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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 brightfield 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.

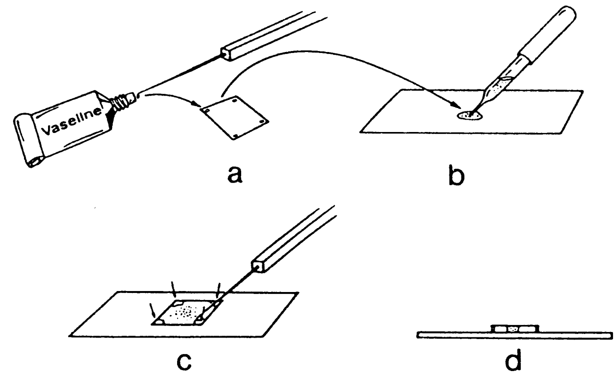

Fig. 1 Preparation of slides for observing living ciliates (after Dragesco & Dragesco–Kernéis, 1986). (a) A small drop of vaseline jelly each is placed at the four corners of a coverslip with a needle or injection syringe; (b) a small volume of water containing the ciliates is placed on a slide (see 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			Saprobity[4]
				Preferred water type	Preferred habitat	Community[3]	
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]
Chaetospira muelleri	80	Ba,Ki, Fl	he	S,F	B,A		b
Chaetospira remex	250	Ba,Fl, Ki	oe	S,F	A,B		b-a
Chilodonella uncinata	11	Ba	he?	F,S,K,Bo	A,B	TRI,CYR,NBE	a
Chilodontopsis depressa	10	Ba,Al, Ki	he	F,S	A,B	PLE,CYR	b
Chlamydonella alpestris	3	Ki,Ba	os	F,S,Bo	A,B	CYR	b-a
Chlamydonellopsis plurivacuolata	50	Ki	os	F	A,B	STE,CYR	b-a
Cinetochilum margaritaceum	5	Ba,Al	ome (he?)	S,F	A,B,P	NBE	eurysaprobic
Climacostomum virens	500	O	he?	S,F	B,P	MOO	b
Codonella cratera	20	Ki,Al?	oe	S,F	P	OLI	b-o
Coleps hirtus	21	O	oms (he?)	S,F	A,B,P	STE	a-b
Coleps nolandi	16	O	he	S,F	A,B	STE	o-a
Coleps spetai	60	Al,Cy	os	S	P		b
Colpidium colpoda	130	Ba,Fl, Al	ome	F,S,K	B	COL,TRI,HBE	p-i
Colpidium kleini	65	Ba	os	F,S	B	TRI	p
Colpoda cucullus	70-140	Ba,Fl, Al	ome?	Bo,S,F	B,A	BOD	p-a
Colpoda ecaudata	5-10	Ba	ome	Bo,K	B	HBE	p-i
Colpoda inflata	40	Ba,Fl	ome?	Bo,S	B		a-p
Colpoda magna	2400	Ba (O)	os	S	B	MAR	a-p
Colpoda steinii	4	Ba	ome	Bo,S,F	P	BOD	a-p[12]
Cothurnia annulata	14	Ba	oe?	S,F	A		o-b
Ctedoctema acanthocryptum	2	Ba	os	S,F	B	STE	b-a
Cyclidium glaucoma	1-3	Ba	he	F,S,K	B,A,P	TRI	a
Cyclidium heptatrichum	2	Ba	ome?	F,S	B,A,P		b
Cyrtolophosis mucicola	2	Ba	he?	Bo,S,F	B	BOD	b-p
Dendrosoma radians	?[10]	R	oms	S,F	A,B,T		b-a
Dexiostoma campylum	26	Ba,Fl, Al	oms	F,S,K	B	COL,HBE	p-i
Dexiotricha granulosa	20	Ba	oe (he?)	S,F	B,A	NBE	a-p
Dexiotrichides centralis	5	Ba	oe?	S,F,K	Fs,B		p-i
Didinium nasutum	500	R	oe?	S,F	B,P		a-b
Dileptus margaritifer	500	O	he	S,F	B,A	PLE	b
Discomorphella pectinata	50	Ba,Sb	he?	S,F	Fs	MET	p-m
Disematostoma buetschlii	400	Al,Ba	os	S	P	MAR	b
Disematostoma tetraedricum	150	Ki	os	S,F	P	MAR	b
Drepanomonas revoluta	1	Ba	oms?	Bo,S,F,K	B,A,P	BOD	a-p

Species	Biomass (mg) of 10^6 ind.[1]	Main food	Salinity tolerance[2]	Occurrence			Sapro-bity[4]
				Preferred water type	Preferred habitat	Community[3]	
Dysteria fluviatilis	5	?	os	F,S	A,B		b
Enchelyodon elegans	200	R?	oe?	S,F	B,A		a
Enchelyomorpha vermicularis	3	-	oms?	K,F,S	Fs,B	MET,HBE	p-m
Enchelys gasterosteus	21	O	os	S,F	B,A	STE	b-a
Epalxella spp.	2-25	Sb	os	S,F	Fs	MET	p-m
Epenardia myriophylli	700	Ba,Sb	os	S,F	B		a-p
Epistylis chrysemydis	260-1300	Ba,Al	oe	F	A,T	CAR,NBE	a
Epistylis coronata	90	Ba	os	S	A		a
Epistylis digitalis	30	Ba?	os	S,F	T		o-b
Epistylis entzii	300	Ba	os	S,F,K	A,T	CAR,NBE	a
Epistylis galea	250	Ba	os	S,F	A		a
Epistylis hentscheli	100	Ba	oms	F,S	A,B	CAR,NBE	a-b
Epistylis nympharum	80	Ba	os	S,F	T		o-a
Epistylis plicatilis	40	Ba	ome?	S,F,K	A,B,T	CAR,NBE	a-b
Epistylis procumbens	40	Ba,Fl	oe?	S,F	P		o-b
Euplotes aediculatus	260	O	oe?	F,S,K	B	CYR,NBE	a
Euplotes affinis	18	Ba,Ki, Al,Fl	he?	F,S,K	B,A	TRI,STE,CYR, NBE	b-a
Euplotes eurystomus	400	O	he?	S,F	B		a
Euplotes moebiusi	23	Ba,Ki,Fl	he	F,S,K	B,A	CYR,NBE	a
Euplotes patella	93	O	he?	F,S,K	B,A	PLE,CYR, NBE	b
Frontonia acuminata	100	O	oms	S,F	B,A,P	STE	b-a
Frontonia angusta	110	O	os	F,S	B,A,P	STE	b-a
Frontonia atra	95	Ki	os?	S,F	B,P		b-a
Frontonia leucas	270	O	oe	S,F	B,A,P	STE	b-a
Gastronauta clatratus	10	Ki	oms	F,S	A,B	PLE,CYR	b-a
Gastronauta membranaceus	15	Ba	oe?	F,S	A,B	PLE,CYR	b
Gastrostyla mystacea	120	O	os	S,Bo	B		p
Gastrostyla steinii	122	O	os	S,F,Bo	B		a
Glaucoma reniforme	10	Ba,Al	os	S,F	B,A		p
Glaucoma scintillans	25	Ba	oe	F,S,K	B,A	COL,TRI	p-a
Halteria chlorelligera	45	Al	os	S,F	P,Fs?		o?
Halteria grandinella	27	Ba,Al	he?	S,F,Bo	P,B	OLI,MAR	b-a
Hastatella radians	30	Ba	oe?	S,F	P	MAR	b-a
Heliophrya minima	10	R	os	S,F	A		b-a
Heliophrya rotunda	40	R	oe?	S,F	A		b-a
Hexotricha caudata	5	Ba	oms?	S,F,K	Fs		p-m
Histriculus vorax	350	Ba	os	S,K	B		a
Holophrya discolor	290	O	he	S,F,K	B,P		a-b

Species	Biomass (mg) of 10^6 ind.[1]	Main food	Salinity tolerance[2]	Occurrence			Sapro-bity[4]
				Preferred water type	Preferred habitat	Community[3]	
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.	-	histophag	-	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: Preferred water type	Occurrence: Preferred habitat	Occurrence: Community[3]	Saprobity[4]
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 (‰).

<table>
<tr><td>Cl</td><td>0-400</td><td>400-2000</td><td>2000-5000</td><td>5000-17000</td><td>>17000</td></tr>
<tr><td>S</td><td>0-1</td><td>1-4</td><td>4-10</td><td>10-30</td><td>>30</td></tr>
<tr><td colspan="6">holo-euryhaline</td></tr>
<tr><td colspan="2">oligostenohaline</td><td colspan="4">meso- to poly-euryhaline</td></tr>
<tr><td colspan="3">oligo- to meso-stenohaline</td><td colspan="3">poly-euryhaline</td></tr>
<tr><td colspan="4">oligo-euryhaline</td><td colspan="2">meso- to poly-stenohaline</td></tr>
<tr><td colspan="5">oligo- to meso-euryhaline</td><td>poly-stenohaline</td></tr>
</table>

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.

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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".

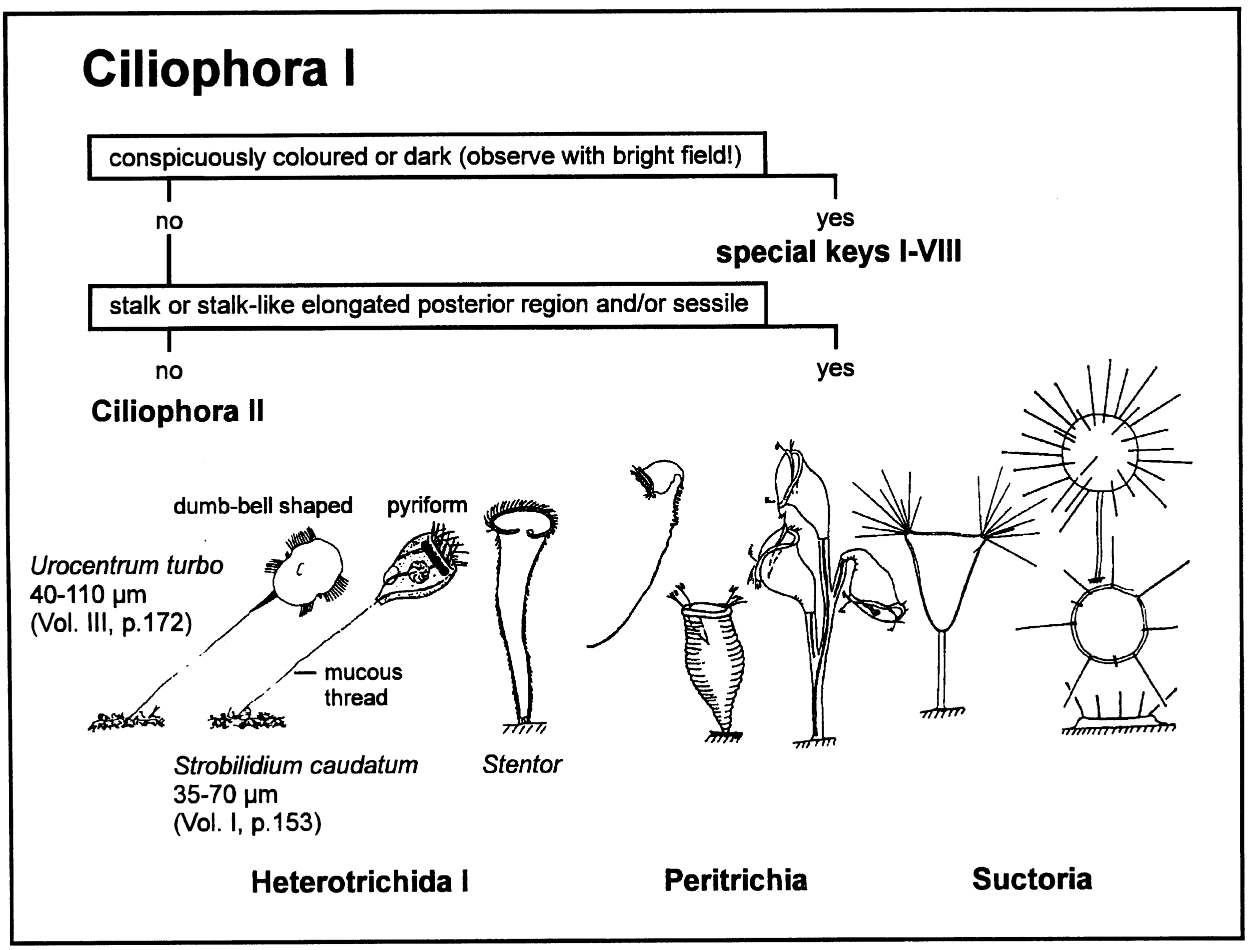


Plate 1

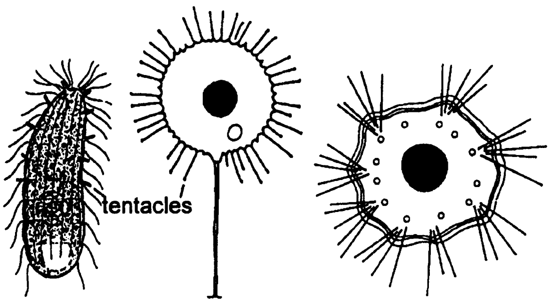
Ciliophora II

* 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)

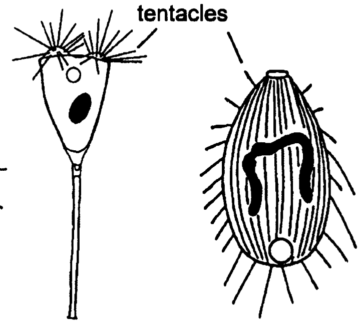
Ciliophora I

tentacles*

- absent → next question (lorica or armour)
- present →



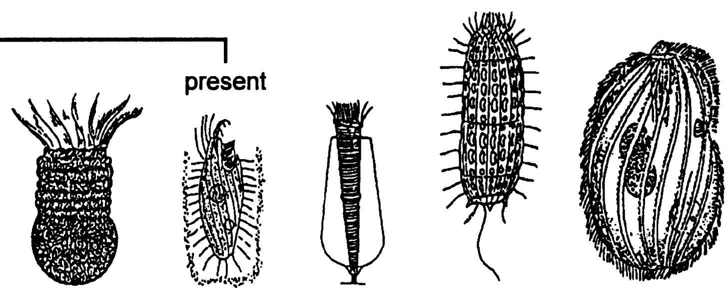
Suctoria



Actinobolina
Gymnostomatida I

lorica or armour

- absent or unknown → next question
- present →



special key IX

very large, about 300 μm or more

- no → next question
- yes → **special key X**

conspicuously (more than 50%) contractile*

- no → next question
- yes → **special key XI**

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

slender, length : width ≥ 5:1

- no → next question
- yes → **special key XII**

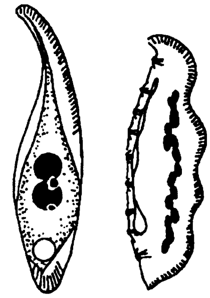
body with distinct furrows

- no → **Ciliophora III**
- yes → **special key XXI**

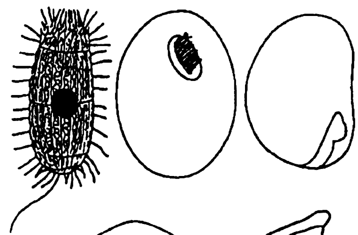
Ciliophora III

Ciliophora II

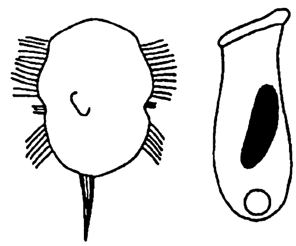
shape lanceolate
- no → next
- yes → **Pleurostomatida**



barrel-shaped, ellipsoid or like a segment of a circle
- no → next
- yes → **special key XIV**



dumb-bell or spatula shaped
- no → next
- yes → **special key XV**



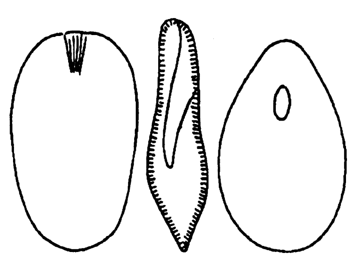
snout-like peak at anterior end
- no → next
- yes → **special key XVI**

proboscis or proboscis-like elongation
- no → next
- yes → **special key XVII**

tail
- no → next
- yes → **special key XVIII**

shape bizarre (with spines, processes, cavities ...)
- no → next
- 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!

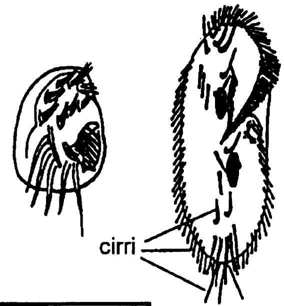
Ciliophora III

shape reniform

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

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

- no → 2 macronuclear nodules (Ma)
- yes → **special key XIX**



2 macronuclear nodules (Ma)

- no or unknown → rod (extrusomes) seam
- yes → adoral zone of membranelles (tufts of cilia; AZM)

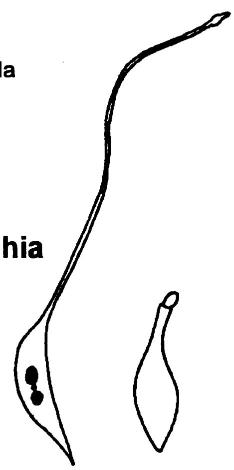
adoral zone of membranelles (tufts of cilia; AZM)

- yes → many **Hypotrichia**
- no → shape

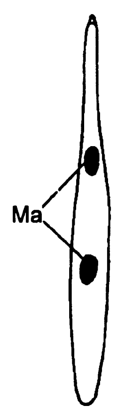
many **Hypotrichia**

shape

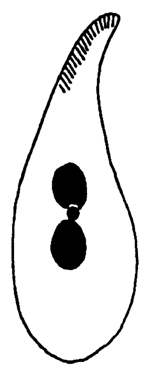
- club-shaped
- rod-shaped
- lanceolate



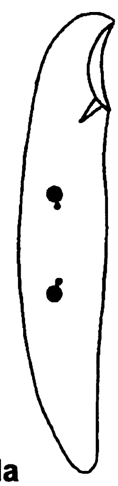
Lacrymaria olor
extended up to 1200 μm
contracted about 100 μm
(Vol. IV, p.163)



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



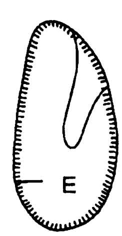
many **Pleurostomatida**



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

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

- no → **Ciliophora V**
- yes → **special key XXIII**



Ciliophora V

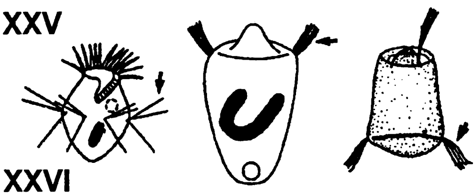
Ciliophora IV

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

- no or unknown
- yes: **special key XXV**

conspicuous ciliary wreaths

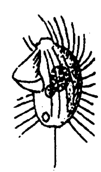
- no
- yes: **special key XXVI**



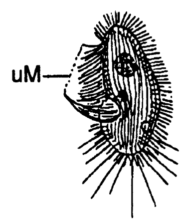
conspicuous, sail-like membrane along oral opening (usually an undulating membrane; uM)

- no
- yes

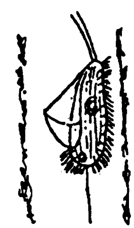
Lembadion
Hymeno-stomata I



Cyclidium
Hymeno-stomata VII



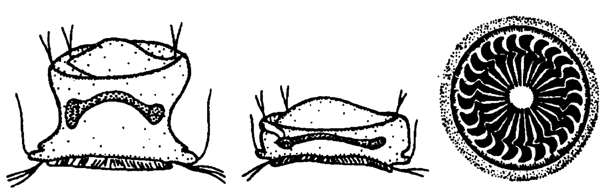
Pleuronema
Hymeno-stomata III



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

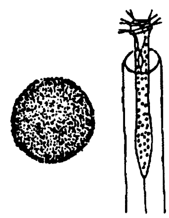
- no: **Ciliophora VI**
- yes: **special key XXIV**

Ciliophora VI

Ciliophora V

colonial species forming 1-10 cm sized, green globules

- no → living in anaerobic mud
- yes → *Ophrydium versatile / eutrophicum* **Peritrichia VII**



living in anaerobic mud

- no or unknown → polysaprobic or alpha-mesosaprobic
- yes → **community Metopetum**

polysaprobic or alpha-mesosaprobic

- no or unknown → euplanktic
- yes → **communities Metopetum, Colpidietum and Trithigmostometum**

euplanktic

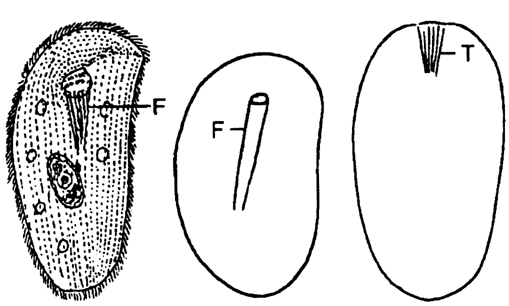
- no or unknown → epizoic
- yes → **special keys XXVIIIa,b and community Oligotrichetea**

epizoic

- no or unknown → mouth
- yes → **special key XXXII**

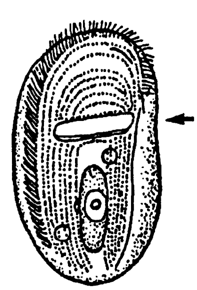
mouth

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



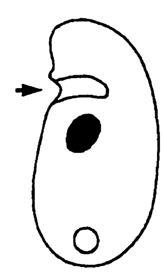
Ciliophora XI and special keys XXIV, XXVII

- conspicuous, transverse cleft → **nose**
  - absent



Gastronauta
Cyrtophorida I

  - present



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

- different → **Ciliophora VII**

Ciliophora VII

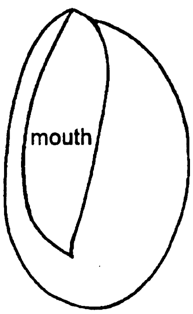
Ciliophora VI

mouth

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

  shape

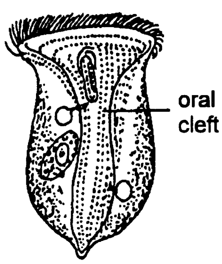
  - ellipsoid

    Lembadion

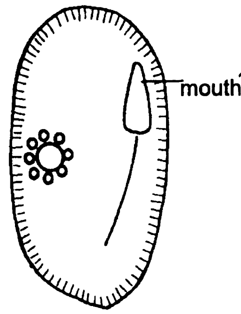
    Hymenostomata I

  - as figured

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

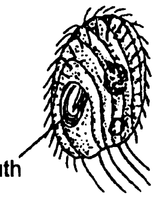
- large, triangular, in anterior third (contractile vacuole in mid-body; distinct seam of extrusomes)

  Frontonia

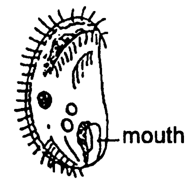
  Hymenostomata V

- subequatorial

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

- near posterior end

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

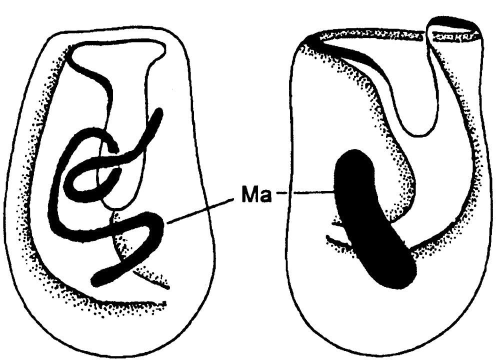
- different

  Ciliophora VIII

- in large cavity

  macronucleus (Ma)

  - thread-like
  - reniform or ellipsoid

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

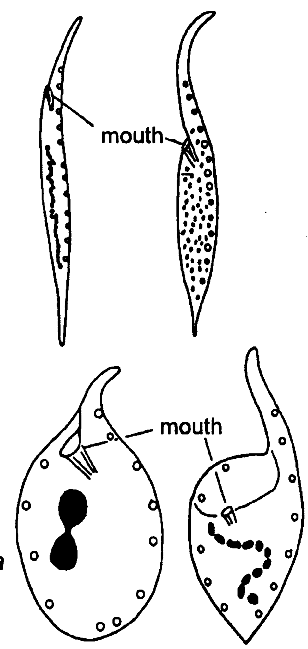
  Bursaridium pseudobursaria
  80-200 µm
  (Vol. I, p.433)

  - moniliform

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

- at base of acontractile proboscis

  Dileptus, Monilicaryon, Trachelius, Paradileptus

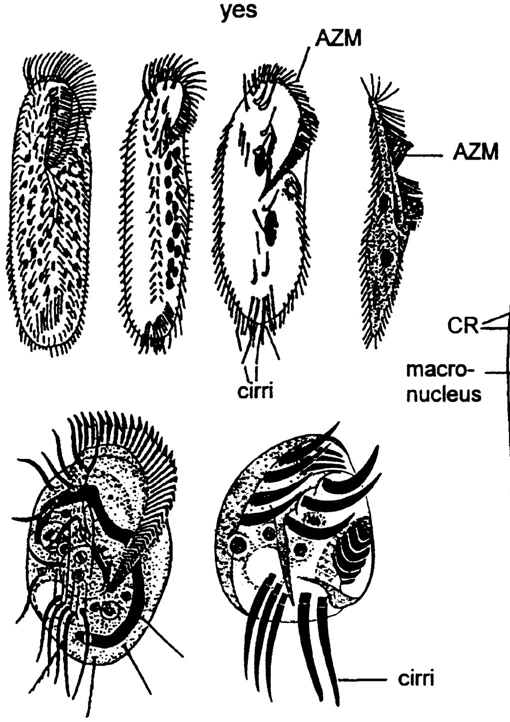
  Gymnostomatida II

Ciliophora VIII

Ciliophora VII

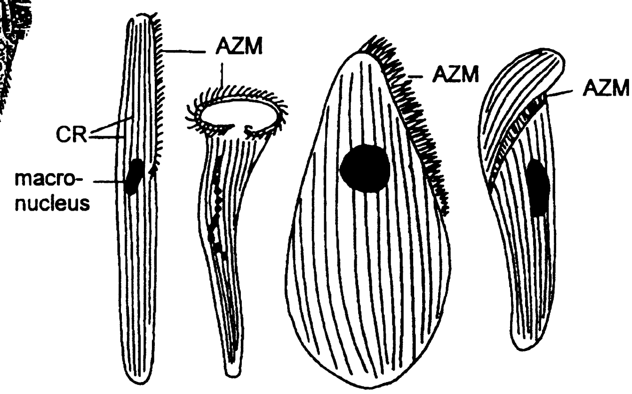
oral ciliature

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



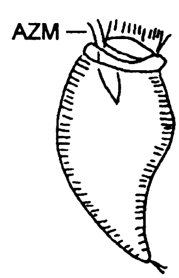
Hypotrichia

    - no
      - **somatic ciliature (ciliary rows; CR); use magnification > X 400**
        - complete



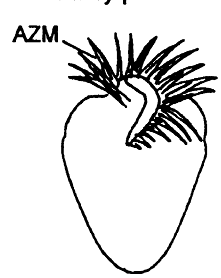
Heterotrichida

        - strongly reduced or lacking
          - **transverse striation (no ciliary rows!); oral ciliature**
            - present; continuous membrane



Peritrichia

            - absent; distinct ciliary plates

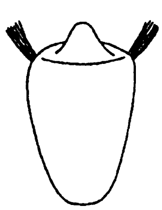


Oligotrichida

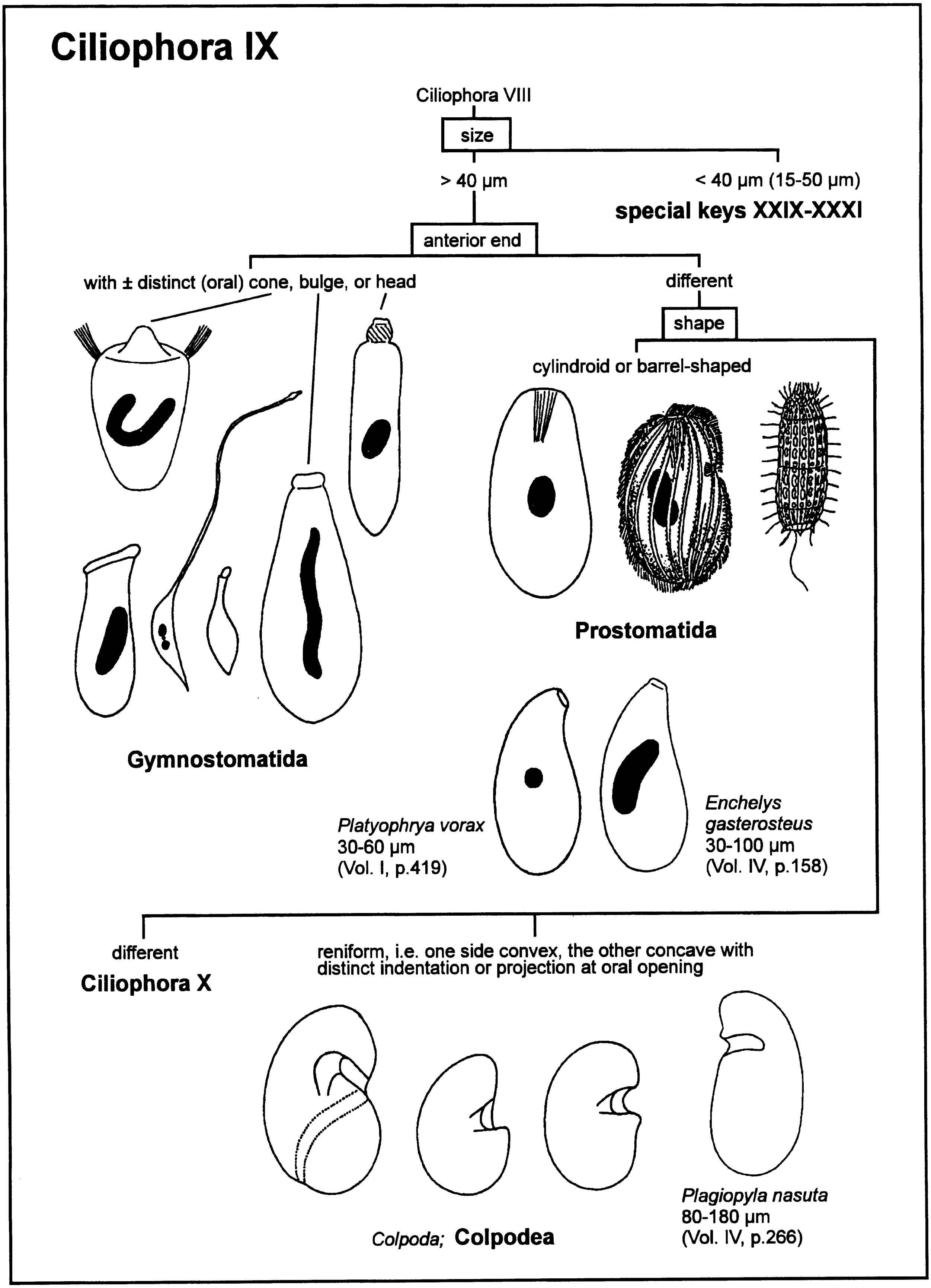
- inconspicuous

Ciliophora IX

* 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)

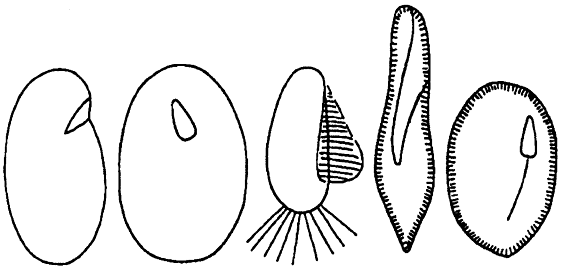

Ciliophora IX
Ciliophora VIII
size
> 40 µm
< 40 µm (15-50 µm)
special keys XXIX-XXXI
anterior end
with ± distinct (oral) cone, bulge, or head
different
shape
cylindroid or barrel-shaped
Prostomatida
Gymnostomatida
Platyophrya vorax
30-60 µm
(Vol. I, p.419)
Enchelys
gasterosteus
30-100 µm
(Vol. IV, p.158)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

Ciliophora X

Ciliophora IX

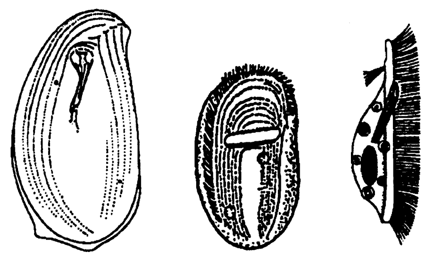
movement; shape and ciliature

- 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



Hymenostomata

- gliding or crawling; surface turned towards substrate flat and ± densely ciliated, opposed surface slightly to distinctly vaulted and very sparsely ciliated



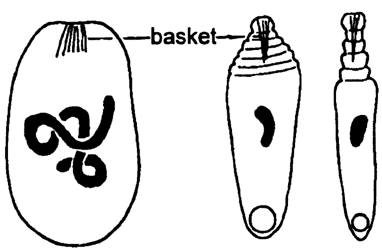
small **Cyrtophorida**

Ciliophora XI

Ciliophora VI

oral basket

- at anterior end



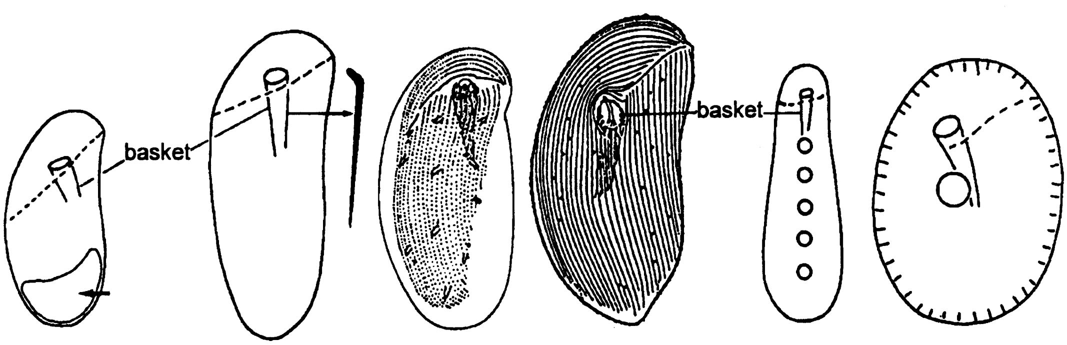
Prostomatida

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

- distinctly subapical

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)

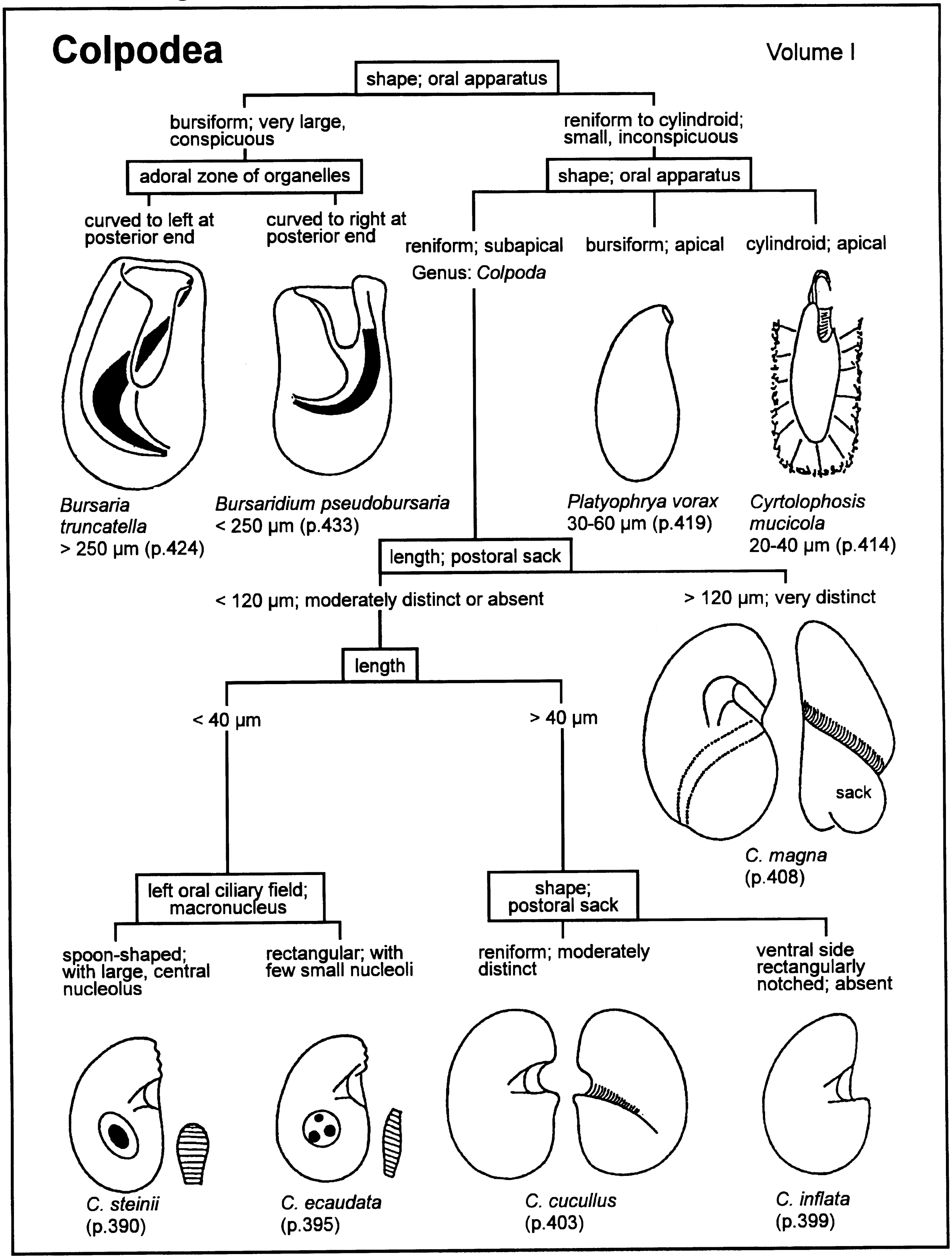
Cyrtophorida

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".

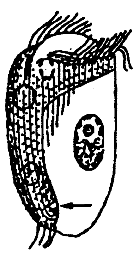


Cyrtophorida I

Volume I

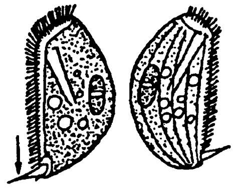
1 styloid process near posterior end

- present
  - **style; left ciliary field**
    - does not project above body margin; about 12 short rows underneath and left of oral basket



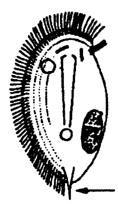
Trochilioides recta
25-75 μm (p.127)

    - projects above body margin; distinctly reduced
      - **dorsal side; anterior end**
        - with crests; obliquely truncate



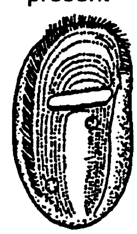
Dysteria fluviatilis
20-35 μm (p.125)

        - flat; rounded



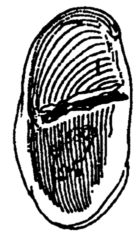
Trochilia minuta
15-40 μm (p.117)

- absent
  - **mouth**
    - conspicuous, transverse cleft
      - **nonciliated postoral field**
        - present



Gastronauta membranaceus
50-70 μm (p.106)

        - absent

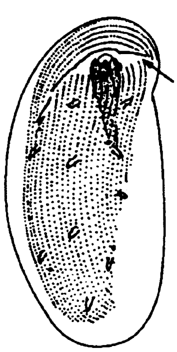


G. clatratus
40-75 μm (p.102)

    - conical basket composed of rods
      - **non-ciliated postoral field; number of ciliary rows; size**
        - distinct and wide, if inconspicuous then size < 40 μm; < 14; < 40 μm

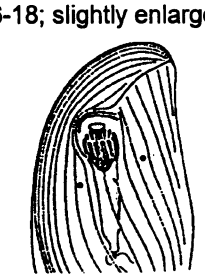
Cyrtophorida II

        - 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)



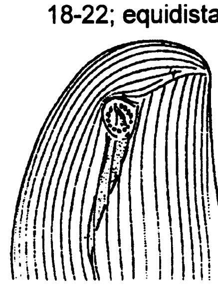
Chlamydonellopsis plurivacuolata
50-110 μm (p. 110)

            - 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



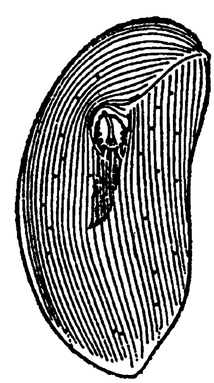
Trithigmostoma srameki
70-100 μm (p.77)

                    - 18-22; equidistant

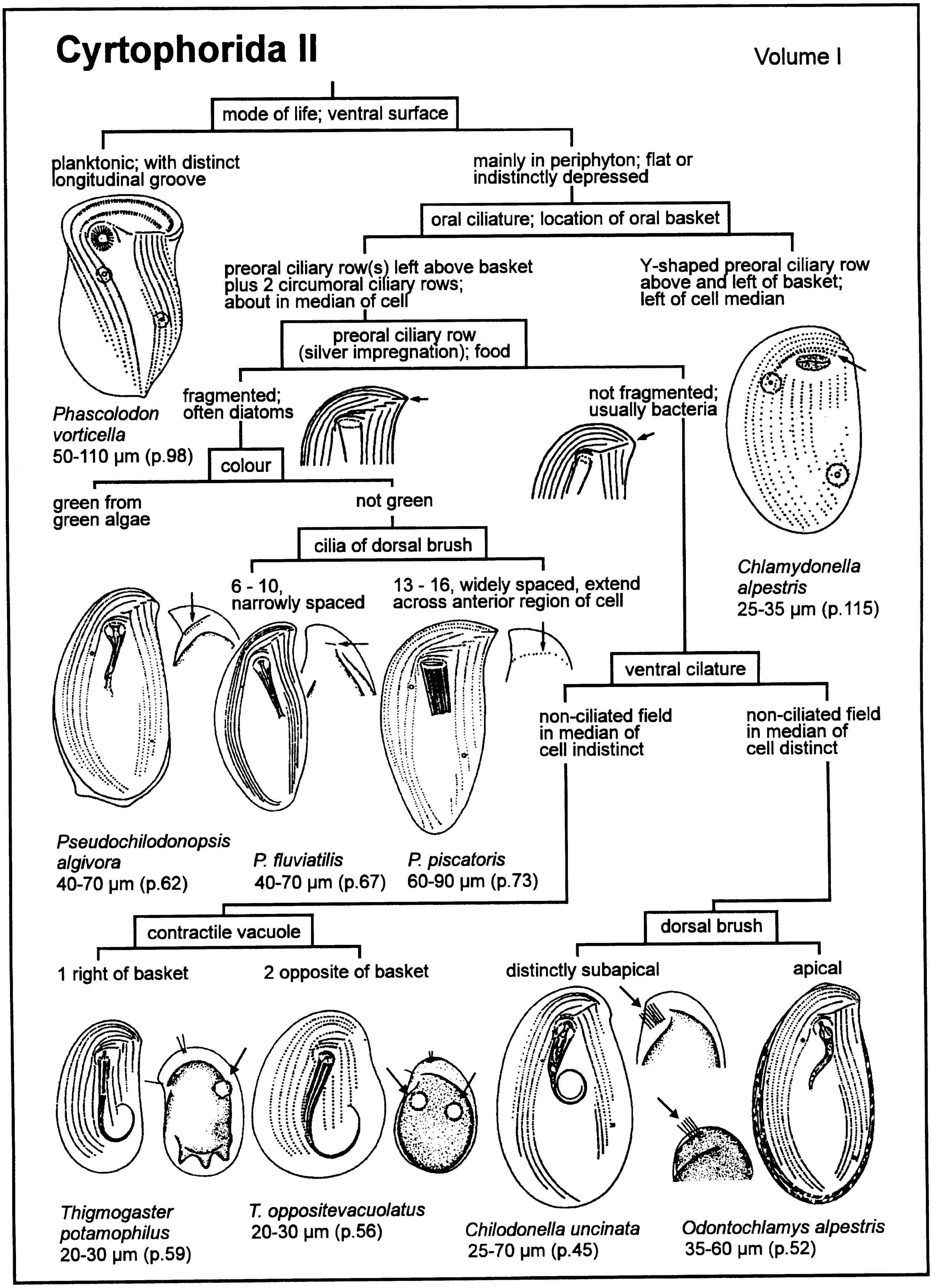


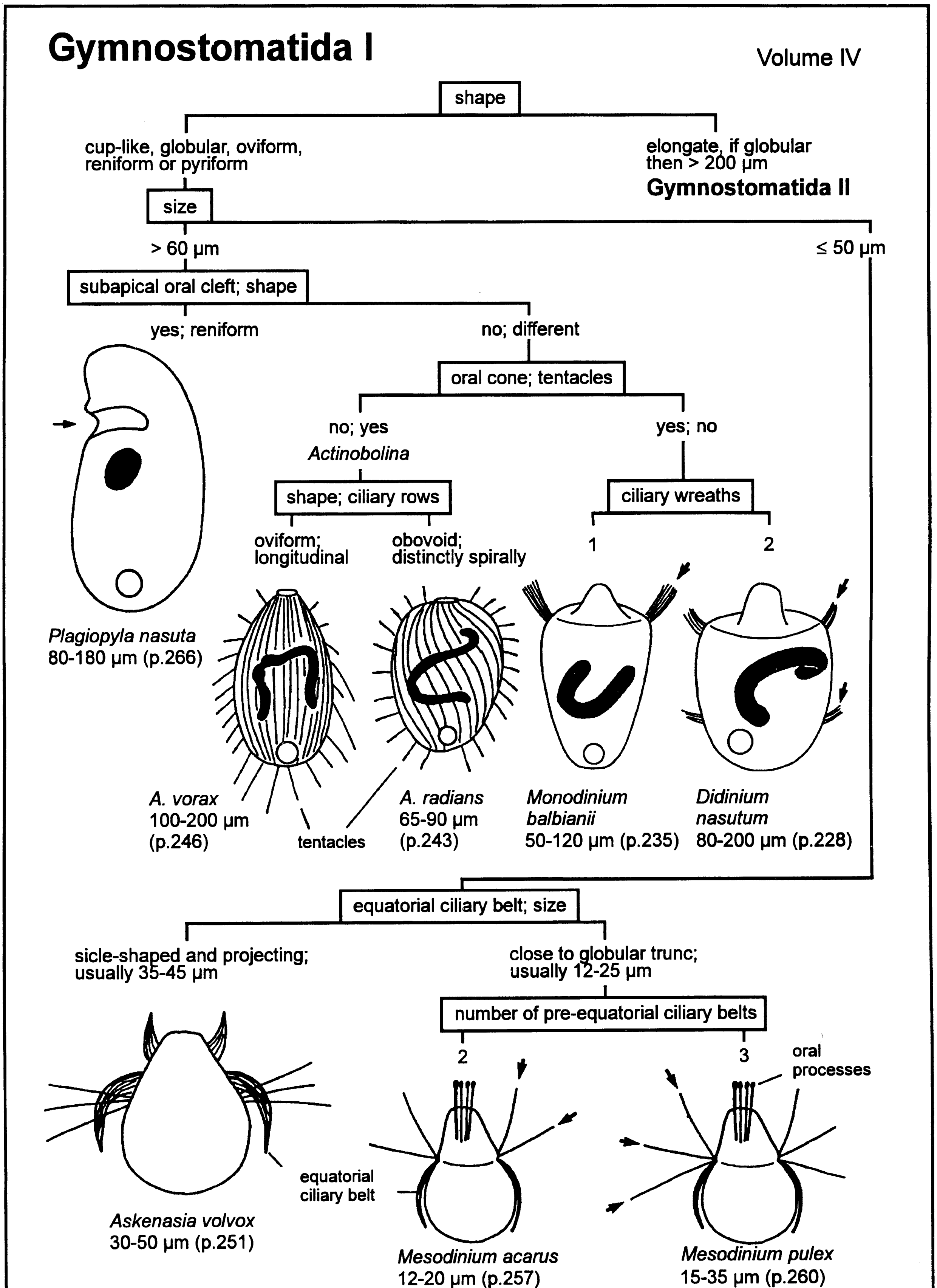
T. cucullulus
80-160 μm (p.82)
(usually ~ 100 μm)

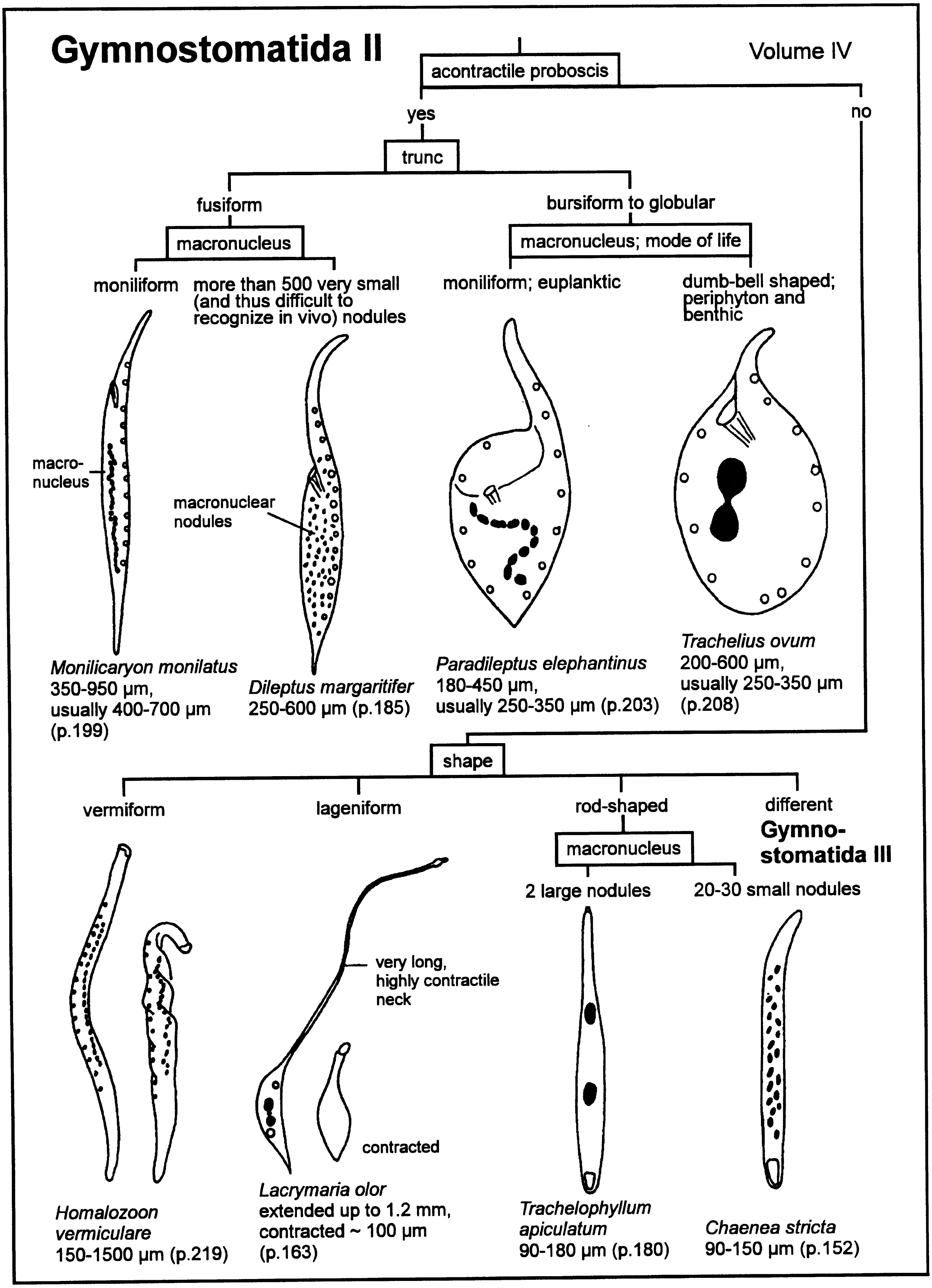
                - > 25; usually > 10

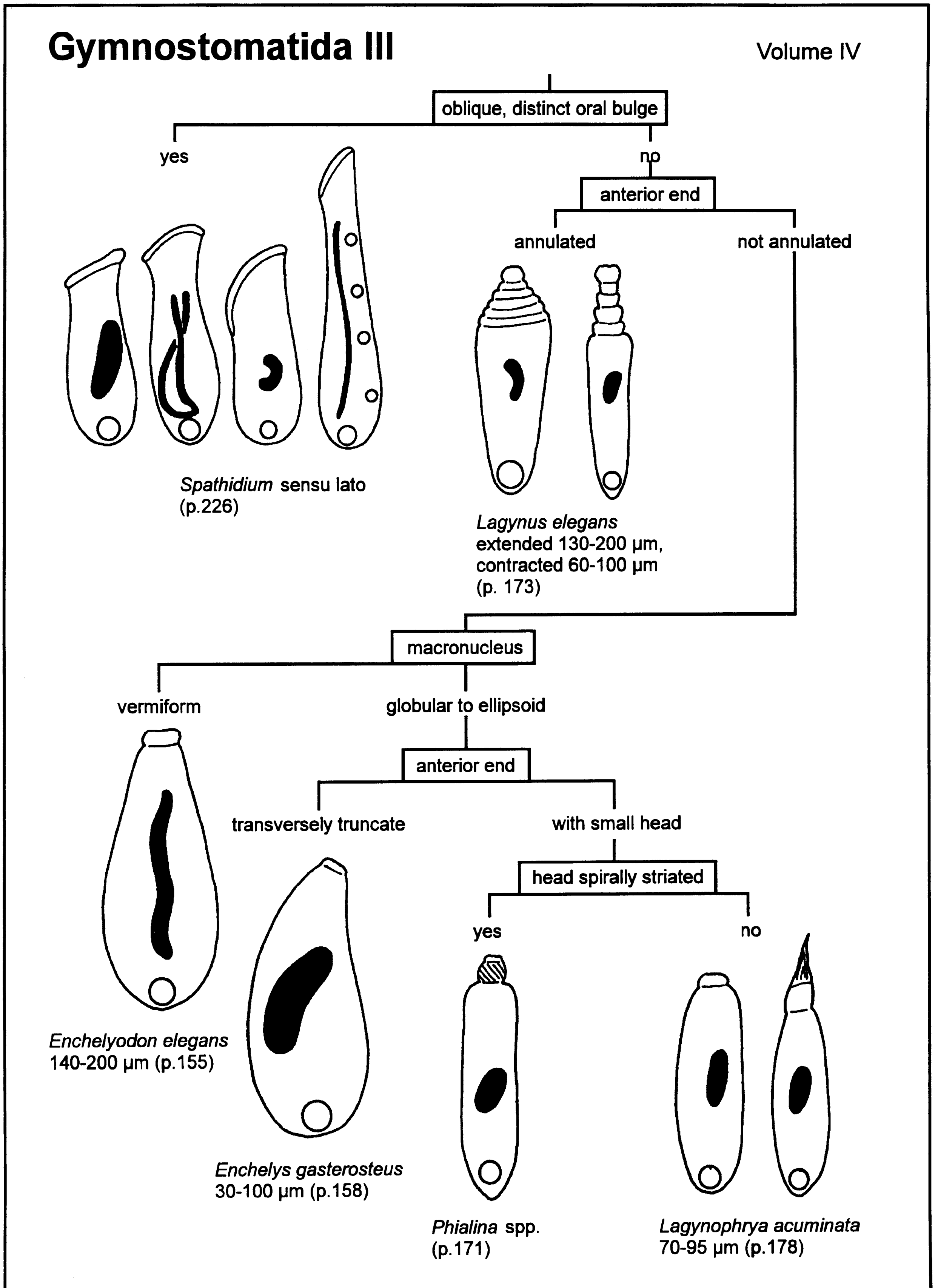


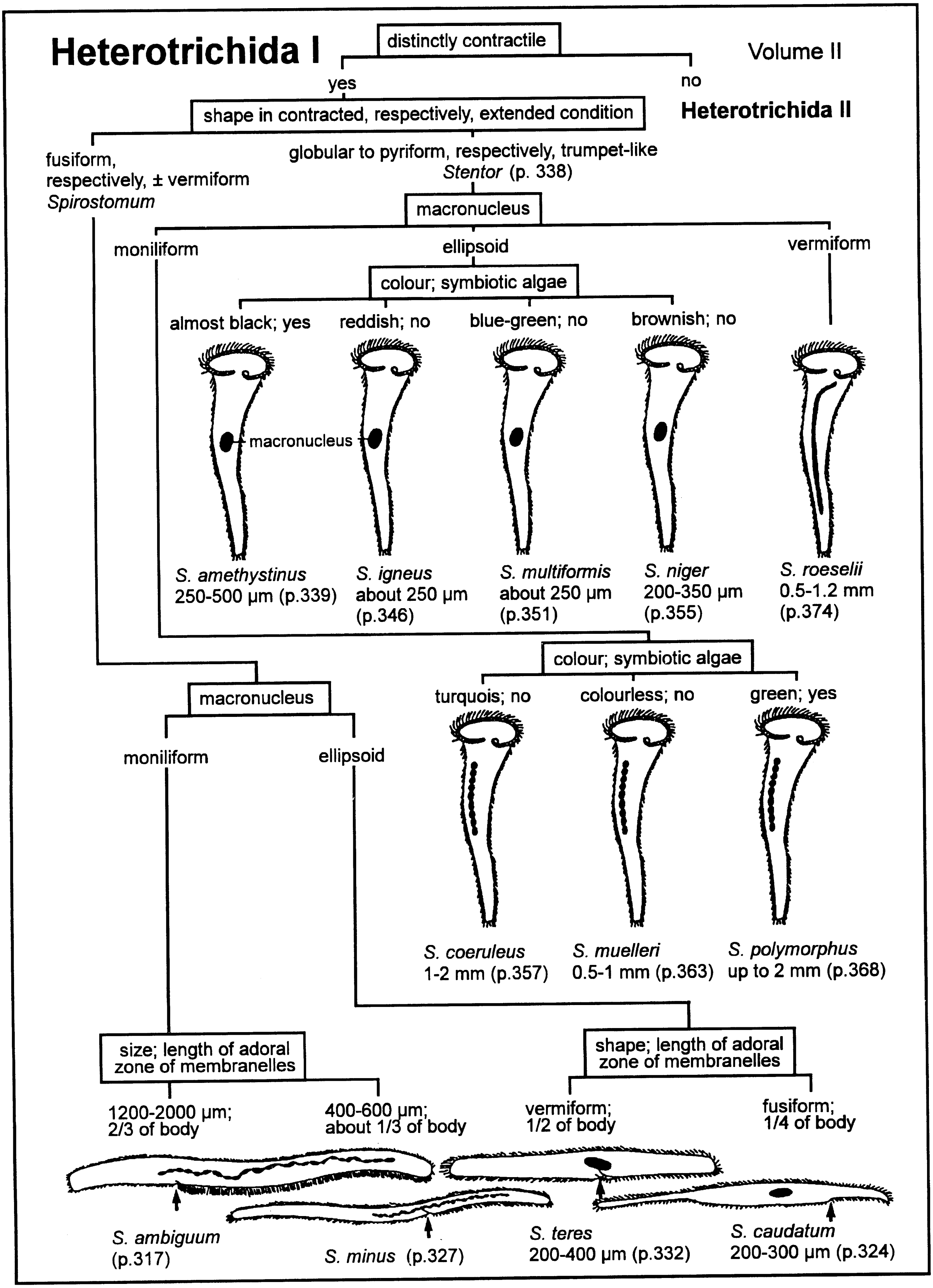
T. steini
90-320 μm (p.92)
(usually ~ 150 μm)


Cyrtophorida II
Volume I
mode of life; ventral surface
planktonic; with distinct longitudinal groove
mainly in periphyton; flat or indistinctly depressed
Phascolodon vorticella
50-110 μm (p.98)
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
ventral cilature
non-ciliated field in median of cell indistinct
non-ciliated field in median of cell distinct
Pseudochilodonopsis algivora
40-70 μm (p.62)
P. fluviatilis
40-70 μm (p.67)
P. piscatoris
60-90 μm (p.73)
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
Plagiopyla nasuta
80-180 µm (p.266)
oral cone; tentacles
no; yes
Actinobolina
yes; no
shape; ciliary rows
oviform; longitudinal
obovoid; distinctly spirally
ciliary wreaths
1
2
A. vorax
100-200 µm
(p.246)
tentacles
A. radians
65-90 µm
(p.243)
Monodinium balbianii
50-120 µm (p.235)
Didinium nasutum
80-200 µm (p.228)
equatorial ciliary belt; size
sicle-shaped and projecting; usually 35-45 µm
close to globular trunc; usually 12-25 µm
number of pre-equatorial ciliary belts
2
3
oral processes
equatorial ciliary belt
Askenasia volvox
30-50 µm (p.251)
Mesodinium acarus
12-20 µm (p.257)
Mesodinium pulex
15-35 µm (p.260)

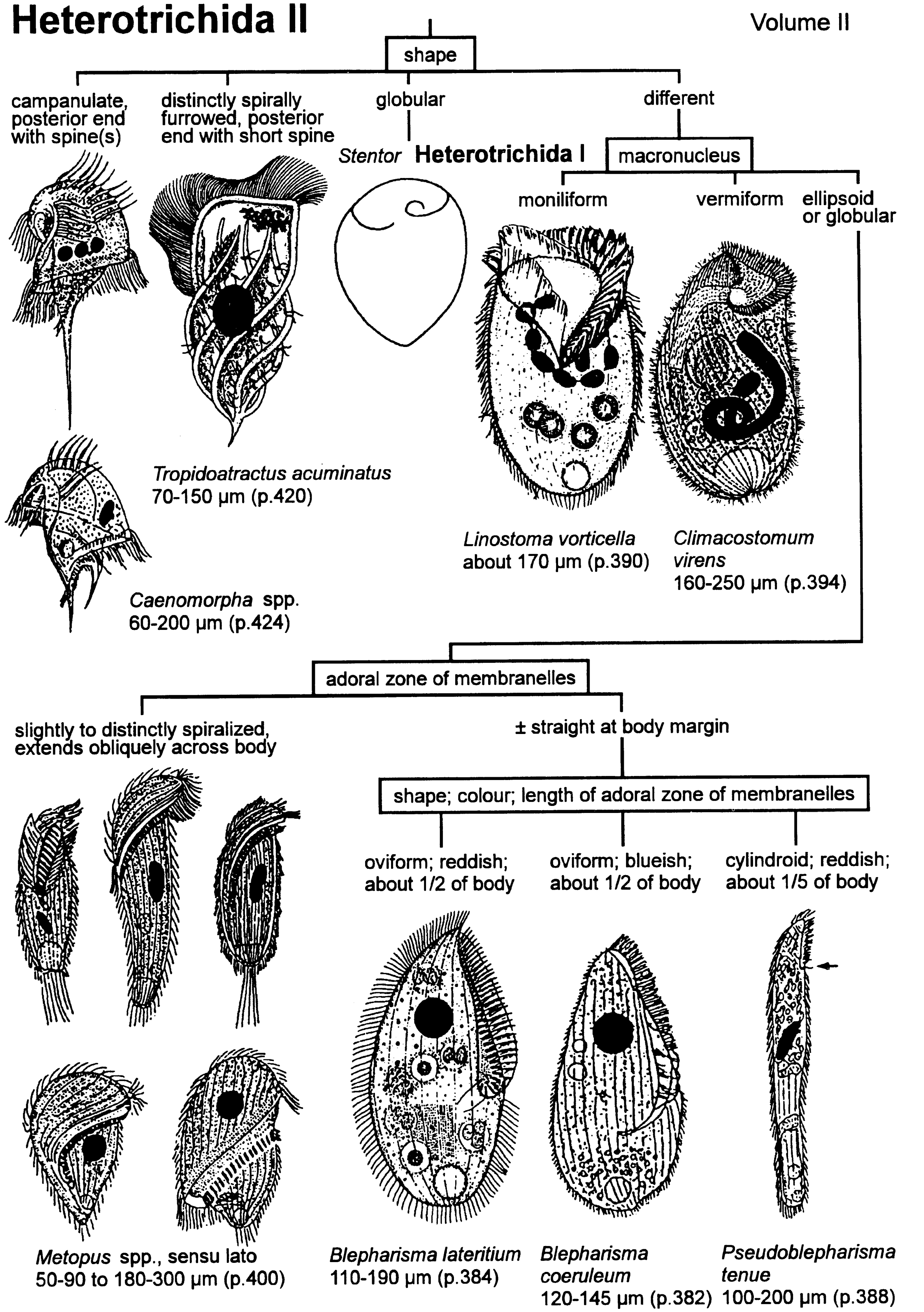

Gymnostomatida II
Volume IV
acontractile proboscis
yes
no
trunc
fusiform
bursiform to globular
macronucleus
macronucleus; mode of life
moniliform
more than 500 very small (and thus difficult to recognize in vivo) nodules
moniliform; euplanktic
dumb-bell shaped; periphyton and benthic
macro-nucleus
macronuclear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

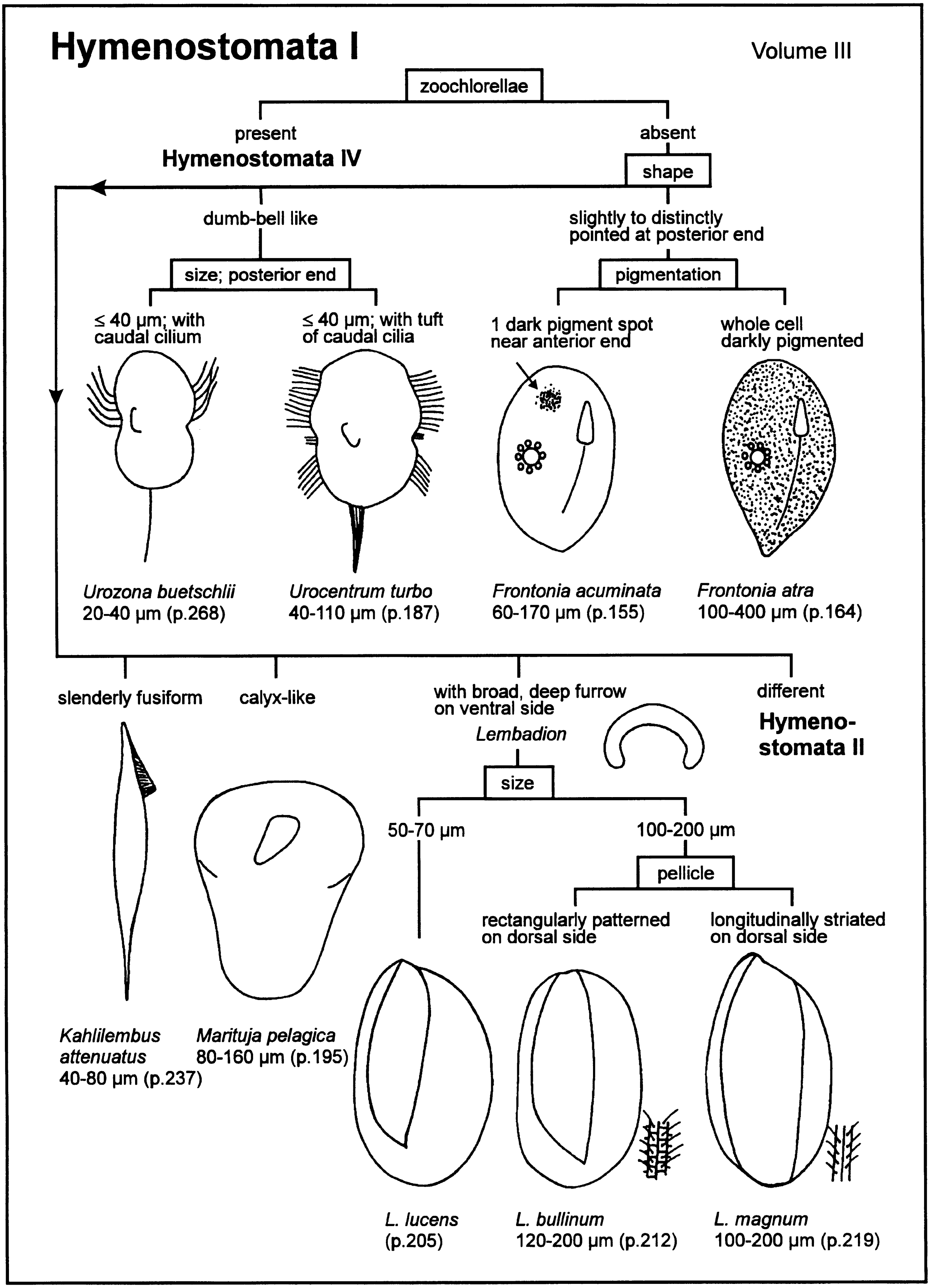

Gymnostomatida III
Volume IV
oblique, distinct oral bulge
yes
no
anterior end
annulated
not annulated
Spathidium sensu lato
(p.226)
Lagynus elegans
extended 130-200 µm,
contracted 60-100 µm
(p. 173)
macronucleus
vermiform
globular to ellipsoid
anterior end
transversely truncate
with small head
head spirally striated
yes
no
Enchelyodon elegans
140-200 µm (p.155)
Enchelys gasterosteus
30-100 µm (p.158)
Phialina spp.
(p.171)
Lagynophrya acuminata
70-95 µm (p.178)


Heterotrichida I
distinctly contractile
Volume II
yes
no
Heterotrichida II
shape in contracted, respectively, extended condition
fusiform,
respectively, ± vermiform
Spirostomum
globular to pyriform, respectively, trumpet-like
Stentor (p. 338)
macronucleus
moniliform
ellipsoid
vermiform
colour; symbiotic algae
almost black; yes
reddish; no
blue-green; no
brownish; no
macronucleus
S. amethystinus
250-500 µm (p.339)
S. igneus
about 250 µm
(p.346)
S. multiformis
about 250 µm
(p.351)
S. niger
200-350 µm
(p.355)
S. roeselii
0.5-1.2 mm
(p.374)
colour; symbiotic algae
turquois; no
colourless; no
green; yes
S. coeruleus
1-2 mm (p.357)
S. muelleri
0.5-1 mm (p.363)
S. polymorphus
up to 2 mm (p.368)
macronucleus
moniliform
ellipsoid
size; length of adoral
zone of membranelles
1200-2000 µm;
2/3 of body
400-600 µm;
about 1/3 of body
shape; length of adoral
zone of membranelles
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

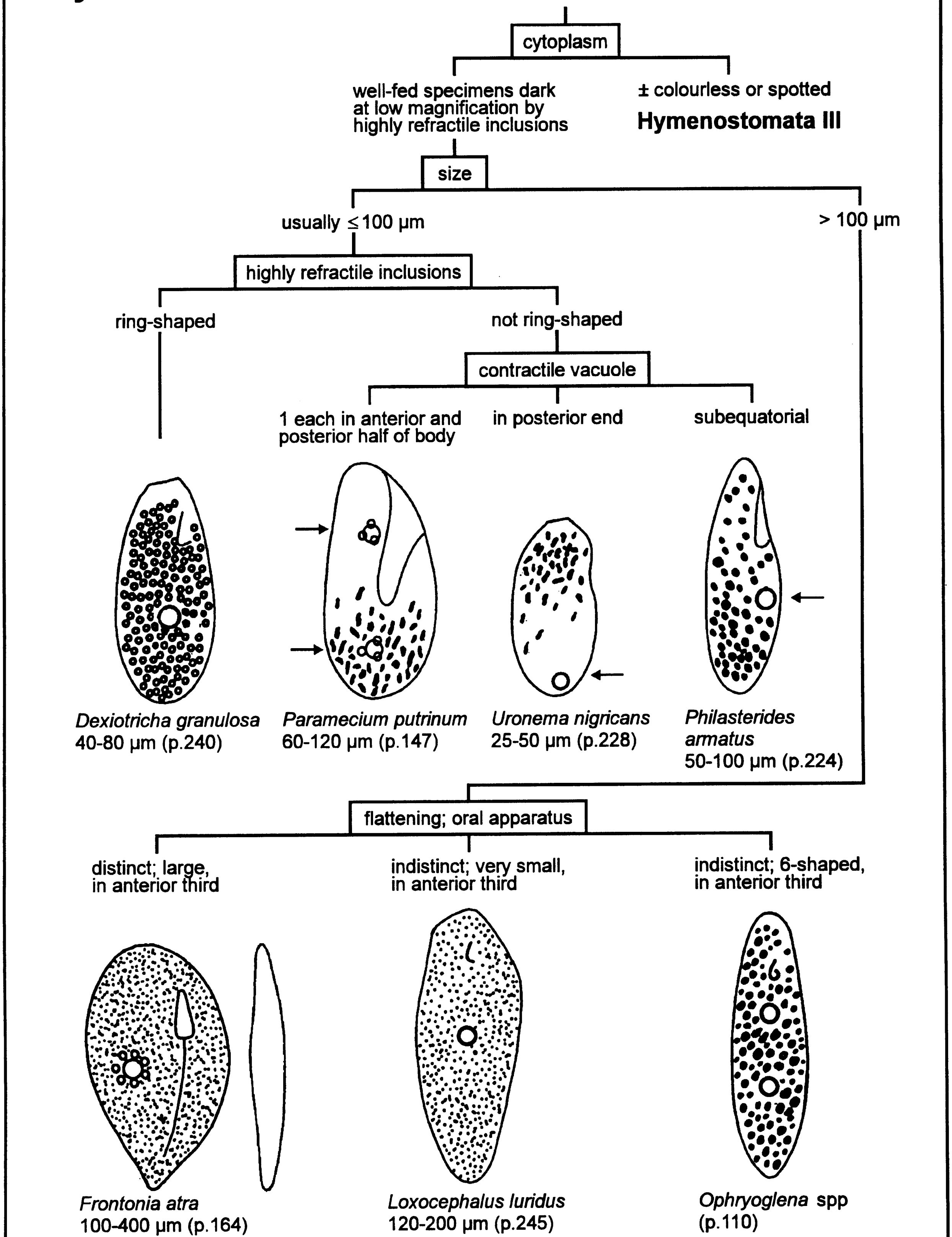
Volume II




Hymenostomata I
Volume III
zoochlorellae
present
Hymenostomata IV
absent
shape
dumb-bell like
slightly to distinctly pointed at posterior end
size; posterior end
≤ 40 µm; with caudal cilium
≤ 40 µm; with tuft of caudal cilia
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
Hymenostomata 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

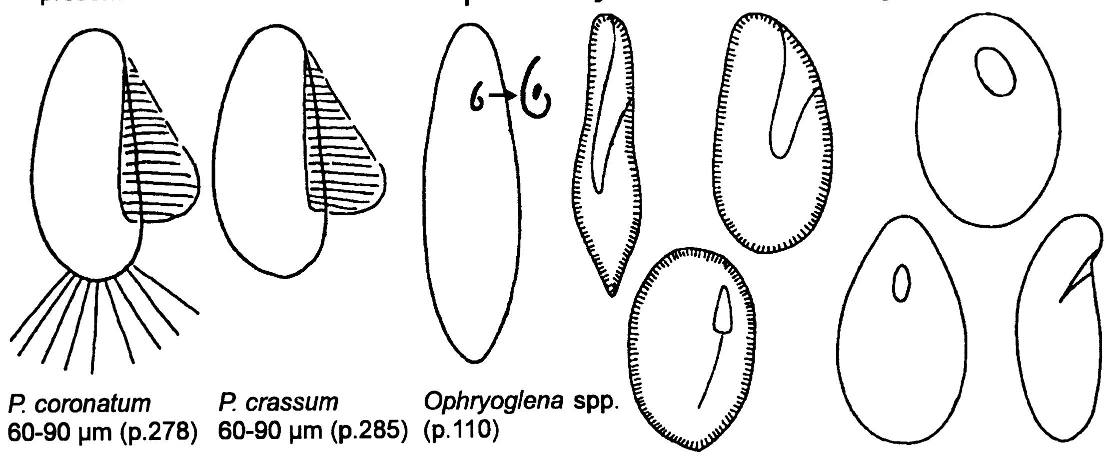
size

usually ≥ 50 µm — oral apparatus

- 2/3 of body length — *Pleuronema* — elongated cilia on posterior end
  - present
  - absent
- 6-shaped, with watch-glass shaped structure
- different — extrusomes; pellicle
  - trichocysts, form distinct layer underneath pellicle; rectangularly patterned — **Hymenostomata V**
  - mucocysts, do not form distinct layer underneath pellicle; smooth — **Hymenostomata VI**

usually ≤ 50 µm — **Hymenostomata VII**

Volume III



P. coronatum 60-90 µm (p.278)

P. crassum 60-90 µm (p.285)

Ophryoglena spp. (p.110)

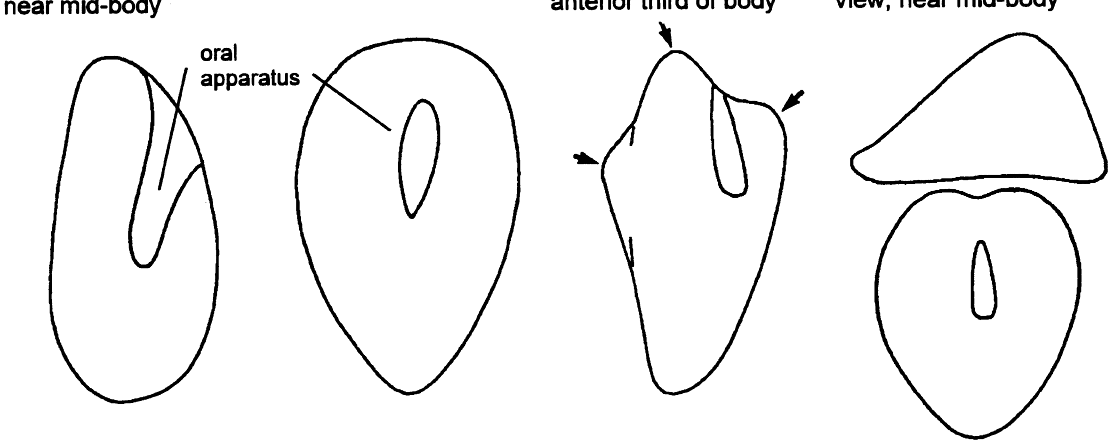
Hymenostomata IV

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

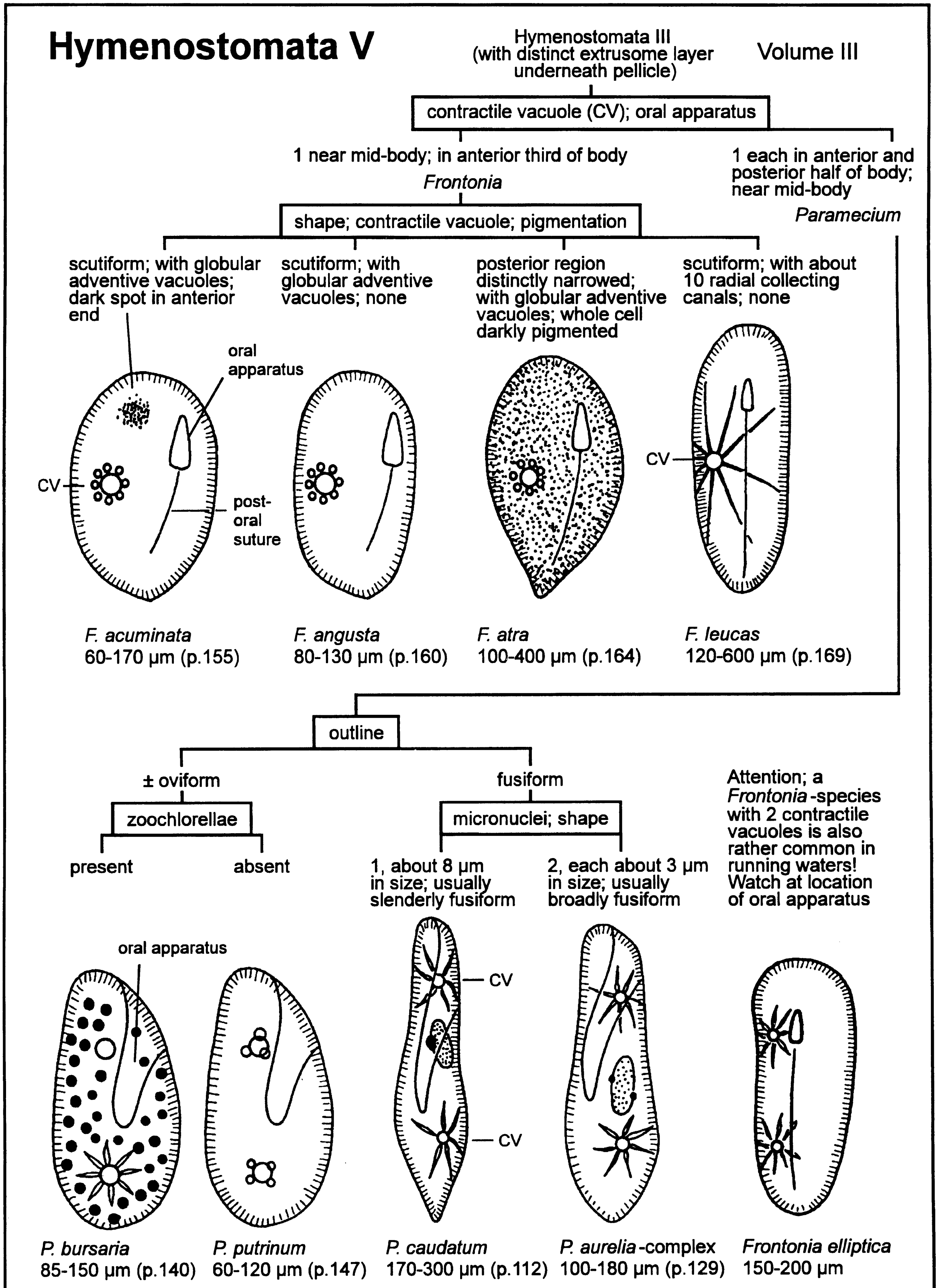


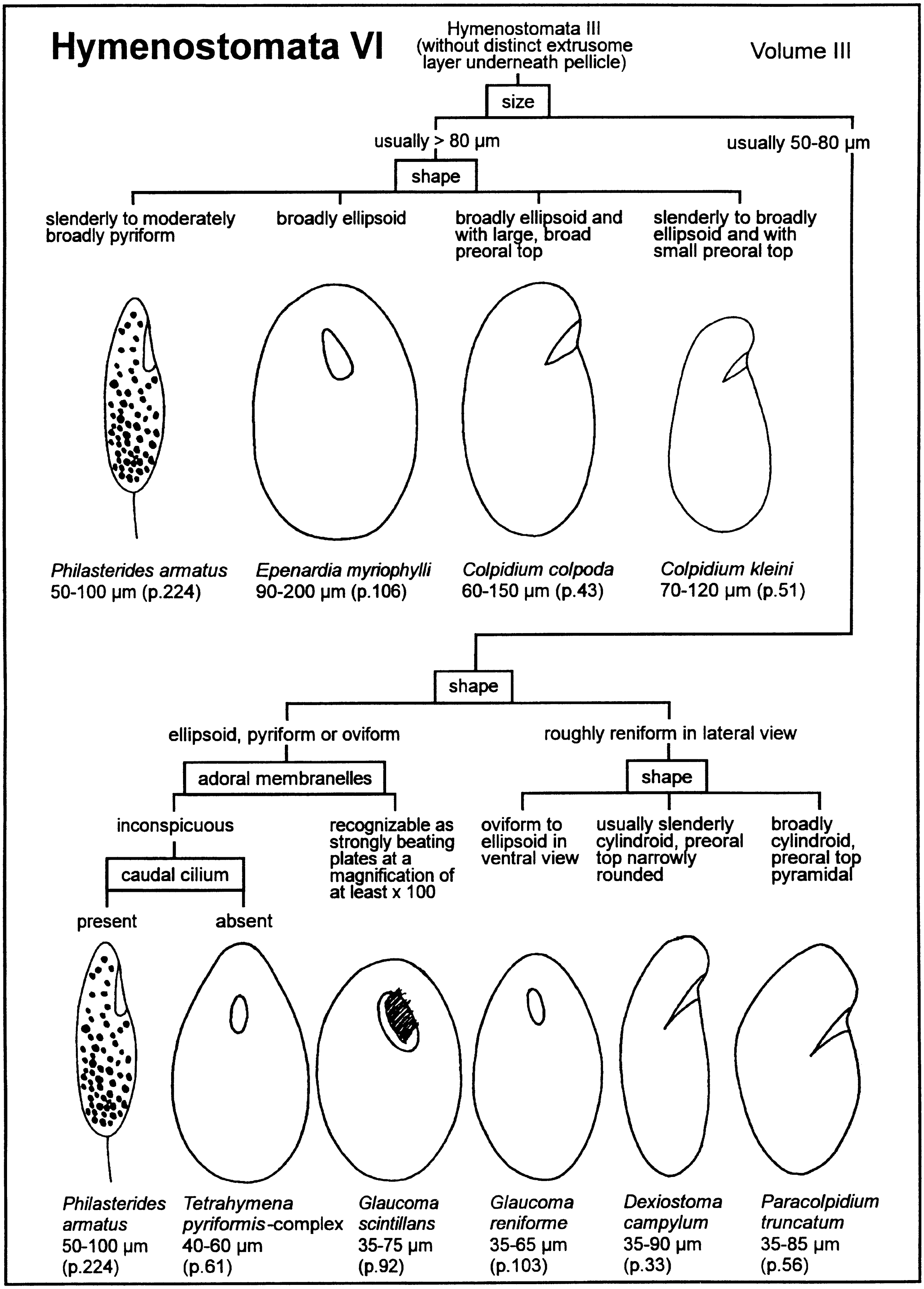
Paramecium bursaria 85-150 µm (p.140)

Disematostoma buetschlii 110-200 µm (p.180)

Disematostoma tetraedricum 100-140 µm (p.185)

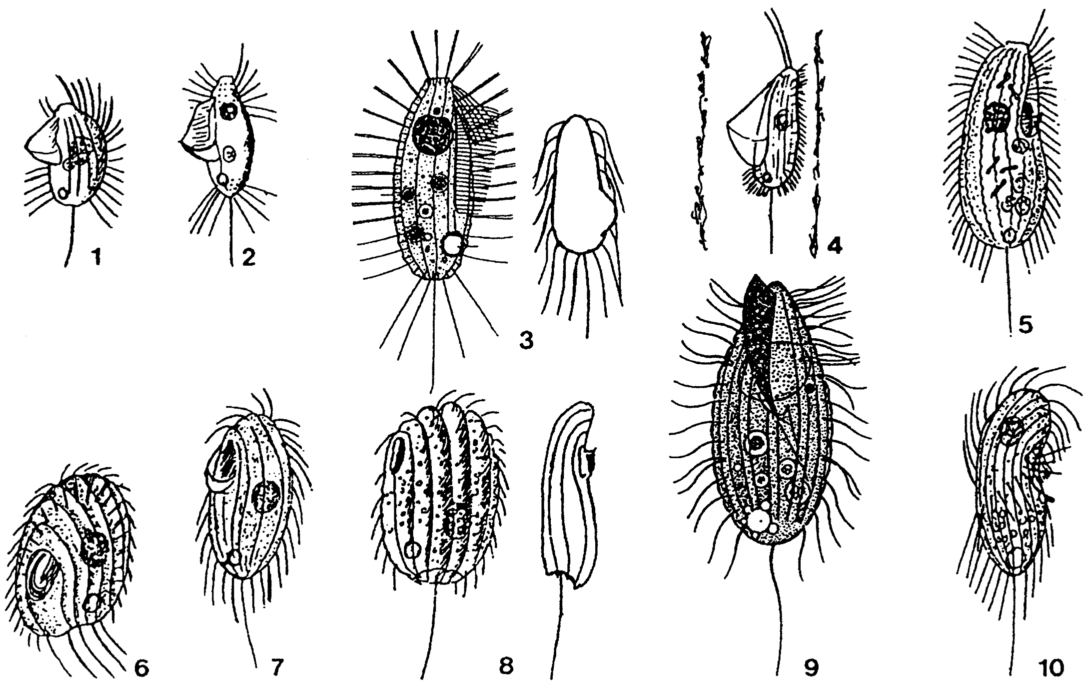
Stokesia vernalis 60-160 µm (p.200)


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
oral apparatus
CV
post-oral suture
CV
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
fusiform
zoochlorellae
present
absent
micronuclei; shape
1, about 8 μm in size; usually slenderly fusiform
2, each about 3 μm in size; usually broadly fusiform
Attention; a Frontonia-species with 2 contractile vacuoles is also rather common in running waters! Watch at location of oral apparatus
oral apparatus
CV
CV
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.

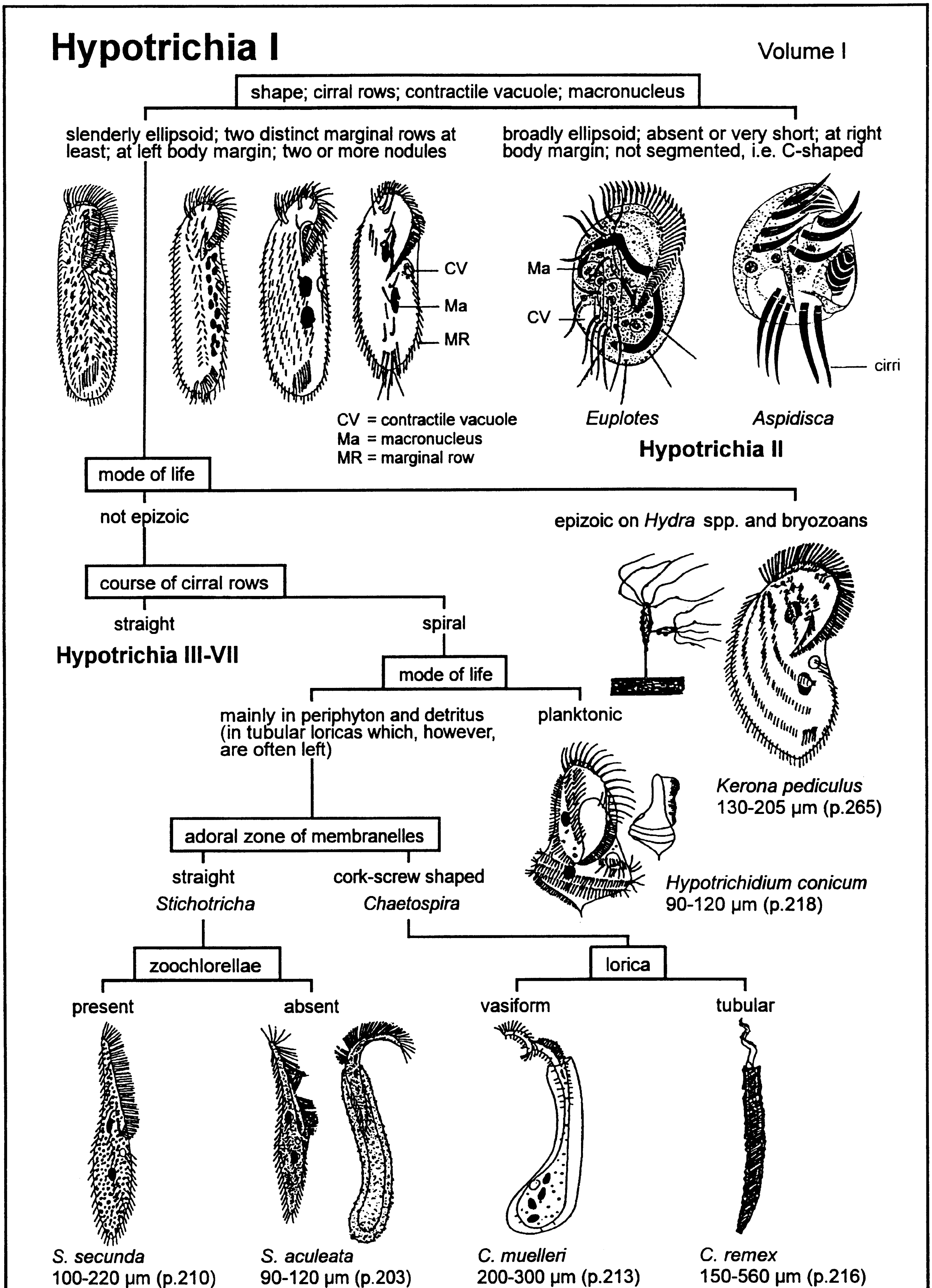
6: ***Cinetochilum margaritaceum***. 25-40 µm; lenticular, strongly flattened laterally, typical notch and about five elongated caudal cilia at posterior end; oral apparatus subequatorial; contractile vacuole opposed to oral apparatus; pantosaprobic.

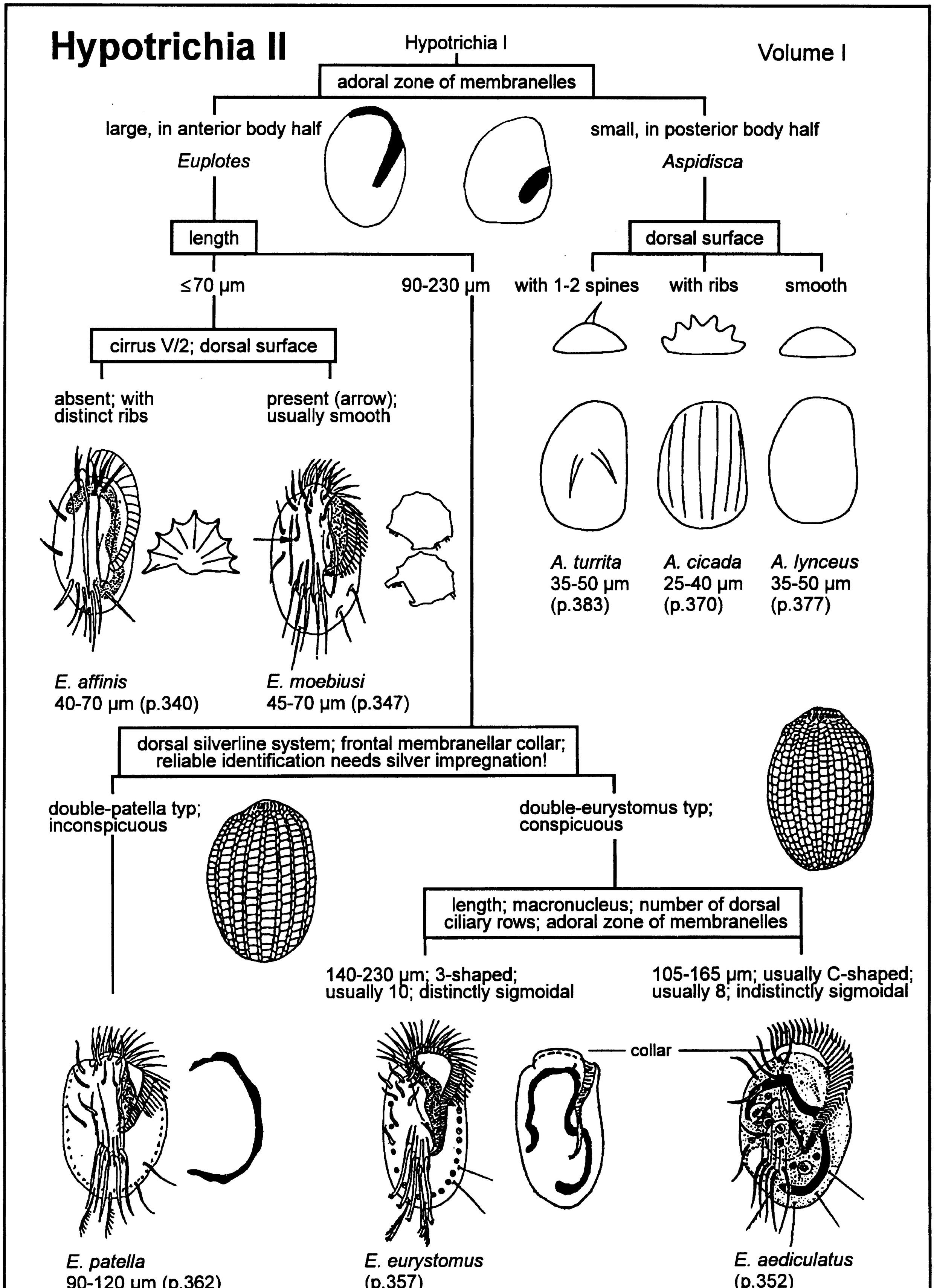
7: ***Sathrophilus muscorum***. 25-40 µm; shape similar to that of *Cinetochilum margaritaceum*, but posterior end without notch and oral apparatus in anterior body half; contractile vacuole slightly subterminal on ventral side; beta- to alphamesosaprobic.

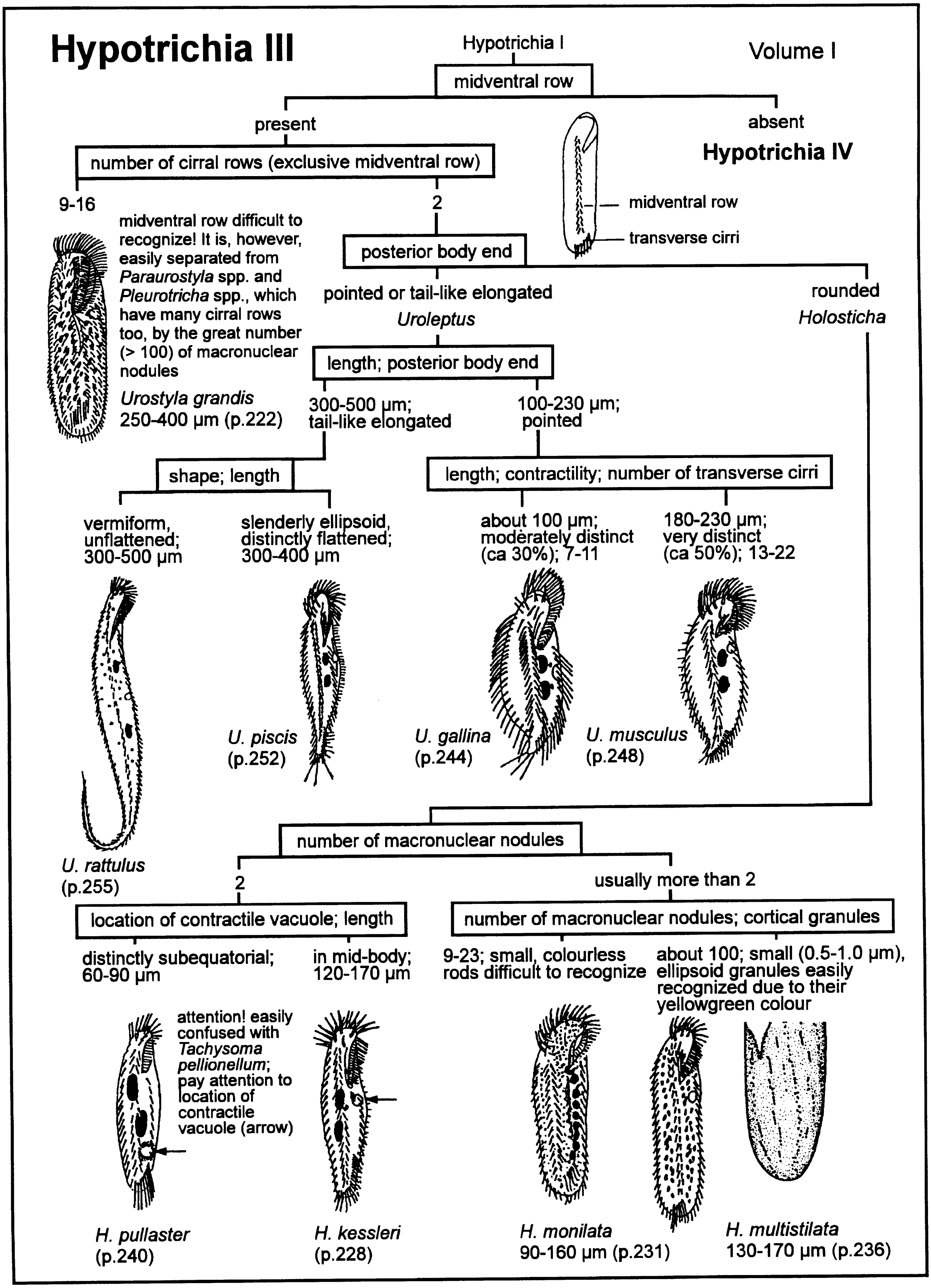
8: ***Platynematum sociale***: Size, shape and posterior notch similar as in *Cinetochilum margaritaceum,* but oral apparatus in anterior body half and contractile vacuole on ventral side; polysaprobic.

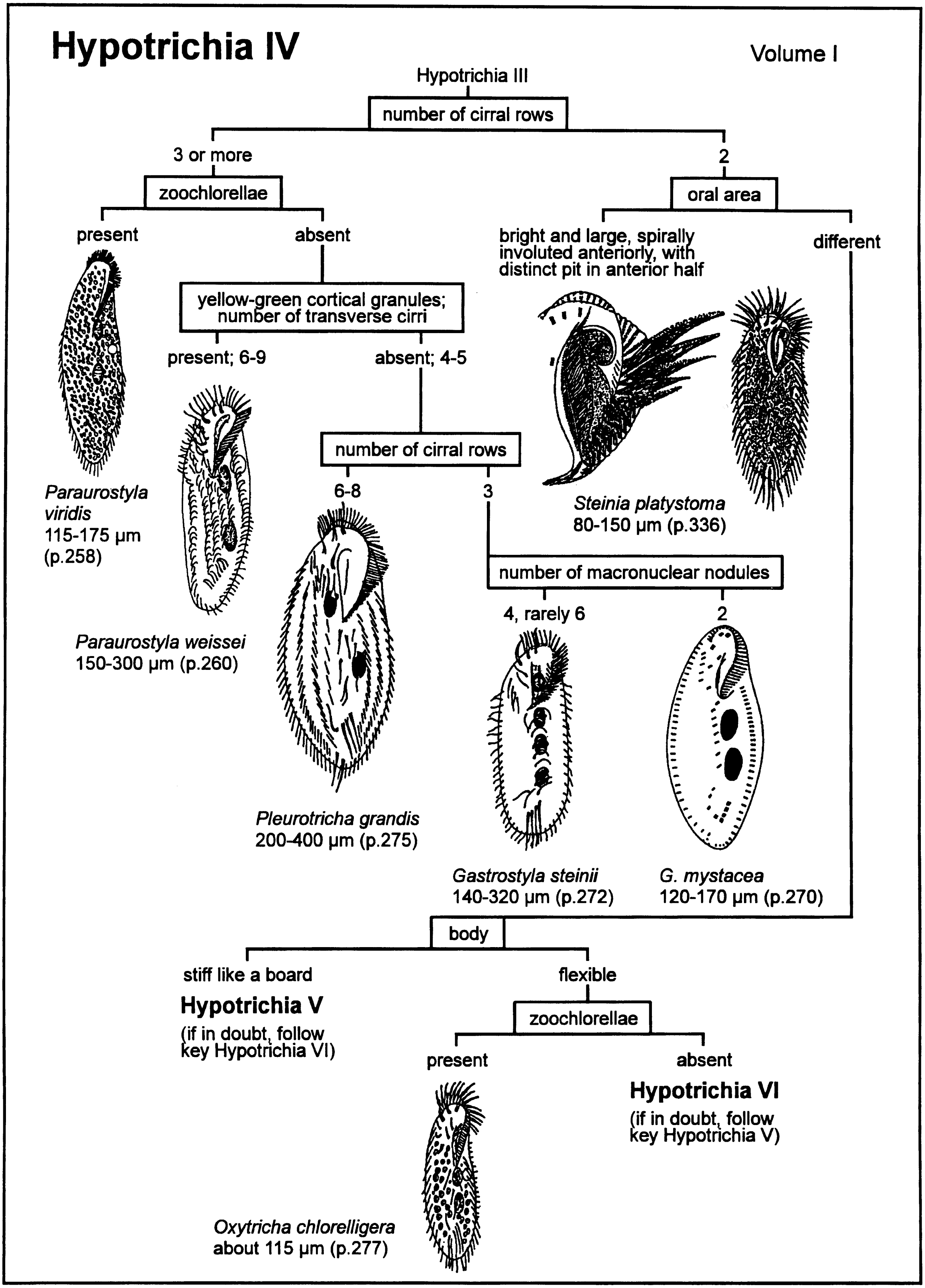
9: ***Pseudocohnilembus pusillus***. 25-50 µm; oviform, in anterior third not indented (difference to *Uronema nigricans*!); oral apparatus about half as long as cell, cleft-like, inconspicuous; moves drilling, never rests; polysaprobic.

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
shape; cirral rows; contractile vacuole; macronucleus
slenderly ellipsoid; two distinct marginal rows at least; at left body margin; two or more nodules
broadly ellipsoid; absent or very short; at right body margin; not segmented, i.e. C-shaped
CV
Ma
MR
Ma
CV
cirri
CV = contractile vacuole
Ma = macronucleus
MR = marginal row
Euplotes
Aspidisca
Hypotrichia II
mode of life
not epizoic
epizoic on Hydra spp. and bryozoans
course of cirral rows
straight
Hypotrichia III-VII
spiral
mode of life
mainly in periphyton and detritus (in tubular loricas which, however, are often left)
planktonic
Kerona pediculus
130-205 μm (p.265)
adoral zone of membranelles
straight
Stichotricha
cork-screw shaped
Chaetospira
Hypotrichidium conicum
90-120 μm (p.218)
zoochlorellae
present
absent
lorica
vasiform
tubular
S. secunda
100-220 μm (p.210)
S. aculeata
90-120 μm (p.203)
C. muelleri
200-300 μm (p.213)
C. remex
150-560 μm (p.216)


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
A. turrita
35-50 µm
(p.383)
A. cicada
25-40 µm
(p.370)
A. lynceus
35-50 µm
(p.377)
E. affinis
40-70 µm (p.340)
E. moebiusi
45-70 µm (p.347)
dorsal silverline system; frontal membranellar collar; reliable identification needs silver impregnation!
double-patella typ; inconspicuous
double-eurystomus typ; conspicuous
length; macronucleus; number of dorsal ciliary rows; adoral zone of membranelles
140-230 µm; 3-shaped; usually 10; distinctly sigmoidal
105-165 µm; usually C-shaped; usually 8; indistinctly sigmoidal
collar
E. patella
90-120 µm (p.362)
E. eurystomus
(p.357)
E. aediculatus
(p.352)


Hypotrichia III
Hypotrichia I
Volume I
midventral row
present
absent
Hypotrichia IV
number of cirral rows (exclusive midventral row)
midventral row
transverse cirri
9-16
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)
2
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. piscis
(p.252)
U. gallina
(p.244)
U. musculus
(p.248)
U. rattulus
(p.255)
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
2
zoochlorellae
present
absent
Paraurostyla viridis 115-175 µm (p.258)
yellow-green cortical granules; number of transverse cirri
present; 6-9
absent; 4-5
Paraurostyla weissei 150-300 µm (p.260)
number of cirral rows
6-8
3
Pleurotricha grandis 200-400 µm (p.275)
number of macronuclear nodules
4, rarely 6
2
Gastrostyla steinii 140-320 µm (p.272)
G. mystacea 120-170 µm (p.270)
oral area
bright and large, spirally involuted anteriorly, with distinct pit in anterior half
different
Steinia platystoma 80-150 µm (p.336)
body
stiff like a board
Hypotrichia V
(if in doubt, follow key Hypotrichia VI)
flexible
zoochlorellae
present
absent
Oxytricha chlorelligera about 115 µm (p.277)
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

number of micronuclei

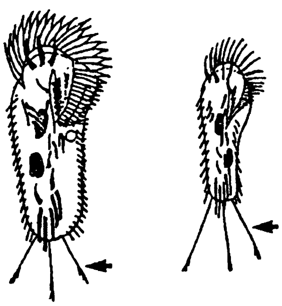
1 between the two macronuclear nodules

Stylonychia stylomuscorum
60-110 μm (p.332)

at least 1 at each macronuclear nodule

shape; caudal cirri

anterior (oral) area distinctly widened; very long and distinctly separate from each other

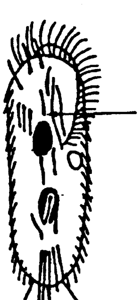


Stylonychia mytilus -complex
90-350 μm (p.315)

ellipsoid or with parallel sides; moderately long, distinctly or indistinctly separate from each other

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)



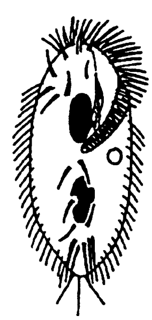
Stylonychia putrina
120-150 μm (p.329)

ellipsoid or with parallel sides, posterior end narrowly rounded; indistinctly separate; indistinctly separate from other frontal cirri

most common of the 3 species treated in this paragraph

S. pustulata
50-200 μm (p.323)

ellipsoid, posterior end narrowly rounded; indistinctly separate; indistinctly separate from other frontal cirri

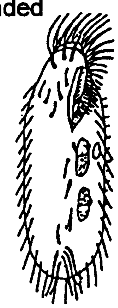


S. vorax
85-120 μm (p.334)

about same length as marginal cirri or absent

caudal cirri; posterior body end

present but hardly recognizable; broadly rounded



Sterkiella histriomuscorum
100-150 μm (p.311)

absent; broadly rounded and sometimes slightly notched

Histriculus vorax
140-190 μm (p.309)

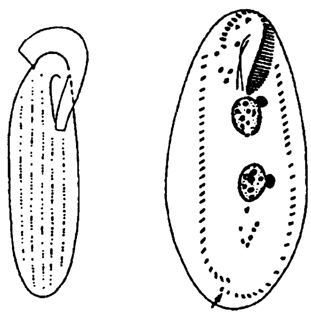
Hypotrichia VI

Volume I

Hypotrichia IV

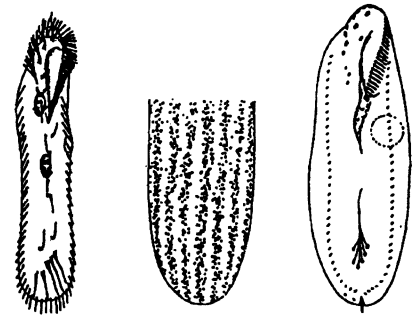
cytoplasm; cortical granules

- orange, reddish or brownish coloured; present
  - **colour of cytoplasm; cortical granules; number of dorsal ciliary rows; marginal cirral rows**
    - orange to reddish; citrine, in longitudinal rows; 4; posteriorly superimposed (arrow)



Oxytricha haematoplasma
120-180 μm (p.287)

    - brownish; brownish, in longitudinal stripes; 5; posteriorly not superimposed (arrow)

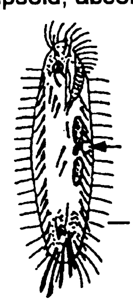


Oxytricha ferruginea
150-260 μm (p.283)

- colourless; absent

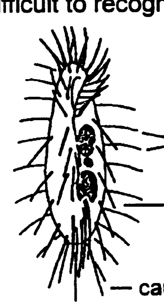
number and location of micronuclei

- 1 between 2 macronuclear nodules
  - **posteriormost marginal cirri**
    - inconspicuous
      - **length of dorsal cilia**
        - 8-15 μm (easily confused with cirri!)
          - **length of body; shape; caudal cirri**
            - 55-100 μm; slenderly ellipsoid; absent



Tachysoma pellionellum (p.304)

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



Oxytricha setigera (p.294)

        - about 6 μm

Oxytricha saprobia, 100 μm (p.292)

    - distinctly larger and longer (arrow)

Tachysoma bicirratum
60-90 μm (p.302)

- 1 or several at each macronuclear nodule

Hypotrichia VII

Hypotrichia VII

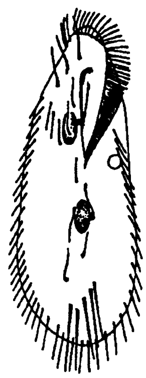
(difficult to determine!)

Volume I

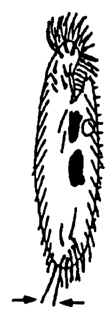
Hypotrichia VI

shape; length of body

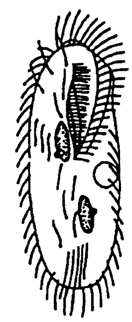
- oviform; 130-180 µm
- broadly or slenderly ellipsoid or with almost parallel sides; 60-120 µm
  - number and arrangement of caudal cirri
    - 2, distinctly elongated, usually directed to right (arrows)
    - 3, hardly longer than marginal cirri



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

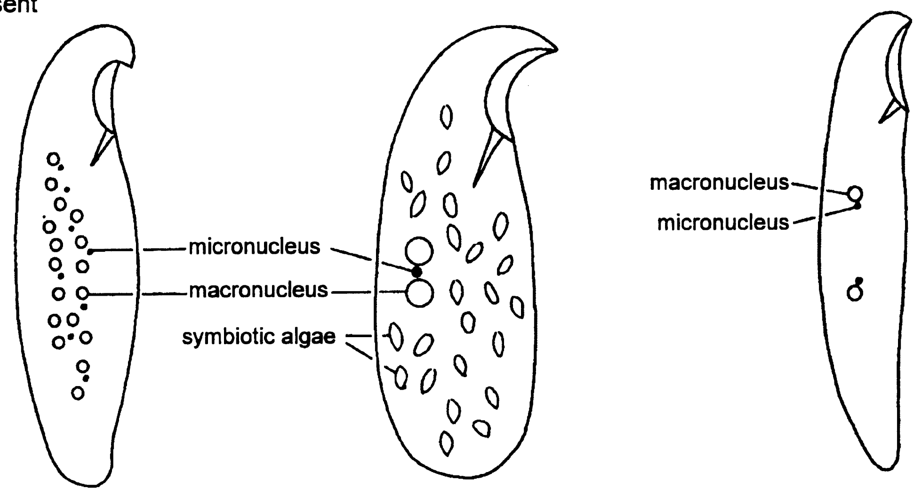
Volume IV

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

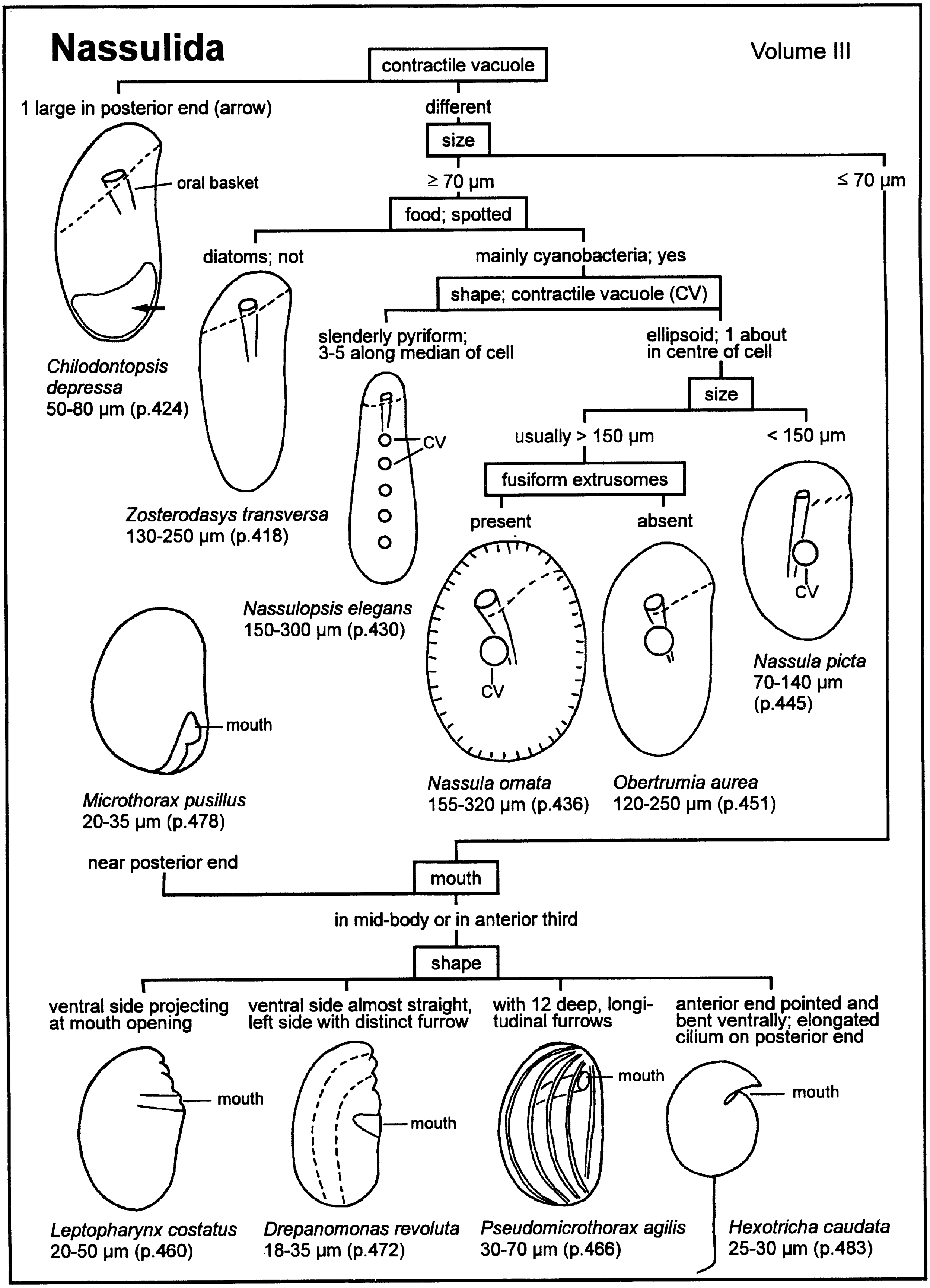
2 widely separate macronuclei each with 1 micronucleus; absent



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

Odontostomatida [1,2]

Volume II

frontal ciliary band; spines

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

Discomorphella pectinata
70-90 µm (p.451)

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

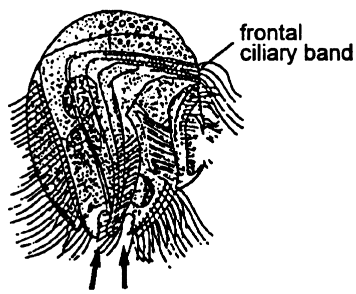
posterior end; ciliature in posterior body half

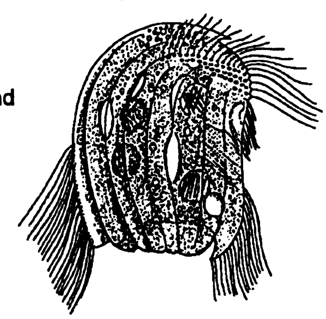
2 rounded notches surrounded by 6 inconspicuous spines (arrows); several ciliary rows commencing near mid-body

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

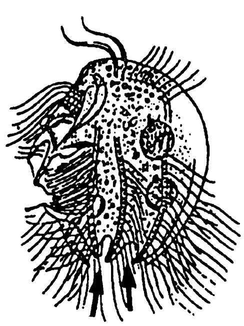
8 short or long, claw-shaped spines (arrow); on spines short ciliary rows

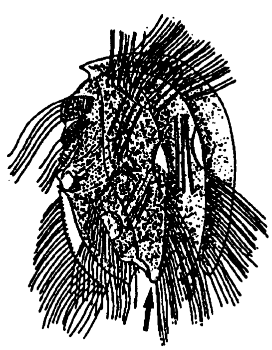
right side

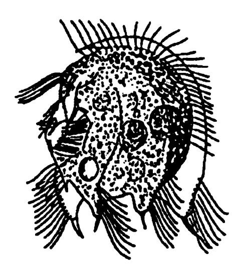




left side







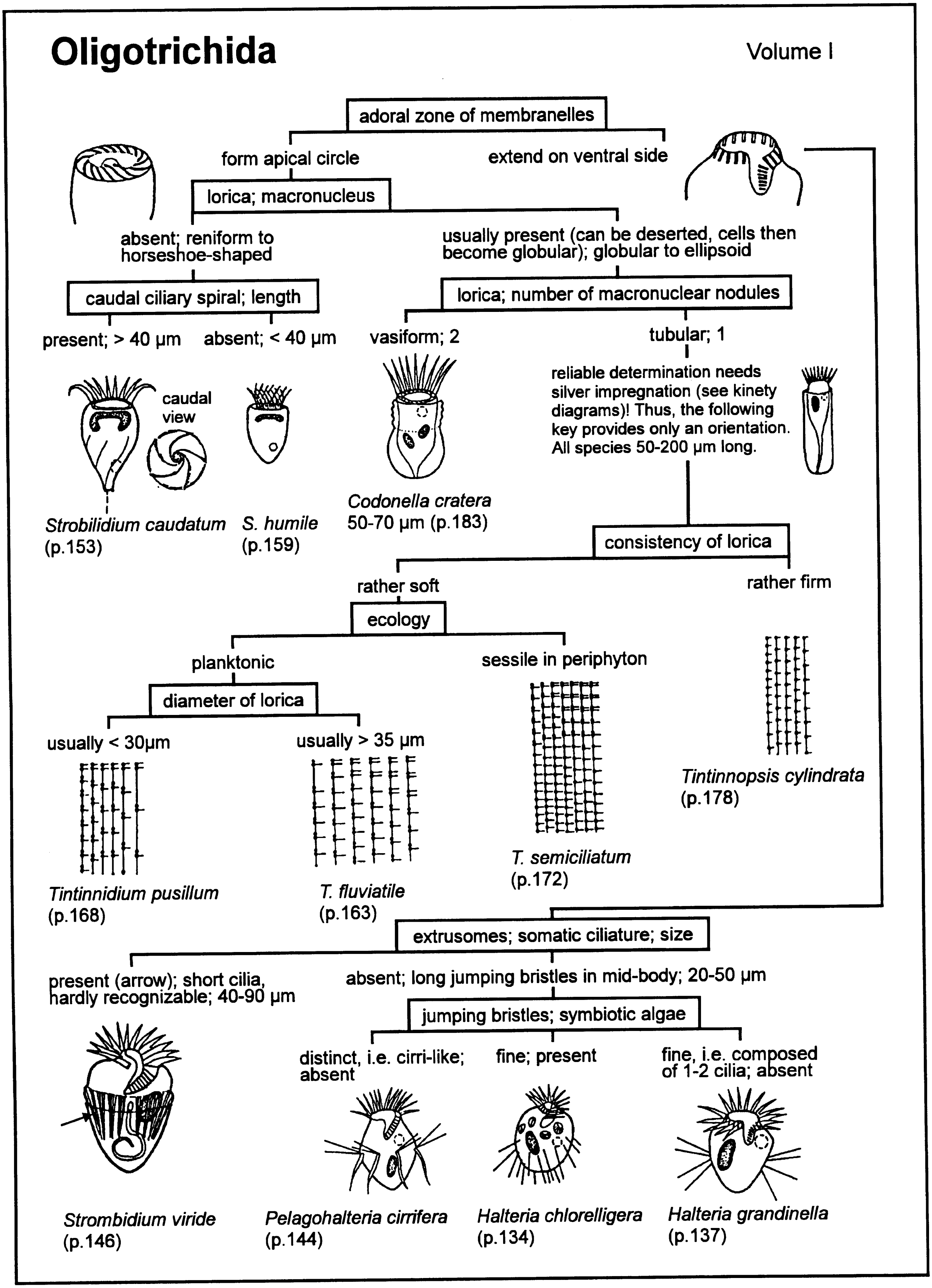
Pelodinium reniforme
40-50 µm (p.437)

Epalxella spp.
25-90 µm (p.440)

Saprodinium spp.
35-80 µm (p.446)

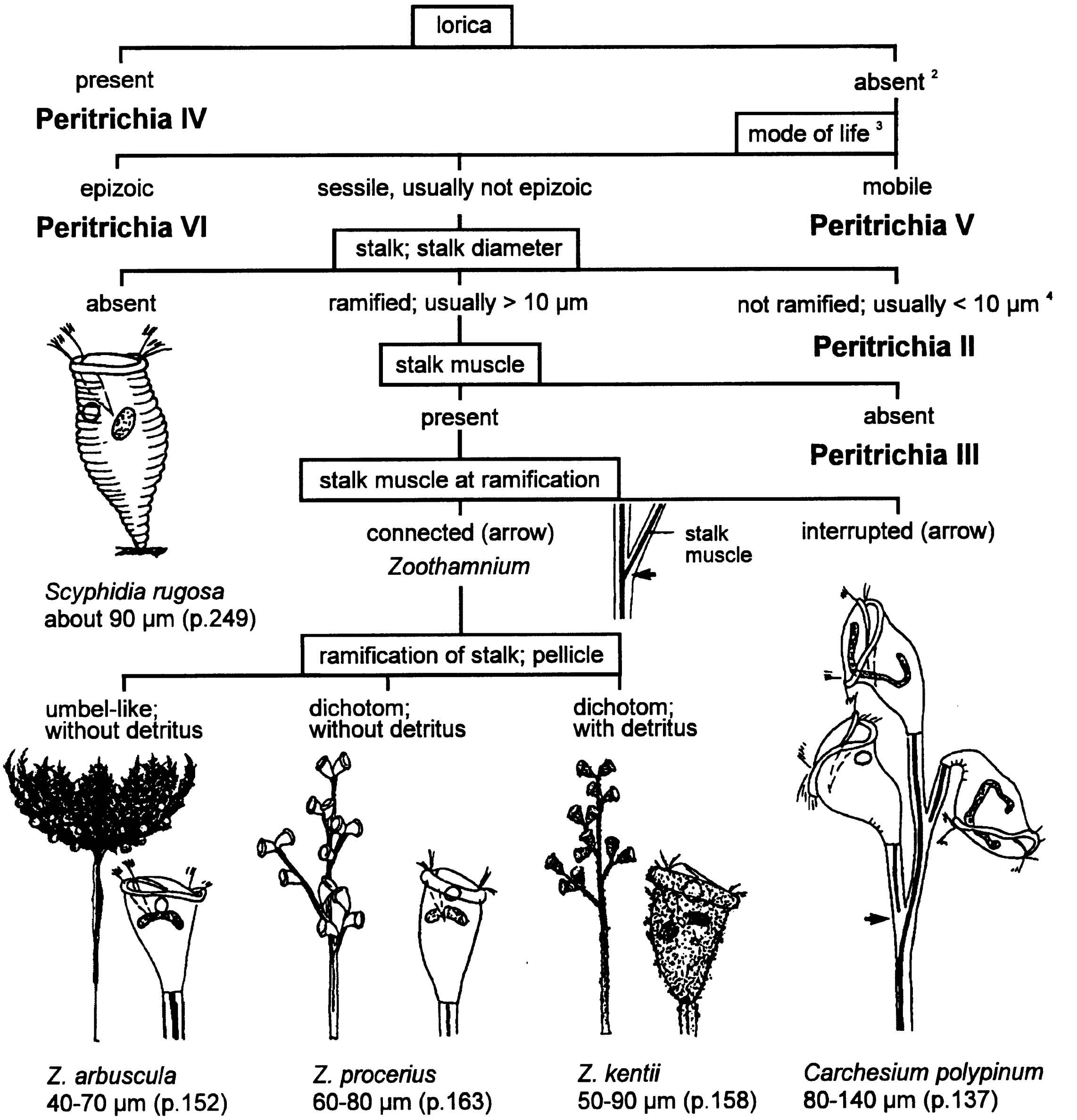
[1] All genera figured and all other odontostomatids live in anaerobic mud, i.e. are metasaprobic. Thus, determination of genera and species is often not necessary, i.e. the differentiation of form types is sufficient for practical work.

[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
present; > 40 µm
absent; < 40 µm
caudal view
Strobilidium caudatum (p.153)
S. humile (p.159)
lorica; number of macronuclear nodules
vasiform; 2
tubular; 1
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
diameter of lorica
usually < 30µm
usually > 35 µm
Tintinnopsis cylindrata (p.178)
T. semiciliatum (p.172)
Tintinnidium pusillum (p.168)
T. fluviatile (p.163)
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

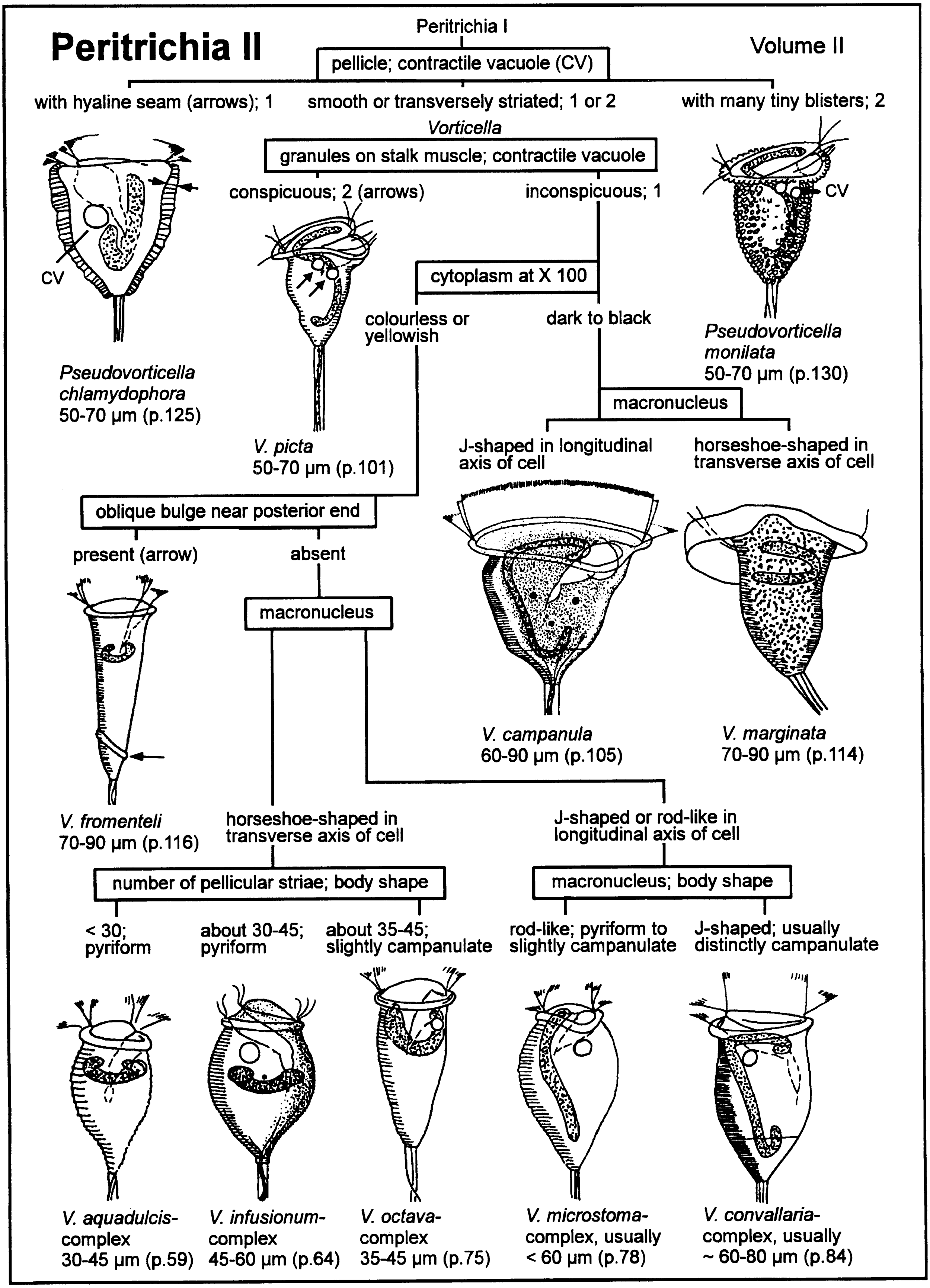


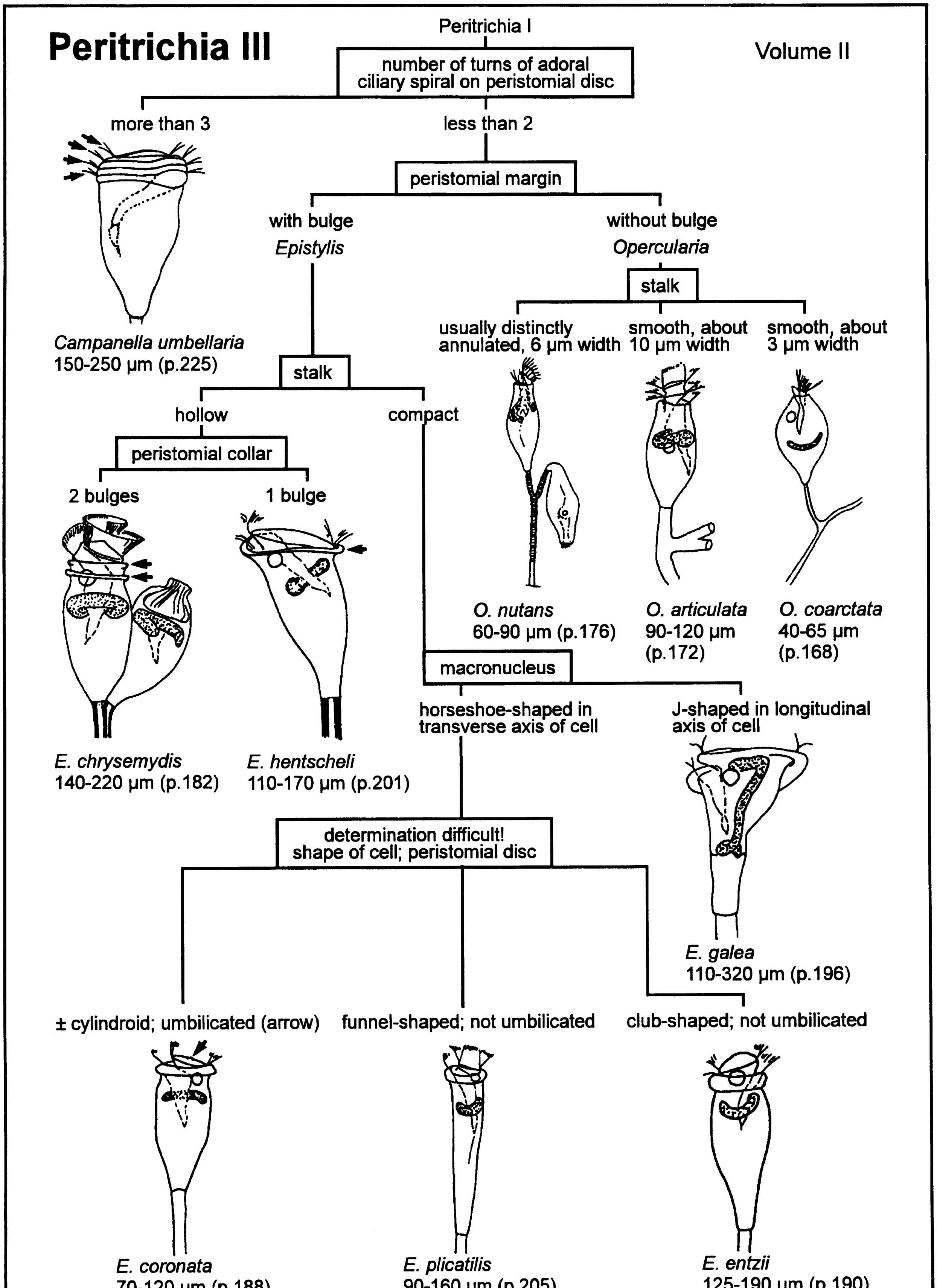
[1] The determination of most peritrich ciliates is simple because they have many distinct characters which, however, are often recognizable only in vital populations. Thus, samples must be investigated within few hours because most species soon become morbid in the collection jars or transform to swarmers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

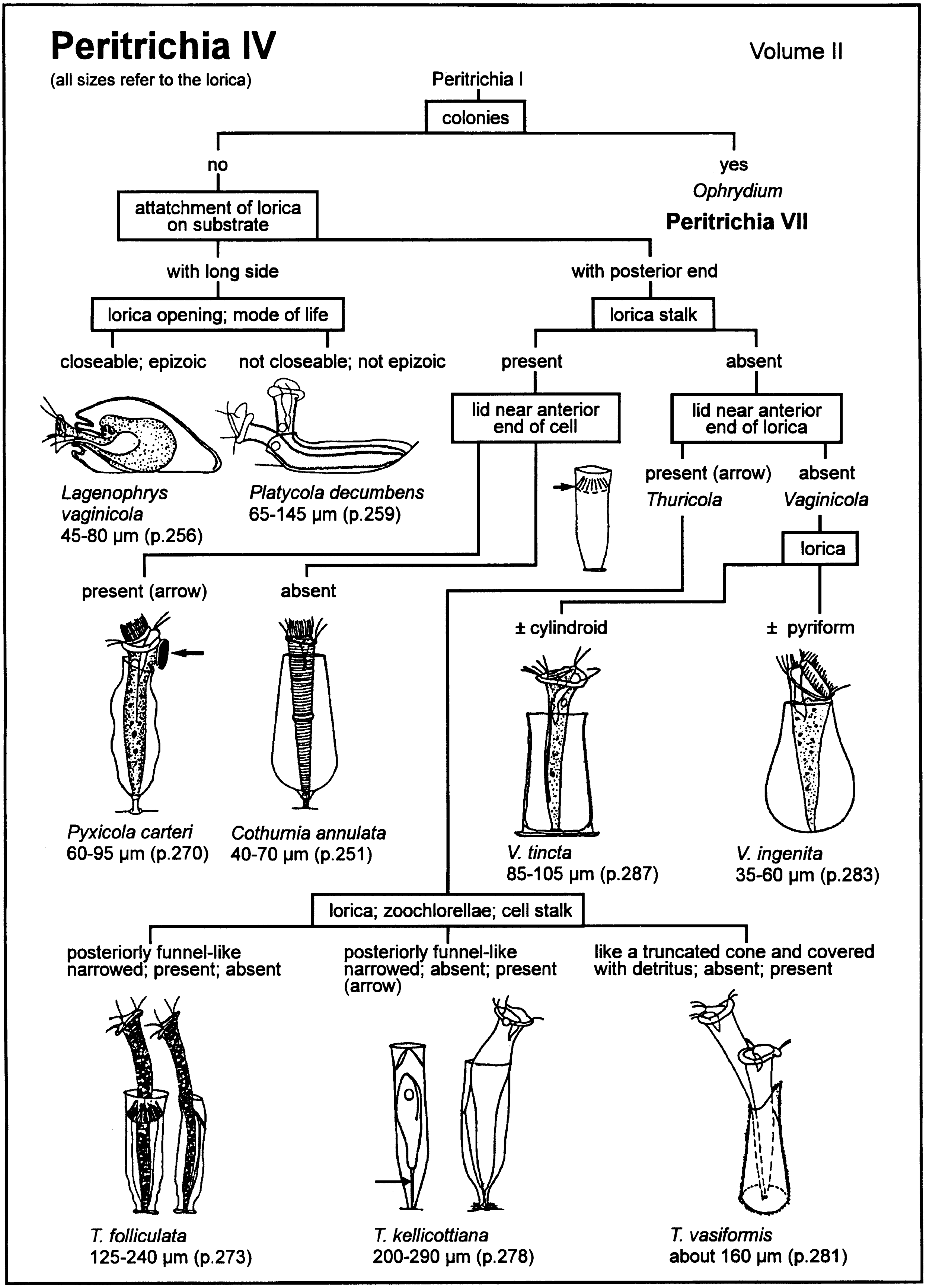
[2] The hyaline, gelatinous loricas of *Ophrydium* species are easily overlooked. Thus, follow key Peritrichia VII for very long and slender specimens.

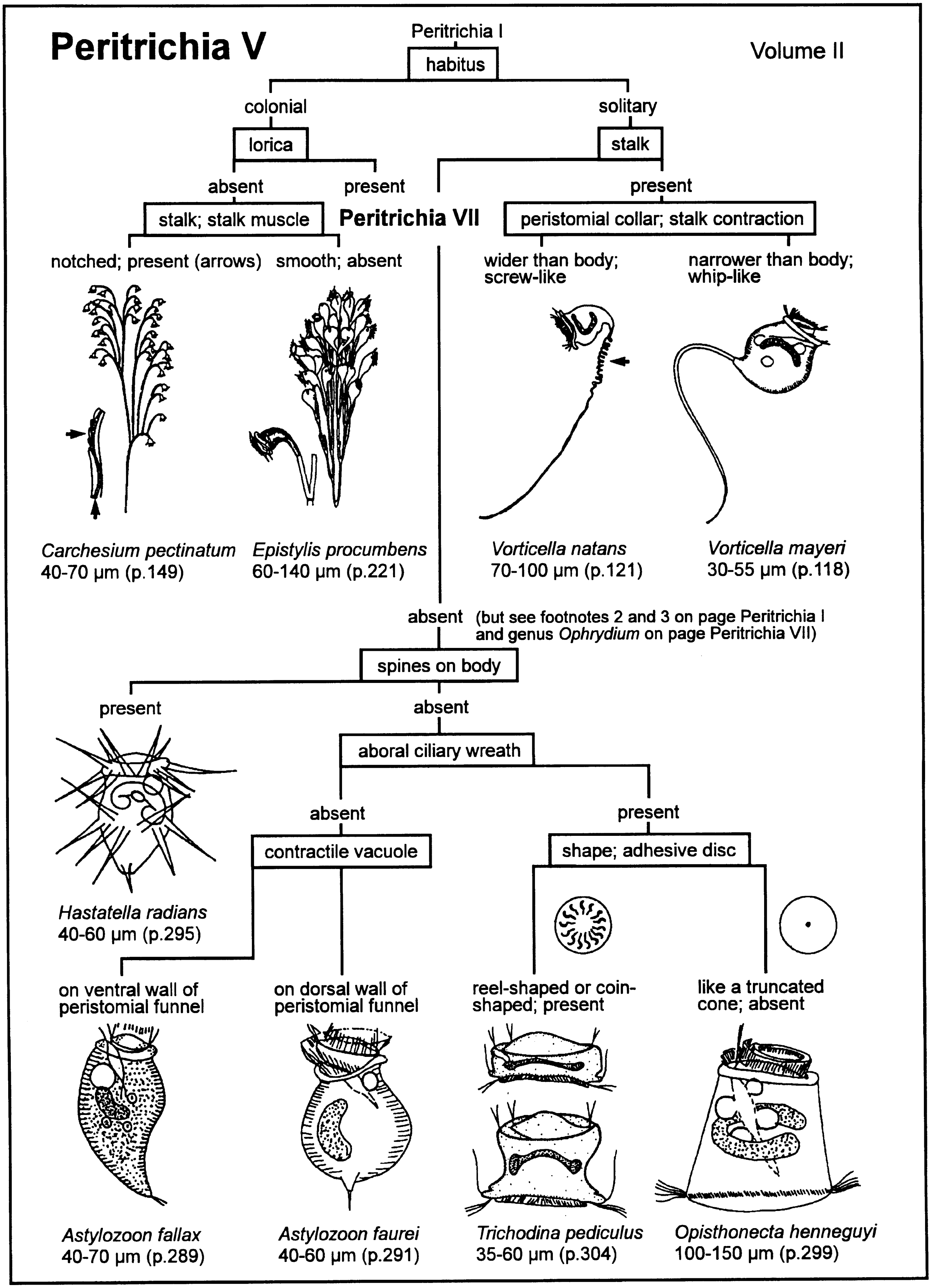
[3] Stalked species detach from the substrate with or without stalk and are then mobile, i.e. free-swimming too. Furthermore, all peritrichs can transform to mobile swarmers, which are difficult to separate from naturally stalkless species (see Peritrichia V, bottom). However, species of these genera (*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
Volume II
Peritrichia I
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
cytoplasm at X 100
colourless or yellowish
dark to black
Pseudovorticella chlamydophora 50-70 µm (p.125)
V. picta 50-70 µm (p.101)
Pseudovorticella monilata 50-70 µm (p.130)
macronucleus
J-shaped in longitudinal axis of cell
horseshoe-shaped in transverse axis of cell
oblique bulge near posterior end
present (arrow)
absent
macronucleus
V. campanula 60-90 µm (p.105)
V. marginata 70-90 µm (p.114)
V. fromenteli 70-90 µm (p.116)
horseshoe-shaped in transverse axis of cell
J-shaped or rod-like in longitudinal axis of cell
number of pellicular striae; body shape
macronucleus; body shape
< 30; pyriform
about 30-45; pyriform
about 35-45; slightly campanulate
rod-like; pyriform to slightly campanulate
J-shaped; usually distinctly campanulate
V. aquadulcis-complex 30-45 µm (p.59)
V. infusionum-complex 45-60 µm (p.64)
V. octava-complex 35-45 µm (p.75)
V. microstoma-complex, usually < 60 µm (p.78)
V. convallaria-complex, usually ~ 60-80 µm (p.84)


Peritrichia III
Volume II
Peritrichia I
number of turns of adoral ciliary spiral on peristomial disc
more than 3
less than 2
Campanella umbellaria
150-250 μm (p.225)
peristomial margin
with bulge
Epistylis
without bulge
Opercularia
stalk
usually distinctly annulated, 6 μm width
smooth, about 10 μm width
smooth, about 3 μm width
O. nutans
60-90 μm (p.176)
O. articulata
90-120 μm (p.172)
O. coarctata
40-65 μm (p.168)
stalk
hollow
compact
peristomial collar
2 bulges
1 bulge
E. chrysemydis
140-220 μm (p.182)
E. hentscheli
110-170 μm (p.201)
macronucleus
horseshoe-shaped in transverse axis of cell
J-shaped in longitudinal axis of cell
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
(all sizes refer to the lorica)
Volume II
Peritrichia I
colonies
no
yes
Ophrydium
Peritrichia VII
attachment of lorica on substrate
with long side
with posterior end
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)
lorica stalk
present
absent
lid near anterior end of cell
lid near anterior end of lorica
present (arrow)
absent
Thuricola
Vaginicola
lorica
present (arrow)
absent
Pyxicola carteri
60-95 µm (p.270)
Cothurnia annulata
40-70 µm (p.251)
± cylindroid
± pyriform
V. tincta
85-105 µm (p.287)
V. ingenita
35-60 µm (p.283)
lorica; zoochlorellae; cell stalk
posteriorly funnel-like narrowed; present; absent
posteriorly funnel-like narrowed; absent; present (arrow)
like a truncated cone and covered with detritus; absent; present
T. folliculata
125-240 µm (p.273)
T. kellicottiana
200-290 µm (p.278)
T. vasiformis
about 160 µm (p.281)


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

Peritrichia VI

Peritrichia I

Volume II

habitus

- solitary — **host**
  - hydrozoans, bryozoans, fishes
  - oligochaetes
  - small crustaceans
- colonial — **stalk**
  - annulated
  - smooth

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

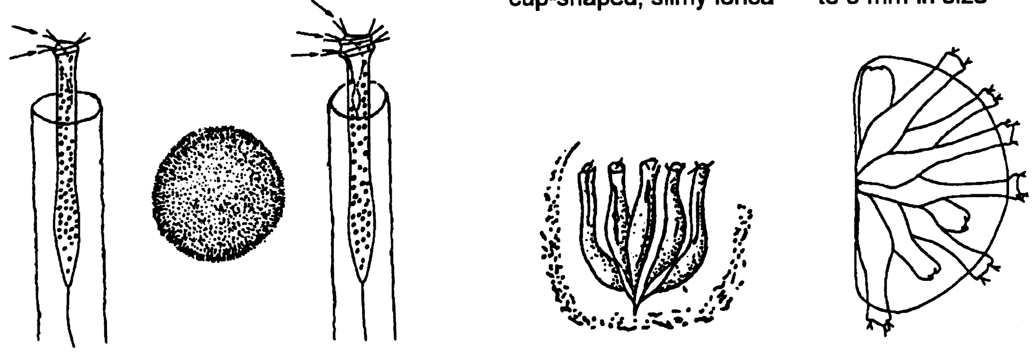
Peritrichia VII[1]

Peritrichia IV, V

Volume II

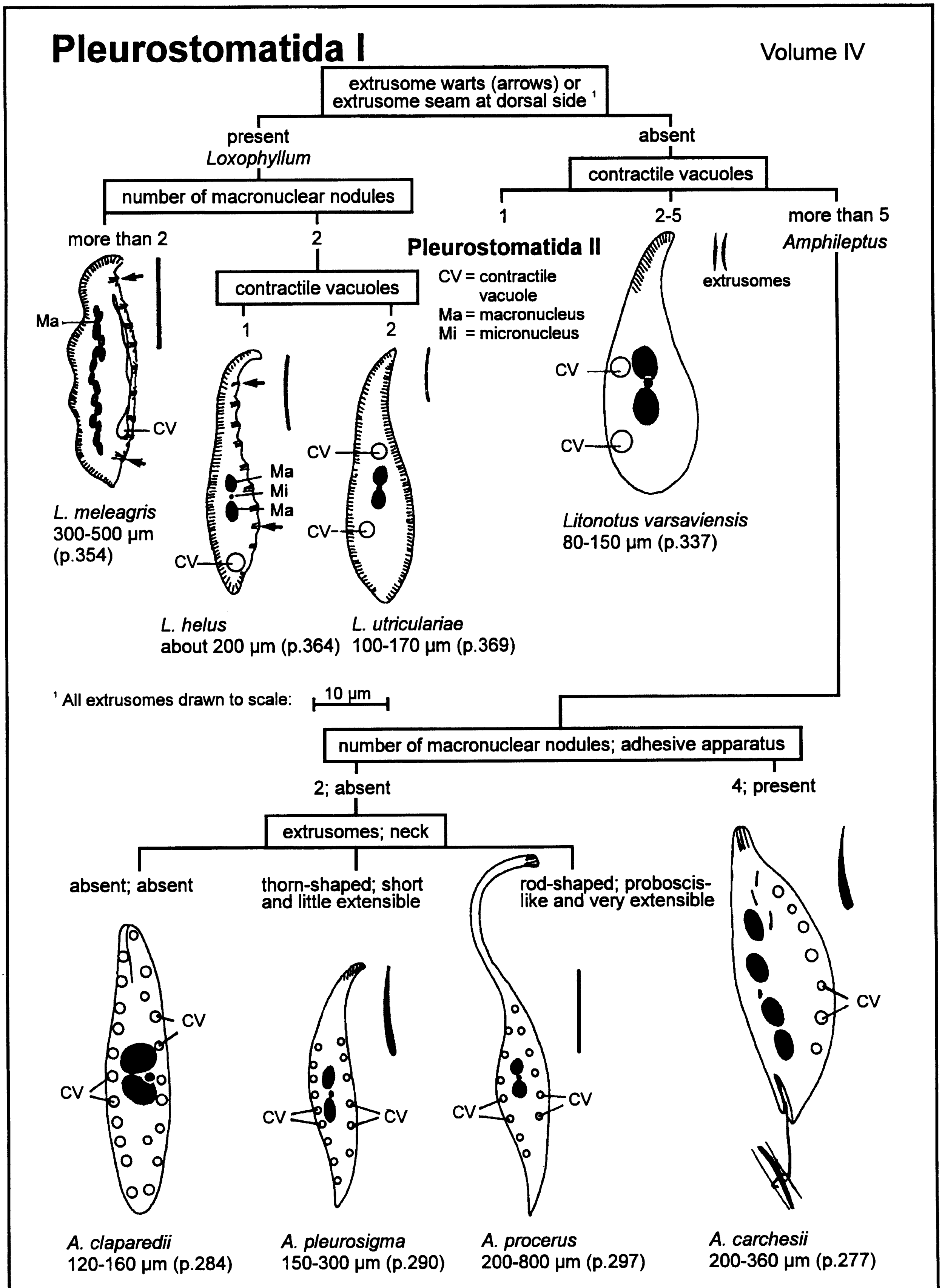
zoochlorellae; colony size

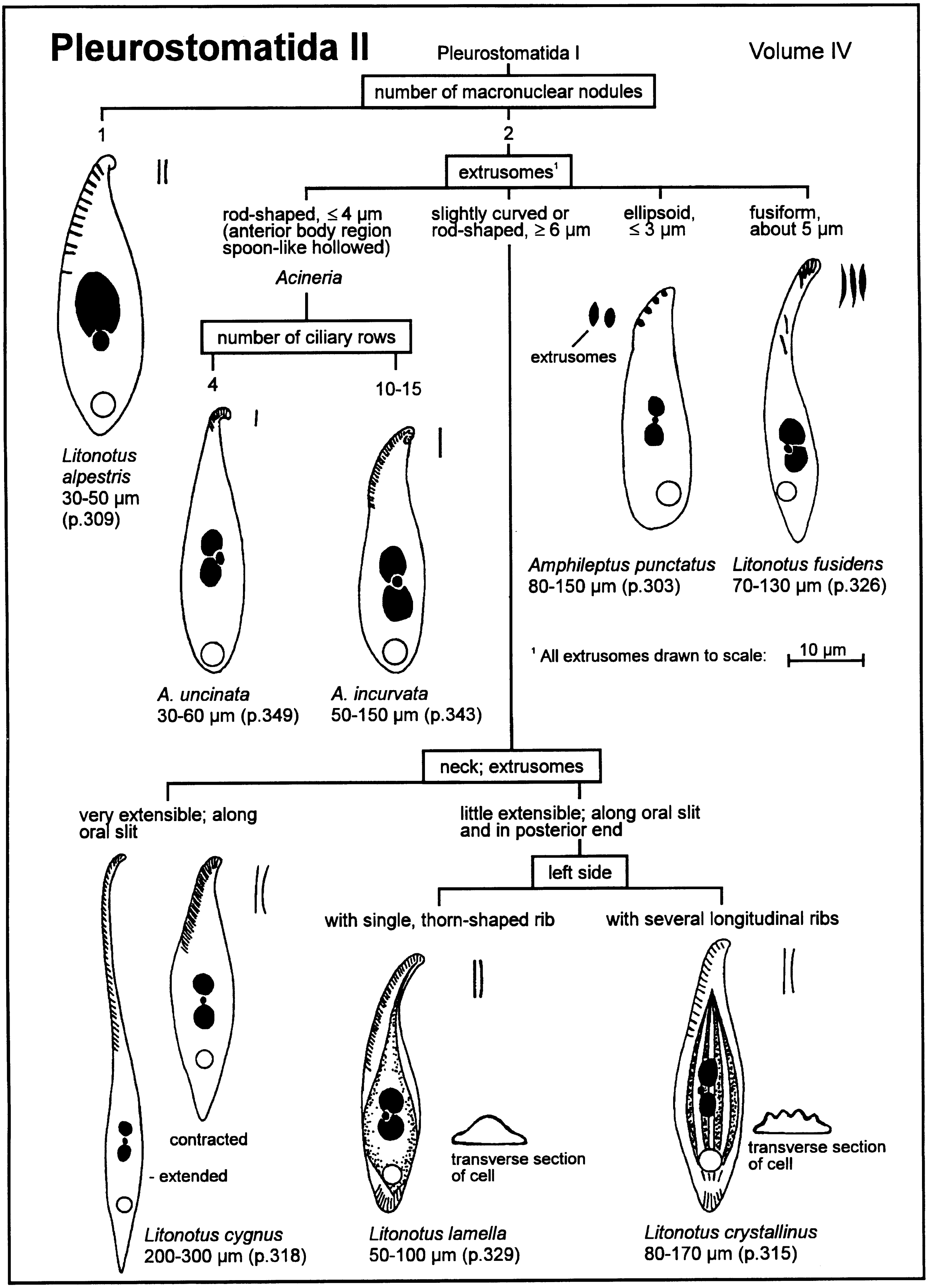
- present; up to 10 cm — **number of turns of adoral ciliary spiral on peristomial disc (arrows)**
  - 1 1/2
  - 2 1/2
- absent; up to 3 mm — **colony shape**
  - up to 5 individuals in cup-shaped, slimy lorica
  - hemispherical, up to 3 mm in size

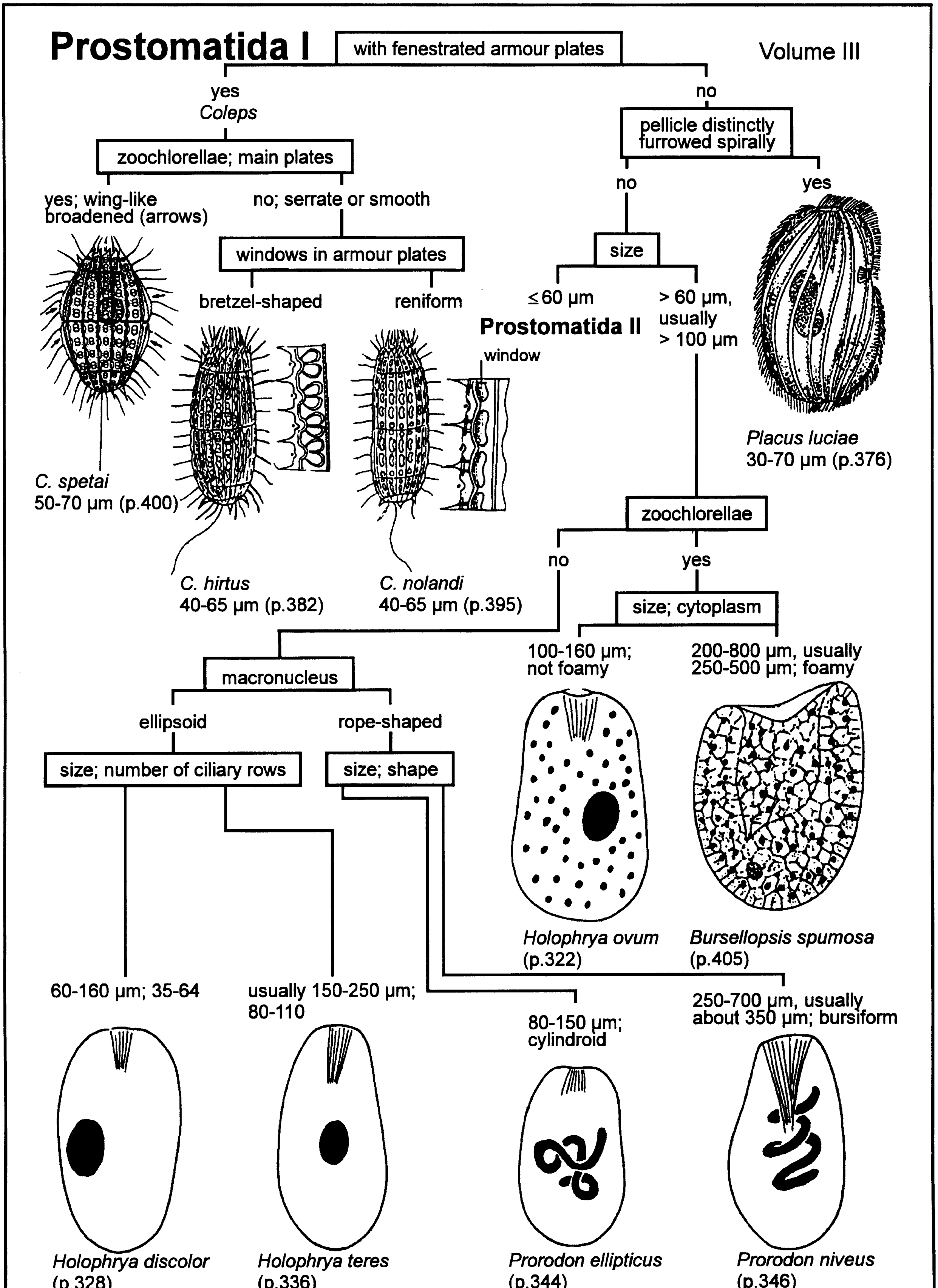


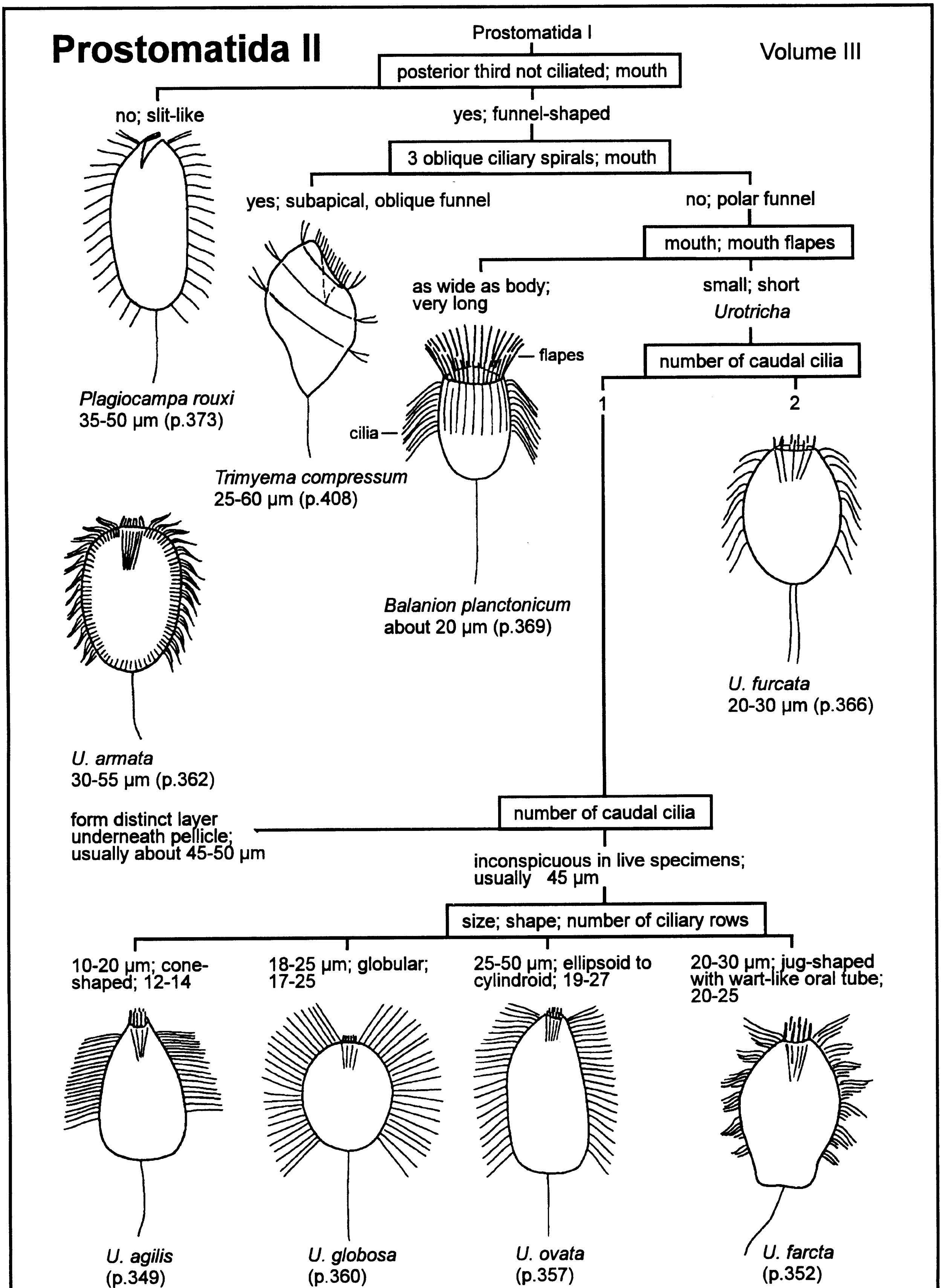
Ophrydium versatile 300-400 µm (p.232)	*Ophrydium eutrophicum* 250-350 µm (p.239)	*Ophrydium crassicaule* 180-200 µm (p.242)	*Ophrydium sessile* 280-320 µm (p.244)

[1] Often only stalkless, loricaless solitary specimens in running waters and plankton; then difficult to separate from *Gerda* spp., which lacks a lorica.

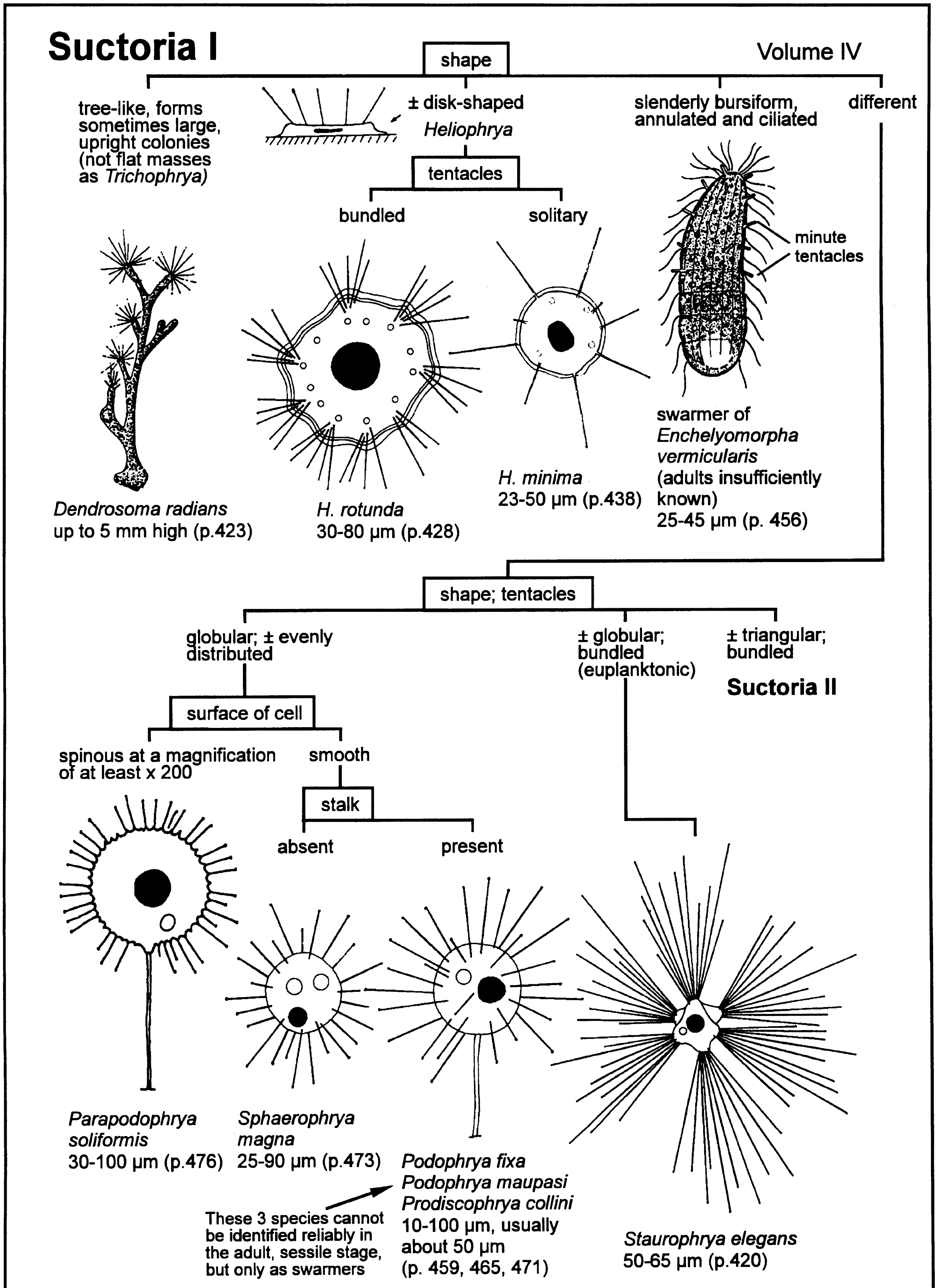

Pleurostomatida I
Volume IV
extrusome warts (arrows) or extrusome seam at dorsal side [1]
present
Loxophyllum
absent
number of macronuclear nodules
contractile vacuoles
more than 2
2
1
2-5
more than 5
Amphileptus
Pleurostomatida II
contractile vacuoles
1
2
CV = contractile vacuole
Ma = macronucleus
Mi = micronucleus
extrusomes
Ma
CV
Ma
Mi
Ma
CV
CV
CV
CV
CV
L. meleagris
300-500 µm
(p.354)
Litonotus varsaviensis
80-150 µm (p.337)
L. helus
about 200 µm (p.364)
L. utriculariae
100-170 µm (p.369)
[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
CV
CV
CV
CV
CV
CV
CV
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
extrusomes¹
rod-shaped, ≤ 4 µm (anterior body region spoon-like hollowed)
slightly curved or rod-shaped, ≥ 6 µm
ellipsoid, ≤ 3 µm
fusiform, about 5 µm
Acineria
number of ciliary rows
4
10-15
extrusomes
Litonotus alpestris 30-50 µm (p.309)
A. uncinata 30-60 µm (p.349)
A. incurvata 50-150 µm (p.343)
Amphileptus punctatus 80-150 µm (p.303)
Litonotus fusidens 70-130 µm (p.326)
¹ All extrusomes drawn to scale: 10 µm
neck; extrusomes
very extensible; along oral slit
little extensible; along oral slit and in posterior end
left side
with single, thorn-shaped rib
with several longitudinal ribs
contracted
- extended
transverse section of cell
transverse section of cell
Litonotus cygnus 200-300 µm (p.318)
Litonotus lamella 50-100 µm (p.329)
Litonotus crystallinus 80-170 µm (p.315)

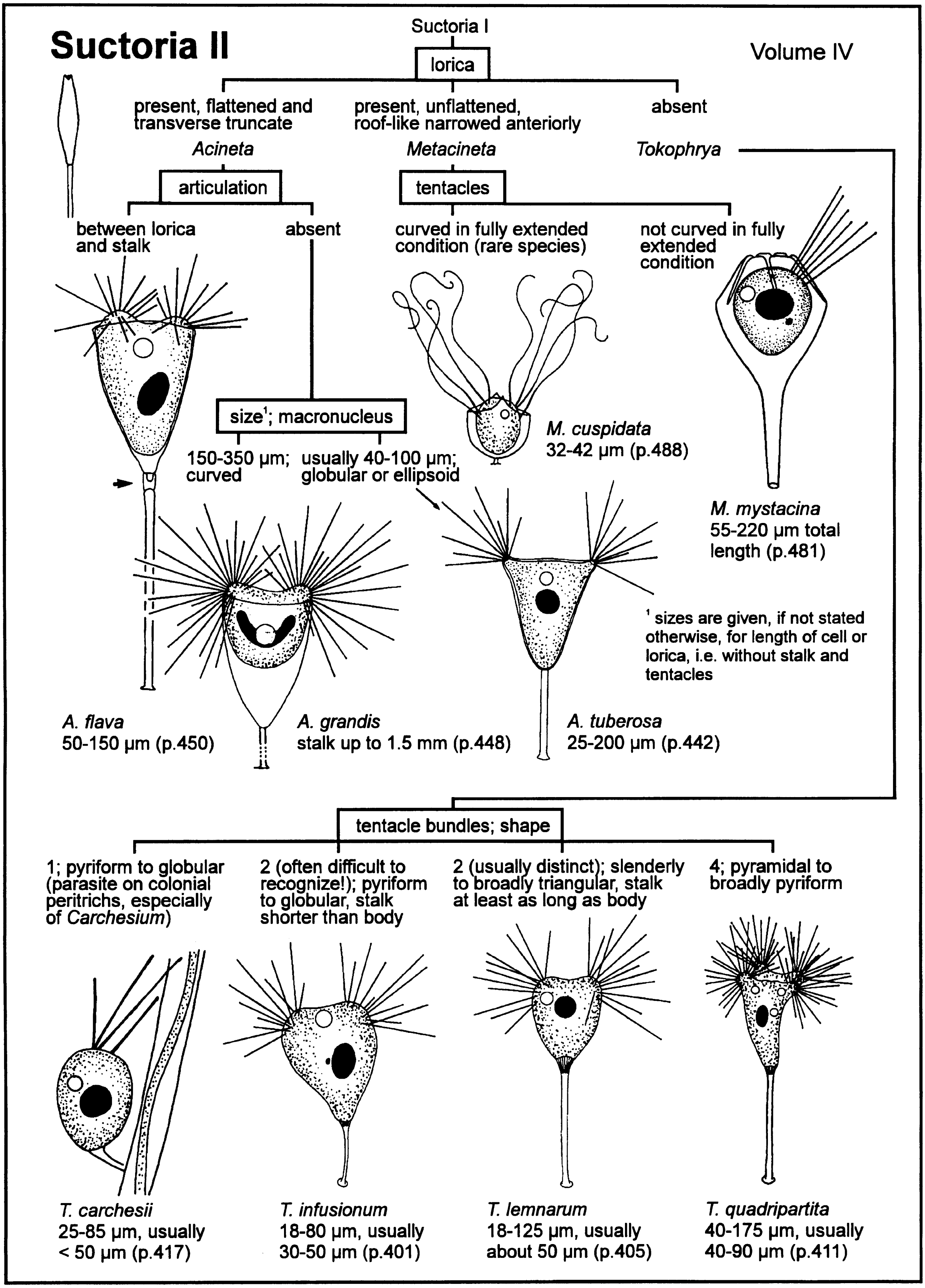

Prostomatida I
with fenestrated armour plates
Volume III
yes
Coleps
no
zoochlorellae; main plates
pellicle distinctly furrowed spirally
yes; wing-like broadened (arrows)
no; serrate or smooth
no
yes
windows in armour plates
size
bretzel-shaped
reniform
≤60 µm
Prostomatida II
> 60 µm, usually > 100 µm
window
C. spetai
50-70 µm (p.400)
Placus luciae
30-70 µm (p.376)
zoochlorellae
C. hirtus
40-65 µm (p.382)
C. nolandi
40-65 µm (p.395)
no
yes
size; cytoplasm
macronucleus
100-160 µm; not foamy
200-800 µm, usually 250-500 µm; foamy
ellipsoid
rope-shaped
size; number of ciliary rows
size; shape
Holophrya ovum
(p.322)
Bursellopsis spumosa
(p.405)
60-160 µm; 35-64
usually 150-250 µm; 80-110
80-150 µm; cylindroid
250-700 µm, usually about 350 µm; bursiform
Holophrya discolor
(p.328)
Holophrya teres
(p.336)
Prorodon ellipticus
(p.344)
Prorodon niveus
(p.346)



Prostomatida II
Volume III
Prostomatida I
posterior third not ciliated; mouth
no; slit-like
yes; funnel-shaped
3 oblique ciliary spirals; mouth
yes; subapical, oblique funnel
no; polar funnel
mouth; mouth flapes
as wide as body; very long
small; short
Urotricha
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)

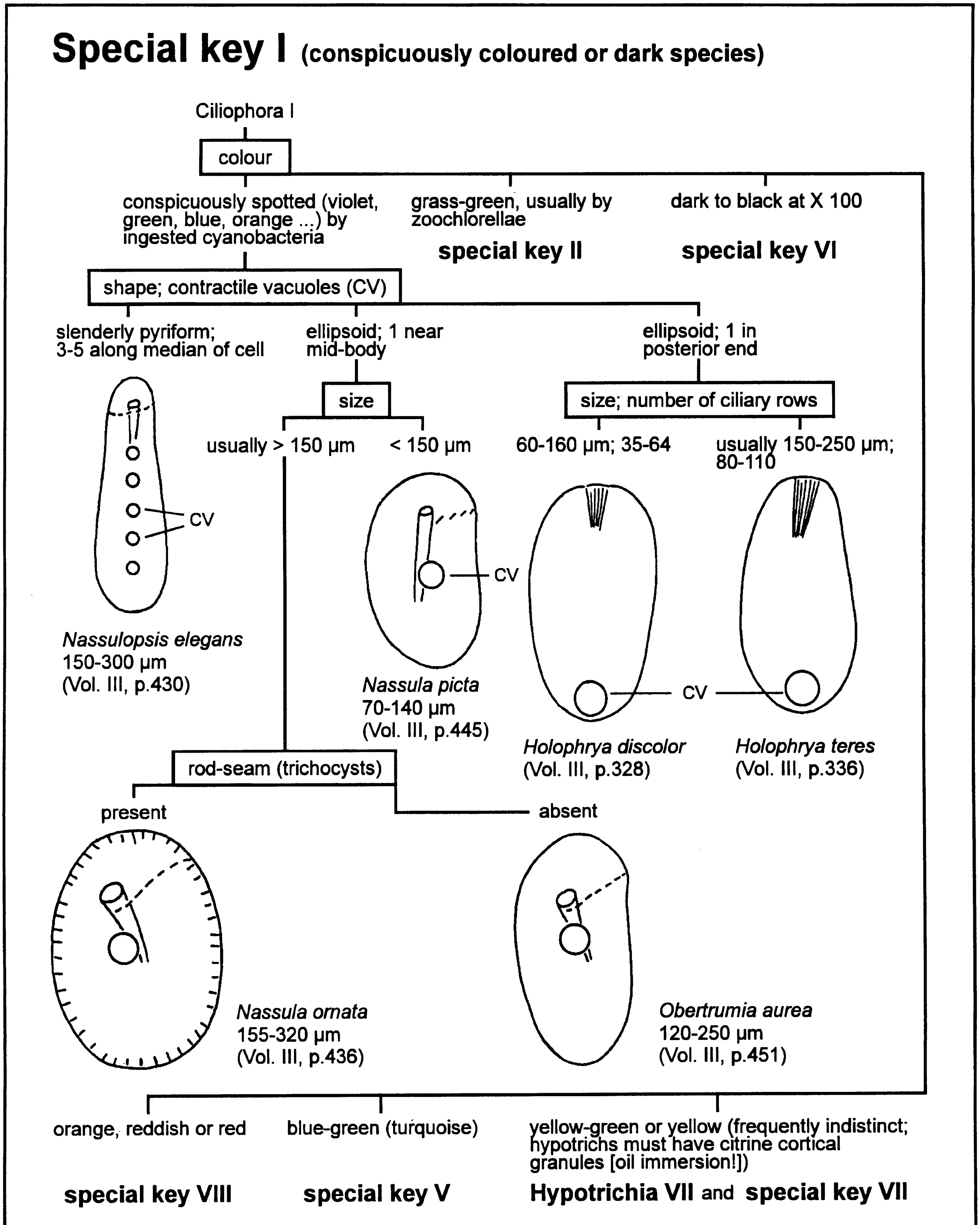


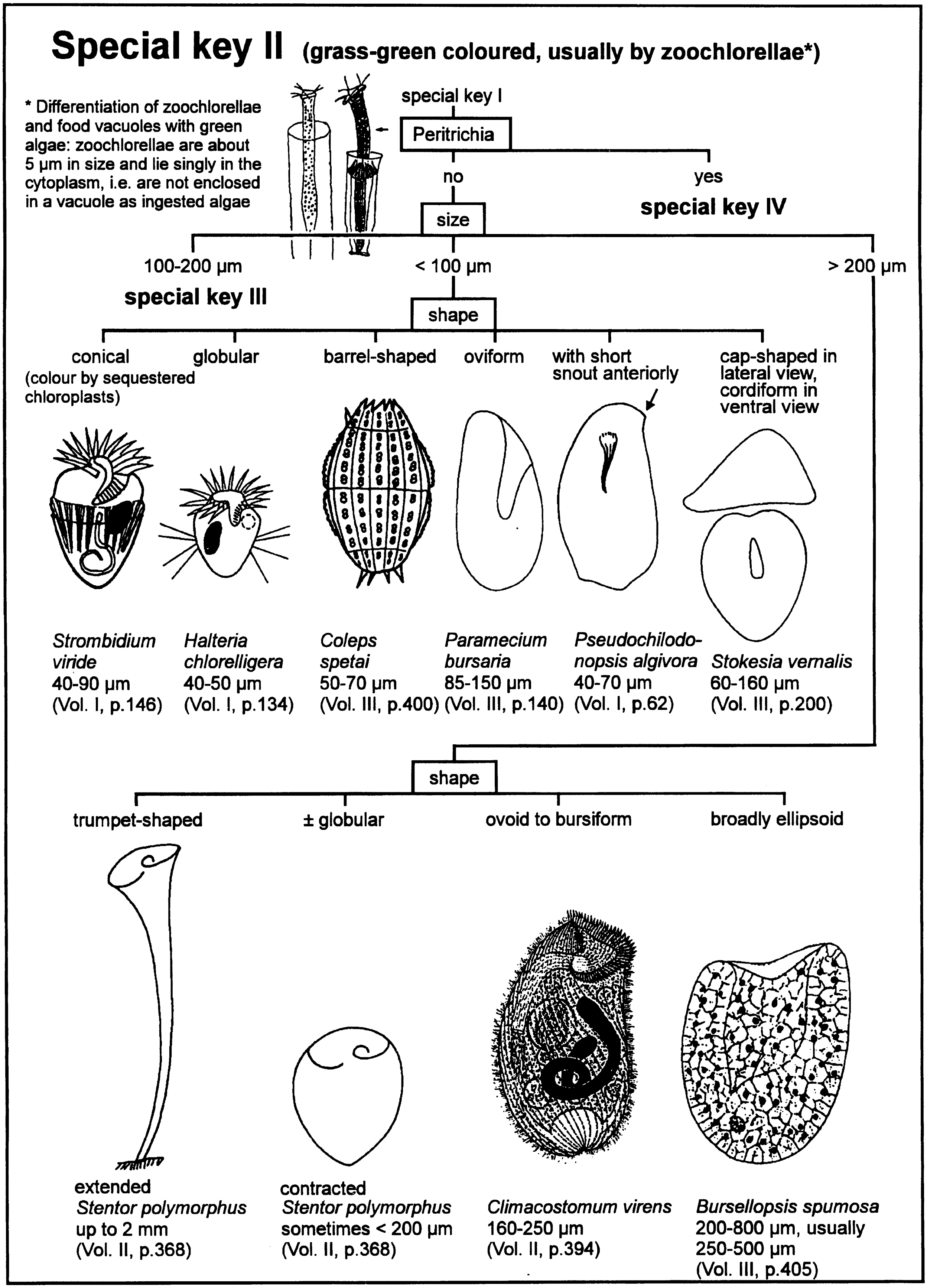
Suctoria I
Volume IV
shape
tree-like, forms sometimes large, upright colonies (not flat masses as Trichophrya)
± disk-shaped
Heliophrya
slenderly bursiform, annulated and ciliated
different
tentacles
bundled
solitary
minute tentacles
Dendrosoma radians
up to 5 mm high (p.423)
H. rotunda
30-80 µm (p.428)
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
Suctoria I
lorica
Volume IV
present, flattened and transverse truncate
present, unflattened, roof-like narrowed anteriorly
absent
Acineta
Metacineta
Tokophrya
articulation
tentacles
between lorica and stalk
absent
curved in fully extended condition (rare species)
not curved in fully extended condition
size[1]; macronucleus
150-350 µm; curved
usually 40-100 µm; globular or ellipsoid
M. cuspidata
32-42 µm (p.488)
M. mystacina
55-220 µm total length (p.481)
[1] sizes are given, if not stated otherwise, for length of cell or lorica, i.e. without stalk and tentacles
A. flava
50-150 µm (p.450)
A. grandis
stalk up to 1.5 mm (p.448)
A. tuberosa
25-200 µm (p.442)
tentacle bundles; shape
1; pyriform to globular (parasite on colonial peritrichs, especially of Carchesium)
2 (often difficult to recognize!); pyriform to globular, stalk shorter than body
2 (usually distinct); slenderly to broadly triangular, stalk at least as long as body
4; pyramidal to broadly pyriform
T. carchesii
25-85 µm, usually < 50 µm (p.417)
T. infusionum
18-80 µm, usually 30-50 µm (p.401)
T. lemnarum
18-125 µm, usually about 50 µm (p.405)
T. quadripartita
40-175 µm, usually 40-90 µm (p.411)

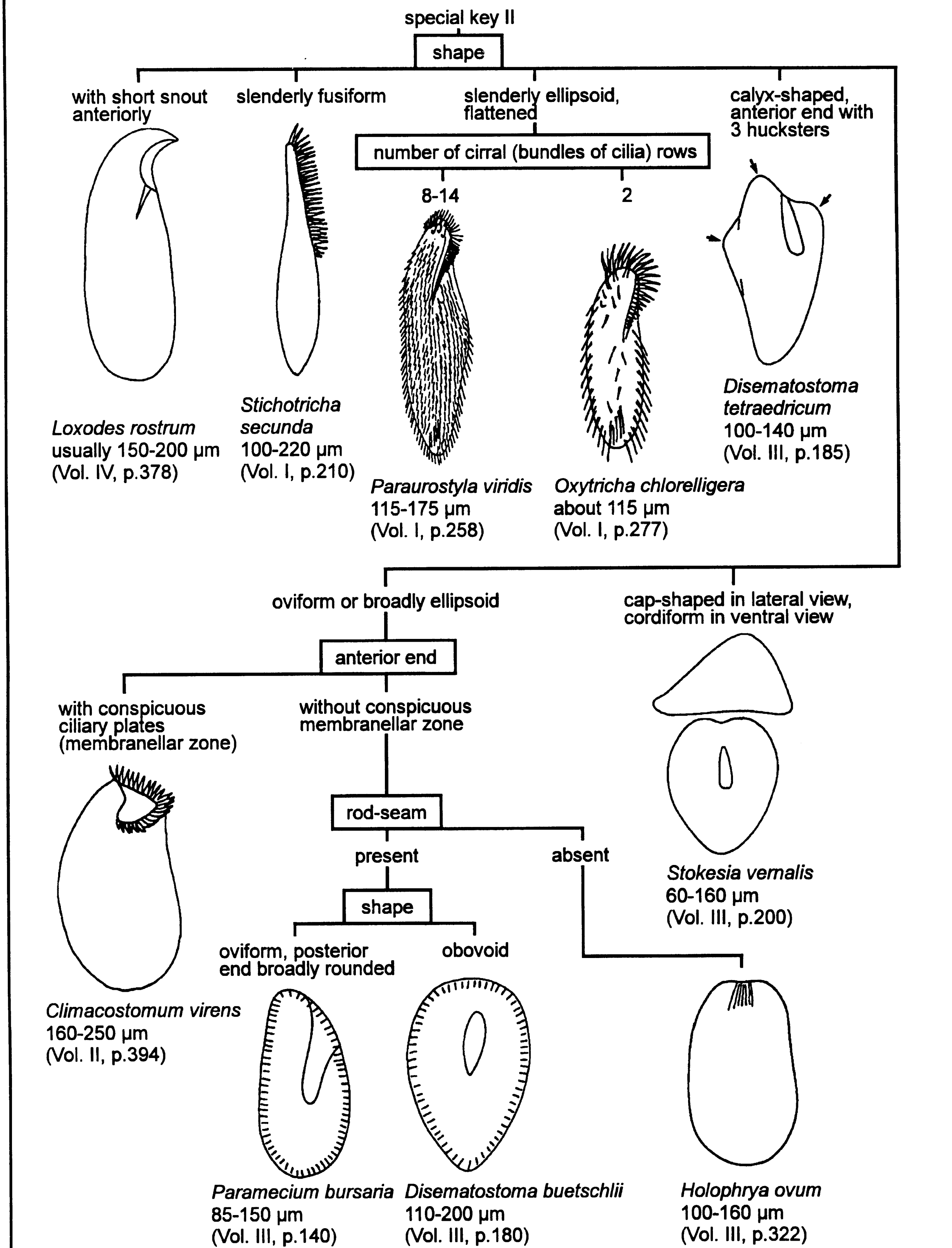
Special keys

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)

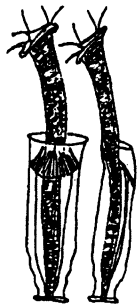


Special key IV (grass-green coloured by zoochlorellae)

special key II

colonial

no

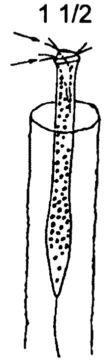


Thuricola folliculata
125-240 µm
(Vol. II, p.273)

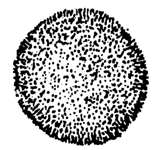
yes

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

1 1/2

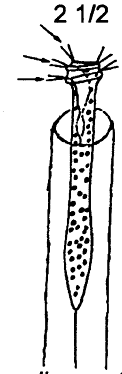


Ophrydium versatile
300-400 µm
(Vol. II, p.232)



globular colonies
up to 10 cm !

2 1/2



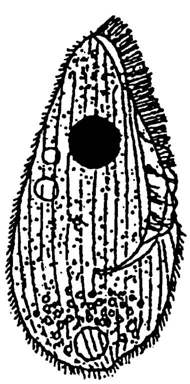
Ophrydium eutrophicum
250-350 µm
(Vol. II, p.239)

Special key V (bluegreen species)

special key I

shape; contractility

oviform; acontractile

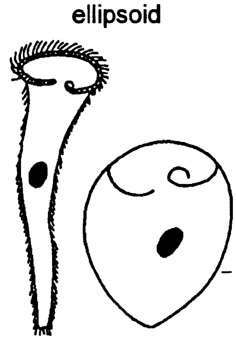


Blepharisma coeruleum
120-150 µm
(Vol. II, p.382)

trumpet-shaped or obovoid; very contractile

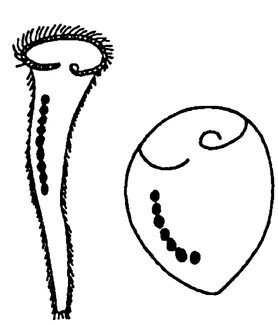
macronucleus

ellipsoid

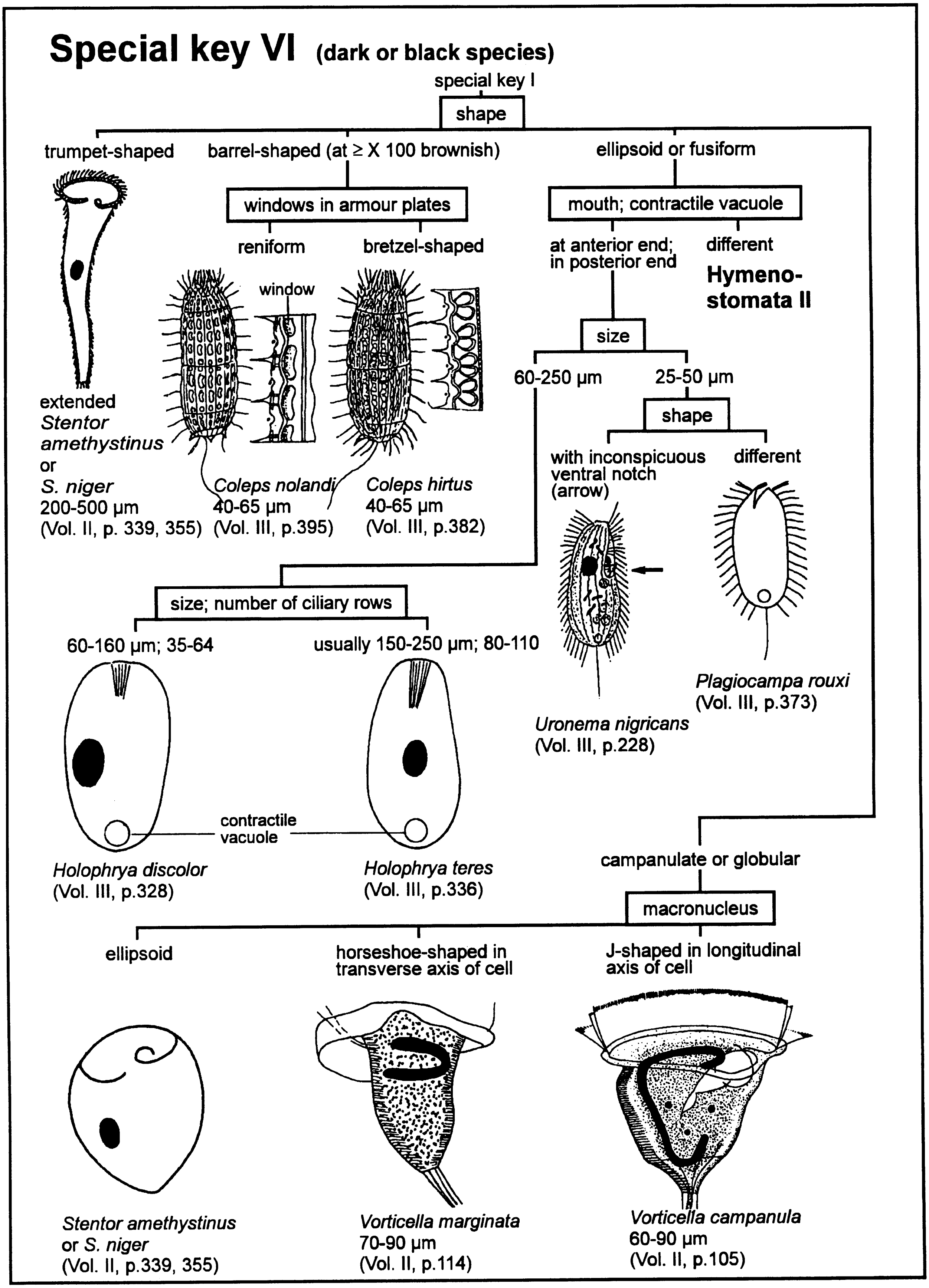


Stentor multiformis
about 250 µm
(Vol. II, p.351)

moniliform



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

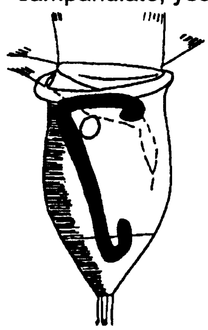

Special key VI (dark or black species)
special key I
shape
trumpet-shaped
barrel-shaped (at ≥ X 100 brownish)
ellipsoid or fusiform
extended
Stentor amethystinus
or
S. niger
200-500 µm
(Vol. II, p. 339, 355)
windows in armour plates
reniform
bretzel-shaped
window
Coleps nolandi
40-65 µm
(Vol. III, p.395)
Coleps hirtus
40-65 µm
(Vol. III, p.382)
mouth; contractile vacuole
at anterior end; in posterior end
different
Hymenostomata II
size
60-250 µm
25-50 µm
shape
with inconspicuous ventral notch (arrow)
different
Uronema nigricans
(Vol. III, p.228)
Plagiocampa rouxi
(Vol. III, p.373)
size; number of ciliary rows
60-160 µm; 35-64
usually 150-250 µm; 80-110
contractile vacuole
Holophrya discolor
(Vol. III, p.328)
Holophrya teres
(Vol. III, p.336)
campanulate or globular
macronucleus
ellipsoid
horseshoe-shaped in transverse axis of cell
J-shaped in longitudinal axis of cell
Stentor amethystinus
or S. niger
(Vol. II, p.339, 355)
Vorticella marginata
70-90 µm
(Vol. II, p.114)
Vorticella campanula
60-90 µm
(Vol. II, p.105)

Special key VII (yellow or yellowgreen coloured species)

special key I

shape; stalk

- campanulate; yes

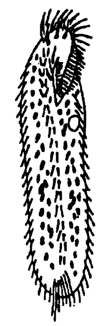


Vorticella citrina
60-80 µm
(belongs to the *Vorticella convallaria*-complex; see key Peritrichia II)

- slenderly ellipsoid, flattened; no
  - **number of macronuclear nodules**
    - many
      - **size**
        - 250-400 µm, usually 300-350 µm

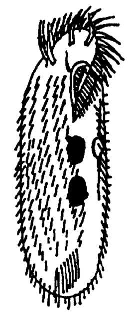
Urostyla grandis
(Vol. I, p.222)

        - 130-170 µm



Holosticha multistilata
(Vol. I, p.236)

    - 2



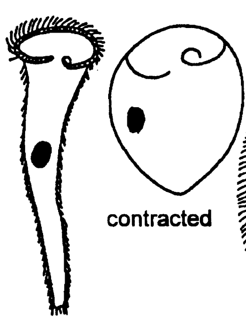
Paraurostyla weissei
150-300 µm
(Vol. I, p.260)

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

special key I

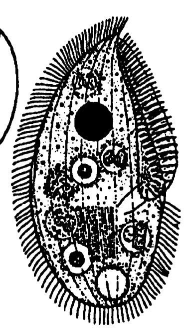
shape

- conical or globular



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

- oviform

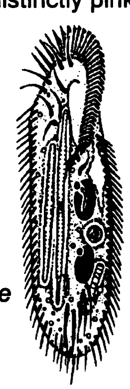


Blepharisma lateritium
110-190 µm
(Vol. II, p.384)

- oblong

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

- ellipsoid
  - **number of macronuclear nodules; colour**
    - 2; orange to distinctly pink

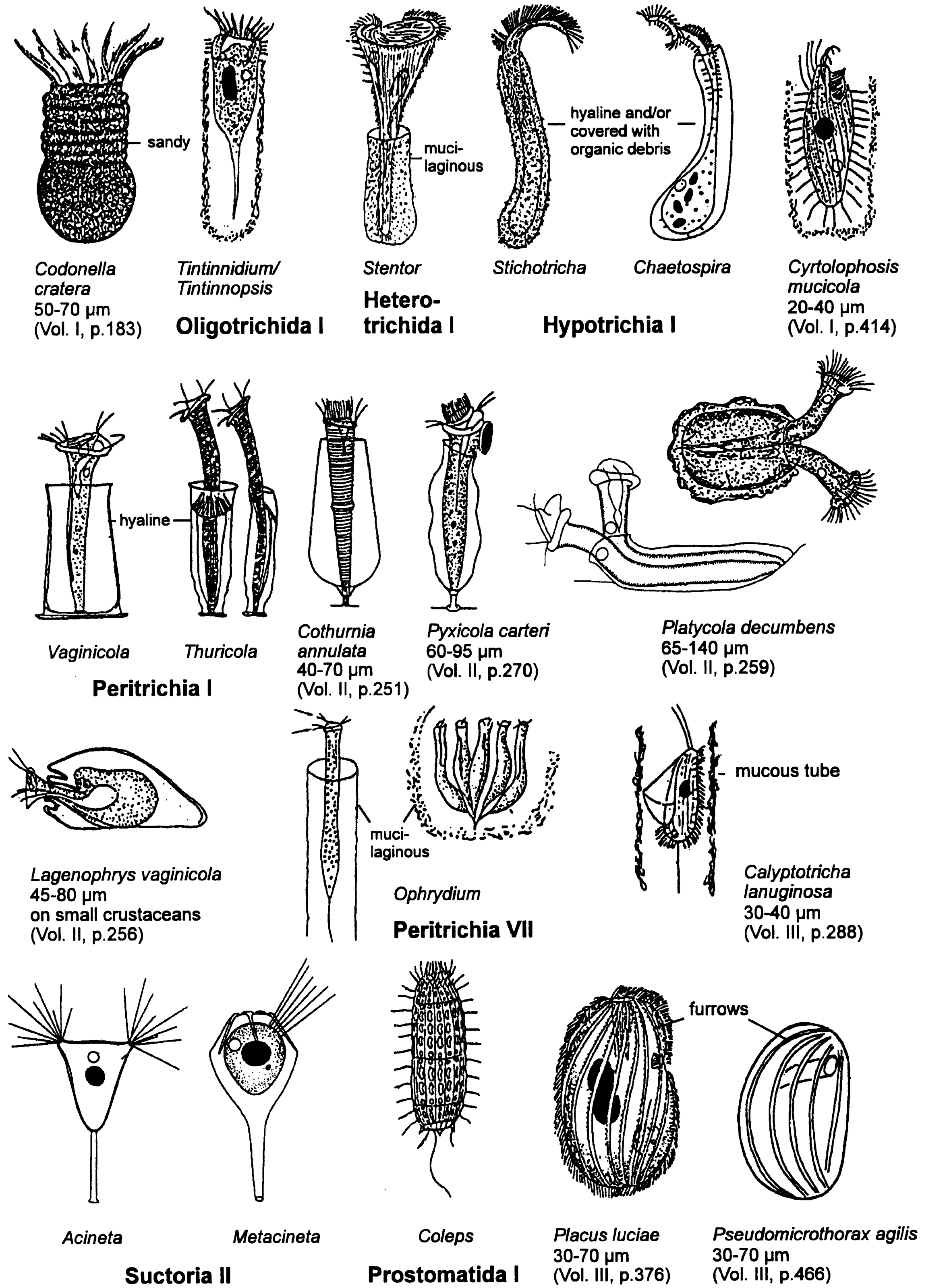


Oxytricha haematoplasma
120-180 µm
(Vol. I, p.287)

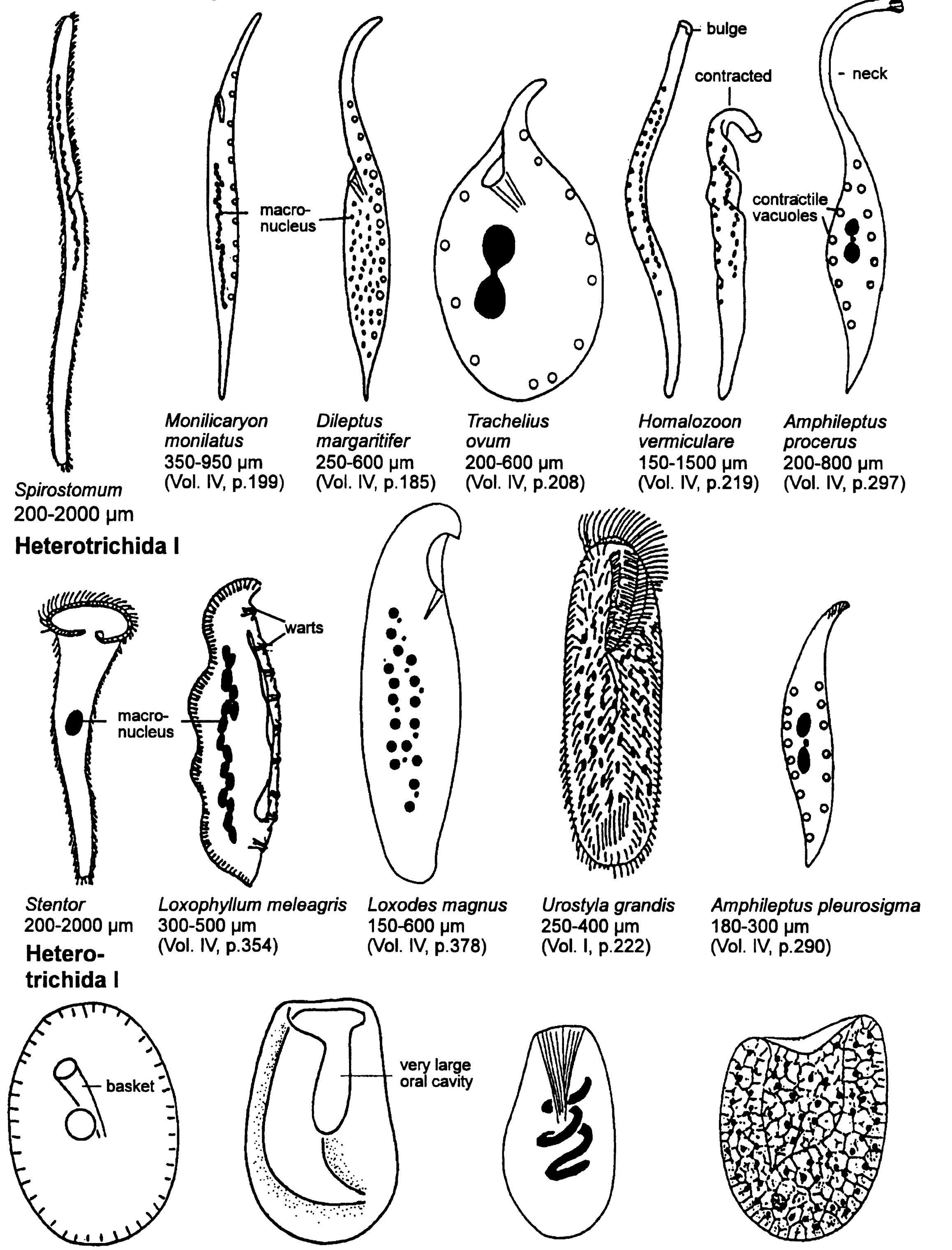
    - many; wine-red

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

Special key IX (loricate or armoured species)



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)

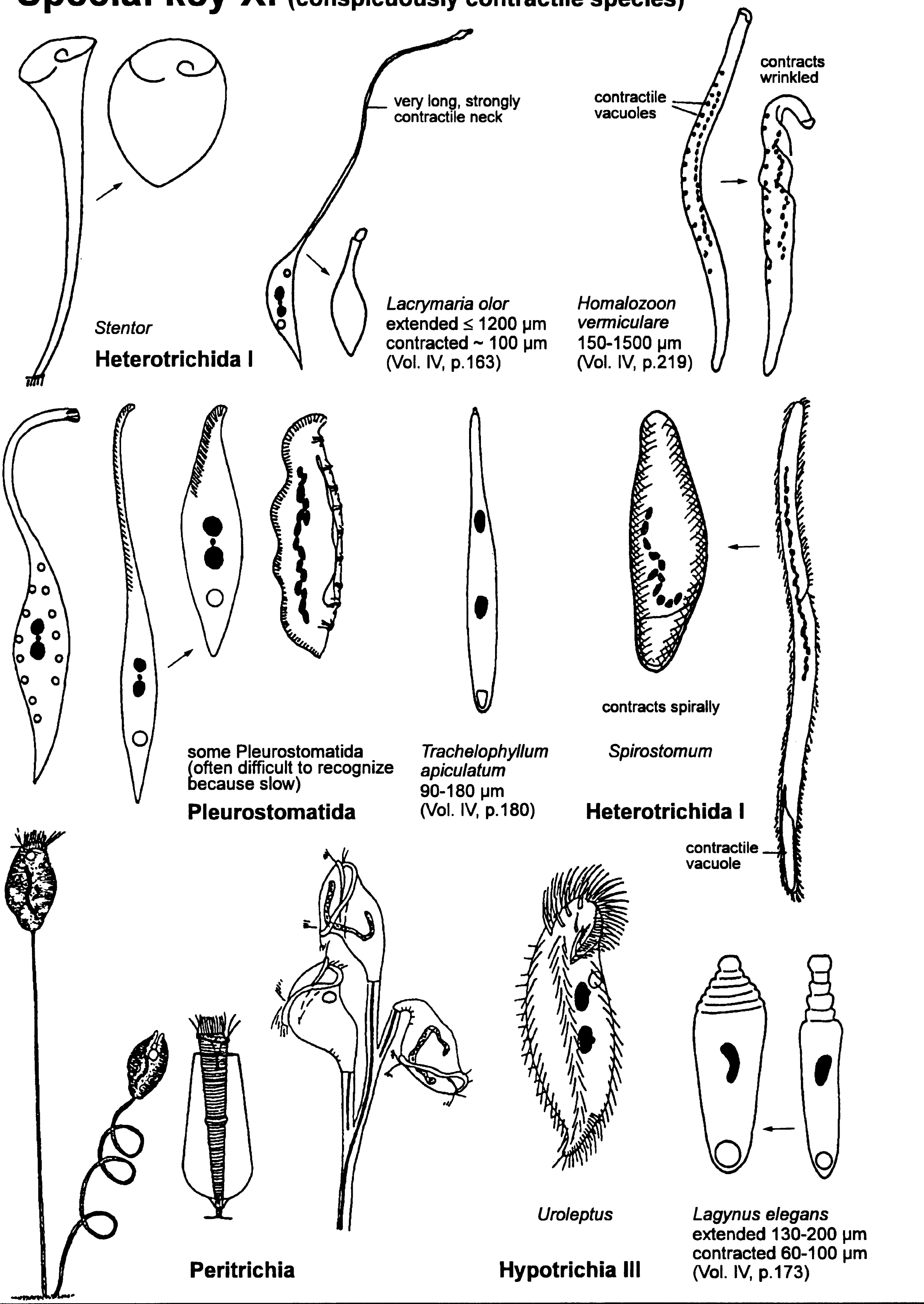
Nassula ornata
155-320 μm
(Vol. III, p.436)

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

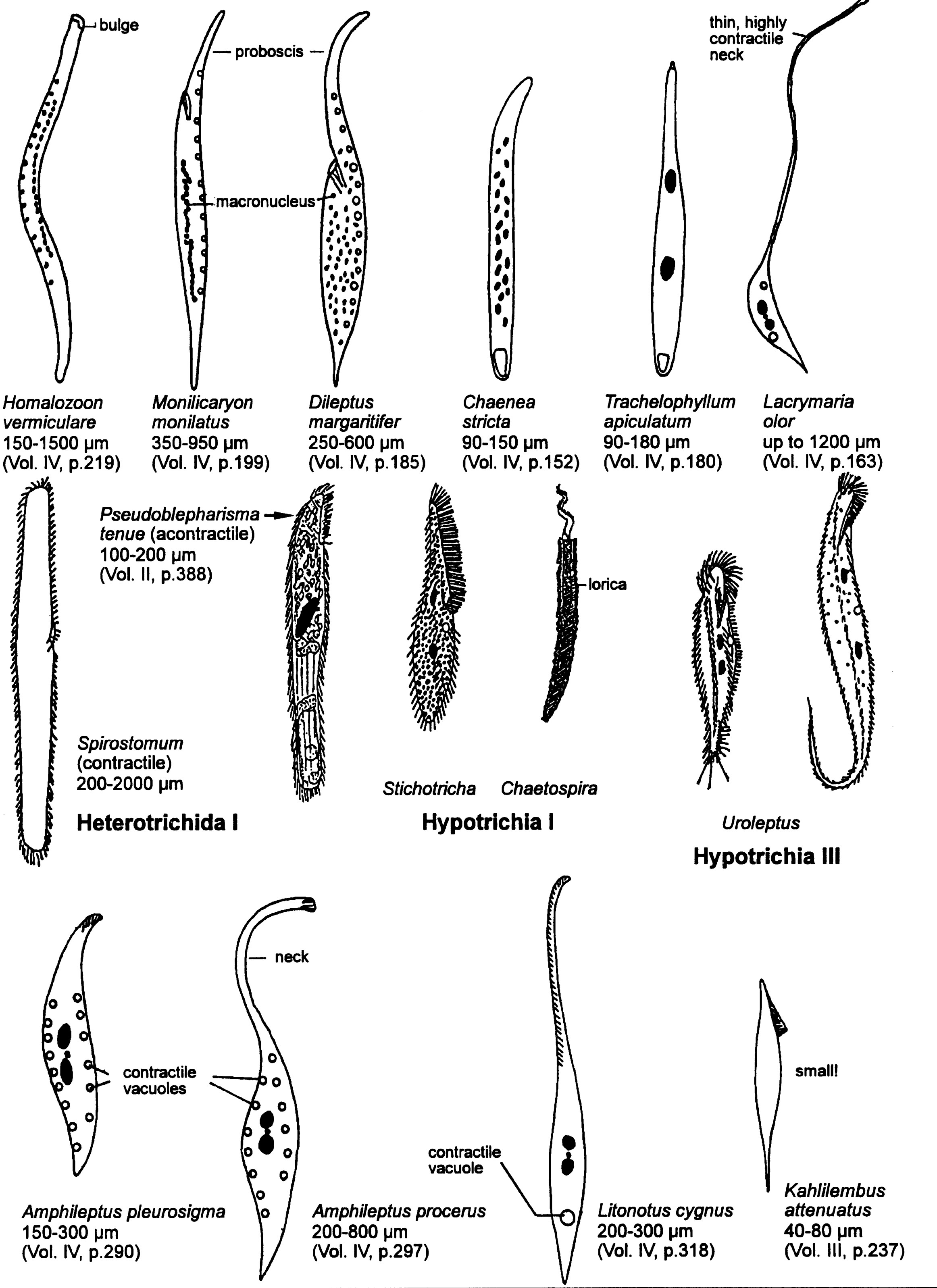
Prorodon niveus
250-700 μm
(Vol. III, p.346)

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

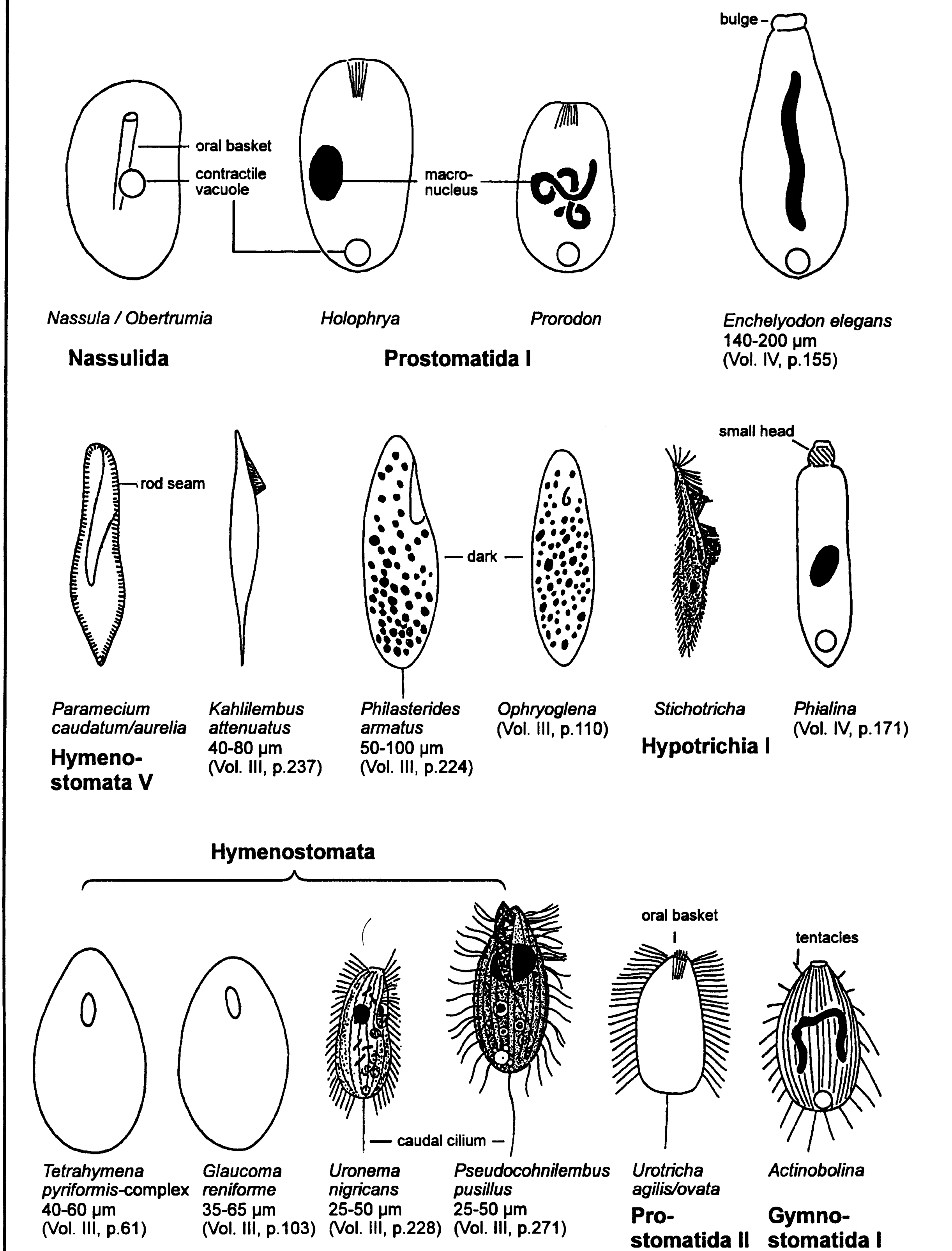
Special key XI (conspicuously contractile species)



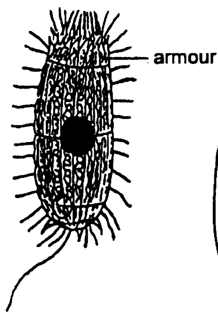
Special key XII (slender species, length : width ratio ≥ 5:1; attention, often highly contractile and then becoming more blunt)



Special key XIII (cylindroid, fusiform or ovoid species)

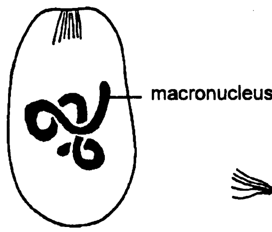


Special key XIV (barrel-shaped, ellipsoid or like a segment of a circle)

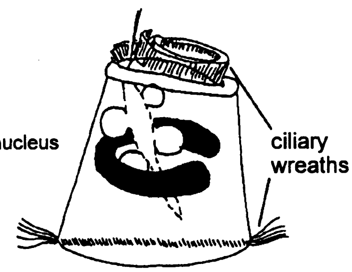


Coleps

Prostomatida I

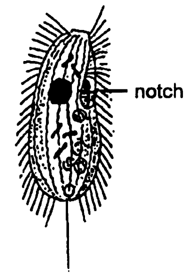


Prorodon ellipticus
80-150 µm
(Vol. III, p.344)

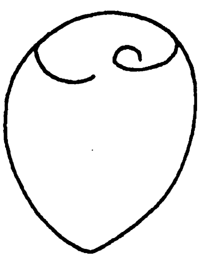


Opisthonecta henneguyi
or swarmers of
sessile peritrichs

Peritrichia

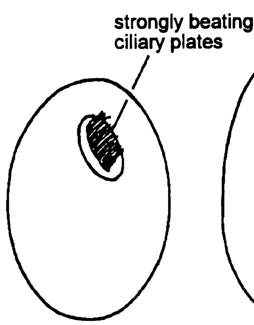


Uronema nigricans
25-50 µm
(Vol. III, p.228)

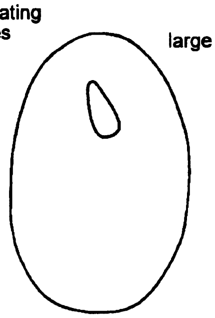


contracted
Stentor

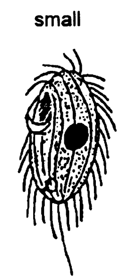
**Hetero-
trichida I**



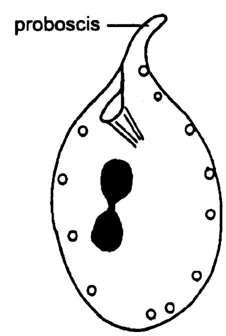
Glaucoma scintillans
35-75 µm
(Vol. III, p.92)



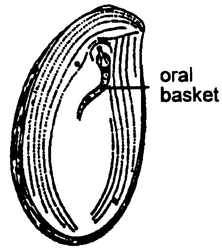
Epenardia myriophylli
90-200 µm
(Vol. III, p.106)



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

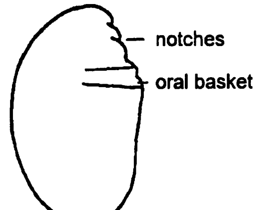


Trachelius ovum
200-600 µm
(Vol. IV, p.208)

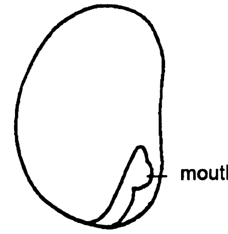


Odontochlamys alpestris
35-60 µm
(Vol. I, p.52)

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

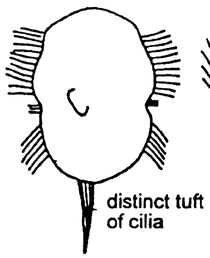


Leptopharynx costatus
20-50 µm
(Vol. III, p.460)

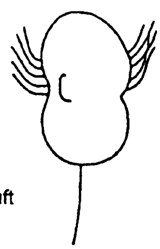


Microthorax pusillus
20-35 µm
(Vol. III, p.478)

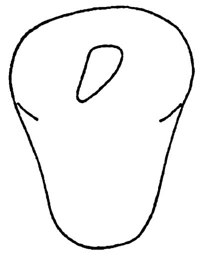
Special key XV (dumb-bell shaped or spatular)

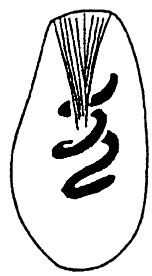


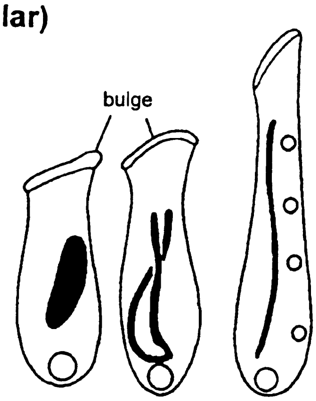
small!



planktonic!







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

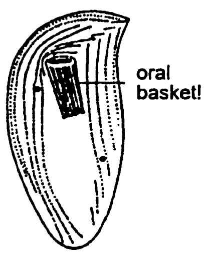
Urozona buetschlii
20-40 μm
(Vol. III, p.268)

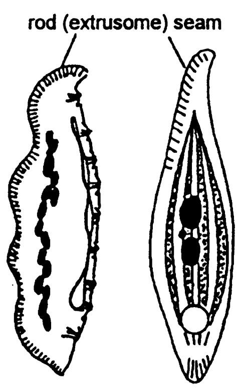
Marituja pelagica
80-160 μm
(Vol. III, p.195)

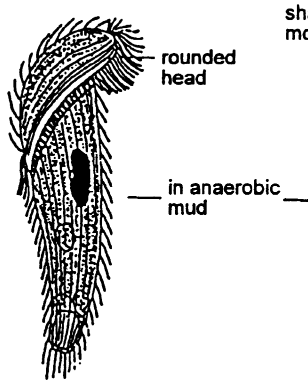
Prorodon niveus
250-700 μm
(Vol. III, p.346)

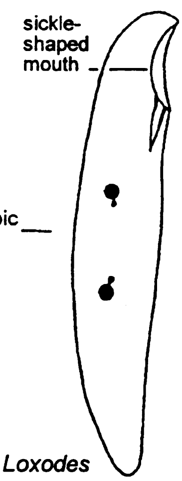
Spathidium
(Vol. IV, p.226)

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







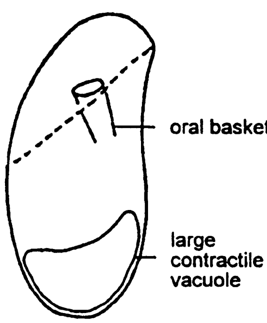


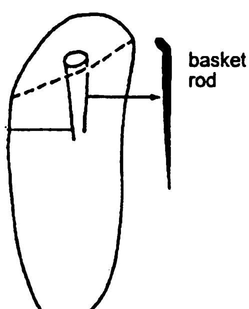
Pseudochilodonopsis
Cyrtophorida II

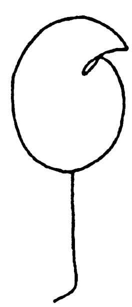
many
Pleurostomatida

Metopus
Heterotrichida II

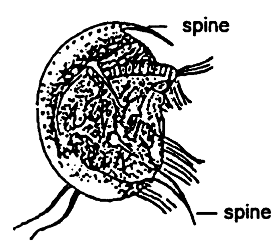
Loxodes
Loxodes







in anaerobic mud



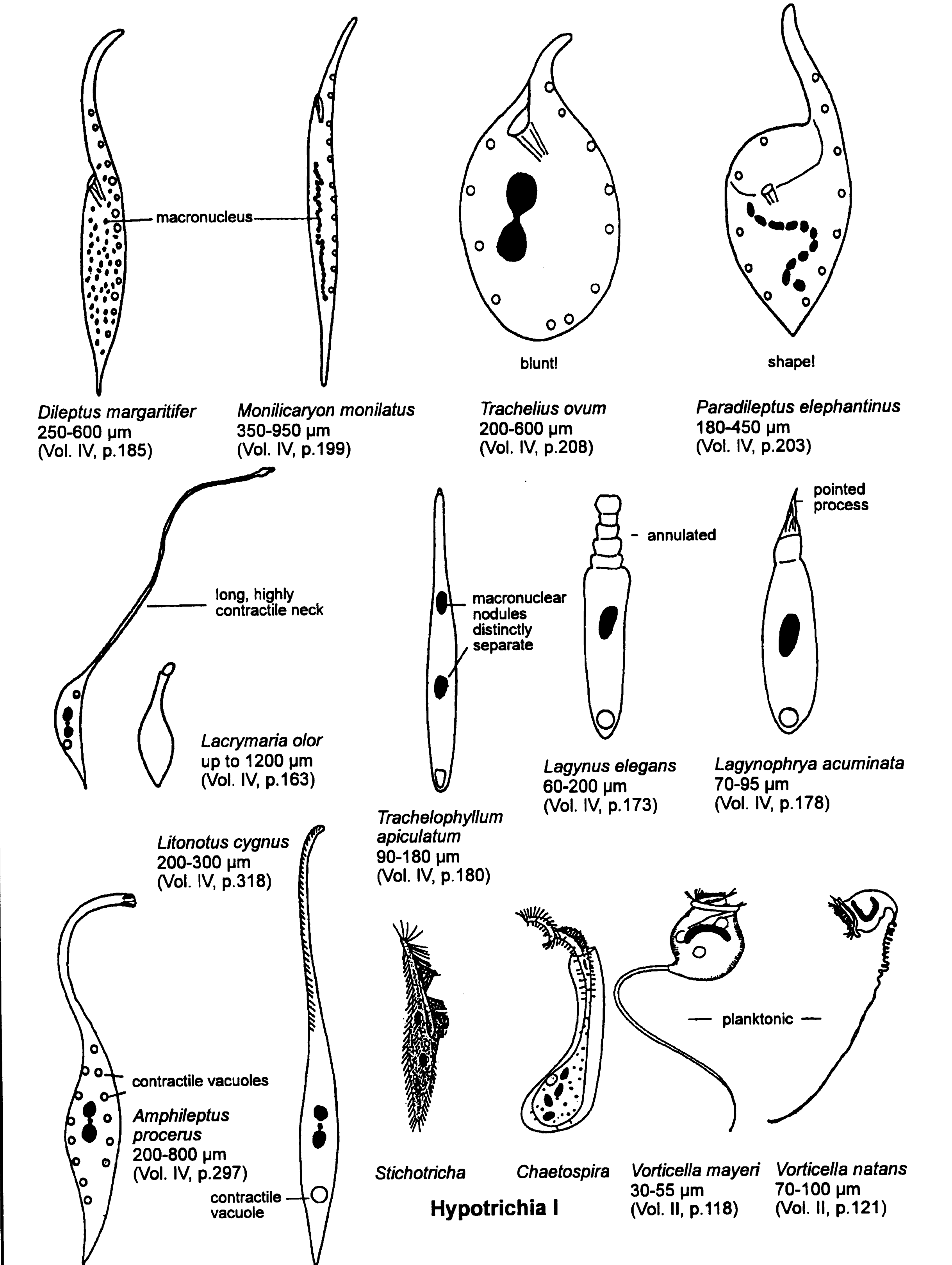
Chilodontopsis depressa
50-80 μm
(Vol. III, p.424)

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

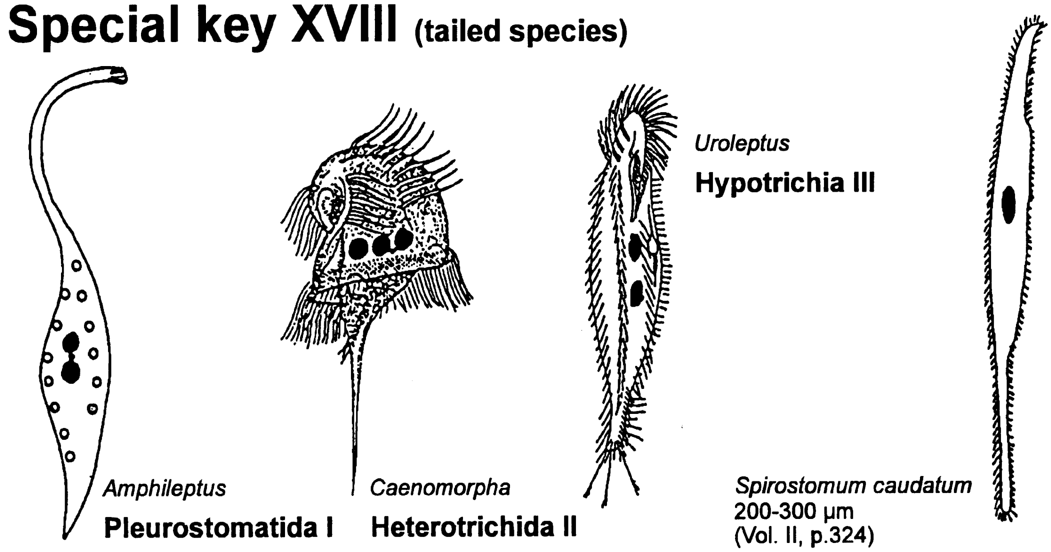
Hexotricha caudata
25-30 μm
(Vol. III, p.483)

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

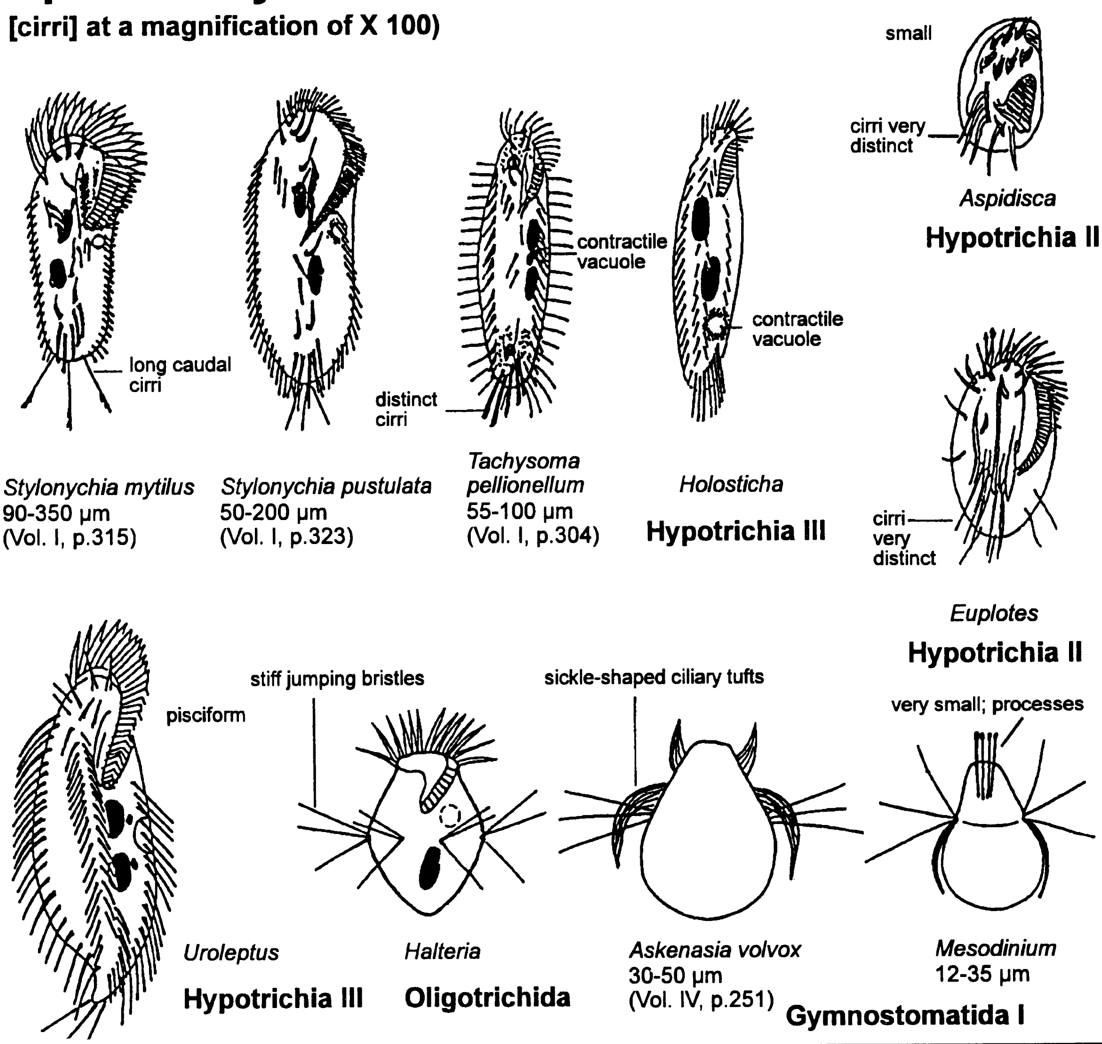
Special key XVII (species with proboscis or proboscis-like process)



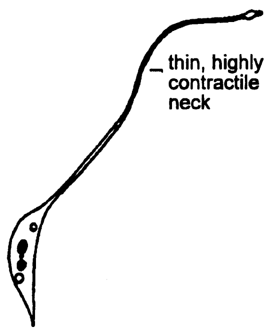
Special key XVIII (tailed species)



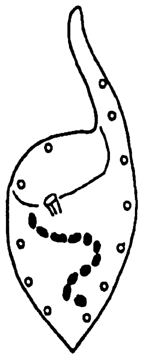
Special key XIX (species having conspicuous "somatic cilia" [cirri] at a magnification of X 100)



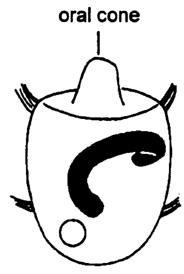
Special key XX (species with bizarre shape)



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

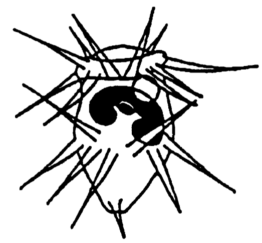


Paradileptus elephantinus
180-450 µm
(Vol. IV, p.203)



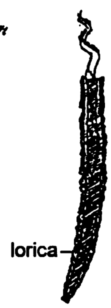
Didinium/Monodinium

Gymnostomatida I



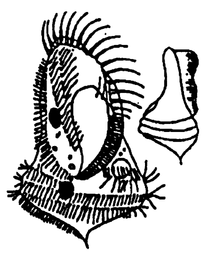
Hastatella radians
40-60 µm
(Vol. II, p.295)

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

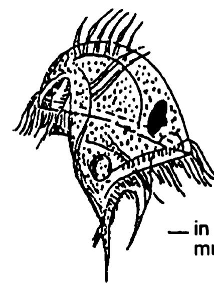


Chaetospira

Hypotrichia I

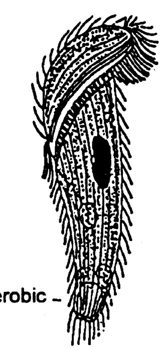


Hypotrichidium conicum
90-120 µm
(Vol. I, p.218)

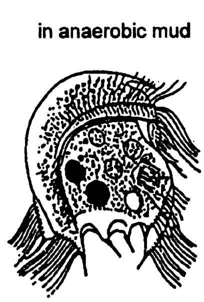


Caenomorpha
(Vol. II, p.424)

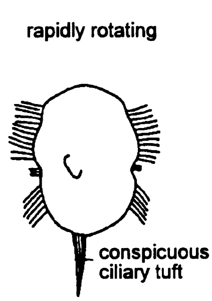
in anaerobic mud



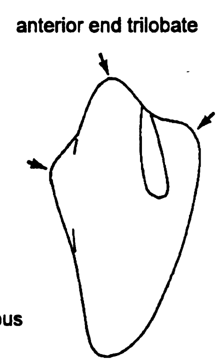
Metopus
(Vol. II, p.400)



Odontostomatida

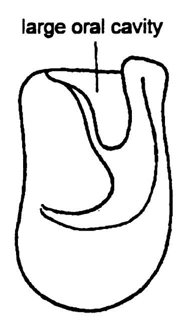


Urocentrum turbo
40-110 µm
(Vol. III, p.187)



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

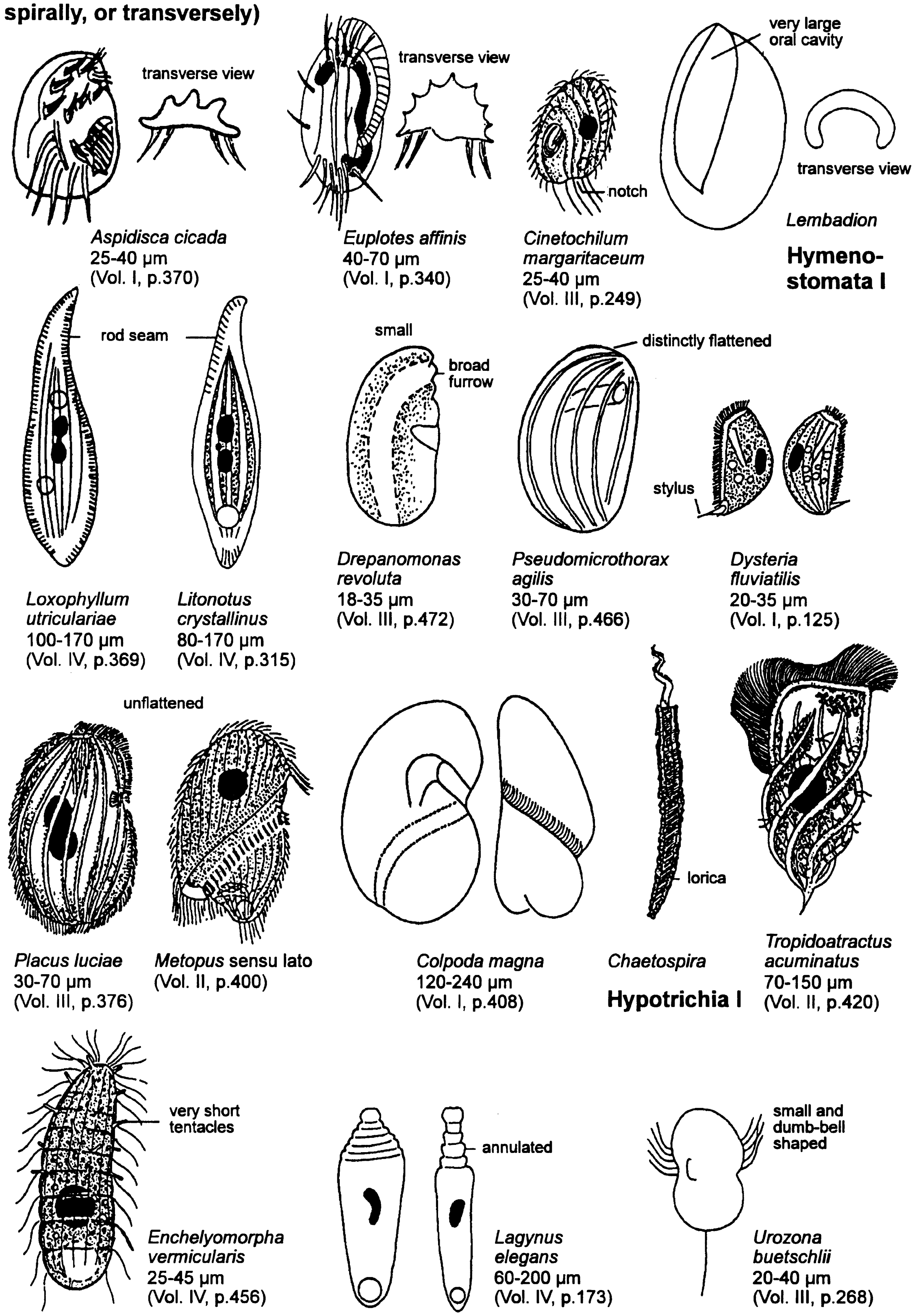
Stokesia vernalis
60-160 µm
(Vol. III, p.200)



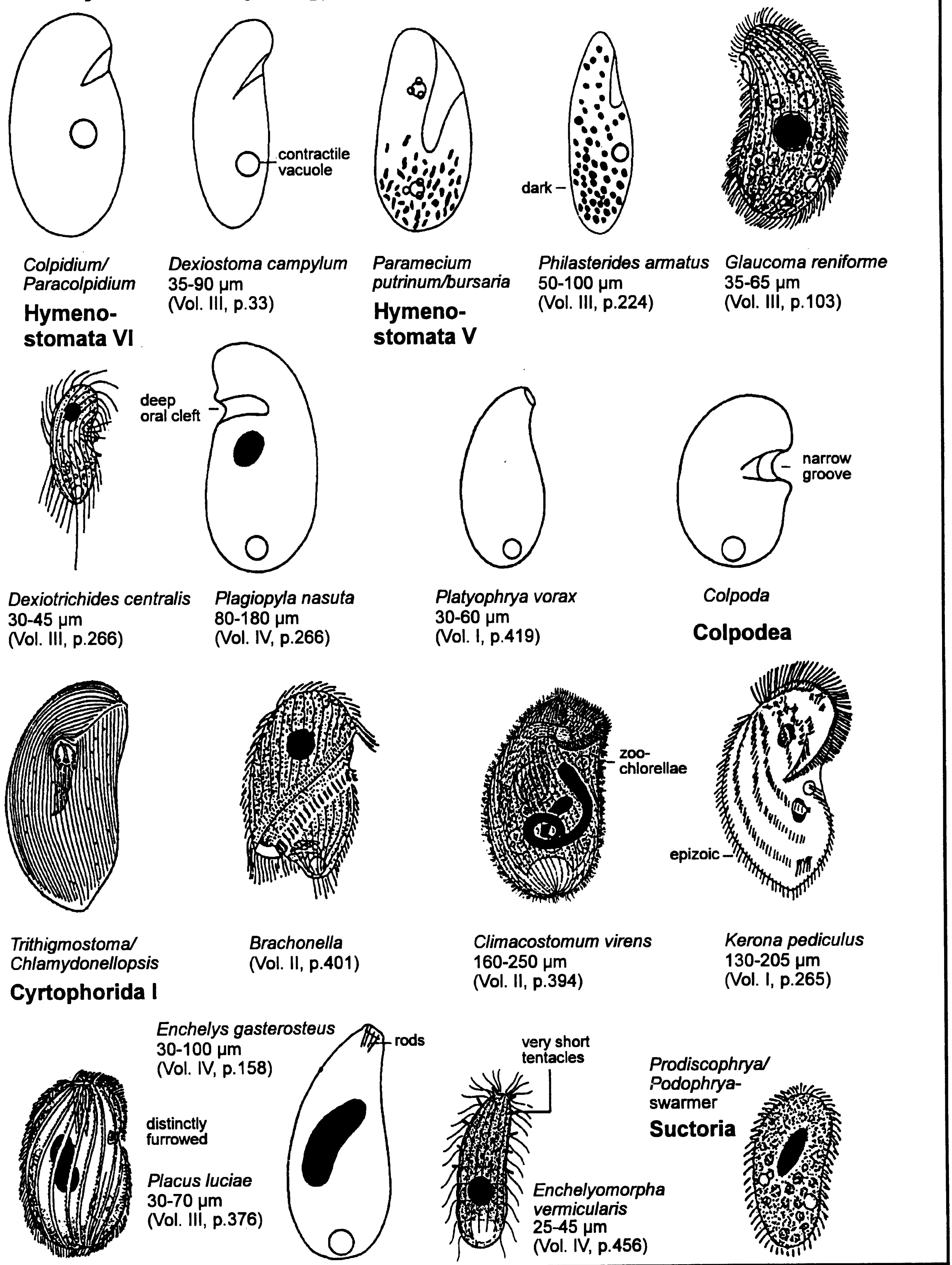
Bursaria/Bursaridium

Colpodea

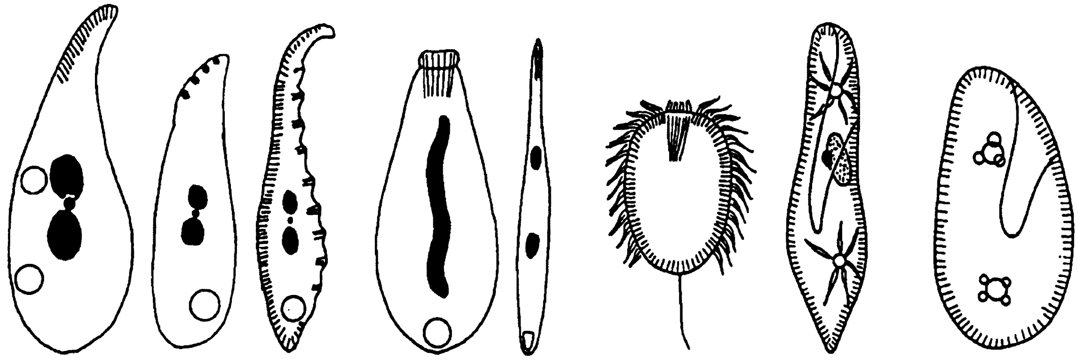
Special key XXI (species distinctly furrowed longitudinally, spirally, or transversely)



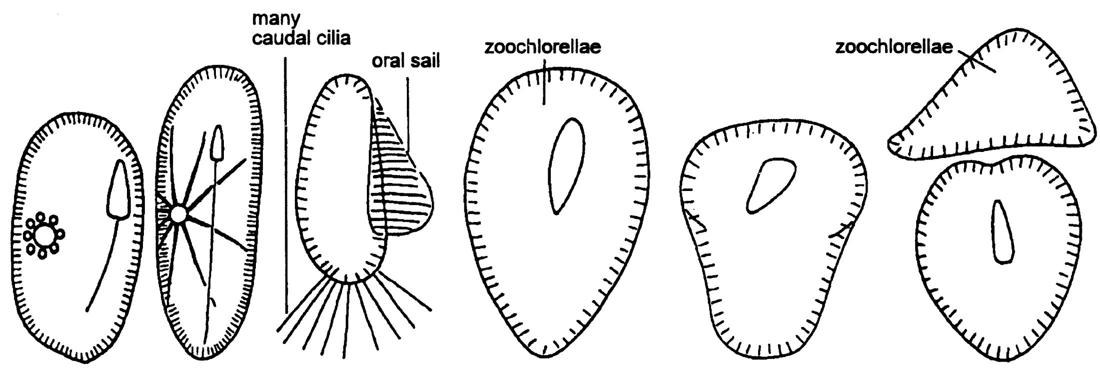
Special key XXII (reniform, i.e. laterally indented species; indentation usually marks oral opening)



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



Pleurostomatida **Gymnostomatida** *Urotricha armata* 30-55 µm (Vol. III, p.362) *Paramecium* **Hymenostomata V**



Frontonia **Hymenostomata V**

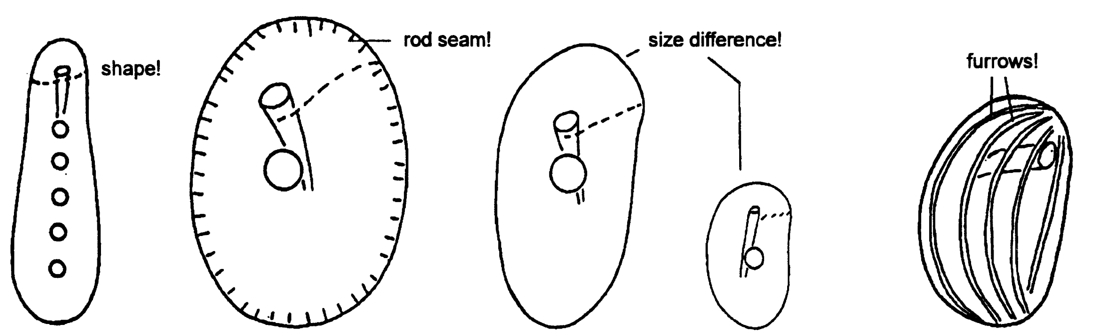
Pleuronema **Hymenostomata III**

Disematostoma **Hymenostomata IV**

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

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

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



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

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

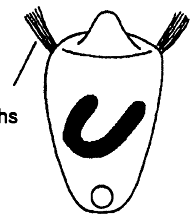
Obertrumia aurea 120-250 µm (Vol. III, p.451)

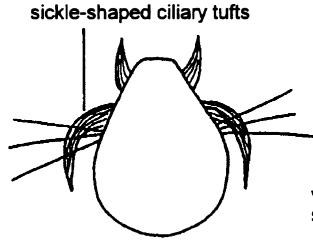
Nassula picta 70-140 µm (Vol. III, p.445)

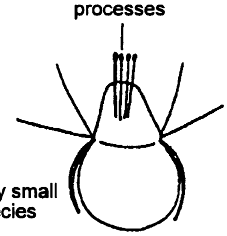
Pseudomicrothorax agilis 30-70 µm (Vol. III, p.466)

Special key XXV (species with conspicuous movement)

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





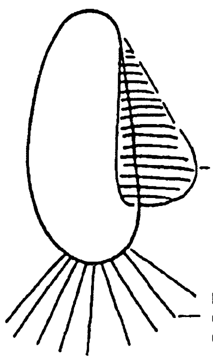


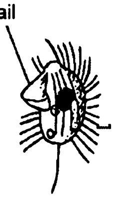
Didinium nasutum
80-200 µm
(Vol. IV, p.228)

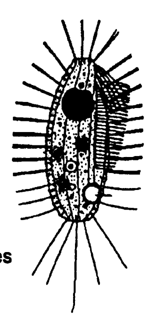
Monodinium balbianii
50-120 µm
(Vol. IV, p.235)

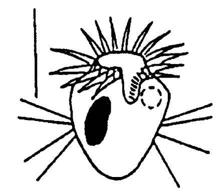
Askenasia volvox
30-50 µm
(Vol. IV, p.251)

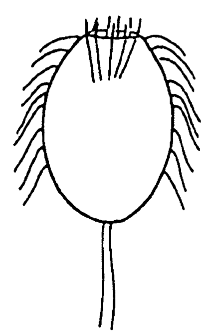
Mesodinium
12-35 µm
Gymnostomatida I











Pleuronema
Hymeno-stomata III

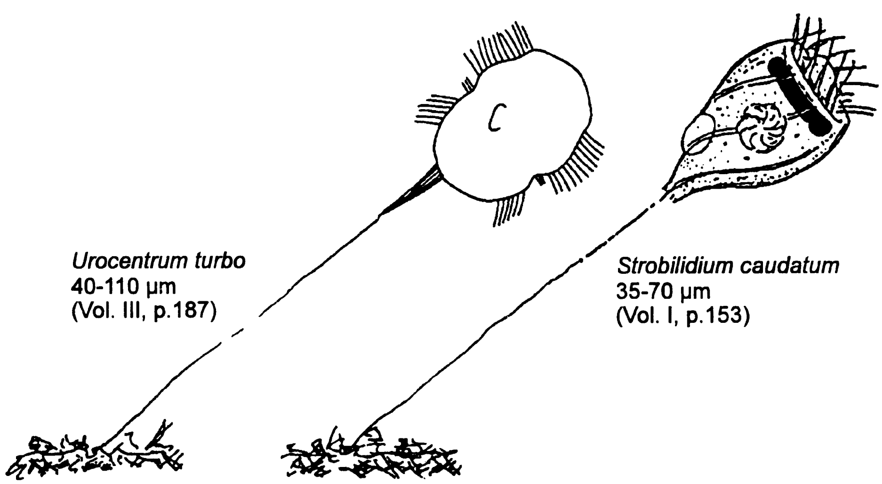
Cyclidium
Hymeno-stomata VII

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

Oligotrichida

Urotricha
Prostomatida II

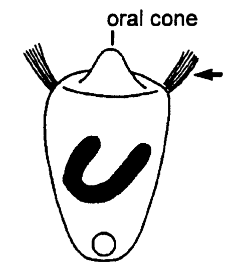
rotating on mucuous filament



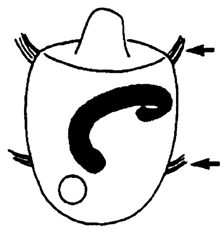
Urocentrum turbo
40-110 µm
(Vol. III, p.187)

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

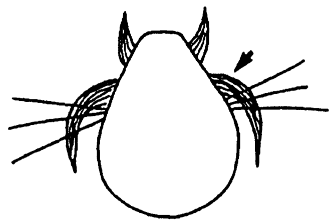
Special key XXVI (species with conspicuous ciliary wreaths [arrows])



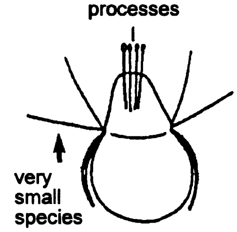
Monodinium balbianii
50-120 µm
(Vol. IV, p.235)



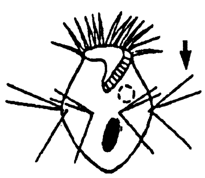
Didinium nasutum
80-200 µm
(Vol. IV, p.228)



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

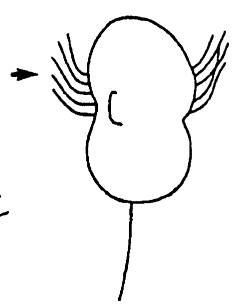


Mesodinium
12-35 µm
Gymnostomatida I



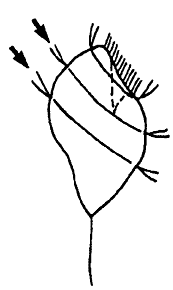
Halteria/
Pelagohalteria
Oligotrichida I

dumb-bell shaped

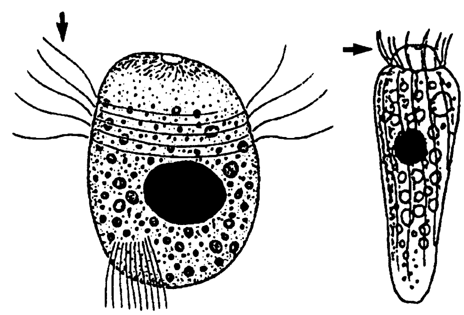


Urozona buetschlii
20-40 µm
(Vol. III, p.268)

blunt, fusiform

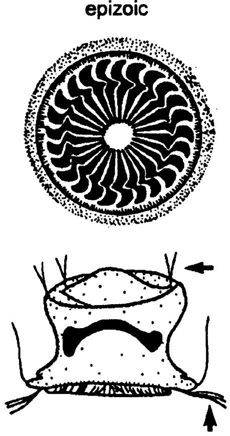


Trimyema compressum
25-60 µm
(Vol. III, p.408)

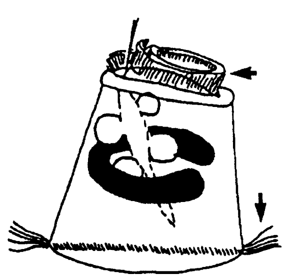


swarmers of suctorians
(indeterminable)

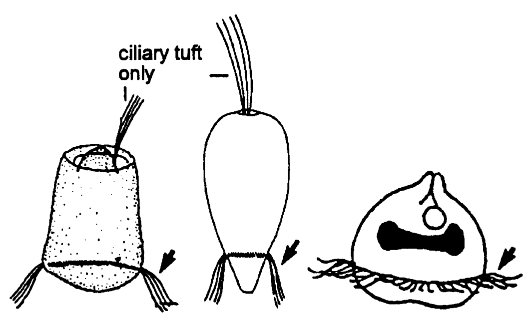
epizoic



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

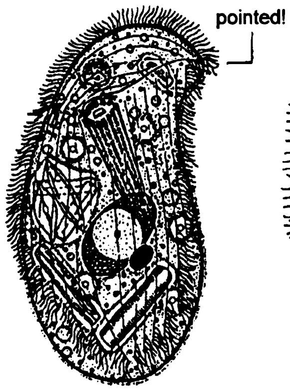


Opisthonecta henneguyi
100-150 µm
(Vol. II, p.299)

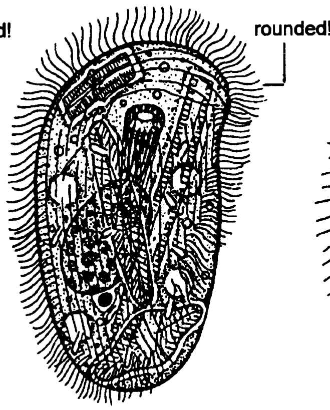


swarmers of peritrichs
(indeterminable)

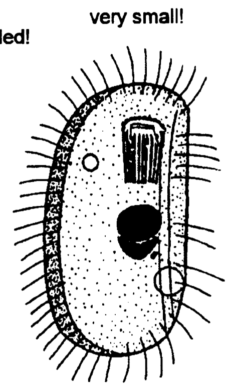
Special key XXVII (species which are frequently densely filled with ingested diatoms)



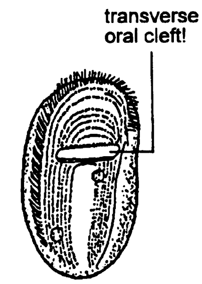
Trithigmostoma
Cyrtophorida I



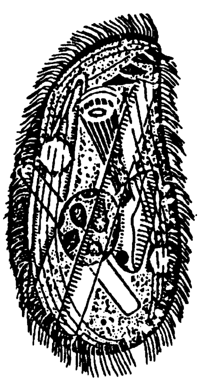
Chlamydonellopsis plurivacuolata
50-110 µm
(Vol. I, p.110)



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

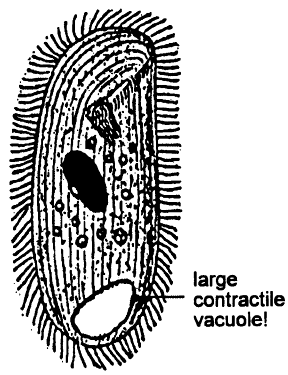


Gastronauta
Cyrtophorida I

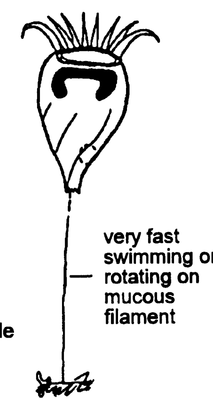


Pseudochilodonopsis
Cyrtophorida II

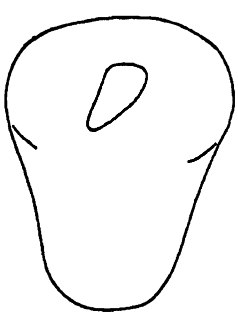
Zosterodasys transversa
130-250 µm
(Vol. III, p.418)



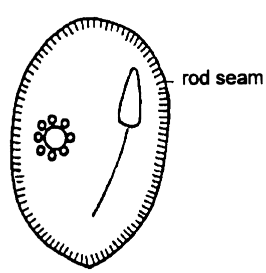
Chilodontopsis depressa
50-80 µm
(Vol. III, p.424)



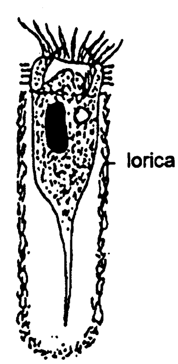
Strobilidium
Oligotrichida



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

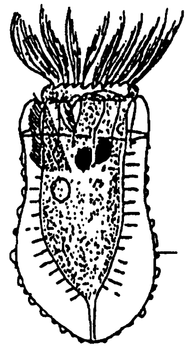


Frontonia
Hymenostomata V

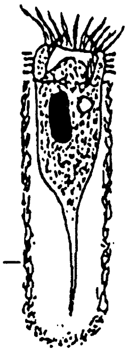


Tintinnidium
Oligotrichida

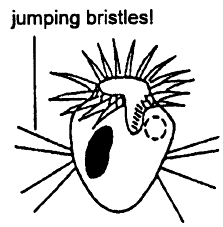
Special key XXVIIIa (euplanktic species)



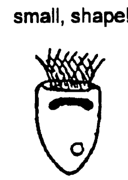
Codonella cratera
50-70 µm
(Vol. I, p.183)



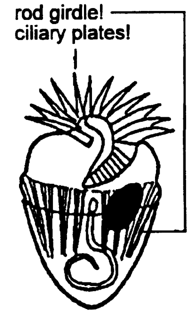
Tintinnidium/ Tintinnopsis



Halteria/ Pelagohalteria

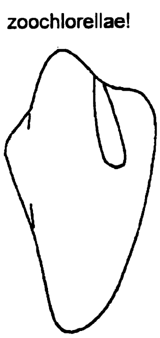


Strobilidium humile
12-38 µm
(Vol. I, p.159)



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

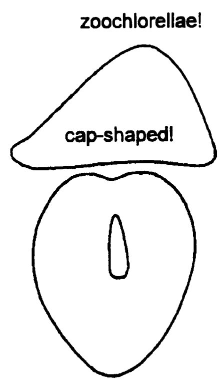
Oligotrichida



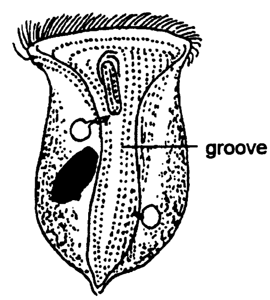
Disematostoma

Hymeno-stomata IV

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

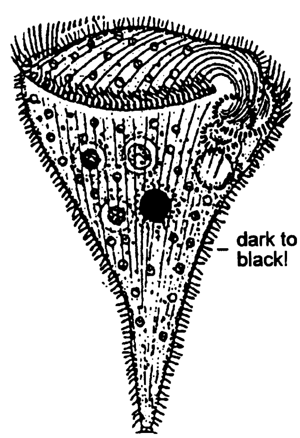


Stokesia vernalis
60-160 µm
(Vol. III, p.200)

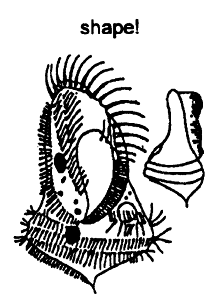


Phascolodon vorticella
50-110 µm
(Vol. I, p.98)

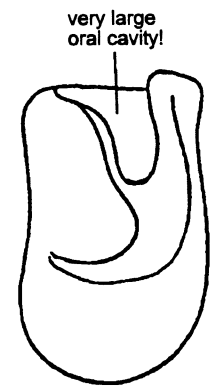
Linostoma vorticella
about 170 µm
(Vol. II, p.390)



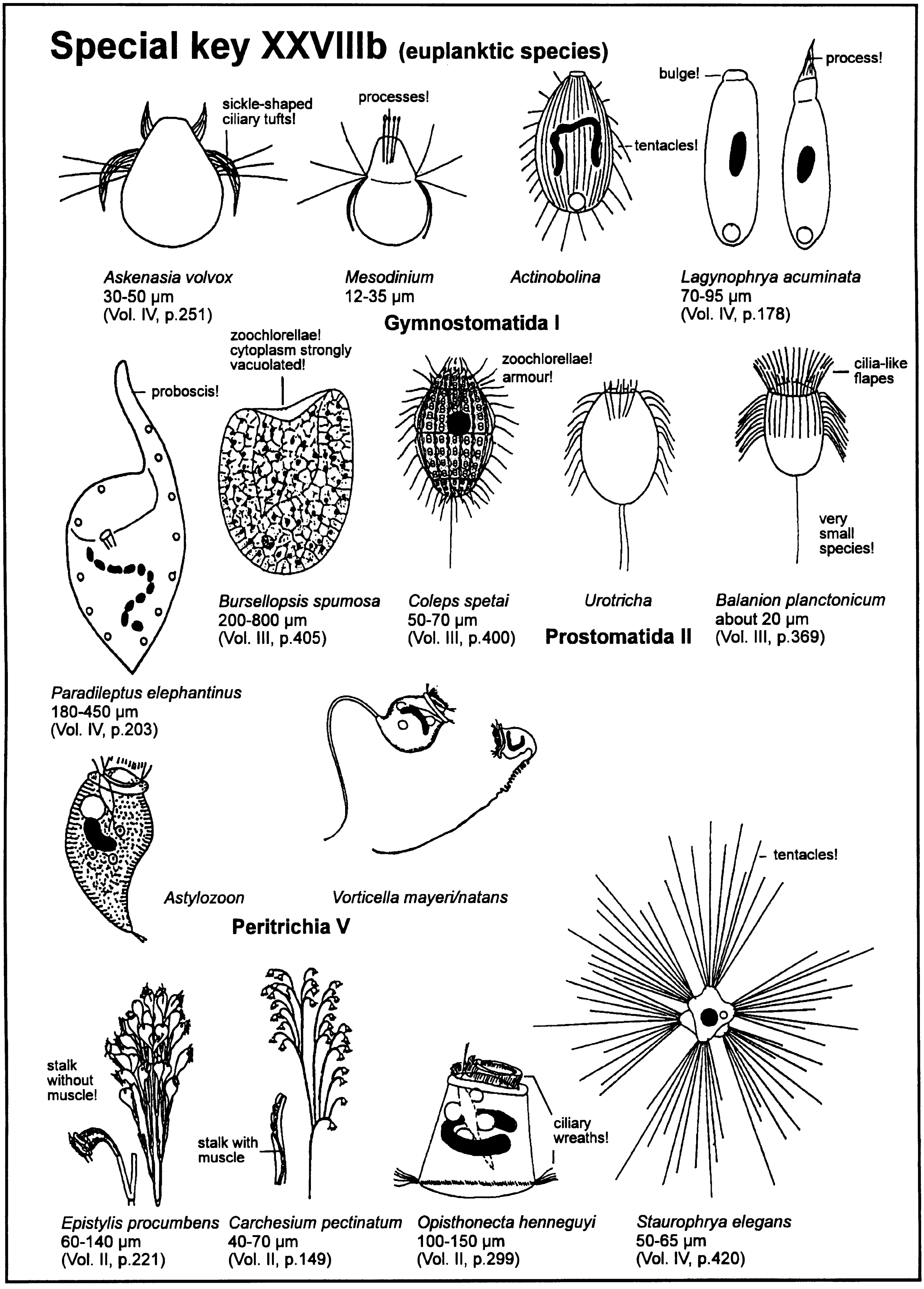
Stentor amethystinus
250-500 µm
(Vol. II, p.339)



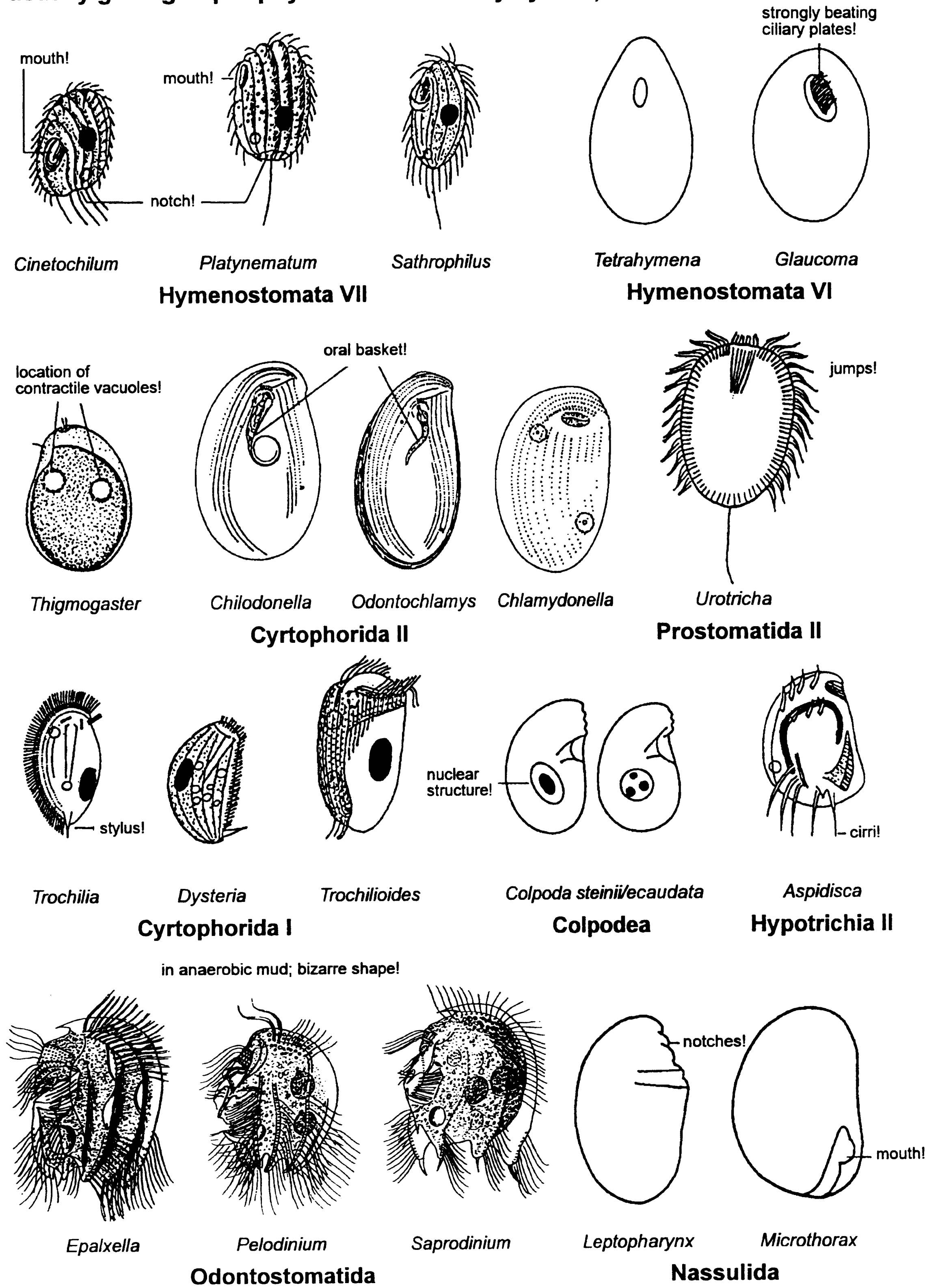
Hypotrichidium conicum
90-120 µm
(Vol. I, p.218)



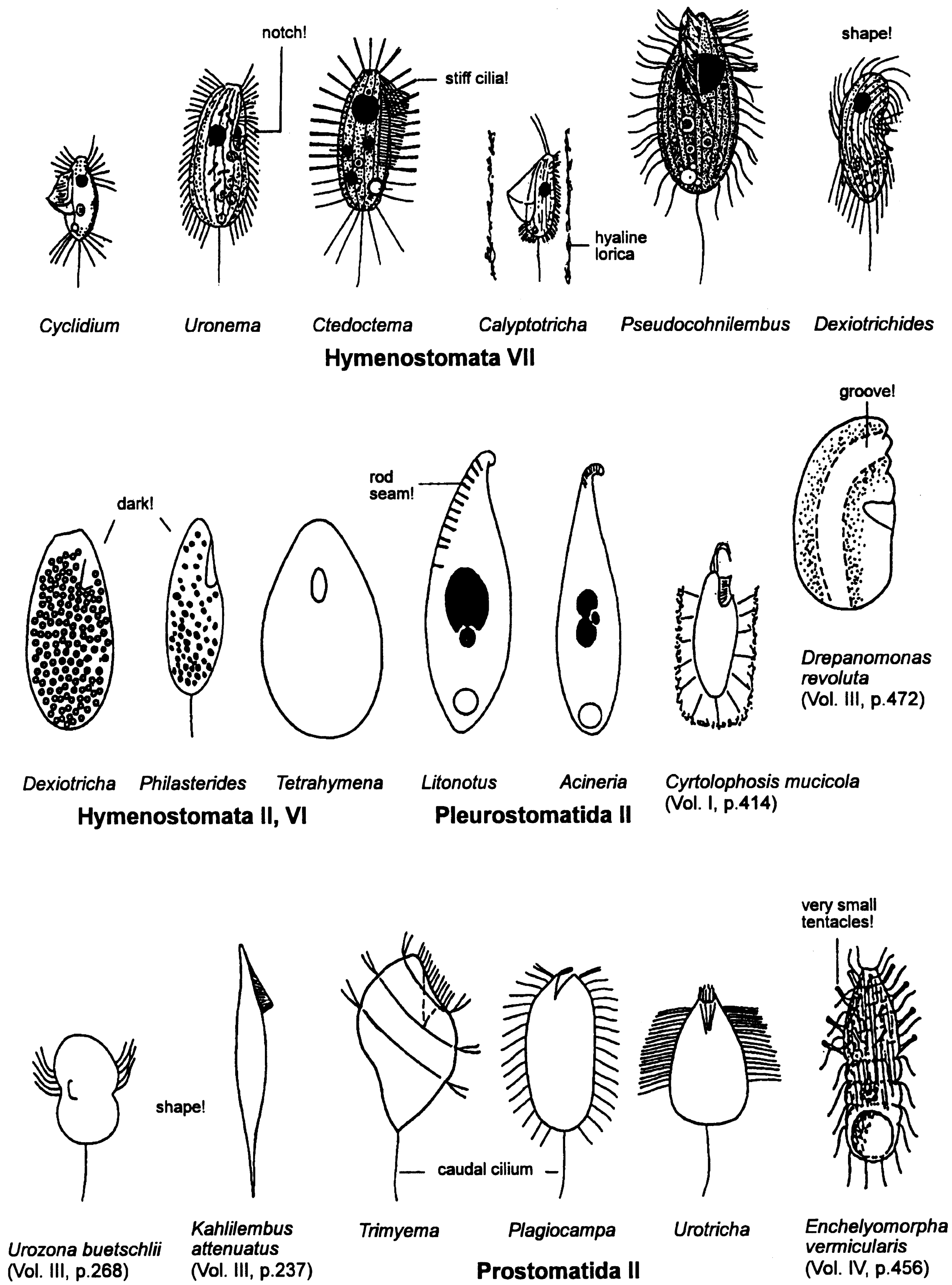
Bursaridium pseudobursaria
80-200 µm
(Vol. I, p.433)


Special key XXVIIIb (euplanktic species)
sickle-shaped ciliary tufts!
processes!
tentacles!
bulge!
process!
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
proboscis!
zoochlorellae! cytoplasm strongly vacuolated!
zoochlorellae! armour!
cilia-like flapes
very small species!
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)
Paradileptus elephantinus
180-450 µm
(Vol. IV, p.203)
Astylozoon
Vorticella mayeri/natans
Peritrichia V
tentacles!
stalk without muscle!
stalk with muscle
ciliary wreaths!
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)

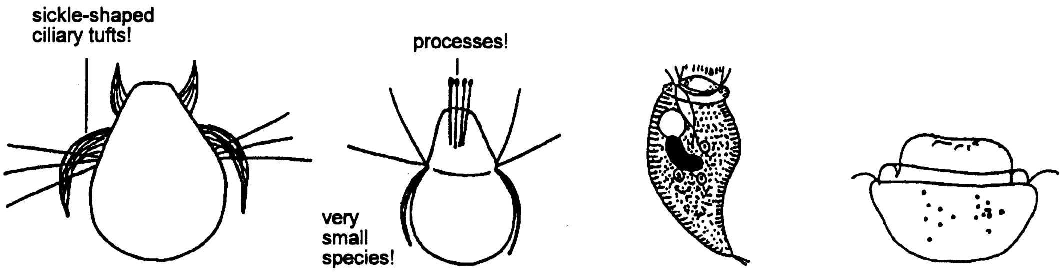
Special key XXIX (15-50 µm [usually < 40 µm] sized, broad species; usually gliding in periphyton and often very hyaline)



Special key XXX (15-50 µm [usually < 40 µm] sized, slender species; usually in detritus)

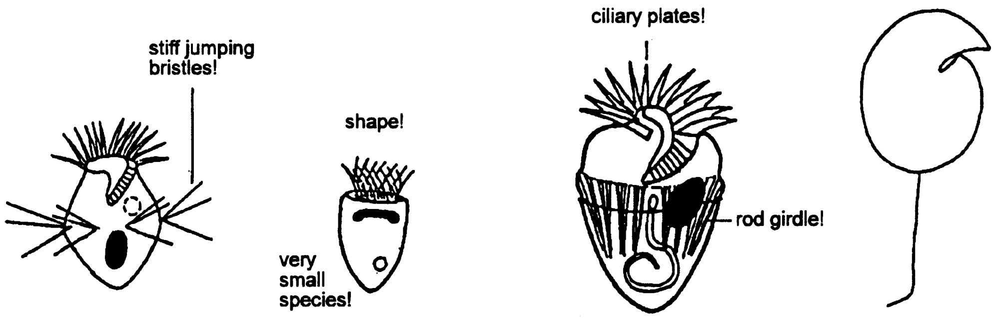


Special key XXXI (15-50 µm [usually < 40 µm] sized, globular or calciform species; usually in plankton)



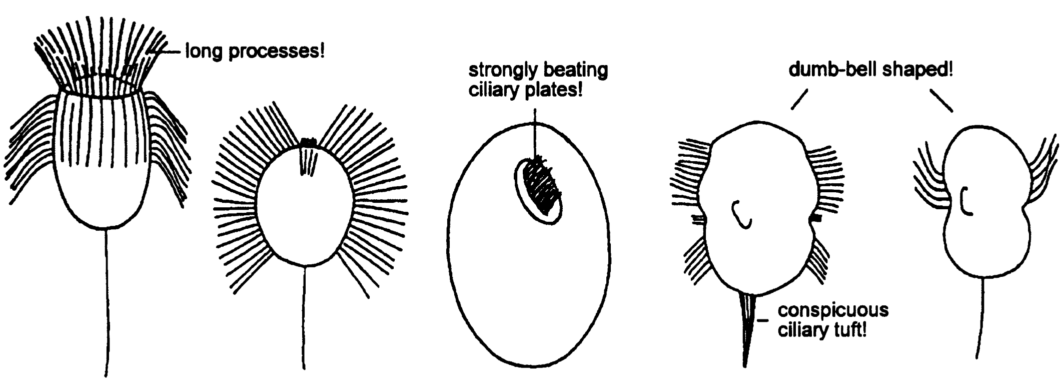
Askenasia volvox *Mesodinium* — **Gymnostomatida I**

Astylozoon swarmer of peritrichs — **Peritrichia V**



Halteria/Pelagohalteria *Strobilidium* *Strombidium* — **Oligotrichida**

Hexotricha caudata (Vol. III, p.483)

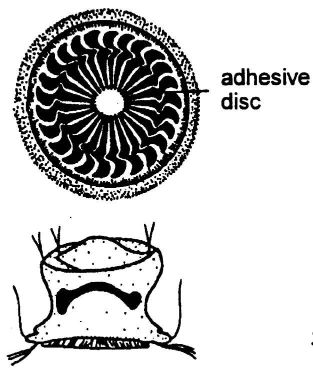


Balanion *Urotricha* — **Prostomatida II**

Glaucoma — **Hymenostomata VI**

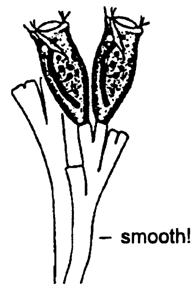
Urocentrum usually > 50 µm
Urozona ≤ 40 µm — **Hymenostomata I**

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

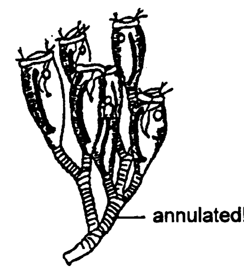


Trichodina pediculus
35-60 µm
on hydras, bryozoans and fishes
(Vol. II, p.304)

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



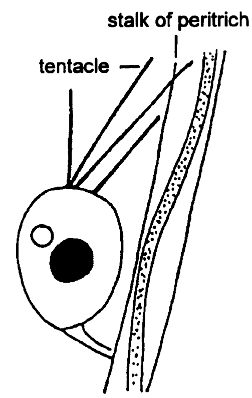
Epistylis nympharum
80-130 µm
colonial on arthropods
(Vol. II, p.217)



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

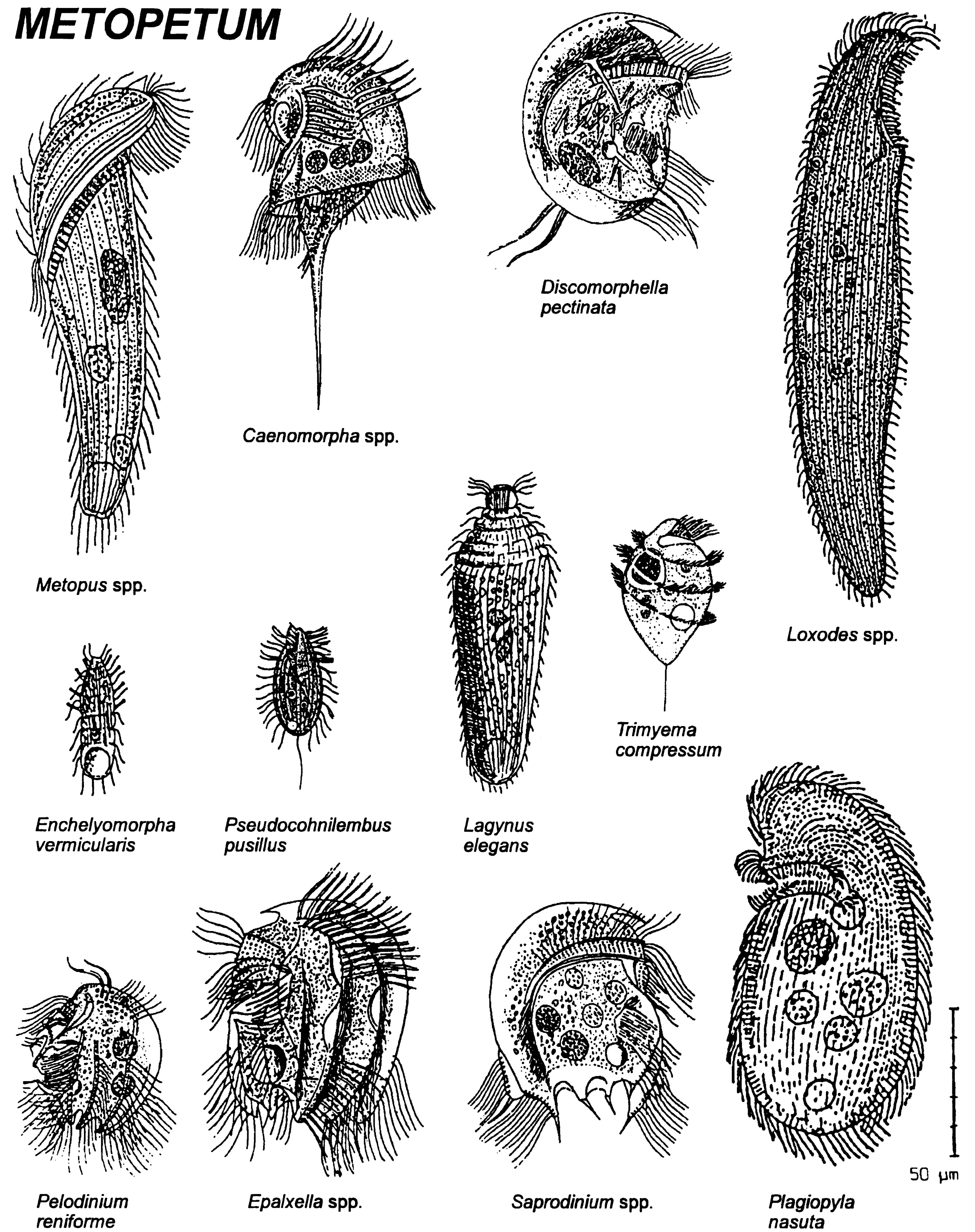
Lagenophrys vaginicola
45-80 µm
on small crustaceans
(Vol. II, p.256)

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

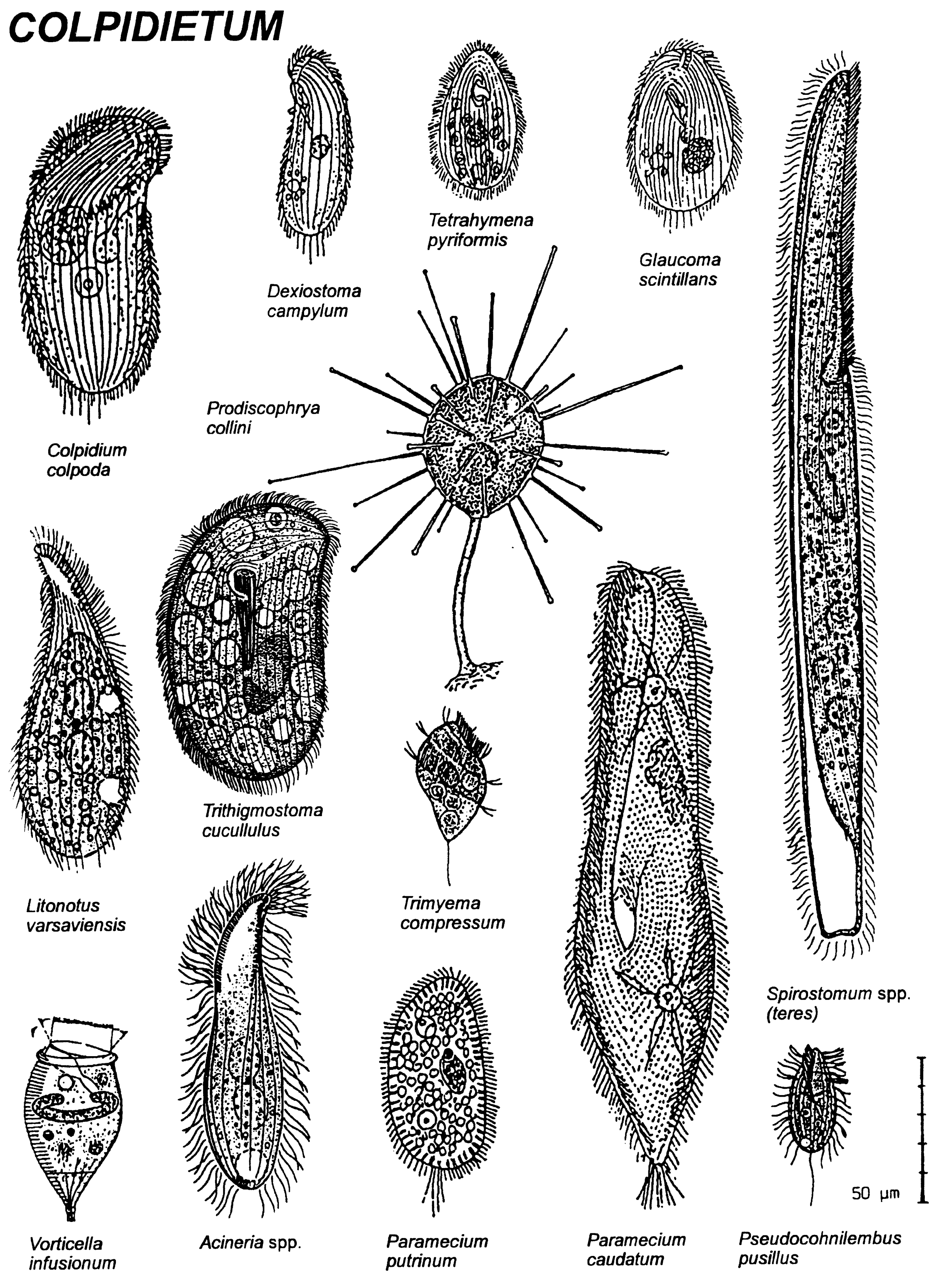


Tokophrya carchesii
25-85 µm
on peritrichs, especially on *Carchesium*
(Vol. IV, p.417)

Ciliate communities, an important aid for water quality evaluation

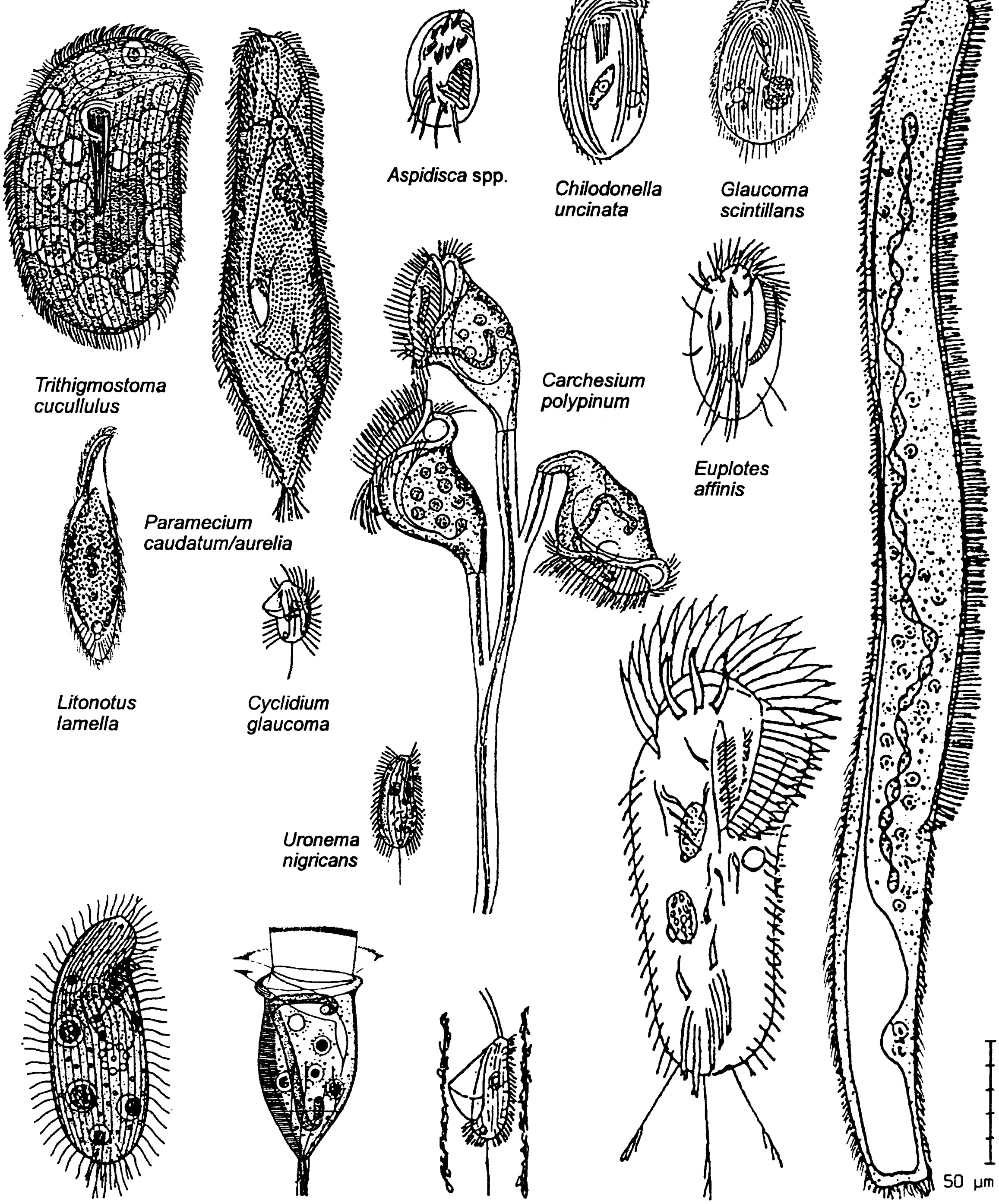


Ciliate community of anaerobic mud (*Metopetum*). Indicator species are members of the genus *Metopus* (s.l.) and certain heterotrichs (all described in Vol. II). Most of the species belonging to the *Metopetum* are strictly bound to anaerobic conditions, i.e. oxygen is poisonous for them; they do not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

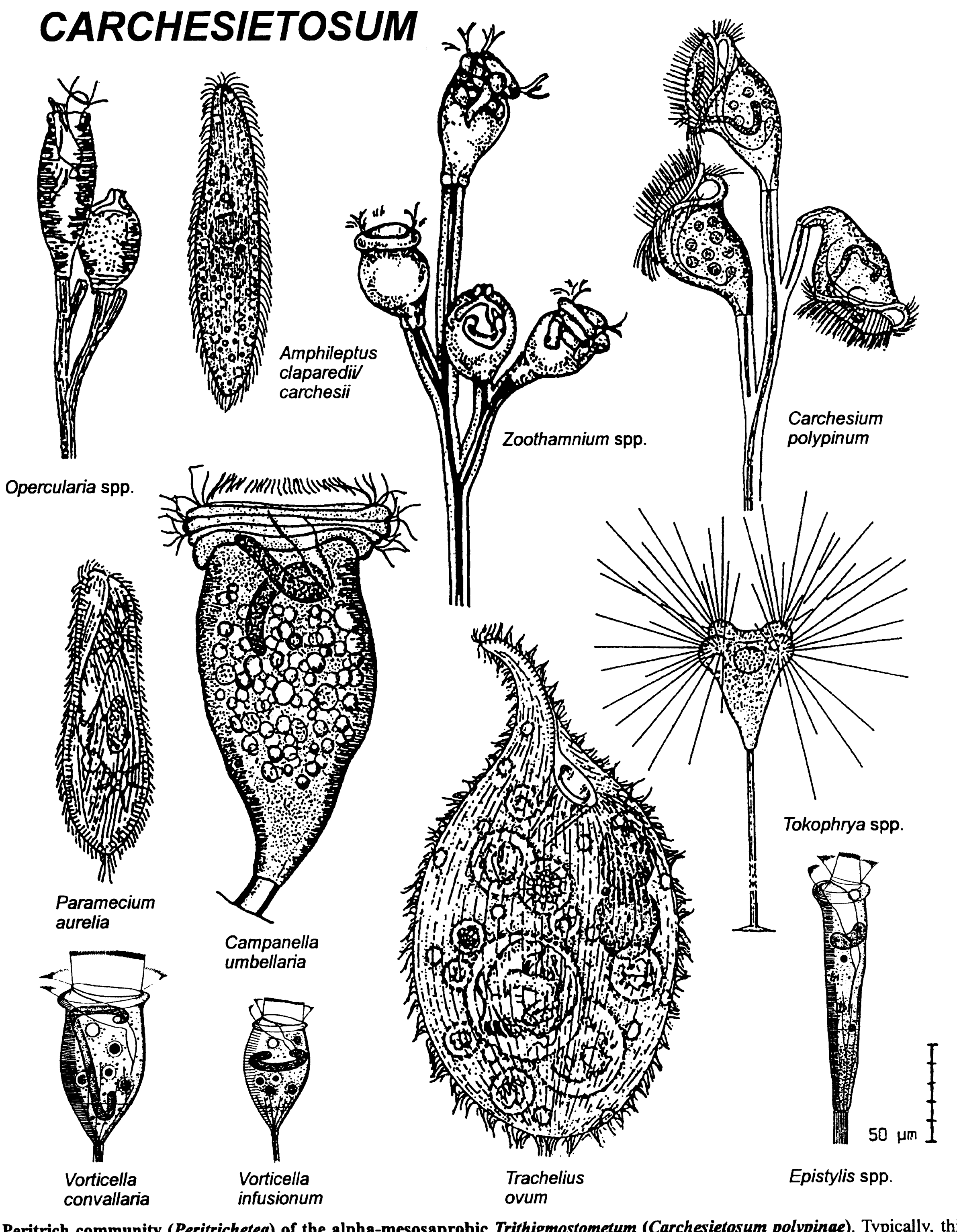


Ciliate community of the polysaprobic self-purification zone *(Colpidietum colpodae).* Indicator species is *Colpidium colpoda*, a hymenostome ciliate (Vol. III). Decomposition is very intensive in this zone and dissolved oxygen is thus usually almost depleted. Few ciliate species (usually < 25 in a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

TRITHIGMOSTOMETUM

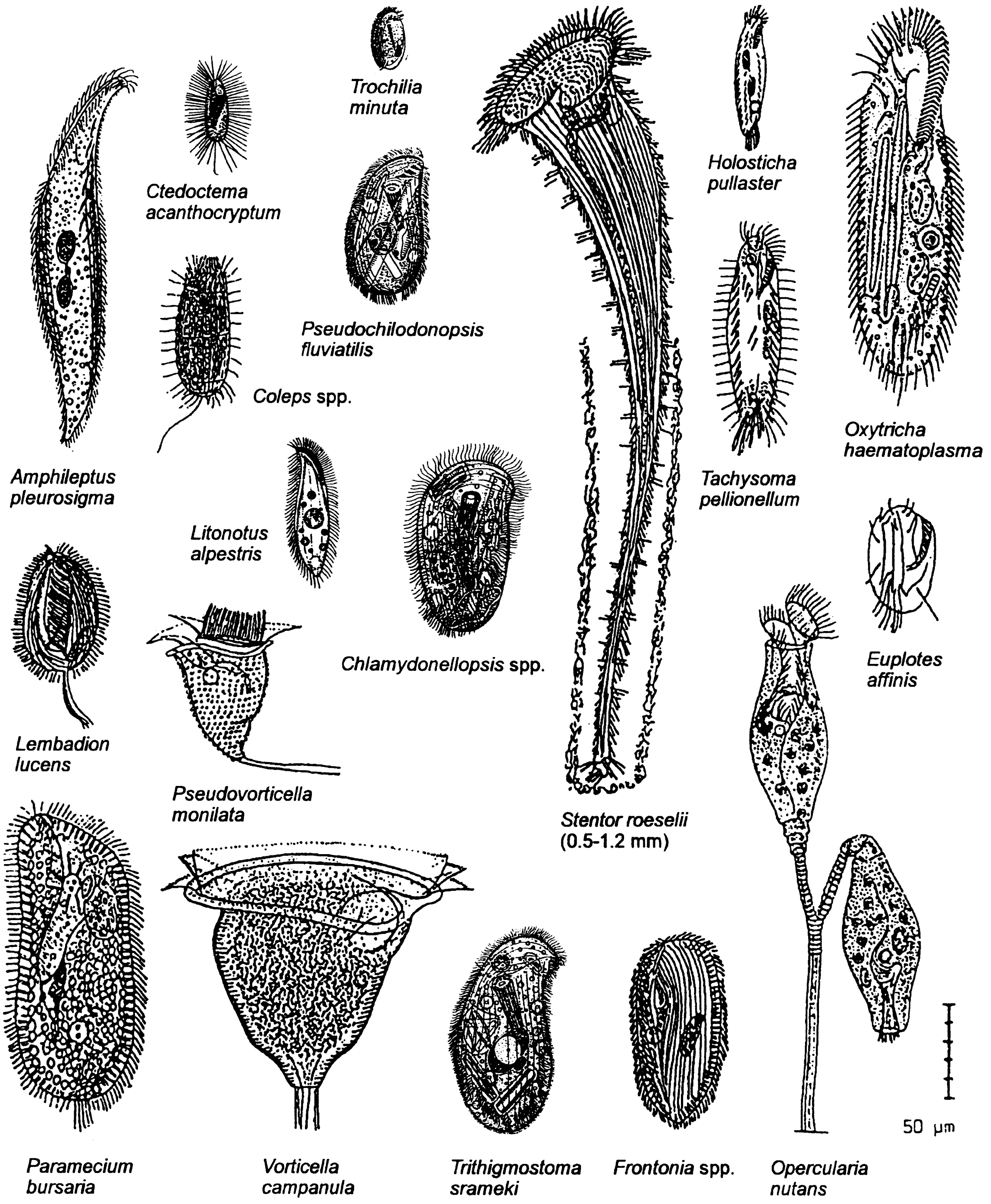


Ciliate community of the alpha-mesosaprobic self-purification zone *(Trithigmostometum cucullulae)*. Indicator species is *Trithigmostoma cucullulus*, a cyrtophorid ciliate (Vol. I). Rather many ciliate species (up to 50 in a sample) occur already in this zone, some have high or very high abundances.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

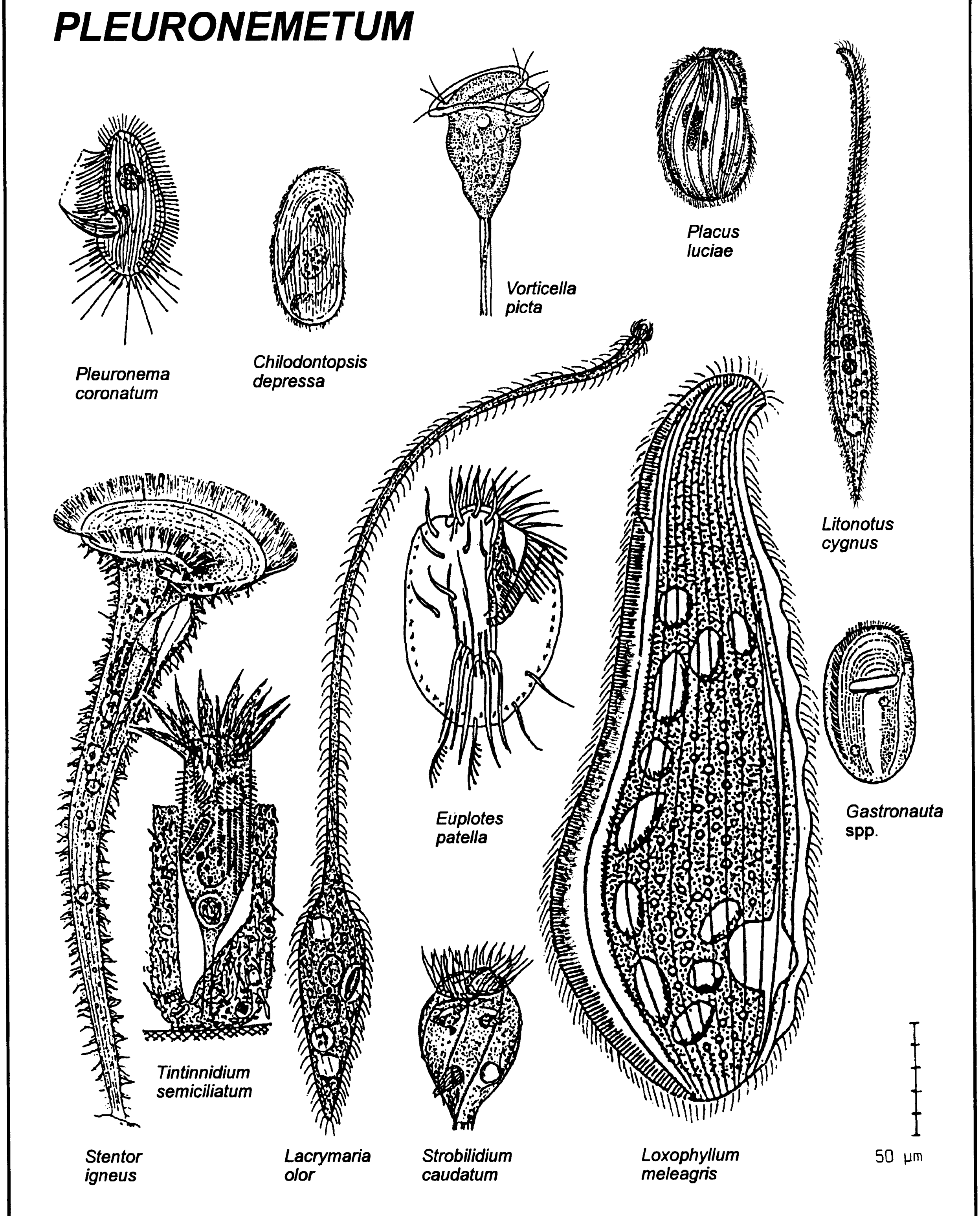


Peritrich community (*Peritrichetea*) of the alpha-mesosaprobic *Trithigmostometum* (*Carchesietosum polypinae*). Typically, this sessile subassociation of the *Trithigmostometum* develops downstream from the effluent of waste water treated only mechanically or in insufficiently operating activated sludge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

STENTORETUM

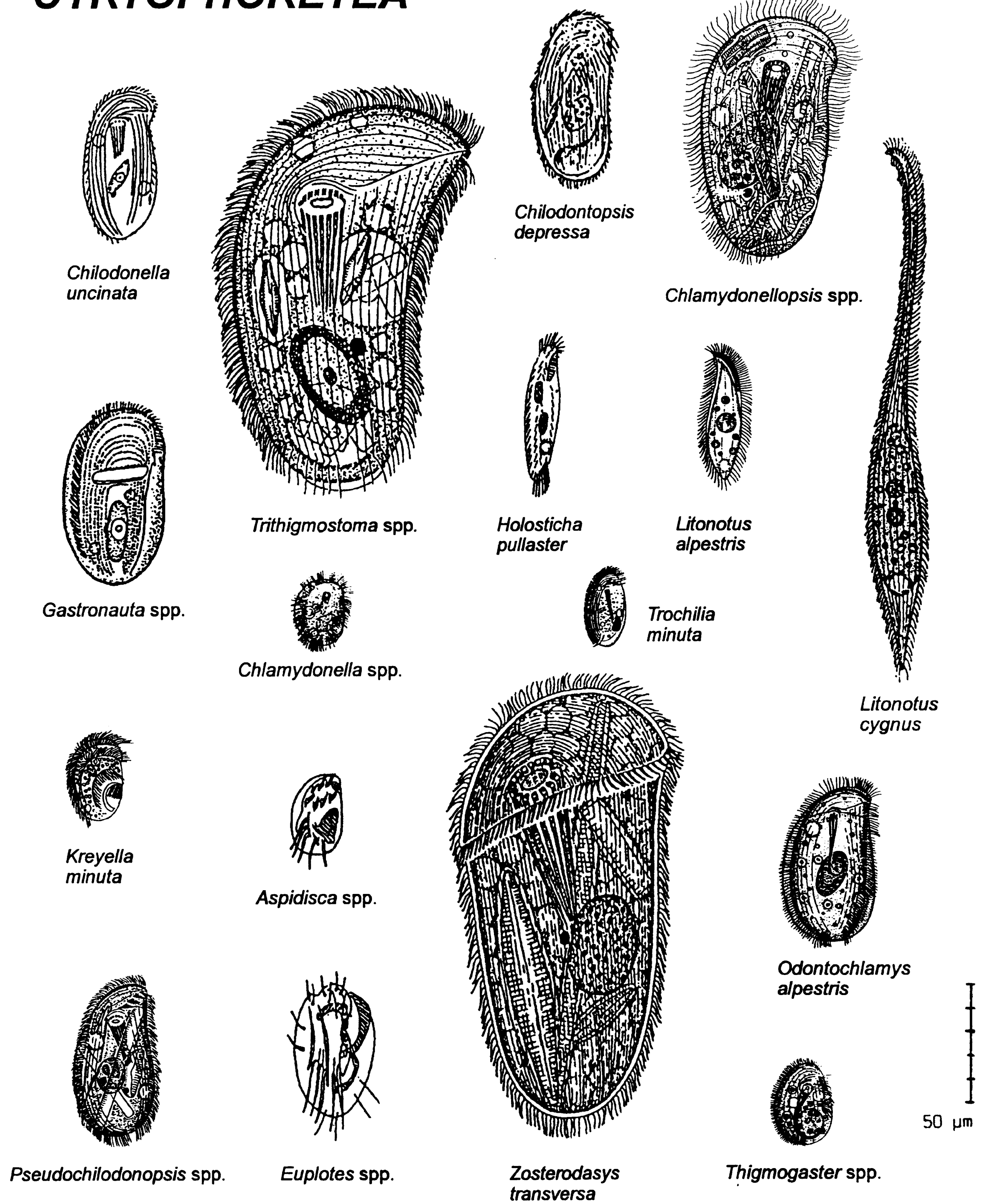


Ciliate community of the beta-mesosaprobic to alpha-mesosaprobic self-purification (transition) zone (*Stentoretum*). This is the most species rich (often more than 60 in a sample) zone in a self-purification reach. The total abundance of the ciliates is still high, but lawns recognizable with the naked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



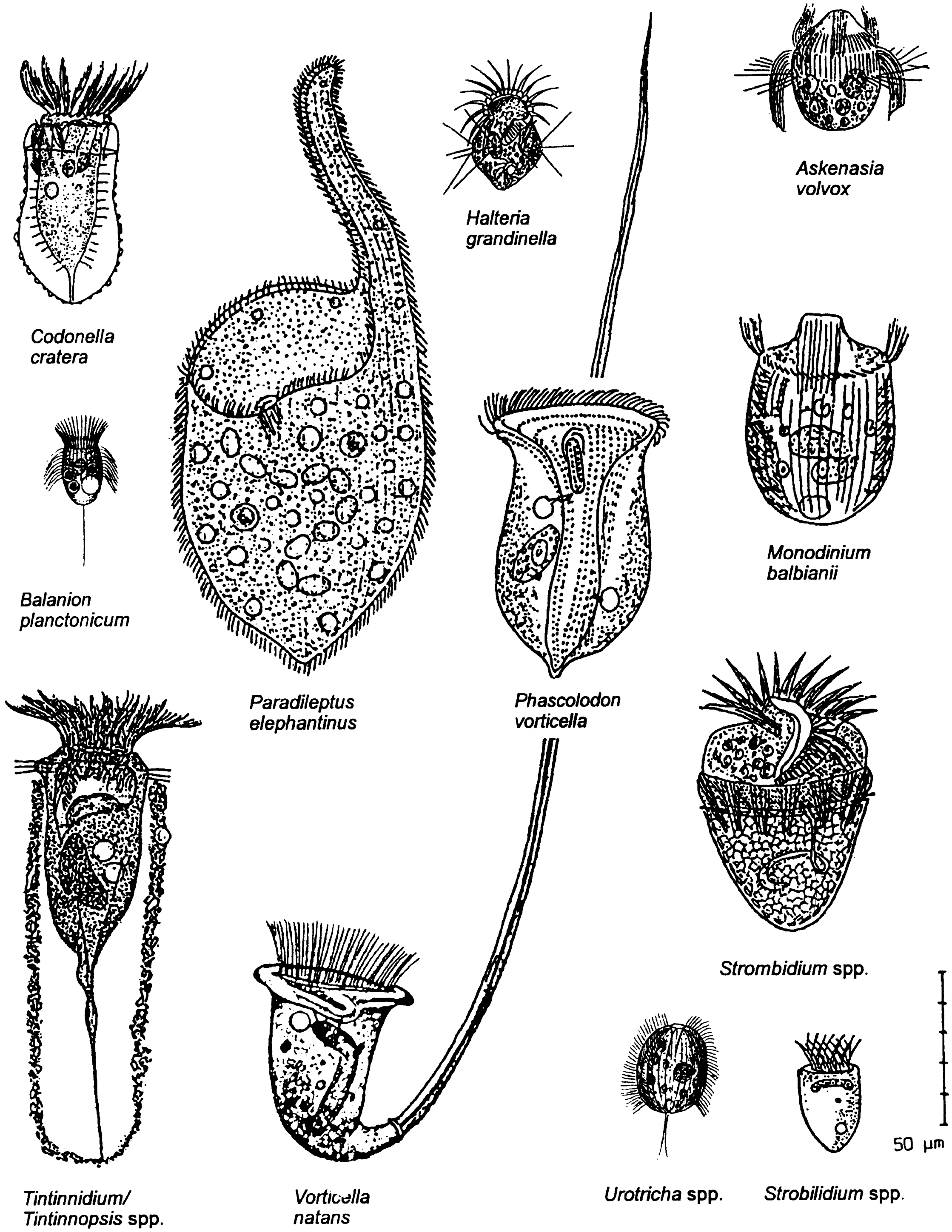
Ciliate community of the beta-mesosaprobic self-purification zone (*Pleuronemetum coronatae*). Indicator species is *Pleuronema coronatum*, a hymenostome ciliate (Vol. III) which is highly frequent and sometimes also rather abundant. The ciliate community is very diverse, but often less than 25 taxa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

CYRTOPHORETEA



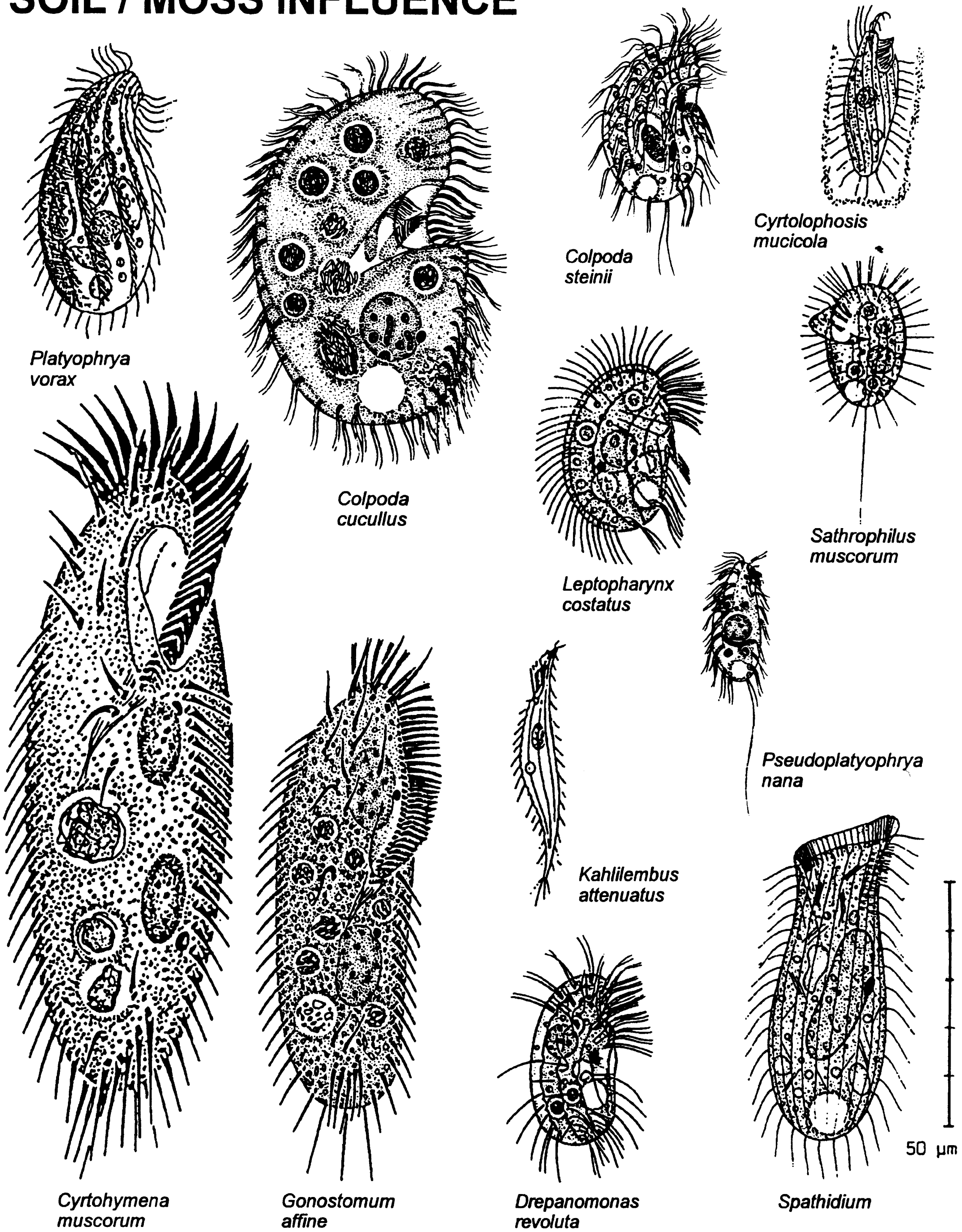
Ciliate community of the vagile periphyton (*Cyrtophoretea*). Cyrtophorid ciliates (Vol. I) are a highly characteristic and usually also very abundant component of the vagile periphyton (Aufwuchs), which preferably develops in spring in oligosaprobic to mesosaprobic, diatom-rich streams. Typical accessory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

OLIGOTRICHETEA / LAKE INFLUENCE



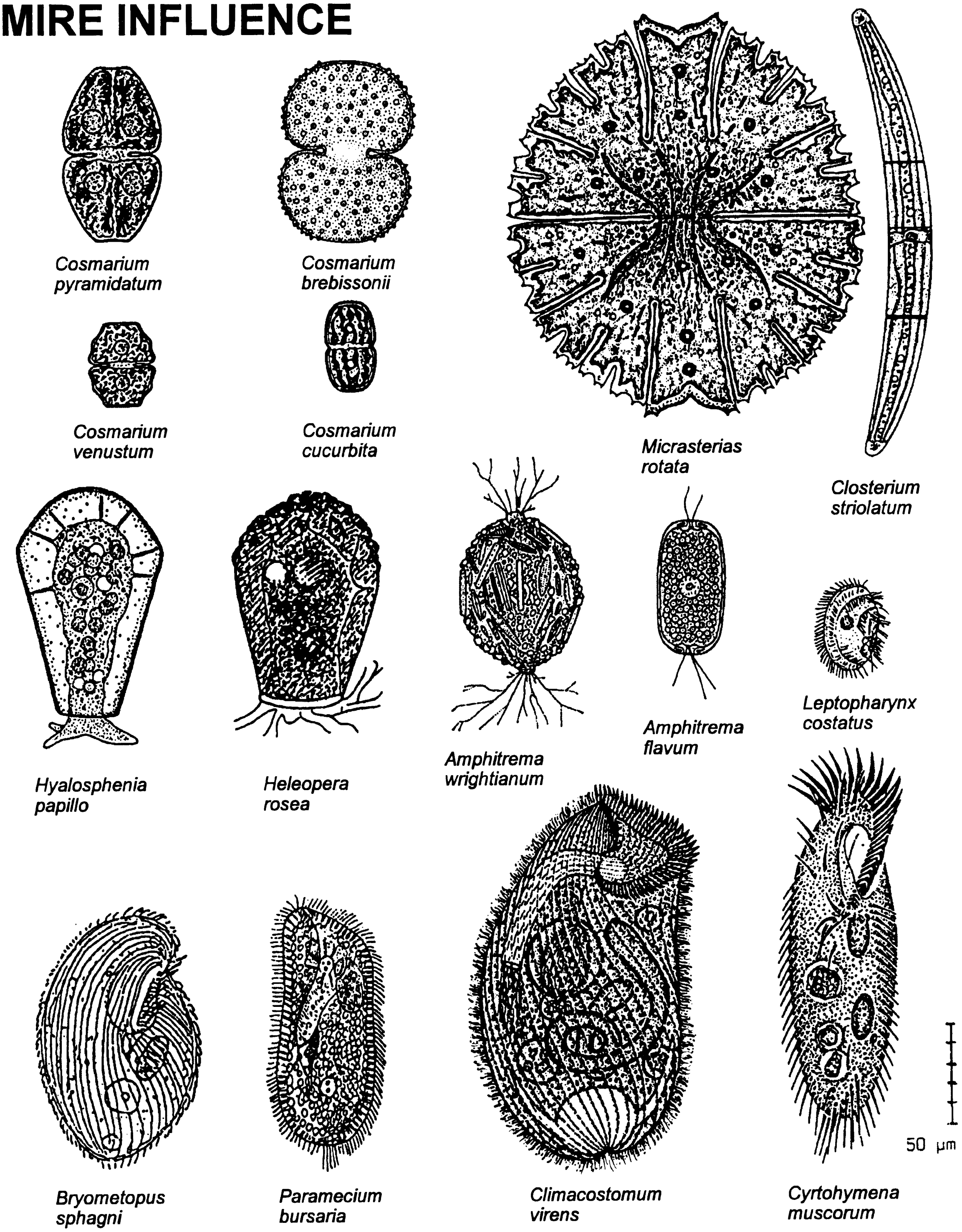
Ciliate community of the pelagial (*Oligotrichetea*). An increased occurrence of oligotrich ciliates (Vol. I) is characteristic for stagnant waters (e.g. lakes, impounding basins) and large, slowly flowing rivers. However, euplanktonic species occur also in most other groups of ciliates (Tab. 1). An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

SOIL / MOSS INFLUENCE



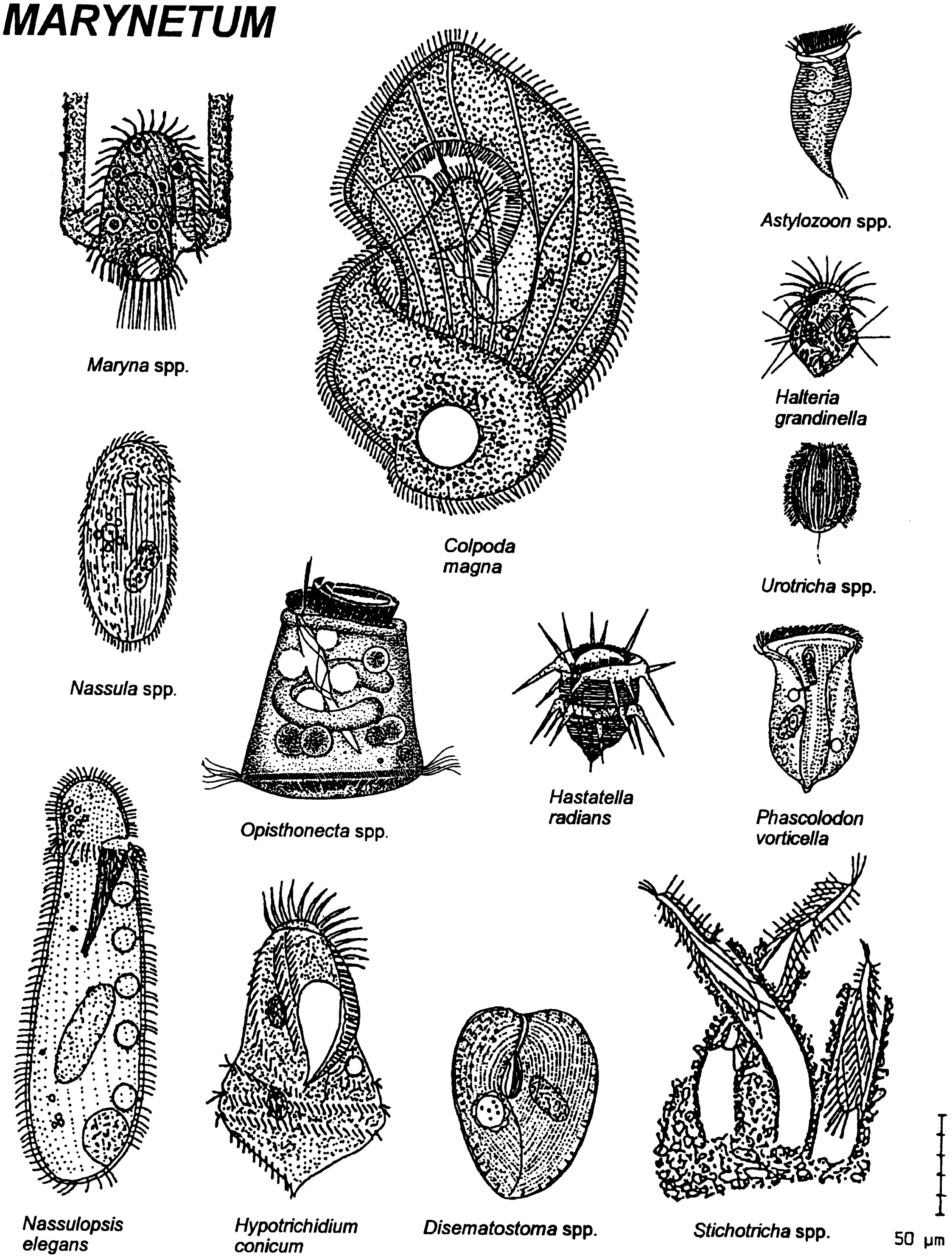
Indicators for terrestrial influence. A highly specific ciliate community lives in soil and moss (Foissner, 1987). Only about 20% of the species occur in both terrestrial and limnetic biotopes. Some of these opportunists have been classified saprobiologically and are shown on this plate. Only if several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

MIRE INFLUENCE



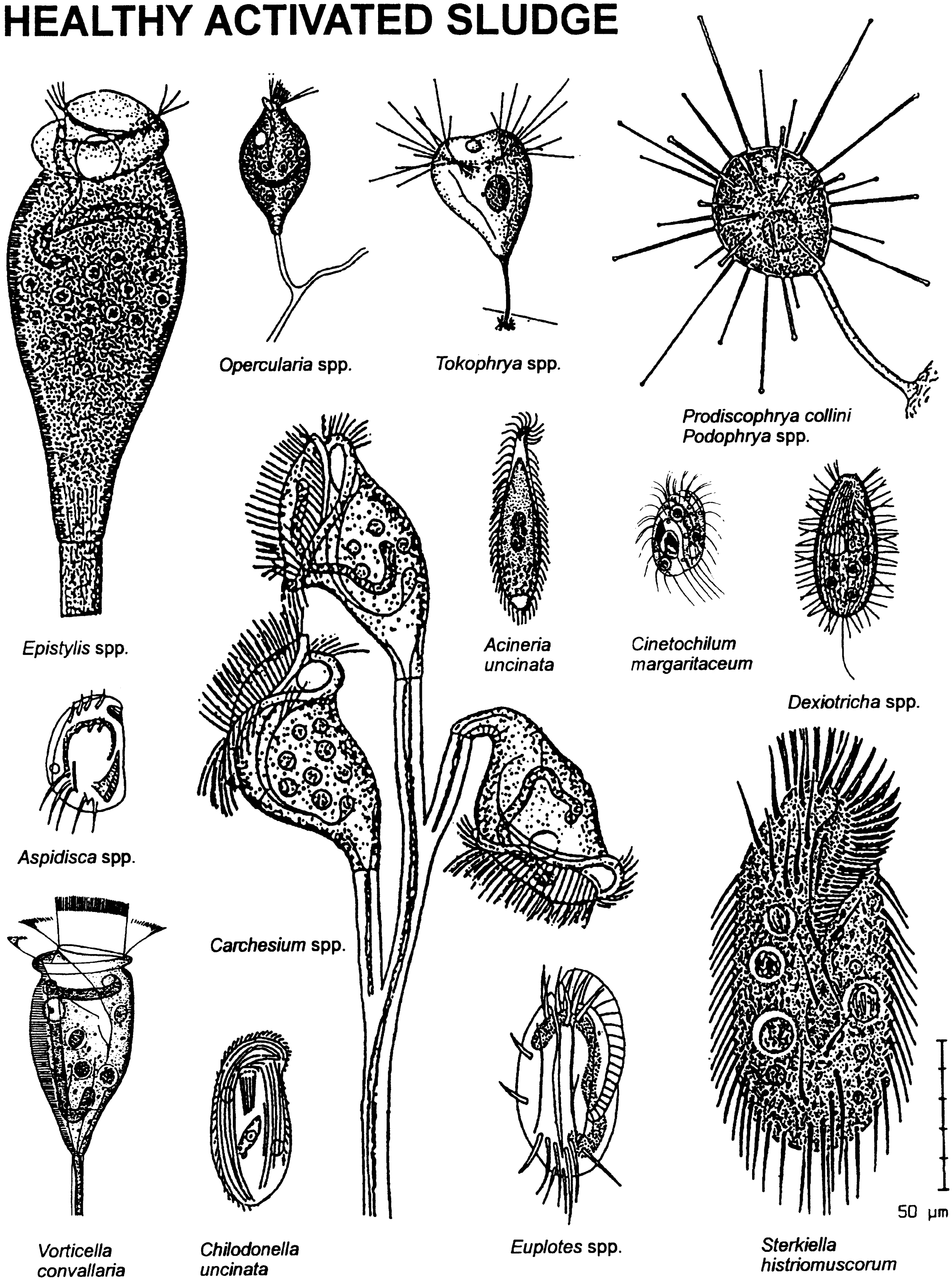
Indicators for mire influence. An increased number of mire-specific organisms, especially desmids and testate amoebae, is found in streams and rivers which receive water from mires and/or moorlands and are not too heavily polluted. The ciliates from such usually acidic biotopes are still poorly explored.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

MARYNETUM



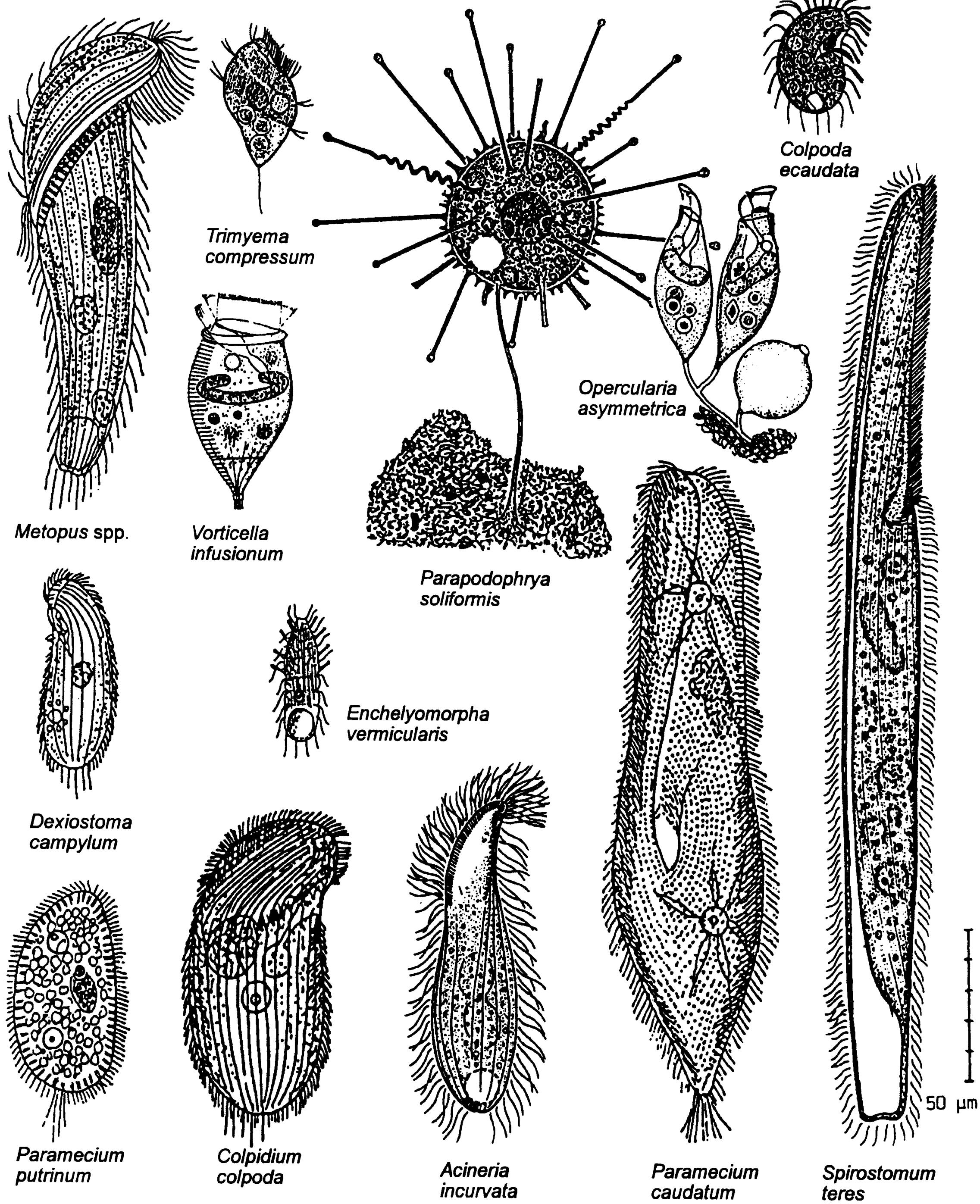
Ciliate community of small, astatic (ephemeral) stagnant waters (*Marynetum*). Marynids are a family of colpodid ciliates (Vol. I) and highly characteristic for small and very small, astatic stagnant waters, like puddles on roads and flooded plains. Usually, they live in mucuous tubes attached to debris 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.

HEALTHY ACTIVATED SLUDGE



Ciliate community of healthy ("normal") activated sludge. An assortment of species usually occurring in moderately and heavily polluted (alpha-mesosaprobic to beta-mesosaprobic, alpha-mesosaprobic) running waters is found in "normal" activated sludge. The species of this community indicate sufficient oxygen supply and appropriate load. Often, ciliates achieve high abundances (> 10000 individuals / ml) and feed on bacteria, thereby reducing the turbidity of the effluent (Curds 1992). See Schleypen & Gschlössl (1992) for detailed advice on activated sludge investigation. Scale bar division 10 µm.

OVERLOADED AND/OR OXYGEN DEFICIENT ACTIVATED SLUDGE



Ciliate community of overloaded and/or oxygen deficient activated sludge. An assortment of species usually occurring in heavily and very heavily polluted (alpha-mesosaprobic to polysaprobic, polysaprobic) running waters is found in overloaded and/or oxygen deficient activated sludge. The species of this community indicate insufficient oxygen supply (*Vorticella infusionum*-complex, *Dexiostoma*), anaerobic conditions (e.g., *Metopus*, *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.