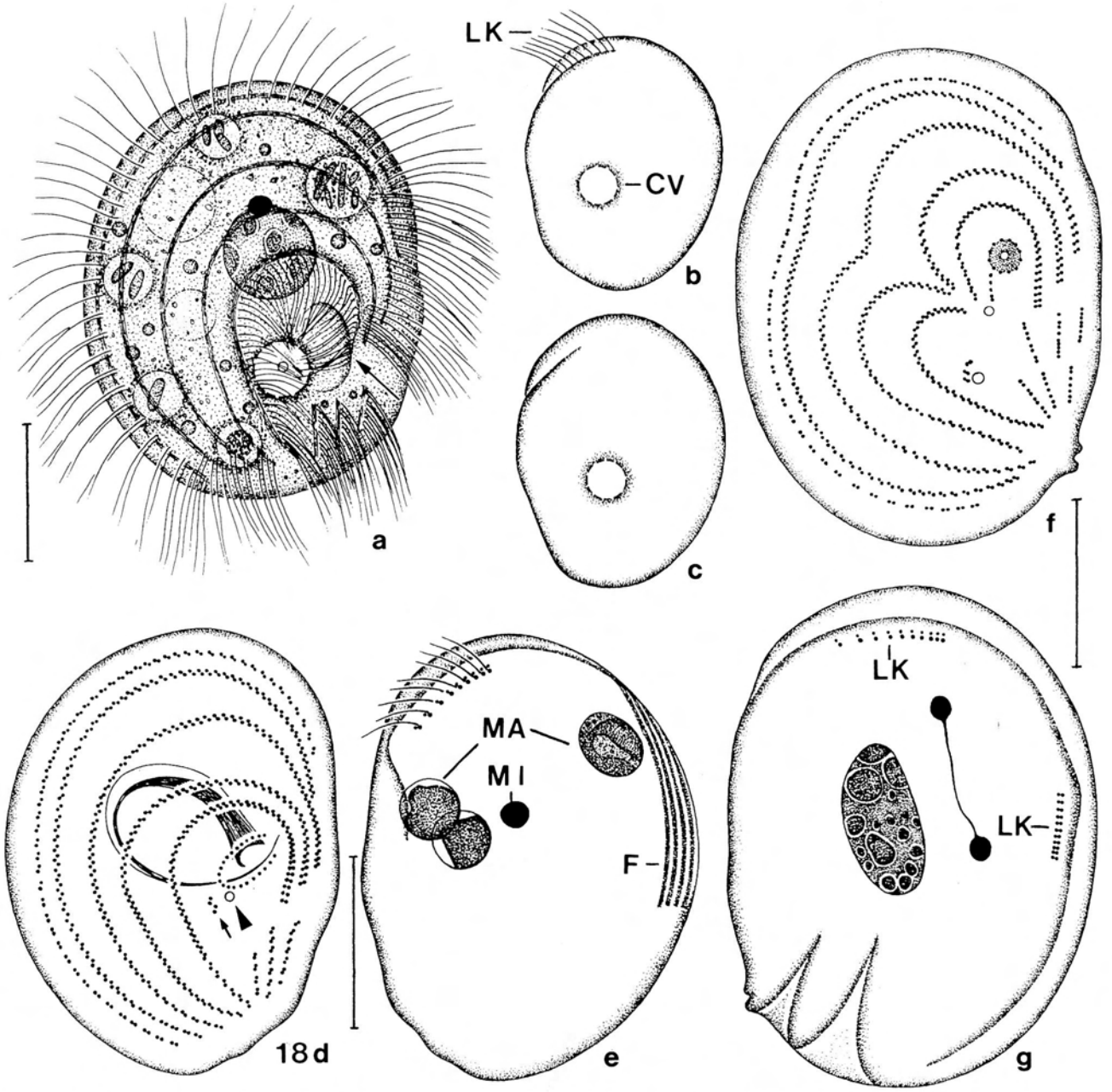
Type location: River Illach, Bavaria (Germany), E 10°55′ N 47°43′.

Type specimen: One holotype slide and two syntype slides with protargol-impregnated cells have been deposited in the Oberösterreichische Landesmuseum in Linz (LI), Austria. Relevant specimens are marked by a black ink circle on the cover glass.

Dedication: I dedicate this new species to Mrs ANITA LANGE as a small token of appreciation for the excellent work she did over many years, and still does, as Editorial Assistant of the Archiv für Protistenkunde and LIMNOLOGICA.

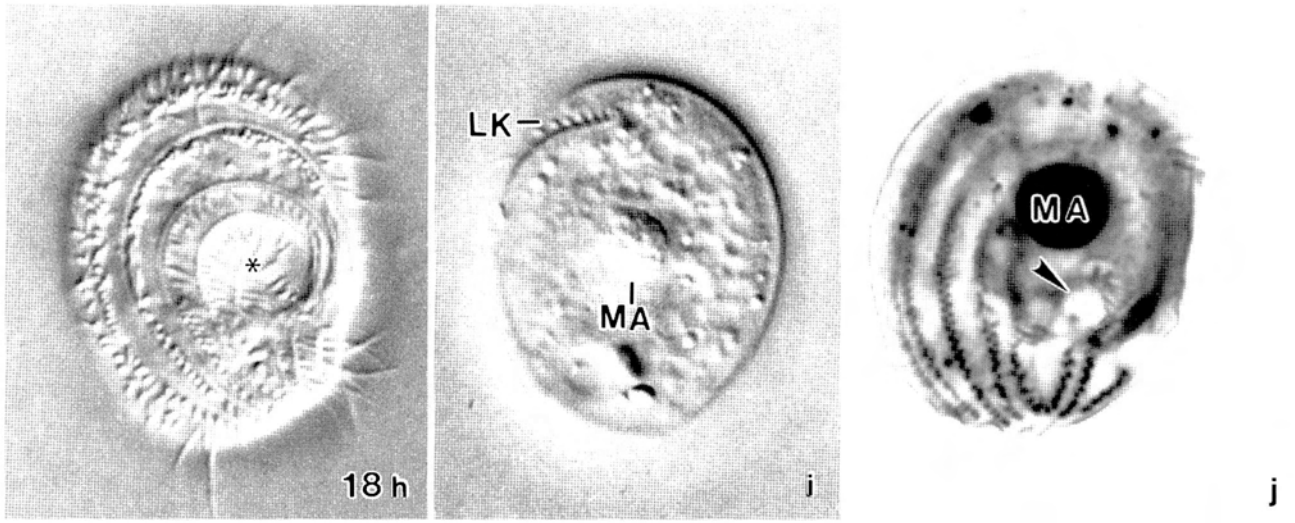
Description: In vivo about 25–35 × 18–25 µm. Shape fairly constant, in lateral view almost circular (Figs. 18a, d, h), rarely occur obovoid specimens with narrowed posterior body portion (Fig. 18c); ventral side usually with small bump at level of oral apparatus. 2–3:1 flattened laterally, ciliated right side flat with oral field, however, distinctly depressed; left side slightly convex and with distinct ventro-lateral furrow near anterior end, where left lateral kinety extends (Figs. 18b, e, i), contains many narrowly spaced, slightly argyrophilic fibres (Fig. 18e). Nuclear apparatus near centre of cell. Macronucleus globular to slightly ellipsoidal, of 30 specimens analyzed, 23 had one macronucleus, 3 had two macronuclei, and 4 had three (Figs. 18a, e, i, j). Micronucleus (two in 1 out of 30 specimens) globular, attached to or near macronucleus. Contractile vacuole and single excretory pore left of midline just beneath oral aperture, both easily recognizable in live specimens (Figs. 18a, d). Cortex soft, flexible, bright, distinctly furrowed by ciliary rows, without conspicuous granules. Cytoplasm colourless, hyaline, contains some 1–2 µm sized fat globules, rather many clear vacuoles without solid content, and some 2–4 µm sized food vacuoles with thick, ellipsoidal bacteria. Creeps moderately fast on organic debris and microscope slides with ciliated surface turned towards substrate; occasionally, it remains almost motionless for some time (Fig. 18h).

Cilia about 7 µm long, arranged in 9 (very rarely 8 due to lack of a postoral kinety) rows consisting of paired, distinctly inclined basal bodies (dikinetids): 5 long, almost circular kineties extending around oral field left of minute cortical ridges; 3 (2 in 1 out of 50 specimens) short, straight postoral kineties in left posterior quadrant of cell; 1 short



Figs. 18a–g. *Hackenbergia langae* from life (a–c) and after protargol impregnation (d–g). **a–c:** Right and left lateral views of typical specimens, video tape records. Arrow marks shallow depression at left margin of oral field, which is covered by the cilia of the first somatic kinety. **d, e:** Infraciliature of right and left side. Arrow marks dikinetids right of excretory pore (arrowhead) of contractile vacuole, possibly vestiges of adoral organelles. Note the strongly curved cytopharynx. **f, g:** Infraciliature of right and left side of a dividing specimen. The innermost ciliary row, whose cilia cover the oral field (Fig. 18a), divides like the other ciliary rows, indicating that it does not belong to the oral ciliature. CV = contractile vacuole, F = fibres extending in left lateral cortex, LK = left lateral kinety, MA = macronucleus, MI = micronucelus. Scale bars 10 μm.

kinety in subapical furrow of left anterior surface (Figs. 18a, d, e, h–j). Circular kineties 1–4 (numbered from oral cavity to dorsal side) gradually shortened at left end, consist of closely spaced, ciliated dikinetids producing distinct zigzag pattern, left end of kineties 1 and 2 extends onto bottom of groove at left margin of oral cavity, cilia of kinety 1 cover oral field like an undulating membrane (Figs. 18a, h); however, some dividing specimens showed that is a real somatic kinety (Fig. 18f, g). Circular kinety 5, extending close to kinety 4 and near dorsal margin of cell, of distinctly different structure: dikinetids less narrowly spaced than in other kineties, those in posterior



Figs. 18h–j. *Hackenbergia langae* from life (h, i) and after protargol impregnation (j). **h, j:** Right side ciliature (cp. Fig. 18d). Star marks centre of oral field covered by the cilia of the innermost somatic ciliary row; arrowhead denotes shallow depression at left margin of oral field. **i:** Left side view.

Table 13. Morphometric characteristics from *Hackenbergia langae*[1]).

Character	$\bar{x}$	M	SD	$SD_{\bar{x}}$	CV	Min	Max	n
Body, length	24.8	25	2.0	0.4	8.0	20	28	30
Body, width	19.1	19	1.4	0.3	7.3	16	21	30
Anterior end to upper margin of oral cavity	10.1	10	1.1	0.2	10.6	8	12	30
Anterior end to excretory pore, distance	15.0	15	1.1	0.2	7.5	12	17	30
Anterior end to macronucleus, distance	8.3	8	2.4	0.4	29.2	5	16	30
Macronucleus, length[2])	5.4	6	0.6	0.1	11.9	4	7	30
Macronucleus, width[2])	5.1	5	0.7	0.1	13.5	4	6	30
Micronucleus, length	1.9	2	0.3	0.1	15.9	1	3	30
Micronucleus, width	1.8	2	0.2	0.1	12.2	1	2	30
Somatic kineties, number	5.0	5	0.0	0.0	0.0	5	5	30
Postoral kineties, number	3.0	3	0.0	0.0	0.0	3	3	30
Dikinetids right of excretory pore, number	2.8	3	–	–	–	2	3	30
Left lateral kineties, number	1.0	1	0.0	0.0	0.0	1	1	30
Cilia in left lateral kinety, number	9.1	9	1.4	0.3	15.3	5	11	30
Macronuclei, number	1.4	1	0.7	0.1	52.6	1	3	30
Micronuclei, number	1.0	1	–	–	–	0	2	30

[1]) Data based on protargol-impregnated and mounted morphostatic specimens from field. Measurements in µm. CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of specimens investigated, SD – standard deviation, $SD_{\bar{x}}$ – standard deviation of arithmetic mean, $\bar{x}$ – arithmetic mean.
[2]) From specimens with single nucleus.

third not inclined, those in anterior portion inclined like those of kineties 1–4 but with barren, slightly smaller anterior basal body. Postoral kineties short and spread fan-like, consist of ciliated dikinetids. Number of dikinetids and cilia highly variable in left lateral kinety, distances between dikinetids decrease from ventral to dorsal, dikinetids have only posterior basal body ciliated, anterior basal body thus slightly smaller, as in anterior half of kinety 5.

Oral field in mid-body left of midline, circular, distinctly depressed, usually covered by cilia of first circular kinety, with small pit containing anterior ends of circular kineties 1 and 2 at left posterior margin. Pharyngeal basket very delicate, invisible in live specimens, extends antero-dorsally and curves back to oral cavity as long, narrow funnel; basket aperture near centre of oral cavity, surrounded by small argyrophilic granules, possibly unciliated basal bodies of a paroral membrane. Right of basket aperture

and excretory pore of contractile vacuole usually 3 ciliated dikinetids, possibly vestiges of an adoral ciliature (Figs. 18d, f, h, j). Brick-shaped adoral organelles, as found in *Pseudochlamydonella* (Fig. 19a, e), are lacking.

Occurrence and ecology: As yet found only at type location in September 1995. It occurred in small numbers in composite samples containing periphyton, sediment and moss bunches. In the laboratory, *H. langae* concentrated in the moss bunches and attached to cover glasses put on the water surface of the sample jar.

Comparison with related species: Live specimens of *H. langae* are easily confused with *Pseudochlamydonella rheophila*, described below, and *Kreyella minuta* FOISSNER (1993a). All have a similar size, shape and ciliary pattern and occur in clean or slightly polluted waters, sometimes even together. However, usually they are easily distinguished by the food ingested and the location of the contractile vacuole (FOISSNER 1993a). *Pseudochlamydonella rheophila* feeds on diatoms, whereas *K. minuta* and *H. langae* feed on bacteria. *Kreyella minuta* has the contractile vacuole in the posterior end, whereas it is distinctly subterminal in *P. rheophila* and *H. langae*. Furthermore, *K. minuta* has rather conspicuous adoral organelles and is not as distinctly disc-shaped as *H. langae*.

Microthorax penardi TUCOLESCO, 1962 highly resembles *H. langae* in body shape and number and arrangement of ciliary rows. However, it is only 15 µm in size and has two vacuoles in the oral field, definitely described („Plusieurs vacuoles médianes; la pulsation n'a pas eté observée de sorte qu'on n'a pas pu établir quelle est la vacuole contractile".) and figured by TUCOLESCO (1962). Thus, identification with *H. langae* would be premature.

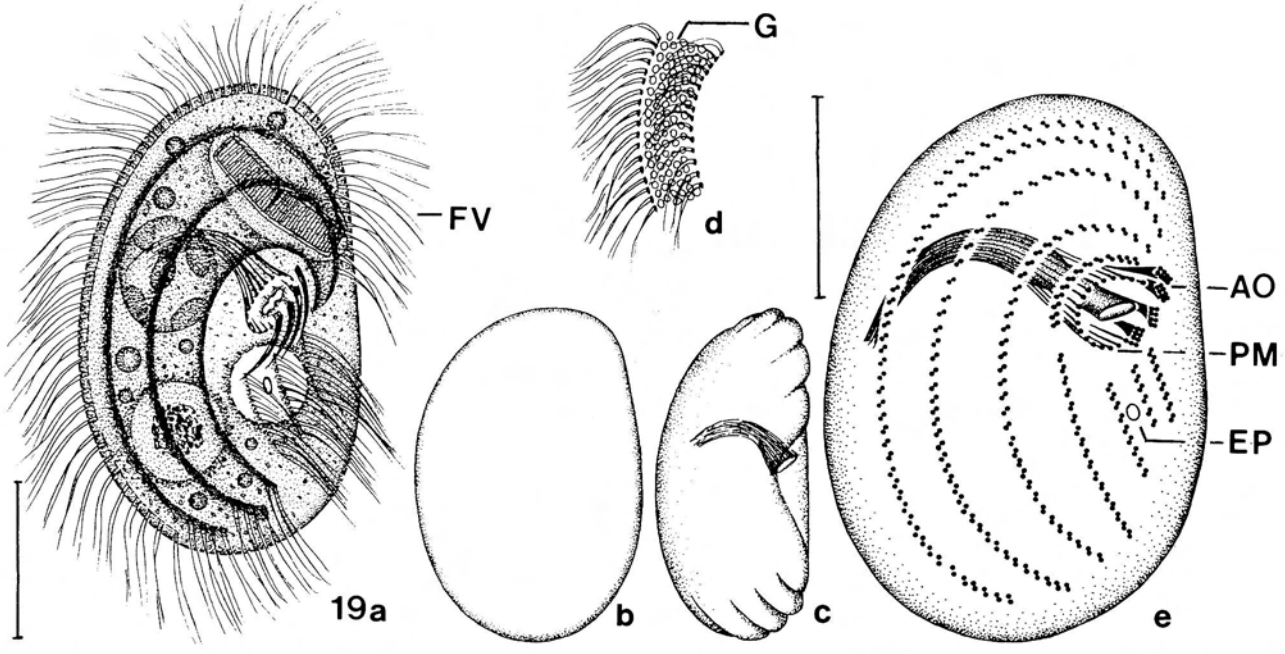
- *Pseudochlamydonella rheophila* BUITKAMP, SONG & WILBERT, 1989 (Figs. 19a–e)

1989 *Pseudochlamydonella rheophila* BUITKAMP, SONG & WILBERT, Acta Protozool., 28: 17.

1993 *Pseudochlamydonella rheophila* BUITKAMP, SONG & WILBERT, 1989 – FOISSNER, Colpodea: 664 (redescription).

This species is briefly redescribed, mainly because it was found together with *Hackenbergia langae* with which it is easily confused (see above). The Illach population is very similar, both in vivo and after silver impregnation, to the Ager population studied by FOISSNER (1993a). Thus, only the in vivo aspect is described according to video tape records and detailed observations with oil immersion.

Size rather constant, about 30 × 18 µm, slightly flattened laterally. Shape also fairly constant, in lateral view ellipsoidal to almost semicircular, i.e. with flat ventral and semicircularly curved dorsal side, both ends broadly rounded. Right surface ornamented by a (noncrenellated) ridge left of each ciliary row, and oral area, distinctly depressed especially at upper and left margin where ciliated part



Figs. 19a–e. *Pseudochlamydonella rheophila* from life (a–d) and after protargol impregnation (e). **a:** Right lateral view of ellipsoidal specimen, video tape record. **b, c:** Right lateral and dorsal view of semicircular specimen. **d:** Surface view showing dense cortical granulation. **e:** Infraciliature of right side (from FOISSNER 1993a). AO = adoral organelles, EP = excretory pore of contractile vacuole, FV = food vacuole with diatom, G = granules, PM = paroral membrane. Scale bars 10 µm.

of cortex is curved counter-clockwise; postorally, oral area flattens gradually and merges into right body surface (Figs. 19a–c). Left side more or less distinctly vaulted, depending on amount of food ingested. Macronucleus in or near centre of cell, about 7 µm in diameter, with pale, globular nucleoli; frequently, specimens with two or three nuclei occur, like in other populations (FOISSNER 1993a). Contractile vacuole subequatorially underneath oral opening, i.e. between ventral side and midline, excretory pore between rightmost postoral kineties, distinct also in live specimens (Figs. 19a, e). Cortex flexible, contains innumerable colourless granules (mucocysts ?), 0.3–0.5 µm across, forming narrowly spaced rows between kineties and in left lateral surface (Fig. 19d). Cytoplasm hyaline, sometimes with yelloworange shimmer, contains comparatively large food vacuoles with small diatoms, mainly *Achnanthes* sp. Glides and crawls moderately fast on microscope slides and organic debris.

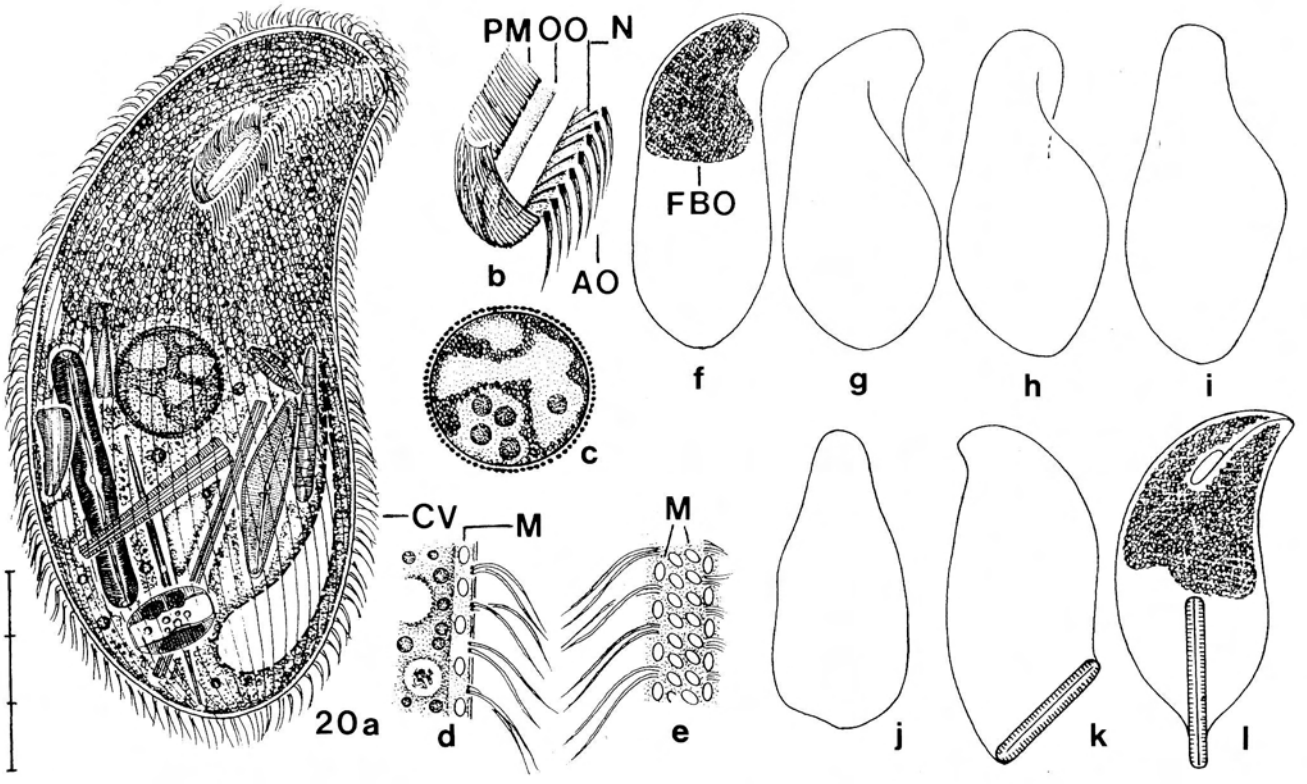
Somatic and oral infraciliature as described by FOISSNER (1993a). Oral opening in mid-body between ventral side and midline; oral basket conspicuous but delicate, thus recognizable only with interference contrast or after protargol impregnation; adoral organelles rather conspicuous, their cilia invariably curved to rear (Figs. 19a, e).

- *Rostrophrya camerounensis* (NJINE, 1979) FOISSNER, 1993 (Figs. 20a–l)

1979 *Rostrophrya camerounensis* NJINE, Protistologica, 15: 346.

1993 *Rostrophrya camerounensis* (NJINE, 1979) nov. comb. – FOISSNER, Colpodea: 620 (see this monograph for nomenclature).

As yet, *R. camerounensis* has been recorded only from the type location, i.e. an ephemeral pool in Cameroun (Africa). It was thus a great surprise to find this species in moss bunches of a small stream (Illach) in Germany. Interestingly, HUBERT BLATTERER (pers. comm.) found *R. camerounensis* at the same time (October and November 1995) in two clean to slightly polluted regions of the rivers Alm and Traun in Upper Austria. It occurred in the periphyton of stones and in sediment. Obviously, *R. camerounensis* is widespread but rare.



Figs. 20a–l. *Rostrophrya camerounensis* from life, video tape records. **a:** Right lateral view of typical specimen containing large fat body in anterior and many ingested diatoms in posterior half. Scale bar division 20 µm. **b:** Proximal part of oral apparatus at high magnification. **c:** The macronucleus is covered by a dense layer of granules and often contains some large globules (parasites ?). **d, e:** Optical section and surface view of cortex, which contains very regularly arranged mitochondria embedded in a gelatinous layer. **f–i:** Shape variant rotating from right (f) to dorsal side (i). **j:** Dorsal view of specimen shown in Fig. 20a. **k, l:** Two specimens deformed by large diatoms. AO = adoral organelles, CV = canal of contractile vacuole, FBO = fat body, M = mitochondria, N = nematodesmata, OO = oral opening, PM = paroral membrane.

NJINE (1979) provided a detailed account on the infraciliature of *R. camerounensis* but no description and figures of live specimens. Thus, I supplement his description with these details.

Size in vivo about 170–250 × 70–120 µm. Shape very much like that of *Trithigmostoma* spp., i.e. ellipsoidal with rostrate anterior end, laterally not or inconspicuously flattened (Figs. 20a, f–i, j), often strongly deformed by large, ingested diatoms (Figs. 20k, l); very soft and flexible. Macronucleus in centre of cell, globular, covered by a layer of narrowly spaced, colourless granules about 0.5 µm across; nucleolus reticulate; most specimens had rather large globules within the nucleus, possibly a parasite (Fig. 20c). Contractile vacuole in posterior end with conspicuous collecting canal extending ventrally to mid-body (Fig. 20a). Cortex about 2 µm thick, conspicuously gelatinous, contains narrowly spaced, particularly arranged ellipsoidal mitochondria but no special granules or extrusomes (Figs. 20d, e). Cytoplasm in anterior half of cell with large "fat body" consisting of innumerable, bright globules 0.5–3 µm across; appears as dark or black patch at low (≤ X 100) magnification (Figs. 20a, f, l). Posterior body half distinctly vacuolated with some fat globules in bridges separating individual vacuoles, contains many small and large diatoms in well-nourished specimens, as also stated by NJINE (1979).

Oral apparatus at base of rostrum, slanted across cell midline, slightly depressed, with distinct central aperture. Pharyngeal fibres very fine, basket thus hardly recognizable, originate from paroral dikinetids and base of adoral organelles. 20–30 brick-shaped adoral organelles along left slope of oral aperture and about 15 adoral organelles in preoral suture, which perfectly matches NJINE's data; cilia of adoral organelles about 10 µm long (Figs. 20a, b).

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