Revision of the genera *Acineria*, *Trimyema* and *Trochiliopsis* (Protozoa, Ciliophora)

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Synopsis

The genera *Acineria*, *Trimyema* and *Trochiliopsis* are reviewed. The revision is based on an investigation of each of the type-species, namely *Acineria incurvata* Dujardin, *Trimyema compressa* Lackey, and *Trochiliopsis opaca* Penard, which were found in a sewage-treatment plant. *Acineria* comprises three species; *A. incurvata*, *A. nasuta*, and *A. uncinata*. *A. acuta* is a synonym of *A. incurvata*. *Trimyema* comprises eight species; *T. alfredkahli*, *T. claviformis*, *T. compressa*, *T. echinometrae*, *T. kahl*, *T. marina*, *T. minuta* and *T. pleurispiralis* but *T. alfredkahli* and *T. claviformis* are perhaps synonyms of *T. marina*. *Trochiliopsis* is monotypic and new for the fauna of Austria. This genus is apparently closely related to the autochthonous soil ciliate *Stammeridium kahli*.

Zusammenfassung


Introduction

Only few activated-sludge ciliates have been characterized by silver-staining techniques which is sometimes necessary for their correct identification. To overcome this deficiency, a project to redescribe the most frequently occurring species was begun. During these studies the poorly known type-species of the genera *Acineria*, *Trimyema*, and *Trochiliopsis* were found. They have been reinvestigated using modern techniques which provide a base upon which to revise these genera.

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Materials and Methods

Acineria incurvata, Trimyema compressa, and Trochiliopsis opaca were obtained from activated sludge of the sewage-treatment plant at Aspach, Upper Austria.

Small samples of activated sludge were placed in glass petri-dishes where they remained without additional aeration. In such cultures a surprising succession and enrichment of ciliates often occurred. Acineria incurvata could also be cultured in tap water enriched with a crushed wheat grain which supported the growth of many small prey ciliates (Dexiotricha, Uronema).

The infraciliature was revealed with a protargol silver-staining method (Foissner, 1982). The silverline system was studied in specimens impregnated by a modified ‘dry’ silver-impregnation technique (Foissner, 1976). The oral structures of Trimyema compressa were impregnated by the pyridinated silver carbonate method of Fernandez-Galiano (1976) as improved by Augustin et al. (1984).

For scanning electron microscopy Acineria cells were fixed for 10 minutes in Parducz’s solution (2% OsO₄ and concentrated Hg-sublimate solution, 4:1), rinsed in 0.05 M sodium cacodylate buffered at pH 6.3, dehydrated in an isopropyl alcohol series (60%, 70%, 80%, 90%, 100%, 100%, five minutes each) and put into a mixture of isopropyl alcohol (100%) and frigen 11 (2:1, 1:1, 1:2, five minutes each). Finally, cells were transferred into pure frigen 11 and critical point dried, using frigen 13. Specimens were gold-sputtered three times for six minutes each.

Each species was drawn from life as well as from impregnated specimens using a camera lucida for the latter. The drawings are only slightly diagrammatic. All statistical procedures follow methods described in Sokal & Rohlí (1981).

Genus ACINERIA Dujardin, 1841

Diagnosis. Amphileptidae Bütschli, 1889 with (1) compressed oral slit anteriorly rolled up and overlapping to the left side forming (together with the anterior dorsal margin) an oblique spoon-like excavation, (2) three perioral kineties (one left and two right of the cytostome), (3) somatic kineties on the right side successively shortened along the cytostome, (4) oral slit measuring less than half of body length being located at the convex side of the tapering anterior. Freshwater and marine, prefers polysaprobic conditions.

Type-species. Acineria incurvata Dujardin, 1841

Remarks. Acineria was mentioned for the first time by Dujardin (1840) in the family ‘Trichodiens’ but without any valid characterization. In 1841 he gave a rather vague diagnosis of the genus and of two species. Maupas (1883) criticized the unsatisfactory diagnosis and gave a better description of Acineria incurvata even noting the overlapping anterior end which is the main character of Acineria; nevertheless, he did not include this character in the diagnosis. How Maupas (1883) arrived at the conclusion that his species was the same as that described by Dujardin remains, however, inexplicable. It was only Kahl (1926) who used the real character of the overlapping dorsal end of the mouth to the left side to distinguish Acineria from the most closely related genus Litonotus. But there is no indication in the infraciliature that the dorsal margin and the left side coalesce as supposed by Kahl (1926, 1931). Thus, Kahl’s interpretation that a part of the ciliated right side of the genus Litonotus has shifted over to the left side in Acineria is not supported by our investigations. We consider the rolled up anterior part of the mouth to be the reason for the anterior overlapping of the dorsal margin. The occurrence of somatic kineties on the left side, as stressed by Kahl (1926) is a weak distinctive character because this happens also, more or less pronounced, in the genera Litonotus and Amphileptus (Foissner, 1984).

Key to the species

1a Single spherical macronucleus
1b Macronucleus in two parts with a single micronucleus between them
2a Cytostome restricted to the rolled up anterior pole, right side with 3 somatic kineties, left side unciliated
2b Cytostome about one third of body length, 10–12 normally ciliated somatic kineties

A. nasuta
A. uncinata
A. incurvata
THE GENERA ACINERIA, TRIMYEMA AND TROCHILIOPSIS

Descriptions of species

Acineria incurvata Dujardin, 1841

?Trachelius anaticula Ehrenberg, 1833
Acineria acuta Dujardin, 1841
?Amphileptus anaticula Claparede & Lachmann, 1859
Lionotus reversus Kahl, 1926
Amphileptus incurvatus Lepsi, 1926a
Lionotus lamella Fryd-Versavel et al., 1975

NEOTYPE-SPECIMENS. Slide (protargol silver impregnated) of neotype-specimens has been deposited in the British Museum (Natural History) in London, reference number 1986:5:30:1.

REDESCRIPTION (Figs 1–3, 12–58, Table 1). Type species of the genus. Freshwater and marine. About 45–200 μm (Dujardin, 1841; Maupas, 1883; Kahl, 1926, 1928, 1931, 1933; Horváth & Kuhn, 1941; Bick, 1972; Foissner, 1977/78). Abnormal, giant individuals up to 500 μm showing most organelles duplicated observed by Foissner (1977/78) and probably by Lepsi (1965) (Figs 28–30). Body oblong, slightly contractile, laterally compressed, rounded posteriorly, narrowing anteriorly to a blunt point. Rather variable in shape (slender to wide and plump) depending on nutritional condition (Figs 31–34). Ventral side more or less convex, dorsal side straight or concave in the anterior, convex in the posterior region. Excavated region conspicuous, shining brightly. Anterior-most dorsal top somewhat refractive, due to the rolled up oral slit. Macronucleus in two spherical to ovoid parts with a single micronucleus between them. 1–3 micronuclei according to Maupas (1883). Macronuclear parts fuse during bipartition (Horváth & Kuhn, 1941) (Figs 38–42) and divide in the later fission stages (Kahl, 1926). Single contractile vacuole at the posterior pole, diameter about 7 μm, with 5–8 pores on the right lateral side (Horváth & Kuhn, 1941) (Fig. 43) which could not be seen in our slides. Cytoproct terminal, a slightly laterally located slit (Maupas, 1883; Kahl, 1926). Pellicle soft, flexible, with longitudinal furrows in which the cilia and bristles originate. Furrows disappear in well-fed individuals. Extrusomes straight to slightly fusiform (arrow-shaped according to Foissner, 1977/78), thin, about 4 μm long (2 μm according to Horváth & Kuhn, 1941), located along the cytostome, a small accumulation of them in the ventral side of the posterior end and even a few scattered throughout the body (Figs 48, 49). Cytoplasm of normally-fed specimens rather clear, containing some small colourless spheres. Carnivorous, feeds on small hymenostome ciliates, e.g. Colpidium, Cyclidium, Glaucoma, Pseudocolohemus, Loxocephalus, Uronema (Maupas, 1883; Lepsi, 1926a; Kahl, 1926, 1931; Buck, 1961; Struhal, 1969). Starved individuals feed even on ‘cysts’ of Euglena viridis (Horváth & Kuhn, 1941) and perhaps on bacteria (Lepsi, 1926a). Ingestion vacuoles rather large, dividing quickly into smaller food vacuoles (Horváth & Kuhn, 1941). Movement moderately quick, gliding on the bottom of the petri-dish or swimming in rotation along its longitudinal axis. Bipartition by transverse fission (Lepsi, 1926a; Horváth & Kuhn, 1941) (Figs 38–42). Opisthe almost spherical when it separates from the proter (Kahl, 1926; Horváth & Kuhn, 1941) (Fig. 40). Very small degenerative forms tend to conjugate; during this process the mouth of an individual fuses with the back of another (Kahl, 1926) (Fig. 20). Encystment frequently occurring when food is depleted (Horváth & Kuhn, 1941). Endocyst forms within an hour, later the macronuclear parts fuse to a worm-shaped product. Wall of ectocyst without visible structure. Cysts surrounded by some material which sticks them to the bottom of the culture dishes or to the bacterial film on the surface of the culture medium (Horváth & Kuhn, 1941) (Fig. 35).

Three different types of cilia: (1) normal cilia, about 10 μm, (2) short bristles, about 0.5–1.0 μm, (3) club-shaped bristles, up to 2.0 μm. Eleven longitudinal kineties with cilia type 1, about 8–9 of them on the right and about 3 on the left side. This is in accordance with the numbers given by Kahl (1926), Horváth & Kuhn (1941), and Fryd-Versavel et al. (1975). In addition to the normal somatic kineties the following are found on the more differentiated left side: (1) a single kinety with cilia type 2 located to the left of the brosse kinety and often extending only to the middle of the body, its posterior basal bodies less closely spaced, (2) one brosse row of obliquely arranged, paired bristles (cilia type 3) being posteriorly continued by a row of unciliated kinetosomes (or by kinetosomes
with very short bristles only), (3) one kinety consisting apically of 2–3 cilia of type 2 (probably constituting a rudimentary borse row) and being continued by a few unciliated kinetosomes (about 5 in the anterior third and about 3 kinetosomes in the middle of the body). Kahl (1926, 1931) described the borse as being built up of 3 rows of bristles (Fig. 21). Foissner (1977/78) observed only a file-shaped structure there, most probably suggested by the single row of paired borse-bristles.

Cytostome more or less curved, anteriorly overlapping to the left side but not to the right as described by Lepsi (1926a,b, 1928). Perioral kinety 1 left of cytostome, with paired basal bodies along the mouth, however, only the anterior basal body each bearing cilia of type 2. Perioral kinety 2 and 3 to the right of the oral slit showing closely spaced basal bodies and constituting the so-called 'mane', a conspicuous compact ciliature. Perioral kinety 2 with paired basal bodies along the oral slit, the anterior basal body bears a cilium of type 1. This kinety appears unciliated post-orally. Perioral kinety 3 with single basal bodies but ciliated along the whole body with cilia type 1. Horváth & Kuhn (1941) misinterpreted the perioral kineties 2 and 3 as left and right perioral kineties. Their drawing, however, shows the correct situation, that is to say also perioral kinety 1 (Figs 43, 44). Fryd-Versavel et al. (1975) overlooked the perioral kinety 3 (Figs 45–47).

The silverline system is a linearly orientated fine-meshed lattice (Foissner, 1977/78) (Fig. 50a).

OCCURRENCE AND ECOLOGY. Dujardin (1841) found this species in a 20-day-old infusion of material from the Mediterranean Sea. It was recorded from the brackish waters of Oldesloe and Kiel (Kahl, 1928, 1933), from the Roumanian littoral of the Black Sea (Lepsi, 1926a,b; Tucolesco, 1962a) and from the periphyton of brackish and marine waters of Königshafen near List (Sylt, Germany) (Küsters, 1974).

Some authors mentioned also terrestrial habitats (Radu & Tomescu, 1972; Tomescu, 1978), but a reliable record is not available (Foissner, 1987). The drawing made by Stella (1948), who claimed to have found Acineria incurvata in a pine forest, indicates that it was (probably) a member of the genus Spathidium (Fig. 22).

Acineria incurvata has been frequently found in strongly saprobic freshwater habitats, such as different sewage-loaded watercourses (Horváth & Kuhn, 1941; Buck, 1961; Bick, 1972; Madoni & Ghetti, 1977; Foissner, 1977/78), in Sphaerotilus tufts (Vašiček, 1964; Struhal, 1969), on the bottom of the river Elbe upstream from Hamburg (Grimm, 1968), in a cesspool (Kahl, 1926), and in sewage-treatment plants (trickling filters in good working order, aeration tanks) (Buck, 1961; Weninger, 1971; Madoni, 1981). Fryd-Versavel et al. (1975) found their 'Litonotus lamella' in a pond in the year 1962. Šrámek-Hušek (1956, 1958) noted it as a true member of the 'Colpidium colpodae'. Weninger (1971) found a decreasing abundance when nitrate or ammonium was added to sewage, whereas phosphate strongly increased its number.

The above data suggest that Acineria incurvata is a widely distributed polysaprobic euryhaline indicator species with a rather high tolerance of lack of oxygen and high concentrations of NH₄⁺.

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Figs 1–23 Acineria.

Figs 1, 2 Acineria incurvata after Dujardin (1841).

Fig. 3 Acineria acuta after Dujardin (1841).

Fig. 4 Acineria nasuta after Lepsi (1962).

Figs 5–11 Acineria uncinata after Tucolesco (1962a). 5 Anterior pole. 6 Posterior pole, 7, 8 Right and left side. 9 Mouth and anterior pole overlapping towards the left side. 10 Ventral view. 11 Dorsal view.

Table 1  Biometrical characterization of *Acineria incurvata*

<table>
<thead>
<tr>
<th>Character</th>
<th>(\bar{x})</th>
<th>M</th>
<th>SD</th>
<th>SE</th>
<th>CV</th>
<th>Min</th>
<th>Max</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body, length</td>
<td>56.25</td>
<td>54.5</td>
<td>7.50</td>
<td>1.67</td>
<td>13.3</td>
<td>46.0</td>
<td>75.0</td>
<td>20</td>
</tr>
<tr>
<td>Body, width</td>
<td>15.50</td>
<td>16.0</td>
<td>2.01</td>
<td>0.45</td>
<td>13.0</td>
<td>12.0</td>
<td>19.0</td>
<td>20</td>
</tr>
<tr>
<td>Number of macronucleus parts</td>
<td>2.00</td>
<td>2.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>2.0</td>
<td>2.0</td>
<td>20</td>
</tr>
<tr>
<td>Macronucleus part, length</td>
<td>9.65</td>
<td>10.0</td>
<td>1.60</td>
<td>0.36</td>
<td>16.6</td>
<td>7.0</td>
<td>13.0</td>
<td>20</td>
</tr>
<tr>
<td>Macronucleus part, width</td>
<td>7.35</td>
<td>7.5</td>
<td>0.83</td>
<td>0.18</td>
<td>13.3</td>
<td>6.0</td>
<td>9.0</td>
<td>20</td>
</tr>
<tr>
<td>Number of micronuclei</td>
<td>1.00</td>
<td>1.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>1.0</td>
<td>1.0</td>
<td>20</td>
</tr>
<tr>
<td>Micronucleus, length</td>
<td>2.42</td>
<td>2.2</td>
<td>0.66</td>
<td>0.15</td>
<td>27.1</td>
<td>1.8</td>
<td>4.0</td>
<td>20</td>
</tr>
<tr>
<td>Micronucleus, width</td>
<td>2.12</td>
<td>2.0</td>
<td>0.47</td>
<td>0.11</td>
<td>22.3</td>
<td>1.6</td>
<td>3.6</td>
<td>20</td>
</tr>
<tr>
<td>Cytostome, length (measured as chord)</td>
<td>22.55</td>
<td>22.0</td>
<td>3.50</td>
<td>0.78</td>
<td>15.5</td>
<td>15.0</td>
<td>28.0</td>
<td>20</td>
</tr>
<tr>
<td>Distance from apex to posterior end of brosse</td>
<td>16.90</td>
<td>19.5</td>
<td>2.66</td>
<td>0.60</td>
<td>13.6</td>
<td>14.0</td>
<td>25.0</td>
<td>20</td>
</tr>
<tr>
<td>Number of brosse-bristles</td>
<td>41.20</td>
<td>40.0</td>
<td>4.18</td>
<td>0.93</td>
<td>10.1</td>
<td>34.0</td>
<td>48.0</td>
<td>20</td>
</tr>
<tr>
<td>Brosse-bristles, maximal length</td>
<td>1.72</td>
<td>1.8</td>
<td>0.24</td>
<td>0.05</td>
<td>14.3</td>
<td>1.2</td>
<td>2.0</td>
<td>20</td>
</tr>
<tr>
<td>Number of left perioral kineties</td>
<td>1.00</td>
<td>1.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>1.0</td>
<td>1.0</td>
<td>20</td>
</tr>
<tr>
<td>Number of right perioral kineties</td>
<td>2.00</td>
<td>2.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>2.0</td>
<td>2.0</td>
<td>20</td>
</tr>
<tr>
<td>Number of normally ciliated kineties (cilia type 1), perioral kineties excluded</td>
<td>10.85</td>
<td>11.0</td>
<td>0.59</td>
<td>0.13</td>
<td>5.4</td>
<td>10.0</td>
<td>12.0</td>
<td>20</td>
</tr>
</tbody>
</table>

1All data are based on protargol silver impregnated specimens. All measurements in \(\mu\m). Legend: \(\bar{x}\), mean; M, median; SD, standard deviation; SE, standard error of mean; CV, coefficient of variation in \%. Min, minimum; Max, maximum; n, sample size.

**Remarks.** *Trachelius anaticula* Ehrenberg, 1833 is an older but unreliable synonym of this species. *Acineria acuta* Dujardin, 1841, which was observed in the water of a wheel-track in 1838, has been very insufficiently described and therefore cannot be discriminated from *Acineria incurvata*. Thus, *Acineria acuta* is here treated as synonym. *Amphileptus anaticula* perhaps is a synonym, too, but the figure given by Claparède & Lachmann (1859) shows an unidentifiable individual with a voluminous ingestion vacuole. The synonym *Lionotus reversus* Kahl, 1926 results *par lapsus*, since Kahl mentioned in a footnote that he had found Maupas' good description of *Acineria incurvata* just after having finished the manuscript. The synonym *Lionotus lamella* results from an obvious misidentification by Fryd-Versavel et al. (1975).

**Acineria nasuta** Lepsi, 1962

**Diagnosis** (Fig. 4). Marine. About 90–100 \(\mu\m\) long, rather wide. Only one single macronucleus. Pellicle with 5–6 distinct stripes. Postapical, to the right of the so-called 'nose' a peculiar line (perhaps the mouth) which is said to be characteristic of this species.

**Occurrence and ecology.** Only a few individuals were found in a raw culture of putrefying marine algae. In the same culture *Holophrya torquabilis* occurred in large numbers, probably serving as food for *Acineria*.

THE GENERA ACINERIA, TRIMYEMA AND TROCHILIOPSIS
Figs 56–58 Acineria incurvata, scanning electron micrographs. 56 Total view of left side. 57 Anterior part with dorsal oral region rolled up forming a spoon-like excavation. Note the club-shaped brosse-bristles, the short bristles of the perioral kinety 1, and the long cilia of perioral kineties 2 and 3 (arrows). 58 Detail of anterior third with brosse-bristles, short bristles and normal cilia (arrows).

Figs 48–55 Acineria incurvata, originals. 48 Left side from life and according to scanning electron microscopic observations, scale = 20 µm. 49 Exrusome, length about 4 µm. 50 Reconstructed cross-sections in different regions of body. 50a Silverline system in the oral region, dry silvered, after Foissner (1977/78). 51 Right side, infraciliature of a protargol silver stained specimen. P2, P3, perioral kineties 2 and 3. 52 Left ventro-lateral view of a protargol silver stained specimen with different types of cilia and bristles according to SEM-observations. 53, 54 Infraciliature of the left ventro-lateral and the right dorso-lateral side of a protargol silver impregnated specimen. P1–3, perioral kineties 1–3; Br, Brosse; scale = 30 µm. 55 Ventral view.
Remarks. Lepsi (1962) assumed that this species, which has remained unmentioned since original description, could be a form of *A. incurvata* and mentioned some relationship with the genera *Chilophrya* and *Plagiocampa*. His figure and description are so incomplete that it is at present impossible to find any reliable affinity. The single macronucleus suggests that it is not an Amphileptidae, although he could have observed a dividing stage with fused macronucleus.

*Acerinia uncinita* Tucolesco, 1962a

Diagnosis (Figs 5–11). Brackish and freshwater. About 35–55 µm. Body lanceolate without lateral edge. Anterior pole overlapping towards the left side. Two spherical macronuclei showing a clearer zone at their central region. Sometimes a single, elongated, tapered nucleus. Contractile vacuole terminal, often surrounded by a group of smaller vacuoles. Cytostome a straight and short slit restricted to the rolled up anterior pole. Can therefore feed only on small prey (flagellates). Three somatic kinetics on the right side with 20–22 cilia each. Cilia at the ventral margin of the anterior third transformed to regularly curved crotchets.

Occurrence and Ecology. This species was found in summer 1954 in a small dirty brackish puddle near Lake Tekirghiol and in mesosaprobic freshwaters of Bucarest.

Remarks. Tucolesco (1962a) separated this species from *A. incurvata* by the non-overlapping post-oral dorsal margin. However, in *A. incurvata* the situation is rather similar (page 199). Thus, we propose the following characters for discrimination from *A. incurvata*: the presence of only three somatic kinetics on the right side, the (probably) unciliated left side, and the short oral slit being restricted to the anterior pole. Unmentioned since description. Note after proof reading: This is a valid species which we rediscovered recently! Redescription is in preparation.

**Genus TRIMYEMA** Lackey, 1925

*Sciadostoma* Kahl, 1926

Diagnosis. Trimyemidae Kahl, 1933 (syn. Sciadostomatidae Kahl, 1926) with vestibulum and cytostome near apical end. Vestibular ciliature consisting of three rows of cilia, two rather long ones arranged approximately in a semicircle at the left margin of the vestibulum and an inner rather short third row located near the cytostome at the posterior left of the vestibulum. Somatic ciliature in longitudinal kinetics but arranged in a way that a more or less wide band of oblique spirals is formed. Prominent caudal cilium. Body small, mostly tapered at both ends. Free-living and endocommensally, freshwater and marine, polysaprobic.

Type-species. *Trimyema compressa* Lackey, 1925

Remarks. There is much confusion about the exact orientation of the cell: dorsal, lateral, and ventral sides are often mixed up in descriptions. In addition some authors have given incorrect figures focusing the microscope on the lower surface of their specimens. Thus, they attained inverted figures (see explanations to figures). Most species of the genus *Trimyema* are only superficially described. The oral structures are known exactly only of *T. compressa* (Figs 83, 107) and

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partly of *T. pleurispiralis* (Fig. 96) and *T. echinometrae* (Fig. 93). From the descriptions and our investigations we deduced the basic structure of the oral apparatus as described above (compare Fig. 107). Fauré-Fremiet (1962) and Borror (1972) obviously overlooked the short third vestibular kinety. Borror (1972) described only an inner and an outer ‘polykinety’. Detcheva *et al.* (1981), however, showed in *T. compressa* electronmicroscopically that, despite their polykinetal appearance, the vestibular ciliary systems are not separate polykineties but are the anterior parts of the somatic kineties that are preceded by parasomal sacs and retain the same fibrillar systems as the somatic kinetosomes. Jankowski (1964*ab*) gave no evidence for his statement that there were four vestibular kineties in *T. compressa*.

Encystment is unknown in this genus. Czapik (1975a) noted that even starved specimens (of *T. compressa*) die without forming cysts. Morphogenesis has not yet been exactly studied. However, the oral apparatus is supposed to reduce before cell division, because during division both proters and opisthe show the same state of development of the oral apparatus (Kahl, 1926) (Figs 67, 69).

The silverline system has been demonstrated only in *T. compressa* (Klein, 1930; Fauré-Fremiet, 1962; Jankowski, 1964*ab*; Czapik, 1975a). Klein (1930) gave the description that best agrees with our observations (Figs 106, 110). But he did not draw the transverse silver lines connecting the longitudinal lines in the region of the ciliary spirals. The granules located at and in the silverlines (Fig. 110) have been said to be mucocysts ('Relationskörner') or rudimentary basal bodies (Klein, 1930). However, the electronmicroscopic investigation shows only mucocysts (Detcheva *et al.*, 1981).

The exact taxonomic position of the genus is still unclear. Kahl (1926) created a new family for the rather special helical ciliation. This author, Corliss (1979), and Curds (1982) included the family in the order Trichostomatida Bütschli, 1889. Fauré-Fremiet (1962) noted that the family Trimyemidae indeed presents one of numerous possibilities existing in the order to use the anterior-most somatic kineties for building up a vestibular ciliation. In addition, he indicated possible affinities of *Trimyema* with *Mycterothrix* and *Maryna*, which are now ‘good’ colpodids (Foissner, 1985a). Jankowski (1980) erected the new order Trimyemida (*incertae sedis*) giving no reasons for this decision. On the contrary, Detcheva *et al.* (1981) stated that *Trimyema* is a member of the Vestibulifera and that the Trimyemidae show the same general type of vestibular architecture as the Plagiopyllidae and the Coelosomidae. However, a more reasonable classification demands further investigations especially on the morphogenetic processes.

Ruinen (1938) is wrong in transferring *Palmarium salinum* Gajevskaja, 1925 to the genus *Trimyema*, since *Palmarium* is illustrated as having an adoral zone of membranelles (Figs 97–101) (Borror, 1972).

*Trimyema pura* (Ehrenberg) is listed by Curds (1975) as a species occurring in percolating filters and in activated sludge. We suppose that this species has been described as *Trichoda pura* Ehrenberg, 1831, which according to Corliss & Dougherty (1967) is a synonym of *Tetrahymena pyriformis*.

Lackey (1925) classified *Trimyema* as female using the latin ending -a for his species *T. compressa*. Since we could not find any greek word comparable to ‘myema’ from which the name of the genus and its sex could be derived we accept Lackey’s proposal of the sex. This, however, requires the endings of *T. claviforme*, *T. marinum*, *T. minutum*, and *T. pleurispirale* to be emended (see below).

### Key to the species

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>3 somatic ciliary spirals</td>
<td>2</td>
</tr>
<tr>
<td>1b</td>
<td>Usually more than 3 somatic ciliary spirals</td>
<td>3</td>
</tr>
<tr>
<td>2a</td>
<td>Posterior end of body tapered, length 25–65 μm</td>
<td><em>T. compressa</em></td>
</tr>
<tr>
<td>2b</td>
<td>Posterior end of body broadly rounded, prominent beak-like pharynx opening, length c. 20 μm</td>
<td></td>
</tr>
<tr>
<td>3a</td>
<td>Body broadly oval, width c. half length of body</td>
<td>4</td>
</tr>
<tr>
<td>3b</td>
<td>Body rather slender, fusiform or oblong, width much less than half length of body</td>
<td>5</td>
</tr>
</tbody>
</table>
THE GENERA *ACINERIA, TRIMYEMA AND TROCHILIOPSIS*

4a 4(−6) somatic ciliary spirals restricted to the anterior half of body, length c. 20–45 μm.  \(T.\) *pleurispiralis*

4b 7 somatic ciliary spirals restricted to the anterior half of body, length c. 25–40 μm, endocommonially in sea-urchins  \(T.\) *echinometrae*

5a Body club-shaped, thickened in the anterior region and slender in the posterior region, length c. 40 μm, (not totally reliable species!)  \(T.\) *claviformis*

5b Body not club-shaped

6a Shape of body obviously asymmetric, tapered at both ends, anterior pole bent to the right, posterior pole bent to the left, peristome measures c. one third of cell length  \(T.\) *kahli*

6b Shape of body symmetrical, slender fusiform to slender oblong

7a Body length c. 40 μm, peristome measures c. one fourth of body.  \(T.\) *marina*

7b Body length c. 60 μm, peristome measures less than one fourth of body (not totally reliable species!)  \(T.\) *alfredkahli*

### Descriptions of species

*Trimyema compressa* Lackey, 1925

*Sciadostoma difficile* Kahl, 1926

*Trimyema compressum* Kahl, 1933

*Trimyema marinarum* Fauré-Fremiet, 1962

**Neotype-specimens.** Slides (dry silvered and protargol silver impregnated) of neotype-specimens have been deposited in the British Museum (Natural History) in London, reference numbers 1986:5:30:2–3.

**Redescription** (Figs 59–86, 104–113, Table 2). Type species of the genus. Freshwater and marine. *In vivo* about 25–50(−60) × 15–20(−35) μm (Lackey, 1925; Kahl, 1926, 1928, 1931, 1933; Wang & Nie, 1935; Liebmann, 1936; Czapik, 1975a; Schmall, 1976; Detcheva *et al.*, 1981). Body fusiform to plump S-shaped, laterally slightly flattened, anterior and posterior end slightly tapered. Dorsally and ventrally an inconspicuous ectoplasmatic ridge, the so-called keel (unrecognized by us) (Kahl, 1926; Wang & Nie, 1935). Macronucleus spherical to slightly oval, located centrally in most specimens. Schmall (1976) found it to be more variable, also located posteriorly. Micronucleus closely attached to the macronucleus. In protargol impregnated specimens often a second, weakly stained macronucleus-like structure, probably a large ingestion vacuole (Fig. 109). Macronucleus usually heavily stained, surrounded by dark, slightly curved rods measuring c. 2 μm in length and 0.5 μm in width. These aggregated rods look like bacteria. Detcheva *et al.* (1981), however, consider them to be mitochondria, which is not supported by recent studies on other sapropelic ciliates (Van Bruggen *et al.*, 1984). Contractile vacuole and its pore located in the region of the last ciliary spiral on the right ventro-lateral side. Cytoproct a slit *circa* 5–10 μm long, located in the right dorso-lateral surface (Figs 104, 105, 108). Pellicle thin, flexible and deformable, with very slight ridges paralleling the longitudinal kinetics. In protargol impregnated specimens these ridges appear darkly stained and produce a negative image of the silverline system. Cytoplasm rather transparent, contains a lot of refractive long-oval (length about 0.5–1.5 μm) granules which are also visible in protargol stained specimens. They are most probably the mucocysts described by Detcheva *et al.* (1981). Food vacuoles about 5 μm in diameter. Cyclosis pronounced (Lackey, 1925). Feeds on bacteria but is not dependent on sulphur bacteria (Liebmann, 1947). Moves slowly and slightly tremblingly in a straight line or in the arc of a circle rotating on its longitudinal axis (Lackey, 1925). Reproduction by transverse fission (Lackey, 1925; Kahl, 1926, 1931; Czapik, 1975a).

Somatic cilia 7–9 μm, strongly beating, arranged in about 50–60 longitudinal kinetics but more commonly viewed as 3 oblique spirals. In the anterior region of these spirals the third, fourth, and fifth kinetosomes are paired, constituting the compact field of cilia, consisting of 3 × 4 and 2 × 2 cilia, described by Schmall (1976) (Figs 75, 113). A short row of about 5–10 cilia on the ventral side extends obliquely from the posterior end of the anteriormost somatic spiral to the right. Posterior
third of body unciliated apart from the caudal cilium measuring about one third to one half of body length (Lackey, 1925; Kahl, 1931; Wang & Nie, 1935); it is perhaps involved in the process of defecation (Liebmann, 1936) (Figs 62–65).

Vestibulum circa one third of body length, funnel-shaped. Left half of the oral depression more excavated than the right one and, as a consequence, the left margin becomes a thin, transparent layer of ectoplasm and forms a cap or hood-like process bordering the vestibulum (Kahl, 1926; Wang & Nie, 1935). Cytopharyngeal fibres inconspicuous, rectangular to the entrance of the vestibulum. Vestibular kinety 1 a bit longer than vestibular kinety 2. At their anterior ends 4 to 5 pairs of basal bodies or single basal bodies with parasomal sacs. Vestibular kinety 3 consists of only 6–7 cilia (Figs 107, 111, 112). In stained specimens somatic as well as vestibular kinetosomes appear to be paired (Figs 106–113) but in fact, the anterior granule is a parasomal sac (Detcheva et al., 1981), probably with the exception of the above mentioned compact field.

About 60 longitudinal silver lines (Czapik, 1975a mentioned 52 lines), connected by transverse lines which are located between the somatic ciliary spirals. In front of the anteriormost ciliary spiral a circumoral silver line from which a few longitudinal lines extend to the vestibulum forming square-like fields at its rim. The longitudinal silver lines fuse at the posterior third forming rough meshes (Figs 106, 110).

OCCURRENCE AND ECOLOGY. First recorded from the sewage disposal of Imhoff tanks in New Jersey and later listed as an obligate anaerobe (Lackey, 1925, 1938; Noland & Gojdics, 1967). Very similar habitats were reported by Liebmann (1936, 1947, 1951), who found T. compressa regularly in waters containing a lot of organic matter and H₂S, such as in over-loaded percolating filters, in Imhoff tanks (3–5 ind.ml⁻¹ and 40 ind.ml⁻¹), in sewers, and at the outfalls of communal waste waters.

Further habitats are the sapropel of ponds near Leningrad (Jankowski, 1964a, b), ponds used for the treatment of sugar factory wastes (Grabacka, 1973), the plankton of the eutrophic pond ‘Poppelsdorfer Weiher’ in Bonn (Wilbert, 1969), a small eutrophic lake at Uttendorf/Salzburg (Foissner, unpublished), and an arctic tundra pond at Barrow/Alaska (Fenchel, 1975). Detcheva (1972) and Czapik (1975a, b) listed up Bulgarian and Polish habitats like ponds, lakes, ditches, and polluted rivers. Wang & Nie (1935) observed some individuals among decaying organic substances taken from Lake Ho Hu. Kahl (1926, 1931, 1933) found it in the sapropel, in a cesspool, in sewage, and more rarely in the brackish waters of Oldesloe (Kahl, 1928) thus considering it to be of freshwater origin. Fauré-Fremiet (1962) found it in a rock pool on the French Atlantic coast. Tucolesco (1962b) recorded it from the Black Sea and from the saliferous, para-marine Lake Tekirghiul in Roumania. According to Sládeček (1972) T. compressa developed in great numbers (up to 10,000 ind.ml⁻¹) in a sample of industrial waste water from a textile factory.

Figs 87–103 Trimyema.

Figs 87–89 Trimyema marina. 87, 88 After Kahl (1933). 89 After Kahl (1931).

Figs 90, 91 Trimyema minuta after Kahl (1931), dorsal and left lateral view.

Fig. 92 Trimyema claviformis after Kahl (1933).

Figs 93, 94 Trimyema echinometrae after Grolière et al. (1980), protargol silver impregnated specimens (inverted), lateral view and ventral view (the latter designated as lateral view, too).

Figs 95, 96 Trimyema pleurispiralis after Borror (1972). 95 Left ventro-lateral view. 96 Anterior pole with anteriormost somatic ciliary spiral (at the left) and with vestibular ciliature.


Fig. 102 Trimyema alfredkahl after Tucolesco (1962a), left lateral view.

Fig. 103 Trimyema kahl after Tucolesco (1962a), left lateral view.
Figs 104–109 *Trimyema compressa*, originals, scale = 20 µm each. 104 Left ventro-lateral view, from life. 105 Right dorso-lateral view of an S-shaped individual. CP, cytoproct. 106 Dorsal view of a dry silvered specimen. 107 Vestibular ciliature revealed by Fernandez-Galiano’s method. The shape of the vestibular kinetics has been slightly deformed by preparation; they are less curved in life. V1–3, vestibular kinetics 1–3. 108, 109 Ventral and dorsal view of a protargol silver impregnated specimen amended with details from individuals impregnated with Fernandez-Galiano’s method. CVP, contractile vacuole pore.
Figs 110–113  *Trimyema compressa*. 110 Silverline system revealed by the dry silver impregnation technique, dorsal view. 111–113 Specimens stained by Fernandez-Galiano’s impregnation technique. 111 Left side with the three ciliary spirals and apex with vestibular ciliature consisting of two long rows and one short row of cilia (arrow). 112 Dorsal view, arrow indicates the three vestibular kinetics. 113 Ventral view, arrow indicates the isolated basal bodies at the anteriormost region of the vestibular kinetics.
Bick (1968, 1972) gave the most detailed ecological characterization. *T. compressa* is an outstanding indicator of polysaprobit (Liebmann, 1951), isosaprobit and even metasaprobit (Sládeček, 1973) and occurs in waters receiving fresh manure and sewage, or waste waters containing cellulose material (paper mill outlets, etc.). The species seems to prefer conditions with low ammonia content, i.e. conditions prevailing during the decay of cellulose and other material poor in nitrogenous compounds. The saprobological evaluation is indicated by Sládeček (1972): $x = 0$, $o = 0$, $p = 10$, $G = 5$, $s = 5.3$ (E, $H_2S$).

**Remarks.** This species differs from *T. minuta* particularly by the tapered posterior end. It can easily be distinguished from the other species by its having only three somatic ciliary spirals. Faure-Fremiet (1962) observed an abundant population of *Trimyema* (Figs 84–86) and identified it as *T. marina* although it was of an ovoid and stocky form which was not described by Kahl (1931, 1933, 1935). On the contrary this author later stated that *T. marina* is usually one third to one half more slender than he drew it in 1931 (Kahl, 1931, Fig. 89; Kahl, 1933, Figs 87, 88). Thus we suppose that Faure-Fremiet worked on *T. compressa*.

**Table 2** Biometrical characterization of *Trimyema compressa*

<table>
<thead>
<tr>
<th>Character</th>
<th>$\bar{x}$</th>
<th>M</th>
<th>SD</th>
<th>SE</th>
<th>CV</th>
<th>Min</th>
<th>Max</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body, length</td>
<td>39.05</td>
<td>39.5</td>
<td>4.58</td>
<td>1.03</td>
<td>11.7</td>
<td>32.0</td>
<td>47.0</td>
<td>20</td>
</tr>
<tr>
<td>Body, width</td>
<td>22.30</td>
<td>23.0</td>
<td>3.01</td>
<td>0.67</td>
<td>13.5</td>
<td>17.0</td>
<td>26.0</td>
<td>20</td>
</tr>
<tr>
<td>Macronucleus, length</td>
<td>11.05</td>
<td>11.0</td>
<td>1.57</td>
<td>0.35</td>
<td>14.2</td>
<td>9.0</td>
<td>14.0</td>
<td>20</td>
</tr>
<tr>
<td>Macronucleus, width</td>
<td>9.35</td>
<td>9.5</td>
<td>1.50</td>
<td>0.34</td>
<td>16.0</td>
<td>6.0</td>
<td>12.0</td>
<td>20</td>
</tr>
<tr>
<td>Number of vestibular ciliary rows</td>
<td>3.00</td>
<td>3.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>3.0</td>
<td>3.0</td>
<td>20</td>
</tr>
<tr>
<td>Number of somatic ciliary rows</td>
<td>3.00</td>
<td>3.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>3.0</td>
<td>3.0</td>
<td>20</td>
</tr>
<tr>
<td>Number of caudal cilia</td>
<td>1.00</td>
<td>1.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>1.0</td>
<td>1.0</td>
<td>20</td>
</tr>
<tr>
<td>Distance from apex to posterior end of vestibulum</td>
<td>9.80</td>
<td>10.0</td>
<td>1.88</td>
<td>0.42</td>
<td>19.2</td>
<td>7.0</td>
<td>15.0</td>
<td>20</td>
</tr>
<tr>
<td>Distance between posterior end of body and posterior end of ciliary spirals</td>
<td>11.00</td>
<td>11.0</td>
<td>1.78</td>
<td>0.40</td>
<td>16.2</td>
<td>7.0</td>
<td>15.0</td>
<td>20</td>
</tr>
</tbody>
</table>

1See footnote Table 1

**Trimyema alfredkahl** Tucolesco, 1962a

**Diagnosis** (Fig. 102). Marine. About 60 µm. Body oblong and slender, slightly tapering anteriorly and posteriorly. Oral apparatus particularly small, bounded at the right margin by a conspicuous dilatation. Macronucleus spherical. Cilia long and fine. According to Tucolesco’s figure ciliary spirals cover nearly the whole body, which contrasts his description. Caudal cilium longer than half body length.

**Occurrence and ecology.** Found in an abundant population in a mixed polysaprobic culture taken from the Black Sea in March 1955.

**Remarks.** This species has remained unmentioned since description. It can perhaps be distinguished from *T. marina* by its oblique orientation of the oral apparatus, which is stressed by Tucolesco (1962a), and by its larger size. However, synonymy cannot be excluded.

**Trimyema claviformis** Kahl, 1933

*Trimyema claviforme* Kahl, 1933

**Diagnosis** (Fig. 92). Marine. *Circa* 40 µm. Body club-shaped. Posterior third of body unciliated.

**Occurrence and ecology.** Found in sapropelic habitats of Sylt and Kiel (Germany).
REMARKS. Very insufficiently described. With exception of the unciliated tapering posterior third of body identical with *T. marina*. Even Kahl (1935) noted that he established this species with some doubt. Thus, synonymy cannot be excluded.

*Trimityema echinometrae* Grolière, Puytorac & Grain, 1980

**Diagnosis** (Figs 93, 94). Marine. Living endocommensally in sea-urchins. About 31 (27–40) × 17 (13–20) μm. Body peg-top like. Macronucleus spherical, 5–7.5 μm in diameter, posteriorly located. Micronucleus not visible. 60 to 70 longitudinal somatic kineties. Cilia distributed in 7 parallel spirals in the anterior half of body. Three vestibular kineties very similarly arranged as in *T. compressa*.

**Occurrence and ecology.** Found in the sea-urchins *Diadema antillarum* and *Echinometra lucunter* from the Gulf of Mexico and the Gulf of Guadeloupe. Housing together with other commensal species like *Biggaria echinometris*, *Metanophrys elongata* and *Metopus circumlabens* (Grolière *et al.*, 1980). Perhaps already Profant (1966) observed this species, since he mentioned *Trimityema sp.* to be a ciliate inhabiting echinoids in the Eastern Pacific Ocean.

**Remarks.** *T. echinometrae* is a reliable species. It differs from the other members of the genus in the number of ciliary spirals. The figures, however, are obviously inverted, because in the genus *Trimityema* the spirals run the other way round. Furthermore, the identification is impeded by the missing drawing from life.

*Trimityema kahli* Tucolesco, 1962a

**Diagnosis** (Fig. 103). Para-marine. About 36–40 μm. Body conspicuously asymmetric, inverted S-shaped. Peristome in the anterior third of body. Macronucleus spherical, usually located in the middle of the cell. Contractile vacuole close behind the middle of body. Cilia long and fine. Ciliary spirals extending to the posterior pole. Caudal cillum almost rigid, bent to the left.

**Occurrence and ecology.** Polysaprobic, found constantly in the para-marine Roumanian Lake Tekirghiol (Tucolesco, 1962a,b).

**Remarks.** This species has remained unmentioned since 1962. However, from its general appearance it seems to be a reliable but insufficiently described species.

*Trimityema marina* (Kahl, 1931)

*Sciadostoma marinum* Kahl, 1931

*Trimityema marinum* Kahl, 1933

**Diagnosis** (Figs 87–89). Marine. About 40 μm. Slender fusiform to slender oblong (4 : 1). In the original figure (Fig. 89) similar to *T. compressa* but later figured and redescribed with 5–6 ciliary spirals (Figs 87, 88).

**Occurrence and ecology.** Repeatedly observed in putrid water of the North and East Sea (Sylt, Kiel) and in salt-water from Oldesloe (Kahl, 1931, 1933, 1935).

**Remarks.** Kahl (1931) considered *T. marina* to be a separable species because he never found similar forms among numerous populations of the freshwater form of *T. compressa*. Later he thought that two forms of this species probably exist and erected the species *T. claviformis* (Kahl, 1933) which, however, is not a totally reliable species (Kahl, 1935). We consider this species and *T. alfredkahli* perhaps to be junior synonyms of *T. marina*.

*Trimityema minuta* nov. comb.

*Sciadostoma minutum* Kahl, 1931

**Diagnosis** (Figs 90, 91). Freshwater and marine. About 20 μm. Rounded posterior and a prominent beak-like pharynx-opening. Ectoplasmatic ridge (keel) more pronounced than in *T.
compressa, extending from the beak-like pharynx-opening over the back to the posterior. Cilia longer and more rigid than in T. compressa.

Occurrence and ecology. This species was found together with T. compressa and was first considered as a modification, but once an abundant population occurred in a ditch contaminated with liquid manure (Kahl, 1931). Wenzel (1961) observed T. minuta in the sponge Halichondria panicea from the Gulf of Naples. Tucolesco (1962b) recorded it twice from old, mixed infusions of the para-marine Roumanian Lake Tekirghiol.

Remarks. Kahl (1931) doubted the species status of this form and did not mention it again in his publication of the year 1935. Further investigations are necessary.

Trinyema pleurispiralis Borr., 1972

Diagnosis (Figs 95, 96). Marine. About 20–44 × 16–23 (usually less than 20) μm. Shape of prepared individuals egg-like, circular in cross section (Fig. 95). Macronucleus spherical, central. Micronucleus not observed. Cytoproct an elongated (approximately 8 μm) slit near posterior pole, lying in the same latitude as cytostome and suture at ends of ciliary spirals. Contractile vacuole pore not observed. Except for elongated caudal cilium, all somatic cilia restricted to anterior half of cell, arranged in at least four spirals (a few individuals possess a partial or even complete fifth spiral, and even a few cilia of a sixth spiral). Outer vestibular kinety in a semicircle dipping posteriorly into vestibulum and terminating near cytostome. Inner vestibular kinety with three regions: (1) anteriormost two isolated tufts of approximately five cilia each, (2) a row of kinetosomes closely paralleling the outer kinety, extending from the tufts down to cytostome, (3) posteriormost a J-shaped field of cilia. As already mentioned, this interpretation of the oral structure is a little erroneous and incomplete.

Occurrence and ecology. Like the other species of this genus T. pleurispiralis is bacterivorous and occurred only irregularly in New Hampshire tidal salt marshes (Borr., 1972).

Remarks. This species differs from the other members of the genus in number and location of ciliary spirals, which are restricted to the anterior half of body. Unfortunately, Borr. (1972) did not give a drawing from life. Thus, the real body shape is unknown. Redescription is needed.

Genus Trochiliopsis Penard, 1922


Type-species. Trochiliopsis opaca Penard, 1922.

Remarks. Trochiliopsis shows many characters which are very likely homologous to genera of the family Microthoracidae Wrześniowski 1870 according to the classification of Foissner (1985b). Thus, a separation of Trochiliopsis at the familial level as suggested by Jankowski (1975) is not justified (Compare Corliss, 1979; Curds, 1982). On the contrary, the organization of Trochiliopsis, especially the general appearance of the infraciliature and the location and structure of the oral apparatus, allows a classification close to the genus Stammeridium. These similarities might have induced Kahl (1931) to synonymize Trochiliopsis with Trichopelma Levander and Leptopharynx Mermod. There are just sufficient differences in the location of the preoral kineties, the paroral membrane, and the shape of the anteriormost region for separating these two genera. Furthermore, by a trivial twist of some organelles of Trochiliopsis, the typical organization of the genus Stammeridium can be achieved (Figs 126, 127): The preoral kineties move to the apex between serrated processes, the paroral membrane gets located obliquely to the longitudinal axis and the contractile vacuole moves close to the ventral side.
Key to the genera of Microthoracina Jankowski 1967 (based on Foissner 1985b)

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
<th>Genus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Microthoracina with somatic cirri-like organelles, fusiform extrusomes, and wide-meshed silver-line system</td>
<td>(Discotrichidae) Discotricha</td>
</tr>
<tr>
<td>1b</td>
<td>Microthoracina with normal cilia, anchor-like extrusomes, and granular or fine-meshed silverline system</td>
<td>(Pseudomicrothoracidae) Pseudomicrothorax</td>
</tr>
<tr>
<td>2a</td>
<td>Microthoracina with more than 10 uninterrupted somatic kineties</td>
<td>(Microthoracidae)</td>
</tr>
<tr>
<td>2b</td>
<td>Microthoracina with fewer than 10, usually 6 partly interrupted somatic and three preoral kineties</td>
<td>Microthorax</td>
</tr>
<tr>
<td>3a</td>
<td>Oral apparatus ventrally in the posterior third of body</td>
<td>Microthorax</td>
</tr>
<tr>
<td>3b</td>
<td>Other</td>
<td>Drepanomonas</td>
</tr>
<tr>
<td>4a</td>
<td>Oral apparatus ventrally between middle and posterior third of body, body more or less oblong</td>
<td>Trochilopsis opaca</td>
</tr>
<tr>
<td>4b</td>
<td>Other</td>
<td>Stammeridium kahl</td>
</tr>
<tr>
<td>5a</td>
<td>Oral apparatus between middle and anterior third of body, rightmost somatic kinety or right side uninterrupted, preoral kineties run in distinct furrows from the ventral to the right body side and form a keel</td>
<td>Leptopharynx</td>
</tr>
<tr>
<td>5b</td>
<td>Other</td>
<td>Trochilopsis opaca</td>
</tr>
<tr>
<td>6a</td>
<td>Rightmost somatic kinety of right side interrupted, preoral kineties run anterior-posteriorly on the left side of the body, paroral membrane circa half body length</td>
<td>single species: Trochilopsis opaca</td>
</tr>
<tr>
<td>6b</td>
<td>Preoral kineties apically in furrows, apex distinctly serrated, paroral membrane shorter than a third of body running obliquely to the longitudinal axis</td>
<td>single species: Stammeridium kahl</td>
</tr>
</tbody>
</table>

Description of species

Trochilopsis opaca Penard, 1922

Trichopelma opaca Kahl, 1931

Leptopharynx opaca Detcheva, 1972

Neotype-specimens. Slides (protargol silver impregnated and dry silvered) of neotype-specimens have been deposited in the British Museum (Natural History) in London, reference numbers 1986:5:30:4–5.

Redescription (Figs 114–131, Table 3). Type species of the genus. Freshwater. In vivo circa 30–40(–50) x 17–20 μm. Body outline oval, anteriorly curved slightly to the ventral side terminating in a pointed beak-like region (peak). Body strongly compressed laterally (circa 2 : 1). Somatic kineties in deep, crenelated furrows, which terminate near the oral peak. Macronucleus spherical, more or less centrally located, in vivo hardly discernible. Micronucleus closely attached to the macronucleus. Contractile vacuole centrally located, close to the right lateral surface, diameter about 4 μm; contractile vacuole pore at the end of the paroral membrane. Cytoproct slightly posterior to the contractile vacuole pore, visible as black line in dry silvered specimin (Fig. 130). Pellicle rigid, colourless, opaque. Extrusomes about 3 μm, fusiform, scattered over the whole body in the ribs between the furrows, show four anchor-like processes at the distal end in the exploded phase. Probably feeds on bacteria, but no food vacuoles were found. Slow, trembling and swaying movements.

Length of cilia 8–10 μm. Six somatic kineties (K1–6), three preoral kineties (P1–3), and a short x-kinety (Figs 124, 125). K1 anterior with 8–10, posterior with 4, K2 anterior with 2, posterior with 5–6, K3 anterior with 12–16, posterior with 5–8, K4 (anterior) with 6–8, K5 anterior with 3–4, posterior with 2, K6 with 10–12 kinetiesomes. At the end of K4 and in the middle of K5 sometimes a single unciliated kinetosome, respectively. Basal bodies of K1–5 mostly paired, K6 always with single kinetosomes. Preoral kinety 1 with 4–5 pairs, preoral kinety 2 constantly with 5 singles, and preoral kinety 3 constantly with 7 singles. x-kinety with 1–2 paired basal bodies located left of the posterior end of the paroral membrane (Figs 120–126).
Fig. 114–126  *Trochiliopsis opaca*, scale = 10 μm each. 114–117 After Penard (1922). 114, 115 Right and left lateral view. 116 View from the apex. 117 Extrusomes with 2, 3, and 4 processes. 118, 119 After Kahl (1931), right and left side. 120–123 Originals, from life and protargol silver stained specimens, right and left side respectively. CP, cytoproct. 124, 125 Schematized organization of *T. opaca*, right and left lateral view. K1–6, somatic kineties 1–6; M, adoral membranelles; PM, paroral membrane; P1–3, preoral kineties 1–3; x–K, x-kinety 126 Probable evolution of *Stammeridium* from *Trochiliopsis*.

Fig. 127  Schematic organization of the genus *Stammeridium* (after Foissner, 1985b).
Figs 128–131 *Trochiliopsis opaca.* 128, 129 Protargol silver impregnated specimens, right and left side. 130, 131 Dry silver impregnated specimens, right and left side.

Probably only two adoral membranelles, located at the oral peak. Anterior adoral membranelle most likely built up by two rows, posterior one probably by three rows of kinetosomes. Paroral membrane with 8–9 paired basal bodies (Figs 120, 122, 124). Cyrtos invisible in life even with interference contrast, but slightly impregnated with protargol silver. Silverline system granular or very fine-meshed.

**Occurrence and ecology.** Penard (1922) found few individuals between dead leaves of the ‘swan pond’ at Ariana (‘… à l'étang des Cygnes’, Switzerland). Kahl (1931) noted *T. opaca* sporadically in the sapropel and sometimes numerous in sapropelic infusions of *Glyceria*. Lackey (1938) recorded it once from a polluted stream, twice from a trickling filter, and five times from an activated-sludge chamber. Noland & Gojdics (1967) mentioned that *T. opaca* occurs when the sludge has reached the finely particulate stage and the bacteria in it are well distributed. Detcheva
(1972) listed some Bulgarian habitats, namely a pond in the surroundings of the village Bosnek in the Witoscha mountains, a marshy meadow in the vicinity of the village Kasitschene near Sofia, and a river in the Wrábniza quarter of Sofia. Apart from in activated sludge, we found this species once in the polysaprobic zone of a heavily polluted river (Ager near Lenzing, Upper Austria). These localities suggest *T. opaca* to be a good indicator of heavily polluted (polysaprobic) conditions. It might also have some tolerance of H2S.

**Table 3** Biometrical characterization of *Trochiliopsis opaca*

<table>
<thead>
<tr>
<th>Character</th>
<th>(\bar{x})</th>
<th>M</th>
<th>SD</th>
<th>SE</th>
<th>CV</th>
<th>Min</th>
<th>Max</th>
<th>n</th>
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<tr>
<td>Body, length</td>
<td>25.66</td>
<td>26.0</td>
<td>1.12</td>
<td>0.37</td>
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<td>6.5</td>
<td>0.35</td>
<td>0.12</td>
<td>5.6</td>
<td>6.0</td>
<td>7.0</td>
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<tr>
<td>Macronucleus, width</td>
<td>6.11</td>
<td>6.0</td>
<td>0.42</td>
<td>0.14</td>
<td>6.8</td>
<td>5.5</td>
<td>7.0</td>
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<td>Distance from apex to the beginning of macronucleus</td>
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<td>12.0</td>
<td>1.30</td>
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<td>0.10</td>
<td>18.7</td>
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<td>Macronucleus, width</td>
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<td>1.5</td>
<td>0.31</td>
<td>0.10</td>
<td>20.8</td>
<td>1.0</td>
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<td>Number of kinetosomes of paroral membrane</td>
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<td>18.0</td>
<td>0.67</td>
<td>0.22</td>
<td>3.7</td>
<td>16.0</td>
<td>18.0</td>
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<td>8.0</td>
<td>0.67</td>
<td>0.22</td>
<td>8.1</td>
<td>8.0</td>
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<tr>
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<tr>
<td>Number of kinetosomes of anterior kinety 2</td>
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<td>Number of kinetosomes of posterior kinety 2</td>
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<td>0.00</td>
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<td>Number of kinetosomes of kinety 6</td>
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<td>Number of kinetosomes of the x-kinety</td>
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<td>0.22</td>
<td>17.6</td>
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<td>9</td>
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<tr>
<td>Number of kinetosomes of preoral kinety 1</td>
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<td>3.4</td>
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<tr>
<td>Number of kinetosomes of preoral kinety 3</td>
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<td>0.0</td>
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1 See footnote Table 1

**References**


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