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Faunistic and Morphological Studies on Ciliates (Protozoa, Ciliophora) from a Small Pond, with Responses of Ciliate Populations to Changing Environmental Conditions

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Abstract: Sixty-nine ciliate species were identified in 19 samples from a small pond covered by *Lemna minor* in Van, Turkey. Statistical analysis was employed to examine the relationships between ciliates and the physical and biological parameters. Total ciliate abundance appears to be related mainly with physical and biological factors such as the dissolved oxygen in the bottom layer and the volume of *Lemna* and temperature in the surface layer. Some species were investigated in detail using live observation, silver impregnation, and morphometry.

Key Words: Ciliated Protozoa, Pond, *Lemna*, Physical Parameters, Ciliate Communities, Infraciliature, Morphology.

Küçük Bir Gölette Bulunan Siliyatlar (Protozoa, Ciliophora) Hakkında Faunistik ve Morfolojik Çalışmalar ile Siliyat Populasyonlarının Değişen Çevresel Koşullara Yanıtları

Özet: Bu çalışmada Van'da bulunan *Lemna minor* ile örtülü bir göletten 19 kez örnekleme yapılmış ve 69 siliyat türü tanımlanmıştır. Fiziksel ve biyolojik parametreler ile siliyat türleri arasındaki ilişkileri incelemek amacıyla istatistiksel analiz yapılmıştır. Toplam siliyat bolluğu esas olarak dipte çözünmüş oksijen; yüzey tabakada *Lemna* hacmi ve sıcaklık gibi fiziksel ve biyolojik faktörler ile ilişkili görünmektedir. Bazı türler canlı gözlem, gümüş empregnasyon ve morfometri ile ayrıntılı olarak incelenmiştir.

Anahtar Sözcükler: Siliyat Protozoa, Gölet, *Lemna*, Fiziksel Parametreler, Siliyat Komuniteleri, İnfrasiliyatür, Morfoloji.

Introduction

In aquatic environments, ciliated protozoa together with flagellates, algae, and small metazoans form a microbial community. Among the members of this community close relationships such as predation and competition occur (Madoni, 1996). Ciliated protozoa constitute a significant portion of the microbial food web and play 2 main roles in aquatic ecosystems (Porter et al., 1985; Finlay et al., 1988; Beaver and Crisman, 1989; Salvado and Gracia, 1991; Sommaruga and Psenner, 1993; Holen, 2000): they link phytoplankton and bacteria in the food web to higher organisms. In addition, these ciliates may be important in nutrient remineralization.

Freeliving ciliates from aquatic ecosystems in some countries have been carefully surveyed by many investigators (Porter et al., 1985; Finlay et al., 1988; Beaver and Crisman, 1989; Madoni, 1991a, 1991b; Salvado and Gracia, 1991; Cabré, 1993; Sommaruga and Psenner, 1993; Madoni, 1996; Biyu, 2000; Holen, 2000). However, there is little published information on the ciliated protozoa occurring in aquatic ecosystems from Turkey.

Identification of ciliates is difficult due to high species diversity in aquatic ecosystems, variability of cell sizes, damage caused by fixatives to cells and cultivation problems. The described species may show morphological variation as well. Therefore taxonomic errors may occur in many lists of ciliate fauna (Foissner and O'Donoghue, 1990). Although the species composition was generally similar, some geographical variations existed in the occurrence of some species. Specifically, many new

species and also endemic species were detected in certain areas by using biometry and cytological staining techniques (Foissner and O'Donoghue, 1990; Foissner, 1997). Similar results could be expected in Turkey.

Indeed, the ciliate composition in freshwater habitats of Turkey has never been studied. We examined some freshwater ciliates in some rivers and water treatment systems (Şenler et al., 1998; Şenler and Yıldız, 1998; 1999a, 1999b; Şenler et al., 1999). It would be of great significance to determine the ciliate fauna of the aquatic ecosystems in Turkey and then make comparisons with faunistic studies about the freshwater fauna of different geographical regions.

The purpose of this study was to determine the ciliate species inhabiting both on the surface and in the bottom of a productive pond covered by macrophytes in Van Castle, Van, Turkey, and to give morphological variations within the species. Statistical analysis was applied to determine the relationships between ciliate species with physical parameters.

Materials and Methods

Study area: The pond, situated at an altitude of 1700 m in Van Castle in the province of Van, has an area of 48 m^2 and maximum depth of 0.7 m. This shallow pond is 21 x 7.5 m and is fed by rainfall and little water bearing stratum emergence. Since the water is highly eutrophic, *Lemna minor* is abundant in the pond. The pond is exposed to the anthropogenic effects of grazing and picnics.

Sampling of ciliated protozoa: The study was conducted at intervals, sometimes monthly and sometimes once in 2 weeks, from May 1999 to May 2000. The pond was sampled 19 times. Samples were collected from both the surface layer and the bottom. Sampling of ciliated protozoa was performed using Madoni's techniques (1991a, 1991b). At the sampling point, the water layer from the surface down to about 2 cm was collected; a surface area of 500 cm^2 was explored. Ciliates from the bottom of the pond were collected with a 2 cm diameter pipe by siphoning.

Identification and enumeration of ciliated microfauna: Samples were investigated on the day of sampling, using a bright field, inverted and phase contrast microscope. In each sample, estimates of ciliate populations were made by direct observation of live samples within 5 h of collection. Taxa were subject to taxonomic (cytological) procedures and identified to species level using the keys of Curds (1982), Foissner et al. (1991, 1992, 1994, 1995), Foissner and Berger (1996) and specific literature cited in the species descriptions. The ciliary pattern and other cytological details were revealed by various silver impregnation techniques, all of which were described by Foissner (1991) and Fernandez-Galiano (1976, 1994). The ciliates were also subject to supravital staining with methyl green, methyl green-salina-formaline (MSF) and Feulgen's nucleal reaction to determine cytological features. All of the cell measurements, given in the study in micrometers, were obtained with the aid of a calibrated ocular micrometer. Morphological characterization was done on randomly selected non-dividing cells after impregnation. Permanent preparations belonging to hypotriches were not achieved because of their fixation problems. Therefore hypotriches with the exception of the species described in vivo were given as total hypotriches.

Estimates of population density in the macrophyte layer and in the bottom were made according to the techniques described by Madoni (1991a, 1991b). For ciliate counts, water samples were concentrated to a small volume by a 23 µm mesh net and counted by HydroBios-Kiell (0.5) counting camera after subsampling. The most convenient drop size (0.05 ml) and number of replicate counts (3 replicates) were selected according to Madoni (1984). The abundance of each taxon was expressed as number of individuals per milliliter of surface and bottom area.

Physical parameters: Temperature (°C), pH, dissolved oxygen (mg l^{-1}), conductivity (µmhos cm^{-1}) and salinity (‰) were measured in the study area with a DO meter (Jenway, 9070) and a salinity-conductivity-temperature (SCT) meter (YSI 33).

Data analysis: The normality assumption was checked for all measurements of physical and biological variables' distribution, and appropriate transformations were made [Variable = ln (Variable + 1)]. Partial correlation analyses were performed to relate numbers of species in samples to the physical parameters measured. The statistics were analyzed using MINITAB and SPSS software. In the accompanying tables, the following abbreviations are used: $\bar{X}$, arithmetic mean; SD, standard

deviation; CV, coefficient of variation; min, minimum; max, maximum; N, number of individuals examined.

Results and Discussion

The values of each physical parameters measured in the pond are summarized in Table 1.

During the study period, 69 species of ciliated protozoa were identified (Table 2). The total number of taxa collected is similar to those reported for ponds with macrophytes; Madoni (1991a, 1996) found 40 and 60 taxa in a pond, collecting samples 17 times over a 1-year period and in a rice field, collecting samples 43 times over a 4-year period, respectively. Our results are also similar to the total number of ciliate species recorded by many authors (Salvado and Gracia, 1991; Cabré, 1993). Moreover, Finlay et al. (1988) reported a significantly higher number of taxa in a small pond with macrophytes similar to those of the investigated pond within a 48 h period. The pond supported a high diversity of ciliated protozoa in the present study. Biyu (2000) showed that the macrophyte-rich lake had greater ciliate species numbers, but lower ciliate abundance than the macrophyte-poor lake. The researcher noted that macrophytes may sustain more diverse ciliate communities, probably through the modification of ciliate food resources and spaces heterogeneity.

Our study indicates that the ciliated protozoa community contains relatively similar ciliate species, at least in eutrophic ponds. The majority of ciliated protozoa determined in the pond have been recorded previously as common to freshwater systems such as lakes (Madoni, 1990; Biyu, 2000), ponds (Pratt et al., 1986; Finlay et al., 1988; Madoni, 1991a; Salvado and Gracia, 1991; Biyu, 2000) and rice fields (Madoni, 1996). Generally, ciliates are considered quite cosmopolitan in their distribution (Madoni, 1990; Biyu, 2000), which may reveal why no endemic species were found during this study.

Average total ciliate abundance or density at the surface and the bottom was 211.90 cells ml^{-1} and 385.60 cells ml^{-1}, respectively. The present study has shown that the pond, which is covered by *Lemna minor*, has greater ciliate abundance. Conversely, in the macrophyte-rich lake, the average ciliate density was 13.5 cells ml^{-1} and in the macrophyte-poor lake the average ciliate density was 35.5 cells ml^{-1} (Biyu, 2000). More productive lakes exhibit greater abundance than oligotrophic lakes, through a strong relationship between the abundance of planktonic ciliates and trophic state, and physical factors together with biological requirements such as food, protection and reproduction (Barbieri and Orlandi, 1989; Beaver and Crisman, 1989; Biyu, 2000).

In the present study, 23 species were observed only at the bottom, and 21 species were found only in the surface layer covered by *Lemna minor*; 25 of these species occurred in both habitats. The majority of the observed species were bactivorous ciliates. Predator forms were observed only in the *Lemna* layer with a few exceptions: *Acineria uncinata* and *Amphileptus pleurosigma* were found both in the surface layer and at the bottom. Sessile ciliates feeding on bacteria represented a relatively more important component in the *Lemna* layer (see Table 2). The sessile peritrich *Epistylis digitalis* was observed as epizoic only attached to copepods. The algivorous species *Paramecium bursaria* and *Trithigmostoma steini* occurred only in the surface layer. Among these species, vorticellid ciliates and

Table 1. Physical characteristics from the pond (N = 19).

Parameter		Mean	Range
Temperature (°C)		11.62	7.1-20.0
PH	Surface layer	7.49	7.00-7.97
	Bottom	7.33	6.83-7.78
Dissolved Oxygen (mg l^{-1})	Surface layer	4.63	1.2-7.00
	Bottom	2.91	0.9-6.5
Conductivity (mmhos cm^{-1})		736.25	680-820
Salinity (‰)		0.46	0.30-0.70

Table 2. Feeding habit, frequency and abundance (individual number ml^{-1}) of ciliate species observed along the study period in the pond. P, predator; Ba, bacteria; SB, sulfur bacteria; Al, algae; O, omnivorous; Di, diatoms; Fl, heterotrophic flagellates; Cy, cyanobacteria.

		Surface layer		Bottom	
Species	Nutrition	Frequency	$\bar{X}$ (min-max)	Frequency	$\bar{X}$ (min-max)
Acineria uncinata	P	21.05	0.34 (0.00-2.00)	31.58	3.85 (0.00-26.60)
Amphileptus pleurosigma	P	31.58	0.42 (0.00-2.48)	5.26	0.35 (0.00-6.60)
Apsiktrata sp.	?			68.42	12.87 (0.00-86.60)
Aspidisca cicada	Ba	52.63	2.57 (0.00-15.34)	89.47	16.74 (0.00-40.00)
Aspidisca lynceus	Ba	21.05	0.24 (0.00-2.00)	26.32	2.44 (0.00-20.00)
Bothrostoma undulans	SB			10.53	0.70 (0.00-6.60)
Brachonella spiralis	SB, Al, Fl, Ba			10.53	0.70 (0.00-6.60)
Caenomorpha uniserialis	Ba, SB			5.26	0.05 (0.00-1.00)
Caenomorpha sp.	Ba, SB			5.26	0.35 (0.00-6.60)
Carchesium polypinum	Ba	31.58	12.9 (0.00-200.00)		
Chilodonella uncinata	Ba	47.37	2.11 (0.00-22.00)	5.26	0.71 (0.00-13.40)
Cinetochilium margaritaceum	Ba, Al	63.16	5.56 (0.00-44.00)	73.68	22.08 (0.00-106.60)
Cirranter mobilis	?			21.05	2.19 (0.00-15.00)
Coleps hirtus	O	26.32	1.95 (0.00-23.00)	47.37	9.47 (0.00-33.40)
Cothurnia annulata	Ba	5.26	0.02 (0.00-0.33)		
Cyclidium glaucoma	Ba	47.37	1.88 (0.00-10.80)	63.16	27.00 (0.00-100.00)
Cyclidium heptatrichum	Ba			47.37	15.77 (0.00-46.60)
Dexiotricha granulosa	Ba			73.68	26.05 (0.00-80.00)
Dexiotrichides centralis	Ba			5.26	0.35 (0.00-6.60)
Didinium nasutum	P	5.26	0.05 (0.00-1.00)		
Dileptus sp.	P	5.26	0.11 (0.00-2.00)		
Epalxella sp.	SB			15.79	8.42 (0.00-100.00)
Epistylis digitalis	Ba	47.37	13.90 (0.00-201.70)		
Euplotes aediculatus	O	63.16	3.08 (0.00-15.34)		
Frontonia angusta	O	10.53	0.29 (0.00-4.46)	63.16	13.58 (0.00-46.60)
Glaucoma scintillans	Ba	15.79	0.16 (0.00-2.30)		
Halteria grandinella	Ba, Al	26.32	0.24 (0.00-2.00)	15.79	3.42 (0.00-53.40)
Holophrya discolor	O			78.95	22.98 (0.00-113.40)
Holophrya sp.	?			26.32	5.25 (0.00-46.60)
Holosticha pullaster	Ba, Di, Al	26.32	0.87 (0.00-7.14)	26.32	2.45 (0.00-13.40)
Homalozoon sp.	O			21.05	2.11 (0.00-13.40)
Lacymaria olor	P	5.26	0.05 (0.00-1.00)		
Lagynus elegans	O			57.89	7.41 (0.00-26.60)
Litonotus cygnus	P	15.79	0.26 (0.00-3.00)		
Litonotus sp.	P	26.32	0.37 (0.00-3.00)		
Loxodes striatus	Al, Di, Cy			43.37	8.76 (0.00-60.00)
Metopus es	Ba, Fl, Al			15.79	1.04 (0.00-6.60)
Metopus striatus	Ba, Fl, Al			5.26	0.35 (0.00-6.60)
Myelostoma anatinum	?	10.53	0.05 (0.00-0.46)	84.21	18.68 (0.00-60.00)
Monodinium balbiani	P	5.26	0.02 (0.00-0.44)		
Opisthonecta sp.	?	15.79	0.73 (0.00-7.84)		
Paramecium bursaria	Ba, Al, Di	68.42	3.09 (0.00-14.00)		
Paramecium caudatum	Ba, Al	15.79	0.12 (0.00-1.00)	15.79	1.40 (0.00-13.40)
Plagiopyla nasuta	Ba, Al, Fl, SB	5.26	0.02 (0.00-0.46)	47.37	4.37 (0.00-20.00)
Platycola decumbens	Ba, Al, Di	5.26	0.05 (0.00-1.00)		
Pseudoconhilembus pusillus	Ba			57.89	19.29 (0.00-93.40)
Satrophilus sp.	?			15.79	1.40 (0.00-13.40)
Spirostomum ambiguum	Ba, Fl, Al	5.26	0.02 (0.00-0.46)	15.79	2.19 (0.00-20.00)
Spirostomum minus	Ba			15.79	2.37 (0.00-20.00)
Spirostomum teres	Ba, Al, Di, SB	5.26	0.44 (0.00-8.40)	31.58	7.71 (0.00-80.00)
Stentor coeruleus	O	21.05	0.15 (0.00-1.00)	15.79	1.04 (0.00-6.60)
Stentor muelleri	Ba, Al, Di	57.89	1.97 (0.00-11.00)	5.26	0.35 (0.00-6.60)
Strobilidium caudatum	Di, Al, Ba	10.53	5.59 (0.00-80.80)		
Stylonychia sp.	?	31.58	3.11 (0.00-29.00)		
Tachysoma pellionellum	Ba, Cy, Al, Di	42.11	2.66 (0.00-12.64)		
Thigmogaster oppositovacuolatus	Ba	26.32	0.32 (0.00-2.30)	5.26	0.35 (0.00-6.60)
Trithigmostoma cucullulus	Di, Al, Cy, Ba			31.58	7.36 (0.00-60.00)
Trithigmostoma steini	Di	26.32	1.32 (0.00-13.60)		
Trochilia minuta	Ba	21.05	1.03 (0.00-9.50)	26.32	8.77 (0.00-80.00)
Urocentrum turbo	Ba, Di	21.05	11.60 (0.00-208.90)	52.63	18.98 (0.00-125.00)
Uronema nigricans	Ba, Fl	10.53	0.16 (0.00-2.00)	42.11	8.77 (0.00-53.40)
Urotricha globosa	Ba, Al			94.74	29.55 (0.00-80.00)
Urotricha sp.	?			47.37	8.25 (0.00-33.40)
Vaginicola tincta	Ba	5.26	0.04 (0.00-0.66)		
Vorticella campanula	Ba, Al	84.21	39.70 (0.00-207.40)	26.32	3.52 (0.00-20.00)
Vorticella convallaria	Ba	100	71.90 (2.00-298.30)	21.05	1.75 (0.00-13.40)
Vorticella microstoma	Ba, Al	36.84	2.87 (0.00-11.00)		
Vorticella octava	Ba	89.47	9.07 (0.00-26.00)	10.53	2.11 (0.00-33.40)
Vorticella picta	Ba, Al	21.05	0.90 (0.00-12.00)		
Other Hypotriches		78.95	7.81 (0.00-53.34)	73.68	19.99 (0.00-106.60)
Total ciliates			211.90 (6.30-569.10)		385.60 (53.00-799.80)

Epistylis have been reported as relatively common in the surface layer of eutrophic ponds (Madoni, 1991a; Cabré, 1993).

In general, at the bottom, the ciliate community prevalently consisted of microaerophylic and anaerobic species. *Bothrostoma undulans*, *Brachonella spiralis*, *Caenomorpha* spp., *Cirranter mobilis*, *Epalxella* sp., *Lagynus elegans*, *Loxodes striatus, Metopus* spp., *Myelostoma anatinum* and *Plagiopyla nasuta* represent the characteristic components of the ciliate fauna of sulfureta (Curds et al., 1983; Madoni, 1990; 1991a; Patterson and Hedley, 1992; Cabré, 1993; Foissner and Berger, 1996). Their densities are generally rather low (see Table 2). These are anaerobic organisms capable of feeding on different types of sulfhur bacteria. Other ciliates like *Apsiktrata* sp., *Cyclidium heptatrichium*, *Dexiotricha granulosa, Holophrya discolor, Pseudocohnilembus pusillus* and *Urotricha* spp. represented a relatively more important component of the species associated with the bottom. Their feeding is very diverse, i.e. bacteria to Protozoa (Foissner and Berger, 1996). *Urotricha globosa* was the most commonly observed species at the bottom. Barbieri and Orlandi (1989) found *Urotricha* spp. in both habitats in an eutrophic reservoir, but with greater density in surface samples. However, in a freshwater reservoir, *Urotricha* sp. are frequently found on the surface with or without *Lemna gibba* (Salvado and Gracia, 1991). Foissner and Berger (1996) reported that the ciliate community of pelagial and small, stagnant water bodies also contained *Urotricha* spp. that are able to live in mucuous tubes attached to debris on the bottom, and feed on bacteria.

Among the ciliates observed both in the surface layer and at the bottom, only a few species, *Aspidisca cicada, Cinetochilium margaritaceum, Cyclidium glaucoma* and *Urocentrum turbo*, occurred with high frequency.

The surface contained some sporadic and accidental species from the bottom like *Myelostoma anatinum* and *Plagiopyla nasuta*, which were represented by only a low abundance and frequency. The bottom also contained some typical surface ciliates like *Vorticella* spp. with lower frequency. These unexpected results in community structure are due to a variety of factors including the shallowness of the pond and effective mixing by winds, anthropogenic effects and run-off from the surrounding picnic areas.

Only species with a significant frequency (>10%) were selected for partial correlation analysis. Table 3 represents the relationship between the ciliates and some physical parameters.

Although ciliate abundance did not correlate with physical-chemical variables, probably by using simple correlation (Biyu, 2000), the present study has shown that there is an obvious correlation between some ciliate abundance or density and physical variables such as temperature, dissolved oxygen and *Lemna* volume (see Table 3) by using partial correlation. It is apparent that temperature is the most important parameter in the surface layer. The highest values for the correlation coefficient were found between *Lemna* and the temperature of the surface. Macrophytes, in fact, were associated with high temperatures. The same correlations were observed for the ciliate *Paramecium bursaria* and taxa such as peritrichs *Vorticella* spp. were associated with high *Lemna* volume and temperature of the surface. Conversely, taxa such as *Chilodonella uncinata*, *Tachysoma pellionellum* and *Trochilia minuta* were associated with low macrophyte and temperature levels.

The positive relationship between *Urocentrum turbo* and temperature of the bottom indicates that high temperatures favor the development of *Urocentrum turbo*. In contrast, *Dexiotricha granulosa, Holosticha pullaster* and *Loxodes striatus* had a negative relationship with the temperature of the bottom.

In conclusion, when total ciliates are considered, the correlation analysis suggested which *Lemna* volume and temperature of the surface and dissolved oxygen of the bottom have the greatest influence on total ciliate abundance. Similar results for *Spirostomum teres* were observed by Madoni (1991b). It is apparent that food availability is major factor controlling the abundance of ciliated Protozoa (Madoni, 1990). Physical conditions such as the presence or absence of oxygen and temperature have also been described as having an effect on the abundance and distribution of these organisms. Finlay (1982) reported that oxygen availability is an important factor controlling the density, biomass and community structure of benthic ciliated Protozoa. The present study also confirmed this view.

The description of species

We carried out a through investigation of the species retrieved from the samples, but no new species were

Table 3. Partial correlation coefficients between ciliated species and some physical variables. * P < 0.05; ** P < 0.01; *** P < 0.001

Species	*Lemna minor*	Temperature (°C)		Dissolved Oxygen (mg l^{-1})	
		Surface	Bottom	Surface	Bottom
Acineria uncinata		0.3073			
Amphileptus pleurosigma	0.4346	0.6844**		0.5202	
Bothrostoma undulans			-0.3281		
Brachonella spiralis					0.3240
Chilodonella uncinata	-0.4737*	-0.5273			
Cirranter mobilis			-0.3024		-0.4282
Cyclidium heptatrichum			-0.3175		-0.5098*
Dexiotricha granulosa			-0.5021*		-0.4430*
Dexiotrichides centralis			-0.3166		
Epistylis digitalis		-0.3165			
Glaucoma scintillans		-0.3490			
Holophrya discolor					-0.4494*
Holophrya sp.					-0.3090
Holostica pullaster			-0.4597*		-0.4399
Litonotus sp.		0.3209			
Homalozoon sp.			0.6227**		
Loxodes striatus			-0.4977*		-0.4301
Monodinium balbiani				-0.3269	
Myelostoma anatinum			0.3669	0.3068	0.3249
Paramecium bursaria	0.5628**	0.5074*			
Paramecium caudatum				-0.6706**	
Plagiopyla nasuta					-0.4276
Satrophilus sp.					0.5104*
Strobilidium caudatum				0.3964	
Stylonychia sp.	0.3442	0.4903*			
Tachysoma pellionellum	-0.4379*				
Trochilia minuta	-0.5865**	-0.5171*		-0.3585	
Urocentrum turbo			0.5517**	-0.4609*	
Urotricha globosa					-0.3311
Urotricha sp.			0.4098		
Vaginicola tincta		0.4627*			
Vorticella campanula	0.3014	0.4002			
Vorticella convollaria	0.6735***	0.6954***	0.5494**		0.3729
Vorticella microstoma	0.5128				
Vorticella octava	0.6082**	0.6185**			
Vorticella picta	0.3025				
Total ciliates	0.6031**	0.4672*			-0.4691*
Temperature	0.8123***				

found. However, some taxa were not determined, mainly because few specimens were found, which made the determination too difficult. Very likely, some of these unidentified taxa were new species too.

Halteria grandinella (MUELLER, 1773) DUJARDIN, 1841

(Figure 1; Table 4)

This species belongs to the order Oligotrichida, family Halteriidae. In vivo it measures 22.50-37.50 x 15.00-

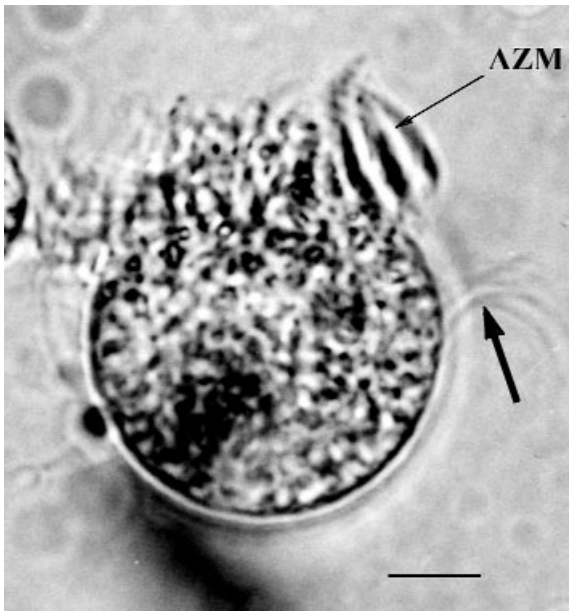

Figure 1. *Halteria grandinella*, in vivo. AZM, adoral zone of membranelles; Arrow, jumping bristles; Bar: 8 µm.

Table 4. Morphometric characterization of *Halteria grandinella*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	36.80	4.50	11.66	30.00	45.00	15
Body, width	37.13	4.70	12.66	30.00	45.00	15
Length/Width (L/W)	1.04	0.04	4.24	1.00	1.11	15
Macronucleus, length	17.87	3.36	18.79	12.00	23.00	15
Macronucleus, width	11.40	1.84	16.18	8.00	15.00	15
Micronucleus, diameter	3.87	0.52	13.34	3.00	5.00	15

32.50 µm ($\bar{X}$ = 26.56, SD = 4.99, CV = 18.79, N = 8; $\bar{X}$ = 22.81, SD = 5.08, CV = 22.27, N = 8) with the L/W ratio 1.19 (1.00-1.67), almost spherical with an equatorial girdle of stiff cirri. An adoral zone of membranelles (AZM) surrounds the anterior end of the cell. Macronucleus ovoid with a spherical micronucleus, and its diameter is on average 3.87 µm.

Euplotes aediculatus PIERSON, 1943

(Figures 2a-c; Table 5)

This species belongs to the order Hypotrichida, family Euplotidae. Its size, after fixation, is approximately 70.00

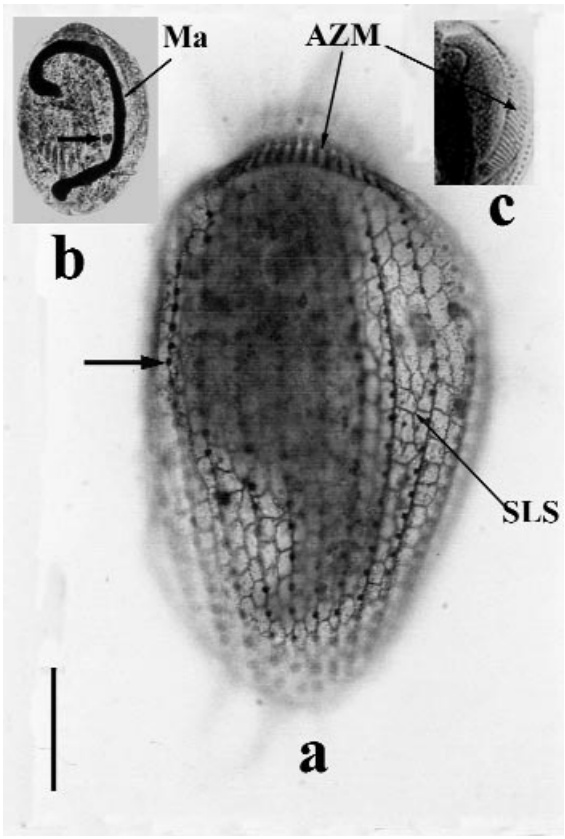

Figure 2. *Euplotes aediculatus*, silver impregnation. AZM, adoral zone of membranelles; Ma, macronucleus; SLS, silver line system; arrow (in b), micronucleus; arrow (in a), kinety; Bar: 20 µm.

Table 5. Morphometric characterization of *Euplotes aediculatus*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	98.85	7.71	7.80	70.00	110.00	40
Body, width	58.45	7.90	13.52	39.00	74.00	40
Length/Width (L/W)	1.71	0.19	11.09	1.35	2.20	40
Dorsal kineties, number	10.14	0.58	5.73	8.00	11.00	29
Adoral zone of membranelles, length	68.56	3.63	5.30	62.00	77.00	16
Adoral zone of membranelles, number	51.78	4.74	9.15	45.00	58.00	9

x 110.00 µm. Body ovoid to expanded ellipsoid; ventral side of the body is flat, dorsal side convex with 10.14 (8.00-11.00) longitudinal kineties. Dorsal silver line system is double-eurystomus type. Dorsal kineties

number is different in those reported by Foissner et al. (1991). Researchers found 8, rarely 9 kineties. The adoral zone of membranelles, with length 68.56 µm (62.00-77.00), contains 45.00-58.00 membranelles. Macronucleus C-shaped with adjacent micronucleus.

Spirostomum minus ROUX, 1901

(Figures 3a, b; Table 6)

Spirostomum spp. belong to the order Heterotrichida, family Spirostomidae. Body elongate, worm-like shape, highly contractile. Size in vivo 490.00-950.00 x 30.00-50.00 µm, with the L/W ratio on average 21.52 (16.33-28.33). The length of adoral zone of membranelles (AZM) is on average 273.10 µm, extends to 34% of the cell length. Macronucleus moniliform, about 4.00-38.00 individual macronuclear segments, each ellipsoidal. General organization of the species is consistent with the previous descriptions (Augustin and Foissner, 1992; Foissner et al., 1992).

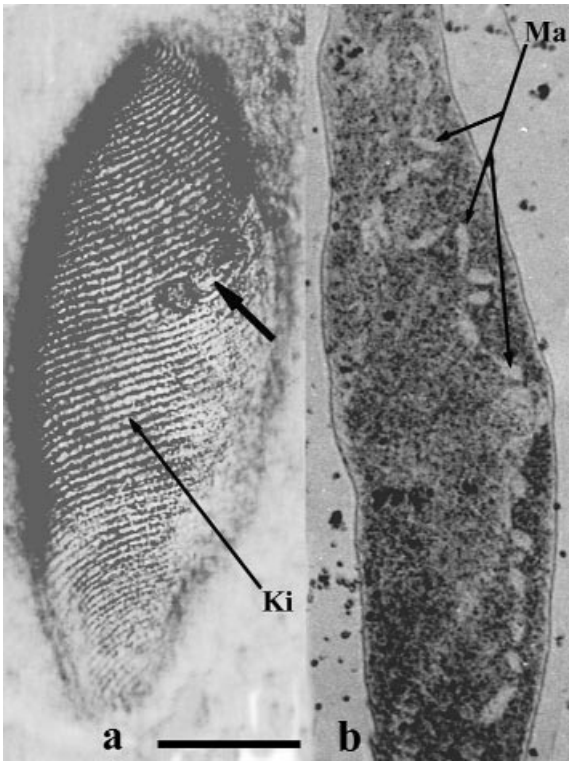

Figure 3. *Spirostomum minus* (a, silver impregnation; b, nuclear reaction). Ki. Kinety; Ma. Macronuclear segments; Arrow. mouth; Bar: 45 µm.

Table 6. Morphometric characterization of *Spirostomum minus*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length (in vivo)	808.80	126.10	15.59	490.00	950.00	13
Body, width (in vivo)	38.08	6.30	16.54	30.00	50.00	13
AZM, length (in vivo)	273.10	54.40	19.92	150.00	350.00	13
AZM/Body length (in vivo)	0.34	0.06	17.33	0.25	0.48	13
Macronucleus, number	18.31	7.80	42.60	4.00	38.00	39
Macronucleus, length	25.19	9.78	38.82	14.00	47.50	24
Macronucleus, width	8.77	4.89	55.77	4.00	20.00	24

Spirostomum teres CLAPARÈDE & LACHMANN, 1858

(Figure 4; Table 7)

Our specimens measure in vivo 300.00-490.00 x 25.00-80.00 µm, with the L/W ratio 10.46 (3.94-14.00) and nearly correspond to those reported by Foissner et al. (1992) and Augustin and Foissner (1992). Macronucleus is located approximately in middle of body, and is ellipsoidal. Contractile vacuole is located at the posterior end and a canal runs towards the anterior of cell. AZM on

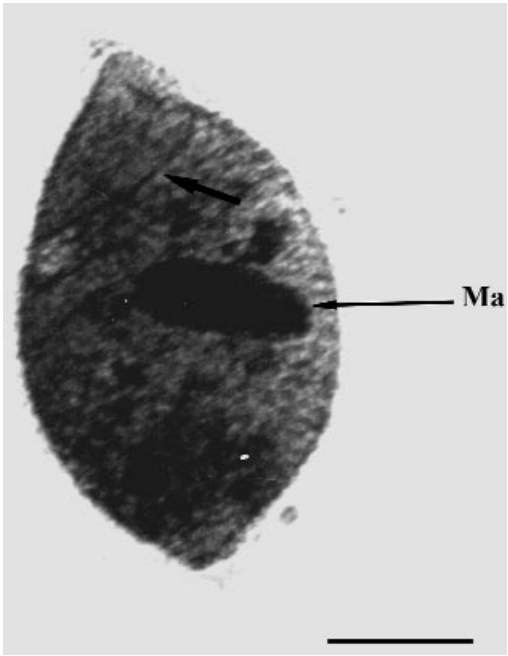

Figure 4. *Spirostomum teres*, silver impregnation. Ma, Macronucleus; Arrow, adoral zone of membranelles; Bar: 30 µm.

Table 7. Morphometric characterization of *Spirostomum teres*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length (in vivo)	377.92	50.66	13.40	300.00	490.00	36
Body, width (in vivo)	37.36	8.90	23.82	25	80.00	36
AZM, length (in vivo)	140.14	20.62	14.71	100.00	215.00	36
AZM/Body length (in vivo)	0.37	0.08	12.78	0.26	0.46	30
Macronucleus, length	30.44	6.61	21.71	22.50	55.00	36
Macronucleus, width	12.04	2.73	22.69	7.50	20.00	36

Table 8. Morphometric characterization of *Stentor coeruleus*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length (in vivo)	410.70	120.40	29.32	240.00	735.00	15
Body, width (in vivo)	127.00	14.49	11.41	105.00	155.00	15
Macronucleus, length	12.88	3.04	23.60	10.00	18.00	8
Macronucleus, width	8.63	2.20	25.51	6.00	12.00	8
Frontal field, number of kineties	24.20	4.27	17.64	20.00	30.00	5

the left body edge is relatively long, extends about 37% of cell length, and its length on average 140.14 µm.

Stentor coeruleus (PALLAS, 1766) EHRENBERG, 1831

(Figures 5a, b; Table 8)

This species belongs to the order Heterotrichida, family Stentoridae. Our specimens measure in vivo 240.00-735.00 x 105.00-155.00 µm, with highly contractile turquoise body. Macronucleus moniliform, the number of macronuclear segments is about 9, size on average is 15.21 x 10.4 µm. There are 24.20 (20.00-30.00) kineties in the frontal field (peristomial field), enclosed by adoral zone of membranelles. The morphological characters observed on the species largely correspond to those of Foissner et al. (1992), but our specimens are rather smaller.

Paramecium bursaria (EHRENBERG, 1831) FOCKE, 1836

(Figures 6a, b; Table 9)

This species belongs to the order Hymenostomatida, family Parameciidae. Our specimens measure in vivo

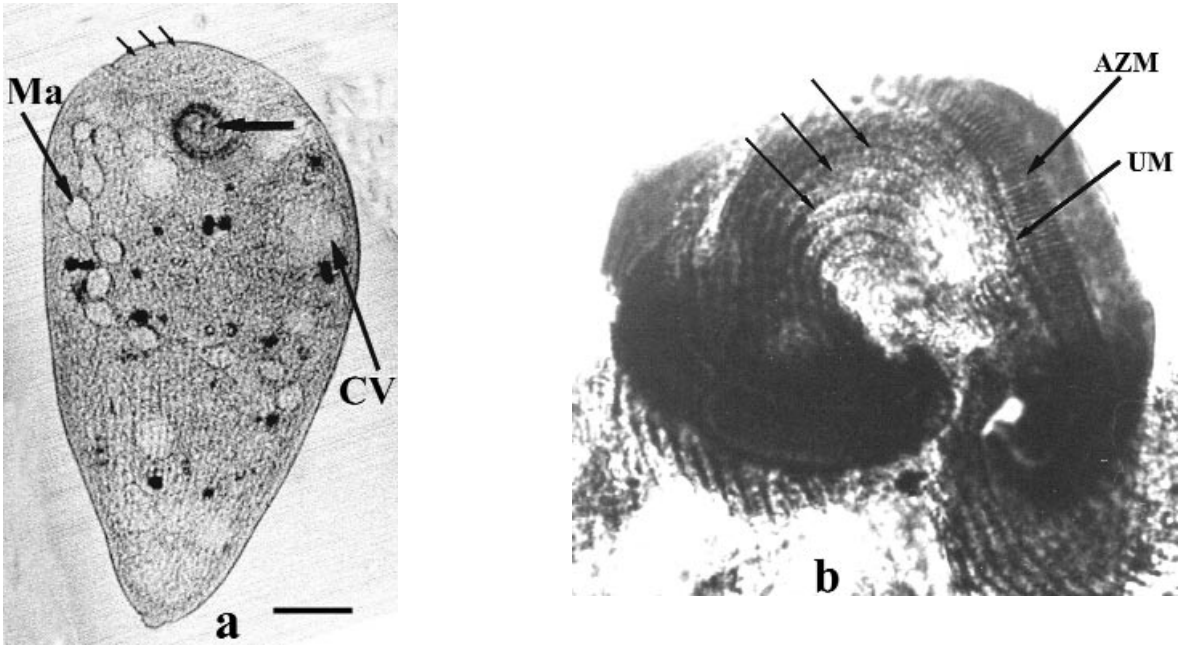

Figure 5. *Stentor coeruleus* (a. in vivo ; b. silver impregnation). Ma, macronuclear segments; Cv, contractile vacuole; AZM, adoral zone of membranelles; UM, undulating membrane; Triple arrows, frontal field; Arrow, oral opening; Bar: 35 µm.

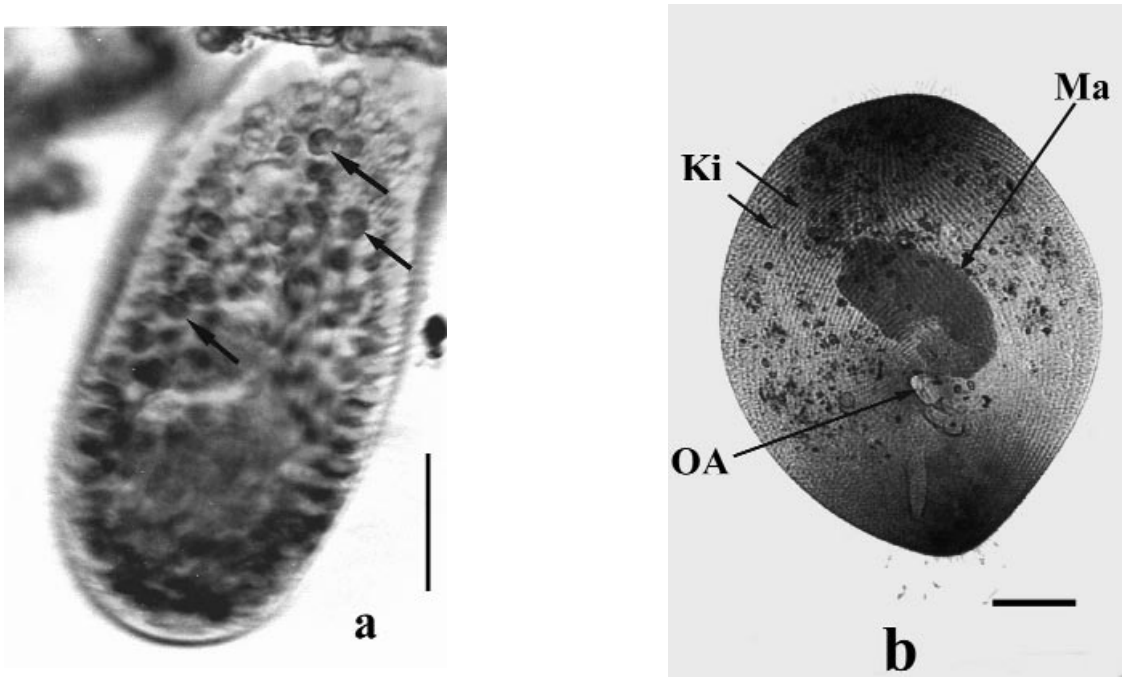

Figure 6. *Paramecium bursaria*, (a. in vivo; b. silver impregnation). Arrows, symbiotic algae; Ki, kinety; Ma, macronucleus; OA, oral apparatus; Bars: 25 µm.

Table 9. Morphometric characterization of *Paramecium bursaria*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	143.19	15.13	10.57	120.00	172.50	21
Body, width	88.33	14.84	16.71	70.00	115.00	21
Length/Width (L/W)	1.63	0.18	11.19	1.33	2.07	21
Macronucleus, length	38.12	4.36	11.45	30.00	47.50	21
Macronucleus, width	19.95	3.07	15.39	15.00	25.00	21
Micronucleus, length	14.76	2.49	16.85	10.00	22.50	21
Micronucleus, width	7.20	0.80	11.10	5.00	7.50	21
Somatic kineties, number	117.62	11.29	9.60	102.00	136.00	8

95.00-137.50 x 45.00-70.00 µm ($\bar{X}$ = 118.68, SD = 12.40, CD = 10.45, n = 19; $\bar{X}$ = 57.63, SD = 7,09, CD = 12.30, N = 19), with the L/W ratio 2.08 (1.73-2.60). Compared to the population morphometrically characterized by Foissner et al. (1994), there was no difference in body size, but our specimens have many somatic kineties.

Frontonia angusta KAHL, 1931

(Figures 7a-c; Table 10)

This species belongs to the order Hymenostomatida, family Frontonidae. Our specimens measure in vivo 125.00-205.00 x 40.00-142.50 µm ($\bar{X}$ = 156.10, SD = 19.97, CV = 12.79, N = 25; $\bar{X}$ = 63.00, SD = 14.03, CV = 22.37, N = 25), with the L/W ratio 2.55 (1.77-3.28), and are largely different from those found by Foissner et al. (1994). Body is cigar-shaped or scutiform, with a slight tapering posteriorly. Nuclear apparatus is represented by elongated macronucleus with one micronucleus. Simple, vesicular contractile vacuole is located in the middle of the body. Endoplasm bright brown, with food vacuoles containing diatom, algae. Oral apparatus typical for genus (Foissner et al., 1994; Alekperov and Asadullayeva, 1999). Foissner et al. (1994) reported 4 vestibular kineties on the right of the oral aperture but the present results conflicted with their view. In our specimens vestibular ciliature is composed of 3 kineties. Somatic kineties uniform with pre-oral and post-oral sutures, terminating at posterior pole. Somatic kineties number 78.00-113.00 and are composed of paired kinetosomes, with 6-7 post oral kineties.

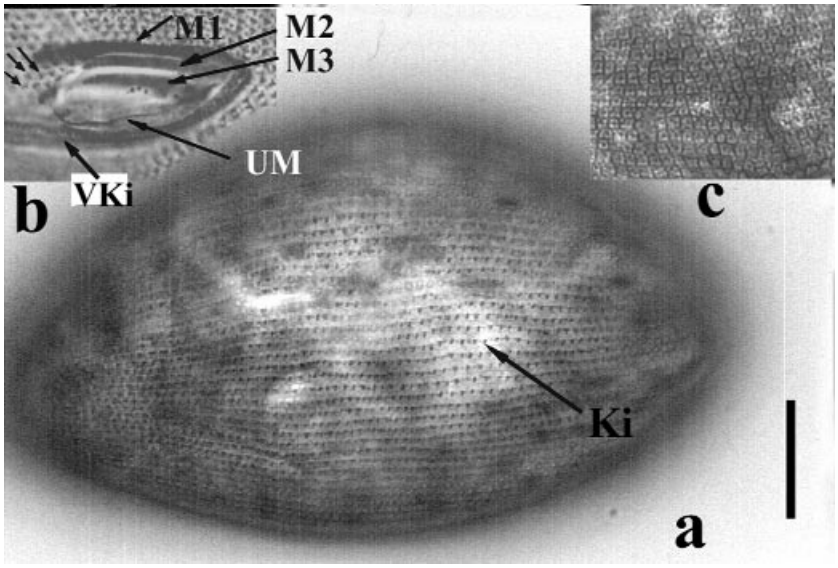

Figure 7. *Frontonia angusta*, silver impregnation. Ki, kinety; VKi, vestibular kineties; UM, undulating membrane; M1-3, adorale membranelles; Arrows, post oral kineties; c, silver line system; Bar: 20 µm.

Table 10. Morphometric characterization of *Frontonia angusta*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	145.67	31.34	21.51	92.50	250.00	45
Body, width	75.00	21.81	29.08	40.00	142.50	45
Length/Width (L/W)	1.99	0.27	13.44	1.38	2.42	45
Macronucleus, length	35.56	8.75	24.61	22.50	55.00	27
Macronucleus, width	22.13	6.07	27.43	10.00	35.00	27
Somatic kineties, number	97.92	9.46	9.66	78.00	113.00	26

Urocentrum turbo (MUELLER, 1786) NITZSCH, 1827

(Figures 8a-d; Table 11)

This species belongs to the order Hymenostomatida, family Urocentridae. Cells in vivo 57.50-72.50 x 42.50-55.00 µm ($\bar{X}$ = 64.00, SD = 5.03, CD = 7.86, N = 19; $\bar{X}$ = 49.50, SD = 4.05, CV = 8.18, N = 19) with the L/W ratio 1.30 (1.21-1.39), oval to spherical. Our specimens are relatively smaller than those of Foissner et al. (1994) and Martín-González et al. (1986). Table 11 illustrates the biometrical characterization of our population. The nuclear apparatus consists of a horseshoe-shaped macronucleus and a spherical micronucleus, situated in the posterior part of the cell. Infraciliature was described in detail by Foissner et al. (1994) and Martín-Gonzáles et al. (1986). The somatic infraciliature comprises anterior

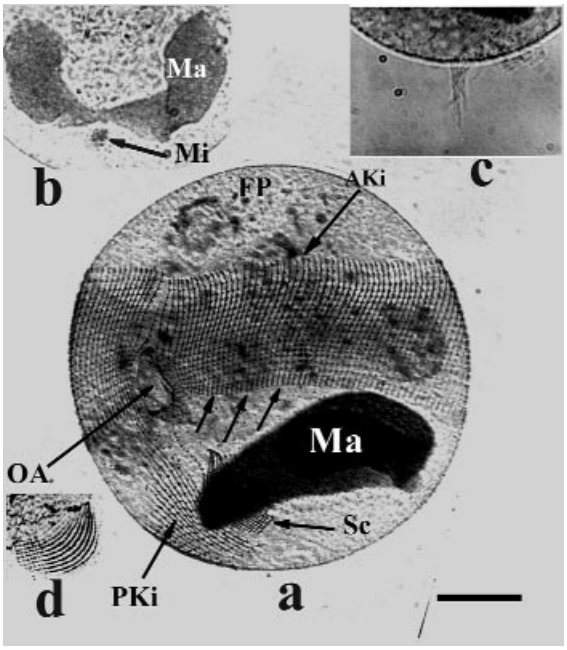

Figure 8. *Urocentrum turbo*, silver impregnation. Ma, macronucleus; Mi, micronucleus; FP, frontal plate; AKi, kineties of anterior ciliary band; PKi, kineties of posterior ciliary band; Sc, scopula; OA, oral apparatus; Arrows, kineties of equatorial ciliary band, c, tuft; d, scopula; Bar: 20 µm.

Table 11. Morphometric characterization of *Urocentrum turbo*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	89.87	7.50	8.35	77.50	102.50	20
Body, width	84.00	9.01	10.73	67.50	100.00	20
Length/Width (L/W)	1.07	0.07	6.17	1.00	1.23	20
Macronucleus, length	34.37	5.61	16.32	22.50	42.50	20
Macronucleus, width	13.00	2.51	19.33	7.50	17.50	20
Macronucleus, length	33.12	5.25	15.85	20.00	40.00	20
Macronucleus, width	13.12	2.28	17.34	7.70	15.00	20
Micronucleus, length	3.33	0.62	18.51	3.00	5.00	15
Micronucleus, width	3.07	0.26	8.42	3.00	4.00	15
Tuft, length (in vivo)	20.25	3.62	17.88	15.00	25.00	10
Scopula, kineties number	9.83	0.72	7.30	9.00	11.00	12
Anterior ciliary band, kineties number	148.50	3.89	2.62	142.00	155.00	13

ciliary band, equatorial ciliary girdle and posterior ciliary band. Distance of the unciliated frontal lam to anterior ciliary band is about 34.5 µm. The anterior band consists of 148.50 (142.00-155.00) kineties with 19 kinetosomes, the first 2 of which lie very close to each other. Equatorial girdle has almost the same number of kineties as the anterior one, and each kinety consists of 5 kinetosomes. The kineties of the posterior ciliary band are more irregular in appearance than those in the anterior ciliary band. In the posterior ciliary band, there are very argentophilic kineties (ciliary field or scopula) consisting of 9.83 (9.00-11.00) kineties that and in caudal cirrus (tuft). The length of the tuft (in vivo) is 20.25 µm (15.00-25.00).

Uronema nigricans (MUELLER, 1786) FLORENTIN, 1901

(Figure 9; Table 12)

This species belongs to the order Scuticociliatida, family Uronematidae. We have no data on living specimens. The general organization of the species, body shape, movement, nuclear apparatus, caudal cilium, and contractile vacuole were consistent with the original

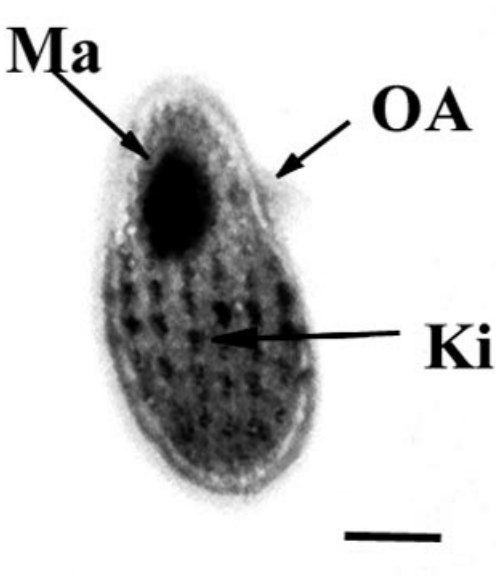

Figure 9. *Uronema nigricans*, silver impregnation. Ma, macronucleus; OA, oral apparatus; Ki, kinety; Bar: 10 µm.

Table 12. Morphometric characterization of *Uronema nigricans*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	43.29	6.16	14.23	34.00	51.00	7
Body, width	18.86	4.78	25.34	12.00	27.00	7
Length/Width (L/W)	2.40	0.64	26.67	1.89	3.75	7
Macronucleus, length	8.57	1.27	14.84	7.00	11.00	7
Macronucleus, width	7.14	1.35	18.83	5.00	9.00	7
Micronucleus, length	2.00	0.63	31.6	1.00	2.00	6
Micronucleus, width	1.83	0.41	22.26	1.00	2.00	6
Unciliated frontal plate (bulge), length	2.40	0.55	22.83	2.00	3.00	5
Somatic kineties, number	15.33	1.51	9.82	14.00	17.00	6

descriptions. Measurements after fixation are given below with biometric characterization. On average 43.29-18.86 µm in size; ovoid, with flattened anterior bulge (frontal plate), in anterior third with small indentation indicating oral opening with a small oral apparatus. Somatic ciliature is on average composed of 15.33 longitudinal kineties. Kineties begin after unciliated frontal plate, its length is 2.40 µm (2.00-3.00), terminating around the caudal cilium in the posterior pole.

Dexiotricha granulosa (KENT, 1888) FOISSNER, BERGER & KOHMANN, 1994

(Figures 10a, b; Table 13)

This species belongs to the order Hymenostomatida, family Loxocephalidae. Our specimens measure in vivo approximately 40.00 x 18.33 µm, egg-shaped, about twice as long as broad, 2.00 x 2.43. Oral apparatus subapical, lightly indented. Distance anterior to mouth is 7.00 µm (5.00-9.00). Macronucleus, spherical to ovoid, is situated nearly in mid-body, with a spherical micronucleus. The distance between the anterior end and the macronucleus is 28.89 µm (19.00-37.00). There is a contractile vacuole about in the middle of the cell. Somatic and oral infraciliature were given in detail by Augustin and Foissner (1992) and Foissner et al. (1994). Longitudinal kineties extend from unciliated anterior field (bulge), its length is approximately 2.32 µm, to posterior pole. Cytoplasm contains heavily ring shaped, refractile granules. Our specimens in many characteristics correspond to those found by Foissner et al. (1994), but with fewer kineties. Somatic ciliature consists of 20 (18.00-26.00) kineties. In this respect our specimens correspond to *Dexiotricha tranquilla* (Augustin and Foissner, 1992).

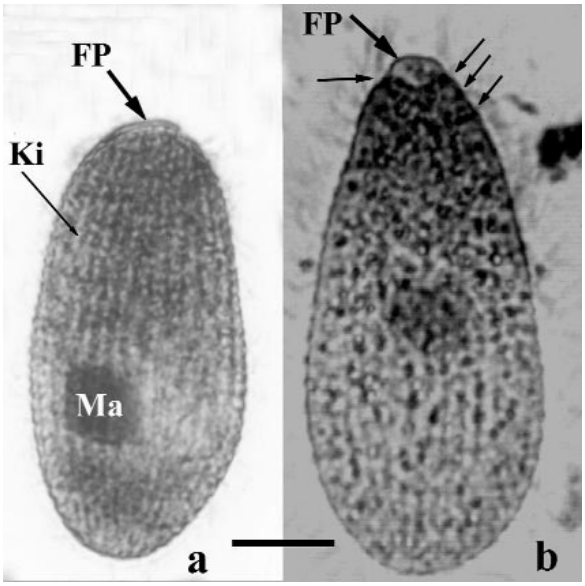

Figure 10. D*exiotricha granulosa*, silver impregnation. FP, frontal plate; Ki, kinety, Arrows, ciliary band; Bar: 10 µm.

Table 13. Morphometric characterization of *Dexiotricha granulosa*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	46.95	3.51	6.17	40.00	51.00	21
Body, width	23.95	5.77	24.09	16.00	37.00	21
Length/Width (L/W)	2.05	0.39	19.98	1.30	2.77	21
Macronucleus, length	11.15	2.21	19.79	7.00	15.00	20
Macronucleus, width	8.40	2.14	25.44	5.00	13.00	20
Micronucleus, length	2.50	0.76	30.44	2.00	4.00	20
Micronucleus, width	2.20	0.62	28.00	1.00	4.00	20
Distance anterior end to oral opening	7.00	1.53	21.83	5.00	9.00	7
Distance anterior end to macronucleus	28.89	4.65	16.10	19.00	37.00	18
Unciliated frontal field (Bulge), length	2.32	0.67	28.97	2.00	4.00	19
Bulge length/body length	0.05	0.02	33.88	0.04	0.10	19
Somatic kineties, number	20.00	2.57	11.28	18.00	26.00	12

Cyclidium glaucoma MUELLER, 1773

(Fiures11a, b; Table 14)

This species belongs to the order Scuticociliatida, family Pleuronematidae. Size in vivo 22.50-30.00 x 10.00-15.00 µm ($\bar{X}$ = 25.16, SD = 1.70, CV = 6.76, N = 16; $\bar{X}$ = 12.34, SD = 1.70, CV = 13.77, N = 16), with the L/W ratio 2.07 (1.67-2.50). Nuclear apparatus consists of a single macronucleus and a spherical micronucleus. Contractile vacuole is terminally situated in posterior of cell. When we compare our findings with those of Foissner et al. (1994), our specimens are slightly larger and show a wider range of somatic kineties number, 13.20 (11.00-15.00). Foissner et al. (1994) observed 10-11 longitudinal kineties. Unciliated frontal field, or bulge, is conspicuous with 3.84 µm (3.00-5.00) length. Somatic kineties are arranged longitudinally, which are usually dikinetids in the anterior of each row. All kineties, with their length 20.31 µm (13.00-31.00), have more or less shortened in posterior portion making a large unciliated posterior field the length of which is 5.69 µm (3.00-8.00). Oral apparatus is typical for the genus *Cyclidium*, extending to about $^1/_2$ of cell length, with prominent undulating membrane on its right margin. Table 14 illustrates the biometrical characterization of our specimens. Song (2000) examined *Cyclidium* spp. by comparing the populations morphometrically.

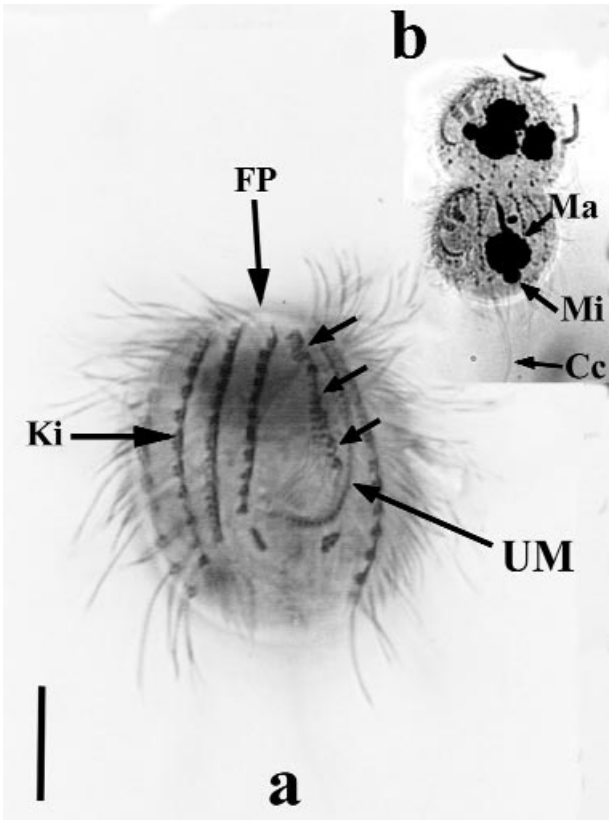

Figure 11. *Cyclidium glaucoma*, Silver impregnation. FP, frontal plate; Ki, kinety; UM, undulating membrane; Arrows, adoral membranelles (M1-3); Ma, macronucleus; Mi, micronucleus; Cc, caudal cilium; b, binary fission; Bar: 10 µm.

Table 14. Morphometric characterization of *Cyclidium glaucoma*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	28.33	3.36	11.84	21.00	35.00	36
Body, width	21.53	3.33	15.45	11.00	27.00	36
Length/Width (L/W)	1.34	0.22	16.17	1.08	2.36	36
Macronucleus, length	9.70	1.88	19.38	6.00	13.00	33
Macronucleus, width	7.58	1.69	22.15	5.00	12.00	33
Micronucleus, diameter	2.46	0.52	21.08	2.00	3.00	13
Unciliated frontal plate (Bulge), length	3.84	0.60	15.67	3.00	5.00	19
Distance anterior end to oral apparatus	7.89	3.52	44.61	4.00	12.00	9
Distance anterior end to	21.12	3.00	14.20	15.00	25.00	8
Oral apparatus, length	13.62	4.31	31.64	8.00	20.00	8
Kinetosomes in paroral membranella, number	37.56	9.82	26.14	16.00	49.00	9
Somatic kineties, number	13.20	0.99	7.53	11.00	15.00	35
Somatic kinety, length	20.31	4.27	21.02	13.00	31.00	13
Somatic kinety, number of kinetosomes	13.13	1.45	11.08	12.00	16.00	24
Unciliated field in posterior, length	5.69	1.25	21.98	3.00	8.00	16
Caudal cilium, length	13.89	1.36	9.82	11.00	15.00	9

Urotricha globosa SCHEWIAKOFF, 1892

(Figures 12a-c: Table 15)

This species belongs to the order Prostomatida, family Plagiocampidae. Our specimens measure in vivo 12.50-25.00 x 10.00-22.50 µm ($\bar{X}$ = 19.67, SD = 3.76, CV = 19.14, N = 15; $\bar{X}$ = 17.17, SD = 4.3, CV = 25.16, N = 15) with the ratio 1.77 (1.00-1.50) and are almost spherical. The morphological characters determined by live observation are consistent with those reported by

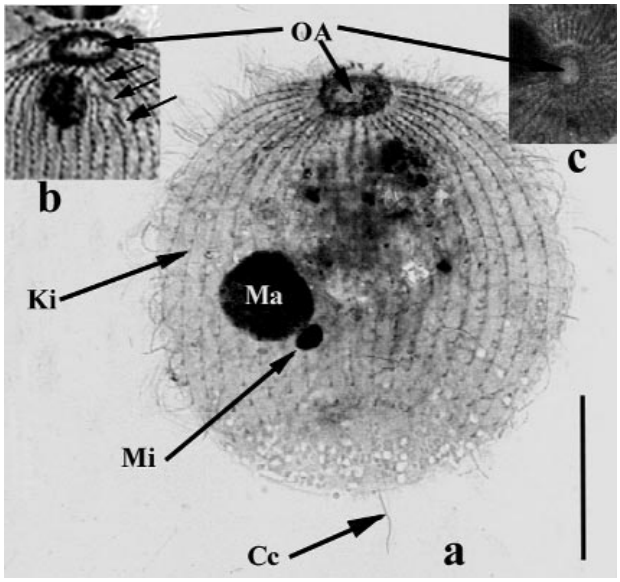

Figure 12. *Urotricha globosa*, silver impregnation. OA, oral apparatus; Ki, kinety; Ma, macronucleus; Mi, micronucleus; Cc, caudal cilium; Arrows, brosse (adoral organelle); Bar: 10 µm.

Table 15. Morphometric characterization of *Urotricha globosa*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	24.79	4.58	18.48	17.00	34.00	28
Body, width	23.14	4.69	20.26	15.00	32.00	28
Length/Width (L/W)	1.08	0.11	10.47	1.00	1.56	28
Macronucleus, length	6.29	1.61	25.56	4.00	11.00	28
Macronucleus, width	5.29	1.08	20.51	4.00	7.00	28
Micronucleus, length	2.32	0.67	28.87	1.00	4.00	28
Micronucleus, width	2.18	0.77	35.43	1.00	4.00	28
Caudal cilium, length	11.31	1.65	14.62	9.00	13.00	13
Somatic kineties, number	22.15	2.77	10.23	18.00	26.00	26
Somatic kinety, length	14.80	1.42	9.62	13.00	18.00	15
Somatic kinety, number of kinetosomes	16.00	2.92	18.22	11.00	20.00	9
Body length/somatic kinety length	1.60	0.13	8.13	1.33	1.80	15

Foissner et al. (1994). Nuclear apparatus consists of a spherical macronucleus and a micronucleus situated in the mid-body. Contractile vacuole in posterior end. Infraciliature is typical for the genus *Urotricha*. Somatic kineties are in a longitudinal arrangement and composed of 22.15 (18.00-26.00) with 11.00-16.00 kinetosomes, extending to average 14.80 µm of the cell length from the anterior end, the rest of the body is not ciliated. The length of caudal cilium in vivo, which is centrally located at posterior pole, is about 11.31 µm (9.00-13.00). Brosse (adoral organelle) composed of 3 kineties, anterior row with 6 kinetids, middle row with 5 to 6 kinetids, posterior row with 6 kinetids.

Coleps hirtus (MUELLER, 1786) NITZSCH, 1827

(Figures 13a, b; Table 16)

This species belongs to the order Prostomatida, family Colepidae. Our observations on the live material usually coincide with those of Foissner et al. (1994), but our specimens are slightly smaller and their sizes in vivo are 37.50-55.00 x 22.50-25.00 µm ($\bar{X}$ = 47.03, SD = 5.10, CV = 10.84, N = 16; $\bar{X}$ = 24.22, SD = 1.20, CV = 4.94, N = 16), with the L/W ratio 1.94 (1.50-2.22). The body is elongated and barrel-shaped to cylindrical. Number of windows in pellicular plates correspond to those given by Foissner et al. (1994) and Foissner (1984b): anterior and posterior side–plates each with 2 windows, anterior and posterior mid-plates with 4 windows. Plate structure is the same as that of *C. amphacanthus* (Foissner and O'Donoghue, 1990) but the number of windows is different from that of *C. amphacanthus*. The windows of *C. hirtus* are very similar in shape to those of the other species, *C. amphacanthus* and *C. spetai* (Foissner and O'Donoghue, 1990; Foissner et al., 1994), which are barrel-shaped. Infraciliature is given in detail by Foissner et al. (1994) and Foissner (1984b); somatic infraciliature is composed of 14.67 (14.00-16.00) longitudinal kineties. Spherical macro- and micronucleus are about in the mid-body. Contractile vacuole is in the posterior.

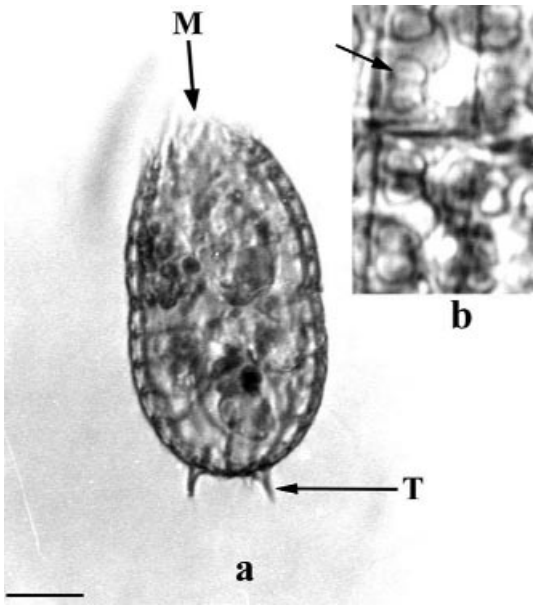

Figure 13. *Coleps hirtus* (a, in vivo, b, silver impregnation). M, mouth; T, thorn; Arrow, windows in armor plates; Bar: 10 µm.

Table 16. Morphometric characterization of *Coleps hirtus*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	50.47	5.65	11.19	40.00	62.00	36
Body, width	28.61	6.36	22.23	18.00	48.00	36
Length/Width (L/W)	1.82	0.32	17.10	0.94	2.50	36
Macronucleus, length	11.05	1.62	14.61	8.00	13.00	19
Macronucleus, width	10.47	1.78	16.95	7.00	13.00	19
Micronucleus, length	2.83	0.75	26.58	2.00	4.00	6
Micronucleus, width	2.67	0.82	30.60	2.00	4.00	6
Somatic kineties, number	14.67	0.97	6.59	14.00	16.00	21

Lagynus elegans (ENGELMANN, 1862) QUENNERSTEDT, 1867

(Figures 14a-c; Table 17)

This species is well known as a member of the bottom fauna but its systematic position is not yet clear. The species belongs to the order Gymnostomatida, family Lacrymariidae (Foissner et al., 1995). However, Foissner (1988) recommended that the genus *Lagynus* should be included in the family Metacystidae (Prostomatida). Sola et al. (1990) suggested that this genus belongs to a new family, Lagynidae, in the order Prorodontida, because of the absence of lorica and the presence of a brosse. The general organization of the species was consistent with some descriptions (Sola et al., 1990; Foissner et al., 1995). The cell of *L. elegans* is prolonged amphora or lamp-chimney in shape. Anterior end of the cell is annulated. The cell consists of 3 parts: anterior cone, its size 6.76 x 9.62 µm, and the oral opening is located there, the main part of the cell is the widest part of the cell, the posterior part of the cell is narrower and

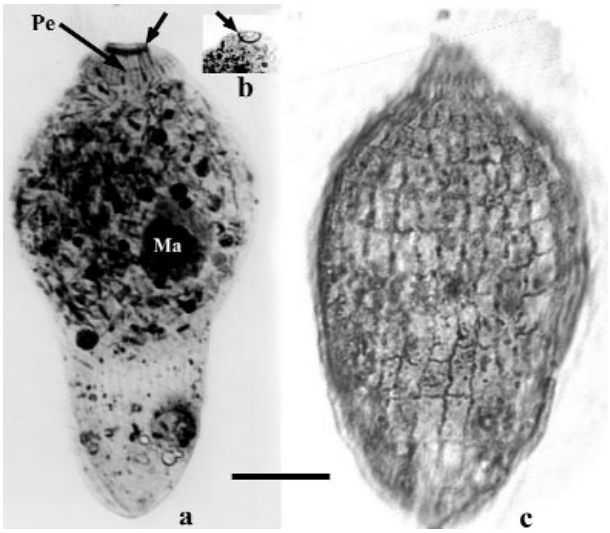

Figure 14. *Lagynus elegans*, silver impregnation. Ma, macronucleus; Pe, circumoral infraciliature; Arrows, nematodesmata, c, silver line system; Bar: 15 µm.

Table 17. Morphometric characterization of *Lagynus elegans*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	75.15	11.63	15.48	56.00	103.00	27
Body, width	31.04	7.54	24.28	22.00	57.00	27
Length/Width (L/W)	2.49	0.42	16.68	1.79	3.24	27
Anterior cone, length	6.76	1.20	17.75	5.00	9.00	25
Anterior cone, width	9.62	2.25	23.36	6.00	15.00	21
Vacuole, length	30.48	7.63	25.16	19.00	45.00	25
Somatic kineties, number	29.56	3.43	11.60	26.00	38.00	9

flattened, and a large contractile vacuole is present. Its length is 30.48 µm (19.00-45.00). Macronucleus is reniform, located in mid-body, with a micronucleus, its length about 17 µm and 14 µm. Somatic infraciliature is composed of 29.56 (26.00-38.00) longitudinal kineties, with single kinetosome.

Didinum nasutum (MUELLER, 1773) STEIN, 1859

(Figures 15a, b; Table 18)

This species belongs to the order Spathidiida, family Didinidae. Our specimens measure in vivo 80.00-107.50 x 45.00-67.50 µm ($\bar{X}$ = 92.31, SD = 7.32, CV = 7.93, N = 13; $\bar{X}$ = 54.23, SD = 6.49, CV = 11.97, N = 13) with the L/W ratio 1.73 (1.28-2.11). General organization of the species is consistent with those reported by Foissner et al. (1995) and Foissner (1984b), but our specimens

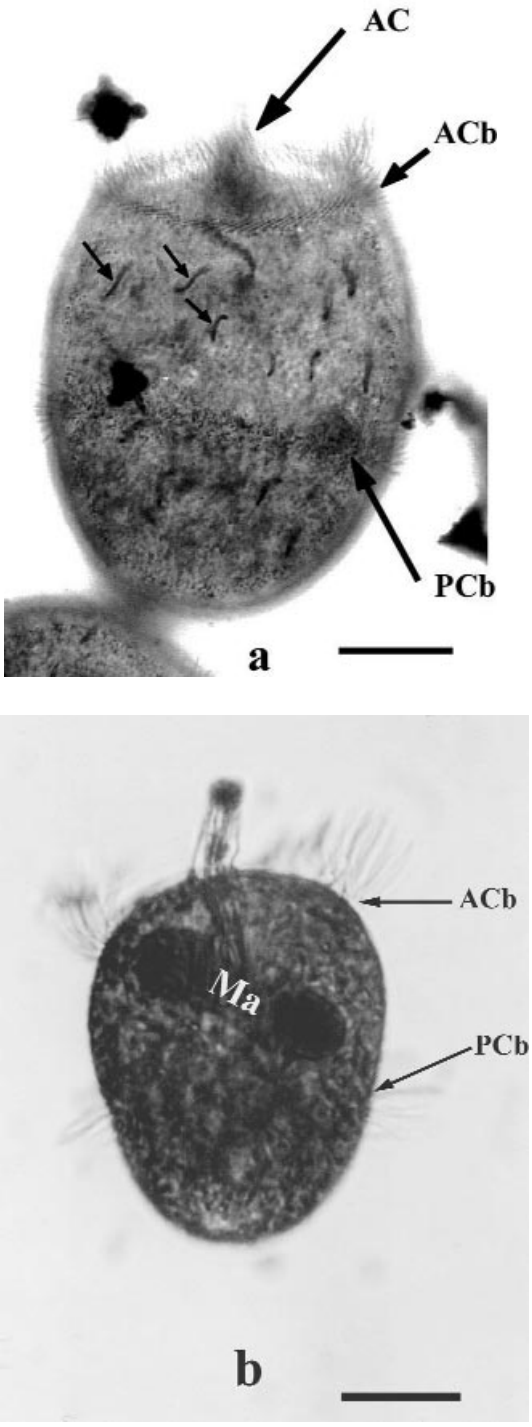

Figure 15. *Didinum nasutum*, silver impregnation. AC, apical cone; ACb, anterior ciliary band, PCb, posterior ciliary band; Ma, macronucleus, Arrows, extrusomes; Bars: 25 µm.

are smaller. With 2 ciliary bands: 1 anterior composed of about 83 kineties and 1 equatorial composed of about 70 kineties. Macronucleus is horseshoe in shape and located

Table 18. Morphometric characterization of *Didinium nasutum*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	104.89	17.89	17.06	82.00	135.00	18
Body, width	76.61	16.33	21.32	52.00	105.00	18
Length/Width (L/W)	1.38	0.11	7.63	1.22	1.58	18
Apical cone, length	9.94	1.47	14.82	7.00	13.00	18
Apical cone length/ body length	0.10	0.02	21.45	0.06	0.13	18
Distance between 2 ciliary bands	44.15	6.59	14.93	35.00	60.00	13

near the mid-body, its width is approximately 20.33 µm, with a spherical micronucleus (6.00-5.33). Anterior part of the ciliate is flattened and has a projecting cone with mouth at the tip of body, its length on average 9.94 µm (7.00-13.00).

Monodinium balbiani FABRE-DOMERGUE, 1888

(Figure 16; Table 19)

M. balbiani is very similar to *Didinium nasutum*, differing from that species mainly with a single band of cilia. Size in vivo about 50.00-87.50 X 37.50-50 µm ($\bar{X}$ = 65.38, SD = 10.94, CV = 16.73, N = 13; $\bar{X}$ = 49.04, SD = 6.58, CV = 13.42, N = 13) with the L/W ratio 1.34 (1.14-1.75). Somatic kineties on ciliary band number 78.33 (75.00-88.00). Macronucleus width 15.8 µm, diameter of the micronucleus 4 µm.

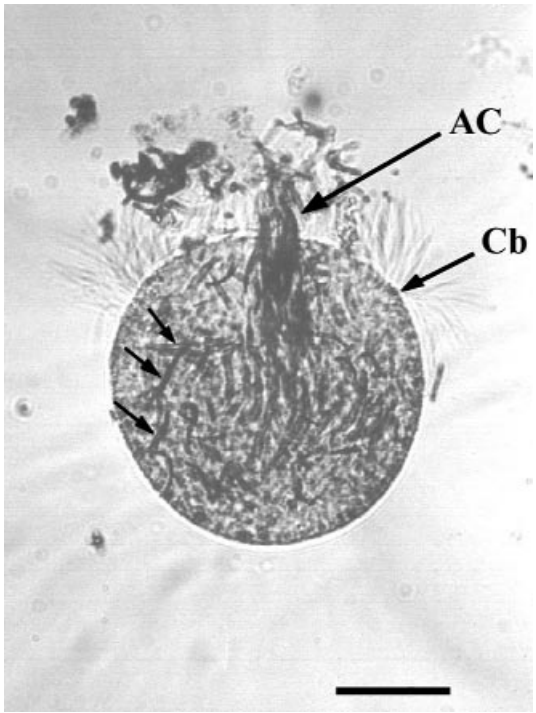

Figure 16. *Monodinium balbiani*, silver impregnation. AC, apical cone; Cb, ciliary band; Arrows, extrusomes; Bar: 25 µm.

Table 19. Morphometric characterization of *Monodinium balbiani*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	83.55	18.63	22.30	49.00	120.00	33
Body, width	67.76	16.75	24.72	35.00	93.00	33
Length/Width (L/W)	1.25	0.10	7.81	1.12	1.57	33
Apical cone, length	8.68	1.82	20.92	6.00	13.00	31
Apical cone length/body length	0.11	0.03	23.92	0.07	0.17	31
Somatic kineties, number	78.83	5.12	6.49	75.00	88.00	6

Plagiopyla nasuta STEIN, 1860

(Figures 17a, b; Table 20)

This species belongs to the order Gymnostomatida, family Plagiopylidae. Ovoid shape, after fixation on average 91.82 x 42.42 µm in size. Oral opening

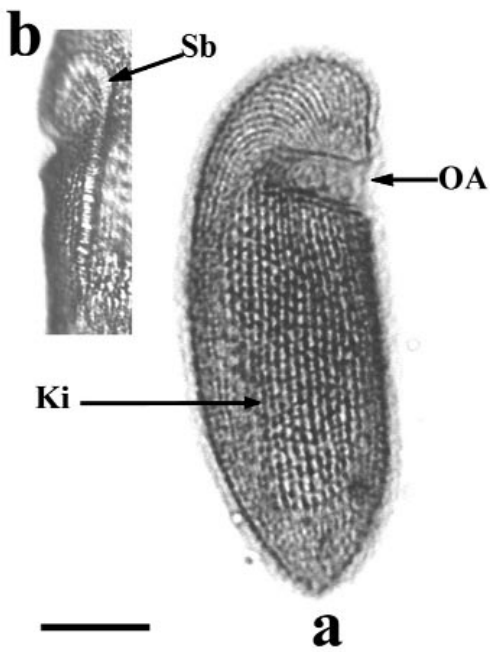

Figure 17. *Plagiopyla nasuta*, silver impregnation. OA, oral apparatus; Ki; kinety; Sb, striped band; Bar: 20 µm.

Table 20. Morphometric characterization of *Plagiopyla nasuta*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	91.82	17.48	19.04	67.00	135.00	25
Body, width	42.42	15.74	37.11	20.00	80.00	25
Length/Width (L/W)	2.32	0.52	22.39	1.59	3.50	25
Distance anterior end to oral opening	17.86	4.26	23.85	11.00	27.50	25
Mouth indentation, length	21.29	6.90	32.40	12.00	38.00	17
Oral opening, length	5.37	0.83	15.48	5.00	8.00	19
Somatic kineties, number	52.83	4.22	7.99	48.00	60.00	6

subapical, on average 5.37 µm width, at right angles to long axis of the cell. Distance between anterior end of cell and oral opening is on average 17.86 µm (11.00-27.50). The length of mouth indentation is 21.29 µm (12.00-38.00). Striped band curves from vestibule and extends along dorsal side. Macronucleus ovoid, 34 x 22 µm, with a spherical micronucleus, its diameter is approximately 2.5 µm. The species possesses on average 52.83 (48.00-60.00) kineties. Our observations on the general organization of the species were consistent with those of Sola et al. (1988) and Foissner et al. (1995).

Amphileptus pleurosigma (STOKES, 1884) FOISSNER, 1984

(Figures 18a, b; Table 21)

This species belongs to the order Pleurostomatida, family Amphileptidae. Our specimens in vivo measure 150.00-280.00 x 37.50-62.50 µm ($\bar{X}$ = 228.50, SD = 36.63, CV = 16.03, N = 15; $\bar{X}$ = 53.00, SD = 8.30, CV = 15.66, N = 15), with the L/W ratio 4.36 (3.18-5.83). The body is spindle-like, tapering anteriorly and posteriorly, moderately contractile. Macronuclear segments located approximately in middle of body, elipsoidal, almost equal in size (19.08 x 13.03 µm; 18.94 x 13.00 µm). Distance between 2 macronuclear segments is on average 22.10 µm (11.00-35.00). Single micronucleus is ellipsoidal (10 x 5 µm), positioned between macronuclear segments. Many contractile vacuoles are present, located along dorsal and ventral edges. Extrusomes are arranged along anterior end, and dispersed throughout cytoplasm. Infraciliature is typical for the genus (Foissner, 1984a; Foissner et al., 1995).

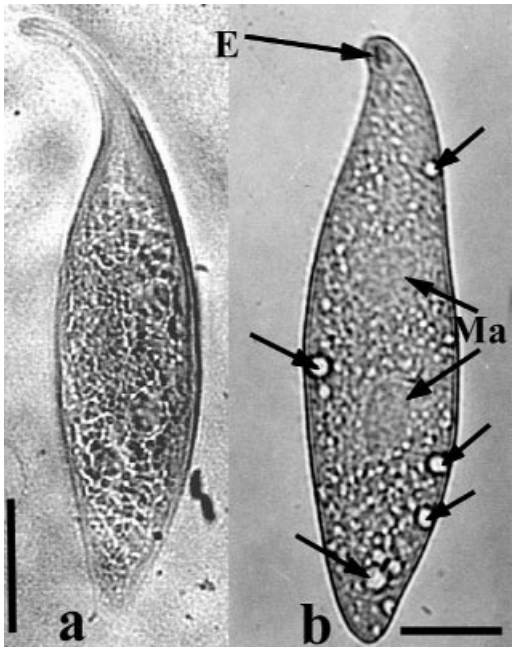

Figure 18. *Amphileptus pleurosigma* (a. silver impregnation; b, in vivo). E, extrusomes; Ma, macronuclear segments; Arrows, contractile vacuoles; Bars: 40 µm.

Table 21. Morphometric characterization of *Amphileptus pleurosigma*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	187.80	40.00	21.30	110.00	250.00	22
Body, width	50.02	15.03	30.05	25.00	75.00	22
Length/Width (L/W)	3.91	0.74	18.96	2.59	5.71	22
Anterior macronucleus, length	19.08	4.73	24.79	12.00	27.50	18
Anterior macronucleus, width	13.03	2.63	20.16	9.00	17.50	18
Posterior macronucleus, length	18.94	4.36	23.02	12.00	25.00	18
Posterior macronucleus, width	13.00	2.31	17.75	10.00	17.50	18
Distance between macronuclear segments	22.10	6.09	27.56	11.00	35.00	15
Somatic kineties, number	19.18	4.29	22.37	13.00	27.00	11

On the right side, approximately 19.18 (13.00-27.00) kineties converge on each other in the anterior region.

Loxedes striatus (ENGELMANN, 1862) PENARD, 1917

(Figure 19; Table 22)

This species belongs to the order Karyorelictida, family Loxodidae. Size in vivo 150.00-50.00 x 50.00-

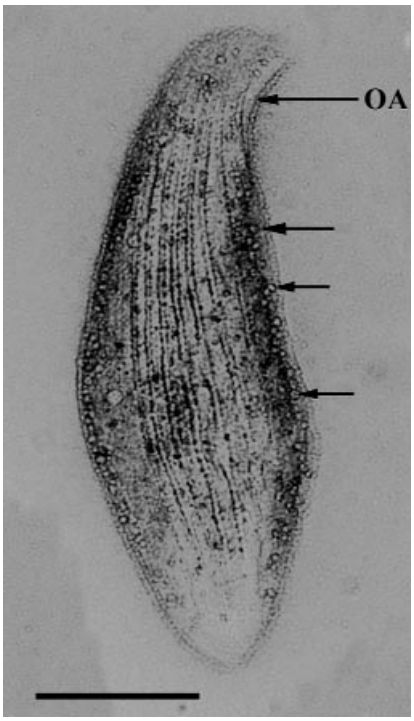

Figure 19. *Loxedes striatus*, silver impregnation. OA, oral apparatus; Arrows, Müller vesicles; Bar: 20 µm.

Table 22. Morphometric characterization of *Loxedes striatus*.

Character	$\bar{X}$	SD	CV	Min	Max	N
Body, length	79.43	13.02	16.39	62.00	120.00	23
Body, width	23.87	3.48	14.58	17.00	34.00	23
Length/Width (L/W)	3.34	3.39	11.61	2.76	4.29	23
Anterior macronucleus, length	4.65	0.49	10.47	4.00	5.00	23
Anterior macronucleus, width	4.44	0.51	11.43	4.00	5.00	23
Posterior macronucleus, length	5.04	0.37	7.27	4.00	6.00	23
Posterior macronucleus, width	4.61	0.50	10.83	4.00	5.00	23
Anterior micronucleus, length	1.78	0.42	0.09	1.00	2.00	23
Anterior micronucleus, width	1.44	0.51	35.33	1.00	2.00	23
Posterior micronucleus, length	1.87	0.34	18.42	1.00	2.00	23
Posterior micronucleus, width	1.52	0.51	33.57	1.00	2.00	23
Distance between macronuclear segments	20.26	5.37	26.51	12.00	32.00	23
Oral opening, length	22.54	3.67	16.28	16.00	30.00	13
Cytopharynx length	14.60	4.33	29.66	9.00	20.00	10
Body lenght/oral opening length	4.26	0.50	11.75	3.67	5.20	13
Body length/cytopharynx length	7.27	2.15	29.58	5.00	12.22	10
Somatic kineties, number	9.34	1.10	11.72	8.00	12.00	32

75.00 µm, with the L/W ratio 2.92 (2.67-3.08). Flattened ciliates with a crescent-shaped mouth, its length on average 22.54 µm (16.00-30.00), situated anteriorly along the ventral edge. Oral apparatus ends with an obvious cytopharynx, its length on average 14.60 µm (9.00-20.00). Nuclear apparatus composed of 2 diploid macronuclei, almost spherical and equal in sized, and 2 spherical micronuclei. Distance between macronuclear segments is on average 20.26 µm (12.00-32.00). Somatic kineties are bipolar. They run from the anterior to the posterior end, and consist of paired kinetosomes. There are 9.34 (8.00-12.00) kineties on the right side and only 2 on the left side, a ventral and dorsal one. Cytoplasm granulated, containing Müller vesicles, a peculiar organelle characteristic of loxodid ciliates, and ample pigment granules, located parallel to the kineties. The structure and function of Müller vesicles were examined in detail by Fenchel and Finlay (1986).

In this study, descriptions of the peritrich ciliates are based on only live observations. *Epistylis digitalis* (LINNAEUS, 1758) EHRENBERG, 1830 (Peritrichida, Epistylididae) is colonial with a non-contractile stalk, and epibiont on copepods. In vivo it measures 60.00-87.50 x 25.00-37.50 µm ($\bar{X}$ = 72.88, SD = 9.00, CV = 12.35, N = 13; $\bar{X}$ = 28.46, SD = 3.61, CV = 12.68, N = 13), with

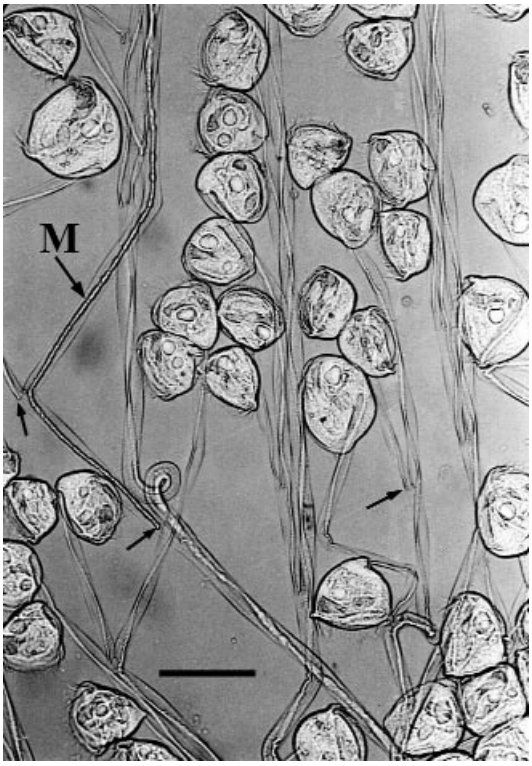

Figure 20. *Carchesium polypinum* (MSF). M, myonema; Arrows, discontinuous myonema; Bar: 60 µm.

the L/W ratio 2.58 (2.17-3.30). *Carchesium polypinum* (LINNAEUS, 1758) EHRENBERG, 1830 (Peritrichida, Vorticellidae) (Figure 20) is colonial with a contractile stalk. Myonema in the stalk is discontinuous. Our specimens measure in vivo 70.00-112.50 x 50.00-72.50 µm ($\bar{X}$ = 87.73, SD = 16.26, CV = 18.53, N = 11; $\bar{X}$ = 54.09, SD = 18.04, CV = 33.35, N = 11) with the L/W ratio 2.65 (1.30-1.54).

References

Alekperov, I.Kh. and Asadullayeva, E.S. 1999. New, little-known and characteristic ciliate species from the Apsheron coast of the Caspian Sea. Turk. J. Zool. 23: 215-22.

Augustin, V.H. and Foissner, W. 1992. Morphologie und ökologie einiger ciliaten (Protozoa: Ciliophora) aus dem belebtschlamm. Arch. Protistenkd. 141: 243-283.

Barbieri, S.M. and Orlandi, J.L. 1989. Ecological studies on the planktonic Protozoa of a eutrophic reservoir (Rio Grande Reservoir-Brazil). Hydrobiologia. 183: 1-10.

Beaver, J.R. and Crisman, T.L. 1989. The role of ciliated Protozoa in pelagic freshwater ecosystems. Microb. Ecol. 17: 111-136.

Biyu, S. 2000. A comparative study on planktonic ciliates in two shallow mesotrophic lakes (China): species composition, distribution and quantitative importance. Hydrobiologia. 427: 143-153.

Cabré, H.S. 1993. Analysis of the structure of ciliate protozoan communities in a trophic gradient of a reservoir from Barcelona (Spain) (in Spanish). Bol. R. Soc. Esp. Hist. Nat. (Sec. Biol.). 90(1-4): 17-28.

Curds, C.R. 1982. British and other freshwater ciliated Protozoa. Part I. Ciliophora: Kinetofragminophora, Cambridge University Press, Cambridge.

Curds, C.R., Gates, M.A. and Roberts, D.McL. 1983. British and other freshwater ciliated Protozoa. Part II. Ciliophora: Olygohymenophora and Polyhymenophora keys and notes for the identification of the free-living genera, Cambridge University Press, Cambridge.

Fenchel, T. and Finlay, B.J. 1986. The structure and function of Müller vesicles in Loxodid ciliates. J. Protozool. 33: 69-76.

Fernandez-Galiano, D. 1976. Silver impregnation of ciliated Protozoa: Procedure yielding good results with the pyridinated silver carbonate method. Trans. Amer. Micros. Soc. 95: 557-560,

Fernandez-Galiano, D. 1994. The ammoniacal silver carbonate method as a general procedure in the study of Protozoa from sewage (and other) waters. Wat. Res. 28: 495-496.

Finlay, B.J. 1982. Effects of seasonal anoxia on the community of benthic ciliated Protozoa in a productive lake. Arch. Protistenkd. 125: 215-222.

Finlay, B.J., Clarke, K.J., Cowling, A.J., Hindle, R.M., Rogerson, A. and Berninger, U.G. 1988. On the abundance and distribution of Protozoa and their food in a productive freshwater pond. Europ. J. Protistol. 23: 205-217.

Foissner, W. 1984a. Taxonomie und ökologie einiger ciliaten (Protozoa, Ciliophora) des saprobiensystems. I: Genera *Litonotus, Amphileptus, Opisthodo*n. Hydrobiologia. 119: 193-208.

Foissner, W. 1984b. Infraciliatur, silberliniensystem und biometrie einiger neuer und wenig bekannter terrestrischer, limnischer und mariner ciliaten (Protozoa: Ciliophora) aus den Klassen Kinetofragminophora, Colpodea und Polyhymenophora. Stapfia. 12: 1-165.

Foissner, W. 1988. Taxonomic and nomenclatural revision of Släde_ek's list of ciliates (Protozoa: Ciliophora) as indicators of water quality. Hydrobiologia. 166: 1-64.

Foissner, W. 1991. Basic and scanning electron microscopic methods for taxonomic studies of ciliated Protozoa. Europ. J. Protistol. 27: 213-330.

Foissner, W. 1997. Faunistic and taxonomic studies on ciliates (Protozoa, Ciliophora) from clean rivers in Bavaria (Germany), with descriptions of new species and ecological notes. Limnologica. 27: 179-238.

Foissner, W. and Berger, H. 1996. 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. Freshwater Biology. 35: 375-482.

Foissner, W., Berger, H., Blaterer, H. and Kohmann, F. 1995. Taxonomiche and ökologishe revision der ciliaten des saprobiensystem, Band IV: Gymnostomatea, *Loxodes*, Suctoria. Informationsberichte des Bayer. Landesamtes für wasser wirtschaft, Heft 1/95.

Foissner, W., Berger, H. and Kohmann, F. 1992. Taxonomiche and ökologishe revision der ciliaten des saprobiensystem, Band II: Peritrichia, Heterotrichida, Odontostomatida. Informationsberichte des Bayer. Landesamtes für wasser wirtschaft, Heft 1/92.

Foissner, W., Berger, H. and Kohmann, F. 1994. Taxonomiche and ökologishe revision der ciliaten des saprobiensystem, Band III: Hymenostomata, Prostomatida, Nassulida. Informationsberichte des Bayer. Landesamtes für wasser wirtschaft, Heft 1/94.

Foissner, W., Blaterer, H., Berger, H. and Kohmann, F. 1991. Taxonomiche and ökologishe revision der ciliaten des saprobiensystem, Band I: Cryptoophorida, Oligotrichida, Hypotrichida, Colpodea. Informationsberichte des Bayer. Landesamtes für wasser wirtschaft, Heft 1/91.

Foissner, W. and O'Donoghue, P.J. 1990. Morphology and infraciliature of some freshwater ciliates (Protozoa: Ciliophora) from Western and South Australia. Invertebr. Taxon. 3: 661-96.

Holen, D.A. 2000. The relative abundance of mixotrophic and heterotrophic ciliates in an oligotrophic lake. Arch. Hydrobiol. 150: 1-15.

Madoni, P. 1984. Estimation of the size of freshwater ciliate populations by a sub-sampling technique. Hydrobiologia. 111: 201-206.

Madoni, P. 1990. The ciliated Protozoa of the monomictic Lake Kinneret (Israel): species composition and distribution during stratification. Hydrobiologia. 190: 111-120.

Madoni, P. 1991a. Community structure and distribution of ciliated Protozoa in a freshwater pond covered by *Lemna minor*. Boll. Zool. 58: 273-280.

Madoni, P. 1991b. Seasonal changes of ciliated Protozoa in a small pond covered by floating macrophytes. Arch. Hydrobiol. 121: 449-461.

Madoni, P. 1996. The contribution of ciliated Protozoa to plankton and benthos biomass in a European ricefield. J. Euk. Microbiol. 43: 193-198.

Martín-González, S., Guinea, A. and Fernández-Galiano, D. 1986. Further studies on *Urocentrum turbo* O.F.M. (Ciliata): Morphology and morphogenesis. Arch. Protistenkd. 132: 11-21.

Patterson, D.J. and Hedley, S. 1992. Free-living freshwater Protozoa. Wolfe Publishing Ltd., London.

Porter, K.G., Sherr, E.B., Sherr, B.F., Pace, M. and Sanders, R.W. 1985. Protozoa in planktonic food webs. J. Protozool. 32: 409-415.

Pratt, J.R., Lang, B.Z., Kaesler, R.L. and Cairns, J. 1986. Effect of seasonal changes on protozoans inhabiting artificial substrates in a small pond. Arch. Protistenkd. 131: 45-57.

Salvado, H. and Gracia, P. 1991. Response of ciliate populations to changing environmental conditions along a freshwater reservoir. Arch. Hydrobiol. 123: 239-255.

Sola, A., Guinea, A., Longas, J.F. and Fernandez-Galiano, D. 1988. Observations sur l'infraciliature de *Plagiopyla nasuta* Stein, 1860. Acta Protozool. 27: 279-286.

Sola, A.I., Guinea, A., Longas, J.F. and Fernandez-Galiano, D. 1990. Buccal and somatic infraciliature of *Lagynus elegans* (Engelmann, 1862) Quennersted, 1867 (Ciliophora, Prostomatea): Remarks on its systematic position. J. Protozool. 37: 328-333.

Sommaruga, R. and Psenner, R. 1993. Nanociliates of the order Prostomatida: Their relevance in the microbial food web of a mesotrophic lake. Aquatic Sciences. 53: 179-187.

Song, W. 2000. Morphological and taxonomical studies on some marine scuticociliates from China sea, with description of two new species, *Philasterides armatalis* sp.n. and *Cyclidium varibonetti* sp.n. (Protozoa: Ciliophora: Scuticociliatida). Acta Protozool. 39: 295-322.

Şenler, N.G., Bıyık, H., Öğün, E. and Yıldız, İ. 1998. The pollution parameters and protozoological investigations on three rivers flowing into Lake Van. Bulletin of Pure and Applied Sciences. 17: 35-50.

Şenler, N.G., Bıyık, H. and Yıldız, İ. 1999. A study of the relationship between microfauna and water quality in biological sewage-treatment plant of Yüzüncü Yıl University in Van. Bio-Science Research Bulletin. 15: 37-47.

Şenler, N.G. and Yıldız, İ. 1998. An investigation on ciliates species on five rivers flowing into Lake Van (in Turkish, with English summary). YYÜ, Fen Bilimleri Enstitüsü Dergisi. 5:1-19.

Şenler, N.G. and Yıldız, İ. 1999a. An investigation on the ciliated Protozoa in biological sewage treatment plant of Yuzuncu Yil University (in Turkish, with English summary). YYÜ Fen Bilimleri Enstitüsü Dergisi. 6: 1-10.

Şenler, N.G. and Yıldız, İ. 1999b. The morphological characteristics of some ciliates (Protozoa: Ciliophora) species from influent of water treatment plant of Yuzuncu Yil University (in Turkish, with English summary). YYÜ Fen Bilimleri Enstitüsü Dergisi. 6: 11-20.