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Spatial distribution of aquatic Oligochaeta in Ilha Grande National Park, Brazil

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ABSTRACT. Ilha Grande National Park is an important conservation unit localized in the Southern part of the upper Paraná river floodplain (Brazil) that includes diverse aquatic environments. Oligochaeta (Annelida) is a large group of invertebrates, with several small specimens inhabiting almost every possible niche at most freshwater ecosystem. The goal of the present study was to examine the spatial variation of Oligochaeta community in five floodplain lakes from the Ilha Grande National Park and relate the distribution with abiotic variables. Samples were taken at five sampling stations using a modified Petersen grab. Thirteen species of Oligochaeta belonging to two families Naididae and Tubificidae were recorded. Different patterns of richness and abiotic factors were identified among the lakes located in the island and at the margin of Paraná river. The different patterns of granulometric texture affected directly the distribution of the Oligochaeta assemblage of theses environments. The results of this study permit to infer that the Oligochaeta assemblage, in preserved areas, present a higher richness in relation to long term studies with more frequent samplings. We concluded that Ilha Grande National Park contributes for the preservation of benthic invertebrates.

Keywords: dominance, floodplain lakes, granulometric, Naididae, Tubificidae.

Distribuição espacial de Oligochaeta aquático no Parque Nacional de Ilha Grande, Brasil

RESUMO. O Parque Nacional de Ilha Grande é uma importante unidade de Conservação localizada ao Sul da Planície de Inundação do alto rio Paraná (Brasil) que abrange diversos ambientes aquáticos. Oligochaeta (Annelida) é um grupo de invertebrados, cujos pequenos espécimes habitam quase todos os nichos dos ecossistemas de água doce. O objetivo desse estudo foi o de analisar a variação espacial da comunidade de Oligochaeta em cinco lagoas de várzea do Parque Nacional de Ilha Grande e relacionar a sua distribuição às variáveis abióticas. As amostras foram coletadas em cinco locais usando pegador de Petersen modificado. Treze espécies de Oligochaeta pertencentes às famílias Naididae e Tubificidae foram encontradas. Foram identificados diferentes padrões de riqueza e de fatores abióticos entre as lagoas de várzea localizadas na ilha e na margem do rio Paraná. Os diferentes padrões de textura granulométrica afetaram diretamente a distribuição da assembleia de Oligochaeta entre esses ambientes. Os resultados deste estudo permitiram inferir que a assembléia de Oligochaeta, em áreas preservadas, apresenta maior riqueza em relação aos estudos de longo prazo com maior esforço amostral. Dessa forma, conclui-se que o Parque Nacional de Ilha Grande contribui para a preservação de invertebrados bentônicos.

Palavras-chave: dominância, lagoas de inundação, granulometria, Naididae, Tubificidae.

Introduction

The upper Paraná river floodplain is the last well preserved area of the Paraná river in Brazil; however, currently it is affected by the construction of dams, especially Engenheiro Sérgio Motta dam that has changed the hydrological system of the floodplain and the connectivity relationships with the geomorphological systems (AGOSTINHO et al., 2007). The Ilha Grande National Park is formed by a fluvial archipelago, comprising hundreds of islands, located in the Southern part of the floodplain (ICMBio, 2008).

Oligochaeta assemblage is important in structuring the sediment from freshwater ecosystem and acts in nutrient cycling. Mermillod-Blondin et al. (2005) stated that Oligochaeta stimulate organic matter mineralization, microbial activity, and increase the sediment aeration. Pelegrí and Blackburn (1995) verified that the oxygen uptake and denitrification of NO_3^- increased when Oligochaeta are registered at high abundances.

Furthermore, this assemblage is considered an excellent indicator of environmental changes.

Although researches about the Oligochaeta assemblage from Brazilian floodplains has been done by Alves and Strixino (2000) in the Mogi-Guaçu river floodplain; Montanholi-Martins and Takeda (1999, 2001), Takeda (1999) and Behrend et al. (2009) in the alluvial plain from the upper Paraná River, there is no research that includes areas from the Southern part of the Ilha Grande National Park. Concerning limnic Oligochaeta, the scarcity of studies is evident, mainly in aquatic environments located in preservation areas (GORNI; ALVES, 2008). In Brazilian territory, i.e. upstream from Itaipu dam, the Park is the last dam-free stretch of the Paraná river and represents a great potential to conservation of the biota from the fluvial system that includes a variety of habitats.

The main goal of this study was to examine the composition, dominance, frequency and spatial variation of Oligochaeta, relating them with abiotic variables in five floodplain lakes from Ilha Grande National Park, in order to evaluate whether the Park contributes for the preservation of benthic invertebrates.

Material and methods

Study area and sampling stations

The Paraná river is the tenth largest river in the world regarding the discharge and occupies the second largest watershed in South America (STEVAUX et al., 2004). The Ilha Grande National Park (78,875 ha) is located between Brazilian States of Paraná and Mato Grosso do Sul at coordinates 23°15' to 24°05'S and 53°40' to 54°17'W (Figure 1).

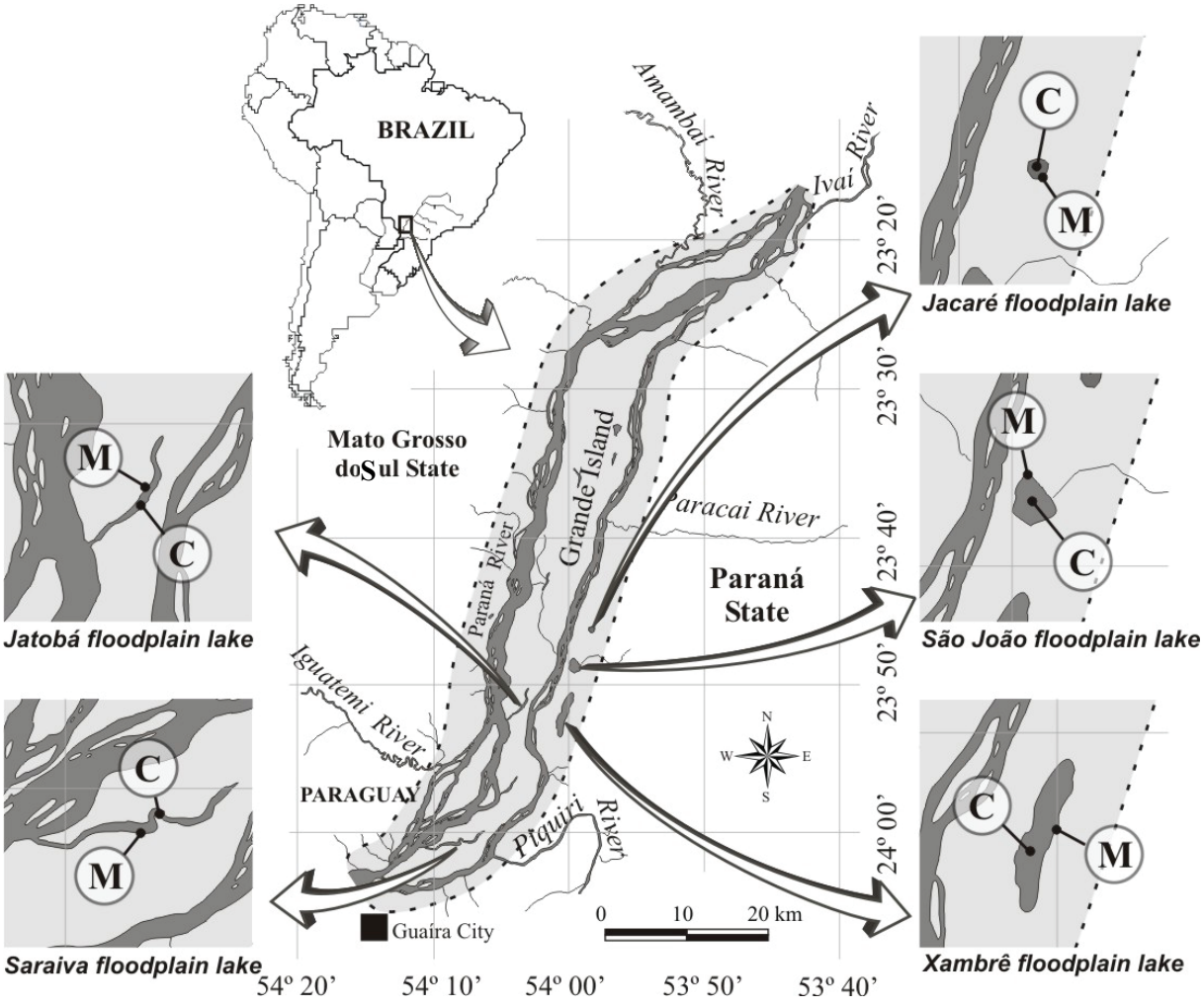

Figure 1. Location of the sampling stations (floodplain lakes) in the Ilha Grande National Park. M = Margin; C = Center.

The floodplain lakes occupy the most depressed parts from the inactive or active secondary channel and areas of the flooding basin. These lakes may maintain constant or intermittent connections with the channels, or may be fed exclusively by the groundwater, with river water entering only during flood periods. Sediment in these environments is dominated by mud and organic matter. The high water period of the Paraná river occurs between November and March and produce different effects according to the intensity. The low water period (dry season) usually occurs between April and October. The average temperature is 22ºC and the precipitation is about 1,200 to 1,300 mm per year. To characterize the benthic Oligochaeta from the Ilha Grande National Park, five sampling stations (floodplain lakes: Saraiva; Jatobá; São João; Jacaré and Xambrê) were sampled along a stretch of 35 km (Figure 1). Saraiva is a natural lake located on the right margin of Ilha Grande, with a permanent connection to the Paraná river. This lake is about 10 km in length and 300 m in width at widest point. The water is dark and clean with quite vegetation in the banks, mainly comprised by *Eichhornia azurea*. A dense riparian forest surrounds the lake, and along with marshes and flooding areas form mosaics with the semi-deciduous seasonal forest (CORIPA, 2003). Jatobá lake is also on the right margin of Ilha Grande, with similar features, but this lake is smaller than Saraiva, and may be isolated during the dry period. São João, Jacaré and Xambrê are isolated lakes located on the left margin of Paraná river, connected with the river during flood periods. Jacaré and Xambrê present an extensive floodplain area on the right margin, which separates them from the Paraná river.

Data gathering

Samples were gathered on July 12 and 13, 2010 using a modified Petersen grab (0.0345 m^2). At each sampling station, six benthic samples were taken near the margin (M) and in the center (C) of the lakes, including five for biological analysis and one for grain size analysis. Samplings in the Ilha Grande National Park was authorized by the Brazilian Environmental Agency (License number: 24156-1) in June 9, 2010.

In order to obtain data about the physical and chemical characteristics of each point (center and margin) from the sampling stations, water temperature (ºC), dissolved oxygen (mg L^{-1}; portable oximeter with YSI equipment) and depth (m; Ecosonda Hondex PS 7) were measured in situ, and water samples were taken from each point, kept into a thermal box with ice and taken to the lab where we measured the conductivity (µS cm^{-1}; portable conductivimeter; Digimed), pH (pHmeter; Digimed), and turbidity (NTU; Quimis turbidimeter model Q-179).

The five samples collected for biological analysis were washed in a sieve system (mesh size from 2.0 to 0.2 mm). All organisms retained on 2.0 and 1.0 mm sieves were immediately picked out. The material retained on the 0.2 mm sieve was fixed in alcohol 80% and sorted under a stereoscopic microscope.

Oligochaeta specimens were identified to species level when mature, and to family level when immature, due to the need of sexual characteristic, adopting the following literature: Brinkhurst and Jamienson (1971), Brinkhurst and Marchese (1991) and Righi (1984). Specimens of Oligochaeta were stored in Laboratório de Zoobentos/ NUPELIA/Universidade Estadual de Maringá. Granulometric textures were determined using the methodology of Wentworth (1922).

Data analysis

Abiotic data (except temperature that was disregarded due to unexpected changes between the first and second sampling days) from all sampling stations were used in a Principal Component Analysis (PCA) for data ordination in order to identify possible differences among the sampling stations, using PCORD 5.0 software (McCUNE; MEFFORD, 1999). The axes were retained for interpretation using the Kaiser-Guttman criterion, i.e., those with eigenvalues higher than 1.0. The main variables responsible for the distribution were evaluated through a correlation between PCA scores and the main matrix of abiotic data. Differences among sampling stations for each axis were tested by a Kruskall-Wallis and multiple comparisons of mean ranks (non parametric) when the assumptions of an Analysis of variance (ANOVA) were not reached. For these analyses we used the software Statistica 7.1 (STATSOFT, 2005).

Oligochaeta abundance data from each sampling station were transformed to density (number of individuals/0.0345 m^2) considering mature and immature individuals. Species richness (*S*) considered just mature individuals due to the need of species level. Dominance index of each species also considered just mature individuals and was calculated and categorized according to Kownacki (1971) for each sampling station.

A rarefaction curve was built using all samples in order to infer about efficiency of real local richness. Additionally, rarefaction curves were built in order to correct richness to the same organisms abundance (which we called rarefied richness) which enables

comparison between lakes located in the island and in the margin of Paraná river. To build the rarefaction curve, we used individuals as sample units, once it can show more clearly richness patterns (GOTELLI; COWELL, 2001). These analyses were made based on a null model algorithm subjected to 10,000 randomizations using the software EcoSim 7.72 (GOTELLI; ENTSMINGER, 2004). To test for species richness differences between marginal lakes and island lakes we used one-way ANOVA.

Shannon-Wiener index of diversity (*H'*) was applied in granulometric texture data in order to obtain the diversity of lake sediments. Differences between diversity of granulometric texture of island and marginal lakes were tested by ANOVA.

Results

Abiotic analyses

In relation to the Principal Component Analysis (PCA), the first two axes explained 72.88% (axis 1 = 41.53% and axis 2 = 31.35%) of total data variability. In the axis 1, dissolved oxygen and pH presented the highest positive correlation and conductivity presented negative correlation. On the axis 2, the depth was the negatively correlated variable, and no strong, positive correlation was found (Figure 2).

The analysis of multiple comparisons of mean ranks differed Saraiva Lake from São João and Jacaré lakes; and Jatobá Lake diverged from São João lake in axis 1. Moreover, Xambrê lake was different from Jatobá and São João Lakes in axis 2 (Table 1).

The granulometric composition varied among the environments. Jacaré and São João Lakes presented higher percentage of mud. Saraiva lake presented high percentage of mud only in the margin, but showed higher percentage of sand in the center, and in the Jatobá.

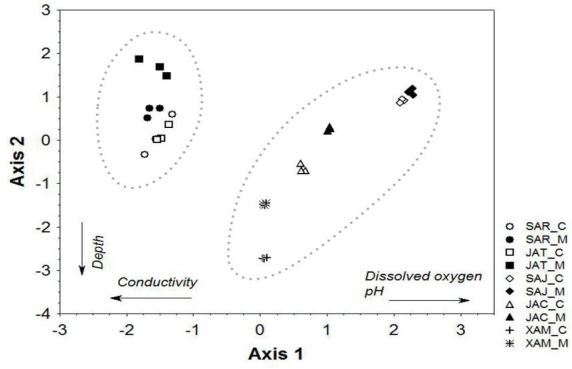

Figure 2. Ordination of the scores for each sampling station, in relation to axes 1 and 2 from the Principal Component Analysis (PCA). SAR – Saraiva lake; JAT – Jatobá lake; SAJ – São João lake; JAC – Jacaré lake; XAM – Xambrê lake. (C- Center; M – Margin).

Table 1. Multiple comparisons of mean ranks for PCA scores applied on water temperature (ºC), dissolved oxygen (mg L^{-1}), depth (m), conductivity (µS cm^{-1}), pH and turbidity (NTU) among five lakes from the Ilha Grande National Park.

	Saraiva		Jatobá		São João		Jacaré		Xambrê	
	z'	p	*z'*	p	*z'*	p	*z'*	p	*z'*	p
Axis 1										
Jatobá	0.33	1.00	-		-		-		-	
São João	4.30	0.00	3.97	0.00	-		-		-	
Jacaré	3.12	0.02	2.79	0.05	1.18	1.00	-		-	
Xambrê	1.93	0.53	1.61	1.00	2.36	0.18	1.18	1.00	-	
Axis 2										
Jatobá	0.92	1.00	-		-		-		-	
São João	1.54	1.00	0.62	1.00	-		-		-	
Jacaré	1.02	1.00	1.93	0.53	2.56	0.11	-		-	
Xambrê	2.59	0.10	3.51	0.00	4.13	0.00	1.57	1.00	-	

Lake were found sand and pebbles (Figure 3A). The percentage of organic matter was higher at the Jacaré Lake, followed by São João and Saraiva lakes (Figure 3B).

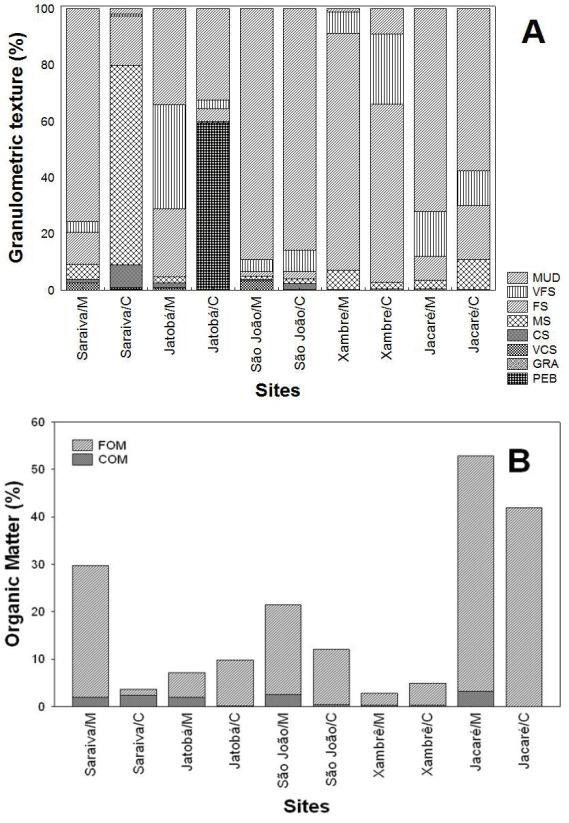

Figure 3. Variations of granulometric texture from the five floodplain lakes at the Ilha Grande National Park: PEB – pebbles; GRA – gravel; VCS – very coarse sand; CS – coarse sand; MS – medium sand; FS – fine sand; VFS – very fine sand; M – mud (A). Variations in the percentage of organic matter in the studied floodplain lakes: FOM – Fine organic matter; COM: Coarse organic matter (B).

Biotic analyses

A total of 127 specimens belonging to thirteen Oligochaeta species were found in the five floodplain lakes from the Ilha Grande National Park. These

species belong to two families – Naididae and Tubificidae. The most representative family was Naididae presenting ten species. Nevertheless, the Tubificidae *A. pigueti* was the most dominant species recorded in Saraiva and Jatoba lakes, followed by the Naididae *P. americana* in Xambrê lake (Table 2). The latter lake also presented higher density of individuals, especially *P. americana* while in Jacaré lake no individual were registered (Figure 4A). Jatobá lake presented the higher species richness from the five studied lakes (Figure 4B).

Shannon-Winner's index for granulometric texture had not been significantly different between the island lakes and marginal ones ($F = 2.46$; $p = 0.1556$) but there was a strong trend to diversity of granulometric texture from the island lakes to be higher than marginal (Figure 5A).

Table 2. Kownacki's dominance index (1971) for Oligochaeta specimens collected from the Ilha Grande National Park: Dominants (10 - 100); Subdominants (1 - 9.99); Non-dominants (0 - 0.99) Non-dominants A (0.1 - 0.99); Non-dominants B (0 - 0.099), where "⋆⋆" represent dominant species and "⋆" represent subdominant species.

	Saraiva		Jatobá		São João		Xambrê		Jacaré	
	M	C	M	C	M	C	M	C	M	C
Naididae										
Pristina proboscidae (Beddard, 1896)		15.00⋆⋆	3.53⋆			20.00⋆⋆				
Pristina americana (Cernosvitov, 1937)			0.59				66.67⋆⋆			
Pristina breviseta (Bourne, 1891)			0.59							
Pristina osborni (Walton, 1906)	1.82⋆									
Dero (Dero) sawayai (Marcus, 1943)			0.59							
Dero (Aulophorus) borellii (Michaelsen, 1900)			2.35⋆	1.60⋆						
Chaetogaster diastrophus (Gruithuisen, 1828)							0.42			
Bratislavia unidentata (Harman, 1973)		2.50⋆	0.59							
Slavina evelinae (Marcus, 1942)			0.59							
Nais communis (Piguet, 1906)	1.82⋆									
Tubificidae										
Paranadrilus descolei (Gavrilov, 1955)			2.35⋆							
Aulodrilus pigueti (Kowalewski, 1914)	29.09⋆⋆	7.50⋆	47.06⋆⋆	96.00⋆⋆			0.42			
Limnodrilus hoffmeisteri (Claparede, 1862)		2.50⋆					1.25⋆			

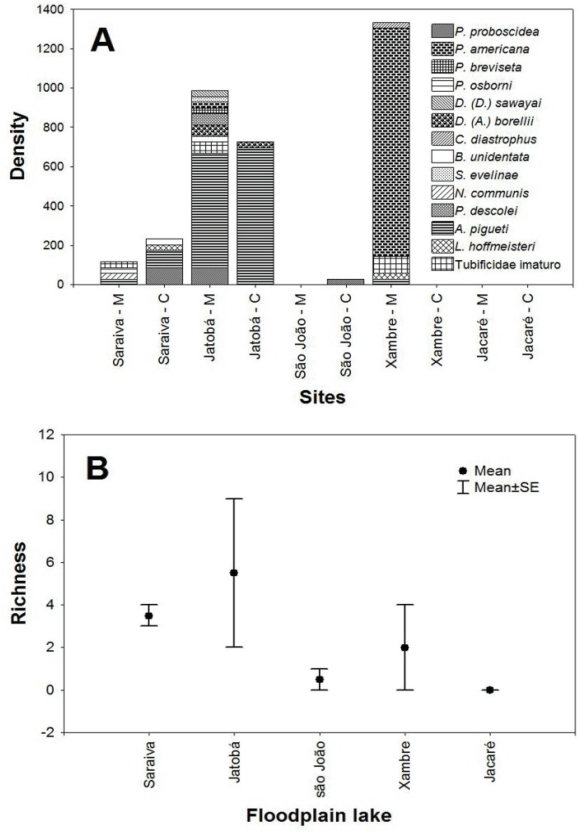

Figure 4. Variations in Oligochaeta density (individuals m^{-2}) in the floodplain lakes: M = margin, C = center (A); Species richness for each studied lake (B).

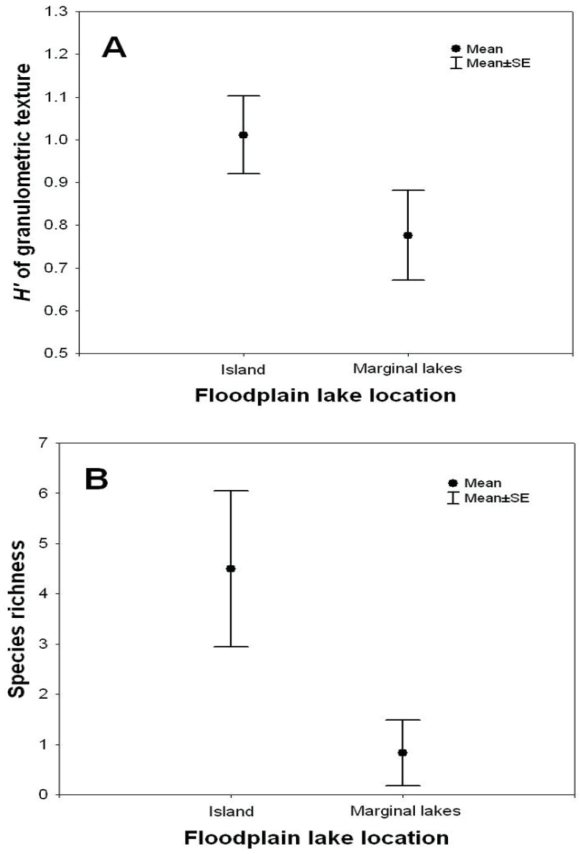

Figure 5. Diversity index of granulometric texture (A), Species richness from the island lakes and marginal lakes (B).

In the same way, the species richness was higher in the island, but in this case, significant difference was found ($F = 6.17$; $p = 0.0378$) (Figure 5B).

The rarefaction curve for Oligochaeta species shows that the asymptote was not reached (Figure 6A), demonstrating that the real richness was underestimated. Despite this, the curves for Oligochaeta species sampled in the island floodplain lakes and marginal floodplain lakes from Ilha Grande National Park, which shows corrected richness under the same abundance, demonstrated that richness in the island lakes was higher than in marginal lakes (Figure 6B).

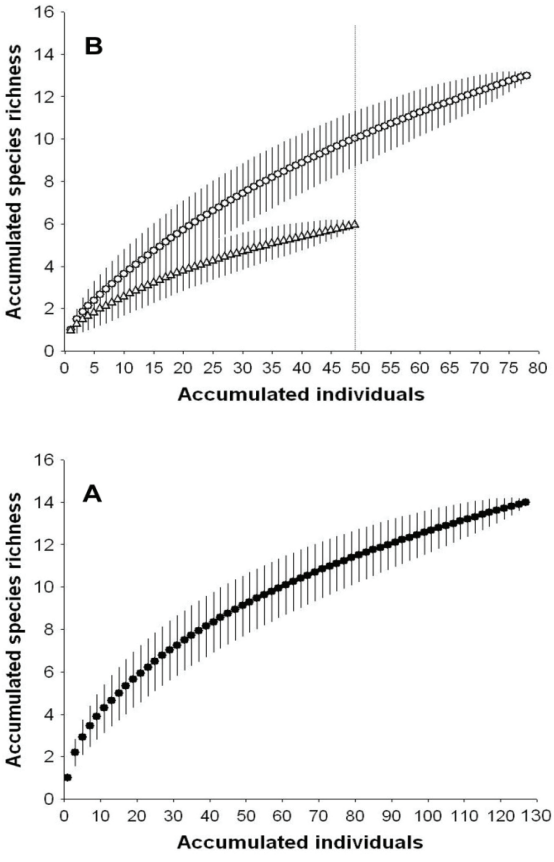

Figure 6. Mean accumulated species richness (± standard error) for Oligochaeta specimens collected in five lakes from Ilha Grande National Park representing the sampling effort on real richness. Non-Asymptotic curve demonstrates that the real richness was not totally sampled (A). Accumulated species richness through rarefaction curves for Oligochaeta species collected at island floodplain lakes (open circles) and marginal floodplain lakes (open triangles) from Ilha Grande National Park. Dashed line shows abundance for comparison of corrected richness under the same abundance (B).

Discussion

According to Righi (1999), 70 species of aquatic Oligochaeta were recorded in Brazil. In the present study, we identified 13 species, 20% from Brazilian known species. The long term ecological programs developed in the upper Paraná river (UEM, 2008) registered 30 species during 10 years of monitoring. Such result indicates the importance of Ilha Grande National Park for the preservation of aquatic Oligochaeta species.

Although the PCA evidenced differences between the island and marginal lakes, it didn't influenced the species richness of these floodplain lakes. The species richness differed between these environments, probably, due to the granulometric divesity texture. As noticed by Montanholi-Martins and Takeda (2001), spatial variation can be influenced by differences in grain size and organic matter quantities in the sediment.

The first trait from a floodplain lake to be considered is the connectivity degree with the main channel, since this factor affects the benthic community both spatially and temporally. Although all the floodplain lakes are directly or indirectly subjected to the river pulse, their communities present distinct structure and function. Each lake in the floodplain provides its own typical characteristic on the benthic community (TAKEDA; FUJITA, 2004). Our data indicated that Saraiva lake, permanently connected to Paraná river, and Jatobá that presents connection almost throughout the year, presented more diversified communities with predominance of Tubificidae, especially *A. pigueti*. Both lakes presented species that were absent in the other study lakes. Xambrê lake, isolated from the Paraná river by an extensive floodplain area, presented dominance of Naididae with abundance of *P. americana*. In accordance with Montanholi-Martins and Takeda (1999), species as *P. americana* are probably related to the higher content of mud and organic matter, deriving near the shore, as well as to the low oxygen conditions.

Both Saraiva and Jatobá lakes are located on island from Ilha Grande National Park, in this way, higher species richness in the island lakes than in marginal ones is possibly associated to the lower anthropogenic impact due to the difficult access.

Substrate type is the determinant factor influencing the community structure. Consolidated bottom substrate favors invertebrates with morphological adaptations to fix or move themselves to capture food and avoid predators. The Paraná river bottom (medium quartz and sand) contains mainly interstitial organisms that inhabit the capillary waters formed around sand grains (TAKEDA; FUJITA, 2004). The granulometric composition of the sediment, more heterogeneous in the Saraiva and Jacaré lakes, providing diversity of

habitat, may also explain the higher species diversity and the dominance of Tubificidae that present detritivorous species, typical of sediment.

The absence of specimens in the Jacaré lake, as in the São João where a single specimen was found, may be due to the excess of organic matter present at these environments. Probably, the layer of particulate organic matter on the bottom is very thick, and the grab caught only this material, not reaching the portion of structured sediment.

Furthermore, the species accumulation curve evidenced that the sampling effort was not enough to reach the asymptote, i.e., possibly the species richness is even higher in these environments, especially in lakes located in the island.

This was the first research on Oligochaeta in floodplain lakes from the Ilha Grande National Park, and even with few samples, we recorded a diversified community of these benthic organisms. Therefore, Oligochaeta can be considered an important component of the fauna from that preservation area and a very relevant tool for future ecological studies in the region.

Conclusion

We concluded that Ilha Grande National Park is important to preserve the aquatic invertebrate diversity, mainly Oligochaeta, due to the great species richness found in the samples. This great number of species registered in a short sampling period, indicated the key role of the Park on the biodiversity maintenance.

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