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Diversity of Chironomidae (Diptera) in decomposing *Nymphoides indica* (L.) Kuntze in two subtropical lakes with different trophic conditions

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Abstract. Chironomids are the most abundant macroinvertebrates in macrophyte detritus. The goal of this study was to characterize the diversity of these animals in decomposing *Nymphoides indica* and their relationship with abiotic variables and mass loss in two subtropical shallow lakes of different trophic conditions (Polegar – oligotrophic, Biguás – eutrophic). Experiments were conducted using litter bags in the summers of 2007 and 2008. Mass loss rate, total N and P concentrations of the detritus, density of chironomids (100 gDW^{-1}), which were identified at the genera level and classified into functional trophic groups, were all recorded. The mass loss of *N. indica* was fast, with merely 8.5% of dried mass remaining in samples from Lake Polegar after five days and 8.7% in those from Lake Biguás after 17 days. The decay coefficient of *N. indica* in the oligotrophic lake, where the experiment lasted 5 days, was high (k=0.4242 d^{-1}), as were the diversity and evenness of chironomids. In the eutrophic lake, the experiment lasted 17 days; the decay coefficient was lower (k=0.1199 d^{-1}), as weel as diversity. The genus *Goeldichironomus* was the most abundant of the 13 genera found in each lake. Our results demonstrate that trophic level influences the colonization of chironomids in detritus in addition to determining the structure and ecological succession of functional trophic groups.

Keywords: macrophyte, functional trophic groups, ecological succession, detritus, leaf breakdown

Resumo. Diversidade de Chironomidae durante a decomposição de *Nymphoides indica* em lagos subtropicais. Os Chironomidae são os macroinvertebrados mais abundantes no detrito de macrófitas. Este estudo objetivou caracterizar a diversidade destes durante a decomposição de *Nymphoides indica*, e sua relação com as variáveis abiótica e perda de peso em dois lagos subtropicais de diferentes trofias (Polegar – oligotrófico, Biguás – eutrófico). O experimento foi realizado no verão de 2007/2008, utilizando *litter bags*. Foram examinados a taxa de perda de peso, concentrações de N e P total do detrito, densidade de Chironomidae (100gPS^{-1}), identificados a nível de gênero e classificados em grupos tróficos funcionais. A perda de peso de *N. indica* foi rápida com 8,5% de peso seco remanescente nas amostras do lago Polegar e 8,7% nas do lago Biguás após 17 dias. A taxa de decaimento de *N. indica* no lago oligotrófico, onde o experimento durou 5 dias, foi alta (k=0,4242 d^{-1}) juntamente com a diversidade e homogeneidade dos Chironomidae. No lago eutrófico, o experimento durou 17 dias; a taxa de decaimento foi menor (k=0,1199 d^{-1}) assim como a diversidade. O gênero *Goeldichironomus* dominou entre os 13 gêneros encontrados em cada lago. Os resultados mostram que o estado de trofia influenciou a colonização de Chironomidae no detrito, além de determinar a estrutura e o processo de sucessão ecológica de grupos tróficos funcionais.

Palavras chave: macrófitas, grupos tróficos funcionais, sucessão ecológica, detritos, degradação foliar

Introduction

Aquatic macrophytes are important components of continental aquatic ecosystems due to their roles in primary productivity, nutrient cycling, and the formation of detritus (Petrucio & Esteves 2000). Little information, however, is available on their decomposition, associated organisms and mass loss rate in subtropical ecosystems.

In habitats of the southern coastal plain of Rio Grande Sul State, small shallow lakes are common (Trindade *et al*. 2008). Large aquatic macrophyte beds are characteristic in these lakes, resulting in high levels of primary productivity (Palma-Silva *et al*. 2008, Trindade *et al*. 2009) and providing shelter for a large number of aquatic invertebrates (Albertoni *et al*. 2005, 2007). Among the most common plants in these environments *Nymphoides indica* (L.) Kuntze a floating leaves macrophyte form dense beds in ecosystems such as lakes and marshes (Cordazzo & Seelinger 1988). This species is an important component in the metabolism of water bodies. It produces a pumping effect by absorbing nutrients from the sediment and releasing them into the water column during decomposition; thus, they are an important link in nutrient cycling for these systems (Esteves & Barbieri 1983, Brum & Esteves 2001a).

Macroinvertebrates use detritus for shelter, substrate, and food (Varga 2003) and are thought to increase the decomposition rate of aquatic macrophytes (Bergey *et al*. 1992). The identification of functional food groups of these organisms indicates the relative importance of shredders and detritivores in the decomposition process (Gonçalves Jr. *et al*. 2000). These groups process the plant material required for invertebrate groups that feed on fine particulate organic matter (FPOM), such as collector-filterers and collector-gatherers (Grafius & Anderson 1980, Vanotte *et al*. 1980, Mulholland *et al*. 1985, Whiles & Wallace 1997).

Chironomids are the most abundant macroinvertebrates associated with the detritus of aquatic macrophytes (Botts 1997, Gonçalves Jr. *et al*. 2000). They occur in large numbers and colonize differentially according to the successional stage in the decomposition process of these plants (Poi de Neiff & Neiff 1989, Stripari & Henry 2002). This can be seen through the alternated dominance of taxa with different functional trophic groups (Gonçalves Jr. *et al*. 2000, 2004). Larvae of several species of Chironomidae live on or in the sediment, where they feed on organic matter (detritus) and on the associated microfauna and flora. They therefore occupy an important position in the trophic dynamics of aquatic freshwater ecosystems, due to the role that they play in recycling nutrients in the sediments. In addition to altering the composition of particulate organic matter, larvae also provide important energetic subsidies to predators (Sankarperumal & Pandian 1992).

Studies on the decomposition of *Nymphoides indica* in shallow subtropical lakes are rare as are studies on the organisms associated with this process. We hypothesized that trophic conditions of lakes could influence the speed of decomposition and the structure of the community associated with this process. Therefore, the goal of this study was to characterize the structure of the Chironomidae (Diptera) assemblage in *N. indica* detritus and determine its relationship with abiotic variables and mass loss in two subtropical shallow lakes of different trophic conditions.

Material and Methods

Study Area

Our study was conducted in two semi-artificial lakes located at the Carreiros Campus of the Federal University of Rio Grande (Universidade Federal do Rio Grande - FURG), municipality of Rio Grande, Rio Grande do Sul State, Brazil (Fig. 1). Despite their proximity, the lakes have different trophic structure, a result of differences in age and input of organic matter (Albertoni *et al.* 2007, Furlanetto *et al.* 2008, Trindade *et al.* 2009). The eutrophic/hypertrophic Biguás Lake contains high concentrations of dissolved oxygen during the day and low concentrations at night (3.05 to 15 $mg.L^{-1}$), high concentrations of chlorophyll-*a* (21.4 to 453.1 $\mu g.L^{-1}$), pH values ranging between acid and basic (6.78 to 10.3), and relatively high electrical conductivity (> 150 $\mu S.cm^{-1}$). Eutrophication is mainly caused by the large input of fecal matter from birds that spend the night on the two islands of the lake (Albertoni *et al.* 2007). The lake is elliptical in shape, approximately 200m long and 100m wide, occupying an area of 1.5ha, with a maximum depth of 2.20m. The margins are colonized by several species of aquatic macrophytes, surrounded by grasses and shrubs that do not restrict the action of winds or sunlight penetration (Albertoni *et al.* 2005).

The Polegar Lake has an area of approximately 1ha with a total depth of 1.5m that varies with rainfall. The lake also has low primary productivity and low concentrations of nutrients (total N and P), characterizing it as an oligo-mesotrophic lake. Despite the low nutrient concentrations, the lake water is very transparent, with low diel DO variation (8 to 13 $mg.L^{-1}$). The pH is close to neutral (6.62 to 8.58). The lake contains a low concentration of chlorophyll-*a* (1.77 to 13.76 $\mu g.L^{-1}$) and has low electrical conductivity (69.4 to 136 $\mu S.cm^{-1}$) (Furlanetto *et al.* 2008). Polegar Lake is surrounded by grasses and two nearby, small forests of *Pinnus* sp. and *Acacia* sp. on opposite sides of the lake. The aquatic vegetation of the lake is dominated by the rooted macrophyte *Nymphoides indica* (Furlanetto *et al.* 2008).

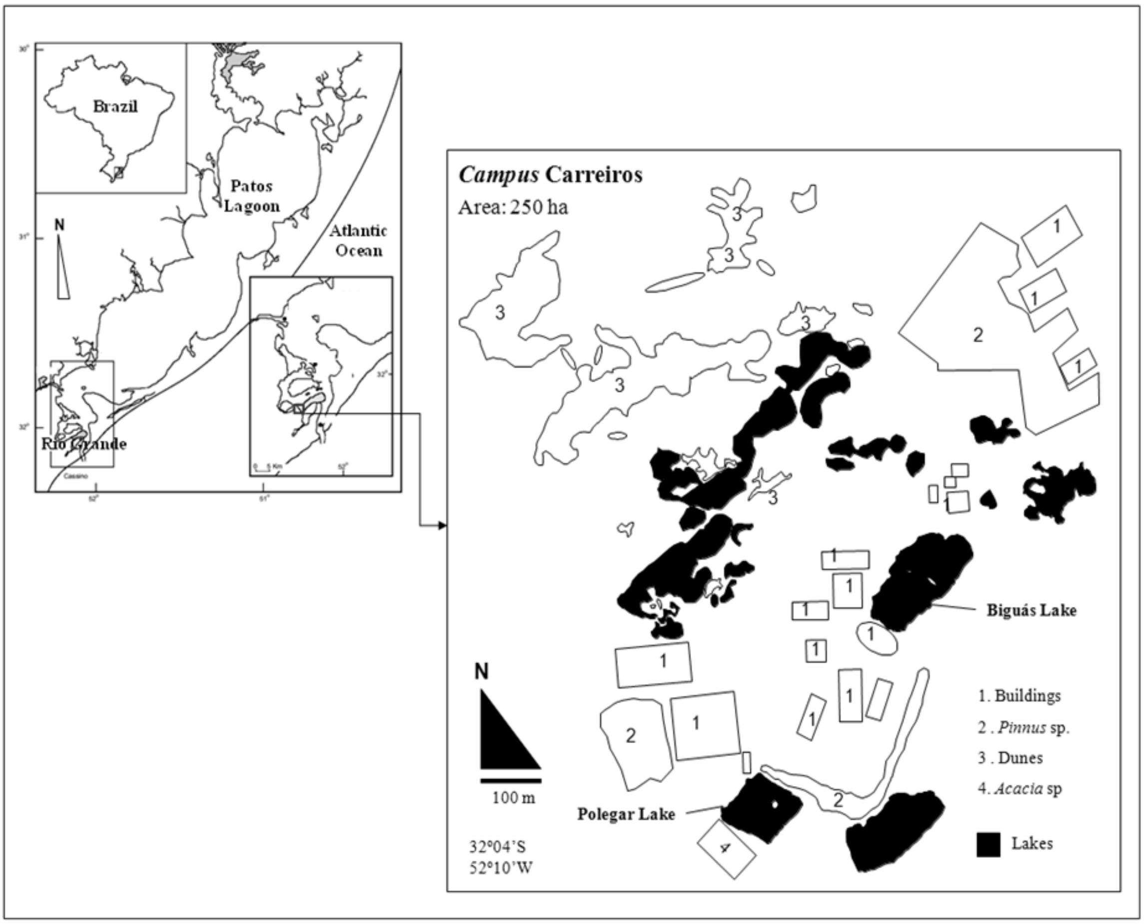

Figure 1. Location of the study area in the city of Rio Grande – RS – Brazil (32° 01'40" S; 52° 05'40"W).

Field experiment

The decomposition rate of *Nymphoides indica* and the simultaneous colonization by chironomids were estimated using the litter bag technique. This method consists of the incubation of measured quantities of plant material in bags of determined dimensions and mesh size. For this study, plastic bags of 30 x 20 cm, with a 10-mm mesh size, and containing 15 g of plant material by dry weight were prepared. The bags were incubated between December 2007 and January 2008 in the coastal region at the two lakes with four samplings for each date. Litter bags were retrieved on five sampling dates, totaling 20 samples per lake. In one of our previous experiments, mass loss in the oligotrophic lake was so fast that no detritus material remained after 6 days, requiring daily samples (1, 2, 3, 4 and 5 days after incubation). A similar study was conducted in the eutrophic lake sampling similar macrophytes (Gonçalves Jr. et al, 2003). Detritus was collected after 1, 3, 5, 11 and 17 days after detritus incubation. The abiotic variables of temperature, dissolved oxygen, pH, and electrical conductivity were measured in the field using a digital oxymeter, pH meter, and conductivity meter, respectively on each sampling date. Water samples were collected to determine the concentration of total nutrients. Nitrogen was measured according to the methods of Mackereth *et al.* (1978), and phosphorus was measured according to Valderrama (1981) and Baumgarten *et al.* (1996).

Laboratory processing

The remaining plant material in the bags after each collection was washed in a 300-μ mesh sieve and later examined under a dissecting microscope to separate chironomids from detritus. Chironomids were preserved in 80% ethanol and, for each individual, temporary slides were prepared with glycerin for identification at the genus level under a light microscope (400x). Digital photos of slides were taken, and the specimens were deposited in the Collection of Subtropical Limnic Invertebrates (ICB-FURG). Identification followed the taxonomic keys of Epler (2001). The categorization of specimens into functional trophic groups (FTG) to examine the succession in feeding habits of chironomids during decomposition followed the classification proposed by Ferrington Jr. *et al.* (2008).

Plant matter without organisms was dried at 60°C for 48 hours to determine dry mass and ground to determine total nitrogen according to Mackereth *et al.* (1978) and total phosphorus was determined according to Fassbender (1973) and Baumgarten *et al.* (1996).

Data analysis

The decomposition coefficients "k" of *N. indica* were calculated with an exponential model using mass loss percentages (transformed data log), according to Bärlocher (2005). To correct the difference in mass between the initial drying of the leaf material (air dry weight) and the mass of the detritus dried after incubation (in stove at 60º C), a linear regression curve was calculated.

The density of individuals found in each litter bag was estimated using the relationship: D= ind*100g.DW^{-1}, according to Gonçalves Jr. *et al.* (2003), where DW is the corrected dry mass of the leaf content in each litter bag.

The nutrient content of the detritus and the number of organisms were compared between lakes for each sampling date using the Student’s t tests. The densities of all samples of the same lake were analyzed by ANOVA (*One-way,* 95%) (data log-transformed). Total densities between lakes were compared with the non-parametric Mann-Whitney test (log-transformed data did not follow a normal distribution). All analyses were carried out using the software GrafPad INSTAT 3.0.

For the assemblage of chironomids, the Shannon-Wiener index of diversity was calculated (H´) as well as the Pielou’s equitability index (J’) according to Magurran (1988). The relationship between the abiotic variables of the lakes and the density of chironomids colonizing the detritus was examined by Canonical Correspondence Analysis (CCA) using the software Past. v. 1.80 (Hammer *et al.* 2001).

Results

Abiotic characterization of the lakes

During the study period, the two lakes showed very distinct trophic characteristics, as shown in Table I, with much higher conductivity and nutrient concentrations in the Biguás Lake, characterizing it as an eutrophic lake according Albertoni *et al.* (2007) and Trindade *et al.* (2009).

Table I. Abiotic variables of the water, averages (±SD) during the study.

Abiotic Variables	*PolegarLake*	*Biguás Lake*
Temperature. (°C)	26.9 (±1.13)	26.5 (±1.67)
Conductivity (μS.cm^{-1})	75 (±1.18)	215.8 (±2.09)
Dissolved Oxygen (mg.L^{-1})	7.2 (±0.27)	10.2 (±0.23)
pH	6.2 (±2.45)	10.1 (±15.6)
total N (mg.L^{-1})	0.660 (±0.12)	4.990 (±0.21)
total P (mg.L^{-1})	0.024 (±0.11)	0.311 (±0.15)

Decomposition of Nymphoides indica

The incubation time of the detritus varied between the two lakes. The decomposition rate was higher in Lake Polegar (k= 0.4242 day^{-1}). Due to this fast decomposition rate, detritus was removed daily, with only 8.5% of material remaining at the end of the experiment. In the Biguás Lake, mass remaining was 8.7%, and k = 0.1199 day^{-1} (Fig. 2).

Total nitrogen concentration in the detritus of both lakes was similar (p= 0.59), although in the Biguás Lake, nitrogen release was higher on the last day (Fig. 3a). Total phosphorus concentration in the detritus of *N. indica* in the Biguás Lake was significantly higher than in the Polegar Lake (p=0.002). In the Biguás Lake, total phosphorus concentration was constant during the first days of incubation, increasing on the 11th day and decreasing on the last day of incubation. In the Polegar Lake, phosphorus was released on the second day of incubation, followed by an increase on the third day and a decrease on the last days (Fig. 3b).

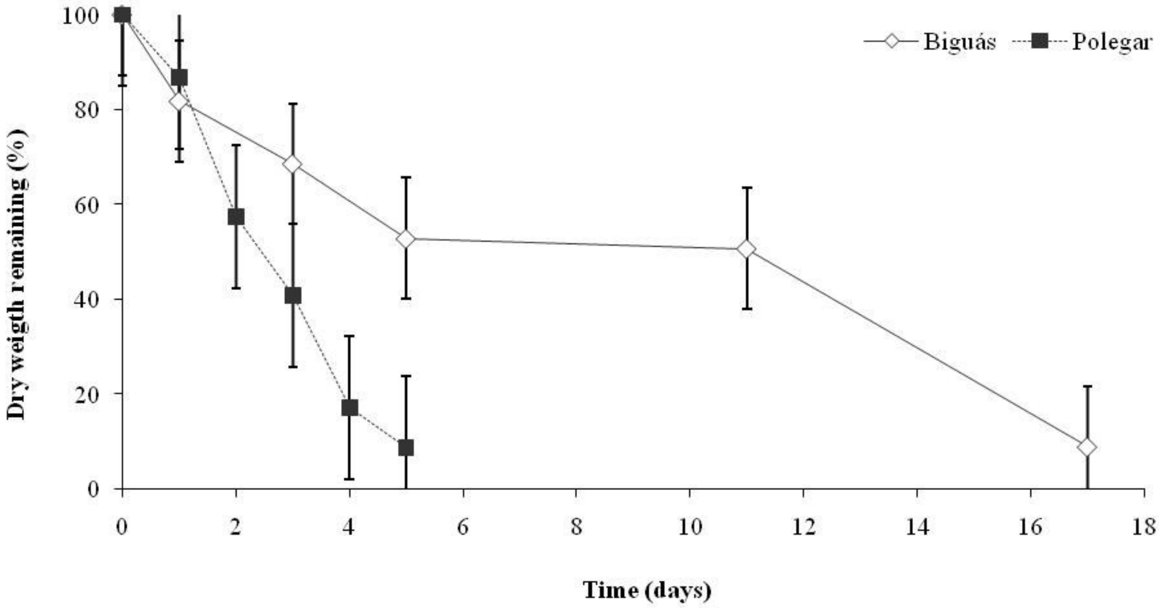

Figure 2. Percentage of mass remaining of *Nymphoide indica* in two lakes with different trophic levels.

Colonization of chironomids

Thirteen genera of Chironomidae were identified from three subfamilies: Chironominae (*Parachironomus* Lenz, 1921; *Pseudochironomus* Saether, 1977; *Aedokritus* Roback, 1958; *Goeldichironomus* Fittkau, 1965; *Chironomus* Meigen, 1803; *Tanytarsus* van der Wulp, 1874. *Rheotanytarsus* Bause, 1913 and *Polypedilum* Kieffer, 1921), Orthocladiinae (*Cricotopus* van der Wulp, 1874 and *Thienemanniella* Kieffer, 1911) and Tanypodinae (*Labrundinia* Fittkau, 1962; *Ablabesmiya* Johannsen, 1905 and *Coelotanypus* Kieffer, 1913). Chironominae was the dominant taxa in the Polegar and Biguás Lakes. A total of 21,848 individuals were recorded in Biguás Lake and 487 were recorded in Polegar Lake. The genus *Coelotanypus* was found only in Biguás Lake, while the genus *Aedokritus* was found only in Polegar Lake. The highest densities for both lakes were observed on the last day of incubation, D= 1,390.05 ind. 100 gDW^{-1} in the oligotrophic lake and D= 74,724.63 ind. 100 gDW^{-1} in the eutrophic lake. Density increased with mass loss (Fig. 4a and 4b).

Despite having a lower density of organisms than the eutrophic lake, the oligotrophic lake exhibited higher diversity (H') and evenness (J') (Fig. 5a and b). In the eutrophic lake, Shannon-Wienner indices ranged from 0.04 to 0.14. The highest index was obtained on the first day of incubation. In the oligotrophic lake, indices ranged from 1.47 to 1.98, and the highest index was obtained on the third day. Evenness followed the same trend as diversity, with the highest values ranging from 0.64 and 0.87 for Polegar Lake, and 0.03 to 0.07 for Biguás Lake (Fig. 5a and 5b). The differences between lakes were significant (H': p=0.0027; J': p=0.0028).

No significant differences in the densities of genera were found among sampling dates in Polegar Lake (F= 0.14; p= 0.96) or Biguás Lake (F= 0.10; p= 0.38). Densities in Biguás Lake did not follow a normal distribution; therefore, total densities between lakes were compared with the non-parametric Mann-Whitney test. The analysis revealed a significant difference (p = 0.025) between the medians that was probably due to the elevated density of the genus *Goeldichironomus*(43.74%) and *Cricotopus* (18.28%) that dominated the samples from Polegar Lake, versus the *Goeldichironomus* (98.95%) and *Chironomus* (0.89%) in samples from Biguás Lake.

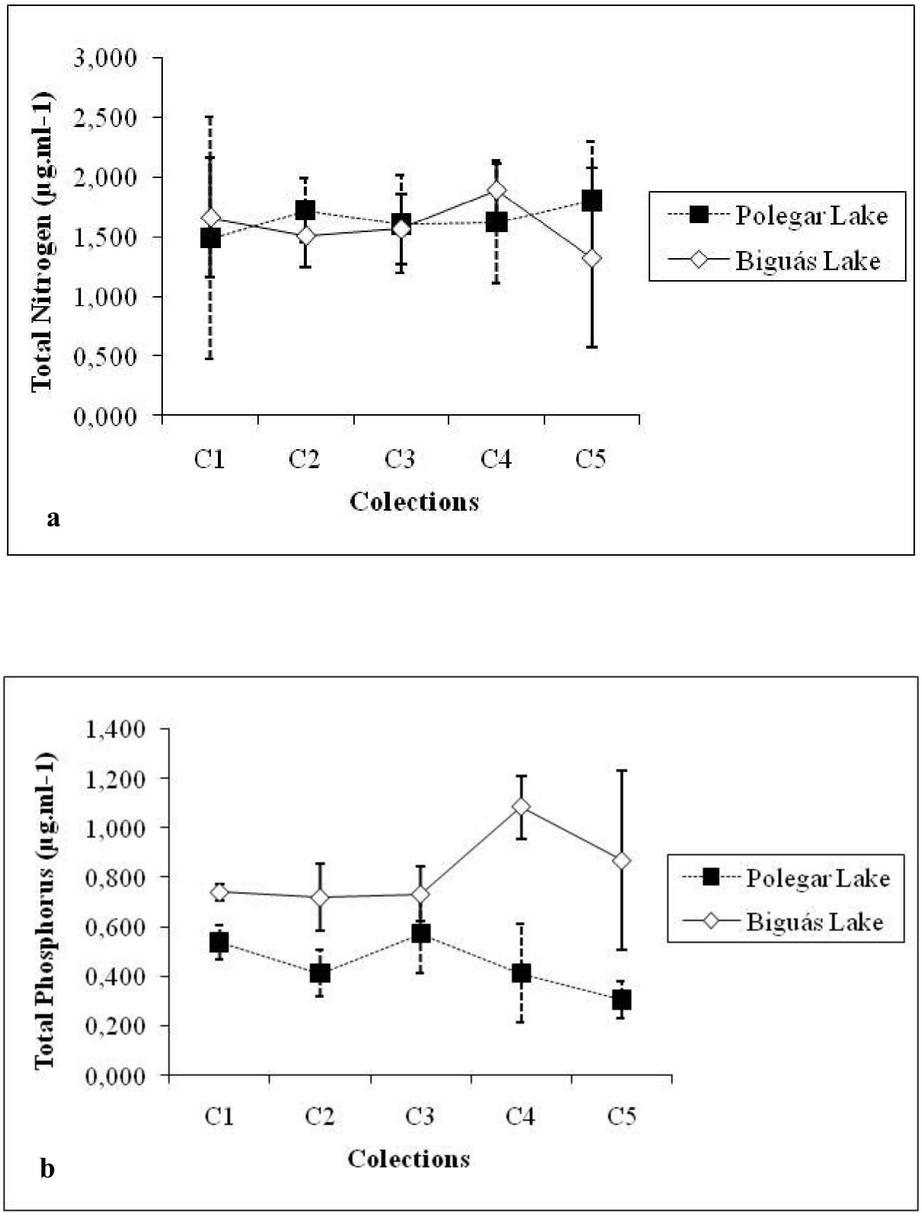

Figure 3. Total nitrogen concentrations (a) and total phosphorus concentrations (b) in *Nymphoide indica* detritus in each sampling (C1, C2, C3, C4 and C5- 1 to 5 collections) during decomposition in two subtropical lakes with distinct trophic characteristics.

Six functional trophic groups were identified among the 13 genera of Chironomidae: collector-gatherers, collector-filterers, shredders, shredder-collectors, predator-collectors, and predators (Table II and III).

Collector-gatherers dominated both lakes, represented mainly by the genus *Goeldichironomus.* In Polegar Lake, an increase in the complexity of the succession of trophic feeding groups of Chironomidae was observed. On the first day of incubation, all trophic groups were present except predators with the number of individuals increasing after the first day of incubation, thus demonstrating a process of ecological succession (Fig. 6a and 6b).

Canonical Correspondence Analysis (CCA) revealed a relationship among the electrical conductivity, total N, total P, pH, and dissolved oxygen of Biguás Lake. Axis 1 explained 82.8% of the total variance, and axis 2 was not considered to be significant. In addition, the genus *Goeldichironomus* is associated with Biguás lake based on the high density that was present, and *Coelotanypus* by its absence in the Polegar Lake (Fig. 7).

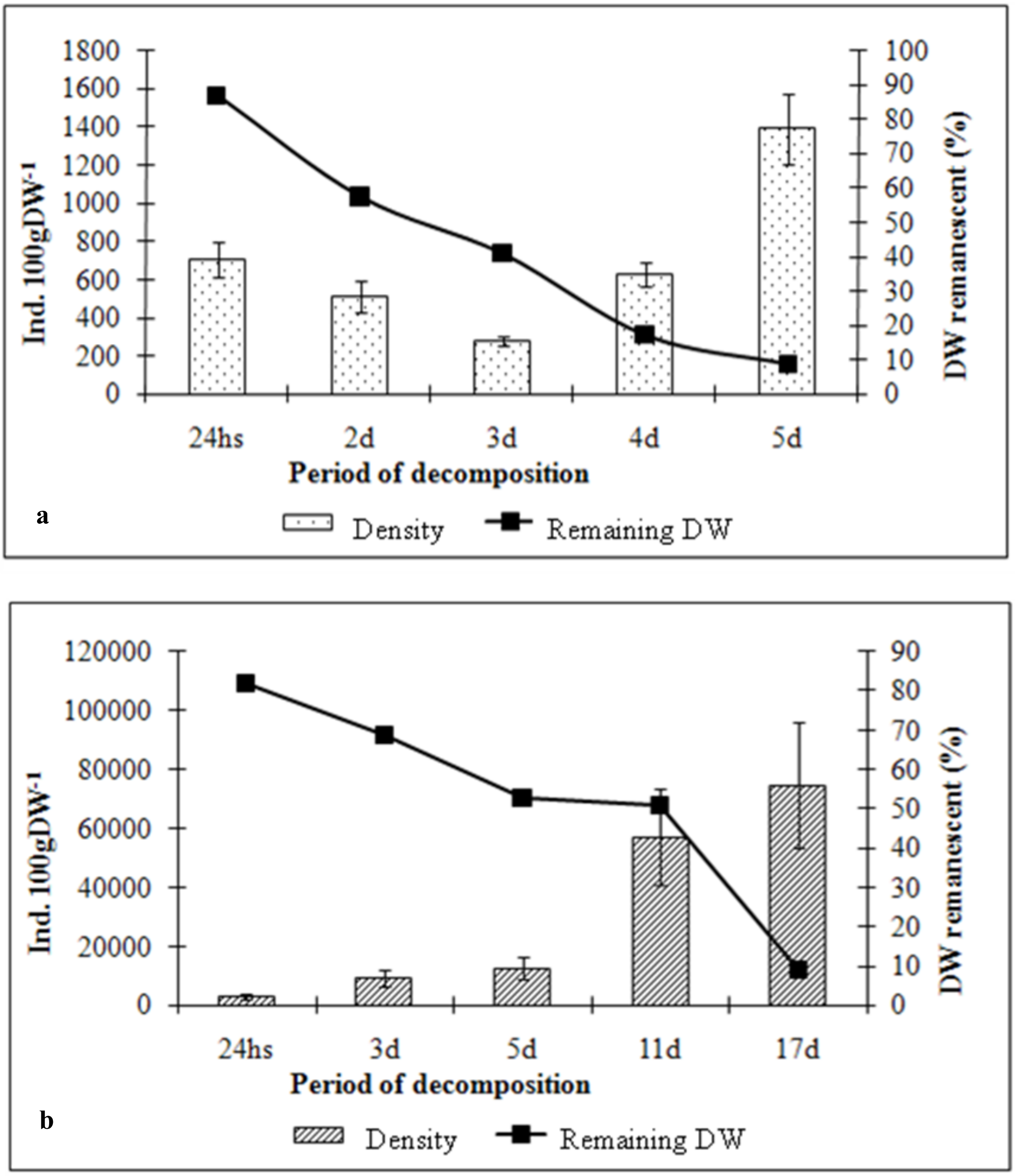

Figure 4. Total density of chironomids associated with mass loss of *Nymphoide indica*: Polegar Lake (a) and Biguás Lake (b).

Discussion

The decomposition process is divided into three stages: leaching of soluble compounds, microbial decomposition, and fragmentation by invertebrates (Gessner *et al.* 1999, Abelho 2001, Graça 2001, Eggert & Wallace 2003, Gonçalves Jr. *et al.* 2006). During this process, a large amount of energy becomes available through the use of the detrital biomass by the organisms responsible for decomposition (bacteria and fungi) and their consumers, recycling the nutrients stored in the detritus (Pieczynska 1993, Gessner 2000). This process is influenced by the physicochemical characteristics of the surrounding water, such as nutrient concentration, temperature, flow rate, and pH (Webster & Benfield 1986, Suberkropp & Chauvet 1995), as well as other factors, such as the chemical composition of the detritus, microorganisms, and invertebrates (Ostrofsky 1997, Suberkropp 1998, Graça 2001).

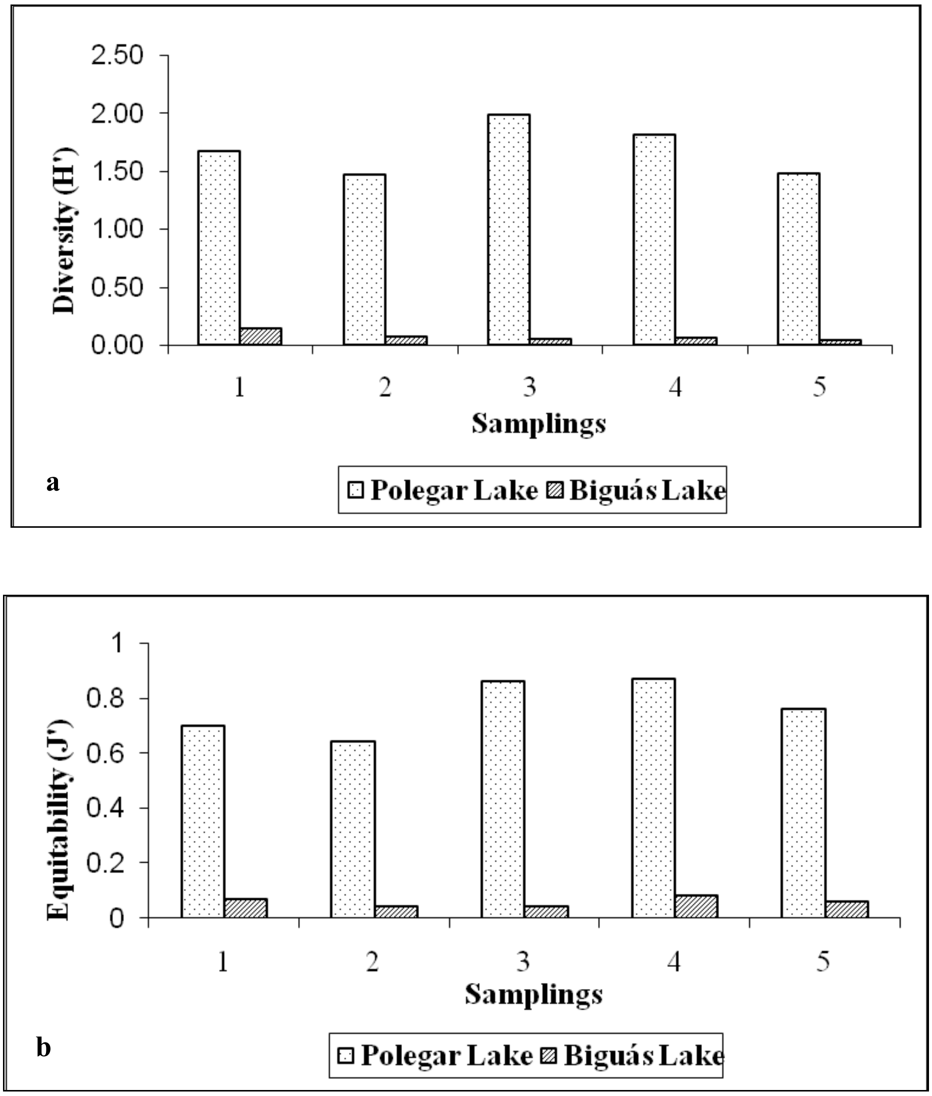

Figure 5. Shannon-Wiener diversity index (a) and Pielou's equitability index (b) in the two study lakes.

Detritus likely represents the dominant energy pathway in most lakes and reservoirs (Webster & Benfield 1986). In general, eutrophied habitats are suitable for detrital colonization by the microbiological and periphytic communities that, according to Graça (2001) and Graça *et al*. (2001), are important in the decomposition process, as they increase the palatability of leaves for consumption by invertebrates, accelerating decomposition. Some authors have suggested that the high concentrations of nitrogen and phosphorus in plants increase the decomposition rate by facilitating microbial colonization (Kaushik & Hynes 1971, Pomogyi *et al.* 1984, Nogueira & Esteves 1993, Brum *et al.* 1999, Brum & Esteves 2001a, b). In addition, these compounds produce a positive effect on the periphytic community (Brum & Esteves 2001a, b), improving the quality of the detritus as a food source for invertebrates. Rejmánková & Houdková (2006) demonstrated in a series of experiments examining the decomposition rate of many enriched wetland systems that the enriched water column promotes the decomposition of plants. Other authors, however, have hypothesized that poorer environments, such as dystrophic lakes and those with pH values closer to acidity, might have a higher mass loss rate of decomposing macrophytes due to the need for faster nutritional turnover to primary producers (Kufel *et al.* 2004). In this study, N and P concentrations were higher at Biguás Lake, but decomposition rate was faster in the oligotrophic lake (Polegar), in support of the Kufel *et al.* (2004) hypothesis.

Table II. Genera of chironomids found in the detritus of *Nymphoides indica in the Polegar Lake*, functional trophic groups (FTG) (P = predator, P/C= predator-collector, C = collector-gatherer, C/F= collector-filter, S = shredder, S/C= shredder-collector) and densities (Ind.100g/PS) (1 to 5 = days of samplings).

Genera Polegar Lake	***FTG***	***Density***					***Total Density***
		1	2	3	4	5	
Chironominae							
Parachironomus	P/C	41,69	15,96	5,10	0	44,64	107.39
Pseudochironomus	C	47,95	37,29	0	0	0	85.24
Aedokritus	-	35,32	20,36	18,35	108,66	0	182.59
Goeldichironomus	C	312,92	288,59	82,00	187,67	469,40	1,340.58
Chironomus	C	0	4,45	47,58	137,90	223,47	413.40
Tanytarsus	C/F	8,90	32,69	17,01	57,92	507,96	624.48
Rheotanytarsus	C/F	24,14	0	11,11	10,55	18,12	63.92
Polypedilum	S	33,18	4,07	7,69	0	62,76	107.70
Orthocladiinae							
Cricotopus	S/C	171,13	82,42	50,10	47,37	0	351.02
Thienemanniella	C	17,97	0	0	0	0	17.97
Tanypodinae							
Labrundinia	P	2,92	4,45	11,22	29,76	0	48.35
Ablabesmiya	P	3,02	20,10	24,47	46,73	63,70	158.02

Table III. Genera of chironomids found in the detritus of *Nymphoides indica in the Biguás Lake*, functional trophic groups (FTG) (P = predator, P/C= predator-collector, C = collector-gatherer, C/F= collector-filter, S = shredder, S/C= shredder-collector) and densities (Ind.100g/PS). (1 to 5 = days of samplings).

Genera Biguás Lake	***FTG***	***Density***					***Total Density***
		1	3	5	11	17	
Chironominae							
Parachironomus	P/C	5,64	6,94	0	0	0	12.58
Pseudochironomus	C	0	3,45	0	0	0	3.45
Aedokritus	-	0	0	0	0	0	-
Goeldichironomus	C	2710,83	8942,34	12595,15	56552,31	74228,59	155,029.22
Chironomus	C	8,58	66,80	99,94	646,09	496,05	1317.45
Tanytarsus	C/F	2,82	0	0	4,97	0	7.79
Rheotanytarsus	C/F	0	3,50	0	10,37	0	13.87
Polypedilum	S	8,57	0	4,44	0	0	13.01
Orthocladiinae							
Cricotopus	S/C	34,72	14,00	0	0	0	48.72
Thienemanniella	C	2,82	0	0	0	0	2.82
Tanypodinae							
Labrundinia	P	0	0	4,82	0	0	4.82
Ablabesmiya	P	0	0	0	4,58	0	4.58
Coelotanypus	P	0	3,50	0	4,58	0	8.08

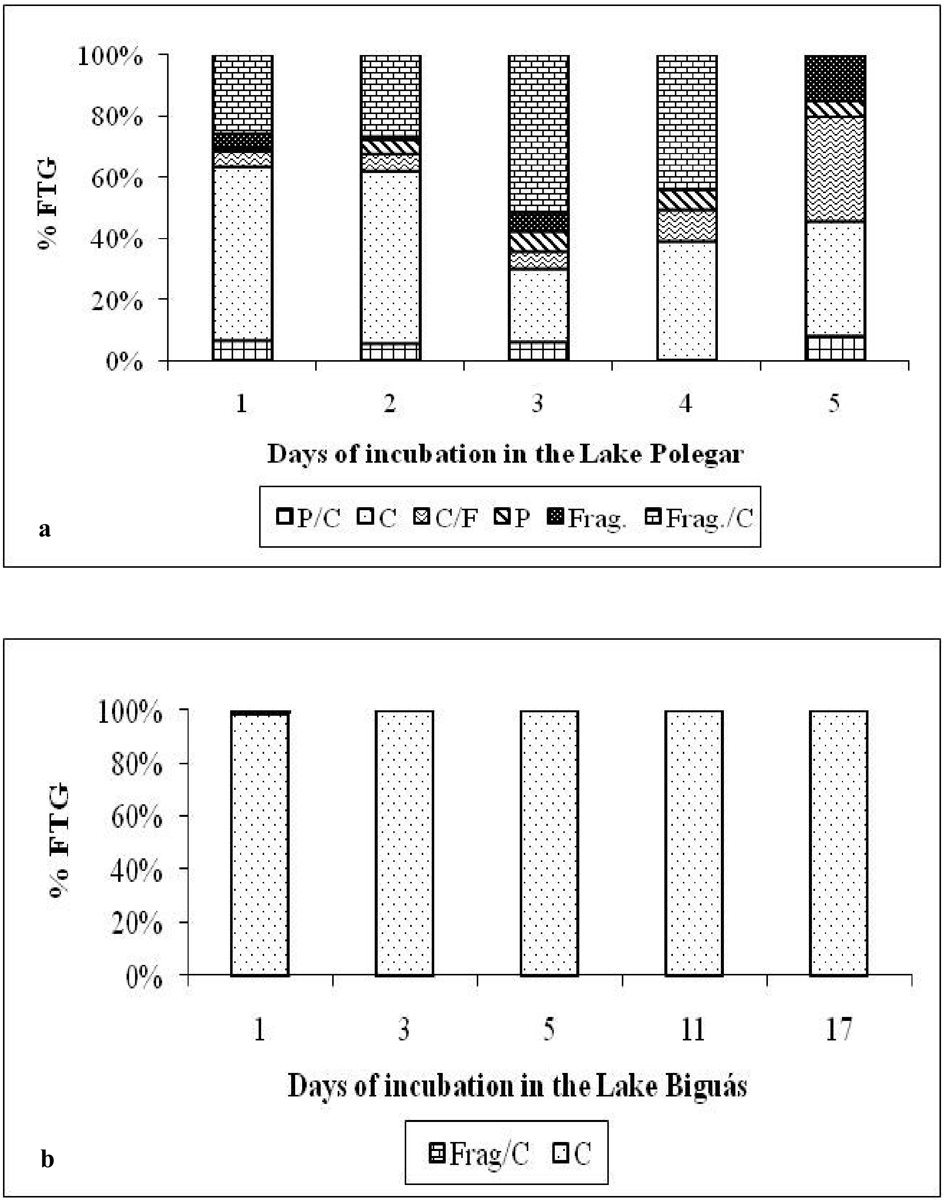

Figure 6. Succession of functional trophic groups (FTG) in *Nymphoide indica* in the two study lakes: (a) Polegar Lake and (b) Biguás Lake. *(P/C = predator-collector; C = collector-gatherer; C/F= collector-filter, P= predator; S = shredder; S/C = shredder-collector).

Some studies have reported that light accelerates the release of organic matter dissolved detritus in the littoral regions of lakes (Mans *et al.* 1998, Kufel *et al.* 2004). In our study, transparency was not analyzed as a variable, but we suggest that it may be one of the factors allowing for the faster decomposition of the detritus of *N. indica*. Although Biguás Lake is shallow, low light levels penetrate the water column, as the transparency in this lake is lower than 0.2 m (Trindade *et al.* 2009). In Polegar Lake, the water column is, by contrast, completely transparent (Furlanetto *et al.* 2008), and we suggest future investigations on light penetration as one of the major factors influencing the speed of decomposition in shallow lakes.

In a study on the colonization by Chironomidae of the detritus of *Nymphaea ampla*, a macrophyte of the same family as *N. indica*, Gonçalves Jr. *et al.* (2003) observed a gradual increase in chironomid larvae; maximum density occurred on the last day of incubation. Our findings also showed this trend, with a gradual increase that peaked on the last day of incubation. According to Kaushik & Hynes (1971) and Smock & Stoneburner (1980), the decomposing leaves have higher nutritional value to invertebrates as decomposition progresses, explaining the inverse relationship between the dry mass remaining of *N. indica* and the density of chironomids in 100 g DW of detritus.

Studies have demonstrated the influence of physical and chemical factors of lakes in the distribution of chironomids. Wright & Burgin (2007) reported a strong influence of pH, electrical conductivity, and geographic localization. In oligotrophic habitats, the decomposing detritus acts as a “resource island” for chironomids, promoting colonization and high diversity (Entrekin *et al.* 2007). In addition, it has been extensively demonstrated that the eutrophication processes of water bodies results in a loss of biodiversity in several groups, including chironomids (Brooks *et al.* 2001) and the dominance of some tolerant taxa. The diversity and equitability indices obtained in our study support these results because Biguás Lake, which is clearly more eutrophied than Polegar Lake, was marked by the strong dominance of the genus *Goeldichironomus*, reflected by low equitability (J’= 0.03) and diversity indices (H’= 0.04) revealed by CCA.

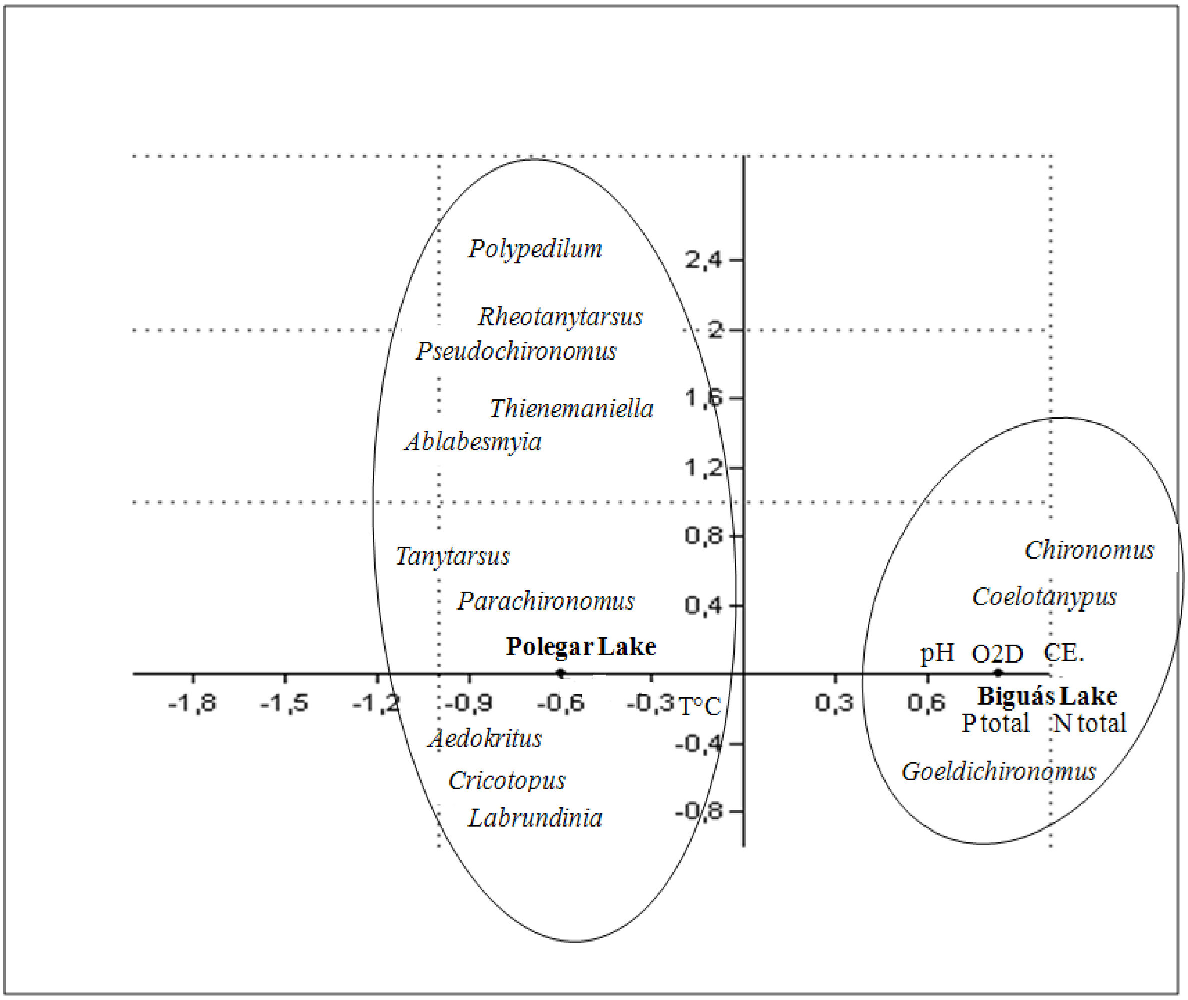

Figure 7. Canonical Correspondence Analysis (CCA) demonstrating the relationship among abiotic variables DO=dissolved oxygen, EC= electric conductivity, Total P= total phosphorus, Total N= total nitrogen) and densiy of Chironomidae genera during decomposition of *Nymphoides indica* in two shallow lakes.

Another factor that might have contributed to the higher decomposition rate in Polegar Lake was the succession of functional groups of genera of chironomids, which was not observed in Biguás Lake. Predators were not observed on the first day of incubation, but they were present during the rest of the experiment. This distribution of invertebrate predators probably depends on fluctuations in the availability of potential prey (Mormul *et al.* 2006). Another very important trophic group in this process is the shredders, as they feed on the decomposing plant and produce fine particulate organic matter particles from coarse detritus, facilitating its use by grazers and collectors (Petersen *et al.* 1989, Malmqvist 1993, Heard & Richardson 1995).

The group of collectors, filters, and predators tend to increase in areas near the margins of lakes. This hypothesis, proposed by Trivinho-Strixino *et al.* (2000), is based on the fact that the accumulation of detritus in aquatic plants may contribute decisively to the presence of chironomid collectors (Mormul *et al.* 2006). In the present study, however, this was not observed because, in both lakes, litter bags were incubated at the margins of the lakes. Filterers and predators were not found in Biguás Lake, suggesting that the absence of succession among FTG was likely caused by the trophic level. This is supported by the fact that organisms are strongly influenced by the physical, chemical and trophic conditions of the habitat (Johnson *et al.* 1995) and are commonly used to examine the structure and functioning of lacustrine ecosystems.

This goal of this study was to examine the decomposition process of aquatic macrophytes and associated organisms in two subtropical shallow aquatic habitats, as regional information on the subject is rare. The results corroborated our hypothesis and demonstrated that the decomposition process of *N. indica*, a common macrophyte in this area, was different in lakes with distinct trophic characteristics, with higher mass loss rate in the oligotrophic habitat. This was reflected in differences in Chironomidae diversity in the lakes and the succession of functional trophic groups in Polegar Lake (oligotrophic), in which certain groups, such as shredders, played important roles in the decomposition process, facilitating the breakdown of the plant material that, in turn, was made available to other organisms.

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