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Spatial distribution of the assemblage of Chironomidae larvae (Diptera) in five floodplain lakes from Ilha Grande National Park (Paraná - Mato Grosso do Sul State, Brazil)

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ABSTRACT. Chironomidae larvae (Diptera) are one of the most important families among aquatic insects due to the higher abundance and species richness, considered an important tool for ecological studies. This study evaluated the richness of Chironomidae assemblage and related the distribution with physical and chemical variables in five lakes of the Paraná river, in the Ilha Grande National Park. There were two samplings, one in the central region and another in the marginal area of the floodplain lakes. In each region were collected six samples, five for biological analysis and one for granulometric analysis. The granulometric composition and organic matter content were the principal variables influencing the density and richness of Chironomidae. The scores of the abiotic data distinguished the marginal lakes (São João, Jacaré and Xambrê) from the island lakes (Saraiva and Jatobá). The same segregation was observed in the distribution of Chironomidae morphotypes, and environments with higher values of organic matter, presented the lowest density and taxa richness. Thus, in this study the environmental variables directly interfered in the distribution, abundance and richness of Chironomidae of the floodplain lakes from Ilha Grande National Park, contributing to the knowledge of the diversity of this group in this area.

Keywords: floodplain lakes, composition, abundance.

Distribuição espacial da assembleia de larvas de Chironomidae (Diptera) de cinco lagoas de inundação do Parque Nacional de Ilha Grande (Estado do Paraná - Mato Grosso do Sul, Brasil)

RESUMO. As larvas de Chironomidae (Diptera) constituem uma das principais famílias entre os insetos aquáticos por sua alta abundância e riqueza taxonômica, consideradas importantes ferramentas nos estudos ecológicos. Este estudo teve por objetivo avaliar a riqueza da assembleia de Chironomidae e relacionar a distribuição desta com variáveis físicas e químicas de cinco lagoas do rio Paraná, no Parque Nacional de Ilha Grande. Foram realizadas duas coletas: uma na região central e outra na região marginal das lagoas. Em cada região foram coletadas seis amostras, cinco para análises biológicas e uma para análise granulométrica. A composição granulométrica e o teor de matéria orgânica foram as principais variáveis que influenciaram a densidade e a riqueza de Chironomidae. Os escores dos dados abióticos separaram as lagoas marginais (São João, Jacaré e Xambrê) das lagoas localizadas na Ilha Grande (Saraiva e Jatobá). A mesma separação foi observada na distribuição dos morfotipos de Chironomidae, cujos ambientes com maiores valores de matéria orgânica apresentaram as menores densidade e riqueza de táxons. Portanto, neste trabalho, as variáveis ambientais interferiram diretamente na distribuição, abundância e riqueza de Chironomidae das lagoas de inundação do Parque Nacional de Ilha Grande, contribuindo para o conhecimento da diversidade deste grupo na área.

Palavras-chave: lagoas de inundação, composição, abundância.

Introduction

Ilha Grande National Park is located in the Southern region of the Paraná river floodplain (SOUZA FILHO; STEVAUX, 2004) and represents the last dam-free stretch of the Paraná River, upstream from the Itaipu Reservoir considered a great potential to biodiversity conservation of the region (CAMPOS, 1999). This area presents several floodplain lakes that 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 (SOUZA-FILHO; STEVAUX, 2004).

In floodplain lakes, Chironomidae larvae usually is the group most abundant (HIGUTI; TAKEDA, 2002; TAKEDA et al., 2004), considered an important tool in the ecological studies (ASHE et al., 1987; EPLER, 2001; SIQUEIRA et al., 2008; ROQUE et al., 2007), since they have high species richness (EPLER, 2001; ROQUE et al., 2010), are widely distributed in the world (FERRINGTON, 2008), and occupy almost every available niche (EPLER, 2001; TAKEDA et al., 2004), where they play different trophic roles (SIQUEIRA et al., 2008; TAKEDA et al., 2004). However, little is known about their interactions with the environment and the interspecific interactions (FRANQUET, 1999).

The present study evaluated the richness of Chironomidae larvae and related the distribution with physical and chemical variables, thus contributing for the knowledge of this group in Ilha Grande National Park, since it is the first survey about Chironomidae composition in this area. The tested hypothesis was that Chironomidae assemblages differ between marginal and island lakes, with higher taxa richness in the island lakes due to their status of environmental preservation.

Material and methods

Study area and sampling stations

The Ilha Grande National Park is located in the Southern region from the Paraná river floodplain, between 23°15' to 24°05'S and 53°40' to 54°17'W (Figure 1), occupying an area of 75.894 ha. This park is composed by a group of islands and lowland areas marginal to the Paraná River (CAMPOS, 1999).

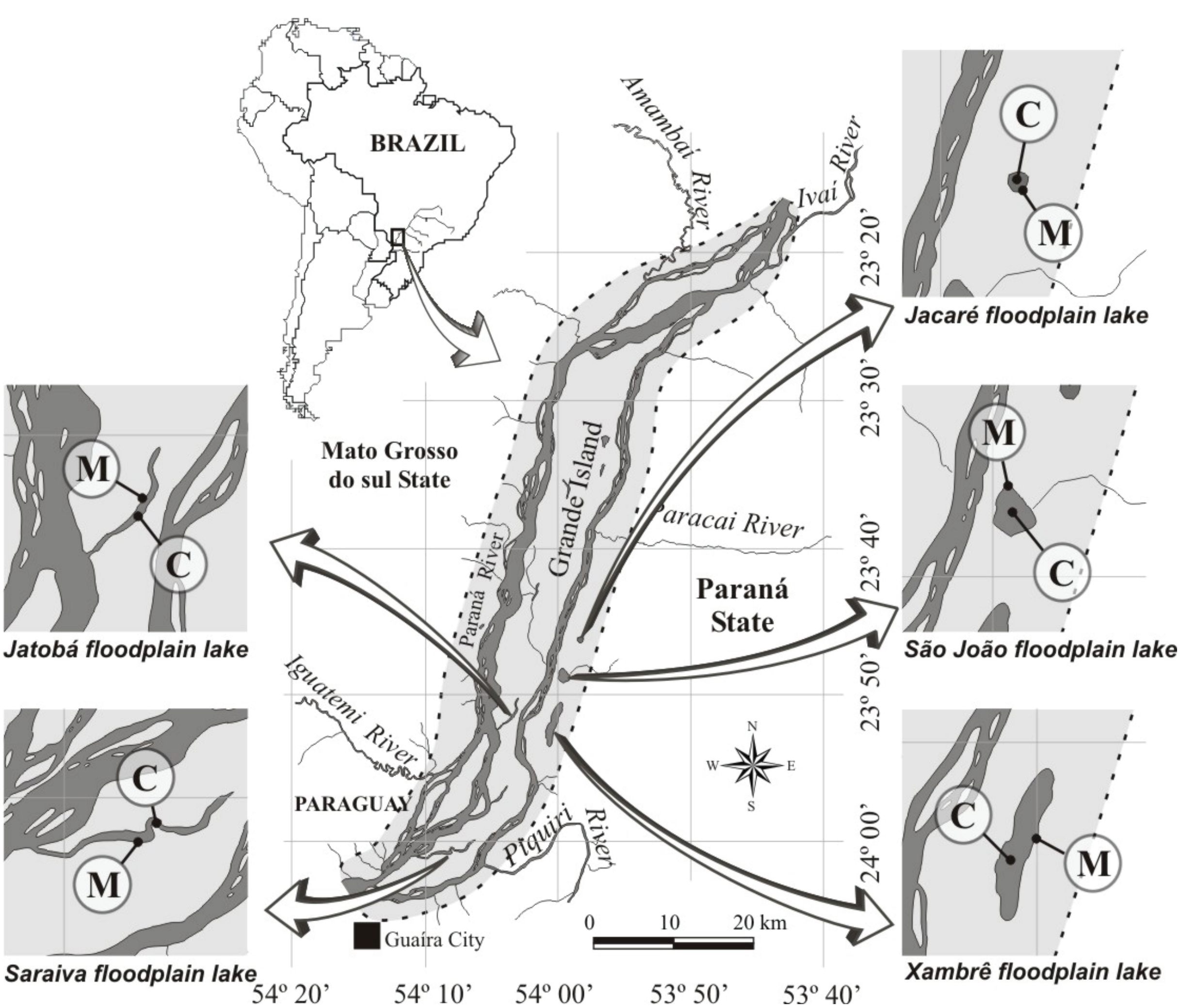

Figure 1. Location of the sampling stations in the Ilha Grande National Park (Paraná State, Brazil). M=Margin; C=Center.

The sediment in floodplain lakes from the Ilha Grande National Park is predominated by mud and organic matter. The higher water level of Paraná river is observed between November and March and causes different effects according to the intensity. On the other hand, the low water period (dry season) occurs between April and October. The mean temperature is 22°C and the precipitation is about 1,200 to 1,300 mm per year.

In order to characterize the community of Chironomidae larvae from the Ilha Grande National Park, we sampled five floodplain lakes of the Paraná river: Saraiva and Jatobá located on the right margin of Ilha Grande and, São João, Jacaré and Xambrê located on the left margin of Paraná River. At each site, 10 samples were taken at two points: five in the central area and five near the margin of the lakes.

Data gathering

Samplings in the Ilha Grande National Park were authorized by the Brazilian Environmental Agency (License number: 24156-1) in June 9, 2010.

Samples were collected on July, 2010 using a modified Petersen grab (0.0345 m^2). Six benthic samples were taken in the margin (M) and center (C), including five for biological analysis and one for grain size analysis. Granulometric textures were determined based on Wentworth scale (SUGUIO, 1973; WENTWORTH, 1922).

Along with biological samples, we measured conductivity (μS cm^{-1}; portable conductivimeter; Digimed); pH (pHmeter; Digimed), turbidity (NTU; Quimis turbidimeter model Q-179), depth (m; Ecosonda Hondex PS 7); temperature (°C) and dissolved oxygen (mg L^{-1}; portable oximeter with YSI equipment).

Samples taken for biological analyses were washed in a sieve system with different 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 ethanol 80% and sorted under a stereoscopic microscope.

Chironomidae larvae were dissected and mounted on slides using Hoyer, afterwards the organisms were identified to the lowest taxonomic level using the following literature: Trivinho-Strixino and Strixino (1995) and Epler (2001). The slides are stored in the Zoobentos laboratory (NUPELIA/UEM).

Statistical analysis

A Principal Component Analysis (PCA) was performed with the physical and chemical variables to summarize the total variation in the data and to identify major environmental gradients (GAUCH, 1986) using PC-ORD 5.0 (MCCUNE; MEFFORD, 1999); after, we tested the significance of the axis scores using a non parametric analysis of variance (Kruskal-Wallis).

Chironomidae density (number of individuals *0.0345 m^{-2}) were log-transformed ($\log_{10}(x + 1)$), and the proportionate share of each taxa were graphically represented. To characterize the Chironomidae community in the studied environments we calculated the Kownacki's dominance index (KOWNACKI, 1971; Equation 1) and Shannon-Wiener diversity index (MAGURRAN, 1988; Equation 2).

$$d = \frac{\bar{Q}.100 \times f}{\sum \bar{Q}} \quad (1)$$

Where: Dominant = 10 < d < 100; Subdominant = 1 < d < 9.99; and Non-dominant = 0.01 < d < 0.99. Only the dominant taxa of each lake and each month were listed.

Shannon-Wiener diversity index:

$$H' = -\sum p_i \ln p_i \quad (2)$$

Where: $\sum p_i$ is the sum of the relative abundance of Chironomidae taxa; and p_i is the relative abundance of taxa in the sample unit analyzed.

We calculated the mean density and richness of each sampling station. The means were graphically represented using the Statistica software (version 7.1).

To summarize the biotic data, the mean density of Chironomidae larvae species was analyzed using Detrended Correspondence Analysis (DCA). In order to minimize the effects of discrepant values, the main matrix was power transformed ($b = Xi, j)^p$, where p = 0.5. A non parametric correlation (Spearman Correlation) was accomplished to evaluate the relationships between the environmental and biotic variables and we tested the significance of the axis scores using a non parametric analysis of variance (Kruskal-Wallis).

A species accumulation curve was carried out to enable comparisons adjusting all richness data to the same number of individuals (which we called rarefied richness). To build the accumulation 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).

Results

Environmental variables

Higher percentage of mud was observed in all sampling stations, except for the center of Saraiva Lake, where we verified higher values of medium sand and Xambrê Lake with higher percentages of fine sand (Figure 2A). For organic matter, the highest percentage was found in Jacaré and Saraiva lakes (Figure 2B).

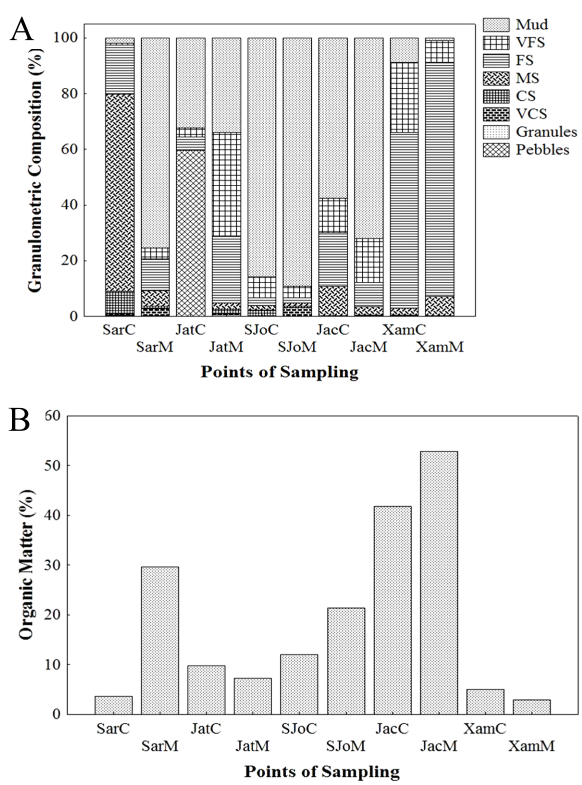

Figure 2. Granulometric composition (A) and organic matter content (B) in the sediment from the different floodplain lakes in the Ilha Grande National Park. SarC= Saraiva center; SarM=Saraiva margin; JatC= Jatobá center; JatM= Jatobá margin; SJoC= São João center; SJoM= São João margin; JacC= Jacaré center; JacM= Jacaré margin; XamC= Xambrê center and XamM= Xambrê margin. VFS = very fine sand; FS = fine sand; MS = medium sand; CS= coarse sand; VCS = very coarse sand.

According to the Kaiser-Guttmann criterion the first two PCA axes were retained for interpretation (Table 1, Figure 3). Two groups were formed: axis 1 grouping the marginal lakes (São João, Jacaré and Xambrê), influenced positively by higher values of pH and dissolved oxygen, whereas the axis 2 was negatively influenced by lowest depth and conductivity observed in the island lakes Saraiva and Jatobá (Figure 3B).

Table 1. Eigenvalues of Principal Components Analysis by the Kaiser-Guttmann criterion and percentage of explanation of the axes.

Axis	Eigenvalue	% of variance	Cum.% of Var.
1	2.07	41.53	41.53
2	1.56	31.35	72.88

The non-parametric analysis (Kruskal-Wallis) performed with the scores of theses axes pointed significant differences for the axis 1 ($H_{9;30} = 27.10$, $p = 0.0013$) and axis 2 ($H_{9;30} = 27.94$, $p = 0.0034$) (Figure 4).

Biotic variables

From the total benthic invertebrates, 41.56% were represented by Chironomidae larvae. A total of seven hundred and ten Chironomidae larvae were recorded, distributed among twenty-two morphotypes, which belonged to two subfamilies – Chironominae (14 taxa) and Tanypodinae (8 taxa). Among these morphotypes, five (*Beardius* sp.1, *Chironomus* sp.1, *Tanytarsus* sp.2, *Ablabesmyia (Karelia)* and *Procladius* sp.2) occurred exclusively in the island lakes and three (*Zavrelimyia* sp.1, *Ablabesmyia gr. annulata* and *Aedokritus* sp.1) at the marginal lakes.

Xambrê Lake presented the higher mean density of Chironomidae larvae while the lowest density was registered in the two points of sampling of Jacaré Lake and in the margin of Saraiva Lake (Figure 5).

Of twenty-two morphotypes captured, eighteen were observed in the island floodplain lakes, and of these, sixteen were recorded in the Jatobá Lake. For the marginal floodplain lakes, the overall composition was sixteen morphotypes being the highest richness recorded in the São João Lake, with eleven morphotypes (Table 2).

According to Dominance Kownacki´s index, higher dominance of *Aedokritus* sp.1 and *Chironomus* sp.3 were registered in the margin and center of Xambrê Lake, respectively, whereas *Coelotanypus* sp.1 was the only dominant taxon in the Jacaré Lake. On the other hand, *Chironomus* sp.2 and *Polypedilum* (*Tripodura*) sp.1 were dominant in Saraiva Lake, *Tanypus* sp. 1 in Jatobá Lake, and *Coelotanypus* sp.1 and *P.* (*Tripodura*) sp.1 in São João Lake (Table 2).

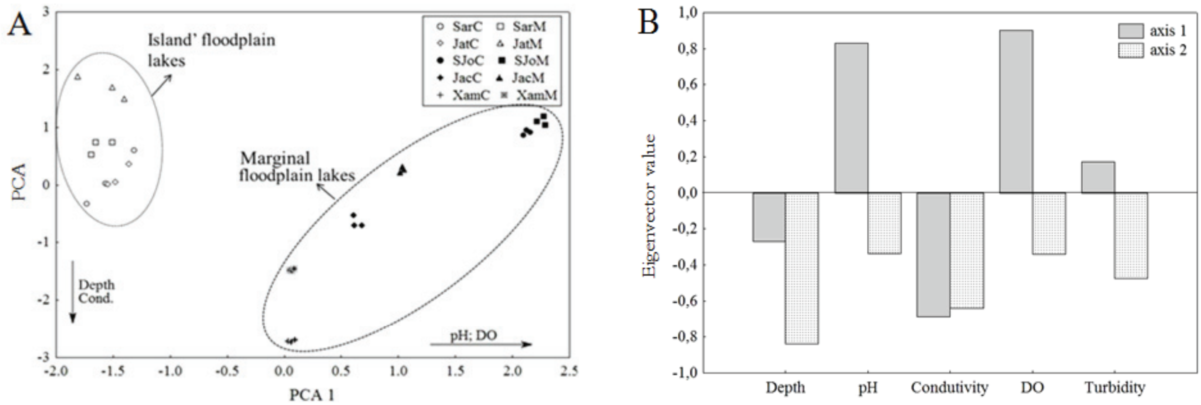

Figure 3. A: Ordination diagram of the first two axes PCA analysis. B: Eigenvector values from the Principal Component Analysis (PCA). DO = Dissolved Oxygen.

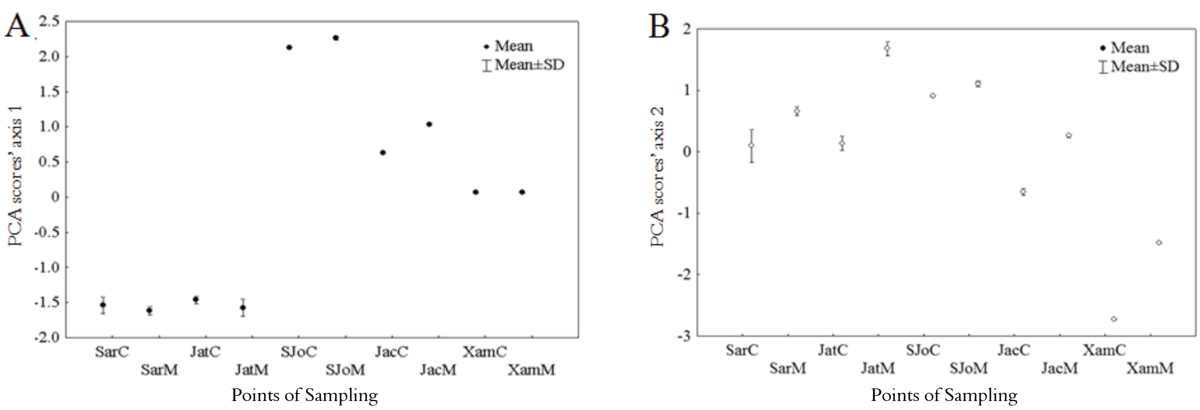

Figure 4. Mean and standard deviation values of PCA scores: A: axis 1; B: axis 2 of points sampled. SarC= Saraiva center; SarM=Saraiva margin; JatC= Jatobá center; JatM= Jatobá margin; SJoC= São João center; SJoM= São João margin; JacC= Jacaré center; JacM= Jacaré margin; XamC= Xambrê center and XamM= Xambrê margin.

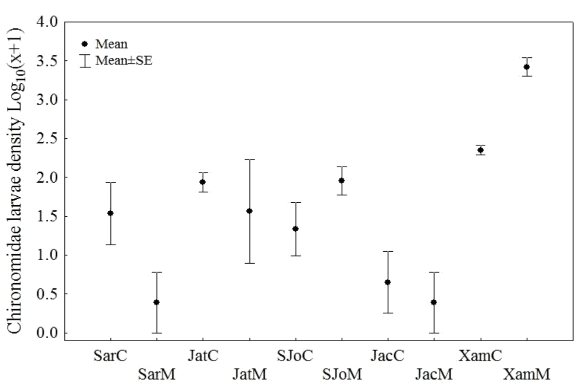

Figure 5. Mean Chironomidae larvae density at five floodplain lakes (SarC= Saraiva center; SarM= Saraiva margin; JatC= Jatobá center; JatM= Jatobá margin; SJoC= São João center; SJoM= São João margin; JacC= Jacaré center; JacM= Jacaré margin; XamC= Xambrê center and XamM= Xambrê margin).

Comparing the richness and Shannon-Wiener diversity index, the group of island lakes (Saraiva and Jatobá) presented higher values both to richness and diversity than the marginal lakes (São João, Jacaré and Xambrê) (Figure 6A and B).

DCA analysis evidenced differences between the marginal floodplain lakes and island floodplain lakes (Figure 7). Marginal lakes were grouped by the most negative correlations of morphotypes: *Aedokritus* sp.1 (r =-0.561), *Goeldchironomus* gr. *pictus* (r =-0.319) and *Chironomus* sp.3 (r =-0.317). Moreover, positive correlations of morphotypes *Tanypus* sp.1 (r = 0.599), Chironomus sp.1 (r = 0.474) and Procladius sp.2 (r = 0.359) grouped the island lakes.

Only the first DCA axis was significant according to Kruskal-Wallis non-parametric analysis ($H_{9;35}$ = 23.68, p = 0.0048), distinguishing the marginal lakes from the island lakes (Figure 8).

The Spearman Correlation Analysis evidenced negative correlations between organic matter and total density of Chironomidae larvae (ρ = -0.83) and positive correlations with pebbles and taxa richness (ρ = 0.76) (Table 3).

Table 2. Dominance values of Kownacki´s index and taxa richness of Chironomidae in the sampled floodplain lakes. Dominant = 10 < d < 100; Subdominant = 1 < d < 9.99; and Non-dominant = 0.01 < d < 0.99.

	Saraiva		Jatobá		São João		Jacaré		Xambrê	
	C	M	C	M	C	M	C	M	C	M
Chironominae										
Aedokritus sp.1							6.67		3.00	96.55
Asheum sp.1				2.00						
Asheum sp.2				0.50		0.91				
Beardius sp.1				6.00						
Caladomyia sp.1				4.00						0.15
Chironomus sp.1			4.71							
Chironomus sp.2	23.08			1.75					5.00	
Chironomus sp.3			1.18		2.86				67.50	0.11
Goeldichironomus gr. pictus	1.54			2.75		7.27				1.49
Pelomus sp.2	6.15					0.91				
Polypedilum (*Tripodura*) sp.1	6.15	13.33	1.18	9.00		18.18	6.67			
Tanytarsus sp.1		6.67		3.50		0.91				
Tanytarsus sp.2	1.54									
Zavreliella sp.2				1.00		0.91				
Tanypodinae										
Ablabesmyia gr. annulata									0.50	
Ablabesmyia (*karelia*)			1.18	0.75						
Coelotanypus sp.1					11.43	29.09		13.33	3.00	
Coelotanypus sp.2	1.54		1.18	1.00	2.86		6.67			
Labrundinia sp.3			1.18	1.00	2.86					
Procladius sp.2	1.54		1.18	0.25						
Tanypus sp.1			42.35	0.25	5.71	0.91			0.50	
Zavrelimyia sp.1								6.67		

C=center region of sampling stations; M=margin region of sampling stations. Bold values = dominant taxa.

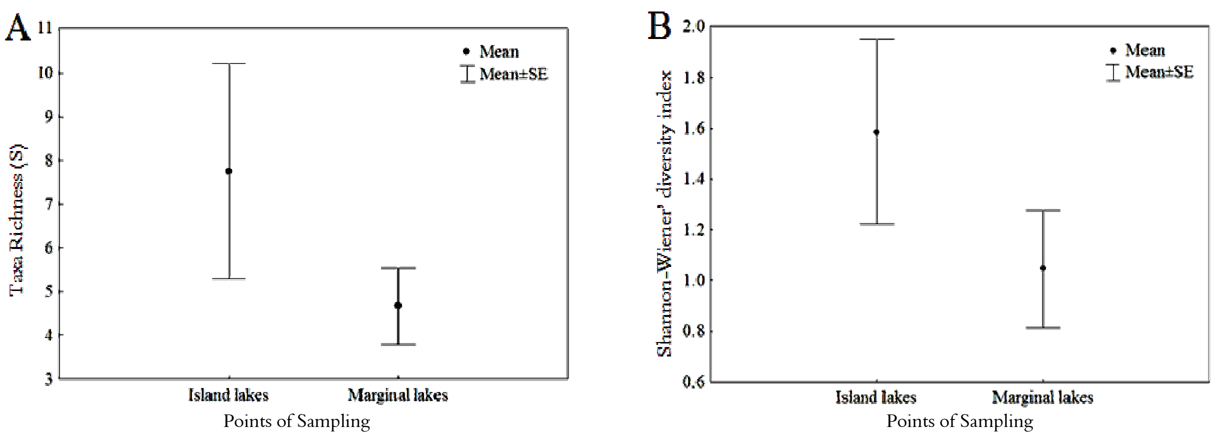

Figure 6. Taxa Richness (A) and Shannon-Wiener diversity index (B). SE: Standard error.

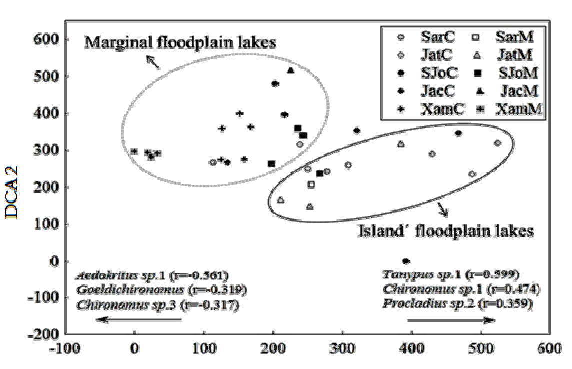

Figure 7. Ordination of sampling stations from the scores of axes 1 and 2 by the Detrended Correspondence Analysis (DCA) for the taxa of Chironomidae larvae.

The species accumulation curve indicated that the sampling effort was enough to evaluate the richness of Chironomidae larvae in floodplain lakes from Ilha Grande National Park (Figure 9).

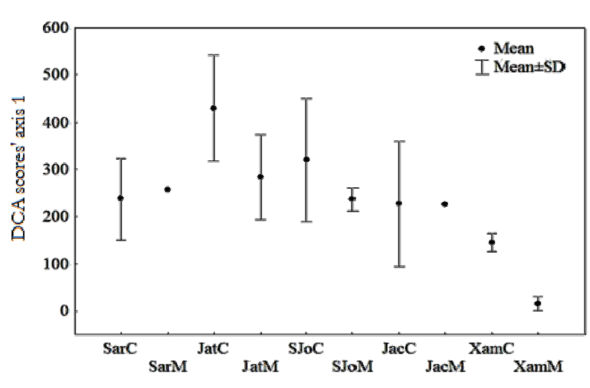

Figure 8. Mean and standard deviation values of DCA scores' axis 1 to the points sampled.

Table 3. Spearman Correlation values for the attributes of Chironomidae assemblage of the sampled lakes. VFS = very fine sand; FS = fine sand; MS = medium sand; CS= coarse sand; VCS = very coarse sand.

	Density	Richness	Shannon-Wiener index
Depth	0.432	0.189	-0.018
pH	-0.365	-0.299	-0.231
Condutivity	0.578	0.213	-0.116
Dissolved oxygen	-0.146	-0.238	-0.207
Turbidity	0.427	-0.162	-0.506
Pebbles	0.266	*0.761*	0.629
Granules	-0.055	0.076	0.336
VCS	-0.041	0.182	0.317
CS	-0.012	0.244	0.571
MS	-0.243	-0.530	-0.316
FS	0.450	-0.098	-0.292
VFS	0.267	-0.049	-0.158
Mud	-0.523	-0.146	0.097
Organic matter	*-0.833*	-0.494	-0.176

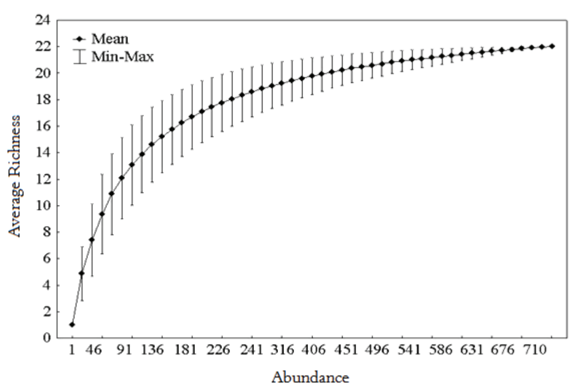

Figure 9. Species accumulation curve made in order to enable comparisons adjusting all richness data to the same number of individuals.

Discussion

The physical and chemical characteristics from the marginal and islands lakes were different probably due to their location, availability and heterogeneity of habitats. Furthermore, the granulometric composition and organic matter content were the principal variables influencing the density and richness of Chironomidae larvae as evidenced by Spearman Correlation, where environments with higher values of organic matter, as Jacaré Lake, presented the lowest density and richness of Chironomidae assemblage.

In this study we recorded the occurrence of Chironominae and Tanypodinae subfamilies that are the most commonly found in Brazilian aquatic habitats. Chironominae were the most species-rich subfamily, corroborating the results from Fittkau (1971), Spies and Reiss (1996), Roque et al. (2000), Rosin and Takeda (2007) and Rosin et al. (2009).

Morphotypes of Chironomidae herein found are characteristic of lentic environments, with high mud content, except the *Harnischia* complex (*Pelomus* genus) that occur almost exclusively in large rivers (PINDER, 1995). Probably, the high percentage of mud was the factor that collaborated to the higher density of some taxa in the sampled lakes. This sediment type is important to diet, tubes construction of larvae (JONHSON et al., 1989; MARGALEF, 1983; PAYNE, 1986) besides offering lower risk of predation when compared to sandy sediments (VOS et al., 2002).

Chironomus and *Goeldichironomus*, as well as *Polypedilum* and *Tanytarsus* were taxa abundant in Saraiva, São João and Xambrê lakes. According to Marchese and Ezcurra De Drago (1992); Cranston (2004); Higuti and Takeda (2002); Nessimian and Henriques-Oliveira (2005) these genera are widely distributed worldwide due to the adaptation to a wide variety of environmental conditions.

Further, the preference of Tanypodinae larvae to environments with predominance of mud (MCLARNON; CARTER, 1998), possibly explains the higher taxa richness found for this group in the sampled lakes. *Coelotanypus* and *Labrundinia,* two taxa of this Subfamily, with *Caladomyia* (Tanytarsini Tribe), are predominant in natural areas and related with environmental conditions characteristic of less impacted areas (FONSECA-LEAL et al., 2004; ROQUE et al., 2000).

Although the muddy sediment had been dominant in the studied lakes, the occurrence of morphotypes exclusives to bottom predominantly sandy was also verified as *Beardius* sp.*1*, *Asheum* sp.1, *Chironomus* sp.1, *Ablabesmyia (Karelia)*, *Ablabesmyia* gr. *annulata* and *Aedokritus* sp.1. This last, despite not exclusive, was quite abundant in Xambrê Lake, environment characterized by high percentage of sand.

The preservation degree of surroundings of floodplain lakes and their own environmental characteristics may be possible explanations to separate the marginal and island lakes, as observed for the attributes of richness and diversity, as well as distinctions in taxonomic composition as evidenced by DCA analysis.

Conclusion

This was the first research on Chironomidae at the Ilha Grande National Park, and even with few samples, it was possible to characterize the Chironomidae assemblage from the sampled lakes as evidenced by species accumulation curve. Therefore, we can conclude that Chironomidae may be considered a key component of the fauna from these floodplain lakes and a potential instrument in further ecological studies in the region.

Acknowledgements

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