Species richness and distribution of oligochaetes in six reservoirs on Middle and Low Tietê River (SP, Brazil).

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ABSTRACT: Species richness and distribution of oligochaetes in six reservoirs on Middle and Low Tietê River (SP, Brazil). The objective of this study was to determine the structure of the Oligochaeta populations in six reservoirs located in the Middle and Low section of Tietê River. Sampling was carried out in November 2002, in the rainy season, and in August 2003, in the dry season. In each reservoir, three transects were established: upper, middle and lower (near dam). Duplicate samples were collected with a van Veen grab which sampled an area of 337.0 cm². Seventeen oligochaetes species were identified. A gradient was observed in the number of species per reservoir, which diminished steadily from Barra Bonita to Três Irmãos dam. Branchiura sowerbyi was the dominant specie in every reservoir from Bariri (58.57%) down to Nova Avanhandava (92.16%), being outnumbered only in Barra Bonita, where Limnodrilus hoffmeisteri was dominant, representing 59% of the oligochaetes recorded. The highest average total densities, 470 ± 205 ind.m^{-2} in November 2002 and 260 ± 123 ind.m^{-2} in August 2003, were recorded in the Bariri reservoir. The average density, as the species richness, of oligochaetes tended to diminish downstream towards Três Irmãos, where the densities varied between 18 ± 6 ind.m^{-2} (November 2002) and 30 ± 12 ind.m^{-2} (August 2003). The grouping of the reservoirs on the basis of oligochaetes density and on the climatic periods joined the reservoirs in accordance with its geographic sequence throughout the river and also reflected their trophic state. The abundance and diversity of oligochaetes reflect the trophic state of the reservoirs and can therefore be used as a biological indicator of trophic state conditions.
Key-words: Oligochaeta, reservoirs, Middle and Low Tietê River.

RESUMO: Riqueza de espécies e distribuição de oligoquetos em seis represas no Médio e Baixo rio Tietê (SP, Brasil). O presente trabalho teve por objetivo analisar a estrutura da taxocenose de Oligochaeta em 6 represas localizadas no médio e baixo rio Tietê. As amostragens foram realizadas em novembro de 2002 (período chuvoso) e agosto de 2003 (período seco). Em cada represa três transectos foram estabelecidos: superior, mediano e inferior (próximo à barragem). As amostras foram coletadas em duplicata com uma draga do tipo van Veen com 337 cm² de área amostral. No total foram identificadas 17 espécies de Oligochaeta. Foi observado um número decrescente de espécies na cascata de represas, no sentido do primeiro (Barra Bonita) à última represa (Três Irmãos). Branchiura sowerbyi foi a espécie dominante em todas as represas, com abundância relativa variando de 58,57% na represa de Bariri a 92,16% na represa de Nova Avanhandava. Porém, na represa de Barra Bonita, a espécie Limnodrilus hoffmeisteri foi a dominante, representando 59% do total de oligoquetos. A densidade total de oligoquetos foi mais elevada nos três primeiros reservatórios (médio Tietê), tendo os valores máximos registrados na represa de Bariri, com 470 ± 205 ind.m^{-2} em novembro 2002 e 260 ± 123 ind.m^{-2} em agosto 2003. Esses valores diminuíram no sentido da cascata, variando entre 18 ± 6 ind.m^{-2} (novembro

2002) e 30 ± 12 ind.m^{-2} (agosto 2003) na represa de Três Irmãos. A análise de agrupamento das represas com base na densidade dos oligoquetos e dos períodos climáticos reuniu-as de acordo com sua seqüência geográfica ao longo do rio, refletindo também o grau de trofia das mesmas. A abundância e a diversidade de oligoquetos refletiram o estado trófico das represas, e podem, portanto, serem utilizadas como indicadores biológicos do estado trófico dos mesmos.
Palavras-chave: Oligochaeta, represas, médio e baixo rio Tietê.

Introduction

Benthic invertebrates play a considerable part in the energy flow and nutrient cycling of freshwater ecosystems. They participate in many food webs, linking a variety of organisms such as bacteria, fungi, plants and other animals (Payne, 1986).

The species composition, abundance and distribution of benthic invertebrates usually depend on many factors, including some abiotic variables recognized as important such as the substrate type, dissolved oxygen concentration and water level fluctuation, besides the biotic food quality and availability, competition and predation (Harper, 1992).

Among the main taxonomic groups present in the most benthic macroinvertebrate communities, the oligochaetes are common and abundant, and some species are considered good bioindicators, particularly for the assessment of trophic state and organic pollution in water bodies (Wetzel, 1983). Oligochaeta have important roles in recycling the material and transfer energy from the system sink at the bottom of sediment, thus helping to maintain prolonged periods of high production in aquatic systems (Covich et al., 1999). Oligochaetes in general have wide geographical distribution patterns (Milbrink, 1973) and their population can sometimes reach large numbers (Brinkhurst & Jamieson, 1971). Many species prefer eutrophic waters, living on muddy sediments with abundant detrital organic matter (Pérez, 1988).

Although more than 5000 species of the class Oligochaeta have been described, including terrestrial and aquatic forms, approximately 1100 occur in freshwater (Wetzel et al., 2006). Up to the year 2002, only 70 species had been recorded in Brazil, 46 of them in São Paulo State (Righi, 1999).

Scientific data on Oligochaeta in Neotropical freshwater, particularly in Brazil, is fragmented and very incomplete (Righi, 1999). A great deal of effort must still be invested in taxonomic and ecological studies, in order to know the diversity of invertebrates in Brazilian freshwater.

The main objective was to analyse the species composition, spatial and temporal distribution of Oligochaeta in the reservoirs of the Middle and Low Tietê River, in two climatic periods, the rainy (November 2002) and the dry seasons (August 2003).

Material and methods

This study was performed in a cascade of six reservoirs located in the Middle and Low section of Tietê River in São Paulo State, constructed in the second half XX century for hydroelectric generation. The reservoirs studied were: Barra Bonita, Bariri and Ibitinga, in the Middle reach and Promissão, Nova Avanhandava and Três Irmãos, in the Low reach of the watershed (Fig. 1).

The main characteristics of the reservoirs studied are presented in Table I.

Sampling was carried out in November 2002, in the rainy season, and in August 2003, in the dry season. In each reservoir, three transects were established in each part of the reservoir: upper, middle and lower (near dam). The samples were taken at different points along each transect, 3 and 6 according to the water depth at each site.

Measurements of physical and chemical water variables (pH, electrical conductivity, dissolved oxygen concentration and temperature) were performed in situ along the water column down to the sediment-water interface, using a Horiba U10 multisensor.

Chemical elements concentrations (total phosphorus, inorganic phosphate, total dissolved phosphate, total nitrogen, nitrite, nitrate, ammonium) were determined according to the methods and procedures described in Golterman et al. (1978) and Mackereth et al. (1978).

Organic matter of sediment was determined according to the method described by Buchman & Brady (1979) and the granulometric analysis followed the procedures described in Suguio (1973).

Figure 1: Localization of São Paulo State (Brazil) and the reservoirs cascade on the Middle and Low Tietê River.

Table 1: Morphometric characteristics and operational parameters of the reservoirs of the Middle (Barra Bonita, Bariri and Ibitinga) and Low (Promissão, Nova Avanhandava and Três Irmãos) Tietê River.

Reservoirs	Residence time (days)	Surface area (km^2)	Volume ($m^3 x\ 10^6$)	Mean depth (m)	Year concluded
Barra Bonita	90.3	310	3135	10.1	1964
Bariri	14.2	63	542.5	8.6	1969
Ibitinga	21.6	56	981	8.6	1969
Promissão	134.1	530	7408	14	1975
N. Avanhandava	45.7	210	2720	13	1985
Três Irmãos	217.9	817	14000	17.2	1991

The Trophic State Index (TSI) of Carlson (1977), modified by Toledo et al. (1983) was applied to determine the trophic state of the reservoirs. The parameters used to calculate the index were: secchi disk readings for water transparency, concentrations of phosphorus (inorganic and total) and chlorophyll a.

Duplicate samples were collected with a van Veen grab which sampled an area of 337cm^2. The material was sieved through a 0.21mm mesh net and oligochaetes as well others invertebrates were sorted on a transiluminatted tray and preserved in 70% alcohol. Oligochaeta specimens were mounted in semi-permanent glass slides with Hoyer medium (Trivinho-Strixino & Strixino, 1995) for posterior analysis of the morphological characteristics relevant to

taxonomical identification (Righi, 1984; Brinkhurst & Marchese, 1992). The existing taxonomic keys (Righi, 1984; Brinkhurst & Marchese, 1992) were used to identify species when possible or genera.

Sites were grouped by cluster analysis (unweighted pair group average linkage, UPGMA) based on Bray Curtis index, using abundance $\log_{10}$ (x+1) transformed data of all oligochaetes (Magurran, 1989).

Results

The results of physical and chemical variables obtained for the reservoirs of Tietê River are showed in Tables II and III. The

Table II: Mean values of physical and chemical variables of water in six reservoirs of Tietê River, in November 2002 (Nov/02) and August 2003 (Aug/03).

Reservoirs		pH	Conductivity (μS.cm^{-1})	Dissolved Oxygen (mg.L^{-1})	Temperature (°C)
Barra Bonita	Nov/02	8.88	317.83	5.62	25.44
	Aug/03	7.44	219.50	7.73	19.08
Bariri	Nov/02	7.99	306.96	8.64	25.61
	Aug/03	7.66	195.84	7.39	19.57
Ibitinga	Nov/02	8.75	255.26	10.12	25.93
	Aug/03	7.90	159.06	8.79	20.21
Promissão	Nov/02	7.37	209.03	9.50	28.17
	Aug/03	7.53	138.40	8.10	20.87
Nova Avanhandava	Nov/02	8.13	142.73	8.70	26.97
	Aug/03	7.80	139.37	8.27	20.60
Três Irmãos	Nov/02	7.33	145.20	7.53	26.83
	Aug/03	7.70	140.63	8.63	20.90

Table III: Mean values of dissolved and total nutrients in all six reservoirs of Tietê River, in November 2002 (Nov/02) and August 2003 (Aug/03).

Reservoirs		Nitrite (μgL^{-1})	Nitrate (μgL^{-1})	Amonium (μgL^{-1})	Total organic nitrogen (mgL^{-1})	Inorganic phosphate (μgL^{-1})	Total dissolved phosphate (μgL^{-1})	Total phosphorus (μgL^{-1})
Barra Bonita	Nov/02	222.61	3678.5	163.53	1.82	87.04	111.77	205.59
	Aug/03	88.42	1246.1	92.27	0.08	37.63	54	111.1
Bariri	Nov/02	106.2	2780.1	96.89	1.49	48.46	68.05	162.28
	Aug/03	25.6	984.57	63.74	0.53	10.43	23.96	70.09
Ibitinga	Nov/02	29.76	1650.5	31.77	6.03	10.66	25.2	148.54
	Aug/03	10.68	821.7	45.12	0.38	3.19	11.5	84.06
Promissão	Nov/02	9.0	815.6	11.8	1.0	6.7	16.0	85.7
	Aug/03	4.1	371.2	24.3	0.5	2.6	9.6	35.8
Nova Avanhandava	Nov/02	3.5	222.8	14.2	1.1	3.9	11.9	106.3
	Aug/03	1.5	215.5	24.0	0.6	4.0	11.3	25.2
Três Irmãos	Nov/02	3.0	164.6	24.8	1.4	5.1	12.8	122.8
	Aug/03	1.1	147.3	18.1	0.3	2.8	7.0	22.8

electrical conductivity of water varied between 138.4 $mS.cm^{-1}$ in Promissão reservoir to 317.83 $mS.cm^{-1}$ in Barra Bonita reservoir. The mean values of pH and temperature had small variation among the reservoirs and dissolved oxygen concentration was registered varying from 5.62 $mg.L^{-1}$ in Barra Bonita reservoir to 10.12 $mg.L^{-1}$ in Ibitinga, both in November 2002 (Tab. II).

Concentrations of total nitrogen for the reservoirs of Tietê River varied from 0.08 mgL^{-1} to 1.82 mgL^{-1} and concentrations of total phosphorus varied from 22.8 mgL^{-1}.to 205.59 mgL^{-1}. The highest values observed to total and dissolved chemical elements were registered in Barra Bonita reservoir in November 2002 (Tab. III).

In Table IV the results obtained for the Trophic State Index of Tietê reservoirs are presented for both seasons. The reservoir classification was different according to the seasons. In November 2002, rainy season, all reservoirs were eutrophic, whereas in August 2003 only Barra Bonita reservoir was eutrophic, Nova Avanhandava reservoir was oligotrophic and all the others were mesotrophic.

The values regarding the concentrations of sand, silt and clay and also organic matter in the sediment, in both seasons sampled are shown Table V. The results have shown that sand was the dominant fraction in the sediment of all six reservoirs, participating with 53 to 80 % of sediment composition, followed by clay, with 15 to 33% and silt that constituted the smallest fraction (2 to 3 %). The maximum mean concentration of organic matter in the sediment was 5 %, considering all points and the seasons sampled.

Table IV: Mean values of Trophic State Index (TSI) in all six reservoirs of Tietê River, in November 2002 (Nov/02) and August 2003 (Aug/03).

Reservoirs	TSI mean			
	Nov/02	Classification	Aug/03	Classification
Barra Bonita	67	Eutrophic	60	Eutrophic
Bariri	61	Eutrophic	50	Mesotrophic
Ibitinga	58	Eutrophic	45	Mesotrophic
Promissão	56	Eutrophic	48	Mesotrophic
Nova Avanhanvava	55	Eutrophic	44	Oligotrophic
Três Irmãos	56	Eutrophic	45	Mesotrophic

Table V: Mean percentage contribution of organic matter, sand, silt and clay in the sediments of the reservoirs of Tietê River in November 2002 (Nov/02) and August 2003 (Aug/03).

Reservoirs		Sand (%)	Silt (%)	Clay (%)	Organic Matter (%)
Barra Bonita	**Nov/02**	75	8	17	3
	Aug/03	80	5	15	2
Bariri	**Nov/02**	56	13	31	5
	Aug/03	58	9	33	5
Ibitinga	**Nov/02**	56	16	28	5
	Aug/03	61	14	25	5
Promissão	**Nov/02**	71	9	20	3
	Aug/03	67	13	21	5
Nova Avanhandava	**Nov/02**	53	15	32	5
	Aug/03	66	11	23	4
Três Irmãos	**Nov/02**	57	12	31	5
	Aug/03	73	7	20	5

Seventeen species of oligochaetes were identified in the cascade of six reservoirs (Tab. VI). Among these, only Opistocysta funiculus (Cordero, 1948) did not belong to the family Tubificidae. The greatest species richness was found in the subfamily Naidinae, which was represented by 12 species. A gradient was observed in the numbers of species per reservoir, which diminished steadily from Barra Bonita (where River Piracicaba joins Tietê River) dam to Três Irmãos (which Tietê River drains into Paraná River). One species, Branchiura sowerbyi (Beddard, 1892) was dominant in every reservoir from Bariri (58.57% of individuals collected) down to Nova Avanhandava (92.16%), being outnumbered only in Barra Bonita, the top reservoir, where Limnodrilus hoffmeisteri (Claparède, 1862) was dominant, representing 59% of oligochaetes recorded.

Only B. sowerbyi, L. hoffmeisteri and Dero (Aulophorus) lodeni (Brinkhurst, 1986) were recorded in the six reservoirs on the Middle and Low Tietê River, while the most of the species had a restricted occurrence. The species represented in the samples by a single specimen were: in the Middle Tietê reservoirs, D. (Dero) pectinata (Aiyer, 1929), Slavina evelinae (Marcus, 1942), in the rainy season and Haemonais waldvogeli (Bretscher, 1900), in the dry. In the Low Tietê reservoirs the species with single specimens were: D. (D.) multibranchiata (Steiren, 1982) and L. udekemianus (Claparède, 1861), in the rainy and D. (A) hymanae (Naidu, 1962), in the dry season (Tab.VI).

Table VI: Density (ind.m²) and relative abundance (%) of Oligochaeta taxa in the six reservoirs on the Tietê River, in the combined samples collected in November 2002 (rainy season) and August 2003 (dry season).

	Barra Bonita		**Bariri**		**Ibitinga**	
	ind.m⁻²	**%**	**ind.m⁻²**	**%**	**ind.m⁻²**	**%**
Family OPISTOCYSTIDAE						
Opistocysta funiculus	1	0.32	-	-	‹ 1	0.20
Family TUBIFICIDAE						
Subfamily RHYACODRILINAE						
Bothrioneurum sp (Stolc, 1888)	12	5.26	-	-	-	-
Branchiura sowerbyi	71	29.82	214	58.57	153	80.04
Subfamily TUBIFICINAE						
Limnodrilus hoffmeisteri	139	58.53	59	16.18	4	2.24
Limnodrilus udekemianus	-	-	-	-	-	-
Subfamily NAIDINAE						
Dero (Aulophorus) furcatus (Müller, 1773)	3	1.12	-	-	-	-
Dero (Aulophorus) hymanae	-	-	-	-	-	-
Dero (Aulophorus) lodeni	2	0.64	6	1.69	26	13.44
Dero (Dero) digitata (Müller, 1773)	-	-	1	0.36	-	-
Dero (Dero) evelinae (Marcus, 1943)	-	-	1	0.36	-	-
Dero (Dero) multibranchiata	-	-	3	0.85	-	-
Dero (Dero) nivea (Aiyer, 1929)	2	0.64	‹ 1	0.12	-	-
Dero (Dero) obtusa (d'Udekem, 1855)	7	2.87	-	-	-	-
Dero (Dero) pectinata	-	-	-	-	‹ 1	0.20
Haemonais waldvogeli	‹ 1	0.16	-	-	-	-
Pristina americana	2	0.64	80	21.86	7	3.87
Slavina evelinae	-	-	‹ 1	0.12	-	-
Total density	238		366		192	
Species richness	10		9		6	

Table VI: Cont.

	Promissão		N. Avanhandava		Três irmãos	
	ind.m^{-}	%	ind.m^{-2}	ind.m^{-2}	%	ind.m^{-2}
Family OPISTOCYSTIDAE						
Opistocysta funiculus	-	-	1	-	-	1
Family TUBIFICIDAE						
Subfamily RHYACODRILINAE						
Bothrioneurum sp (Stolc, 1888)	-	-	-	-	-	-
Branchiura sowerbyi	84	82.43	46	84	82.43	46
Subfamily TUBIFICINAE						
Limnodrilus hoffmeisteri	7	6.76	1	7	6.76	1
Limnodrilus udekemianus	-	-	‹ 1	-	-	‹ 1
Subfamily NAIDINAE						
Dero (Aulophorus) furcatus (Müller, 1773)	-	-	-	-	-	-
Dero (Aulophorus) hymanae	1	0.46	-	1	0.46	-
Dero (Aulophorus) lodeni	10	9.46	‹ 1	10	9.46	‹ 1
Dero (Dero) digitata (Müller, 1773)	-	-	-	-	-	-
Dero (Dero) evelinae (Marcus, 1943)	-	-	-	-	-	-
Dero (Dero) multibranchiata	-	-	-	-	-	-
Dero (Dero) nivea (Aiyer, 1929)	-	-	-	-	-	-
Dero (Dero) obtusa (d'Udekem, 1855)	-	-	-	-	-	-
Dero (Dero) pectinata	-	-	-	-	-	-
Haemonais waldvogeli	-	-	-	-	-	-
Pristina americana	1	0.90	-	1	0.90	-
Slavina evelinae	-	-	-	-	-	-
Total density	102		50	102		50
Species richness	5		5	5		5

The highest average of total densities, 470 ± 205 ind.m^{-2} in November 2002 and 260 ± 123 ind.m^{-2} in August 2003, were recorded in Bariri reservoir. Similarly to what was observed for species richness, the mean density of oligochaetes tended to diminish in the downstream direction towards Três Irmãos, where the densities were low, varying between 18 ± 6 ind.m^{-2} and 30 ± 12 ind.m^{-2} in November 2002 and August 2003, respectively (Fig. 2).

The distributions of oligochaete species across the three transects analyzed, in all six reservoirs, to represent upper, middle and lower (near dam) compartments of the reservoirs, are shown in Figures 3 (Middle Tietê) and 4 (Low Tietê).

The highest density (765 ind.m^{-2}) was reached for Pristina americana (Cernosvitov, 1937) in the upper part of Bariri reservoir in the rainy season. In the same reservoir, the highest density of B. sowerbyi (400 ind.m^{-2}) was recorded in the dry season, whereas L. hoffmeisteri (393 ind.m^{-2}) occurred only in the rainy season, in the upper part (Fig. 3). Among the several Dero (Oken, 1815) species, the most abundant was D. (A.) lodeni, with a maximum density of 57 ind.m^{-2}, observed near the dam, in Ibitinga reservoir in November 2002. The highest density (212 ind.m^{-2}) recorded by B. sowerbyi in the Low Tietê River was at the top of the Três Irmãos reservoir in August 2003 (Fig. 4). In the Low reservoir, most of the species had very low densities, with values below 10 ind.m^{-2}.

Cluster analysis of average oligochaetes densities (Fig. 5), evidenced two major groups in rainy season: group 1 formed by the Três Irmãos - Nova Avanhandava reservoirs whose waters are characterized by lower total nitrogen and phosphorus

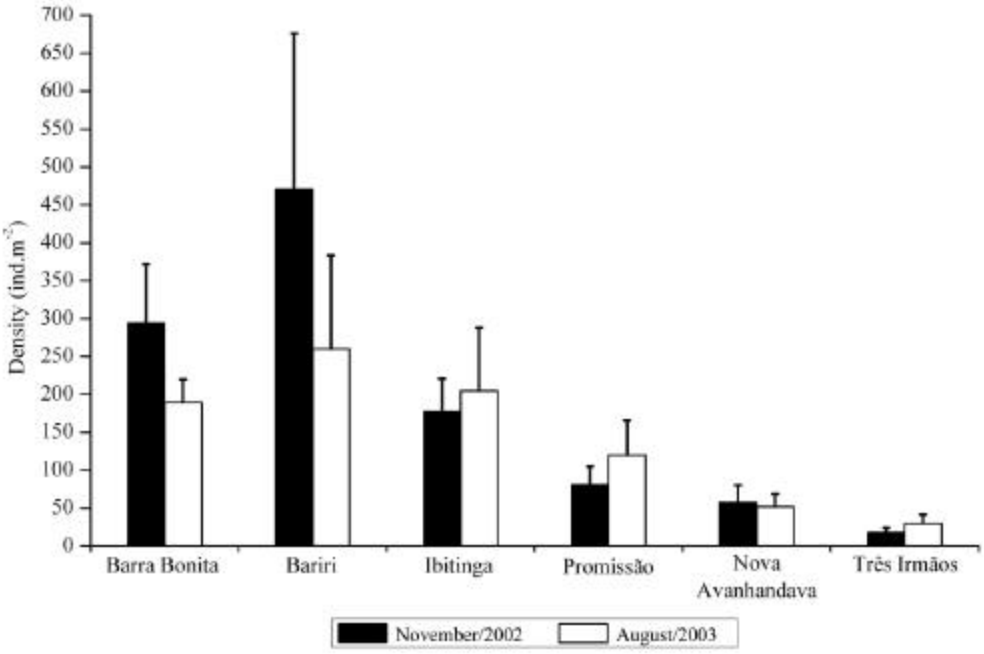

Figure 2: Density (mean ± standard error) of oligochaetes in all six reservoirs of Tietê River in November 2002 and August 2003.

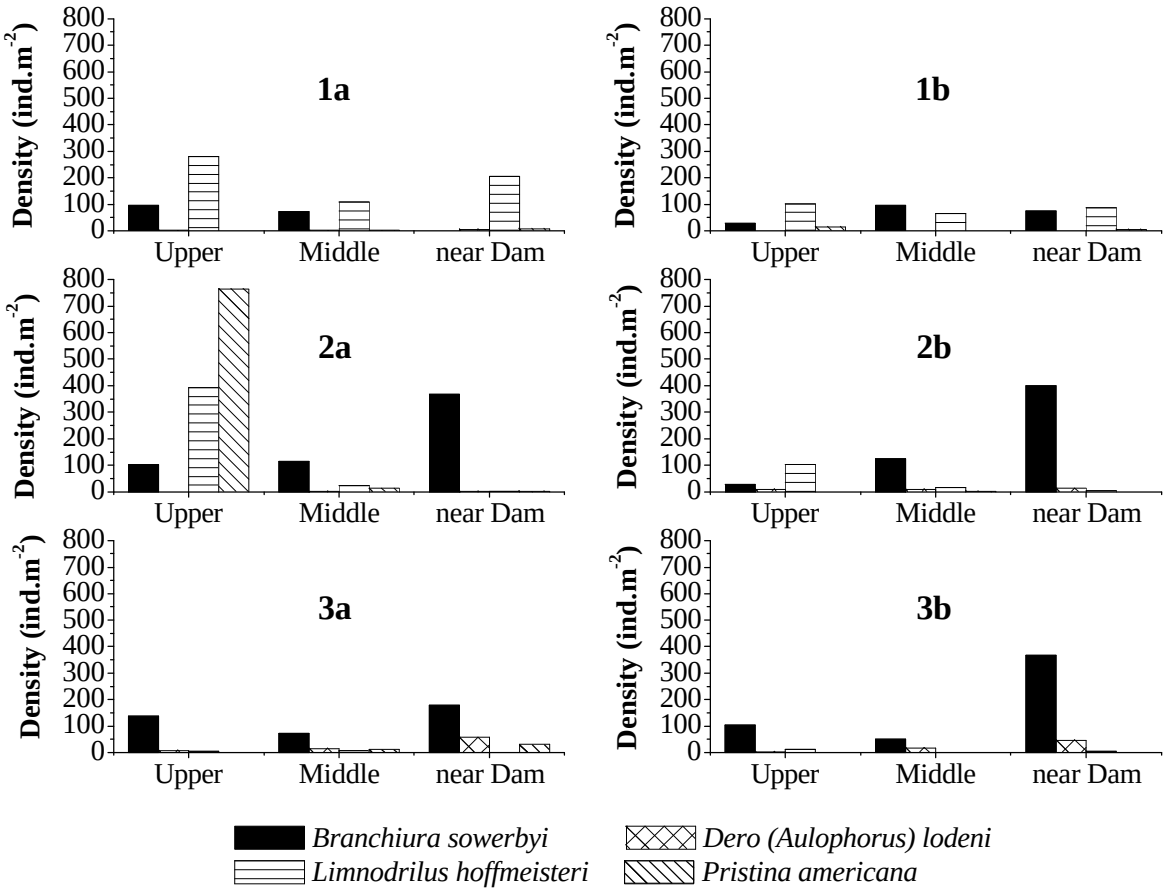

Figure 3: Density of main Oligochaeta species on the three sampling transects (upper, middle and near dam) across Barra Bonita (1), Bariri (2) and (3) Ibitinga reservoir in November 2002 (a) and August 2003 (b).

concentrations (Tab. III); whereas group II, formed by Promissão - Ibitinga and Barra Bonita - Bariri had higher nutrient levels. Barra Bonita and Bariri reservoirs had the highest oligochaetes densities and species richness. Group II of reservoirs are also characterized by high values of electrical conductivity that together with nutrient levels characterize them as highly eutrophic environments (Tab. III and IV).

During dry season this pattern was modified and Barra Bonita reservoir (most upstream) became markedly different from the rest, with a Bray-Curtis distance of 0.60 from the cluster containing the other 5 reservoirs (Fig. 5). The two most similar reservoirs regarding oligochaetes assemblages were Bariri and Ibitinga, both characterized by the lowest water residence time and relatively similar flooded area and mean depth (Tab. I).

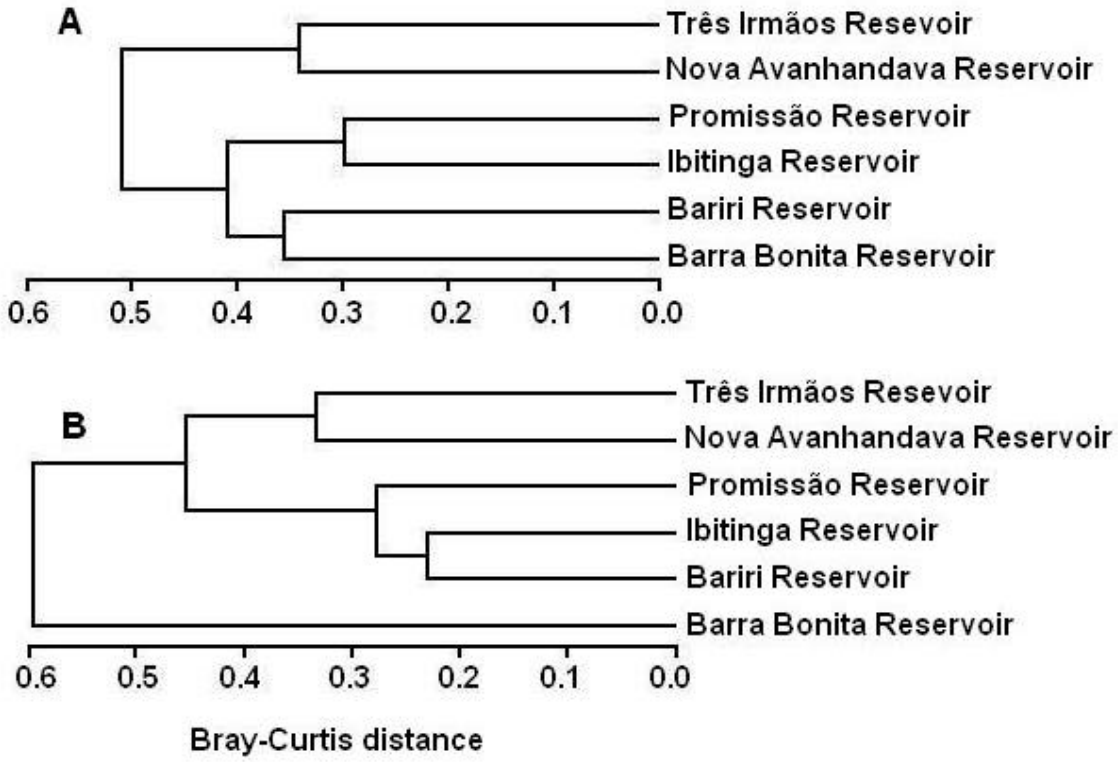

Figure 5: Similarity dendrograms for the Middle-Low Tietê River reservoirs, based on oligochaetes collected in (A) November 2002 and (B) August 2003 (derived from cluster analysis performed by UPGMA method). Abundance data were transformed to Log_{10} (x+1).

Discussion

When single specie represents a large percentage of the individual in a community, or a few species are dominant, this may be a sign of disturbance in the environment or highly eutrophicated water (Rosenberg & Resh, 1993; Popp & Hoagland, 1995). Few species of Oligochaeta, according to Qi (1987) can to stand the stressful conditions resulting from an excessive input of organic matter, so this conditions lead to a simplification of this community to a small number of tolerant species, which may develop abundant populations. In this study, B. sowerbyi was the dominant species in all the reservoirs, except in Barra Bonita, suggesting these ecosystems were under environmental stress. In fact, a large amount of nutrients is discharged into these reservoirs, in the form of domestic and industrial wastes, as well as run-off water from cultivated areas, mainly sugarcane plantations (Tundisi & Matsumura-Tundisi, 1990), and such nutrients aggravate straggly the process of breakdown of a balanced aquatic ecosystem.

In the Tietê River reservoirs, the density of oligochaetes was higher in the first three

reservoirs (Middle Tietê), falling steadily from Bariri to Três Irmãos. The existence of spots with reduced levels of oxygen, sometimes even anoxia, in the first three reservoirs, and especially in Barra Bonita and Bariri may have favored the development of tolerant species in the system.

Many authors have suggested that large numbers of total oligochaetes occur when the water is highly polluted (see, for example, Howmiller & Beeton, 1971; Aston, 1973; Nutall & Purvers, 1974; Chapman et al., 1980, 1982a,b; Rosenberg & Resh, 1993; Reynoldson & Rodriguez, 1999). In particular, great abundance of some tubificids is related to their outstanding ability to adapt to low levels of oxygen, bordering anaerobic conditions (Aston, 1973).

Brinkhurst (1966) and Diaz (1994) point out that B. sowerbyi and L. hoffmeisteri are cosmopolitan species that generally are found in places rich in organic matter. In the water-bodies under study, these were indeed the two commonest species, conforming their role as an indicator of organic pollution.

P. americana, which occurred in great numbers in the rainy season (80 ind.m^{-2}) in Bariri, deserves a special mention, as Takeda (1999) reported that this specie was the only that had been adapted to practically every kind of freshwater habitat in the Paraná River floodplain, demonstrating its great plasticity in response to the environment.

L. udekemianus is a cosmopolitan species found in a diversity of environments, but rarely it was abundant (Wetzel & Taylor, 2001). In South America, D. (A.) hymanae had previously been registered only in Argentina (Brinkhurst & Marchese, 1992). The present record thus adds to the number of oligochaete species known to occur in São Paulo State and in Brazil.

According to Rocha et al. (2006), Minillo (2005) and Zanata (2005) the concentration of chemical elements (total nitrogen and total phosphorus) decreases throughout downstream the Tietê River.

The highest values of trophic index state in Middle Tietê River can be explained by the continuous loading of nutrients due to the entrance of heavily polluted Tietê and Piracicaba Rivers in Barra Bonita Reservoir and also Bauru River in Bariri Reservoir. As a consequence of the high input of nutrients there is an increase in the overall productivity of the reservoirs favoring the tolerant oligochates, as Branchiura sowerbyi and Limnodrilus hoffmeisteri.

The species richness of oligochaetes are usually low and numerical abundance is high in eutrophic water bodies (Milbrink, 1980). Similar pattern was observed in the Tietê River reservoirs. In both sampling seasons, the arrangement of reservoirs resulting from the cluster analysis resulted from the fact that the oligochaete assemblages differ between Middle and Low Tietê Reservoirs. Oligochaete densities, species dominance and assemblage richness appears to correlate well with the reservoir trophic state.

Conclusions

During the rainy period all Tietê reservoirs receive a great input of nutrients from the main tributaries. Electrical conductivity of the water and the concentrations of phosphorus and nitrogen compounds were higher in the rainy than in the dry season.

All six reservoir are eutrophic in the rainy period mainly due to he contribution of the main rivers in the basin:Tietê and Piracicaba in Barra Bonita reservoir and Bauru River in Ibitinga Reservoir.

During the dry period the lower input of the tributaries as well as from the basin run-off reflects in the trophic state of the reservoirs which become mesotrophic, except the first, Barra Bonita reservoir.

There is a trophic state gradient along the reservoirs, with a decrease in the trophic state degree between the Middle and Low Tietê reservoirs.

A higher number of oligochaetes were obtained in the rainy season in the Middle and Low Tietê reservoirs, owing mainly to the greater input of organic matter during the rains.

The oligochaetes were distributed rather heterogeneously, but significantly higher species richness could be observed in the reservoirs of the Middle Tietê than in those of the Low.

The species B.sowerbyi and L. hoffmeisteri were present in the highest density, in both sampling seasons, in the reservoirs of the Middle and Low Tietê River.

The abundance and diversity of oligochaetes reflect the trophic state of the reservoirs and can therefore be used as a biological indicator of trophic state conditions.

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