Acta Scientiarum
http://www.uem.br/acta
ISSN printed: 1679-9283
ISSN on-line: 1807-863X
Doi: 10.4025/actascibiolsci.v35i4.18579

Structure of planktonic ciliates community (Protist, Ciliophora) from an urban lake of southern Brazil

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ABSTRACT. This study examined temporal and spatial (vertical) variations of composition, richness and abundance of the planktonic ciliates community in an urban and eutrophic lake, as well as identified the limnological factors involved in determining the patterns observed. To this end, samples of ciliates and measures of limnological variables were taken at different depths and hydrological periods. 35 ciliate species were identified, among which 14 species occurred in all periods and strata, being Prostomatida the most specious, followed by Gymnostomatida, Oligotrichida, Peritrichida, and Scuticociliatida. The patterns found for composition, abundance and species richness evidenced a vertical and temporal variation of these attributes. However, in general the composition and species richness have varied more along the vertical gradient than between periods, whereas for the abundance, only temporal differences could be detected. Results observed herein indicated that benthic species seem to be mainly influenced by the amount of organic matter, phosphorus and ammonia, while planktonic ones, abundant at the surface, were mainly associated with higher dissolved oxygen concentrations. In this way, seasonal and vertical variations of limnological characteristics were decisive for the patterns of occurrence and abundance of ciliate species.

Keywords: protist, density, species composition, richness, plankton.

Estrutura da comunidade de ciliados planctônicos (Protista, Ciliophora) de um lago urbano do Sul do Brasil

RESUMO. O presente estudo teve como objetivo investigar as variações temporais e espaciais (vertical) da composição, riqueza de espécies e abundância da comunidade de ciliados planctônicos em um lago urbano, eutrófico, e identificar alguns fatores limnológicos intervenientes na determinação dos padrões observados. Para tal, amostras de ciliados, bem como as mensurações das variáveis limnológicas foram obtidas em diferentes profundidades e períodos hidrológicos. Trinta e cinco espécies de ciliados foram identificadas, das quais 14 ocorreram em ambos os períodos e estratos. Prostomatida foi a ordem com maior número de espécies, seguida por Gymnostomatida, Oligotrichida, Peritrichida e Scuticociliatida. A composição e riqueza de espécies, em geral, variaram mais verticalmente que temporalmente, enquanto que para a abundância, diferenças foram observadas apenas entre os períodos hidrológicos Os resultados indicaram que espécies bentônicas parecem ser influenciadas principalmente pela quantidade de matéria orgânica, fósforo total e amônia, enquanto que as espécies planctônicas, abundantes na superfície, estiveram principalmente associadas com as maiores concentrações de oxigênio dissolvido. Desta forma, as variações sazonais e verticais das características limnológicas foram decisivas na determinação dos padrões de ocorrência e abundância de espécies de ciliados.

Palavras-chave: protozoários, densidade, composição de espécies, riqueza de espécies, plâncton.

Introduction

Urban lakes are usually shallow, extremely rich in phosphates and receive a considerable amount of nutrients (BIRCH; MCCASKIE, 1999). Owing the landscape full of trees, they receive a great amount of leaf litter that contributes with the accumulation of sediment and nutrients on the bottom leading to a high demand for oxygen (BIRCH; MCCASKIE, 1999). These nutrients, under low oxygen concentrations, are released from the sediment and promote a significant enrichment of the water column.

In this way, the effect of urban drainage on these water bodies is reflected in their water quality, hydrology and environmental conditions (OBERHOLSTER et al., 2006). This undesirable eutrophication directly affects the organization of different aquatic communities inhabiting these lakes, which can be more or less able to minimize the effects of this process on the whole system. In this way, microbial communities are important components of inland aquatic environments once they are involved in complex and dynamic processes (energy flow and nutrients remineralization) that control the metabolism of these environments (GOMES; GODINHO, 2004). Nevertheless, only from the 1980's the importance of these microbial communities was recognized in trophic webs, climaxing with the proposition of the microbial loop paradigm (AZAM et al., 1983). Among microbial community protozoans can contribute substantially for the total production of zooplankton in lakes, reaching over 50% zooplankton biomass in these environments (ZINGEL, 1999).

In aquatic ecosystems, ciliates have an important role in nutrient cycling and transfer of matter and energy in the food chains. Probably due to their short life cycle, ciliates increase the availability of nutrients (especially phosphorus) in the environment making them available for the assimilation by primary producers (BEAVER; CRISMAN, 1982). According to Finlay and Esteban (1998), predation of ciliate on other microorganisms stimulates the microbial community, increasing the rate of nutrient cycling which otherwise would be retained in the microbial biomass. In this way, protozoa stimulate the decomposition rate of the organic rate.

Typical communities of ciliate are found in specific habitats. In this way,great variation in their diversity is observed, according to the trophic status, seasonality (BUOSI et al., 2011; GOMES; GODINHO, 2003; PAULETO et al., 2009), or even among compartments of the same environment, such as epilimnion and hipolimnion (FINLAY; ESTEBAN, 1998; ZINGEL; OTT, 2000).

In aquatic environments the structure of ciliate communities is strongly affected by physical, chemical and geomorphological characteristics (MADONI; BAGHIROLI, 2007), and changes in these conditions are reflected in biotic changes such as species composition and richness (ANDRUSHCHSHYN et al., 2003). Besides that, the system productivity, i.e. the resource availability is a preponderant factor for determining the variation patterns in spatial and temporal distribution of planktonic ciliate abundance (BIYU, 2000; VELHO et al., 2005). Other studies point out an increase in the abundance of most ciliate species according to the amount of organic pollution (BLATTERER, 2002; DIAS et al., 2008; MADONI; BRAGHIROLI, 2007).

Considering that ciliates communities are integrally linked to aquatic habitats and their abundance and community structure are related to both chemical and physical in lake conditions become them useful biological indicators (FOISSNER; BERGER, 1996; JIANG; SHEN, 2003; JIANG et al., 2012).

Therefore, the present study aimed to investigate temporal and spatial variations (vertical) of composition, species richness and abundance (density and biomass) of planktonic ciliate communities in an urban, eutrophic lake of the northwestern region of the Paraná State. For this, the following hypotheses were tested: i) The limnological variables characterize the distinct hydrological periods and water column strata; ii) the ciliate species composition is significantly altered between the upper (epilimnium) and lower (hypolimnion) strata of the water column, considering the relative contribution of euplanktonic and benthic species; iii) the values of richness and abundance are greater in the hypolimnion, where the resource availability is high given the greater amount of organic matter from the sediment; iv) the values of richness and abundance are greater in the dry period due to the higher environmental stability in this period.

Material and methods

Study area

This study was conducted in a lake situated in the Ingá Park located in the city of Maringá, in the northwestern region of the Paraná State, Brazil. The Ingá Park is a permanent preservation area by the organic law of the municipality, being the main natural reserve of the region and one of the last remnants of Atlantic Forest with 47.3 hectares of native forest in the heart of the city. However, at the same time that the Ingá Park is lawfully a conservation area, it is also a typical urban green area of recreation and intensive use with an estimated annual visitation exceeding one million people.

The studied lake is the central point of the park, with mean depth of 4 m, 480 m long, and 142 m width, 68160 m^2 area and 1,115 m perimeter (Figure 1), formed by the man-made impoundment of the Moscados Stream. Currently the lake has undergone changes resulting from human activities on its limnological characteristics, such as domestic and industrial pollution (GRAÇA; MACHADO, 2007).

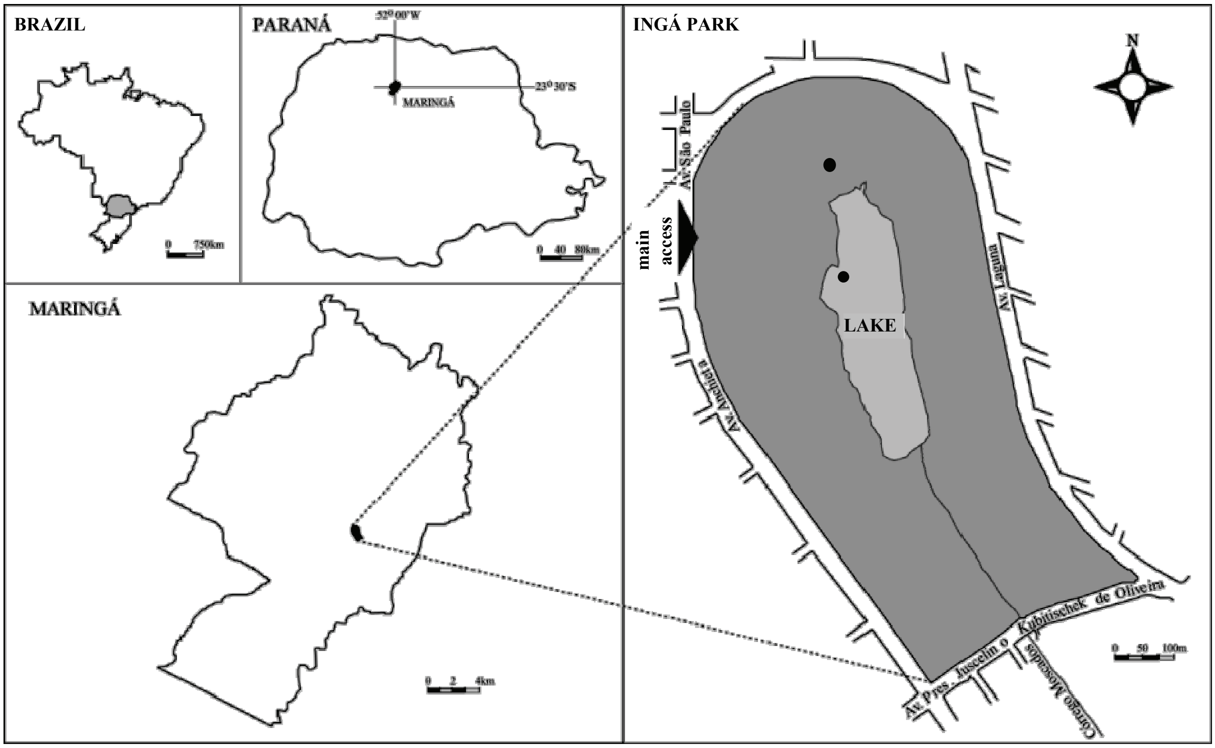

Figure 1. Map of the Ingá Park localization, evidencing the sampling sites.

Sampling and laboratory analysis

Aiming to obtain information of the entire hydrological period, rainfall data of the rainy period represented the daily mean values of January, February and March 2007, and of the dry period, of May, June and July 2007, excluding the days subsequent to each sampling. Rainfall data were obtained at the Principal Climatological Station of Maringá.

Samplings were conducted in March (rainy period) and July (dry period) of 2007, in the water surface and at the bottom, with the aid of a Van Dorn bottle in two sampling sites of the limnetic region of the lake. The following limnological variables were determined in the field: water temperature (°C), dissolved oxygen (mg L^{-1}, YSI 550A), pH and electrical conductivity (YSI 63). Chlorophyll-*a* (mg L^{-1}) (GOLTERMAN et al., 1978), turbidity (turbidimeter), organic matter (APHA, 1985), and concentration of total phosphorus (total-P) (μg L^{-1}), orthophosphate (mg L^{-1}) (GOLTERMAN et al., 1978), total nitrogen (total-N) (μg L^{-1}) (MACKERETH et al., 1978) and N-ammonia (KOROLEFF, 1976) were determined in laboratory.

For collecting ciliates, 2.0 L-water samples were taken at triplicate and concentrated into 100 mL through reverse filtration with 12 μM-net and analyzed in the laboratory. In order to prevent the loss of cells and alterations in the size and shape of cell caused by fixation, the analysis of ciliates was performed "in vivo".

Using single channel micropipettes (Eppendorf) were obtained aliquots totalizing 500 μL per sample, placed on glass slides and taken to optical microscope (Olympus CX41).

The identification and count of ciliates (cells L^{-1}) were performed whenever possible at species level. Further qualitative analyses were carried out aiming to register species not observed in the counts, using a Sedgewick-Rafter.

Ciliates had their images captured using a digital camera (Motic MCCamera) coupled to the microscope. These individuals were measured through the Motic Images Plus software in order to obtain data of cell biovolume (in μm^3, from approximate geographical shape) and ciliate community biomass (considering that 1 μm^3 = 110 fg C - WEISSE, 1991).

Data analysis

In order to summarize limnological data a PCA (principal component analysis) was performed to distinguish the sampling units according to limnological variables (pH, chlorophyll-*a*, turbidity, dissolved oxygen, conductivity, organic matter, orthophosphate, ammonia, whose data were gently provided by the Limnology Laboratory of Nupélia). Prior analysis, data were log transformated except pH. Besides that, a DCA (detrended correspondence analysis) was employed to a matrix of ciliate abundance, aiming to identify patterns of species distribution in the different sampling units (depths and periods). These analyses were carried out using the software PC-ORD (MCCUNE; MEFFORD, 1999). For these analyses, each sample were considered as a sampling unit, while for the graphic presentation the sampling sites were grouped.

Analyses of variance (STATSOFT INC, 2000) were run to test the statistical significance of differences observed for richness, density, biomass and species diversity, between periods and depths.

With the aim to infer about the influence of environmental variables on the ciliate community structure, Pearson Correlation analyses were performed between the PCA and DCA scores.

Results

Rainfall and limnological parameters

Results of rainfall values evidenced a strong seasonality, characterizing distinct hydrological periods, so that high mean value (199.1 mm) was observed in the rainy season, while the lower one (19.7 mm) was observed in the dry season.

In the Table 1 are presented the mean values of the distinct limnological variables. The first two PCA axes were significant according to Broken-Stick criteria. These axes explained 77.1% of the total variance of the data. The first axis (55.8%) was positively correlated with the chlorophyll-*a*, conductivity, pH, and total phosphorus, and negatively with the turbidity, orthophosphate, water temperature, and total nitrogen. The second axis (21.3%) was positively correlated with the organic matter and ammonia, and negatively with dissolved oxygen.

Table 1. Mean values of limnological variables in the Ingá lake (S = surface; B = bottom).

Season	Rainy		Dry	
Variables/Strata	S	B	S	B
Temperature (°C)	26.5	29.8	20.7	20.0
Dissolved oxygen (mg L^{-1})	6.56	5.43	8.97	4.55
pH	7.6	6.3	8.1	7.5
Conductivity (μS cm^{-1})	77.48	75.68	106.48	107.18
Chlorophyll-*a* (μg L^{-1})	61.58	68.40	100.62	102.39
Turbidity	13.27	15.79	4.83	4.71
Organic matter (mg L^{-1})	5.65	6.23	5.92	6.15
Total phosphorus (μg L^{-1})	25.80	27.22	35.53	37.87
Orthophosphate (μg L^{-1})	3.18	3.71	2.73	2.92
Total nitrogen (μg L^{-1})	274.91	264.10	202.75	228.33
Ammonia (μg L^{-1})	99.81	93.46	7.89	146.12

In general, the first PCA axis set apart the sampling periods (rainy/March and dry/July), while the second axis evidenced a trend for distinction between surface and bottom samples (Figure 2). In summary, the dry season had in general higher values of chlorophyll-a, conductivity, pH, and total phosphorus, while the rainy was correlated with greater values of turbidity, orthophosphate, water temperature and total nitrogen. It was observed a trend for higher values of organic matter total phosphorus and ammonia on the bottom, and higher concentrations of dissolved oxygen at the surface.

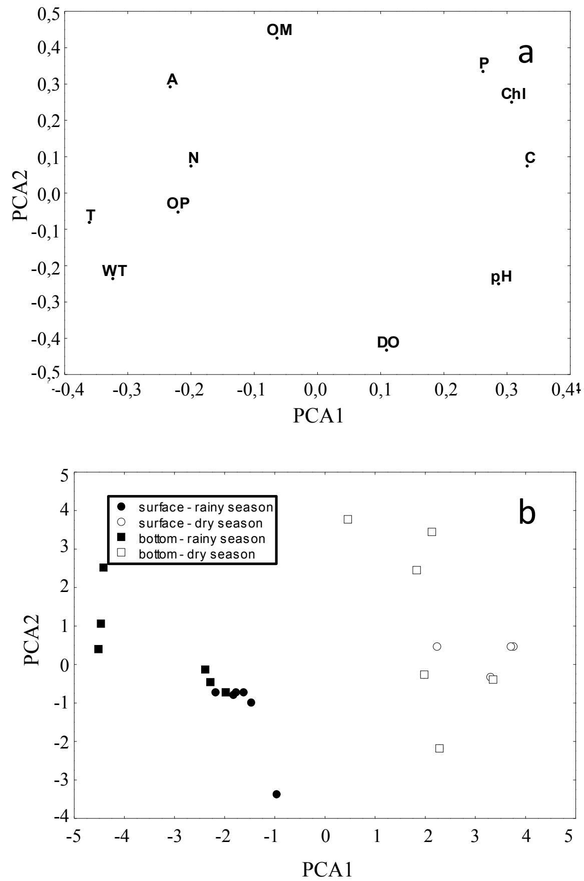

Figure 2. Scores of limnological variables (a) and samples (b) along the axes 1 and 2 of PCA (T = turbidity; OM = organic matter; A = N-ammonia; DO = dissolved oxygen; C = conductivity; P = total phosphorus; WT = water temperature; Chl = chlorophyll-*a*; N = total nitrogen; OP = orthophosphate).

Composition

The Table 2 lists the 35 ciliate species identified, among which 14 species occurred in all periods and strata. The species registered belong to 11 orders, being Prostomatida the most specious (7 species), followed by Gymnostomatida, Oligotrichida, Peritrichida (with 5 species each), and Scuticociliatida (4 species).

Regarding the occurrence of species, 13 species were exclusive of the deeper region (hipolimnion), while all species registered at the surface (epilimnion) were also recorded on the bottom. Moreover, it was observed a clear temporal variation for the ciliate species composition, with eight species occurring only in the rainy season, while other eight were observed only in the dry season.

Table 2. List of ciliate species and occurrence in hydrological periods and depths sampled in the lake of the Ingá Park (Code = code of species used in the DCA; S = surface; B = bottom).

Code	Order/Species Season	Rainy		Dry	
	Depth	S	B	S	B
	Colpodida				
sp.8	*Cyrtolophosis mucicola* (Stokes, 1885)	X	X	X	X
	Gymnostomatida				
sp.1	*Askenasia volvox* (Eichwald, 1852)	X			X
sp.9	*Didinium nasutum* (Müller, 1773)	X	X		X
sp.10	*Dileptus* sp.		X		
sp.15	*Lagynophrya acuminata* (Kahl, 1935)	X	X	X	X
sp.18	*Mesodinium pulex* (Claparède & Lachmann, 1859)	X	X	X	X
	Heterotrichida				
sp.27	*Spirostomum teres* (Claparède & Lachmann, 1858)				X
sp.28	*Stentor roeselii* (Ehrenberg, 1835)				X
	Hymenostomatida				
sp.20	*Paramecium aurélia* (Müller, 1773)				X
sp.29	*Stokesia vernalis* (Wenrich, 1929)	X	X		
sp.31	*Urocentrum turbo* (Müller, 1786)				X
	Hypotrichida				
sp.2	*Aspidisca cicada* (Müller, 1786)		X		
	Karyorelictida				
sp.17	*Loxodes magnus* (Stokes, 1887)				X
	Nassulida				
sp.19	*Microthorax pusillus* (Engelmann, 1862)	X	X		X
	Oligotrichida				
sp.13	*Halteria grandinella* (Muller, 1793)	X	X	X	X
sp.16	*Limnostrombidium* sp.	X	X	X	X
sp.25	*Rimostrombidium humile* (Penard, 1922)	X	X	X	X
sp.26	*Rimostrombidium lacustris* (Foisser, Skogstad & Pratt, 1988)	X	X	X	X
sp.30	*Tintinnidium* sp.	X	X	X	X
	Peritrichida				
sp.11	*Epistylis anastatica* (Linnaeus, 1767)		X		
sp.12	*Epistylis pygmaeum* (Ehrenberg, 1838)	X		X	X
sp.21	*Pelagovorticella mayeri* (Fauré-Fremiet, 1920)	X	X	X	X
sp.22	*Pelagovorticella natans* (Fauré-Fremiet, 1924)				X
sp.35	*Vorticella convallaria* (Linnaeus, 1758)				X
	Prostomatida				
sp.3	*Balanion planctonicum* (Foissner et al., 1990)	X	X		
sp.6	*Coleps hirtus* (Müller, 1786)	X	X	X	X
sp.14	*Holophrya discolor* (Ehrenberg, 1833)		X		
sp.23	*Plagyocampa rouxi* (Kahl, 1926)		X		X
sp.32	*Urotricha farcta* (Claparède & Lachmann, 1859)	X	X	X	X
sp.33	*Urotricha* sp.	X	X	X	X
sp.34	*Urotricha platystoma* (Stokes,1886)		X		
	Scuticociliatida				
sp.4	*Calyptotricha lanuginosa* (Penard, 1922)	X	X	X	X
sp.5	*Cinetochilum margaritaceum* (Ehrenberg, 1831)	X	X	X	X
sp.7	*Cyclidium glaucoma* (Muller, 1773)	X	X		
sp.24	*Platynematum sociale* (Penard, 1922)				X

Species richness, density and biomass of the community.

The species richness has varied significantly between depths (F = 4.453; p = 0.048), with higher values on the bottom (between 10 and 21 species) than on the surface (8 to 19 species). However, significantly differences were not detected for richness between sampling periods (F = 2.044; p = 0.168) (Figure 3a).

The density of ciliates in the study period varied between 3500 cels. L^{-1}, in a surface sample in March (rainy season), and 17990 cels. L^{-1}, registered in a bottom sample in July (dry season). There was a significant increase between rainy and dry seasons (F = 13.56; p = 0.001), with higher values of this attribute in the last period. In relation to the depths, significant differences were not observed (F = 1.61; p = 0.219) (Figure 3b).

In relation to the contribution of species registered for the total density of ciliates, in the rainy season *Calyptotricha lanuginosa*, *Mesodinium pulex* and *Coleps hirtus* were the most important taxa at the surface (2900, 2300 and 1800 cel. L^{-1}, respectively) and at the bottom (8900, 1600 and 3400 cel. L^{-1}, respectively).

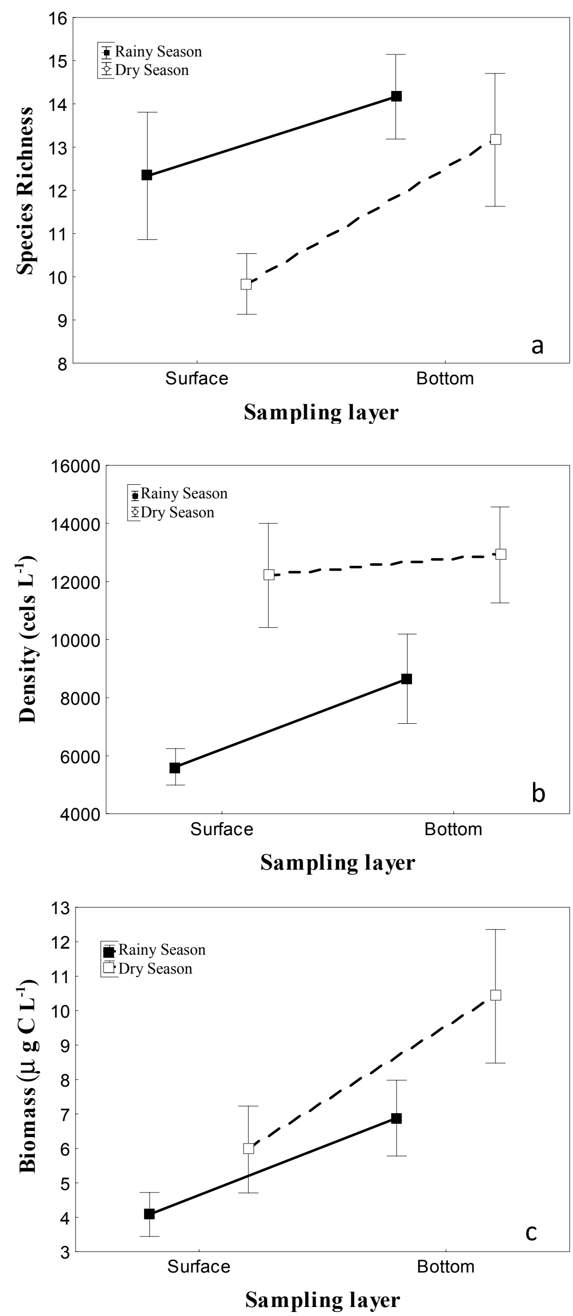

Figure 3. Species richness (a), density (b) and biomass (c) of ciliates in the different periods and depths sampled (symbols represent mean values and vertical bars represent the confidence interval).

In the dry season, the species that have dominated in density at the surface were *Cyrtolophosis mucicola* (6000 cel. L^{-1}), *Pelagovorticella mayeri* (4400 cel. L^{-1}), *Calyptotricha lanuginose* (3200 cel. L^{-1}), *Coleps hirtus* (2800 cel. L^{-1}), *Rimostrombidium humile* (2600 cel. L^{-1}) and *Cinetochilum margaritaceum* (1800 cel. L^{-1}). At the bottom, stood out *Coleps hirtus* (5800 cel. L^{-1}), *Plagiocampa rouxi* (4300 cel. L^{-1}), *Calyptotricha lanuginosa* (4000 cel. L^{-1}) and *Pelagovorticella mayeri* (3200 cel. L^{-1}).

Regarding the biomass, values ranged from 2.02 μg C L^{-1} in a surface sample of the dry season, to a peak of 18.27 μg C L^{-1} on the bottom in the same period. The results of a two-way Anova evidenced a significant variation between periods and depths ($F = 4.217$; $p = 0.051$ – $F = 7.54$; $p = 0.012$, respectively). In this way, higher biomass values were observed in the dry season, and at the deepest layer of the water column in both periods sampled (Figure 3c).

In the rainy season, species that contributed most to the total biomass were *Coleps hirtus, Mesodinium pulex* and *Calyptotricha lanuginosa*, with high values both on the surface (2.06, 0.97 and 0.83 μg C L^{-1}, respectively) and on the bottom (3.89, 0.71 and 2.56 μg C L^{-1}, respectively) besides *Rimostrombidium lacustres* which was important only for the surface (1.42 μg C L^{-1}) and *Epistylis anastatica*, for the bottom (0.78 μg C L^{-1}).

In the dry season, the species representative for the biomass on the surface and bottom was *Coleps hirtus* (3.05 and 6.64 μg C L^{-1}). Besides this species, stood out at the surface *Lagynophrya acuminata* (2.61 μg C L^{-1}) and *Pelagovorticella mayeri* (2.51 μg C L^{-1}), and at the bottom, *Stentor roeselii* (6.03 μg C L^{-1}) *Tintinnidium* sp. (3.51 μg C L^{-1}) and *Plagiocampa rouxi* (3.02 μg C L^{-1}).

Comunnity structure

The results of DCA based on the distribution of ciliate species showed that the axes 1 and 2 have distinguished the periods and depths of sampling, forming three large groups of samples (Figure 4).

In the first group, the most negatively related to the axis 1, predominated samples of the dry season (July) with dominance of *Cinetochilum margaritaceum*, *Cyrtolophosis mucicola*, *Lagynophrya acuminata*, *Limnostrombidium* sp. *Pelagovorticella natans*, *Rimostrombidium lacustris* and *Tintinnidium* sp. (Figure 4, Table 2).

The second group had been positively correlated with the axis 2 of DCA and was characterized by most samples of the bottom, where prevailed *Epistylis anastatica*, *Mesodinium pulex*, *Pelagovorticella mayeri*, *Plagyocampa rouxi*, *Platynematum sociale*, *Rimostrombidium humile*, *Stokesia vernalis*, *Urotricha* sp., *U. farcta* and *Urotricha platystoma* (Figure 4, Table 2).

The last group consisted of most samples of the rainy season (March), characterized by the predominance of *Askenasia volvox*, *Aspidisca cicada*, *Balanium planctonicum*, *Cyclidium glaucoma*, *Dileptus* sp., *Holophrya discolor*, *Loxodes magnus*, *Microthorax pusillus*, *Paramecium aurelia* and *Vorticella convallaria* (Figure 4, Table 2).

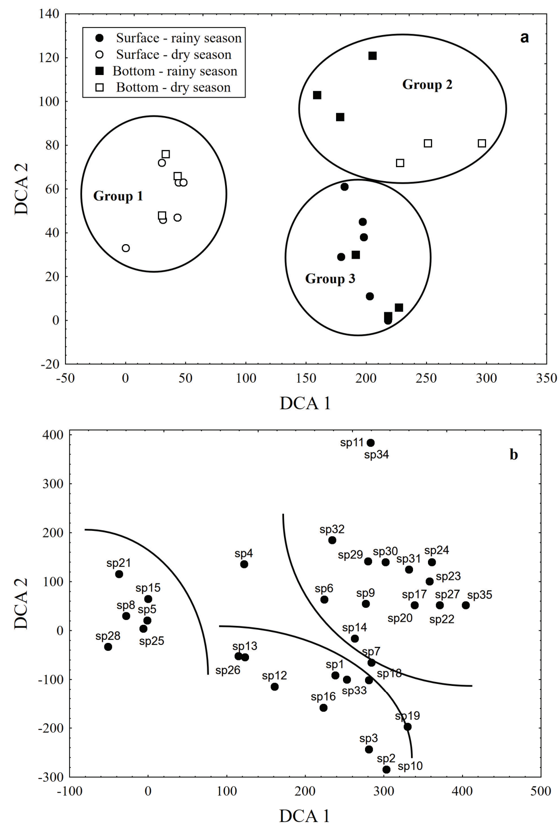

Figure 4. Scatter plot of scores of samples (a) and species (b) of ciliates along the axes 1 and 2 of DCA.

Influence of limnological conditions on ciliate community

Pearson correlations estimated to infer about the influence of limnological parameters on the ciliate community structure, have indicated that the axes DCA1 and PCA1 were significantly and negatively correlated. On the other hand, significant and positive correlations were verified between DCA1 and PCA2, and DCA2 and PCA2 (Table 3).

Table 3. Values of *r* and *p* for significant Pearson correlations between PCA and DCA axes.

	r	p
DCA1 x PCA1	-0.659622	0.000454
DCA1 x PCA2	0.404721	0.049793
DCA2 x PCA2	0.471979	0.019881

Discussion

Studies have shown that in eutrophic lakes, the number of species found is somewhat variable, from high (XU et al., 2005) until low diversity (SANDERS et al., 1989). The total number of species recorded in the present study (35 species) is similar to those observed in other studies in Brazilian freshwater environments (ARAÚJO; COSTA, 2007; BOSSOLAN; GODINHO, 2000; GOMES; GODINHO, 2003). However, the diversity here recorded is substantially lower than described to the plankton ciliates community from the upper Paraná river floodplain (61 species) (PAULETO et al., 2009), an ecosystem with a high spatial and temporal environmental heterogeneity, reflecting in high ciliate diversity.

The predominance of Prostomatida, Gymnostomatida and Oligotrichida orders in the Ingá Lake corroborates the composition pattern observed in other studies (ARAÚJO; COSTA, 2007; MIECZAN, 2007; PAULETO et al., 2009), which is related to their pelagic habit.

Besides that, stands out the occurrence of a great number of species exclusive to the bottom layer (14 species) evidencing a great vertical variation of the community composition. This was due to the occurrence of species of Hymenostomatida, Heterotrichida, Hypotrichida and Peritrichida only in this portion of the water column, once these orders are greatly made up by littoral and benthic species (BERGER; FOISSNER, 2003). Furthermore, a representative number of species occurred only in the rainy season, and others in the dry season, suggesting that the rainfall regime had an important influence on the ciliate species composition in the plankton of the lake of the Ingá Park.

In general, patterns of composition and species richness found in the present study also corroborate the hypotheses raised that community attributes vary vertically and temporally. Thus, in relation to the species richness, results indicated significant differences only between depths, with greater values on the deeper layer of the water column, in both study periods. This pattern was certainly determined as discussed before by the great occurrence of littoral and benthic species (BERGER; FOISSNER, 2003) registered in the layer of the water column.

As for the ciliate abundance, the Anova results pointed out a significant increase in density and biomass in the dry season in relation to the rainy one. Researches have shown that lower values of density are usually found in the rainy season (BOSSOLAN; GODINHO, 2000; XU et al., 2005), owing the dilution effect. Moreover, the higher values of chlorophyll-*a* and total phosphorus registered in the dry season have suggested a greater productivity of the system, determined by a lower environmental instability in this period, promoting a greater availability of resources for ciliates. According to Mathes and Arndt (1994) and Velho et al. (2005), a positive correlation between ciliate and nutrient concentrations has suggested that food resource availability prevails in determining the abundance distribution of these organisms. On the other hand, rainfall in the summer determined the greater values of turbidity in the water column in this period, may leeding in a lower primary productivity of the system.

Considering the participation of different species in the ciliate abundance, several species present specific requirements that restrict them to specific compartments such as epilimnium, hypolimnion and anoxic region of the same environment (FINLAY; ESTEBAN, 1998; MIECZAN, 2008; ZINGEL; OTT, 2000). The species with greater density and biomass observed in the present study can be considered euplanktonic, being cosmopolitan and commonly found in lacustrine environments (PFISTER et al., 2002).

In the rainy season, both higher biomass and higher density were observed for species of the orders Gymnostomatida and Prostomatida. It was also observed high values of these attributes for species of the orders Oligothrichida and Scuticociliata, all important in the metalimnion and hypolimnion of stratified lakes (ZINGEL, 2005). The homogeneous vertical distribution, mostly omnivorous and bacterivorous, suggests a great and continuous input of organic matter for the whole water column, eased in a small sized environment as the urban lake studied. The high biomass values observed for the orders Oligothichida and Prostomatida in the examined environment corroborate the results of several studies (MIECZAN, 2008; ZINGEL, 2005; ZINGEL; OTT, 2000).

In the dry season, although higher density and biomass had been verified for species of the orders Heterotrichida and Peritrichia, mostly comprised of benthic species, other species with great values of these attributes in the present study, *Pelagovorticella mayeri, Tintinnidium* sp. and *Coleps hirtus,* have pelagic habit (BERGER; FOISSNER, 2003), indicating that these organisms were not taken from other compartment, and are actually developing in the pelagic region, determining this high abundances in the dry season.

Results of Pearson correlations between axes of PCA and DCA evidenced these seasonal and vertical variations of limnological characteristics greatly influenced the structure of ciliate communities.

Significant relationships between axes of DCA and PCA suggested that species discriminated in the samples of the group 2 seem to be mainly influenced by the amount of organic matter (food availability) and ammonia (from organic matter decay) in the water, being this group formed especially by species typically from the bottom (e.g. *Loxodes magnus* and *Spirostomum teres*). On the other hand, the group 3 of samples was characterized by euplanktonic species (e.g. *Halteria grandinella* and *Askenasia volvox*) that predominated on the surface, with high concentration of dissolved oxygen. These species are in general small, with high swimming activity to maintain on the water column, requiring in this way greater concentrations of dissolved oxygen (LAYBOURN-PARRY, 1992).

In turn, species that characterized the samples of the group 1 seem to be favored by conditions of lower temperature and greater primary productivity of phytoplankton, observed during the dry season. According to Zingel et al. (2002) the phytoplankton is a food resource used by some ciliate species.

At short, our predictions were only partially corroborated. In this way, patterns found for composition, abundance and species richness have shown a vertical and temporal variation of the attributes of ciliate community. Nevertheless, in general the composition and richness have varied more along the vertical gradient than between hydrological periods, whereas for the abundance, only temporal differences could be detected. In general, results registered in this study also evidenced that seasonal and vertical variations of limnological characteristics have influenced the community structure, and were decisive for the patterns of occurrence and abundance of ciliate species.

Conclusion

Our research provided further evidence that the characteristics of the structure and composition of protozoan community in lakes can reflect the temporal change in water quality. Moreover, our data also have shown a vertical variation of the attributes of ciliate community, demonstrating the contributions of local processes on the regulation of communities, as is known the ciliates have specific requirements that restrict them to specific compartments of the same environment. Therefore it is necessary to accomplish further studies with a longer temporal scale for a better understanding of the processes that regulate the structure and dynamic of the ciliate community in urban lakes.

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Received on September 11, 2012.
Accepted on October 5, 2012.