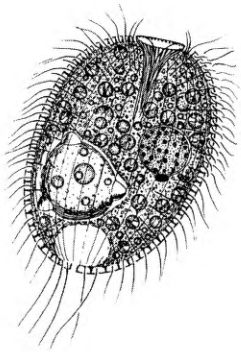
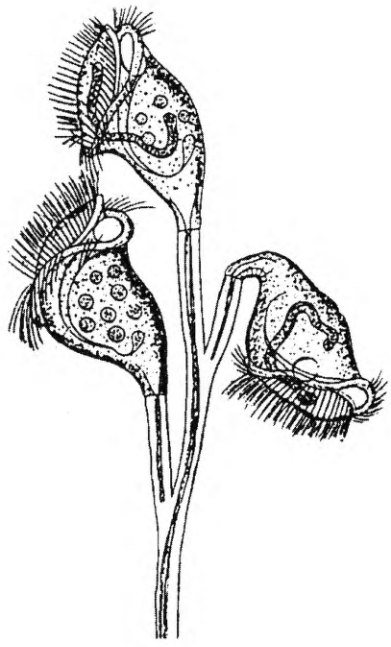
III-2.1
Illustrated guide and ecological notes to ciliate indicator species (Protozoa, Ciliophora) in running waters, lakes, and sewage plants

H. Berger and W. Foissner





Content

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1 Introduction

The usefulness of ciliates in ecosystem assessment is well known to most protistologists and many limnologists. 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 past decade and published them in six books comprising about 3200 pages, 9000 figures, 4000 references, and many tables and ecograms (Berger et al. 1997, Foissner et al. 1991, 1992, 1994, 1995, 1999). These detailed monographs allow renewed and increased usage of ciliates not only by river and lake ecologists but also by students of drinking-water treatment systems, sewage plants, and other freshwater ecosystems.

Our work on benthic ciliates 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 (Foissner & Berger 1996). Here it is combined with our illustrated key on pelagic ciliates (Foissner et al. 1999) which get renewed interest since the discovery of the microbial loop. Thus, the user will be able to identify 357 common benthic and planktonic freshwater ciliates via a single key. 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, 1935), although still very useful, can be applied only by specialists, that is, if one already knows the family or genus to which a particular species belongs. The more recent guides by Curds (1982), Curds et al. (1983), and Lynn & Small (2000), though very helpful, guide to genera only. Certainly, the present key does not include the vast taxonomic, faunistic, and ecological information contained in our monographs. However, we summarized the main ecological characteristics of the species keyed in a table.

The benthic species included were selected from the catalogues by Sládeček (1973) and Sládeček et al. (1981), who compiled the species used as bioindicators in general and in the saprobic system in particular. Admittedly, the saprobic system is not widely known outside central Europe. Briefly, the saprobic system evaluates water quality, specifically organic pollution, by indicator species. Four main zones of pollution, respectively, self-purification are distinguished: polysaprobity (very heavily polluted), alphamesosaprobity (heavily polluted), betamesosaprobity (moderately polluted), oligosaprobity (clean or very little 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).

The key on planktonic ciliates contains 118 species more or less commonly occurring in the pelagial of lakes, ponds, reservoirs, and large rivers. Pelagic ciliates and protozoa in general have been ignored for a long time by plankton ecologists, although studies from the sixties and eighties showed that they form an integral part of the planktonic food web and contribute significantly to the total zooplankton standing crop (for example, Nauwerck 1963, Beaver & Crisman 1989). It was the concept of the microbial loop, developed by Azam et al. (1983), which stimulated more detailed and intensive research which is reviewed in our book on limnetic plankton ciliates (Foissner et al. 1999).

2 Methods

There are several more or less detailed sampling and investigation protocols available for ciliates, but all in German language (Berger et al. 1997, Foissner et al. 1991, Tümpling & Friedrich 1999). Thus, we present an English version based on Berger et al. (1997) and Foissner & Berger (1996). See Cairns (1982) for sampling with artificial substrates.

2.1 Sampling

2.1.1 Running waters (qualitative sampling with abundance estimation)

Sampling sites, sampling time, and frequency of sampling depend on goals and financial resources. Ideally, samples are taken during low run-off periods because these represent the most worse conditions in polluted running waters. None the less, sampling is possible even one week after floods because ciliates have high reproduction rates and can thus compensate rapidly for flood losses. Slight and moderate floods even increase species richness in our experience; further, the saprobity index is very robust and thus hardly reacts to slight changes in species composition and individual abundances. Current velocity and season influence species composition and dominance structure more distinctly, for instance, cyrtophorid ciliates (e.g. *Chilodonella*, *Trithigmostoma*) have higher richness and abundance in spring. Generally, however, the microsapro-

bity index can be ascertained all the year round because there are always many ciliate indicator species present.
Usually, semiquantitative sampling is sufficient. Small streams are sampled over the whole width, while in large rivers, which are too deep to be traversed, both banks are sampled, paying special attention to wastewater vanes. For sampling, wide-mouthed (about 8 cm), 500 ml plastic bottles should be used, but filled with material to three quarters only to keep an air reserve; this is especially important for oxygen-demanding, heavily polluted material. Usually, the Aufwuchs (periphyton), the mud, and macrophytes are sampled separately. As concerns the Aufwuchs, brush or scrape off three to five larger stones or ten to twenty smaller ones and collect the material in a bottle, as described above. Sometimes artificial or exposed substrates, such as bricks, piles, concrete surfaces, microscope slides, or polyurethane foams are also usable. The sample should consist of about one third of Aufwuchs material and two thirds of site water. The aerobic mud (psammal, pelal, and especially the surface of organic mud) is collected with a spoon or an aspirator to a depth of up to 3 cm; again, the sample should consist of one third of mud and two third of site water. Mud rich in only partially decomposed organic matter and visibly covered by bacteria and/or diatoms should be collected according to the relative amount it covers the stream bed. Anaerobic mud, which is poisonous to aerobic organisms, must be collected separately. The third bottle is filled, if present at all, with about 50 % each of site water and submerged macrophytes, mosses, and filamentous algal mats; do not squash such materials because they might then release substances toxic for ciliates. The following details should also be considered:

- Mixed samples are disadvantageous because they disturb identification and ecological analysis. At least, Aufwuchs, mud, and plants should be collected separately, as described above.
- Take care for whitish and/or greyish, thin films or dots on submerged macrophytes and/or mosses and on the bottom side of bed stones. Such films might be ciliate lawns (usually sessile peritrichs, for instance, *Carchesium polypinum*) or filamentous bacteria (e. g., *Sphaerotilus*), both being very important because indicating strong (alpha-mesosaprobity) or very strong (polysaprobity) pollution. Such lawns are scraped off or aspirated with a pipette and put in a separate, small jar.
- Lentic zones or accumulations of leaf litter should be sampled separately, especially if they are anaerobic (H_2S odour!).
- Anaerobic mud, if present (H_2S odour!), must be collected separately by pushing a small plastic jar repeatedly deep into the sediment.
- If investigation close underneath the pollution source is demanded, that is, before the wastewater is entirely mixed with the river water, then the opposite river bank must be assessed separately.
- There might be plankton growth in large rivers, dams, or very slowly running waters. Such "Potamoplankton" has to be studied with the methods used in plankton investigations.
- If there are conspicuous features in a river, for instance, green, blue, or pink dots, areas, and/or water blooms (possibly bacterial or ciliate lawns or blooms), these should be sampled and investigated separately.
- Cyanobacteria mats often provide rich ciliate material; they also should be collected separately.

Samples must be transported under cool conditions (about 5°C) and investigated within 24 (better 12) hours. In the laboratory, the bottles are opened and the ciliates investigated with the cover glass method, a simple but very effective technique: place two 40 × 20 mm cover glasses on the water surface of the bottle and remove one with a cover glass forceps after 30 min; the second cover glass is removed when the first has been done. Put the cover glass on an ordinary microscope slide and look for the numbers and kinds of ciliates present. Ciliates accumulate on the cover glass due to oxygen depletion in the deeper zones of the bottle and because of their life style viz., many are Aufwuchs inhabitants and thus attach to solid surfaces, that is, the cover glass. The ciliate community obtained in this way is very clean and rich. Do not distribute the material collected in a large Petri dish! This would slow down oxygen depletion and ciliate attachment to the cover glass. It was just this mistake why KRIEG (in TÜMPLING & FRIEDRICH 1999) did not succeed with the cover glass method (pers. inform.). Finally, take some drops from the bottle's sediment surface and investigate it for bottom-dwellers, which usually do not, or with low abundance, attach to the cover glass.
Individual numbers are estimated either by a rating scale (e.g., PANTLE & BUCK 1955: 1 = few, 3 = moderate, 5 = many or masses) or the semiquantitative method of BLATTERER (1995), which is highly recommendable in more detailed investigations.

2.1.2 Stagnant waters (Plankton of lakes ...)

For general information, see text books on limnological methods (SCHWOERBEL 1994). Here, only some specific problems will be addressed. For literature, see FOISSNER et al. (1999).
Qualitative sampling for identification must be performed with very fine-meshed (10–20 µm) plankton nets because many species are very small and flexible: up to 50 µm-sized specimens may pass through a 12 µm net, if they are slender and flexible! Mild centrifugation (about 1500 rot. min^{-1} for 30–60 s) is survived by most species and must be used to collect rare and/or very small species, which usually escape even a 10 µm net. Large species (> 120 µm) should be collected with micropipettes under the dissecting microscope; usually, they do not withstand even mild centrifugation. Most species are very sensitive to temperature changes; thus, take care to keep samples cold, respectively, at the actual temperature.
Quantitative sampling and counting are performed with classical limnological methods, for instance, a Ruttner bottle and the Utermöhl technique. However, whenever it is possible, live counts should be preferred because they are fast and more reliable than conventional techniques with preserved material. Furthermore, identification is easier and biomass estimations are more reliable (see below). More recently, quantitative protargol stains (QPS) are preferred by many protozoan ecologists because preserved material can be used and identification to at least genus level is often possible. See MONTAGNES & LYNN (1987, 1993) and SKIBBE (1994) for detailed protocols. Some workers prefer ordinary cytological stains (BERECZKY 1985).

Commonly used preservatives are acid Lugol solution (1 % v/v), mercuric chloride (2.5 % w/v), glutaraldehyde (0.5 % v/v), and unbuffered formaldehyde (2 % w/v). Unfortunately, these fixatives preserve ciliates rather poorly, at least in the concentrations used. This may explain the paucity of large plankton ciliates in the species lists! Most of the large plankton ciliates, and there are many (!), are rather fragile and even difficult to preserve with the fixatives used by taxonomists. Accordingly, abundances and especially biomasses of plankton ciliates are very likely greatly underestimated at present! Note that specimens dissolve more or less completely in the fixatives mentioned above, if samples are stored too long: means of 7.2 %, 16.4 % and 30.7 % respectively after 3, 6 and 9 month of storage have been reported.
Preserved material usually shrinks by 30 to 70 %, but may also become inflated. Such rates are common and must be taken into account in biomass estimations and identification. Unfortunately, an overall conversion factor can not be provided because the extent of shrinkage or inflation highly depends on many factors, such as kind of species and storage time of the sample. Silver methods also change cell volume. Usually, specimens shrink: 5–10 % of body length with silver nitrate methods; 10–20 % with protargol methods; silver carbonate and Wilbert's protargol method, in contrast, often cause swelling of the cells.
Certainly, shrinkage and swelling of specimens pose serious problems on biomass estimations. Thus, live specimens should be measured, whenever this is possible. Table 1 provides live biomasses for the species contained in this review. They were calculated from the common live size of the individual species. Although there may be considerable variation in size of specimens from different sites, our values are probably more reliable than those obtained from preserved and/or stained cells.

2.1.3 Activated sludge

Use fresh sludge, which is taken from the plant with a trowel, put into a 500 ml bottle, and transported to the laboratory under cool conditions. Take care for anaerobic zones, which must be sampled and assessed separately.
For investigation, shake the bottle, take a small drop (about 0.1 ml) with an ordinary pipette, put it on a microscope slide, and cover the preparation with a cover glass. Three replications should be investigated to obtain reliable data on the species present.
Usually, semiquantitative investigation with a rating scale will be sufficient. However, quantitative investigation is also possible and easily performed with the method by AUGUSTIN et al. (1989). Sludge quality is assessed with the sludge biotic index (SBI) of MADONI (1994).

2.2 How to identify ciliates

The guide is designed for determination of live ciliates using a compound microscope equipped with differential interference contrast. A few species demand more sophisticated methods, for example, silver impregnation, to be identified accurately. These techniques are described in FOISSNER et al. (1999).

2.2.1 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 (for example, nickel sulphate) or physical slowing down by increasing the viscosity of the medium (for example, 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. 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 (for example, objective 4 : 1, ocular 10×). If 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, onto 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 (for example, nuclear and oral apparatus, contractile vacuole) and then the details (for example, extrusomes, micronucleus) can easily be observed under low (100–300×) and high (oil immersion objective) magnification.

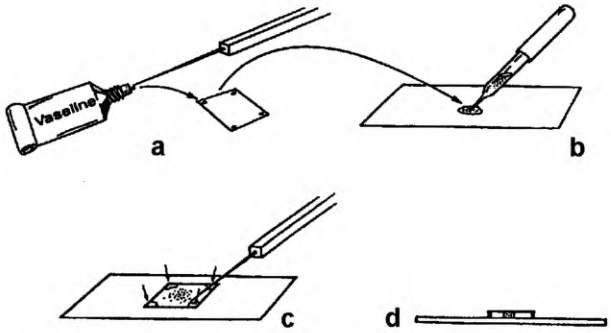


Figure 1: Preparation of slides for observing living ciliates (after DRAGESCO & DRAGESCO-KERNÉIS 1986). **a:** A small drop of vaseline jelly each is placed at the four corners of a coverslip with a needle or injection syringe. **b:** A small volume of water containing the ciliates is placed on a slide (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:** Side view of the complete preparation.

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 about 1 mm) pipette must first be investigated under low magnification (100–400×). Some species are too fragile to withstand handling with the micropipette and coverslip trapping without deterioration. Investi-

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

2.2.2 Nuclear staining

Beginners might find it difficult to recognize the cell's nuclear apparatus or to differentiate it from other inclusions, for example, 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 following simple staining protocol:

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., Köngen/N., Germany; 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.

3 How to use the guide

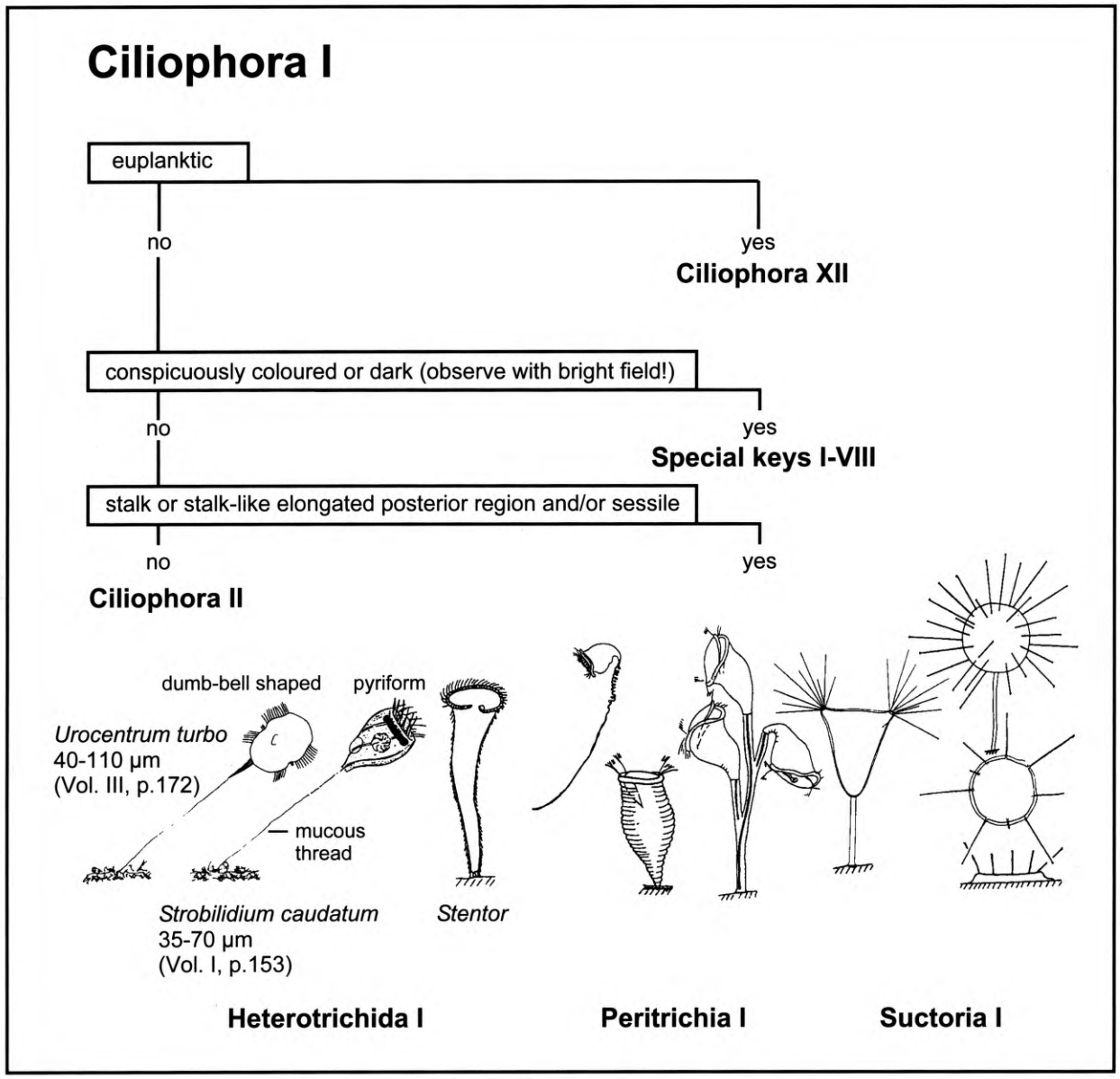
The guide is designed for identifying specimens from life and for users not specifically trained in taxonomy of ciliates. However, we presume a good deal of basic knowledge in biology, taxonomy, and protozoology. If some revision is necessary, we recommend reading Corliss (1979) and Hausmann & Hülsmann (1996). Valuable ecological reviews are the books by Curds (1992), Fenchel (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 (general keys, some special keys, species keys) or as simple plates showing related forms (most special keys, communities). Many species are keyed several times to increase the chance of identification (see systematic index). Remember, however, that only 357 of the 3000 freshwater species known are contained in the guide. Thus, all features mentioned in the charts must match and all specific identifications should be checked against the detailed descriptions and figures contained in our monographs (Foissner et al. 1991, 1992, 1994, 1995, 1999). This point is crucial because there are usually several similar species. Certainly, a userfriendly guide should avoid to apply all the fine details, often difficult to recognize, commonly used by specialists. However, this increases the possibility of misidentifications. All pictorial guides, which key out a certain fraction from a taxonomic unit, have this deficiency, that is, are a compromise between accuracy and practicability. On the other hand, such selective guides have the advantage to provide rapid species identifications even for users not specifically trained in taxonomy.
The **general keys** Ciliophora I–XXV guide to the (i) species keys, that is, to the main groups (Colpodea, Cyrtophorida, Gymnostomatida, Heterotrichida, Hymenostomata, Hypotrichia, *Loxodes*, Nassulida, Odontostomatida, Oligotrichida, Peritrichia, Pleurostomatida, Prostomatida, Suctoria); (ii) to the special keys I–XLIV; or, (iii) more rarely, directly to a certain species. In the last case, the volume and page are provided, where the species is described in the monographs.
Most **special keys** I–XLIV are not dichotomous. These charts contain species with special features (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 in the species keys (see below), the volume and page are provided, where a certain species is described in our monographs.
The **species keys** are dichotomous and ordered according to the alphabetically arranged main groups mentioned above. The volume of the Ciliate Atlas (Foissner et al. 1991 [Volume I], 1992 [II], 1994 [III], 1995 [IV]), where a certain group is contained, is found in the right upper corner of the charts, while the page, where the detailed description commences, is added to the species name. Thus, for instance, "Volume I, p. 414" says that the description of *Cyrtolophosis mucicola* is found on page 414 of Volume I of the Ciliate Atlas (Foissner et al. 1991). In contrast, keys from the plankton book (Foissner et al. 1999) are marked by "Plankton Ciliates" in the right upper corner.
Typical **ciliate communities** are shown on the last 13 charts. They provide information on what species can be found in particular circumstances and habitats, some of which have highly characteristic ciliate communities.

4 General keys (Ciliophora I–XXV)

The general keys, the special keys, and the species keys contain all species described in our monographs plus some planktonic forms not treated in detail. The keys are easy to use and most supraspecific taxa are keyed out at least two times. Furthermore, with few exceptions, all characters asked can be easily recognized in live specimens at low magnification (about 100×).

The general keys Ciliophora I–XXV guide (i) to the species keys, that is, to the main groups (Colpodea, Cyrtophorida, Gymnostomatida, Heterotrichida, Hymenostomata, Hypotrichia, *Loxodes*, Nassulida, Odontostomatida, Oligotrichida, Peritrichia, Pleurostomatida, Prostomatida, Suctoria); (ii) to the special keys I–XLIV; or, (iii) more rarely, directly to a certain species. In the last case, check your identifications carefully against the detailed description and figures in our monographs. Plates Ciliophora XXI–XXV are designed to identify specimens from protargol slides, in which about 70 % of the taxa can be identified to at least genus level.

Note that all volume and page references refer to the monographs (Foissner et al. 1991, 1992, 1994, 1995, 1999), not to the present guide. When a key guides to a main group (e.g., "Suctoria") this can be found via the "Table of Content" and the "Systematic Index". Within a main group at first the keys to the benthic species are given, followed by the keys to the planktonic forms.



Ciliophora II

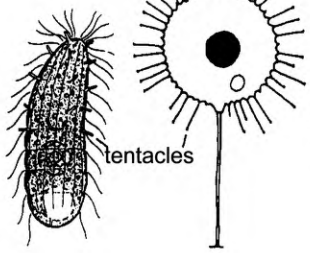
from Ciliophora I

tentacles*

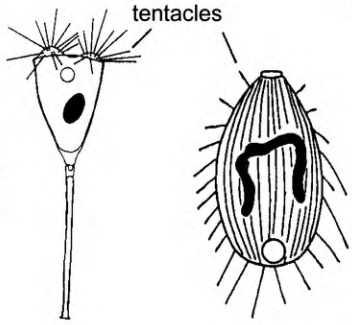
absent

present

* 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).



Suctoria I



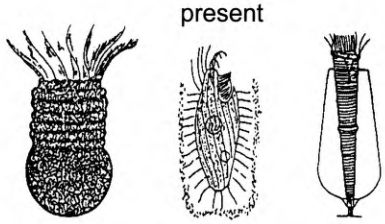
Actinobolina

Gymnostomatida I

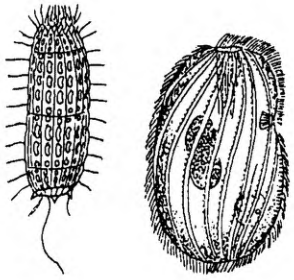
lorica or armour

absent or unknown

present



Special key IX



very large, about 300 µm or more

no

yes

Special key X

conspicuously (more than 50%) contractile*

no

yes

Special key XI

* touch cells or cover glass with mounted eyelash or needle, respectively

slender, length : width ≥ 5:1

no

yes

Special key XII

body with distinct furrows

no

Ciliophora III

yes

Special key XXI

Ciliophora III

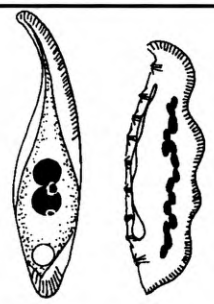
from Ciliophora II

shape lanceolate

no

yes

Pleurostomatida I

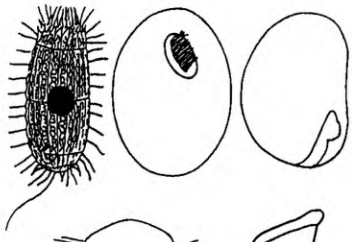


barrel-shaped, ellipsoid or like a segment of a circle

no

yes

Special key XIV

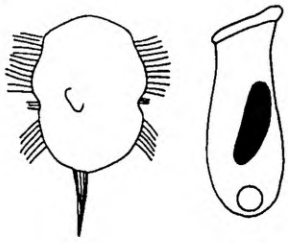


dumb-bell or spatula shaped

no

yes

Special key XV



snout-like peak at anterior end

no

yes

Special key XVI

proboscis or proboscis-like elongation

no

yes

Special key XVII

tail

no

yes

Special key XVIII

shape bizarre (with spines, processes, cavities ...)

no

yes

Special key XX

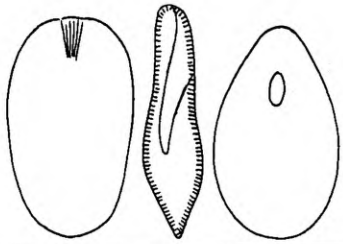
shape cylindrical, i.e. length : width ratio 2-3 : 1, fusiform or oviform (usually not sessile)

no

yes

Ciliophora IV

Special key XIII



Ciliophora IV

from Ciliophora III

shape reniform

no

yes

Special key XXII

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

no

yes

Special key XIX

2 macronuclear nodules (Ma)

no or unknown

yes

adoral zone of membranelles (tufts of cilia; AZM)

yes

no

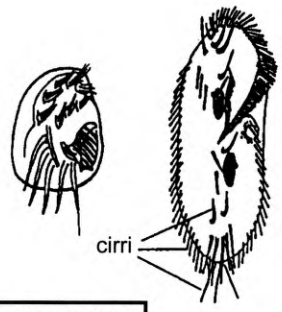
shape

club-shaped

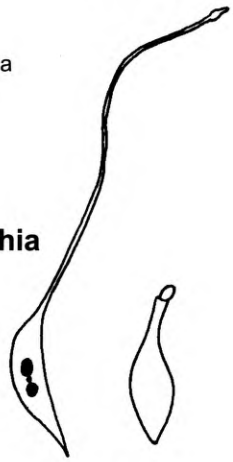
rod-shaped

lanceolate

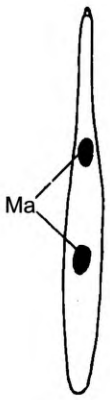
* Discrimination of cilia and cirri (= several adhering cilia forming fairly thick bundles): if you see cilia at a magnification of X 100-400, i.e. without oil immersion, then these are very likely cirri!



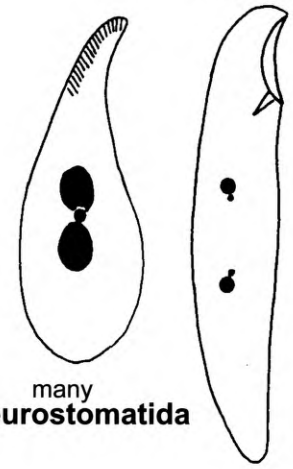
many **Hypotrichia**



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



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



many
Pleurostomatida

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

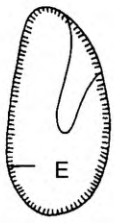
rod (extrusomes) seam (E; observe at X 400 and with bright field!)

no

yes

Ciliophora V

Special key XXIII



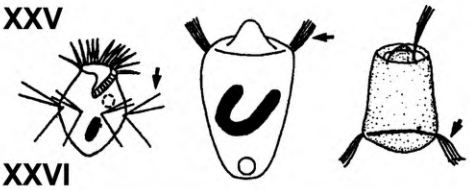
Ciliophora V

from Ciliophora IV

movement remarkable (jumping, spinning, rotating on a thread)

no or unknown — yes

Special key XXV



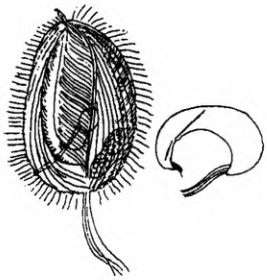
conspicuous ciliary wreaths

no — yes

Special key XXVI

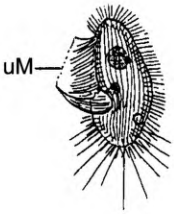
conspicuous, sail-like membrane along oral opening (usually an undulating membrane; uM)

no — yes



Lembadion
Hymeno-stomata I

Cyclidium
Hymeno-stomata VII

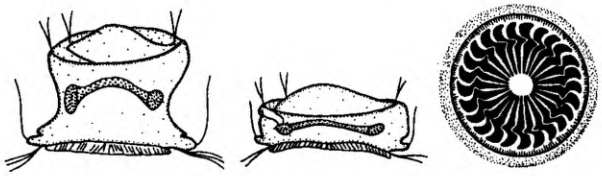


Pleuronema
Hymeno-stomata III

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

Ciliophora VI — **Special key XXIV**

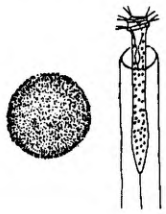
Ciliophora VI

from 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 Trithigmostometum

euplanktic

no or unknown

yes

Ciliophora XII, special keys XXVIIIa,b, and community Oligotrichetea

epizoic

no or unknown

yes

Special key XXXII

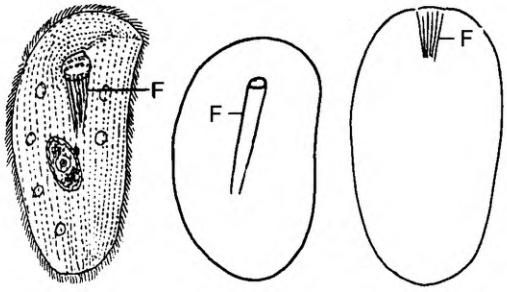
mouth

with distinct funnel (F) composed of slender rods, recognizable at a magnification of ≥ X 250

conspicuous, transverse cleft

different

Ciliophora VII

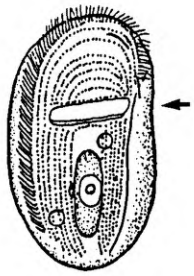


Ciliophora XI and special keys XXIV, XXVII

nose

absent

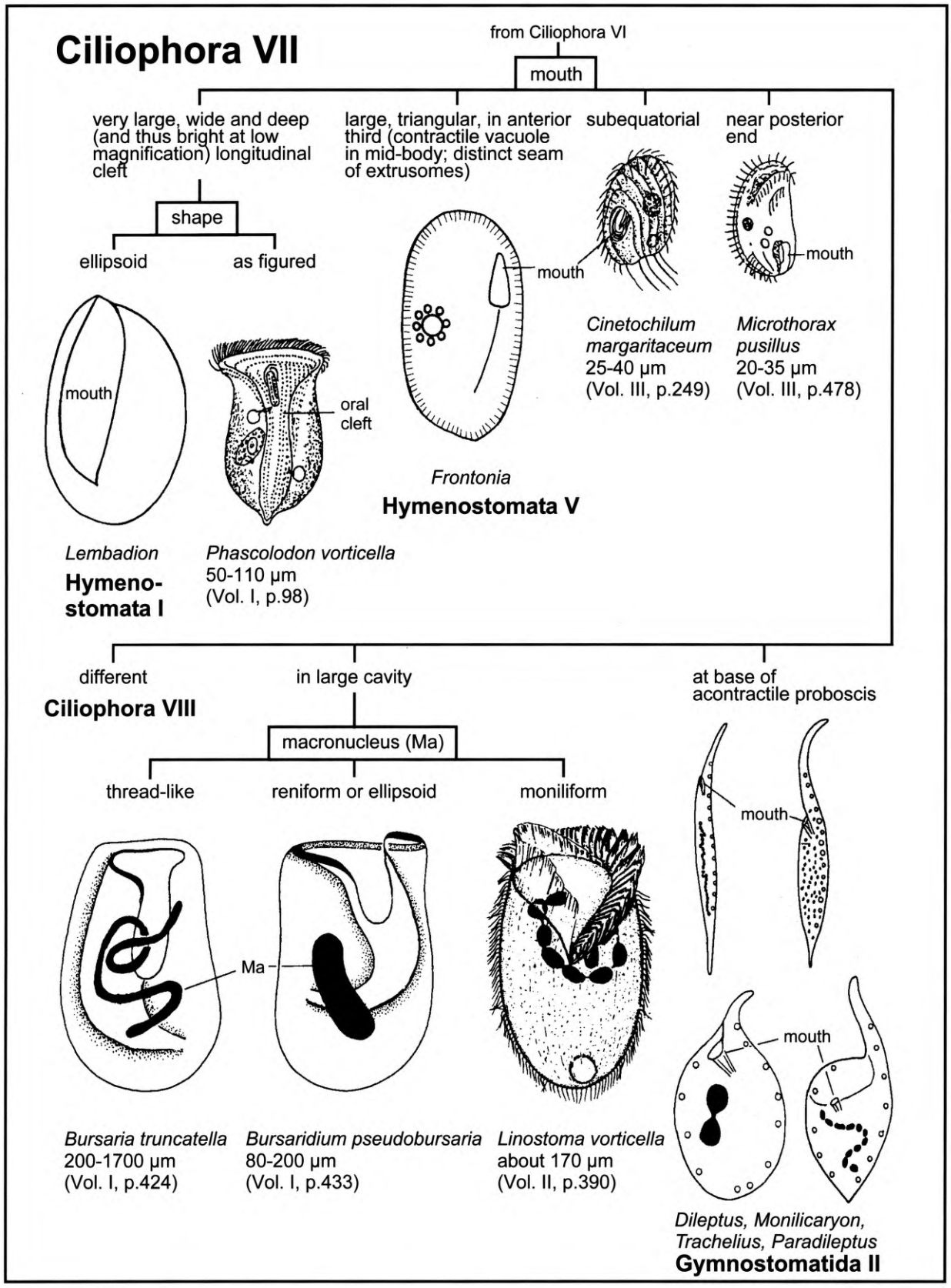
present



Gastronauta

Cyrtophorida I

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


Ciliophora VII
from Ciliophora VI
mouth
very large, wide and deep (and thus bright at low magnification) longitudinal cleft
large, triangular, in anterior third (contractile vacuole in mid-body; distinct seam of extrusomes)
subequatorial
near posterior end
shape
ellipsoid
as figured
mouth
mouth
mouth
oral cleft
Cinetochilum margaritaceum
25-40 µm
(Vol. III, p.249)
Microthorax pusillus
20-35 µm
(Vol. III, p.478)
Frontonia
Hymenostomata V
Lembadion
Hymeno-stomata I
Phascolodon vorticella
50-110 µm
(Vol. I, p.98)
different
Ciliophora VIII
in large cavity
at base of acontractile proboscis
macronucleus (Ma)
thread-like
reniform or ellipsoid
moniliform
mouth
Ma
mouth
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

Ciliophora VIII

from 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

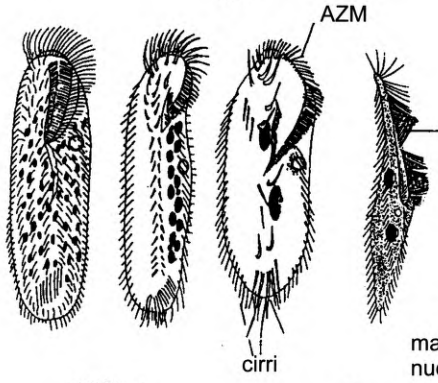
inconspicuous

Ciliophora IX

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

yes

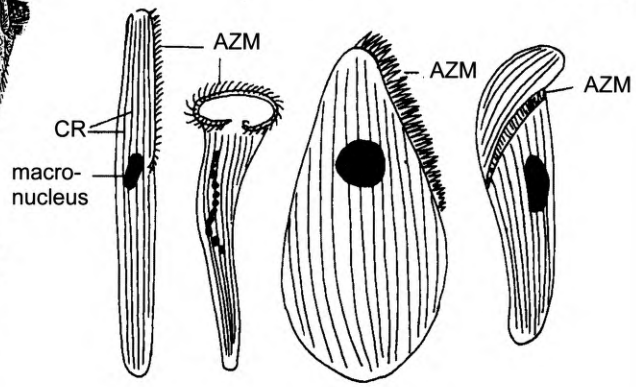
no



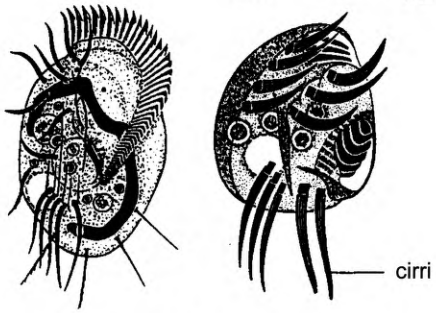
somatic ciliature (ciliary rows; CR); use magnification > X 400

complete

strongly reduced or lacking



Heterotrichida

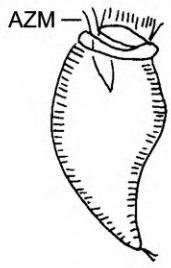


Hypotrichia

transverse striation (no ciliary rows!); oral ciliature

present; continuous membrane

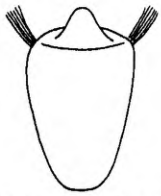
absent; distinct ciliary plates



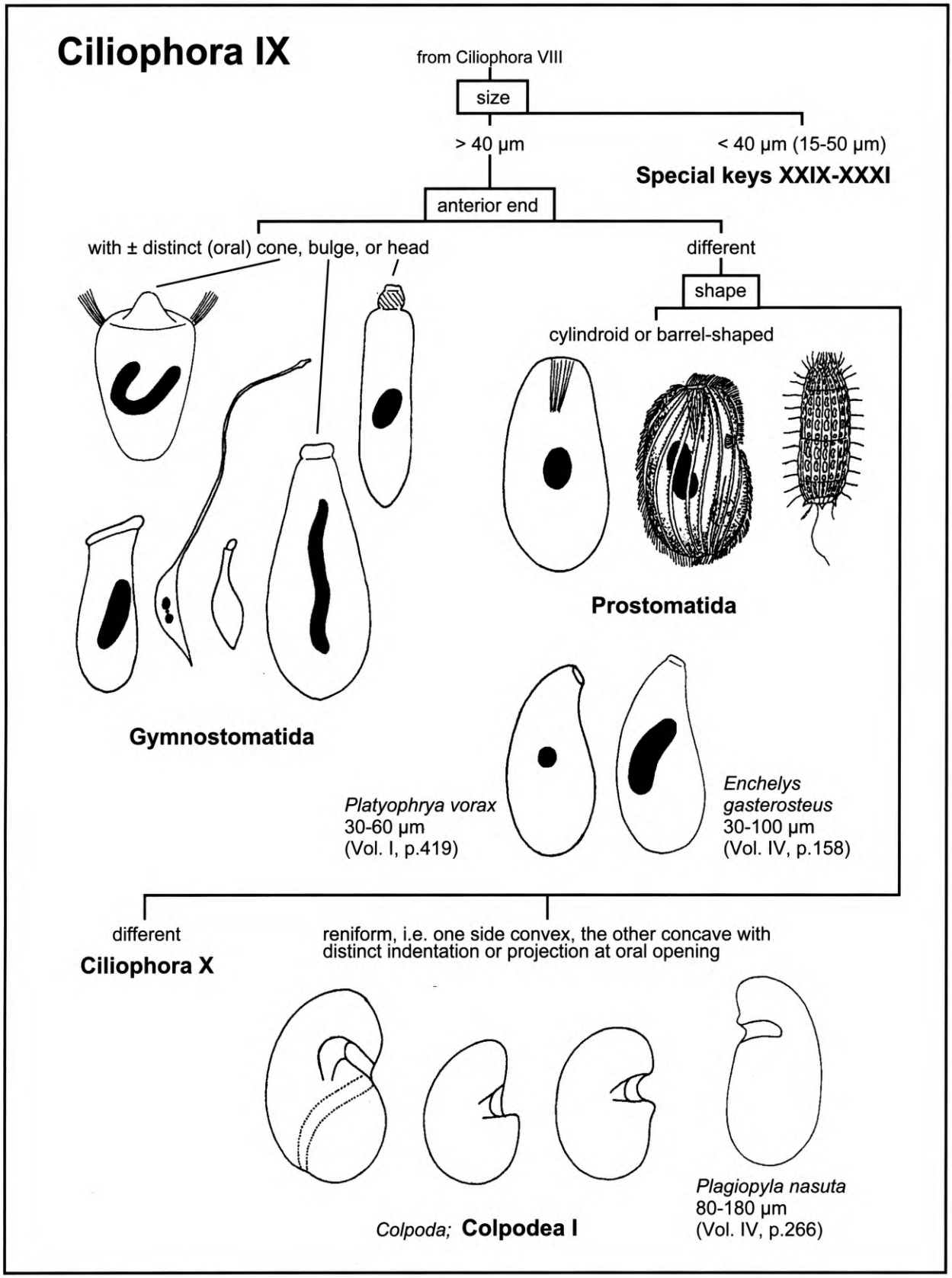
Peritrichia

Oligotrichida

* 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!



attention, do not confuse with
Didinium / Monodinium
Ciliophora IX


Ciliophora IX
from Ciliophora VIII
size
> 40 µm
< 40 µm (15-50 µm)
Special keys XXIX-XXXI
anterior end
with ± distinct (oral) cone, bulge, or head
different
shape
cylindroid or barrel-shaped
Prostomatida
Gymnostomatida
Platyophrya vorax
30-60 µm
(Vol. I, p.419)
Enchelys gasterosteus
30-100 µm
(Vol. IV, p.158)
different
Ciliophora X
reniform, i.e. one side convex, the other concave with distinct indentation or projection at oral opening
Plagiopyla nasuta
80-180 µm
(Vol. IV, p.266)
Colpoda; Colpodea I

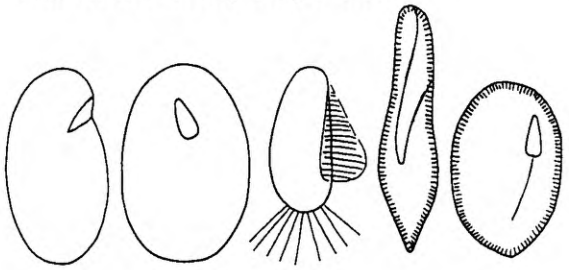
Ciliophora X

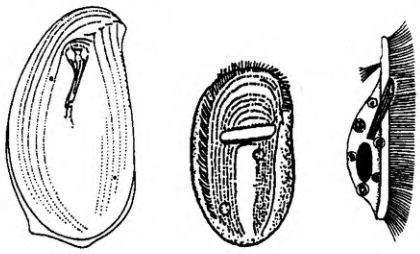
from Ciliophora IX

movement; shape and ciliature

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**

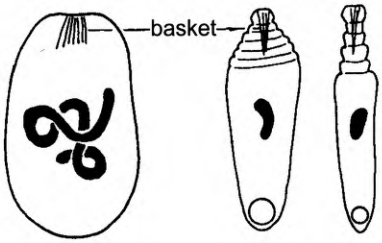
Ciliophora XI

from Ciliophora VI

oral basket

at anterior end

distinctly subapical



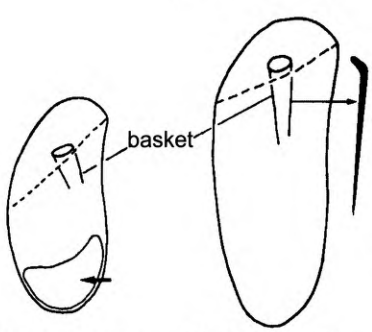
Prostomatida

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

shape; movement; food

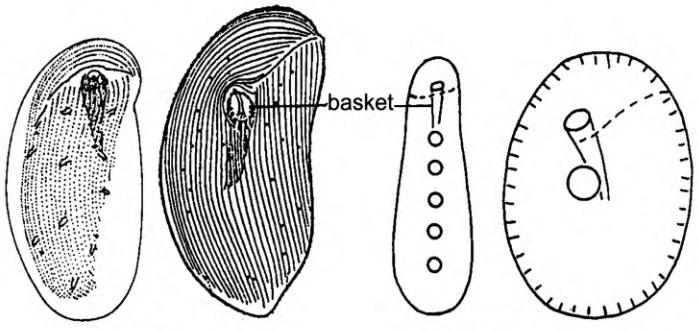
ventral side flat, dorsal vaulted; usually gliding or crawling; usually diatoms and/or bacteria

± cylindroid; 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.

Plankton Ciliates

Ciliophora XII (Ciliophora plates XII–XX are for live identification)

from Ciliophora I

method

live observation at ≤ ×100

protargol impregnation
Ciliophora XXI

conspicuous ciliary corona (arrow) at anterior end

absent, not recognizable or inconspicuous
Ciliophora XIII

present

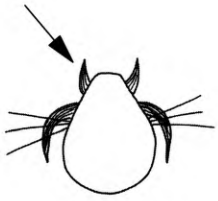
contractile; somatic cilia

no; yes, form tufts in mid-body

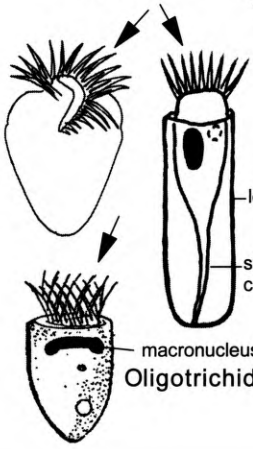
± no; sparse

yes; lacking

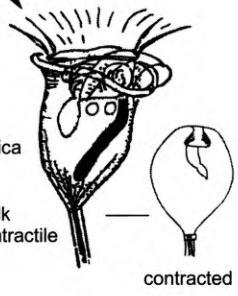
no; numerous



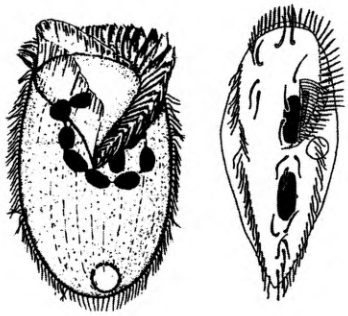
Askenasia/ Rhabdoaskenasia
Gymnostomatida VI



Oligotrichida II



Peritrichia VIII



Heterotrichida III
or Hypotrichia VIII

Ciliophora XIII

Plankton Ciliates

[1] Use vital organisms only! Note that many plankton ciliates become rapidly morbid and globular after sampling and, especially, when transferred to the slide! If in doubt, continue with "no".

from Ciliophora XII

conical[1]

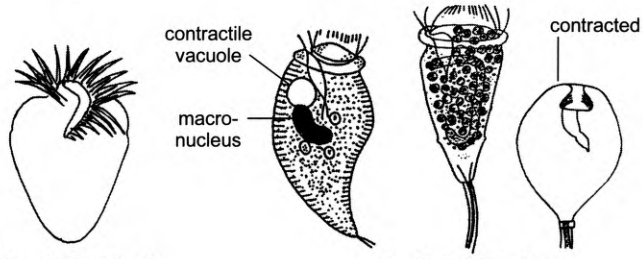
no or unknown

yes

contractile

no

yes



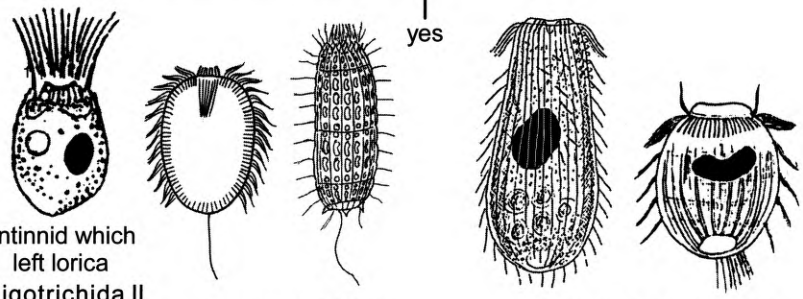
Oligotrichida II

Peritrichia VIII

barrel-shaped or ellipsoidal[1]

no or unknown

yes



tintinnid which left lorica Oligotrichida II

Prostomatida III

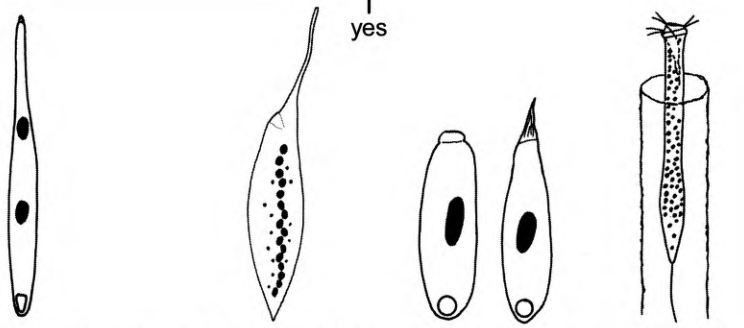
Gymnostomatida IV

slender[1], length : width ≥ 5:1

no or unknown

Ciliophora XIV

yes



Lepidotrachelophyllum lineare
300–500 µm
(p. 262)

Pelagodileptus trachelioides
230–800 µm
(p. 232)

Lagynophrya acuminata
70–95 µm
(p. 258)

Ophrydium
Peritrichia
VIII, IX

Ciliophora XIV

Plankton Ciliates

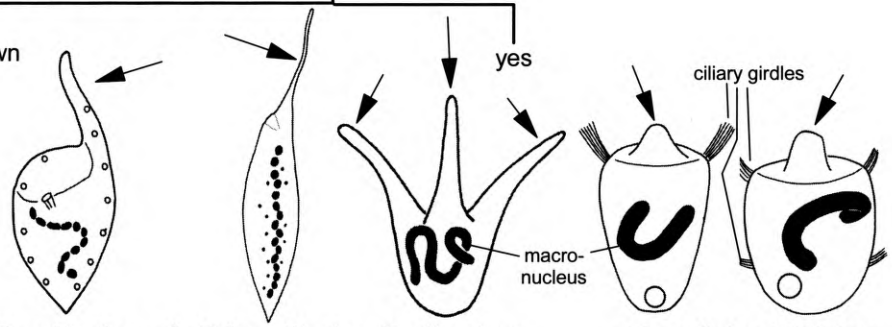
[1] Use vital organisms only! Note that many plankton ciliates become rapidly morbid and globular after sampling and, especially, when transferred to the slide! If in doubt, continue with "no".

from Ciliophora XIII

proboscis or proboscis-like elongation (arrow)[1]

no or unknown

yes

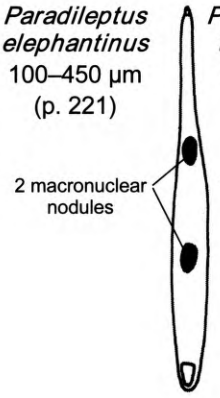


Paradileptus elephantinus
100–450 µm
(p. 221)

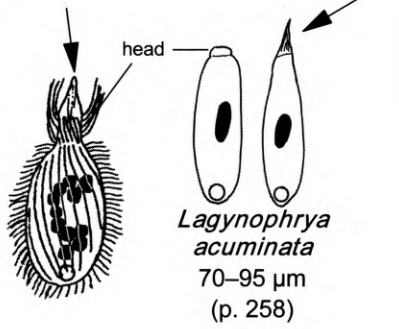
Pelagodileptus trachelioides
230–800 µm
(p. 232)

Teuthophrys trisulca
150–300 µm
(p. 238)

Monodinium/Didinium
Gymnostomatida VI, VIII



Lepidotrachelophyllum lineare
300–500 µm
(p. 262)



Pelagolacrymaria
Gymnostomatida IV

Lagynophrya acuminata
70–95 µm
(p. 258)

shape bizarre (with spines, processes, cavities ...)[1]

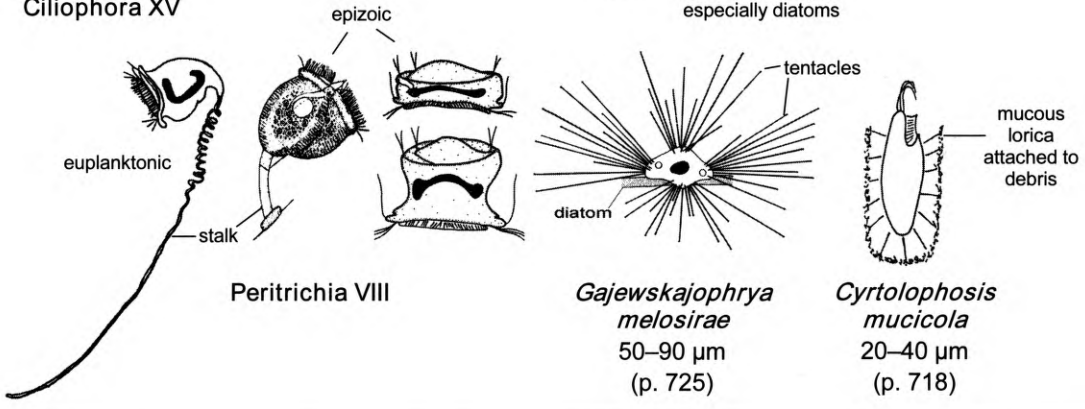
no or unknown

yes
Special key XXXIII

stalk and/or attached to plankton organisms

no or unknown
Ciliophora XV

yes



Peritrichia VIII

Gajewskajophrya melosirae
50–90 µm
(p. 725)

Cyrtolophosis mucicola
20–40 µm
(p. 718)

Ciliophora XV

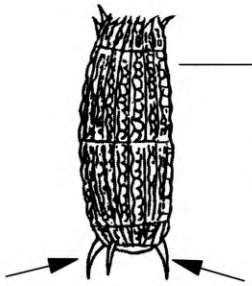
Plankton Ciliates

from Ciliophora XIV

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)

body with spines

- absent or not recognizable
- present

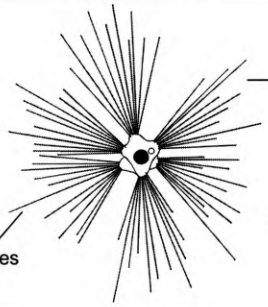


Coleps
Prostomatida III

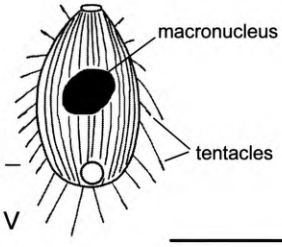
Hastatella radians
40–60 µm
(p. 460)

tentacles[1]

- absent or not recognizable
- present



Suctoria III

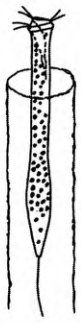


Actinobolina or *Belonophrya*
Gymnostomatida V

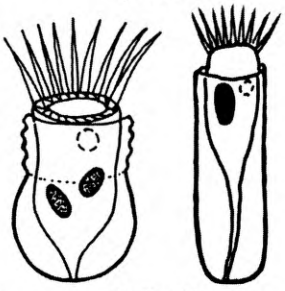
tentacles

lorica

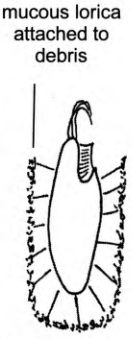
- absent or unknown
- present



Ophrydium versatile or *O. eutrophicum*
Peritrichia VIII



tintinnids
Oligotrichida II



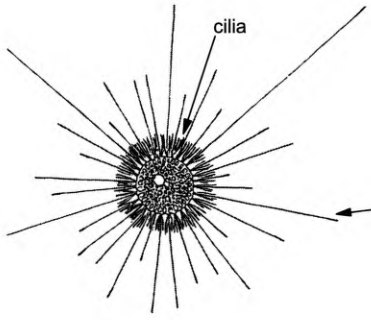
Cyrtolophosis mucicola
20–40 µm
(p. 718)

large (>200 µm)

- no
- yes → Special key XXXIV

small (<50 µm)

- no → Ciliophora XVI
- yes → Special key XXXV



Actinobolina/ Belonophrya
with extended tentacles

Ciliophora XVI

Plankton Ciliates

from Ciliophora XV

[1] See also the less common species *Hastatella radians* (Peritrichia VIII), *Histiobalantium bodamicum* (Hymenostomata VIII), and *Spiretella plancticola* (Hypotrichia VIII)

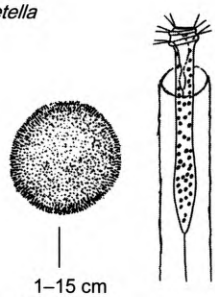
colonial

no or unknown

yes

Epistylis or *Epicarchesium*
Peritrichia IX, XI

Ophrydium
Peritrichia VIII, IX



1–15 cm sized, green globules

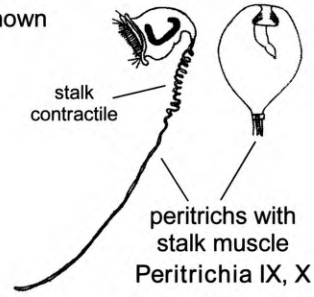
conspicuously coloured (including zoochlorellae bearing species) or dark (observe with bright field)

no or unknown

yes
Special key XXXVI

conspicuously (more than 50 %) contractile (touch with a needle or a mounted eyelash)

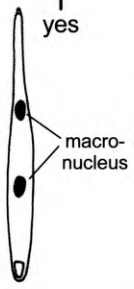
no or unknown



peritrichs with stalk muscle
Peritrichia IX, X

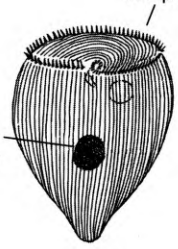
yes

contracts and extends very slowly



Lepidotrachelophyllum lineare
300–500 µm
(p. 262)

usually only fully contracted specimens are found in the samples!



Stentor
Heterotrichida III

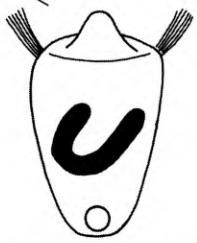
movement

different or unknown
Ciliophora XVII

fast-rotating and/or jumping[1]

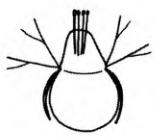
extremely fast, straight or zigzag

urotrichs
Prostomatida IV–VI



Didinium/ Monodinium
Gymnostomatida VI, VIII

Halteria/Pelagohalteria
Oligotrichida III



Askenasia or *Mesodinium*
Gymnostomatida V, VI

Limnostrombidium, Pelagostrombidium or *Rimostrombidium*
Oligotrichida III, IV

Ciliophora XVII

Plankton Ciliates

from Ciliophora XVI

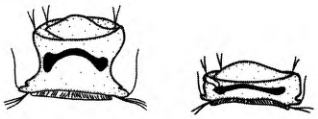
[1] Discrimination of cilia and cirri (= several adhering cilia forming fairly thick bundles): if you see cilia at a magnification of ×100–400, that is, without oil immersion, then these are very likely cirri!

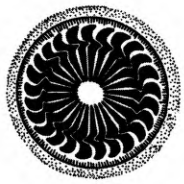
conspicuous ciliary girdles

- absent or unknown
- present → Special key XLIV

denticle disc on posterior end

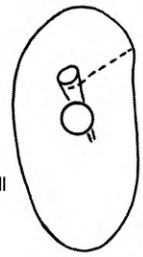
- absent or unknown
- present → *Trichodina* Peritrichia VIII





cytoplasm with ingested filamentous cyanobacteria

- no or unknown
- yes → *Obertrumia aurea* 120–250 µm (p. 700)



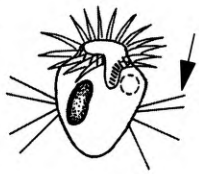
colourfull

do you see "cilia" (cirri[1]; arrow) on body at a magnification of ×100

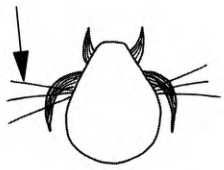
- no or unknown
- yes

To recognize the following characters, specimens must be slightly squeezed (flattened) and studied with a magnification of at least ×250

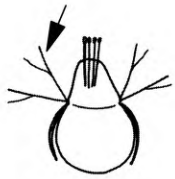
Hypotrichia VIII



Halteria/ Pelagohalteria Oligotrichida III



Askenasia/ Rhabdoaskenasia Gymnostomatida VI



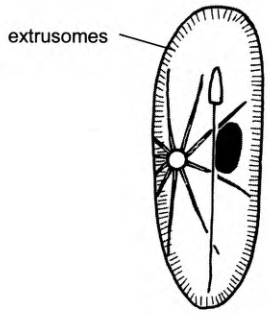
Mesodinium Gymnostomatida V

macronucleus

- globular, ellipsoidal or reniform
- C-shaped, J-shaped, vermiform, moniliform, or composed of 2 nodules → Special key XLI

rod (extrusome) fringe or conspicuous bundles of extrusomes (observe at ×400 and with bright field)

- absent or unknown → Ciliophora XVIII
- present → Special key XLIII



Ciliophora XVIII

Plankton Ciliates

from Ciliophora XVII

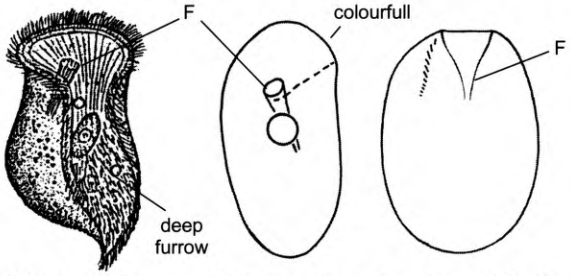
mouth (use magnification ≥ ×250)

with distinct funnel (F) composed of slender rods

in large cavity

at base of a proboscis (arrow)

different Ciliophora XIX



Phascolodon vorticella
60–90 µm
(p. 693)

Obertrumia aurea
120–250 µm
(p. 700)

Prostomatida III

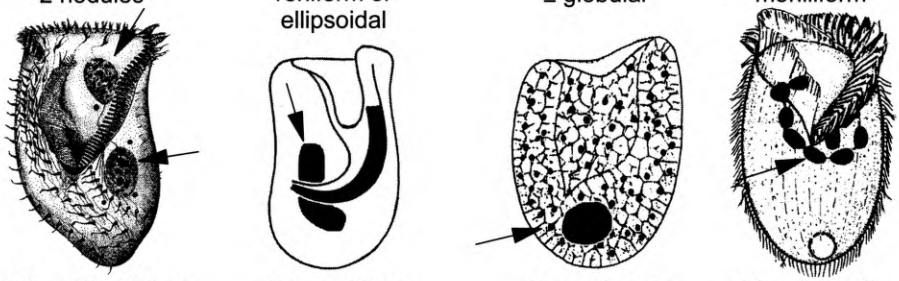
macronucleus (arrow)

2 nodules

reniform or ellipsoidal

± globular

moniliform

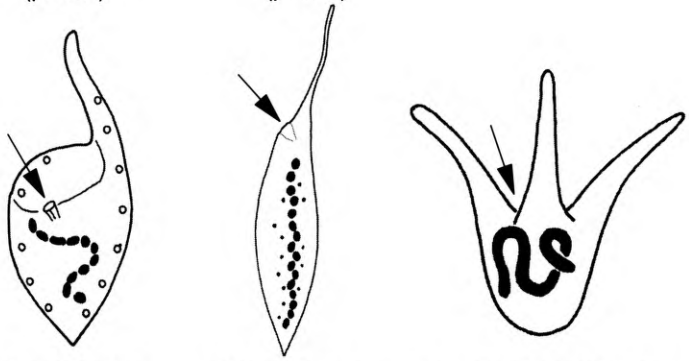


Pelagotrichidium faurei
about 280 µm
(p. 683)

Bursaridium pseudobursaria
80–200 µm
(p. 709)

Bursellopsis
Prostomatida VI

Linostomella vorticella
about 170 µm
(p. 655)



Paradileptus elephantinus
100–450 µm
(p. 221)

Pelagodileptus trachelioides
230–800 µm
(p. 232)

Teuthophrys trisulca
150–300 µm
(p. 238)

Ciliophora XIX

Plankton Ciliates

[1] Discrimination of cilia and cirri (= several adhering cilia forming fairly thick bundles): if you see cilia at a magnification of ×100–400, that is, without oil immersion, then these are very likely cirri!

from Ciliophora XVIII

oral ciliature

conspicuous, that is, tufts of cilia (adoral membranelles or adoral zone of membranelles) at anterior and/or lateral margin (easily recognizable at a magnification of ≥ ×100)

inconspicuous

size

>40 µm → Ciliophora XX

<40 µm (10–50 µm) → Special key XXXV

do you see "cilia" (cirri[1]) on body at a magnification of ×100

yes

adoral zone of membranelles

cirri

Hypotrichia VIII

no

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

complete

adoral zone of membranelles

CR

Heterotrichida III

strongly reduced or lacking

body contractility; oral ciliature

distinct, especially under slight coverglass pressure; continuous membrane

adoral ciliary spiral

pellicle with fine transverse striation (use ≥ ×400)

Peritrichia VIII

contracted

somatic ciliary girdle

macro-nucleus

attention, do not confuse with *Didinium/Monodinium*

Gymnostomatida VI, VIII

absent; distinct ciliary plates

body

stalk contractile

Oligotrichida II

tintinnid which left lorica

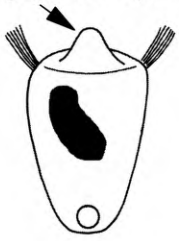
Ciliophora XX

Plankton Ciliates

from Ciliophora XIX

anterior end

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

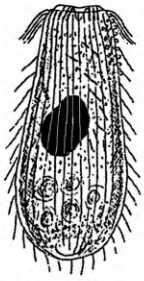


Gymnostomatida IV

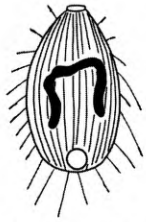
different

shape; mouth

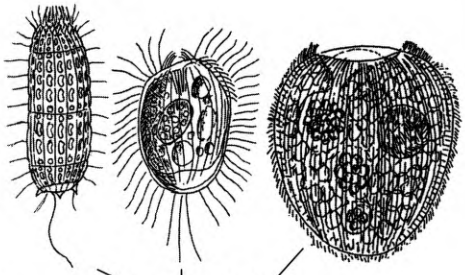
cylindroid, barrel-shaped, or globular; apical



Balantidion



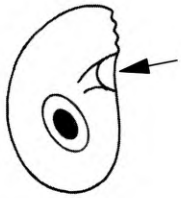
Actinobolina/ Belonophrya



Prostomatida III

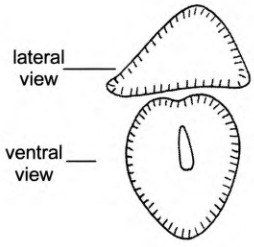
Gymnostomatida IV, V

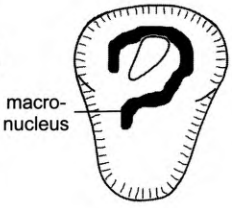
reniform, that is, one side convex, the other concave with indentation at oral opening; supapical

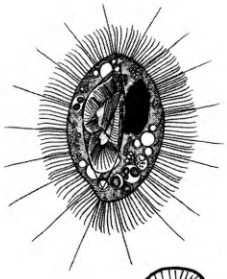


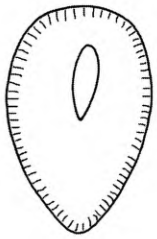
Colpoda steinii
10–60 µm
(p. 714)

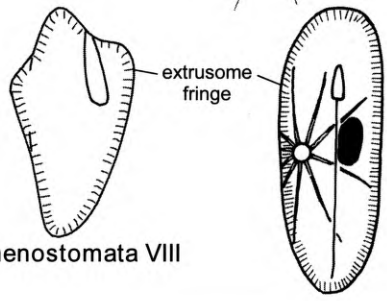
cap-shaped, obconical, lemon-shaped, obovoid, calyx-shaped; slightly to distinctly supapical











Hymenostomata VIII

Ciliophora XXI (Ciliophora plates XXI–XXV are for identification of protargol-impregnated specimens)

Plankton Ciliates

from Ciliophora XII

adoral zone of membranelles (AM) = serially arranged stacks of oral cilia

absent

present

cirri = patches of basal bodies

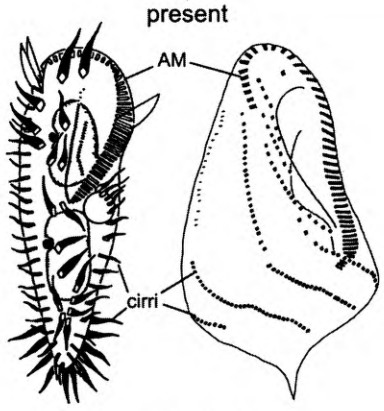
present

absent

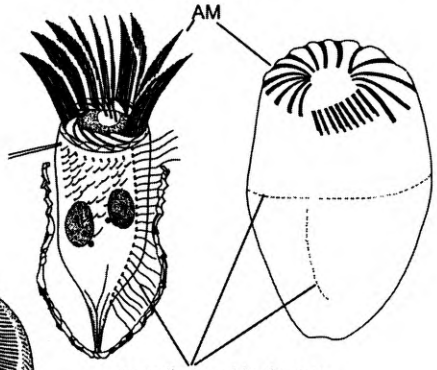
somatic ciliature

± strongly reduced

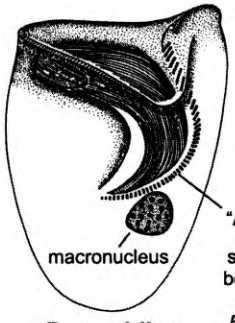
(peritrichs, which also lack somatic ciliature, do not have an adoral zone of mebranelles, but long, spirally arranged oral basal body [ciliary] rows)



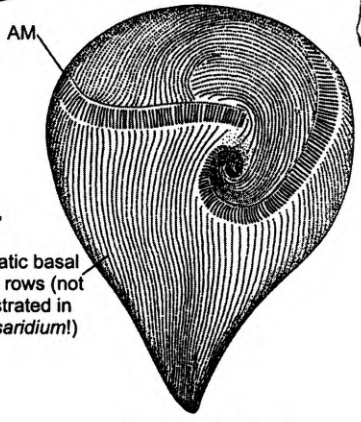
Hypotrichia VIII



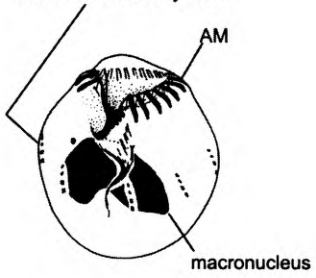
complete



Bursaridium pseudobursaria
in life 80–200 µm
(p. 709)



Heterotrichida III



Oligotrichida II

macronucleus

globular, ellipsoidal, reniform, or not clearly recognizable
Ciliophora XXII

C-shaped, J-shaped, vermiform, moniliform, or composed of 2 nodules
Special key XLI

Ciliophora XXII

Plankton Ciliates

from Ciliophora XXI

size

- 50–200 µm
- >200 µm — Special key XXXIV
- <50 µm — Special key XXXV

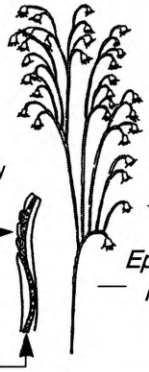
shape

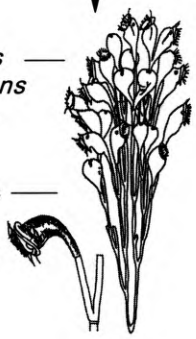
- different
- with proboscis or proboscis-like elongation — Ciliophora XIV first question
- with stalk — Peritrichia IX–XI
- with conspicuous spines

Hastatella radians in life 40–60 µm (p. 460)

colonial

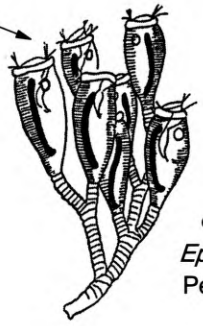
- no or unknown
- yes (zooids usually globular in preparations)





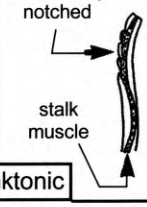
Epistylis procumbens (p. 527)

euplanktonic



epiplanktonic

Epistylis spp.
Peritrichia XI



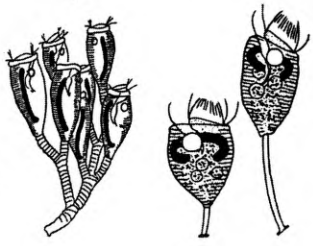
stalk locally notched

stalk muscle

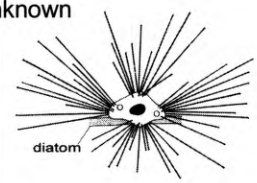
Epicarchesium pectinatum (p. 508)

epiplanktonic

- no or unknown
- yes



Peritrichia VIII

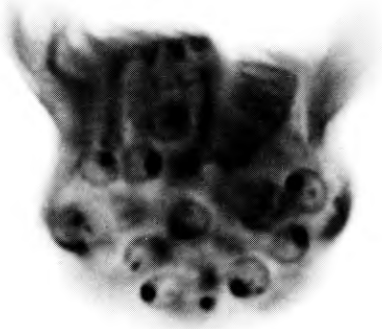


diatom

Gajewskajophrya melosirae 50–90 µm (p. 725)

zoochlorellae

- absent or unknown — Ciliophora XXIII
- present — Special key XXXVII



Differentiation from ingested algal food: usually numerous, of same size and morphology, and not in vacuoles; 4–6 µm across with distinct membrane and dark central or acentral globule (see micrograph)

Ciliophora XXIII

Plankton Ciliates

from Ciliophora XXII

oral apparatus (OA)

apical
Ciliophora XXIV

subapical

dorsal side (arrow) almost without basal bodies

yes

no

nassulid ciliature (arrow)
(silver carbonate impregnation preferred)

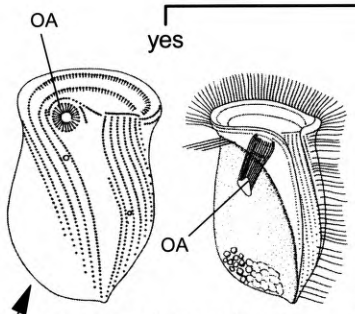
yes

no

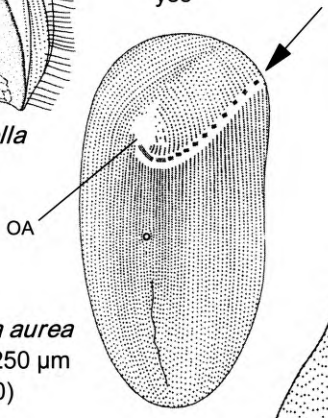
proboscis

present

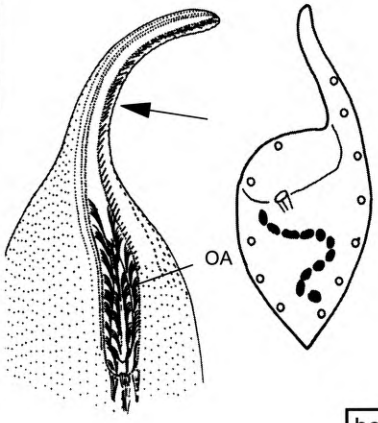
lacking



Phascolodon vorticella
in life 60–90 µm
(p. 693)



Obertrumia aurea
in life 120–250 µm
(p. 700)

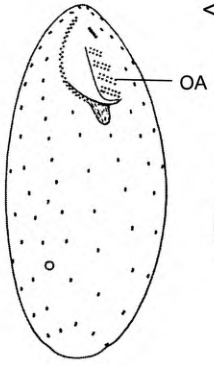


Teuthophrys,
Paradileptus or
Pelagodileptus
Gymnostomatida IV

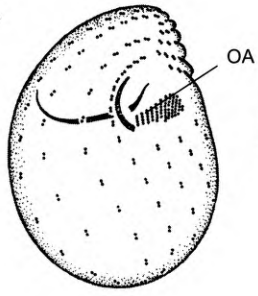
body length

<40 µm

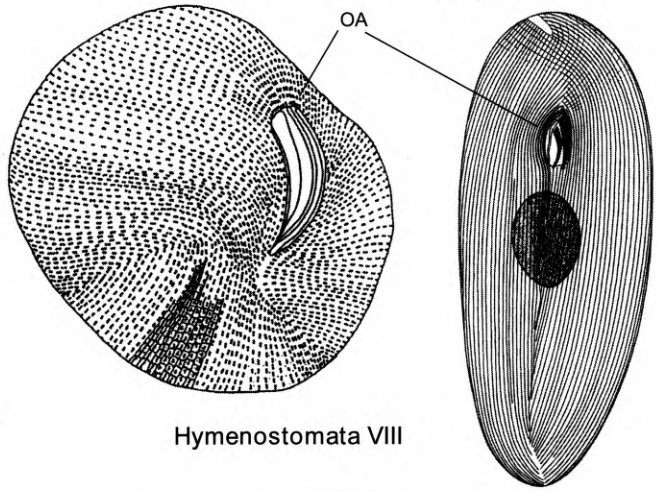
>40 µm



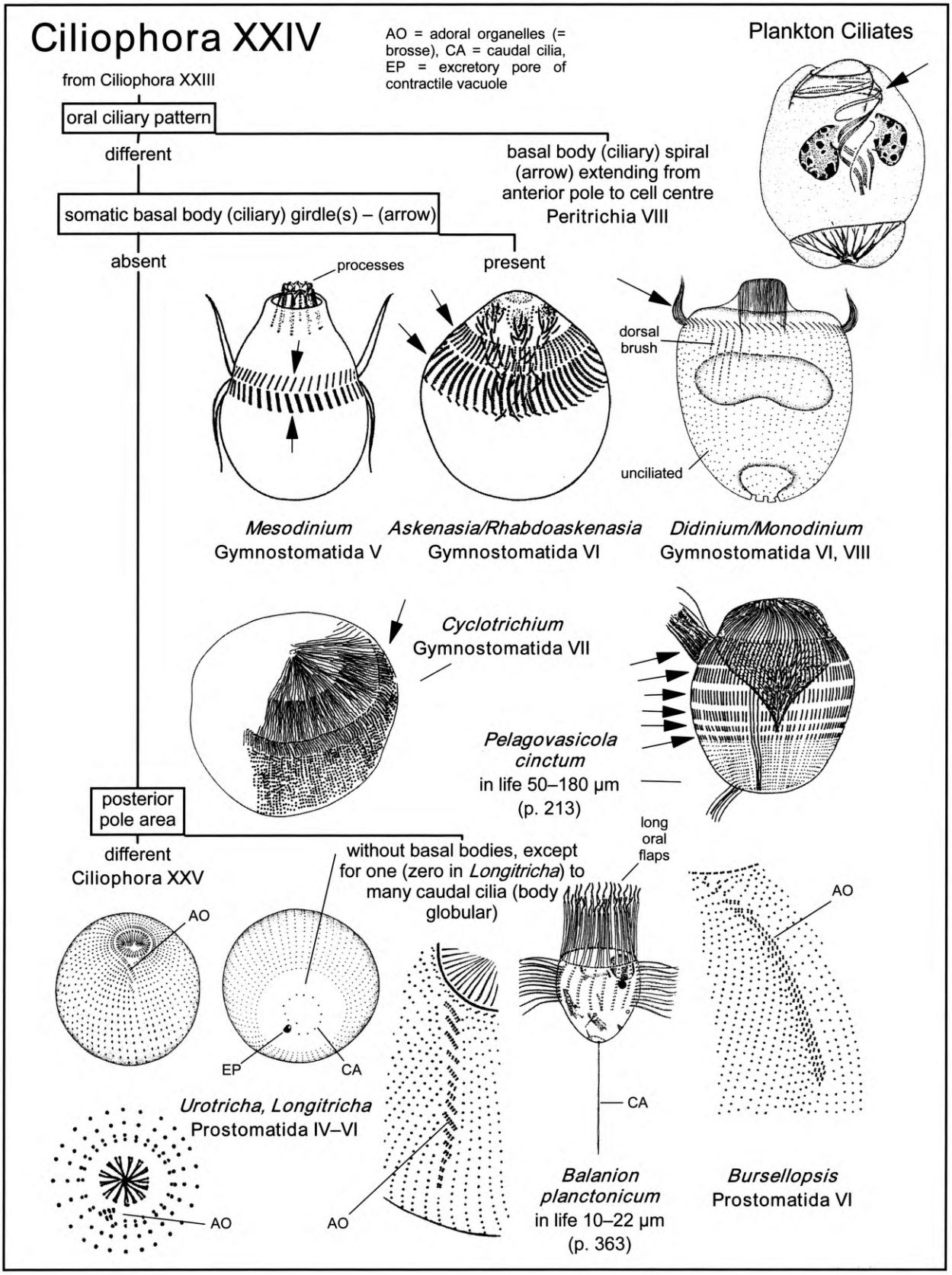
Cyrtolophosis mucicola
in life 20–40 µm
(p. 718)

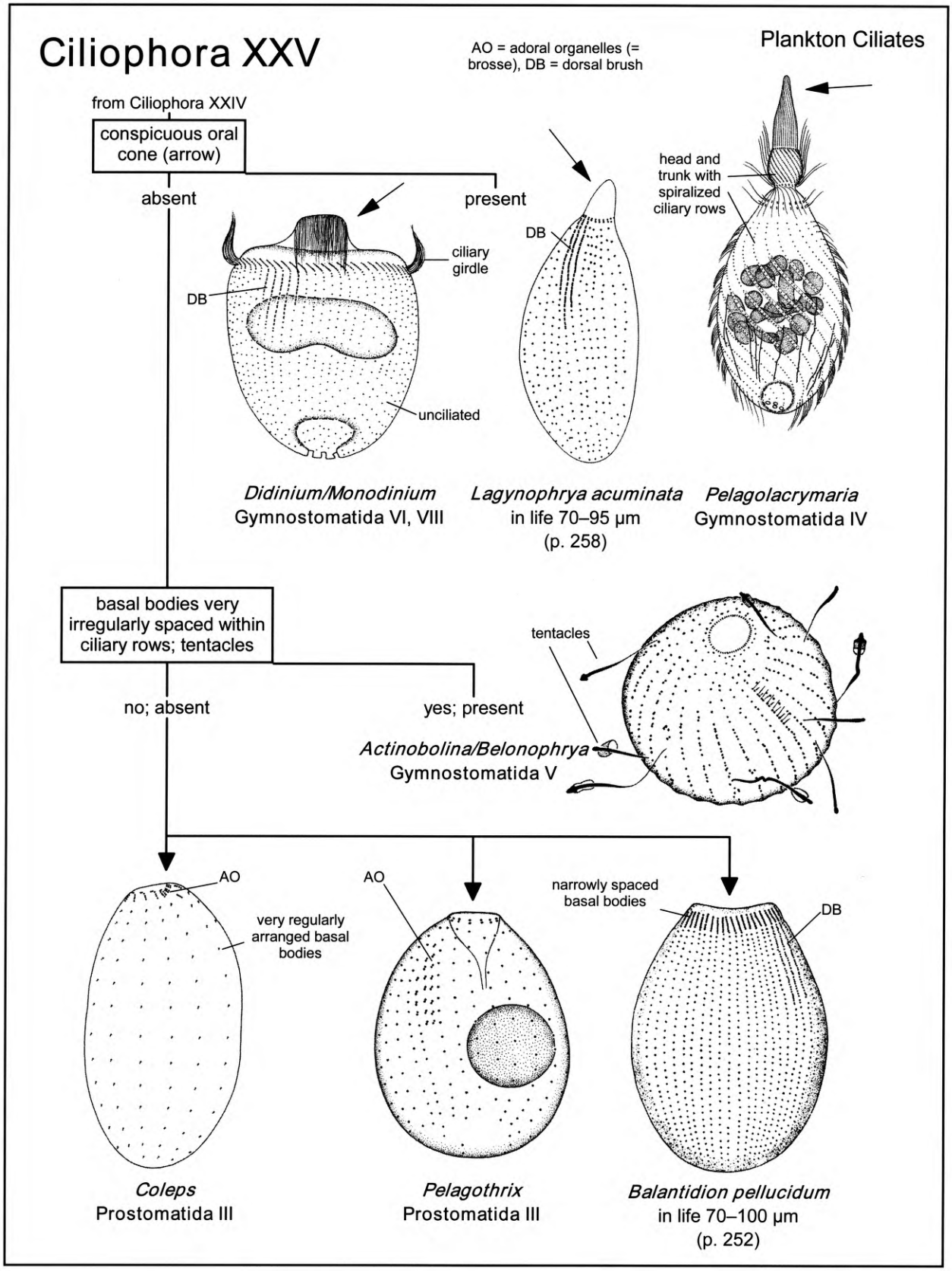


Colpoda steinii
in life 10–60 µm, usually
20–40 µm
(p. 714)



Hymenostomata VIII


Ciliophora XXIV
AO = adoral organelles (= brosse), CA = caudal cilia, EP = excretory pore of contractile vacuole
Plankton Ciliates
from Ciliophora XXIII
oral ciliary pattern
different
basal body (ciliary) spiral (arrow) extending from anterior pole to cell centre
Peritrichia VIII
somatic basal body (ciliary) girdle(s) – (arrow)
absent
present
processes
dorsal brush
unciliated
Mesodinium
Gymnostomatida V
Askenasia/Rhabdoaskenasia
Gymnostomatida VI
Didinium/Monodinium
Gymnostomatida VI, VIII
Cyclotrichium
Gymnostomatida VII
Pelagovasicola cinctum
in life 50–180 µm
(p. 213)
posterior pole area
different
Ciliophora XXV
without basal bodies, except for one (zero in Longitricha) to many caudal cilia (body globular)
long oral flaps
AO
EP
CA
Urotricha, Longitricha
Prostomatida IV–VI
AO
AO
CA
Balanion planctonicum
in life 10–22 µm
(p. 363)
AO
Bursellopsis
Prostomatida VI


Ciliophora XXV
Plankton Ciliates
AO = adoral organelles (= brosse), DB = dorsal brush
from Ciliophora XXIV
conspicuous oral cone (arrow)
absent
present
ciliary girdle
DB
unciliated
DB
head and trunk with spiralized ciliary rows
Didinium/Monodinium
Gymnostomatida VI, VIII
Lagynophrya acuminata
in life 70–95 µm
(p. 258)
Pelagolacrymaria
Gymnostomatida IV
basal bodies very irregularly spaced within ciliary rows; tentacles
no; absent
yes; present
tentacles
Actinobolina/Belonophrya
Gymnostomatida V
AO
very regularly arranged basal bodies
AO
narrowly spaced basal bodies
DB
Coleps
Prostomatida III
Pelagothrix
Prostomatida III
Balantidion pellucidum
in life 70–100 µm
(p. 252)

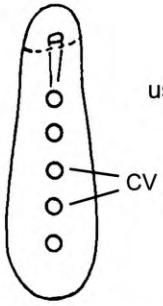
5 Special keys I–XLIV

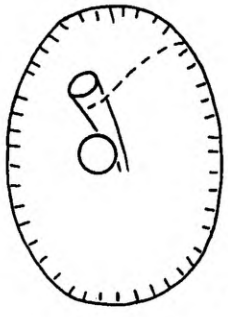
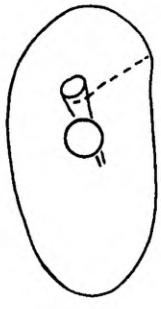
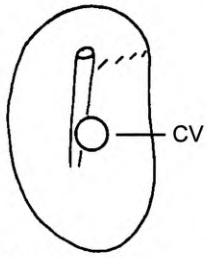
The following keys contain some groups and species which have conspicuous characters and are thus easily determined.

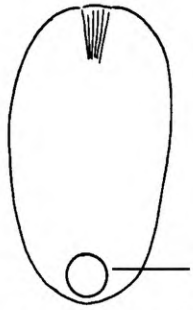
Special key I (conspicuously coloured or dark species)

from Ciliophora I

colour

- conspicuously spotted (violet, green, blue, orange ...) by ingested cyanobacteria → shape; contractile vacuoles (CV)
  - slenderly pyriform; 3-5 along median of cell → 

    Nassulopsis elegans 150-300 µm (Vol. III, p.430)
  - ellipsoid; 1 near mid-body → size
    - usually > 150 µm → rod-seam (trichocysts)
      - present → 
        Nassula ornata 155-320 µm (Vol. III, p.436)
      - absent → 
        Obertrumia aurea 120-250 µm (Vol. III, p.451)
    - < 150 µm → 

      Nassula picta 70-140 µm (Vol. III, p.445)
  - ellipsoid; 1 in posterior end → size; number of ciliary rows
    - 60-160 µm; 35-64 → 

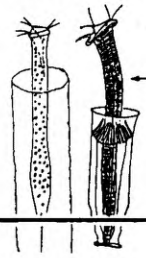
      Holophrya discolor (Vol. III, p.328)
    - usually 150-250 µm; 80-110 → 

      Holophrya teres (Vol. III, p.336)
- grass-green, usually by zoochlorellae → **Special key II**
- dark to black at X 100 → **Special key VI**

- orange, reddish or red → **Special key VIII**
- blue-green (turquoise) → **Special key V**
- yellow-green or yellow (frequently indistinct; hypotrichs must have citrine cortical granules [oil immersion!]) → **Hypotrichia VII** and **Special key VII**

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



from special key I

Peritrichia

no

yes

Special key IV

size

100-200 µm

Special key III

< 100 µm

> 200 µm

shape

conical (colour by sequestered chloroplasts)

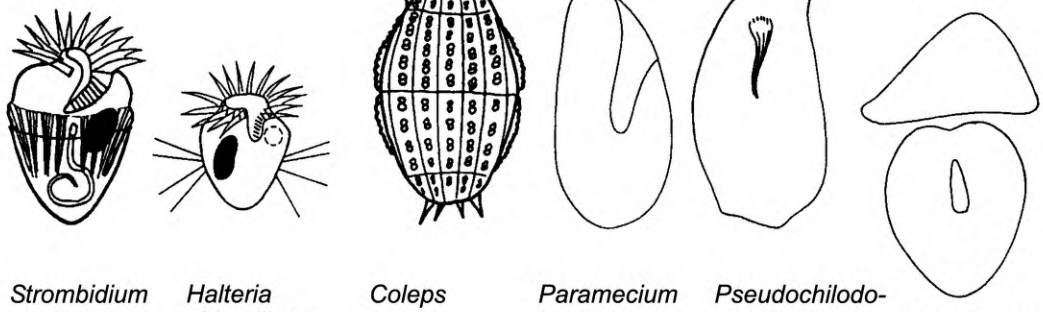
globular

barrel-shaped

oviform

with short snout anteriorly

cap-shaped in lateral view, cordiform in ventral view



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

Halteria chlorelligera
40-50 µm
(Vol. I, p.134)

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

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

Pseudochilodonopsis algivora
40-70 µm
(Vol. I, p.62)

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

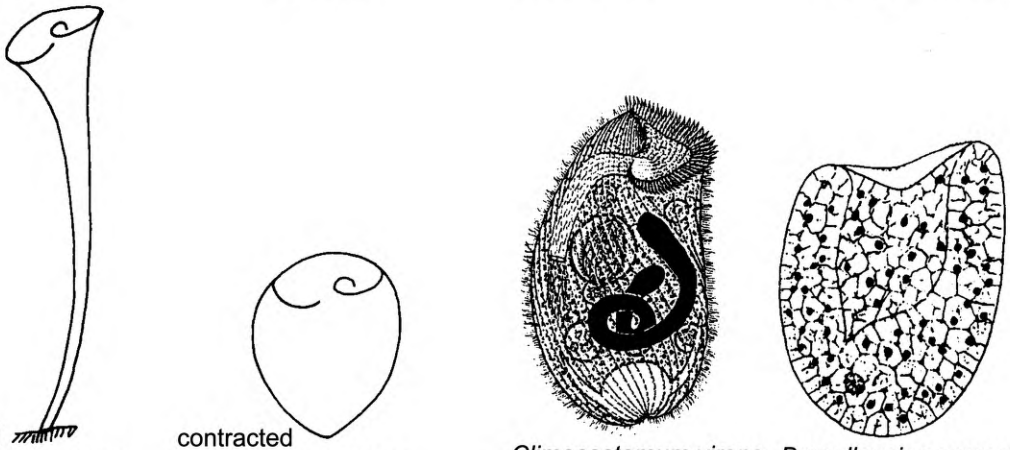
shape

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)

Bursellopsis spumosa
200-800 µm, usually
250-500 µm (Vol. III, p.405)

Special key III (grass-green coloured by zoochlorellae)

from special key II

shape

with short snout anteriorly

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

slenderly fusiform

Stichotricha secunda
100-220 µm
(Vol. I, p.210)

slenderly ellipsoid, flattened

number of cirral (bundles of cilia) rows

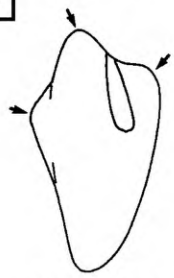
8-14

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

2

Oxytricha chlorelligera
about 115 µm
(Vol. I, p.277)

calyx-shaped, anterior end with 3 hucksters

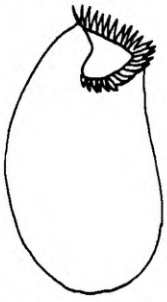


Disematostoma tetraedricum
100-140 µm
(Vol. III, p.185)

oviform or broadly ellipsoid

anterior end

with conspicuous ciliary plates (membranellar zone)



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

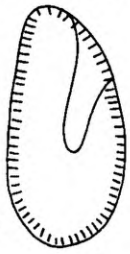
without conspicuous membranellar zone

rod-seam

present

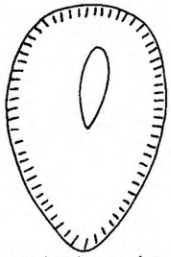
shape

oviform, posterior end broadly rounded



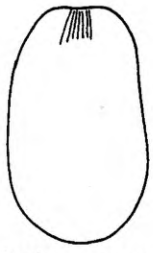
Paramecium bursaria
85-150 µm
(Vol. III, p.140)

obovoid



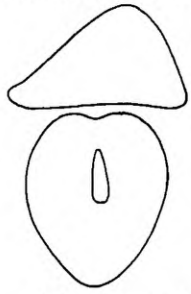
Disematostoma buetschlii
110-200 µm (Vol. III, p. 180)

absent



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

cap-shaped in lateral view, cordiform in ventral view



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

Special key IV (grass-green coloured by zoochlorellae)

from special key II

colonial

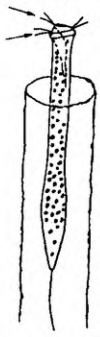
no

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

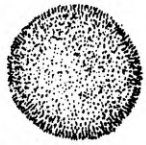
yes

number of turns of adoral ciliary spiral on anterior end of cell

1 1/2

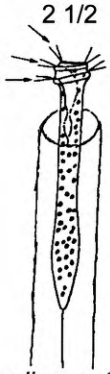


Ophrydium versatile
300-400 µm
(Vol. II, p.232)



globular colonies
up to 10 cm !

2 1/2



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

Special key V (bluegreen species)

from special key I

shape; contractility

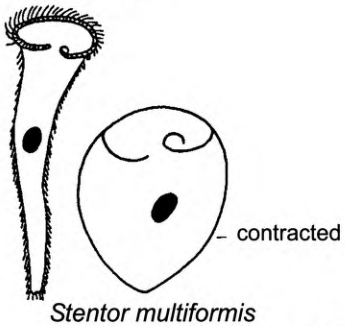
oviform; acontractile

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

trumpet-shaped or obovoid; very contractile

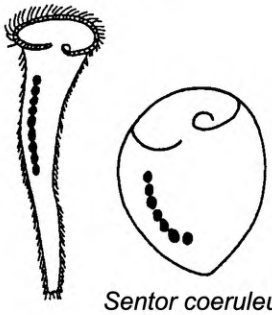
macronucleus

ellipsoid



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

moniliform



Sentor coeruleus
1-2 mm (Vol. II, p.357)

Special key VI (dark or black species)

from special key I

shape

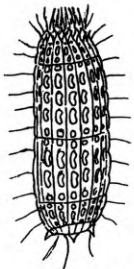
trumpet-shaped

extended *Stentor amethystinus* or *S. niger* 200-500 µm (Vol. II, p.339, 355)

barrel-shaped (at ≥ X 100 brownish)

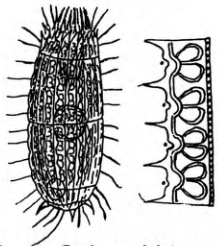
windows in armour plates

reniform



Coleps nolandi 40-65 µm (Vol. III, p.395)

bretzel-shaped



Coleps hirtus 40-65 µm (Vol. III, p.382)

ellipsoid or fusiform

mouth; contractile vacuole

at anterior end; in posterior end

different

Hymeno-stomata II

size

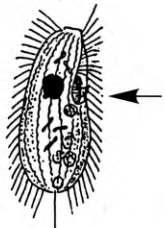
60-250 µm

25-50 µm

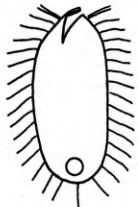
shape

with inconspicuous ventral notch (arrow)

different



Uronema nigricans (Vol. III, p.228)

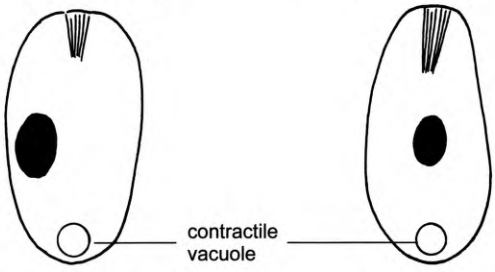


Plagiocampa rouxi (Vol. III, p.373)

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)

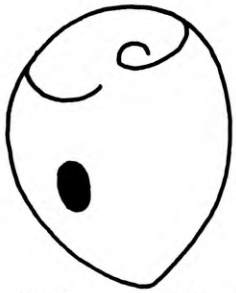
campanulate or globular

macronucleus

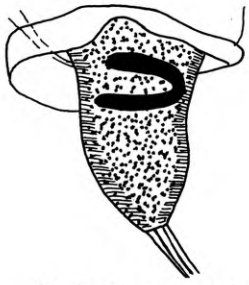
ellipsoid

horseshoe-shaped in transverse axis of cell

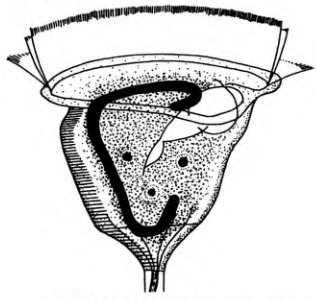
J-shaped in longitudinal axis of cell



Stentor amethystinus or *S. niger* (Vol. II, p.339, 355)



Vorticella marginata 70-90 µm (Vol. II, p.114)



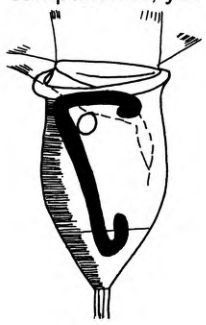
Vorticella campanula 60-90 µm (Vol. II, p.105)

Special key VII (yellow or yellowgreen coloured species)

from special key I

shape; stalk

campanulate; yes



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

slenderly ellipsoid, flattened; no

number of macronuclear nodules

many

size

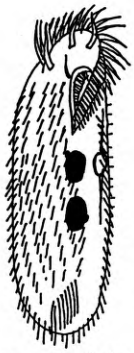
250-400 µm,
usually 300-350 µm

Urostyla grandis
(Vol. I, p.222)

130-170 µm

Holosticha multistilata
(Vol. I, p.236)

2



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

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

from special key I

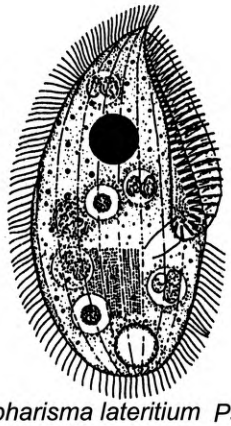
shape

conical
or globular

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

contracted

oviform



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

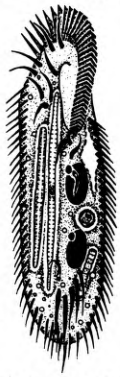
oblong

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

ellipsoid

number of macronuclear nodules; colour

2; orange to
distinctly pink

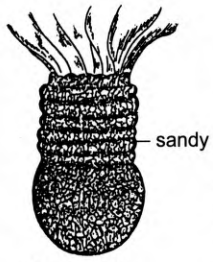


Oxytricha haematoplasma
120-180 µm
(Vol. I, p.287)

many; wine-red

Diaxonella
trimarginata
130-170 µm
(not described
in main work)

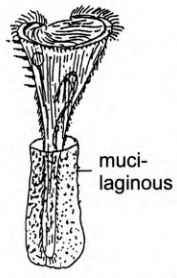
Special key IX (loricate or armoured species)



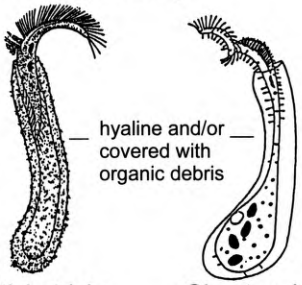
Codonella cratera
50-70 µm
(Vol. I, p.183)

Tintinnidium/ Tintinnopsis

Oligotrichida I



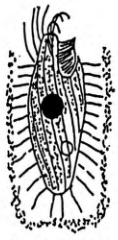
Stentor



Stichotricha

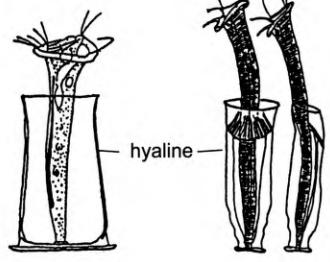
Chaetospira

Hetero-trichida I



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

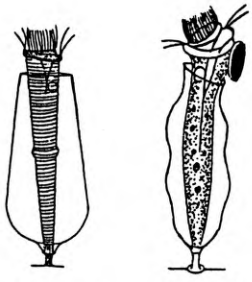
Hypotrichia I



Vaginicola

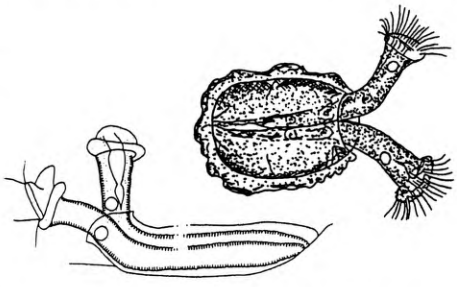
Thuricola

Peritrichia I

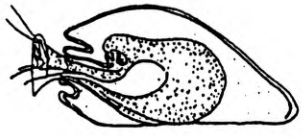


Cothurnia annulata
40-70 µm
(Vol. II, p.251)

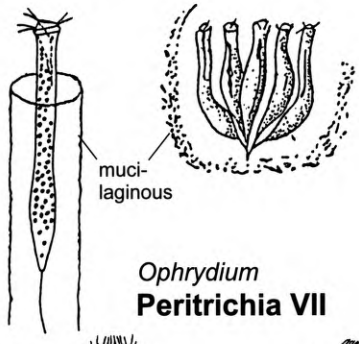
Pyxicola carteri
60-95 µm
(Vol. II, p.270)



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

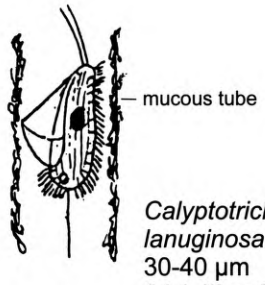


Lagenophrys vaginicola
45-80 µm
on small crustaceans
(Vol. II, p.256)

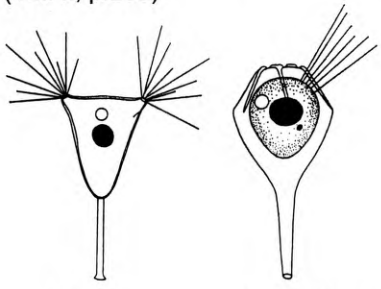


Ophrydium

Peritrichia VII



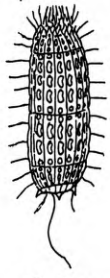
Calyptotricha lanuginosa
30-40 µm
(Vol. III, p.288)



Acineta

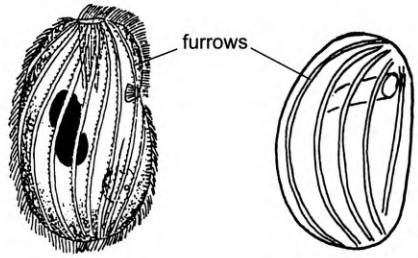
Metacineta

Suctoria II



Coleps

Prostomatida I

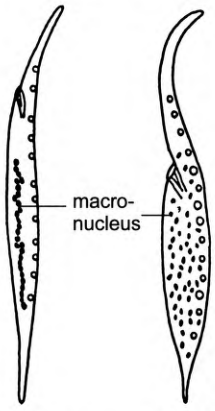


Placus luciae
30-70 µm
(Vol. III, p.376)

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

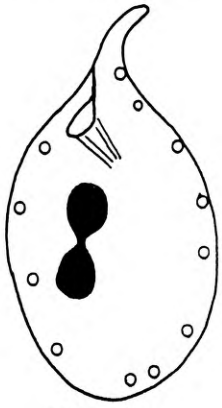
Special key X (very large [> 300 µm] species)

Spirostomum
200-2000 µm

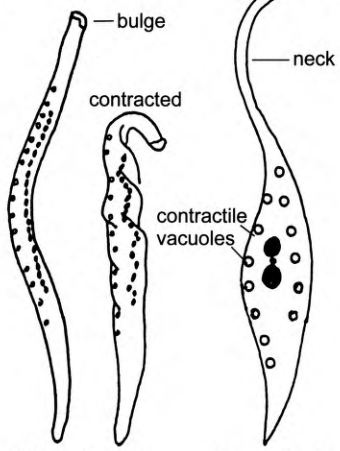


Monilicaryon monilatus
350-950 µm
(Vol. IV, p.199)

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



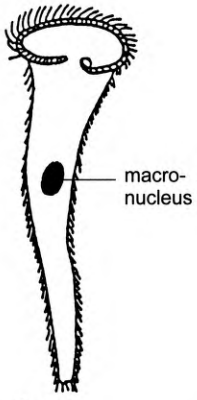
Trachelius ovum
200-600 µm
(Vol. IV, p.208)



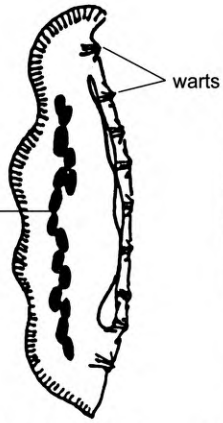
Homalozoon vermiculare
150-1500 µm
(Vol. IV, p.219)

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

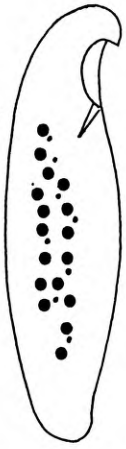
Heterotrichida I



Stentor
200-2000 µm



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

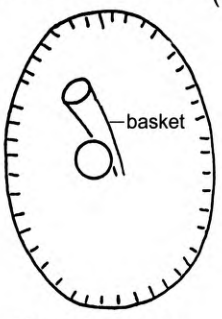


Loxodes magnus
150-600 µm
(Vol. IV, p.378)

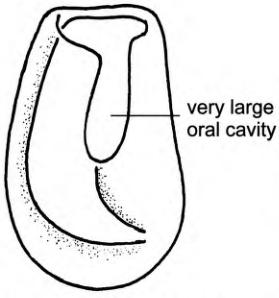
Urostyla grandis
250-400 µm
(Vol. I, p.222)

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

Heterotrichida I

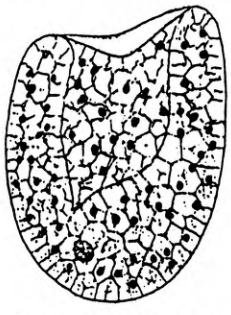


Nassula ornata
155-320 µm
(Vol. III, p.436)

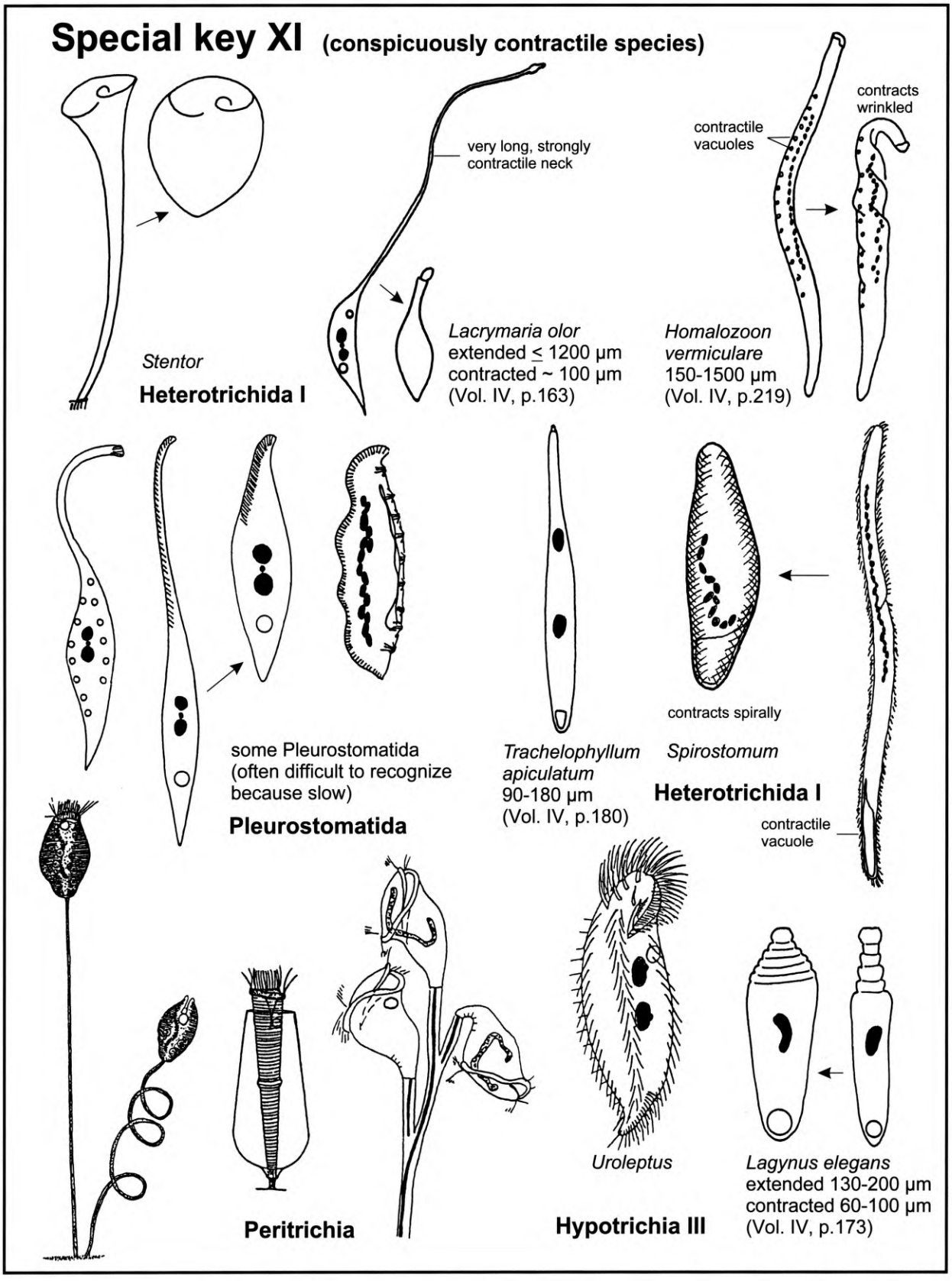


Bursaria truncatella
200-1700 µm
(Vol. I, p.424)

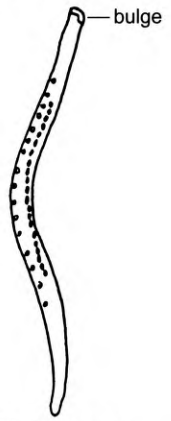
Prorodon niveus
250-700 µm
(Vol. III, p.346)



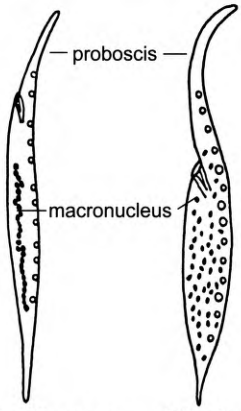
Bursellopsis spumosa
200-800 µm
(Vol. III, p.405)


Special key XI (conspicuously contractile species)
Stentor
Heterotrichida I
very long, strongly contractile neck
Lacrymaria olor
extended ≤ 1200 µm
contracted ~ 100 µm
(Vol. IV, p.163)
contractile vacuoles
contracts wrinkled
Homalozoon 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)
contracts spirally
Spirostomum
Heterotrichida I
contractile vacuole
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 ≥ 5:1; attention, often highly contractile and then becoming more blunt)



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



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

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

Chaenea stricta
90-150 µm
(Vol. IV, p.152)

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

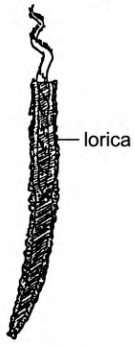
Lacrymaria olor
up to 1200 µm
(Vol. IV, p.163)

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

Spirostomum (contractile)
200-2000 µm

Heterotrichida I

Stichotricha

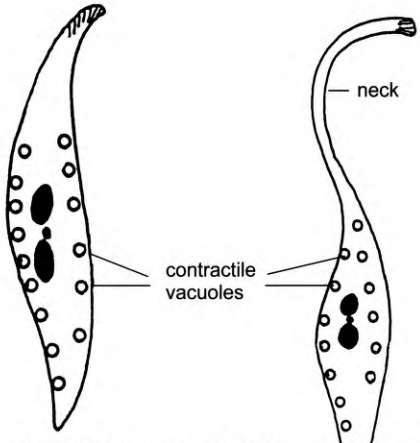


Chaetospira

Hypotrichia I

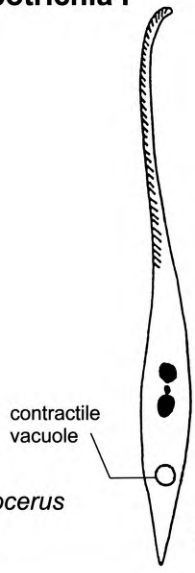
Uroleptus

Hypotrichia III

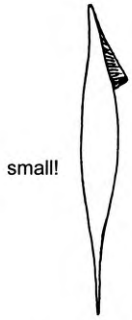


Amphileptus pleurosigma
150-300 µm
(Vol. IV, p.290)

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

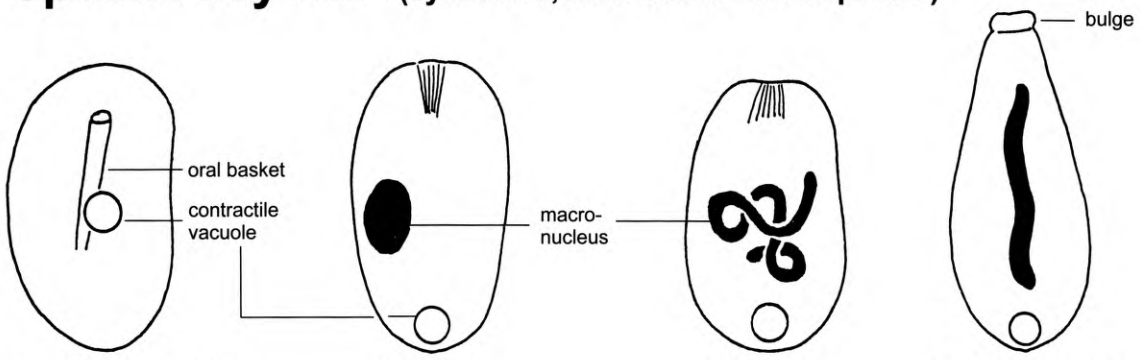


Litonotus cygnus
200-300 µm
(Vol. IV, p.318)



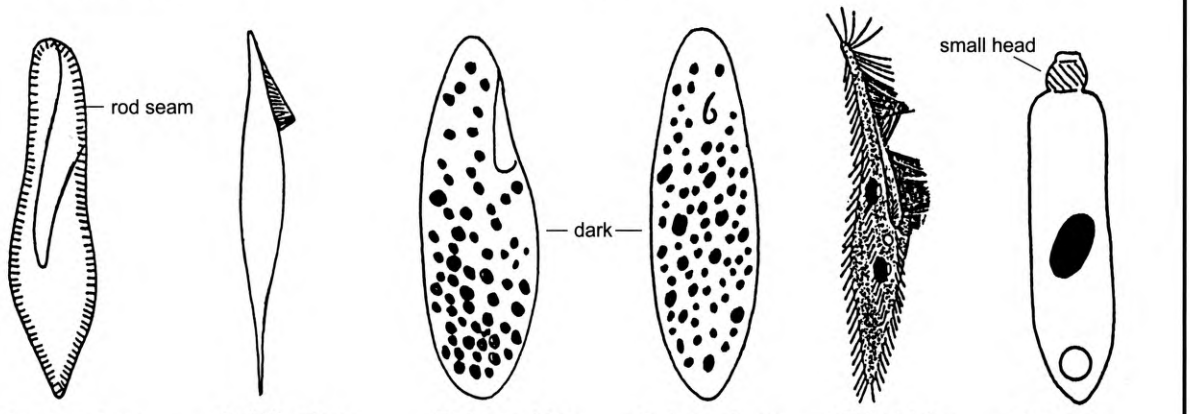
Kahlilembus attenuatus
40-80 µm
(Vol. III, p.237)

Special key XIII (cylindroid, fusiform or ovoid species)



Nassula / Obertrumia — *Holophrya* — *Prorodon* — *Enchelyodon elegans* 140-200 µm (Vol. IV, p.155)

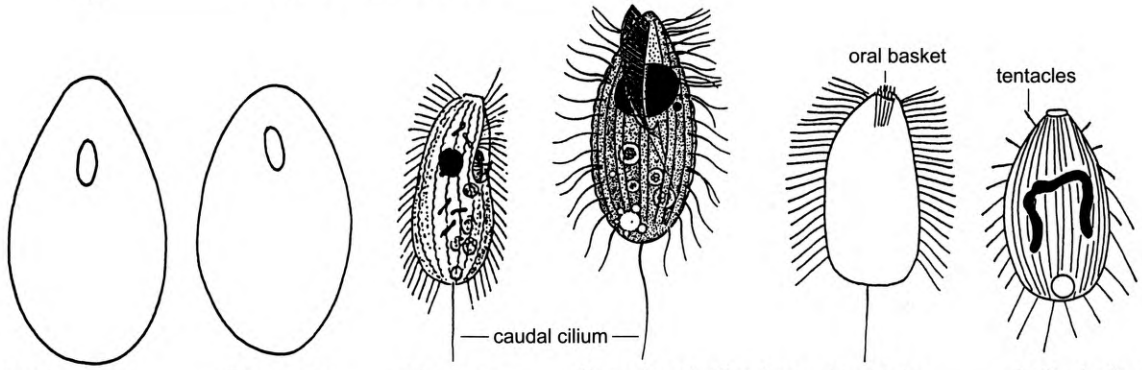
Nassulida — **Prostomatida I**



Paramecium caudatum/aurelia — *Kahlilembus attenuatus* 40-80 µm (Vol. III, p.237) — *Philasterides armatus* 50-100 µm (Vol. III, p.224) — *Ophryoglena* (Vol. III, p.110) — *Stichotricha* — *Phialina* (Vol. IV, p.171)

Hymeno-stomata V — **Hypotrichia I**

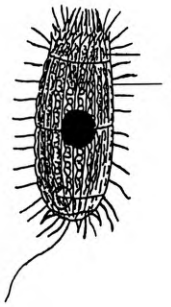
Hymenostomata



Tetrahymena pyriformis-complex 40-60 µm (Vol. III, p.61) — *Glaucoma reniforme* 35-65 µm (Vol. III, p.103) — *Uronema nigricans* 25-50 µm (Vol. III, p.228) — *Pseudocohnilembus pusillus* 25-50 µm (Vol. III, p.271) — *Urotricha agilis/ovata* — *Actinobolina*

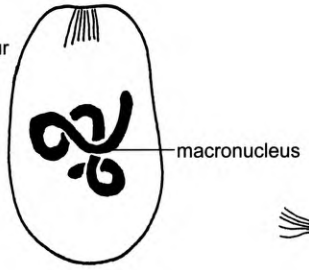
Pro-stomatida II — **Gymno-stomatida I**

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

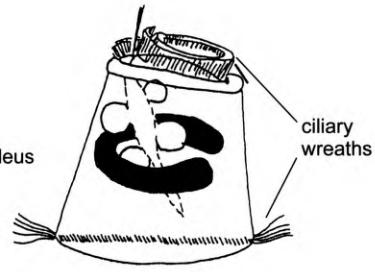


Coleps

Prostomatida I

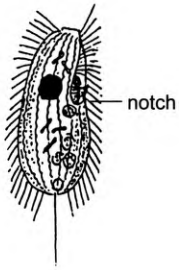


Prorodon ellipticus
80-150 µm
(Vol. III, p.344)

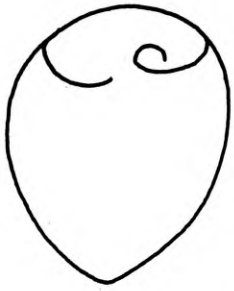


Opisthonecta henneguyi
or swarmers of
sessile peritrichs

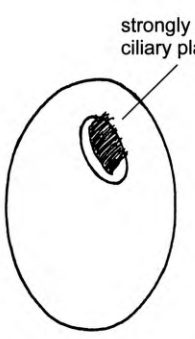
Peritrichia



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



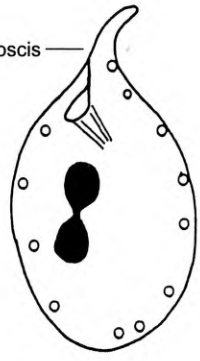
contracted
Stentor



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

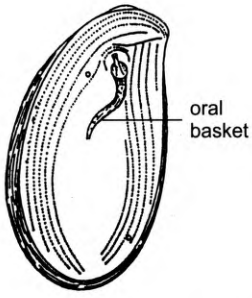
Epenardia myriophylli
90-200 µm
(Vol. III, p.106)

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

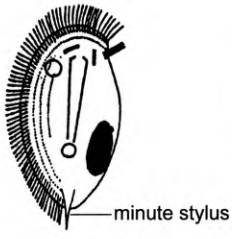


Trachelius ovum
200-600 µm
(Vol. IV, p.208)

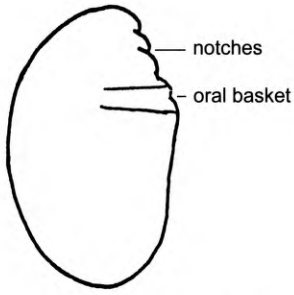
Hetero-
trichida I



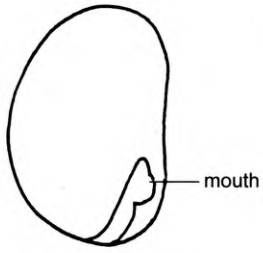
Odontochlamys alpestris
35-60 µm
(Vol. I, p.52)



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

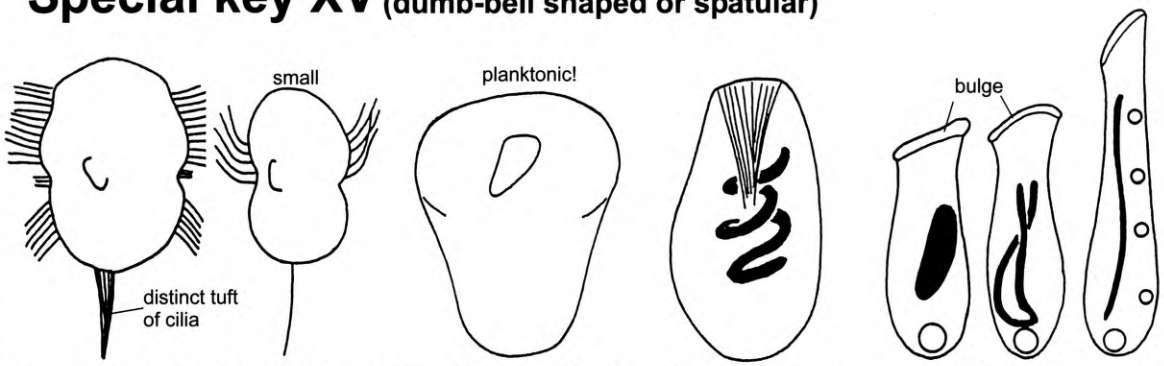


Leptopharynx costatus
20-50 µm
(Vol. III, p.460)



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

Special key XV (dumb-bell shaped or spatular)



Urocentrum turbo
40-100 µm
(Vol. III, p.187)

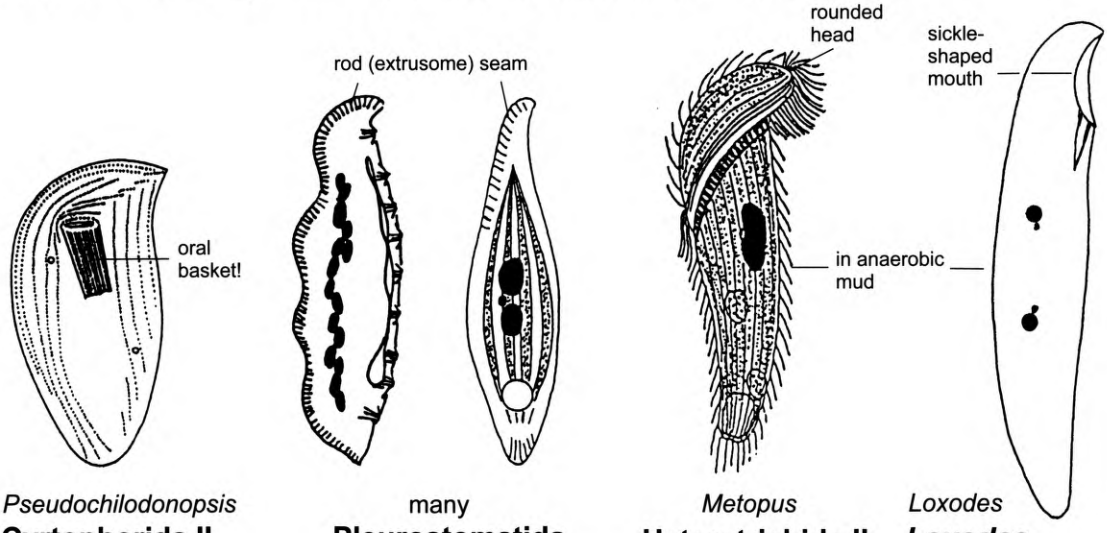
Urozona buetschlii
20-40 µm
(Vol. III, p.268)

Marituja pelagica
80-160 µm
(Vol. III, p.195)

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

Spathidium
(Vol. IV, p.226)

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

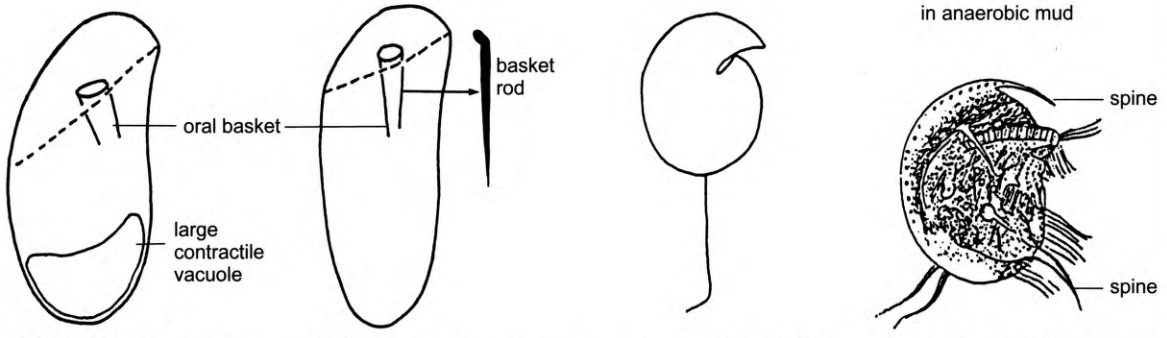


Pseudochilodonopsis
Cyrtophorida II

many
Pleurostomatida

Metopus
Heterotrichida II

Loxodes
Loxodes



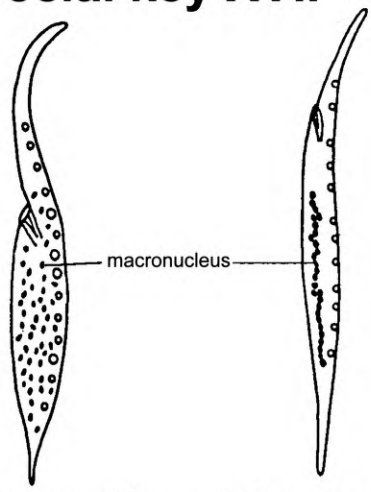
Chilodontopsis depressa
50-80 µm
(Vol. III, p.424)

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

Hexotricha caudata
25-30 µm
(Vol. III, p.483)

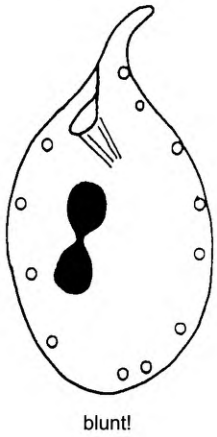
Discomorphella pectinata
70-90 µm
(Vol. II, p.451)

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



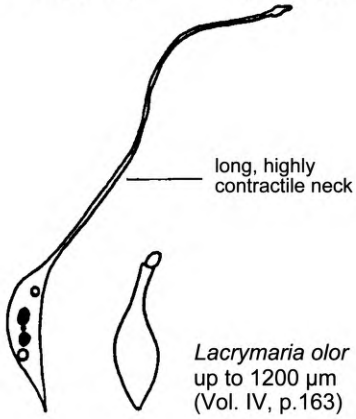
Dileptus margaritifer
250-600 µm
(Vol. IV, p.185)

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)



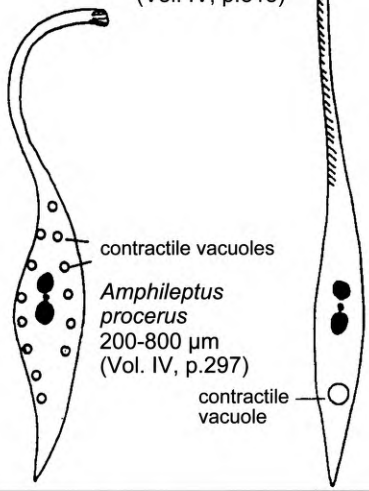
Lacrymaria olor
up to 1200 µm
(Vol. IV, p.163)

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

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

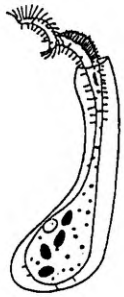
Lagynophrya acuminata
70-95 µm
(Vol. IV, p.178)

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

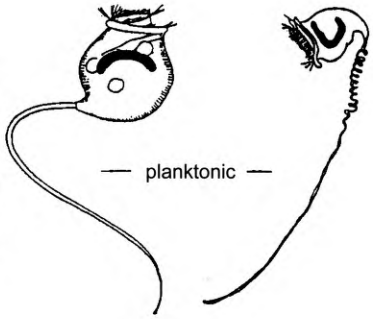


Amphileptus procerus
200-800 µm
(Vol. IV, p.297)

Stichotricha



Chaetospira



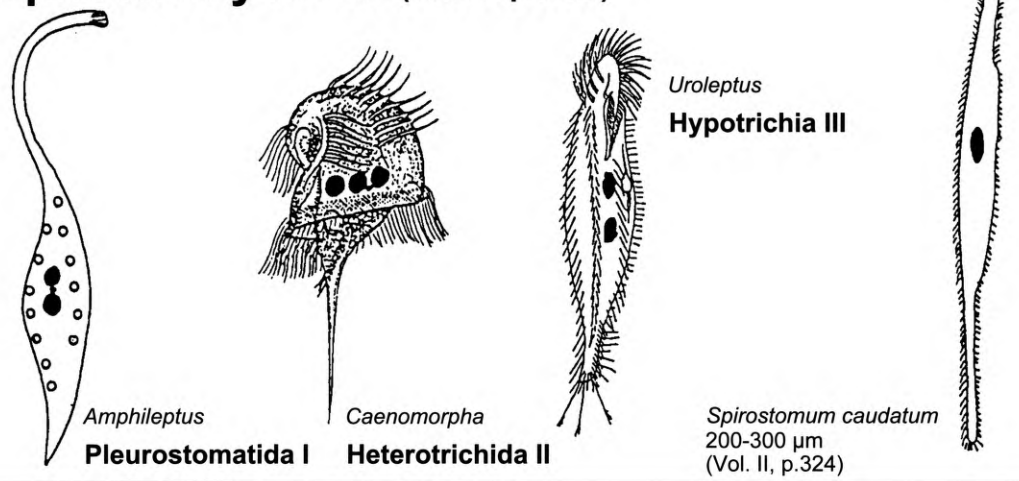
Vorticella mayeri
30-55 µm
(Vol. II, p.118)

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

Hypotrichia I

(see also Peritrichia IX, *Pelagovorticella)*

Special key XVIII (tailed species)



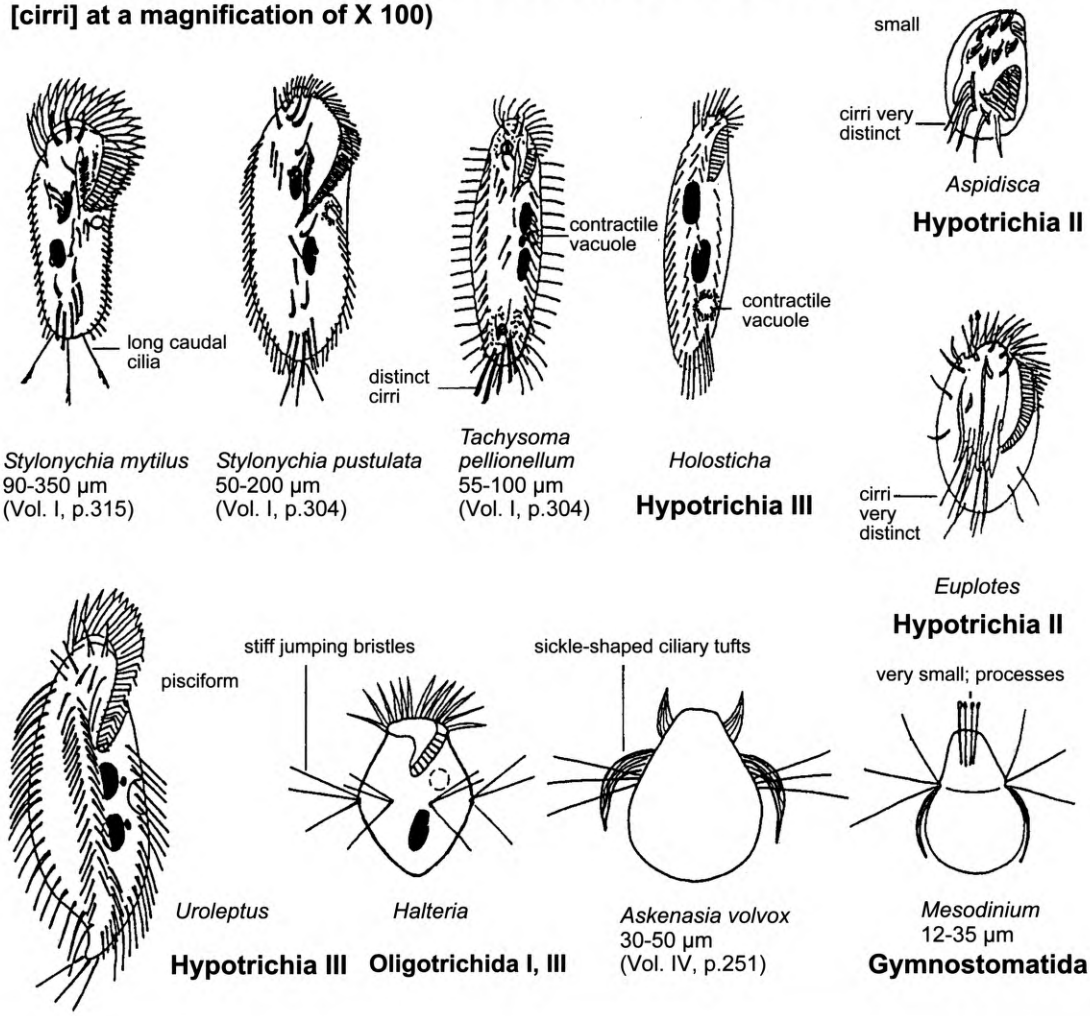
Amphileptus
Pleurostomatida I

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)



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

Stylonychia pustulata
50-200 µm
(Vol. I, p.304)

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

Holosticha
Hypotrichia III

Aspidisca
Hypotrichia II

Euplotes
Hypotrichia II

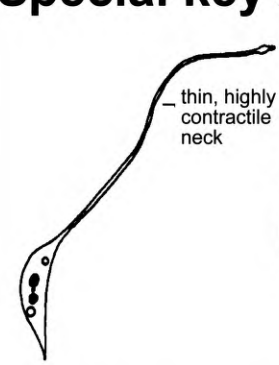
Uroleptus
Hypotrichia III

Halteria
Oligotrichida I, III

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

Mesodinium
12-35 µm
Gymnostomatida I

Special key XX (species with bizarre shape)

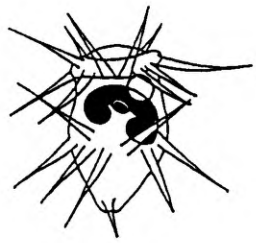


Lacrymaria olor
up to 1200 µm
(Vol. IV, p.163)

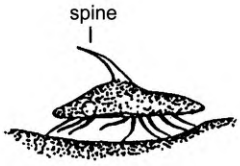
Paradileptus elephantinus
180-450 µm
(Vol. IV, p.203)

Didinium/Monodinium

Gymnostomatida I



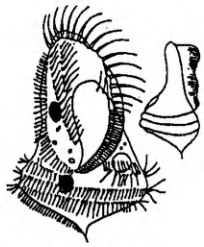
Hastatella radians
40-60 µm
(Vol. II, p.295)



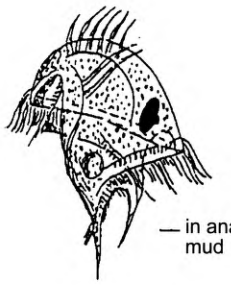
Aspidisca turrita
35-50 µm
(Vol. I, p.383)

Chaetospira

Hypotrichia I

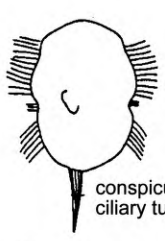


Hypotrichidium conicum
90-120 µm
(Vol. I, p.218)

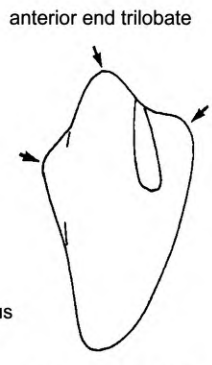


Caenomorpha
(Vol. II, p.424)

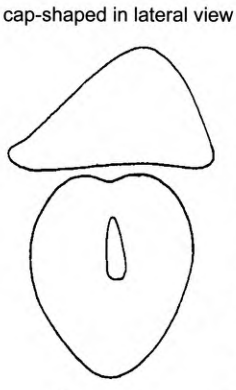
Metopus
(Vol. II, p.400)



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



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



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

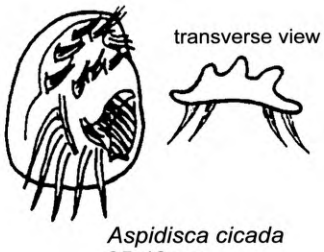
Bursaria/Bursaridium

Odontostomatida

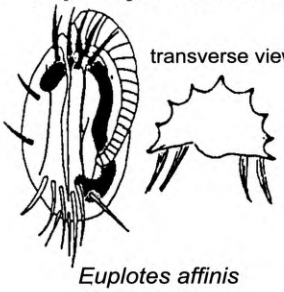
Colpodea

Special key XXI

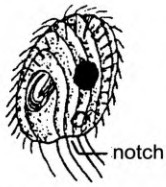
(species distinctly furrowed longitudinally, spirally, or transversely)



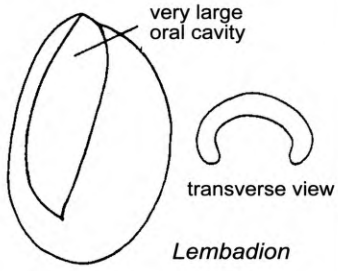
Aspidisca cicada
25-40 µm
(Vol. I, p.370)



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

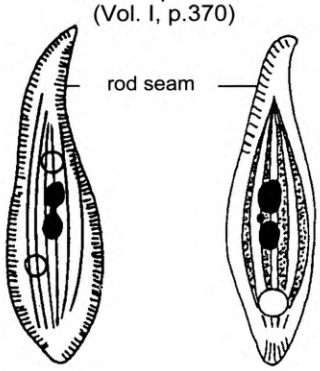


Cinetochilum margaritaceum
25-40 µm
(Vol. III, p.249)



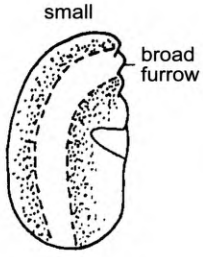
Lembadion

Hymeno-stomata I

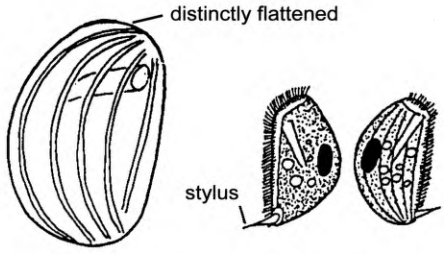


Loxophyllum utricullariae
100-170 µm
(Vol. IV, p.369)

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

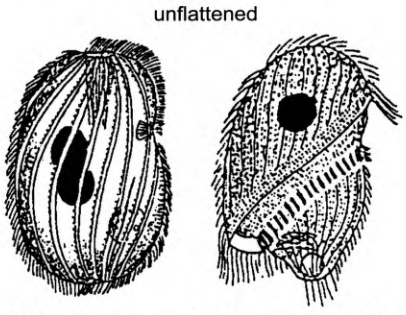


Drepanomonas revoluta
18-35 µm
(Vol. III, p.472)



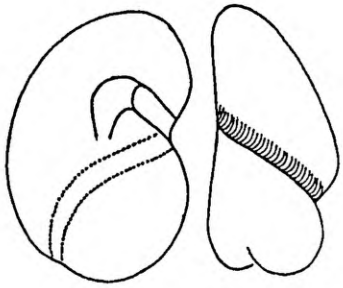
Pseudomicrothorax agilis
30-70 µm
(Vol. III, p.466)

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



Placus luciae
30-70 µm
(Vol. III, p.376)

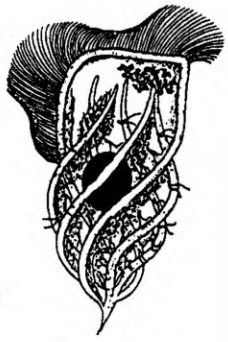
Metopus sensu lato
(Vol. II, p.400)



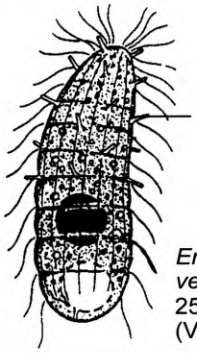
Colpoda magna
120-240 µm
(Vol. I, p.408)

Chaetospira

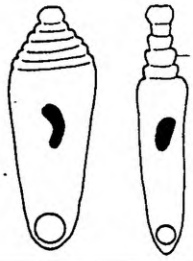
Hypotrichia I



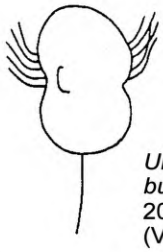
Tropidoatractus acuminatus
70-150 µm
(Vol. II, p.420)



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

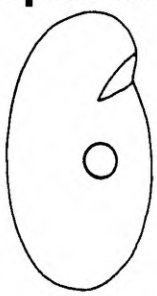


Lagynus elegans
60-200 µm
(Vol. IV, p.173)



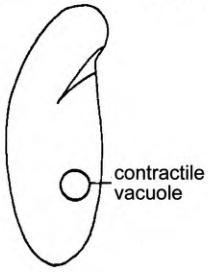
Urozona buetschlii
20-40 µm
(Vol. III, p.268)

Special key XXII (reniform, i.e. laterally indented species; indentation usually marks oral opening)



Colpidium/ Paracolpidium

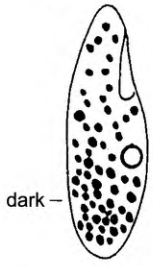
Hymeno-stomata VI



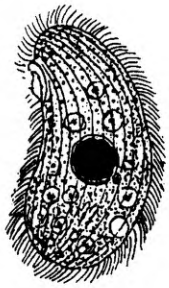
Dexiostoma campylum
35-90 µm
(Vol. III, p.33)

Paramecium putrinum/bursaria

Hymeno-stomata V



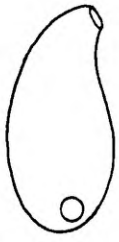
Philasterides armatus
50-100 µm
(Vol. III, p.224)



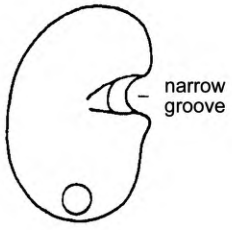
Glaucoma reniforme
35-65 µm
(Vol. III, p.103)

Dexiotrichides centralis
30-45 µm
(Vol. III, p.266)

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

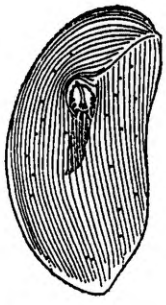


Platyophrya vorax
30-60 µm
(Vol. I, p.419)



Colpoda

Colpodea I



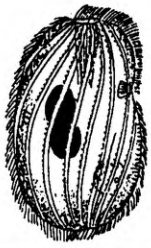
Trithigmostoma/ Chlamydonellopsis

Cyrtophorida I

Brachonella
(Vol. II, p.401)

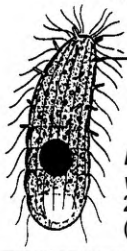
Climacostomum virens
160-250 µm
(Vol. II, p.394)

Kerona pediculus
130-205 µm
(Vol. I, p.265)



Placus luciae
30-70 µm
(Vol. III, p.376)

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

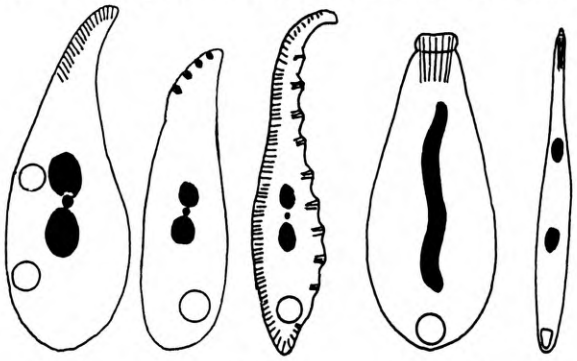


Enchelyomorpha vermicularis
25-45 µm
(Vol. IV, p.456)

Prodiscophrya/ Podophrya-
swarmer

Suctoria

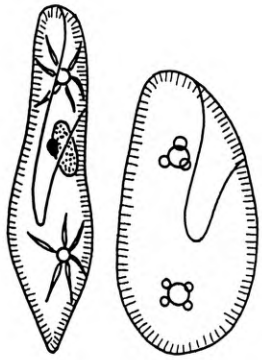
Special key XXIII (species with conspicuous seam of rods [extrusomes] or with bundles of extrusomes)



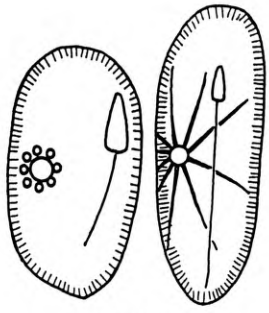
Pleurostomatida

Gymnostomatida

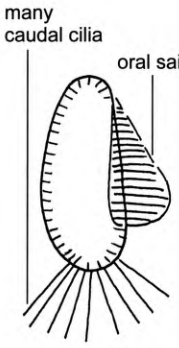
Urotricha armata
30-55 µm
(Vol. III, p.362)



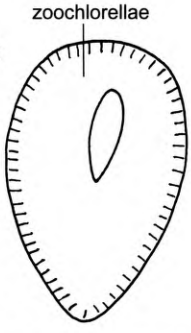
Paramecium
Hymenostomata V



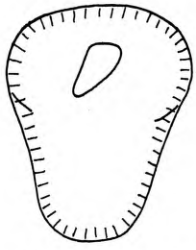
Frontonia
Hymeno-stomata V



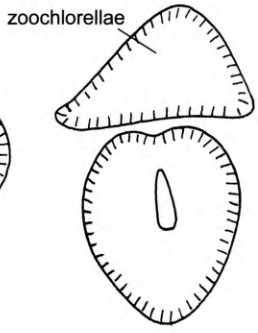
Pleuronema
Hymeno-stomata III



Disematostoma
Hymeno-stomata IV

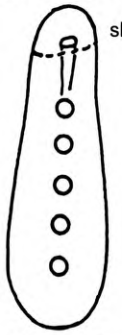


Marituja pelagica
80-160 µm
(Vol. III, p.195)

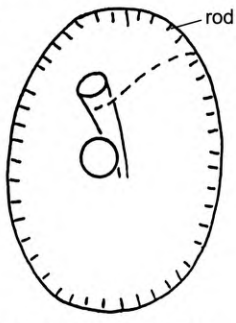


Stokesia vernalis
60-160 µm
(Vol. III, p.200)

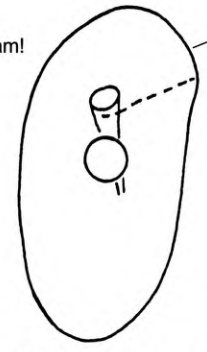
Special key XXIV (species densely filled with filamentous bluegreen algae [cyanobacteria])



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

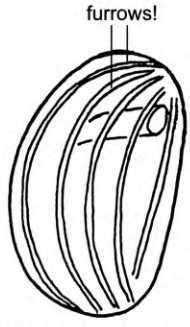


Nassula ornata
155-320 µm
(Vol. III, p.436)



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

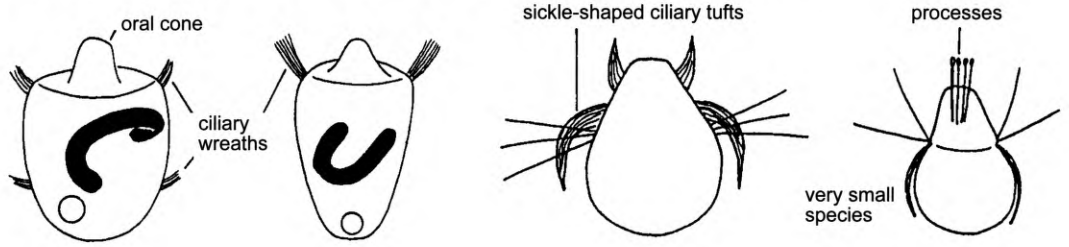
Nassula picta
70-140 µm
(Vol. III, p.445)



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

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



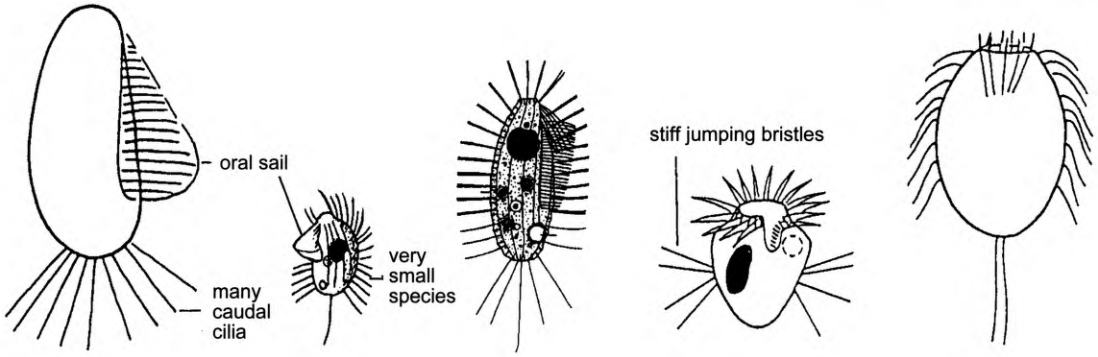
Didinium nasutum
80-200 µm
(Vol. IV, p.228)

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

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

Mesodinium
12-35 µm

Gymnostomatida I



Pleuronema

Hymeno-stomata III

Cyclidium

Hymeno-stomata VII

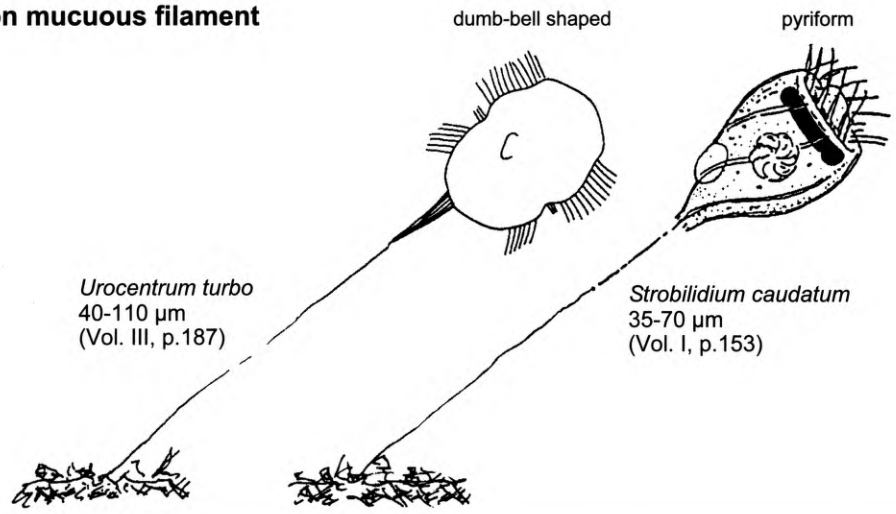
Ctedoctema acanthocryptum
20-40 µm
(Vol. III, p.294)

Oligotrichida

Urotricha

Prostomatida II

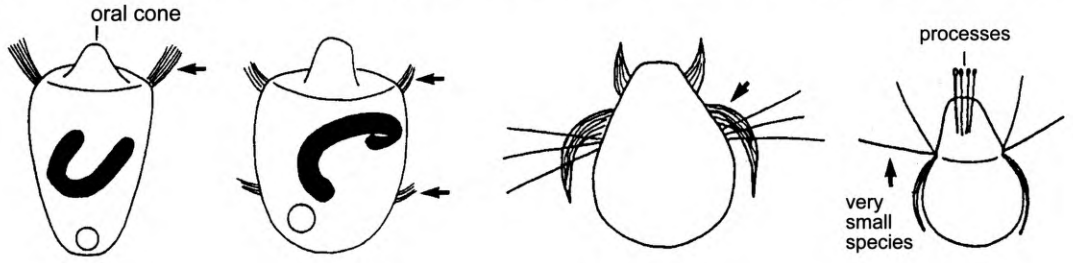
rotating on mucuous filament



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

Strobilidium caudatum
35-70 µm
(Vol. I, p.153)

Special key XXVI (species with conspicuous ciliary wreaths [arrows])



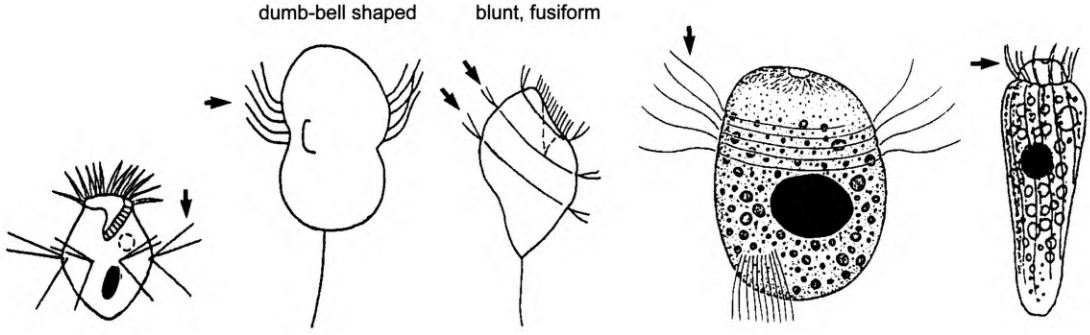
Monodinium balbianii
50-120 µm
(Vol. IV, p.235)

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

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

Mesodinium
12-35 µm

Gymnostomatida I



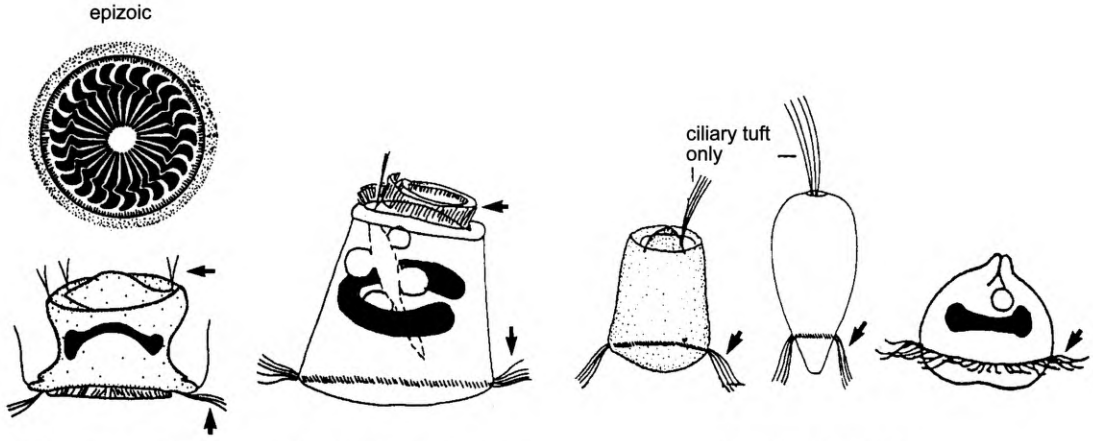
Halteria/
Pelagohalteria

Oligotrichida I

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

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

swarmers of suctorians
(indeterminable)

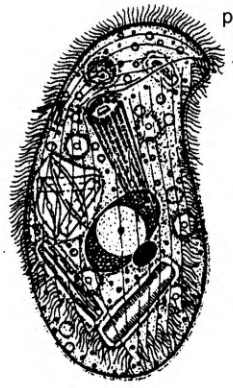


Trichodina pediculus
35-60 µm
(Vol. II, p.304)

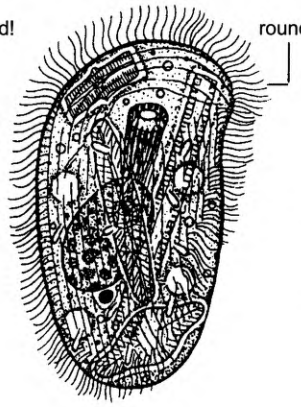
Opisthonecta henneguyi
100-150 µm
(Vol. II, p.299)

swarmers of peritrichs
(indeterminable)

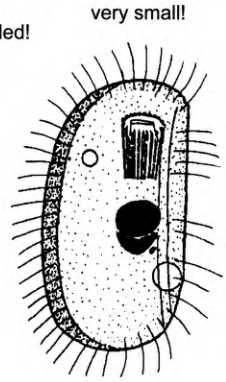
Special key XXVII (species which are frequently densely filled with ingested diatoms)



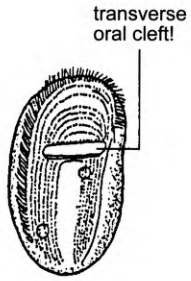
Trithigmostoma
Cyrtophorida I



Chlamydonellopsis plurivacuolata
50-110 µm
(Vol. I, p.110)



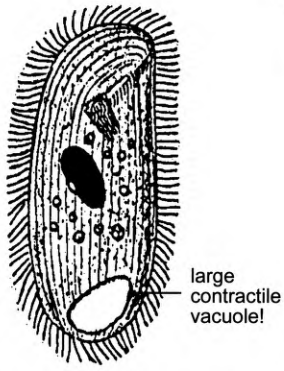
Chlamydonella alpestris
25-35 µm
(Vol. I, p.115)



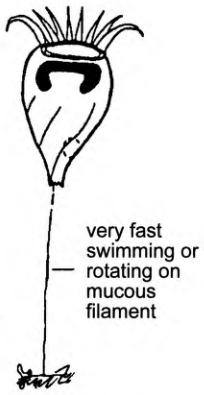
Gastronauta
Cyrtophorida I

Pseudochilodonopsis
Cyrtophorida II

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

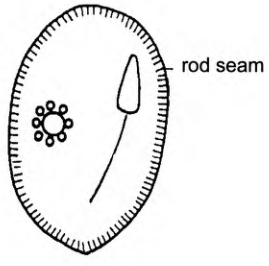


Chilodontopsis depressa
50-80 µm
(Vol. III, p.424)

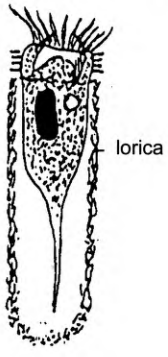


Strobilidium
Oligotrichida

Marituja pelagica
80-160 µm
(Vol. III, p.195)

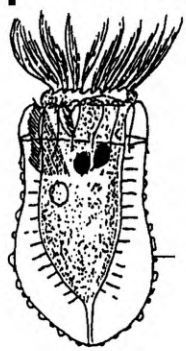


Frontonia
Hymenostomata V

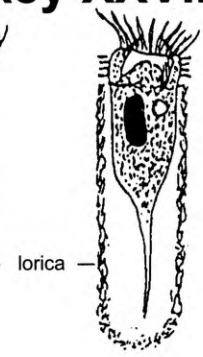


Tintinnidium
Oligotrichida

Special key XXVIIIa (euplanktic species; see also Ciliophora XII)



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)

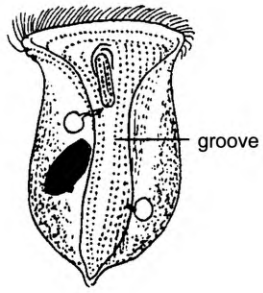
Oligotrichida

Disematostoma

Hymeno-
stomata IV

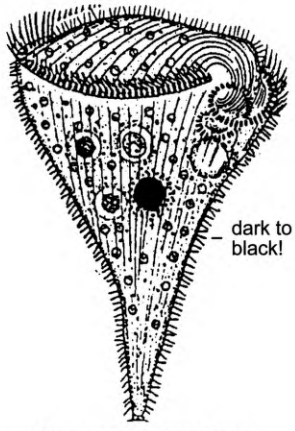
Marituja pelagica
80-160 µm
(Vol. III, p.195)

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



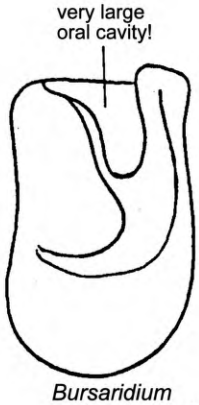
Phascolodon vorticella
50-110 µm
(Vol. I, p.98)

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



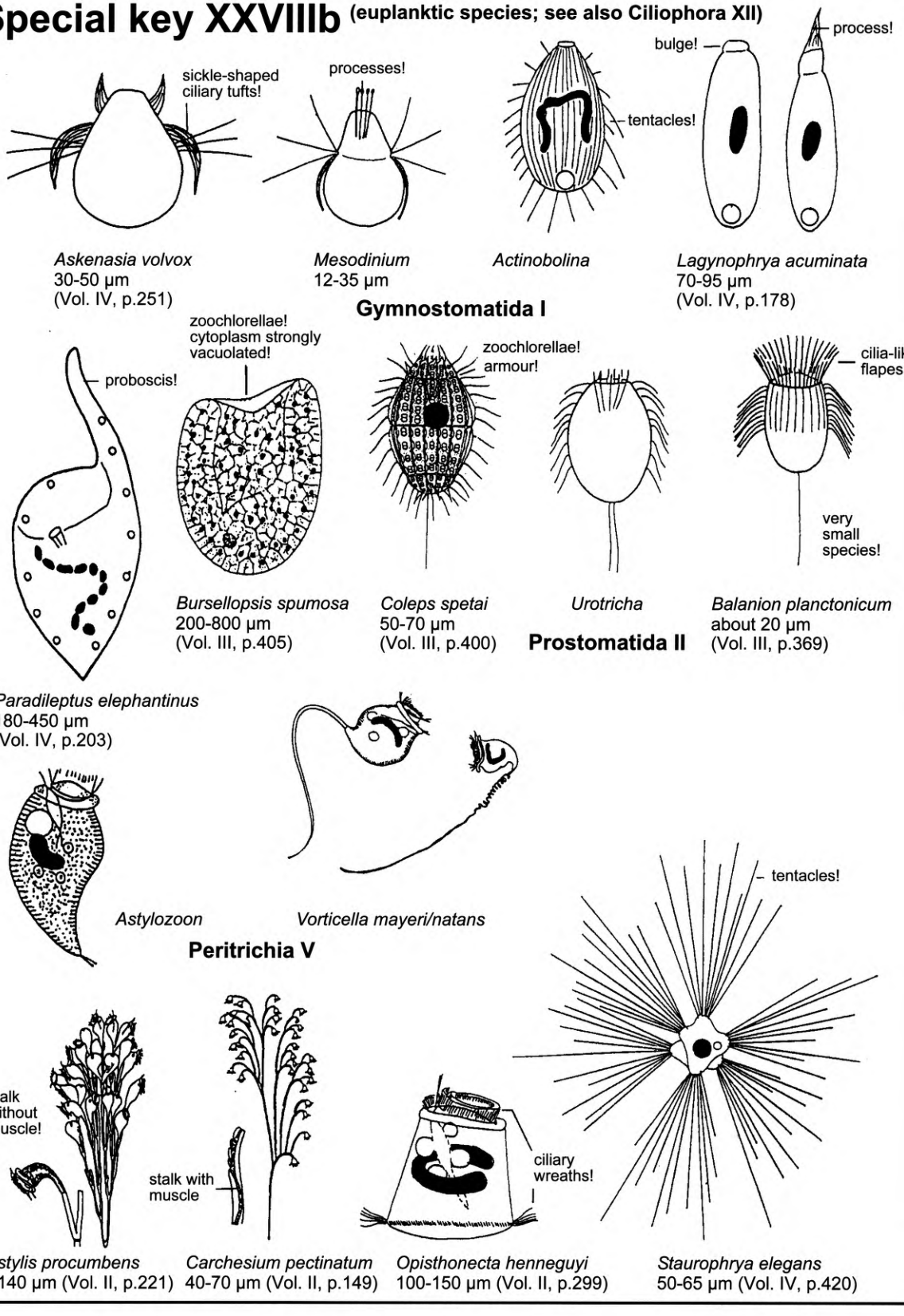
Stentor amethystinus
250-500 µm
(Vol. II, p.339)

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

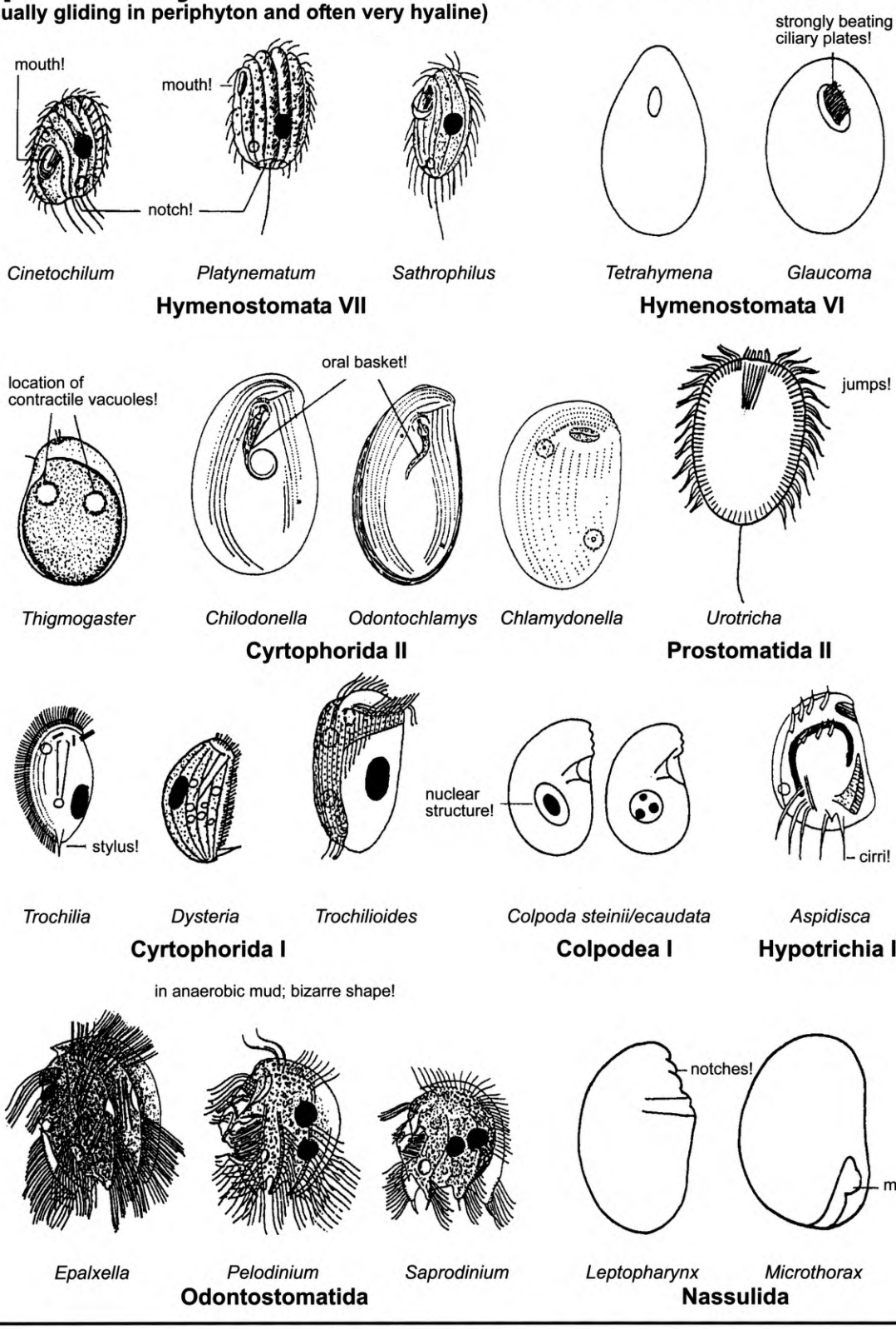


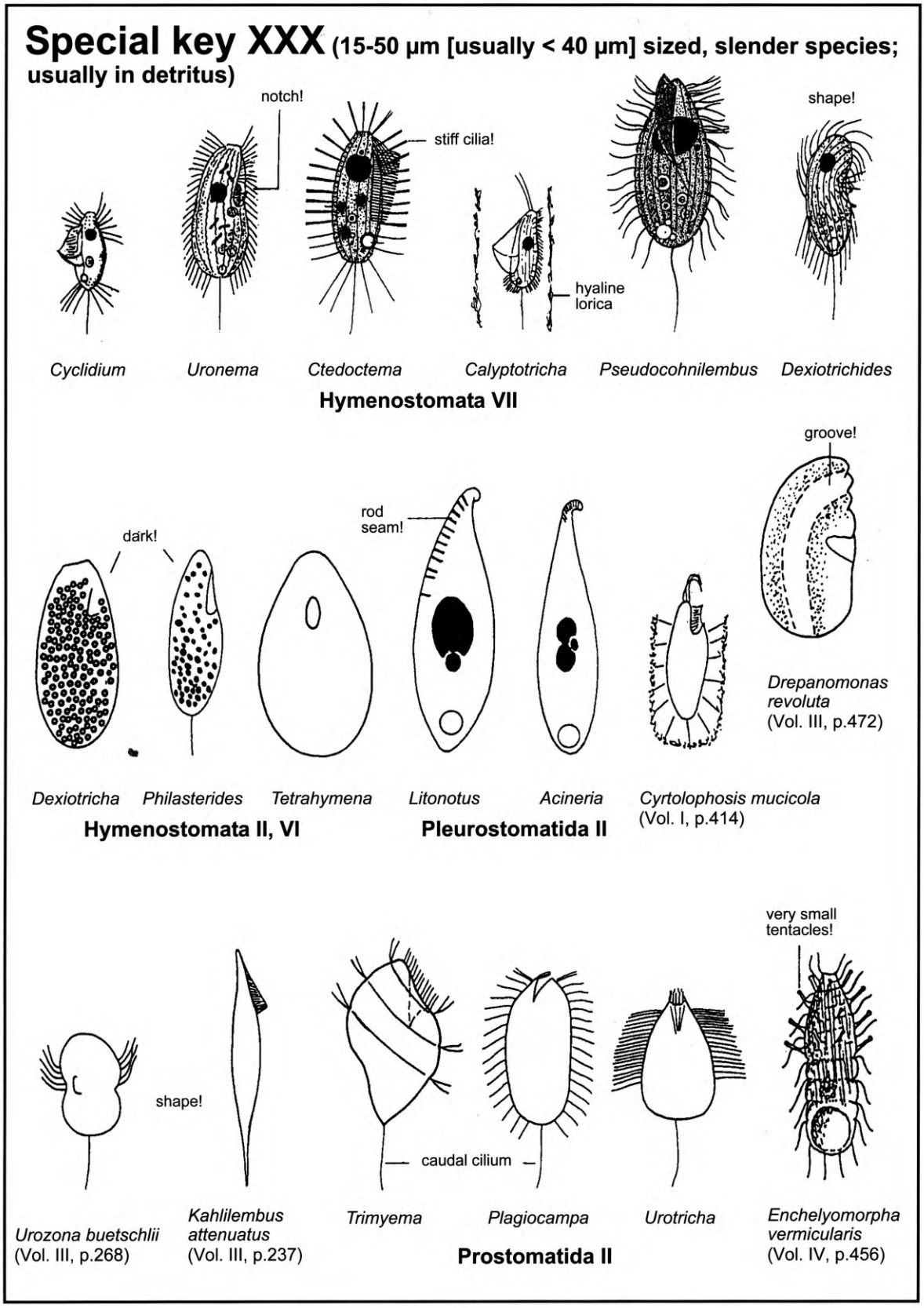
Bursaridium
pseudobursaria
80-200 µm
(Vol. I, p.433)

Special key XXVIIIb (euplanktic species; see also Ciliophora XII)

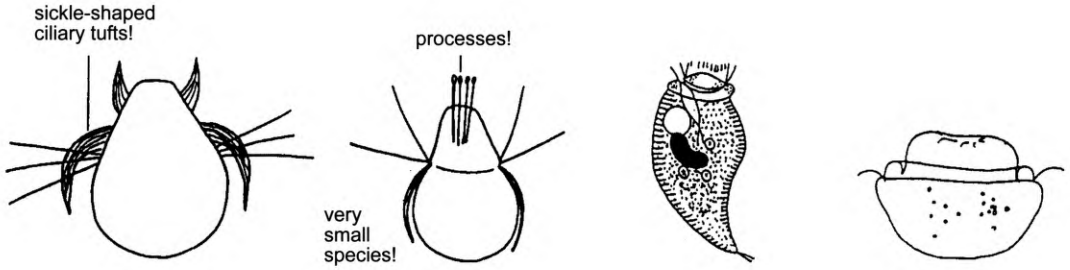


Special key XXIX (15-50 µm [usually < 40 µm] sized, broad species; usually gliding in periphyton and often very hyaline)



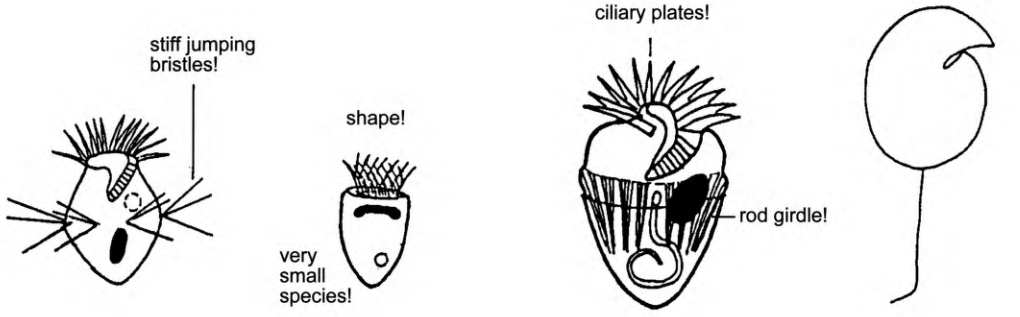

Special key XXX (15-50 µm [usually < 40 µm] sized, slender species; usually in detritus)
notch!
stiff cilia!
shape!
hyaline lorica
Cyclidium
Uronema
Ctedoctema
Calyptotricha
Pseudocohnilembus
Dexiotrichides
Hymenostomata VII
groove!
dark!
rod seam!
Drepanomonas revoluta (Vol. III, p.472)
Dexiotricha
Philasterides
Tetrahymena
Litonotus
Acineria
Cyrtolophosis mucicola (Vol. I, p.414)
Hymenostomata II, VI
Pleurostomatida II
very small tentacles!
shape!
caudal cilium
Urozona buetschlii (Vol. III, p.268)
Kahlilembus attenuatus (Vol. III, p.237)
Trimyema
Plagiocampa
Urotricha
Enchelyomorpha vermicularis (Vol. IV, p.456)
Prostomatida II

Special key XXXI (15-50 µm [usually < 40 µm] sized, globular or calciform species; usually in plankton)



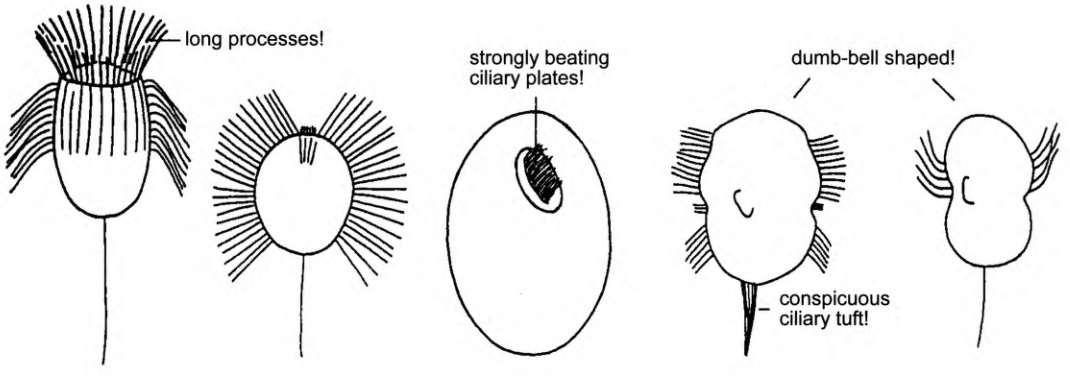
Askenasia volvox — *Mesodinium* — *Astylozoon* — swarmer of peritrichs

Gymnostomatida I — **Peritrichia V**



Halteria/Pelagohalteria — *Strobilidium* — *Strombidium* — *Hexotricha caudata* (Vol. III, p.483)

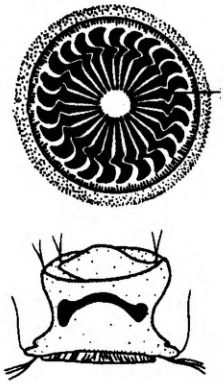
Oligotrichida I



Balanion — *Urotricha* — *Glaucoma* — *Urocentrum* usually > 50 µm — *Urozona* ≤ 40 µm

Prostomatida II — **Hymenostomata VI** — **Hymenostomata I**

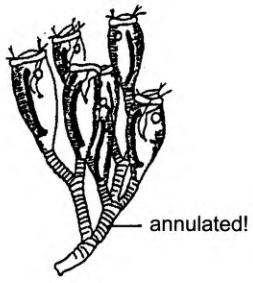
Special key XXXII (epizoic species; note that many other species, although being not true epizoons, especially peritrichs and suctorians, are sometimes attached to small invertebrates)



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)

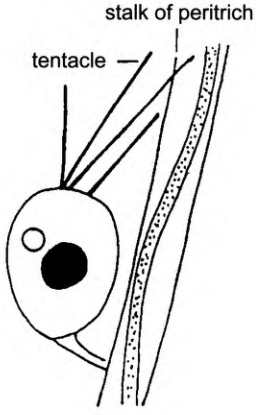
Epistylis nympharum
80-130 µm
colonial on arthropods
(Vol. II, p.217)



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)

Special key XXXIII (species with bizarre shape)

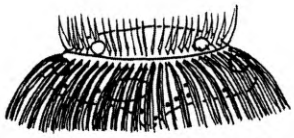
Plankton Ciliates

[1] Species not treated in detail!

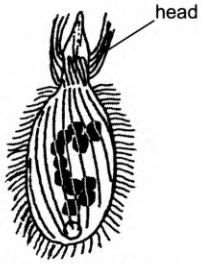
from Ciliophora XIV

Paradileptus elephantinus
100–450 µm
(p. 221)

Didinium/Monodinium
Gymnostomatida VI, VIII

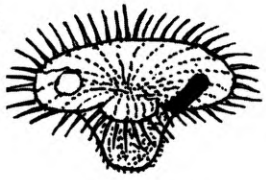


Cyclotrichium humilis[1]
25 × 56 µm

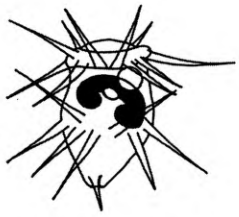


Pelagolacrymaria
Gymnostomatida IV

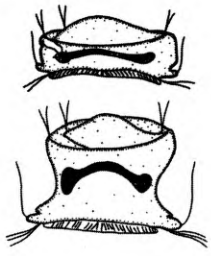
Teuthophrys trisulca
150–300 µm
(p. 238)



Liliimorpha viridis
diameter 110 µm
(p. 164)

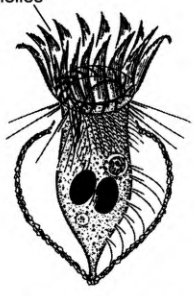


Hastatella radians
40–60 µm
(p. 460)

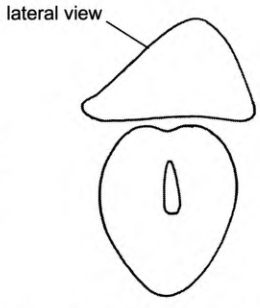


Trichodina
Peritrichia VIII

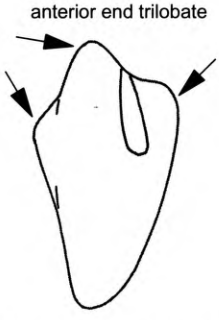
Codonella cratera
50–70 µm
lorica 43–63 µm
(p. 617)



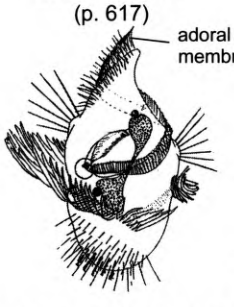
Stenosemella lacustris[1]
about 70 µm
lorica 40–48 µm
(p. 618)



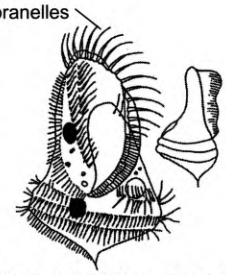
Stokesia vernalis
100–220 µm
(p. 439)



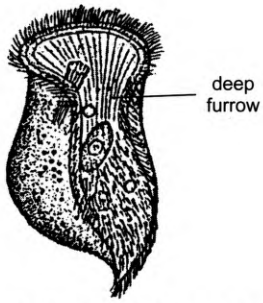
Disematostoma tetraedricum
100–140 µm
(p. 414)



Spiretella plankticola
95–160 µm
(p. 688)



Hypotrichidium conicum
90–120 µm
(p. 677)



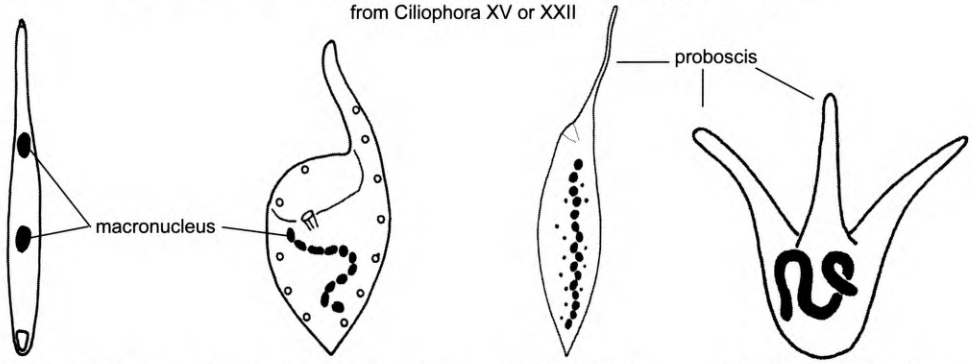
Phascolodon vorticella
60–90 µm
(p. 693)

Bursaridium pseudobursaria
80–200 µm
(p. 709)

Special key XXXIV (large [usually >200 µm] species)

Plankton Ciliates

from Ciliophora XV or XXII

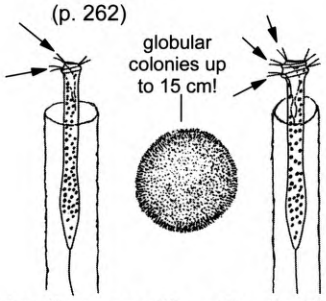


Lepidotrachelophyllum lineare
300–500 µm
(p. 262)

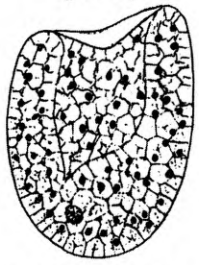
Paradileptus elephantinus
100–450 µm
(p. 221)

Pelagodileptus trachelioides
230–800 µm
(p. 232)

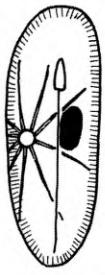
Teuthophrys trisulca
150–300 µm
(p. 238)



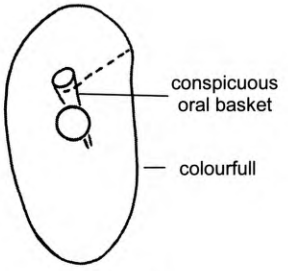
Ophrydium versatile or *O. eutrophicum*
extended 250–400 µm long
Peritrichia VIII



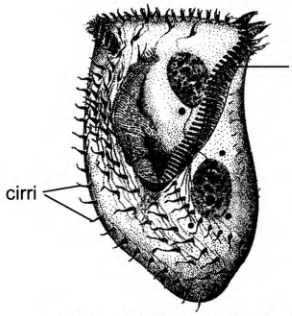
large *Bursellopsis* spp.
130–800 µm
Prostomatida IV, VI



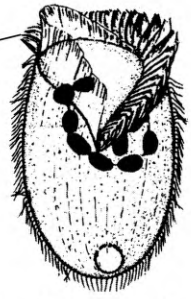
Frontonia leucas
120–600 µm
(p. 416)



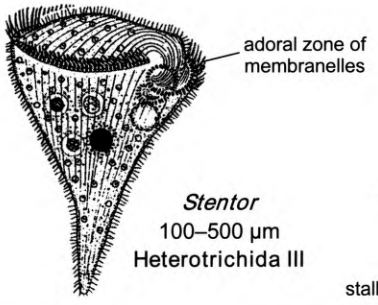
Obertrumia aurea
120–250 µm
(p. 700)



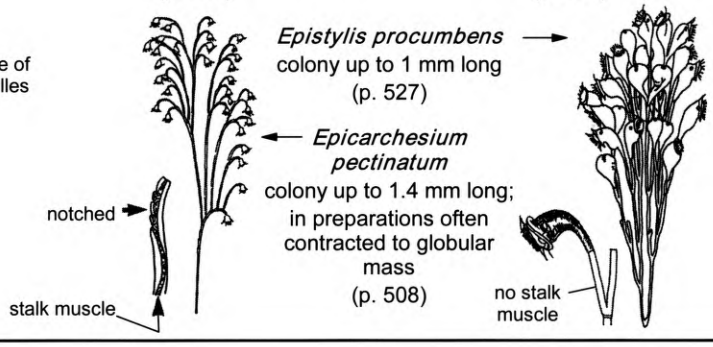
Pelagotrichidium faurei
about 280 µm
(p. 683)



Linostomella vorticella
100–210 µm
(p. 655)



Stentor
100–500 µm
Heterotrichida III



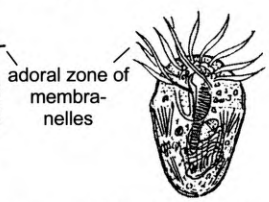
Epistylis procumbens
colony up to 1 mm long
(p. 527)

Epicarchesium pectinatum
colony up to 1.4 mm long; in preparations often contracted to globular mass
(p. 508)

Special key XXXV (small [<50 µm] species)

Plankton Ciliates

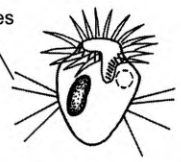
Limnostrombidium pelagicum
30–60 µm
(p. 574)



Pelagostrombidium mirabile
30–70 µm
(p. 590)

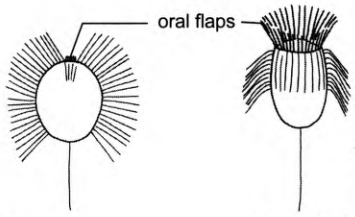
tintinnid which left lorica
Oligotrichida II

Rimostrombidium
Oligotrichida IV

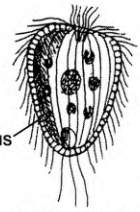


Halteria/Pelagohalteria
Oligotrichida III

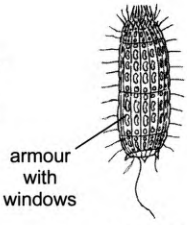
Urotricha
Prostomatida IV, V



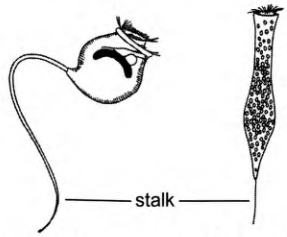
Balanion planctonicum
10–22 µm
(p. 363)



Pelagothrix
Prostomatida III

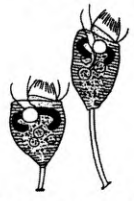


Coleps
Prostomatida III
usually 50–70 µm



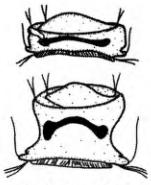
vorticellids
Peritrichia IX, X

Ophrydium naumanni
40–50 µm
(p. 551)

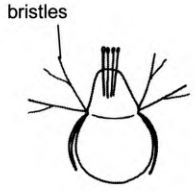


Epistylis pygmaeum
22–50 µm
(p. 535)

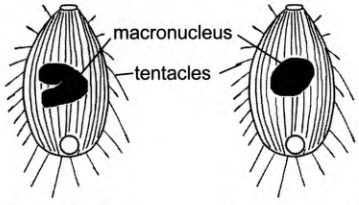
Astylozoon
Peritrichia VIII



Trichodina
Peritrichia VIII

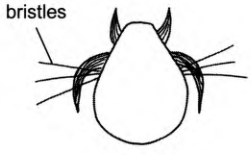


Mesodinium
Gymnostomatida V



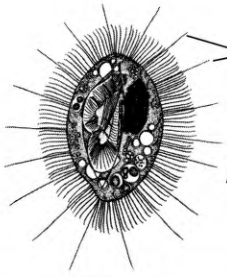
Actinobolina smalli
42–60 µm
(p. 115)

Belonophrya pelagica
40–70 µm
(p. 124)

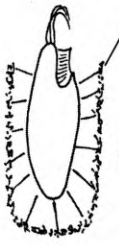


Askenasia/ Rhabdoaskenasia
Gymnostomatida VI

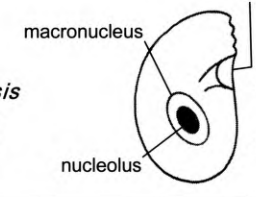
Monodinium
Gymnostomatida VI



Histiobalantium bodamicum
40–60 µm
(p. 424)



Cyrtolophosis mucicola
20–40 µm
(p. 718)



Colpoda steinii
10–60 µm,
usually
20–40 µm
(p. 714)

Special key XXXVI (conspicuously coloured or dark species)

Plankton
Ciliates

from Ciliophora XVI

colour

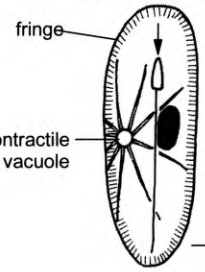
conspicuously spotted (violett, green, blue, orange ...) by ingested cyanobacteria or other food

extrusome fringe; oral apparatus

absent; conical basket (arrow)

present; triangular oral opening (arrow)

Obertrumia aurea
120–250 µm
(p. 700)



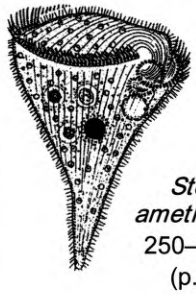
Frontonia leucas
120–600 µm
(p. 416)

grass green by zoochlorellae and/or cleptoplasts (note: number of algae sometimes rather low!)

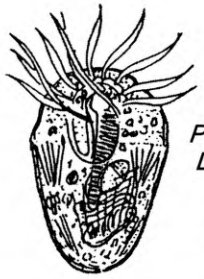
Special key XXXVII

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

± black at ×100



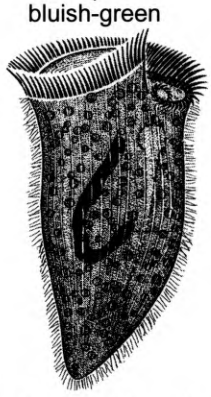
Stentor amethystinus
250–500 µm
(p. 664)



yellow-green

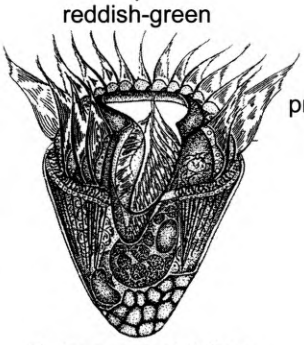
Pelagostrombidium/ Limnostrombidium
30–70 µm
Oligotrichida III

bluish-green



Stentor araucanus
100–270 µm
(p. 671)

reddish-green



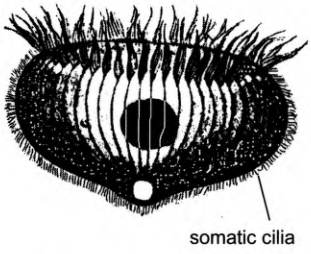
Pelagostrombidium fallax
40–90 µm
(p. 585)

brownish

armour plates with windows

present

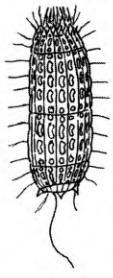
absent

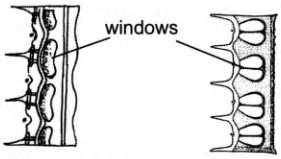


Cyclotrichium brunneum
100–105 µm
Species not treated in detail!

windows in armour

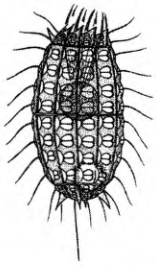
reniform





Coleps nolandi
40–65 µm
(p. 297)

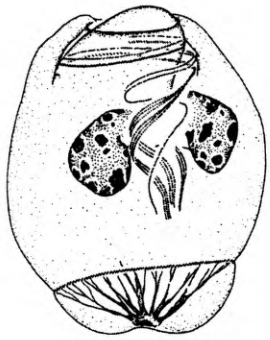
bretzel-shaped



Coleps hirtus hirtus or *C. elongatus*
Prostomatida III

Special key XXXVII (grass green coloured, usually by zoochlorellae)

Plankton Ciliates



protargol-impregnated peritrich

from Special key XXXVI

Peritrichia

no

yes

shape

campanulate

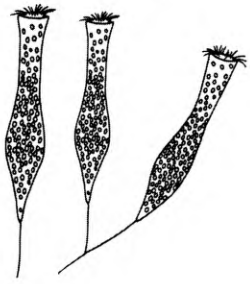
slender vase-shaped *Ophrydium*

size (extended)

40–50 µm

250–400 µm

Vorticella chlorellata
44–64 µm
(p. 491)



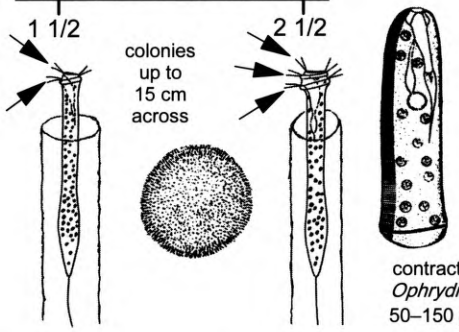
O. naumanni
solitary or colonies with ≤20 zooids
(p. 551)

number of turns of adoral ciliary spiral on peristomial disc (arrows)

1 1/2

2 1/2

colonies up to 15 cm across



O. versatile
300–400 µm
(p. 543)

O. eutrophicum
250–350 µm
(p. 540)

contracted *Ophrydium*
50–150 µm

size

<200 µm
Special key XXXVIII

>200 µm

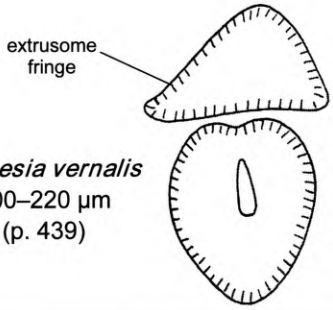
shape

cap-shaped in lateral view, cordiform in ventral view (populations with few zoochlorellae frequent)

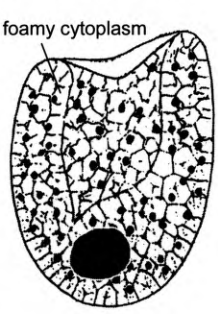
broadly ellipsoidal

1 proboscis

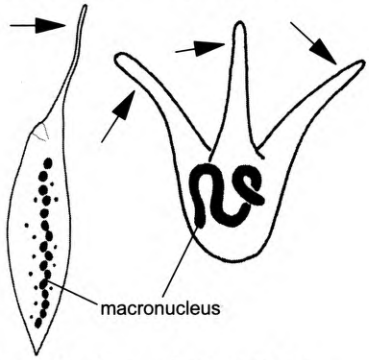
3 proboscides



Stokesia vernalis
100–220 µm
(p. 439)



Bursellopsis spumosa
400–800 µm
(p. 372)



Pelagodileptus trachelioides
230–800 µm
(p. 232)

Teuthophrys trisulca trisulca
150–300 µm
(p. 238)

Special key XXXVIII (grass green coloured, usually by zoochlorellae)

Plankton Ciliates

from Special key XXXVII

size

<100 µm
Special key XXXIX

100–200 µm

shape

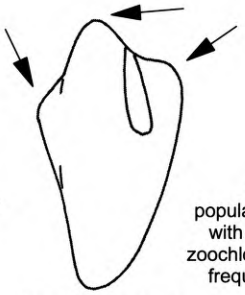
with 3 proboscides

Teuthophrys trisulca trisulca
150–300 µm
(p. 238)

with prominent oral cone

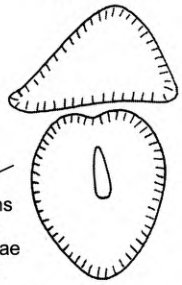
Didinium chlorelligerum
80–110 µm
(p. 167)

pyramidal, anterior end with 3 hucksters



Disematostoma tetraedricum
100–150 µm
(p. 414)

cap-shaped in lateral view, cordiform in ventral view

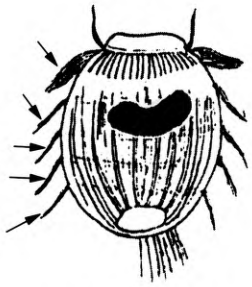


Stokesia vernalis
100–220 µm
(p. 439)

globular, ellipsoidal, or obovoidal

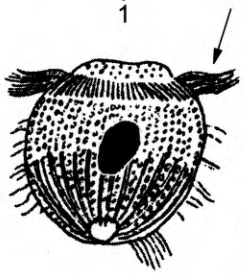
ciliary girdles

5–7



Pelagovasicola cinctum
50–180 µm
(p. 213)

1

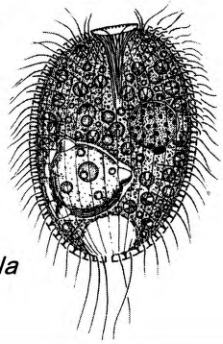


Cyclotrichium viride
66–150 µm
(p. 205)

lacking

shape; mouth

ellipsoidal; apical

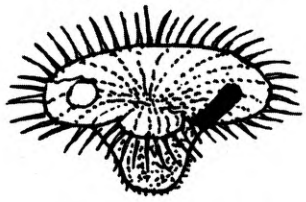


Pelagothrix plancticola
55–100 µm
(p. 401)

obovoidal; subapical

Disematostoma buetschlii
110–200 µm
(p. 409)

broadly campanulate



Liliimorpha viridis
diameter 110 µm
(p. 164)

Special key XXXIX (grass green by zoochlorellae or cleptoplasts)

Plankton Ciliates

from Special key XXXVIII

conspicuous ciliary corona (AM) at anterior end

AM = adoral zone of membranelles

present

absent
Special key XL

shape; jumping bristles

globular, urceolate or pyriform; present

obconical; absent

sickle-shaped ciliary tufts present

no

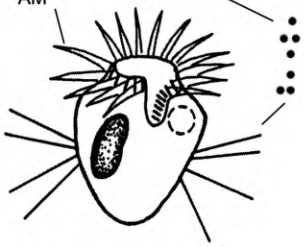
yes

shape of jumping bristle complexes (protargol preparation necessary!)

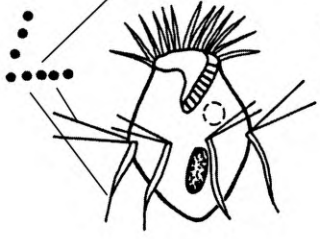
I-shaped

L-shaped

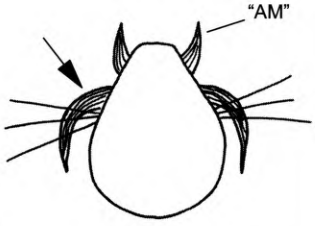
AM



Halteria bifurcata
20–30 µm
(p. 554)



Pelagohalteria viridis
20–30 µm
(p. 569)



Askenasia chlorelligera
30–50 µm
(p. 151)

distinct cortical ridges

absent

present

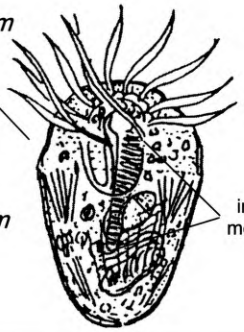
buccal cavity; inner portion of adoral zone

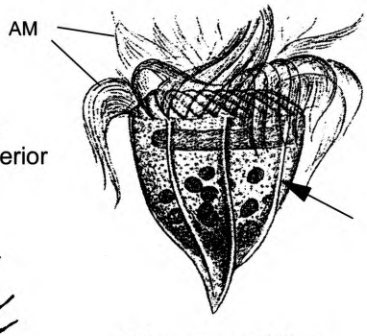
flat, short; extends almost horizontally near anterior body end

deep, long; extends meridionally to near posterior body end

Pelagostrombidium mirabile
30–70 µm
(p. 590)

Limnostrombidium viride
50–70 µm
(p. 577)

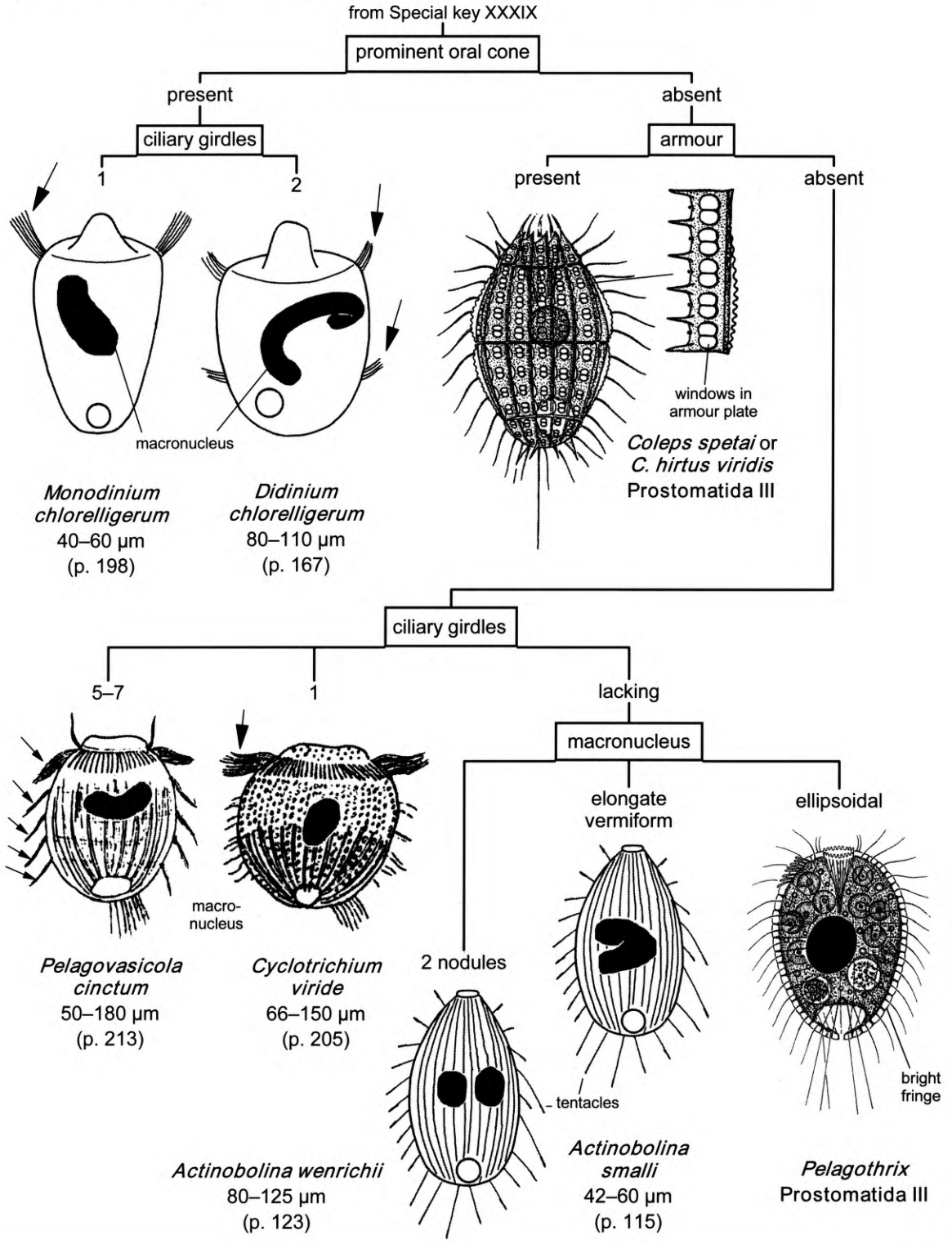




Rimostrombidium velox
30–50 µm
(p. 604)

Plankton Ciliates

Special key XL (grass green coloured, usually by zoochlorellae)



Special key XLI (macronucleus)

Plankton Ciliates

[1] Discrimination of cilia and cirri (= several adhering cilia forming fairly thick bundles): if you see cilia at a magnification of × 100–400, that is, without oil immersion, then these are very likely cirri!

from Ciliophora XVII, XXI

macronucleus

2 nodules

moniliform

different
Special key XLII

adoral zone of membranelles (AM)

present

absent

cirri (arrows)[1]

size; shape

present

absent

300–500 µm; club-shaped

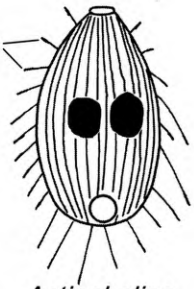
80–125 µm; oviform

Hypotrichia VIII

tintinnids
Oligotrichida II

tintinnid which left lorica

Lepidotrachelophyllum lineare (p. 262) or *Trachelophyllum* spp. (species not treated)



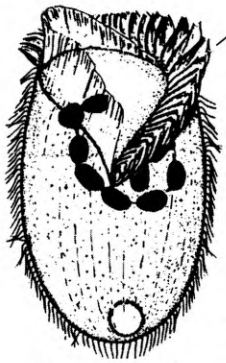
Actinobolina wenrichii (p. 123)

adoral zone of membranelles (AM)

present

absent

size



Linostomella vorticella
100–210 µm
(p. 655)

70–120 µm

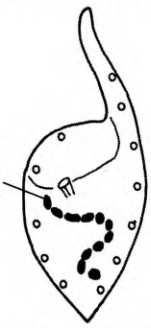
>100 µm

trunk; zoochlorellae

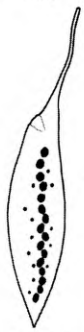
obconical; absent

fusiform; present

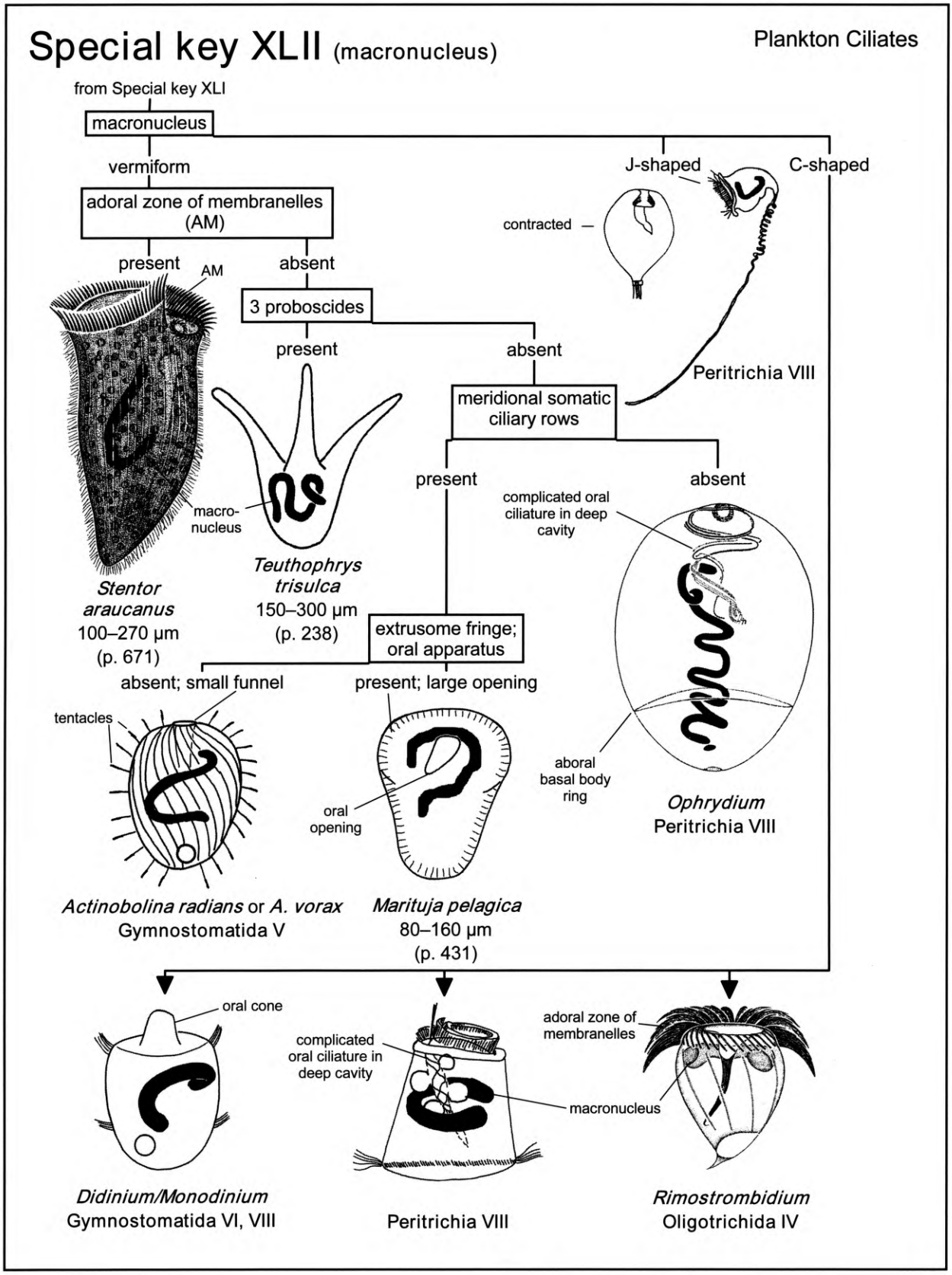
Pelagolacrymaria moserae
(p. 265)



Paradileptus elephantinus
100–450 µm
(p. 221)

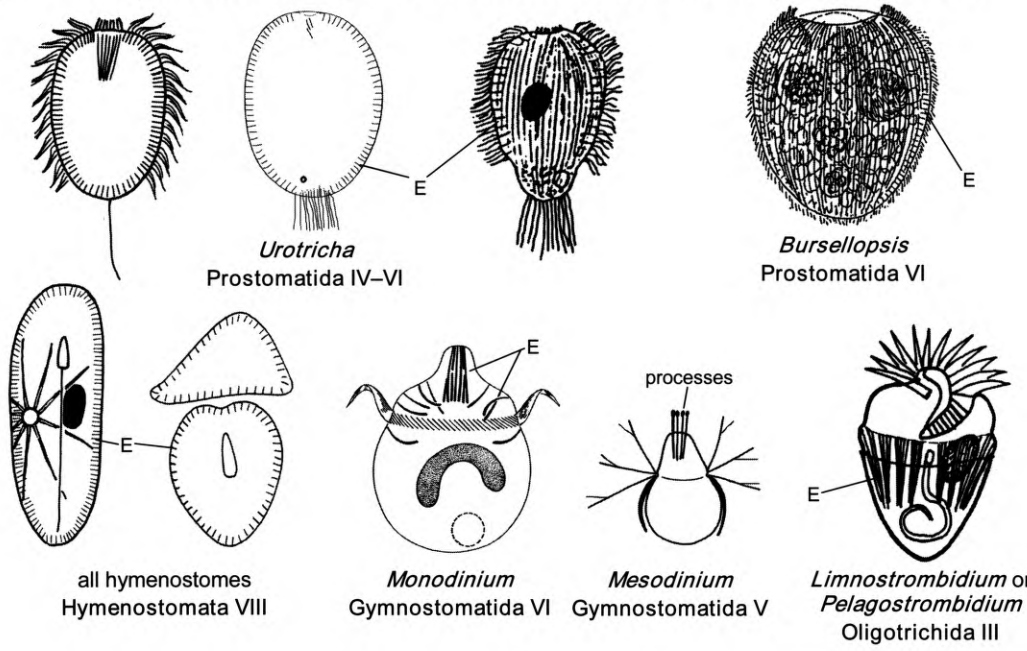


Pelagodileptus trachelioides
230–800 µm
(p. 232)


Special key XLII (macronucleus)
Plankton Ciliates
from Special key XLI
macronucleus
vermiform
adoral zone of membranelles (AM)
present
AM
absent
3 proboscides
present
absent
J-shaped
C-shaped
contracted
Peritrichia VIII
meridional somatic ciliary rows
present
absent
complicated oral ciliature in deep cavity
extrusome fringe; oral apparatus
absent; small funnel
present; large opening
tentacles
oral opening
aboral basal body ring
Stentor araucanus
100–270 µm
(p. 671)
macro-nucleus
Teuthophrys trisulca
150–300 µm
(p. 238)
Ophrydium
Peritrichia VIII
Actinobolina radians or A. vorax
Gymnostomatida V
Marituja pelagica
80–160 µm
(p. 431)
oral cone
complicated oral ciliature in deep cavity
adoral zone of membranelles
macronucleus
Didinium/Monodinium
Gymnostomatida VI, VIII
Peritrichia VIII
Rimostrombidium
Oligotrichida IV

Plankton Ciliates

Special key XLIII (species with conspicuous fringe of rods [extrusomes; E] or with bundles of extrusomes) from Ciliophora XVII



Urotricha
Prostomatida IV–VI

Bursellopsis
Prostomatida VI

all hymenostomes
Hymenostomata VIII

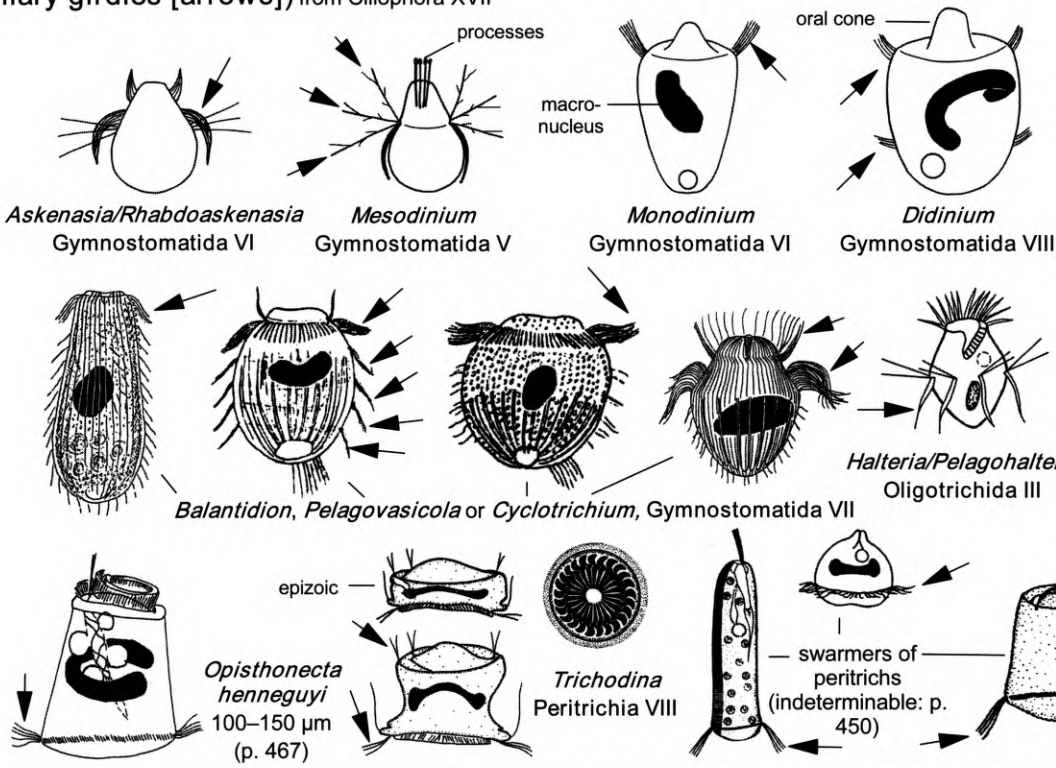
Monodinium
Gymnostomatida VI

Mesodinium
Gymnostomatida V

Limnostrombidium or *Pelagostrombidium*
Oligotrichida III

Plankton Ciliates

Special key XLIV (species with conspicuous ciliary girdles [arrows]) from Ciliophora XVII



Askenasia/Rhabdoaskenasia
Gymnostomatida VI

Mesodinium
Gymnostomatida V

Monodinium
Gymnostomatida VI

Didinium
Gymnostomatida VIII

Halteria/Pelagohalteria
Oligotrichida III

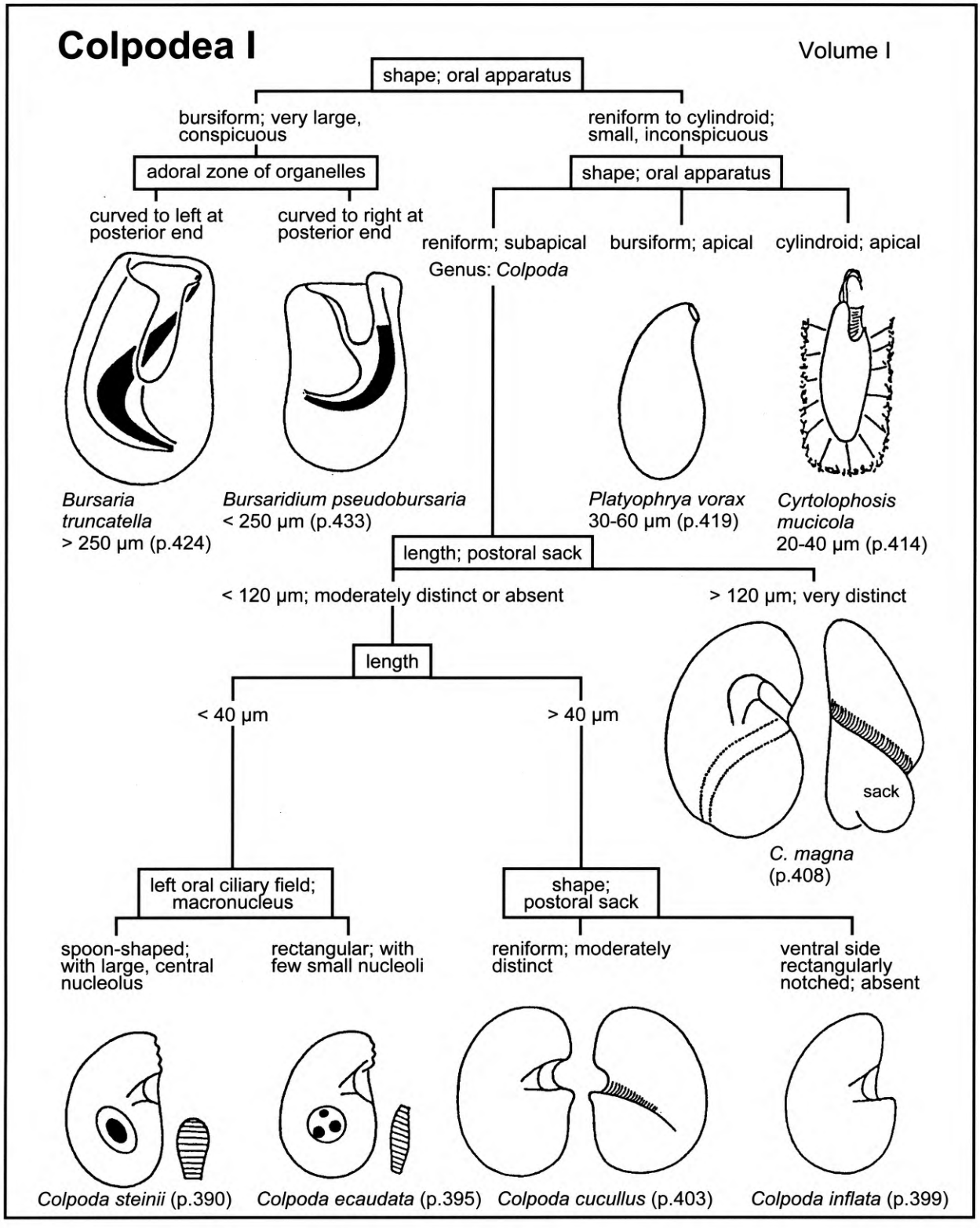
Balantidion, *Pelagovasicola* or *Cyclotrichium*, Gymnostomatida VII

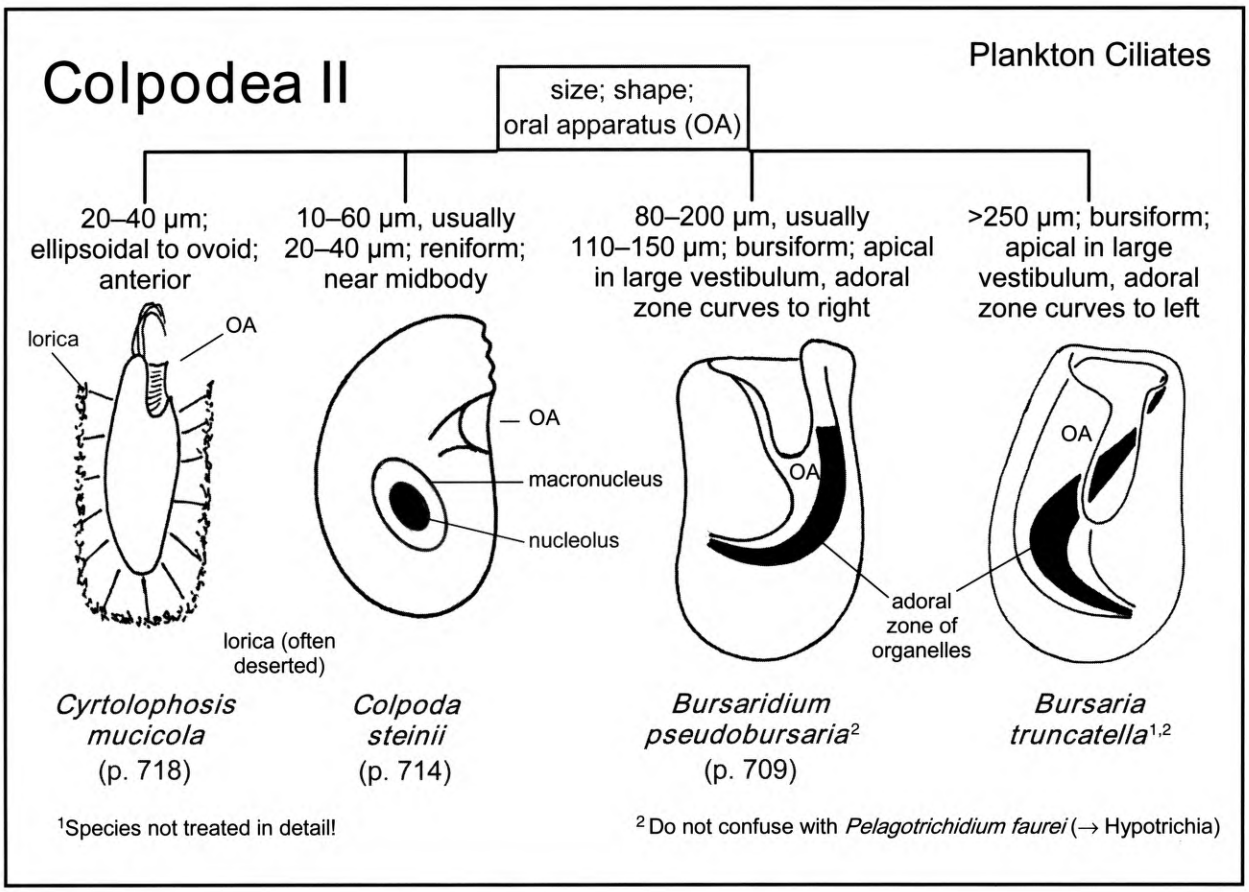
Opisthonecta henneguyi
100–150 µm
(p. 467)

Trichodina
Peritrichia VIII

6 Species keys (main groups ordered alphabetically)

Check identifications against detailed figures and descriptions in Volumes I–IV of the Ciliate Atlas and the Plankton book.




Colpodea II
Plankton Ciliates
size; shape;
oral apparatus (OA)
20–40 µm;
ellipsoidal to ovoid;
anterior
10–60 µm, usually
20–40 µm; reniform;
near midbody
80–200 µm, usually
110–150 µm; bursiform; apical
in large vestibulum, adoral
zone curves to right
>250 µm; bursiform;
apical in large
vestibulum, adoral
zone curves to left
lorica
OA
OA
macronucleus
nucleolus
OA
OA
adoral
zone of
organelles
lorica (often
deserted)
Cyrtolophosis
mucicola
(p. 718)
Colpoda
steinii
(p. 714)
Bursaridium
pseudobursaria[2]
(p. 709)
Bursaria
truncatella[1,2]
[1]Species not treated in detail!
[2] Do not confuse with Pelagotrichidium faurei (→ Hypotrichia)

Cyrtophorida I

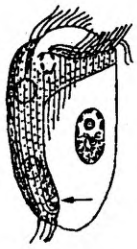
Volume I

1 styloid process near posterior end

present

style; left ciliary field

does not project above body margin; about 12 short rows underneath and left of oral basket

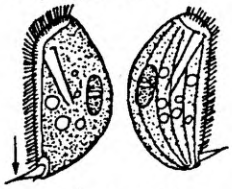


Trochilioides recta
25-75 µm (p.127)

projects above body margin; distinctly reduced

dorsal side; anterior end

with crests; obliquely truncate



Dysteria fluviatilis
20-35 µm (p.125)

flat; rounded

Trochilia minuta
15-40 µm (p.117)

absent

mouth

conical basket composed of rods

conspicuous, transverse cleft

nonciliated postoral field

present

Gastronauta membranaceus
50-70 µm (p.106)

absent

G. clatratus
40-75 µm (p.102)

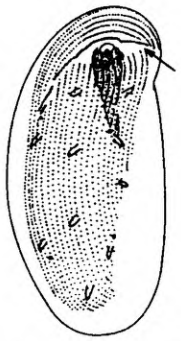
non-ciliated postoral field; number of ciliary rows; size

distinct and wide, if inconspicuous then size < 40 µm; < 14; < 40 µm

absent; > 16; > 60 µm

oral ciliature; styles on ventral side

perioral ciliary row (arrow) curved, extends above oral basket to right body margin; present (difficult to recognize)



Chlamydonellopsis plurivacuolata
50-110 µm (p. 110)

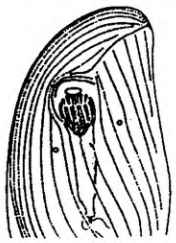
perioral ciliary row left of oral basket only; absent

number of ciliary rows; number of contractile vacuoles

< 22; usually < 10

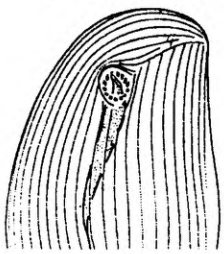
number of ciliary rows; distance between postoral ciliary rows

16-18; slightly enlarged



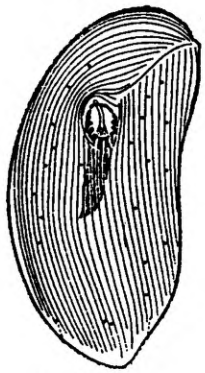
Trithigmostoma srameki
70-100 µm (p.77)

18-22; equidistant



T. cucullulus
80-160 µm (p.82)
(usually ~ 100 µm)

> 25; usually > 10



T. steini
90-320 µm (p.92)
(usually ~ 150 µm)

Cyrtophorida II

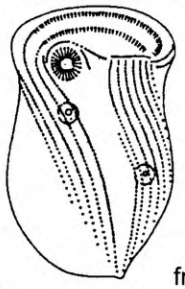
Cyrtophorida II

Volume I

from Cyrtophorida II

mode of life; ventral surface

planktonic; with distinct longitudinal groove



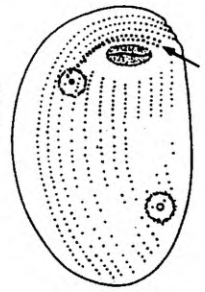
Phascolodon vorticella
50-110 µm (p.98)

mainly in periphyton; flat or indistinctly depressed

oral ciliature; location of oral basket

preoral ciliary row(s) left above basket plus 2 circumoral ciliary rows; about in median of cell

Y-shaped preoral ciliary row above and left of basket; left of cell median



Chlamydonella alpestris
25-35 µm (p.115)

preoral ciliary row (silver impregnation); food

fragmented; often diatoms

not fragmented; usually bacteria

colour

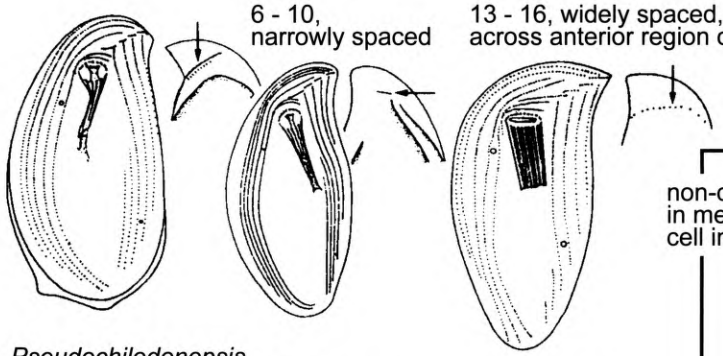
green from green algae

not green

cilia of dorsal brush

6 - 10, narrowly spaced

13 - 16, widely spaced, extend across anterior region of cell



Pseudochilodonopsis algivora
40-70 µm (p.62)

P. fluviatilis
40-70 µm (p.67)

P. piscatoris
60-90 µm (p.73)

ventral cilature

non-ciliated field in median of cell indistinct

non-ciliated field in median of cell distinct

contractile vacuole

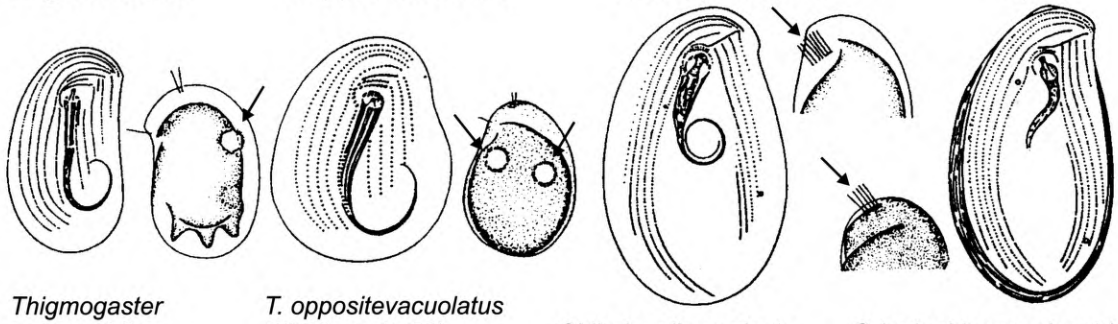
1 right of basket

2 opposite of basket

dorsal brush

distinctly subapical

apical

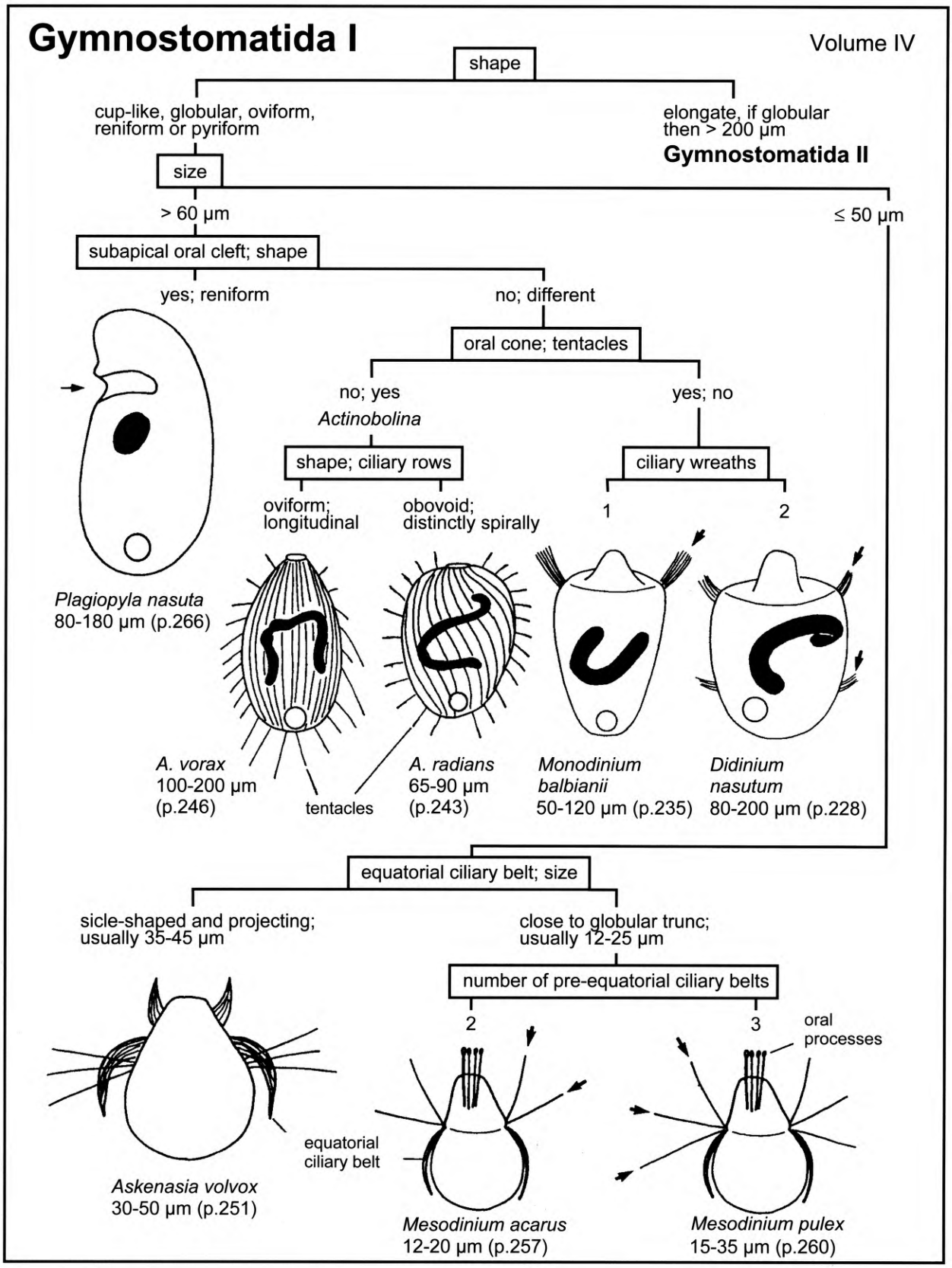


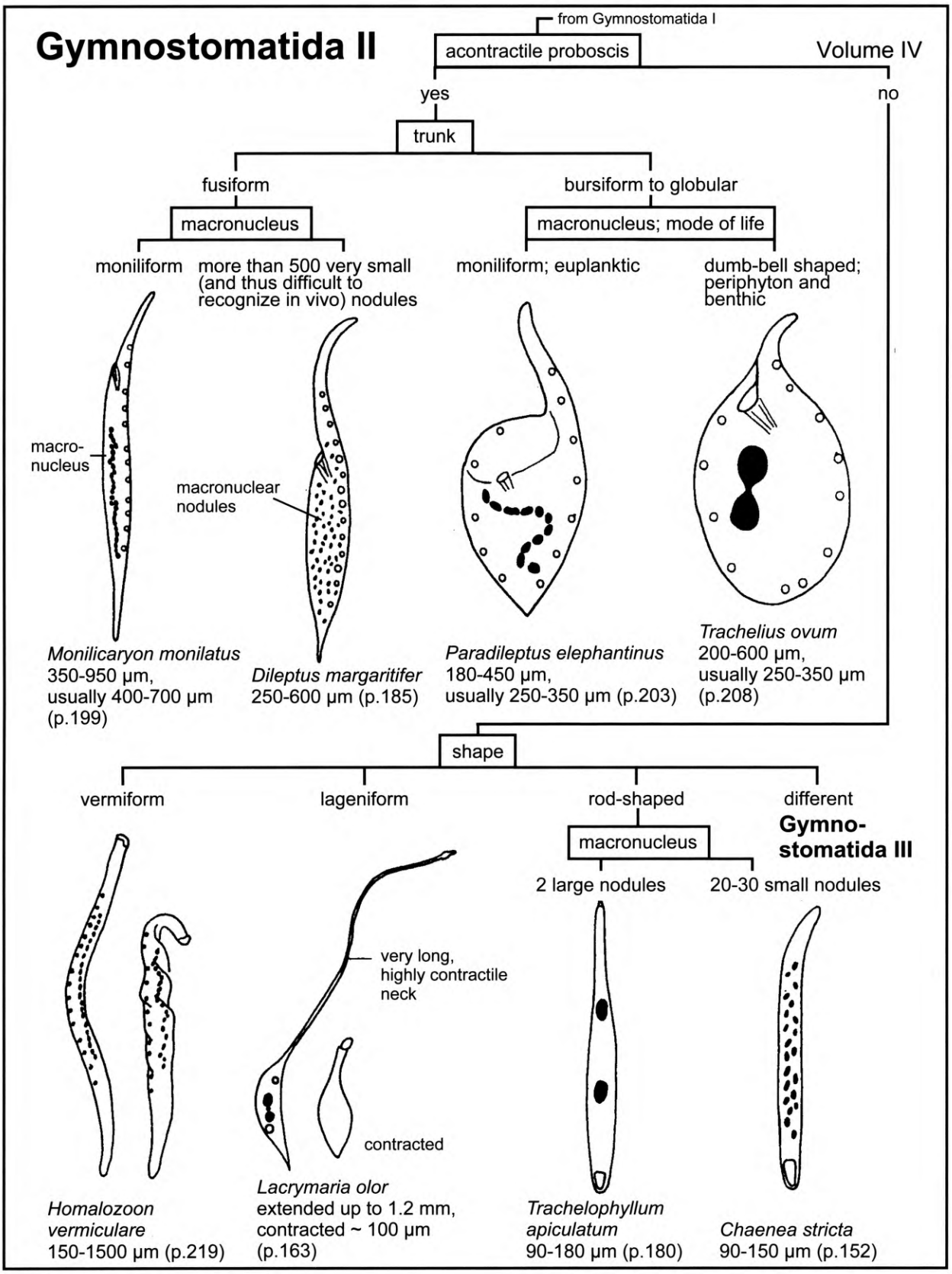
Thigmogaster potamophilus
20-30 µm (p.59)

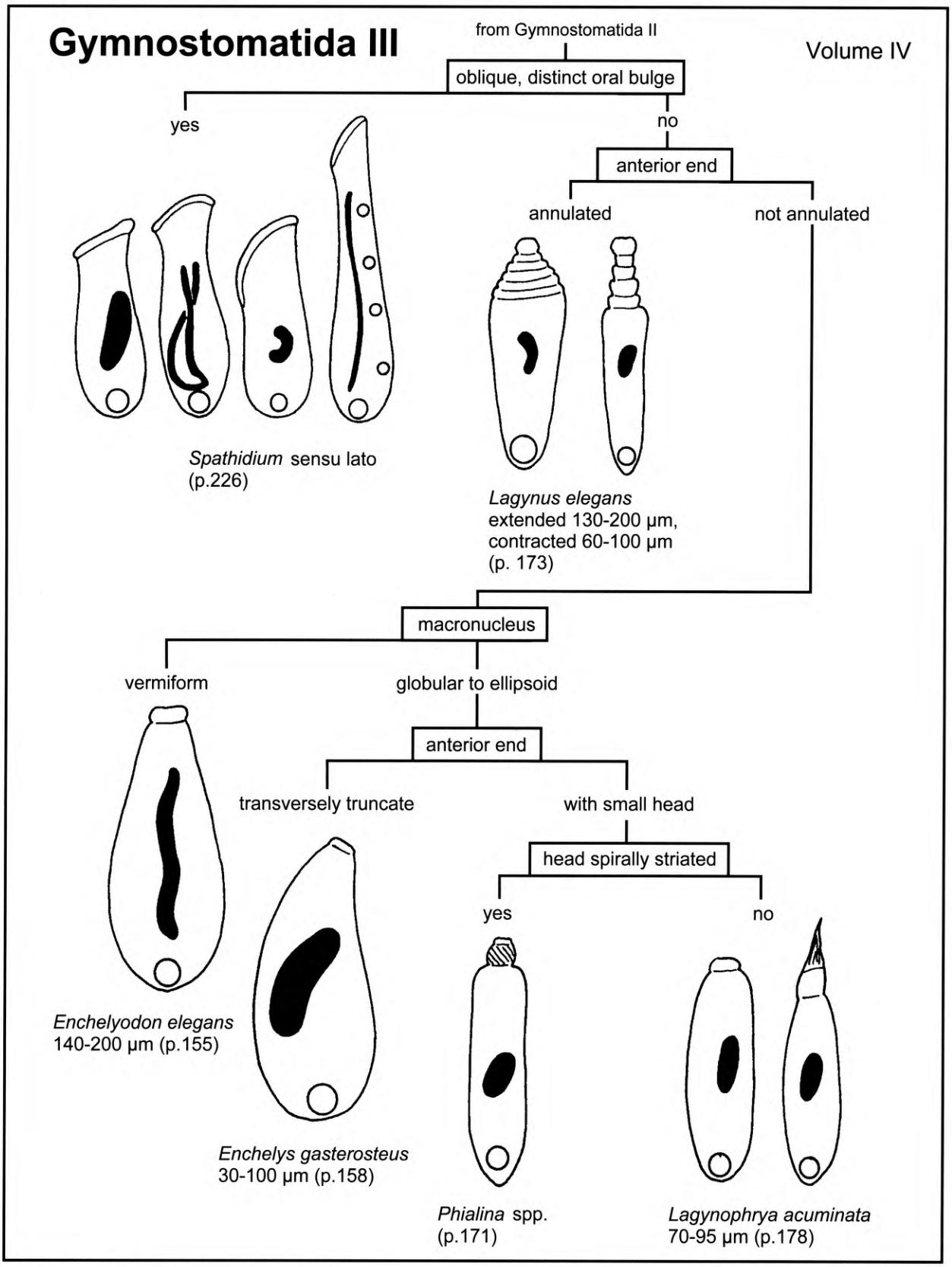
T. oppositevacuolatus
20-30 µm (p.56)

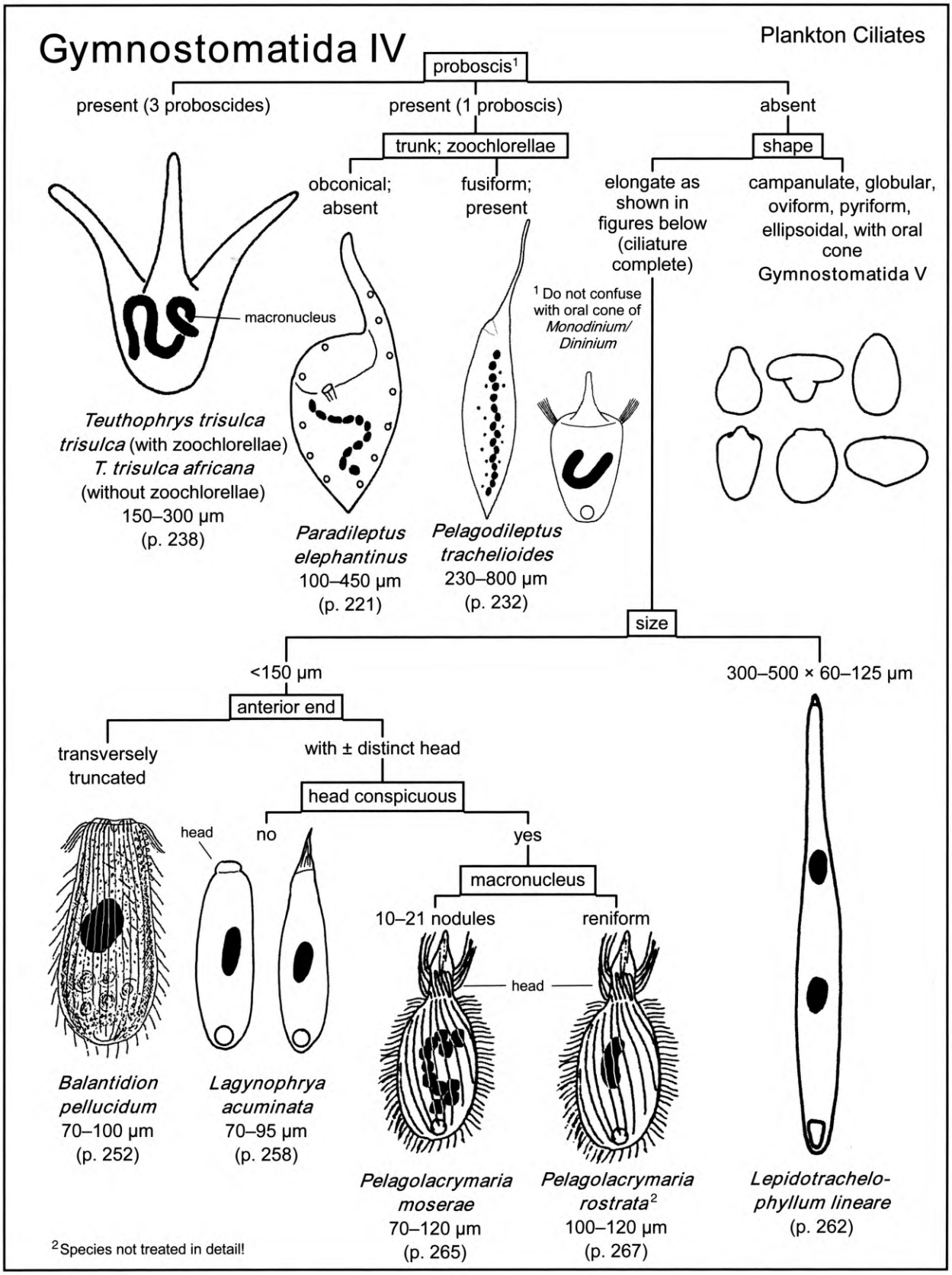
Chilodonella uncinata
25-70 µm (p.45)

Odontochlamys alpestris
35-60 µm (p.52)


Gymnostomatida I
Volume IV
shape
cup-like, globular, oviform, reniform or pyriform
elongate, if globular then > 200 µm
Gymnostomatida II
size
> 60 µm
≤ 50 µm
subapical oral cleft; shape
yes; reniform
no; different
oral cone; tentacles
no; yes
Actinobolina
yes; no
shape; ciliary rows
ciliary wreaths
oviform; longitudinal
obovoid; distinctly spirally
1
2
Plagiopyla nasuta
80-180 µm (p.266)
A. vorax
100-200 µm
(p.246)
tentacles
A. radians
65-90 µm
(p.243)
Monodinium balbianii
50-120 µm (p.235)
Didinium nasutum
80-200 µm (p.228)
equatorial ciliary belt; size
sicle-shaped and projecting; usually 35-45 µm
close to globular trunc; usually 12-25 µm
number of pre-equatorial ciliary belts
2
3
oral processes
equatorial ciliary belt
Askenasia volvox
30-50 µm (p.251)
Mesodinium acarus
12-20 µm (p.257)
Mesodinium pulex
15-35 µm (p.260)


Gymnostomatida II
from Gymnostomatida I
acontractile proboscis
Volume IV
yes
no
trunk
fusiform
bursiform to globular
macronucleus
macronucleus; mode of life
moniliform
more than 500 very small (and thus difficult to recognize in vivo) nodules
moniliform; euplanktic
dumb-bell shaped; periphyton and benthic
macro-nucleus
macronuclear nodules
Monilicaryon monilatus
350-950 µm,
usually 400-700 µm
(p.199)
Dileptus margaritifer
250-600 µm (p.185)
Paradileptus elephantinus
180-450 µm,
usually 250-350 µm (p.203)
Trachelius ovum
200-600 µm,
usually 250-350 µm
(p.208)
shape
vermiform
lageniform
rod-shaped
different
Gymno-stomatida III
macronucleus
2 large nodules
20-30 small nodules
very long, highly contractile neck
contracted
Homalozoon vermiculare
150-1500 µm (p.219)
Lacrymaria olor
extended up to 1.2 mm,
contracted ~ 100 µm
(p.163)
Trachelophyllum apiculatum
90-180 µm (p.180)
Chaenea stricta
90-150 µm (p.152)


Gymnostomatida III
from Gymnostomatida II
Volume IV
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)


Gymnostomatida IV
Plankton Ciliates
proboscis[1]
present (3 proboscides)
present (1 proboscis)
absent
trunk; zoochlorellae
shape
obconical; absent
fusiform; present
elongate as shown in figures below (ciliature complete)
campanulate, globular, oviform, pyriform, ellipsoidal, with oral cone
Gymnostomatida V
[1] Do not confuse with oral cone of Monodinium/ Dininium
macronucleus
Teuthophrys trisulca trisulca (with zoochlorellae)
T. trisulca africana (without zoochlorellae)
150–300 µm
(p. 238)
Paradileptus elephantinus
100–450 µm
(p. 221)
Pelagodileptus trachelioides
230–800 µm
(p. 232)
size
<150 µm
300–500 × 60–125 µm
anterior end
transversely truncated
with ± distinct head
head conspicuous
head
no
yes
macronucleus
10–21 nodules
reniform
head
Balantidion pellucidum
70–100 µm
(p. 252)
Lagynophrya acuminata
70–95 µm
(p. 258)
Pelagolacrymaria moserae
70–120 µm
(p. 265)
Pelagolacrymaria rostrata[2]
100–120 µm
(p. 267)
Lepidotrachelo-phyllum lineare
(p. 262)
[2] Species not treated in detail!

Gymnostomatida V

from Gymnostomatida IV

Plankton Ciliates

ciliary girdles[1]; tentacles (in morbid specimens often difficult to recognize)[2]

absent; present

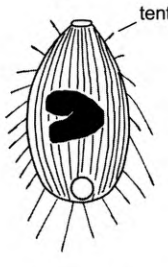
zoochlorellae

present

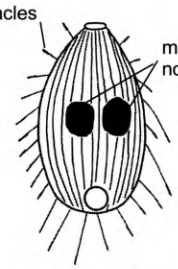
macronuclear nodules

1

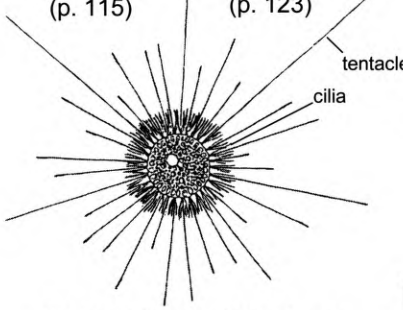
2



Actinobolina smalli
42–60 µm
(p. 115)



Actinobolina wenrichii
80–125 µm
(p. 123)



Actinobolina/Belonophrya
with extended tentacles

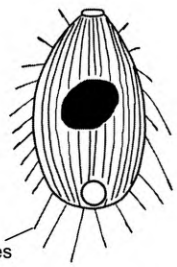
Do not confuse with → Suctoria and Heliozoa which lack cilia, or with → *Mesodinium* spp. which are ≤30 µm

present; absent

absent

shape of macronucleus

ellipsoidal to reniform

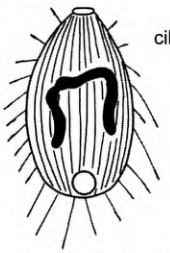


Belonophrya pelagica
40–70 µm
(p. 124)

vermiform

shape; ciliary rows

oviform; 30–60, meridional



Actinobolina vorax
100–200 µm (p. 118)

obovoidal; about 30, distinctly spiral

Actinobolina radians
65–90 µm
(p. 112)

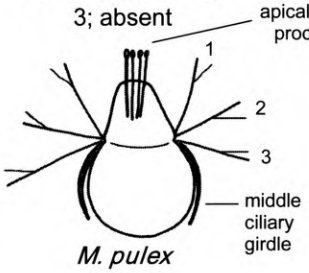
apical processes; size; bristles distally furcated

present; 12–30 µm; yes
Mesodinium

absent; >20 µm; no or bristles absent
Gymnostomatida VI

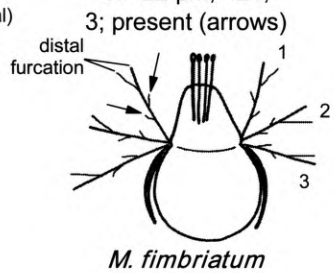
size; ciliary rows; circlets formed by anterior ciliary girdle; barbs

20–30 µm; 23–34; 3; absent



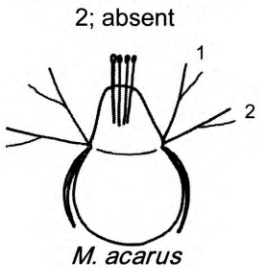
M. pulex
(p. 139)

17–22 µm; ~21; 3; present (arrows)



M. fimbriatum
(p. 138)

12–20 µm; 16–25; 2; absent

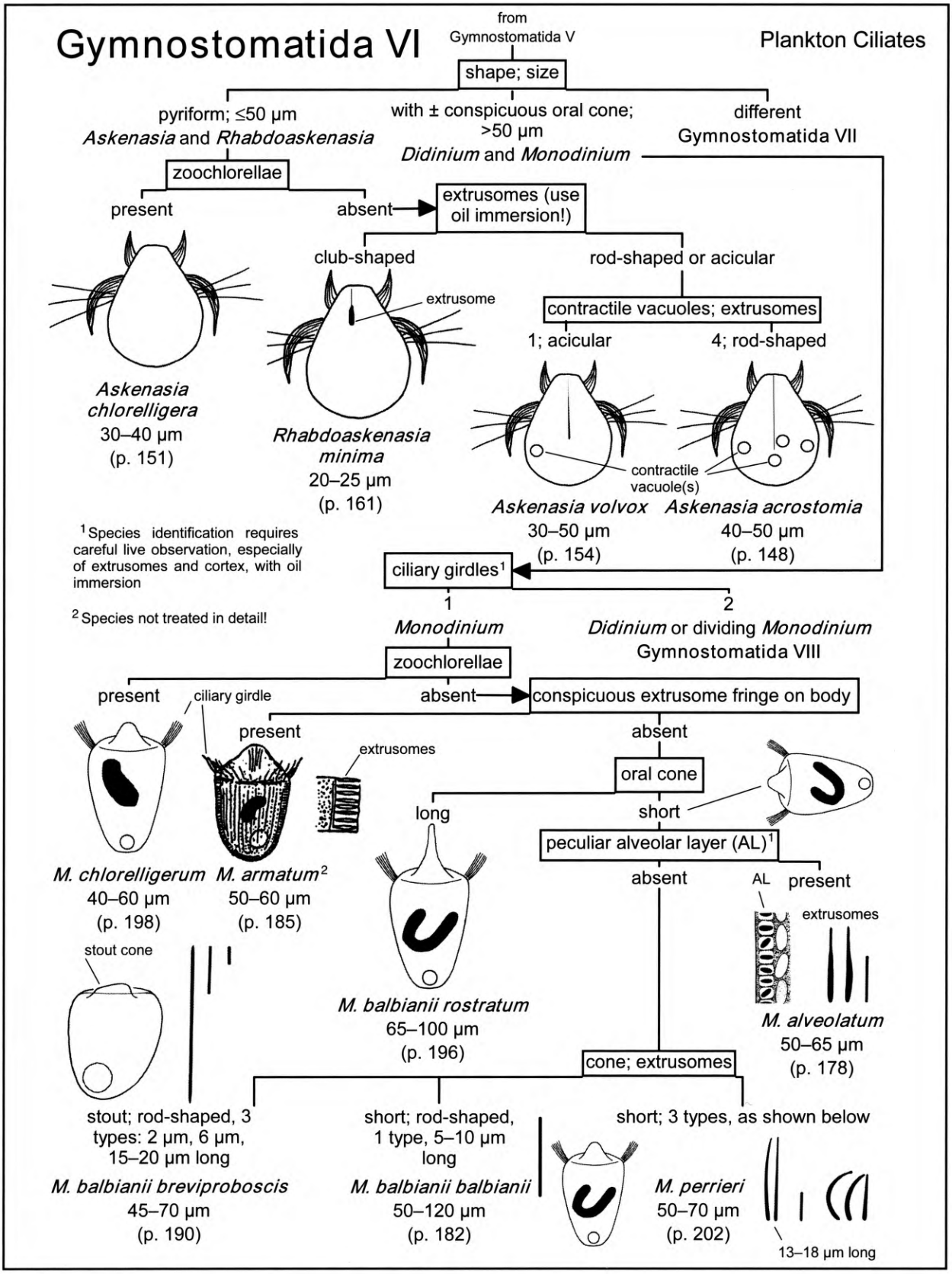


M. acarus
(p. 135)

Species not treated in detail!

[1] Inconspicuous in *Mesodinium*, where they appear bristle-like

[2] Usually, tentacles are numerous 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


Gymnostomatida VI
from Gymnostomatida V
Plankton Ciliates
shape; size
pyriform; ≤50 µm
Askenasia and Rhabdoaskenasia
with ± conspicuous oral cone; >50 µm
Didinium and Monodinium
different Gymnostomatida VII
zoochlorellae
present
absent
extrusomes (use oil immersion!)
club-shaped
rod-shaped or acicular
extrusome
contractile vacuoles; extrusomes
1; acicular
4; rod-shaped
Askenasia chlorelligera
30–40 µm
(p. 151)
Rhabdoaskenasia minima
20–25 µm
(p. 161)
contractile vacuole(s)
Askenasia volvox
30–50 µm
(p. 154)
Askenasia acrostomia
40–50 µm
(p. 148)
[1] Species identification requires careful live observation, especially of extrusomes and cortex, with oil immersion
[2] Species not treated in detail!
ciliary girdles[1]
1
2
Monodinium
Didinium or dividing Monodinium
Gymnostomatida VIII
zoochlorellae
present
absent
ciliary girdle
conspicuous extrusome fringe on body
present
absent
extrusomes
oral cone
long
short
peculiar alveolar layer (AL)[1]
M. chlorelligerum
40–60 µm
(p. 198)
M. armatum[2]
50–60 µm
(p. 185)
absent
AL
present
extrusomes
stout cone
M. balbianii rostratum
65–100 µm
(p. 196)
M. alveolatum
50–65 µm
(p. 178)
cone; extrusomes
stout; rod-shaped, 3 types: 2 µm, 6 µm, 15–20 µm long
short; rod-shaped, 1 type, 5–10 µm long
short; 3 types, as shown below
M. balbianii breviproboscis
45–70 µm
(p. 190)
M. balbianii balbianii
50–120 µm
(p. 182)
M. perrieri
50–70 µm
(p. 202)
13–18 µm long

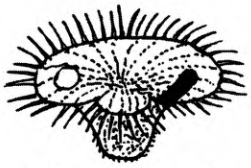
Gymnostomatida VII

Plankton Ciliates

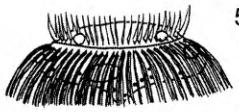
from Gymnostomatida VI

shape

- broadly campanulate (zoochlorellae present)
- almost disciform, that is, distinctly wider than long
- obovoidal or globular



Liliimorpha viridis
diameter 110 µm
(p. 164)



Cyclotrichium humilis[1]
25 × 56 µm

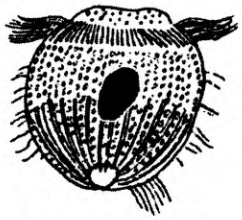
ciliary girdles

- 5–7 distinct girdles
- 1–2 girdles

Pelagovasicola cinctum
50–180 µm
(p. 213)

green due to zoochlorellae

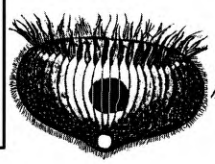
- yes
- no



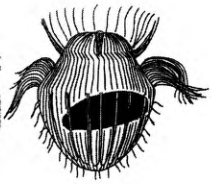
Cyclotrichium viride
66–150 µm
(p. 205)

size; shape

- about 100 µm; broader than long
- about 60 µm; longer than broad



Cyclotrichium brunneum[1]



Cyclotrichium faurei[1]
(p. 215)

[1] Species not treated in detail!

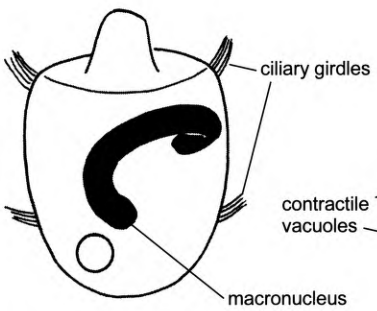
Gymnostomatida VIII

Plankton Ciliates

from Gymnostomatida VI

zoochlorellae; size

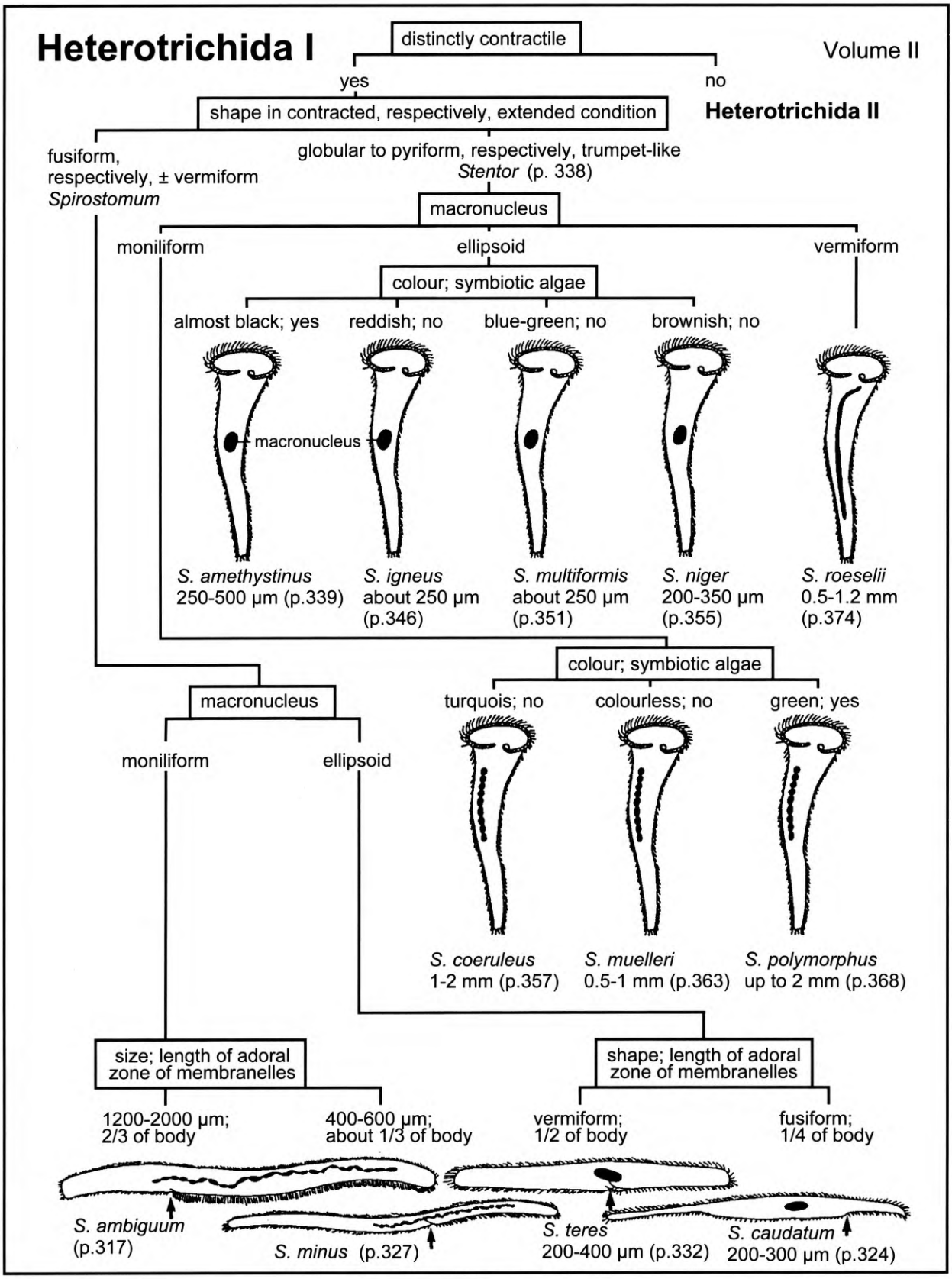
- present; 80–110 µm
- absent; 80–200 µm, usually about 150 µm

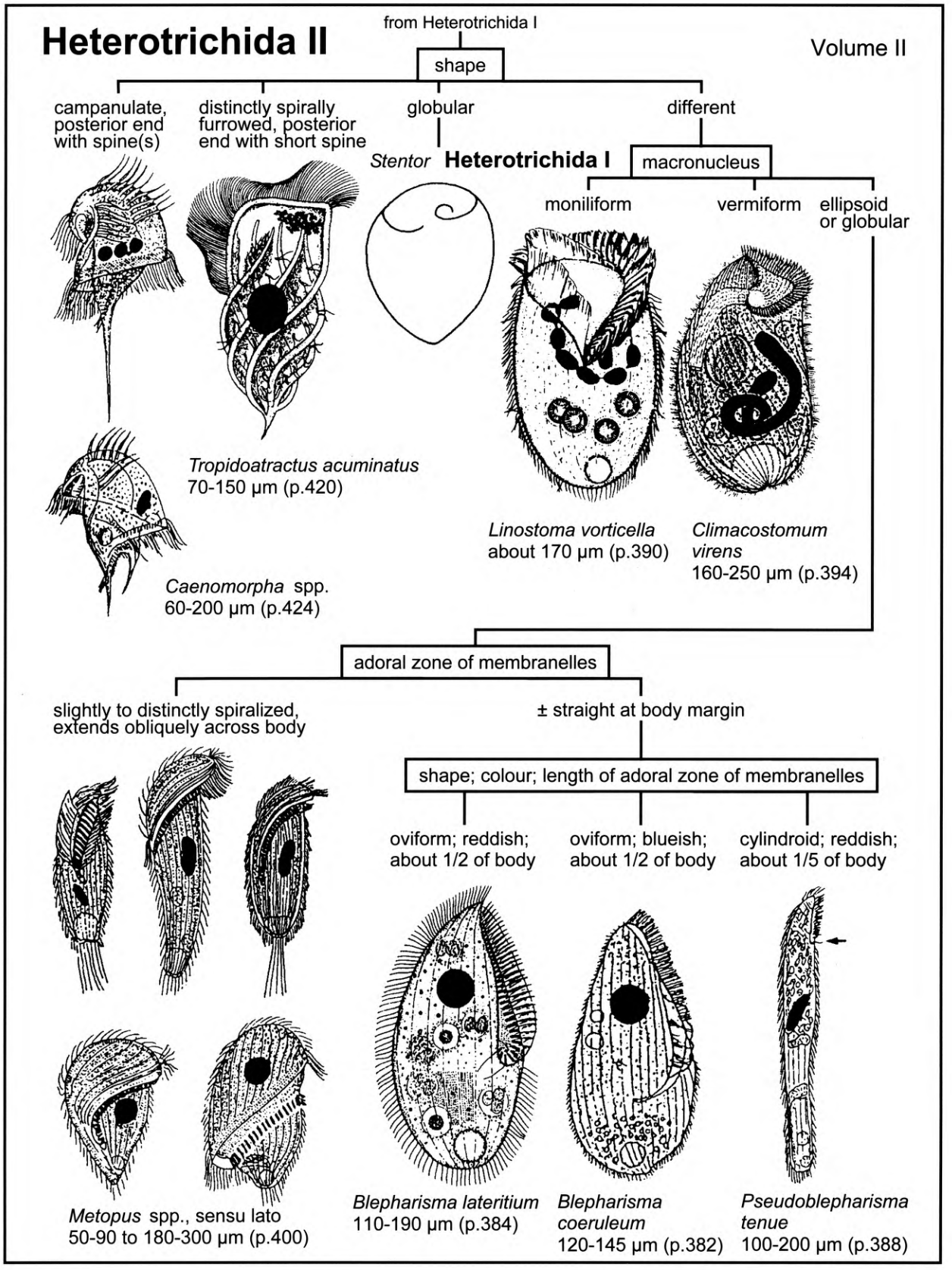


Didinium chlorelligerum
(p. 167)

dividing *Monodinium* spp. have 2 contractile vacuoles!

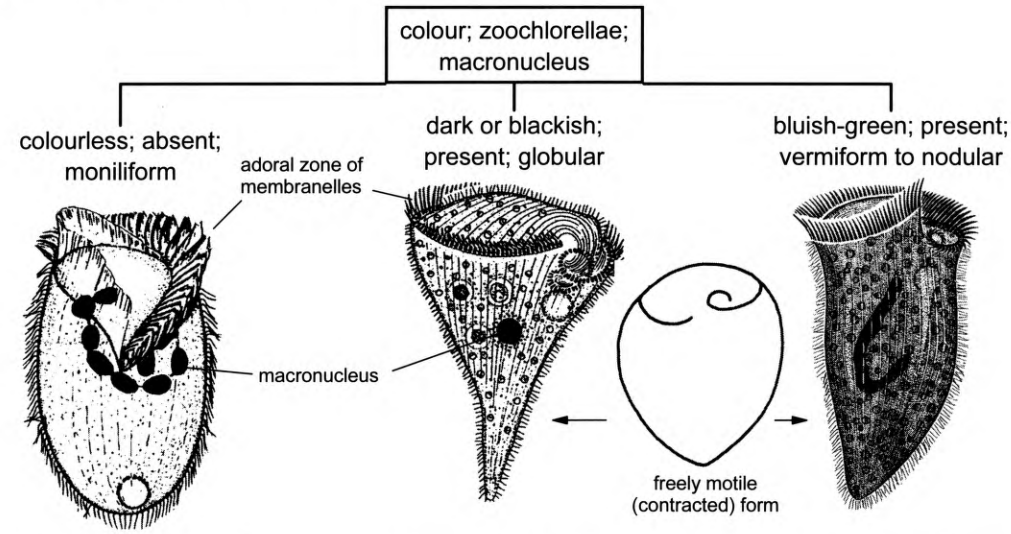
Didinium nasutum
(p. 171)
dividing *Didinium* spp. have 2 contractile vacuoles and 4 ciliary girdles


Heterotrichida I
Volume II
distinctly contractile
yes
no
Heterotrichida II
shape in contracted, respectively, extended condition
fusiform, respectively, ± vermiform
Spirostomum
globular to pyriform, respectively, trumpet-like
Stentor (p. 338)
macronucleus
moniliform
ellipsoid
vermiform
colour; symbiotic algae
almost black; yes
reddish; no
blue-green; no
brownish; no
macronucleus
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)
colour; symbiotic algae
turquois; no
colourless; no
green; yes
macronucleus
moniliform
ellipsoid
S. coeruleus
1-2 mm (p.357)
S. muelleri
0.5-1 mm (p.363)
S. polymorphus
up to 2 mm (p.368)
size; length of adoral zone of membranelles
shape; length of adoral zone of membranelles
1200-2000 µm;
2/3 of body
400-600 µm;
about 1/3 of body
vermiform;
1/2 of body
fusiform;
1/4 of body
S. ambiguum
(p.317)
S. minus (p.327)
S. teres
200-400 µm (p.332)
S. caudatum
200-300 µm (p.324)


Heterotrichida II
from Heterotrichida I
Volume II
shape
campanulate, posterior end with spine(s)
distinctly spirally furrowed, posterior end with short spine
globular
different
Stentor
Heterotrichida I
macronucleus
moniliform
vermiform
ellipsoid or globular
Tropidoatractus acuminatus
70-150 µm (p.420)
Linostoma vorticella
about 170 µm (p.390)
Climacostomum virens
160-250 µm (p.394)
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 coeruleum
120-145 µm (p.382)
Pseudoblepharisma tenue
100-200 µm (p.388)

Heterotrichida III

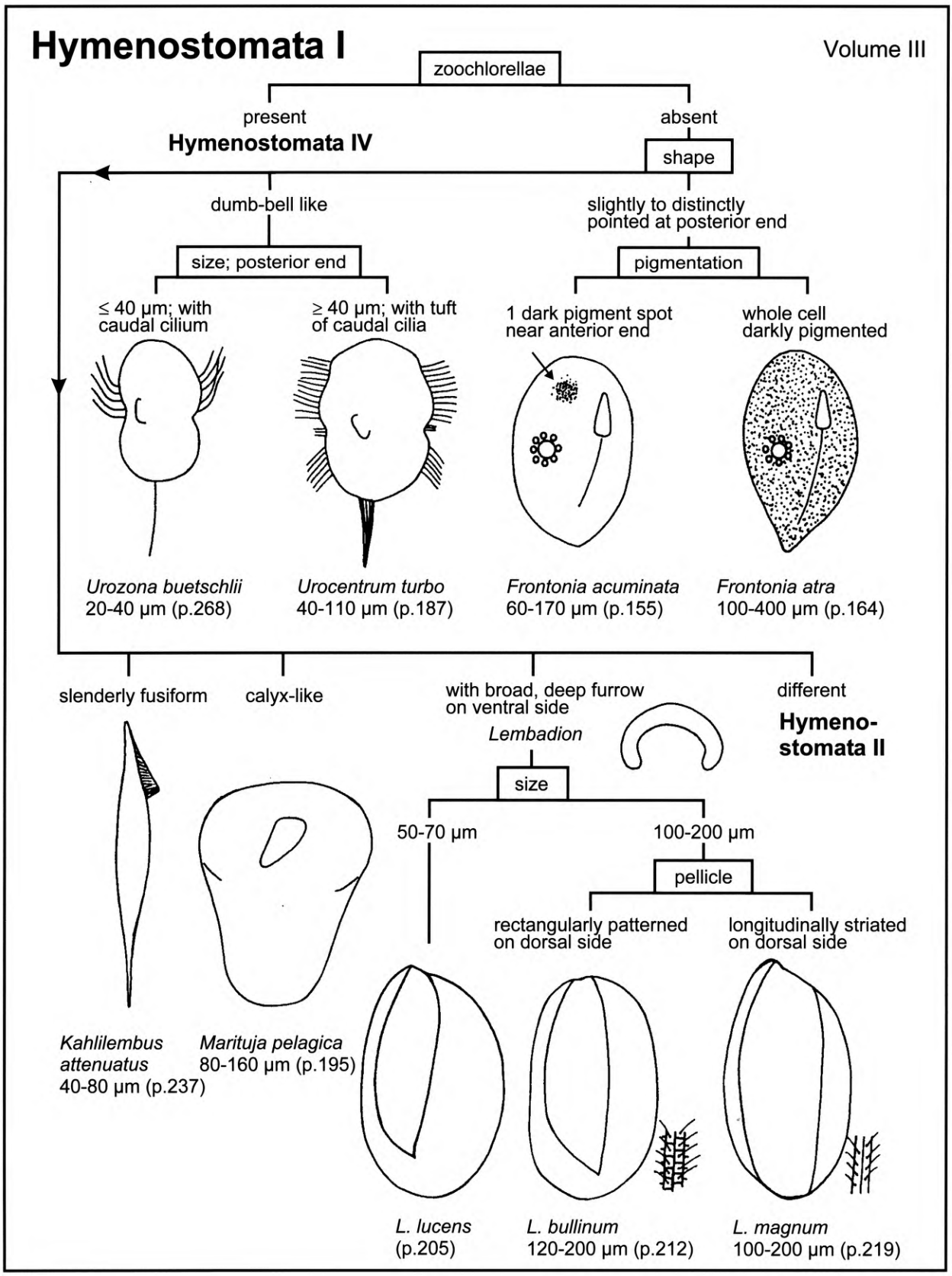
Plankton Ciliates

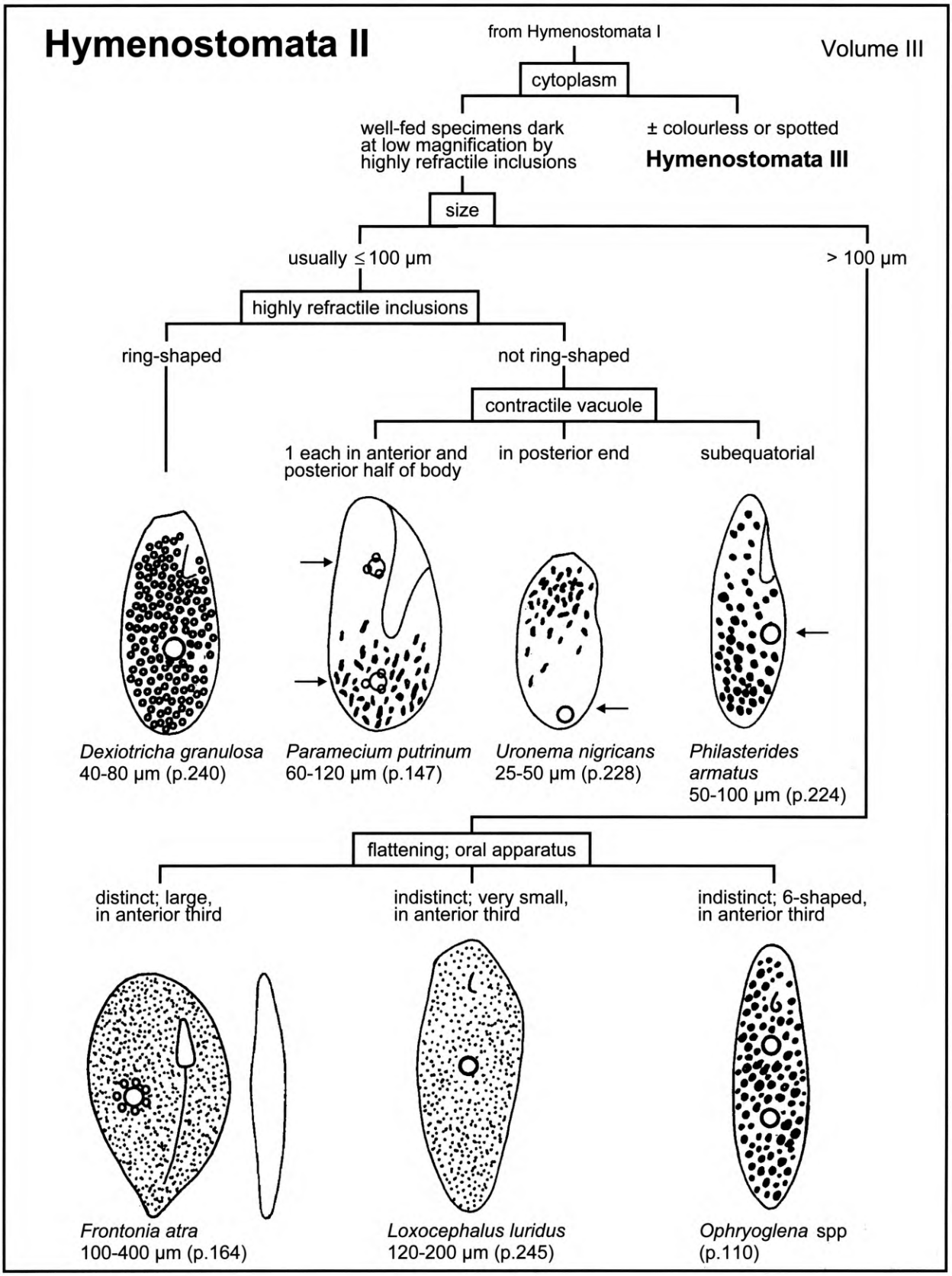


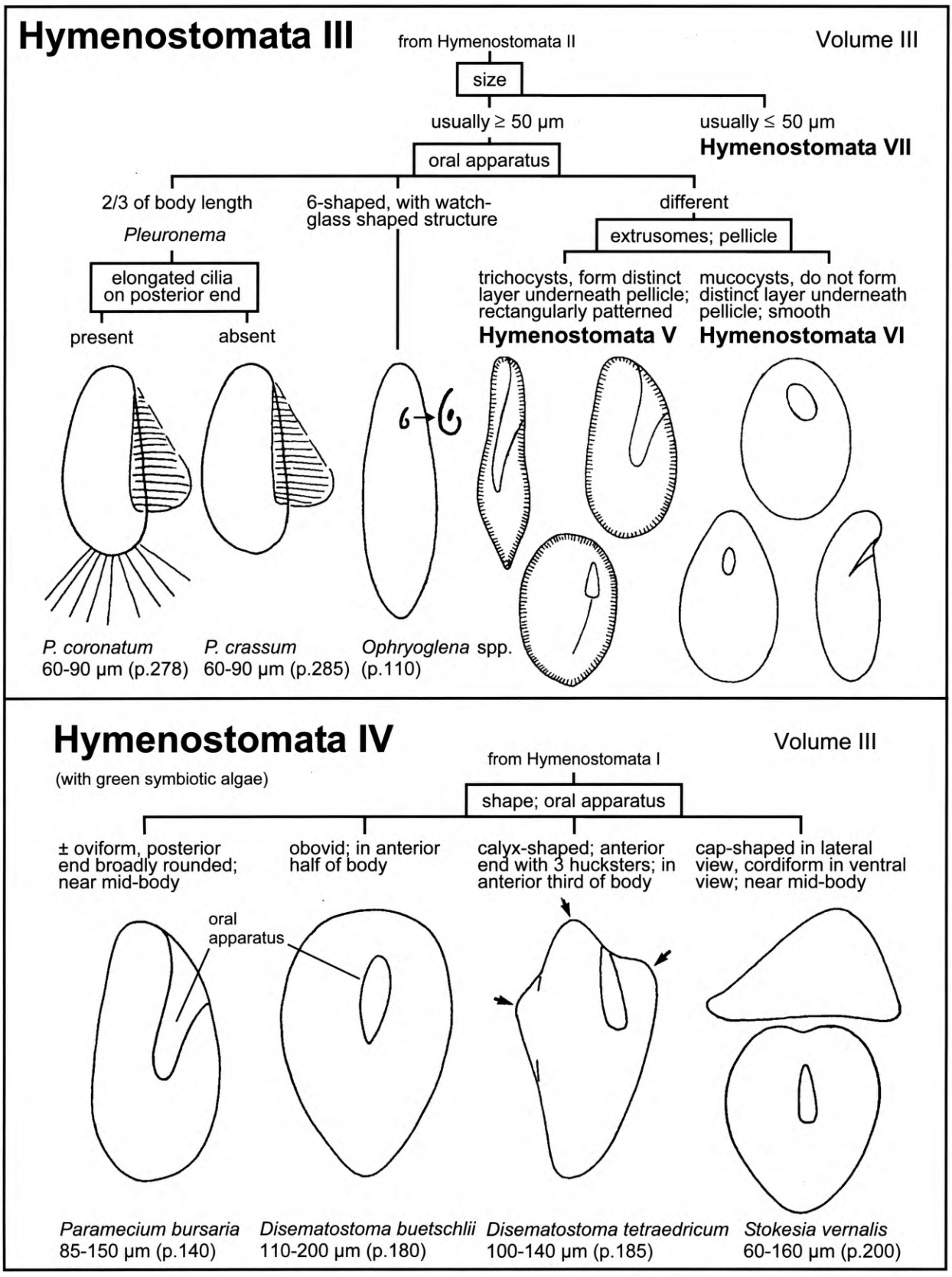
Linostomella vorticella
100–210 µm
(p. 655)

Stentor amethystinus
250–500 µm
(p. 664)

Stentor araucanus
100–270 µm
(p. 671)


Hymenostomata I
Volume III
zoochlorellae
present
Hymenostomata IV
absent
shape
dumb-bell like
slightly to distinctly pointed at posterior end
size; posterior end
pigmentation
≤ 40 µm; with caudal cilium
≥ 40 µm; with tuft of caudal cilia
1 dark pigment spot near anterior end
whole cell darkly pigmented
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)
slenderly fusiform
calyx-like
with broad, deep furrow on ventral side
different
Hymeno-stomata II
Lembadion
size
50-70 µm
100-200 µm
pellicle
rectangularly patterned on dorsal side
longitudinally striated on dorsal side
Kahlilembus attenuatus
40-80 µm (p.237)
Marituja 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
from Hymenostomata I
Volume III
cytoplasm
well-fed specimens dark at low magnification by highly refractile inclusions
± colourless or spotted
Hymenostomata III
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 nigricans
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
from Hymenostomata II
Volume III
size
usually ≥ 50 µm
usually ≤ 50 µm
Hymenostomata VII
oral apparatus
2/3 of body length
Pleuronema
6-shaped, with watch-glass shaped structure
different
extrusomes; pellicle
elongated cilia on posterior end
present
absent
trichocysts, form distinct layer underneath pellicle; rectangularly patterned
Hymenostomata V
mucocysts, do not form distinct layer underneath pellicle; smooth
Hymenostomata VI
P. coronatum
60-90 µm (p.278)
P. crassum
60-90 µm (p.285)
Ophryoglena spp.
(p.110)
Hymenostomata IV
(with green symbiotic algae)
Volume III
from Hymenostomata I
shape; oral apparatus
± oviform, posterior end broadly rounded; near mid-body
obovid; in anterior half of body
calyx-shaped; anterior end with 3 hucksters; in anterior third of body
cap-shaped in lateral view, cordiform in ventral view; near mid-body
oral apparatus
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

Volume III

(with distinct extrusome layer underneath pellicle)

from Hymenostomata III

contractile vacuole (CV); oral apparatus

1 near mid-body; in anterior third of body

Frontonia

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

Paramecium

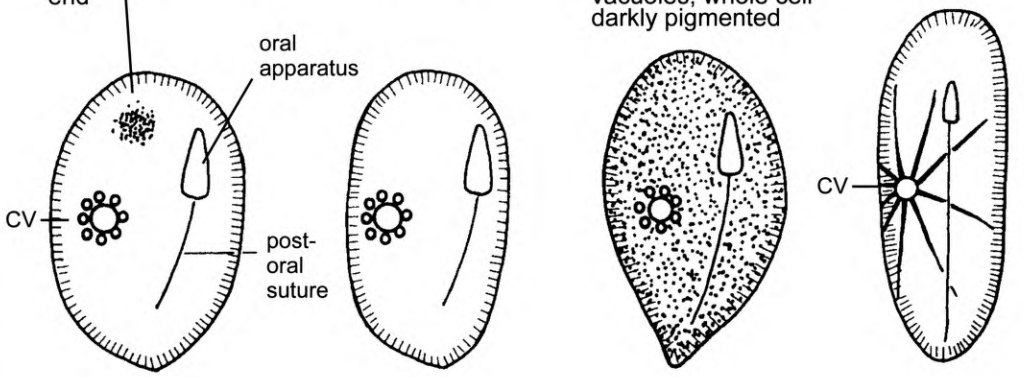
shape; contractile vacuole; pigmentation

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

scutiform; with globular adventive vacuoles; none

posterior region distinctly narrowed; with globular adventive vacuoles; whole cell darkly pigmented

scutiform; with about 10 radial collecting canals; none



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)

outline

± oviform

zoochlorellae

present

absent

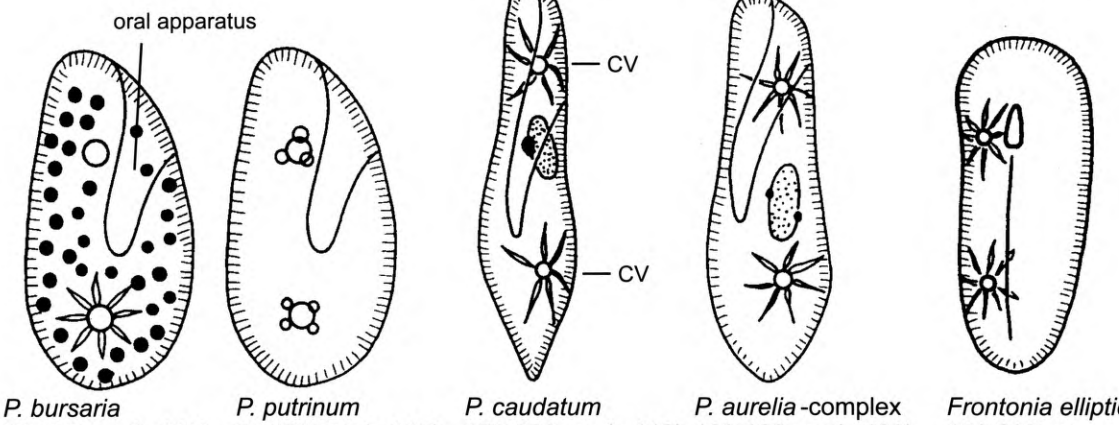
fusiform

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



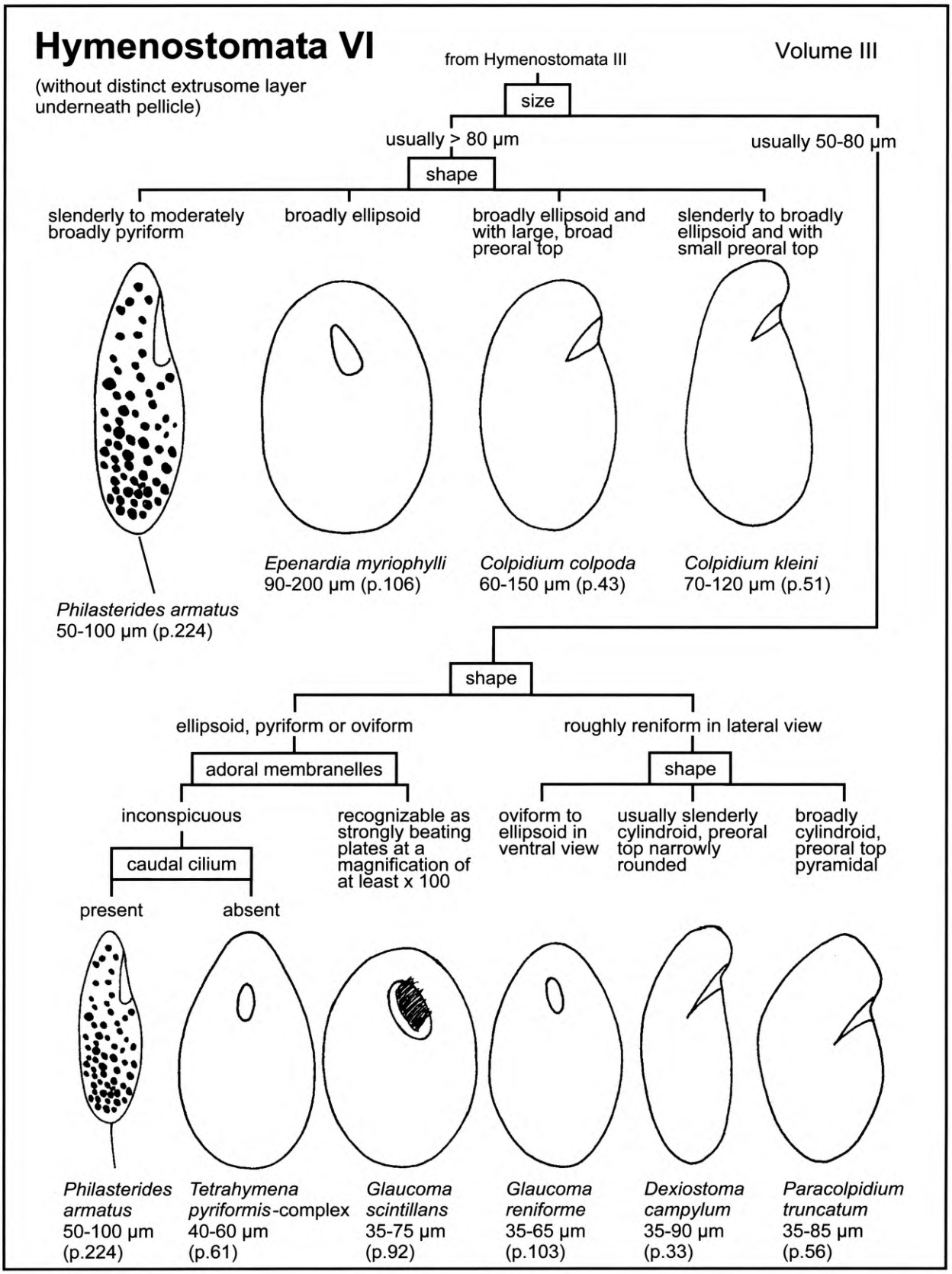
P. bursaria
85-150 µm (p.140)

P. putrinum
60-120 µm (p.147)

P. caudatum
170-300 µm (p.112)

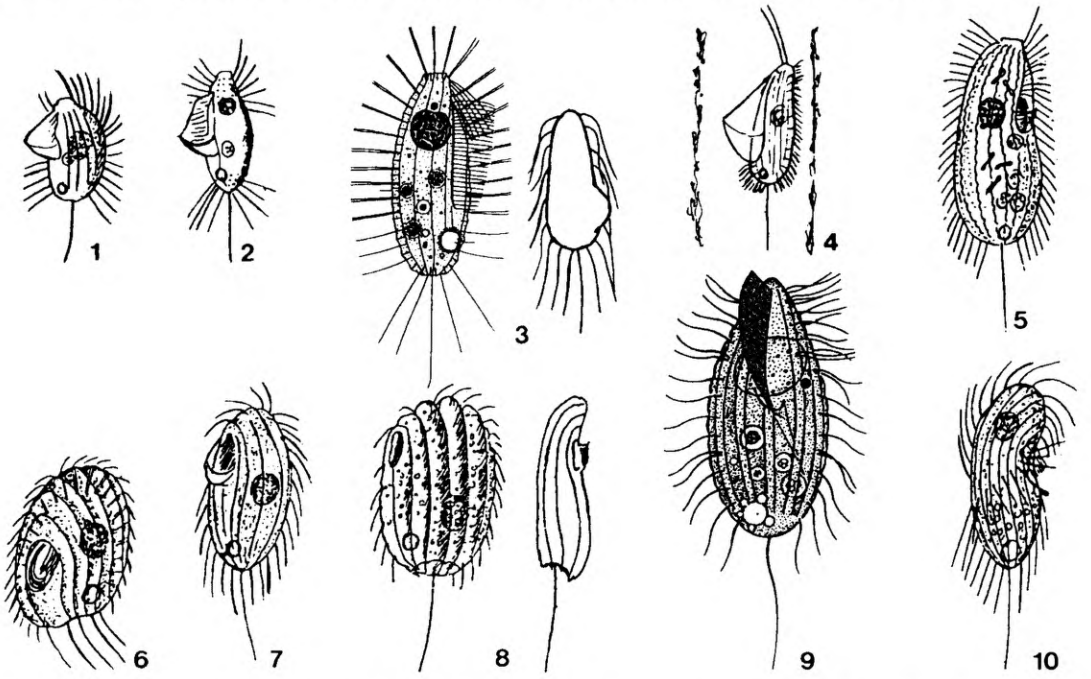
P. aurelia-complex
100-180 µm (p.129)

Frontonia elliptica
150-200 µm


Hymenostomata VI
Volume III
(without distinct extrusome layer underneath pellicle)
from Hymenostomata III
size
usually > 80 µm
usually 50-80 µm
shape
slenderly to moderately broadly pyriform
broadly ellipsoid
broadly ellipsoid and with large, broad preoral top
slenderly to broadly ellipsoid and with small preoral top
Philasterides armatus
50-100 µm (p.224)
Epenardia myriophylli
90-200 µm (p.106)
Colpidium colpoda
60-150 µm (p.43)
Colpidium kleini
70-120 µm (p.51)
shape
ellipsoid, pyriform or oviform
roughly reniform in lateral view
adoral membranelles
shape
inconspicuous
recognizable as strongly beating plates at a magnification of at least x 100
oviform to ellipsoid in ventral view
usually slenderly cylindroid, preoral top narrowly rounded
broadly cylindroid, preoral top pyramidal
caudal cilium
present
absent
Philasterides armatus
50-100 µm
(p.224)
Tetrahymena pyriformis-complex
40-60 µm
(p.61)
Glaucoma scintillans
35-75 µm
(p.92)
Glaucoma reniforme
35-65 µm
(p.103)
Dexiostoma campylum
35-90 µm
(p.33)
Paracolpidium truncatum
35-85 µm
(p.56)

Hymenostomata VII: small scuticociliates difficult to identify Volume III

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 loose 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 alpha- mesosaprobic.

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

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 muscorum*. 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.

Hymenostomata VIII

Plankton Ciliates

All species with distinct extrusome fringe!

[1] Rare in several populations

size

>40 µm

15–50 µm
Hymenostomata VII

zoochlorellae[1]

present

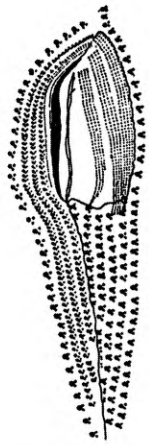
absent

shape; oral apparatus

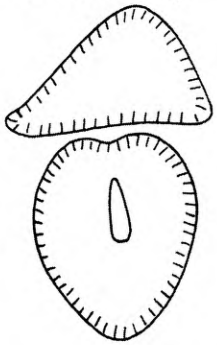
cap-shaped in lateral view, cordiform in ventral view; near mid-body

obovoid; in anterior half of body

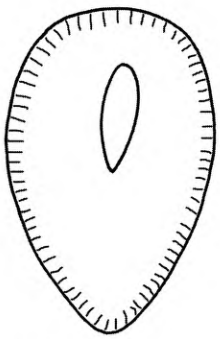
calyx-shaped, anterior end with 3 hucksters (arrows); in anterior third of body



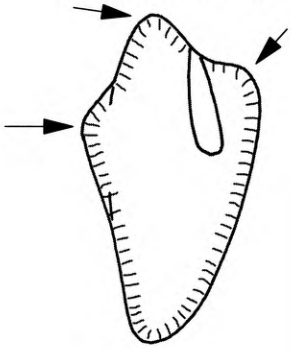
oral ciliary pattern of a hymenostome



Stokesia vernalis
100–220 µm
(p. 439)



Disematostoma buetschlii
110–200 µm
(p. 409)



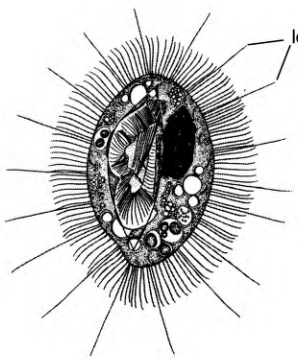
Disematostoma tetraedricum
100–140 µm
(p. 414)

length; shape

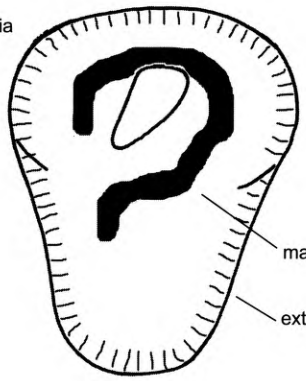
40–60 µm; broadly ellipsoidal to lemon-shaped

80–160 µm; obconical

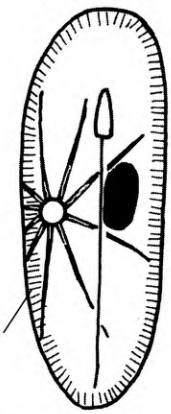
120–600 µm, usually 150–350 µm; elongate obovoidal



Histiobalantium bodamicum
(p. 424)



Marituja pelagica
(p. 431)



Frontonia leucas
(p. 416)

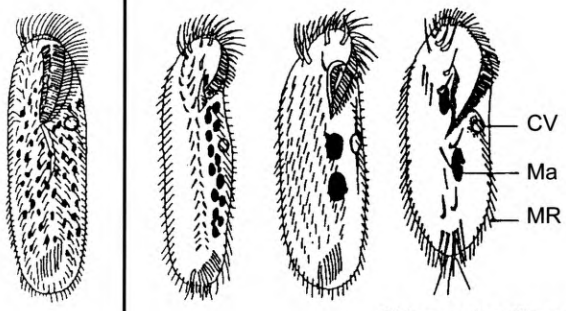
Hypotrichia I

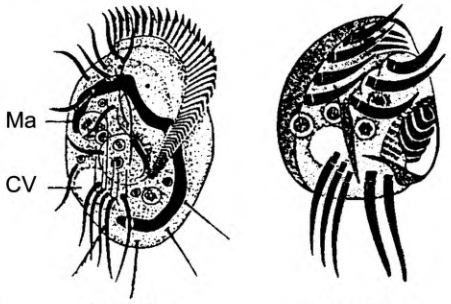
Volume I

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





CV = contractile vacuole
Ma = macronucleus
MR = marginal row

Euplotes

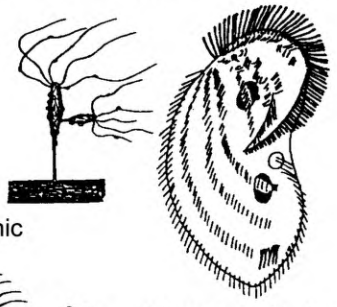
Aspidisca

Hypotrichia II

mode of life

not epizoic

epizoic on *Hydra* spp. and bryozoans



course of cirral rows

straight

Hypotrichia III-VII

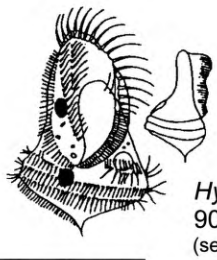
spiral

mode of life

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

planktonic

Kerona pediculus
130-205 µm (p.265)



Hypotrichidium conicum
90-120 µm (p.218)
(see also Hypotrichia VIII)

adoral zone of membranelles

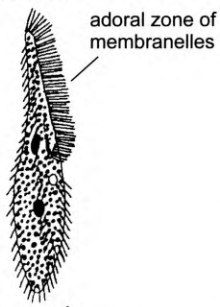
straight
Stichotricha

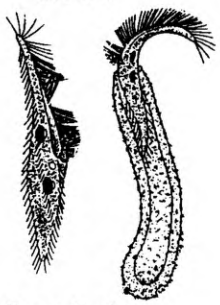
cork-screw shaped
Chaetospira

zoochlorellae

present

absent





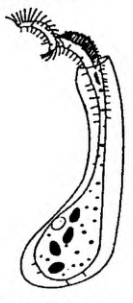
S. secunda
100-220 µm (p.210)

S. aculeata
90-120 µm (p.203)

lorica

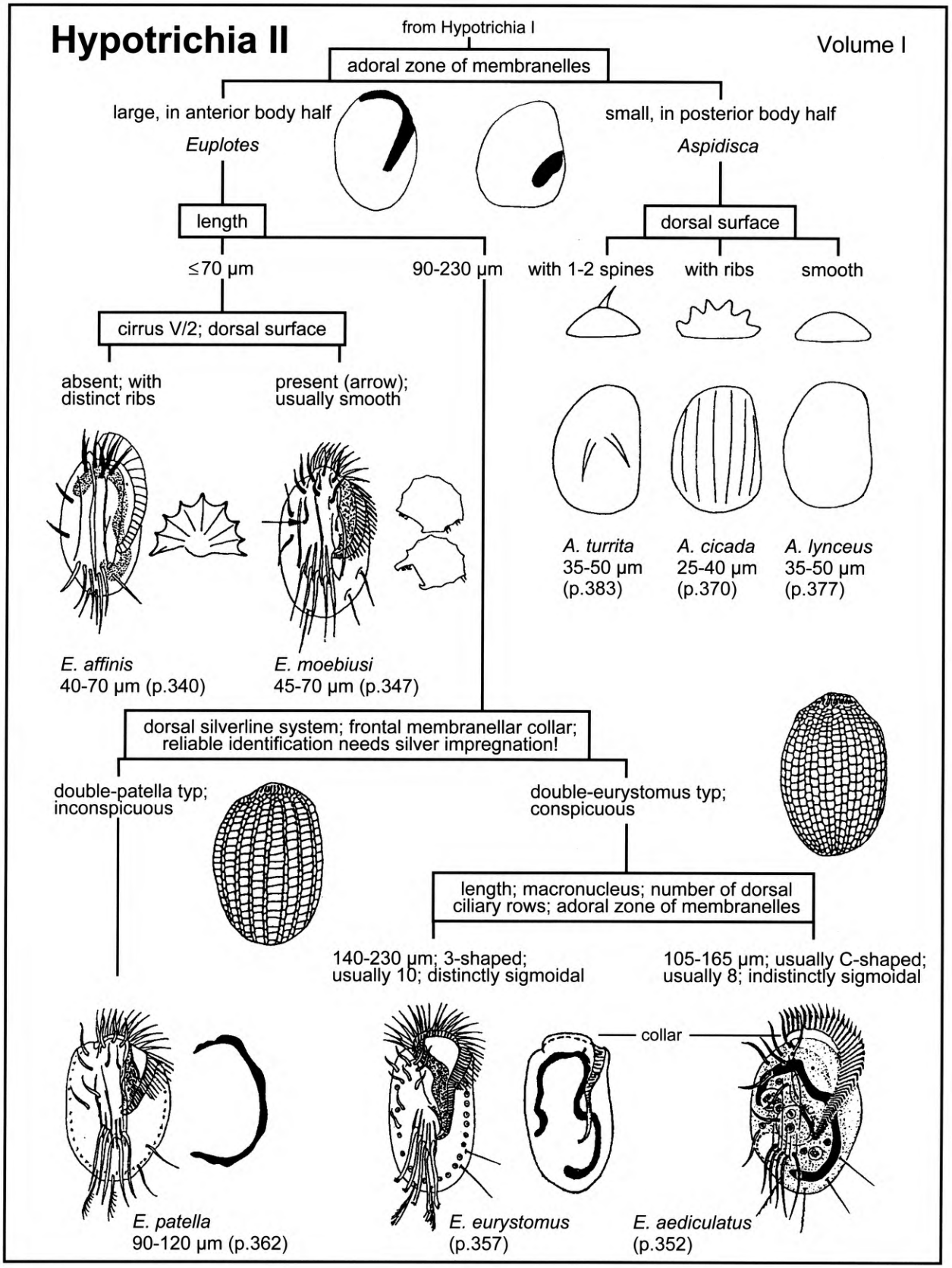
vasiform

tubular



C. muelleri
200-300 µm (p.213)

C. remex
150-560 µm (p.216)


Hypotrichia II
from Hypotrichia I
Volume I
adoral zone of membranelles
large, in anterior body half
Euplotes
small, in posterior body half
Aspidisca
length
dorsal surface
≤70 µm
90-230 µm
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. lynceus
35-50 µm
(p.377)
E. affinis
40-70 µm (p.340)
E. moebiusi
45-70 µm (p.347)
dorsal silverline system; frontal membranellar collar; reliable identification needs silver impregnation!
double-patella typ; inconspicuous
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
collar
E. patella
90-120 µm (p.362)
E. eurystomus
(p.357)
E. aediculatus
(p.352)

Hypotrichia III

Volume I

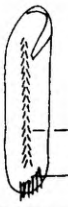
from Hypotrichia I

midventral row

present

absent

Hypotrichia IV



number of cirral rows (exclusive midventral row)

9-16

2

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)

posterior body end

pointed or tail-like elongated
Uroleptus

rounded
Holosticha

length; posterior body end

300-500 µm;
tail-like elongated

100-230 µm;
pointed

shape; length

length; contractility; number of transverse cirri

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

U. rattulus
(p.255)

U. piscis
(p.252)

U. gallina
(p.244)

U. musculus
(p.248)

number of macronuclear nodules

2

usually more than 2

location of contractile vacuole; length

number of macronuclear nodules; cortical granules

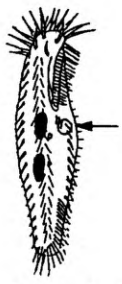
distinctly subequatorial;
60-90 µm

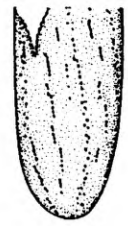
in mid-body;
120-170 µm

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

attention! easily confused with *Tachysoma pellionellum*; pay attention to location of contractile vacuole (arrow)





H. pullaster
(p.240)

H. kessleri
(p.228)

H. monilata
90-160 µm (p.231)

H. multistilata
130-170 µm (p.236)

Hypotrichia IV*

from Hypotrichia III

Volume I

number of cirral rows

3 or more

zoochlorellae

present

absent

2

oral area

bright and large, spirally involuted anteriorly, with distinct pit in anterior half

different

yellow-green cortical granules; number of transverse cirri

present; 6-9

absent; 4-5

number of cirral rows

6-8

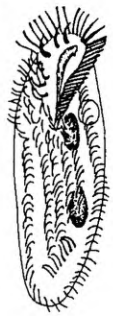
3

number of macronuclear nodules

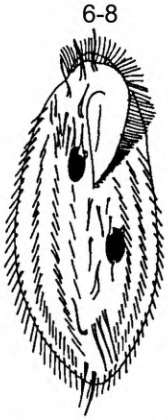
4, rarely 6

2

Paraurostyla viridis
115-175 µm
(p.258)



Paraurostyla weissei
150-300 µm (p.260)



Pleurotricha grandis
200-400 µm (p.275)

Steinia platystoma
80-150 µm (p.336)

Gastrostyla steinii
140-320 µm (p.272)

G. mystacea
120-170 µm (p.270)

body

stiff like a board

Hypotrichia V

(if in doubt, follow key Hypotrichia VI)

flexible

zoochlorellae

present

absent

Hypotrichia VI

(if in doubt, follow key Hypotrichia V)

Oxytricha chlorelligera
about 115 µm (p.277)

* For review on the species presented on plates Hypotrichia IV–VII, see also Berger (1999)

Hypotrichia V

(difficult to determine!)

from Hypotrichia IV

Volume I

caudal cirri

distinctly longer than marginal cirri

about same length as marginal cirri or absent

number of micronuclei

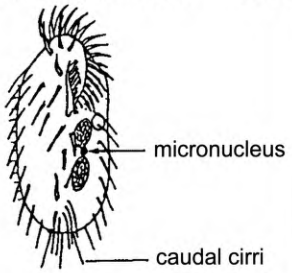
caudal cirri; posterior body end

1 between the two macronuclear nodules

at least 1 at each macronuclear nodule

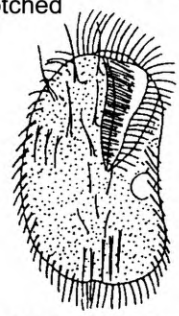
present but hardly recognizable; broadly rounded

absent; broadly rounded and sometimes slightly notched



Stylonychia stylomuscorum
60-110 µm (p.332)

Sterkiella histriomuscorum
100-150 µm (p.311)

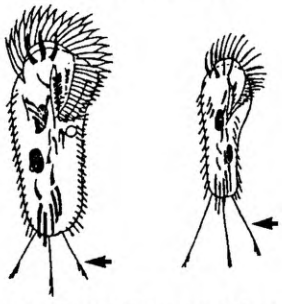


Histriculus vorax
140-190 µm (p.309)

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



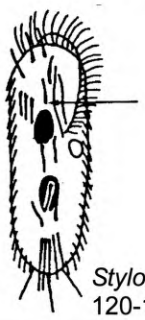
Stylonychia mytilus -complex
90-350 µm (p.315)

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

sides almost parallel, posterior end broadly rounded; distinctly separate; 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; indistinctly separate; indistinctly separate from other frontal cirri



Stylonychia putrina
120-150 µm (p.329)

most common of the 3 species treated in this paragraph

S. pustulata
50-200 µm (p.323)

S. vorax
85-120 µm (p.334)

Hypotrichia VI

from Hypotrichia IV

Volume I

cytoplasm; cortical granules

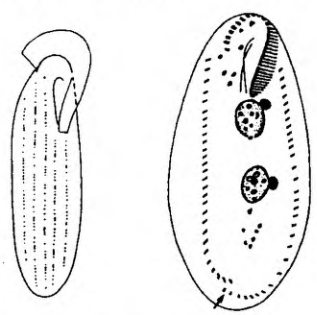
orange, reddish or brownish coloured; present

colourless; absent

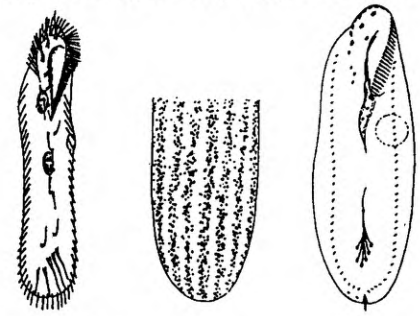
colour of cytoplasm; cortical granules; number of dorsal ciliary rows; marginal cirral rows

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)

number and location of micronuclei

1 between 2 macronuclear nodules

1 or several at each macronuclear nodule

Hypotrichia VII

posteriormost marginal cirri

inconspicuous

distinctly larger and longer (arrow)

Tachysoma bicirratum
60-90 µm (p.302)

length of dorsal cilia

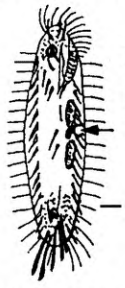
8-15 µm (easily confused with cirri!)

about 6 µm

length of body; shape; caudal cirri

55-100 µm; slenderly ellipsoid; absent

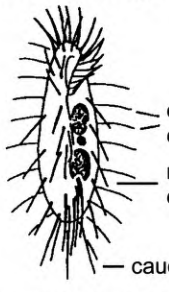
40-60 µm; oviform; present (but difficult to recognize)



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

dorsal cilia

Tachysoma pellionellum (p.304)



dorsal cilia

marginal cirri

caudal cirri

Oxytricha setigera (p.294)

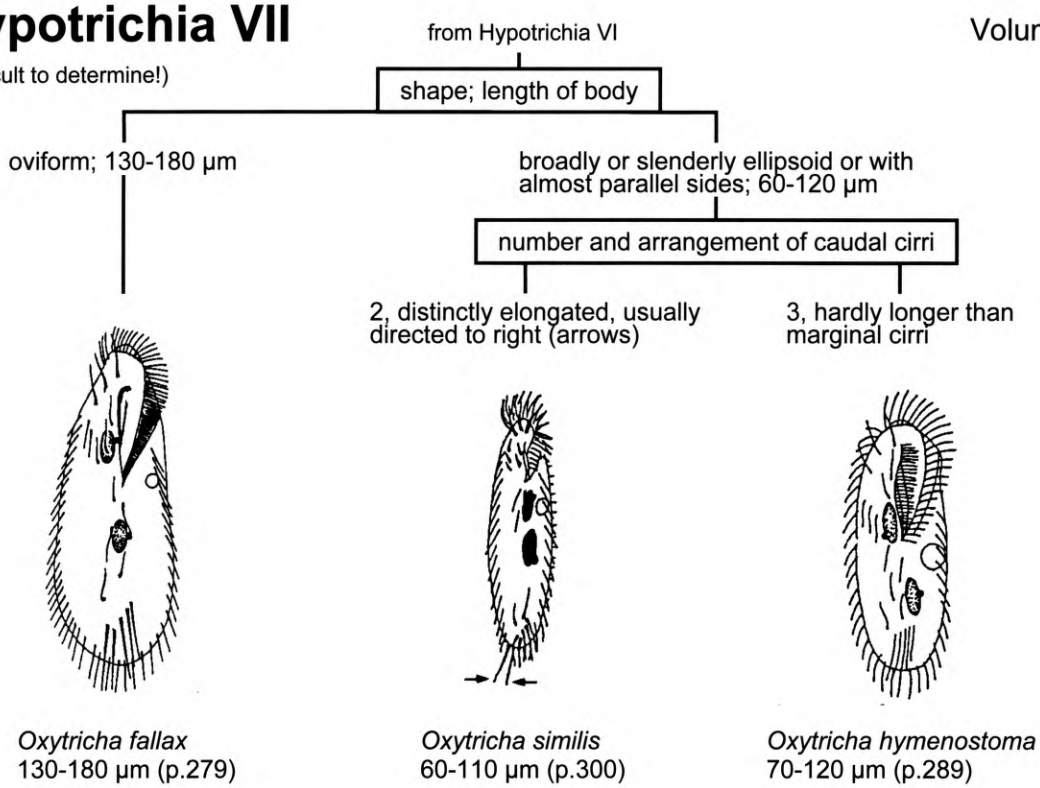
marginal cirri

Oxytricha saprobia, 100 µm (p.292)

Hypotrichia VII

(difficult to determine!)

Volume I



Oxytricha fallax
130-180 µm (p.279)

Oxytricha similis
60-110 µm (p.300)

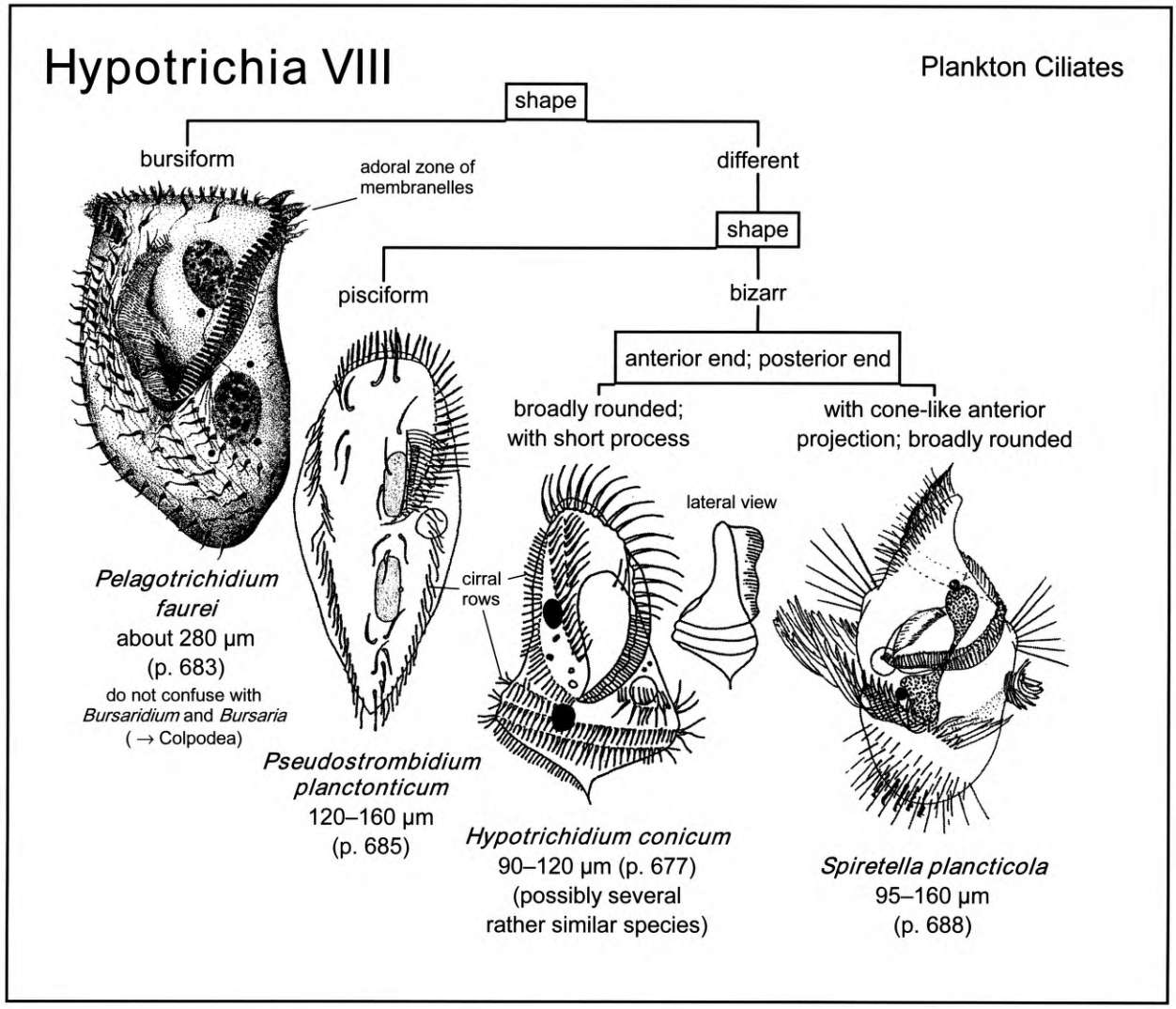
Oxytricha hymenostoma
70-120 µm (p.289)

Volume I

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)

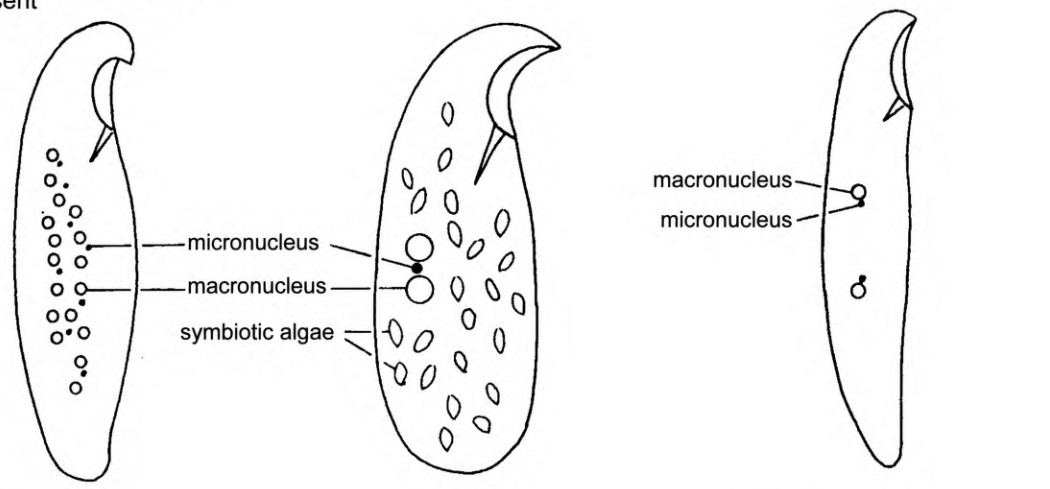

Hypotrichia VIII
Plankton Ciliates
shape
bursiform
different
adoral zone of membranelles
shape
pisciform
bizarr
anterior end; posterior end
broadly rounded; with short process
with cone-like anterior projection; broadly rounded
lateral view
cirral rows
Pelagotrichidium faurei
about 280 µm
(p. 683)
do not confuse with Bursaridium and Bursaria
(→ Colpodea)
Pseudostrombidium planctonticum
120–160 µm
(p. 685)
Hypotrichidium conicum
90–120 µm (p. 677)
(possibly several rather similar species)
Spiretella plancticola
95–160 µm
(p. 688)

Loxodes

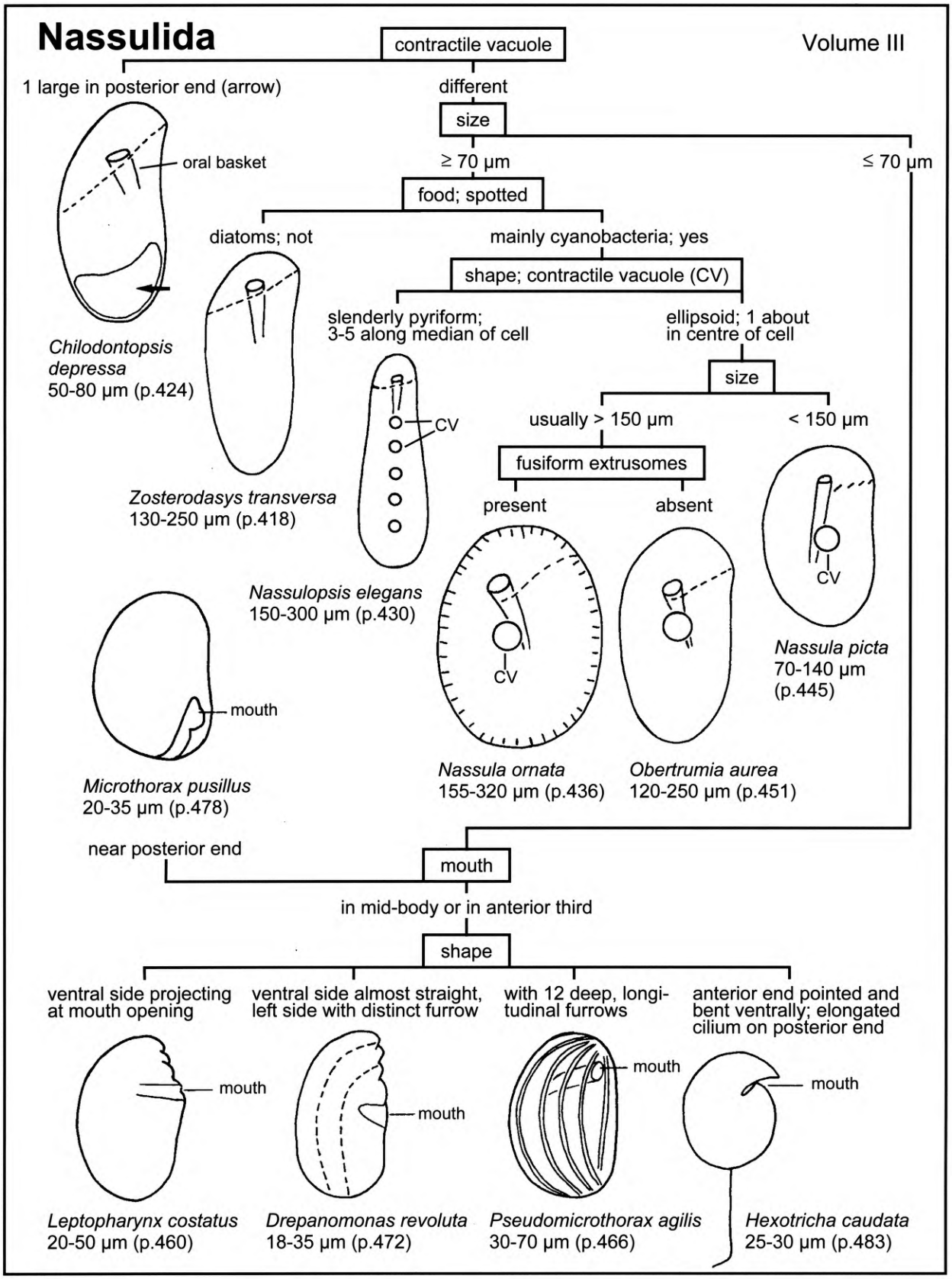
Volume IV

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)

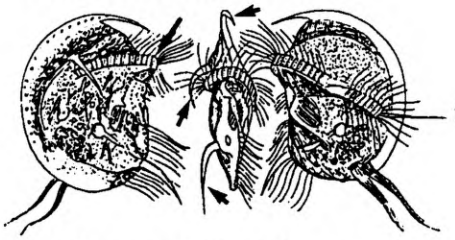

Nassulida
Volume III
contractile vacuole
1 large in posterior end (arrow)
different
size
oral basket
≥ 70 µm
≤ 70 µm
food; spotted
diatoms; not
mainly cyanobacteria; yes
shape; contractile vacuole (CV)
slenderly pyriform;
3-5 along median of cell
ellipsoid; 1 about
in centre of cell
Chilodontopsis
depressa
50-80 µm (p.424)
CV
size
usually > 150 µm
< 150 µm
fusiform extrusomes
present
absent
Zosterodasys transversa
130-250 µm (p.418)
Nassulopsis elegans
150-300 µm (p.430)
CV
CV
Nassula picta
70-140 µm
(p.445)
mouth
Microthorax pusillus
20-35 µm (p.478)
Nassula ornata
155-320 µm (p.436)
Obertrumia aurea
120-250 µm (p.451)
near posterior end
mouth
in mid-body or in anterior third
shape
ventral side projecting
at mouth opening
ventral side almost straight,
left side with distinct furrow
with 12 deep, longi-
tudinal furrows
anterior end pointed and
bent ventrally; elongated
cilium on posterior end
mouth
mouth
mouth
mouth
Leptopharynx costatus
20-50 µm (p.460)
Drepanomonas revoluta
18-35 µm (p.472)
Pseudomicrothorax agilis
30-70 µm (p.466)
Hexotricha caudata
25-30 µm (p.483)

Odontostomatida [1,2]

Volume II

frontal ciliary band; spines

horseshoe-shaped on projecting bulge (long arrow); anterior and on right side a total of 3 long spines (short arrows)



Discomorphella pectinata
70-90 µm (p.451)

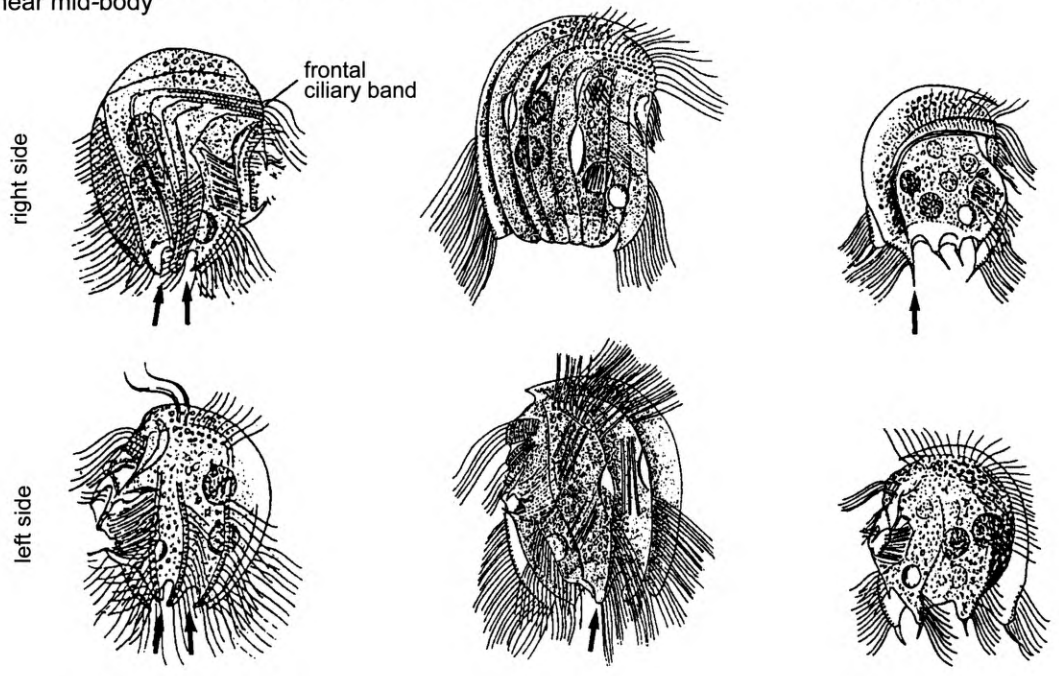
does not extend on left side and not bulge-like separate from body; right and left side without spines, posterior end usually with distinct spines

posterior end; ciliature in posterior body half

2 rounded notches surrounded by 6 inconspicuous spines (arrows); several ciliary rows commencing near mid-body

right side wavy, left with 6-8 rounded spines (arrow); several short ciliary rows

8 short or long, claw-shaped spines (arrow); on spines short ciliary rows



Pelodinium reniforme
40-50 µm (p.437)

Epalxella spp.
25-90 µm (p.440)

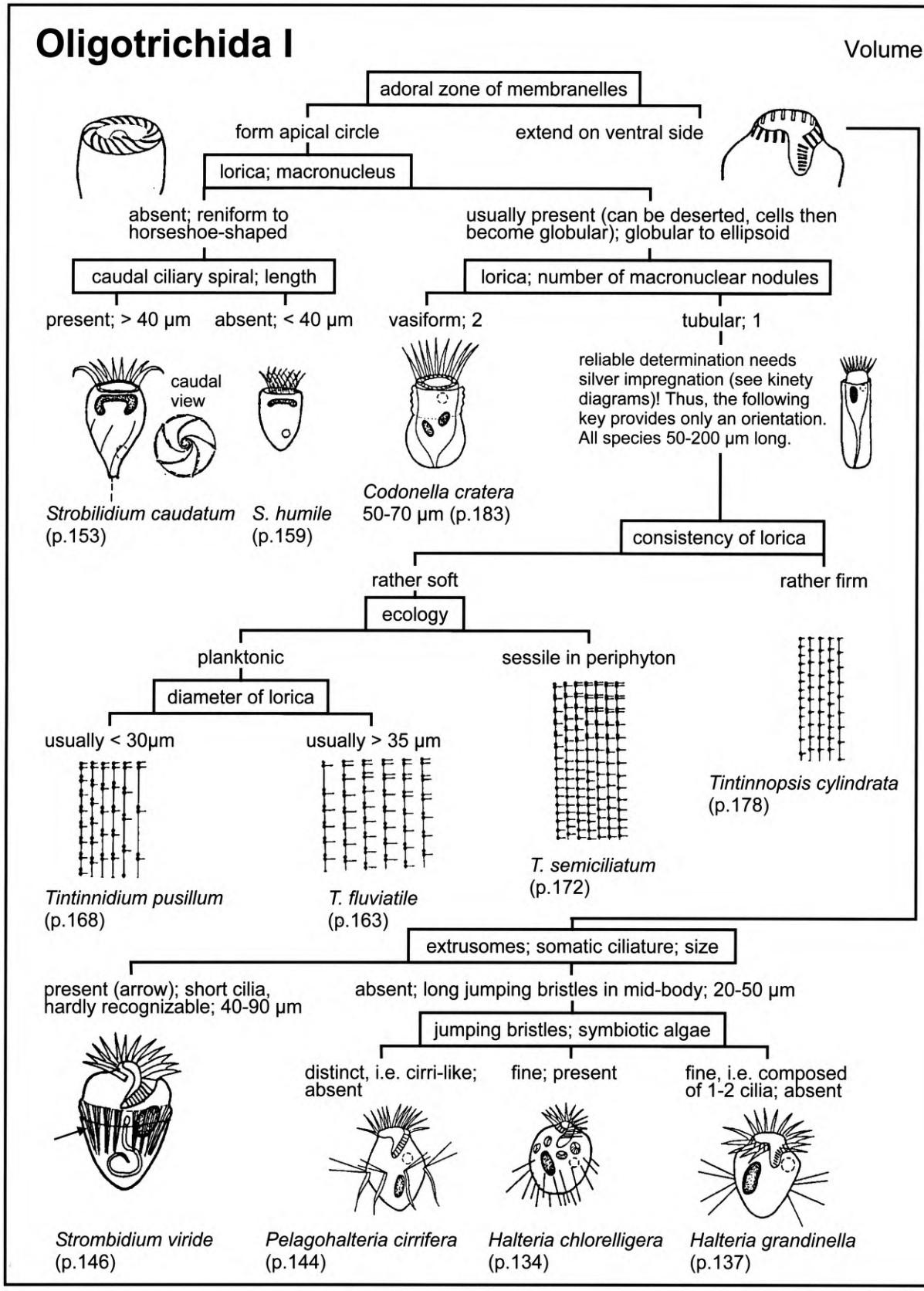
Saprodinium spp.
35-80 µm (p.446)

[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 I

Volume I



Oligotrichida II

Plankton Ciliates

lorica[1,2]

present

absent
Oligotrichida III

shape of lorica; macronuclear nodules

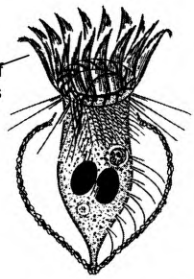
urceolate; 2 | cordiform; 2 | funnel-shaped; 2 | tubular; 1or 2

adoral zone of membranelles

[1] Do not confuse deserted loricae with shells of testate amoebae!

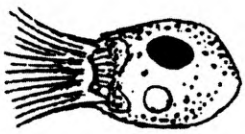
[2] Lorica often deserted when sample is older than 30 min. Specimens without lorica become stout-cylindroidal or globular and are thus easily confused with other oligotrichs, especially *Rimostrombidium* spp. Check macronucleus and/or ciliary pattern!

Codonella cratera
lorica 43–63 µm
(p. 617)



Stenosemella lacustris
lorica 40–48 µm (p. 618)
Species not treated in detail!

Tintinnidium ephemeridum
lorica 130–160 µm
(p. 636)



macronuclear nodules; subterminal lorica membrane (arrows)

2; present

1; absent

lorica

usually >100 × 30 µm, rather soft

usually <100 × 30 µm, rather stable

lorica size

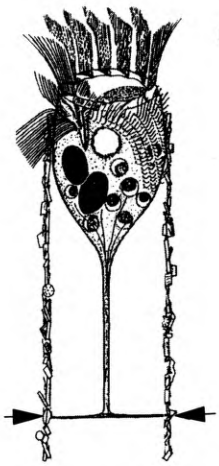
>90 µm
see footnote 3

≤90 µm

ciliary rows (silver impregnation)

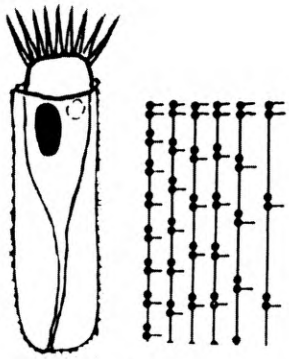
composed of paired basal bodies

composed of single basal bodies

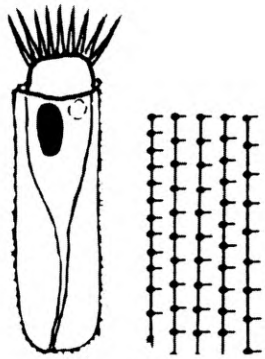


Membranicola tamari
lorica 90–160 µm
(p. 626)

Tintinnidium fluviatile
lorica 95–280 µm
(p. 637)



Tintinnidium pusillum
lorica 48–90 µm
(p. 642)



Tintinnopsis cylindrata
lorica 40–90 µm
(p. 648)

[3] Lorica of *Membranicola tamari* of similar size as in *Tintinnidium fluviatile* but composed mainly of mineral particles and thus more stable.

Oligotrichida III

Plankton Ciliates

from Oligotrichida II

jumping bristles

present[1]

absent

[1] Do not confuse with *Mesodinium* and *Askenasia* (→ Gymnostomatida)

shape of jumping bristle complexes (protargol impregnation!)

I-shaped
Halteria

L-shaped
Pelagohalteria

zoochlorellae; fine structure of bristle complexes

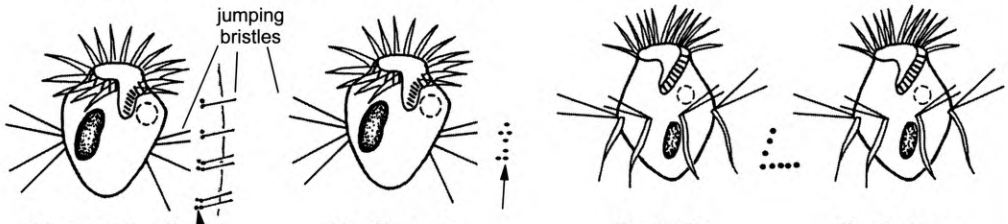
zoochlorellae; number of bristle complexes

absent; 3–6 basal body pairs

present; 7 basal bodies arranged as shown

present; 8–11

absent; 7



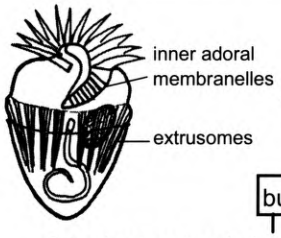
H. grandinella
20–40 µm (p. 559)

H. bifurcata
20–30 µm (p. 554)

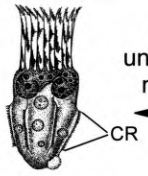
P. viridis
20–30 µm (p. 569)

P. cirrifera
25–50 µm (p. 566)

Either of the four features is sufficient to separate the groups: adoral zone of membranelles; macronucleus; distinct, rod-shaped extrusomes; ≥3 meridional to spiral ciliary rows along ± distinct cortical ridges (CR)



spiral; ellipsoidal in mid-body; present; absent
Limnostrombidium or *Pelagostrombidium*



circular; semicircular underneath adoral zone of membranelles; absent; present
Rimostrombidium
Oligotrichida IV

buccal cavity; inner adoral membranelles (IAM)

flat, short; extend almost horizontally near anterior body end: *Limnostrombidium*

deep, long; extend meridionally underneath mid-body: *Pelagostrombidium*

size; inner adoral membranelles; basal body pairs in ventral ciliary row (VR; silver impregnation)

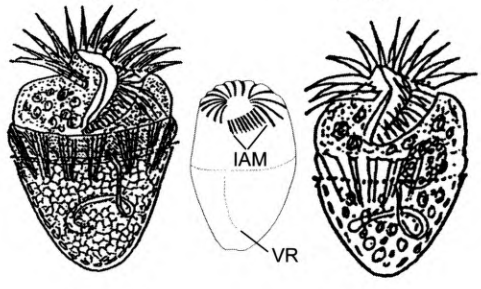
colour; size; number of inner adoral membranelles

50–70 µm; 12–16; 13–18

30–60 µm; 8–12; 7–10

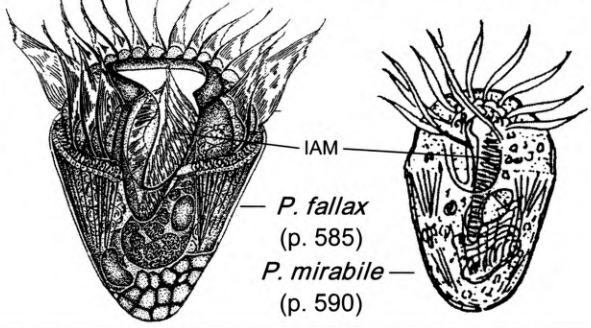
reddish-brown (see frontispiece); 40–90 µm, mean 70 × 60 µm; 19–22

yellowish or greenish (see frontispiece); 30–70 µm, mean 43 × 38 µm; 12–17



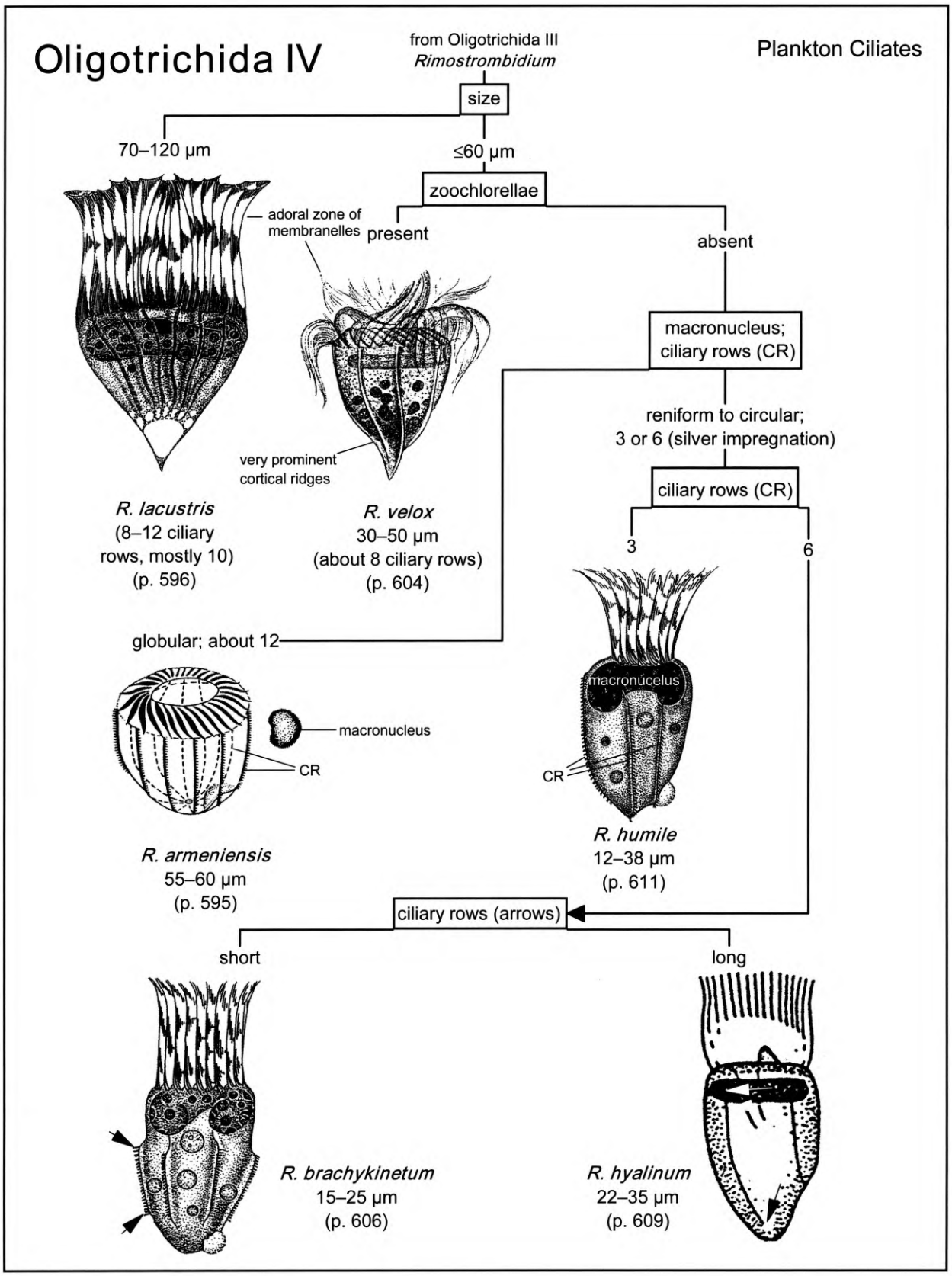
L. viride
(p. 577)

L. pelagicum
(p. 574)



P. fallax
(p. 585)

P. mirabile
(p. 590)


Oligotrichida IV
from Oligotrichida III
Rimostrombidium
Plankton Ciliates
size
70–120 µm
≤60 µm
zoochlorellae
present
absent
adoral zone of membranelles
very prominent cortical ridges
macronucleus; ciliary rows (CR)
reniform to circular; 3 or 6 (silver impregnation)
ciliary rows (CR)
3
6
globular; about 12
macronucleus
CR
macronucelus
CR
ciliary rows (arrows)
short
long
R. lacustris
(8–12 ciliary rows, mostly 10)
(p. 596)
R. velox
30–50 µm
(about 8 ciliary rows)
(p. 604)
R. armeniensis
55–60 µm
(p. 595)
R. humile
12–38 µm
(p. 611)
R. brachykinetum
15–25 µm
(p. 606)
R. hyalinum
22–35 µm
(p. 609)

Peritrichia I[1]

Volume II

lorica

present → **Peritrichia IV**

absent [2] → mode of life [3]

epizoic → **Peritrichia VI**

sessile, usually not epizoic → stalk; stalk diameter

mobile → **Peritrichia V**

absent → *Scyphidia rugosa* about 90 µm (p.249)

ramified; usually > 10 µm → stalk muscle

not ramified; usually < 10 µm [4] → **Peritrichia II**

present → stalk muscle at ramification

absent → **Peritrichia III**

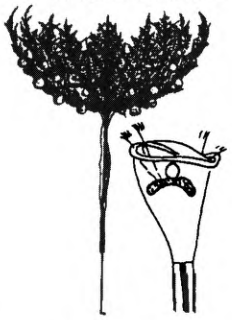
connected (arrow) *Zoothamnium*

stalk muscle

interrupted (arrow)

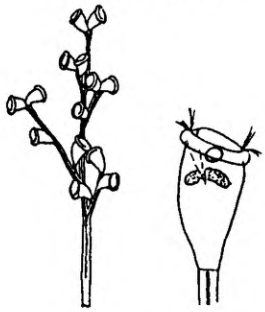
ramification of stalk; pellicle

umbel-like; without detritus



Z. arbuscula 40-70 µm (p.152)

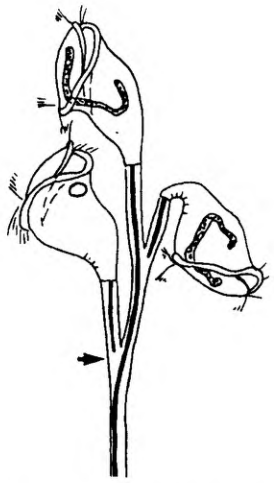
dichotom; without detritus



Z. procerius 60-80 µm (p.163)

dichotom; with detritus

Z. kentii 50-90 µm (p.158)



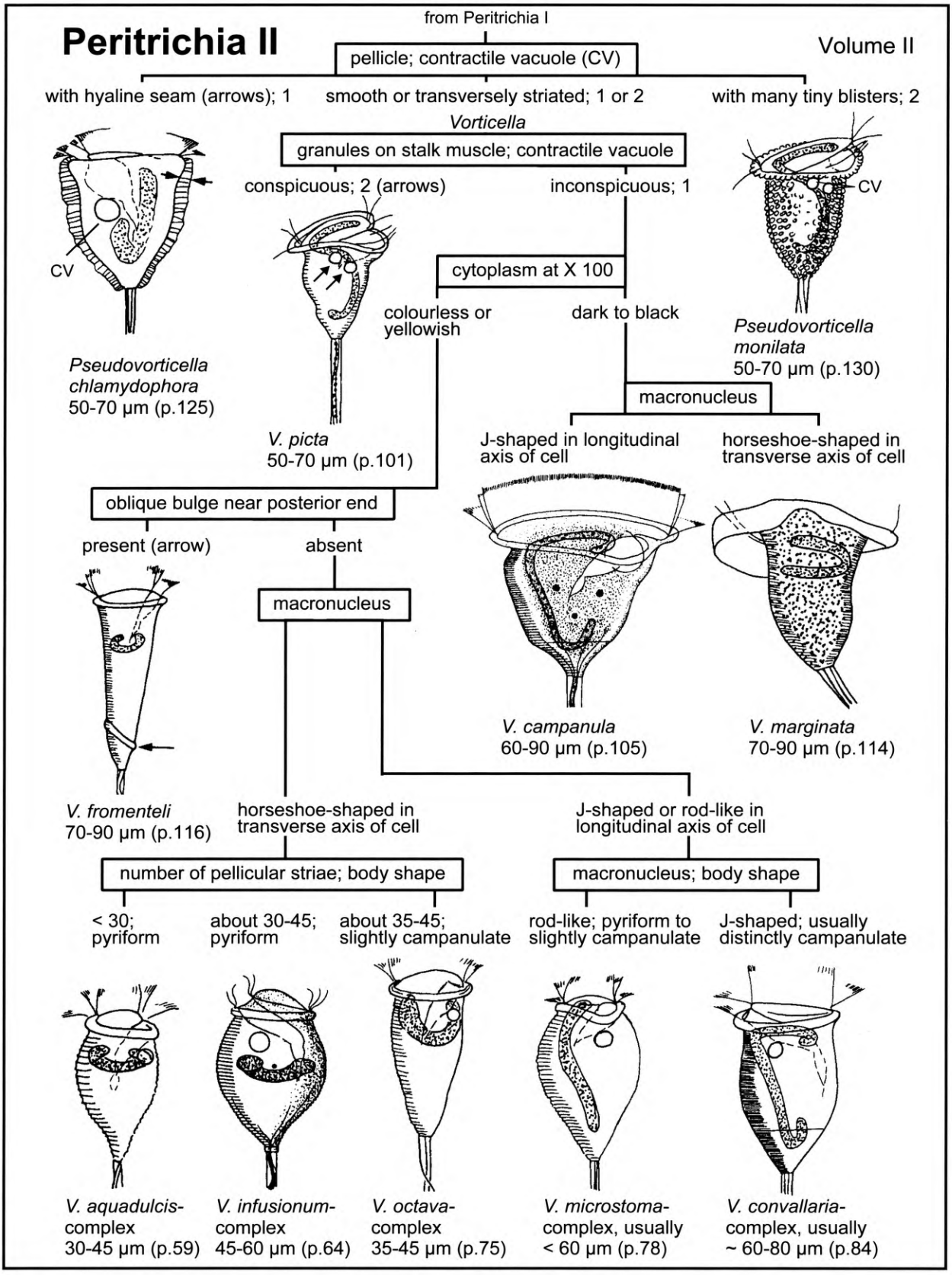
Carchesium polypinum 80-140 µm (p.137)

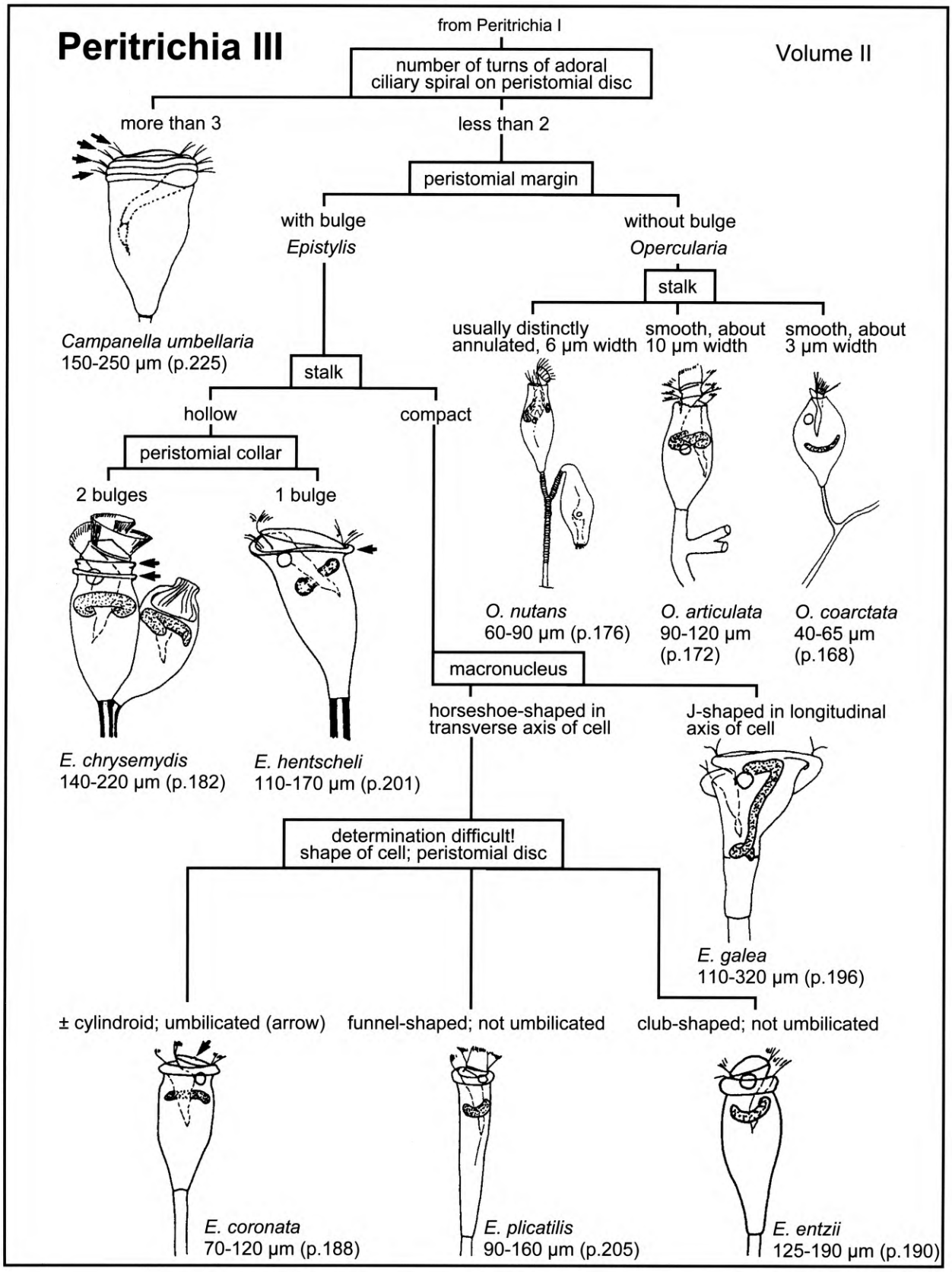
[1] The determination of most peritrich ciliates is simple because they have many distinct characters which, however, are often recognizable only in vital populations. Thus, samples must be investigated within few hours because most species soon become morbid in the collection jars or transform to swarmers 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 swarmers, which are difficult to separate from naturally stalkless species (see Peritrichia V, bottom). However, species of these genera (*Opisthonecta*, *Astylozoon*, *Hastatella*) 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 epizoons (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.


from Peritrichia I
Peritrichia II
Volume II
pellicle; contractile vacuole (CV)
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
CV
CV
Pseudovorticella chlamydophora 50-70 µm (p.125)
V. picta 50-70 µm (p.101)
Pseudovorticella monilata 50-70 µm (p.130)
cytoplasm at X 100
colourless or yellowish
dark to black
macronucleus
J-shaped in longitudinal axis of cell
horseshoe-shaped in transverse axis of cell
oblique bulge near posterior end
present (arrow)
absent
macronucleus
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
J-shaped or rod-like in longitudinal axis of cell
number of pellicular striae; body shape
macronucleus; 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 III
Volume II
from Peritrichia I
number of turns of adoral ciliary spiral on peristomial disc
more than 3
less than 2
Campanella umbellaria
150-250 µm (p.225)
peristomial margin
with bulge
Epistylis
without bulge
Opercularia
stalk
usually distinctly annulated, 6 µm width
smooth, about 10 µm width
smooth, about 3 µm width
stalk
hollow
compact
peristomial collar
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
E. chrysemydis
140-220 µm (p.182)
E. hentscheli
110-170 µm (p.201)
determination difficult! shape of cell; peristomial disc
E. galea
110-320 µm (p.196)
± cylindroid; umbilicated (arrow)
funnel-shaped; not umbilicated
club-shaped; not umbilicated
E. coronata
70-120 µm (p.188)
E. plicatilis
90-160 µm (p.205)
E. entzii
125-190 µm (p.190)

Peritrichia IV

(all sizes refer to the lorica)

Volume II

from Peritrichia I

colonies

no

yes

Ophrydium

Peritrichia VII

attatchment of lorica on substrate

with long side

with posterior end

lorica opening; mode of life

lorica stalk

closeable; epizoic

not closeable; not epizoic

present

absent

lid near anterior end of cell

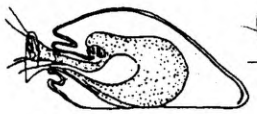
lid near anterior end of lorica

present (arrow)

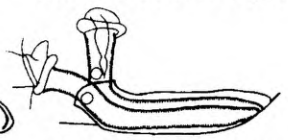
absent

Thuricola

Vaginicola



Lagenophrys vaginicola
45-80 µm (p.256)



Platycola decumbens
65-145 µm (p.259)

lorica

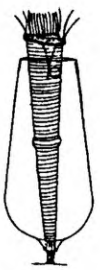
present (arrow)

absent

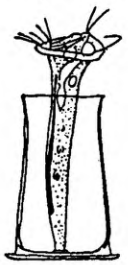
± cylindroid

± pyriform

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)

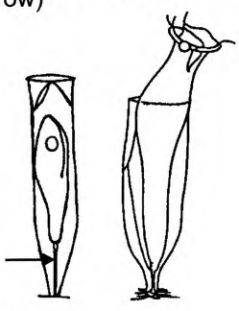
lorica; zoochlorellae; cell stalk

posteriorly funnel-like narrowed; present; absent

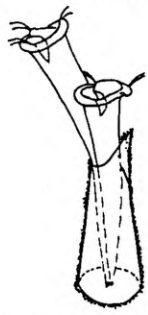
posteriorly funnel-like narrowed; absent; present (arrow)

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

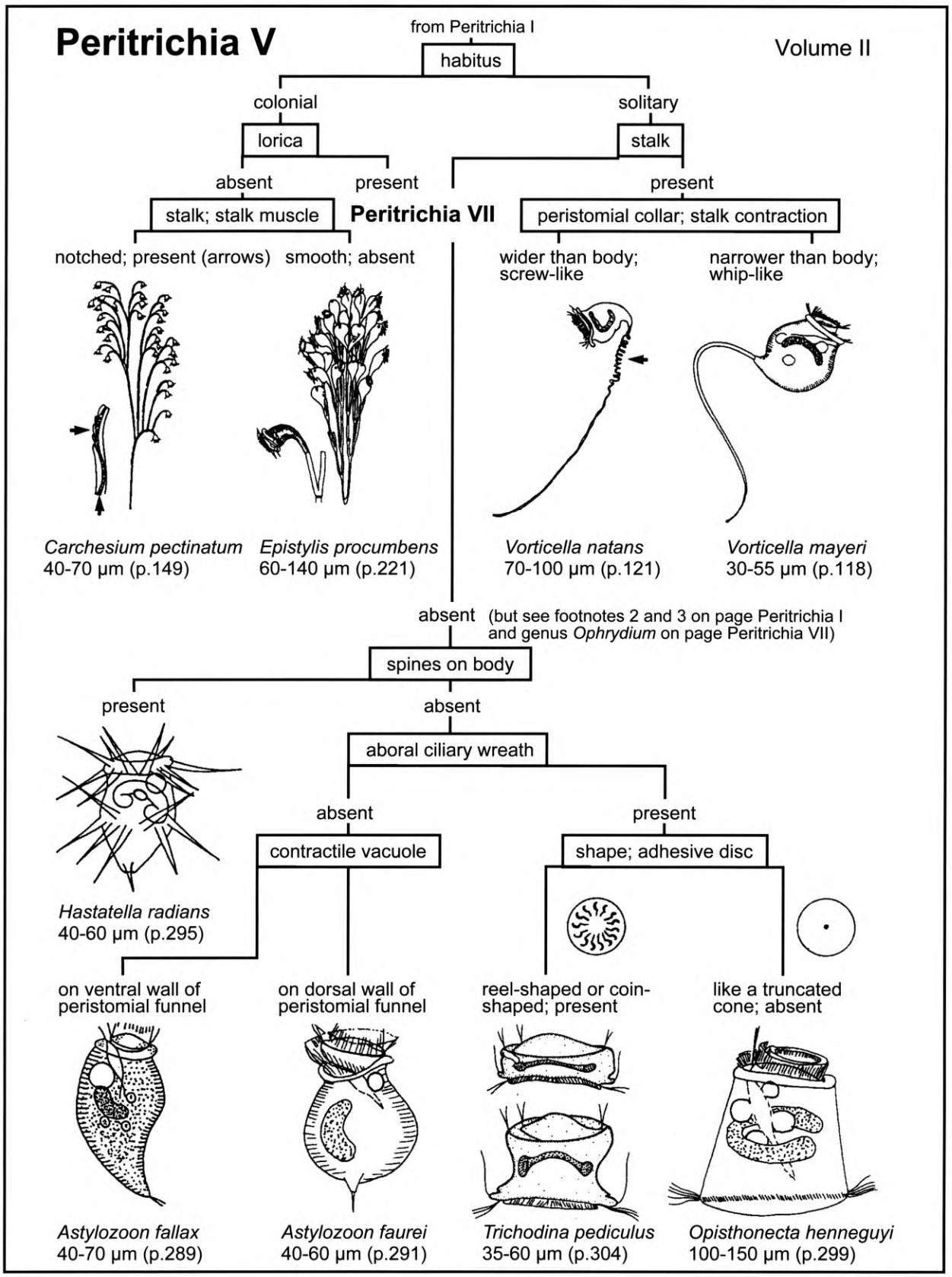
T. folliculata
125-240 µm (p.273)



T. kellicottiana
200-290 µm (p.278)

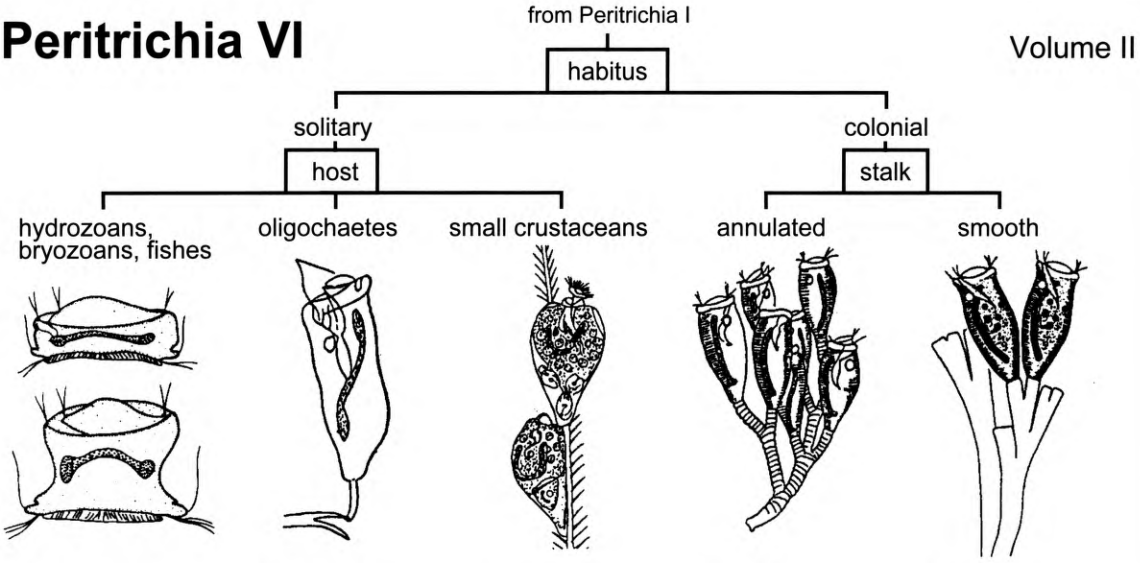


T. vasiformis
about 160 µm (p.281)


Peritrichia V
Volume II
from Peritrichia I
habitus
colonial
solitary
lorica
stalk
absent
present
present
stalk; stalk muscle
Peritrichia VII
peristomial collar; stalk contraction
notched; present (arrows)
smooth; absent
wider than body; screw-like
narrower than body; whip-like
Carchesium pectinatum
40-70 µm (p.149)
Epistylis procumbens
60-140 µm (p.221)
Vorticella natans
70-100 µm (p.121)
Vorticella mayeri
30-55 µm (p.118)
absent (but see footnotes 2 and 3 on page Peritrichia I and genus Ophrydium on page Peritrichia VII)
spines on body
present
absent
aboral ciliary wreath
Hastatella radians
40-60 µm (p.295)
absent
present
contractile vacuole
shape; adhesive disc
on ventral wall of peristomial funnel
on dorsal wall of peristomial funnel
reel-shaped or coin-shaped; present
like a truncated cone; absent
Astylozoon fallax
40-70 µm (p.289)
Astylozoon faurei
40-60 µm (p.291)
Trichodina pediculus
35-60 µm (p.304)
Opisthonecta henneguyi
100-150 µm (p.299)

Peritrichia VI

Volume II



Trichodina pediculus
35-60 µm (p.304)

Rhabdostyla inclinans
45-80 µm (p.246)

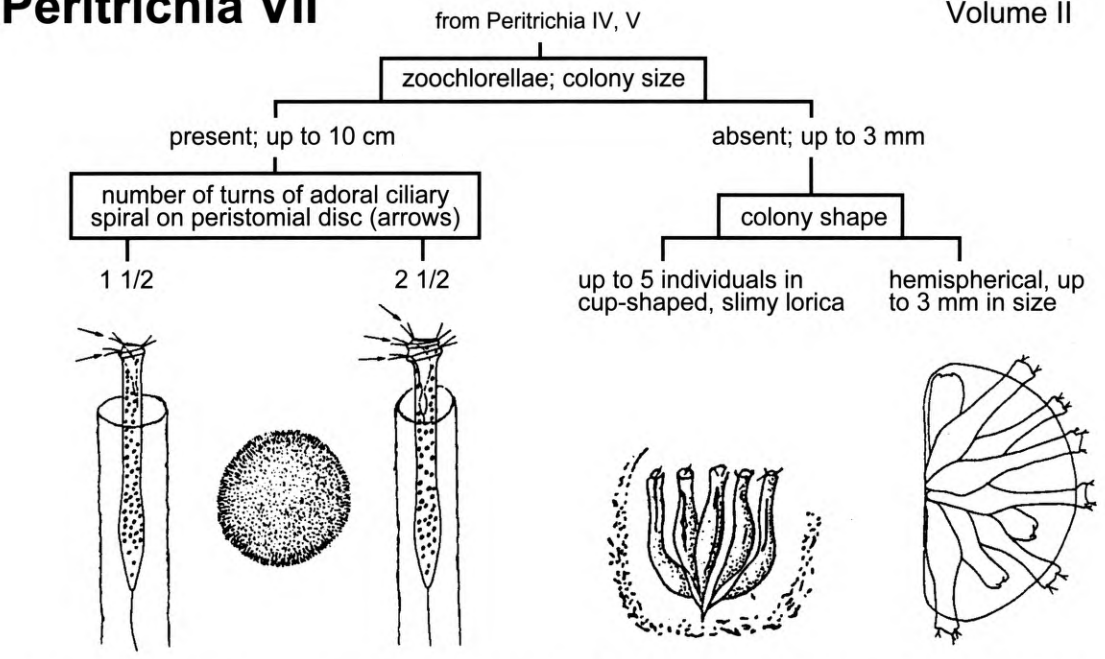
Lagenophrys vaginicola
45-80 µm (p.256)

Epistylis digitalis
80-100 µm (p.212)

Epistylis nympharum
80-130 µm (p.217)

Peritrichia VII [1]

Volume II



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, loricaless solitary specimens in running waters and plankton; then difficult to separate from *Gerda* spp., which lacks a lorica!

Peritrichia VIII (length without stalk)

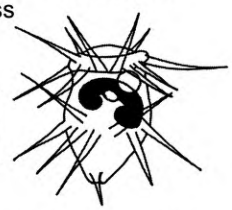
Plankton Ciliates

Identification of peritrichs usually requires live observation!

habitus

large, green, globular or flabby and flattened colonies up to 15 cm across
Ophrydium

with spines



Hastatella radians
40–60 µm
(p. 460)

different

stalk

absent

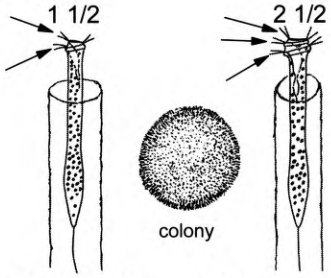
present
Peritrichia IX

Actually, there is no character that would unequivocally sepa- rate stalkless peritrichs from swarmers of stalked species. Some experience is necessary, and look for stalked peritrichs at your site. Usually, swarmers have an aboral ciliary wreath, do not whirl food into buccal cavity and/or have the oral apparatus recessed and closed. If movement is slow and staggering and the peristome open, it may be a dying stalked peritrich.

number of turns of adoral ciliary spiral on peristomial disc (arrows)

1 1/2

2 1/2



O. versatile
300–400 µm
(p. 543)

O. eutrophicum
250–350 µm
(p. 540)

aboral ciliary wreath (AW); bristles in centre of posterior end

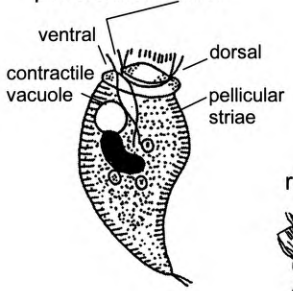
absent; present[1]

present; absent

contractile vacuole

shape; adhesive disc with denticles; life style

on ventral wall of peristomial funnel



Astylozoon fallax
40–70 µm
(p. 453)

on dorsal wall of peristomial funnel
Astylozoon faurei complex

macronucleus

reniform

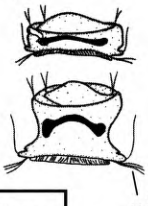
A. faurei
35–65 µm
(p. 455)

semicircular

A. enriquesi
35–65 µm
(p. 455)

denticles

coin-shaped or reel-shaped; present; epizoic
Trichodina



micronucleus; number of denticles in adhesive disc; host

like a truncated cone; absent; free-living

Opisthonecta henneguyi[2]
100–150 µm
(p. 467)

inconspicuous; 24–36; hydrozoans, bryozoans, fish

T. pediculus
diameter 35–100 µm
(p. 472)

conspicuous; 19–22; planktonic copepods

T. domergue megamicronucleata
diameter 50–75 µm
(p. 479)

Species not treated in detail!

[1] The bristles usually clearly separate *Astylozoon* spp. from swarmers of stalked peritrichs

[2] Easily confused with swarmes of stalked peritrichs; look for large oral apparatus, where the adoral ciliature makes 3–4 windings within buccal cavity (see introduction to group; p. 450). However, other *Opisthonecta* species have a normal-sized oral apparatus and are thus even more difficult to separate from swarmers of stalked peritrichs.

Peritrichia IX

Plankton Ciliates

(length without stalk)

from Peritrichia VIII

lorica

present (usually hyaline or deserted and thus easily overlooked)
Ophrydium versatile or
O. eutrophicum (→ Peritrichia VIII)
There are rather many loricate epiphytoplanktonic peritrichs (*Vaginicola*, *Thuricola*, ...), which are poorly known and were thus excluded from the book (for determination, consult KAHL 1935, SOMMER 1951, STILLER 1940, 1971)

absent

mode of life

epiplanktonic, that is, attached to other planktonic organisms (or debris)
Peritrichia X

euplanktonic, that is, not attached to other plankton organisms or debris[1]

[1] Occasionally, epiplanktonic, colonial peritrichs detach with the stalk from the substrate. If in doubt, follow keys "Peritrichia X, XI"

stalk

branched (colonial)

stalk; shape; zoochlorellae

contractile; campanulate; absent

acontractile; campanulate; absent

acontractile; vase-shaped (globular when contracted); present

unbranched (solitary)

shape; zoochlorellae; stalk

vase-shaped; present; acontractile

campanulate or pyriform; absent; contractile

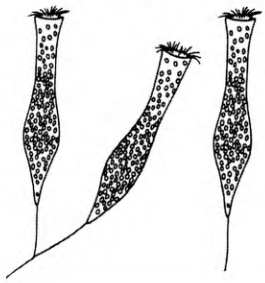
peristomial collar; stalk contraction

wider than body; srew-like (arrow)

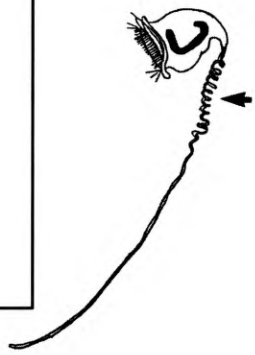
narrower than body; whipe-like

Epicarchesium pectinatum
40–70 µm
(p. 508)

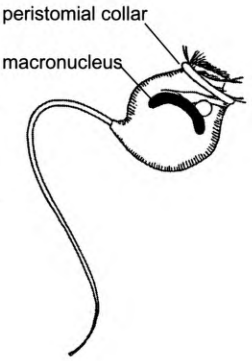
Epistylis procumbens
60–140 µm
(p. 527)



Ophrydium naumanni
solitary or in small colonies
40–50 µm
(p. 551)



Pelagovorticella natans
70–100 µm
(p. 482)



Pelagovorticella mayeri
30–55 µm
(p. 480)

Peritrichia X

(length without stalk)

Plankton Ciliates

from Peritrichia IX

stalk

unbranched (solitary)

branched (colonial)
Epistylis
Peritrichia XI

zoochlorellae

present
Vorticella chlorellata
44–64 µm
(p. 491)

absent

stalk muscle

present

absent

Epistylis pygmaeum
22–50 µm
epibiontic on planktonic rotifers and crustaceans
(p. 535)
or *Rhabdostyla* species

stalk contraction; stalk length

zigzag (sinuous); usually ≤ body length
Pseudohaplocaulus
(usually attached to *Anabaena*)

helical; usually ≥ body length
Vorticella and *Pseudovorticella*

size; shape;surface; granules on stalk muscle

15–55 µm, usually 35 µm; pyriform; coarse transverse striae; very inconspicuous

40–56 µm; campanulate; fine transverse striae, few to numerous blisters; inconspicuous

50–70 µm; campanulate; fine transverse striae; conspicuous

50–70 µm; campanulate; vesicular; inconspicuous

contractile vacuole

benthic and epiphyto-planktonic

usually attached to planktonic diatom colonies

usually benthic

usually benthic

Vorticella aquadulcis complex
(p. 486)

Vorticella vernalis
(p. 494)

Vorticella picta

Pseudovorticella monilata

see Peritrichia II

location of contractile vacuoles (arrows)

both on ventral wall of peristomial funnel

one on ventral, the other on dorsal wall of peristomial funnel

dorsal

ventral

Pseudohaplocaulus infravacuolatus

arrows mark *Vorticella chlorellata*

P. infravacuolatus
47–67µm
(p. 501)

P. anabaenae
40–50 µm
Species not treated in detail!

Peritrichia XI

(length without stalk)

Plankton Ciliates

from Peritrichia X

stalk

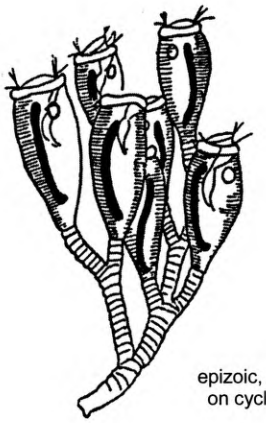
annulated

smooth

size

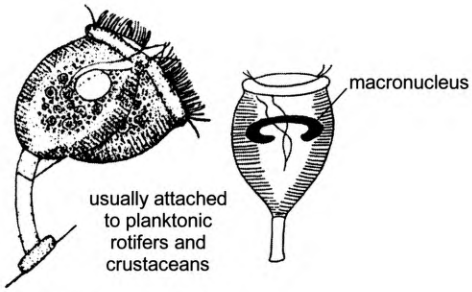
22–50 µm

>60 µm



epizoic, mainly on cyclopids

Epistylis digitalis
60–120 µm
(p. 523)

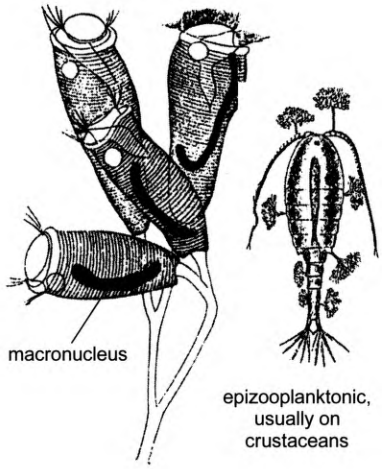


Epistylis pygmaeum
(p. 535)

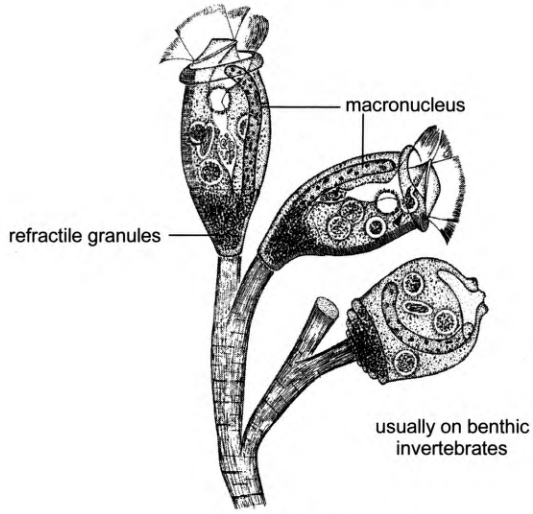
size; stalk; shape

60–100 µm; 8–12 µm; funnel-shaped

>100 µm; 20–26 µm; barrel-shaped



Epistylis anastatica
(p. 515)



Epistylis nympharum
(p. 521)

Species not treated in detail!

Pleurostomatida I

Volume IV

extrusome warts (arrows) or extrusome seam at dorsal side [1]

present
Loxophyllum

absent

number of macronuclear nodules

contractile vacuoles

more than 2

2

1

2-5

more than 5
Amphileptus

contractile vacuoles

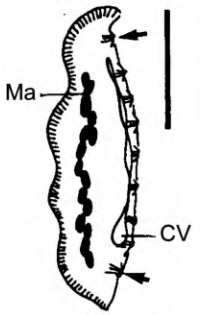
1

2

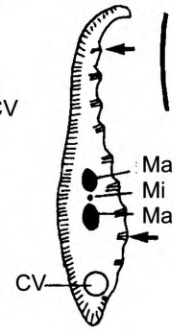
Pleurostomatida II

CV = contractile vacuole
Ma = macronucleus
Mi = micronucleus

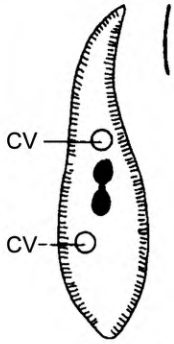
extrusomes



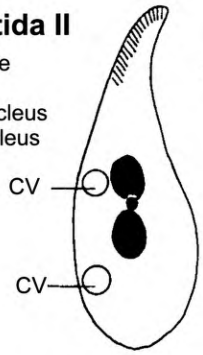
L. meleagris
300-500 µm
(p.354)



L. helus
about 200 µm (p.364)



L. utriculariae
100-170 µm (p.369)



Litonotus varsaviensis
80-150 µm (p.337)

[1] All extrusomes drawn to scale: 10 µm

number of macronuclear nodules; adhesive apparatus

2; absent

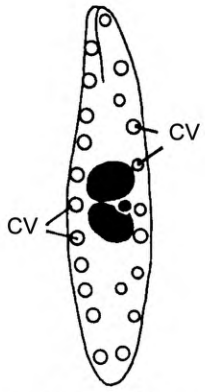
4; present

extrusomes; neck

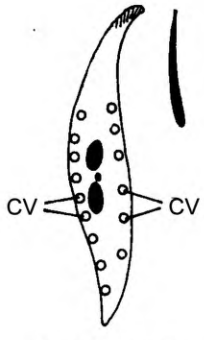
absent; absent

thorn-shaped; short and little extensible

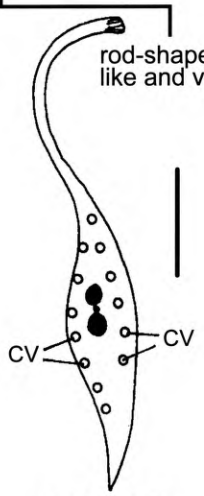
rod-shaped; proboscis-like and very extensible



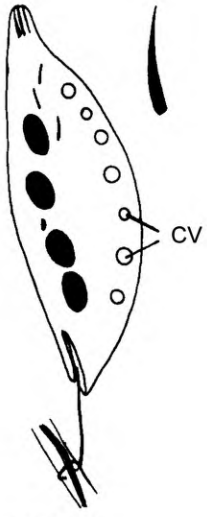
A. claparedii
120-160 µm (p.284)



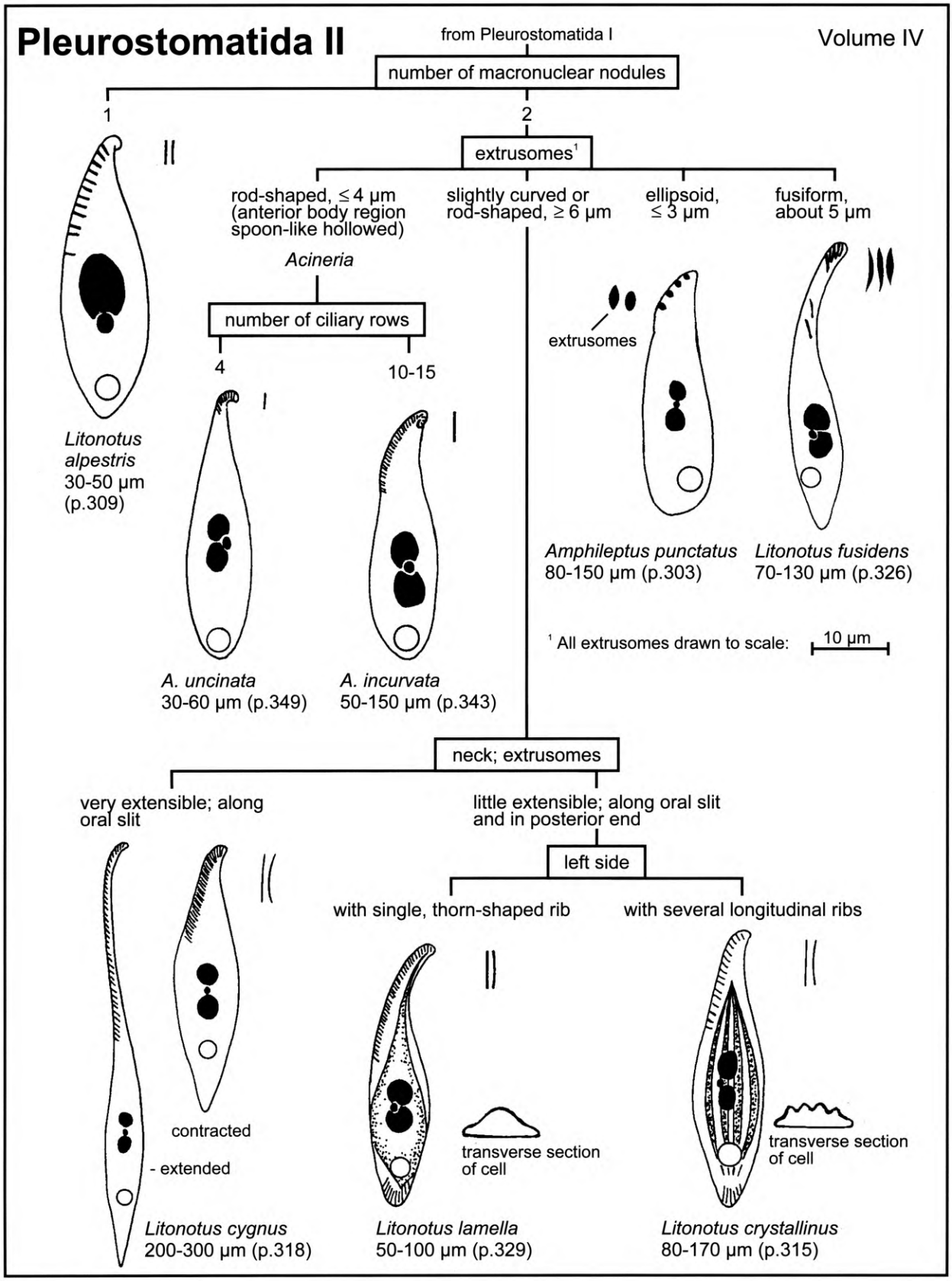
A. pleurosigma
150-300 µm (p.290)

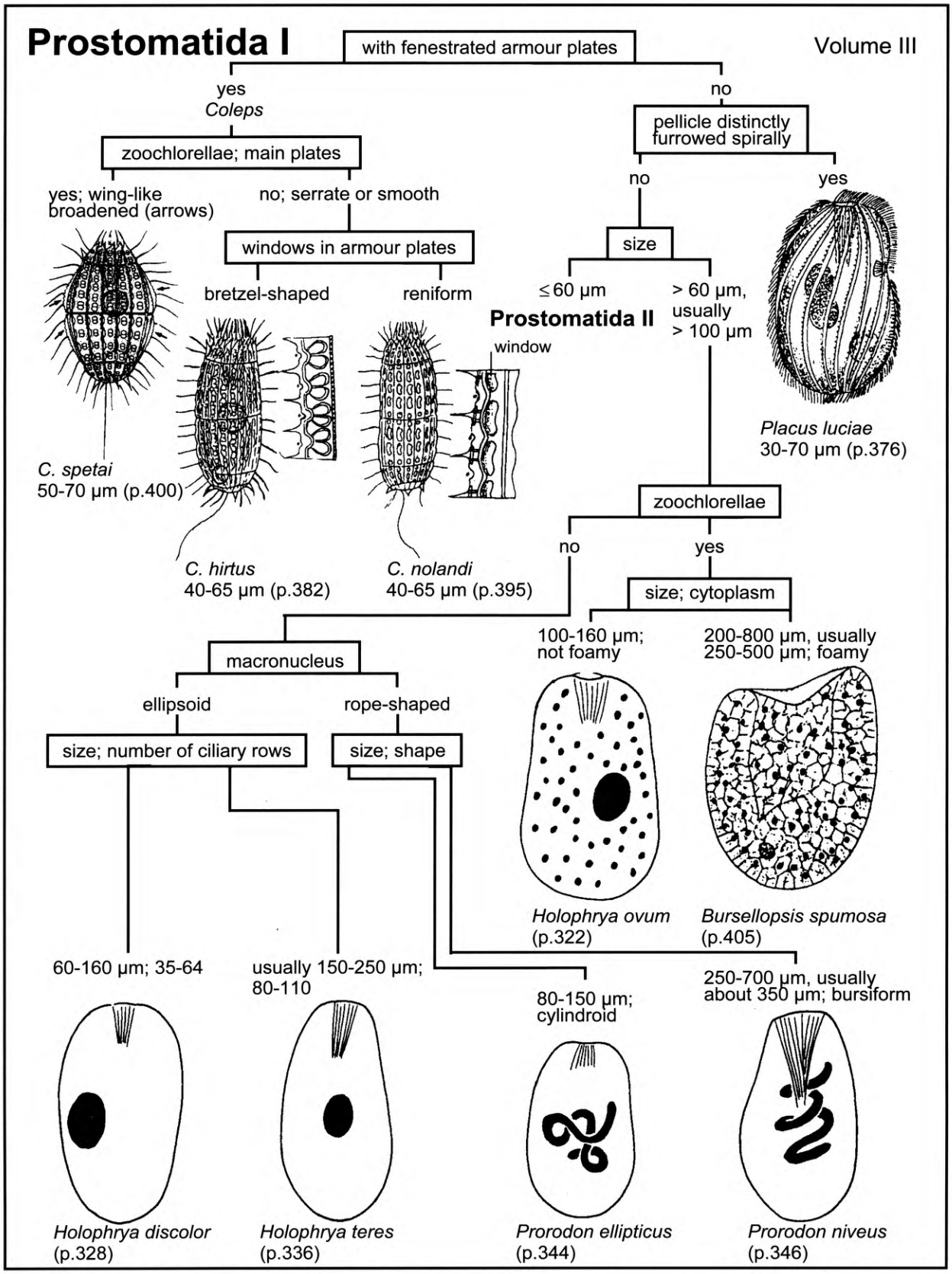


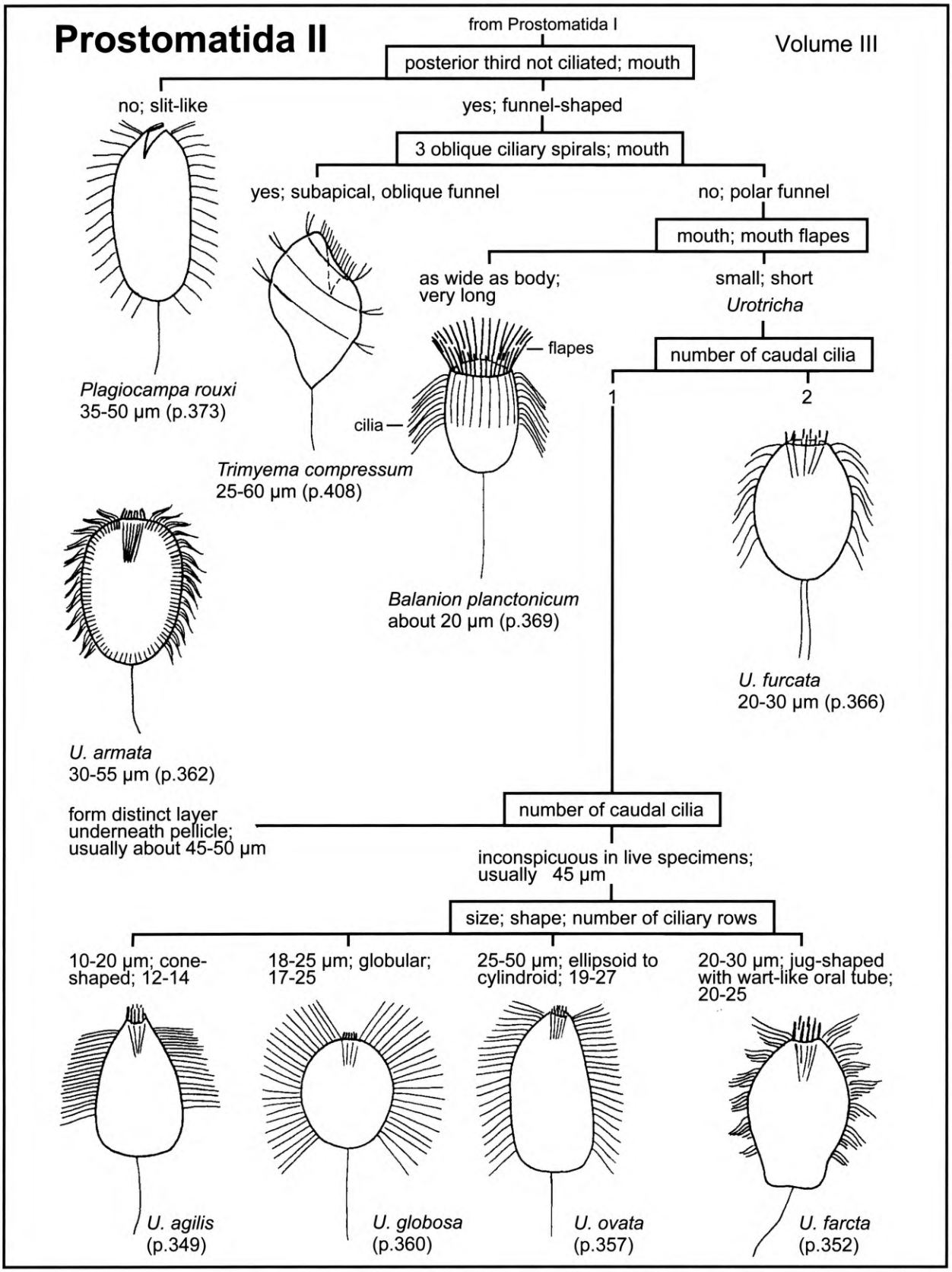
A. procerus
200-800 µm (p.297)



A. carchesii
200-360 µm (p.277)


Pleurostomatida II
from Pleurostomatida I
Volume IV
number of macronuclear nodules
1
2
extrusomes[1]
rod-shaped, ≤ 4 µm (anterior body region spoon-like hollowed)
slightly curved or rod-shaped, ≥ 6 µm
ellipsoid, ≤ 3 µm
fusiform, about 5 µm
Acineria
number of ciliary rows
4
10-15
extrusomes
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)
[1] All extrusomes drawn to scale: 10 µm
neck; extrusomes
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
contracted
- extended
transverse section of cell
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
Volume III
with fenestrated armour plates
yes
Coleps
no
zoochlorellae; main plates
yes; wing-like broadened (arrows)
no; serrate or smooth
windows in armour plates
bretzel-shaped
reniform
pellicle distinctly furrowed spirally
no
yes
size
≤ 60 µm
> 60 µm, usually > 100 µm
Prostomatida II
window
C. spetai
50-70 µm (p.400)
C. hirtus
40-65 µm (p.382)
C. nolandi
40-65 µm (p.395)
Placus luciae
30-70 µm (p.376)
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
Holophrya ovum
(p.322)
Bursellopsis spumosa
(p.405)
60-160 µm; 35-64
usually 150-250 µm; 80-110
80-150 µm; cylindroid
250-700 µm, usually about 350 µm; bursiform
Holophrya discolor
(p.328)
Holophrya teres
(p.336)
Prorodon ellipticus
(p.344)
Prorodon niveus
(p.346)


Prostomatida II
Volume III
from Prostomatida I
posterior third not ciliated; mouth
no; slit-like
yes; funnel-shaped
3 oblique ciliary spirals; mouth
yes; subapical, oblique funnel
no; polar funnel
mouth; mouth flapes
as wide as body; very long
small; short
Urotricha
number of caudal cilia
1
2
flapes
cilia
Plagiocampa rouxi
35-50 µm (p.373)
Trimyema 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
number of caudal cilia
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 cylindroid; 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. farcta
(p.352)

Prostomatida III

Plankton Ciliates

Species identification usually requires live observation and silver impregnation. Study carefully "Comparison with related species"!

fenestrated armour plates and minute spines at rear end

[1] Do not confuse with extrusome fringe!

present

Coleps

absent

zoochlorellae

present

anterior main plates

with 5 windows each, marginal ridge wing-like broadened (arrowheads)

with 4 windows each, marginal ridge not wing-like broadened

absent

windows in armour plates

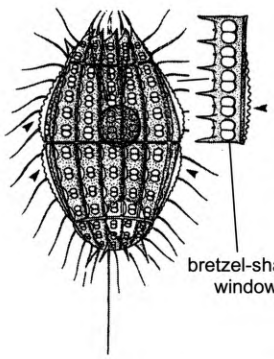
bretzel-shaped

anterior main plates; caudal cilia

with 4 windows each; 1

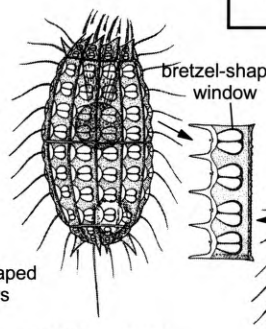
with 5 windows each; 2

reniform



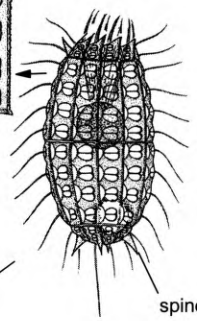
bretzel-shaped windows

C. spetai
50–70 µm
(p. 288)

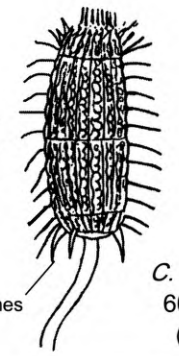


bretzel-shaped window

C. hirtus viridis
40–50 µm
(p. 284)

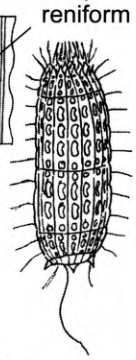


C. hirtus hirtus
40–65 µm
(p. 273)



spines

C. elongatus
60–80 µm
(p. 292)

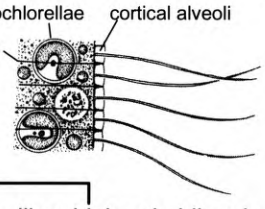


C. nolandi
40–65 µm
(p. 297)

cortex

inconspicuous
Prostomatida IV

conspicuous alveoli form bright fringe [1]
Pelagothrix

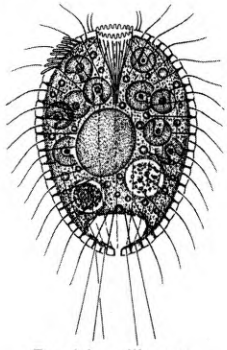


body shape; cross-section; size; extrusomes

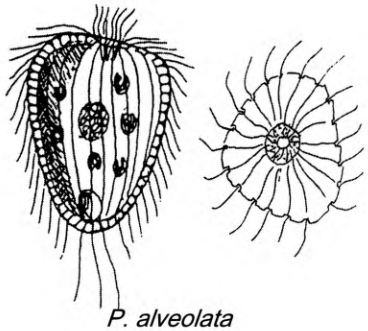
obovoidal; circular; 40–60 µm, present

triangular; triangular; 30–40 µm; absent?

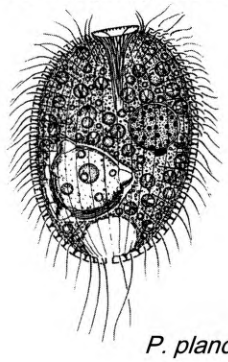
broadly ellipsoidal and obliquely truncate anteriorly; ± circular; 55–100 µm; present



P. chlorelligera
(p. 395)



P. alveolata
(p. 397)
Not treated in detail!



P. plancticola
(p. 401)

Prostomatida IV

Plankton Ciliates

from Prostomatida III

zoochlorellae; size

present; 400–800 µm

absent; ≤250 µm

[1] Species identification needs silver impregnation

size

<50 µm

>50 µm
Prostomatida VI

number of caudal cilia

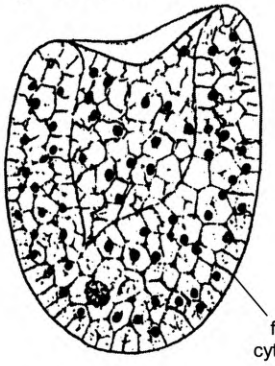
≥3 (usually at least 4)

1 or 2
Prostomatida V

extrusomes

fusiform

rod-shaped



Bursellopsis spumosa
(p. 372)

extrusomes;
ciliary rows

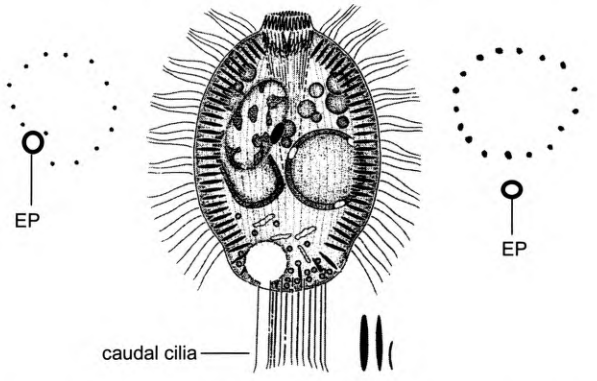
ciliary rows; excretory pore (EP) of contractile vacuole[1]

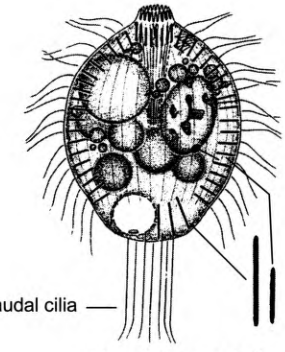
2.5–4.0 µm long;
40–50
Urotricha matthesi

2 size types: somatic ones 3 µm long, those in posterior plug 6 µm long; about 30

51–62; within circle formed by caudal cilia

42–50; outside circle formed by caudal cilia





Urotricha apsheronica
40–75 µm (p. 302)

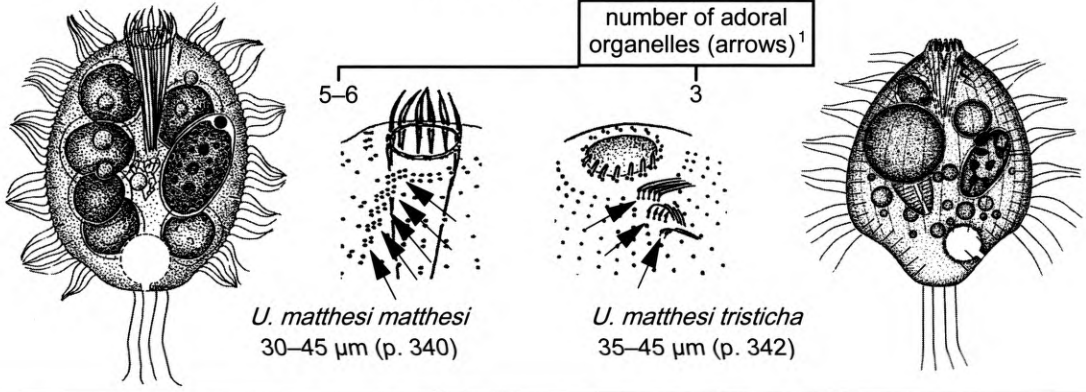
Urotricha pelagica
40–70 µm (p. 309)

Urotricha castalia
30–40 µm
(p. 335)

number of adoral organelles (arrows)[1]

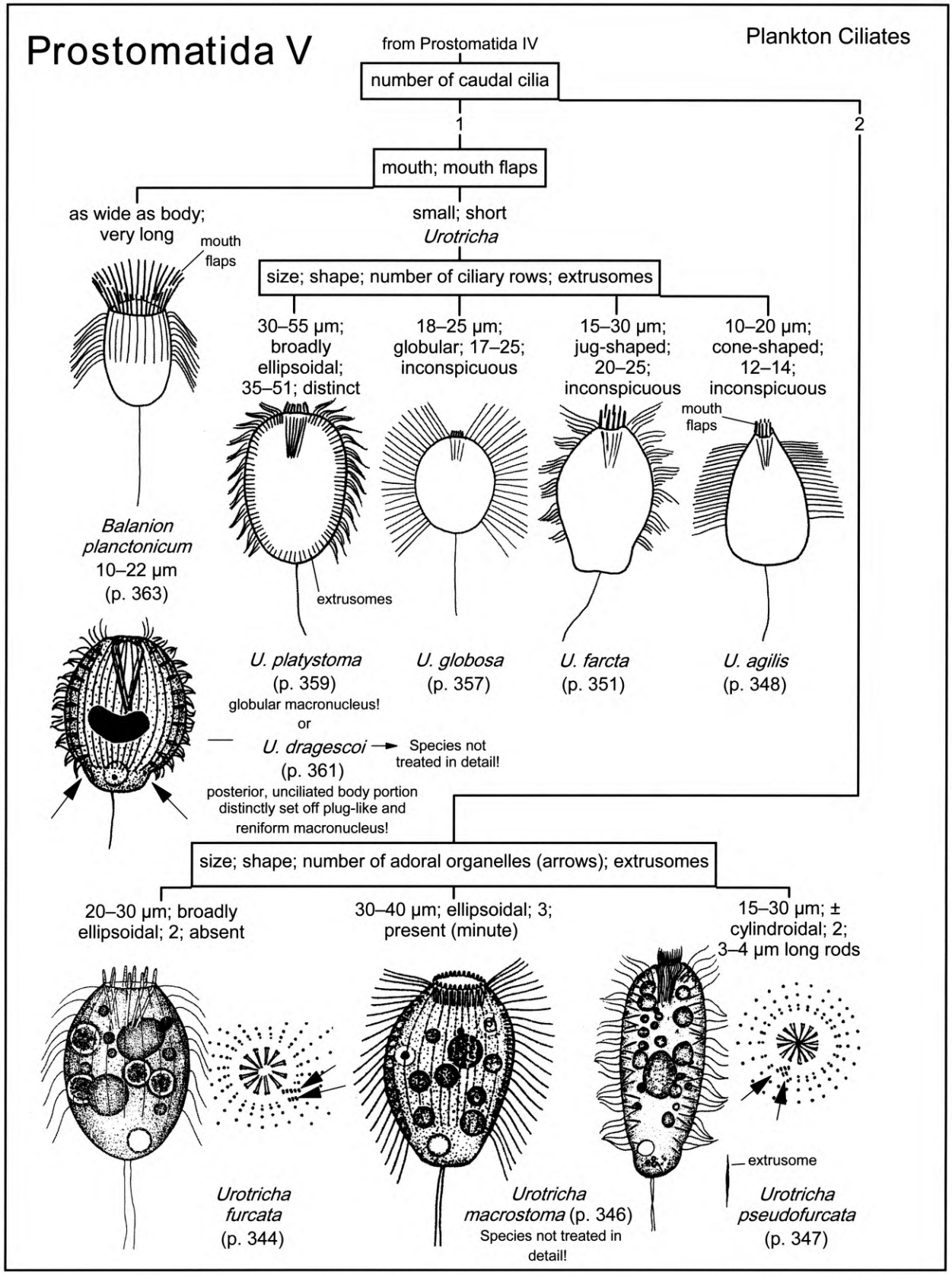
5–6

3



U. matthesi matthesi
30–45 µm (p. 340)

U. matthesi tristicha
35–45 µm (p. 342)


Prostomatida V
Plankton Ciliates
from Prostomatida IV
number of caudal cilia
1
2
mouth; mouth flaps
as wide as body; very long
small; short
Urotricha
mouth flaps
size; shape; number of ciliary rows; extrusomes
30–55 µm; broadly ellipsoidal; 35–51; distinct
18–25 µm; globular; 17–25; inconspicuous
15–30 µm; jug-shaped; 20–25; inconspicuous
10–20 µm; cone-shaped; 12–14; inconspicuous
mouth flaps
Balanion planctonicum
10–22 µm
(p. 363)
extrusomes
U. platystoma
(p. 359)
globular macronucleus!
or
U. dragescoi
(p. 361)
posterior, unciliated body portion distinctly set off plug-like and reniform macronucleus!
Species not treated in detail!
U. globosa
(p. 357)
U. farcta
(p. 351)
U. agilis
(p. 348)
size; shape; number of adoral organelles (arrows); extrusomes
20–30 µm; broadly ellipsoidal; 2; absent
30–40 µm; ellipsoidal; 3; present (minute)
15–30 µm; ± cylindroidal; 2; 3–4 µm long rods
extrusome
Urotricha furcata
(p. 344)
Urotricha macrostoma (p. 346)
Species not treated in detail!
Urotricha pseudofurcata
(p. 347)

Prostomatida VI

AO = adoral organelles = brosse; EP = excretory pore of contractile vacuole; OB = oral basket; UM = undulating membrane

from Prostomatida IV

Plankton Ciliates

oral opening

[1] If in doubt, use brosse (silver impregnation or interference contrast)

inconspicuous

large

shape; caudal cilia

posterior, unciliated body portion plug-like set off from rest of cell; present

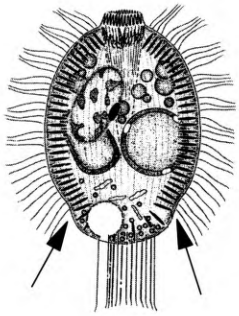
ovoid or globular; present

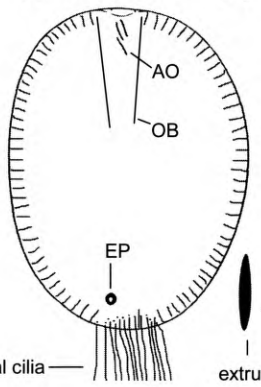
globular; absent

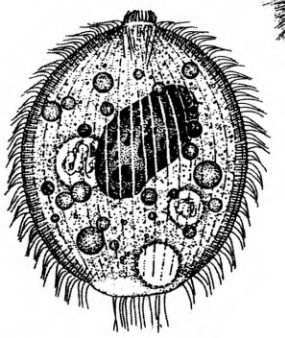
size; ciliary rows

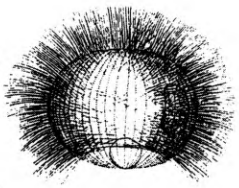
60–120 × 40–80 µm; 98–127 (mean = 106)

55–70 × 45–55 µm; 76–87 (mean = 81)









Longitricha puytoraci about 50 µm (p. 368)

extrusomes fusiform in all species

Urotricha venatrix (p. 315)

Urotricha valida (p. 313)

cilary rows; excretory pore of contractile vacuole

! (footnote 1)

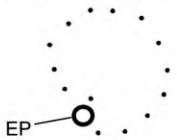
brosse

51–62; within circle formed by caudal cilia

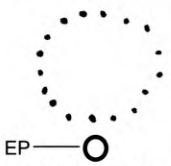
42–50; outside circle formed by caudal cilia

12–20 obliquely arranged short rows

3 ± meridionally arranged, long rows

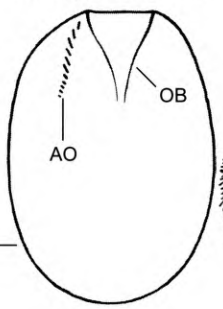


Urotricha apsheronica 40–75 µm (p. 302)

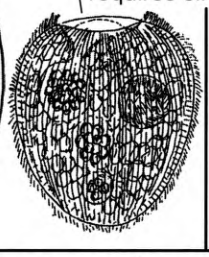


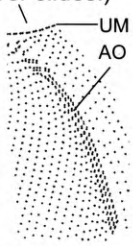
Urotricha pelagica 40–70 µm (p. 309)

Urotricha simonsbergeri 70–120 µm (p. 324)



Bursellopsis (identification difficult, requires silver slides!)





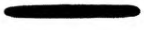
size (in life); ciliary rows (mean, range); oral basal body pairs (mean, range); extrusomes

130–250 µm; 159, 130–198; 121, 97–160; rod-shaped, 10 µm long

100–200 µm; 116, 95–140; 75, 60–98; fusiform, 5–7 µm long

80–180 µm; 90, 85–104; -, 46–60; fusiform, 3–4 µm long

50–110 µm; 60, 52–69; 42, 32–50; fusiform, 2.0–2.5 µm long

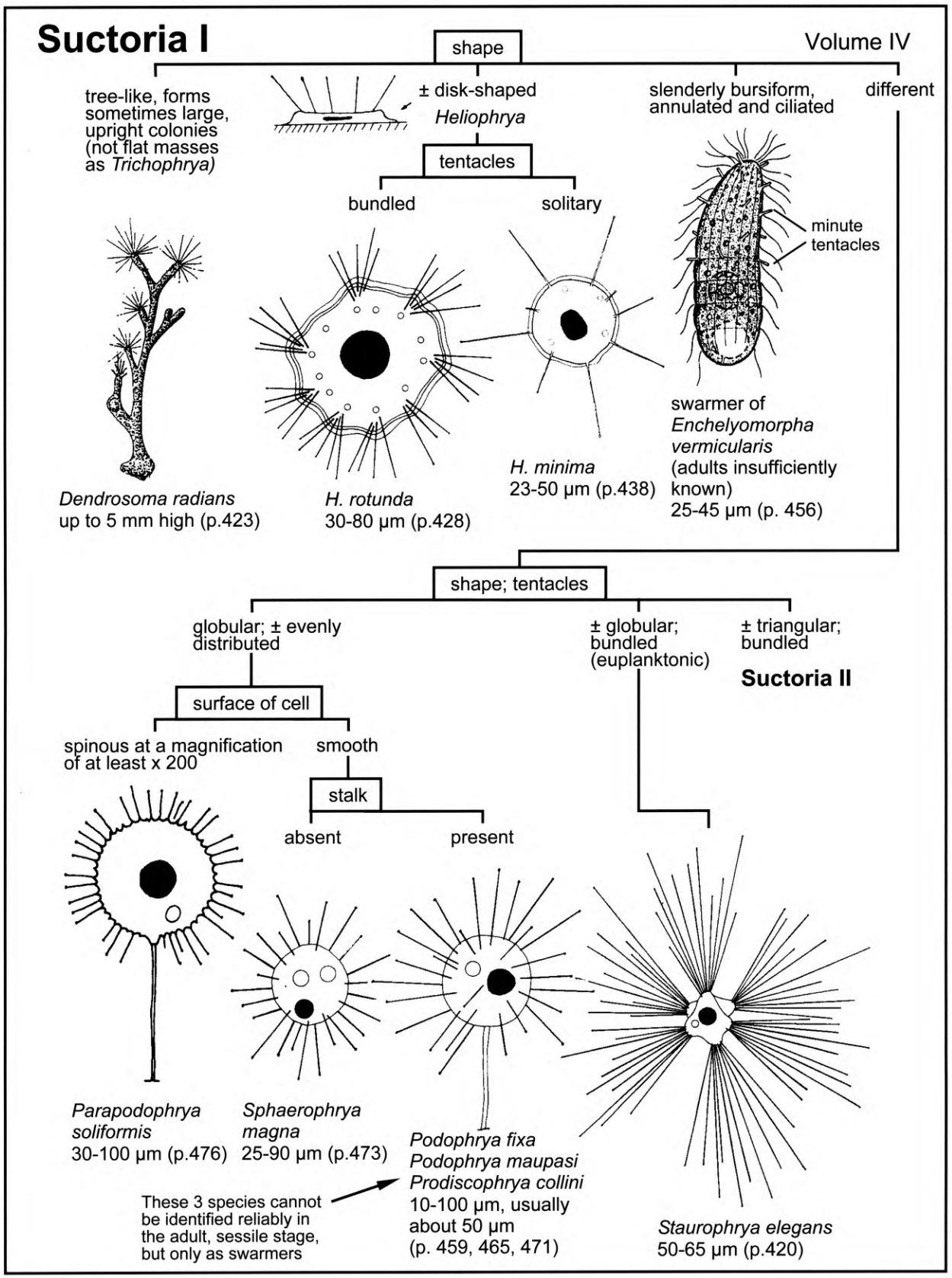


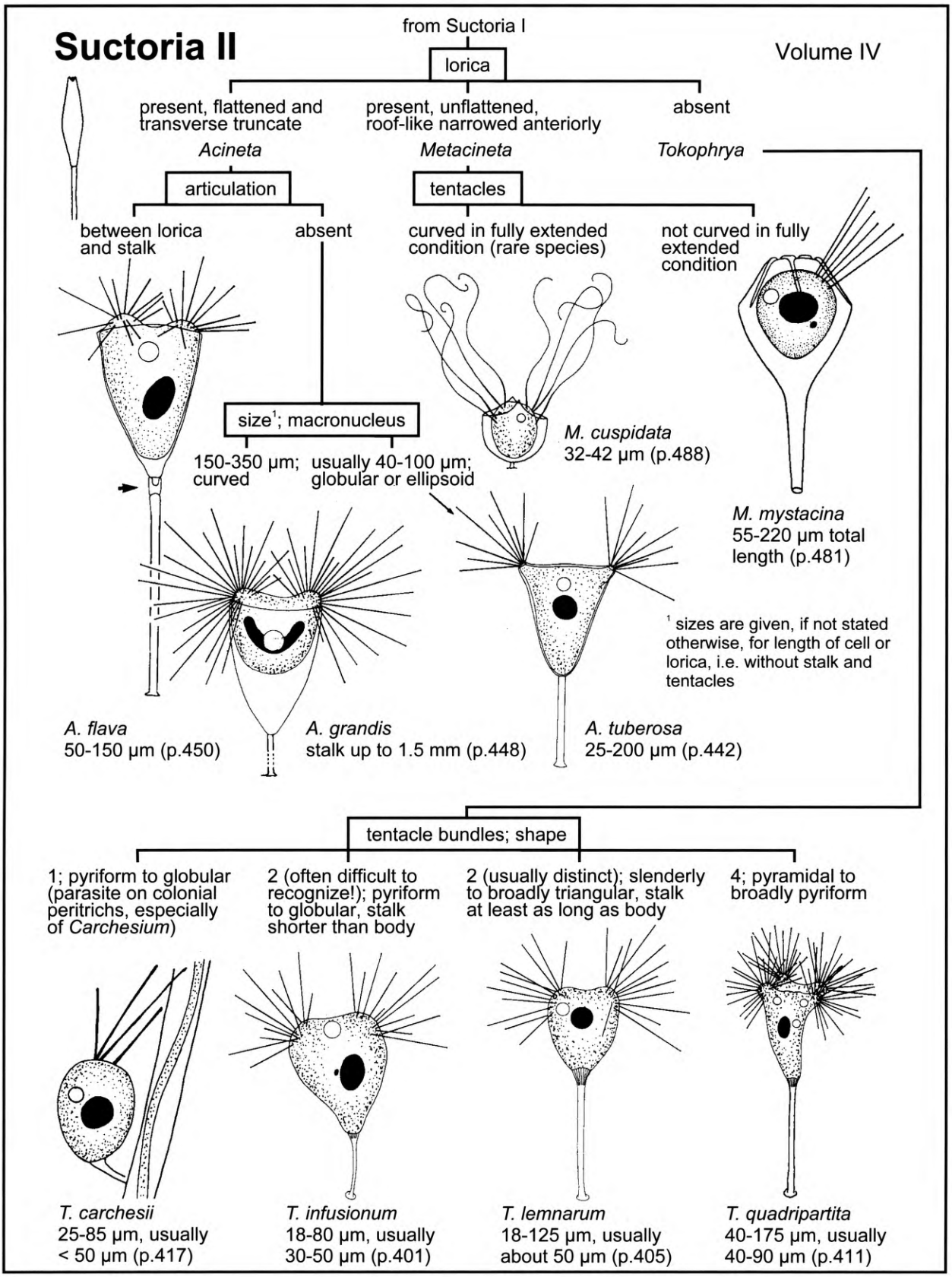
B. pelagica (p. 375)

B. nigricans mobilis (p. 387)

B. nigricans nigricans (p. 383)

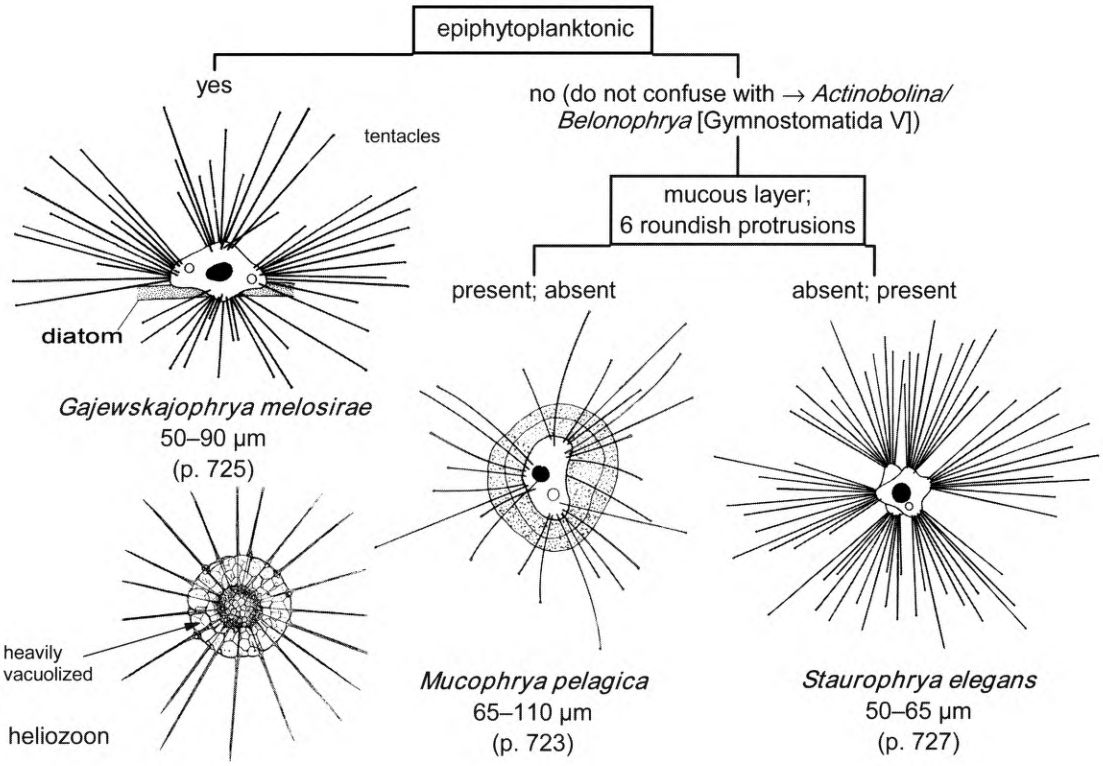
B. truncata (p. 391)


Suctoria I
Volume IV
shape
tree-like, forms sometimes large, upright colonies (not flat masses as Trichophrya)
± disk-shaped
Heliophrya
slenderly bursiform, annulated and ciliated
different
tentacles
bundled
solitary
minute tentacles
Dendrosoma radians
up to 5 mm high (p.423)
H. rotunda
30-80 µm (p.428)
H. minima
23-50 µm (p.438)
swarmer of Enchelyomorpha vermicularis
(adults insufficiently known)
25-45 µm (p. 456)
shape; tentacles
globular; ± evenly distributed
± globular; bundled (euplanktonic)
± triangular; bundled
Suctoria II
surface of cell
spinous at a magnification of at least x 200
smooth
stalk
absent
present
Parapodophrya soliformis
30-100 µm (p.476)
Sphaerophrya magna
25-90 µm (p.473)
Podophrya fixa
Podophrya maupasi
Prodiscophrya collini
10-100 µm, usually about 50 µm
(p. 459, 465, 471)
These 3 species cannot be identified reliably in the adult, sessile stage, but only as swarmers
Staurophrya elegans
50-65 µm (p.420)

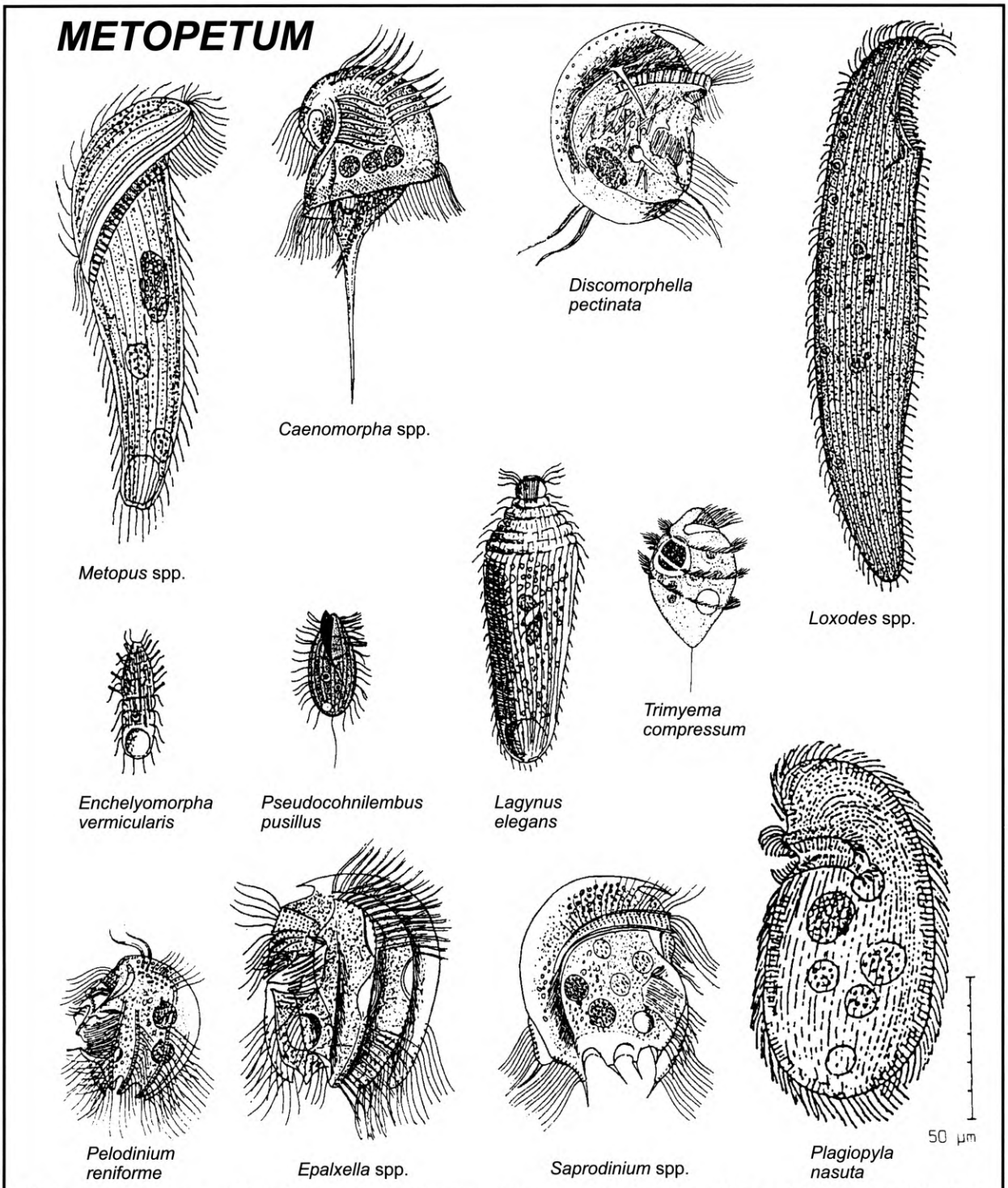

Suctoria II
Volume IV
from Suctoria I
lorica
present, flattened and transverse truncate
present, unflattened, roof-like narrowed anteriorly
absent
Acineta
Metacineta
Tokophrya
articulation
tentacles
between lorica and stalk
absent
curved in fully extended condition (rare species)
not curved in fully extended condition
size[1]; macronucleus
150-350 µm; curved
usually 40-100 µm; globular or ellipsoid
M. cuspidata
32-42 µm (p.488)
M. mystacina
55-220 µm total length (p.481)
[1] sizes are given, if not stated otherwise, for length of cell or lorica, i.e. without stalk and tentacles
A. flava
50-150 µm (p.450)
A. grandis
stalk up to 1.5 mm (p.448)
A. tuberosa
25-200 µm (p.442)
tentacle bundles; shape
1; pyriform to globular (parasite on colonial peritrichs, especially of Carchesium)
2 (often difficult to recognize!); pyriform to globular, stalk shorter than body
2 (usually distinct); slenderly to broadly triangular, stalk at least as long as body
4; pyramidal to broadly pyriform
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)

Plankton Ciliates

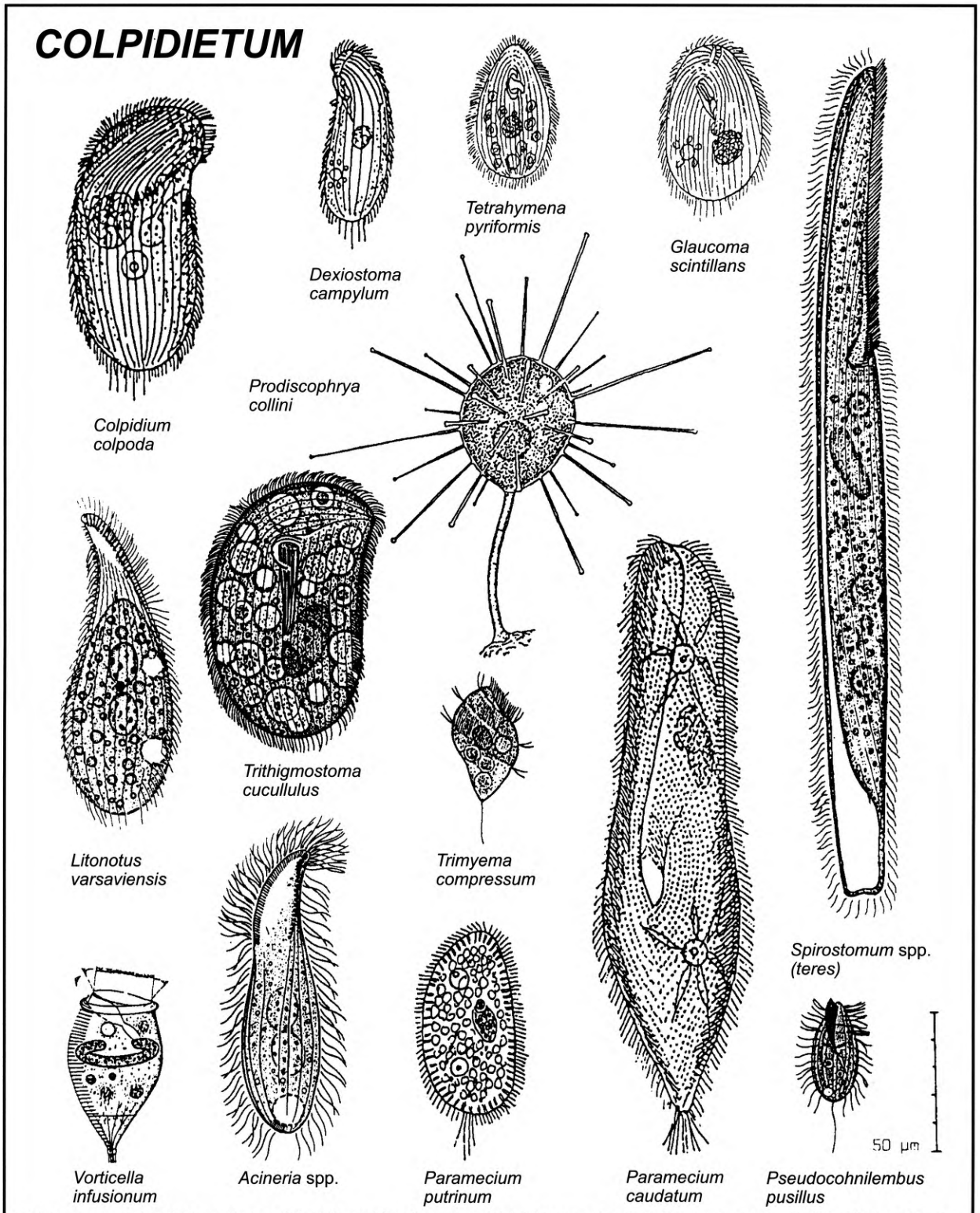
Suctoria III (very likely, many epiphytoplanktonic and parasitic species have not yet been described)



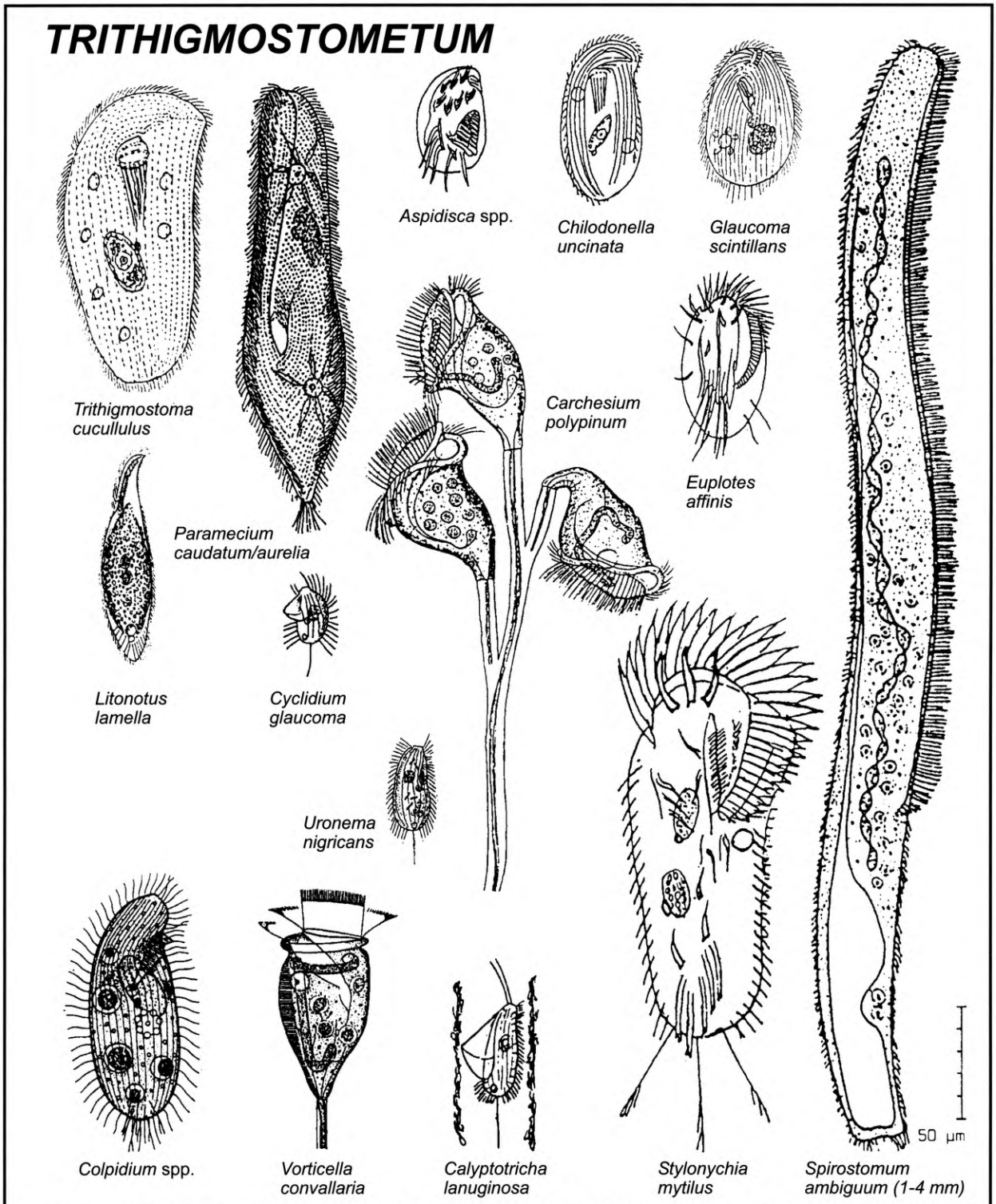
7 Ciliate communities, an important aid for water quality evaluation



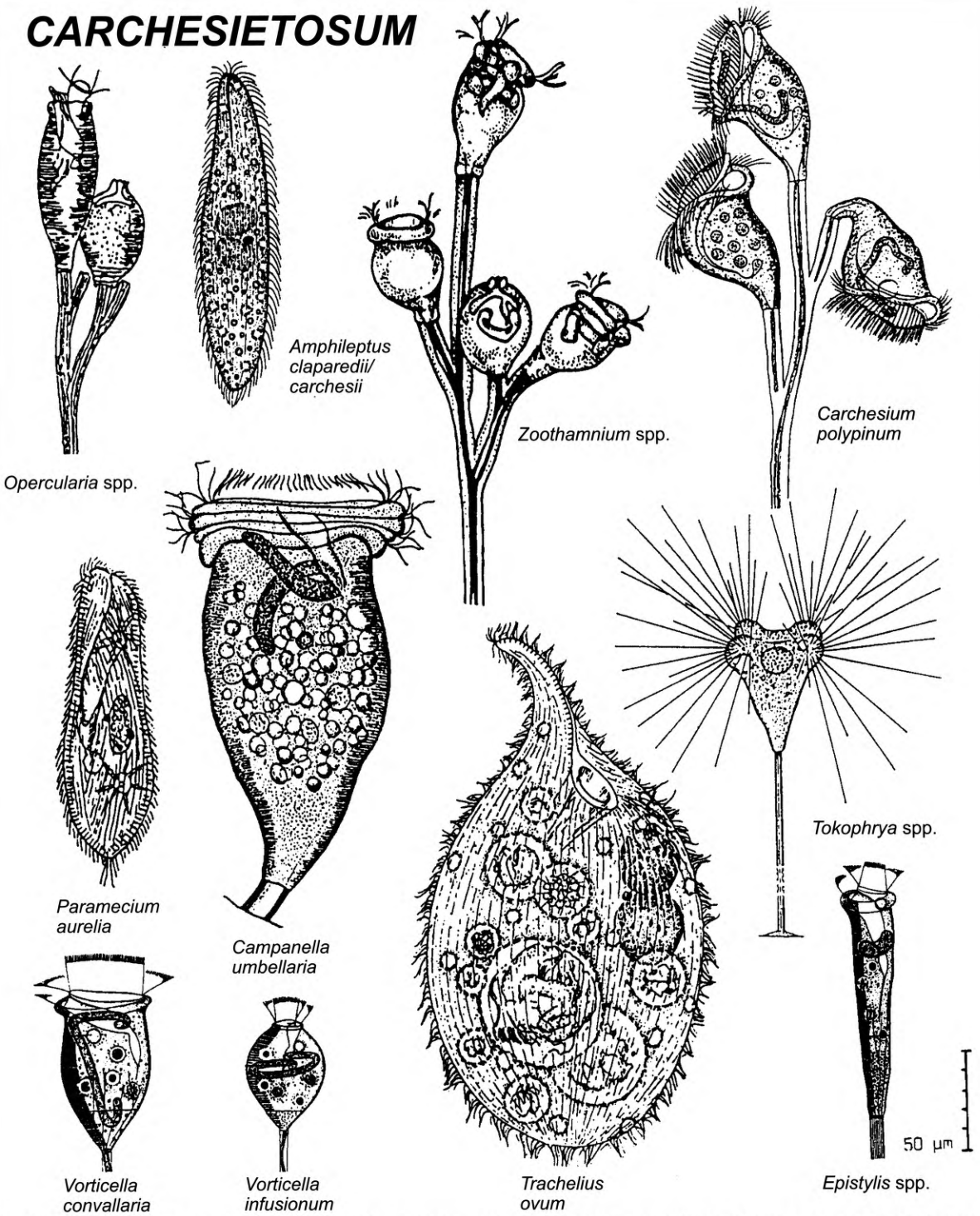
Ciliate community of anaerobic mud (*Metopetum*). Indicator species are members of the genus *Metopus* (s.l.) and certain heterotrichs (all described in Vol. II). Most of the species belonging to the *Metopetum* are strictly bound to anaerobic conditions, i.e. oxygen is poisonous for them; they do not have mitochondria but hydrogenosomes and tolerate the richly occurring H_2S 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.



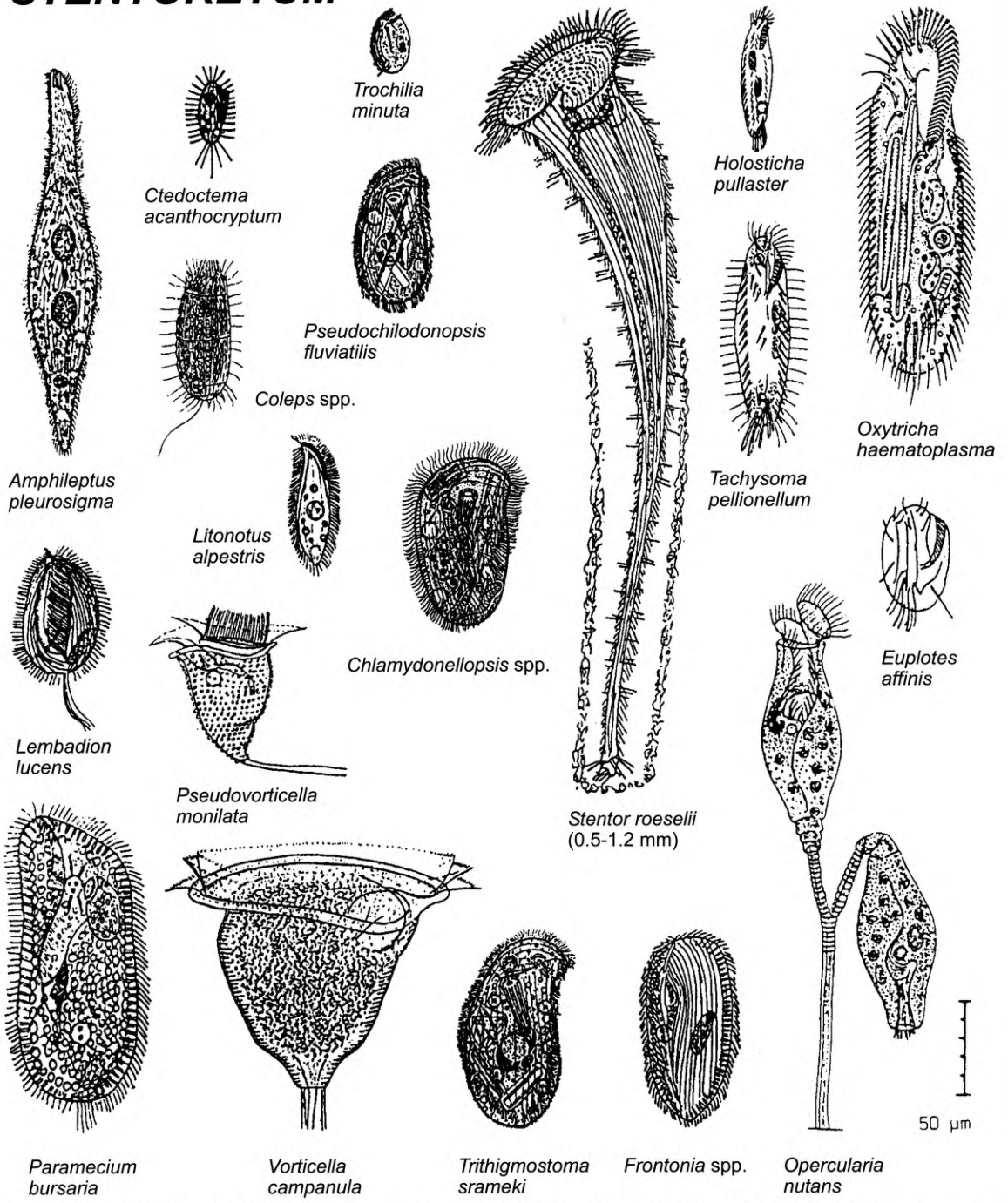
Ciliate community of the polysaprobic self-purification zone *(Colpidietum colpodae)*. Indicator species is *Colpidium colpoda*, a hymenostome ciliate (Vol. III). Decomposition is very intensive in this zone and dissolved oxygen is thus usually almost depleted. Few ciliate species (usually < 25 in a sample) occur, although, some are in great numbers. Most feed on bacteria, which are very abundant. Scale bar division 10 µm.



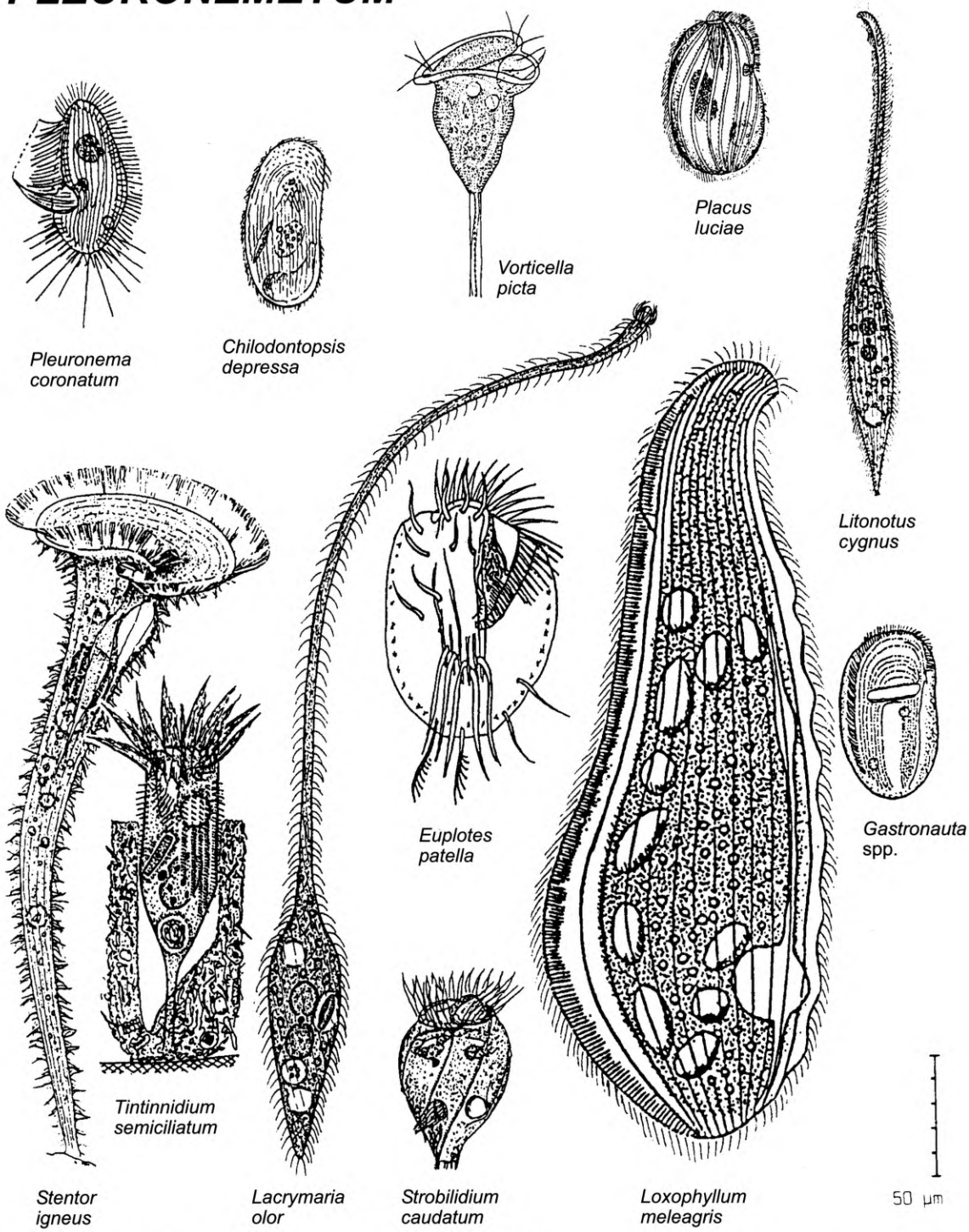
Ciliate community of the alpha-mesosaprobic self-purification zone *(Trithigmostometum cucullulae)*. Indicator species is *Trithigmostoma cucullulus*, a cyrtophorid ciliate (Vol. I). Rather many ciliate species (up to 50 in a sample) occur already in this zone, some have high or very high abundances. Especially conspicuous are peritrichs (*Carchesium polypinum*, *Epistylis* spp., *Vorticella* spp.), which often form greyish lawns recognizable with the naked eye on the bottom side of stones and/or on submersed macrophytes (see also *Carchesietosum*, the sessile portion of the *Trithigmostometum*). Bacteria feeders still dominate. Scale bar division 10 µm.



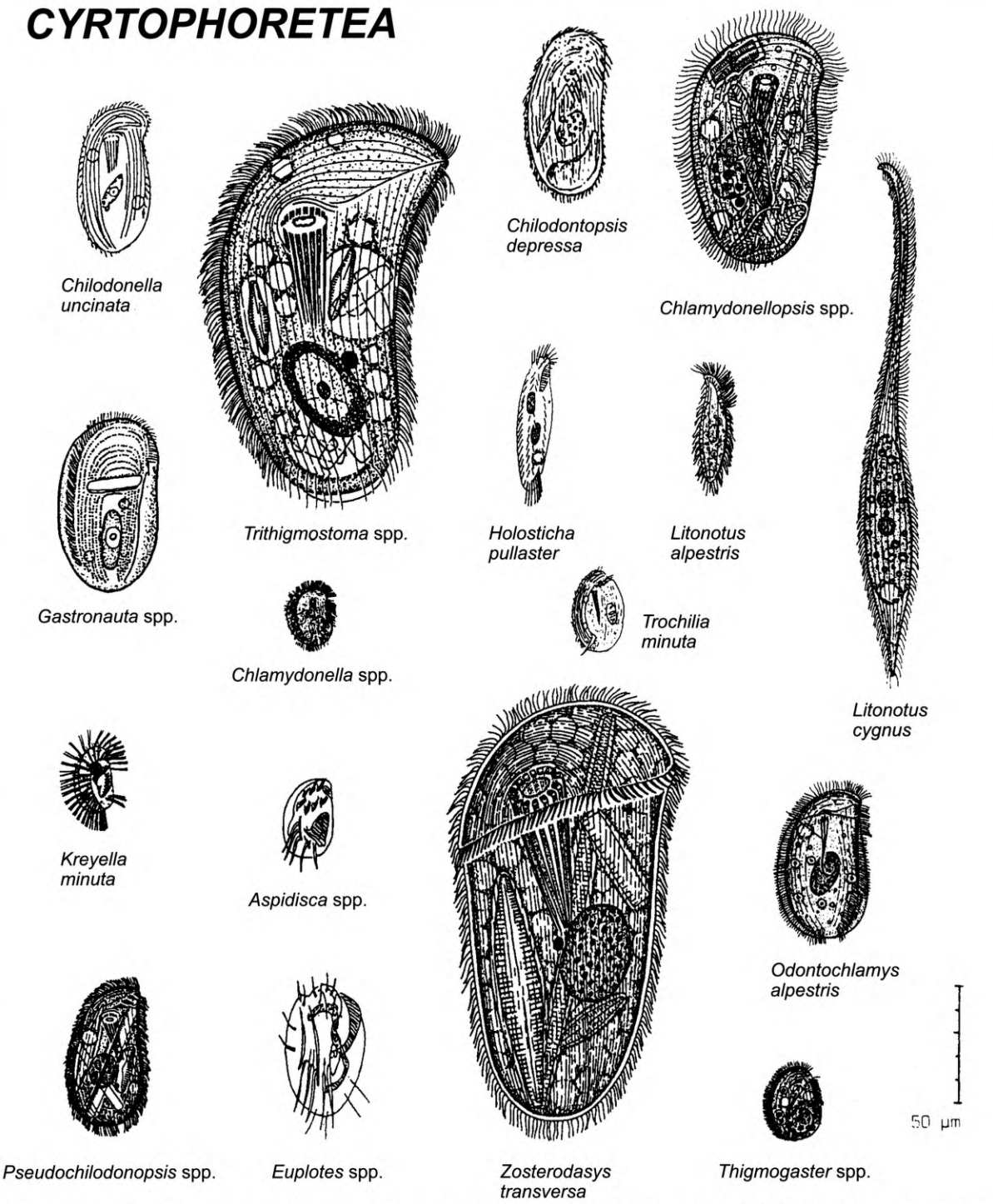
Peritrich community (*Peritrichetea*) of the alpha-mesosaprobic *Trithigmostometum* (*Carchesietosum polypinae*). Typically, this sessile subassociation of the *Trithigmostometum* develops downstream from the effluent of waste water treated only mechanically or in insufficiently operating activated sludge 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 submersed 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.



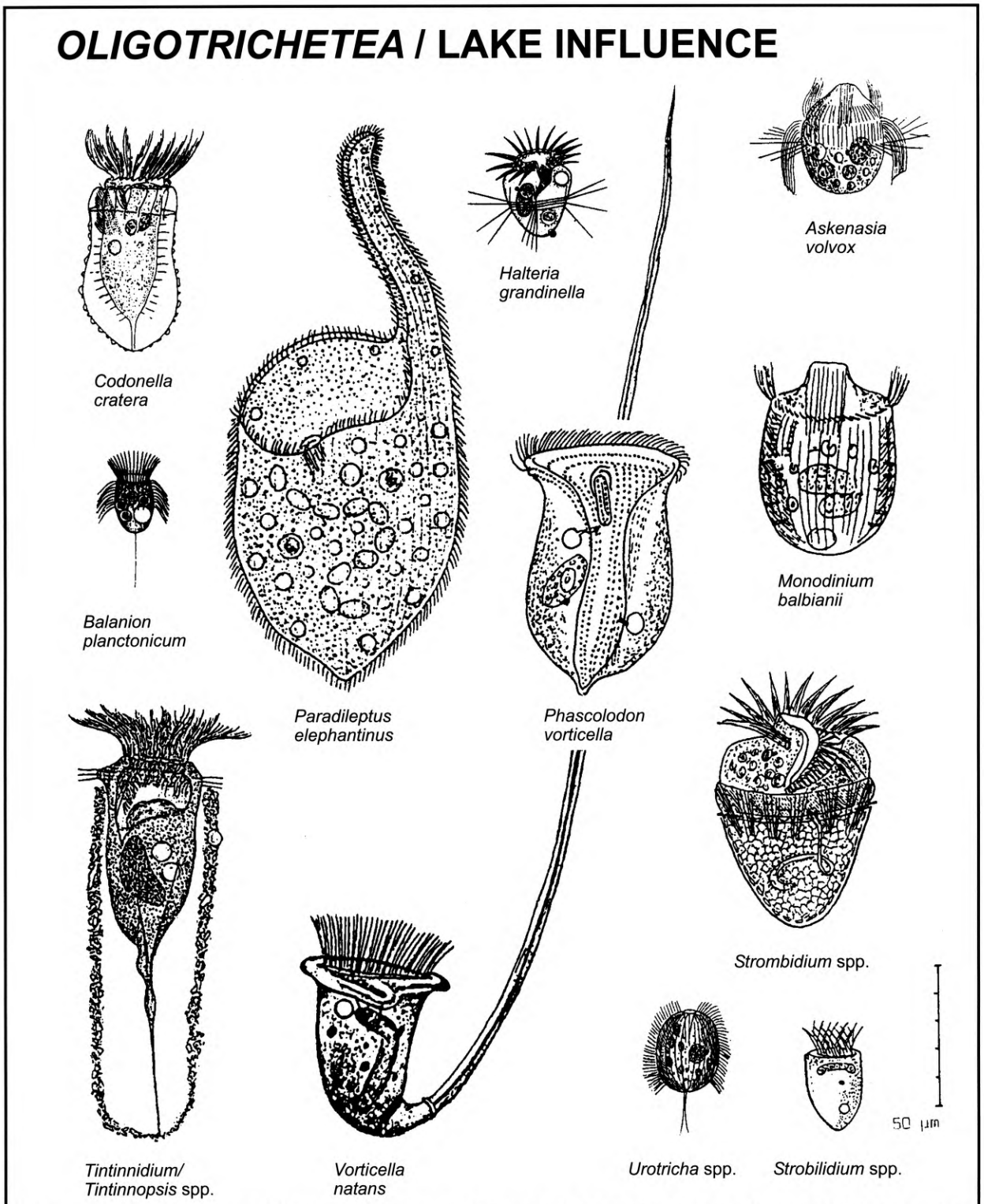
Ciliate community of the beta-mesosaprobic to alpha-mesosaprobic self-purification (transition) zone (*Stentoretum*). This is the most species rich (often more than 60 in a sample) zone in a self-purification reach. The total abundance of the ciliates is still high, but lawns recognizable with the naked eye are rare. All feeding types are present. Main indicator is the heterotrich ciliate *Stentor* (Vol. II), especially *S. roeselii*, 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 gasterosteus*, *Holosticha monilata*, *Opercularia articulata*, *Spirostomum minus*, *Vorticella aquadulcis*-complex, and *Zoothamnium* spp. Scale bar division 10 µm.



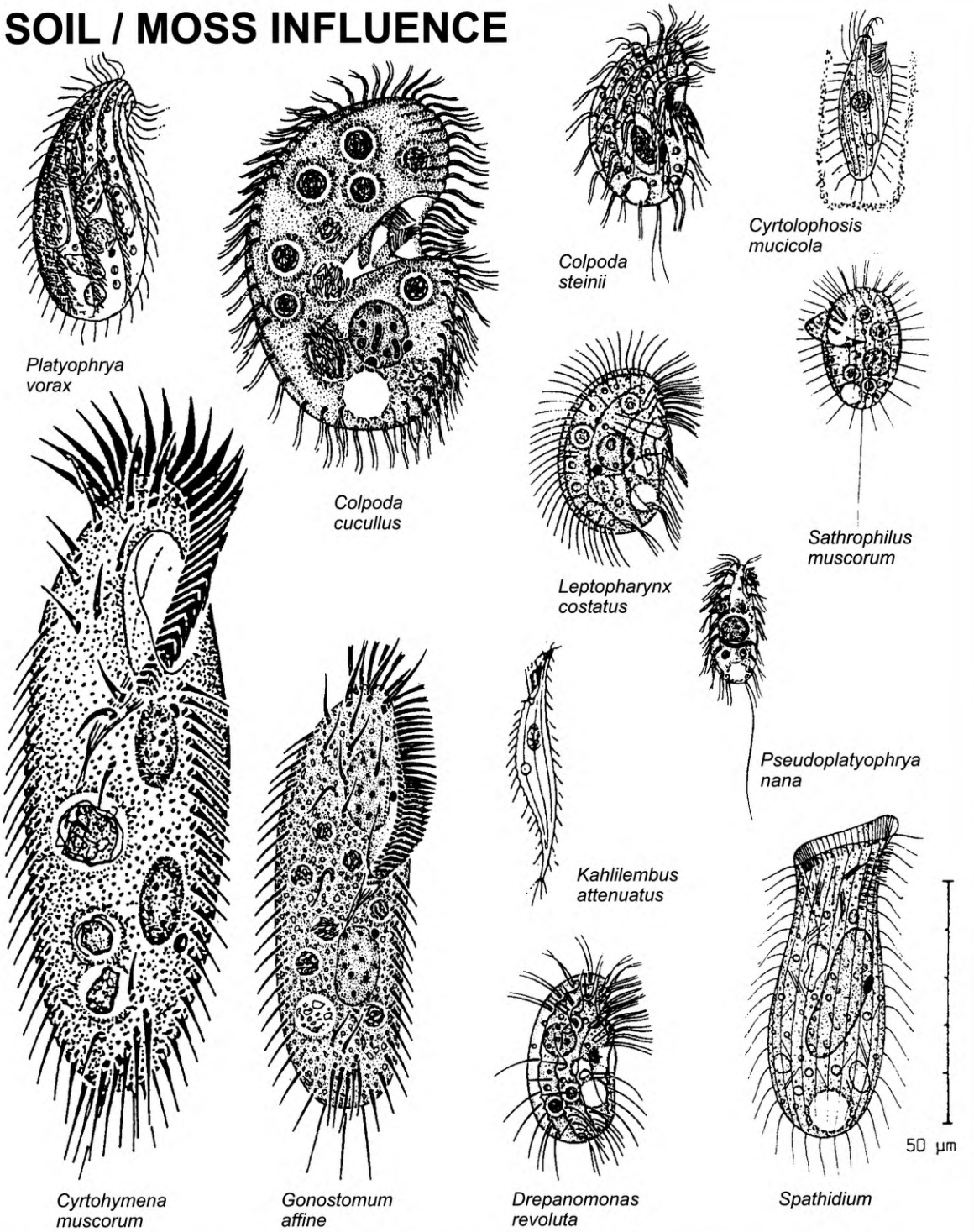
Ciliate community of the beta-mesosaprobic self-purification zone (*Pleuronemetum coronatae*). Indicator species is *Pleuronema coronatum*, a hymenostome ciliate (Vol. III) which is highly frequent and sometimes also rather abundant. The ciliate community is very diverse, but often less than 25 taxa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



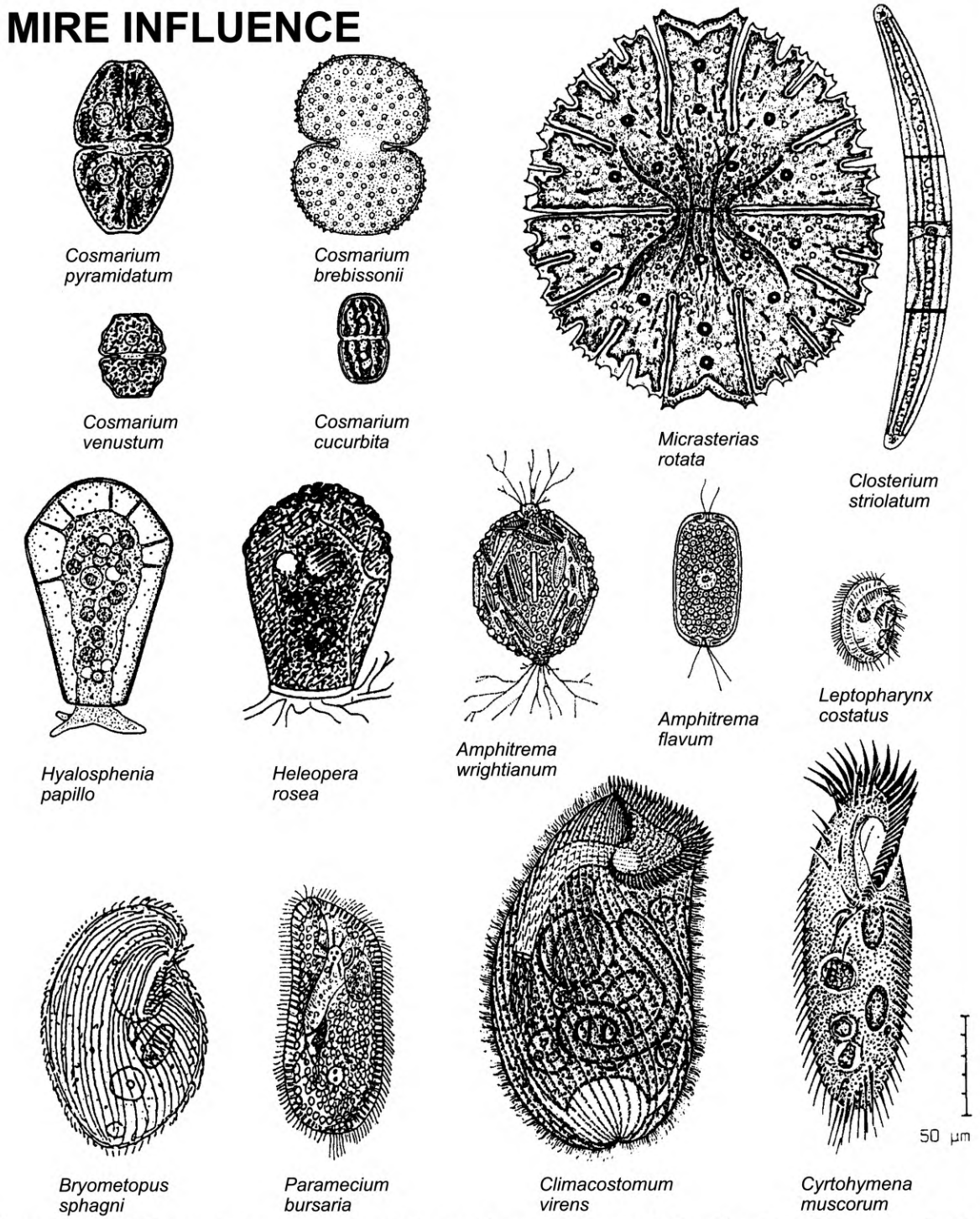
Ciliate community of the vagile periphyton (*Cyrtophoretea*). Cyrtophorid ciliates (Vol. I) are a highly characteristic and usually also very abundant component of the vagile periphyton (Aufwuchs), which preferably develops in spring in oligosaprobic to mesosaprobic, diatom-rich streams. Typical accessory species are, in addition to some aberrant nassulids (*Chilodontopsis depressa*, *Zosterodasys transversa*) and colpodids (*Kreyella minuta*, *Pseudochlamydonella rheophila*), hypotrichs (e.g., *Stylonychia* spp., *Tachysoma pellionellum*, *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.



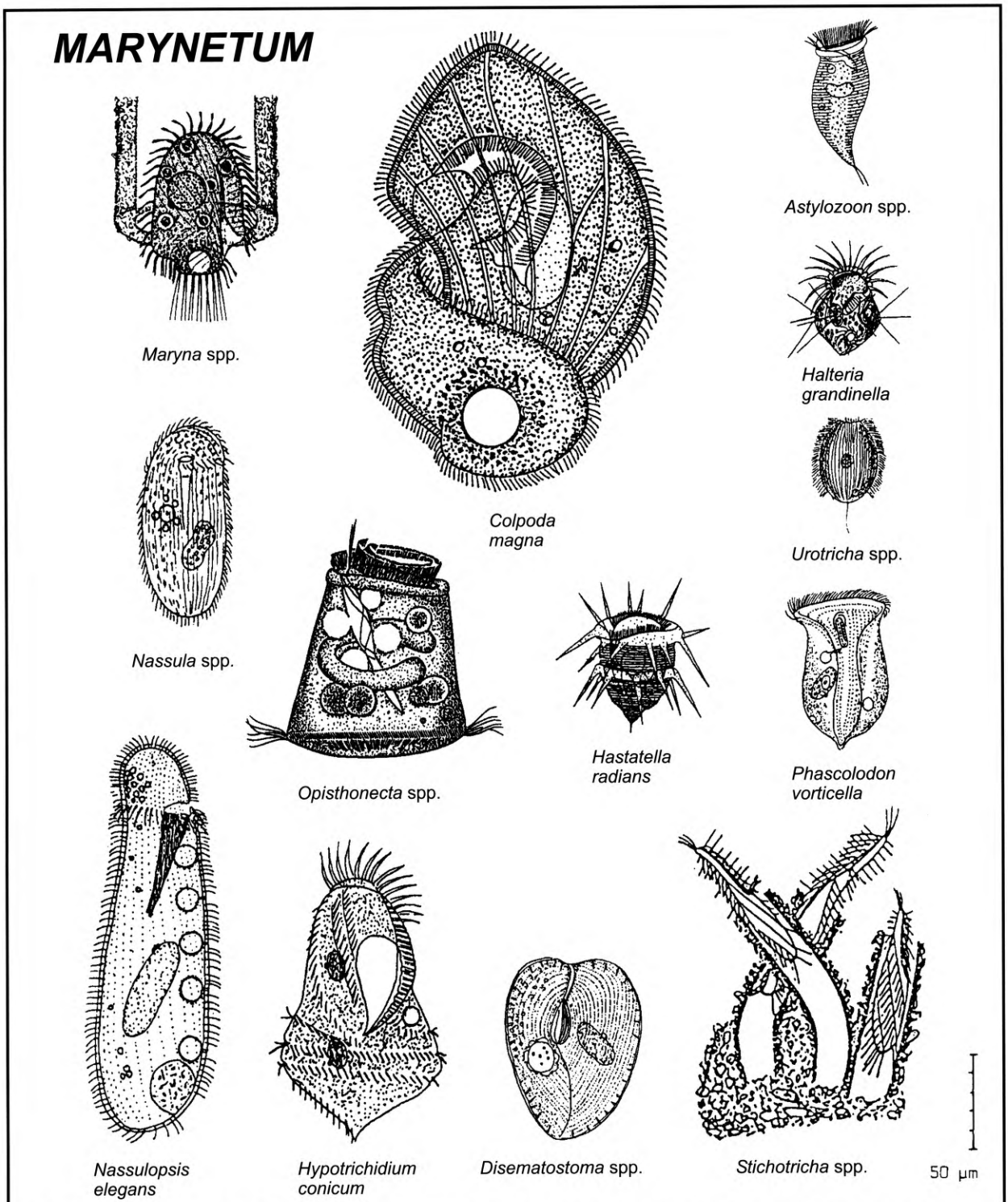
Ciliate community of the pelagial (*Oligotrichetea*). An increased occurrence of oligotrich ciliates (Vol. I, Plankton book) is characteristic for stagnant waters (e.g. lakes, impounding basins) and large, slowly flowing rivers. However, euplanktonic species occur also in most other groups of ciliates (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.



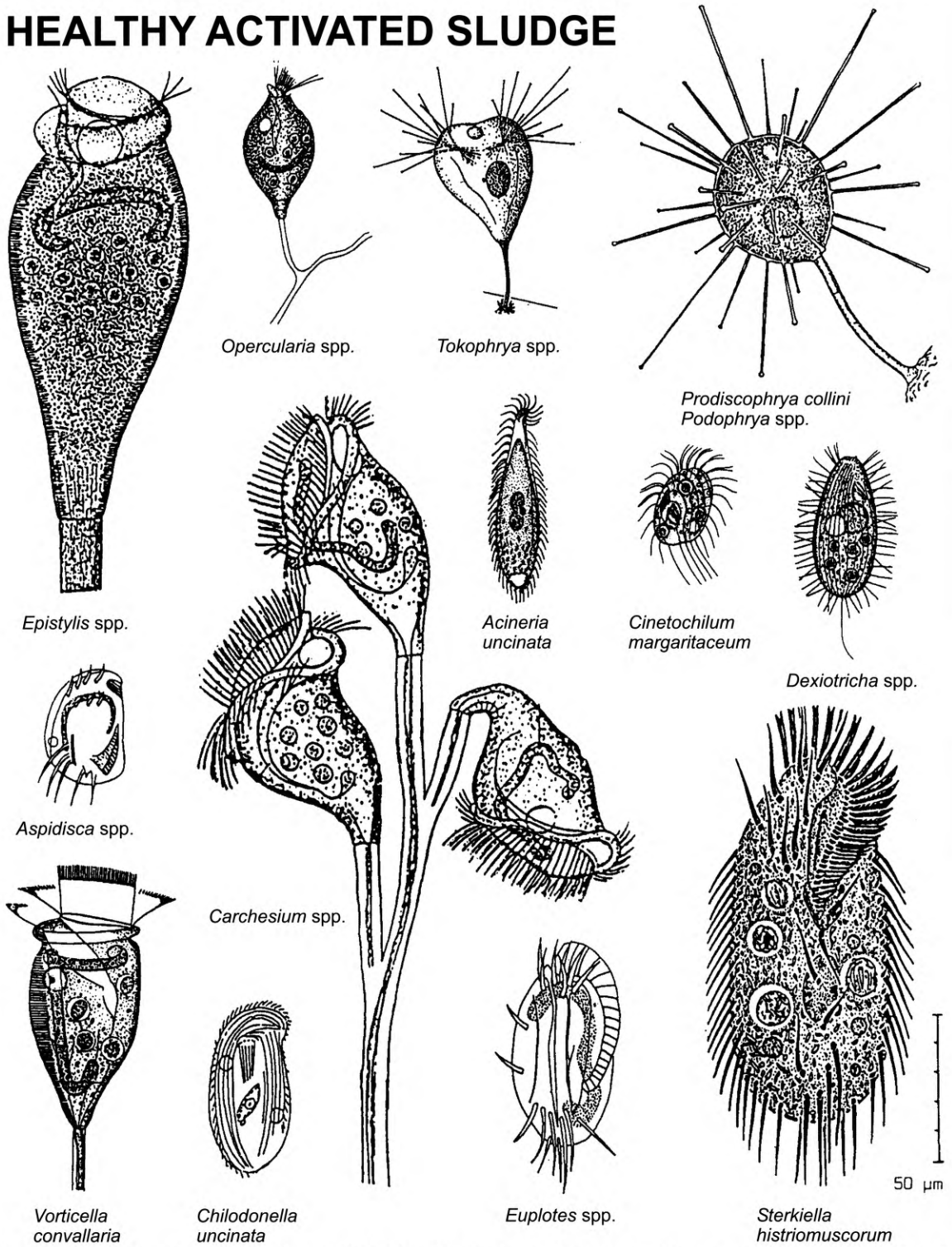
Indicators for terrestrial influence. A highly specific ciliate community lives in soil and moss (Foissner 1987). Only about 20% of the species occur in both terrestrial and limnetic biotopes. Some of these opportunists have been classified saprobiologically and are shown on this plate. Only if several 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.



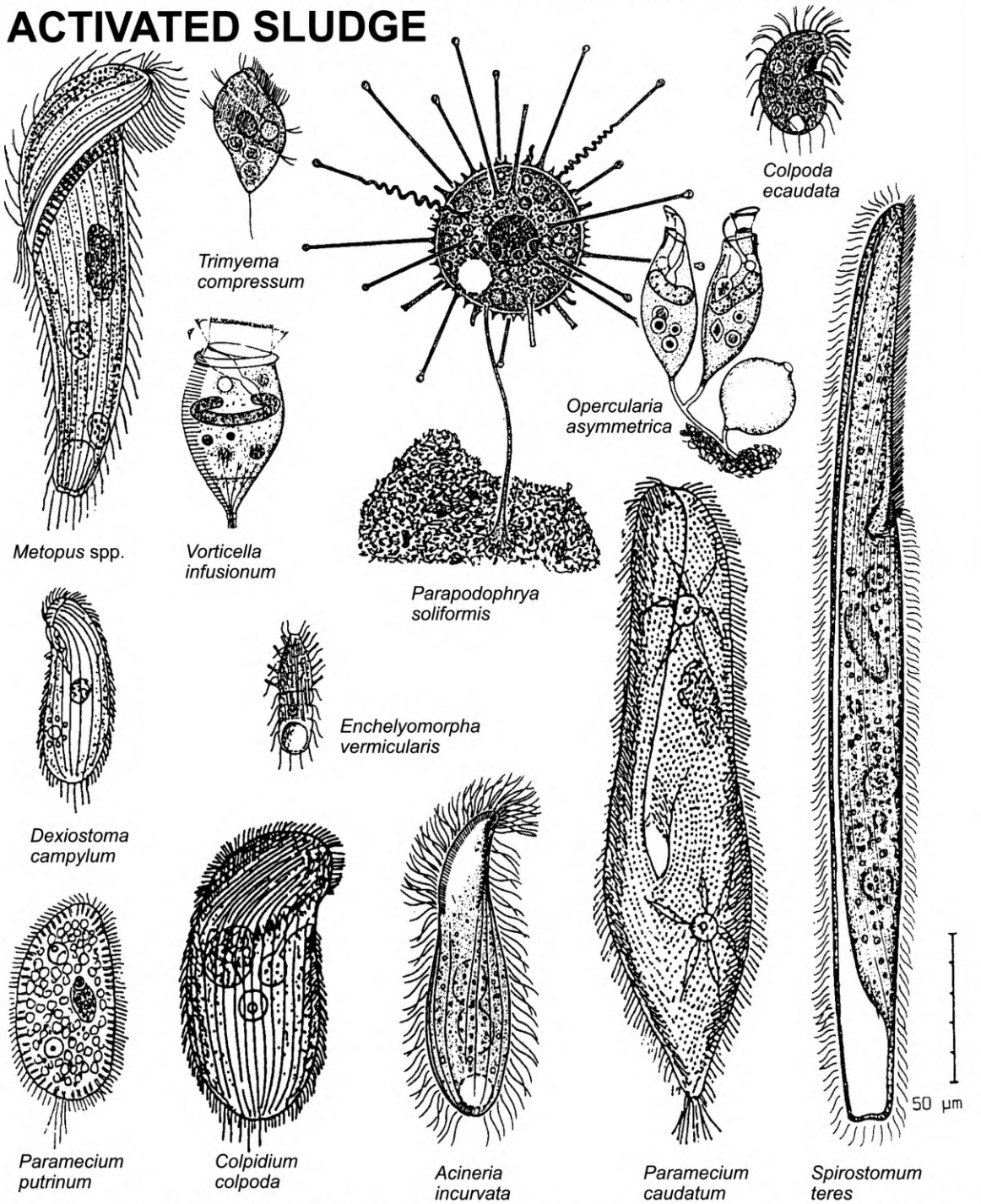
Indicators for mire influence. An increased number of mire-specific organisms, especially desmids and testate amoebae, is found in streams and rivers, which receive water from mires and/or moorlands and are not too heavily polluted. The ciliates from such usually acidic biotopes are still poorly explored. Groliere (1978) selected some characteristic species in French mires, viz. *Cyclidium sphagnetorum*, *Bryometopus sphagni*, *Vorticella muralis*, → *Leptopharynx costatus*, and → *Climacostomum virens*. Typical associates are: *Keronopsis wetzeli*, → *Urotricha ovata*, *Blepharisma musculus*, *Spathidium amphoriforme*, → *Holosticha monilata*, *Furgasonia protectissima*, *Histriculus sphagni*, and *Blepharisma sphagni*. Only few of these species are classified saprobiologically (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 mucuous 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.



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, Trimyema*) 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.

8 Ecological summary of the species contained (Table)

Table 1 is a compilation of tables contained in FOISSNER et al. (1995, 1999). It orientates about live biomass (and thus much more useful than many literature data based on preserved and stored specimens), food (many species likely have a broader range), salinity tolerance, preferred water and habitat type, community allocation, and saprobic classification (re-assessed in the monographs cited and thus sometimes different from that contained in the key works by SLÁDEČEK (1973) and SLÁDEČEK et al. (1981).

Table 1: Ecological characterization of the species described in the Ciliate Atlas (FOISSNER et al. 1991, 1992, 1994, 1995) and the plankton book (FOISSNER et al. 1999). **a** = alphamesosaprobic, **A** = Aufwuchs (periphyton), **Al** = algae (except of diatoms, but inclusive autotrophic flagellates), **b** = betamesosaprobic, **B** = benthal, **Ba** = bacteria, **Bo** = terrestrial (mostly wetland) soils, **BOD** = influence of soil and/or moss, **C** = ciliates, **CAR** = Carchesietosum polypinae, **COL** = Colpidietum colpodae, **Cy** = cyanobacteria, **CYR** = Cyrtophoretea, **e** = eurysaprobic, **EP** = eupelagic, **ECP** = epiplanktonic on cyanobacteria, **EPP** = epiphytoplanktonic, **EZB** = epizoobenthic, **EZP** = epizooplanktonic, **F** = flowing waters, **Fl** = heteotrophic flagellates, **Fs** = anaerobic mud (and anaerobic zones in the pelagial), **h** = histophagous, **HBE** = high-load and/or oxygen deficient activated sludge, **he** = holo-euryhaline, **i** = isosaprobic, **K** = sewage-treatment works (activated sludge plants), **Ki** = diatoms, **m** = metasaprobic, **M** = mixotrophic, that is, autotrophic (due to symbiotic algae or sequestered chloroplasts) and heterotrophic, **MAR** = Marynetum, **MET** = Metopetum, **MOO** = mire influence, **mpe** = meso- to poly-euryhaline, **mps** = meso- to poly-stenohaline, **NBE** = normal activated sludge, **O** = omnivorous (feeds on autotrophic and heterotrophic protists, sometimes even on small metazoans), **o** = oligosaprobic, **oe** = oligo-euryhaline, **OLI** = Oligotrichetea (lake influence), **ome** = oligo- to meso-euryhaline, **oms** = oligo- to meso-stenohaline, **os** = oligo-stenohaline, **p** = polysaprobic, **P** = pelagial, **pe** = poly-euryhaline, **PLE** = Pleuronematum coronatae, **ps** = poly-stenohaline, **R** = predacious (feeds on protozoa, mostly ciliates, some species even ingest small metazoans), **Ro** = rotifera, **S** = stagnant waters, **Sb** = sulphur bacteria, **STE** = Stentoretum, **T** = epizoic, **TRI** = Trithigmostometum cucullulae, **x** = xenosaprobic.

Species	Biomass (mg) of 10^6 ind.[a]	Main food	Salinity tolerance[b]	Occurrence			
				Preferred water type	Preferred habitat	Community[c]	Saprobity[d]
Acineria incurvata	55	R	he	F, S, K	A, B	COL, HBE	p–i
Acineria uncinata	10	R	os	F, S, K	A, B	COL, NBE	a–p
Acineta flava	30	R	oe?	F, S	A, T		b
Acineta grandis	150	R	oe?	F, S	A, T		b–o
Acineta tuberosa	20	R	he	S, F, K	A, T		a–b
Actinobolina radians	125	R	oe?	S, F	P, A, B	OLI	b
Actinobolina smalli	11	M, R	os	S	P, B	OLI	
Actinobolina vorax	250	R	oms?	S	EP, Bo	OLI	o
Actinobolina wenrichii	90	M, R	os	S	EP?	OLI	
Amphileptus carchesii	200	R	os	S, F	A	CAR	a
Amphileptus claparedii	60	R	he?	S, F	A	CAR	a
Amphileptus pleurosigma	150	R	oms	S, F	A, B	STE	b–a
Amphileptus procerus	160–1500	R	os	S, F	B		b–a
Amphileptus punctatus	80	R	os	S, F	A, B		a
Askenasia acrostomia	32	Al, C	os	S	EP	OLI	
Askenasia chlorelligera	20	M	os	S	EP	OLI	
Askenasia volvox	35	Al, Ki	oe?	S, F	P, B	OLI	b
Aspidisca cicada	10	Ba	he?	F, S, K	B, A	TRI, CYR, NBE	a–b
Aspidisca lynceus	17	Ba	ome?	F, S, K	B, A	TRI, CYR, NBE	b–a
Aspidisca turrita	7	Ba	he	F, S, K	B, A	NBE	a–b
Astylozoon fallax	30	Ba	os	S	EP	MAR, OLI	b–a
Astylozoon faurei	50	Ba	oms?	S, F	EP	MAR, OLI	b–a
Astylozoon faurei-complex	50	Ba	oms?	S, F	EP	MAR, OLI	b–a
Balanion planctonicum	0.3–3.6	Al, Ba	os	S	EP	OLI	o
Balantidion pellucidum	60	O	os	S	EP	OLI	
Belonophrya pelagica	11	Ro	os	S	EP	OLI	
Blepharisma coeruleum	250	Al (O)	os	S, F	B		b
Blepharisma lateritium	250	Ba, Al	os	S	B, P		b

Species	Biomass (mg) of 10^6 ind.[a]	Main food	Salinity tolerance[b]	Occurrence			
				Preferred water type	Preferred habitat	Community[c]	Saprobity[d]
Bursaria truncatella	50000	O	ome?	S, F	B, P		b–a
Bursaridium pseudobursaria	342	Al	os	S, F	EP		o–b
Bursellopsis nigricans mobilis	900	Ro	os	S	EP	OLI	
Bursellopsis nigricans nigricans	350	Al, Fl	os	S	EP	OLI	
Bursellopsis pelagica	2000	O	os	S	EP	OLI	
Bursellopsis spumosa	18000	M, O	os	S, F	EP	OLI	o
Bursellopsis truncata	150	Al	os	S	EP?	OLI	
Caenomorpha spp.	120 [g]	Ba, Sb	os	S, F, K	Fs	MET	p–m
Calyptotricha lanuginosa	5	Ba, Al, Fl	ome	S, F	B, A	TRI	a
Campanella umbellaria	850	Ba	oms	S, F	A, B, T	CAR	a–b
Carchesium pectinatum [o]	60	Ba, Al	he?	S, F	EP	OLI	o–b
Carchesium polypinum	150	Ba	oe	F, S, K	B, A, T	TRI, CAR, NBE	a
Chaenea stricta	10	Ba	os	F, S	B, A		b–a
Chaetospira muelleri	80	Ba, Ki, Fl	he	S, F	B, A		b
Chaetospira remex	250	Ba, Fl, Ki	oe	S, F	A, B		b–a
Chilodonella uncinata	11	Ba	he?	F, S, K, Bo	A, B	TRI, CYR, NBE	a
Chilodontopsis depressa	10	Ba, Al, Ki	he	F, S	A, B	PLE, CYR	b
Chlamydonella alpestris	3	Ki, Ba	os	F, S, Bo	A, B	CYR	b–a
Chlamydonellopsis plurivacuolata	50	Ki	os	F	A, B	STE, CYR	b–a
Cinetochilum margaritaceum	5	Ba, Al	ome (he?)	S, F	A, B, P	NBE	e
Climacostomum virens	500	O	he?	S, F	B, P	MOO	b
Codonella cratera	20	Ki, Al (O?)	oe	S, F	EP	OLI	b–o
Coleps elongatus	45	O	os	S	P, B		
Coleps hirtus [p]	21	O	oms (he?)	S, F	A, B, P	STE	a–b
Coleps hirtus hirtus [p]	21	O	oms (he?)	S, F	A, B, P	STE	
Coleps hirtus viridis [p]	21	M, O	os	S, F	P	OLI	
Coleps nolandi	16	O	he	S, F	A, B, P	STE	o–a
Coleps spetai	60	M, O	os	S	EP	OLI	b
Colpidium colpoda	130	Ba, Fl, Al	ome	F, S, K	B	COL, TRI, HBE	p–i
Colpidium kleini	65	Ba	os	F, S	B	TRI	p
Colpoda cucullus	70–140	Ba, Fl, Al	ome?	Bo, S, F	B, A	BOD	p–a
Colpoda ecaudata	5–10	Ba	ome	Bo, K	B	HBE	p–i
Colpoda inflata	40	Ba, Fl	ome?	Bo, S	B		a–p
Colpoda magna	2400	Ba (O)	os	S	B	MAR	a–p
Colpoda steinii	4	Ba	ome	Bo, S, F	P, B, Bo	BOD	a–p [l]
Cothurnia annulata	14	Ba	oe?	S, F	A		o–b
Ctedoctema acanthocryptum	2	Ba	os	S, F	B	STE	b–a
Cyclidium glaucoma	1–3	Ba	he	F, S, K	B, A, P	TRI	a
Cyclidium heptatrichum	2	Ba	ome?	F, S	B, A, P		b
Cyclotrichium viride	500	M, O	os	S	EP	OLI	
Cyrtolophosis mucicola	2	Ba	he?	Bo, S, F	B, P, Bo	BOD	b–p
Dendrosoma radians	? [j]	R	oms	S, F	A, B, T		b–a
Dexiostoma campylum	26	Ba, Fl, Al	oms	F, S, K	B	COL, HBE	p–i
Dexiotricha granulosa	20	Ba	oe (he?)	S, F	B, A	NBE	a–p
Dexiotrichides centralis	5	Ba	oe?	S, F, K	Fs, B		p–i
Didinium chlorelligerum	170	M, R?	os	S	EP	OLI	

Species	Biomass (mg) of 10^6 ind. [a]	Main food	Salinity tolerance[b]	Occurrence			
				Preferred water type	Preferred habitat	Community[c]	Saprobity[d]
Didinium nasutum	500	R	oe?	S, F	B, P		a–b
Dileptus margaritifer	500	O	he	S, F	B, A	PLE	b
Discomorphella pectinata	50	Ba, Sb	he?	S, F	Fs	MET	p–m
Disematostoma buetschlii	400	M, Al, Ba	os	S	EP	MAR, OLI	b
Disematostoma tetraedricum	150	M, Ki	os	S, F	EP	MAR	b
Drepanomonas revoluta	1	Ba	oms?	Bo, S, F, K	B, A, P	BOD	a–p
Dysteria fluviatilis	5	?	os	F, S	A, B		b
Enchelyodon elegans	200	R?	oe?	S, F	B, A		a
Enchelyomorpha vermicularis	3	–	oms?	K, F, S	Fs, B	MET, HBE	p–m
Enchelys gasterosteus	21	O	os	S, F	B, A	STE	b–a
Epalxella spp.	2–25	Sb	os	S, F	Fs	MET	p–m
Epenardia myriophylli	700	Ba, Sb	os	S, F	B		a–p
Epicarchesium pectinatum [o]	60	Ba, Al	he?	S, F	EP	OLI	o–b
Epistylis anastatica	60	Ba	os	S	EZP	OLI	
Epistylis chrysemydis	260–1300	Ba, Al	oe	F	A, T	CAR, NBE	a
Epistylis coronata	90	Ba	os	S	A		a
Epistylis digitalis	30	Ba	os	S, F	EZP, EZB	OLI	o–b
Epistylis entzii	300	Ba	os	S, F, K	A, T	CAR, NBE	a
Epistylis galea	250	Ba	os	S, F	A		a
Epistylis hentscheli	100	Ba	oms	F, S	A, B	CAR, NBE	a–b
Epistylis nympharum [r]	80	Ba	os	S, F	T		o–a
Epistylis plicatilis	40	Ba	ome?	S, F, K	A, B, T	CAR, NBE	a–b
Epistylis procumbens	40	Ba, Fl	oe?	S, F	EP	OLI	o–b
Epistylis pygmeum	20	Ba	ome?	S	EZP	OLI	
Euplotes aediculatus	260	O	oe?	F, S, K	B	CYR, NBE	a
Euplotes affinis [o]	18	Ba, Ki, Al, Fl	he?	F, S, K	B, A	TRI, STE, CYR, NBE	b–a
Euplotes eurystomus [o]	400	O	he?	S, F	B		a
Euplotes moebiusi	23	Ba, Ki, Fl	he	F, S, K	B, A	CYR, NBE	a
Euplotes patella [o]	93	O	he?	F, S, K	B, A	PLE, CYR, NBE	b
Euplotopsis affinis [o]	18	Ba, Ki, Al, Fl	he?	F, S, K	B, A	TRI, STE, CYR, NBE	b–a
Euplotopsis eurystomus [o]	400	O	he?	S, F	B		a
Euplotopsis patella [o]	93	O	he?	F, S, K	B, A	PLE, CYR, NBE	b
Frontonia acuminata	100	O	oms	S, F	B, A, P	STE	b–a
Frontonia angusta	110	O	os	F, S	B, A, P	STE	b–a
Frontonia atra	95	Ki	os?	S, F	B, P		b–a
Frontonia leucas	270	O	oe	S, F	B, A, P	STE	b–a
Gajewskajophrya melosirae	150	Fl?, C?	os	S	EPP	OLI	
Gastronauta clatratus	10	Ki	oms	F, S	A, B	PLE, CYR	b–a
Gastronauta membranaceus	15	Ba	oe?	F, S	A, B	PLE, CYR	b
Gastrostyla mystacea	120	O	os	S, Bo	B		p
Gastrostyla steinii	122	O	os	S, F, Bo	B		a
Glaucoma reniforme	10	Ba, Al	os	S, F	B, A		p
Glaucoma scintillans	25	Ba	oe	F, S, K	B, A	COL, TRI	p–a
Halteria bifurcata	8	M, Ba	os	S	P, B		

Species	Biomass (mg) of 10^6 ind. [a]	Main food	Salinity tolerance[b]	Occurrence			
				Preferred water type	Preferred habitat	Community[c]	Saprobity[d]
Halteria grandinella	14–27	Ba, Al	he?	S, F, Bo	P, B	OLI, MAR	b–a
Hastatella radians	30	Ba	oe?	S, F	EP	MAR	b–a
Heliophrya minima	10	R	os	S, F	A		b–a
Heliophrya rotunda	40	R	oe?	S, F	A		b–a
Hexotricha caudata	5	Ba	oms?	S, F, K	Fs		p–m
Histiobalantium bodamicum	34	Al, Ba	os	S	EP	OLI	
Histriculus vorax	350	Ba	os	S, K	B		a
Holophrya discolor	290	O	he	S, F, K	B, P		a–p
Holophry aovum	400	Ba, Cy, Al	oms	S, F	B, P		a–p
Holophrya teres	1300	O	he	S, F	B, P		b–p
Holosticha kessleri	66	Ba, Ki	pe	S, F	B		a–b
Holosticha monilata	52	Ba, Ki, Al	ome	F, S	B	STE, MOO	a–b
Holosticha multistilata	109	O	ome	F, S, Bo	B		a–b
Holosticha pullaster	12	Ba, Ki, Al	he	F, S	B	STE, CYR	b–a
Homalozoon vermiculare	300	O	oe	S, F	B, A		b–a
Hypotrichidium conicum	150	O	oms?	S	EP	MAR	b–p
Kahlilembus attenuatus	3	Ba	he?	S, F, Bo	B, A	BOD	b
Kerona pediculus	230	Al, Ki [e]	os	S, F	T, P		b–o
Lacrymaria olor	33	R	he	S, F	B, A	PLE	b
Lagenophrys vaginicola	40	Ba	os	S	T		o
Lagynophrya acuminata	25	Al	os	S	EP	OLI	o
Lagynus elegans	200	O	he	S, F	Fs, B	MET	p–i
Lembadion bullinum	200	O	oe?	S, F	B	PLE	b
Lembadion lucens	40	O	oms	S, F	B, P	STE	b–a
Lembadion magnum	120	O	os	S, F	B, P	PLE	b
Lepidotrachelophyllum lineare	500	R or O	os	S	EP	OLI	
Leptopharynx costatus	5	Ba, Al	os	Bo, S, F	B, A, P	BOD, MOO	o–a
Liliimorpha viridis	40	M	os	S	EP	OLI	
Limnostrombidium pelagicum	30	Al	os	S	EP	OLI	
Limnostrombidium viride [o]	50	M, Ki, Al, Ba	oe	S, F	EP	OLI	b
Linostoma vorticella [o]	1000	O	oe?	S, F	P, B		b–a
Linostomella vorticella [o]	1000	O	oe?	S, F	P, B		b–a
Litonotus alpestris	2	Ba?, Fl?	os	F, S	B, A	STE, CYR	b–a
Litonotus crystallinus	13–100	R?	os	S, F	B, A		b–a
Litonotus cygnus	40	R	he	F, S	B, A	PLE, CYR	b
Litonotus fusidens	20–80	R	he?	S, F	B, A		b–p
Litonotus lamella	15	R	he?	F, S, K	B, A	TRI	a
Litonotus varsaviensis	60	R	he?	F, S	B, A	COL	p–i
Longitricha puytoraci	65	Al	os	S	EP	OLI	
Loxocephalus luridus	300	Ba	oe	S, F	B, A, Fs		p–i
Loxodes magnus	960	O	os	S, F	B, P	MET	p
Loxodes rostrum	250	O	oms	S, F	B, P	MET	p
Loxodes striatus	200	Al, Ki, Cy	os	S, F	B, P	MET	p
Loxophyllum helus	160	R	he	S, F	A, B		b
Loxophyllum meleagris	700	R	he?	S, F	A, B	PLE	b

Species	Biomass (mg) of 10^6 ind. [a]	Main food	Salinity tolerance[b]	Occurrence			
				Preferred water type	Preferred habitat	Community[c]	Saprobity[d]
Loxophyllum utriculariae [o]	90	R	oe?	F, S	A		b
Marituja pelagica	190	Ki, Cy, Al (O)	os	S	EP	OLI	o
Membranicola tamari	50	Al	os	S	EP	OLI	
Mesodinium acarus	1.5	O	he	S, F	P, B		b
Mesodinium pulex	5	O	he	S, F	P, B		b
Metacineta cuspidata	16	R	os	S, F	A		b–a
Metacineta mystacina	65	R	ome	S, F	A, T		b–a
Metopus spp. sensu lato	15–500	Ba, Fl, Al	he	S, F, K	Fs	MET, HBE	p–m
Microthorax pusillus	1	Ba	he	S, F	B, A		a
Monilicaryon monilatus	900	O	os	S, F	B, A	PLE	b
Monodinium alveolatum	40	Al, Fl	oe?	S	EP	OLI	
Monodinium balbianii [p]	55	R	he?	S, F	P, B, Bo	OLI	o–a
Monodinium balbianii balbianii [p]	55	R	he?	S, F	P, B, Bo	OLI	o–a
Monodinium balbianii breviproboscis [p]	33	C	os	S	EP	OLI	
Monodinium balbianii rostratum [p]	50	?	oe?	S	EP	OLI	
Monodinium chlorelligerum	30	M, Al, Fl	os	S	EP	OLI	
Monodinium perrieri	45	C	os	S	EP	OLI	
Mucophrya pelagica	170	C?	os	S	EP	OLI	
Nassula ornata	1600	Cy	oms	S, F	B, A, P	MAR	b
Nassula picta	224	Cy (O)	oe?	S, F, Bo	B, A, P	MAR	b
Nassulopsis elegans	400	Cy	he?	S, F	B, P	MAR	b
Obertrumia aurea	500	Cy	he?	S, F	B, P	MAR	b–a
Odontochlamys alpestris	10	Ba	os	F, Bo	A, B	CYR	b–a
Opercularia articulata	140	Ba	os	F, S, K	A, T	CAR, STE, NBE	a–b
Opercularia coarctata	25	Ba	os	F, K	A, B	CAR, NBE	a
Opercularia nutans	70	Ba	os	S, F	A, T	CAR, STE, NBE	b–a
Ophrydium crassicaule	180	Ba, Al	oms	S	A		b–a
Ophrydium eutrophicum	215	M, Ba	os	S	A, P		b–a
Ophrydium naumanni	5	M, Ba	os	S	EP	OLI	
Ophrydium sessile	350	Ba	oe?	S	A		a–b
Ophrydium versatile	280	M, Ba, Al	he?	S	A, P		o
Ophryoglena spp.	–	h	–	S, F	B		–
Opisthonecta henneguyi	1000	Ba, Fl	os	S, F, K	P, B	MAR	b–p
Oxytricha chlorelligera	35	Ba, Fl, Ki	oms	S, F	B, A		a
Oxytricha fallax	155	O	he?	S, F	B		a
Oxytricha ferruginea	125	Ba, Cy, Al, Ki	oe?	F, S	B		o
Oxytricha haematoplasma [o]	80	O	os	F, S	B	STE	b–a
Oxytricha hymenostoma	30	O	os	F, S, K	B, A		p
Oxytricha saprobia	34	Ba, Fl	os	S, F	B		a–p
Oxytricha setigera	8	Ba, Fl	os	F, S, Bo	B		a–b
Oxytricha similis	14	Ba	he?	F, S	B		b–a
Paracolpidium truncatum	30	Ba	os	F, S	B		a
Paradileptus elephantinus	1000	O	os	S	EP	OLI	b

Species	Biomass (mg) of 10^6 ind. [a]	Main food	Salinity tolerance[b]	Occurrence			
				Preferred water type	Preferred habitat	Community[c]	Saprobity[d]
Paramecium aurelia-complex	150	Ba	ome	S, F, K	B, P	TRI, CAR	a–b
Paramecium bursaria	120	Ba, Al, Ki	ome	S, F	A, B, P	STE, MOO	b–a
Paramecium caudatum	500	Ba, Al	ome	S, F, K	B, P	COL, TRI, HBE	p–a
Paramecium putrinum	70	Ba, Sb, Cy, Fl	ome [m]	F, S, K	B, A, P	COL, HBE	p
Parapodophrya soliformis	65	R	oms?	S, K	Fs	HBE	p
Paraurostyla viridis	87	Ba	os	S	B		b–a
Paraurostyla weissei	240	O	ome?	S, F	B		a
Pelagodileptus trachelioides	4500	M, O	os	S	EP	OLI	
Pelagohalteria cirrifera	14–35	Al	os	S, F	EP	OLI	o–b
Pelagohalteria viridis	7	M, Ba, Al	oe	S	EP	OLI	
Pelagolacrymaria moserae	47	C	os	S	EP	OLI	
Pelagostrombidium fallax	120	M, Ba, Cy, Ki, Al	os	S	EP	OLI	
Pelagostrombidium mirabile	30	A, Al	oms?	S	EP	OLI	
Pleagothrix chlorelligera	27	M	os	S	EP	OLI	
Pelagothrix plancticola	45	M, O	os	S	EP	OLI	
Pelagotrichidium faurei	2500	?	os	S	EP	OLI	
Pelagovasicola cinctum	250	O	os	S	EP	OLI	
Pelagovorticella mayeri [o]	50	Ba	os	S, F	EP		b
Pelagovorticella natans [o]	90	Ba, Al	oe?	S, F	EP	OLI	b
Pelodinium reniforme	20	Sb	he?	S, F	Fs	MET	p–m
Phascolodon vorticella	75	Al, Ki, Cy, Ba	oe	S, F	EP	OLI, MAR	b–a
Phialina spp.	–	R	–	S, F, Bo	B, A	–	–
Philasterides armatus	25	h	os	S, F	B, A		b–a
Placus luciae	25	O	ome	S, F	B, A	PLE	b–o
Plagiocampa rouxi	7	Ba, Al	he	S, F, Bo	B, A, P		a–b
Plagiopyla nasuta	120	Ba, Sb, Al, Fl	oe?	S, F	Fs	MET	p–i
Platycola decumbens	35	Ba, Al, Fl	ome	S, F	A		b–a
Platynematum sociale	4	Ba	ome	S, F	B, A		p
Platyophrya vorax	5–12	O	os	Bo, S, F	B	BOD	p–i
Pleuronema coronatum	60	O	he?	S, F	B	PLE	b
Pleuronema crassum	60	Ba, Al, Ki	he	S, F	B		b–a
Pleurotricha grandis	1300	Ki, Al	oms?	S, F	B		b
Podophrya fixa	50	R	he?	S, F, K	A, B	NBE	a
Podophrya maupasii	30–110	R	he	S, F	A, B	NBE	a
Prodiscophrya collini	78	R	os	S, F, K	A, B	COL, NBE	a–p
Prorodon ellipticus	190	R	he?	S, F	B, A		b–a
Prorodon niveus	2500	R	oms?	S, F	B		b–o
Pseudoblepharisma tenue	30	Ba	os	S, Fs, F	B		p
Pseudochilodonopsis algivora	9	Al, Ba	he?	S, F	B, P	CYR	a[k]
Pseudochilodonopsis fluviatilis	15	Ki	os	F, K	A, B	STE, CYR	b–a
Pseudochilodonopsis piscatoris	19	Al, Ki	os	S, F	A	CYR	b
Pseudocohnilembus pusillus	6	Ba	he	S, F, K, Bo	B, P	MET, COL	p–i
Pseudohaplocaulus infravacuolatus	30	Al	os	S	ECP	OLI	

Species	Biomass (mg) of 10^6 ind. [a]	Main food	Salinity tolerance[b]	Occurrence			
				Preferred water type	Preferred habitat	Community[c]	Saprobity[d]
Pseudomicrothorax agilis	14	Cy (Ba, Al)	oe?	S, F	A, B		b
Pseudostrombidium planctonticum	110	Fl, Ki, Al	os	S, F	EP	OLI	
Pseudovorticella chlamydophora	50	Ba, Al	ome	S, F	A, B		b–a
Pseudovorticella monilata	70	Ba	ome? (he?)	S, F	A, B	STE	b–a
Pyxicola carteri	20	Ba	os	S	A		o–b
Rhabdoaskenasia minima	10	?	os	S	EP	OLI	
Rhabdostyla inclinans	35	Ba	oms?	S, F	T		a
Rimostrombidium armeniensis	100	?	os	S	EP	OLI	
Rimostrombidium brachykinetum	3	Al, Ba, Cy	os	S	EP	OLI	
Rimostrombidium humile [o]	4	Ki	oms?	S	P, B	OLI	b
Rimostrombidium hyalinum	5	? (Al, Ba, Cy)	os	S	EP	OLI	
Rimostrombidium lacustris	90	Al	os	S	EP	OLI	
Rimostrombidium velox	50	M, Al	ome?	S	EP	OLI	
Rubrioxytricha haematoplasma [o]	80	O	os	F, S	B	STE	b–a
Saprodinium spp.	17–50	Ba, Sb	os	S, F, K	Fs	MET	p–m
Sathrophilus muscorum	12	Ba, Fl	os	Bo, S, F	A	BOD	b–a
Scyphidia rugosa	90	Ba?	os	S, F	A, B		a
Siroloxophyllum utriculariae [o]	90	R	oe?	F, S	A		b
Spathidium sensu lato	–	R	–	S, F	A, B, P	BOD	–
Sphaerophrya magna	65	R	he	S, F	A, B, P		p
Spiretella plancticola	400	Al, Fl	os	S	EP	OLI	
Spirostomum ambiguum	14600	Ba, Fl, Al	oe	S, F	B, P	TRI	a
Spirostomum caudatum	130	Ba	he	S	B		o–b
Spirostomum minus	425	Ba	oe?	S, F	B, P	STE	a–b
Spirostomum teres	380	Sb, Ba, Al, Ki	oe (he?)	S, F, B, P, Fs	COL, HBE		p
Staurophrya elegans	110	C	oe	S, F	EP	OLI	o–a
Steinia platystoma	75	O	os	S, F	A, B		b–a
Stentor amethystinus	4000	Ba, Al, Ki	os	S	P		b
Stentor araucanus	1200	Al, Ba	os	S	EP		
Stentor coeruleus	12000	O	oe	S, F	B, A, P		a–b
Stentor igneus	450	Ba, Al, Ki	os	S, F	B, P	PLE	b
Stentor muelleri	4500	Ba, Al, Ki	ome	S, F	A	STE	b–a
Stentor multiformis	600	Al, Ba	he	S, F	B, A	STE	b–a
Stentor niger	1000	Al	oms	S, F	A, B		o–b
Stentor polymorphus	4500	O	oms	S, F	B, A	STE	b–a
Stentor roeselii	5000	O	oe	S, F	B, A	STE	a–b
Sterkiella histriomuscorum	72	O	os	F, S, K, Bo	B	NBE	a
Stichotricha aculeata	20	Ba, Al	he?	S, F	B	MAR	b–a
Stichotricha secunda	30	Ba, Al, Ki	ome	S, F	B, A	MAR	o
Stokesia vernalis	400	M, Ba, Al, Ki	os	S, F	EP		b
Strobilidium caudatum	45	Ki, Al, Ba	oms?	S, F	B, P	PLE	o–b
Strobilidium humile [o]	4	Ki	oms?	S	P, B	OLI	b
Strombidium viride [o]	50	M, Ki, Al, Ba	oe	S, F	EP	OLI	b

Species	Biomass (mg) of 10^6 ind. [a]	Main food	Salinity tolerance[b]	Occurrence			
				Preferred water type	Preferred habitat	Community[c]	Saprobity[d]
Stylonychia mytilus-complex	400	O	ome	S, F	B, A	TRI, CYR	a
Stylonychia pustulata [o]	80	O	he?	S, F	B, A	CYR	b
Stylonychia putrina	68	O	ome	S, F	B		a
Stylonychia stylomuscorum	30	Ki, Fl	os	F	B		b
Stylonychia vorax	57	O	os	S	B		b
Tachysoma bicirratum	15	Ba, Al	os	S, F	B		a–p
Tachysoma pellionellum	15	Ba, Cy, Al, Ki	ome (he?)	F, S	B, A	STE, CYR	b–a
Tetmemena pustulata [o]	80	O	he?	S, F	B, A	CYR	b
Tetrahymena pyriformis-complex	15	Ba	oms?	F, S, K	B	COL	p–i
Teuthophrys trisulca africana	1000	Ro	oms	S	EP		
Teuthophrys trisulca trisulca	1000	M, Ro	oms	S	EP		
Thigmogaster oppositevacuolatus	15	Ba [h]	os	F, K	A, B	CYR	a–b
Thigmogaster potamophilus	2.5	Ki, Al	os	F	A, B	CYR	b–a
Thuricola folliculata	120	Ba, Al	he	S, F	A		b
Thuricola kellicottiana	200	Al	oms?	S, F	A		b
Thuricola vasiformis	130	Ba	os	S	A, B		a
Tintinnidium ephemeridum	50	?	os	S	EP	OLI	
Tintinnidium fluviatile	50	Al, Ki	oe	S, F	EP	OLI	o–b
Tintinnidium pusillum	40	Al, Ki, Ba	oms?	S, F	EP	OLI	b
Tintinnidium semiciliatum	40	Al, Ki	os	S, F	A, B	PLE	b
Tintinnopsis cylindrata	20	Al	os	S, F	EP	OLI	b
Tokophrya carchesii	12	R	os	S, F	T	CAR	a
Tokophrya infusionum	30	R	os	S, F	A, B	CAR, NBE	b–a
Tokophrya lemnarum	16	R	oms?	S, F, K	A, B, T	CAR, NBE	a
Tokophrya quadripartita	75	R	oms?	S, F, K	A, B, T	CAR, NBE	a–b
Trachelius ovum	3000	R	oms	F, S	A, B, P	CAR	a–b
Trachelophyllum apiculatum	39	O	he?	S, F	A, B		b–a
Trichodina pediculus	80	Ba [f]	he?	S, F	T, P [n]		b
Trimyema compressum	10	Ba	he	S, F, K	Fs	MET, COL, HBE	p–m
Trithigmostoma cucullulus	50	Ki, Al, Cy, Ba	he?	F, S, K	A, B	COL, TRI, CYR	a–p
Trithigmostoma srameki	40	Ki	os	F, S	A, B	STE, CYR	b–a
Trithigmostoma steini	150	Ki	os	F, S	A, B	CYR	b–a
Trochilia minuta	1.5	Ba	os	F, K	A, B	STE, CYR	b–a
Trochilioides recta	25	Sb	he	F, S	A, B, Fs		a
Tropidoatractus acuminatus	20	Ba	os	S	Fs		p–m
Urocentrum turbo	70	Ba, Ki	he?	S, F	B, A, P		a–p
Uroleptus gallina	72	Al	oms?	S, F	B		b
Uroleptus musculus	214	O	oms?	S, F	B, A		a
Uroleptus piscis	400	Ba, Cy, Ki	oe?	S, F	B, A		a
Uroleptus rattulus	400	Ba, Al	oe?	S, F	B, A		b
Uronema nigricans	5	Ba, Fl	he	F, S	B, A, P	TRI	a–p
Urostyla grandis	500	O	he?	S, F	B		a
Urotricha agilis	0.5	Ba, Fl	os	S	B, P	OLI, MAR	b–a
Urotricha apsheronica	35	O	os	S	EP	OLI	
Urotricha armata [q]	15	R	oe (he?)	S, F	B, A	MAR	a

Species	Biomass (mg) of 10^6 ind. [a]	Main food	Salinity tolerance[b]	Occurrence			
				Preferred water type	Preferred habitat	Community[c]	Saprobity[d]
Urotricha castalia	12	Al, Fl	os	S	EP	OLI	
Urotricha farcta	5	Ba, Al, Fl	oms?	S, F	B, P	OLI, MAR	a–b
Urotricha furcata	3–4	Ba, Al	os	S, F	EP	OLI, MAR	b
Urotricha globosa	7	Ba, Al	he?	S	EP	OLI, MAR	b
Urotricha matthesi matthesi	17	?	os	S	EP	OLI	
Urotricha matthesi tristicha	18	Al, Ki, Fl	os	S	EP	OLI	
Urotricha ovata	15	Al	oe? [i]	S, F	B, P	OLI, MAR, MOO	a–p
Urotricha pelagica	35	Ba, Ki	oe	S	EP	OLI	
Urotricha platystoma [q]	15	R	oe (he?)	S, F	B, A	MAR	a
Urotricha pseudofurcata	2	?	os	S	EP	OLI	
Urotricha simonsbergeri	350	O	os	S	EP	OLI	
Urotricha valida	80	?	os	S	EP?	OLI	
Urotricha venatrix	220	Ro	os	S	EP	OLI	
Urozona buetschlii	3	Ba	os	S, K, F	B, P		p
Vaginicola ingenita	3–4	Ba	he	S, F	A, T		b
Vaginicola tincta	15	Ba	os	S, F	A		o–b
Vorticella aquadulcis-complex	15	Ba, Al	he?	S, F, K	A, B, EPP, EZP	STE	b–a
Vorticella campanula	135	Ba, Al	oe (he?)	S, F, K	A B, T	STE	a–b
Vorticella chlorellata	25	M, Ba	os	S	ECP	OLI	
Vorticella convallaria-complex	50–75	Ba	he	S, F, K	A, B, T	TRI, CAR, NBE	a
Vorticella fromenteli	35	Ba	oe	S	A		a
Vorticella infusionum-complex	25	Ba	he?	S, F, K, Bo	A, B, T	COL, CAR, HBE	p–a
Vorticella marginata	100	Ba	os	S, F	A, B		b
Vorticella mayeri [o]	50	Ba	os	S, F	EP		b
Vorticella microstoma-complex	30	Ba, Al	oms?	S, F	A, B		p–a
Vorticella natans [o]	90	Ba, Al	oe?	S, F	EP	OLI	b
Vorticella octava-complex	20	Ba	oe	S, F	A		b–a
Vorticella picta	40	Ba, Al	oe?	S, F	A	PLE	b
Vorticella vernalis	40	Al, Ba	os	S	EPP, EZP, B		
Zoothamnium arbuscula	55	Ba	ome?	S, F	A		b–a
Zoothamnium kentii	40	Ba	ome	F, S	A	CAR, STE	b–a
Zoothamnium procerius	45	Ba	he	F, S	A, B, T	CAR, STE	b–a
Zosterodasys transversa	300	Ki	he	F, S	A, B	CYR	b

[a] Wet mass; 1 µm³ = 1 pg, that is, specific gravity of the protoplasm is 1.0 (FINLAY 1982).
[b] 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.
[c] See community plates. Many species cannot yet be classified into a certain community.
[d] According to Table 3 in FOISSNER et al. (1995).
[e] Feeds also on epidermal cells, cnidocysts, and food residues of *Hydra*.
[f] Ingests also fish epidermal cells, cnidocysts, and food residues of *Hydra*.
[g] For *Caenomorpha medusula*.
[h] Also histophagous, that is, feeding on cells of dying or dead metazoans.
[i] Erroneously written "3.5 mg/l" in FOISSNER et al. (1994).
[j] Not calculated because of complicated shape.
[k] If very abundant, otherwise use a–b.
[l] If very abundant, otherwise use b–a.
[m] According to ALBRECHT (1984); erroneously classified as holo-euryhaline in FOISSNER et al. (1994).
[n] Epizoic on a wide range of hosts (hydrozoans, bryozoans, amphibian larvae, fish); detached specimens survive for some time and may thus be found in the pelagial.

(o) The generic classification changed. Such species are contained in this table under both, the former and the recent binomen. This concerns the following species: *Carchesium pectinatum* = now *Epicarchesium pectinatum*; *Euplotes affinis* = now *Euplotopsis affinis*; *Euplotes eurystomus* = now *Euplotoides eurystomus*; *Euplotes patella* = now *Euplotoides patella*; *Linostoma vorticella* = now *Linostomella vorticella*; *Loxophyllum utriculariae* = now *Siroloxophyllum utriculariae*; *Oxytricha haematoplasma* = now *Rubrioxytricha haematoplasma*; *Strobilidium humile* = now *Rimostrombidium humile*; *Strombidium viride* = now *Limnostrombidium viride*; *Stylonychia pustulata* = now *Tetmemena pustulata*; *Vorticella mayeri* = now *Pelagovorticella mayeri*; *Vorticella natans* = now *Pelagovorticella natans*.

(p) Two species contained in the "Ciliate Atlas" (Foissner et al. 1994, 1995) were later split into two or several subspecies (Foissner et al. 1999): *Monodinium balbianii* → *Monodinium balbianii balbianii*, *M. balbianii breviproboscis*, *M. balbianii rostratum*; *Coleps hirtus* → *Coleps hirtus hirtus*, *C. hirtus viridis*.

(q) *Urotricha armata* is the junior synonym of *Urotricha platystoma* (see Foissner et al. 1999).

(r) Misidentified in Foissner et al. (1992). Detailed redescription in Foissner (1996) under the name *Epistylis lacustris magna* (detailed explanation, see Foissner et al. 1999).

Table 2: Salinity terminology (after Albrecht 1984). Cl = chloride (mg l^{-1}), S = salinity (‰).

<table>
<tr><td>Cl</td><td>0–400</td><td>400–2000</td><td>2000–5000</td><td>5000–17000</td><td>>17000</td></tr>
<tr><td>S</td><td>0–1</td><td>1–4</td><td>4–10</td><td>10–30</td><td>>30</td></tr>
<tr><td></td><td colspan="5">holo-euryhaline</td></tr>
<tr><td></td><td>oligo-stenohaline</td><td colspan="4">meso- to poly-euryhaline</td></tr>
<tr><td></td><td colspan="2">oligo- to meso-stenohaline</td><td colspan="3">poly-euryhaline</td></tr>
<tr><td></td><td colspan="3">oligo-euryhaline</td><td colspan="2">meso- to poly-stenohaline</td></tr>
<tr><td></td><td colspan="4">oligo- to meso-euryhaline</td><td>poly-stenohaline</td></tr>
</table>

9 Summary

A user-friendly guide to 357 common benthic and pelagic freshwater ciliate species (Protozoa, Ciliophora), used as bioindicators by river, lake, and waste water ecologists is provided. The guide is a compilation of the flow charts contained in the monographs on plankton ciliates (Foissner et al. 1999) and on the indicator ciliates used in the saprobic system ("Ciliate-Atlas"; Foissner et al. 1991, 1992, 1994, 1995). The keys are designed for users not specifically trained in identification of ciliates. Main groups and species are keyed dichotomously on 85 flow charts using simple characters usually recognizable in live specimens. Species with conspicuous features, for example, large size or distinct colour, are shown on 44 separate charts, the "special keys". Typical ciliate communities found in natural and polluted habitats are briefly described and figured on 13 plates. Although the flow charts give a high probability of correct identification, determinations should nevertheless be checked against the detailed figures and descriptions contained in the monographs. The species keyed and their main ecological characteristics (biomass, food preference, salinity tolerance, preferred occurrence, saprobiological classification) are summarized in a Table. A glossary to morphological terms and a detailed systematic index are also provided. We hope that this user-friendly guide will allow renewed and increased usage of ciliates by river ecologists, limnologists, and pollution biologists, in spite of the recent financial constraints reducing water pollution assessment to a few higher metazoan taxa.

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11 Glossary to ciliate morphology

The glossary contains mainly general terms used in this book. For more detailed glossaries, see Corliss (1979), Corliss & Lom (1985), and Hausmann & Hülsmann (1996).

adoral zone of membranelles: → membranelles.

adoral organelles: compound ciliary structures belonging to the → oral apparatus; in our book only used for the → membranelles of the → prostomatids.

alveolus (*pl.* alveoli): flattened vesicle or sac, bounded by a unit membrane, lying just beneath the surface or plasma membrane of the cell.

anlage: a developing, differentiating, or even presumptive structure or → organelle. The anlage of the → oral apparatus, for example, is often composed of an irregular accumulation of → basal bodies.

argyrome: → silverline system.

basal body: subpellicularly located, about 1.2 × 0.3 µm sized microtubular structure, from which the cilium originates, homologous to the metazoan centriole; usually associated with several types of → fibres and bundles of microtubules; often arranged in pairs (= dikinetids, for example in the → colpodids or in the → dorsal brush of the → gymnostomatids) or groups (for example, → cirri and → adoral membranelles of → hypotrichs).

bristles: stiff or almost immobile, usually rather short (<5 µm) and often paired cilia, possibly with sensory function (thus, previously often termed sensory bristles).

buccal cavity: depression or invaginated, more or less densely ciliated area of body leading directly to the → cytostome; part of the → oral apparatus.

caudal cilium: a cilium (or group of cilia) usually longer than the other somatic cilia arising at the posterior end of the cell; in → hypotrichs modified to → (caudal)cirri.
circumoral: around the mouth.
cirrus (*pl.* cirri): more or less large number of cilia which adhere together; typically found in → hypotrichs.
conjugation: sexual reproduction where the partners usually fuse locally, exchange genetic material (nuclei), and separate; does not increase the number of individuals.
contractile vacuole: liquid-filled → organelle (sometimes multiple), serving as an osmoregulator in the cytoplasm of all freshwater ciliates; generally pulsates with a certain frequency; empties over one or more excretory pores.
cortex: the outer portion or layer of the ciliate body; comprising, inter alia, the → pellicle, the → basal bodies, and the → fibres associated with the basal bodies.
cortical (subpellicular) granules: about 0.5–2 µm sized granules in the outer cell layer (→ cortex). Colour, shape, size, and arrangement of the granules are important species characteristics, which are, however, usually recognizable only in live specimens. Some granules are likely special → extrusomes.
crystals: usually small, highly refractile, edged or globular ("lithosomes") structures, composed of an inorganic (phosphorus, calcium, magnesium, sulfur, chlorine) and organic component and enclosed in → vacuoles. Some are ion regulators, others are presumable end products of the metabolism.
cyrtos: → oral basket.
cyst: nonmotile, usually globular stage in the life cycle of many ciliates; several types have been described, for example, resting cysts, digestive cysts, division cysts.
cytopharynx: → pharynx.
cytopyge (cytoproct): cell anus; usually in posterior body half or in the → vestibulum (for example, in → peritrichs).
cytostome: cell mouth; permanent or pre-formed opening which denotes the end of any ciliation and through which (via the following → pharynx) food materials pass into the cytoplasm. Usually, the cytostome is surrounded by specialized ciliature (→ adoral organelles, → undulating membrane, → circumoral ciliary row) and located at the cell surface (for example, in → gymnostomatids) or in a deep → (buccal) cavity, the → vestibulum (e.g. → peritrichs, → *Bursaridium*).
division: → morphogenesis; in contrast to → conjugation, the number of individuals is increased.
dorsal brush: field of usually stiff and short cilia (→ bristles) at the dorsal side of the anterior body portion of → gymnostomatids and cyrtophorids (→ *Phascolodon*).
endoral membrane: one of the two → undulating membranes of the → hypotrichs; extends on bottom of → buccal cavity.
encystment: formation of a → cyst.
extrusome: a structure, usually arranged near cell surface, which is extruded under conditions of appropriate chemical or mechanical stimulation; used for prey capture and defence. According to size, shape, and function many types are distinguished, for example, → mucocysts, → trichocysts, → toxicysts, haptocysts, → cortical granules.
excystment: leaving of the → cyst.
fibres: thread-like structures (filaments and microtubules), mainly in the → cortex (→ also myoneme).
food vacuole: intracellular vesicle (vacuole) containing food within which the latter is digested; usually formed at inner end of → pharynx.
granules: → cortical granules.
infraciliature: ciliary pattern; assembly of all → basal bodies and associated → fibres.
kinetome: → infraciliature.
kinetosome: → basal body.
kinety: ciliary row.
macronucleus: vegetative or trophic nucleus of ciliates; controls the organisms phenotype. Usually polyploid, except for the Karyorelictea (e.g., *Loxodes*) where it is diploid. Shape and number (one to many hundred) of macronuclear nodules are important taxonomic features. Originates from → micronucleus during sexual reproduction (→ conjugation).
membrane: generalized term with a variety of particular meanings depending on its specific modifier (for example, cell membrane, → endoral membrane, → undulating membrane).
membranelles: compound structure composed of many adhering cilia in left portion of → oral apparatus; many serially arranged membranelles form the → adoral zone of membranelles of → heterotrichs and → hypotrichs.
micronucleus: generative (and usually smaller) nucleus of ciliates; is concerned with sexual processes. Invariably diploid and usually spherical or ellipsoidal. The → macronucleus takes its rise from a part of the micronucleus genome during sexual reproduction (→ conjugation).
morphogenesis: division sensu lato; comprises the formation of the new oral apparatus (→ stomatogenesis), nucleus division and division of the cell (cytokinesis); in contrast to → conjugation, the number of individuals is increased.
mouth: → cytostome; sometimes (incorrectly) used instead of → oral apparatus.
mucocysts: slimy → extrusomes as defence against poison and probably involved in → cyst formation.
myoneme: contractile, fibrillar structure; well recognizable in the stalk (as "stalk muscle") of → peritrichs (for example → *Vorticella*).
nematodesma (*pl.* nematodesmata): → oral basket.
nuclear apparatus: → macronucleus plus → micronucleus.
nucleolus (*pl.* nucleoli): dense site(s) in the → macronucleus, where rRNA is synthesized and ribonucleoproteins, the precursers of ribosomes, are formed.
ontogenesis: ± → morphogenesis.
oral apparatus: all structures and → organelles involved in or quite directly related with feeding, for example, → adoral organelles, → cytostome, → pharynx, → undulating membrane.
oral basket (cyrtos, rhabdos): usually distinct, funnel-shaped structure composed of microtubular bundles (oral basket rods, nematodesmata) and strengthening the → pharynx. Depending on the origin of the microtubules, a cyrtos (e.g. cyrtophorids [→ *Phascolodon*]) and rhabdos (e.g. → gymnostomatids) type of oral basket are distinguished.
oral basket rods: → oral basket.
oral primordium: → anlage.
organelle: "organ" of an unicellular organism, for example, → the contractile vacuole; analogous to the organs (for example, kidney) of the metazoans. Organelles are compartments of **one** cell, organs are composed of many cells.

paroral membrane: → undulating membrane.
pellicle: "skin" of the ciliates, sensu lato identical with → cortex, sensu stricto with cell membrane and pellicular → alveoli.
peristome: ± → oral apparatus.
pharynx: throat; nonciliated tubular passeway leading from the → cytostome proper into the inner cytoplasm; typically, → food vacuoles are formed at its inner end; often strengthened by oral basket rods (nematodesmata, → oral basket) made of microtubules.
postoral: behind (underneath) of → oral apparatus.
preoral: in front (above) of → oral apparatus.
protargol: silver-protein-compound (→ silver impregnation).
reorganization band: special section in the → macronucleus of some ciliates (→ hypotrichs, → oligotrichs), involved in DNA replication and histone synthesis.
replication band: → reorganization band.
rhabdos: → oral basket.
scopula: stalk forming and attachment → organelle at posterior pole of → peritrichs. The analogous structure of stalked → suctorians is named scopuloid.
scutica: usually a small group of barren → basal bodies underneath the → oral apparatus; during → stomatogenesis, a part of the new → mouth is formed by this structure, which occurs only in the scuticociliates (for example, → *Histiobalantium*), a group of the → hymenostomes.
silver impregnation: cytological methods where silver ions (e.g. → protargol, silver nitrate) deposit onto argyrophilic sites (especially the → basal bodies) and which are then visible in the light microscope. For a detailed description of these methods, see FOISSNER et al. (1999).
silverline system: striated or reticulate cortical structure, which can be stained (impregnated) with silver nitrate (→ silver impregnation); usually composed of → fibres, and possibly involved in → morphogenetic processes and/or conduction of stimuli.
somatic: belonging to the body; as opposed to oral.
stomatogenesis: formation of the new → oral apparatus during cell division (→ morphogenesis).
suture: the linear space left between the ends of converging ciliary rows (for example, in front of and behind the → oral apparatus of → *Frontonia*).
swarmer: freely motile disperse stage in the life cycle of a number of sessile ciliates, for example, of → peritrichs and → suctorians.
symbiotic algae: single-celled algae living symbiotic in the ciliate cytoplasm (→ zoochlorellae).
toxicysts: → extrusomes filled with poison and used for capture of prey.
trichocysts: needle-shaped → extrusomes used for defence.
type species: species on which a genus is based; the sole species which cannot be removed from the genus.
undulating membrane (paroral membrane): one or several rows of narrowly spaced cilia, which usually adhere together at the right margin of the → oral apparatus; see also → endoral membrane.
vacuole: vesicle; → contractile vacuole and → food vacuole.
vestibulum: → buccal cavity.
zoochlorellae: → symbiotic algae of the genus *Chlorella*.
zooids: the individuals of → peritrichs with branched stalk.

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13 Sytematic Index

The index contains all scientific names mentioned in the flow charts. It is two-sided, that is, species appear both with the generic name first (if one knows only the genus name) and, more importantly, with the species-group name first (if one knows the species-group 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 (for example, *Carchesium*) and species names (for example, *Carchesium polypinum*) appear in *italics*; suprageneric taxa (main groups, for example, **Peritrichia**) are given in **boldface**; communities (for example, Carchesietosum polypinae) are written in ordinary roman type.