CILIATE PROTISTS FROM CABIÚNAS LAGOON (RESTINGA DE JURUBATIBA, MACAÉ, RIO DE JANEIRO) WITH EMPHASIS ON WATER QUALITY INDICATOR SPECIES AND DESCRIPTION OF *Oxytricha marcili* sp. n.

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ABSTRACT

We found 34 species of ciliate protists in the samples collected by the margins of Cabiúnas Lagoon during 2001. The ciliates were cultivated in the laboratory, where they were examined *in vivo* and identified through silver impregnation techniques. A new species, *Oxytricha marcili* (Ciliophora, Oxytrichidae), was found and characterized as follows: *in vivo* length about 60-80 µm x 30-40 µm wide; on average 22 adoral membranelles; 18 left marginal cirri; 18 right marginal cirri; and 3 small caudal cirri. All specimens analyzed presented 7 frontal cirri (3 anterior + 4 posterior), 1 buccal cirrus, 4 ventral cirri (3 postoral + 1 pre-transverse), and 5 transverse cirri. Among the species found, some are considered as water quality indicators ranging from alpha-mesosaprobity to polysaprobity and isosaprobity.

Key words: *Oxytricha marcili*, new species, ciliates composition, coastal lagoon.

RESUMO

Protistas ciliados da lagoa de Cabiúnas (Restinga de Jurubatiba, Macaé, Rio de Janeiro), com ênfase em espécies indicadoras de qualidade de água e descrição de *Oxytricha marcili* sp.n.

Foram encontradas 34 espécies de protistas ciliados nas amostras coletadas nas margens da lagoa de Cabiúnas em 2001. Os ciliados foram cultivados em laboratório, onde foram examinados *in vivo* e identificados por meio de técnicas de impregnação pela prata. Uma nova espécie, *Oxytricha marcili* (Ciliophora, Oxytrichidae), foi encontrada e caracterizada. Mede, *in vivo*, aproximadamente 60-80 µm de comprimento por 30-40 µm de largura. Apresenta em média 22 membranelas adorais, 18 cirros marginais esquerdos, 18 cirros marginais direitos e 3 cirros caudais de dimensões reduzidas. Todos os espécimes analisados apresentam 7 cirros frontais (3 anteriores + 4 posteriores), 1 cirro bucal, 4 cirros ventrais (3 pós-orais + 1 pré-transverso) e 5 cirros transversos. Dentre as espécies identificadas, algumas são consideradas indicadoras de qualidades de água que variam de alfa-mesossaprobidade a polissaprobidade e isossaprobidade.

Palavras-chave: *Oxytricha marcili*, espécie nova, composição de ciliados, lagoa costeira.

INTRODUCTION

Restingas, common along the Brazilian coast, are coastal sand dune habitats covered with herbaceous and shrubby vegetation (Suguio & Tessler, 1984).

Among the complex of coast lakes is Cabiúnas Lagoon (also called Jurubatiba Lagoon), located in the Parque Nacional da Restinga de Jurubatiba, in the city of Macaé. Cabiúnas Lagoon presents a rich diversity of microorganisms, among among them the ciliate protists found in both benthos and plankton. In the benthos, a considerable amount of ciliate species may be encysted. These can be stimulated to excystment in the laboratory by adding crushed rice or wheat grains to the sample flasks containing the cysts. The resulting bacterial populations serve as food for the ciliates. Also, water conditions inside the flasks change over time in the laboratory. This variation and the presence of food can be associated with conditions accompanying excystment of many species present in sediments, making it possible to observe an ecological succession in the laboratory.

Endemic species are common in coastal lakes and lagoons (Dragesco & Dragesco-Kernéis, 1991). In the studied lagoon we found *Oxytricha marcili*, a new species of the genus *Oxytricha* Bory de Saint-Vincent *in* Lamouroux, Bory de Saint-Vincent & Deslongchamps, 1824. This genus is the one with most valid species characterized (about 50 in accordance to Berger & Foissner, 1997) within the subfamily Oxytrichinae Jankowski, 1979. Due to such a high count of known species and synonyms, characterization of this and other oxytrichid genus must be well detailed and are subject to constant revisions and redescriptions (Borror, 1972; Corliss, 1979; Jankowski, 1979; Small & Lynn, 1985; Tuffrau, 1987; Berger & Foissner, 1997; Eigner, 1997).

Coastal lakes and lagoons are water bodies of great economic and ecological importance because of their high productivity and intense utilization, including as aloctone residue deposits, for activities such as acquiculture and recreation (Spaulding, 1994). According to Gomes & Godinho (1999), efforts are urgently needed to further understand natural interactions occurring in these ecosystems, in order to find ways to preserve water bodies by either preventing them from harm or, if that has already been done, repairing the damage.

The present paper consists in a taxonomic study of the diversity of species composing the fauna of ciliates present in Cabiúnas Lagoon. These organisms, that play an important role in bacterial population control, have until now never been the object of such studies in this region. Therefore, the importance of this study lies in the fact that it identifies diverse ciliate species considered by many authors (Sládeček, 1973; Sládeček *et al.*, 1981; Wegl, 1983; Mauch *et al.*, 1985) as indicators of water quality. Puytorac *et al.* (1987) affirms that ciliates can be used as biological indicators of water quality in relation to dissolved oxygen concentration variations.

MATERIALS AND METHODS

Study area

Cabiúnas Lagoon is perpendicular to the coast, having originated from a barrage of rivers, whose valleys were sculptured in the crystalline shield that composes the ground of the region, flooding the ridges formed by sand cords of restinga. It presents water of medium dark coloration (light penetration = 1.3 m from the bottom), aquatic surface of 0.34 km², average depth of 3.2 m, temperature around 24.8ºC, pH = 6.6, and average salinity of 1.1 ppt (Petrucio, 1998).

We collected samples of water and sediments from 4 sampling stations (Fig. 1) during 2001. Station 1 is about 1m distant from the margin, which has abundant vegetation (*Typha domingensis*). Samples were collected from about a 20 cm depth. Water is clean transparent and salinity = 1.3 ppt. Station 2 is about 3 m distant from the margin, from which abundant tufts of algae grow. Samples were collected from about a 70 cm depth. Water is clean transparent and salinity = 1.4 ppt. Station 3 is right by the margin, and samples were collected from about a 15 cm depth. Water is medium dark, of yellowish coloration. Salinity = 0.7 ppt. Station 4 is located far from the coast, right after the second sand cord. Samples were collected right by the margin. Water in this station is medium dark, of yellowish coloration, darker than that at Station 3. Salinity = 0.6 ppt. The description of the sampling stations is based on both field observations and data obtained in laboratory from recently collected samples.

Dissolved oxygen concentration measured during 2001 in an area close to where the sampling stations were established is according to Projeto ECOLagoas of Laboratório de Limnologia, Departamento de Ecologia, Instituto de Biologia, CCS, Universidade Federal do Rio de Janeiro.

Methodology

Samples were brought to the laboratory, where they were first examined under a stereoscopic microscope. After isolating the ciliates, done using micropipettes, the specimens were preliminarily observed *in vivo*, through bright field, phase contrast, and differential interferential contrast (DIC) microscopy. Cultures were made using both water from the location in which the ciliates were isolated and that had been filtered, and mineral water from Petrópolis, Rio de Janeiro. To all cultures we added crushed rice or wheat grains to induce bacterial growth, thus making possible ciliate population growth.

After fixation with alcoholic Bouin or Stieves' fixative, we prepared permanent slides by silver impregnation techniques: protargol (Dieckmann, 1995) and "dry" silver (Klein, 1958), so as to observe morphologic characters.

For scanning electron microscopy, ciliates were fixed with a mixture of 2 ml of glutaraldheyde 10% + 1 ml of osmium tetroxyde 2% + 1 ml of buffer sodium cacodylate 0.2 M, as proposed by Silva-Neto (1994).

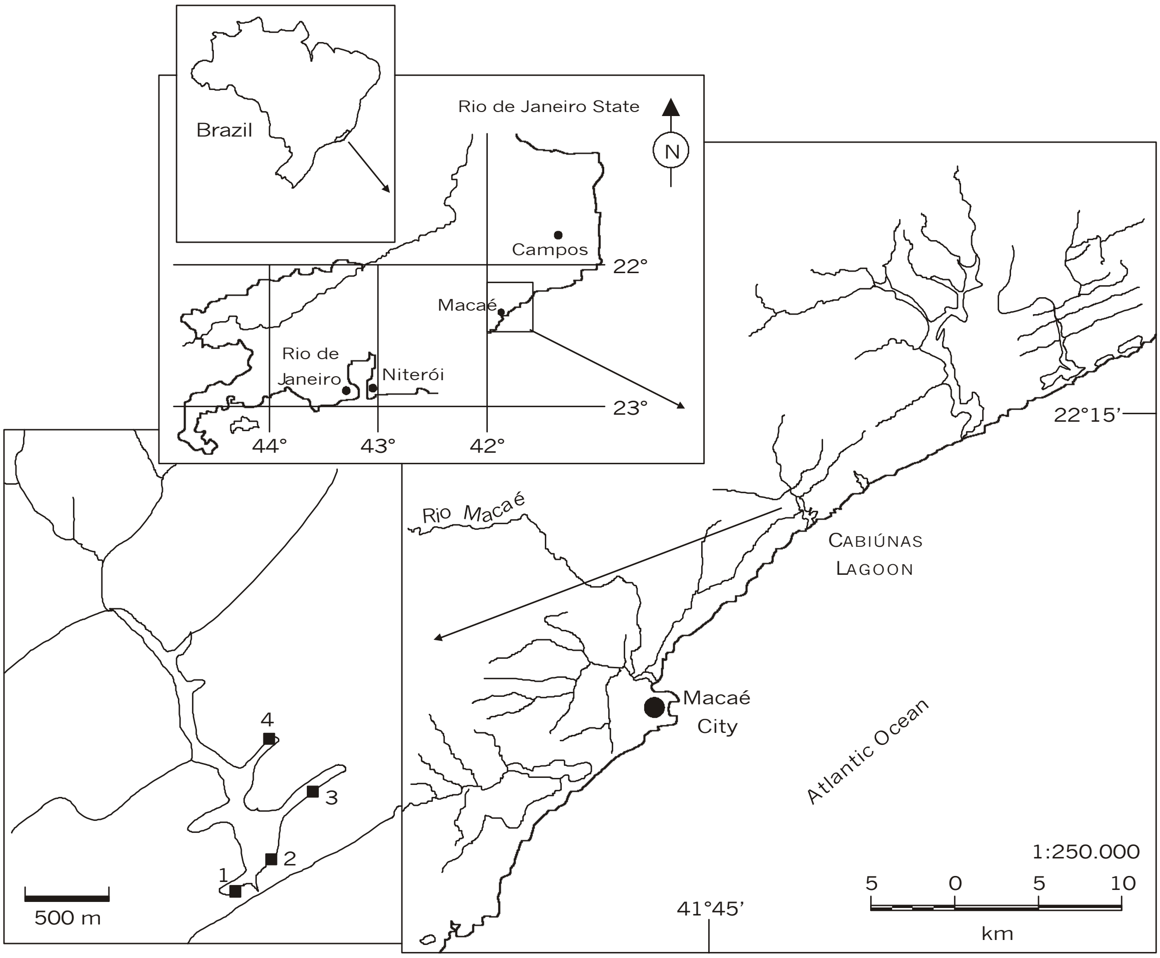


Fig. 1 — Map of the Cabiúnas Lagoon location on the Rio de Janeiro coast (from Branco, 1998). The small square marks indicate the sampling stations.

The cells were then washed successively with distilled water and some drops of sodium hypochlorite 0.3%, in order to remove fixative excess and attached particles. We used a JEOL: JSM-5310 scanning electron microscope to make observations and acquire electromicrographic images of the specimens.

The photomicrographic images were obtained through digital and analogical cameras attached to Zeiss and Olympus optical microscopes.

Living specimen morphological data were obtained using coverless slides (except for DIC observations) and at 200x magnification. All countings and measurements in the morphometric table were made using protargol slides and at 1.000x magnification. All measurements were in µm. Schematic drawings of protargol stained specimens were made using a modular camera lucida, and are based on the most representative specimens; *in vivo* drawings are based on freehand sketches and micrographs of specimens observed using phase contrast. All drawings are oriented with the anterior end of the organism directed to the top of the page.

The holotype of *Oxytricha marcili* (IBZ-UFRJ 0008-1 – 1 slide), its paratypes (IBZ-UFRJ 0008-2, 0008-3 and 0008-4 – 4 slides) and slides of the other species found in Cabiúnas Lagoon have been deposited in the collection of Laboratório de Protistologia, Depto. de Zoologia, Instituto de Biologia, Universidade Federal do Rio de Janeiro (UFRJ).

RESULTS

Taxonomic composition of ciliates

We found 34 species of ciliates, distributed in the classes Karyorelictea, Heterotrichea, Hypotrichea, Oligotrichea, Colpodea, Nassophorea, and Oligohymenophorea (Table 1).

Species succession in laboratory

Loxodes sp. was found in recently collected samples from Station 3. A very small number of specimens were observed, thus, making it very difficult to keep in cultures. This species was found in the same samples as was *P. bursaria*, which was successfully cultivated.

In recently collected samples from Station 1, living among populations of *Coleps* sp., *L. lucens*, *U. nigricans*, and *P. pusilus*, *Coleps* spetai was found. A couple of days after the cultures were made, we observed that both *Coleps* and *L. lucens* populations had disappeared. The other ciliate populations suffered no perceptible alteration.

Colpoda ecaudata was present in old cultures from Station 3 samples. This species population grew alone and was substituted after a few days by oligotrichid ciliate *H. grandinella*. Populations of *C. inflata* and *Colpoda* sp. grew simultaneously in cultures made from samples from stations 2 and 3, where the presence of *Gastrostyla mystacea*, *Vorticela infusionum* (Station 2 only), and *T. pyriformis* was detected. Small swarms of flagellate protozoan (*Cryptomonas*) were observed surrounding specimens of *V. infusionum*, suggesting that these flagellates feed on bacteria brought by the water current generated by the peritrichid's ciliature movements. Huge populations of these flagellates were also observed living among vast populations of *U. nigricans*.

Medium size populations of *U. turbo* were found in cultures made from Station 4 samples, living among small populations of *P. aurelia* (which was also present in cultures from Station 2 samples), *Blepharisma sinuosum*, and *P. caudatum*. After a few days, both *Paramecium* population sizes decreased, and a new population of *S. pustulata* started to grow, followed by *G. scintillans* about 2 weeks later.

Frontonia sp. was found in recent samples from Station 2. After cultures were made, we observed that they were soon substituted by populations of *E. eurystomus*, which also occurred in some cultures from Station 4, as well as in cultures from Station 3, which were replaced by *C. inflata* and *Colpoda* sp.

Huge populations of *V. campanula* were found growing in cultures made from Station 3 samples. In these cultures, we also observed the growth of *S. ambiguum* populations. *V. campanula* almost disappeared after 2 weeks.

Stentor sp. was found in recent collected samples from Station 2. Only a few specimens of this ciliate were observed.

Metopus striatus excysted in very old cultures (about 2 months after collection) from Station 3 samples. We observed among this species the growth of *Pelagohalteria viridis* (which also grew in some cultures from stations 1 and 2), *O. marcili*, *Tachysoma* sp, and *Urosomoida agilis*. The populations of both *Tachysoma* sp. and *U. agilis* started to increase in size as the populations of *M. striatus* and *O. marcili* decreased. In about 3 weeks, *M. striatus* disappeared and a somewhat constant growth was noted in these 3 species populations, plus that of another, hypotrichid ciliate *Notohymena* sp. We also found *Vorticella chlorellata* living among populations of *O. marcili*, in cultures where the algae *Chlorella* were also growing in abundance.

In most of the oldest (5 to 6 weeks) cultures obtained from stations 1, 2, and 3 samples, populations of *Euplotes octocarinatus* were found growing along with rotifers.

Description of* Oxytricha marcili *sp. n.

Diagnosis: *in vivo* length about 60-80 µm x 30-40 µm wide (n = 5); on average 22 adoral membranelles, 18 left marginal cirri (Max = 22, Min = 15; n = 20), 18 right marginal cirri (Max = 24, Min = 16; n = 20), 3 small caudal cirri. All specimens analyzed presented 7 frontal cirri (3 anterior + 4 posterior), 1 buccal cirrus, 5 ventral cirri (3 postoral + 1 pre-transverse), and 5 transverse cirri.

Dedication: named in honor of Marcil da Silva, grandfather of this paper's first author.

Type specimens location: found in sediments from sampling Station 3 of Cabiúnas Lagoon.

Description: body shape pyriform and elongated, with posterior region broader than anterior; dorsal side convex. Flexible, but constant in shape, tending to get rounder when squeezed under a cover slip. Two macronuclear nodules elipsoidal and very close together ($\overline{x}$ = 1.8 µm; n = 20) in the middle of body. Usually 2 micronuclear nodules attached to each macronuclear nodule; in most specimens, both are oriented in opposite directions. When in 4, 2 micronuclear nodules are attached per macronucleus. Contractile vacuole close to dorsal side, in the middle of the body, at left margin. Cytopyge found in the posterior region of cell, above pre-transverse cirrus. Colorless pellicle and greenish cytoplasm, containing small round- shaped algae (*Chlorella*) that stain with protargol. Some specimens were observed ingesting these algae, which they probably feed on, as suggested by the green pigment in the cytoplasm. The two marginal cirri rows tend to converge at the posterior end of the cell, but not actually join, as in *O. similis* Engelmann, 1862. Dorsal kineties are 4 in number, of which kineties 1, 2, and 3 each end on on a small caudal cirrus, located just above the posterior border of the cell. Kinety 4 is shortened and ends right after the equatorial region of the body, bearing no caudal cirrus (Figs. 2-8). Dorsal morphogenesis in *Oxytricha* pattern.

Oral apparatus and conspicuous adoral zone of membranelles occupy about 37% of body length. Paroral and endoral membranes as in most species of this genus.

DISCUSSION

The new species, *Oxytricha marcili*, differs from other small-sized species like *O. hymenostoma* Stokes, 1887, *O. ludibunda* Stokes, 1891, *O. minor* Dragesco, 1966, and *O. setigera* Stokes, 1891 in both cell shape and ventral cirri pattern. It may also be confused with *O. chlorelligera* Kahl, 1932, in which cytoplasmatic inclusions of *Chlorella* algae were also observed, but from which it differs in characters such as average body size, ventral cirri pattern, macronuclear nodule size, and average micronuclei number. *O. granulifera* Foissner & Adam, 1983 (holotype of genus *Oxytricha*) and the subspecies *O. granulifera quadricirrata* Blatterer & Foissner, 1988, are other two small-sized congeners that may cause confusion, but from which *O. marcili* differs mainly in the organizational pattern of frontal cirri, as well as ventral cirri pattern and number of dorsal kineties. An important distinguishing detail of *O. marcili* is the reduced number of cirri in the posterior region of the ventral side, a reduction which has also been observed in some species such as *O. granulifera quadricirrata*, *O. auripuncta* Foissner, 1988 and *O. rubripuncta* Berger & Foissner, 1987. This makes them variants of the genus with the usual fronto-vental-transverse cirri number (18 FVT), but in these species, this reduction is associated with the number of transverse cirri. In *O. marcili*, we observe the presence of a single, instead of 2, pre-transverse cirrus in all analyzed specimens. That makes this species another kind of variation of the usual *Oxytricha* FVT pattern, i.e., a variation in the number of pre-transverse cirri, since no reduction is shown in the transverse cirri count. As usually characterized in most oxytrichids, the pre-transverse cirrus is shorter and less thick than transverse cirri, and has the same size asf postoral cirri (Figs. 9-12).

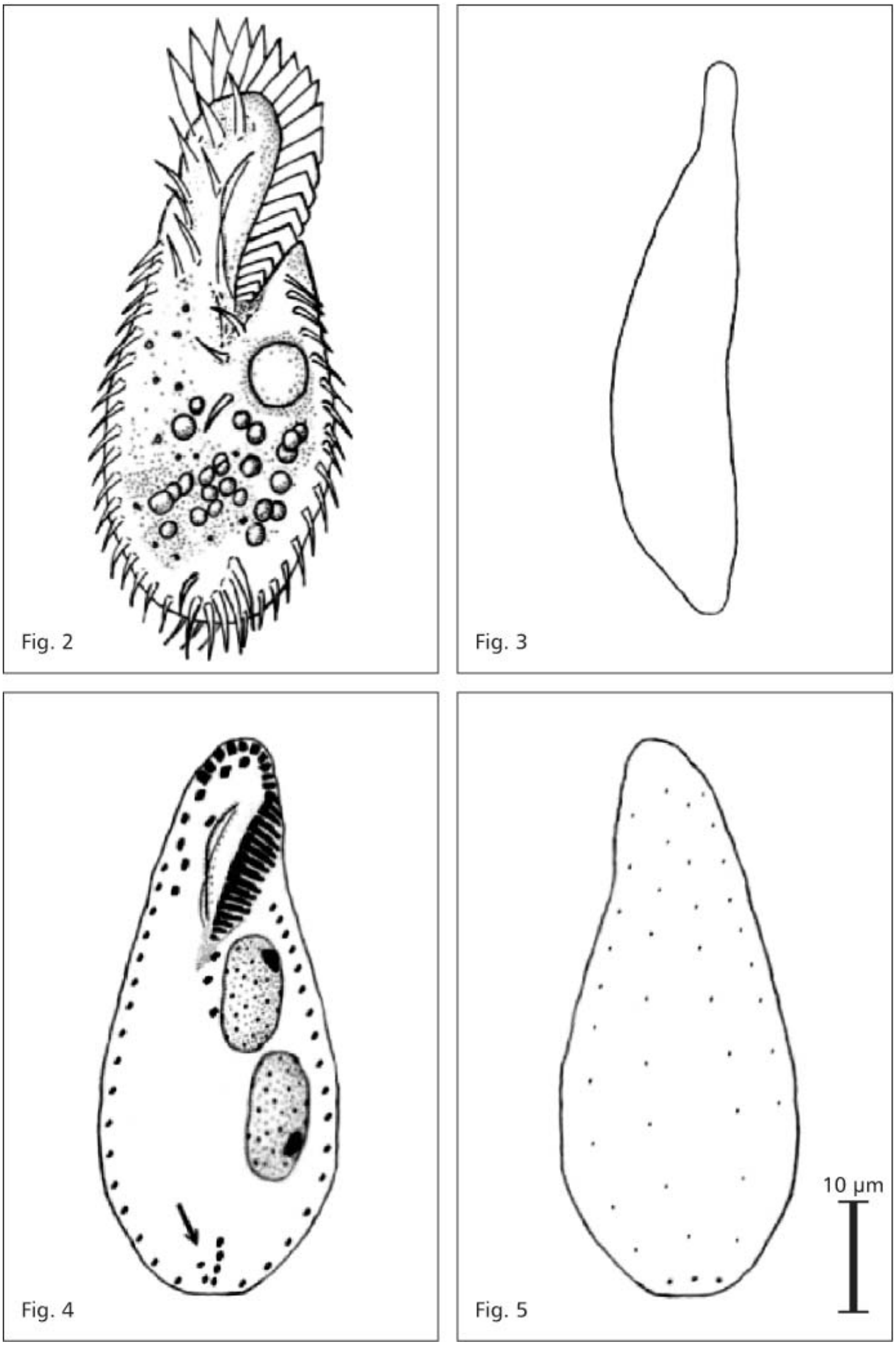
O. marcili was included in genus *Oxytricha* because of usual shape of paraoral and endoral membranelles, shape of adoral zone of membranelles, number of dorsal kineties, presence of caudal cirri, and usual set of 5 transverse cirri, found in most species. It was not included in genus *Urosomoida* Hemberger *in* Foissner, 1982, a genus of oxytrichids characterized as having a single pre-transverse cirrus (Berger & Foissner, 1997) because of characters such as the fragmentation of one dorsal kinety during morphogenesis, number of transverse cirri, which is constant in the studied population, and number of caudal cirri usual in most *Oxytricha* species. See detailed morphometric characterization of *O. marcili* in Table 2.

The saprobic system for determination of water quality, developed by Kolkwitz & Marsson (1908, 1909), has been widely used since its creation, and revised and extended by many authors. Foissner (1988), and Foissner *et al.* (1995), updated the list of water quality ciliates published by Sládecek *et al.* (1981) and Wegl (1983), adding more data concerning water quality and repairing nomenclatural and taxonomic errors. According to this revision, 23 of the ciliate species found in Cabiúnas Lagoon are considered as indicators: *Colpoda inflata*, *Uronema nigricans*, and *Pseudocohnilembus pusilus* for alpha-mesosaprobitc to polisaprobitc waters; *Tetrahymena pyriformis* for alpha-mesosaprobic to isosaprobic waters; *Paramecium caudatum*, *Spirostomum ambiguum*, and *Euplotes eurystomus* for alpha-mesosaprobic waters; *Paramecium aurelia*, *Lembadion lucens*, and *Halteria grandinella* for beta-mesosaprobic to alpha-mesosaprobic waters; *Coleps* spetai, *Paramecium bursaria*, *Urocentrum turbo*, *Vorticella campanula*, *Halteria grandinella*, and *Stylonychia pustulata* for beta-mesosaprobic waters; *Vorticella infusionum* for polissaprobic to alpha-mesossaprobic waters; *Gastrostyla mystacea* for polissaprobic waters; and *Loxodes* sp., *Colpoda ecaudata*, *Glaucoma scintillans*, and *Metopus striatus* for polisaprobic to isosaprobic waters.

The saprobity associated with *Coleps* sp. and *Frontonia* sp. may be imprecise, since the species of these two genera present in Cabiúnas Lagoon can be different than those Sládecek used to develop his list. As for *Loxodes* sp., it is listed in Foissner *et al.*, 1995, as "*Loxodes* spp.". As this is genus having very few species characterized, we consider that this data may be useful to our study area.

Among dissolved gases in water, oxygen is one of the most important in the dynamics and characterization of aquatic ecosystems (Esteves, 1988). It is also a useful element in determining water quality. The dissolved oxygen concentration was measured in the samples from the bottom of Cabiúnas Lagoon during every month in 2001, as shown in Fig. 16. According to Friedrich (1990), concentrations ranging from 5 to 8 mg/L, like those found during the first half of the year, may be indicative of oligosaprobic to beta-mesosaprobic, beta-mesosaprobic, and beta- to alpha mesosaprobic waters. Concentrations ranging from 7.5 to 8 mg/L and higher, like those found in the second half of year may be indicative of oligosaprobic to beta-mesosaprobic waters.

Based on our results, we can conclude that the composition of ciliates present in the areas where the samples from Cabiúnas Lagoon were collected is more concentrated in the classes Oligohymenophorea and Hypotrichea, as clearly seen in the diagram in Fig. 17. We also have to consider that the growth in abundance of the most of the identified species populations was observed in laboratory cultures. The conditions present in these can be somewhat different from those observed in the field, in such a way as to allow the excystment and growth of ciliate populations like *M. striatus* and others that are indicators of conditions such as polisaprobity and abundant in polluted habitats. Taylor (1981), emphasizes the importance of mechanisms such as encystment which allow many species of ciliates to resist predation, physical and chemical stress, and exhaustion of food supply. The presence of these species can be useful in understanding possible modifications in the physical and chemical conditions of ecosystems caused by anthropic impacts.



Figs. 2-5 — Schematic drawings of *Oxytricha marcili* – 1: *in vivo* ventral side; 2: lateral view based on the observation of free motile living specimens; 3: ventral side after protargol impregnation. The arrow marks the single pre-transverse cirrus; 4: dorsal side after protargol impregnation.

TABLE 1
Ciliate protists found in Cabiúnas Lagoon.

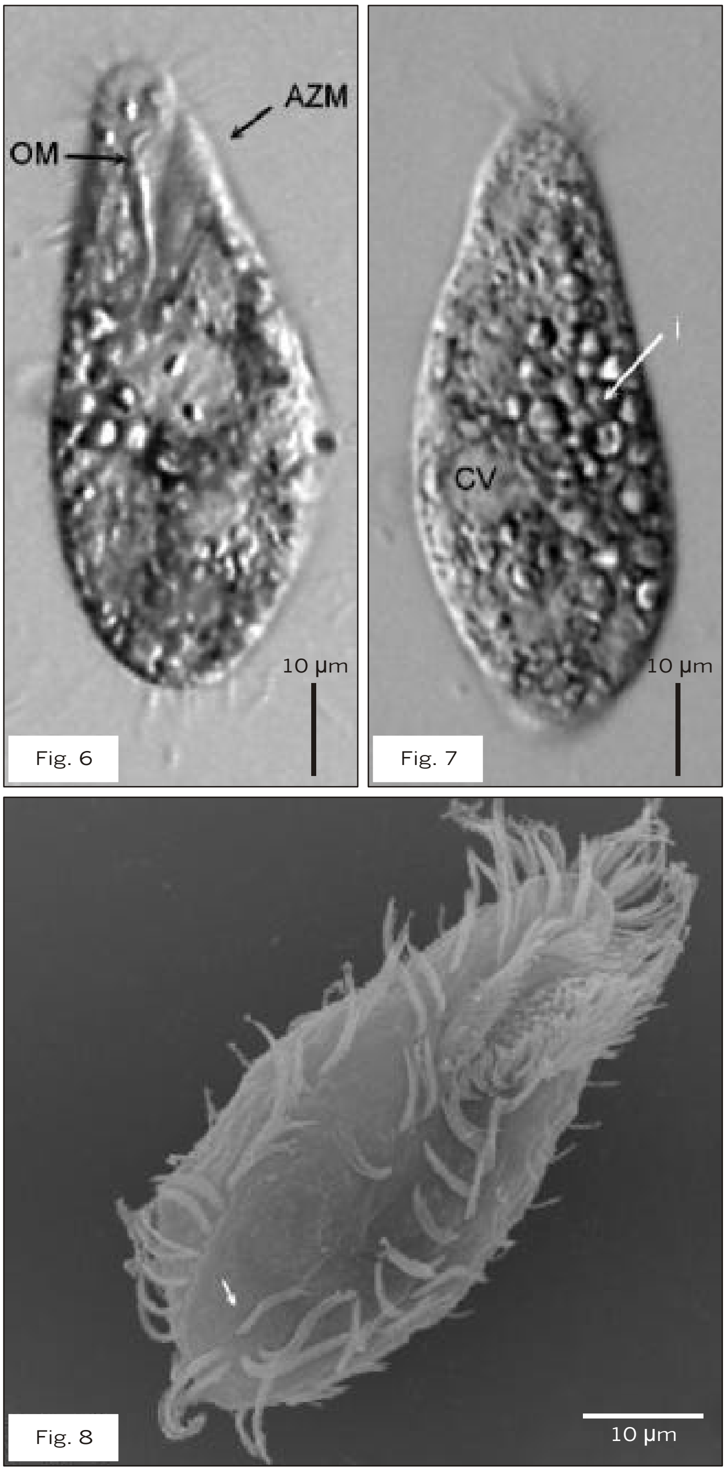
Class	Subclass	Species	s	S 1	S 2	S 3	S 4	M
Class Karyorelictea Corliss, 1974								
	Subclass Loxodia Jankowski, 1980							
		Loxodes sp.	p-i			+		
Class Heterotrichea Stein, 1859								
	Subclass Heterotrichia Stein, 1859							
		Blepharisma sinuosum Sawaya, 1940	–				+	+
		Metopus striatus McMurrich, 1884	p-i			+		
		Spirostomum ambiguum (Müller, 1786) Ehrenberg, 1835	a			+		+
		Stentor sp.	a-b		+			
Class Hypotrichea Stein, 1859								
	Subclass Euplotia Tuffrau & Fleury in de Puytorac et al., 1993							
		Euplotes eurystomus Wrzésniowski, 1870	a			+	+	+
		Euplotes octocarinatus Carter, 1972	–	+	+	+		+
	Subclass Oxytrichia Tuffrau & Fleury in de Puytorac et al., 1993							
		Gastrostyla mystacea (Stein,1859) Sterki, 1878	p		+			+
		Notohymena sp.	–			+		+
		Oxytricha marcili sp. n	–			+		+
		Stylonychia pustulata Müller, 1786	b				+	+
		Tachysoma sp.	–			+		+
		Urosomoida agilis Engelmann, 1862	–		+	+		
Class Oligotrichea, Bütschli, 1887								
	Subclass Oligotrichia Bütschli, 1887							
		Halteria grandinella (Mueller, 1773) Dujardin, 1841	b-a			+		+
		Pelagohalteria viridis Fromentel, 1876	–	+	+	+		+
Class Colpodea Small & Lynn, 1981								
	Subclass Colpodia Foissner, 1985							
		Colpoda ecaudata Liebmann, 1936	p-i			+		+
		Colpoda inflata (Stokes, 1884) Kahl, 1931	a-p		+			+
		Colpoda sp.	–		+			+
Class Nassophorea Small & Lynn, 1981								
	Subclass Prostomatia Schewiakoff, 1896							
		Coleps spetai Foissner, 1984.	b	+				
		Coleps sp.	a-b	+	+			
Class Oligohymenophorea de Puytorac *et al.*, 1974								
	Subclass Peniculia Fauré-Fremiet in Corliss, 1956							
		Frontonia sp.	b			+		
		Lembadion lucens (Maskell, 1887) Kahl, 1931	b-a	+				
		Paramecium aurelia Müller, 1773	b-a		+		+	+
		Paramecium bursaria (Ehrenberg, 1831) Focke, 1836	b			+		
		Paramecium caudatum Ehrenberg, 1833	a				+	+
		Urocentrum turbo Müller, 1786	b				+	
	Subclass Scuticociliatia Small, 1964							
		Uronema nigricans (Müller, 1786) Florentin, 1901	a-p	+	+	+		+
		Pseudocohnilembus pusillus (Quennerstedt, 1869) Foissner & Wilbert, 1981	a-p	+	+	+		+
	Subclass Peritrichia Stein, 1859							
		Vorticella infusionum Dujardin, 1841	p-a		+			+
		Vorticella chlorellata Stiller, 1940	–		+	+		+
		Vorticella campanula Ehrenberg, 1831	b			+		+
		Vorticella sp.	–		+			+
	Subclass Hymenostomatia Delage & Hérouard, 1896							
		Glaucoma scintillans Ehrenberg, 1830	p-i				+	+
		Tetrahymena pyriformis (Ehrenberg, 1830)	a-i		+	+		

Classification according to Puytorac (1994). *Legend*: s = saprobity, according to Sládecek (1981), Foissner (1988), and Foissner *et al.* (1995); S(n) = cultures made with water from the sampling stations (n = sample station number); M = cultures made with mineral water from Petrópolis, Rio de Janeiro; a = alpha-mesosaprobity; b = beta-mesosaprobity; p = polisaprobity; i = isosaprobity.

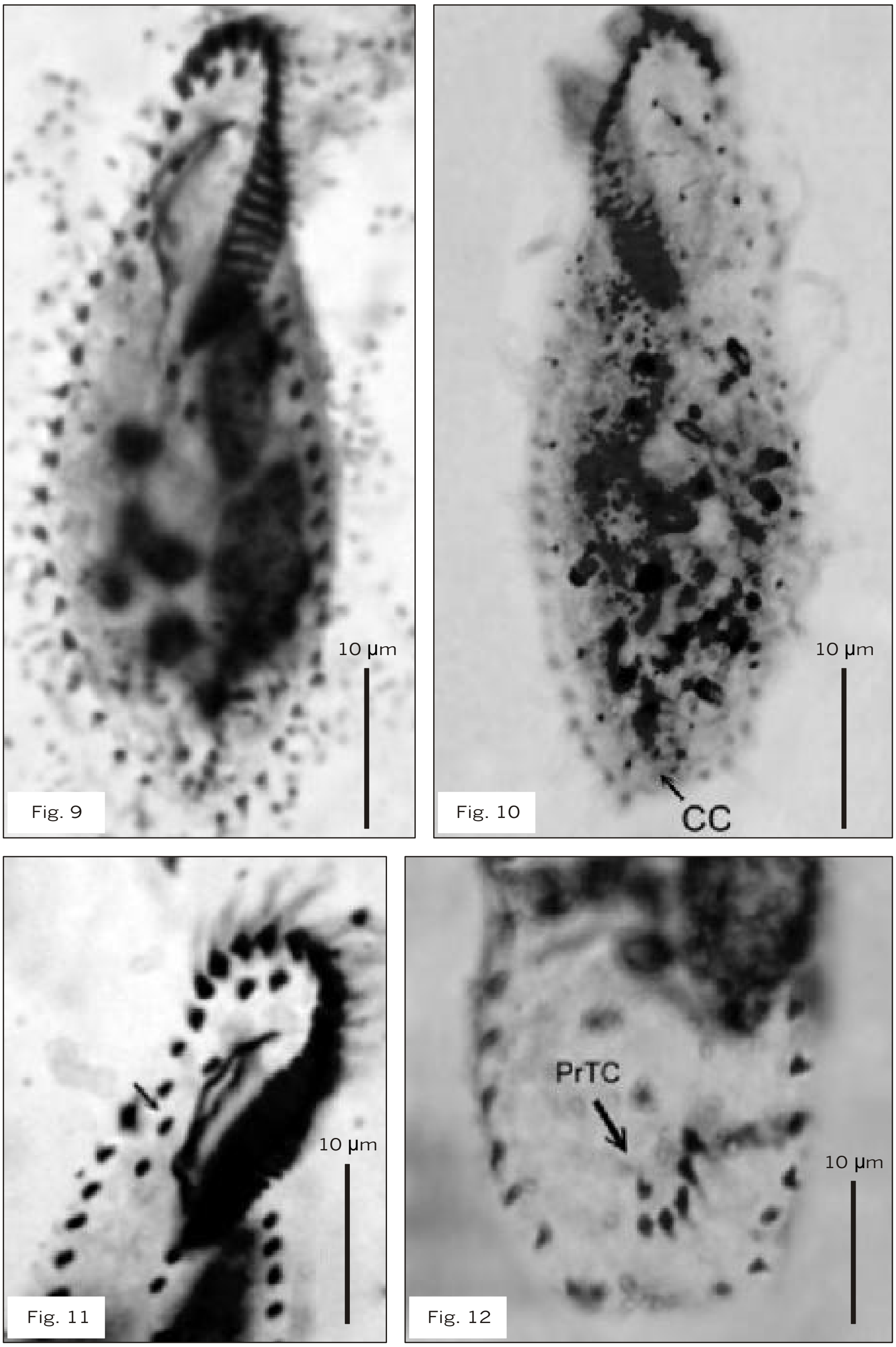
TABLE 2
Morphometric characterization of *Oxytricha marcili*.

Character	$\overline{X}$	M	SD	SE	CV	Min	Max	n
Body, length	54.1	55	6.743	1.508	12.463	45	70	20
Body, width	19.95	20	3.778	0.485	18.929	12	26	20
Anterior somatic end to proximal end of adoral zone of membranelles, distance	20.2	20	1.005	0.227	4.976	19	23	20
Adoral membranelles, number	22.3	23	2.007	0.449	9.001	20	26	20
Macronuclear nodules, number	2.0	2	0	0	0	2	2	20
Anterior macronuclear nodule, length	9.85	10	1.927	0.431	19.563	6	15	20
Anterior macronuclear nodule, width	4.85	5	0.587	0.131	12.106	4	6	20
Posterior macronuclear nodule, length	10.95	11	1.791	0.400	16.357	9	15	20
Posterior macronuclear nodule, width	4.75	4	0.639	0.143	13.446	4	6	20
Distance between macronuclear nodules	1.8	1	1.152	0.258	63.981	1	4	20
Micronuclei, number	2.85	2	0.988	0.400	34.67	2	4	20
Micronuclei, length	3.03	3	0.255	0.057	1.881	2.5	4	20
Left marginal cirri, number	17.55	17	1.820	0.407	10.376	15	22	20
Right marginal cirri, number	17.9	18	1.804	0.403	10.075	16	24	20
Anterior frontal cirri, number	3.0	3	0	0	0	3	3	20
Posterior frontal cirri, number	4.0	4	0	0	0	4	4	20
Buccal cirri, number	1.0	1	0	0	0	1	1	20
Postoral cirri, number	3.0	3	0	0	0	3	3	20
Pre-transverse cirri, number	1.0	1	0	0	0	1	1	20
Transverse cirri, number	5.0	5	0	0	0	5	5	20
Dorsal kineties, number	4.0	4	0	0	0	4	4	20
Caudal cirri, number	2.92	3	0.267	0.071	9.144	2	3	14

Legend: $\overline{X}$ = arithmetic mean; M = median; SD = standard deviation; SE = standard error of the arithmetic mean; CV = coefficient of variation (in %), Max = maximum value; Min = minimum value; n = sample size. All statistical procedures according to Sokal & Rohlf (1981).



Figs. 6-7 — *In vivo* photomicrographic images – 6: ventral side (DIC); 7: dorsal side (DIC); Fig. 8: scanning electromicrographic image of ventral side. Arrow shows pre-transverse cirrus; CV = contractile vacuole; i = cytoplasmic inclusion (*Chlorella*); OM = oral (undulating) membranelles.



Figs. 9-12 — Photomicrographic images of silver impregnated specimens – 9: ventral side; 10: dorsal side; 11: ventral side, anterior region. Arrow shows pattern of posterior frontal cirri; 12: ventral side, posterior region showing pre-transverse cirrus and transverse cirri. CC = caudal cirri; PrTC = pre-transverse cirrus.

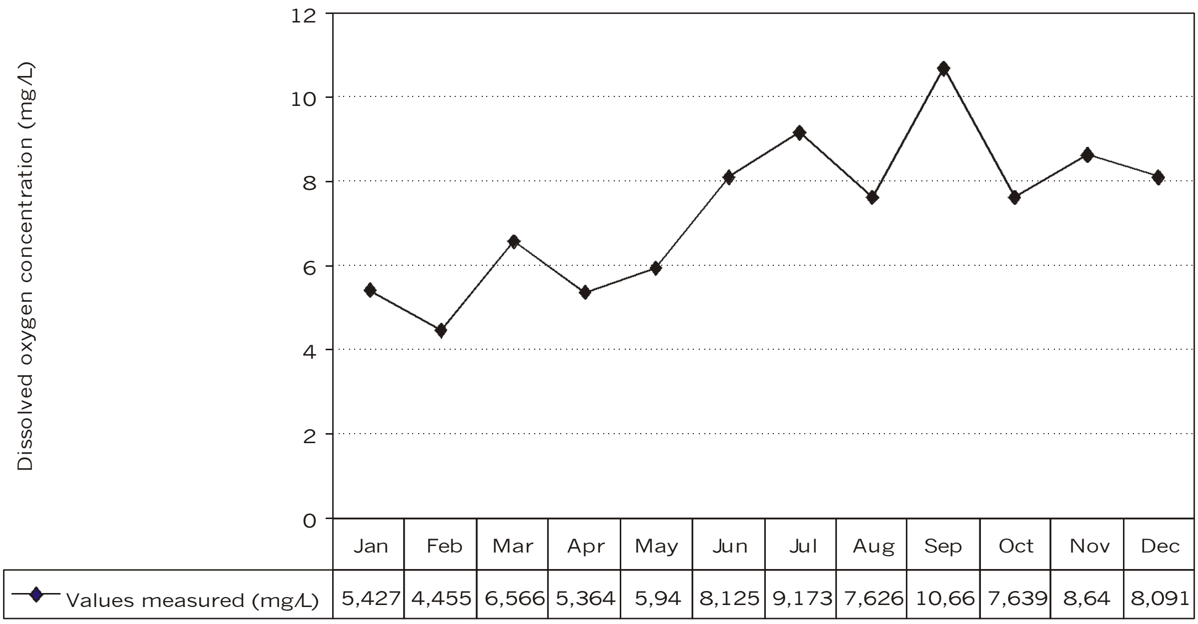


Fig. 13 — Variation of the dissolved oxygen concentration during 2001.

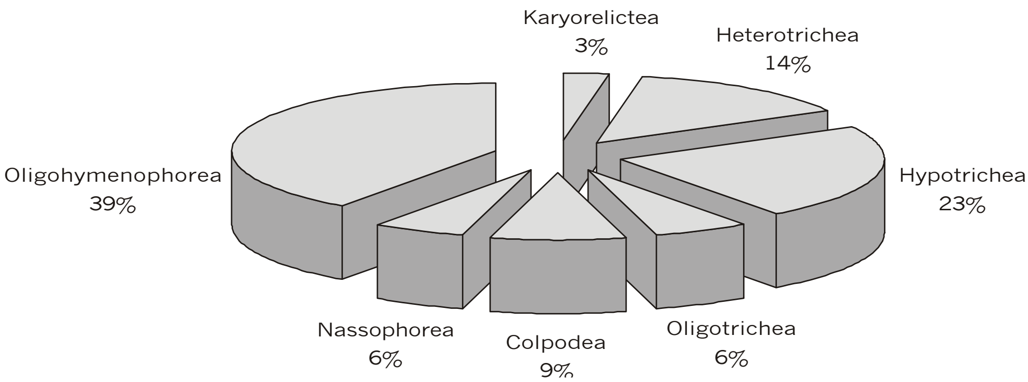


Fig. 14 — Diagram showing distribution of classes that compose the fauna of ciliates observed in the area where samples were obtained.

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REFERENCES

BERGER, H. & FOISSNER, W., 1987, Morphology and biometry of some soil Hypotrichs (Protozoa: Ciliophora). *Zool. Jb. Syst.*, *114*: 193-239.

BERGER, H. & FOISSNER, W., 1997, Cladistic relationships and generic characterization of Oxytrichid Hypotrichs (Protozoa, Ciliophora). *Arch. Protistenkd.*, *148*: 125-155.

BLATTERER, H. & FOISSNER, W., 1988, Beitrag zur terricolen Ciliaten fauna (Protozoa: Ciliophora) Australiens. *Stapfia*, *17*: 1-84.

BORROR, A. C., 1972, Revision of the Order Hypotrichida (Ciliophora, Protozoa). *T. Protozool.*, *19*(1): 1-23.

BRANCO, C. W. C., 1998, *Comunidades zooplanctônicas e aspectos limnológicos de três lagoas costeiras da Região Fluminense (Macaé, RJ)*. Tese de Doutorado, CCS, Instituto de Biofísica Carlos Chagas Filho, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 127p.

CORLISS, J. O., 1979, The *ciliated protozoa. characterization, classification and guide to the literature*. Oxford, New York, Toronto, Sidney, Paris, Frankfurt, 455p.

DIECKMANN, J., 1995, An improved protargol impregnation for ciliates yielding reproducible results. *Europ. J. Protistol.*, *31*: 372-382.

DRAGESCO, J., 1966a, Ciliés libres de Thonon et ses environs. *Protistologica, 2*: 59-95.

DRAGESCO, J., 1966b, Observations sur quelques ciliés libres. *Arch. Protistenk.*, *109*: 155-206.

DRAGESCO, J. & DRAGESCO-KERNÉIS, A., 1991, Free-living Ciliates from the Coastal Area of Lake Tanganyika (Africa). *Europ. J. Protistol.*, *26*: 216-235.

EIGNER, P., 1997, Evolution of morphogenetic processes in the Orthoamphisiellidae N. Fam., Oxytrichidae, and Parakahliellidae N. Fam., and their depiction using a computer method (Ciliophora, Hypotrichida). *J. Euk. Microbiol.*, *44*(6): 553-573.

ESTEVES, F. A., 1988, *Fundamentos de limnologia*. Ed. Interciência/FINEP, Rio de Janeiro, 575p.

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

FOISSNER, W. & ADAM, H., 1983, Morphologie und Morphogenese des Bodenciliaten *Oxytricha granulifera* sp. n. (Ciliophora, Oxytrichidae). *Zool. Scr., 12*: 1-11.

FOISSNER, W., BERGER, H., BLATTERER, H. & KOHMANN, F., 1995, Taxonomische und ökologische Revision der Ciliaten des Saprobiensystems – Band IV: Gymnostomatea, Loxodes, Suctoria. Informationsberichte des Bayer. *Landesamtes für Wasserwirtschaft, 1/95*: 1-540.

FRIEDRICH, G., 1990, Eine revision des saprobiensytems. *Z. wiss. Abwass. Forsch.*, *23*: 141-152.

GOMES, E. A. T. & GODINHO, M. J. L., 1999, Bactérias e protozoários em ambientes aquáticos: amostragem e análise. *In*: C. E. M. Bicudo & D. Bicudo (eds.), *Amostragem em limnologia*. FAPESP/Sociedade de Limnologia do Brasil, SBL, São Paulo. (No prelo).

HEMBERGER, H., 1982, *Revision der Ordnung Hypotrichida Stein (Ciliophora, Protozoa) and Hand von Protargolpräparaten und Morphogenesedarstellungen*. Diss. Math.-Naturwiss, Fak. Univ. Bonn, Bonn. 296p.

JANKOWSKI, A. W., 1979, Revision of the order Hypotrichida Stein, 1859. Generic catalogue, phylogeny, taxonomy. *Trudy zool. Inst., Leningr.*, *86*: 48-85.

KAHL, A., 1932, Urtiere oder Protozoa I: Wimpertiere oder Ciliata (Infusoria) 3. Spirotricha. *Tierwelt. Dtl.*, *25*: 399-650.

KLEIN, B. M., 1958, The "dry" silver method and its proper use. *J. Protozool.*, *5*(2): 99-103.

KOLKWITZ, R. & MARSSON, K., 1908, Ökologie der pfanzlichen Saprobien. *Ber. dt. bot. Ges.*, *26A*: 505-519.

KOLKWITZ, R. & MARSSON, K., 1909, Ökologie der tierischen Saprobien. *Int. Revue ges. Hydrobiol. Hydrogr.*, *2*: 126-152.

LAMOUROUX, J.-V.-F., BORY DE SAINT-VINCENT, J. B. & DESLONGCHAMPS, E., 1824, *Encyclopédie Méthodique. Histoire Naturelle des Zoophytes, ou Animaux Rayonnés.* Faisant Suite a l'Histoire Naturelle des Vers de Bruguière, Paris, Volume II, Paris, I-VIII, 819p.

MAUCH, E., KOHMANN, F. & SANZIN, W., 1985, Biologische Gewäseranalyse in Bayern. Informationsberichte Bayer. *Landesamt für Wasserwirtschaft, 1*: 1-254.

PETRUCIO, M. M., 1998, Caracterização das Lagoas Imboassica, Cabiúnas, Comprida e Carapebus a partir da temperatura, salinidade, condutividade, alcalinidade, O_2 dissolvido, pH, transparência e material em suspensão, pp. 109-122. *In:* F. A. Esteves, (ed.), *Ecologia das lagoas costeiras do Parque Nacional da Restinga de Jurubatiba e do Município de Macaé (RJ)*. Núcleo de Pesquisas Ecológicas de Macaé (NUPEM), Universidade Federal do Rio de Janeiro.

PUYTORAC, P. de, GRAIN, J. & MIGNOT, J. P., 1987, *Précis de protistologie*. Boubée éd., 263p.

PUYTORAC, P. de, 1994, Phylum Ciliophora Doflein, 1901. *Traité de zoologie*, *2*(2): 1-15.

SILVA-NETO, I. D. da, 1994, Observations sur é ultrastructure du cilié heterotriche Licnophora auerbachi Cohn, 1866, epibionte de l'etoile de mer. *Annales des Sciences Naturelles, Zoologie*, Paris. 3a ser., *2*(15): 49-62.

SLÁDECEK, V., 1973, System of water quality from the biological point of view. *Arch. Hydrobiol. Beih. Ergebn. Limnol.*, *7*: I-IV, 1-218.

SLÁDECEK, V., ZELINKA, M., ROTSCHEIN, J. & MORACOVÁ, V., 1981, Biologický rozbor povrchové vody. Komentár k CSN 830532 – cásti 6: *Stanoveni saprobniho indexu*. Vydalo Vydavatelstvi Üradu pro normalizaci a mereni, Praha, 186p.

SMALL, E. B. & LYNN, D. H., 1985, Phylum Ciliophora DOFLEIN, 1901, pp. 393-575. *In*: J. J. Lee, S. H. Hunter & E. C. Bovee (eds.), *An illustrated guide to the Protozoa*, Lawrence.

SOKAL, R. R. & ROHLF, F. J., 1981, *Biometry*. 2nd ed. San Francisco, 859p.

SPAULDING, M. L., 1994, Modeling of circulation and dispersion in coastal lagoons, pp. 103-132. *In*: B. Kjerfve (ed.), *Coastal lagoon processes*. Elsevier Oceanography Series n.60, Amsterdam.

STOKES, A. C., 1887, Some new hypotrichous infusoria from

American fresh waters. *Ann. Mag. nat. Hist.*, *20*: 104-114.

STOKES, A. C., 1891, Notices of new infusoria from fresh waters of the United States. *Jl. R. microsc. Soc.*, pp. 697-704.

SUGUIO, K. & TESSLER, M. G., 1984, Planícies de cordões litorâneos quaternários do Brasil: origem e nomenclatura, pp. 15-25. *In*: L. D. Lacerda, D. S. D. Araújo, R. Cerqueira & B. Turcq (eds.), *Restingas: origem, estrutura, processos*. Centro Editorial da UFF, Niterói, RJ.

TAYLOR, W. D., 1981, Temporal heterogenity and the ecology of lotic ciliates, pp. 209-223. *In*: M. A. Lock & D. D. Williams (eds.), *Perspectives in running water ecology*. Plenum Publishing Corporation, Ontario, Canada.

TUFFRAU, M., 1987, Proposition d'une classification nouvelle de l'orde Hypotrichida (Protozoa, Ciliophora), fondée sur quelques données récentes. *Annls Sci. Nat. (Zool.)*, *8*(1986-1987): 111-117.

WEGL, R., 1983, Index für die Limnosaprobität. *Wass. Abwass.*, Wien, *26*: 1-175.

WRZÉSNIOWSKI, A., 1870, Beobachtungen über Infusorien aus der Umgebung von Warschau. *Z. wiss. Zool.*, *20*: 467-511.