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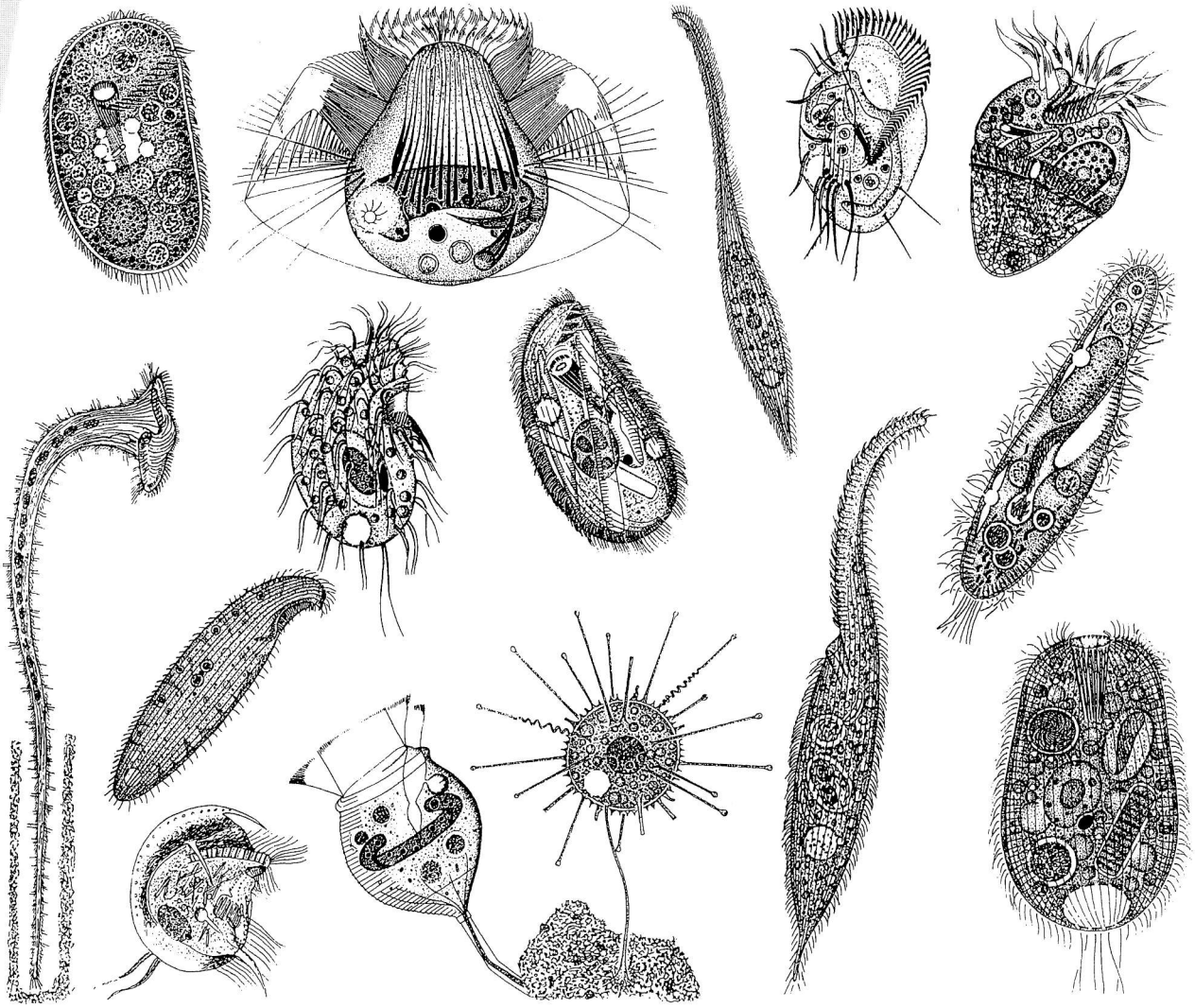

Wilhelm Foissner and Helmut Berger: A user-friendly guide to the ciliates (Protozoa, Ciliophora) commonly used by hydrobiologists as bioindicators in rivers, lakes, and waste waters, with notes on their ecology 375

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APPLIED ISSUES

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

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SUMMARY

1. A user-friendly guide to 300 ciliate species (Protozoa, Ciliophora) used as bioindicators by river, lake and waste water ecologists is provided. The guide is an English translation of the flow charts written in German and published by Foissner *et al.* (1991, 1992, 1994, 1995) in the *Ciliate Atlas*, a monograph on the ciliates used as bioindicators in the saprobic system. This guide is designed for users not specifically trained in identification of ciliates. Main groups and species are keyed dichotomously on forty-seven flow charts using simple characters usually recognizable in live specimens. Species with conspicuous characters, e.g. large size or distinct colour, are shown on thirty-two separate charts designated 'special keys'. Although the flow charts give a high probability of correct species identifications, these should nevertheless be checked against the detailed figures and descriptions contained in the *Ciliate Atlas*.
2. A table with the species keyed and their main ecological characteristics (biomass, food preference, salinity tolerance, preferred occurrence, saprobiological classification) is also provided.
3. Typical ciliate communities found in natural and polluted habitats are briefly described and figured on thirteen plates.
4. A detailed systematic index is provided for all taxa mentioned in the flow charts.

Introduction

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

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

The more recent guides by Curds (1982) and Curds, Gates & Roberts (1983), although very helpful, provide guides to genera only.

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

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

Equipment and methods

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

Observing living ciliates

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

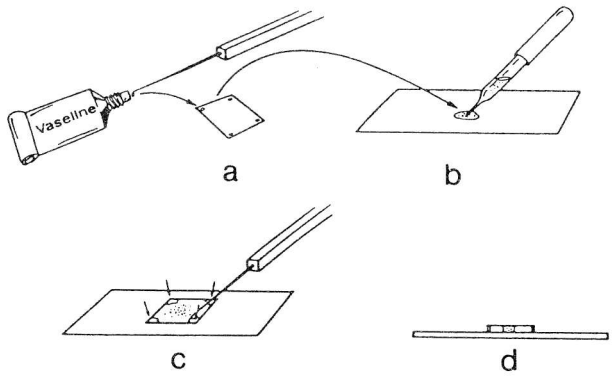

Fig. 1 Preparation of slides for observing living ciliates (after Dragesco & Dragesco-Kernéis, 1986). (a) A small drop of vaseline jelly each is placed at the four corners of a coverslip with a needle or injection syringe; (b) a small volume of water containing the ciliates is placed on a slide (see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

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

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

Table 1 Ecological characterization of species keyed. a = alphamesosaprobic, A = Aufwuchs (periphyton), Al = algae (except of diatoms, but inclusive autotrophic flagellates), b = betamesosaprobic, B = benthos, Ba = bacteria, Bo = terrestrial soils, BOD = influence of soil and/or moss, CAR = *Carchesietosum polypinae*, COL = *Colpidietum colpodae*, Cy = cyanobacteria, CYR = *Cyrtophoretea*, F = flowing waters, Fl = heterotrophic flagellates, Fs = anaerobic mud (and anaerobic zones in the pelagial), 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, 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 organisms and protozoa, 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 = planktonic, pe = poly-euryhaline, PLE = *Pleuronemetum coronatae*, ps = poly-stenohaline, R = predator (feeds on protozoa, mostly ciliates, some species even ingest small metazoans), S = stagnant waters, Sb = sulphur bacteria, STE = *Stentoretum*, T = epizoic, TRI = *Trithigmostometum cucullulae*, x = xenosaprobic.

Species	Biomass (mg) of 10^6 ind.[1]	Main food	Salinity tolerance[2]	Occurrence			
				Preferred water type	Preferred habitat	Community[3]	Saprobity[4]
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
Actinobolina vorax	250	R	oms?	S	P		o
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 volvox	35	Al,Ki	oe?	S,F	P	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	P	MAR	b-a
Astylozoon faurei	50	Ba	oms?	S,F	P	MAR	b-a
Balanion planctonicum	0.3-3.6	Al	os	S	P	OLI	o
Blepharisma coeruleum	250	Al (O)	os	S,F	B		b
Blepharisma lateritium	250	Ba,Al	os	S	B,P		b
Bursaria truncatella	50000	O	ome?	S,F	B,P		b-a
Bursaridium pseudobursaria	342	Al	os	S,F	P		o-b
Bursellopsis spumosa	18000	O	os	S,F	P		o
Caenomorpha spp.	120[7]	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	60	Ba?	he?	S,F	P		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

Species	Biomass (mg) of 10^6 ind.[1]	Main food	Salinity tolerance[2]	Occurrence			
				Preferred water type	Preferred habitat	Community[3]	Saprobity[4]
Holophrya ovum	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	P	MAR	b-p
Kahlilembus attenuatus	3	Ba	he?	S,F,Bo	B,A	BOD	b
Kerona pediculus	230	Al,Ki[5]	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	P		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
Leptopharynx costatus	5	Ba,Al	os	Bo,S,F	B,A,P	BOD,MOO	o-a
Linostoma vorticella	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
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
Loxophyllum utriculariae	90	R	oe?	F,S	A		b
Marituja pelagica	190	Ki,Cy, Al (O)	os	S	P		o
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

Species	Biomass (mg) of 10^6 ind.[1]	Main food	Salinity tolerance[2]	Occurrence			
				Preferred water type	Preferred habitat	Community[3]	Saprobity[4]
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 balbianii	55	R	he?	S,F	P,B	OLI	o-a
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	Ba	os	S	A,P		b-a
Ophrydium sessile	350	Ba	oe?	S	A		a-b
Ophrydium versatile	280	Ba,Al	he?	S	A,P		o
Ophryoglena spp.	-	histo-phag	-	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	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	P	OLI	b
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[13]	F,S,K	B,A,P	COL,HBE	p
Parapodophrya soliformis	65	R	oms?	S,K	Fs	HBE	p

Species	Biomass (mg) of 10^6 ind.[1]	Main food	Salinity tolerance[2]	Occurrence			
				Preferred water type	Preferred habitat	Community[3]	Saprobity[4]
Paraurostyla viridis	87	Ba	os	S	B		b-a
Paraurostyla weissei	240	O	ome?	S,F	B		a
Pelagohalteria cirrifera	35	Al	os	S,F	P		o-b
Pelodinium reniforme	20	Sb	he?	S,F	Fs	MET	p-m
Phascolodon vorticella	75	Al,Ki	oe	S,F	P	OLI,MAR	b-a
Phialina spp.	-	R	-	S,F,Bo	B,A	-	-
Philasterides armatus	25	histo-phag	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[11]
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
Pseudomicrothorax agilis	14	Cy (Ba,Al)	oe?	S,F	A,B		b
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
Rhabdostyla inclinans	35	Ba	oms?	S,F	T		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

Species	Biomass (mg) of 10^6 ind.[1]	Main food	Salinity tolerance[2]	Occurrence			
				Preferred water type	Preferred habitat	Community[3]	Saprobity[4]
Spathidium sensu lato	-	R	-	S,F	A,B,P	BOD	-
Sphaerophrya magna	65	R	he	S,F	A,B,P		p
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	R	oe?	S,F	P		o-a
Steinia platystoma	75	O	os	S,F	A,B		b-a
Stentor amethystinus	4000	Ba,Al, Ki	os	S	P		b
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	Ba,Al, Ki	os	S,F	P		b
Strobilidium caudatum	45	Ki,Al, Ba	oms?	S,F	B,P	PLE	o-b
Strobilidium humile	4	Ki	oms?	S	P,B	OLI	b
Strombidium viride	50	Ki,Al, Ba	oe	S,F	P	OLI	b
Stylonychia mytilus-complex	400	O	ome	S,F	B,A	TRI,CYR	a
Stylonychia pustulata	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
Tetrahymena pyriformis-complex	15	Ba[8]	oms?	F,S,K	B	COL	p-i
Thigmogaster oppositevacuolatus	15	Ba	os	F,K	A,B	CYR	a-b

Species	Biomass (mg) of 10^6 ind.[1]	Main food	Salinity tolerance[2]	Occurrence			Saprobity[4]
				Preferred water type	Preferred habitat	Community[3]	
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 fluviatile	50	Al,Ki	oe	S,F	P	OLI	o-b
Tintinnidium pusillum	40	Al,Ki, Ba	oms?	S,F	P	OLI	b
Tintinnidium semiciliatum	40	Al,Ki	os	S,F	A,B	PLE	b
Tintinnopsis cylindrata	20	Al	os	S,F	P	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[6]	he?	S,F	T,P		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-b
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 armata	15	R	oe (he?)	S,F	B,A	MAR	a
Urotricha farcta	5	Ba,Al, Fl	oms?	S,F	B,P	OLI,MAR	a-b
Urotricha furcata	3-4	Ba,Al	os	S,F	P	OLI,MAR	b
Urotricha globosa	7	Ba,Al	he?	S	P	OLI,MAR	b
Urotricha ovata	15	Al	oe?[9]	S,F	B,P	OLI,MAR, MOO	a-p
Urozona buetschlii	3	Ba	os	S,K,F	B,P		p

Species	Biomass (mg) of 10^6 ind.[1]	Main food	Salinity tolerance[2]	Occurrence			
				Preferred water type	Preferred habitat	Community[3]	Saprobity[4]
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	STE	b-a
Vorticella campanula	135	Ba,Al	oe (he?)	S,F,K	A,B,T	STE	a-b
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	50	Ba	os	S,F	P		b
Vorticella microstoma-complex	30	Ba,Al	oms?	S,F	A,B		p-a
Vorticella natans	90	Ba,Al	oe?	S,F	P	OLI	b
Vorticella octava-complex	20	Ba	oe	S,F	A		b-a
Vorticella picta	40	Ba,Al	oe?	S,F	A	PLE	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

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

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

Cl	0-400	400-2000	2000-5000	5000-17000	>17000
S	0-1	1-4	4-10	10-30	>30
holo-euryhaline					
oligostenohaline	meso- to poly-euryhaline				
oligo- to meso-stenohaline		poly-euryhaline			
oligo-euryhaline				meso- to poly-stenohaline	
oligo- to meso-euryhaline					poly-stenohaline

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

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

Nuclear staining

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

1 Pick out desired specimens with a micropipette and place the small drop of fluid in the centre of a slide.

2 Add an equally sized drop of methylgreen-pyronin (1% (w/v); Chroma-Gesellschaft, Schmid GmbH + Co., D-7316 Köngen/N.; this solution is stable and can be used for years) and mix the two drops gently by swivelling the slide. If ciliates were already mounted under the coverslip then add a drop of the dye at one edge of the coverslip and pass it through the preparation with a piece of filter paper placed at the other end of the coverslip.

3 Place a coverslip with vaselined corners on the preparation (Fig. 1) and press it down until cells become flattened. Observe immediately. Cells die and stain within 2–5 min. The nuclear apparatus usually stains blue or, in insufficiently flattened specimens, violet. Cytoplasm, food vacuoles and mucocysts (extrusomes) stain reddishly. The preparation is temporary. After 5–10 min the cytoplasm becomes heavily stained and obscures other details.

How to use the guide

The guide is designed for identifying specimens from life and for users not specifically trained in taxonomy of ciliates. However, we presume a good deal of basic knowledge in biology, taxonomy and protozoology. If some revision is necessary, we recommend reading Corliss (1979) and/or Puytorac (1994). Valuable ecological reviews are the books by Curds (1992), 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 (main key and species keys) or as simple plates showing related forms (special keys, communities). Many species are keyed several times to increase the chances of identification (see systematic index). Remember, however, that only 300 of the 3000 freshwater species known are contained in the guide. Thus, all characters mentioned in the charts must match and all specific identifications should ideally be checked against the detailed descriptions and figures contained in the *Ciliate Atlas*.* This point is crucial because there are usually several other species having similar characters. Certainly, a user-friendly guide should avoid referring to all the fine details, often difficult to recognize, commonly used by specialists. Admittedly, this increases the possibility of misidentifications. All pictorial guides, which key out a certain fraction from a taxonomic unit, have this deficiency, i.e. are a compromise between accuracy and practicability. On the other hand, such selective guides have the advantage of providing rapid species identifications even for users not specifically trained in taxonomy.

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

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

Most **Special keys** I–XXXII are not dichotomous.

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

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

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

Acknowledgments

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References

Albrecht J. (1984) Zur Autökologie ausgewählter Aufwuchsciliaten des Weser–Fluβsystems (Protozoa: Ciliophora). *Decheniana*, **137**, 132–167.

Corliss J.O. (1979) *The Ciliated Protozoa. Characterization, Classification and Guide to the Literature*, 2nd edn. Pergamon Press, Oxford.

Curds C.R. (1982) British and other freshwater ciliated protozoa. Part I Ciliophora: Kinetofragminophora. Keys and notes for the identification of the free–living genera. *Synopses British Fauna (N.S.)*, **22**, 1–387.

Curds C.R. (1992) *Protozoa and the Water Industry*. Cambridge University Press, Cambridge.

Curds C.R., Gates M.A. & Roberts D. McL. (1983) British and other freshwater ciliated protozoa. Part II Ciliophora: Oligohymenophora and Polyhymenophora. Keys and notes for the identification of the free–living genera. *Synopses British Fauna (N.S.)*, **23**, 1–474.

Dragesco J. & Dragesco–Kernéis A. (1986) Ciliés libres de l'Afrique intertropicale. Introduction à la connaissance et à l'étude des ciliés. *Faune tropicale*, **26**, 1–559.

Fenchel T. (1987) *Ecology of Protozoa: The Biology of Free–Living Phagotrophic Protists*. Brock/Springer series in contemporary bioscience (ed T. H. Brock). Science Tech. Publishers, Madison, Wisconsin.

Finlay B.J. (1982) Procedures for the isolation, cultivation and identification of protozoa. *Experimental Microbial Ecology* (eds R. G. Burns and J. H. Slater), pp. 44–65. Blackwell Scientific Publications, Oxford.

Foissner W. (1987) Soil protozoa: fundamental problems, ecological significance, adaptations in ciliates and testaceans, bioindicators, and guide to the literature. *Progress in Protistology*, **2**, 69–212.

Foissner W. (1993) *Colpodea (Ciliophora)*. Fischer, Stuttgart.

Foissner W., Blatterer H., Berger H. & Kohmann F. (1991) Taxonomische und ökologische Revision der Ciliaten des Saprobiensystems – Band I: Cyrtophorida, Oligotrichida, Hypotrichia, Colpodea. *Informationsberichte des Bayerischen Landesamtes für Wasserwirtschaft*, **1/91**, 1–478.

Foissner W., Berger H. & Kohmann F. (1992) Taxonomische und ökologische Revision der Ciliaten des Saprobiensystems – Band II: Peritrichia, Heterotrichida, Odontostomatida. *Informationsberichte des Bayerischen Landesamtes für Wasserwirtschaft*, **5/92**, 1–502.

Foissner W., Berger H. & Kohmann F. (1994) Taxonomische und ökologische Revision der Ciliaten des Saprobiensystems – Band III: Hymenostomata, Prostomatida, Nassulida. *Informationsberichte des Bayerischen Landesamtes für Wasserwirtschaft*, **1/94**, 1–548.

Foissner W., Berger H., Blatterer H. & Kohmann F. (1995) Taxonomische und ökologische Revision der Ciliaten des Saprobiensystems – Band IV: Gymnostomatea, *Loxodes*, Suctoria. *Informationsberichte des Bayerischen Landesamtes für Wasserwirtschaft*, **1/95**, 1–540.

Friedrich G. (1990) Eine Revision des Saprobiensystems. *Zeitschrift für Wasser– und Abwasser Forschung*, **23**, 141–152.

Grolière C.–A. (1978) Contribution a l'étude des ciliés des sphaignes III. Étude mathématique des résultats. *Protistologica*, **14**, 295–311.

Kahl A. (1930) Urtiere oder Protozoa I: Wimpertiere oder Ciliata (Infusoria) 1. Allgemeiner Teil und Prostomata. *Tierwelt Deutschlands*, **18**, 1–180.

Kahl A. (1931) Urtiere oder Protozoa I: Wimpertiere oder Ciliata (Infusoria) 2. Holotricha auβer den im 1. Teil behandelten Prostomata. *Tierwelt Deutschlands*, **21**, 181–398.

Kahl A. (1932) Urtiere oder Protozoa I: Wimpertiere oder Ciliata (Infusoria) 3. Spirotricha. *Tierwelt Deutschlands*, **25**, 399–650.

Kahl A. (1934) Suctoria. *Tierwelt* der *Nord-und Ostsee*, **26** (Teil II, c5), 184–226.

Kahl A. (1935) Urtiere oder Protozoa I: Wimpertiere oder Ciliata (Infusoria) 4. Peritricha und Chonotricha. *Tierwelt Deutschlands*, **30**, 651–886.

Puytorac P. de (Ed) (1994) Infusoires ciliés. *Traité de Zoologie*, **2** (2), 1–880.

Schleypen P. & Gschlössl T. (1992) Das mikroskopische Bild bei der aeroben Abwasserreinigung. 2nd edn. *Informationsberichte des Bayerischen Landesamtes für Wasserwirtschaft*, **1/90**, 1–101 & Anhang I, II.

Sládeček V. (1973) System of water quality from the biological point of view. *Archiv für Hydrobiologie, Beihefte Ergebnisse der Limnologie und Planktonkunde*, **7**, IV+1–218.

Sládeček V., Zelinka M., Rothschein J. & Moravcová V. (1981) *Biologický rozbor povrchové vody*. Komentař k ČSN 830532–části 6: Stanoveni saprobniho indexu. Vydalo Vydavatelstvi Uradu pro normalizaci a mereni, Praha (in Czech), 186 pp.

(*Manuscript accepted 20 November 1995*)

General key (Ciliophora I-XI)

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

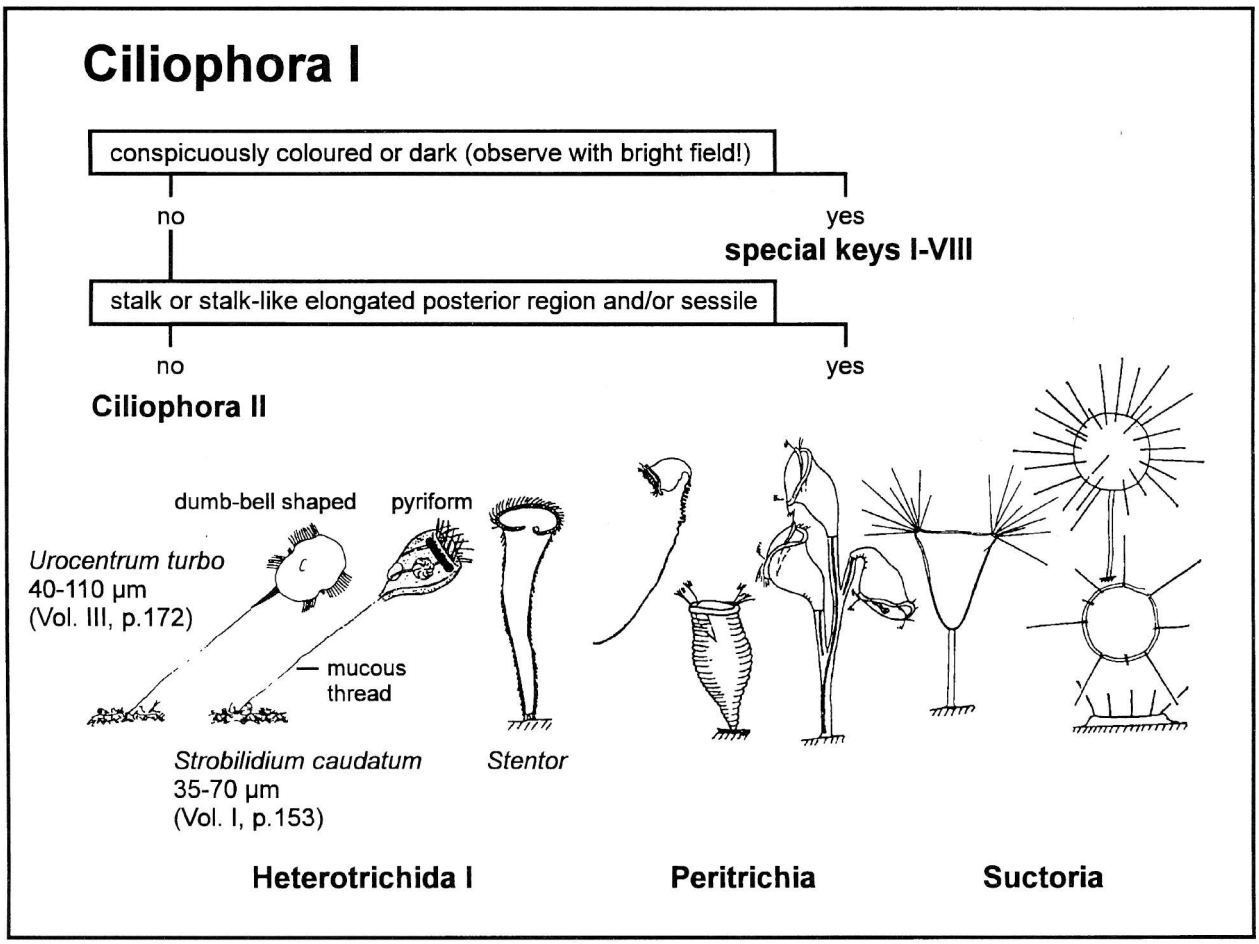


Plate 1

Ciliophora II

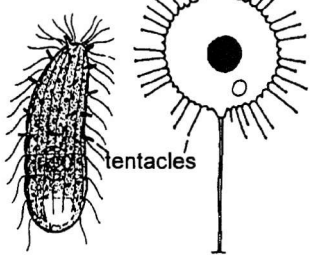
* Usually, tentacles are retractile rods with a small distal knob, i.e. are widest at the anterior end. Cilia, cirri (=bundle of cilia), adoral membranelles, and spines gradually narrow to the distal end, i.e. are widest at the posterior (proximal) end (see figures)

Ciliophora I

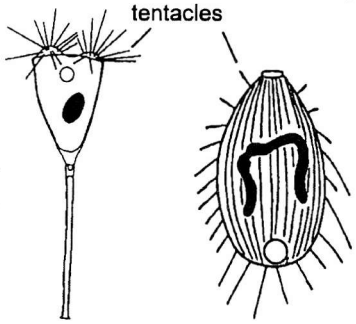
tentacles*

absent

present



Suctoria



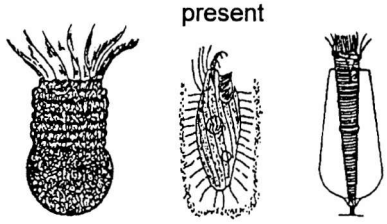
Actinobolina

Gymnostomatida I

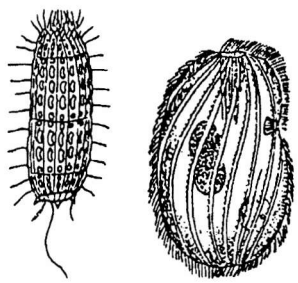
lorica or armour

absent or unknown

present



special key IX



very large, about 300 µm or more

no

yes

special key X

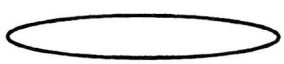
conspicuously (more than 50%) contractile*

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

yes

Ciliophora III

special key XXI

Ciliophora III

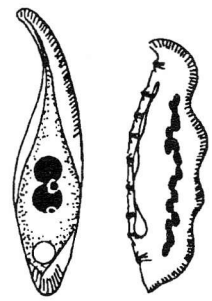
Ciliophora II

shape lanceolate

no

yes

Pleurostomatida

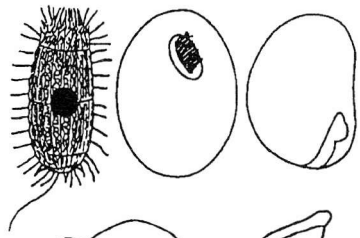


barrel-shaped, ellipsoid or like a segment of a circle

no

yes

special key XIV

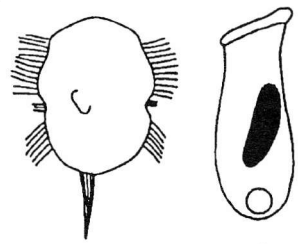


dumb-bell or spatula shaped

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

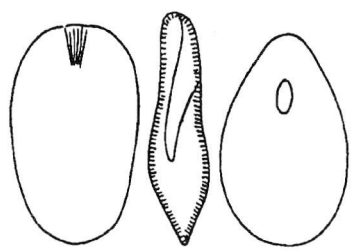
shape cylindrical, i.e. length : width ratio 2-3 : 1, fusiform or oviform (usually not sessile)

no

Ciliophora IV

yes

special key XIII



Ciliophora IV

* 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!

Ciliophora III

shape reniform

no

yes

special key XXII

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

no

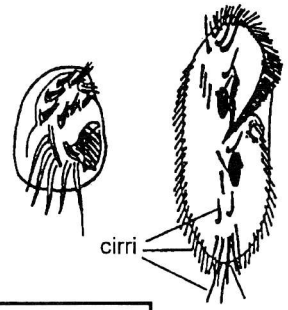
yes

2 macronuclear nodules (Ma)

special key XIX

no or unknown

yes



adoral zone of membranelles (tufts of cilia; AZM)

yes

no

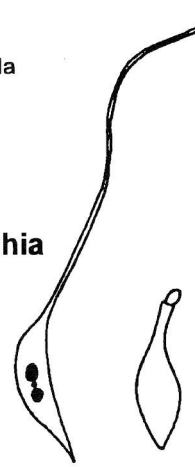
many **Hypotrichia**

shape

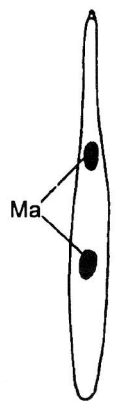
club-shaped

rod-shaped

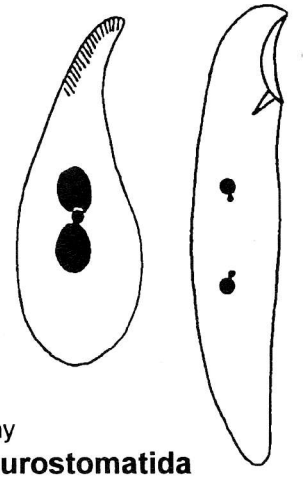
lanceolate



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)

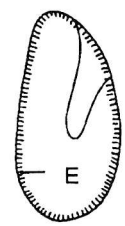
rod (extrusomes) seam (E; observe at X 400 and with bright field!)

no

yes

Ciliophora V

special key XXIII



Ciliophora V

Ciliophora IV

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

no or unknown

yes

special key XXV

conspicuous ciliary wreaths

no

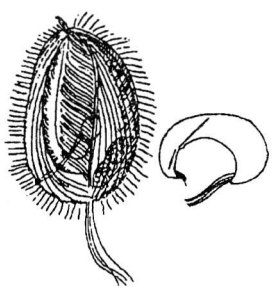
yes

special key XXVI

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

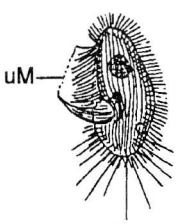
no

yes



Lembadion
Hymeno-stomata I

Cyclidium
Hymeno-stomata VII



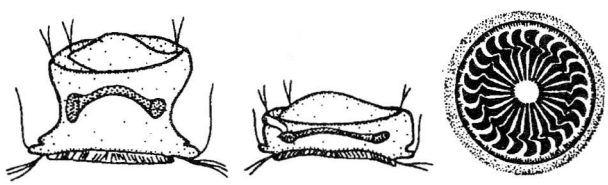
Pleuronema
Hymeno-stomata III

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

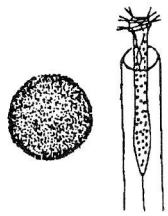
special key XXIV

Ciliophora VI

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

special keys XXVIIIa,b and community Oligotrichetea

epizoic

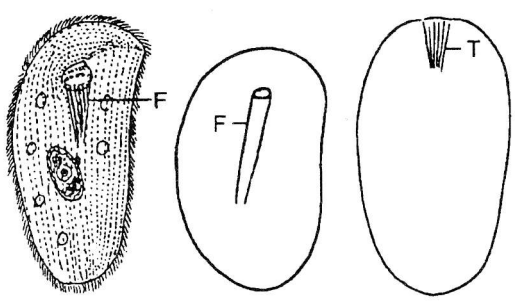
no or unknown

yes

special key XXXII

mouth

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



Ciliophora XI and special keys XXIV, XXVII

conspicuous, transverse cleft

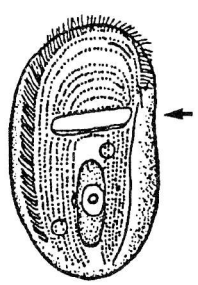
different

Ciliophora VII

nose

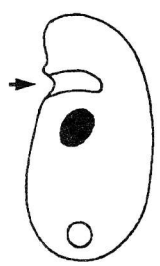
absent

present



Gastronauta

Cyrtophorida I



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

Ciliophora VII

Ciliophora VI

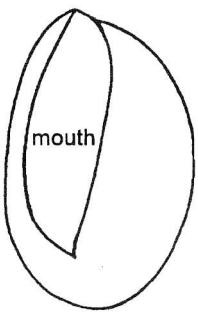
mouth

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

shape

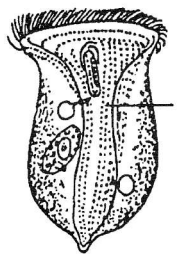
ellipsoid

as figured



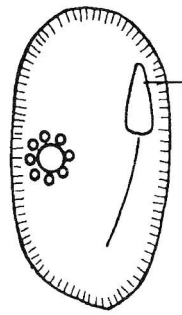
Lembadion

Hymeno-stomata I



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

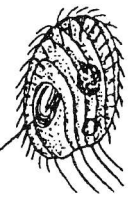
large, triangular, in anterior third (contractile vacuole in mid-body; distinct seam of extrusomes)



Frontonia

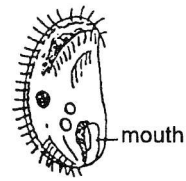
Hymenostomata V

subequatorial



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

near posterior end



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

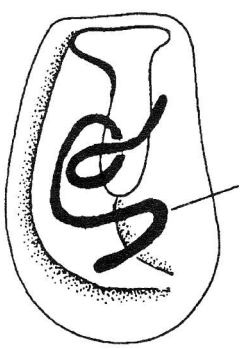
different

Ciliophora VIII

in large cavity

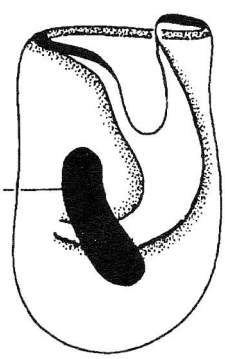
macronucleus (Ma)

thread-like



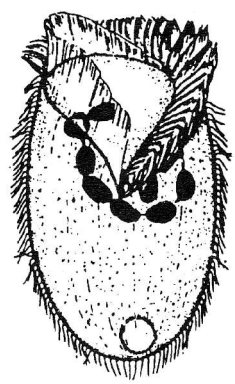
Bursaria truncatella
200-1700 µm
(Vol. I, p.424)

reniform or ellipsoid



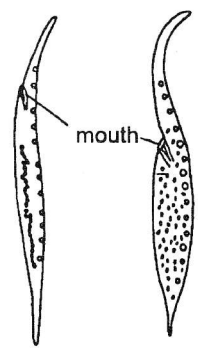
Bursaridium pseudobursaria
80-200 µm
(Vol. I, p.433)

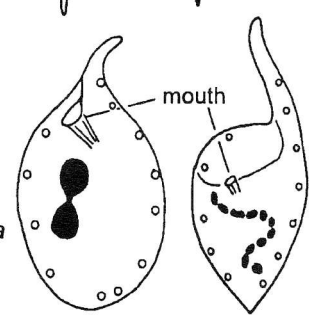
moniliform



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

at base of acontractile proboscis





Dileptus, Monilicaryon, Trachelius, Paradileptus

Gymnostomatida II

Ciliophora VIII

Ciliophora VII

oral ciliature

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

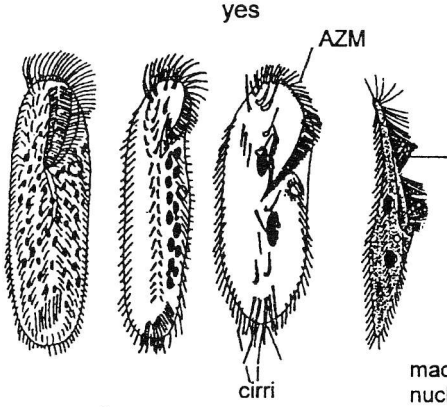
inconspicuous

Ciliophora IX

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

yes

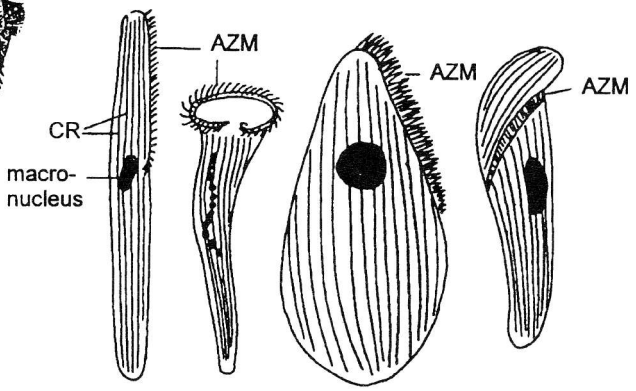
no



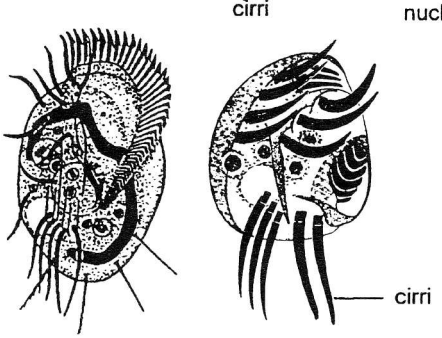
somatic ciliature (ciliary rows; CR); use magnification > X 400

complete

strongly reduced or lacking



Heterotrichida

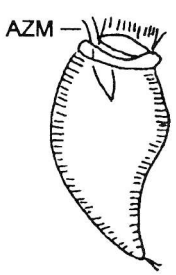


Hypotrichia

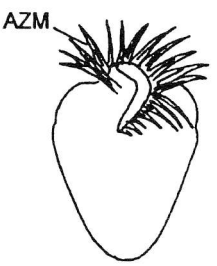
transverse striation (no ciliary rows!); oral ciliature

present; continuous membrane

absent; distinct ciliary plates

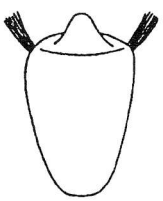


Peritrichia



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

Ciliophora VIII

size

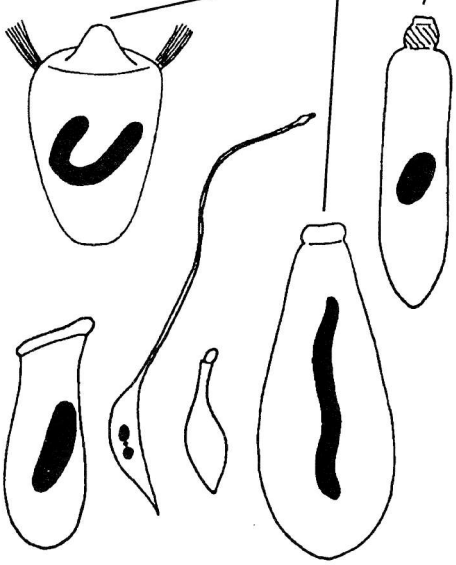
> 40 µm

< 40 µm (15-50 µm)

special keys XXIX-XXXI

anterior end

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

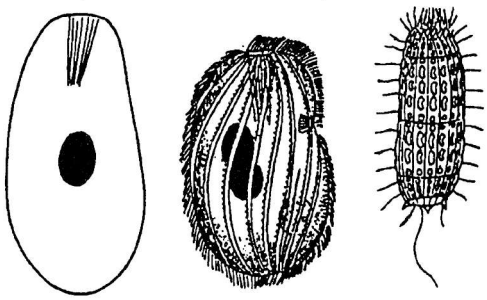


Gymnostomatida

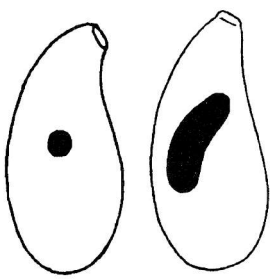
different

shape

cylindroid or barrel-shaped



Prostomatida



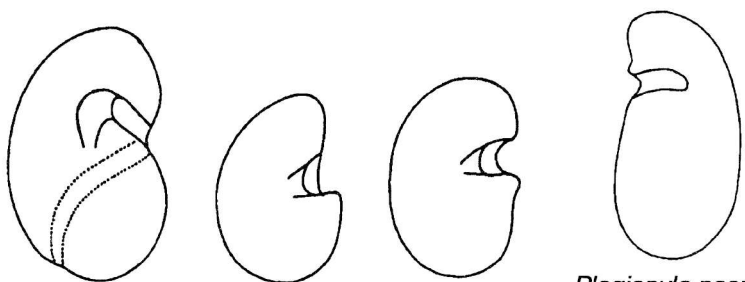
Platyophrya vorax
30-60 µm
(Vol. I, p.419)

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



Colpoda; **Colpodea**

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

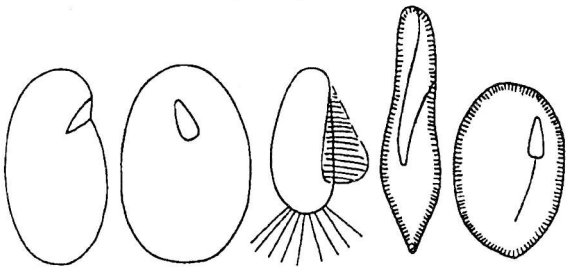
Ciliophora X

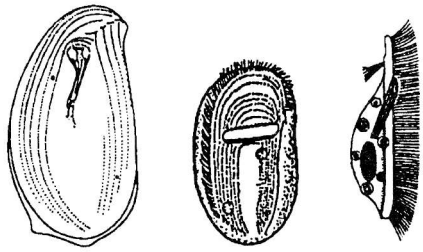
Ciliophora IX

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**

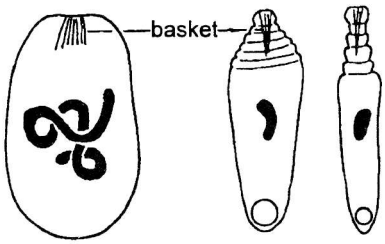
Ciliophora XI

Ciliophora VI

oral basket

at anterior end

distinctly subapical



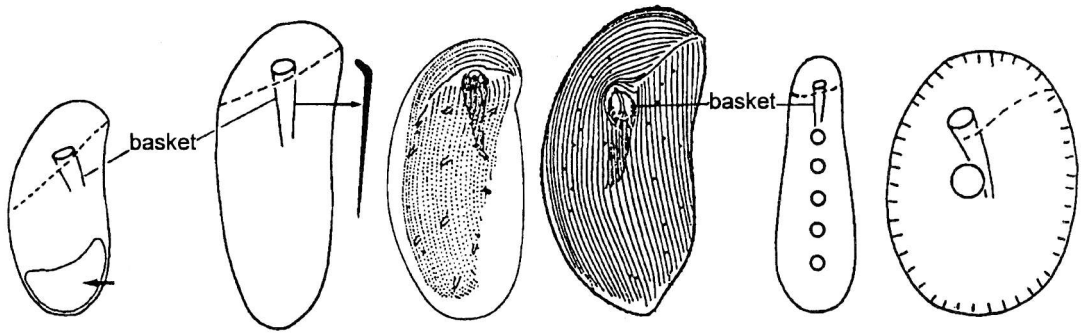
Prostomatida

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)

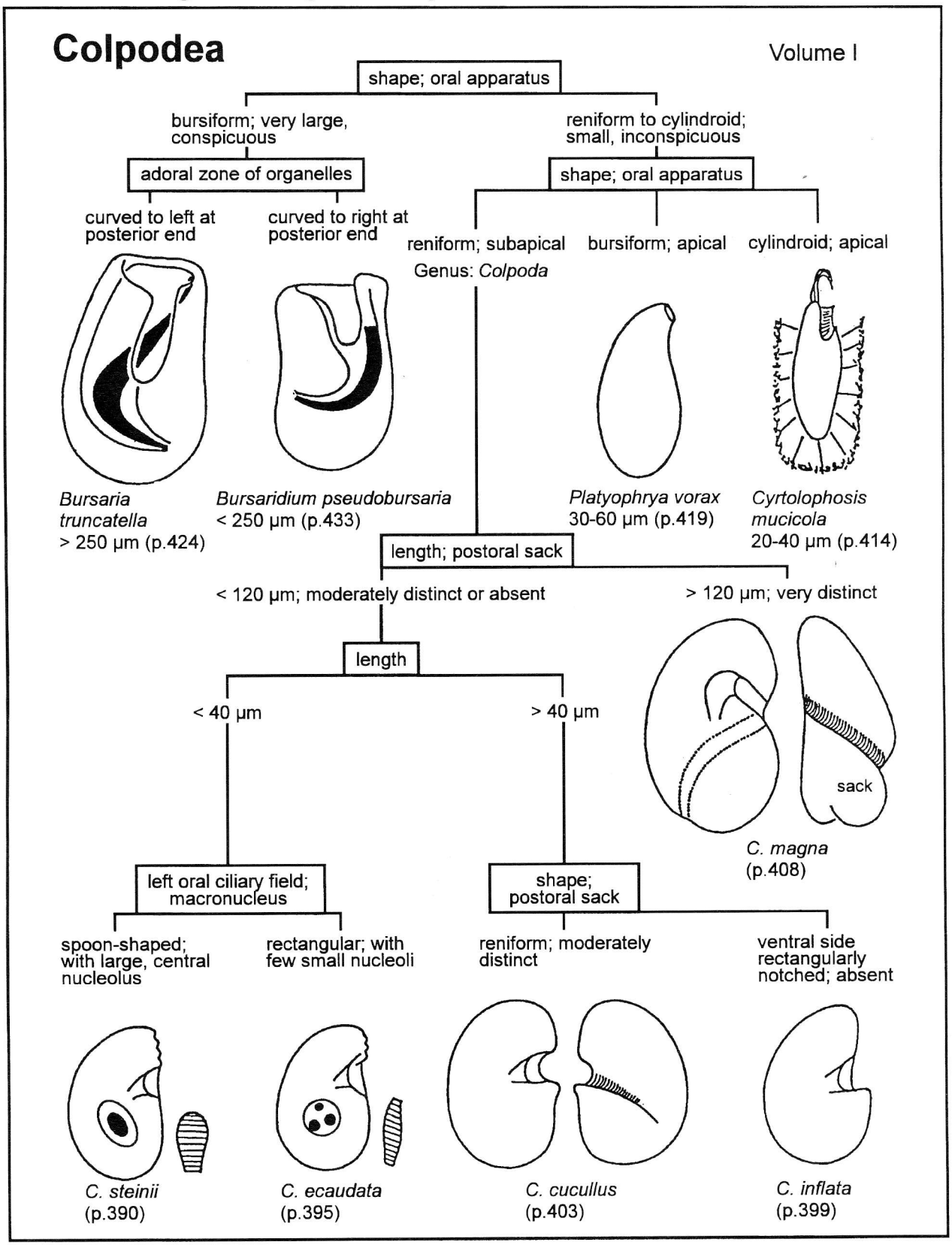
Cyrtophorida

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.

Keys to species (main groups ordered alphabetically)

Check identifications against detailed figures and descriptions in the "Ciliate Atlas".



Cyrtophorida I

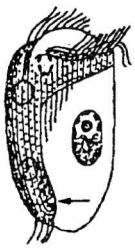
Volume I

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)

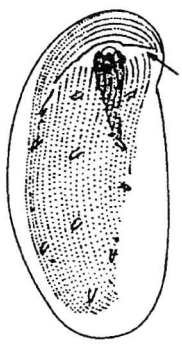
non-ciliated postoral field; number of ciliary rows; size

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)

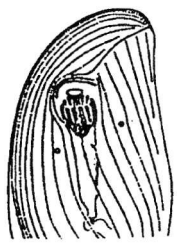
perioral ciliary row left of oral basket only; absent

number of ciliary rows; number of contractile vacuoles

< 22; usually < 10

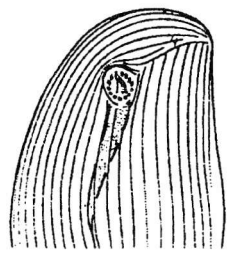
number of ciliary rows; distance between postoral ciliary rows

16-18; slightly enlarged



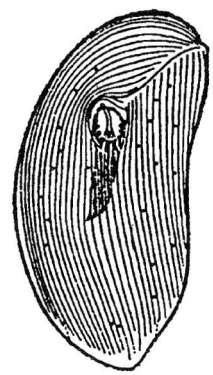
Trithigmostoma srameki
70-100 µm (p.77)

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)

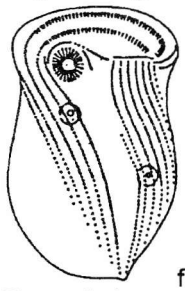
Cyrtophorida II

Cyrtophorida II

Volume I

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

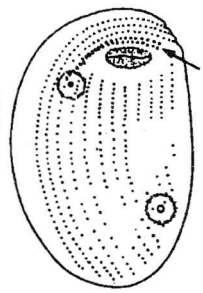
preoral ciliary row(s) left above basket plus 2 circumoral ciliary rows; about in median of cell

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

preoral ciliary row (silver impregnation); food

fragmented; often diatoms

not fragmented; usually bacteria



Chlamydonella alpestris
25-35 µm (p.115)

colour

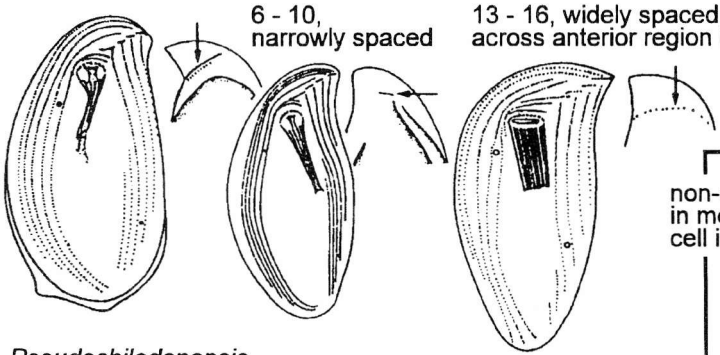
green from green algae

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

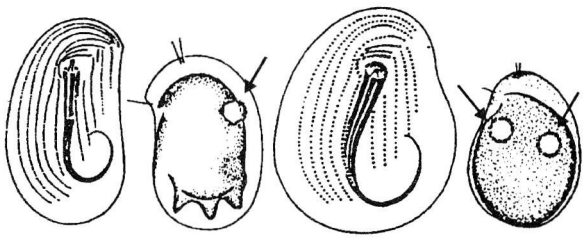
1 right of basket

2 opposite of basket

dorsal brush

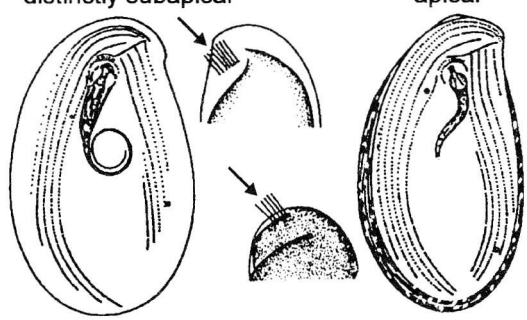
distinctly subapical

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

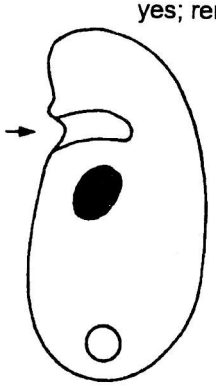
ciliary wreaths

oviform; longitudinal

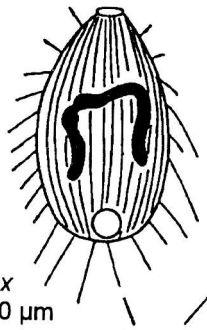
obovoid; distinctly spirally

1

2

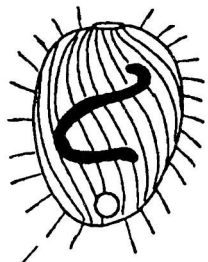


Plagiopyla nasuta
80-180 µm (p.266)



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

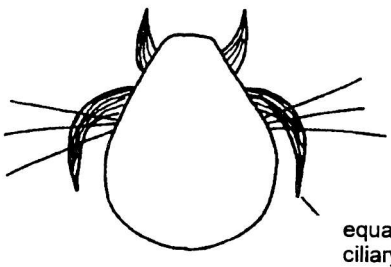
close to globular trunc; usually 12-25 µm

number of pre-equatorial ciliary belts

2

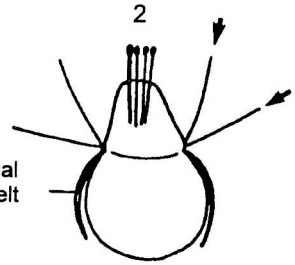
3

oral processes

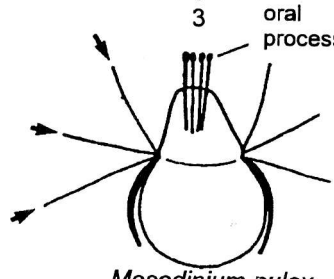


Askenasia volvox
30-50 µm (p.251)

equatorial ciliary belt



Mesodinium acarus
12-20 µm (p.257)



Mesodinium pulex
15-35 µm (p.260)

Gymnostomatida II

Volume IV

acontractile proboscis

yes

no

trunc

fusiform

bursiform to globular

macronucleus

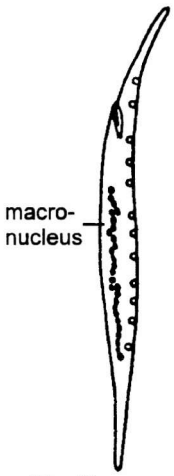
macronucleus; mode of life

moniliform

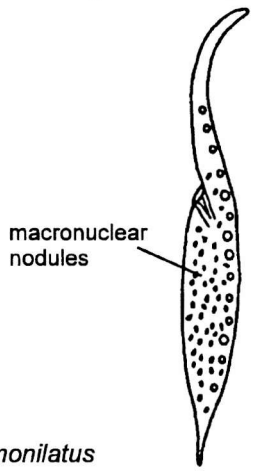
more than 500 very small (and thus difficult to recognize in vivo) nodules

moniliform; euplanktic

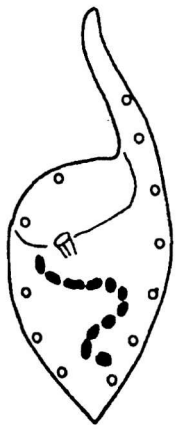
dumb-bell shaped; periphyton and benthic



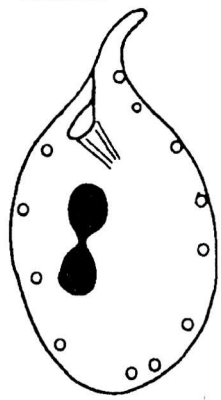
Monilicaryon monilatus
350-950 µm,
usually 400-700 µm
(p.199)



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

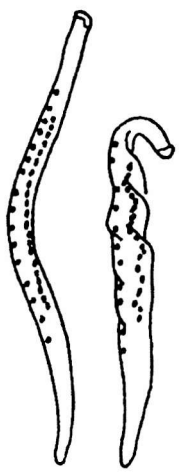
vermiform

lageniform

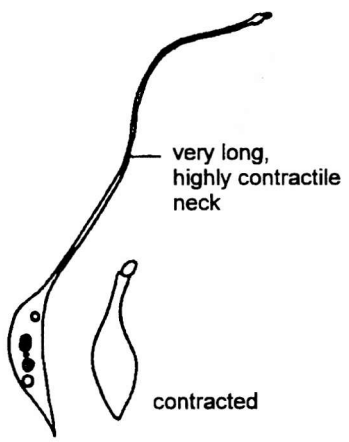
rod-shaped

different

Gymno-stomatida III



Homalozoon vermiculare
150-1500 µm (p.219)



Lacrymaria olor
extended up to 1.2 mm,
contracted ~ 100 µm
(p.163)

macronucleus

2 large nodules

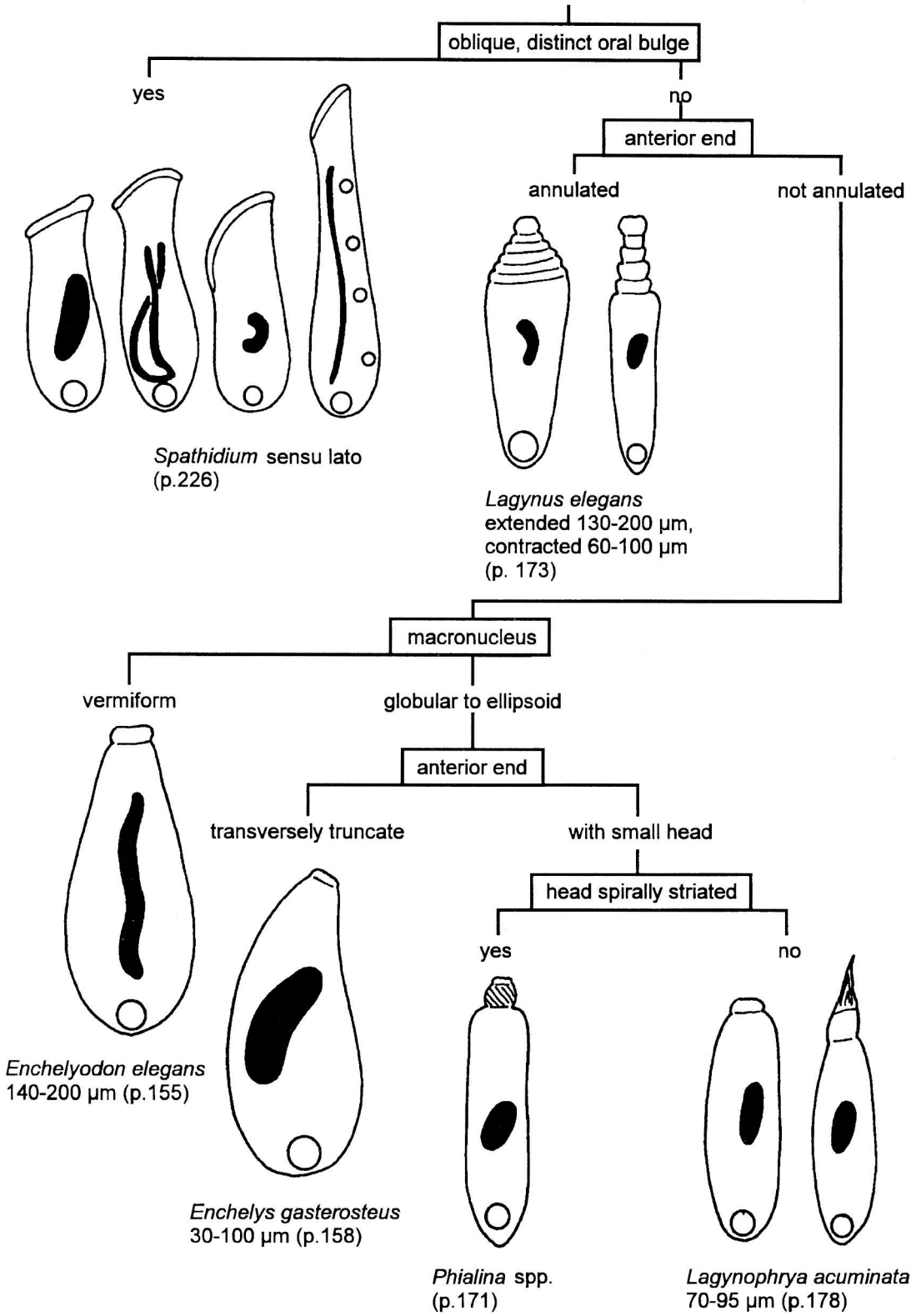
20-30 small nodules

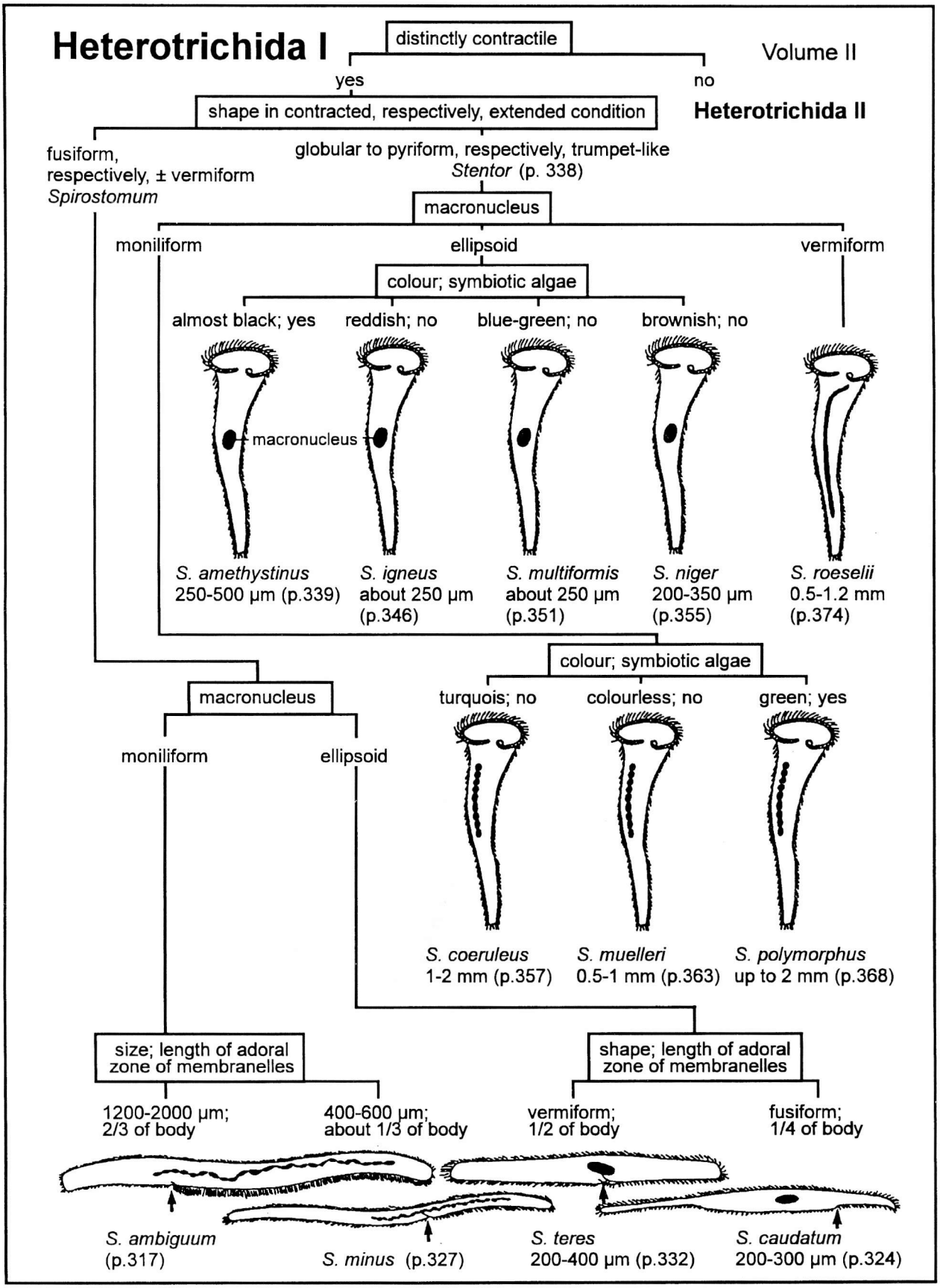
Trachelophyllum apiculatum
90-180 µm (p.180)

Chaenea stricta
90-150 µm (p.152)

Gymnostomatida III

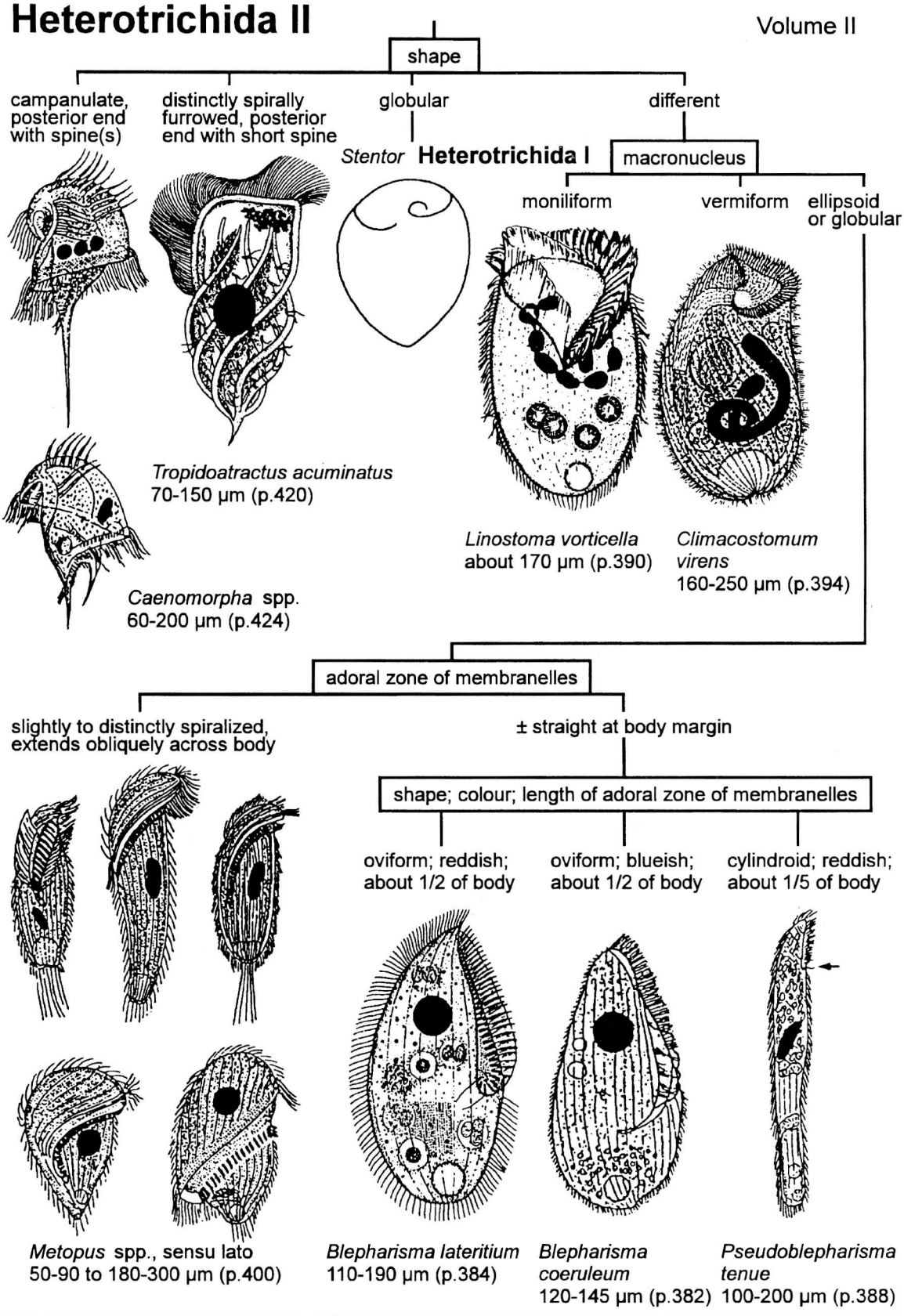
Volume IV

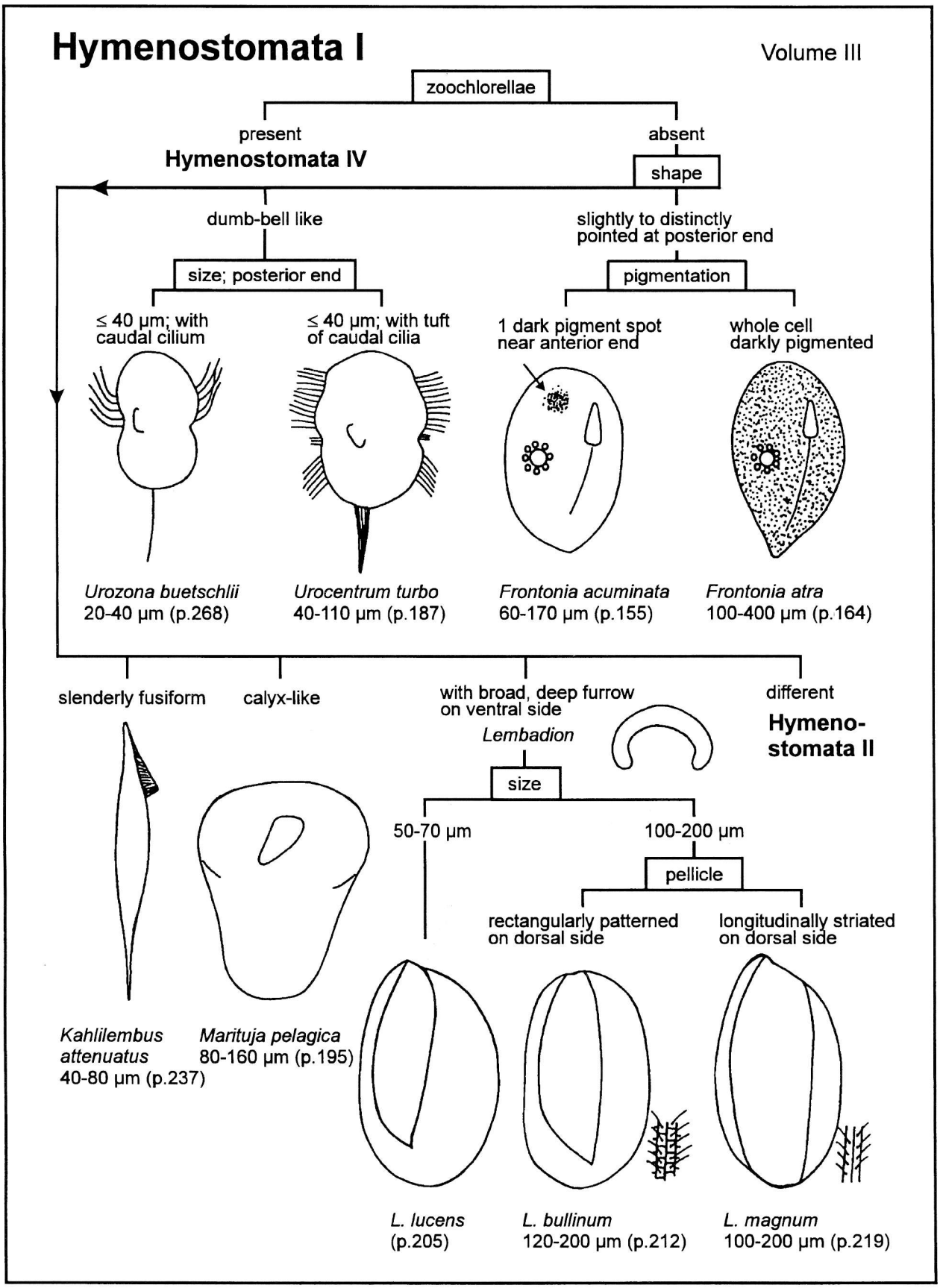



Heterotrichida I
distinctly contractile
yes
no
Volume II
Heterotrichida II
shape in contracted, respectively, extended condition
fusiform, respectively, ± vermiform
Spirostomum
globular to pyriform, respectively, trumpet-like
Stentor (p. 338)
macronucleus
moniliform
ellipsoid
vermiform
colour; symbiotic 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
macronucleus
turquois; no
colourless; no
green; yes
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

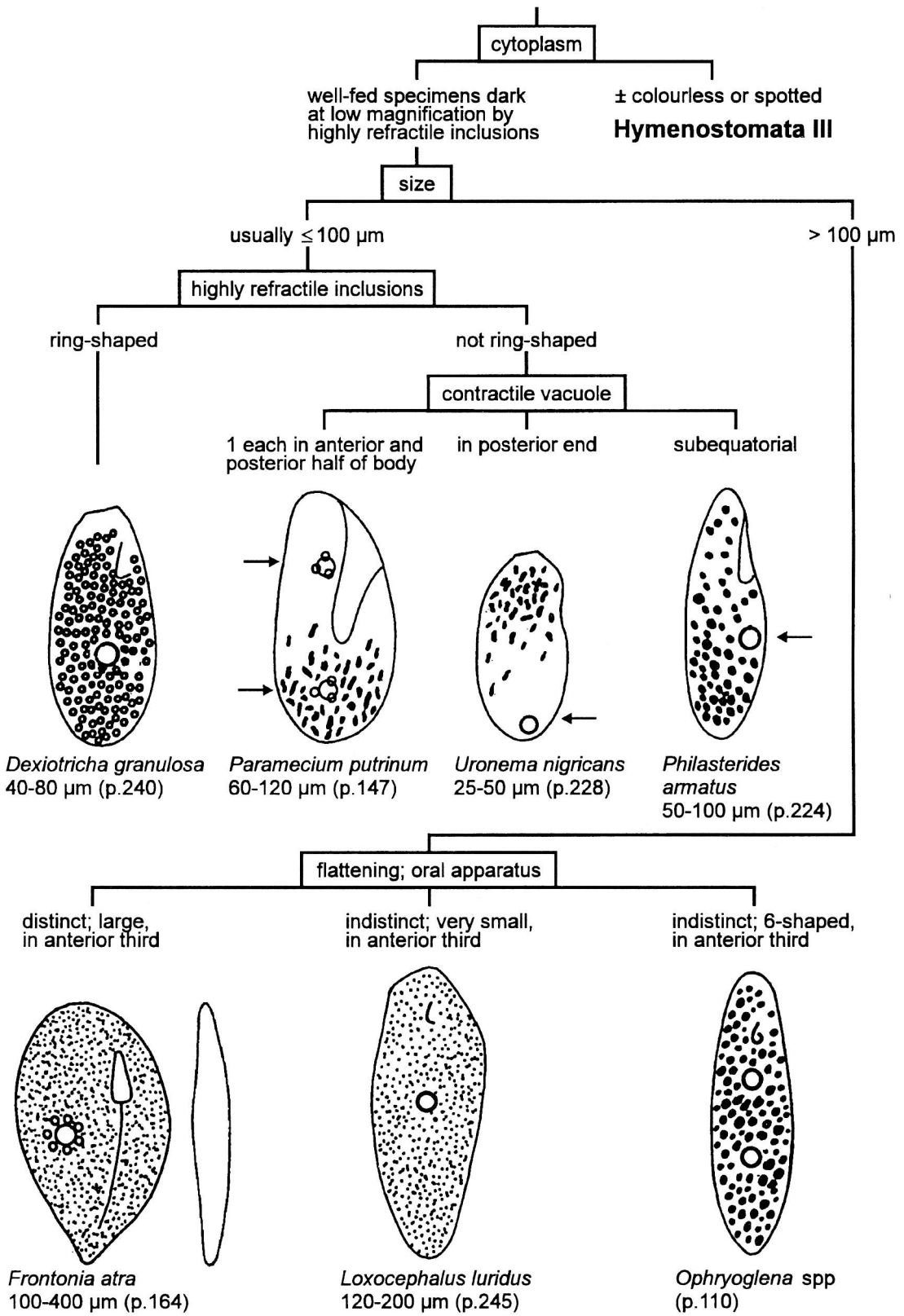
Volume II

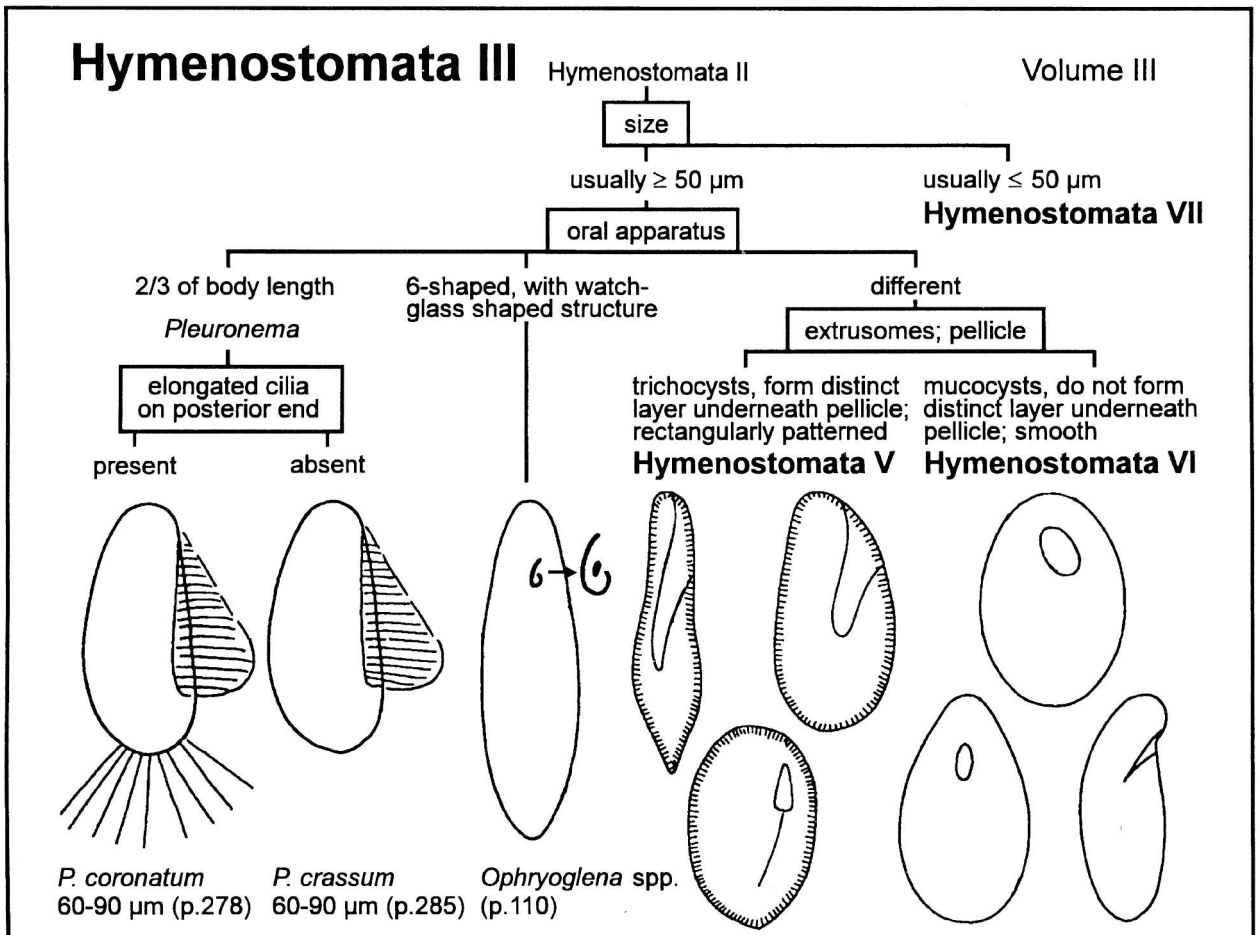


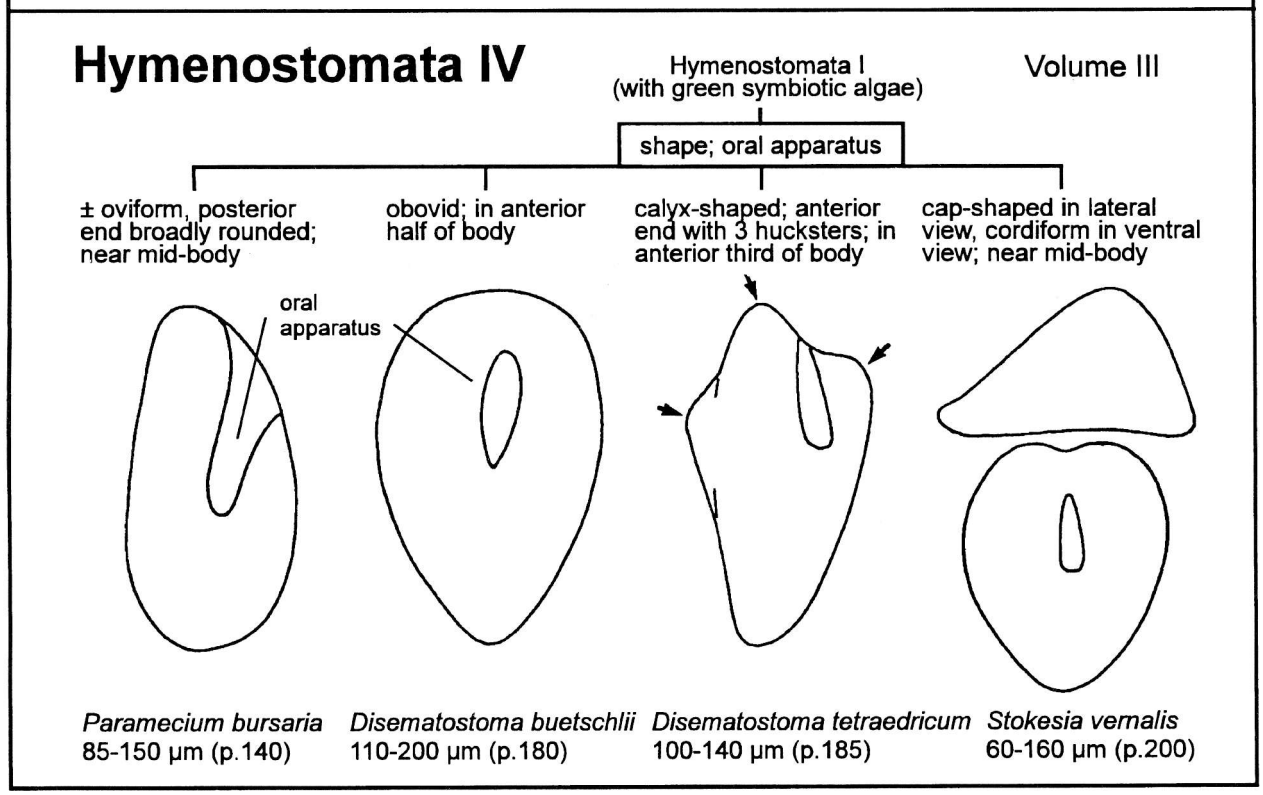

Hymenostomata I
Volume III
zoochlorellae
present
Hymenostomata IV
absent
shape
dumb-bell like
size; posterior end
≤ 40 µm; with caudal cilium
≤ 40 µm; with tuft of caudal cilia
slightly to distinctly pointed at posterior end
pigmentation
1 dark pigment spot near anterior end
whole cell darkly pigmented
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
Lembadion
different
Hymeno-stomata II
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

Volume III




Hymenostomata III
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
Hymenostomata I (with green symbiotic algae)
Volume III
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

Hymenostomata III (with distinct extrusome layer underneath pellicle) — Volume 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*

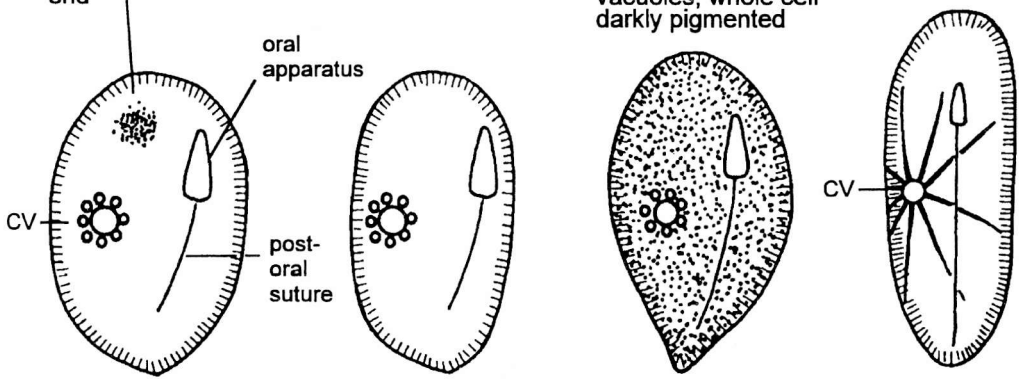
shape; contractile vacuole; pigmentation

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

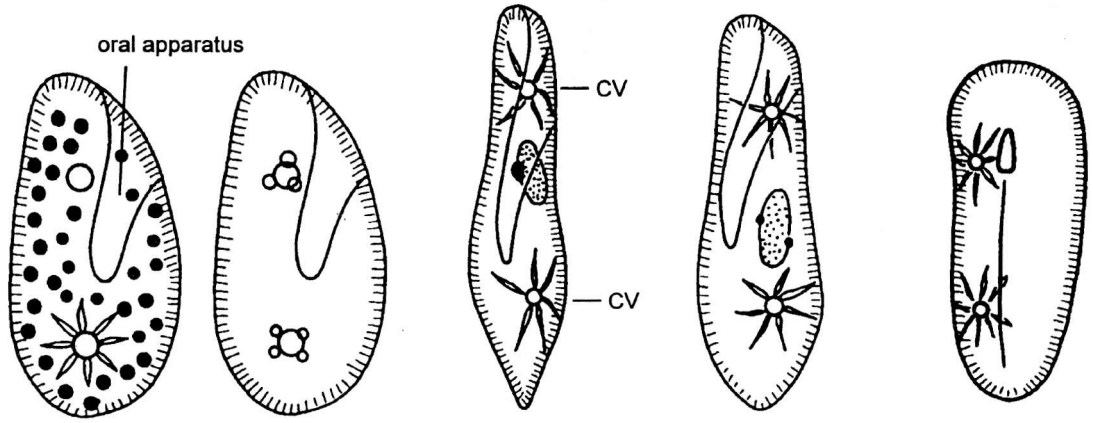
fusiform

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



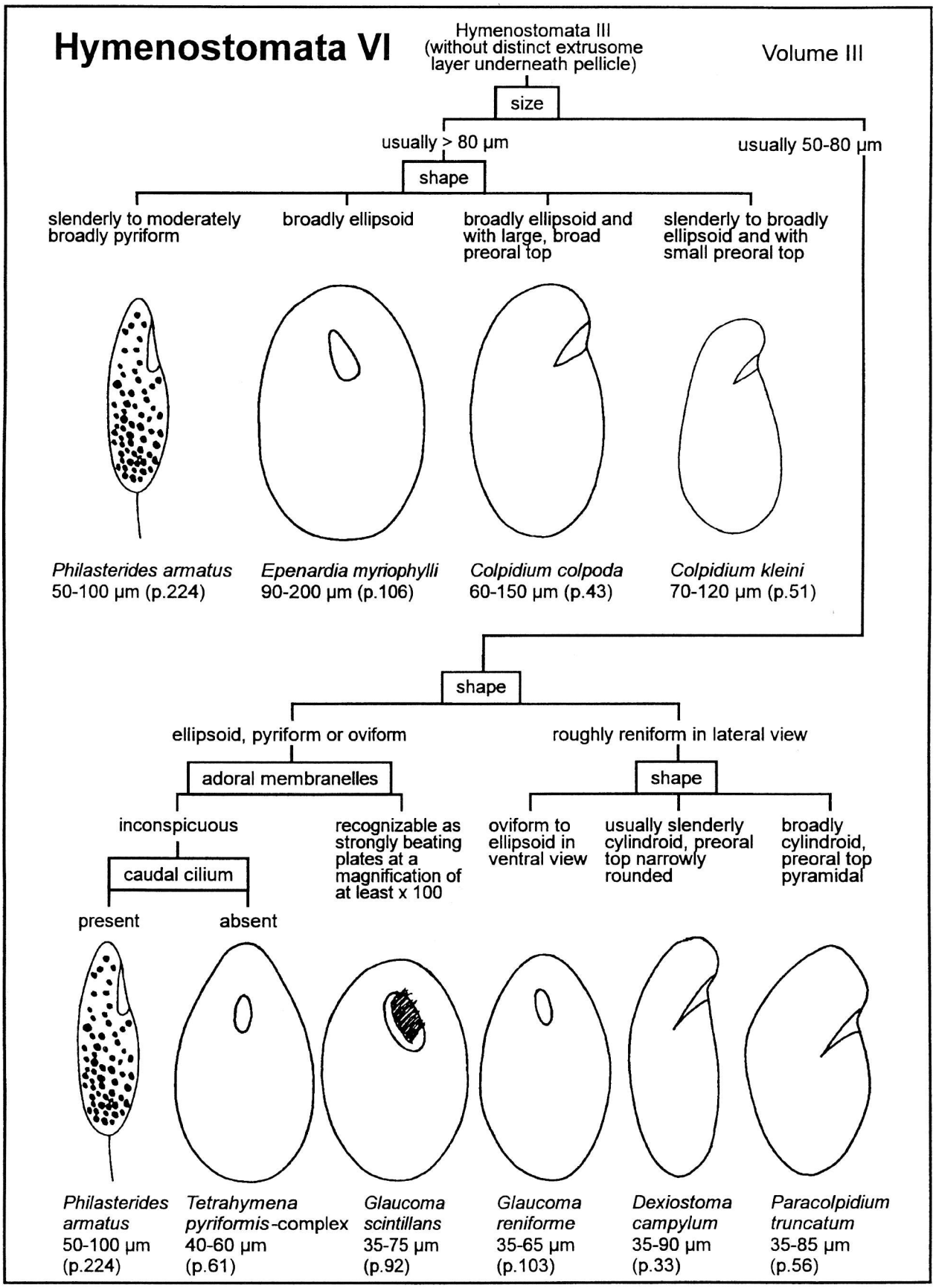
P. bursaria 85-150 µm (p.140)

P. putrinum 60-120 µm (p.147)

P. caudatum 170-300 µm (p.112)

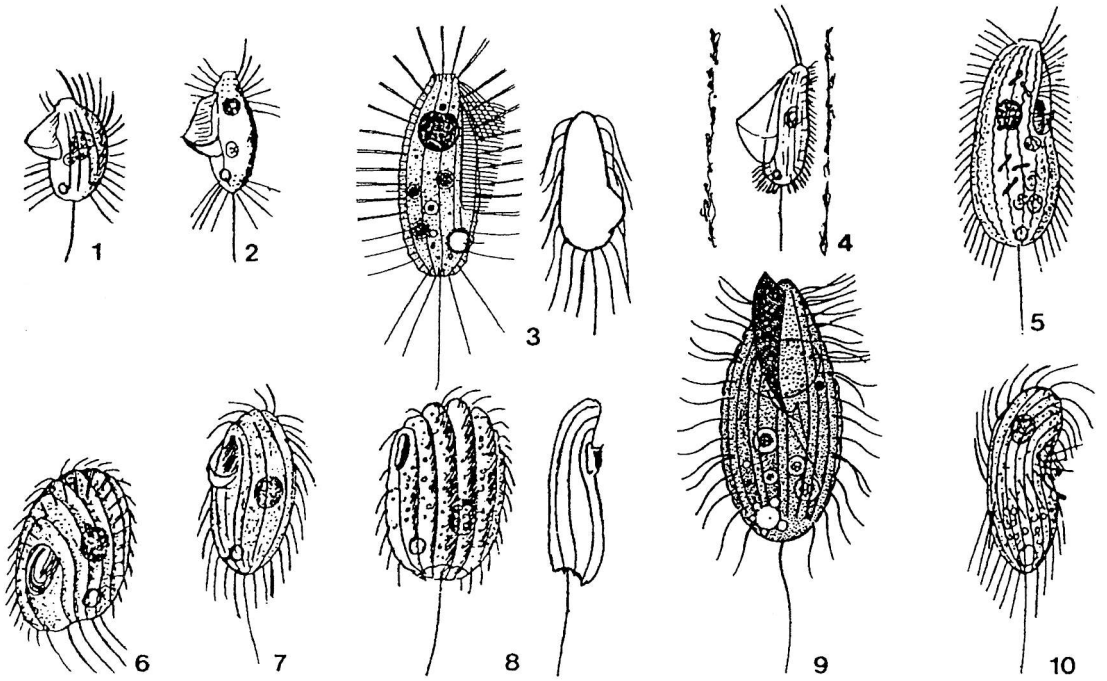
P. aurelia-complex 100-180 µm (p.129)

Frontonia elliptica 150-200 µm


Hymenostomata VI
Hymenostomata III (without distinct extrusome layer underneath pellicle)
Volume 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.

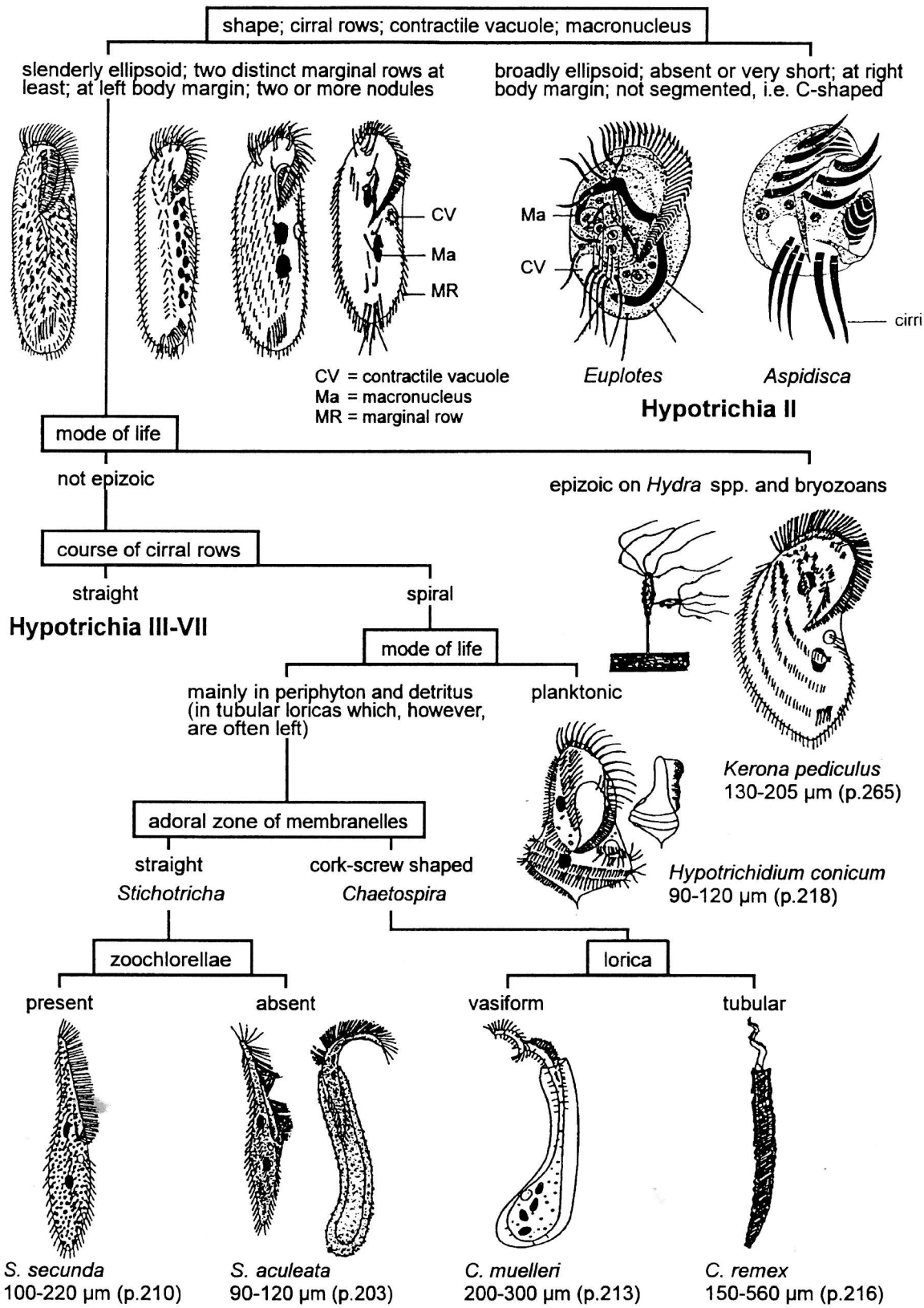
8: *Platynematum sociale*: Size, shape and posterior notch similar as in *Cinetochilum margaritaceum,* but oral apparatus in anterior body half and contractile vacuole on ventral side; polysaprobic.

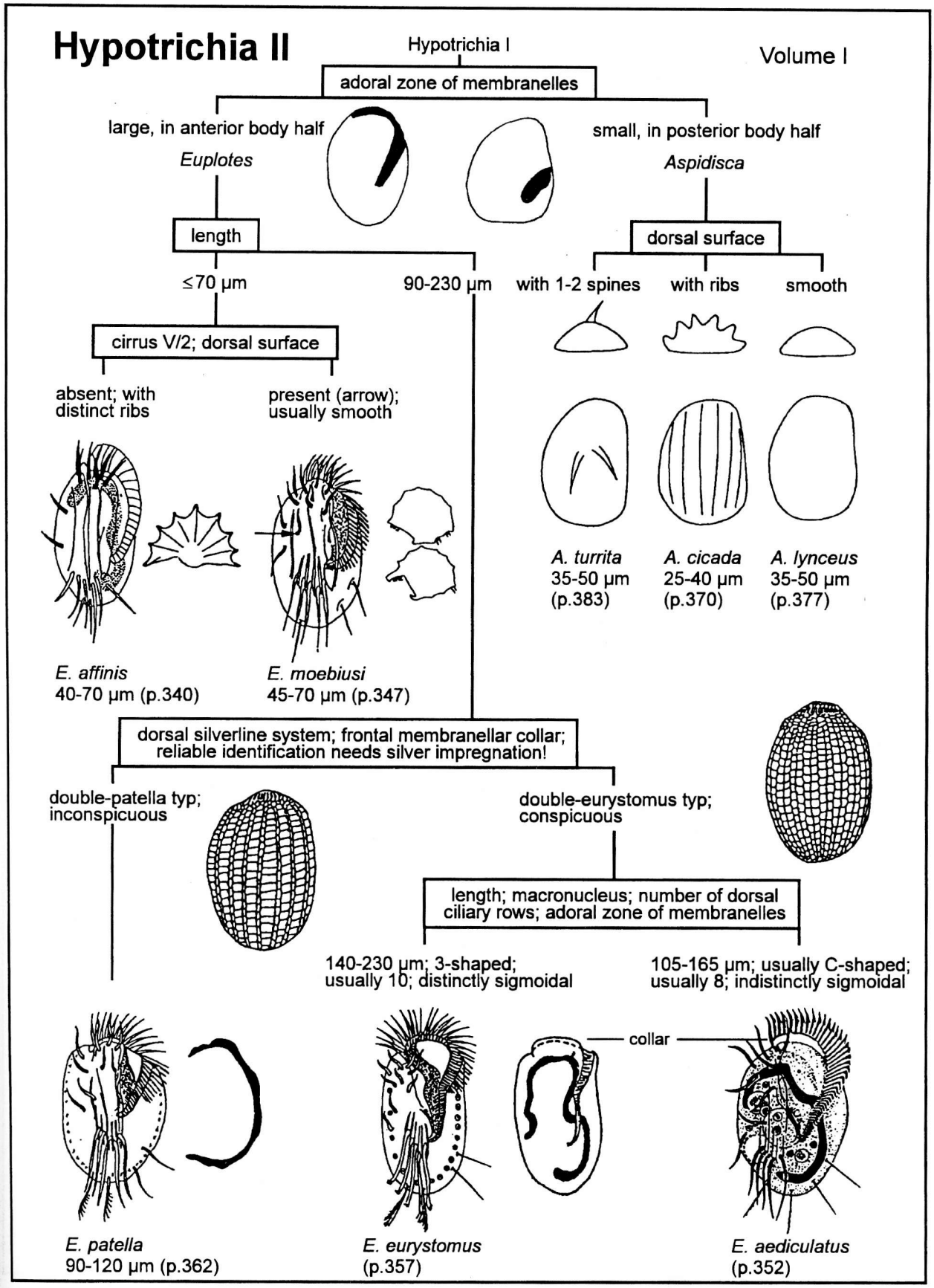
9: *Pseudocohnilembus pusillus*. 25-50 µm; oviform, in anterior third not indented (difference to *Uronema nigricans*!); oral apparatus about half as long as cell, cleft-like, inconspicuous; moves drilling, never rests; polysaprobic.

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.

Hypotrichia I

Volume I




Hypotrichia II
Hypotrichia I
Volume I
adoral zone of membranelles
large, in anterior body half
Euplotes
small, in posterior body half
Aspidisca
length
≤70 µm
90-230 µm
dorsal surface
with 1-2 spines
with ribs
smooth
cirrus V/2; dorsal surface
absent; with distinct ribs
present (arrow); usually smooth
E. affinis
40-70 µm (p.340)
E. moebiusi
45-70 µm (p.347)
A. turrita
35-50 µm
(p.383)
A. cicada
25-40 µm
(p.370)
A. lynceus
35-50 µm
(p.377)
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

Hypotrichia I

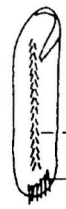
Volume I

midventral row

present

absent

Hypotrichia IV



midventral row

transverse cirri

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

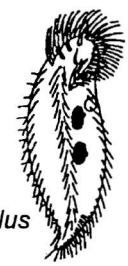
about 100 µm; moderately distinct (ca 30%); 7-11

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

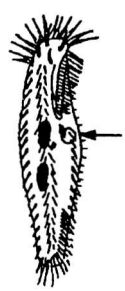
distinctly subequatorial; 60-90 µm

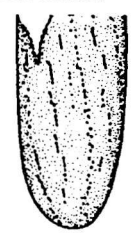
in mid-body; 120-170 µm

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

Volume I

Hypotrichia III

number of cirral rows

3 or more

zoochlorellae

present

Paraurostyla viridis
115-175 µm
(p.258)

absent

yellow-green cortical granules; number of transverse cirri

present; 6-9

Paraurostyla weissei
150-300 µm (p.260)

absent; 4-5

number of cirral rows

6-8

Pleurotricha grandis
200-400 µm (p.275)

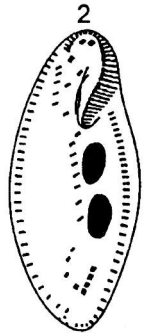
3

number of macronuclear nodules

4, rarely 6

Gastrostyla steinii
140-320 µm (p.272)

2

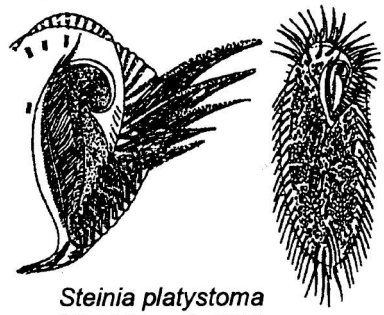


G. mystacea
120-170 µm (p.270)

2

oral area

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



Steinia platystoma
80-150 µm (p.336)

different

body

stiff like a board

Hypotrichia V

(if in doubt, follow key Hypotrichia VI)

flexible

zoochlorellae

present

Oxytricha chlorelligera
about 115 µm (p.277)

absent

Hypotrichia VI

(if in doubt, follow key Hypotrichia V)

Hypotrichia V

(difficult to determine!)

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

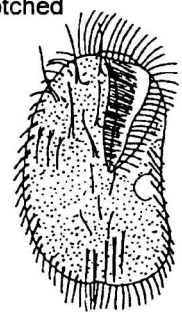
at least 1 at each macronuclear nodule

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)

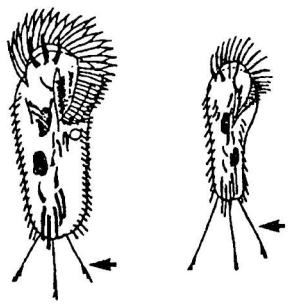


Histriculus vorax
140-190 µm (p.309)

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



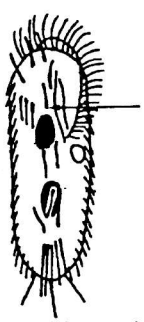
Stylonychia mytilus-complex
90-350 µm (p.315)

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 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

Hypotrichia IV

Volume I

cytoplasm; cortical granules

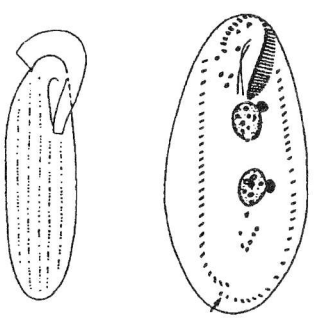
orange, reddish or brownish coloured; present

colourless; absent

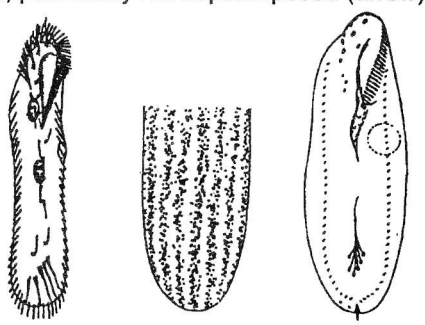
colour of cytoplasm; cortical granules; number of dorsal ciliary rows; marginal cirral rows

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

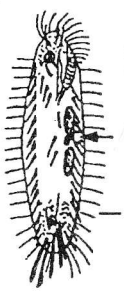
8-15 µm (easily confused with cirri!)

about 6 µm

length of body; shape; caudal cirri

55-100 µm; slenderly ellipsoid; absent

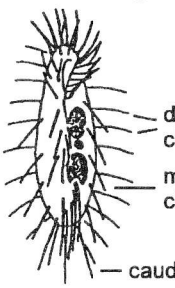
40-60 µm; oviform; present (but difficult to recognize)



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)

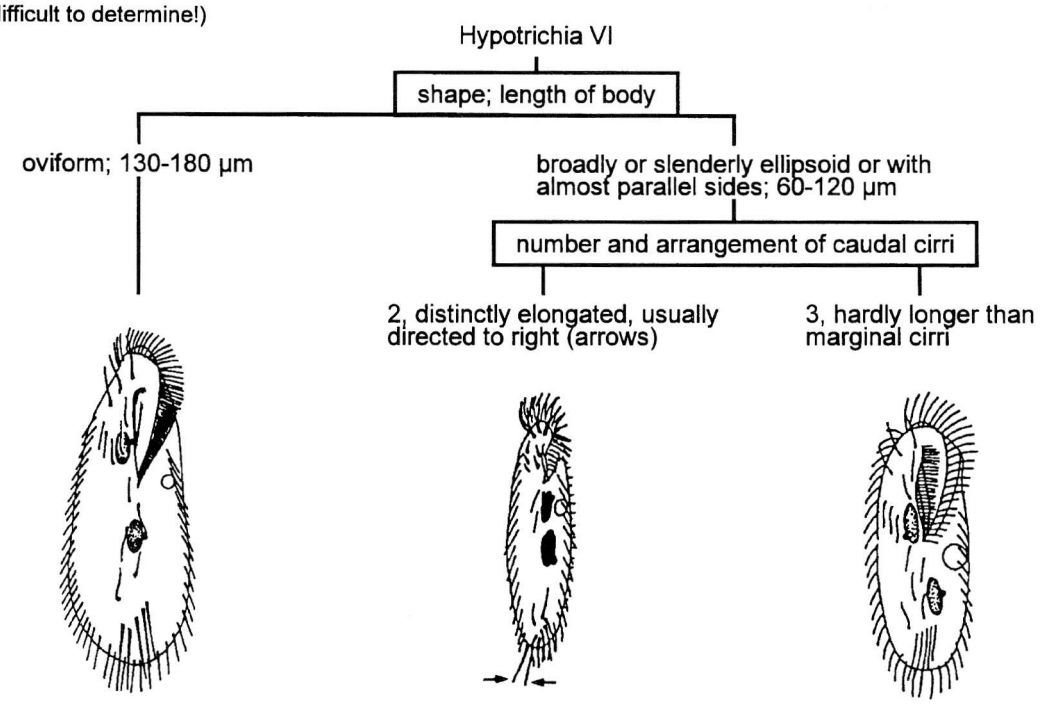
marginal cirri

Oxytricha saprobia, 100 µm (p.292)

Hypotrichia VII

Volume I

(difficult to determine!)



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)

Loxodes

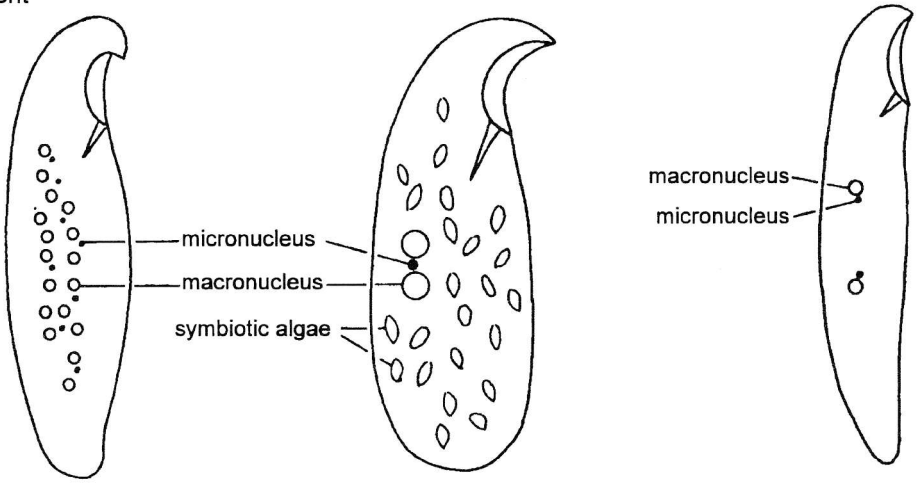
Volume IV

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

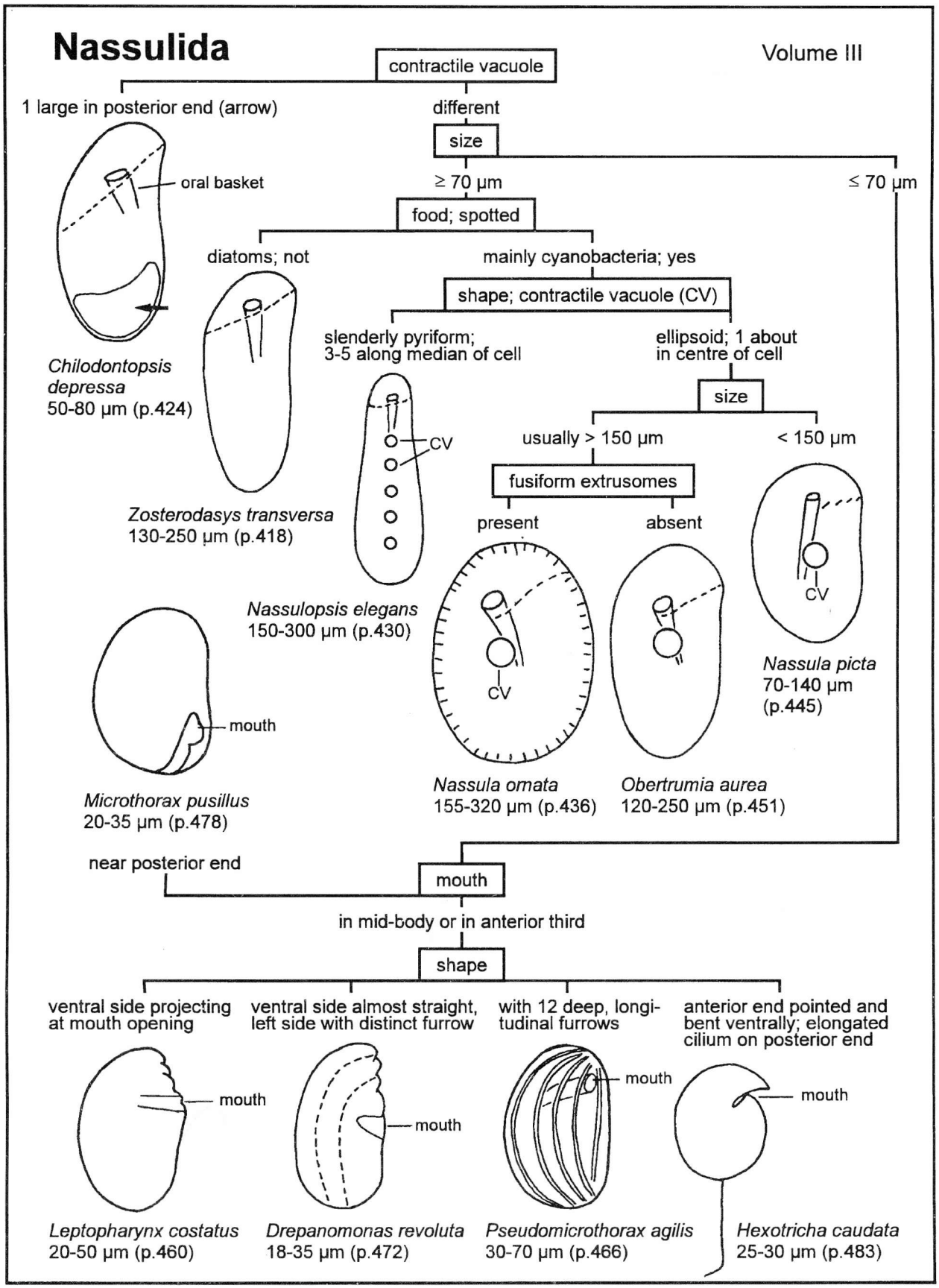
2 widely separate macronuclei each with 1 micronucleus; absent



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
≥ 70 µm
≤ 70 µm
oral basket
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)
Zosterodasys transversa 130-250 µm (p.418)
CV
size
usually > 150 µm
< 150 µm
fusiform extrusomes
present
absent
Nassulopsis elegans 150-300 µm (p.430)
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, longitudinal furrows
anterior end pointed and bent ventrally; elongated cilium on posterior end
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)

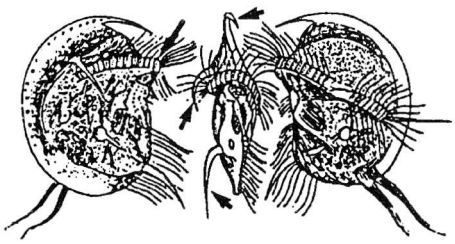
Odontostomatida [1,2]

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)

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



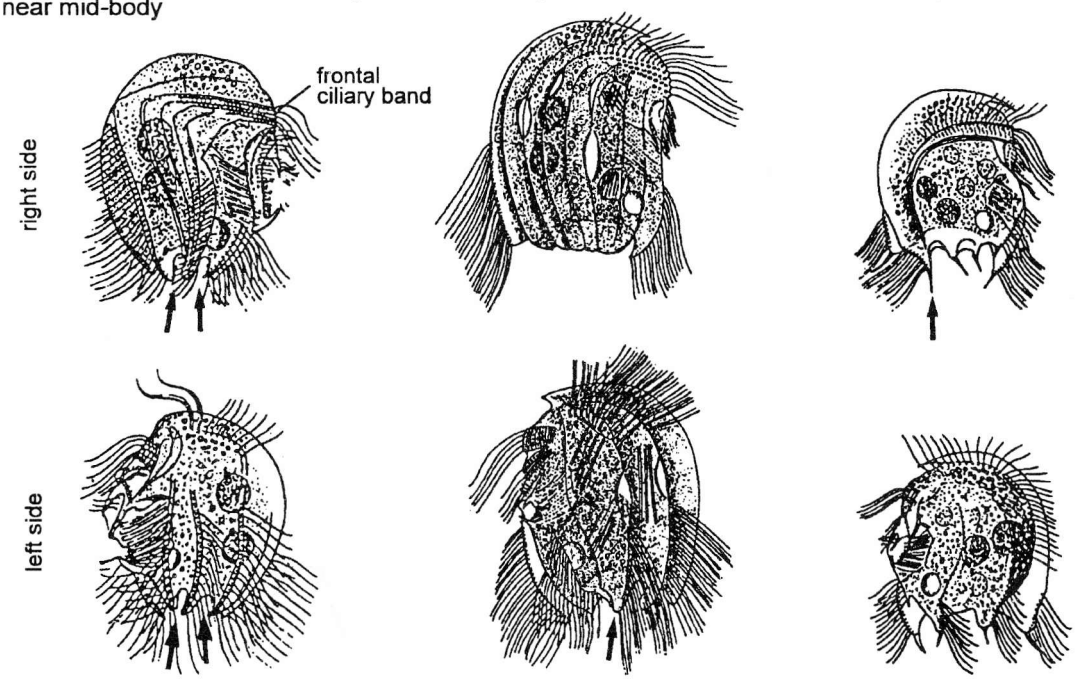
Discomorphella pectinata
70-90 µm (p.451)

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

Volume I

adoral zone of membranelles

form apical circle

extend on ventral side

lorica; macronucleus

absent; reniform to horseshoe-shaped

usually present (can be deserted, cells then become globular); globular to ellipsoid

caudal ciliary spiral; length

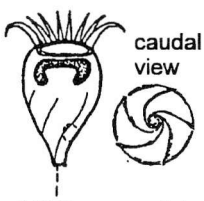
lorica; number of macronuclear nodules

present; > 40 µm

absent; < 40 µm

vasiform; 2

tubular; 1



Strobilidium caudatum (p.153)

S. humile (p.159)

Codonella cratera 50-70 µm (p.183)

reliable determination needs silver impregnation (see kinety diagrams)! Thus, the following key provides only an orientation. All species 50-200 µm long.

consistency of lorica

rather soft

rather firm

ecology

planktonic

sessile in periphyton

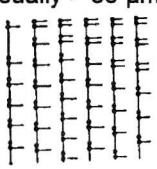
Tintinnopsis cylindrata (p.178)

diameter of lorica

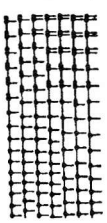
usually < 30µm

usually > 35 µm

Tintinnidium pusillum (p.168)



T. fluviatile (p.163)



T. semiciliatum (p.172)

extrusomes; somatic ciliature; size

present (arrow); short cilia, hardly recognizable; 40-90 µm

absent; long jumping bristles in mid-body; 20-50 µm

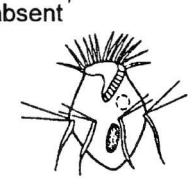
jumping bristles; symbiotic algae

distinct, i.e. cirri-like; absent

fine; present

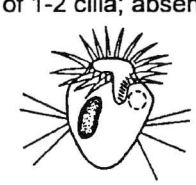
fine, i.e. composed of 1-2 cilia; absent

Strombidium viride (p.146)



Pelagohalteria cirrifera (p.144)

Halteria chlorelligera (p.134)



Halteria grandinella (p.137)

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**

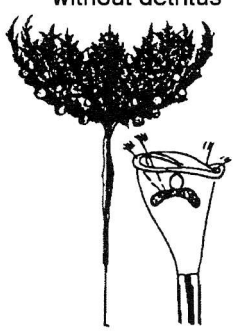
connected (arrow) *Zoothamnium*

stalk muscle

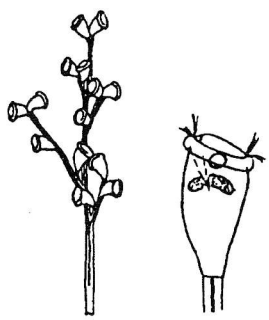
interrupted (arrow)

ramification of stalk; pellicle

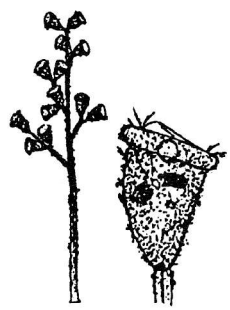
umbel-like; without detritus → *Z. arbuscula* 40-70 µm (p.152)

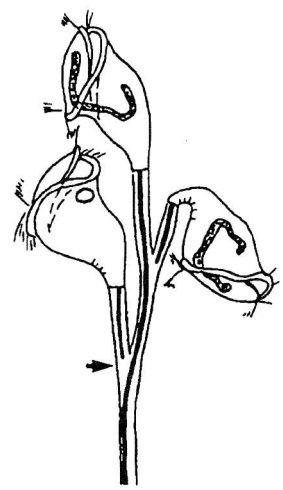


dichotom; without detritus → *Z. procerius* 60-80 µm (p.163)



dichotom; with detritus → *Z. kentii* 50-90 µm (p.158)





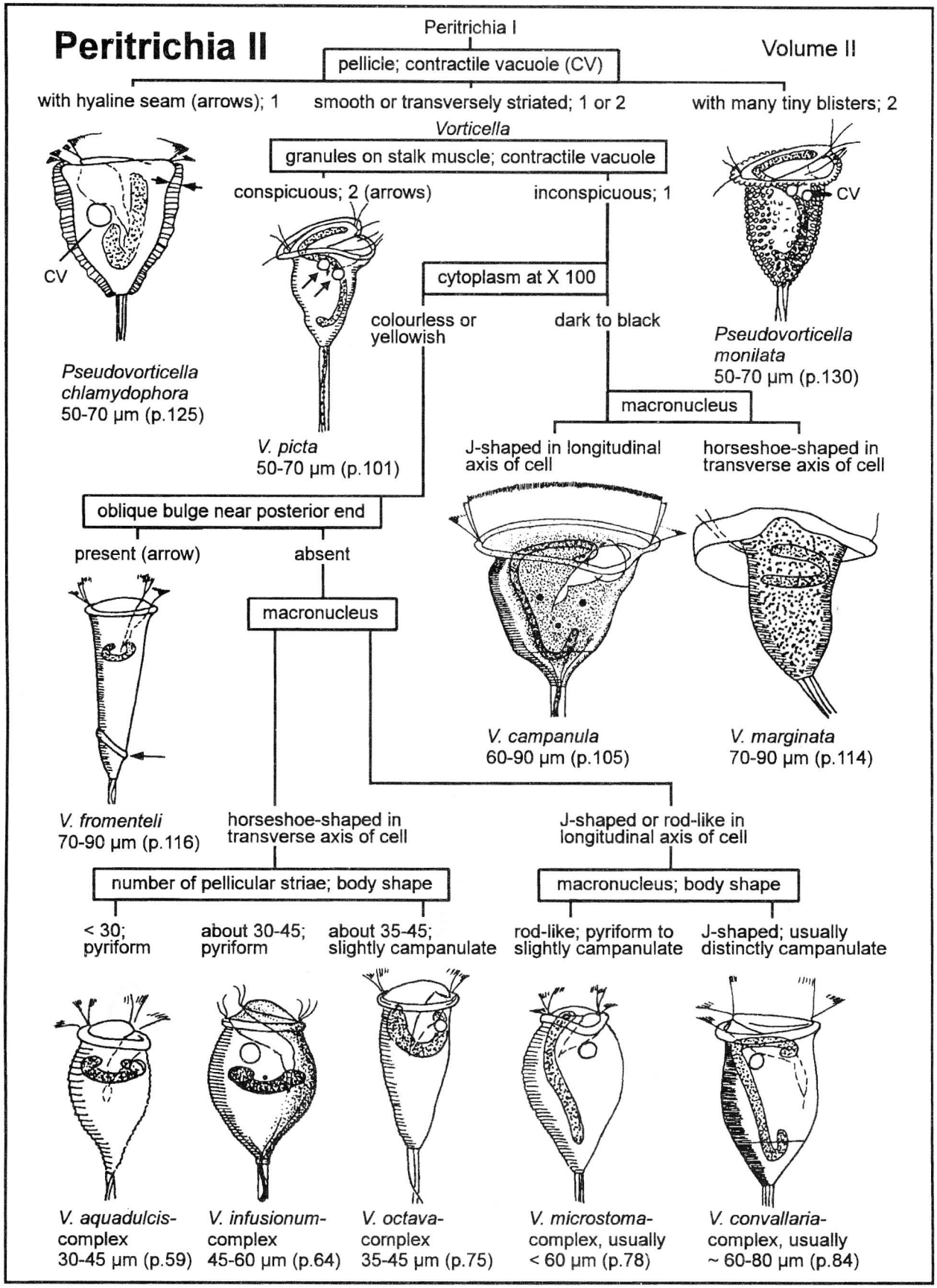
Carchesium polypinum 80-140 µm (p.137)

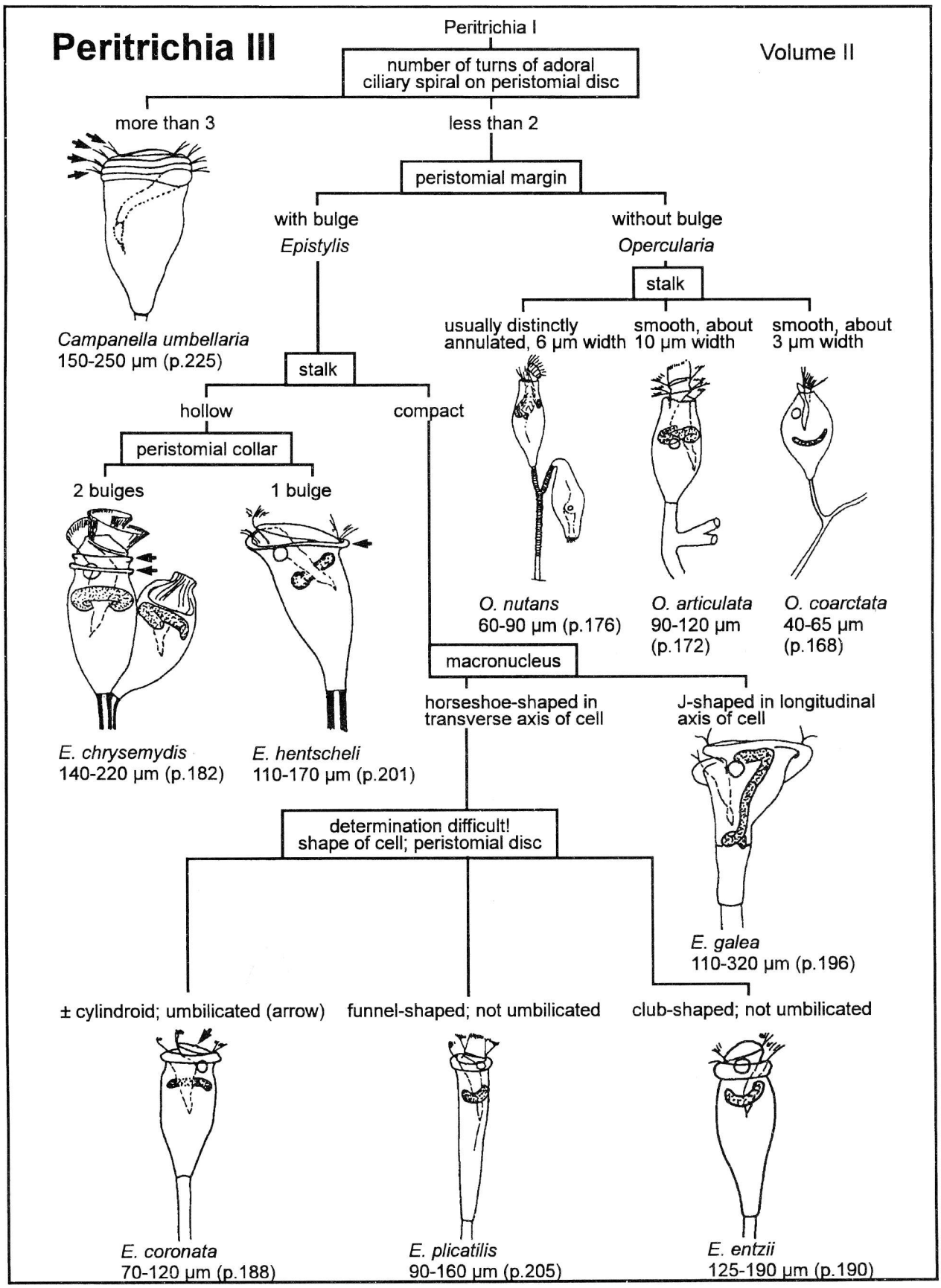
[1] The determination of most peritrich ciliates is simple because they have many distinct characters which, however, are often recognizable only in vital populations. Thus, samples must be investigated within few hours because most species soon become morbid in the collection jars or transform to swarmers 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.


Peritrichia II
Peritrichia I
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
Peritrichia I
Volume II
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)
E. galea
110-320 µm (p.196)
determination difficult! shape of cell; peristomial disc
± 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

Volume II

(all sizes refer to the lorica)

Peritrichia I

colonies

no

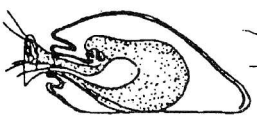
attatchment of lorica on substrate

with long side

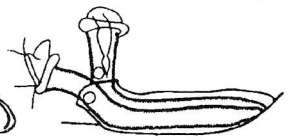
lorica opening; mode of life

closeable; epizoic

not closeable; not epizoic



Lagenophrys vaginicola
45-80 µm (p.256)



Platycola decumbens
65-145 µm (p.259)

yes

Ophrydium

Peritrichia VII

with posterior end

lorica stalk

present

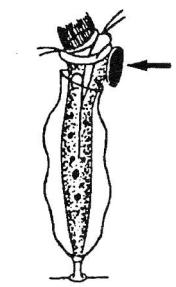
absent

lid near anterior end of cell

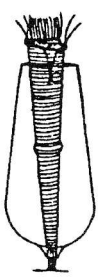
lid near anterior end of lorica

present (arrow)

absent



Pyxicola carteri
60-95 µm (p.270)



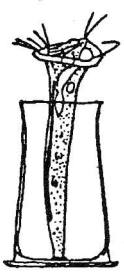
Cothurnia annulata
40-70 µm (p.251)

present (arrow)
Thuricola

absent
Vaginicola

lorica

± cylindroid



V. tincta
85-105 µm (p.287)

± pyriform

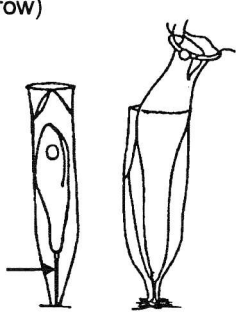
V. ingenita
35-60 µm (p.283)

lorica; zoochlorellae; cell stalk

posteriorly funnel-like narrowed; present; absent

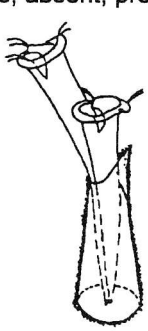
T. folliculata
125-240 µm (p.273)

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



T. kellicottiana
200-290 µm (p.278)

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



T. vasiformis
about 160 µm (p.281)

Peritrichia V

Volume II

Peritrichia I

habitus

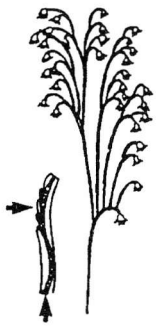
colonial

lorica

absent

stalk; stalk muscle

notched; present (arrows)



Carchesium pectinatum
40-70 µm (p.149)

present

smooth; absent

Epistylis procumbens
60-140 µm (p.221)

solitary

stalk

present

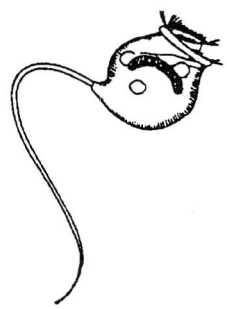
Peritrichia VII

peristomial collar; stalk contraction

wider than body; screw-like

Vorticella natans
70-100 µm (p.121)

narrower than body; whip-like

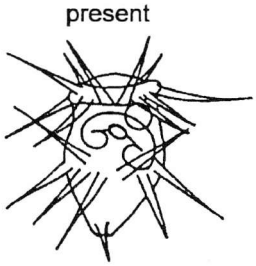


Vorticella mayeri
30-55 µm (p.118)

absent (but see footnotes 2 and 3 on page Peritrichia I and genus *Ophrydium* on page Peritrichia VII)

spines on body

present



Hastatella radians
40-60 µm (p.295)

absent

aboral ciliary wreath

absent

contractile vacuole

on ventral wall of peristomial funnel

Astylozoon fallax
40-70 µm (p.289)

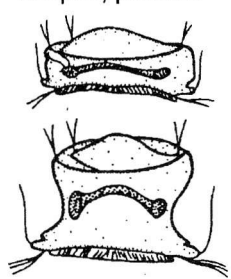
on dorsal wall of peristomial funnel

Astylozoon faurei
40-60 µm (p.291)

present

shape; adhesive disc

reel-shaped or coin-shaped; present



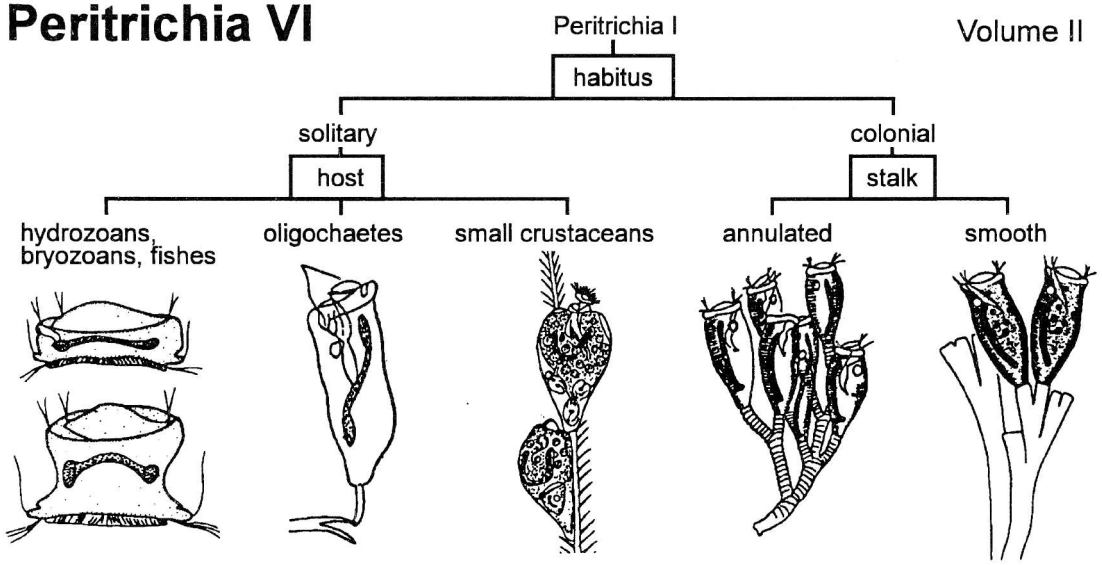
Trichodina pediculus
35-60 µm (p.304)

like a truncated cone; absent

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)

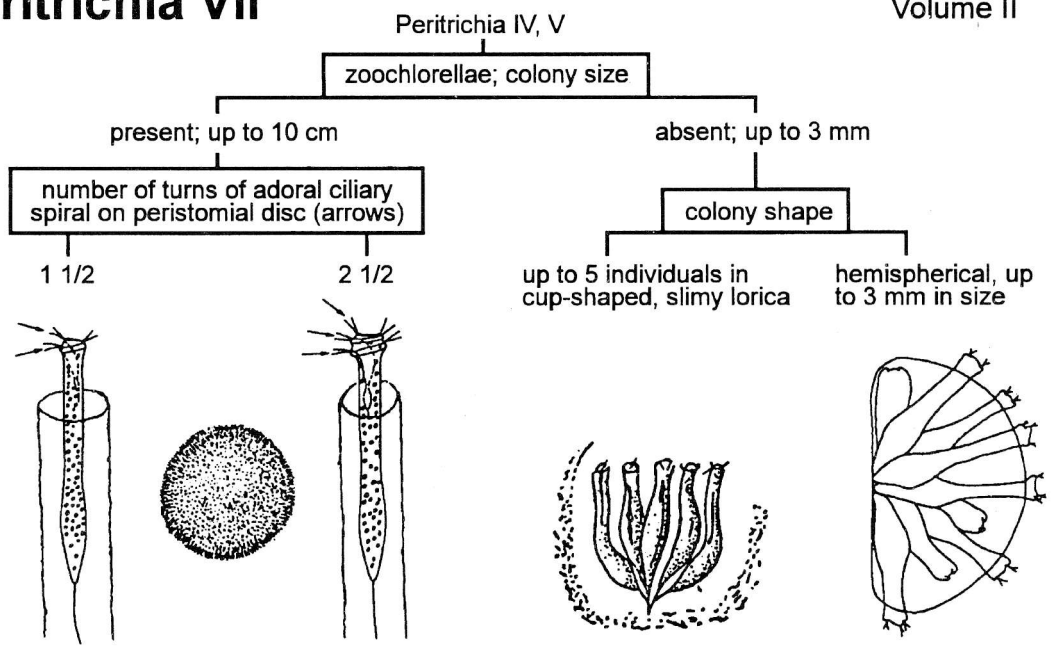
Lagenophrys vaginicola 45-80 µm (p.256)

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.

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

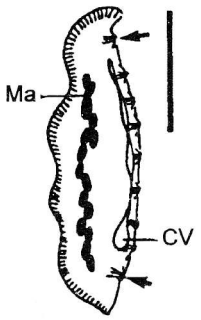
2-5

more than 5 *Amphileptus*

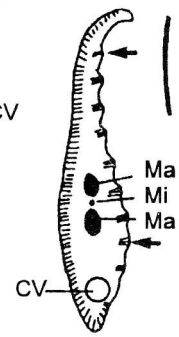
Pleurostomatida II

CV = contractile vacuole
Ma = macronucleus
Mi = micronucleus

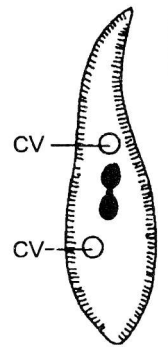
extrusomes



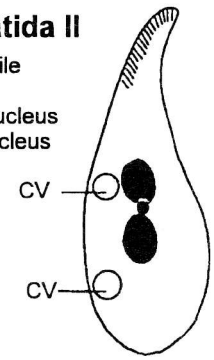
L. meleagris
300-500 µm
(p.354)



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

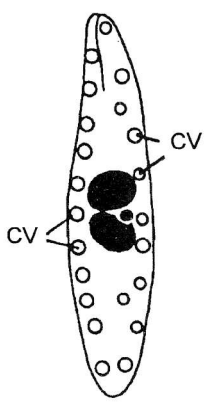
4; present

extrusomes; neck

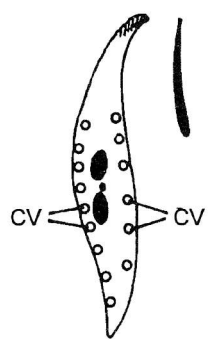
absent; absent

thorn-shaped; short and little extensible

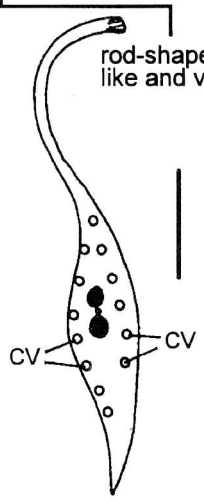
rod-shaped; proboscis-like and very extensible



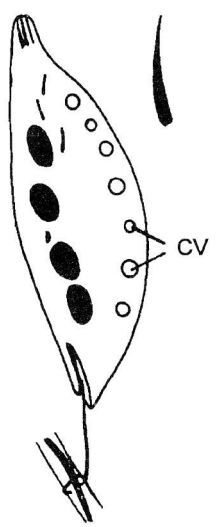
A. claparedii
120-160 µm (p.284)



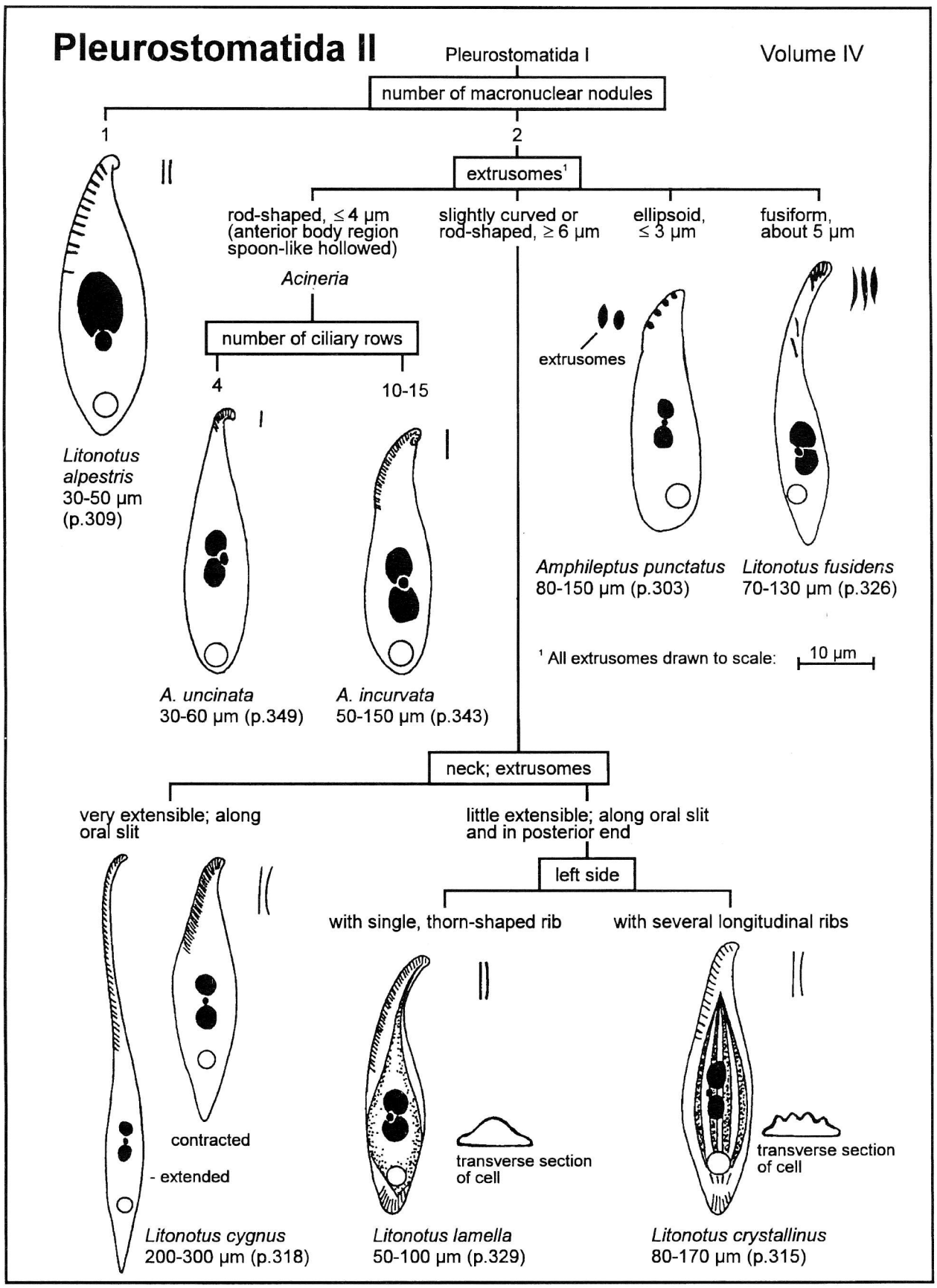
A. pleurosigma
150-300 µm (p.290)

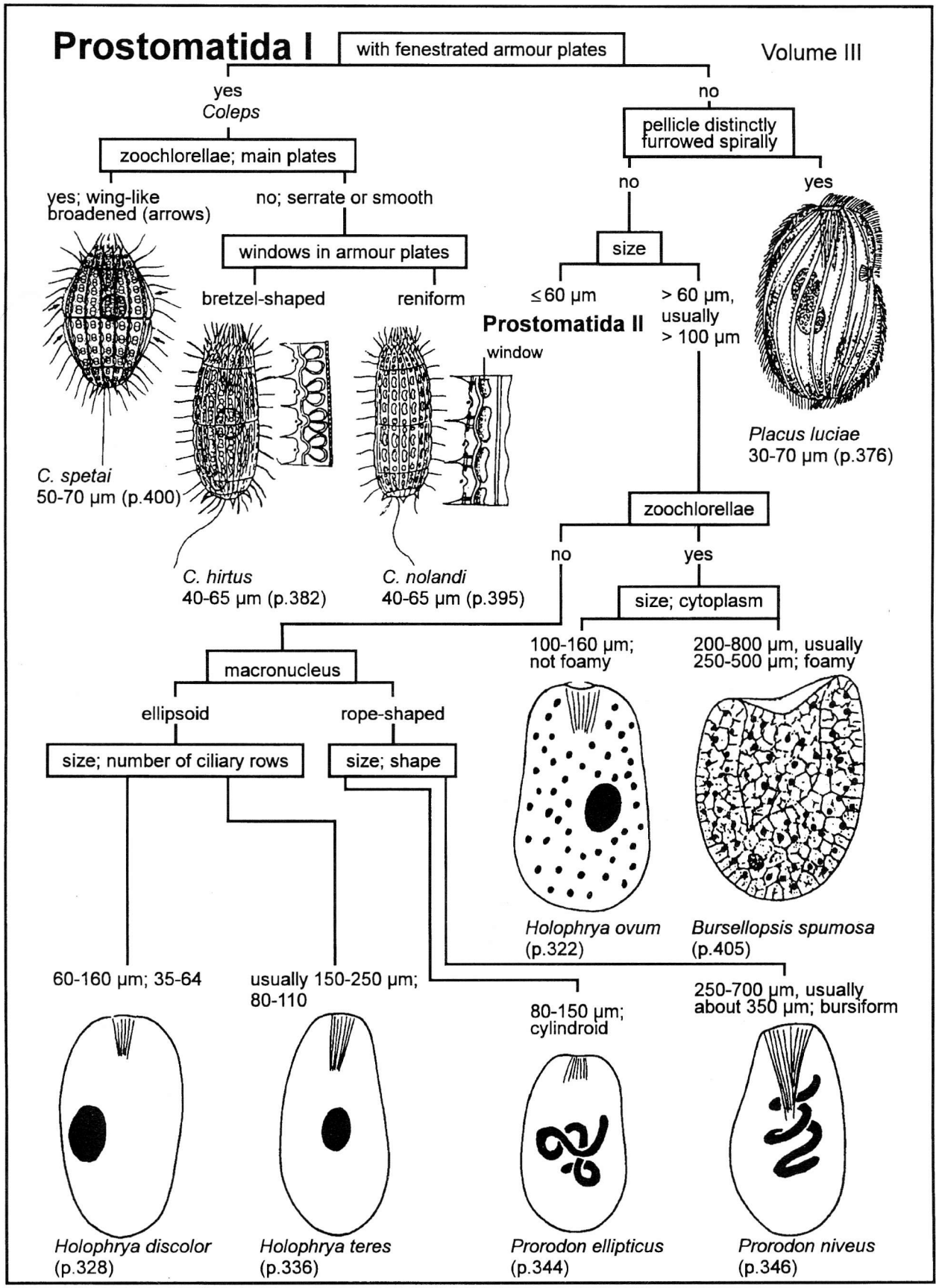


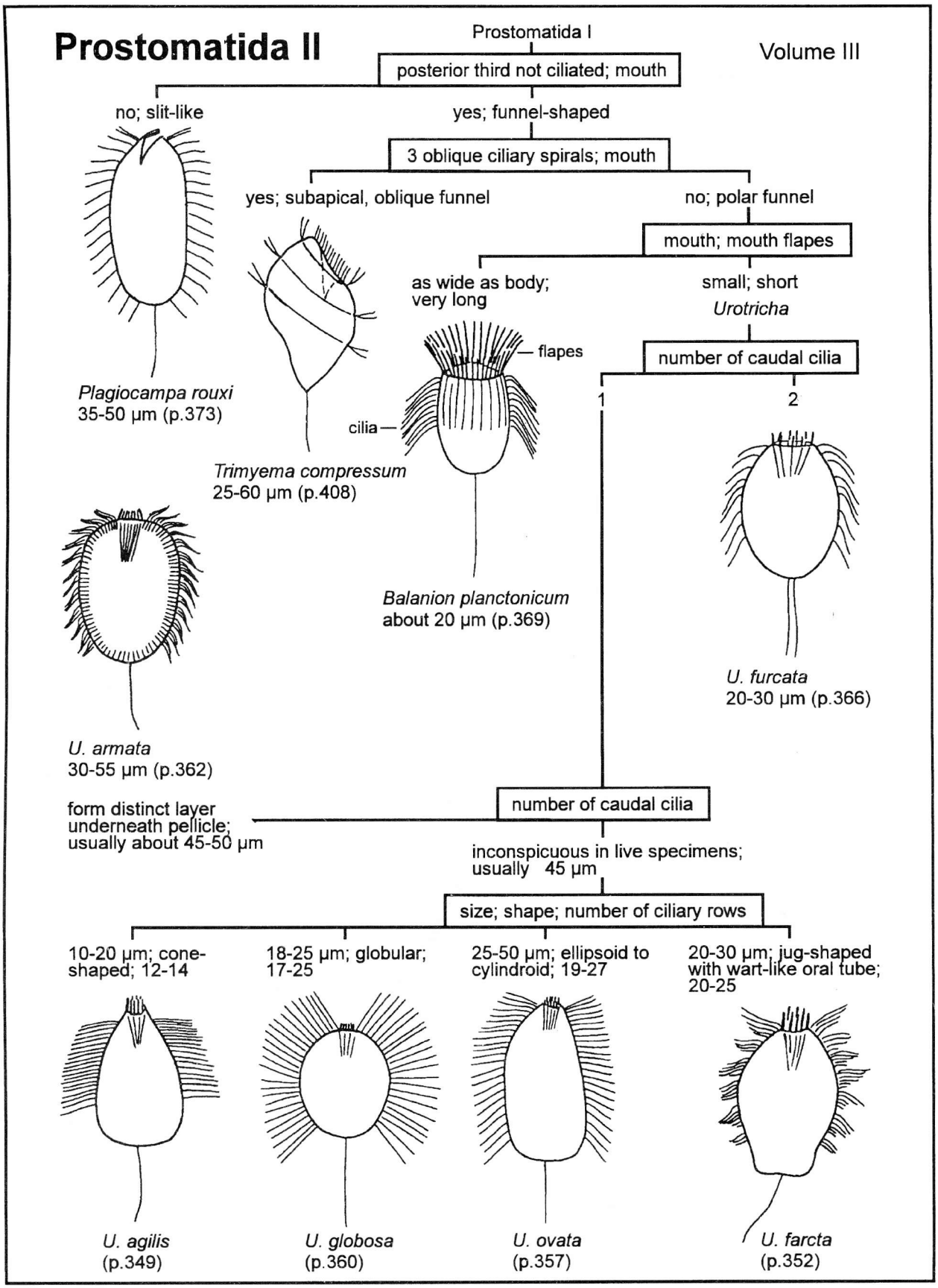
A. procerus
200-800 µm (p.297)

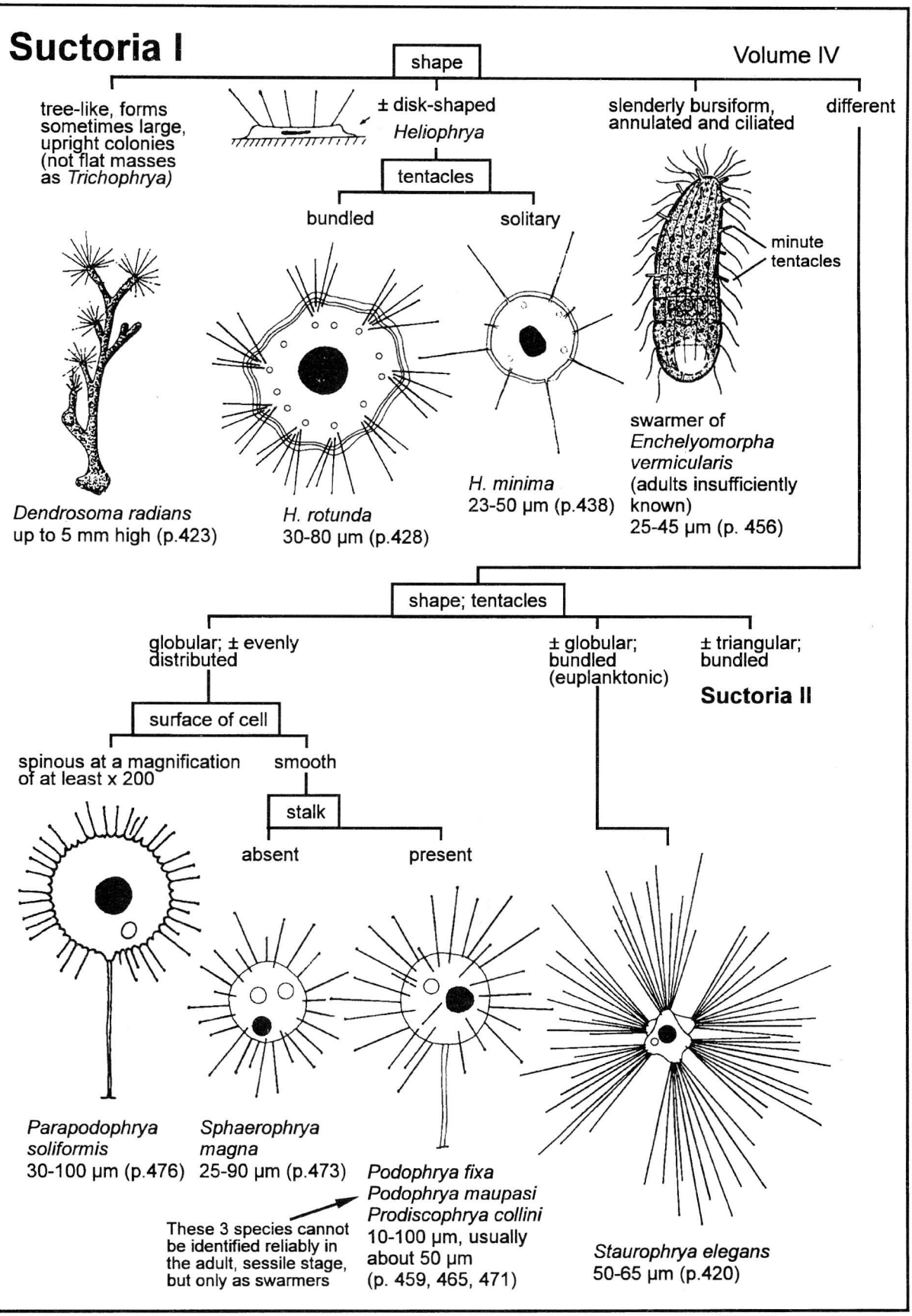


A. carchesii
200-360 µm (p.277)


Pleurostomatida II
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
Litonotus alpestris 30-50 µm (p.309)
A. uncinata 30-60 µm (p.349)
A. incurvata 50-150 µm (p.343)
extrusomes
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
Litonotus cygnus 200-300 µm (p.318)
transverse section of cell
Litonotus lamella 50-100 µm (p.329)
transverse section of cell
Litonotus crystallinus 80-170 µm (p.315)


Prostomatida I
with fenestrated armour plates
Volume III
yes
Coleps
no
pellicle distinctly furrowed spirally
zoochlorellae; main plates
no
yes
yes; wing-like broadened (arrows)
no; serrate or smooth
size
windows in armour plates
bretzel-shaped
reniform
≤ 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
Prostomatida I
Volume III
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
flapes
cilia
number of caudal cilia
1
2
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)


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

Suctoria I

lorica

present, flattened and transverse truncate — *Acineta*

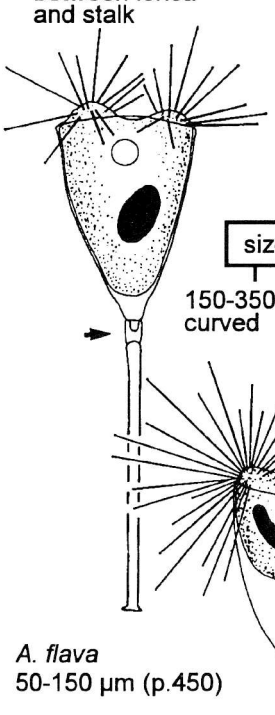
present, unflattened, roof-like narrowed anteriorly — *Metacineta*

absent — *Tokophrya*

articulation

between lorica and stalk

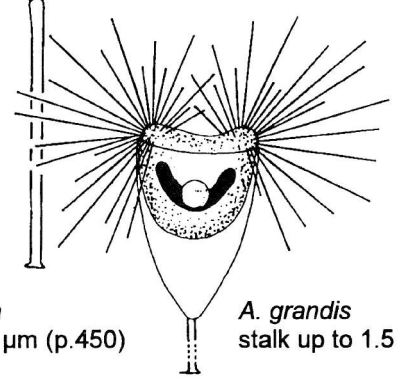
absent



size[1]; macronucleus

150-350 µm; curved

usually 40-100 µm; globular or ellipsoid

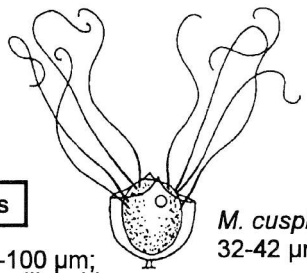


A. flava
50-150 µm (p.450)

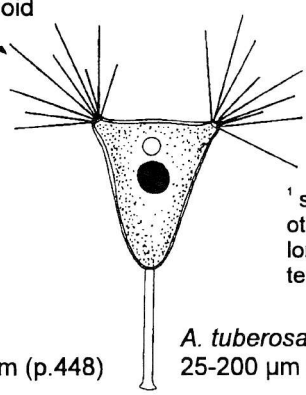
A. grandis
stalk up to 1.5 mm (p.448)

tentacles

curved in fully extended condition (rare species)

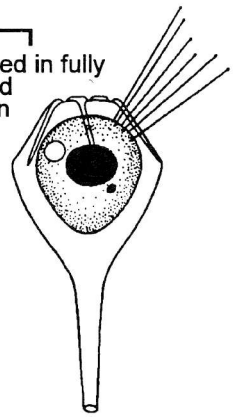


M. cuspidata
32-42 µm (p.488)



A. tuberosa
25-200 µm (p.442)

not curved in fully extended condition

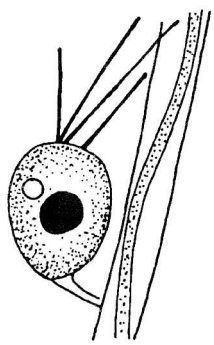


M. mystacina
55-220 µm total length (p.481)

[1] sizes are given, if not stated otherwise, for length of cell or lorica, i.e. without stalk and tentacles

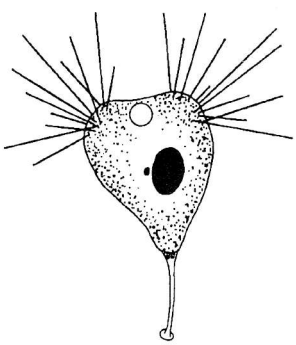
tentacle bundles; shape

1; pyriform to globular (parasite on colonial peritrichs, especially of *Carchesium*)



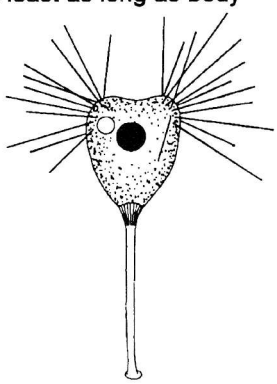
T. carchesii
25-85 µm, usually < 50 µm (p.417)

2 (often difficult to recognize!); pyriform to globular, stalk shorter than body



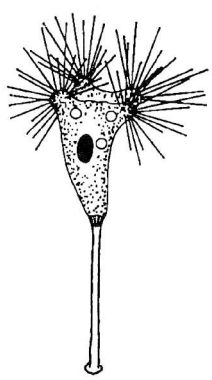
T. infusionum
18-80 µm, usually 30-50 µm (p.401)

2 (usually distinct); slenderly to broadly triangular, stalk at least as long as body



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

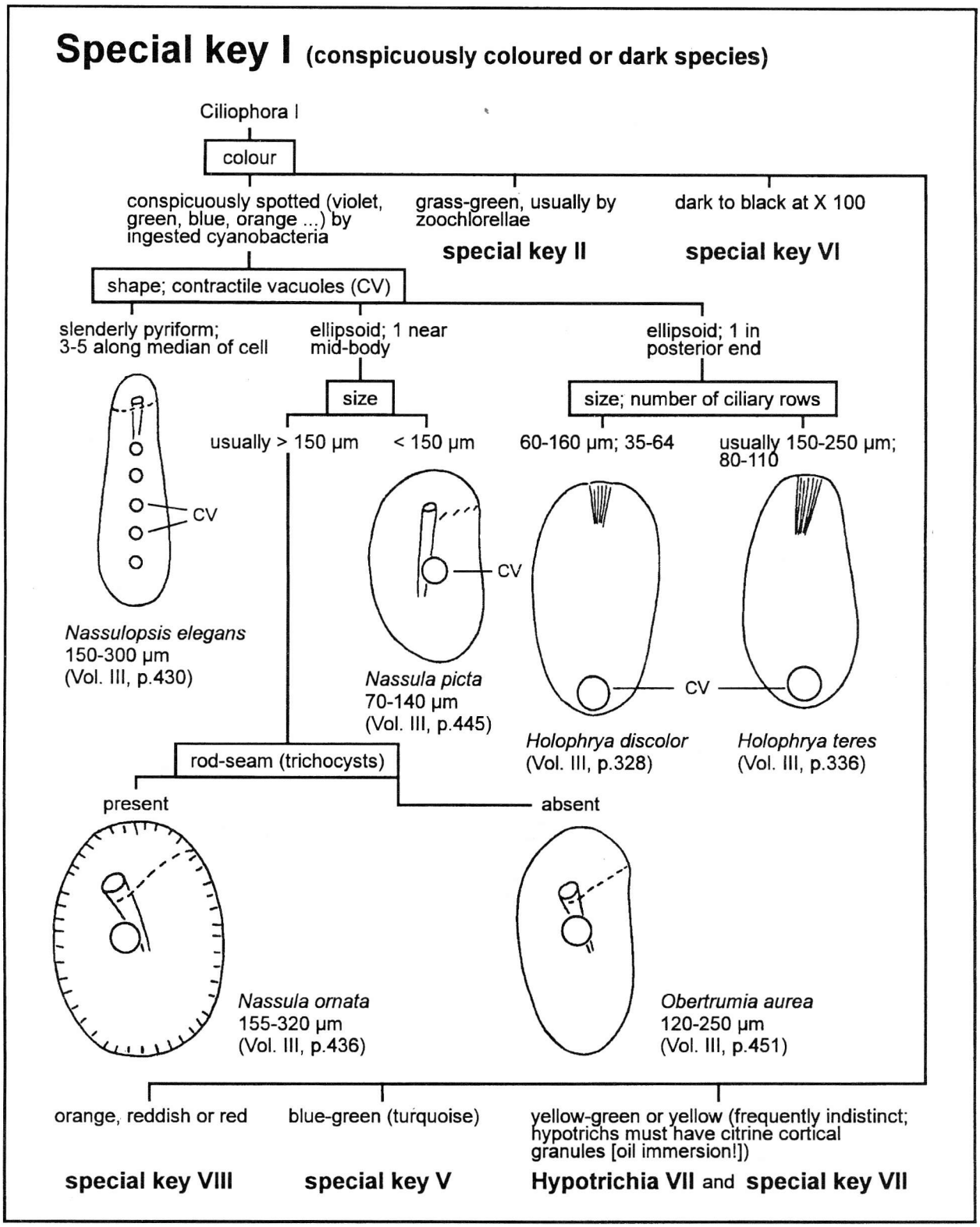
4; pyramidal to broadly pyriform



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

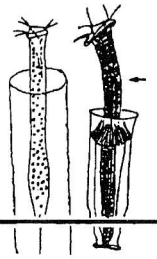
Special keys

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



Special key 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



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)

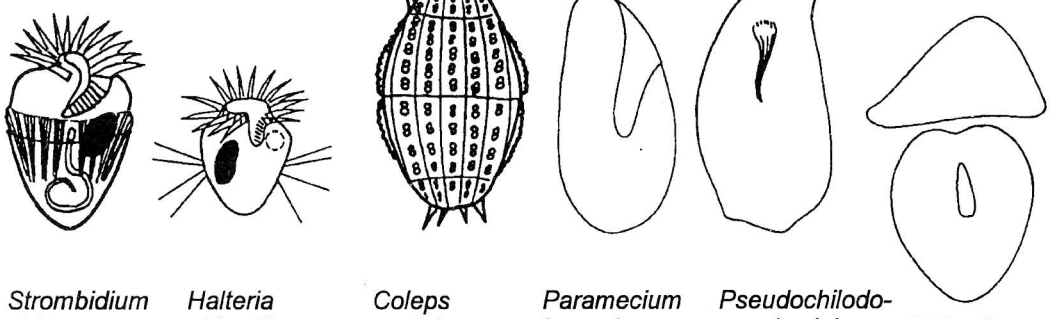
globular

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)

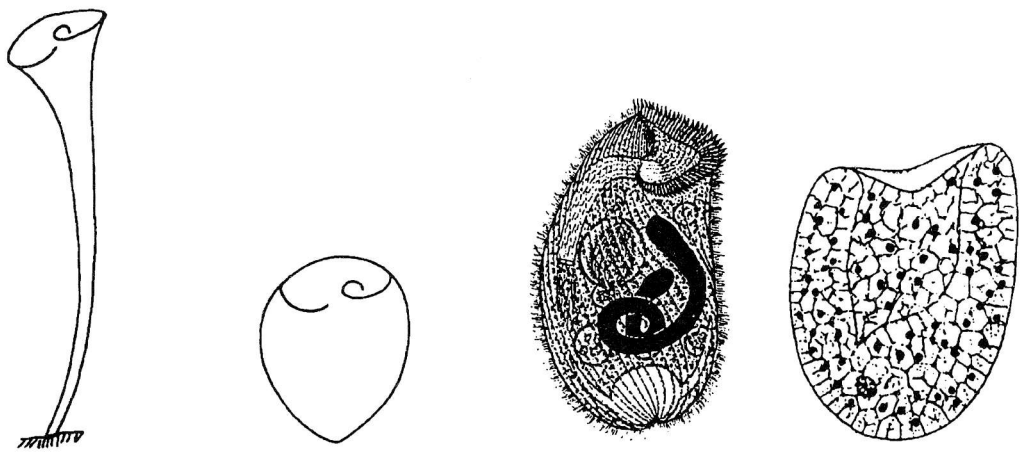
shape

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)

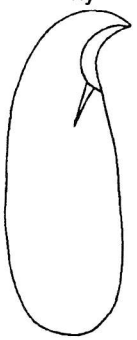
Bursellopsis spumosa
200-800 µm, usually
250-500 µm
(Vol. III, p.405)

Special key III (grass-green coloured by zoochlorellae)

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

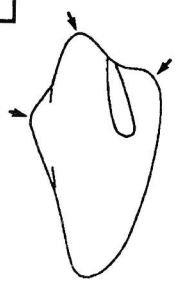
8-14

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

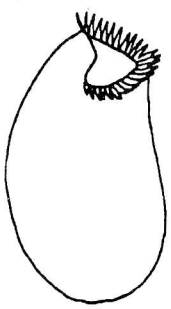


Disematostoma tetraedricum
100-140 µm
(Vol. III, p.185)

oviform or broadly ellipsoid

anterior end

with conspicuous ciliary plates (membranellar zone)



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

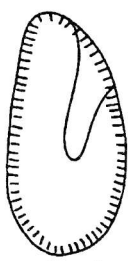
without conspicuous membranellar zone

rod-seam

present

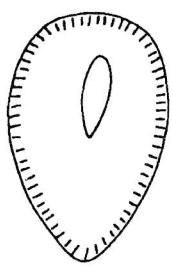
shape

oviform, posterior end broadly rounded



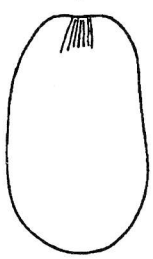
Paramecium bursaria
85-150 µm
(Vol. III, p.140)

obovoid



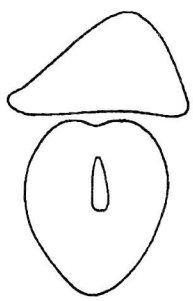
Disematostoma buetschlii
110-200 µm
(Vol. III, p.180)

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)

special key II

colonial

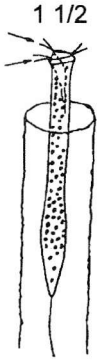
no

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

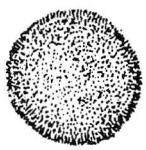
yes

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

1 1/2

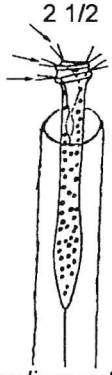


Ophrydium versatile
300-400 µm
(Vol. II, p.232)



globular colonies
up to 10 cm !

2 1/2



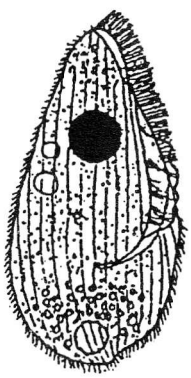
Ophrydium eutrophicum
250-350 µm
(Vol. II, p.239)

Special key V (bluegreen species)

special key I

shape; contractility

oviform; acontractile

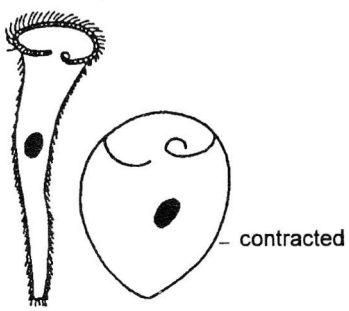


Blepharisma coeruleum
120-150 µm
(Vol. II, p.382)

trumpet-shaped or obovoid; very contractile

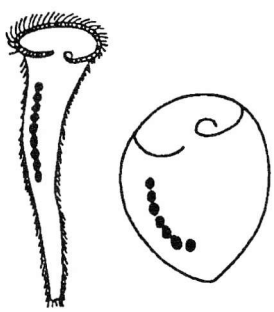
macronucleus

ellipsoid



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

moniliform



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

Special key VI (dark or black species)

special key I

shape

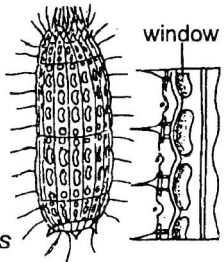
trumpet-shaped

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

barrel-shaped (at ≥ X 100 brownish)

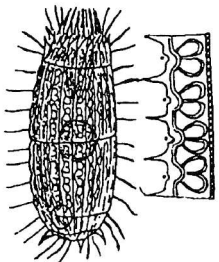
windows in armour plates

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

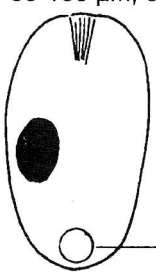
at anterior end; in posterior end

size

60-250 µm

size; number of ciliary rows

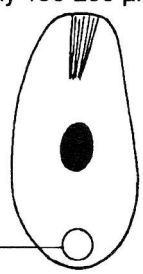
60-160 µm; 35-64



contractile vacuole

Holophrya discolor (Vol. III, p.328)

usually 150-250 µm; 80-110

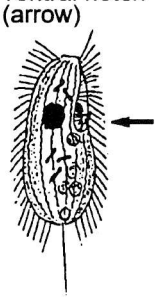


Holophrya teres (Vol. III, p.336)

25-50 µm

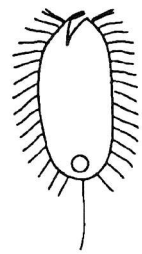
shape

with inconspicuous ventral notch (arrow)



Uronema nigricans (Vol. III, p.228)

different



Plagiocampa rouxi (Vol. III, p.373)

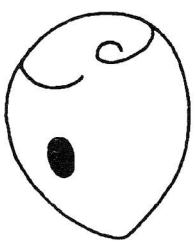
different

Hymeno-stomata II

campanulate or globular

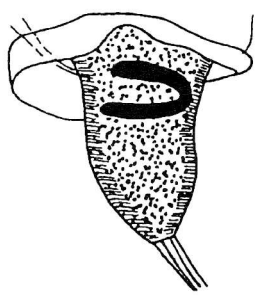
macronucleus

ellipsoid



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

horseshoe-shaped in transverse axis of cell



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

J-shaped in longitudinal axis of cell

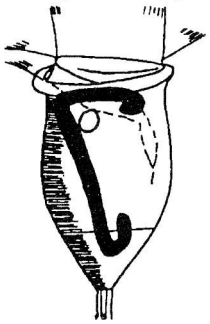
Vorticella campanula 60-90 µm (Vol. II, p.105)

Special key VII (yellow or yellowgreen coloured species)

special key I

shape; stalk

campanulate; yes



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

slenderly ellipsoid, flattened; no

number of macronuclear nodules

many

size

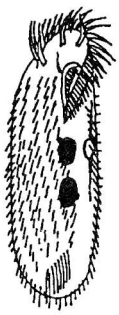
250-400 µm, usually 300-350 µm

Urostyla grandis
(Vol. I, p.222)

130-170 µm

Holosticha multistilata
(Vol. I, p.236)

2



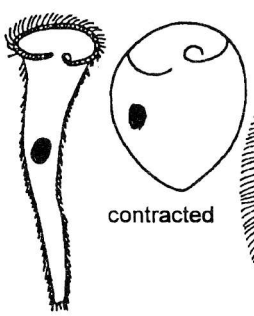
Paraurostyla weissei
150-300 µm
(Vol. I, p.260)

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

special key I

shape

conical or globular



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

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

oviform

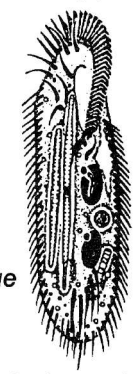
oblong

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

ellipsoid

number of macronuclear nodules; colour

2; orange to distinctly pink

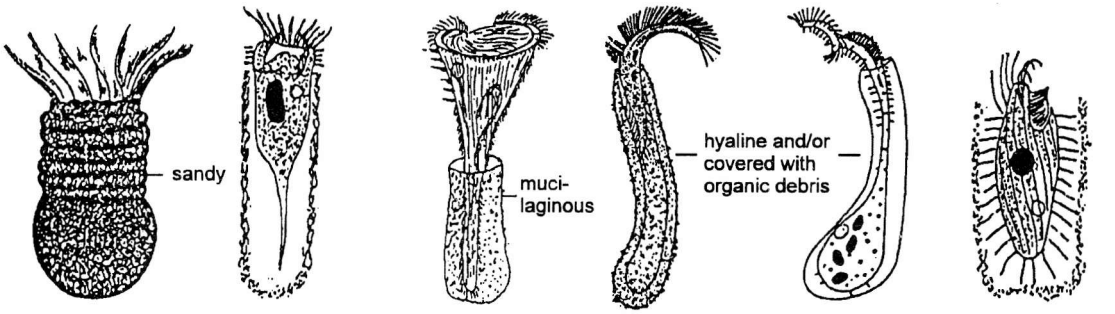


Oxytricha haematoplasma
120-180 µm
(Vol. I, p.287)

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

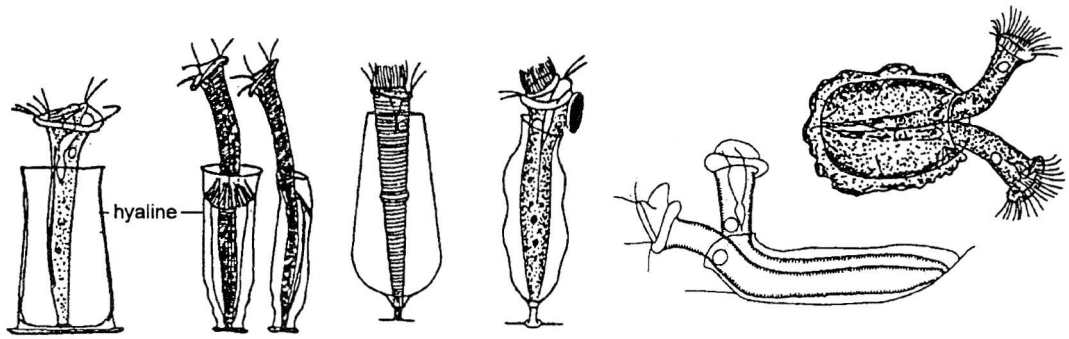
Hetero-trichida I

Stichotricha

Chaetospira

Hypotrichia I

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



Vaginicola

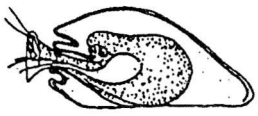
Thuricola

Peritrichia I

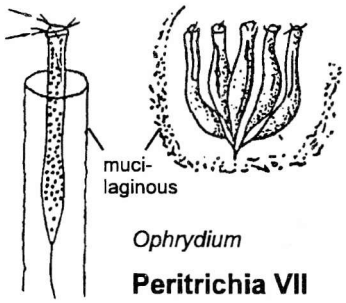
Cothurnia annulata
40-70 µm
(Vol. II, p.251)

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

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

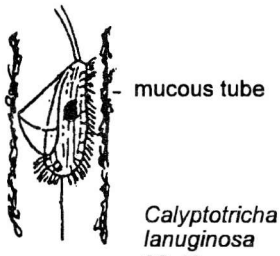


Lagenophrys vaginicola
45-80 µm
on small crustaceans
(Vol. II, p.256)

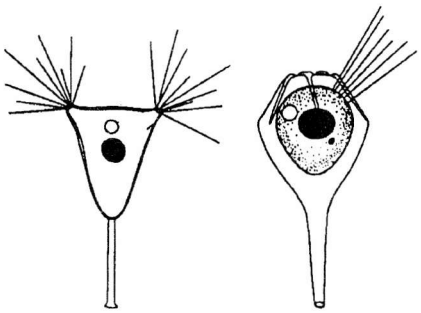


Ophrydium

Peritrichia VII



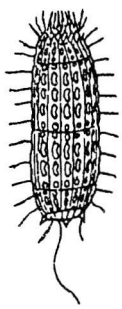
Calyptotricha lanuginosa
30-40 µm
(Vol. III, p.288)



Acineta

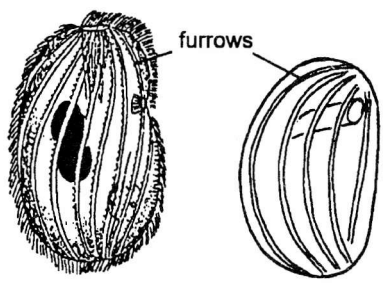
Metacineta

Suctoria II



Coleps

Prostomatida I

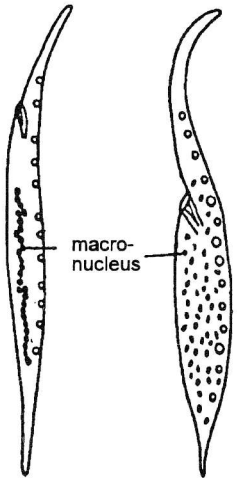


Placus luciae
30-70 µm
(Vol. III, p.376)

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

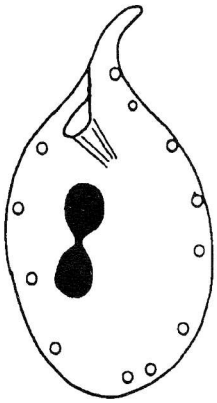
Special key X (very large [> 300 µm] species)

Spirostomum
200-2000 µm
Heterotrichida I

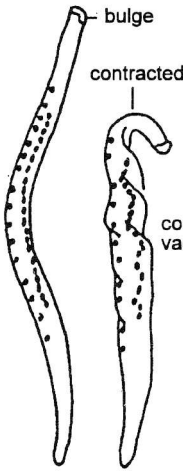


Monilicaryon monilatus
350-950 µm
(Vol. IV, p.199)

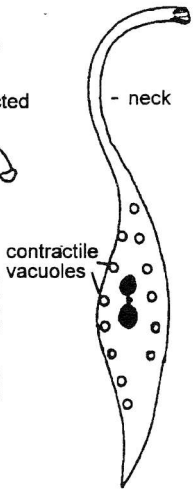
Dileptus margaritifer
250-600 µm
(Vol. IV, p.185)



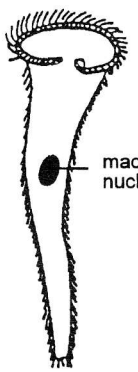
Trachelius ovum
200-600 µm
(Vol. IV, p.208)



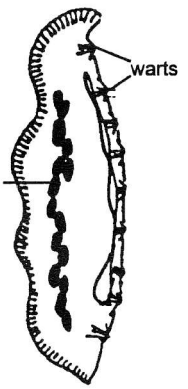
Homalozoon vermiculare
150-1500 µm
(Vol. IV, p.219)



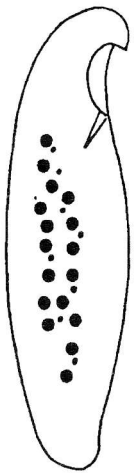
Amphileptus procerus
200-800 µm
(Vol. IV, p.297)



Stentor
200-2000 µm
Hetero-trichida I



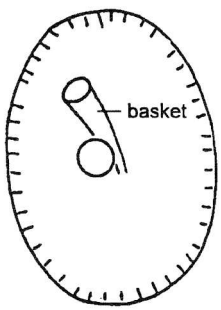
Loxophyllum meleagris
300-500 µm
(Vol. IV, p.354)



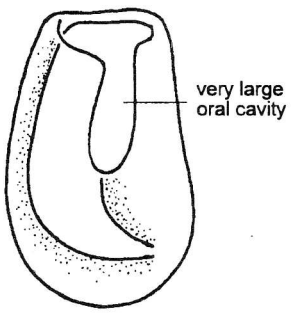
Loxodes magnus
150-600 µm
(Vol. IV, p.378)

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

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

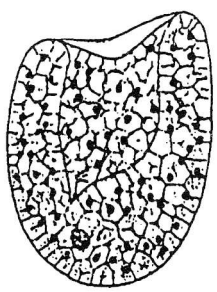


Nassula ornata
155-320 µm
(Vol. III, p.436)



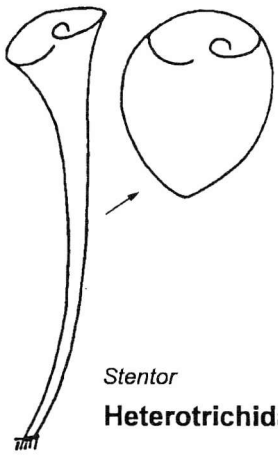
Bursaria truncatella
200-1700 µm
(Vol. I, p.424)

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



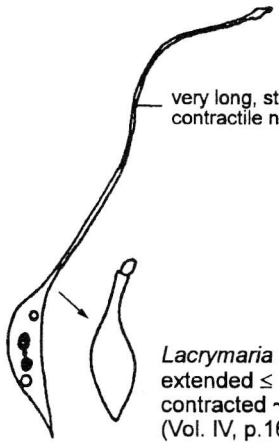
Bursellopsis spumosa
200-800 µm
(Vol. III, p.405)

Special key XI (conspicuously contractile species)

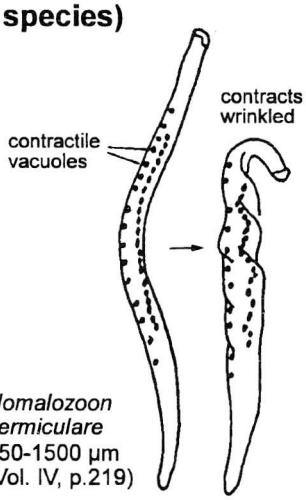


Stentor

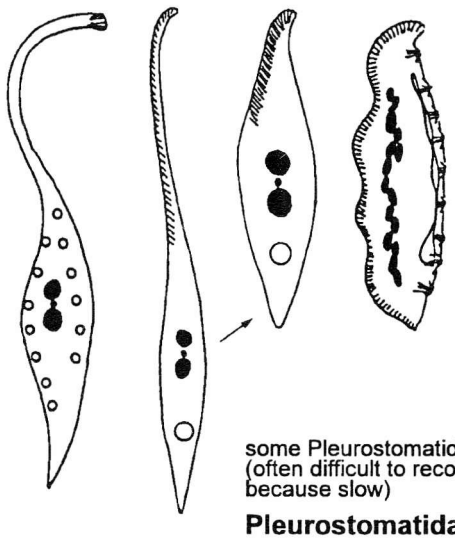
Heterotrichida I



Lacrymaria olor
extended ≤ 1200 µm
contracted ~ 100 µm
(Vol. IV, p.163)



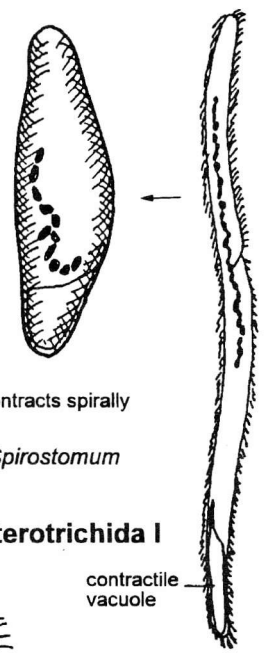
Homalozoon vermiculare
150-1500 µm
(Vol. IV, p.219)



some Pleurostomatida
(often difficult to recognize
because slow)

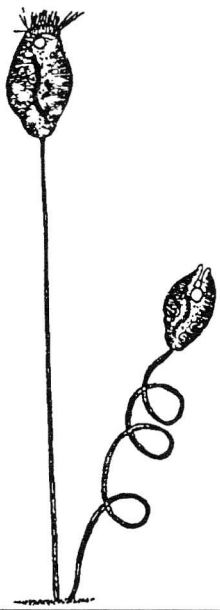
Pleurostomatida

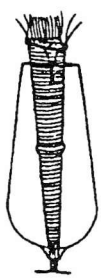
Trachelophyllum apiculatum
90-180 µm
(Vol. IV, p.180)

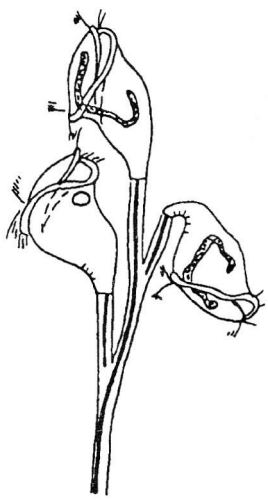


Spirostomum

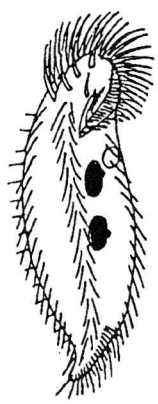
Heterotrichida I







Peritrichia

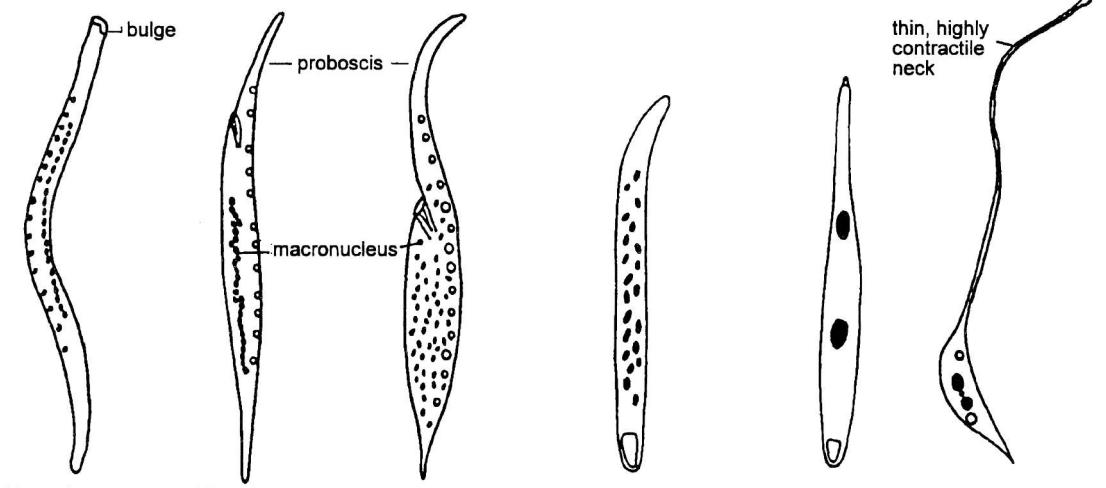


Uroleptus

Hypotrichia III

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

Special key XII (slender species, length : width ratio ≥ 5:1; attention, often highly contractile and then becoming more blunt)



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

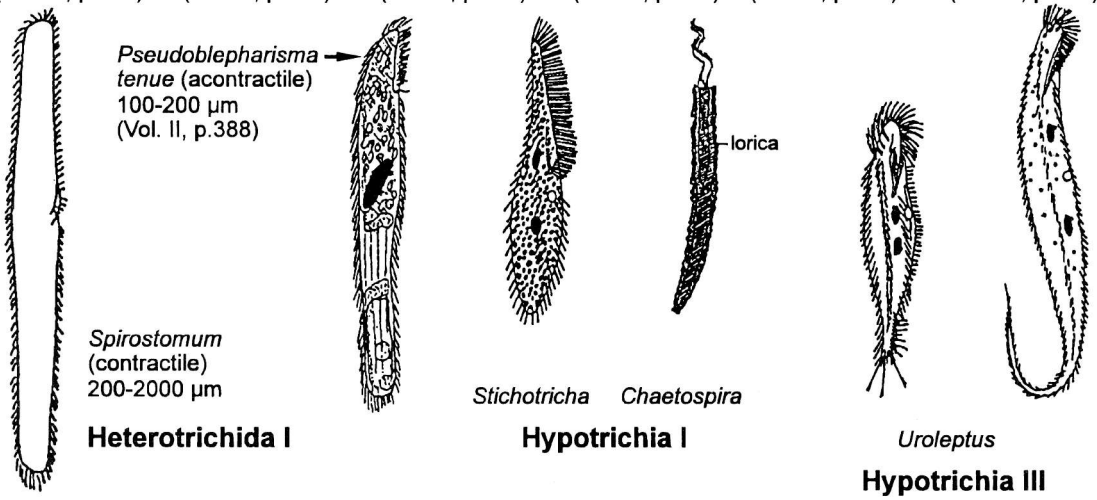
Monilicaryon monilatus
350-950 µm
(Vol. IV, p.199)

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)



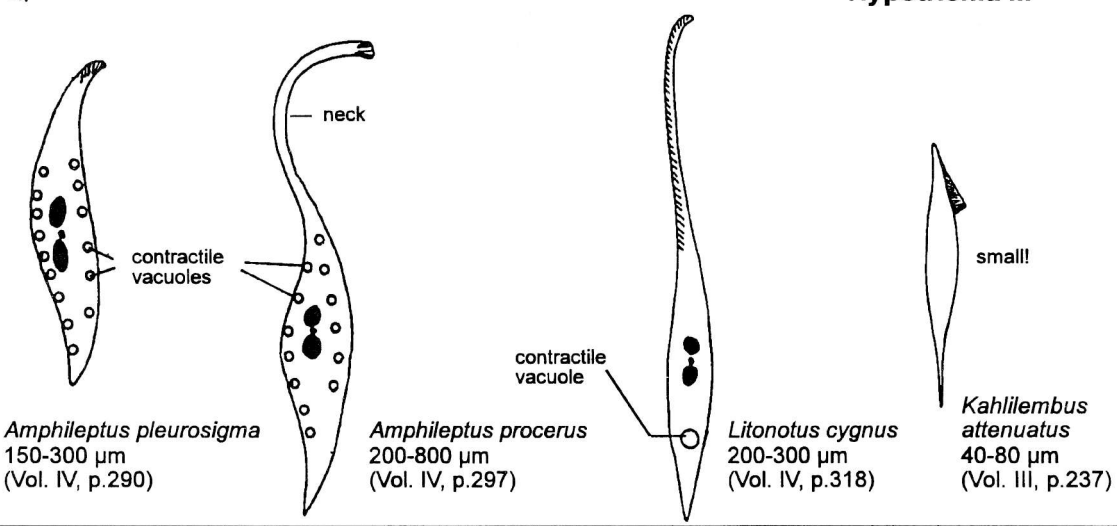
Heterotrichida I

Stichotricha *Chaetospira*

Hypotrichia I

Uroleptus

Hypotrichia III



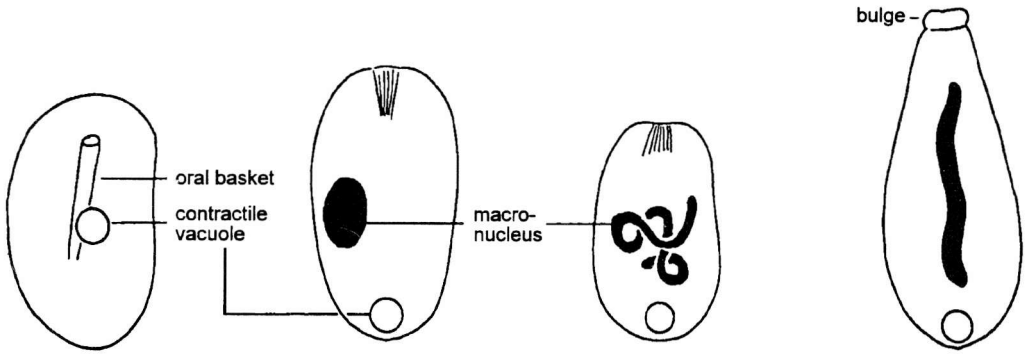
Amphileptus pleurosigma
150-300 µm
(Vol. IV, p.290)

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)



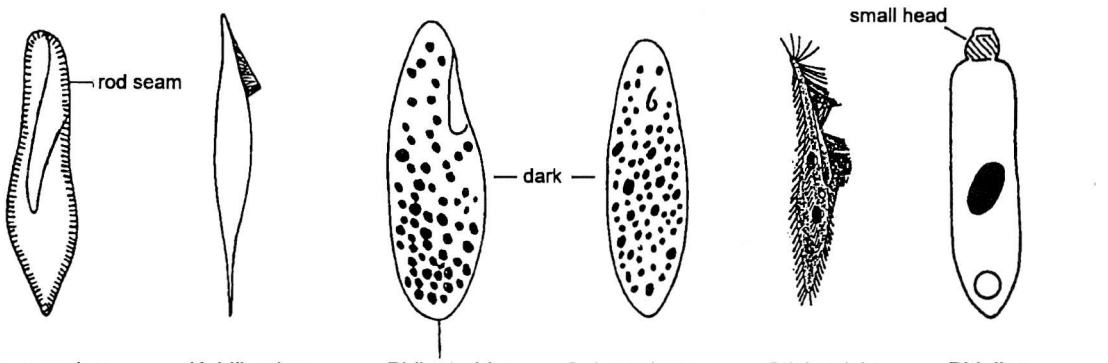
Nassula / Obertrumia

Nassulida

Holophrya *Prorodon*

Prostomatida I

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



Paramecium caudatum/aurelia

Hymeno-stomata V

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

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

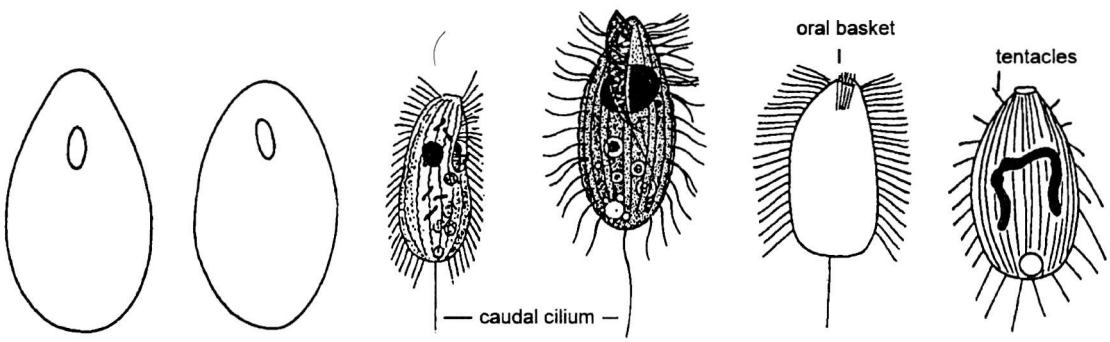
Ophryoglena
(Vol. III, p.110)

Stichotricha

Hypotrichia I

Phialina
(Vol. IV, p.171)

Hymenostomata



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

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

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

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

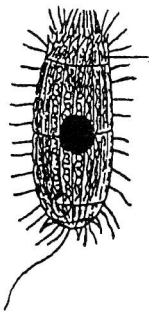
Urotricha agilis/ovata

Pro-stomatida II

Actinobolina

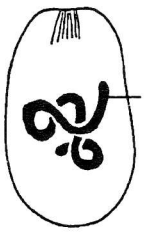
Gymno-stomatida I

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

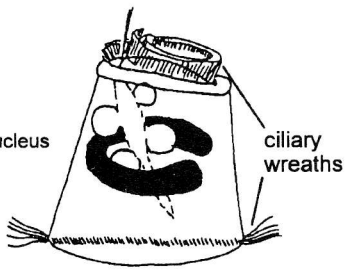


Coleps

Prostomatida I

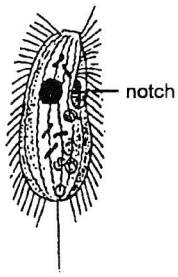


Prorodon ellipticus
80-150 µm
(Vol. III, p.344)

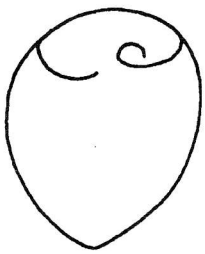


Opisthonecta henneguyi
or swarmers of
sessile peritrichs

Peritrichia

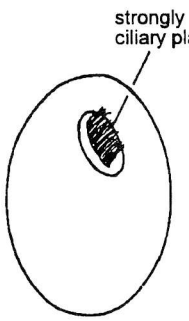


Uronema nigricans
25-50 µm
(Vol. III, p.228)

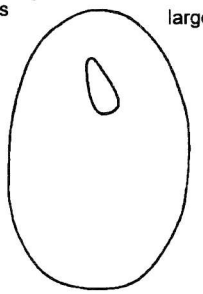


contracted
Stentor

**Hetero-
trichida I**

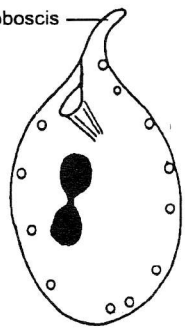


Glaucoma scintillans
35-75 µm
(Vol. III, p.92)

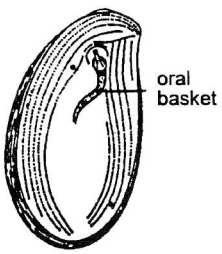


Epenardia myriophylli
90-200 µm
(Vol. III, p.106)

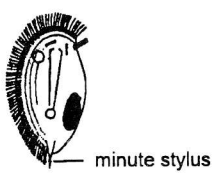
Sathrophilus muscorum
25-40 µm
(Vol. III, p.259)



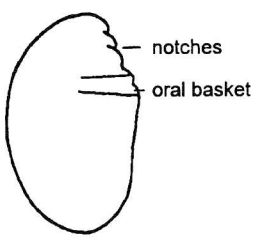
Trachelius ovum
200-600 µm
(Vol. IV, p.208)



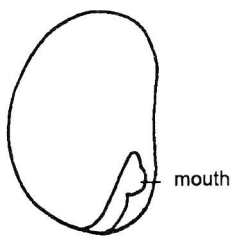
Odontochlamys alpestris
35-60 µm
(Vol. I, p.52)



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

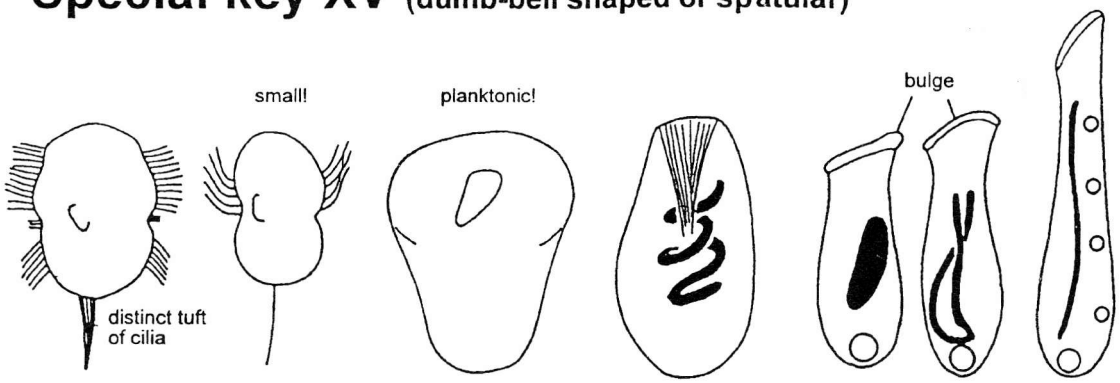


Leptopharynx costatus
20-50 µm
(Vol. III, p.460)



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)

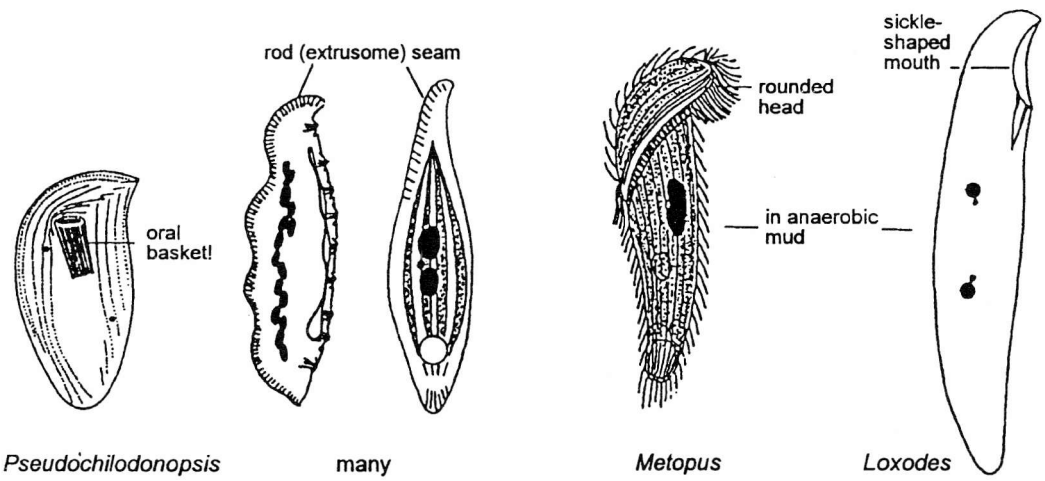
Urozona buetschlii 20-40 µm (Vol. III, p.268)

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)

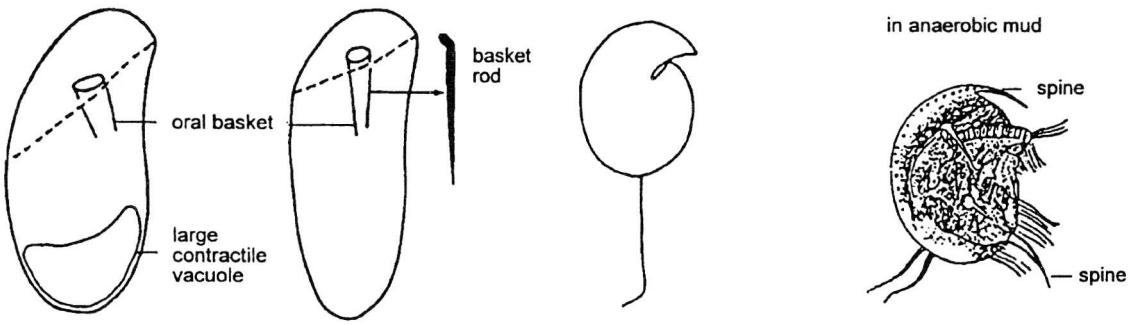


Pseudochilodonopsis
Cyrtophorida II

many
Pleurostomatida

Metopus
Heterotrichida II

Loxodes
Loxodes



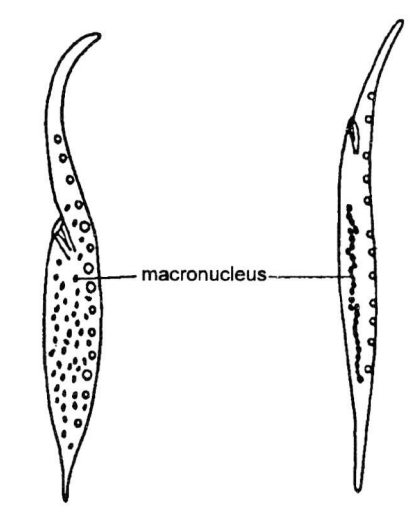
Chilodontopsis depressa 50-80 µm (Vol. III, p.424)

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

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

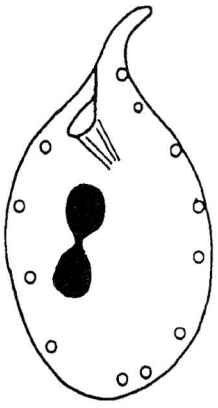
Discomorphella pectinata 70-90 µm (Vol. II, p.451)

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

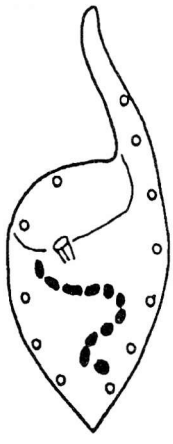


Dileptus margaritifer
250-600 µm
(Vol. IV, p.185)

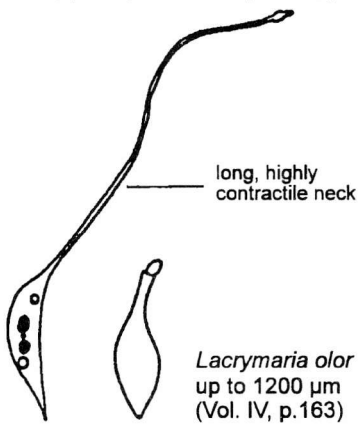
Monilicaryon monilatus
350-950 µm
(Vol. IV, p.199)



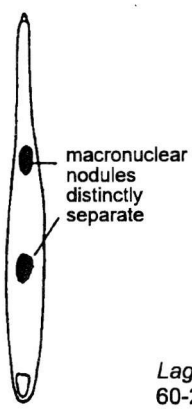
Trachelius ovum
200-600 µm
(Vol. IV, p.208)



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



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

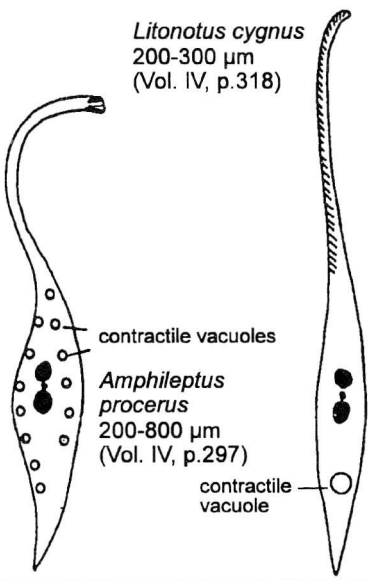


Trachelophyllum apiculatum
90-180 µm
(Vol. IV, p.180)

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

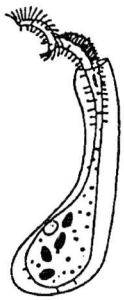
Lagynophrya acuminata
70-95 µm
(Vol. IV, p.178)

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

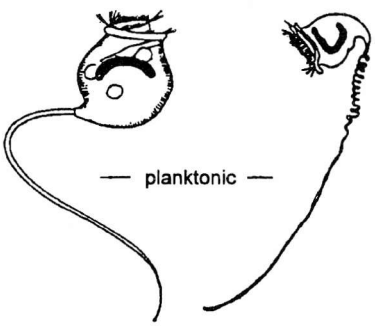


Amphileptus procerus
200-800 µm
(Vol. IV, p.297)

Stichotricha



Chaetospira

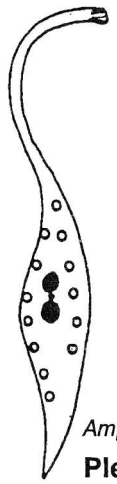


Vorticella mayeri
30-55 µm
(Vol. II, p.118)

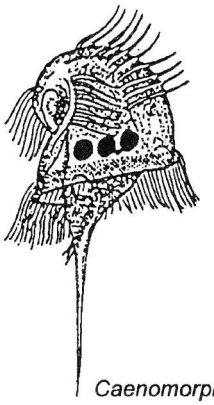
Vorticella natans
70-100 µm
(Vol. II, p.121)

Hypotrichia I

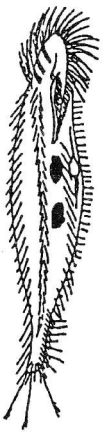
Special key XVIII (tailed species)



Amphileptus
Pleurostomatida I



Caenomorpha
Heterotrichida II



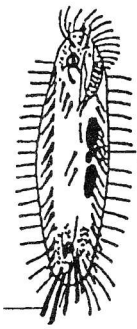
Uroleptus
Hypotrichia III

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

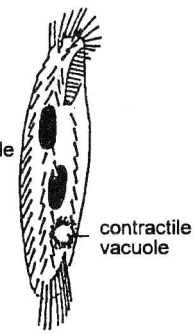
Special key XIX (species having conspicuous "somatic cilia" [cirri] at a magnification of X 100)

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

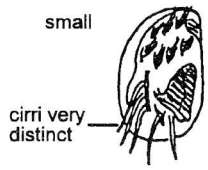
Stylonychia pustulata
50-200 µm
(Vol. I, p.323)



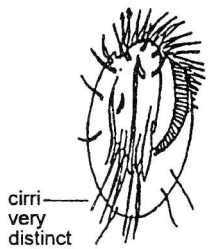
Tachysoma pellionellum
55-100 µm
(Vol. I, p.304)



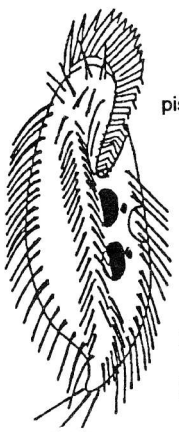
Holosticha
Hypotrichia III



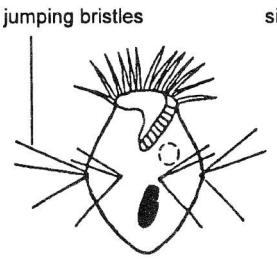
Aspidisca
Hypotrichia II



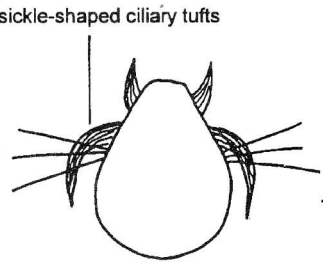
Euplotes
Hypotrichia II



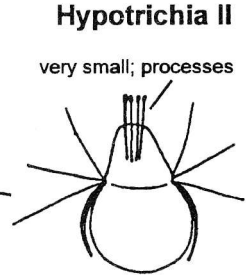
Uroleptus
Hypotrichia III



Halteria
Oligotrichida

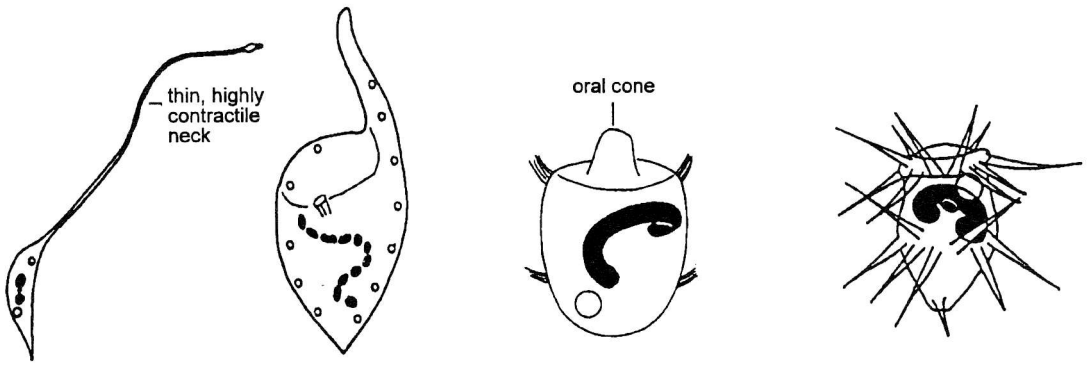


Askenasia volvox
30-50 µm
(Vol. IV, p.251)



Mesodinium
12-35 µm
Gymnostomatida I

Special key XX (species with bizarre shape)



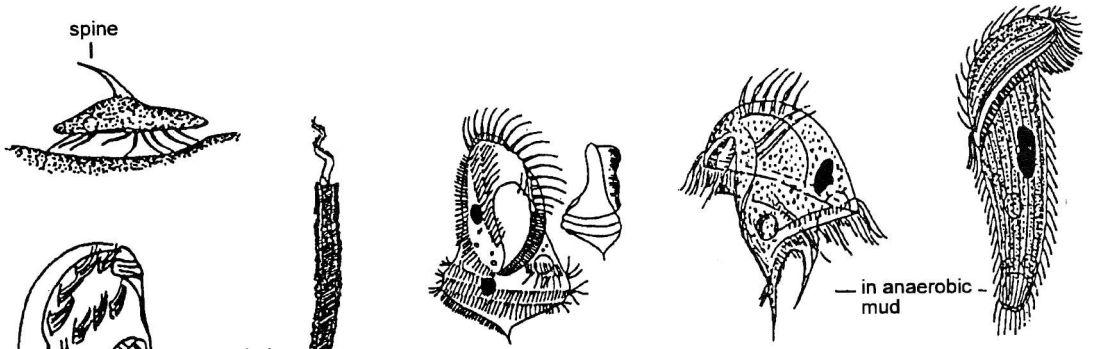
Lacrymaria olor
up to 1200 µm
(Vol. IV, p.163)

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)

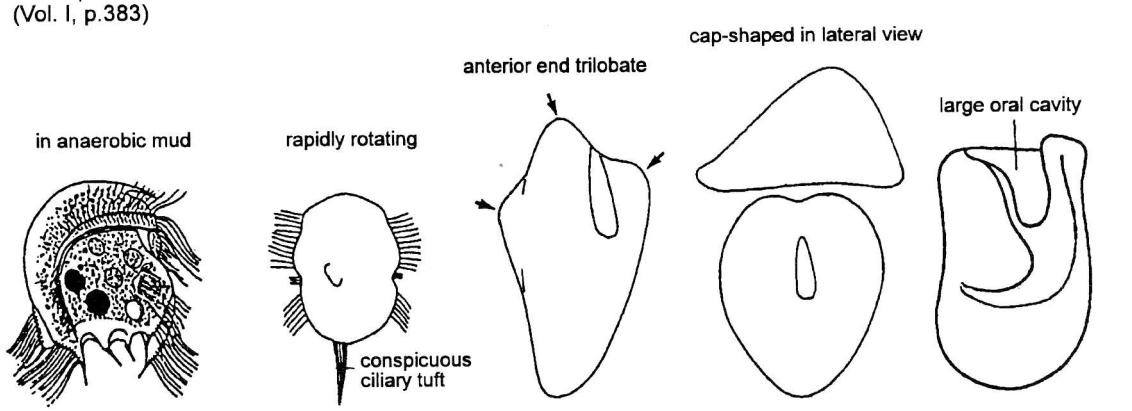
Chaetospira

Hypotrichia I

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

Caenomorpha
(Vol. II, p.424)

Metopus
(Vol. II, p.400)



Odontostomatida

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

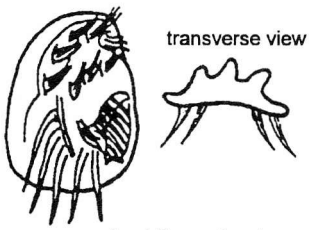
Dissematostoma tetraedricum
100-140 µm
(Vol. III, p.185)

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

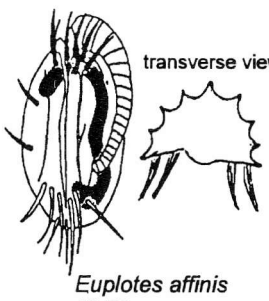
Bursaria/Bursaridium

Colpodea

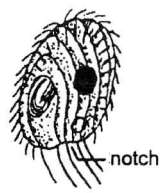
Special key XXI (species distinctly furrowed longitudinally, spirally, or transversely)



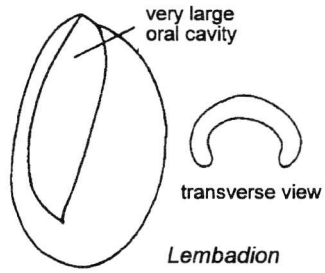
Aspidisca cicada
25-40 µm
(Vol. I, p.370)



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

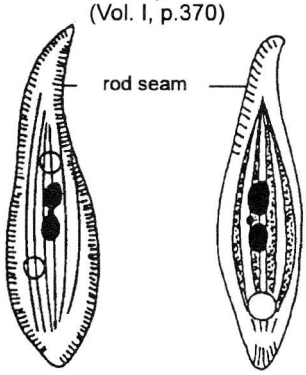


Cinetochilum margaritaceum
25-40 µm
(Vol. III, p.249)



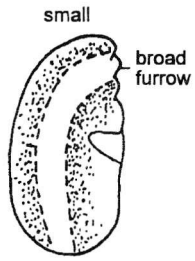
Lembadion

Hymeno-stomata I

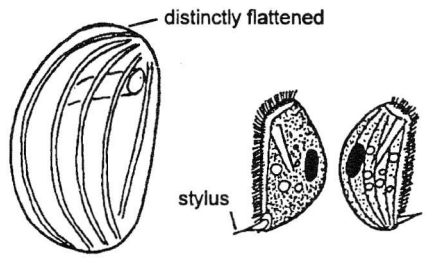


Loxophyllum utricullariae
100-170 µm
(Vol. IV, p.369)

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

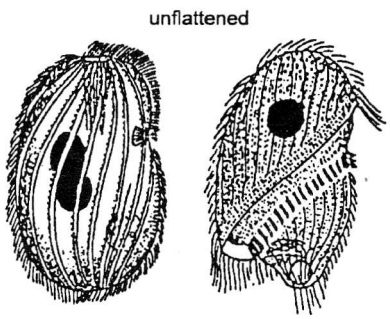


Drepanomonas revoluta
18-35 µm
(Vol. III, p.472)



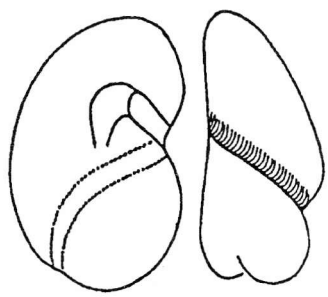
Pseudomicrothorax agilis
30-70 µm
(Vol. III, p.466)

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)

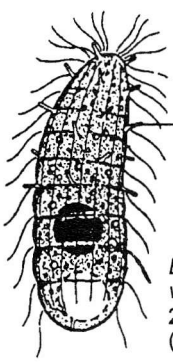


Colpoda magna
120-240 µm
(Vol. I, p.408)

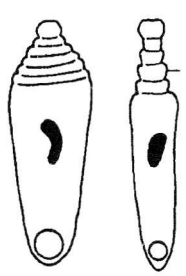
Chaetospira

Hypotrichia I

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



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

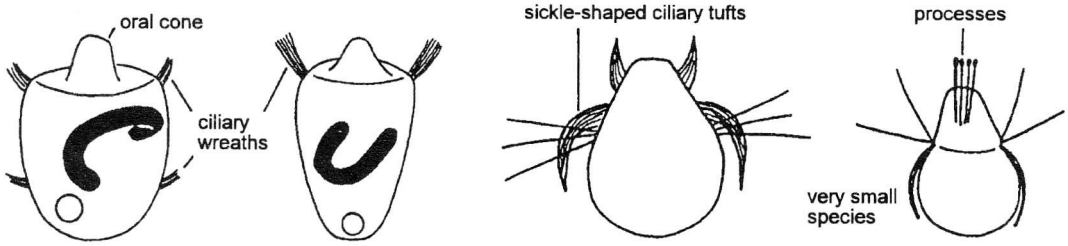


Lagynus elegans
60-200 µm
(Vol. IV, p.173)

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

Special key 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



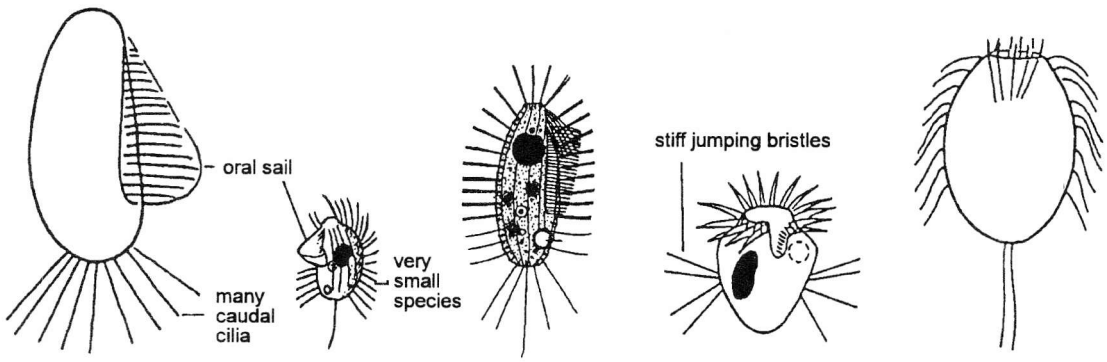
Didinium nasutum
80-200 µm
(Vol. IV, p.228)

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

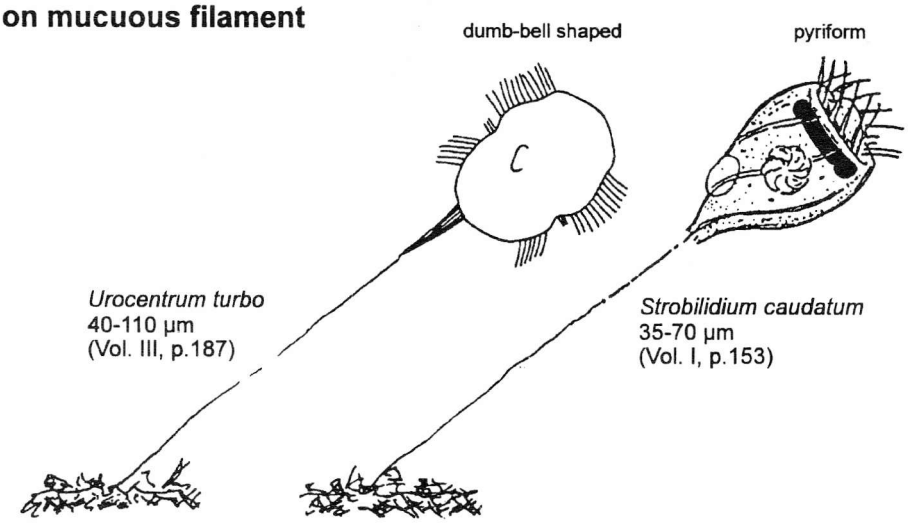
Ctedoctema acanthocryptum
20-40 µm
(Vol. III, p.294)

Oligotrichida

Urotricha

Prostomatida II

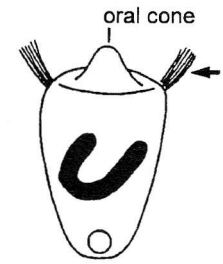
rotating on mucuous filament



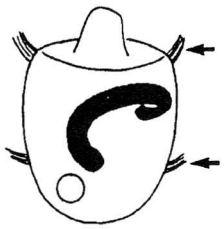
Urocentrum turbo
40-110 µm
(Vol. III, p.187)

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

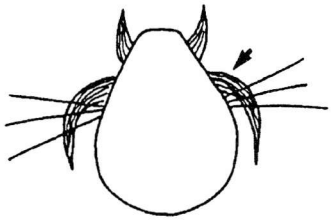
Special key XXVI (species with conspicuous ciliary wreaths [arrows])



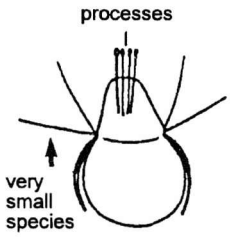
Monodinium balbianii
50-120 µm
(Vol. IV, p.235)



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

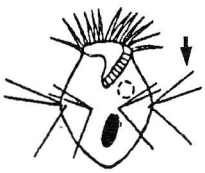


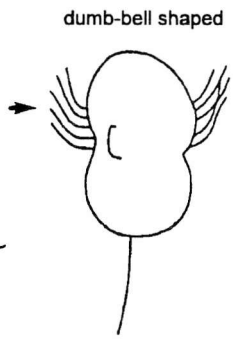
Askenasia volvox
30-50 µm
(Vol. IV, p.251)

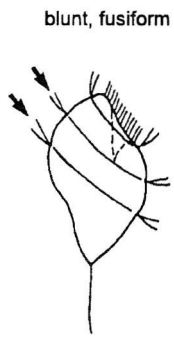


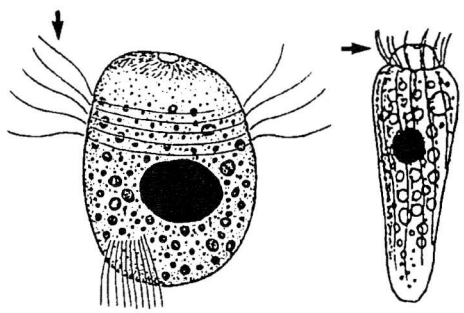
Mesodinium
12-35 µm

Gymnostomatida I









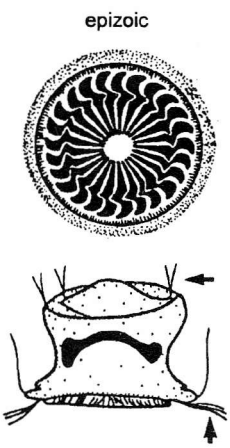
Halteria/
Pelagohalteria

Oligotrichida I

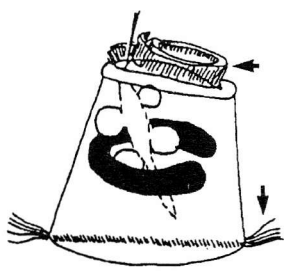
Urozona buetschlii
20-40 µm
(Vol. III, p.268)

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

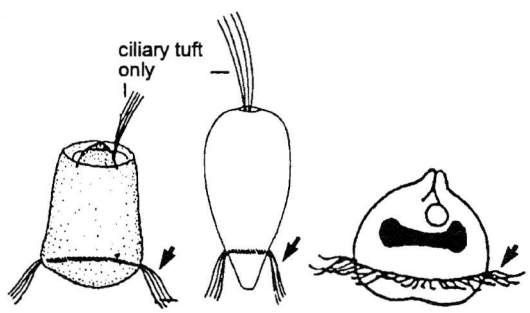
swarmers of suctorians
(indeterminable)



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

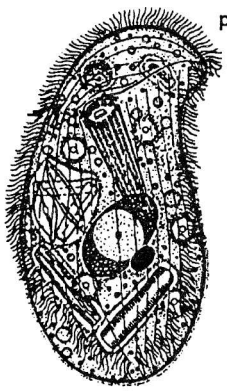


Opisthonecta henneguyi
100-150 µm
(Vol. II, p.299)

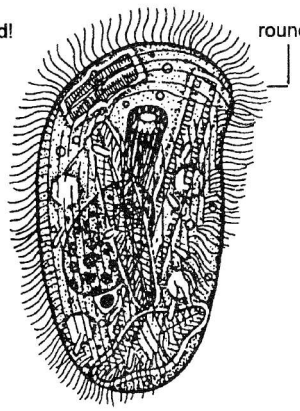


swarmers of peritrichs
(indeterminable)

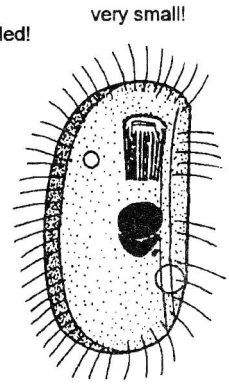
Special key XXVII (species which are frequently densely filled with ingested diatoms)



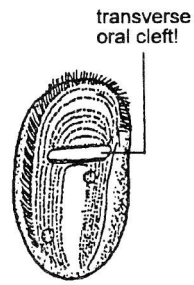
Trithigmostoma
Cyrtophorida I



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



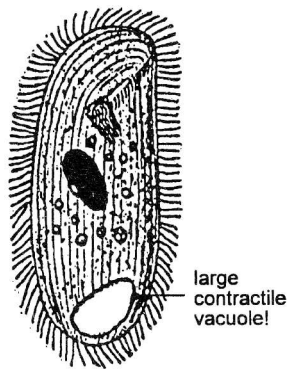
Chlamydonella alpestris
25-35 µm
(Vol. I, p.115)



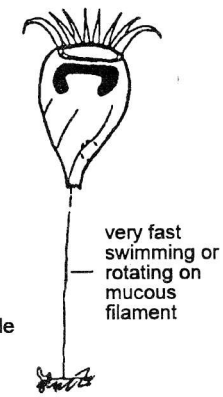
Gastronauta
Cyrtophorida I

Pseudochilodonopsis
Cyrtophorida II

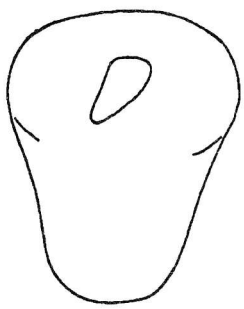
Zosterodasys transversa
130-250 µm
(Vol. III, p.418)



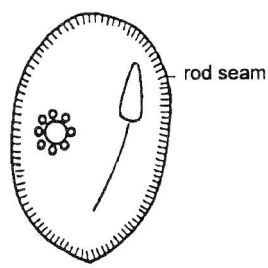
Chilodontopsis depressa
50-80 µm
(Vol. III, p.424)



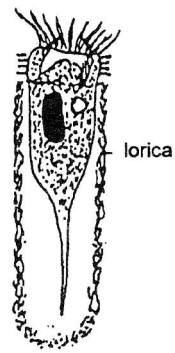
Strobilidium
Oligotrichida



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

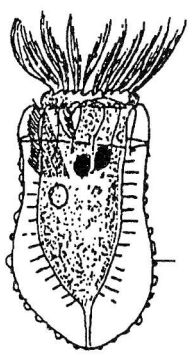


Frontonia
Hymenostomata V

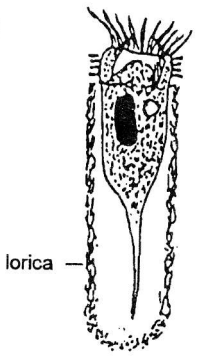


Tintinnidium
Oligotrichida

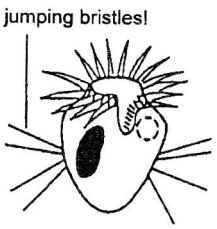
Special key XXVIIIa (euplanktic species)



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

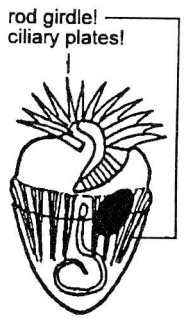


Tintinnidium/
Tintinnopsis



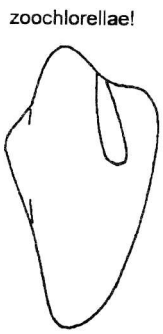
Halteria/
Pelagohalteria

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



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

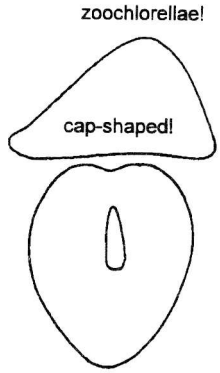
Oligotrichida



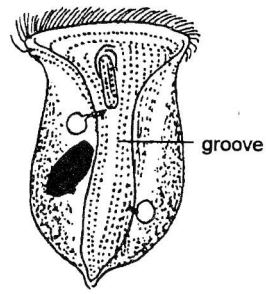
Disematostoma

Hymeno-
stomata IV

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

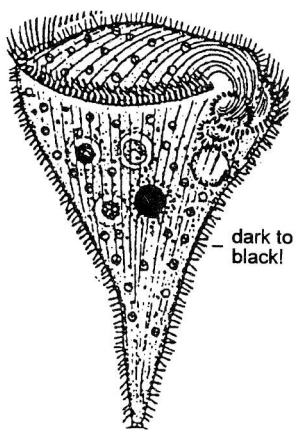


Stokesia vernalis
60-160 µm
(Vol. III, p.200)

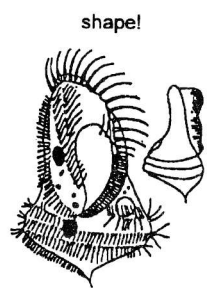


Phascolodon vorticella
50-110 µm
(Vol. I, p.98)

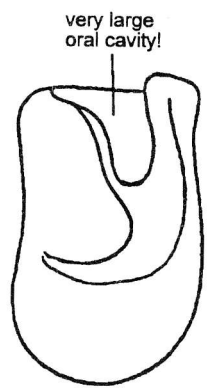
Linostoma vorticella
about 170 µm
(Vol. II, p.390)



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

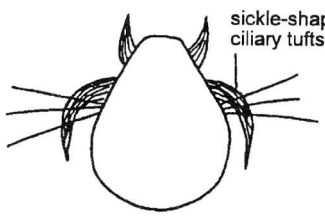


Hypotrichidium conicum
90-120 µm
(Vol. I, p.218)

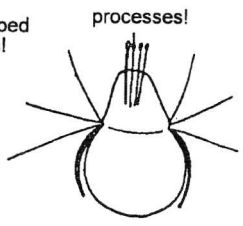


Bursaridium
pseudobursaria
80-200 µm
(Vol. I, p.433)

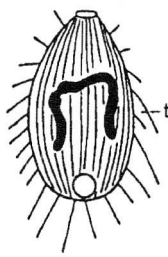
Special key XXVIIIb (euplanktic species)



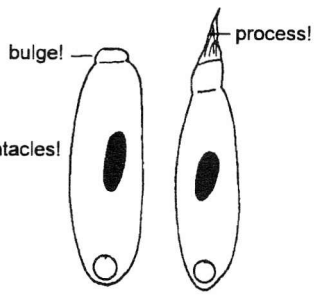
Askenasia volvox
30-50 µm
(Vol. IV, p.251)



Mesodinium
12-35 µm

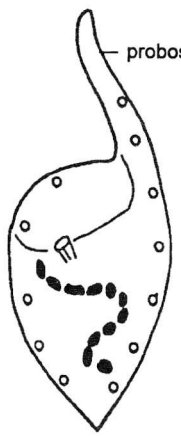


Actinobolina

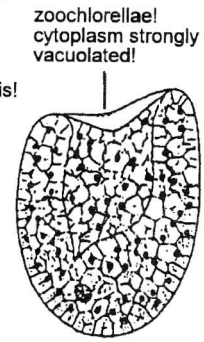


Lagynophrya acuminata
70-95 µm
(Vol. IV, p.178)

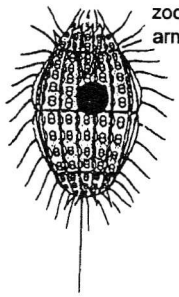
Gymnostomatida I



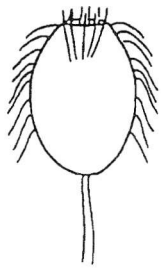
Paradileptus elephantinus
180-450 µm
(Vol. IV, p.203)



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

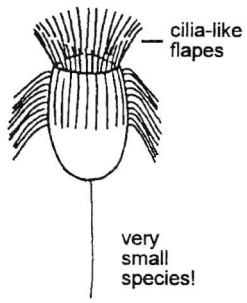


Coleps spetai
50-70 µm
(Vol. III, p.400)



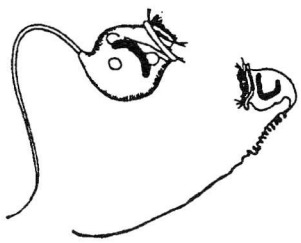
Urotricha

Prostomatida II



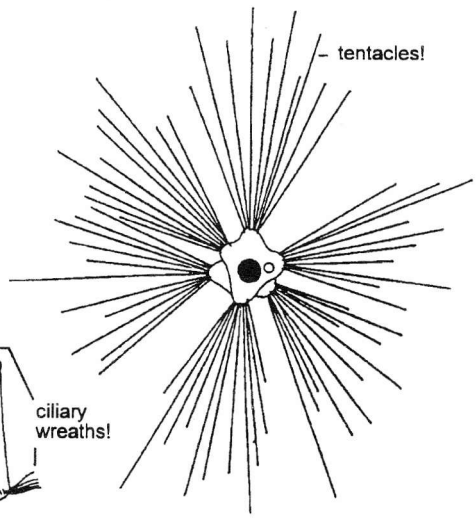
Balanion planctonicum
about 20 µm
(Vol. III, p.369)

Astylozoon

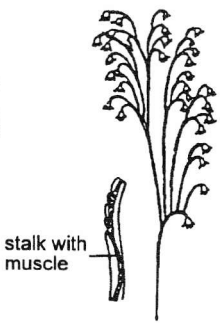


Vorticella mayeri/natans

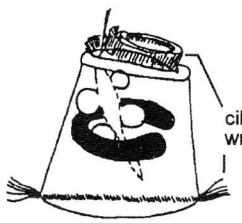
Peritrichia V



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



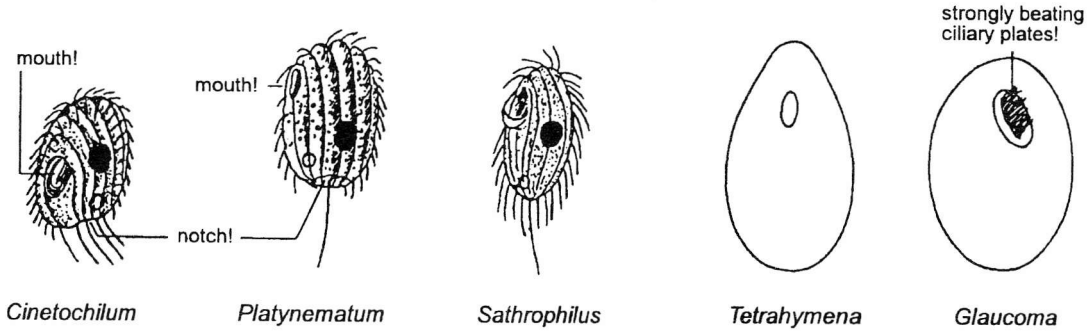
Carchesium pectinatum
40-70 µm
(Vol. II, p.149)



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

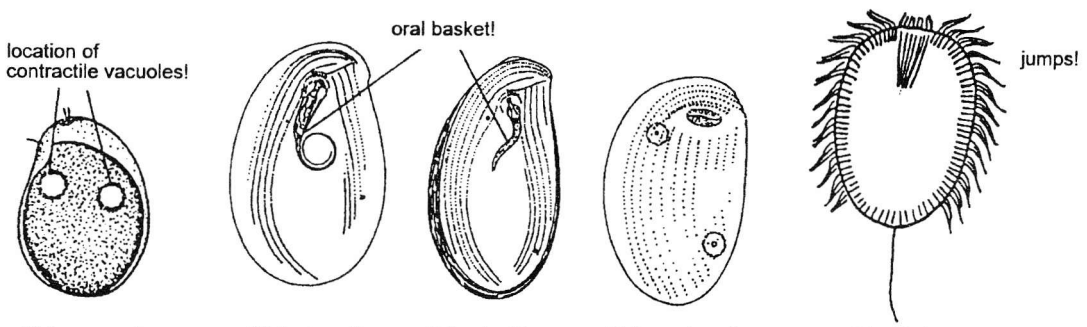
Staurophrya elegans
50-65 µm
(Vol. IV, p.420)

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



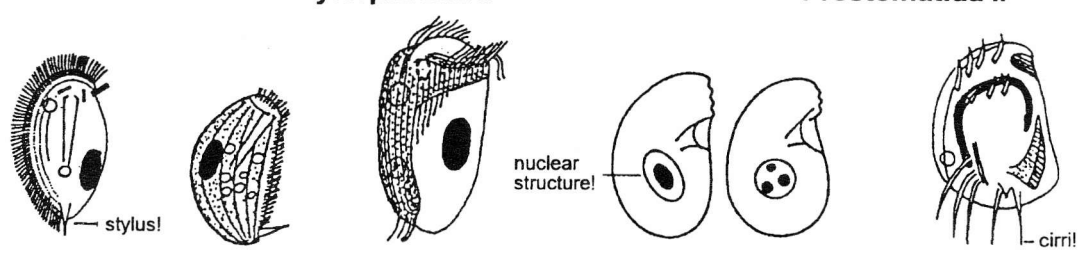
Cinetochilum *Platynematum* *Sathrophilus* *Tetrahymena* *Glaucoma*

Hymenostomata VII **Hymenostomata VI**



Thigmogaster *Chilodonella* *Odontochlamys* *Chlamydonella* *Urotricha*

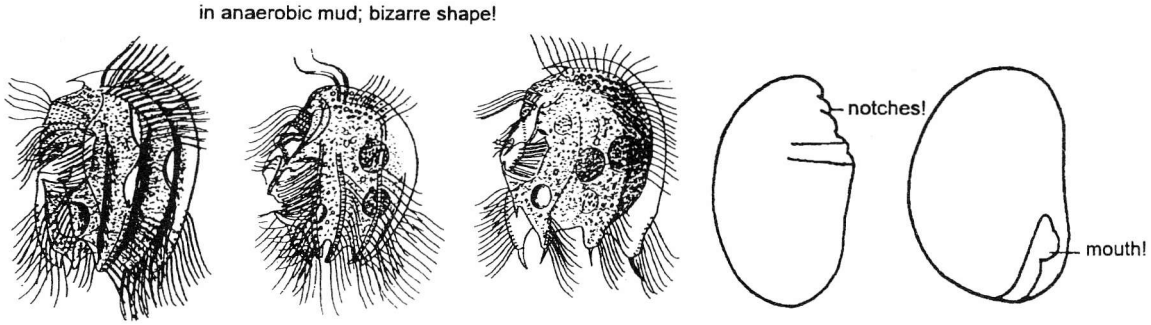
Cyrtophorida II **Prostomatida II**



Trochilia *Dysteria* *Trochilioides* *Colpoda steinii/ecaudata* *Aspidisca*

Cyrtophorida I **Colpodea** **Hypotrichia II**

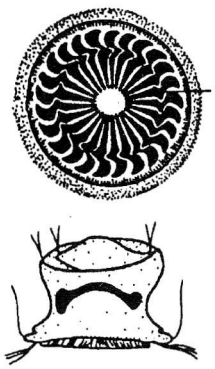
in anaerobic mud; bizarre shape!



Epalxella *Pelodinium* *Saprodinium* *Leptopharynx* *Microthorax*

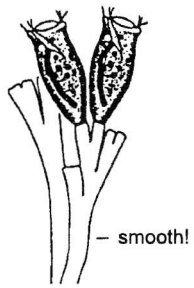
Odontostomatida **Nassulida**

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

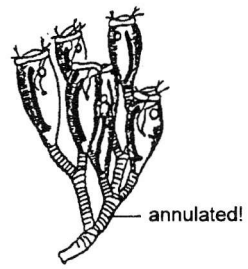


Trichodina pediculus
35-60 µm
on hydras, bryozoans and fishes
(Vol. II, p.304)

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



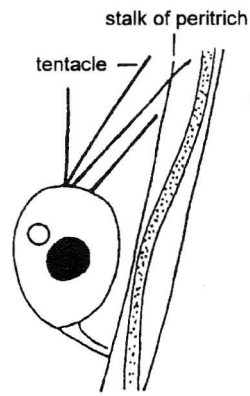
Epistylis nympharum
80-130 µm
colonial on arthropods
(Vol. II, p.217)



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

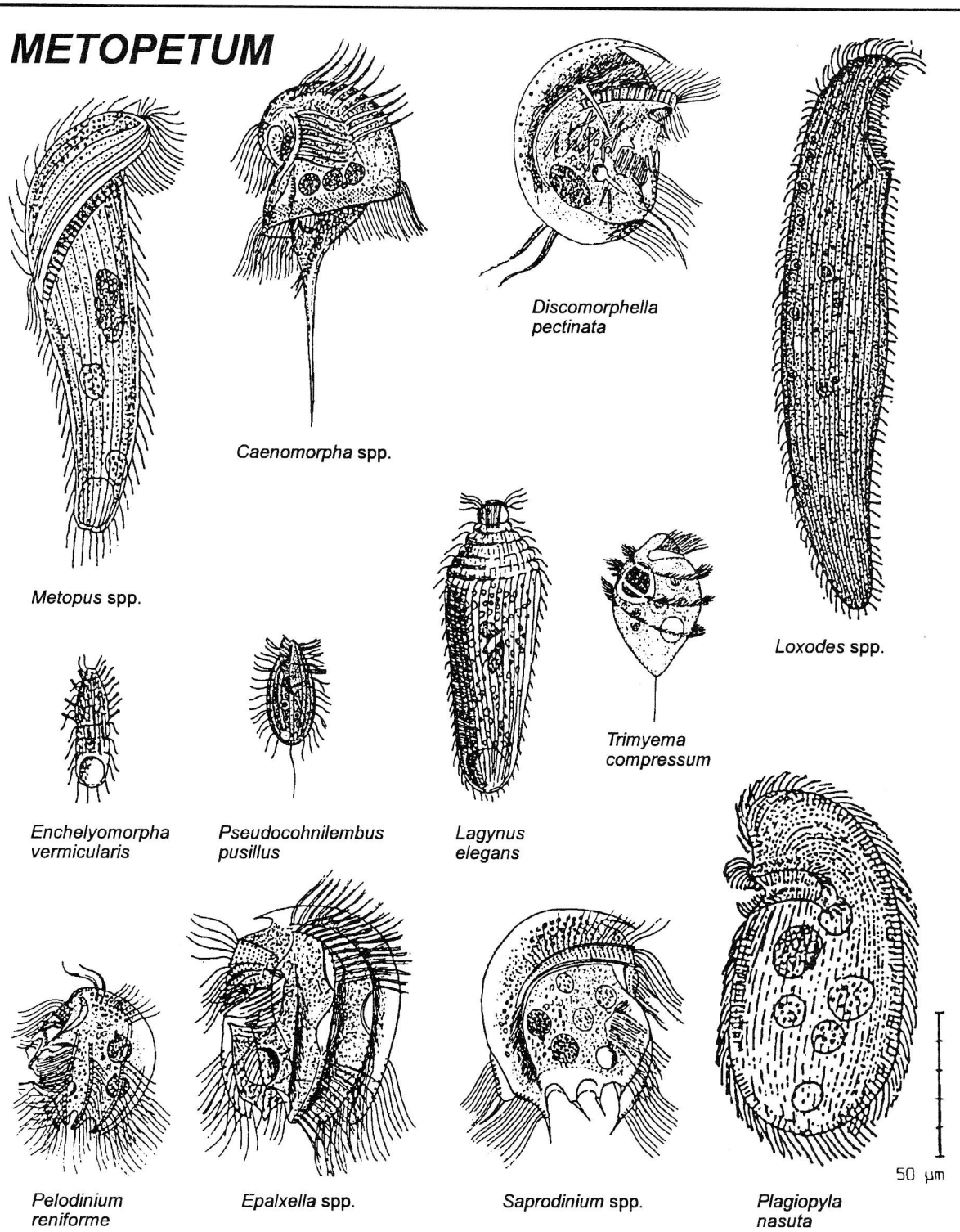
Lagenophrys vaginicola
45-80 µm
on small crustaceans
(Vol. II, p.256)

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

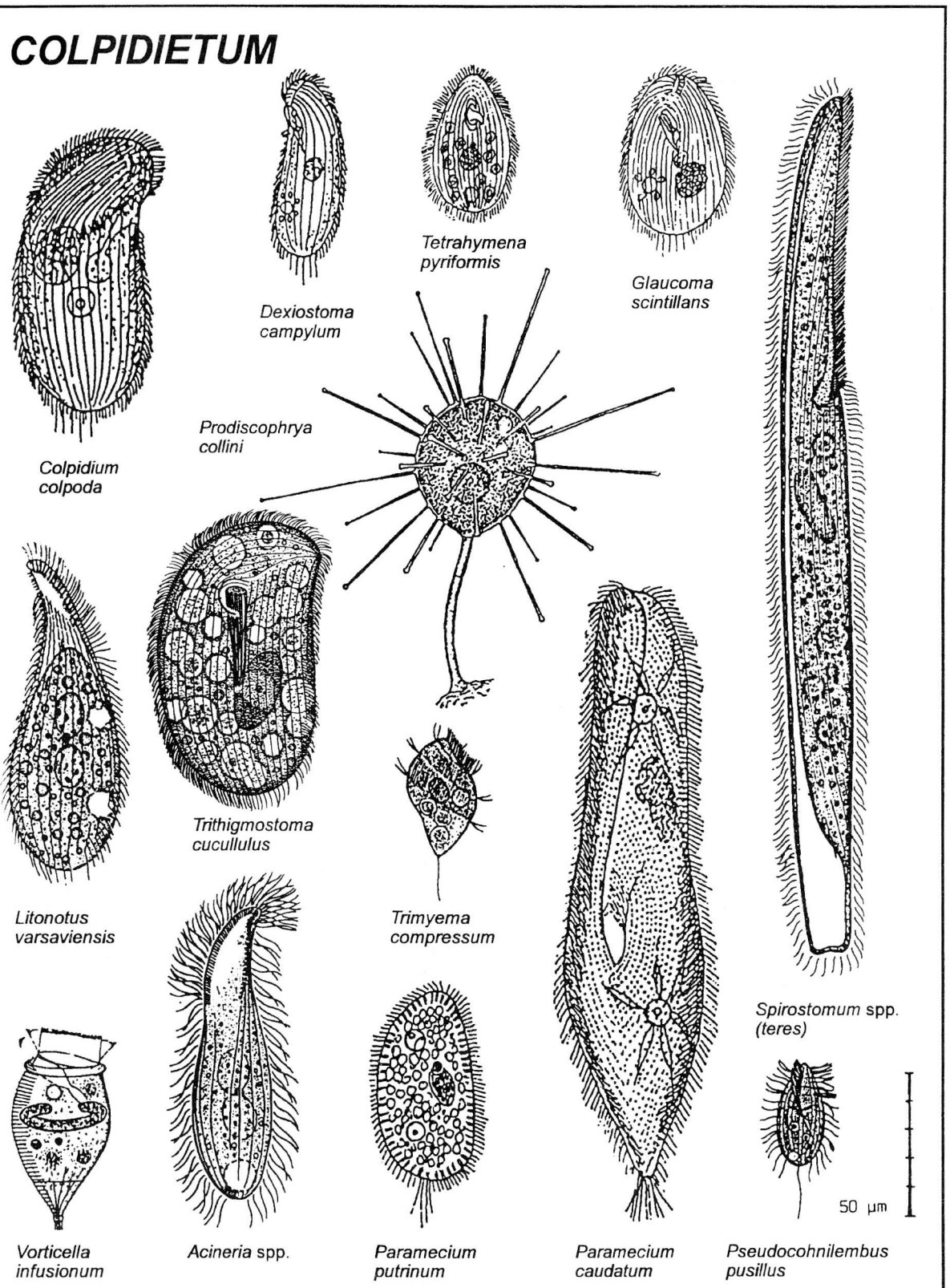


Tokophrya carchesii
25-85 µm
on peritrichs, especially on *Carchesium*
(Vol. IV, p.417)

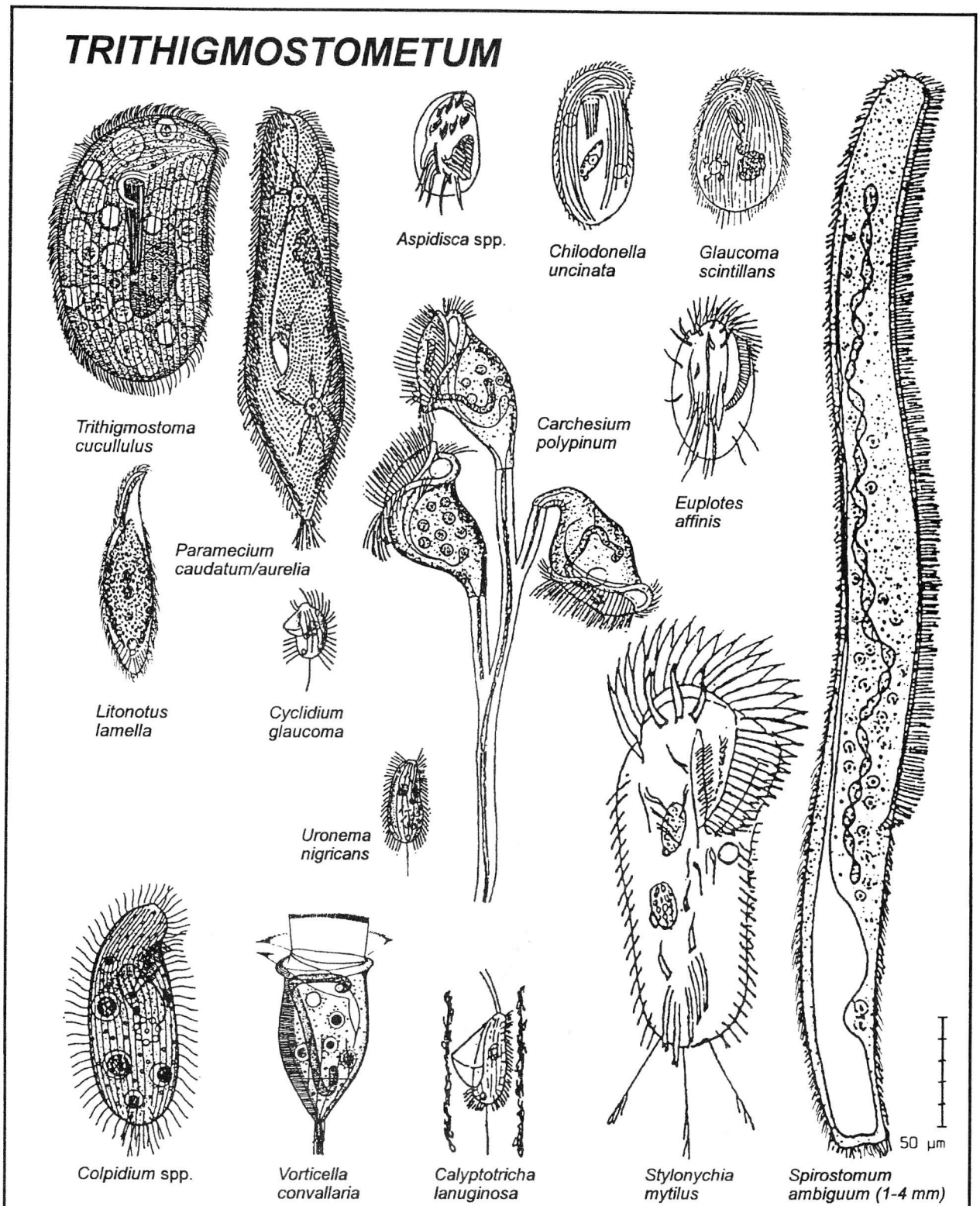
Ciliate communities, an important aid for water quality evaluation



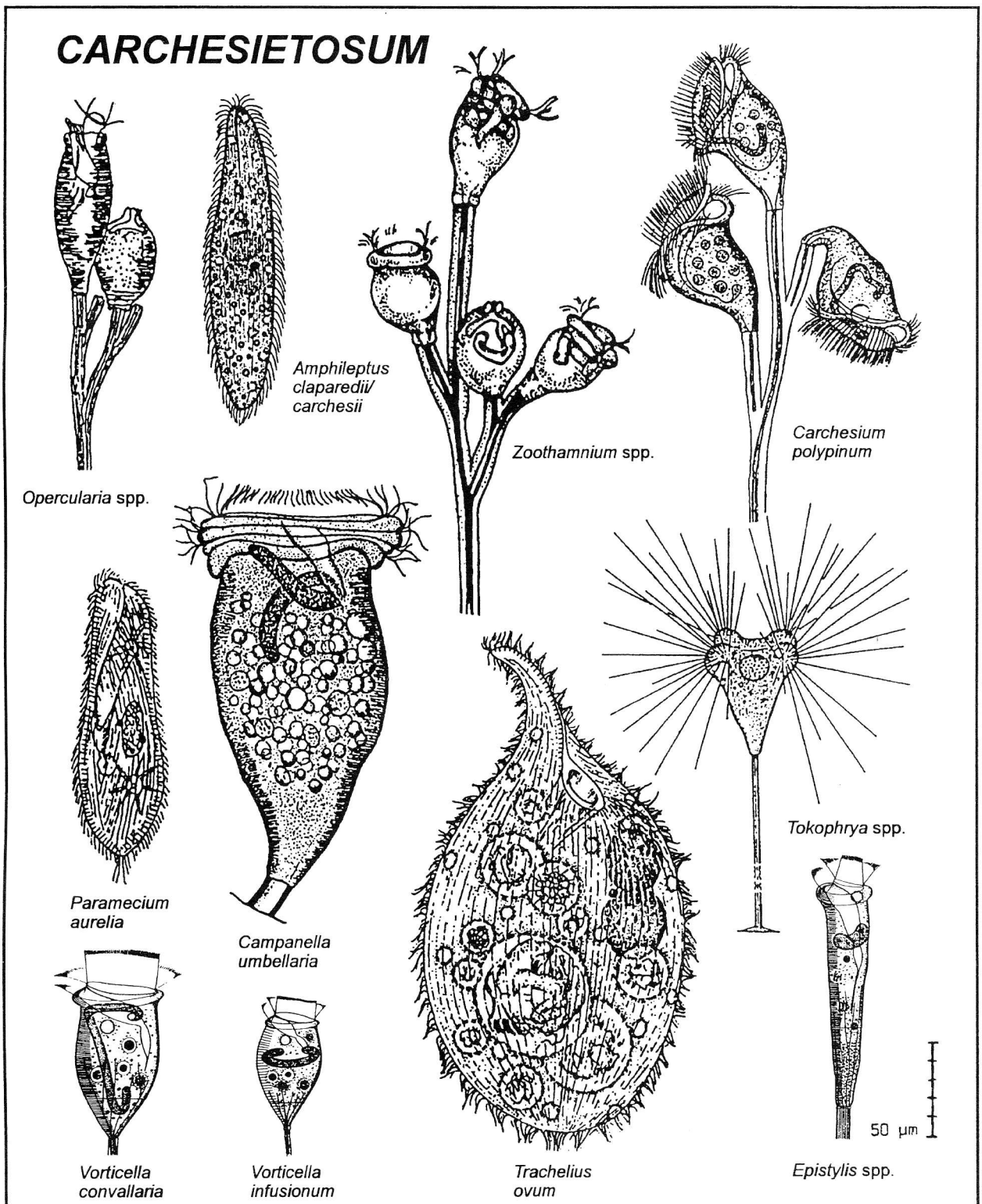
Ciliate community of anaerobic mud (*Metopetum*). Indicator species are members of the genus *Metopus* (s.l.) and certain heterotrichs (all described in Vol. II). Most of the species belonging to the *Metopetum* are strictly bound to anaerobic conditions, i.e. oxygen is poisonous for them; they do not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



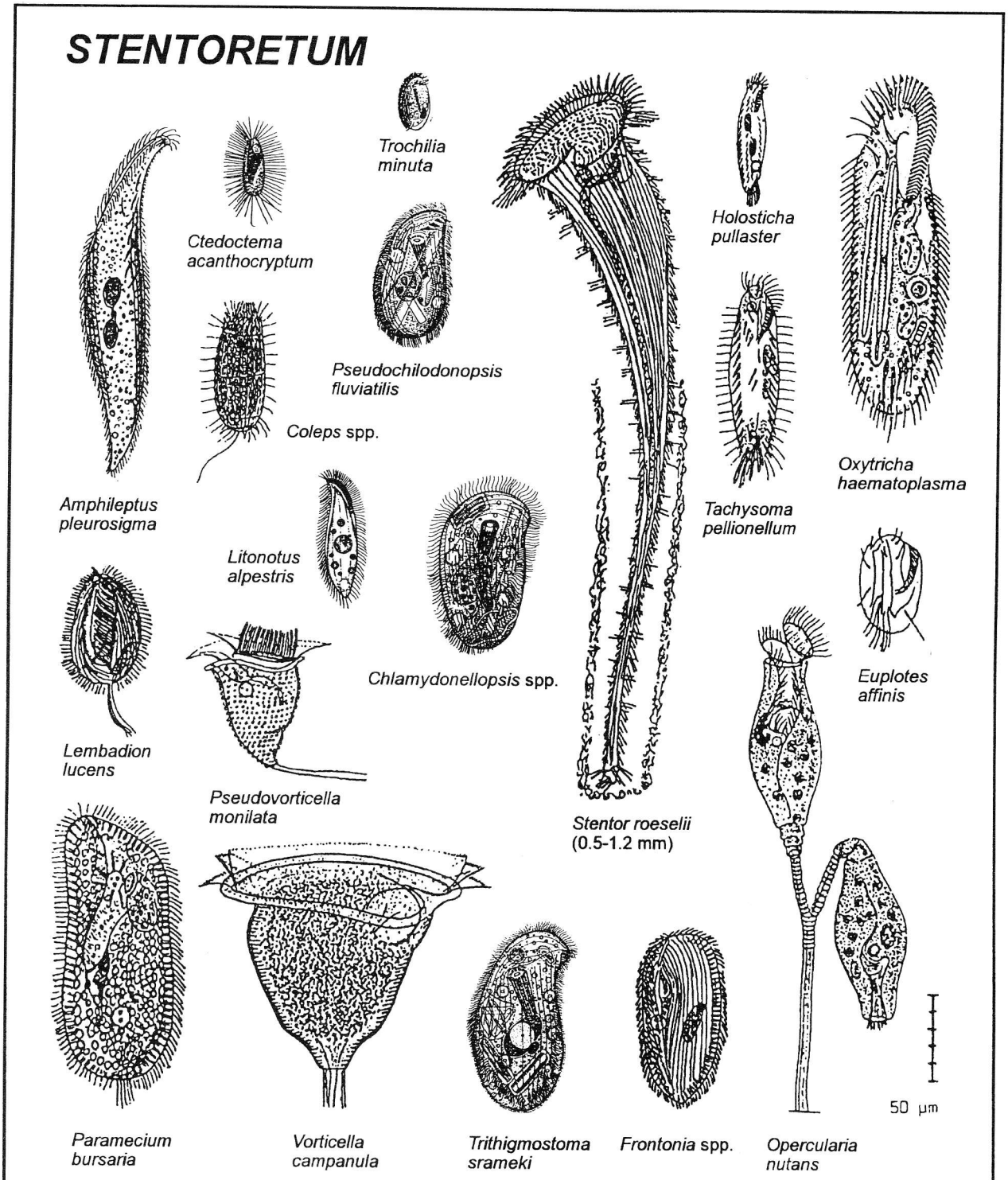
Ciliate community of the polysaprobic self-purification zone *(Colpidietum colpodae)*. Indicator species is *Colpidium colpoda*, a hymenostome ciliate (Vol. III). Decomposition is very intensive in this zone and dissolved oxygen is thus usually almost depleted. Few ciliate species (usually < 25 in a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



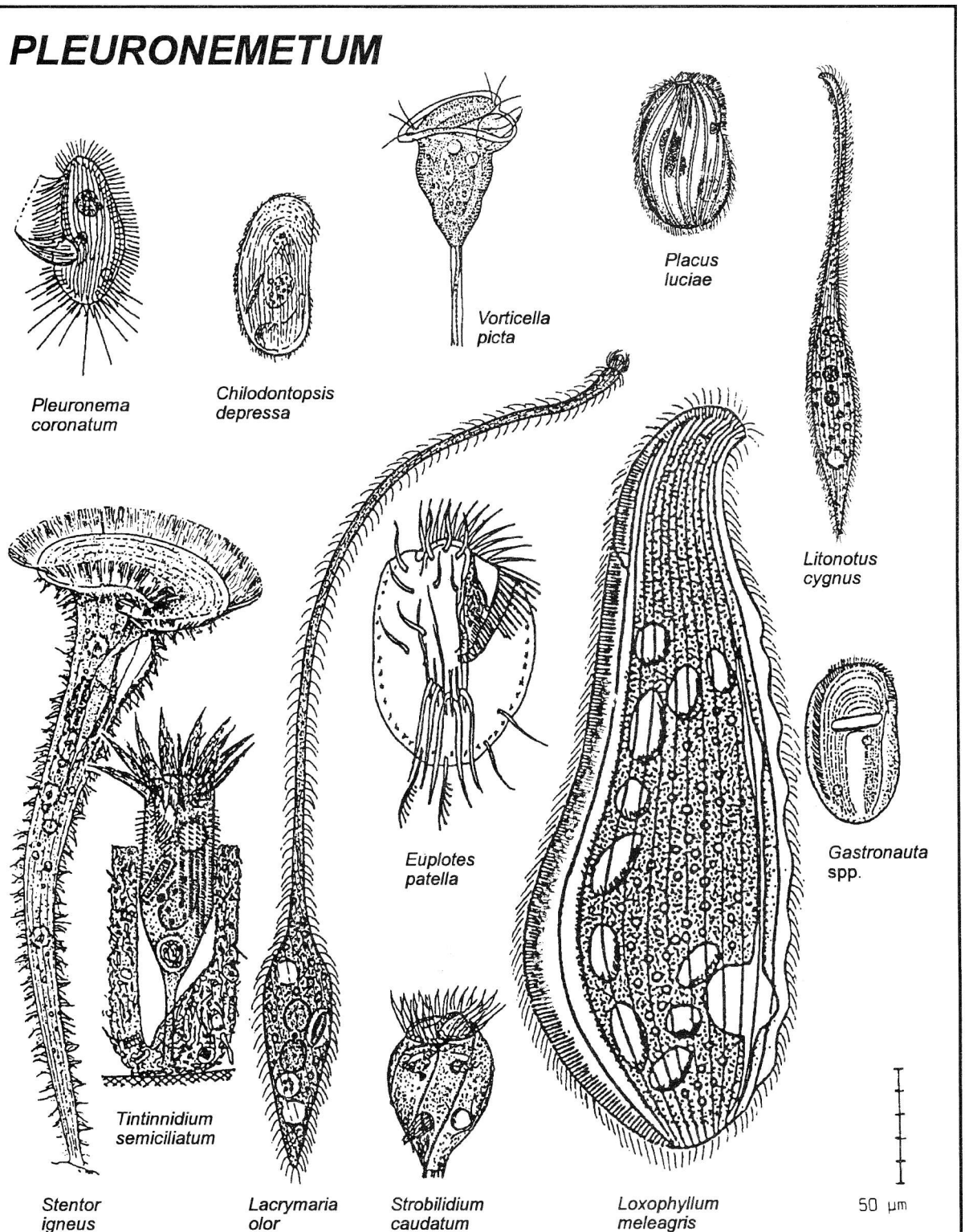
Ciliate community of the alpha-mesosaprobic self-purification zone *(Trithigmostometum cucullulae)*. Indicator species is *Trithigmostoma cucullulus*, a cyrtophorid ciliate (Vol. I). Rather many ciliate species (up to 50 in a sample) occur already in this zone, some have high or very high abundances. 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.



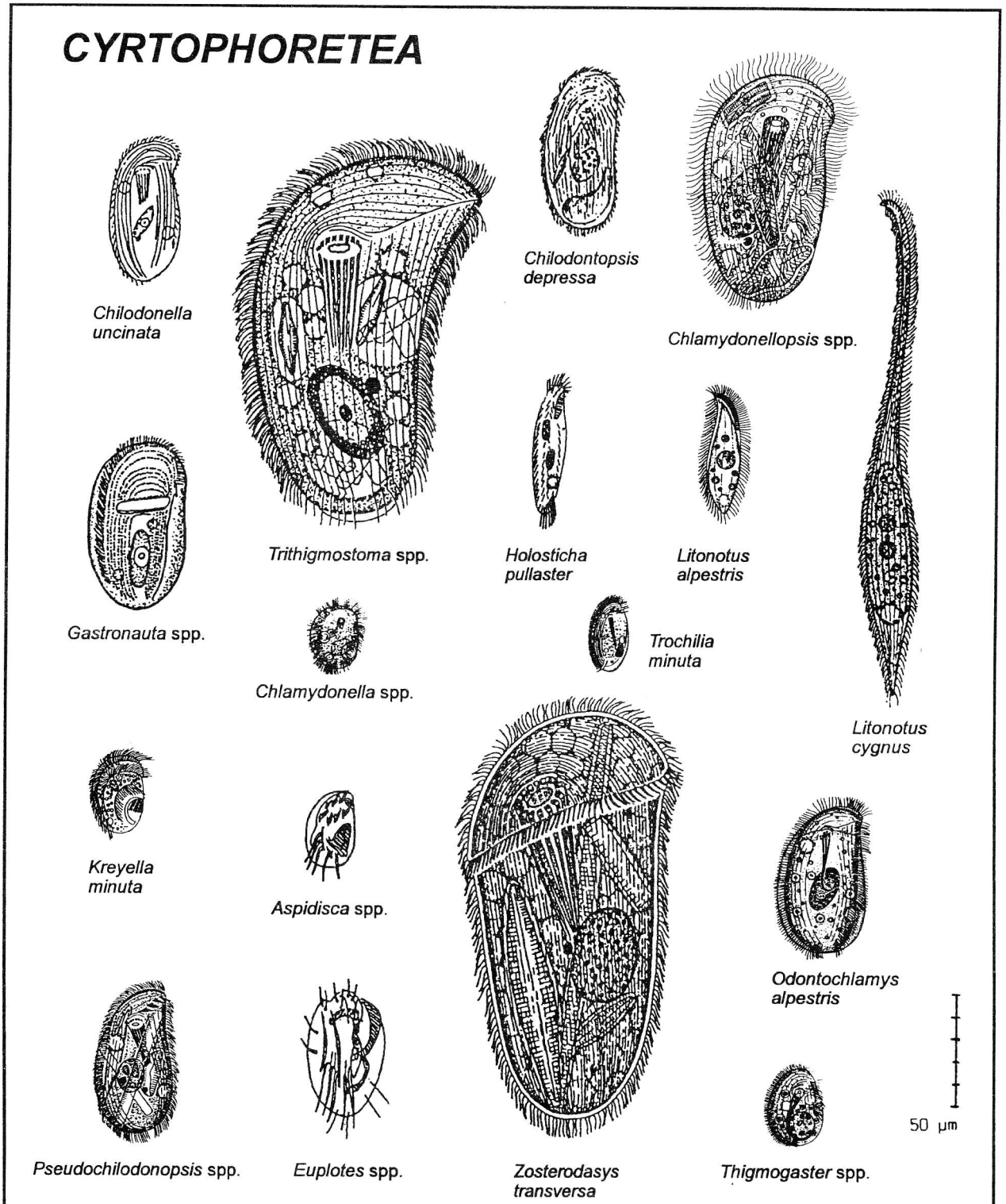
Peritrich community (*Peritrichetea*) of the alpha-mesosaprobic *Trithigmostometum* (*Carchesietosum polypinae*). Typically, this sessile subassociation of the *Trithigmostometum* develops downstream from the effluent of waste water treated only mechanically or in insufficiently operating activated sludge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



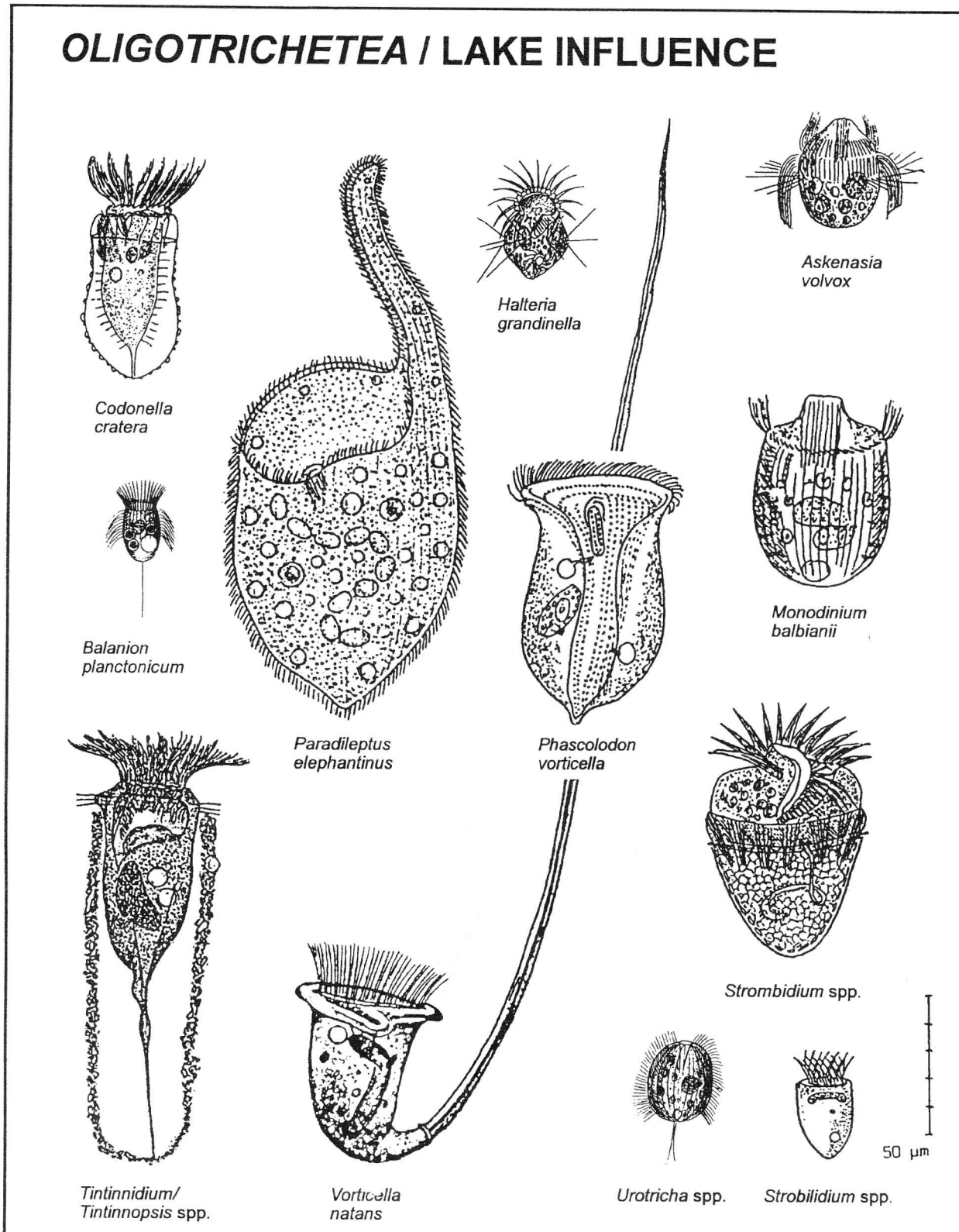
Ciliate community of the beta-mesosaprobic to alpha-mesosaprobic self-purification (transition) zone (*Stentoretum*). This is the most species rich (often more than 60 in a sample) zone in a self-purification reach. The total abundance of the ciliates is still high, but lawns recognizable with the naked 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.



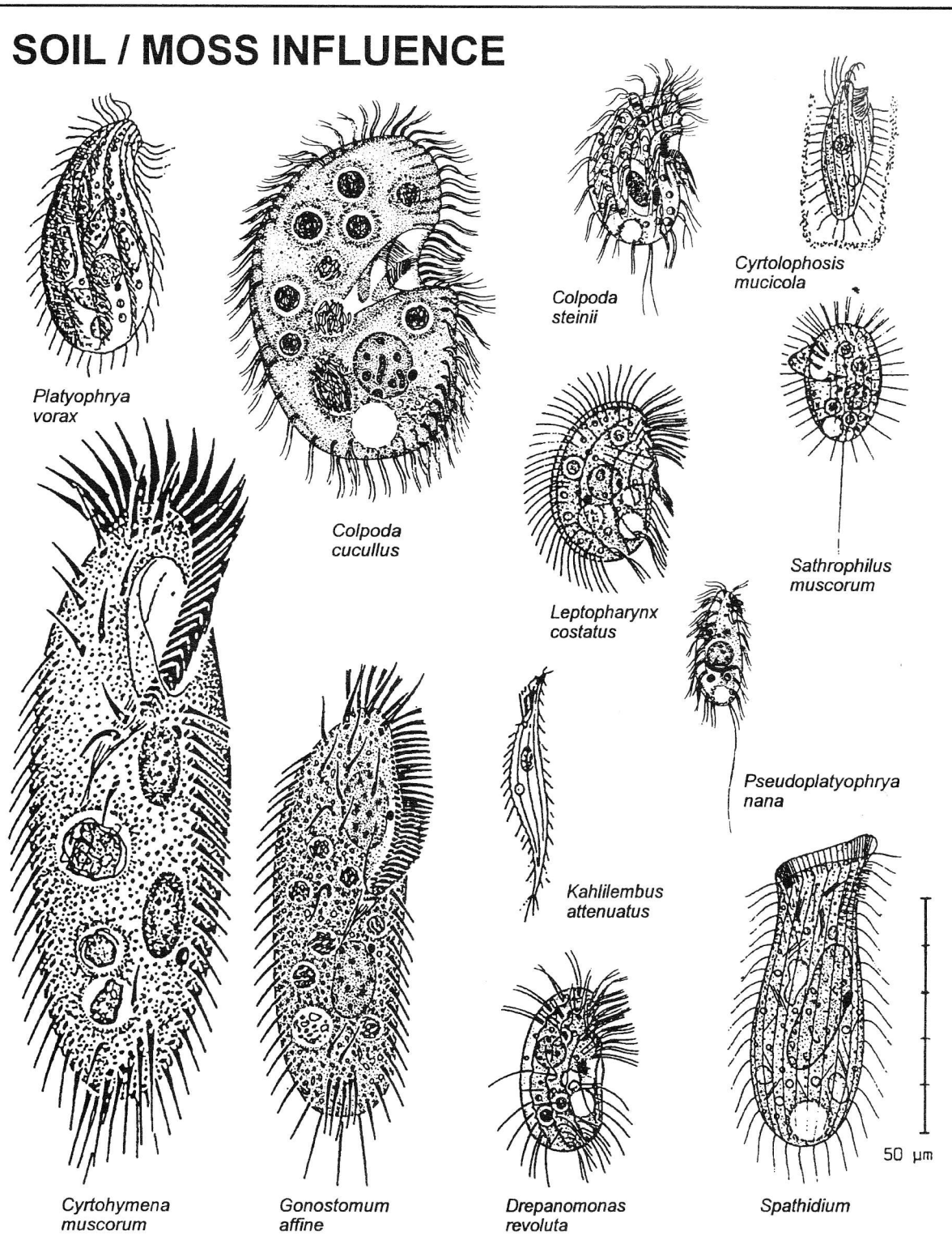
Ciliate community of the beta-mesosaprobic self-purification zone (*Pleuronemetum coronatae*). Indicator species is *Pleuronema coronatum*, a hymenostome ciliate (Vol. III) which is highly frequent and sometimes also rather abundant. The ciliate community is very diverse, but often less than 25 taxa 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.



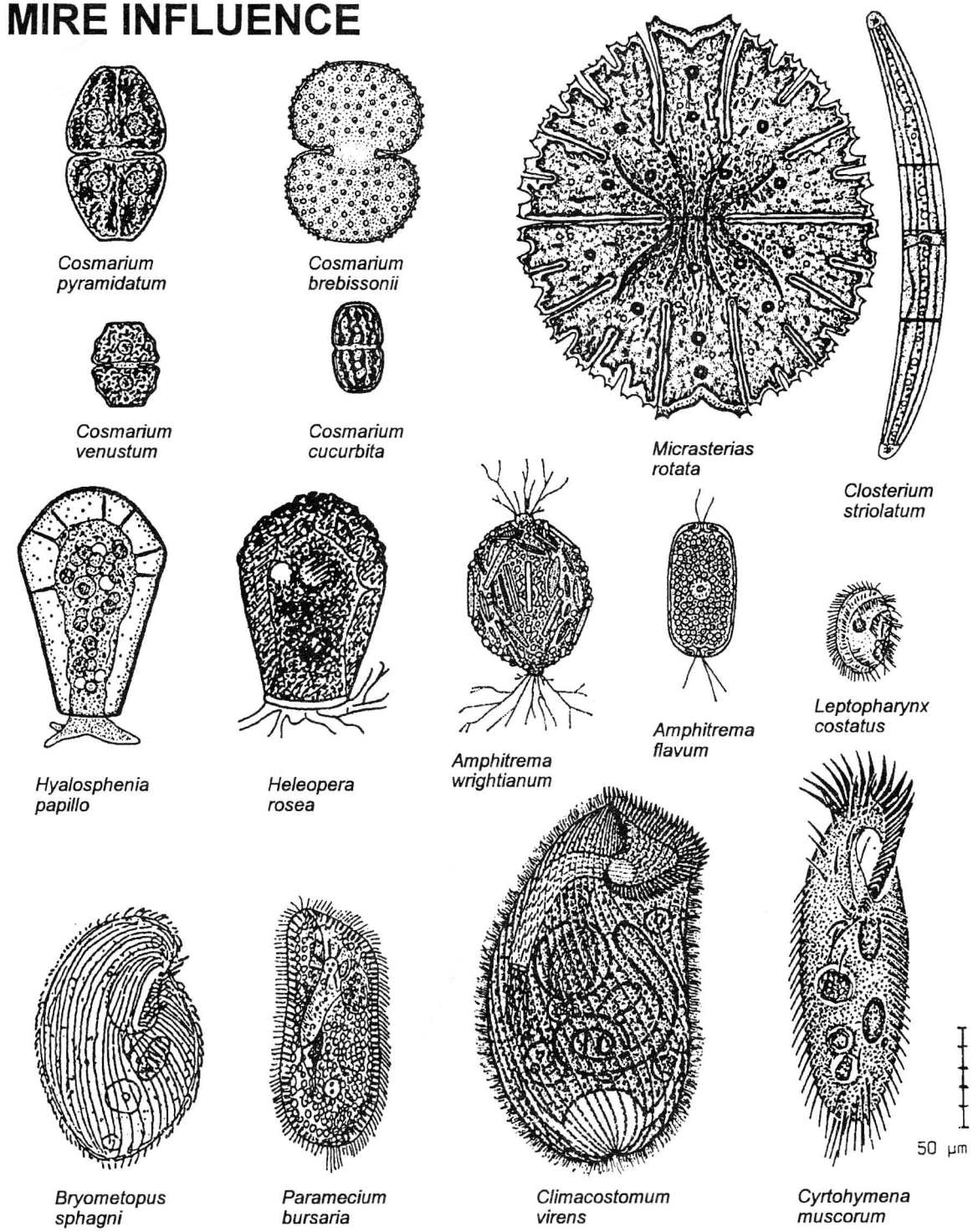
Ciliate community of the vagile periphyton (*Cyrtophoretea*). Cyrtophorid ciliates (Vol. I) are a highly characteristic and usually also very abundant component of the vagile periphyton (Aufwuchs), which preferably develops in spring in oligosaprobic to mesosaprobic, diatom-rich streams. Typical accessory 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.



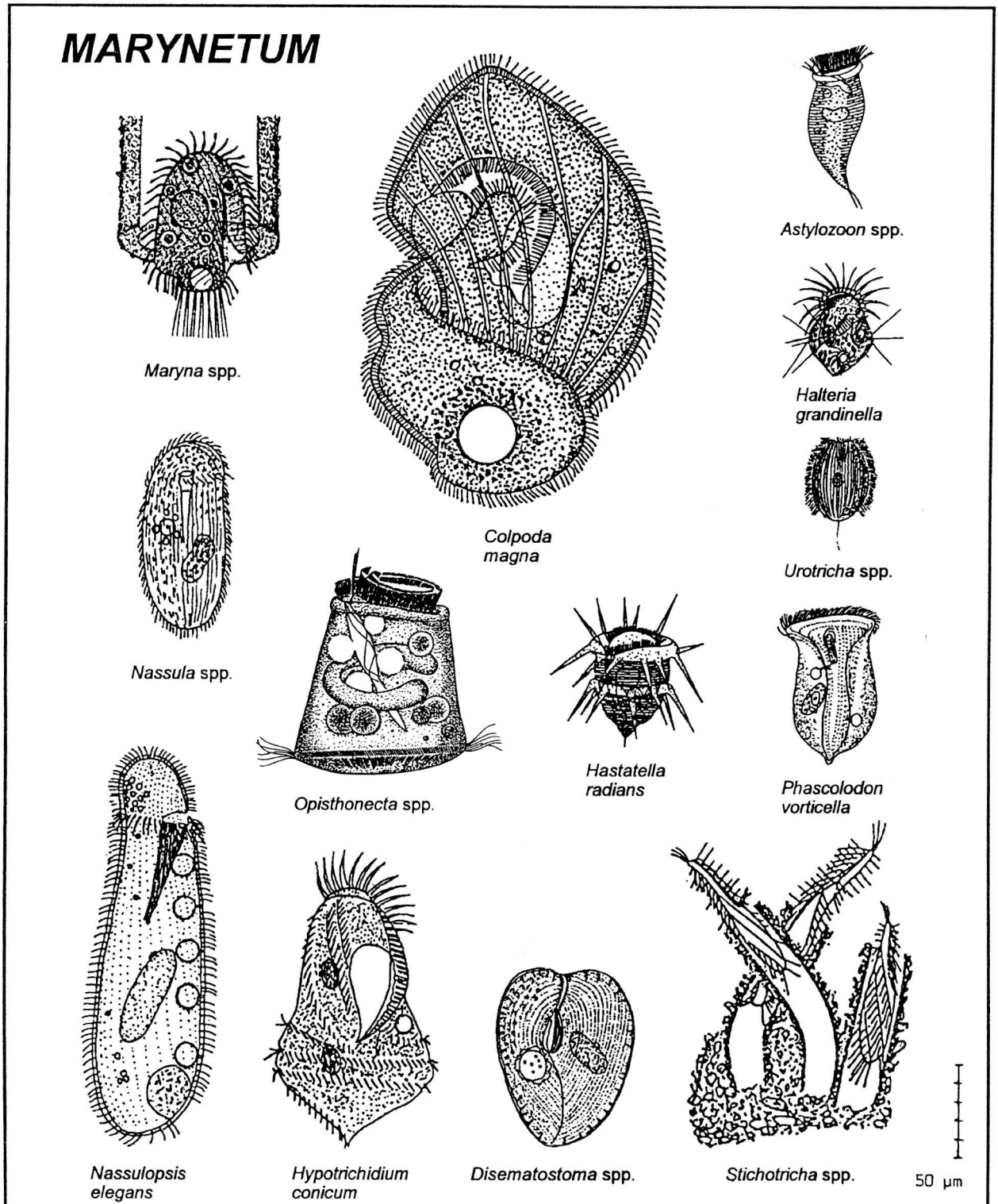
Ciliate community of the pelagial (*Oligotrichetea*). An increased occurrence of oligotrich ciliates (Vol. I) is characteristic for stagnant waters (e.g. lakes, impounding basins) and large, slowly flowing rivers. However, euplanktonic species occur also in most other groups of ciliates (Tab. 1). An 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.



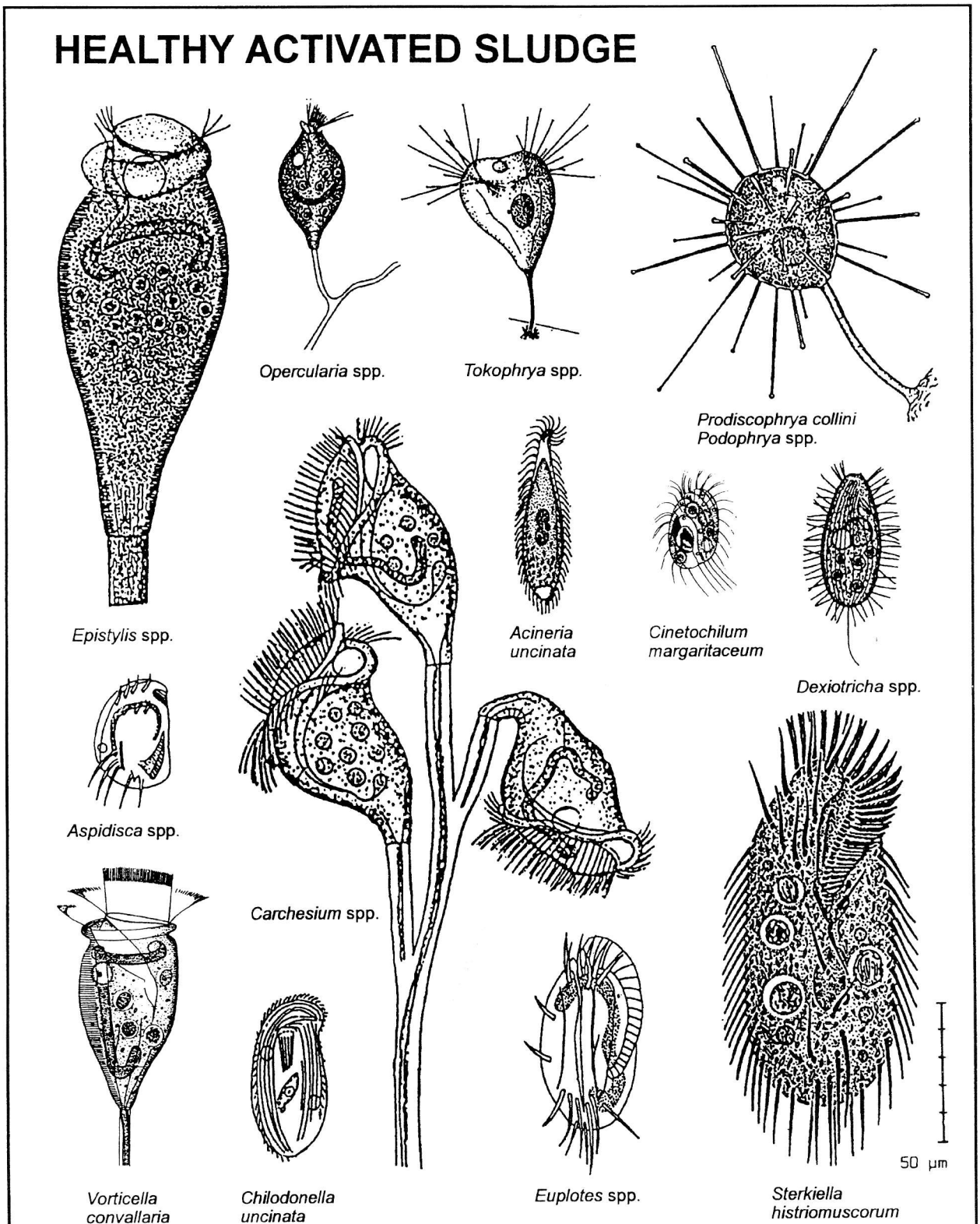
Indicators for terrestrial influence. A highly specific ciliate community lives in soil and moss (Foissner, 1987). Only about 20% of the species occur in both terrestrial and limnetic biotopes. Some of these opportunists have been classified saprobiologically and are shown on this plate. Only if several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



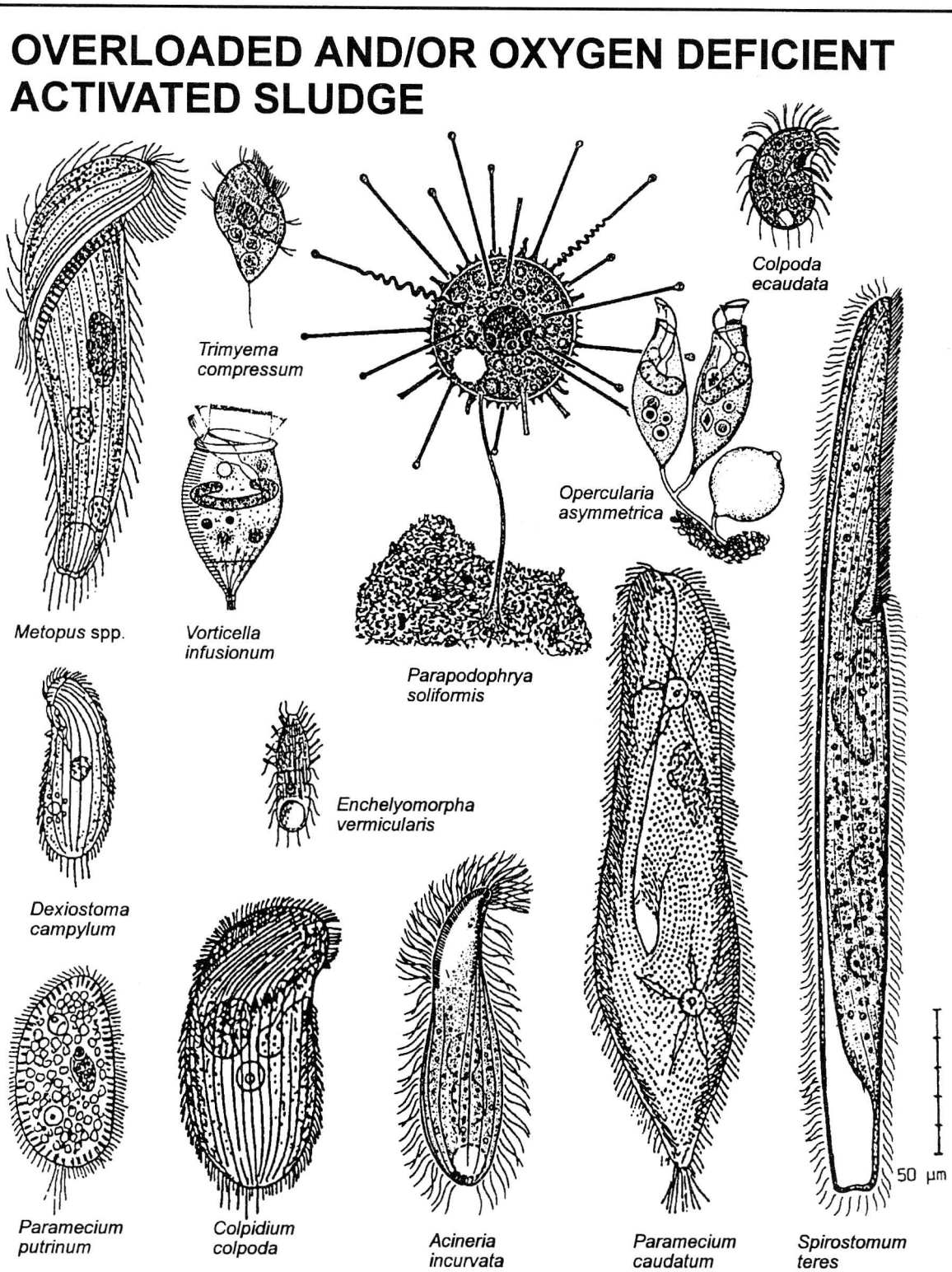
Indicators for mire influence. An increased number of mire-specific organisms, especially desmids and testate amoebae, is found in streams and rivers which receive water from mires and/or moorlands and are not too heavily polluted. The ciliates from such usually acidic biotopes are still poorly explored. 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.

Systematic index

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

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