DOI: 10.4025/actascibiolsci.v32i4.7456

Study of testacean assemblages (Protozoa: Rhizopoda) in touristic waterfall regions of Chapada dos Guimarães National Park, Mato Grosso State, Brazil

Márcia Teixeira de Oliveira* and Edna Lopes Hardoim

*Universidade Federal de Mato Grosso, Av. Fernando Corrêa da Costa, s/n, 78060-900, Coxipó, Cuiabá, Mato Grosso, Brazil. *Author for correspondence. E-mail: marciatoli@yahoo.com.br*

ABSTRACT. An evaluation was made of the effect of temporal variations on an assembly of Testaceae in several water bodies located in Chapada dos Guimarães National Park. A sampling point was selected at each study site, where 4 samplings were collected per season, considering the climatic conditions of the dry and rainy periods. The findings revealed 80 infrageneric taxa, 05 families and 12 genera. Pearson's correlation between the second axis of the DCA and the first axis of the PCA was significant, even after applying Bonferroni's correction for multiple significance tests *(*r = 0.683; p = 0.014*)*. Thus, the temporal variation of the limnological data, which showed higher values of turbidity, total solids, color and temperature for the rainy period and higher concentrations of nitrogen and phosphorus during the dry season, was significantly correlated with the biotic data. The second axis of the PCA indicated that the variables remained unchanged during the seasonal periods under study.

Key words: Testacean, protozoa, rhizopoda, waterfall regions.

RESUMO. Estudo das assembléias de Testáceas (Protozoa – Rhizopoda) em regiões encachoeiradas turísticas do Parque Nacional Chapada dos Guimarães, Estado do Mato Grosso, Brasil. O presente trabalho objetivou avaliar os efeitos da variação temporal sobre assembleia de Testáceas de alguns corpos d'água localizados no Parque Nacional da Chapada dos Guimarães. Elegeu-se, em cada estação de estudo, um ponto amostral e realizaram-se quatro amostragens/estação, considerando-se as condições climáticas do período de estiagem e chuvoso. Os resultados obtidos evidenciaram 80 táxons infragenéricos, cinco famílias e 12 gêneros. A correlação de Pearson entre o segundo eixo da DCA e o primeiro eixo da PCA foi significativa, mesmo após a correção de Bonferroni para múltiplos testes de significância (r = 0,683; p = 0,014). Deste modo, a variação temporal dos dados limnológicos, que evidenciou maiores valores de turbidez, sólidos totais, cor e temperatura para o período chuvoso, e maiores concentrações de nitrogênio e fósforo na estiagem, correlacionou-se significativamente com os dados bióticos. O segundo eixo da PCA evidenciou que as variáveis não variaram durante os períodos sazonais estudados.

Palavras-chave: Testacea, protozoa, Rhizopoda, regiões encachoeiradas.

Introduction

Chapada dos Guimarães National Park was created by Federal Decree 97656 of April 12, 1989 to ensure full protection of the region's fauna, flora, water resources and natural beauty. In this context, several local groups representing civil entities have been developing environmental education projects aimed at reversing the current situation of degradation that is visible in several locations in this region. The park has a rich diversity of watercourses, many of them with waterfalls, which are its main tourist attraction.

The park has a rich diversity of watercourses, many of them with waterfalls, which are its main tourist attraction, e vem sofrendo constante alteração provacada pelo homem. However, it has been suffering constant impacts caused by humans. Anthropic interference, whether concentrated, as in the generation of domestic sewage, or disperse, contributes toward the introduction of both organic and inorganic compounds into the water, affecting its quality. Therefore, water quality is the result of both natural phenomena and human actions (ALVES et al., 2008).

The thecamoebian group is composed of a heterogeneous group of rhizopodan amoebae that share a common trait of rigid carapaces, also known as thecae or shells, which are unique characteristics of each species (VUCETICH; LOPRETO, 1995).

The first study of Testaceae in Brazil was conducted by Ehrenberg (1841), followed by Daday (1905), Prowazeck (1910), Cunha (1913) and Pinto (1925). Starting in the 1970s, the studies of these protozoans adopted a more ecological approach, which allowed for the inclusion of this group in the planktonic community.

In Brazil, studies of these assemblages are still only incipient. The first record for the state was made by Cunha (1913), followed by Green (1970), in the Suiá-Missu river. Two decades later, the studies of this biological group were resumed by Hardoim and Heckman (1996), who, albeit still using with a taxonomic approach, began to turn to investigations of an ecological nature. More recent studies in rivers were conducted by Grego and Dabés (2001) and by Souza (2005).

In the planktonic community as participants in the food chain, in the cycling of nutrients, and their possible use as biomarkers of water quality, it has become increasingly necessary to investigate this group of organisms that have so far received so little attention from the scientific community. When this type of work was carried, it was in reservoirs, lakes and rivers connected to large flooded areas, but there are no records of studies of Testaceae in waterfall regions. The data reported here therefore offer a unique contribution to the body of knowledge on the composition and richness of Testacean amoebae in rivers with waterfalls.

Material and methods

The present study was carried out in pools formed by several waterfalls in *Chapada dos Guimarães* National Park in Mato Grosso State. These waterfalls were *Véu de Noiva* (V) – Altitude 592 m, *Cachoeirinha* (C) – Altitude 624 m, and *Salgadeira* (S) – Altitude 586 m.

The Testaceae specimens were collected seasonally, with four samplings made at each study site, using a 38 μm mesh plankton net, making a total of 24 samplings. The species were divided taxonomically into the various families according to Deflandre (1953). The specimens were Rose Bengal stained, and only stained organisms were counted, identified with the help of specialized literature, and deposited in the Latemas collection (the laboratory of taxonomy and ecology of aquatic and symbiontic microorganisms of the Federal University of Mato Grosso).

The abiotic variables (pH, conductivity, oxygen, ammonium, phosphorus, iron, silicate, temperature, total nitrogen and total solids) were determined as described by Franson (1992). The precipitation (rainfall) data were supplied by the Civil Defense State Agency of Mato Grosso.

The abiotic variables were analyzed by principal components analysis (PCA). All the variables except the pH were first logarithmically transformed. The patterns of similarity among the samples (periods/collection sites), according to species density (individuals L^{-1}), were synthesized by means of a detrended correspondence analysis with removal of the arch effect (DCA) (GAUCH, 1982; HILL; GAUCH, 1980). The analysis was performed with the PC-ORD program (McCUNE; MEFFORD, 1997), using the option of weighting the rare species. Twenty-six segments were used to remove the arch. The data were previously transformed into logarithms (log(density + 1)). Only species with an absolute frequency higher than or equal to two were included in the DCA (maximum frequency equal to 12, i.e., the number of observations in the data matrix: 3 sites x 4 collections). The relationship between the scores derived from the DCA (biological data) and those derived from the PCA was then quantified through Pearson's linear correlation coefficient.

The values of species richness (S), Shannon-Wiener diversity (H') and equitability (E) were estimated for each period, using the Pc-ORD statistical program (McCUNE; MEFFORD, 1997).

Results

The testacean assemblages recorded in the 96 samples collected at the three sampling sites were composed of 80 infrageneric taxa belonging to 5 families and 12 genera, with a total of 643 individuals observed (Table 1). The greatest abundance was represented by the families Centropyxidae (59.28%), Arcellidae (19.32%), Difflugidae (12.63%) and Nebellidae (8.58%). These four families represented 98.8% of the total abundance of testaceae.

The highest densities of Centropyxidae and Difflugidae were found in the rainy period, while the families Arcellidae and Nebellidae were denser in the dry period (Table 1).

The genera *Centropyxis* (17 taxa), *Difflugia* (19 taxa), *Arcella* (16 taxa) and *Cyclopyxis* (11 taxa) are the ones that best represent the study sites. In addition to these genera, *Nebella* (9 taxa), *Curcubitella* (2 taxa), *Lesquereusia* (2 taxa), and one taxon each of *Diphochlamys*, *Hialosphenia, Pontigulasia* and *Quadrulella* were also found.

Table 1. Occurrence of family, thecal shape, and total abundance of the inventoried testacean taxa at the three waterfalls (*Véu de Noiva* (V), *Cachoeirinha* (C) and *Salgadeira* (S)) in the dry and rainy seasons in *Chapada dos Guimarães* National Park, Mato Grosso State, Brazil.

Family	Taxon	Shape of the theca	Absolute abundance		Occurrence in the season/period	
			Dry	Rainy	Dry	Rainy
Arcellidae						
	Arcella arenaria (Greef, 1866)	flattened	7	3	V, C and S	C
	A. dentata (Ehrenberg, 1838)	flattened	0	3	-	C
	A. discoide (Ehrenberg, 1843)	flattened	14	6	V, C and S	V and C
	A. multilobata (Ehrenberg, 1871)	flattened	0	3	-	C
	A. rotundata (Playfair, 1818)	flattened	3	6	V and C	V, C and S
	A. atava (Collin, 1914)	hemispherical	9	11	V, C and S	V and C
	A. catinus (Pénard, 1870	hemispherical	2	6	C	V and C
	A. conica (Playfair, 1917)	hemispherical	1	2	C	V
	A. costata (Ehrenberg, 1847)	hemispherical	3	0	C	-
	A. crenulata (Deflandre, 1928)	hemispherical	2	0	V	-
	*A. gibbosa (*Pénard, 1810)	hemispherical	6	4	V,C and S	V and C
	A. hemisphaerica (Perty, 1852)	hemispherical	13	2	V, C and S	V
	A. lobostoma (Deflandre, 1928)	hemispherical	0	3	-	V
	A. marginata (Daday, 1905)	hemispherical	2	0	S	-
	A. vulgaris (Ehrenberg, 1830)	hemispherical	3	5	V	V and C
	A. mitrata (Leidy, 1879)	spherical	0	3	-	V and C
Centropyxidae						
	Centropyxis aculeata (Ehrenberg,1838)	flattened	33	99	V, C and S	V, C and S
	C. aerophila (Deflandre, 1929)	flattened	7	14	V, C and S	V, C and S
	C. cassis (Wallich, 1864)	flattened	9	7	V, C and S	V, C and S
	C. compressa (Cushman, 1830)	flattened	2	0	V, C and S	-
	C. constricta (Ehrenberg, 1838)	flattened	13	15	V, C and S	V, C and S
	C. ecornis (Ehrenberg, 1841)	flattened	13	25	C and S	V, C and S
	C. hirsuta, (Deflandre, 1929)	flattened	4	1	V and C	V
	C. pannosus (Decloitre, 1929)	flattened	1	1	S	V
	C .platystoma (Pénard, 1890)	flattened	6	0	C and S	V, C and S
	C. spinosa (Cash, 1905)	flattened	2	0	S	V, C and S
	C. torquatus (Decloitre, 1929)	flattened	0	3	-	V
	C. gauthieri (Thomas, 1959)	hemispherical	1	1	S	C
	C. gibbosas (Pénard, 1890)	hemispherical	3	1	C and S	V
	C. laevigata (Pénard, 1890)	hemispherical	1	1	C	V
	C. minuta (Deflandre, 1929)	hemispherical	18	28	V, C and S	V, C and S
	C. orbicularis (Deflandre, 1929)	hemispherical	5	1	V, C and S	C
	C. marsupiformis (Deflandre,1929)	elongated	0	4	-	V, C and S
	Cyclopyxis ambigua (Decloitre, 1977)	spherical	0	5	-	V and C
	C. amplicta (Decloitre, 1977)	spherical	2	2	V and C	C and S
	C. arcelloides (Pénard, 1902)	spherical	3	26	V and S	V, C and S
	C. eurystoma (Deflandre, 1957)	spherical	1	3	C	V and C
	C. kahli (Deflandre, 1929)	spherical	0	2	-	V and C
	C. sexangularis (Decloitre, 1977)	hemispherical	2	0	C	-
	C. arenata (Decloitre, 1977)	flattened	1	1	S	V
	C. plathystoma (Deflandre, 1929)	flattened	0	2	-	V
	C. penardi (Deflandre, 1929)	flattened	3	0	S	-
	C. pirini (Decloitre, 1977)	flattened	0	3	-	C
	C. plana (Decloitre, 1977)	flattened	3	2	V and C	C
Difflugiidae						
	Curcubitella dentata (Pénard, 1893)	spherical	2	0	S	-
	Difflugia acuminata (Ehrenberg, 1838)	elongated	1	3	C	V and C
	D. ampholaris (Cash, 1909)	elongated	1	2	C	C
	D. bicruris (Gi & Thomas, 1958)	elongated	1	2	C	C
	D. brevicola (Cash and Hopkinson, 1909)	elongated	2	0	C	-
	D.cf. bryophila (Pénard, 1902)	elongated	0	2	-	C
	D. distenda (Ogden, 1983)	elongated	1	1	C	C
	D. elegans (Pénard, 1890)	elongated	1	1	C	V
	D. lacustris (Pénard, 1890)	elongated	1	1	S	V
	D. lucida (Pénard, 1890)	elongated	2	2	V and C	V
	D. mammilaris (Pénard, 1893)	elongated	4	0	C	-
	D. manicata (Ehrenberg, 1838)	elongated	0	2	-	C
	D. oblonga (Ehrenberg, 1838)	elongated	9	11	C and S	V, C and S
	D. penardi (Hopkinson, 1909)	elongated	0	1	-	C
	D. pyriformis (Perty, 1899)	elongated	0	4	-	V and S
	D. sinuata Sp. Nov	elongated	0	4	-	C
	D. lebes (Pénard, 1893)	spherical	0	5	-	V
	D. microstoma (Thomas, 1954)	spherical	1	1	C	C
	D. angulostoma (Gauthier-Lievre and Thomas, 1958)	hemispherical	1	2	C	S
	D. globulosa (Wallich, 1837)	hemispherical	3	0	C	-
	D. oviformis (Cash, 1909)	hemispherical	3	1	V and S	V
Microcoryciidae						
	Diphochlamys tímida (Wallich, 1864)	spherical	3	0	S	-
Nebelidae						
	Hyalosphenia elegans (Taranek, 1882)	elongated	5	5	-	V, C and S

Continue...

...continuation

Family	Taxon	Shape of the theca	Absolute abundance		Occurrence in the season/period	
			Dry	Rainy	Dry	Rainy
	Lesquereusia modesta (Rhumbler,1896)	elongated	8	2	C and S	V
	L. spiralis (Ehrenberg, 1841)	elongated	3	1	S	C
	Nebela americana (Taránek, 1882)	elongated	2	0	S	-
	N. barbata (Leidy, 1874)	elongated	3	1	S	S
	N. carinata (Leidy, 1874)	elongated	0	4	-	C
	N. collaris (Ehrenberg, 1848)	elongated	4	3	S	V, C and S
	N. dentistoma (Pénard, 1890)	elongated	1	2	C	V and S
	N. tenella (Pénard, 1893)	elongated	0	3	-	C
	N. tincta (Leidy, 1879)	elongated	2	0	S	-
	N. vas (Carter, 1889)	elongated	4	0	C	-
	N. flabellulum (Leidy, 1879)	hemispherical	2	0	S	-
	Pontigulasia compressa (Carter, 1864)	elongated	3	0	C	-
	Quadrulella symmetrica (Wallich, 1863)	elongated	0	2	-	S
5 families	80 species	4 shapes	271 ind.	372 ind.		

The most frequent taxa found in the three waterfalls of this study were Arcella atava, Arcella discoides, Arcella hemisphaerica, Centropyxis aculeata, Centropyxis aerophila, Centropyxis minuta, Centropyxis constricta, Centropyxis ecornis, Cyclopyxis arcelloides, Cyclopyxis minuta, Cyclopyxis arcelloides e Difflugia oblonga. The taxa Arcella discoides and Arcella hemisphaerica were more frequent in the dry period, while the taxa Arcella atava, Centropyxis aculeata, Centropyxis aerophila, Centropyxis constricta, Centropyxis ecornis, Centropyxis minuta, Cyclopyxis arcelloides and Difflugia oblonga were more frequent in the rainy season. Among the taxa recorded, Centropyxis aculeata was the only species classified as common in the rainy season, according to the classification of Gomes (1989) (Table 1). There was no representativeness of common or dominant species in the dry season.

A greater abundance, albeit not significant, was found at the *Cachoeirinha* waterfall (238 individuals), followed by *Véu de Noiva* (226 individuals) and *Salgadeira* (179 individuals). A larger number of individuals were generally found in the rainy period (Table 1). Among the three waterfalls, the greatest richness was recorded at *Cachoeirinha* (C) in the dry period. In the rainy season, the *Véu de Noiva* (V) and *Cachoeirinha* (C) sites presented similar values, unlike that of *Salgadeira*, which showed less richness.

According to Sorensen's similarity coefficient (MAGURRAM, 1988), the *Véu de Noiva* site showed the greatest similarity between the periods studied, with 56.07%, followed by *Cachoeirinha* with 47.43% and *Salgadeira* with 46.63%.

The Spearman correlation between density and precipitation, diversity and precipitation data revealed a distinct result for each waterfall in this study. The diversity and density data of *Véu de Noiva* correlated positively with precipitation, presenting their highest values in the rainy period (r = 0.80; p = 0.017). *Cachoerinha* did not show a significant variation between the seasonal periods. At *Salgadeiro*, they correlated negatively and both correlations showed significant results (r = -0.80; p = 0.02) (Figures 1, 2 and 3).

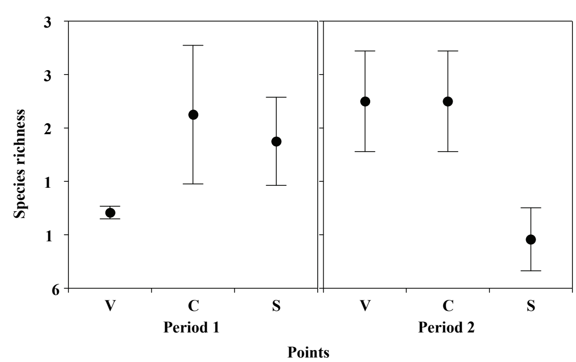

Figure 1. Variation in the richness of the testacean assemblage sampled at the *Véu de Noiva* (V), *Cachoeirinha* (C) and *Salgadeira* (S) sites in the dry (1) and rainy (2) periods in 2000 and 2001, respectively, in *Chapada dos Guimarães* National Park, Mato Grosso State, Brazil.

The equitability values were higher in the dry period. *Salgadeira* presented the greatest dissimilarity in species distribution over the periods under study (Figure 4).

The PCA-derived scores applied to the environmental data demonstrated that the rainy (March and April) and dry (July and August) periods presented differentiated limnological characteristics (Figure 5).

An analysis of the structure coefficients indicated the main variables responsible for this temporal differentiation. The first two axes of the PCA explained 57.6% of the total variability of the data.

The first axis explained 36.41% and was negatively correlated to the variables of turbidity (r = -0.93), total solids (r = -0.86), color (r = -0.77) and temperature (r = -0.72), presenting higher values in the rainy season. These variables were also strongly correlated to each other. The dry period was characterized by higher concentrations of ions and nutrients such as phosphorus (r = 0.62) and nitrogen (r = 0.65), and was positively correlated with the first principal component. The second axis of the principal component, which explained 21.65%, was positively correlated with the variable silicate (r = 0.72) and DBO (r = 0.66), and negatively correlated with dissolved oxygen concentrations (r = -0.72) and with pH (r = -0.78). These variables did not present a clear temporal variation, unlike the variables related with the first axis (Table 2). The PCA-derived scores applied to the environmental data did not show a significant difference among the sampling sites (p = 0.72).

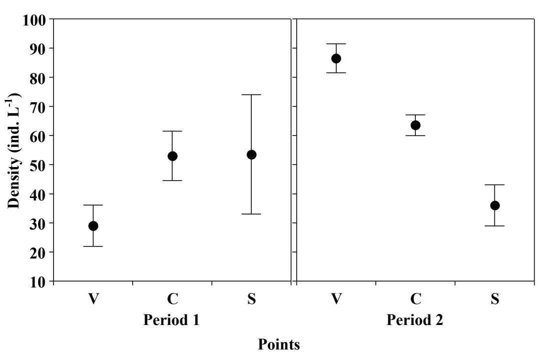

Figure 2. Variation in the density of the testacean assemblage sampled at the *Véu de Noiva* (V), *Cachoeirinha* (C) and *Salgadeira* (S) sites in the dry (1) and rainy (2) periods in 2000 and 2001, respectively, in *Chapada dos Guimarães* National Park, Mato Grosso State, Brazil.

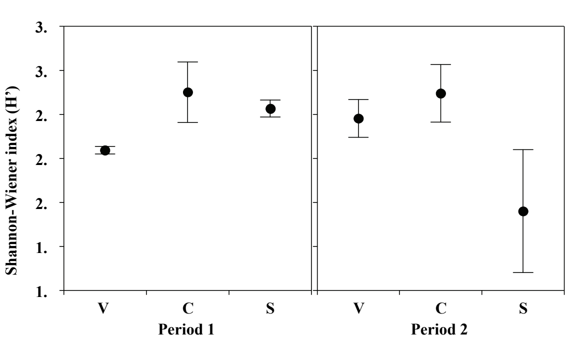

Figure 3. Variation in the diversity (H') of the testaceae sampled at the *Véu de Noiva* (V), *Cachoeirinha* (C) and *Salgadeira* (S) sites in the dry (1) and rainy (2) periods in 2000 and 2001, respectively, in *Chapada dos Guimarães* National Park, Mato Grosso State, Brazil.

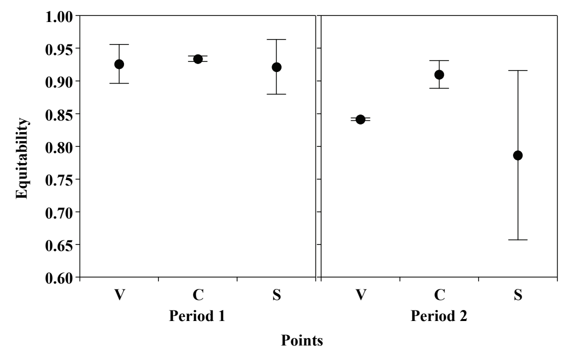

Figure 4. Variation in the equitability of the testacean assemblages sampled at the *Véu de Noiva* (V), *Cachoeirinha* (C) and *Salgadeira* (S) sites in *Chapada dos Guimarães* National Park in the dry (1) and rainy (2) periods in 2000 and 2001, respectively.

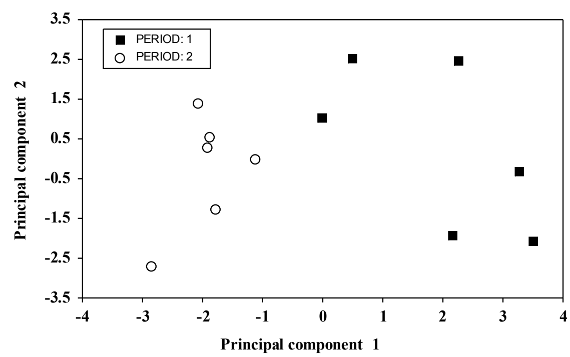

Figure 5. PCA-derived scores applied to the limnological data. Period 1 = dry, and Period 2 = rainy.

Table 2. Pearson correlations between the original variables and the principal components scores (structure coefficients).

Variables	PC1	PC2
Temperature	-0.72	0.49
Alkalinity	0.39	0.18
Cond	0.66	0.26
Color	-0.77	0.19
DBO	0.28	0.66
OD	0.32	-0.72
Fe	-0.11	0.02
P	0.68	0.30
N	0.65	-0.40
Silicate	0.54	0.72
pH	-0.28	-0.78
SOLT	-0.86	0.07
Turbidity	-0.93	0.22
% explained	36.41	21.65

For the biological data on testacean densities, the DCA indicated that the species compositions at the *Véu de Noiva* and *Cachoeirinha* sampling sites were more similar to each other, and the *Salgadeira* site differed from the two aforementioned sites, varying consistently between the sampling periods (p = 0.015), as indicated by the DCA axis (Figure 6a).

The results of the DCA carried out on the distribution data of the thecamoebian species at the three sampling sites in the two seasonal periods showed no clear segregation of the samples along axis 1 of the DCA (Figure 7). The second axis differentiated the periods.

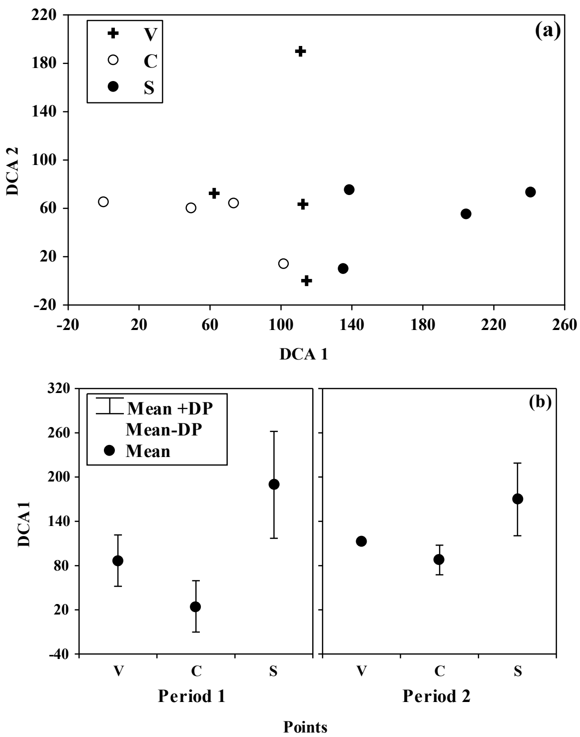

Figure 6. (a) Scores of the samples derived from DCA axes 1 and 2. The classification was based on the collection sites (V – *Véu de Noiva*, C – *Cachoeirinha* and S – *Salgadeira*). (b) Means of the scores for axis 1 of the DCA, considering the sampling sites and sampling periods.

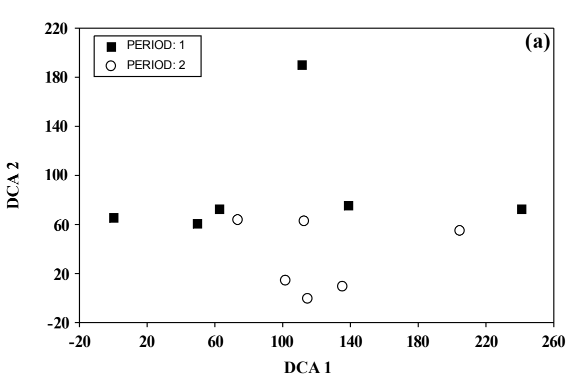

Figure 7. Scores of the samples derived from DCA axes 1 and 2. The classification was defined according to the sampling periods (Period 1 = dry; Period 2 = rainy).

Pearson's correlation between the second axis of the DCA and the first axis of the PCA was significant, even after applying Bonferroni's correction for multiple significance tests ($r = 0.683$; $p = 0.014$). Thus, the temporal variation of the limnological data (expressed by the first axis of the PCA), which showed higher values of turbidity, total solids, color and temperature for the rainy period and higher concentrations of nitrogen and phosphorus during the dry season, was significantly correlated with the temporal variation in the biological data (expressed by the second axis of the DCA) (Figure 7).

Twenty-nine elongated (36.2%), 21 flattened (26.2%), 20 hemispherical (25%) and 10 spherical (12.5%) thecae taxa were recorded, with the highest diversity found in species with elongated shells. As for the density of individuals, elongated thecae were the most representative (50.07%), followed by hemispherical (22.86%), elongated (17.88%) and spherical (9.43%) species. The elongated species represented 46.09% of the individuals in the dry period and 53.02% in the rainy season, followed by the hemispherical species, with 29.36% in the dry period and 18.2% in the rainy period.

The thecal-shaped characteristics and families the species share were not sufficient to predict the composition of species that vary spatially or temporally. In general, species belonging to a given family or with a given shape occurred indistinctly in the four quadrants of the bivariate space formed by the first axes of the DCA (Figure 8a and b). Groupings of species that share a given characteristic could make it easy to establish generalizations.

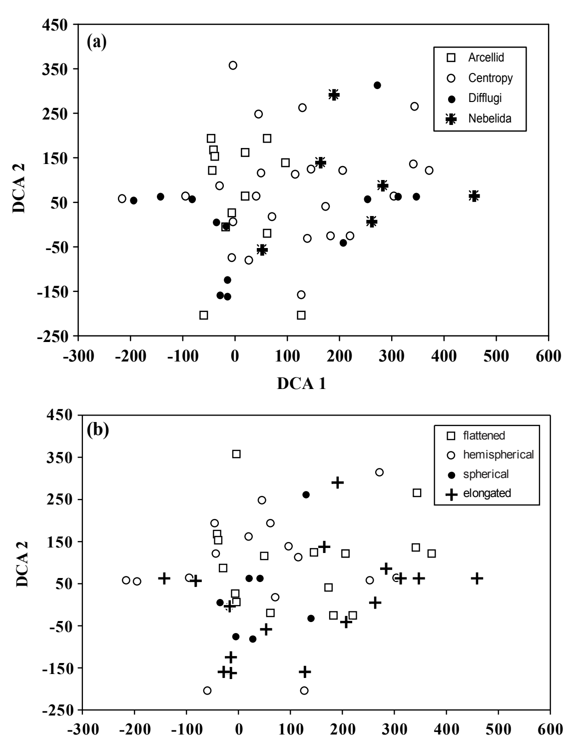

Figure 8. Scores of the species along DCA axes 1 and 2. The species in (a) were characterized by family, and in (b) by thecal shape.

Discussion

In general, it was found that the testacean assemblages presented low densities; the development of high densities in these environments seems to be unfavorable due to the fast-flowing currents (VELHO et al., 2003). Moreover, these low densities may be ascribed to the constant impact of the waterfall, hindering the establishment of the testacean assemblage.

Organisms that live in environments under the influence of intense water flows tend to present morphological and behavioral adaptations designed to prevent them from being dragged downstream (VELHO et al., 2003), developing shapes aimed at minimizing resistance to water flow and facilitate floating (LAMPERT; SOMMER, 1997).

The most abundant species was *Centropyxis aculeata* (Centropyxidae), whose flat-shaped theca presented an enormously varied morphology ranging from different numbers of aculei to different sizes. The same finding has been reported by many authors (DECLÓITRE, 1978; VELHO et al., 2003 among others), suggesting that this species' ability to adapt to stressful environments may be high due to its wide variety of morphotypes. Other flat-shelled species such as *Centropyxis ecornis, C. constricta, C. aerophila* and *C. minuta* were abundant, indicating that this characteristic facilitated the permanence of these species in the upper water column, enabling to float in environments with strong currents and large water flows.

According to Velho et al. (2003), flat-shelled taxa are typical of lotic environments, since this is shape most adapted to lotic conditions because it renders individuals less susceptible to the drag forces of the current.

The families Arcellidae, Difflugiidae and Centropyxidae were three of the four most abundant families, representing 90.66% of the total Testaceae found in the three waterfalls under study. These results have been found in other studies (VELHO et al., 1996; VELHO et al., 2000; VELHO et al., 2003). The occurrence of 80 species of Testaceae in samples of plankton from rivers with waterfalls represents a pioneer record in research conducted on this group.

Significant differences were found in the number of species and the density among the environments of this study, so Spearman's correlation between density and precipitation, diversity and precipitation data showed differentiated results for each of the waterfalls. Further studies in the region are needed to gain a broader understanding of the behavior of these protozoa in waterfall environments. Studies such as those of Lansac-Tôha et al. (2000), Velho et al. (2003), Fulone et al. (2005) and Fulone et al. (2008) revealed higher densities in the rainy season due to entrainment of testaceans from the sediment, but in the case of the waterfalls, this factor was only observed at *Véu da Noiva*, while at *Cachoeirinha* the correlation with the precipitation factor did not show a significant variation and at *Salgadeira* the correlation was negative.

Véu da Noiva waterfall displayed the greatest richness as well as the highest density in the dry period, leading us to believe that the strong impact of the waterfall (86 m) hinders the permanence of many species that are common in lotic environments. Hence, only species that present adaptive strategies to withstand strong impacts are able to become established in such conditions, favoring the increase in the abundance of these populations.

The variables of pH, BOD, silicate and dissolved oxygen did not vary between the periods under study. The high indices of dissolved oxygen were expected, since this is a region of waterfalls, whose mechanical falling water action promotes constant aeration. Contrary to the findings of many other studies (NECCHI et al., 1996), oxygen was not a limiting factor due to its constancy. The pH was characterized as slightly acid to circumneutral throughout the hydrological period of this study.

The results of Pearson's correlation between the second axis of the DCA and the first axis of the PCA indicated that the abundance of species presented a well defined variation according to the temporal variation between the dry and rainy periods. This finding indicates that the species *Arcella atava*, *A. discoides*, *Centropyxis aerophilla*, *C. aculeta*, *C. constricta*, *C. ecornis*, *C. minuta*, *Cyclopyxis arcelloides* and *Difflugia oblonga* were more abundant in the presence of higher concentrations of total solids, temperature, turbidity and color, a situation typical of the rainy period. Velho et al. (2003) and others, suggest that in the rainy season rhizopods are washed out of the marginal vegetation and dragged to the plankton, so that the species richness recorded in the plankton reflects the fauna of the entire environment reasonably well.

The species *Arcella atava* and *A. hemisphaerica hemisphaerica* occurred in greater abundance in the presence of higher concentrations of nitrogen and phosphorus, which are extremely important nutrients for microalgal development. The connection of these two species with increased nitrogen and phosphorus should be investigated in greater depth. Many organisms used as biomarkers of water quality are related to the increase of these nutrients, originating from diverse anthropic activities.

It is extremely important to intensify studies in Brazil aimed at identifying probable thecamoebian species that serve as indicators of environmental quality. Such studies, in which we seek simple and easily applicable tools, are crucial for the management of aquatic environments.

References

ALVES, E. C.; SILVA, C. F.; COSSICH, E. S.; TAVARES, C. R. G.; FILHO, E. E. S.; CARNIEL, A. Avaliação da qualidade da água da bacia do rio Pirapó – Maringá, Estado do Paraná, por meio de parâmetros físicos, químicos e microbiológicos. **Acta Scientiarum. Technology**, v. 30, n. 1, p. 39-48, 2008.

CUNHA, A. M. Contribuição para o conhecimento da fauna de protozoários do Brasil. **Memórias do Instituto Oswaldo Cruz**, v. 5, n. 1 p. 101-128, 1913.

DADAY, E. Untersuchunen über die süsswasser mikrofauna Paraguaya. **Zoologia**, v. 18, n. 44, p. 342, 1905.

DECLOITRE, G. Le genre centropyxis I. **Archiv fur Protistenkunde**, v. 120, n. 30, p. 63-85, 1978.

DEFLANDRE, G. Thécamoebiens. In: GRASSÉ, P. P. (Ed.). **Traité de zoologie**. Paris: Masson, v. 1, n. 2, p. 97-149, 1953.

EHRENBERG, C. G. Verbreitung ung einfluss des mikroskopischen Leben in Süd-un-Nord Amérika. **Akademie der Wissenschaften zu Berlin**, v. 1 n. 63, p. 291-446, 1941.

FRANSON, M. A. **Métodos normalizados para el análise de água potables y residuales**. Madri: APHA, 1992. p. 73.

FULONE, L. J.; LIMA, A. F.; ALVES, G. M.; VELHO, L. F. M.; LANSAC-TÔHA, F. A. Composição de amebas testáceas (Protozoa – Rhizopoda) de dois córregos do estado de São Paulo, incluindo novos registros para o Brasil. **Acta Scientiarum. Biological Sciences**, v. 27, n. 2, p. 113-118, 2005.

FULONE, L. J.; VIEIRA, L. C. G.; VELHO, L. F. M.; LIMA, A. F. Influence of depth and rainfall on testate amoebae (Protozoa-Rhizopoda) composition from two streams in northwestern São Paulo state. **Acta Limnologia Brasiliensia**, v. 20, n. 1, p. 29-34, 2008.

GAUCH, H. G. **Multivariate analysis in community structure**. Cambridge: Cambridge University Press, 1982.

GOMES, A. S. **Distribuição especial dos moluscos bivalves na região da plataforma continental de Cabo Frio, Praia de Maçambaba, Estado do Rio de Janeiro, Brasil**. 1989. 122f. Dissertação (Mestrado em Zoologia)-Universidade Federal do Rio de Janeiro, Museu Nacional, Rio de Janeiro, 1989.

GREEN, J. Freshwater ecology in the Mato Grosso, Central Brazil. I. The condutivity of some natural waters. **Journal of Natural History**, v. 4, n. 3, p. 289-299, 1970.

GREGO, M. K. B.; DABÉS, M. B. G. S. Comparação da microfauna litorânea com e sem presença de macrófita *Mayaca sellowiana* (Mayacaceae), Ribeirão Passageiro, MG. **Bios**, v. 9, n. 9, p. 9-14, 2001.

HARDOIM, E. L.; HECKMAN, C. W. The seasonal sucession of biotic communities in wetlands of the tropical wet and dry climatic zone: IV. Free living sarcodines and ciliates of the Pantanal of Mato Grosso, Brasil. **Internationale Revue der Gesamten Hydrobiologie und Hydrographie**, v. 81, n. 3, p. 367-384, 1996.

HILL, M. O.; GAUCH, H. G. Detrended Correspondence Analysis: an improved ordination technique. **Vegetatio**, v. 42, n. 1-3, p. 47-58, 1980.

LAMPERT, W.; SOMMER, U. **Limnoecology**: the ecologia of lakes and streams. Oxford: Oxford University Press, 1997.

LANSAC-TÔHA, F. M.; VELHO, L. F. M.; BONECKER, C. C.; AOYAGUI, A. S. M. Horizontal distribution patterns of testate amoebae (Rhizopoda, Amoebazoa) in plankton samples of the Corumbá reservoir area, state of Goiás, Brazil. **Acta Scientiarum. Biological Sciences**, v. 22, n. 2, p. 347-353, 2000.

MAGURRAM, A. E. **Ecological diversity and its measurement**. Cambridge: Cambridge University Press, 1988.

McCUNE, B.; MEFFORD, M. J. **Multivariation analysis in ecological data**. Oregon: Gleneden Beach, 1997.

NECCHI, J. O.; BRANCO, L. H. Z.; BRANCO, C. C. Z. Análise nictemeral e sazonal de algumas variáveis limnológicas em um riacho no noroeste do Estado de São Paulo. **Acta Limnologica Brasiliensia**, v. 8, n. 1, p. 169-182, 1996.

PINTO, C. Protozoários observados no Brasil. **Memórias do Instituto Oswaldo Cruz**, v. 18, n. 1, p. 211-302, 1925.

PROWAZEK, S. V. Contribuição para o conhecimento de fauna de protozoários do Brasil. **Memórias do Instituto Oswaldo Cruz**, v. 2, n. 2, p. 149-158, 1910.

SOUZA, M. B. G. Tecamebas (Protozoa-Rhizopoda) associadas às macrófitas aquáticas da bacia do rio Jequitinhonha: Parque Estadual do Rio Preto e Parque Estadual do Grão Mogol, MG. **Unimontes Científica**, v. 7, n. 2, p. 129-142, 2005.

VELHO, L. F. M.; LANSAC-TÔHA, F. A.; SERAFIM-JUNIOR, M. Testate amoebae (Rhizopoda-Sarcodina) from zooplankton of the high Paraná river floodplain, state of Mato Grosso do Sul, Brazil. In Families Arcellidae and Centropyxidae. **Studies on Neotropical Fauna and Environment**, v. 31, n. 1, p. 35-50, 1996.

VELHO, L. F. M.; LANSAC-TÔHA, F. A.; BONECKER, C. C.; ZIMMERMANN-CALLEGARI, M. C. On the occurrence of testate amoebae (Protozoa-Rhizopoda) in Brazilian inland waters. II. Families

Centropyxidae, Trigonopyxidae and Plagiopyxidae. **Acta Scientiarum. Biological Sciences**, v. 22 n. 2, p. 365-374, 2000.

VELHO, L. F. M.; LANSAC-TÔHA, F. A.; BINI, L. M. Influence of environmental heterogenity on the structure of testate amoebae (Protozoa, Rhizopoda) assemblages in the plankton of the upper Paraná river floodplain, Brasil. **Hydrobiologia**, v. 88, n. 2, p. 154-166, 2003.

VUCETICH, M. C.; LOPRETTO, E. C. Rizhopoda (Testaceos). In: LOPRETO, E. C.; TELL, G. (Ed.). **Ecossistemas de águas continentales**: metodologia para su estúdio. La Plata: Ediciessur, 1995. p. 541-555, Tomo II.

Received on June 26, 2009.
Accepted on July 8, 2009.