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APPLIED ISSUES

A user-friendly guide to the ciliates (Protozoa, Ciliophora) commonly used by hydrobiologists as bioindicators in rivers, lakes, and waste waters, with notes on their ecology

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SUMMARY

1. A user-friendly guide to 300 ciliate species (Protozoa, Ciliophora) used as bioindicators by river, lake and waste water ecologists is provided. The guide is an English translation of the flow charts written in German and published by Foissner et al. (1991, 1992, 1994, 1995) in the Ciliate Atlas, a monograph on the ciliates used as bioindicators in the saprobic system. This guide is designed for users not specifically trained in identification of ciliates. Main groups and species are keyed dichotomously on forty-seven flow charts using simple characters usually recognizable in live specimens. Species with conspicuous characters, e.g., large size or distinct colour, are shown on thirty-two separate charts designated ‘special keys’. Although the flow charts give a high probability of correct species identifications, these should nevertheless be checked against the detailed figures and descriptions contained in the Ciliate Atlas.

2. A table with the species keyed and their main ecological characteristics (biomass, food preference, salinity tolerance, preferred occurrence, saprobiological classification) is also provided.

3. Typical ciliate communities found in natural and polluted habitats are briefly described and figured on thirteen plates.

4. A detailed systematic index is provided for all taxa mentioned in the flow charts.

Introduction

The usefulness of ciliates in ecosystem assessment is well known to most protistologists and many pollution ecologists. However, their wider and proper use has been hampered over the years because of debates about taxonomy, limited and widely distributed ecological information, and the difficulty of obtaining accurate identification literature. Thus, we gathered these data during the last 5 years and published them in four books (about 2000 pages, 6000 figures, 3000 references, many tables and ecograms) vernacularly called the Ciliate Atlas (Foissner et al., 1991, 1992, 1994, 1995). We hope that this detailed monograph will allow renewed and increased usage of ciliates not only by river ecologists but also by students of lakes, sewage plants, drinking-water treatment systems, and other potentially organically polluted bodies of water.

Our work was appreciated by many reviewers but several complained that it was written in German. This prompted us to prepare at least an English translation of the pictorial guide, which is the essence of the taxonomic portion of the monograph and is specifically designed for users not trained in identifying ciliates. The preparation of such a guide is difficult in general and for ciliates in particular because it is the first of its kind. The monographs and keys by Kahl (1930, 1931, 1932, 1934, 1935), although still very useful, can be applied only by specialists, i.e. if one already knows the family or genus to which a particular species belongs.
The more recent guides by Curds (1982) and Curds, Gates & Roberts (1983), although very helpful, provide guides to genera only.

The English version of our guide largely matches the German original. However, the flow charts were redesigned and slightly improved based on the experience with two student courses. Certainly, the present paper does not include the vast taxonomic, faunistic and ecological information contained in the original work. However, the main ecological characteristics of the species keyed have been summarized in Table 1.

The species keyed were selected from the catalogues by Sládeček (1973) and Sládeček et al. (1981), who assembled the species used as bioindicators in general and in the saprobic system in particular. The saprobic system is not widely known outside central Europe. Briefly, the saprobic system evaluates water quality and more specifically organic pollution, by indicator species. Four main zones of pollution and self-purification are distinguished: polysaprobit (very heavily polluted), a-mesosaprobity (heavily polluted), b-mesosaprobity (moderately polluted) and oligosaprobity (clean or very slightly polluted). A brief characterization of these zones is contained in the legends to the 'Ciliate communities'. More detailed accounts are to be found in Curds (1992), Friedrich (1990) and, especially, in Sládeček (1973).

**Equipment and methods**

The guide is designed for determination of live ciliates using a compound microscope equipped with differential interference contrast. If not available, use bright-field or phase-contrast; the latter is only satisfactory for flat species or for observing details in squeezed specimens. A few species demand more sophisticated methods, e.g. silver impregnation, to be identified accurately. These techniques are described in Foissner (1993).

**Observing living ciliates**

Many physical and chemical methods have been described for retarding the movement of ciliates in order to observe structural details. Chemical immobilization (e.g. nickel sulphate) or physical slowing down by increasing the viscosity of the medium (e.g. methyl cellulose) are, in our experience, usually unsuitable. These procedures often change the shape of the cell or cause premortal alterations of various cell structures.

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**Fig. 1 Preparation of slides for observing living ciliates (after Dragesco & Dragesco-Kernéis, 1986).** (a) A small drop of vaseline jelly each is placed at the four corners of a coverslip with a needle or injection syringe; (b) a small volume of water containing the ciliates is placed on a slide (see text); (c) the coverslip is placed over the drop and the vaselined corners are pressed down with a mounted needle until the ciliates become slightly squeezed and held firmly between slide and coverslip; (d) shows a side view of the complete preparation.

The following simple method is therefore preferable (Fig. 1a–d): place about 0.5 ml of the raw sample on a slide and pick out (collect) the desired specimens with a micropipette under a compound microscope equipped with low magnification (e.g. objective 4:1, ocular 10×). If the specimens are large enough they can be picked out from a Petri dish under a dissecting microscope. Working with micropipettes, the diameter of which must be adjusted to the size of the specimens, requires some training. Transfer the collected specimens, which are now in a very small drop of fluid, on to a slide. Apply small dabs of vaseline (Petroleum jelly) to each of the four corners of a coverslip. Place this coverslip on the droplet containing the ciliates. Press on the vaselined corners with a mounted needle until ciliates are held firmly between slide and coverslip. As the pressure is increased the ciliates gradually become less mobile and more transparent. Hence, first the location of the main cell organelles (e.g. nuclear and oral apparatus, contractile vacuole) and then the details (e.g. extrusomes, micronucleus) can easily be observed under low (100–300×) and high (oil immersion objective) magnification.

The shape of the cells is of course altered by this procedure. Therefore, specimens taken directly from the raw culture with a large-bore (opening ~ 1 mm) pipette must first be investigated under low magnification (100–400×). Many species are too fragile.

Table 1: Ecological characterization of species keyed. 

<table>
<thead>
<tr>
<th>Species</th>
<th>Biomass (mg) of 10&quot; ind.&quot;</th>
<th>Main food</th>
<th>Salinity tolerance</th>
<th>Occurrence</th>
<th>Saprobity</th>
</tr>
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<tbody>
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<td></td>
<td></td>
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<td>Preferred water type</td>
<td>Preferred habitat</td>
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<td>os</td>
<td>S,F</td>
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<table>
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<tr>
<th>Species</th>
<th>Biomass (mg) of 10^6 ind.</th>
<th>Main food</th>
<th>Salinity tolerance</th>
<th>Occurrence</th>
<th>Community</th>
<th>Saprobity</th>
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<td>B</td>
<td>STE,MOO</td>
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<td>B,P</td>
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<td>B,A</td>
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<td>Species</td>
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<td>Main food</td>
<td>Salinity tolerance</td>
<td>Occurrence</td>
<td>Saprobity</td>
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<td>b</td>
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</tr>
<tr>
<td>Tokophrya quadripartita</td>
<td>75</td>
<td>R</td>
<td>oms?</td>
<td>S,F,K</td>
</tr>
<tr>
<td>Trachelius ovum</td>
<td>3000</td>
<td>R</td>
<td>oms?</td>
<td>F,S</td>
</tr>
<tr>
<td>Trachelophyllum apiculatum</td>
<td>39</td>
<td>O</td>
<td>he?</td>
<td>S,F</td>
</tr>
<tr>
<td>Trichodina pediculus</td>
<td>80</td>
<td>Ba^5</td>
<td>he?</td>
<td>S,F</td>
</tr>
<tr>
<td>Trinymea compressum</td>
<td>10</td>
<td>Ba</td>
<td>he</td>
<td>S,F,K</td>
</tr>
<tr>
<td>Trithegmastoma cucullulus</td>
<td>50</td>
<td>Ki, Al,</td>
<td>he?</td>
<td>F,S,K</td>
</tr>
<tr>
<td>Trithegmastoma srameki</td>
<td>40</td>
<td>Ki</td>
<td>os</td>
<td>F,S</td>
</tr>
<tr>
<td>Trithegmastoma steini</td>
<td>150</td>
<td>Ki</td>
<td>os</td>
<td>F,S</td>
</tr>
<tr>
<td>Trochilia minuta</td>
<td>1.5</td>
<td>Ba^6</td>
<td>os</td>
<td>F,K</td>
</tr>
<tr>
<td>Trochiloides recta</td>
<td>25</td>
<td>Sb</td>
<td>he</td>
<td>F,S</td>
</tr>
<tr>
<td>Tropidotaactius acuminatus</td>
<td>20</td>
<td>Ba</td>
<td>os</td>
<td>S</td>
</tr>
<tr>
<td>Urocentrum turbo</td>
<td>70</td>
<td>Ba, Ki</td>
<td>he?</td>
<td>S,F</td>
</tr>
<tr>
<td>Uroleptus gallina</td>
<td>72</td>
<td>Al</td>
<td>oms?</td>
<td>S,F</td>
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<tr>
<td>Uroleptus musculus</td>
<td>214</td>
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<td>oms?</td>
<td>S,F</td>
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<tr>
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<td>Ba, Cy,</td>
<td>oes?</td>
<td>S,F</td>
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<tr>
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<td>400</td>
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<td>oes?</td>
<td>S,F</td>
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<tr>
<td>Uronema nigeriens</td>
<td>5</td>
<td>Ba, Fl</td>
<td>he</td>
<td>F,S</td>
</tr>
<tr>
<td>Urostyla grandiads</td>
<td>500</td>
<td>O</td>
<td>he?</td>
<td>S,F</td>
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<tr>
<td>Urotricha agilis</td>
<td>0.5</td>
<td>Ba, Fl</td>
<td>oes?</td>
<td>S</td>
</tr>
<tr>
<td>Urotricha armata</td>
<td>15</td>
<td>R</td>
<td>oes?</td>
<td>S,F</td>
</tr>
<tr>
<td>Urotricha farcata</td>
<td>5</td>
<td>Ba, Al,</td>
<td>oms?</td>
<td>S,F</td>
</tr>
<tr>
<td>Urotricha farcata</td>
<td>3-4</td>
<td>Ba, Al</td>
<td>oes?</td>
<td>S,F</td>
</tr>
<tr>
<td>Urotricha globosa</td>
<td>7</td>
<td>Ba, Al</td>
<td>oes?</td>
<td>S</td>
</tr>
<tr>
<td>Urotricha ovata</td>
<td>15</td>
<td>Al</td>
<td>oes?</td>
<td>S,F</td>
</tr>
<tr>
<td>Urozona buetschlii</td>
<td>3</td>
<td>Ba</td>
<td>oes?</td>
<td>S,K,F</td>
</tr>
</tbody>
</table>
A user-friendly guide to freshwater ciliates

<table>
<thead>
<tr>
<th>Species</th>
<th>Biomass (mg) of 10^6 ind.</th>
<th>Main food</th>
<th>Salinity tolerance</th>
<th>Occurrence</th>
<th>Saprobity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaginicola ingenita</td>
<td>3-4</td>
<td>Ba</td>
<td>he</td>
<td>S,F</td>
<td>A,T</td>
</tr>
<tr>
<td>Vaginicola tincta</td>
<td>15</td>
<td>Ba</td>
<td>os</td>
<td>S,F</td>
<td>A</td>
</tr>
<tr>
<td>Vorticella aquadulcis-complex</td>
<td>15</td>
<td>Ba,Al</td>
<td>he?</td>
<td>S,F,K</td>
<td>A,B</td>
</tr>
<tr>
<td>Vorticella campanula</td>
<td>135</td>
<td>Ba,Al</td>
<td>oe (he?)</td>
<td>S,F,K</td>
<td>A,B,T</td>
</tr>
<tr>
<td>Vorticella convallaria-complex</td>
<td>50-75</td>
<td>Ba</td>
<td>he</td>
<td>S,F,K,Bo</td>
<td>A,B,T</td>
</tr>
<tr>
<td>Vorticella fromenteli</td>
<td>35</td>
<td>Ba</td>
<td>oe</td>
<td>S</td>
<td>A</td>
</tr>
<tr>
<td>Vorticella infusionum-complex</td>
<td>25</td>
<td>Ba</td>
<td>he?</td>
<td>S,F,K</td>
<td>A,B,T</td>
</tr>
<tr>
<td>Vorticella marginata</td>
<td>100</td>
<td>Ba</td>
<td>os</td>
<td>S,F</td>
<td>A,B</td>
</tr>
<tr>
<td>Vorticella mayeri</td>
<td>50</td>
<td>Ba</td>
<td>os</td>
<td>S,F</td>
<td>P</td>
</tr>
<tr>
<td>Vorticella microstoma-complex</td>
<td>30</td>
<td>Ba,Al</td>
<td>oms?</td>
<td>S,F</td>
<td>A,B</td>
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<tr>
<td>Vorticella nantans</td>
<td>90</td>
<td>Ba,Al</td>
<td>oe?</td>
<td>S,F</td>
<td>P</td>
</tr>
<tr>
<td>Vorticella octava-complex</td>
<td>20</td>
<td>Ba</td>
<td>oe</td>
<td>S,F</td>
<td>A</td>
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<tr>
<td>Vorticella picta</td>
<td>40</td>
<td>Ba,Al</td>
<td>oe?</td>
<td>S,F</td>
<td>A</td>
</tr>
<tr>
<td>Zoothamnium arbuscula</td>
<td>55</td>
<td>Ba</td>
<td>ome?</td>
<td>S,F</td>
<td>A</td>
</tr>
<tr>
<td>Zoothamnium kentii</td>
<td>40</td>
<td>Ba</td>
<td>ome</td>
<td>F,S</td>
<td>A</td>
</tr>
<tr>
<td>Zoothamnium procerius</td>
<td>45</td>
<td>Ba</td>
<td>he</td>
<td>F,S</td>
<td>A,B,T</td>
</tr>
<tr>
<td>Zosterodasy transversa</td>
<td>300</td>
<td>Ki</td>
<td>he</td>
<td>F,S</td>
<td>A,B</td>
</tr>
</tbody>
</table>

1 Wet mass: 1 µm^3 = 1 pg, i.e. specific gravity of the protoplasm is 1.0 (Finlay, 1982).
2 For classification see Table 2. Data are often highly questionable and thus are then marked with a "?". Very few limnetic ciliates occur in truly marine environments although many species tolerate high salinities. Many freshwater species occur in saline estuaries together with some marine species, however, few marine ciliates occur in strongly saline inland waters.
3 See community plates. Many species cannot yet be classified into a certain community.
4 According to Table 3 in Foissner et al. (1995).
5 Feeds also on epidermal cells, cnidocysts and food residues of Hydra.
6 Ingests also fish epidermal cells if the latter are very abundant.
7 For Caenomorpha medusula.
8 Also histophagous, i.e. feeding on cells of dying or dead metazoans.
9 Eroneously written "3.5 mg/l" in Foissner et al. (1994).
10 Not calculated because of complicated shape.
11 If very abundant, otherwise use a-b.
12 If very abundant, otherwise use b-a.
13 According to Albrecht (1984); erroneously classified as holo-euryhaline in Foissner et al. (1994).

Table 2 Salinity terminology (after Albrocht, 1984). CI = chloride (mg/l CI), S = salinity (%).

<table>
<thead>
<tr>
<th>CI</th>
<th>0-400</th>
<th>400-2000</th>
<th>2000-5000</th>
<th>5000-17000</th>
<th>&gt;17000</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>0-1</td>
<td>1-4</td>
<td>4-10</td>
<td>10-30</td>
<td>&gt;30</td>
</tr>
</tbody>
</table>

- holo-euryhaline
- oligostenohaline
- meso- to poly-euryhaline
- oligo- to meso-stenohaline
- poly-euryhaline
- oligo-euryhaline
- meso- to poly-stenohaline
- oligo- to meso-euryhaline
- poly-stenohaline

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to withstand handling with the micropipette and coverslip trapping without deterioration.

Investigation with low magnification also requires some experience but it guarantees that undamaged cells are recorded. Video-microscopy is very useful at this point of investigation.

**Nuclear staining**

Beginners might find it difficult to recognize the cell’s nuclear apparatus or to differentiate it from other inclusions, e.g. food vacuoles. Usually, the macronucleus appears as a bright (bright-field) or more or less distinct dark (phase-contrast, interference contrast), *homogenous* mass in slightly squeezed specimens. If in doubt, use the simple staining protocol listed below.

1. Pick out desired specimens with a micropipette and place the small drop of fluid in the centre of a slide.
2. Add an equally sized drop of methylgreen-pyronin (1% w/v); Chroma-Gesellschaft, Schmid GmbH + Co., D-7316 Köngen/N.; this solution is stable and can be used for years) and mix the two drops gently by swivelling the slide. If ciliates were already mounted under the coverslip then add a drop of the dye at one edge of the coverslip and pass it through the preparation with a piece of filter paper placed at the other end of the coverslip.
3. Place a coverslip with vaselined corners on the preparation (Fig. 1) and press it down until cells become flattened. Observe immediately. Cells die and stain within 2–5 min. The nuclear apparatus usually stains blue or, in insufficiently flattened specimens, violet. Cytoplasm, food vacuoles and mucocysts (extrusomes) stain reddishly. The preparation is temporary. After 5–10 min the cytoplasm becomes heavily stained and obscures other details.

**How to use the guide**

The guide is designed for identifying specimens from life and for users not specifically trained in taxonomy of ciliates. However, we presume a good deal of basic knowledge in biology, taxonomy and protozoology. If some revision is necessary, we recommend reading Corliss (1979) and/or Puytorac (1994). Valuable ecological reviews are the books by Curds (1992), Fenichel (1987) and Sládeček (1973); the last mentioned monograph specifically addresses the saprobic system, while Curds’ booklet contains an excellent overview on the use of protozoa in pollution control.

The guide consists of four parts designed as easy-to-follow flow charts (main key and species keys) or as simple plates showing related forms (special keys, communities). Many species are keyed several times to increase the chances of identification (see systematic index). Remember, however, that only 300 of the 3000 freshwater species known are contained in the guide. Thus, all characters mentioned in the charts must match and all specific identifications should ideally be checked against the detailed descriptions and figures contained in the *Ciliate Atlas.* This point is crucial because there are usually several other species having similar characters. Certainly, a user-friendly guide should avoid referring to all the fine details, often difficult to recognize, commonly used by specialists. Admittedly, this increases the possibility of misidentifications. All pictorial guides, which key out a certain fraction from a taxonomic unit, have this deficiency, i.e. are a compromise between accuracy and practicability. On the other hand, such selective guides have the advantage of providing rapid species identifications even for users not specifically trained in taxonomy.

The General key (Ciliophora I–XI) is dichotomous and guides to the main groups (Colpodea, Cytrophorida, Gymnostomatida, Heterotrichida, Gymnolabidida, Gymnostomata, Hypotrichia, Loxodes, Nassulida, Odontostomatida, Oligotrichida, Peritrichia, Pleurostomatida, Prostomatida, Suctoria) or to the special keys I–XXXII or, more rarely, to the communities or directly to a certain species. In the last case, the volume and page where the species is described in the *Ciliate Atlas* is provided.

The Species keys are also dichotomous and ordered according to the main groups mentioned above. The volume of the *Ciliate Atlas* where a certain group is contained is found in the right upper corner of the charts, while the page where the detailed description commences has been added to the species name. Thus, for instance, ‘Volume I, p. 414’ means that the description of *Cylotilophosis mucicola* is found on page 414 of Volume I of the *Ciliate Atlas.*

Most Special keys I–XXXII are not dichotomous.

*The four volumes of this monograph are still available and can be purchased at: Wasserwirtschaftsamt Deggendorf, Schriftgutversandstelle, Postfach 2060, D-94460 Deggendorf, Germany.*

These charts contain species with special characters (large size, conspicuous colour or shape...). Simply compare shape, size and macronucleus of the species figured with the particular specimen under your microscope. This often provides a rapid, correct species identification. As before, the volume and page where each species is described in the Ciliate Atlas is provided.

Typical Ciliate communities are shown on the last thirteen charts. They provide information on what species can be found in particular circumstances and habitats, some of which have highly characteristic ciliate communities.

Acknowledgments

We thank Dr Fritz Kohmann (BfG Koblenz, Germany) for initiating the work, Dr Margit Falzenberger (University of Salzburg) for redesigning the keys with a computer imaging system, and Brigitte Moser and Dipl.-Ing. (FH) Birgit Gietl for typing the manuscript and preparation of the tables. Financial support was provided by the Austrian Science Foundation (FWF, Project PO 8924–Bio) and the Bayerischen Landesamt für Wasservirtschaft.

References


General key (Ciliophora I-XI)

This key guides you to the main groups (Colpodea, Cyrtophorida, Gymnostomatida, Heterotrichida, Hymenostomatida, Hypotrichia, Loxodes, Nassulida, Odontostomatida, Oligotrichida, Peritrichia, Pleurostomatida, Prostomatida, Suctoria) or to the "Special keys I-XXXII" or, more rarely, directly to a certain species. In the last case, check your identifications against the detailed figures and descriptions in the "Ciliate Atlas".

Plate 1

* Usually, tentacles are retractile rods with a small distal knob, i.e. are widest at the anterior end. Cilia, cirri (=bundle of cilia), adoral membranelles, and spines gradually narrow to the distal end, i.e. are widest at the posterior (proximal) end (see figures).

Ciliophora II

Ciliophora I

<table>
<thead>
<tr>
<th>Tentacles*</th>
<th>Absent</th>
<th>Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suctoria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actinobolina Gymnostomatida I</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lorica or armour

<table>
<thead>
<tr>
<th>Absent or unknown</th>
<th>Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suctoria</td>
<td></td>
</tr>
<tr>
<td>Actinobolina Gymnostomatida I</td>
<td></td>
</tr>
</tbody>
</table>

Very large, about 300 μm or more

<table>
<thead>
<tr>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special key IX</td>
<td></td>
</tr>
<tr>
<td>Special key X</td>
<td></td>
</tr>
</tbody>
</table>

Conspicuously (more than 50%) contractile*

<table>
<thead>
<tr>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special key XI</td>
<td></td>
</tr>
<tr>
<td>Special key XII</td>
<td></td>
</tr>
</tbody>
</table>

Slender, length : width ≥ 5:1

<table>
<thead>
<tr>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special key XII</td>
<td></td>
</tr>
</tbody>
</table>

Body with distinct furrows

<table>
<thead>
<tr>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ciliophora III</td>
<td>Special key XXI</td>
</tr>
</tbody>
</table>

* Touch cells or cover glass with mounted eyelash or needle, respectively.

### Ciliophora III

<table>
<thead>
<tr>
<th>Ciliophora II</th>
<th>special key XIV</th>
<th>special key XV</th>
<th>special key XVI</th>
<th>special key XVII</th>
<th>special key XVIII</th>
<th>special key XX</th>
<th>special key XIII</th>
</tr>
</thead>
<tbody>
<tr>
<td>shape lanceolate</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>barrel-shaped, ellipsoid or like a segment of a circle</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>dumb-bell or spatula shaped</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>snout-like peak at anterior end</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>proboscis or proboscis-like elongation</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>tail</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>shape bizarre (with spines, processes, cavities ...</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>shape cylindrical, i.e. length : width ratio 2-3 : 1, fusiform or oviform (usually not sessile)</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>

Ciliophora IV

Ciliophora III
- shape reniform

no
- special key XXII
  do you see "cilia" (cirri*) on body at a magnification of X 100?
  yes
- special key XIX
  2 macronuclear nodules (Ma)

no or unknown
- adoral zone of membranelles (tufts of cilia; AZM)

no
- shape
  club-shaped
  rood-shaped
  lanceolate

many Hypotrichia

Lacrymaria olor
extended up to 1200 µm
contracted about 100 µm
(Vol. IV, p.163)

Trachelophyllum apiculatum
90-180 µm
(Vol. IV, p.180)

Loxodes striatus
usually ~ 200 µm
(Vol. IV, p.378)

no
- rod (extrusomes) seam (E; observe at X 400 and with bright field!)

no
- Ciliophora V

special key XXIII

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Ciliophora V

Ciliophora IV

- movement remarkable (jumping, spinning, rotating on a thread)
  - no or unknown
  - yes

  special key XXV

- conspicuous ciliary wreaths
  - no
  - yes

  special key XXVI

- conspicuous, sail-like membrane along oral opening (usually an undulating membrane; uM)
  - no
  - yes

  - Lembadion
  - Hymenostomata I
  - Cyclidium
  - Hymenostomata VII
  - Pleuronema
  - Hymenostomata III
  - Calyptotricha lanuginosa
  - 30-40 μm
  - (Vol. III, p.288)

- denticle disc at posterior end
  - no
  - yes

  - Trichodina pediculus
  - 35-60 μm
  - (Vol. II, p.304)

- cytoplasm with many diatoms
  - no
  - yes

  special key XXVII

- cytoplasm with many cyanobacteria
  - no
  - yes

  special key XXIV

Ciliophora VI
A user-friendly guide to freshwater ciliates

Ciliophora VI

Ciliophora V

- colonial species forming 1-10 cm sized, green globules
  - no
  - yes
    - Ophrydium versatile / eutrophicum
    - Peritrichia VII

- living in anaerobic mud
  - no or unknown
  - yes
    - community Metopetum

- polysaprobic or alpha-mesosaprobic
  - no or unknown
  - yes
    - communities Metopetum, Colpidietum and Trithigmmostometum

- eulaplanktic
  - no or unknown
  - yes
    - special keys XXVIIa, b and community Oligotrichetea

- epizoic
  - no or unknown
  - yes
    - special key XXXII

- mouth
  - with distinct funnel (F) composed of slender rods, recognizable at a magnification of ≥ X 250
  - conspicuous, transverse cleft
  - different
    - Ciliophora VII

Ciliophora XI and special keys XXIV, XXVII

Gastronauta

Cyrtophorida I

Plagiopyla nasuta
80-180 μm
(Vol. IV, p.266)
Ciliophora VII

very large, wide and deep
(and thus bright at low
magnification) longitudinal
cleft

ellipsoid

large, triangular, in anterior
third (contractile vacuole
in mid-body; distinct seam
of extrusomes)

subequatorial

near posterior
end

shape

Ciliophora VI

mouth

Frontonia

Hymenostomata V

Lembadion

Hymenostomata I

Phascolodon vorticella

50-110 μm
(Vol. I, p.98)

different

in large cavity

Ciliophora VIII

macronucleus (Ma)

thread-like

reniform or ellipsoid

moniliform

at base of
acontractile proboscis

Bursaria truncatella

200-1700 μm
(Vol. I, p.424)

Bursaridium pseudobursaria

80-200 μm
(Vol. I, p.433)

Linostoma vorticella

about 170 μm
(Vol. II, p.390)

Dileptus, Monilicaryon,
Trachelius, Paradileptus

Gymnostomatida II

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Ciliophora VIII

Ciliophora VII
oral ciliature

conspicuous, i.e. tufts of cilia (adoral membranelles or adoral zone of membranelles; AZM) along anterior and/or lateral margin (easily recognizable at a magnification of > X 200)

Ciliophora IX
inconspicuous

do you see "cilia" (cirri*) on body at a magnification of X 100?

yes

Hypotrichia

AZM

cirri

AZM

cirri

Discrimination of cilia and cirri (= several adhering cilia forming fairly thick bundles): if you see cilia at a magnification of X 100-400, i.e. without oil immersion, then these are very likely cirri!

*Discrimination of cilia and cirri (= several adhering cilia forming fairly thick bundles): if you see cilia at a magnification of X 100-400, i.e. without oil immersion, then these are very likely cirri!

Didinium / Monodinium
(→ Ciliophora IX)

If you see "cilia" (cirri*) on body at a magnification of X 100?

no

Peritrichia

AZM

Oligotrichida

Heterotrichida

somatic ciliature (ciliary rows; CR); use magnification > X 400

complete

strongly reduced or lacking

transverse striation (no ciliary rows!); oral ciliature

present; continuous membrane

absent; distinct ciliary plates

attention, do not confuse with

Ciliophora IX

Ciliophora VIII

- size
  - > 40 μm
  - < 40 μm (15-50 μm)

special keys XXIX-XXXI

- anterior end

with ± distinct (oral) cone, bulge, or head

Ciliophora X

- different
- reniform, i.e. one side convex, the other concave with distinct indentation or projection at oral opening

Prostomatida

Gymnostomatida

Platyophrya vorax
30-60 μm
(Vol. l, p. 419)

Enchelys gasterosteus
30-100 μm
(Vol. IV, p. 158)

Plagiopyla nasuta
80-180 μm
(Vol. IV, p. 266)

Colpoda; Colpodea
Ciliophora X

- free-swimming while rotating about main body axis, burrowing in mud or motionless while feeding; ellipsoid, fusiform, oviform, unflattened or distinctly flattened and ± completely ciliated
- gliding or crawling; surface turned towards substrate flat and ± densely ciliated, opposed surface slightly to distinctly vaulted and very sparsely ciliated

Hymenostomata

small Cyrtophorida

Ciliophora XI

- at anterior end
- basket

Prostomatida

Lagynus elegans 60-200 μm (Vol. IV, p.173)

- ventral side flat, dorsal vaulted; usually gliding or crawling; usually diatoms and/or bacteria
- ± cylinroid; often free-swimming; usually spotted by ingested cyanobacteria

Chilodontopsis depressa* 50-80 μm (Vol. III, p.424)

Zosterodasys transversa* 130-250 μm (Vol. III, p.418)

Cyrtophorida

Nassulida

*Chilodontopsis and Zosterodasys both belong to the Nassulida and are difficult to separate from certain cyrtophorids! Zosterodasys has very thick pharyngeal (basket) rods whose anterior portion is distinctly curved, Chilodontopsis has a large contractile vacuole (arrow) in the posterior body region.

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Keys to species (main groups ordered alphabetically)
Check identifications against detailed figures and descriptions in the "Ciliate Atlas".

**Colpodea**

**shape; oral apparatus**

- bursiform; very large, conspicuous
- reniform to cylindroid; small, inconspicuous

**adoral zone of organelles**

- curved to left at posterior end
- curved to right at posterior end

**Genus: Colpoda**

- **Bursaria truncatella**
  - $> 250 \mu$m (p.424)

- **Bursaridium pseudobursaria**
  - $< 250 \mu$m (p.433)

- **Platophrya vorax**
  - 30-60 $\mu$m (p.419)

- **Cyrtolophosis mucicola**
  - 20-40 $\mu$m (p.414)

**Platyophrya vorax**

- length; postoral sack

- $< 120 \mu$m; moderately distinct or absent
- $> 120 \mu$m; very distinct

**left oral ciliary field; macronucleus**

- spoon-shaped; with large, central nucleolus
- rectangular; with few small nucleoli

**shape; postoral sack**

- reniform; moderately distinct
- ventral side rectangularly notched; absent

**C. steinii**
- (p.390)

**C. ecaudata**
- (p.395)

**C. cucullus**
- (p.403)

**C. inflata**
- (p.399)

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Cyrtophorida II

- mode of life; ventral surface
  - planktonic; with distinct longitudinal groove
  - mainly in periphyton; flat or indistinctly depressed

- oral ciliation; location of oral basket
  - preoral ciliary row(s) left above basket
  - Y-shaped preoral ciliary row above and left of basket; left of cell median
  - preoral ciliary row (silver impregnation); food
    - fragmented; often diatoms
    - not fragmented; usually bacteria

- colour
  - green from green algae
  - not green

- cilia of dorsal brush
  - 6 - 10, narrowly spaced
  - 13 - 16, widely spaced, extend across anterior region of cell

- contractile vacuole
  - 1 right of basket
  - 2 opposite of basket

- dorsal brush
  - distinctly subapical
  - apical

- Thigmogaster potamophilus
  - 20-30 μm (p.59)

- T. oppositewatercolatus
  - 25-70 μm (p.45)

- Chilodonella uncinata
  - 25-70 μm (p.45)

- Odontochlamys alpestris
  - 35-60 μm (p.52)

- Pseudochilodonopsis algivora
  - 40-70 μm (p.62)

- P. fluviatilis
  - 40-70 μm (p.67)

- P. piscatoris
  - 60-90 μm (p.73)

A user-friendly guide to freshwater ciliates

Gymnostomatida I

- cup-like, globular, oviform, reniform or pyriform
- subapical oral cleft; shape
  - yes; reniform
  - no; different
    - oral cone; tentacles
      - no; yes
        - Actinobolina
          - shape; ciliary rows
            - oviform; longitudinal
            - ovoid; distinctly spirally
        - yes; no
          - ciliary wreaths
  - close to globular trunc; usually 12-25 µm
    - number of pre-equatorial ciliary belts
      - 2
        - oral processes
      - 3
    - equatorial ciliary belt
      - size
        - 50-120 µm (p.235)

Gymnostomatida II

- elongate, if globular then > 200 µm
- ≤ 50 µm

Plagiopyla nasuta
80-180 µm (p.266)

A. vorax
100-200 µm
(p.246)

A. radians
65-90 µm
(p.243)

Monodinium balbianii
50-120 µm (p.235)

Didinium nasutum
80-200 µm (p.228)

Monodinium balbianii
50-120 µm (p.235)

Askenasia volvox
30-50 µm (p.251)

Mesodinium acarus
12-20 µm (p.257)

Mesodinium pulex
15-35 µm (p.280)

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Gymnostomatida II

- Trachelius ovum
  - Bursiform to globular
  - Macronucleus; mode of life
  - Macronucleus
  - Dumb-bell shaped; periphyton and benthic
  - 200-600 µm, usually 250-350 µm (p.208)

- Dileptus margaritifer
  - Fusiform
  - Macronucleus
  - More than 500 very small (and thus difficult to recognize in vivo) nodules
  - 180-450 µm, usually 400-700 µm (p.199)

- Monilicaryon monilatus
  - Vermiform
  - Macronucleus
  - Contractile proboscis
  - Yes
  - Macronuclear nodules
  - 350-950 µm, usually 400-700 µm (p.199)

- Trachelophyllum apiculatum
  - Rod-shaped
  - Macronucleus
  - Very long, highly contractile neck
  - 90-150 µm (p.152)

- Chaenea stricta
  - Macronucleus
  - 2 large nodules
  - 90-180 µm (p.180)

- Larvamia olor
  - Lageniform
  - Macronucleus
  - 150-1500 µm (p.219)

- Homalozoon vermiculare
  - Extended up to 1.2 mm, contracted ~ 100 µm (p.163)

- Trachelophyllum apiculatum
  - Vermiform
  - Macronucleus
  - 90-180 µm (p.180)

- Homostraa vermiculare
  - Vermiform
  - Macronucleus
  - 150-1500 µm (p.219)
Gymnostomatida III

- oblique, distinct oral bulge
  - yes
  - no
  - anterior end
    - annulated
    - not annulated

Spathidium sensu lato
(p. 226)

Lagynus elegans
extended 130-200 μm,
contracted 60-100 μm
(p. 173)

- macronucleus
  - vermiform
  - globular to ellipsoid
    - anterior end
      - transversely truncate
      - with small head
        - head spirally striated
          - yes
          - no

Enchelyodon elegans
140-200 μm (p. 155)

Enchelys gasterosteus
30-100 μm (p. 158)

Phialina spp.
(p. 171)

Lagynophrya acuminata
70-95 μm (p. 178)
Heterotrichida I

- distinctly contractile
  - yes
  - no

- shape in contracted, respectively, extended condition
  - fusiform, respectively, ± vermiform (Spirostomum)

- globular to pyriform, respectively, trumpet-like (Stentor (p. 338))

- macronucleus

- ellipsoid
  - colour; symbiotic algae
    - almost black; yes
    - reddish; no
    - blue-green; no
    - brownish; no

- vermiform

- S. amethystinus
  - 250-500 μm (p. 339)

- S. igneus
  - about 250 μm (p. 346)

- S. multiformis
  - about 250 μm (p. 351)

- S. niger
  - 200-350 μm (p. 355)

- S. roeselii
  - 0.5-1.2 mm (p. 374)

- S. coeruleus
  - 1-2 mm (p. 357)

- S. muelleri
  - 0.5-1 mm (p. 363)

- S. polymorphus
  - up to 2 mm (p. 368)

- S. ambiguum
  - (p. 317)

- S. minus
  - (p. 327)

- S. terris
  - 200-400 μm (p. 332)

- S. caudatum
  - 200-300 μm (p. 324)

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Heterotrichida II

- campanulate, posterior end with spine(s)
- distinctly spirally furrowed, posterior end with short spine

Stentor

Heterotrichida I

- globular
- different

Stentor

macronucleus

- moniliform
- vermiform
- ellipsoid or globular

Climacostomum

Linostoma vorticella

about 170 μm (p.390)

Climacostomum virens

160-250 μm (p.394)

Tropidoatractus acuminatus

70-150 μm (p.420)

Caenomorpha spp.

60-200 μm (p.424)

adoral zone of membranelles

- slightly to distinctly spiralized, extends obliquely across body
- ± straight at body margin
- shape; colour; length of adoral zone of membranelles

- oviform; reddish; about 1/2 of body
- oviform; blueish; about 1/2 of body
- cylindroid; reddish; about 1/5 of body

Metopus spp., sensu lato

50-90 to 180-300 μm (p.400)

Blepharisma lateritium

110-190 μm (p.384)

Blepharisma coerulescens

120-145 μm (p.382)

Pseudoblepharisma tenue

100-200 μm (p.388)

Hymenostomata I

- **zooclorellae**
- **Hymenostomata IV**
  - **present**
  - **Hymenostomata IV**
  - **dumb-bell like**
  - **< 40 μm; with caudal cilia**
  - **≤ 40 μm; with tuft of caudal cilia**
  - **Urozona buetschlii**
    - 20-40 μm (p.268)
  - **Urocentrum turbo**
    - 40-110 μm (p.187)
  - **Frontonia acuminata**
    - 60-170 μm (p.155)
  - **Frontonia atra**
    - 100-400 μm (p.164)

- **absent**
  - **shape**
  - **slightly to distinctly pointed at posterior end**
  - **pigmentation**
  - **whole cell darkly pigmented**

- **Hymenostomata II**
  - **Kahlilembus attenuatus**
    - 40-80 μm (p.237)
  - **Maritua pelagica**
    - 80-160 μm (p.195)
  - **L. lucens**
    - (p.205)
  - **L. bullinum**
    - 120-200 μm (p.212)
  - **L. magnum**
    - 100-200 μm (p.219)

Hymenostomata II

Volume III

- Cytoplasm
  - Well-fed specimens dark at low magnification by highly refractile inclusions
  - ± colourless or spotted

- Size
  - Usually ≤ 100 µm
  - > 100 µm

- Highly refractile inclusions
  - Ring-shaped
  - Not ring-shaped

- Contractile vacuole
  - 1 each in anterior and posterior half of body
  - In posterior end
  - Subequatorial

- Dexiotricha granulosa
  - 40-80 µm (p.240)

- Paramecium putrinum
  - 60-120 µm (p.147)

- Uronema nigicans
  - 25-50 µm (p.228)

- Philasterides armatus
  - 50-100 µm (p.224)

- Flattening; oral apparatus
  - Distinct; large, in anterior third
  - Indistinct; very small, in anterior third
  - Indistinct; 6-shaped, in anterior third

- Frontonia atra
  - 100-400 µm (p.164)

- Loxocephalus luridus
  - 120-200 µm (p.245)

- Ophryoglena spp
  - (p.110)
Hymenostomata III

<table>
<thead>
<tr>
<th>Hymenostomata II</th>
<th>Volume III</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>size</strong></td>
<td></td>
</tr>
<tr>
<td>usually ≥ 50 μm</td>
<td>usually ≤ 50 μm</td>
</tr>
<tr>
<td><strong>oral apparatus</strong></td>
<td></td>
</tr>
<tr>
<td>2/3 of body length</td>
<td>different</td>
</tr>
<tr>
<td><em>Pleuronema</em></td>
<td></td>
</tr>
<tr>
<td>elongated cilia on posterior end</td>
<td>exosomes; pellicle</td>
</tr>
<tr>
<td>present</td>
<td></td>
</tr>
<tr>
<td>absence</td>
<td></td>
</tr>
</tbody>
</table>

Hymenostomata VII

<table>
<thead>
<tr>
<th>trichocysts, form distinct layer underneath pellicle; rectangularly patterned</th>
<th>mucocysts, do not form distinct layer underneath pellicle; smooth</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ophryoglena spp.</em></td>
<td><em>Hymenostomata V</em></td>
</tr>
<tr>
<td>60-90 μm (p.285)</td>
<td>60-90 μm (p.110)</td>
</tr>
</tbody>
</table>

P. coronatum 60-90 μm (p.278)  P. crassum 60-90 μm (p.285) (p.110)

Hymenostomata IV

<table>
<thead>
<tr>
<th>Hymenostomata I (with green symbiotic algae)</th>
<th>Volume III</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>shape; oral apparatus</strong></td>
<td></td>
</tr>
<tr>
<td>± oviform, posterior end broadly rounded; near mid-body</td>
<td>cap-shaped in lateral view; cordiform in ventral view; near mid-body</td>
</tr>
<tr>
<td>ovoid; in anterior half of body</td>
<td></td>
</tr>
<tr>
<td>calyx-shaped; anterior end with 3 hucksters; in anterior third of body</td>
<td></td>
</tr>
</tbody>
</table>

*Paramecium bursaria* 85-150 μm (p.140)  *Disematostoma buetschlii* 110-200 μm (p.180)  *Disematostoma tetraedricum* 100-140 μm (p.185)  *Stokesia vernalis* 60-160 μm (p.200)

Hymenostomata V

Hymenostomata III
(with distinct extrusome layer
underneath pellicle)

contractile vacuole (CV); oral apparatus

1 near mid-body; in anterior third of body
Frontonia

shape; contractile vacuole; pigmentation

1 each in anterior and
posterior half of body;
near mid-body
Paramecium

scutiform; with globular
adventive vacuoles; dark spot in anterior
end
Frontonia

oral apparatus

post-oral suture

F. acuminata
60-170 μm (p.155)

F. angusta
80-130 μm (p.160)

F. atra
100-400 μm (p.164)

F. leucas
120-600 μm (p.169)

± oviform

zoochlorellae

present

absent

fusiform

micronuclei; shape

1, about 8 μm
in size; usually
slenderly fusiform

2, each about 3 μm
in size; usually
broadly fusiform

Attention; a
Frontonia-species
with 2 contractile
vacuoles is also
rather common in
running waters!
Watch at location
of oral apparatus

oral apparatus

P. bursaria
85-150 μm (p.140)

P. putrinum
60-120 μm (p.147)

P. caudatum
170-300 μm (p.112)

P. aurelia-complex
100-180 μm (p.129)

Frontonia elliptica
150-200 μm
Hymenostomata VI

Hymenostomata III
(without distinct extrusome layer underneath pellicle)

<table>
<thead>
<tr>
<th>Volume III</th>
</tr>
</thead>
<tbody>
<tr>
<td>size</td>
</tr>
<tr>
<td>usually &gt; 80 μm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>slenderly to moderately broadly pyriform</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Philasterides armatus</th>
<th>Epenardia myriophylli</th>
<th>Colpidium colpoda</th>
<th>Colpidium kleinii</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-100 μm (p.224)</td>
<td>90-200 μm (p.106)</td>
<td>60-150 μm (p.43)</td>
<td>70-120 μm (p.51)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>ellipsoid, pyriform or oviform</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>adoral membranelles</th>
</tr>
</thead>
<tbody>
<tr>
<td>inconspicuous</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>caudal cillum</th>
</tr>
</thead>
<tbody>
<tr>
<td>present</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Philasterides armatus</th>
<th>Tetrahymena pyriformis-complex</th>
<th>Glaucoma scintillans</th>
<th>Glaucoma reniforme</th>
<th>Dexiotoma campylum</th>
<th>Paracolpidium truncatum</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-100 μm (p.224)</td>
<td>40-60 μm (p.61)</td>
<td>35-75 μm (p.92)</td>
<td>35-65 μm (p.103)</td>
<td>35-90 μm (p.33)</td>
<td>35-85 μm (p.56)</td>
</tr>
</tbody>
</table>

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Hymenostomata VII: small scuticociliates difficult to identify

According to our experience, beginners find it difficult to identify small (15-50 µm) scuticociliates, because the characters are not easily recognized due to the small size of the organisms. Especially the determination of dying specimens needs some experience because they lose their typical movement. Thus, we relinquish a dichotomous key but put these forms simply side by side. All determinations must be verified by the detailed descriptions given in the "differential diagnosis" (Foissner et al., 1994). All species have a single (whereas Cinetochilum margaritaceum has about five), elongated cilium (caudal cilium) on the posterior end.

1: Cyclidium glaucoma. 14-30 µm; barrel-shaped; contractile vacuole in posterior end; pellicle smooth; ciliation uniform; moves by short jumps, cilia become stiff and the undulating membrane is sail-like spread in the rests between the jumps; alphamesosaprobic.

2: Cyclidium heptatrichum. As C. glaucoma, but ciliation is more sparse in mid-body and some slightly elongated cilia occur in posterior body region; betamesosaprobic.

3: Ctedoctema acanthocryptum. 20-40 µm; slender-ellipsoid, dying specimens usually with small blister in posterior third of body; contractile vacuole subterminal; pellicle slightly notched by short extrusomes; jumps less conspicuously than C. glaucoma, but cilia become also stiff in resting specimens; beta- to alphamesosaprobic.

4: Calyptotricha lanuginosa. 30-40 µm; ovoid to ellipsoid; contractile vacuole terminal; pellicle smooth; never rests, except when being in its tube-shaped, slimy lorida which, however, is often deserted; alphamesosaprobic.

5: Uronema nigricans. 25-50 µm; barrel-shaped, in anterior third with small indentation marking oral opening; contractile vacuole terminal; pellicle smooth; often dark by highly refractile inclusions; swims fast, cilia stiff when resting (but does not jump like Cyclidium and Ctedoctema), but undulating membrane becomes not recognizable due to its small size and short cilia; alphamesosaprobic to polysaprobic.

6: Cinetochilum margaritaceum. 25-40 µm; lenticular, strongly flattened laterally, typical notch and about five elongated caudal cilia at posterior end; oral apparatus subequatorial; contractile vacuole opposed to oral apparatus; pantosaprobic.

7: Sathrophilus muscosum. 25-40 µm; shape similar to that of Cinetochilum margaritaceum, but posterior end without notch and oral apparatus in anterior body half; contractile vacuole slightly subterminal on ventral side; beta- to alphamesosaprobic.

8: Platynematum sociale. Size, shape and posterior notch similar as in Cinetochilum margaritaceum, but oral apparatus in anterior body half and contractile vacuole on ventral side; polysaprobic.

9: Pseudocohnilembus pusillus. 25-50 µm; oviform, in anterior third not indented (difference to Uronema nigricans); oral apparatus about half as long as cell, cleft-like, inconspicuous; moves drilling, never rests; polysaprobic.

10: Dexiotrichides centralis. 30-45 µm; reniform; cilia of anterior half directed anteriorly, those of posterior half posteriorly; moves zigzag, cilia stiff when resting; polysaprobic.
Hypotrichia I

shape; cirral rows; contractile vacuole; macronucleus

slenderly ellipsoid; two distinct marginal rows at least; at left body margin; two or more nodules

broadly ellipsoid; absent or very short; at right body margin; not segmented, i.e. C-shaped

mode of life

not epizoic

course of cirral rows

straight

spiral

Hypotrichia III-VII

mode of life

mainly in periphyton and detritus (in tubular loricas which, however, are often left)

planktonic

adoral zone of membranelles

straight

Cork-screw shaped

Stichotricha

Chaetosipra

zoochorellae

present

absent

lorica

vasiform

tubular

S. secunda

100-220 µm (p.210)

S. acuteata

90-120 µm (p.203)

C. muelleri

200-300 µm (p.213)

C. remex

150-560 µm (p.216)
Euplotes Hypotrichia

Hypotrichia II

- adoral zone of membranelles
  - large, in anterior body half: Euplotes
  - small, in posterior body half: Aspidisca

- dorsal surface
  - with 1-2 spines
  - with ribs
  - smooth

- cirrus V/2; dorsal surface
  - absent; with distinct ribs
  - present (arrow); usually smooth

- A. turrita 35-50 μm (p.383)
- A. cicada 25-40 μm (p.370)
- A. lyneus 35-50 μm (p.377)

- E. affinis 40-70 μm (p.340)
- E. moebiussi 45-70 μm (p.347)

- dorsal silverline system; frontal membranellar collar; reliable identification needs silver impregnation!

- double-patella typ; conspicuous
- double-eurystomus typ; conspicuous

- length; macronucleus; number of dorsal ciliary rows; adoral zone of membranelles
  - 140-230 μm; 3-shaped; usually 10; distinctly sigmoidal
  - 105-165 μm; usually C-shaped; usually 8; indistinctly sigmoidal

- E. patella 90-120 μm (p.362)
- E. eurystomus (p.357)
- E. aediculatus (p.352)
Hypotrichia III

Hypotrichia I

midventral row present

midventral row (exclusive midventral row)

Hypotrichia IV

midventral row absent

Hypotrichia III

midventral row difficult to recognize! It is, however, easily separated from Paraurostyla spp. and Pleurotricha spp., which have many cirral rows too, by the great number (> 100) of macronuclear nodules.

Urostyla grandis
250-400 μm (p.222)

shape; length

vermiform, unflattened; 300-500 μm

slenderly ellipsoid, distinctly flattened; 300-400 μm

about 100 μm; moderately distinct (ca 30%), 7-11

180-230 μm; very distinct (ca 50%), 13-22

length; posterior body end

300-500 μm; tail-like elongated

100-230 μm; pointed

number of macronuclear nodules

Urostyla piscis (p.252)

Urostyla gallina (p.244)

Urostyla musculus (p.248)

number of macronuclear nodules

distinctly subequatorial; 60-90 μm

in mid-body; 120-170 μm

9-23; small, colourless rods difficult to recognize

about 100; small (0.5-1.0 μm), ellipsoid granules easily recognized due to their yellowgreen colour

location of contractile vacuole; length

H. pullaster (p.240)

H. kessleri (p.228)

H. monilata (p.231)

H. multistitlata (p.236)
A user-friendly guide to freshwater ciliates

**Hypotrichia IV**

- **Hypotrichia III**
  - **number of cirral rows**
    - 3 or more
      - **zoochlorellae**
        - present
        - absent
      - **yellow-green cortical granules; number of transverse cirri**
        - present; 6-9
        - absent; 4-5
  - **oral area**
    - bright and large, spirally involuted anteriorly, with distinct pit in anterior half
- **Steinia platytonoma**
  - 80-150 μm (p.336)
  - **number of macronuclear nodules**
    - 4, rarely 6
  - **body**
- **Gastrostyla steinii**
  - 140-320 μm (p.272)
- **G. mystacea**
  - 120-170 μm (p.270)
- **Pleurotricha grandis**
  - 200-400 μm (p.275)

- **Paraurostyla viridis**
  - 115-175 μm (p.258)
- **Paraurostyla weissei**
  - 150-300 μm (p.260)

- **Hypotrichia V**
  - (if in doubt, follow key Hypotrichia VI)
    - **stiff like a board**
    - **flexible**
    - **zoochlorellae**
      - present
      - absent

- **Hypotrichia VI**
  - (if in doubt, follow key Hypotrichia V)
    - **Oxytricha chloroellegera**
      - about 115 μm (p.277)

Hypotrichia V
(difficult to determine)

- distinctly longer than marginal cirri
- about same length as marginal cirri or absent

- 1 between the two macroanuclear nodules
- number of micronuclei
- at least 1 at each macroanuclear nodule
- caudal cirri; posterior body end
- present but hardly recognizable; broadly rounded
- absent; broadly rounded and sometimes slightly notched

Stylonychia stylopuscorum
60-110 μm (p.332)

Sterkiella histriomuscorum
100-150 μm (p.311)

Histiculus vorax
140-190 μm (p.309)

- shape; caudal cirri

- anterior (oral) area distinctly widened; very long and distinctly separate from each other
- ellipsoid or with parallel sides; moderately long, distinctly or indistinctly separate from each other

Stylonychia putrina - complex
90-350 μm (p.315)

- determination difficult; shape; caudal cirri; location of left frontoventral cirrus

- sides almost parallel; posterior end broadly rounded; distinctly separate from other frontal cirri (arrow)
- ellipsoid or with parallel sides; posterior end narrowly rounded; indistinctly separate; indistinctly separate from other frontal cirri
- ellipsoid, posterior end narrowly rounded; distinctly separate; indistinctly separate from other frontal cirri

Stylonychia putrina
120-150 μm (p.329)

S. pustulata
50-200 μm (p.323)

S. vorax
85-120 μm (p.334)

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Hypotrichia VI

Hypotrichia IV

Volume I

cytoplasm; cortical granules

orange, reddish or brownish coloured; present

colour of cytoplasm; cortical granules; number of dorsal ciliary rows; marginal cirral rows

colourless; absent

orange to reddish; citrine, in longitudinal rows; 4; posteriorly superimposed (arrow)
brownish; brownish, in longitudinal stripes; 5; posteriorly not superimposed (arrow)

Oxytricha haematoplasma
120-180 μm (p.287)

Oxytricha ferruginea
150-260 μm (p.283)

Hypotrichia VII

1 between 2 macronuclear nodules

posteriormost marginal cirri

inconspicuous

distinctly larger and longer (arrow)

Tachysoma bicirratum
60-90 μm (p.302)

1 or several at each macronuclear nodule

number and location of micronuclei

length of dorsal cilia

8-15 μm (easily confused with cirri)

length of body; shape; caudal cirri

55-100 μm; slenderly ellipsoid; absent

40-60 μm; oviform; present (but difficult to recognize)

attention! easily confused with Holosticha pullaster; pay attention to location of contractile vacuole (arrow)

Tachysoma pellionellum (p.304) Oxytricha setigera (p.294) Oxytricha saprobia, 100 μm (p.292)

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Hypotrichia VII
(difficult to determine)

Oxytricha fallax
130-180 µm (p.279)

Oxytricha similis
60-110 µm (p.300)

Oxytricha hymenostoma
70-120 µm (p.289)

Key to species with cortical granules (use oil immersion!)

1. cytoplasm ± colourless .................................................................3
   - cytoplasm orange, reddish or brownish ........................................2
2. granules citrine, in short, longitudinal rows; cytoplasm orange
   or reddish .............................................................................................................Oxytricha haematoplasma
   - granules brownish, in longitudinal stripes; cytoplasm brownish ..........Oxytricha ferruginea
3. 2 macronuclear nodules, granules citrine ........................................Paraurostyla weissei
   - more than 2 macronuclear nodules .........................................................4
4. about 9-23 macronuclear nodules, granules colourless ......................Holosticha monilata
   - about 100 or more macronuclear nodules ..............................................5
5. about 10-17 cirral rows, granules citrine ..............................................Urostyla grandis
   - 2 marginal rows and 1 midventral row, granules citrine ......................Holosticha multistilata

(remarks: there are other coloured or granulated species that are not contained in this key)
Loxodes

Volume IV

nuclear apparatus; symbiotic algae

3-31 (usually about 17) macronuclei in 2 indistinct longitudinal rows and 2-32 (usually about 12) micronuclei; absent

2 macronuclei with 1 micronucleus between; present

2 widely separate macronuclei each with 1 micronucleus; absent

Loxodes magnus
usually 300-600 μm (p.378)

Loxodes rostrum
usually 150-200 μm (p.378)

Loxodes striatus
usually about 200 μm (p.378)
**Odontostomatida**

<table>
<thead>
<tr>
<th>Frontal ciliary band; spines</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>horseshoe-shaped on projecting bulge (long arrow); anterior and on right side a total of 3 long spines (short arrows)</td>
<td>does not extend on left side and not bulge-like separate from body, right and left side without spines, posterior end usually with distinct spines</td>
</tr>
<tr>
<td><em>Discomorphella pectinata</em> 70-90 μm (p.451)</td>
<td></td>
</tr>
<tr>
<td>posterior end; ciliature in posterior body half</td>
<td></td>
</tr>
<tr>
<td>2 rounded notches surrounded by 6 inconspicuous spines (arrows); several ciliary rows commencing near mid-body</td>
<td>right side wavy, left with 6-8 rounded spines (arrow); several short ciliary rows</td>
</tr>
<tr>
<td>8 short or long, claw-shaped spines (arrow); on spines short ciliary rows</td>
<td></td>
</tr>
<tr>
<td><em>Pelodinium reniforme</em> 40-50 μm (p.437)</td>
<td><em>Epalxella</em> spp. 25-90 μm (p.440)</td>
</tr>
</tbody>
</table>

1. All genera figured and all other odontostomatids live in anaerobic mud, i.e. are metasaprobic. Thus, determination of genera and species is often not necessary, i.e. the differentiation of form types is sufficient for practical work.

2. Easily confused with microthoracids (see Nassulida).

### Oligotrichida

**Volume I**

- **Adoral zone of membranelles**
  - Form apical circle
  - Extend on ventral side

- **Lorica; macronucleus**
  - Absent; reniform to horseshoe-shaped
  - Usually present (can be deserted, cells then become globular), globular to ellipsoid

- **Caudal ciliary spiral; length**
  - Present; > 40 μm
  - Absent; < 40 μm

- **Lorica; number of macronuclear nodules**
  - Vascular; 2
  - Tubular; 1

- **Strobilidium caudatum** (p.153)
  - Usualy  50-70 μm
  - Consistency of lorica: rather soft

- **S. humile** (p.159)
  - Usualy 50-70 μm
  - Consistency of lorica: rather firm

- **Tintinnidium pusillum** (p.168)
  - Usually < 30 μm

- **Codonella cratera** (p.183)
  - Usually > 35 μm

- **T. fluvialite** (p.163)
  - Usually > 35 μm

- **Tintinnopsis cylindrata** (p.178)
  - Usually > 35 μm

- **T. semiciliatum** (p.172)
  - Usually > 35 μm

- **Extrusomes; somatic ciliature; size**
  - Present (arrow); short cilia, hardly recognizable; 40-90 μm
  - Absent; long jumping bristles in mid-body; 20-50 μm

- **Jumping bristles; symbiotic algae**
  - Strombidium viride (p.146)
  - Distinct, i.e. cirri-like; absent
  - Pelagohalteria cirriforma (p.144)
  - Fine; present

- **Halteria chlorelligera** (p.134)
  - Fine, i.e. composed of 1-2 cilia; absent

- **Halteria grandinella** (p.137)
  - Fine, i.e. composed of 1-2 cilia; absent
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**Peritrichia I**

<table>
<thead>
<tr>
<th>Present</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peritrichia IV</strong></td>
<td><strong>Peritrichia V</strong></td>
</tr>
<tr>
<td>Epiizoic</td>
<td>Mobile</td>
</tr>
<tr>
<td>Sessile, usually not epizoic</td>
<td>Not ramified; usually &lt; 10 μm</td>
</tr>
</tbody>
</table>

**Peritrichia VI**

<table>
<thead>
<tr>
<th>Ramified; usually &gt; 10 μm</th>
<th>Not ramified; usually &lt; 10 μm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peritrichia II</strong></td>
<td><strong>Peritrichia III</strong></td>
</tr>
<tr>
<td>Stalk; stalk diameter</td>
<td>Absent</td>
</tr>
<tr>
<td>Stalk muscle</td>
<td>Ramification of stalk; pellicle</td>
</tr>
</tbody>
</table>

**Peritrichia IV**

- **Z. arbuscula**
  - 40-70 μm (p.152)
- **Z. procerius**
  - 60-80 μm (p.163)
- **Z. kentii**
  - 50-90 μm (p.158)
- **Carchesium polypinum**
  - 80-140 μm (p.137)

1. The determination of most peritrich ciliates is simple because they have many distinct characters which, however, are often recognizable only in vital populations. Thus, samples must be investigated within few hours because most species soon become morbid in the collection jars or transform to swimmers which are indeterminable. This should be considered when samples are collected: many peritrichs form whitish lawns on macrophytes, mosses, and the underside of stones. Such lawns should be picked up with a pipette and collected in a separate vessel, which greatly facilitates determination.

2. The hyaline, gelatinous loricas of *Ophrydium* species are easily overlooked. Thus, follow key Peritrichia VII for very long and slender specimens.

3. Stalked species detach from the substrate with or without stalk and are then mobile, i.e. free-swimming too. Furthermore, all peritrichs can transform to mobile swimmers, which are difficult to separate from naturally stalkless species (see Peritrichia V, bottom). However, species of these genera (*Opisthodiscus, Astyloses*), *Haslatella* are rare in running waters, usually occurring only in ephemeral and/or dammed waters. Many of the sessile species are sometimes attached on animals although being not true epizoos (e.g. *Carchesium polypinum*). Thus, if in doubt, first follow key Peritrichia VI; if it does not fit any of these species choose "sessile".

4. Colony founders, which may occur in older samples, are solitary, i.e. not ramified. Pay attention to stalk diameter.

**Peritrichia II**

with hyaline seam (arrows); 1 smooth or transversely striated; 1 or 2 with many tiny blisters; 2

Vorticella

granules on stalk muscle; contractile vacuole conspicuous; 2 (arrows) inconspicuous; 1
cytoplasm at X 100

colourless or yellowish dark to black

Pseudovorticella monilata 50-70 μm (p.130)

macronucleus

V. picta 50-70 μm (p.101)

J-shaped in longitudinal axis of cell

V. campanula 60-90 μm (p.105)

V. marginata 70-90 μm (p.114)

V. fromenteli 70-90 μm (p.116)

horseshoe-shaped in transverse axis of cell

number of pellicular striae; body shape

< 30; pyriform

about 30-45; pyriform

about 35-45; slightly campanulate

rod-like; pyriform to slightly campanulate

J-shaped; usually distinctly campanulate

V. aquadulcis-complex 30-45 μm (p.59)

V. infusionum-complex 45-60 μm (p.64)

V. octava-complex 35-45 μm (p.75)

V. microstoma-complex, usually < 60 μm (p.78)

V. convallaria-complex, usually ~ 60-80 μm (p.84)

Peritrichia I

- **Peritrichia III**
- number of turns of adoral ciliary spiral on peristomial disc
  - more than 3
  - less than 2
- peristomial margin
  - with bulge
    - Epistylis
    - Campanella umbellaria
      - 150-250 μm (p.225)
    - hollow
      - stalk
      - compact
      - 2 bulges
      - 1 bulge
        - O. nutans
          - 60-90 μm (p.176)
        - O. articulata
          - 90-120 μm (p.172)
        - O. coarctata
          - 40-65 μm (p.168)
        - macronucleus
        - horseshoe-shaped in transverse axis of cell
        - J-shaped in longitudinal axis of cell
        - determination difficult!
          - shape of cell; peristomial disc
            - ± cylindroid; umbilicated (arrow)
            - funnel-shaped; not umbilicated
            - club-shaped; not umbilicated
    - E. chrysemydis
      - 140-220 μm (p.182)
    - E. hentscheli
      - 110-170 μm (p.201)
      - E. galea
        - 110-320 μm (p.196)
      - E. coronata
        - 70-120 μm (p.188)
    - E. plicatilis
      - 90-160 μm (p.205)
    - E. entzii
      - 125-190 μm (p.190)

Volume II
Peritrichia IV
(all sizes refer to the lorica)

Peritrichia I

no

attachment of lorica on substrate

with long side

lorica opening; mode of life

closeable; epizoic

not closeable; not epizoic

Lagenophrys vaginicola
45-60 µm (p.256)

Platycola decumbens
65-145 µm (p.259)

present (arrow)

absent

Platycola decumbens
65-145 µm (p.259)

Pyxicola carteri
60-95 µm (p.270)

Cothurnia annulata
40-70 µm (p.251)

V. tincta
85-105 µm (p.287)

V. ingenita
35-60 µm (p.283)

lorica; zoochlorellae; cell stalk

posteriorly funnel-like narrowed; present; absent

posteriorly funnel-like narrowed; absent; present (arrow)

like a truncated cone and covered with detritus; absent; present

T. folliculata
125-240 µm (p.273)

T. kellicottiana
200-290 µm (p.278)

T. vasiformis
about 160 µm (p.281)

Peritrichia VII

with posterior end

lorica stalk

present

± cylindrical

absent

± pyriform

Ophrydium

Volume II
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Peritrichia V

- $\text{Habitus}$
  - $\text{Colonial}$
    - $\text{Lorica}$
      - $\text{Absent}$
      - $\text{Present}$
  - $\text{Solitary}$
    - $\text{Stalk}$
      - $\text{Present}$
  - $\text{Stalk; Stalk Muscle}$
  - $\text{Peritrichia II}$
    - $\text{Peristomial Collar; Stalk Contraction}$

- $\text{Carchesium pectinatum}$
  - $40-70 \mu m$ (p.149)
- $\text{Epistyliis procumbens}$
  - $60-140 \mu m$ (p.221)
- $\text{Vorticella natans}$
  - $70-100 \mu m$ (p.121)
- $\text{Vorticella mayeri}$
  - $30-55 \mu m$ (p.118)

- $\text{Absence}$ (but see footnotes 2 and 3 on page Peritrichia I and genus Ophrydium on page Peritrichia VII)

- $\text{Spines on Body}$
  - $\text{Present}$
  - $\text{Absent}$

- $\text{Aboral Ciliary Wreath}$
  - $\text{Absent}$
  - $\text{Present}$

- $\text{Hastatella radians}$
  - $40-60 \mu m$ (p.295)
  - $\text{On Ventral Wall of Peristomial Funnel}$
  - $\text{Contractile Vacuole}$

- $\text{Astylozoon fallax}$
  - $40-70 \mu m$ (p.289)
- $\text{Astylozoon faurei}$
  - $40-60 \mu m$ (p.291)
- $\text{Trichodina pediculus}$
  - $35-60 \mu m$ (p.304)
- $\text{Opisthontecta henneygui}$
  - $100-150 \mu m$ (p.299)

Peritrichia VI

- solitary host
  - hydrozoans, bryozoans, fishes
  - oligochaetes
  - small crustaceans

- annulated
  - smooth

- Trichodina pediculus 35-60 μm (p.304)
- Rhabdostyla inclinans 45-80 μm (p.246)
- Lagenophrys vaginicola 45-80 μm (p.256)
- Epistylis digitalis 80-100 μm (p.212)
- Epistylis nympharum 80-130 μm (p.217)

Peritrichia VII

- Peritrichia IV, V
  - zoociorellae; colony size
    - present; up to 10 cm
    - absent; up to 3 mm

  - number of turns of adoral ciliary spiral on peristomial disc (arrows)
    - 1 1/2
    - 2 1/2

  - colony shape
    - up to 5 individuals in cup-shaped, slimy lorida
    - hemispherical, up to 3 mm in size

- Ophrydium versatile 300-400 μm (p.232)
- Ophrydium eutrophicum 250-350 μm (p.239)
- Ophrydium crassicaule 180-200 μm (p.242)
- Ophrydium sessile 280-320 μm (p.244)

1 Often only stalkless, loridaless solitary specimens in running waters and plankton; then difficult to separate from Gerda spp., which lacks a lorida

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Pleurostomatida I

- Extrusome warts (arrows) or extrusome seam at dorsal side
  - Present: *Loxophyllum*
  - Absent

- Number of macronuclear nodules
  - More than 2

  - *L. meleagris*
    - About 300-500 µm
    - (p. 354)

  - *L. helus*
    - About 200 µm
    - (p. 364)

  - *L. utriculariae*
    - About 100-170 µm
    - (p. 369)

Pleurostomatida II

- Contractile vacuoles
  - 1
  - 2

  - CV = contractile vacuole
  - Ma = macronucleus
  - Mi = micronucleus

- *Litonotus varsaviensis*
  - About 80-150 µm
  - (p. 337)

- *Amphileptus*
  - More than 5

- Extrusomes drawn to scale:

  - 10 µm

  - Number of macronuclear nodules; adhesive apparatus
    - 2; absent
    - 4; present

  - Absent; absent
  - Thorn-shaped; short and little extensible
  - Rod-shaped; proboscis-like and very extensible

- *A. claparedii*
  - 120-160 µm
  - (p. 284)

- *A. pleurosigma*
  - 150-300 µm
  - (p. 290)

- *A. procerus*
  - 200-800 µm
  - (p. 297)

- *A. carchesii*
  - 200-360 µm
  - (p. 277)

Pleurostomatida II

Pleurostomatida I

Volume IV

number of macronuclear nodules

1

2

extrusomes

rod-shaped, ≤ 4 μm
terrestrial region
spoon-like hollowed)

slightly curved or
rod-shaped, ≥ 4 μm

ellipsoid, ≤ 3 μm
fusiform, about 5 μm

Acineria

number of ciliary rows

Litonotus alpestris
30-50 μm (p.309)

A. uncinata
30-60 μm (p.349)

A. incurvata
50-150 μm (p.343)

Amphileptus punctatus
80-150 μm (p.303)

Litonotus fusidens
70-130 μm (p.326)

All extrusomes drawn to scale: 10 μm

very extensible; along
oral slit

little extensible; along oral slit
and in posterior end

left side

with single, thorn-shaped rib
with several longitudinal ribs

contrasted
- extended

transverse section
of cell

Litonotus cygnus
200-300 μm (p.318)

Litonotus lamella
50-100 μm (p.329)

Litonotus crystallinus
80-170 μm (p.315)
Prostomatida I  
with fenestrated armour plates

yes

Coleps

zoochlorellae; main plates

yes; wing-like broadened (arrows)

no; serrate or smooth

windows in armour plates

bretzel-shaped

reniform

C. spetai

50-70 µm (p. 400)

C. hirtus

40-65 µm (p. 382)

C. nolandi

40-65 µm (p. 395)

Prostomatida II

pellicle distinctly furrowed spirally

no

size

≤ 60 µm

> 60 µm, usually > 100 µm

Prostomatida II

zoochlorellae

no

yes

size, cytoplasm

100-160 µm; not foamy

200-800 µm, usually 250-500 µm; foamy

Macronucleus

ellipsoid

rope-shaped

size; number of ciliary rows

size; shape

60-160 µm; 35-64

usually 150-250 µm;

80-110

Holophrya ovum

(p. 322)

Bursellopsis spumosa

(p. 405)

Holophrya discolor

(p. 328)

Holophrya teres

(p. 336)

Prorodon ellipticus

(p. 344)

Prorodon niveus

(p. 346)

Placus luciae

30-70 µm (p. 376)

Prostomatida II

Prostomatida I

posterior third not ciliated; mouth

yes; funnel-shaped

3 oblique ciliary spirals; mouth

yes; subapical, oblique funnel

no; polar funnel

mouth; mouth flaps

Plagiocampa rouxi
35-50 μm (p.373)

as wide as body; very long

flaps

number of caudal cilia

Tritymyema compressum
25-60 μm (p.408)

Balanion planctonicum
about 20 μm (p.369)

U. furcata
20-30 μm (p.366)

U. armata
30-55 μm (p.362)

form distinct layer underneath pellicle; usually about 45-50 μm

inconspicuous in live specimens; usually 45 μm

size; shape; number of ciliary rows

10-20 μm; cone-shaped; 12-14

18-25 μm; globular; 17-25

25-50 μm; ellipsoid to cylindrical; 19-27

20-30 μm; jug-shaped with wart-like oral tube; 20-25

U. agilis
(p.349)

U. globosa
(p.360)

U. ovata
(p.357)

U. farcata
(p.352)

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Suctoria I

- Tree-like, forms sometimes large, upright colonies (not flat masses as Trichophrya)

- Dendrosoma radians
  - Up to 5 mm high (p.423)

- H. rotunda
  - 30-80 μm (p.428)

- H. minima
  - 23-50 μm (p.438)

- Different shapes
  - + disk-shaped
  - Heliophrya
  - Tentacles
    - Bundled
    - Solitary

- Minute tentacles

- Swarmer of Enchelyomorpha vermicularis
  - (adults insufficiently known)
  - 25-45 μm (p.458)

Suctoria II

- Globular; ± evenly distributed
  - Surface of cell
    - Spinous at a magnification of at least x 200
    - Smooth

- Stalk
  - Absent
  - Present

- Different shapes
  - ± globular; bundled (euplanktonic)
  - ± triangular; bundled

- Sphaerophrya magna
  - 25-90 μm (p.473)

- Podophrya fixa
  - 10-100 μm, usually about 50 μm
  - (p.459, 465, 471)

- Staurophrya elegans
  - 50-65 μm (p.420)

- These 3 species cannot be identified reliably in the adult, sessile stage, but only as swarvers

Parapodophrya soliformis
- 30-100 μm (p.476)

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Suctoria II

present, flattened and transverse truncate
Acineta
articulation between lorica and stalk

size; macronucleus
150-350 µm; curved
usually 40-100 µm; globular or ellipsoidal

present, unflattened, roof-like narrowed anteriorly
Metacina

absent
curved in fully extended condition (rare species)
not curved in fully extended condition

Suctoria I
lorica

tentacles

M. cuspidata
32-42 µm (p.488)

M. mystacina
55-220 µm total length (p.481)

A. flava
50-150 µm (p.450)

A. grandis
stalk up to 1.5 mm (p.448)

A. tuberosa
25-200 µm (p.442)

M. cuspidata
32-42 µm (p.488)

M. mystacina
55-220 µm total length (p.481)

T. carchesii
25-85 µm, usually < 50 µm (p.417)

T. infusionum
18-80 µm, usually 30-50 µm (p.401)

T. lemnarum
18-125 µm, usually about 50 µm (p.405)

T. quadripartita
40-175 µm, usually 40-90 µm (p.411)

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Special keys

The following keys contain some groups and species which have conspicuous characters and are thus easily determined. These keys belong to the general key (Ciliophora I-XI).

**Special key I** (conspicuously coloured or dark species)

- **Ciliophora I**
  - colour
  - conspicuously spotted (violet, green, blue, orange ... by ingested cyanobacteria)
  - grass-green, usually by zoochlorellae
  - dark to black at X 100

**Special key II**
- shape; contractile vacuoles (CV)
- slenderly pyriform; 3-5 along median of cell
- ellipsoid; 1 near mid-body
- size
  - usually > 150 μm
  - < 150 μm

**Special key VI**
- ellipsoid; 1 in posterior end
- size; number of ciliary rows
  - 60-160 μm; 35-64
  - usually 150-250 μm; 80-110

- **Nassulopsis elegans**
  - 150-300 μm
  - (Vol. III, p.430)

- **Nassula picta**
  - 70-140 μm
  - (Vol. III, p.445)

- **Holophrya discolor**
  - (Vol. III, p.328)

- **Holophrya teres**
  - (Vol. III, p.336)

- **Obertrumia aurea**
  - 120-250 μm
  - (Vol. III, p.451)

- **Nassula ornata**
  - 155-320 μm
  - (Vol. III, p.438)

- **blue-green (turquoise)**

- **special key VIII**
- present

- **special key V**
- absent

- **Hypotrichia VII and special key VII**
- orange, reddish or red
- yellow-green or yellow (frequently indistinct; hypotrichs must have citrine cortical granules [oil immersion])

**Special key II** (grass-green coloured, usually by zoochlorellae*)

* Differentiation of zoochlorellae and food vacuoles with green algae: zoochlorellae are about 5 μm in size and lie singly in the cytoplasm, i.e. are not enclosed in a vacuole as ingested algae

<table>
<thead>
<tr>
<th>Special key I</th>
<th>Peritrichia</th>
<th>no</th>
<th>yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>100-200 μm</td>
<td>&lt; 100 μm</td>
<td>&gt; 200 μm</td>
</tr>
</tbody>
</table>

**Special key III**

<table>
<thead>
<tr>
<th>Shape</th>
<th>Conical</th>
<th>Globular</th>
<th>Barrel-shaped</th>
<th>Oviform</th>
<th>With short snout anteriorly</th>
<th>Cap-shaped in lateral view, cordiform in ventral view</th>
</tr>
</thead>
</table>

- Strombidium viride 40-90 μm (Vol. I, p.146)
- Coleps spatia 50-70 μm (Vol. III, p.400)
- Paramecium bursaria 85-150 μm (Vol. III, p.140)
- Pseudochilodonomopsis algivora 40-70 μm (Vol. I, p.62)
- Stokesia vernalis 60-160 μm (Vol. III, p.200)

**Special key IV**

- Trumpet-shaped
- Globular
- Ovoid to bursiform
- Broadly ellipsoid

- Extended: Stentor polymorphus up to 2 mm (Vol. II, p.368)
- Contracted: Stentor polymorphus sometimes < 200 μm (Vol. II, p.368)
- Climacostomum virens 160-250 μm (Vol. II, p.394)
- Burselopsis spumosa 200-800 μm, usually 250-500 μm (Vol. III, p.405)

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Special key III (grass-green coloured by zoochlorellae)

<table>
<thead>
<tr>
<th>Shape</th>
<th>Number of cirral (bundles of cilia) rows</th>
<th>Calyx-shaped, anterior end with 3 hucksters</th>
</tr>
</thead>
<tbody>
<tr>
<td>with short snout anteriorly</td>
<td>8-14</td>
<td></td>
</tr>
<tr>
<td>slenderly fusiform</td>
<td></td>
<td></td>
</tr>
<tr>
<td>slenderly ellipsoid, flattened</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

- **Loxodes rostrum**
  - usually 150-200 μm
  - (Vol. IV, p.378)

- **Stichotricha secunda**
  - 100-220 μm

- **Paraurostyla viridis**
  - 115-175 μm
  - (Vol. I, p.258)

- **Oxytricha chloreiligera**
  - about 115 μm
  - (Vol. I, p.277)

- **Disematostoma tetraedricum**
  - 100-140 μm
  - (Vol. III, p.185)

- **Stokesia vernalis**
  - 60-160 μm
  - (Vol. III, p.200)

- **Climacostomum virens**
  - 160-250 μm
  - (Vol. II, p.394)

- **Paramecium bursaria**
  - 85-150 μm
  - (Vol. III, p.140)

- **Disematostoma buetschlii**
  - 110-200 μm
  - (Vol. III, p.180)

- **Holophrya ovum**
  - 100-160 μm
  - (Vol. III, p.322)

Special key IV (grass-green coloured by zoochlorellae)

- **Thuricola folliculata**
  - 125-240 μm
  - (Vol. II, p.273)

Special key V (bluegreen species)

- **Blepharisma coeruleum**
  - 120-150 μm
  - (Vol. II, p.382)

- **Ophrydium versatile**
  - 300-400 μm
  - (Vol. II, p.232)

- **Ophrydium eutrophicum**
  - 250-350 μm
  - (Vol. II, p.239)

- **Stentor multiformis**
  - about 250 μm
  - (Vol. II, p.351)

- **Stentor coerules**
  - 1-2 mm
  - (Vol. II, p.357)
**Special key VI** (dark or black species)

- **shape**
  - trumpet-shaped
  - barrel-shaped (at ≥ X 100 brownish)
  - ellipsoid or fusiform
- **windows in armour plates**
  - reniform
  - bretzel-shaped
- **mouth; contractile vacuole**
  - at anterior end; in posterior end
  - different
- **Hymenostomata II**
  - **size**
    - 60-250 μm
    - 25-50 μm
  - **shape**
    - with inconspicuous ventral notch (arrow)
    - different
  - **Uronema nigricans**
    (Vol. III, p.373)
  - **Plagiocampa rouxi**
    (Vol. III, p.228)

- **size; number of ciliary rows**
  - 60-160 μm; 35-64
  - usually 150-250 μm; 80-110

- **Holophrya discolor**
  (Vol. III, p.328)
- **Holophrya teres**
  (Vol. III, p.336)

- **contractile vacuole**
  - ellipsoid
  - horseshoe-shaped in transverse axis of cell
  - J-shaped in longitudinal axis of cell

- **Vorticella marginata**
  70-90 μm
  (Vol. II, p.114)
- **Vorticella campanula**
  60-90 μm
  (Vol. II, p.105)

- **Stentor amethystinus**
  or S. niger
  (Vol. II, p.339, 355)
- **Coleps nodulatus**
  40-65 μm
  (Vol. III, p.395)
- **Coleps hirtus**
  40-65 μm
  (Vol. III, p.382)

Special key VII (yellow or yellowgreen coloured species)

- **shape; stalk**
  - campanulate; yes
  - slenderly ellipsoid, flattened; no

- **number of macronuclear nodules**
  - many
  - size
  - 2

- **size**
  - 250-400 μm, usually 300-350 μm
  - 130-170 μm

- **Vorticella citrina**
  - 60-80 μm
  - (belongs to the Vorticella convallaria-complex; see key Peritrichia II)

- **Paraurostyla weissei**
  - 150-300 μm
  - (Vol. I, p.260)

- **Urostyla grandis**
  - (Vol. I, p.222)

- **Holosticha multistilata**
  - (Vol. I, p.236)

Special key VIII (orange, reddish or red coloured species)

- **shape**
  - conical or globular
  - oviform
  - oblong
  - ellipsoid

- **number of macronuclear nodules; colour**
  - 2; orange to distinctly pink
  - many; wine-red

- **Stentor igneus**
  - about 250 μm
  - (Vol. II, p.346)

- **Blepharisma lateritium**
  - 110-190 μm
  - (Vol. II, p.384)

- **Pseudoblepharisma tenue**
  - 100-200 μm
  - (Vol. II, p.388)

- **Oxytricha haematoplasma**
  - 120-180 μm
  - (Vol. I, p.287)

- **Diaxonella trimarginata**
  - 130-170 μm
  - (not described in main work)
**Special key IX** (loricate or armoured species)

- **Codonella cratera**
  - sandy
  - 50-70 μm
  - (Vol. I, p. 183)

- **Tintinnidium/Tintinnopsis**
  - mucilaginous

- **Stentor**
  - hyaline and/or covered with organic debris

- **Cyrtolophosis mucicola**
  - 20-40 μm
  - (Vol. I, p. 414)

- **Oligotrichida I**
  - **Codonella**
  - 50-70 μm
  - (Vol. I, p. 183)

- **Tintinnidium/Tintinnopsis**
  - 40-70 μm
  - (Vol. II, p. 251)

- **Stenoceratida**
  - **Heterotrichida I**
  - **Stentor**
  - **Stichotricha**
  - **Chaetospora**

- **Peritrichia I**
  - **Vaginicola**
  - **Thuricola**
  - **Cyrtolophosis mucicola**
  - 20-40 μm
  - (Vol. I, p. 414)

- **Codonella cratera**
  - 50-70 μm
  - (Vol. I, p. 183)

- **Tintinnidium/Tintinnopsis**
  - 40-70 μm
  - (Vol. II, p. 251)

- **Stenoceratida**
  - **Heterotrichida I**
  - **Cyonmedion**
  - **Hypotrichia I**

- **Cyrtolophosis mucicola**
  - 20-40 μm
  - (Vol. I, p. 414)

- **Peritrichia VII**
  - **Lagenophrys vaginicola**
  - 45-80 μm
  - on small crustaceans
  - (Vol. II, p. 258)

- **Pyxicola carteri**
  - 60-95 μm
  - (Vol. II, p. 270)

- **Pyxicola decumbens**
  - 65-140 μm
  - (Vol. II, p. 259)

- **Peritrichia VII**
  - **Vaginicola**
  - **Thuricola**
  - **Cytolophosis mucicola**
  - 20-40 μm
  - (Vol. I, p. 414)

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  - **Vaginicola**
  - **Thuricola**
  - **Cytolophosis mucicola**
  - 20-40 μm
  - (Vol. I, p. 414)

Special key X (very large [> 300 μm] species)

Monilicaryon monilatus
350-950 μm
(Vol. IV, p.189)

Dileptus marmalifer
250-600 μm
(Vol. IV, p.185)

Trachelius ovum
200-600 μm
(Vol. IV, p.208)

Homalozeon vermiculare
150-1500 μm
(Vol. IV, p.219)

Amphileptus procerus
200-800 μm
(Vol. IV, p.297)

Spirostomum
200-2000 μm

Heterotrichida l

Stentor
200-2000 μm

Loxophyllum meleagris
300-500 μm
(Vol. IV, p.354)

Loxodes magnus
150-600 μm
(Vol. IV, p.378)

Urostyla grandis
250-400 μm
(Vol. I, p.222)

Amphileptus pleurosigma
180-300 μm
(Vol. IV, p.290)

Nassula ornata
155-320 μm
(Vol. III, p.436)

Bursaria truncatella
200-1700 μm
(Vol. I, p.424)

Prorodon niveus
250-700 μm
(Vol. III, p.346)

Bursellopsis spumosa
200-800 μm
(Vol. III, p.405)
Special key XI (conspicuously contractile species)

**Stentor**

**Heterotrichida I**

Lacrimaryol or extended ≤ 1200 μm
contracted ~ 100 μm
(Vol. IV, p. 163)

Homalozoan
vermiculare
150-1500 μm
(Vol. IV, p. 219)

some Pleurostomatida
(often difficult to recognize
because slow)

**Pleurostomatida**

Trachelophyllum
apiculatum
90-180 μm
(Vol. IV, p. 180)

**Spirostomum**

contracted spirally

**Heterotrichida I**

Peritrichia

**Uroleptus**

Hypotrichia III

Lagynus elegans
extended 130-200 μm
contracted 60-100 μm
(Vol. IV, p. 173)
**Special key XII** (slender species, length : width ratio $\geq 5:1$; attention, often highly contractile and then becoming more blunt)

- **Heterotrichida I**
  - Homalozoon vermiculare
    - Length: 150-1500 μm
    - Width: 90-180 μm
    - (Vol. IV, p.199)

- **Monilicaryon monilatus**
  - Length: 350-950 μm
  - Width: 90-150 μm
  - (Vol. IV, p.185)

- **Dileptus margaritifer**
  - Length: 250-600 μm
  - Width: 90-150 μm
  - (Vol. IV, p.152)

- **Chaenea stricta**
  - Length: 90-180 μm
  - Width: up to 1200 μm
  - (Vol. IV, p.180)

- **Trachelophyllum apiculatum**
  - Length: 250-600 μm
  - Width: 90-150 μm
  - (Vol. IV, p.163)

- **Lacrymaria vermiculare**
  - Length: 150-1500 μm
  - Width: 90-150 μm
  - (Vol. IV, p.199)

- **Pseudolepharisma tenue**
  - Length: 100-200 μm
  - Width: 90-180 μm
  - (Vol. II, p.388)

- **Spirostomum**
  - Length: 200-2000 μm
  - Width: 90-180 μm
  - (Vol. IV, p.163)

- **Stichotricha Chaetospira**
  - Length: 150-300 μm
  - Width: 90-180 μm
  - (Vol. IV, p.297)

- **Amphileptus pleurosigma**
  - Length: 150-300 μm
  - Width: 90-180 μm
  - (Vol. IV, p.290)

- **Amphileptus procerus**
  - Length: 200-800 μm
  - Width: 90-180 μm
  - (Vol. IV, p.297)

- **Litonotus cygnus**
  - Length: 200-300 μm
  - Width: 90-180 μm
  - (Vol. IV, p.318)

- **Kahillembus attenuatus**
  - Length: 40-80 μm
  - Width: 90-180 μm
  - (Vol. III, p.237)
Special key XIII (cylindroid, fusiform or ovoid species)

Nassula / Obertrumia
Nassulida

Holophrya

Prorodon
Prostomatida I

Enchelyodon elegans
140-200 μm
(Vol. IV, p.155)

Paramecium caudatum/aurelia
Hymenostomata V

Kahlilembus attenuatus
40-80 μm
(Vol. III, p.237)

Philasterides armatus
50-100 μm
(Vol. III, p.224)

Ophryoglena
(Vol. III, p.110)

Stichotricha
Hypotrichia I

Phialina
(Vol. IV, p.171)

Hymenostomata

Tetrahymena pyriformis-complex
40-60 μm
(Vol. III, p.61)

Glaucoma reniforme
35-65 μm
(Vol. III, p.103)

Uromema nigricans
25-50 μm
(Vol. III, p.228)

Pseudocohnilembus pusillus
25-50 μm
(Vol. III, p.271)

Urotricha agilis/ovata
Prostomatida II

Gymnostomatida I

Special key XIV (barrel-shaped, ellipsoid or like a segment of a circle)

Coléps

Prostomatida I

Prorodon ellipticus
80-150 µm
(Vol. III, p.344)

Opisthonecta henneguyi or swarvers of sessile peritrichs

Peritrichia

Uronema nigricans
25-50 µm
(Vol. III, p.228)

Strongly beating ciliary plates

Glaucoma scintillans
35-75 µm
(Vol. III, p.92)

Epenardia myriophylli
90-200 µm
(Vol. III, p.106)

Sathrophilus muscorum
25-40 µm
(Vol. III, p.259)

Trachelius ovum
200-600 µm
(Vol. IV, p.208)

Contracted

Stentor

Hetero-trichida I

Odontochlamys aipestris
35-60 µm
(Vol. I, p.52)

Trockilia minuta
15-40 µm
(Vol. I, p.117)

Leptopharynx costatus
20-50 µm
(Vol. III, p.460)

Microthorax pusillus
20-35 µm
(Vol. III, p.478)

Mouth

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**Special key XV** (dumb-bell shaped or spatular)

![Diagram of ciliates showing different shapes and sizes]

- **Urocentrum turbo** (40-100 µm) (Vol. III, p.187)
- **Urozona buetschlii** (20-40 µm) (Vol. III, p.268)
- **Maritua pelagica** (80-160 µm) (Vol. III, p.195)
- **Proodon niveus** (250-700 µm) (Vol. III, p.346)
- **Spathidium** (Vol. IV, p.226)

**Special key XVI** (species with snout-like anterior end)

![Diagram of ciliates showing different features]

- **Pseudochilodontopsis** (Cytophorida II)
- **Metopus** (Heterotrichida II)
- **Loxodes** (Pleurostomatida)
- **Zosterodasys transversa** (130-250 µm) (Vol. III, p.418)
- **Hexotracha caudata** (25-30 µm) (Vol. III, p.483)
- **Discomorphella pectinata** (70-90 µm) (Vol. III, p.451)

Special key XVII (species with proboscis or proboscis-like process)

- **Dileptus margaritifer**
  - 250-600 µm
  - (Vol. IV, p.185)

- **Monilicaryon monilatus**
  - 350-950 µm
  - (Vol. IV, p.199)

- **Trachelius ovum**
  - 200-600 µm
  - (Vol. IV, p.208)

- **Paradileptus elephantinus**
  - 180-450 µm
  - (Vol. IV, p.203)

- **Lacrymaria olor**
  - up to 1200 µm
  - (Vol. IV, p.163)

- **Lagynus elegans**
  - 60-200 µm
  - (Vol. IV, p.173)

- **Lagynophrya acuminata**
  - 70-95 µm
  - (Vol. IV, p.178)

- **Litonotus cygnus**
  - 200-300 µm
  - (Vol. IV, p.318)

- **Trachelophyllum apiculatum**
  - 90-180 µm
  - (Vol. IV, p.180)

- **Amphileptus procerus**
  - 200-800 µm
  - (Vol. IV, p.297)

- **Stichotricha**
  - (Vol. II, p.118)

- **Chaetospira**
  - 30-55 µm
  - (Vol. II, p.121)

- **Hypotrichia**
  - 30-55 µm
  - (Vol. II, p.118)

- **Vorticella mayeri**
  - 70-100 µm
  - (Vol. II, p.121)

- **Vorticella natans**
  - 70-100 µm
  - (Vol. II, p.121)
Special key XVIII (tailed species)

Amphileptus
Pleurostomatida I

Caenomorpha
Heterotrichida II

Uroleptus
Hypotrichia III

Spirostomum caudatum
200-300 μm
(Vol. II, p.324)

Special key XIX (species having conspicuous "somatic cilia" [cirri] at a magnification of X 100)

Aspidisca
Hypotrichia II

Hypotrichia III

Holosticha

Stylonychia mytilus
90-350 μm
(Vol. I, p.315)

Stylonychia pustulata
50-200 μm
(Vol. I, p.323)

Tachysoma pellionellum
55-100 μm
(Vol. I, p.304)

Uroleptus
Hypotrichia III

Halteria
Oligotrichida

Askenasia volvox
30-50 μm
(Vol. IV, p.251)

Masodinium
12-35 μm

Gymnostomatida I

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Special key XX (species with bizarre shape)

- Lacrymaria olor
  - up to 1200 µm
  - (Vol. IV, p.163)

- Paradileptus elephantinus
  - 180-450 µm
  - (Vol. IV, p.203)

- Didinium/Monodinium
  - Gymnostomatida l

- Hastateilla radians
  - 40-60 µm
  - (Vol. II, p.295)

- spine

- lorica

- Hypotrichidium conicum
  - 90-120 µm
  - (Vol. I, p.218)

- Caenomorpha
  - (Vol. II, p.424)

- Metopus
  - (Vol. II, p.400)

- in anaerobic mud

- in anaerobic mud

- rapidly rotating

- conspicuous ciliary tuft

- anterior end trilobate

- cap-shaped in lateral view

- large oral cavity

- Urocentrum turbo
  - 40-110 µm
  - (Vol. III, p.187)

- Disematostoma tetraedricum
  - 100-140 µm
  - (Vol. III, p.185)

- Stokesia vemalis
  - 60-160 µm
  - (Vol. III, p.200)

- Bursaria/Bursaridium

- Colpodea

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Special key XXI (species distinctly furrowed longitudinally, spirally, or transversely)

- Aspidisca cicada
  25-40 µm
  (Vol. I, p.370)

- Euplotes affinis
  40-70 µm
  (Vol. I, p.340)

- Cinetoecium
  margaritaceum
  25-40 µm
  (Vol. III, p.249)

- Lembadium

- Hymenostomata I

- Loxophyllum
  utriculariae
  100-170 µm
  (Vol. IV, p.369)

- Litonotus
  crystallinus
  80-170 µm
  (Vol. IV, p.315)

- Drepanomonas
  revoluta
  18-35 µm
  (Vol. III, p.472)

- Pseudomicrothorax
  agilis
  30-70 µm
  (Vol. III, p.466)

- Dysteria
  fluviatilis
  20-35 µm
  (Vol. I, p.125)

- Placus lumiae
  30-70 µm
  (Vol. II, p.400)

- Metopus
  sensu lato

- Colpoda magna
  120-240 µm
  (Vol. I, p.408)

- Chaetospira

- Hypotrichia I

- Tropidoatractus
  acuminatus
  70-150 µm
  (Vol. II, p.420)

- Enchelyomorpha
  vermicularis
  25-45 µm
  (Vol. IV, p.456)

- Lagynus
  elegans
  60-200 µm
  (Vol. IV, p.173)

- Urozona
  buetschlii
  20-40 µm
  (Vol. III, p.268)
Special key XXV (species with conspicuous movement)

jumping (between jumps often some time motionless) and/or rotating; note that many ciliates become almost motionless and ingest food particles in preparations which were undisturbed for some time

Didinium nasutum
80-200 μm
(Vol. IV, p.228)

Monodinium balbianii
50-120 μm
(Vol. IV, p.235)

Askenasia volvox
30-50 μm
(Vol. IV, p.251)

Mesodinium
12-35 μm
Gymnostomatida I

Didinium volvox
30-50 μm
(Vol. IV, p.251)

Dolichomastix
20-40 μm
(Vol. III, p.212)

Pleuronema
Hymenostomata III

Cyclidium
Hymenostomata VII

Ctedoctema
acanthocryptum
20-40 μm
(Vol. III, p.294)

Oligotrichida
Urotictis
Prostomatida II

Pleuronema
Hymenostomata III

Cyclidium
Hymenostomata VII

Ctedoctema
acanthocryptum
20-40 μm
(Vol. III, p.294)

Oligotrichida
Urotictis
Prostomatida II

rotating on mucuous filament

Didinium nasutum
80-200 μm
(Vol. IV, p.228)

Monodinium balbianii
50-120 μm
(Vol. IV, p.235)

Askenasia volvox
30-50 μm
(Vol. IV, p.251)

Mesodinium
12-35 μm
Gymnostomatida I

Didinium volvox
30-50 μm
(Vol. IV, p.251)

Dolichomastix
20-40 μm
(Vol. III, p.212)

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Hymenostomata III

Cyclidium
Hymenostomata VII

Ctedoctema
acanthocryptum
20-40 μm
(Vol. III, p.294)

Oligotrichida
Urotictis
Prostomatida II
Special key XXVI (species with conspicuous ciliary wreaths [arrows])

**Monodinium balbianii**
50-120 µm
(Vol. IV, p. 235)

**Didinium nasutum**
80-200 µm
(Vol. IV, p. 228)

**Askenasia volvox**
30-50 µm
(Vol. IV, p. 251)

**Mesodinium**
12-35 µm

**Gymnostomatida I**

**Halteria/ Pelagohalteria**

**Oligotrichida I**

**Urozona buetschlii**
20-40 µm
(Vol. III, p. 268)

**Tramyema compressum**
25-60 µm
(Vol. III, p. 408)

**Halteria/ Pelagohalteria**

**Oligotrichida I**

**Trichodina pediculus**
35-60 µm
(Vol. II, p. 304)

**Opisthonecta henneguyi**
100-150 µm
(Vol. II, p. 299)

**swarmers of peritrichs (indeterminable)**

Special key XXVII (species which are frequently densely filled with ingested diatoms)

- **Trithigmostoma**
  - Cyrtophorida I
  - Chlamydonopsis plurivacuolata 50-110 μm (Vol. I, p.110)
- **Chlamydonella alpestris** 25-35 μm (Vol. I, p.115)
- **Gastronauta**
  - Cyrtophorida I
  - Gradually narrowed posteriorly!
- **Pseudochilodonopsis**
  - Cyrtophorida II
  - Zosterodasys transversa 130-250 μm (Vol. III, p.418)
  - Chlodontopsis depressa 50-80 μm (Vol. III, p.424)
- **Strobilidium**
  - Oligotrichida
  - Very fast swimming or rotating on mucous filament
- **Marituja pelagica**
  - Oligotrichida
  - 80-160 μm (Vol. III, p.195)
- **Frontonia**
  - Hymenostomata V
  - Rod seam
- **Tintinnidium**
  - Oligotrichida
  - Lorica

Special key XXVIIa (euplanktic species)

- **Codonella cratera**
  50-70 μm
  (Vol. I, p.183)

- **Tintinnidium/ Tintinnopsis**

- **Halteria/ Pelagohalteria**

- **Strobilidium humile**
  12-38 μm
  (Vol. I, p.159)

- **Strombidium viride**
  40-90 μm
  (Vol. I, p.146)

**Oligotrichida**

- **Codonella cratera**
  50-70 μm
  (Vol. I, p.183)

- **Tintinnidium/ Tintinnopsis**

- **Halteria/ Pelagohalteria**

- **Strobilidium humile**
  12-38 μm
  (Vol. I, p.159)

- **Strombidium viride**
  40-90 μm
  (Vol. I, p.146)

**Oligotrichida**

- **Disematostoma**
- **Maritua pelagica**
  80-180 μm
  (Vol. III, p.195)

- **Stokesia vermaiis**
  60-180 μm
  (Vol. III, p.200)

- **Phascolodon vorticella**
  50-110 μm
  (Vol. I, p.98)

**Zoochlorellae**

- **Linostoma vorticella**
  about 170 μm
  (Vol. II, p.390)

- **Stentor amethystinus**
  250-500 μm
  (Vol. II, p.339)

- **Hypotrichidium conicum**
  90-120 μm
  (Vol. I, p.218)

- **Bursaidium pseudobursaria**
  80-200 μm
  (Vol. I, p.433)

Special key XXVIIIb (euplanktic species)

1. Askenasia volvox
   30-50 μm
   (Vol. IV, p. 251)

2. Mesodinium
   12-35 μm

3. Actinobolina

4. Lagynophrya acuminata
   70-95 μm
   (Vol. IV, p. 178)

5. Gymnostomatida I

6. Bursellopsis spumosa
   200-600 μm
   (Vol. III, p. 405)

7. Coleps setaI
   50-70 μm
   (Vol. III, p. 400)

8. Urotricha

9. Prostomatida II

10. Paradileptus elephantinus
   160-450 μm
    (Vol. IV, p. 203)

11. Astylozoon

12. Vorticella mayeri/infans

13. Peritrichia V

14. Epistyris procumbens
   60-140 μm
   (Vol. II, p. 221)

15. Carchesium pectinatum
   40-70 μm
   (Vol. II, p. 149)

16. Opisthoneccta henneguyi
   100-150 μm
   (Vol. II, p. 299)

17. Staurophrya elegans
   50-65 μm
   (Vol. IV, p. 420)

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Special key XXIX (15-50 µm [usually < 40 µm] sized, broad species; usually gliding in periphyton and often very hyaline)

**Hymenostomata VII**
- Cinetochilum
- Platynematum
- Sathrophilus
- Tetrahymena
- Glaucoma

**Hymenostomata VI**
- location of contractile vacuoles!
- oral basket!

**Cyrtophorida II**
- Thigmogaster
- Chilodonella
- Odontochlamys
- Chlamydonella
- Urotricha

**Prostomatida II**
- stylus!
- nuclear structure!
- cirri!

**Cyrtophorida I**
- in anaerobic mud; bizarre shape!

**Colpodea**
- Colpoda steini/lecaudata

**Aspidisca**

**Hypotrichia II**

**Odontostomatida**
- Epaixella
- Pelodinium
- Saprodictium
- Leptopharynx

**Nassulida**
- Leptopharynx
- Microthorax

Special key XXXII (epizoic species; note that many other species, although being not true epizoons, especially peritrichs and suctorians, are sometimes attached to small invertebrates)

- **Trichodina pediculus**
  - 35-60 µm
  - on hydras, bryozoans and fishes
  - (Vol. II, p.304)

- **Rhabdostyla inclinans**
  - 45-80 µm
  - solitary on oligochaetes
  - (Vol. II, p.246)

- **Epistylis nympharum**
  - 80-130 µm
  - colonial on arthropods
  - (Vol. II, p.217)

- **Epistylis digitalis**
  - 80-100 µm
  - colonial on small crustaceans, especially cyclopids
  - (Vol. II, p.212)

- **Lagenophrys vaginicola**
  - 45-80 µm
  - on small crustaceans
  - (Vol. II, p.256)

- **Kerona pediculus**
  - 130-205 µm
  - on hydras and bryozoans
  - (Vol. I, p.265)

- **Tokophrya carchesii**
  - 25-85 µm
  - on peritrichs, especially on *Carchesium*
  - (Vol. IV, p.417)
Ciliate communities, an important aid for water quality evaluation

METOPETUM

Discomorphella pectinata
Caenomorpha spp.
Metopus spp.
Enchelyomorpha vermicularis
Pseudocohnilembus pusillus
Lagynus elegans

Pelodinium reniforme
Epixella spp.
Saprodinium spp.
Plagiopyla nasuta

Ciliate community of anaerobic mud (Metopetum). Indicator species are members of the genus Metopus (s.l.) and certain heterotrichs (all described in Vol. II). Most of the species belonging to the Metopetum are strictly bound to anaerobic conditions, i.e. oxygen is poisonous for them; they do not have mitochondria but hydrogenosomes and tolerate the richly occurring H₂S without damage. This community is often poor in species and individuals and feeds mainly on (sulphur) bacteria. The occurrence of one or several of these species in a sample is an unfailing indication of microaerobic or anaerobic conditions. Scale bar division 10 μm.

Ciliate community of the polysaprobic self-purification zone (*Colpidietum colpodae*). Indicator species is *Colpidium colpoda*, a hymenostome ciliate (Vol. III). Decomposition is very intensive in this zone and dissolved oxygen is thus usually almost depleted. Few ciliate species (usually < 25 in a sample) occur, although, some are in great numbers. Most feed on bacteria, which are very abundant. Scale bar division 10 μm.
Ciliate community of the alpha-mesosaprobic self-purification zone (*Trithigmmostometum cucullulent*). Indicator species is *Trithigmmostoma cucullulent*, a cyrtophorid ciliate (Vol. I). Rather many ciliate species (up to 50 in a sample) occur already in this zone, some have high or very high abundances. Especially conspicuous are peritrichs (*Carchesium polypinum*, *Epiptylits* spp., *Vorticella* spp.), which often form greyish lawns recognizable with the naked eye on the bottom side of stones and/or on submerged macrophytes (see also *Carchesium*, the sessile portion of the *Trithigmmostometum*). Bacteria feeders still dominate. Scale bar division 10 μm.
Typically, this sessile subassociation of the Trithigmotomatum develops downstream from the effluent of waste water treated only mechanically or in insufficiently operating activated sludge plants, especially if the stream receiving the effluent is comparatively rich in dissolved oxygen because of high current velocity and/or turbulence. Then the indicator species, Carchesium polypinum, and its associates form whitish lawns recognizable with the naked eye on the bottom side of stones and/or submerged macrophytes and mosses. Vagile accessory species are Amphileptus claparedii and Trachelius ovum (Vol. IV), feeding on the peritrichs comprising the community.

Scale bar division 10 μm.
Ciliate community of the beta-mesosaprobic to alpha-mesosaprobic self-purification (transition) zone (Stentoretum). This is the most species rich (often more than 60 in a sample) zone in a self-purification reach. The total abundance of the ciliates is still high, but lawns recognizable with the naked eye are rare. All feeding types are present. Main indicator is the heterotrich ciliate Stentor (Vol. II), especially S. roeseli, but also S. muelleri, S. multiformis and S. polymorphus, which frequently occur and sometimes even form lawns. Stentor coeruleus, conspicuous by its large size and blue colour, is not included because it also occurs under polysaprobic conditions. Frequently, Stentor spp. are accompanied by Frontonia spp. (Vol. III), especially F. acuminata and F. angusta. Other typical accessory species: Enchelys gasterostei, Holosticha monilata, Opercularia articulata, Spirostomum minus, Vorticella aquadulcis-complex, and Zoanthamnium spp. Scale bar division 10 μm.

Ciliate community of the beta-mesoprobic self-purification zone (*Pleuronemeta pink*) (Pleonetae). Indicator species is *Pleuronema coronatum*, a hymenostome ciliate (Vol. III) which is highly frequent and sometimes also rather abundant. The ciliate community is very diverse, but often less than 25 taxa are found in a sample because the abundances of most species are very low. All feeding types are present. Other typical species: *Dileptus margaritifer*, *Lembladion bullatum*, *L. magnum*, *Monilicaryon monilatus*. Scale bar division 10 μm.

**CYRTOPHORETEA**

Ciliate community of the vagile periphyton (Cyrtophoretea). Cyrtophorid ciliates (Vol. I) are a highly characteristic and usually also very abundant component of the vagile periphyton (Aufwuchs), which preferably develops in spring in oligosaprobic to mesosaprobic, diatom-rich streams. Typical accessory species are, in addition to some aberrant nassulids (Chilodontopsis depressa, Zosterodasys transversa) and colpodids (Kreyella minuta, Pseudochilodonopsis rheophila), hypotrichs (e.g., Stylochila spp., Tachysoma pellinellum, Euplotes spp.) and pleurostomatids (e.g., Litonotus spp., Amphileptus spp.). Most of these species are small to medium-sized, distinctly flattened, usually ciliated completely only on one side, and preferably feed on diatoms. Scale bar division 10 μm.

Ciliate community of the pelagial (Oligotrichetea). An increased occurrence of oligotrich ciliates (Vol. I) is characteristic for stagnant waters (e.g. lakes, impounding basins) and large, slowly flowing rivers. However, euplanktonic species occur also in most other groups of ciliates (Tab. 1). An increased occurrence and number of oligotrichs and other euplanktonic ciliates in small streams usually indicates that stagnant water enters, e.g. from lakes, fish ponds, or dams. Scale bar division 10 μm.
SOIL / MOSS INFLUENCE

Indicators for terrestrial influence. A highly specific ciliate community lives in soil and moss (Foissner, 1987). Only about 20% of the species occur in both terrestrial and limnetic biotopes. Some of these opportunists have been classified saprobiologically and are shown on this plate. Only if several of them occur in a sample may this be used as an indication of soil and/or bank erosion or increased leaf litter entry. Specifically, Gonostomum and Pseudoplatyophrya (a very small, 15-30 μm long fungal feeder) indicate edaphic influence in running waters, just as does the simultaneous occurrence of two or more Colpoda species (Vol. I). Scale bar division 10 μm.

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Indicators for mire influence. An increased number of mire-specific organisms, especially desmids and testate amoebae, is found in streams and rivers which receive water from mires and/or moorlands and are not too heavily polluted. The ciliates from such usually acidic biotopes are still poorly explored. Groliere (1978) selected some characteristic species in French mires, viz. Cyclidium sphagnetorum, Bryometopus sphagni, Vorticella muralis, → Leptopharynx costatus, and → Climacostomum virens. Typical associates are: Keropasis wezeli, → Urotricha ovata, Blepharisma musculus, Spathidium amphoriforme, → Holosticha muscula, Furgaronia projectiitura, Histriocharis sphagni, and Blepharisma sphagni. Only few of these species are classified saprobiontologically (marked by arrow) and occur in running waters. Scale bar division 10 μm.
Ciliate community of small, astatic (ephemeral) stagnant waters (*Marynetum*). Marynids are a family of colpodid ciliates (Vol. I) and highly characteristic for small and very small, astatic stagnant waters, like puddles on roads and flooded plains. Usually, they live in mucous tubes attached to debris on the bottom, can quickly encyst, and feed on bacteria. Important associates are nassulids (Vol. III), which preferably feed on the cyanobacteria developing quickly and plentifully on the bottom of such biotopes. Many other species, some of which have been classified saprobiologically (see figures), are also found rather frequently, but are not confined to these biotopes. Scale bar division 10 μm.
Ciliate community of healthy ("normal") activated sludge. An assortment of species usually occurring in moderately and heavily polluted (alpha-mesosaprobic to beta-mesosaprobic, alpha-mesosaprobic) running waters is found in "normal" activated sludge. The species of this community indicate sufficient oxygen supply and appropriate load. Often, ciliates achieve high abundances (> 10000 individuals / ml) and feed on bacteria, thereby reducing the turbidity of the effluent (Curds 1992). See Schleypen & Gschlössl (1992) for detailed advice on activated sludge investigation. Scale bar division 10 µm.
OVERLOADED AND/OR OXYGEN DEFICIENT ACTIVATED SLUDGE

Ciliate community of overloaded and/or oxygen deficient activated sludge. An assortment of species usually occurring in heavily and very heavily polluted (alpha-mesosaprobic to polysaprobic, polysaprobic) running waters is found in overloaded and/or oxygen deficient activated sludge. The species of this community indicate insufficient oxygen supply (Vorticella infusionum-complex, Dexiostoma), anaerobic conditions (e.g., Metopus, Tronyma) or overload (e.g., Colpidium, Dexiostoma, Paramecium). The effluent is often turbid because free bacteria are insufficiently eliminated. See Schleypen & Gschlössl (1992) for detailed advice on activated sludge investigation. Scale bar division 10 µm.
Systematic index

The index contains all scientific names mentioned in the flow charts. It is ‘two-sided’, i.e. taxa appear both with the generic name first (if one knows only the genus name) and, more importantly, with the species name first (if one knows the species name but not the newest generic combination). Furthermore, all pages where a certain species is mentioned are indexed, which provides some sort of cross-referencing showing where the same species may be separately arrived at.

Generic and species names appear in italics; suprageneric taxa (main groups, e.g. Colpodea, Heterotrichida) are given in boldface; communities are written in normal roman type.

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