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Diversity and abundance of aquatic macroinvertebrates in a lotic environment in Midwestern São Paulo State, Brazil

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ABSTRACT

This study analyzed the diversity and abundance of aquatic macroinvertebrates community in the Vargem Limpa stream located in Bauru, Midwestern São Paulo State, and characterized the water quality based on biological parameters. The sampling was carried out during the rain season (December, 2004). It was analyzed and identified 3,068 organisms belonging to 9 macroinvertebrate families. The system showed low richness and diversity of organisms in response to water quality.

Keywords: Diversity; richness; bioindicators; ecology.

Diversidade e abundância de macroinvertebrados aquáticos em um ambiente lótico da região centro-oeste do Estado de São Paulo, Brasil

RESUMO

Este estudo analisou a diversidade e abundância da comunidade de macroinvertebrados aquáticos presente no córrego Vargem Limpa, região centro-oeste do Estado de São Paulo, e caracterizou a qualidade das águas, baseado em parâmetros biológicos. As coletas foram realizadas na estação chuvosa (dezembro - 2004). 3.068 organismos pertencentes a 9 famílias de macroinvertebrados foram analisados e identificados. O sistema apresentou baixa riqueza e diversidade de organismos em resposta à qualidade da água do sistema aquático.

Palavras-chave: Diversidade; riqueza; bioindicadores; ecologia.

1. INTRODUCTION

Anthropogenic activities in water bodies (e.g., mining, dam construction, artificial eutrophication, river canalization, and recreation) have caused a number of environmental impacts with negative consequences to water quality. These factors can affect the communities of aquatic organisms leading to loss of diversity and species extinction (Primack and Rodrigues, 2001). The detection of these impacts on streams depends on studies on biological communities, associated to the evaluation of habitat diversity and measurements of abiotic parameters (Pompeu et al., 2005; Casatti et al., 2006).

Biological indicators have the advantage of monitoring water quality over a period of time, providing a more exact measure of anthropogenic effects on aquatic ecosystems, where physical and chemical data provide only momentary evidence (Camargo et al., 2004; Callisto et al., 2001). Freshwater macroinvertebrates have frequently been used in water quality studies as bioindicators. These animals, used in such investigations, offer several benefits including easy identification of high taxonomic levels (such as family) by non-specialists, high sensitivity of a great number of species to environmental stress, a wide distribution in various freshwater habitats, and a relatively sedentary behavior and short life cycle, in comparison to fish, which facilitates the detection of changes over time (Johnson et al., 1993).

The benthic community in lotic environments is represented by various phyla, such as Artropoda (insects, mites and crustaceans), Mollusca (gastropods and bivalves), Anellida (oligochaetes), Nematoda, and Platyhelminthes (Hauer and Resh, 1996). Among benthic macroinvertebrates, insects are noteworthy in terms of diversity and abundance (Lake, 1990). The distribution of these organisms is directly related to water current, quality and availability of food, type of substratum (sandy, stone, wood or aquatic macrophytes), water temperature, and concentrations of dissolved oxygen and hydrogen sulfide (Pamplin et al., 2006).

The present study aims to characterize the water quality of a lotic environment, located in the Midwestern region of São Paulo State (SP), based on biological parameters, including the analysis of the diversity and abundance of aquatic macroinvertebrates.

2. MATERIAL AND METHODS

This study was carried out in the córrego Vargem Limpa, municipality of Bauru (22º 19’18”S and 49º04’13”W), located in the Midwest of São Paulo State (Figure 1). This water body runs through a protected area and receives discharges of domestic and industrial effluents in different points along its course (Figure 2). Sediment samples were collected during the month of December 2004 (rainy season) in 4 sample sites: Point 1 (P1) located inside the perimeter of the city’s botanical garden (JBMB), is a spring system and present many sedimentation areas; Point 2 (P2) is a stretch of lentic character connected to a reservoir within the city’s zoo (PZMB); Point 3 (P3), beside industrial accumulators, shows various sediment deposits due to silting processes;and Point 4 (P4), located in the industrial district of Bauru, receives input domestic sewage and industrial effluents.

A total of 84 samples (3 replicates in each site) were collected during seven days using an Ekman-Birge grab (area of 0.0225 m^2) and immediately fixed in a 10% formalin solution. In the laboratory, the samples were washed using 0.250 mm sieves, sorted and preserved in 70% ethanol. The organisms were subsequently identified, under stereomicroscope, using appropriate literature (Brinkhurst and Marchese, 1989; Merrit and Cummins 1996; Fernandez and Dominguez, 2001) and counted.

The relative participation of each taxon was calculated separately for the four sampling sites. The ecosystem diversity was evaluated through species richness (S), Shannon diversity index (H’), Pielou evenness index (equitability) (J), and Simpson dominance index (D), according to Pinto-Coelho (2002). Pearson’s correlation analyses (Zar, 1974) were performed between association descriptions and the water variables. It was utilized significance level of 5% ($p<0.05$).

The temperature, pH, and electrical conductivity values were determined in situ by mercury thermometer, a Corning – pH 30 meter and a Corning – CD-55 meter, respectively. The oxygen concentration was determined in laboratory by Winkler method (Golterman et al. (1978).

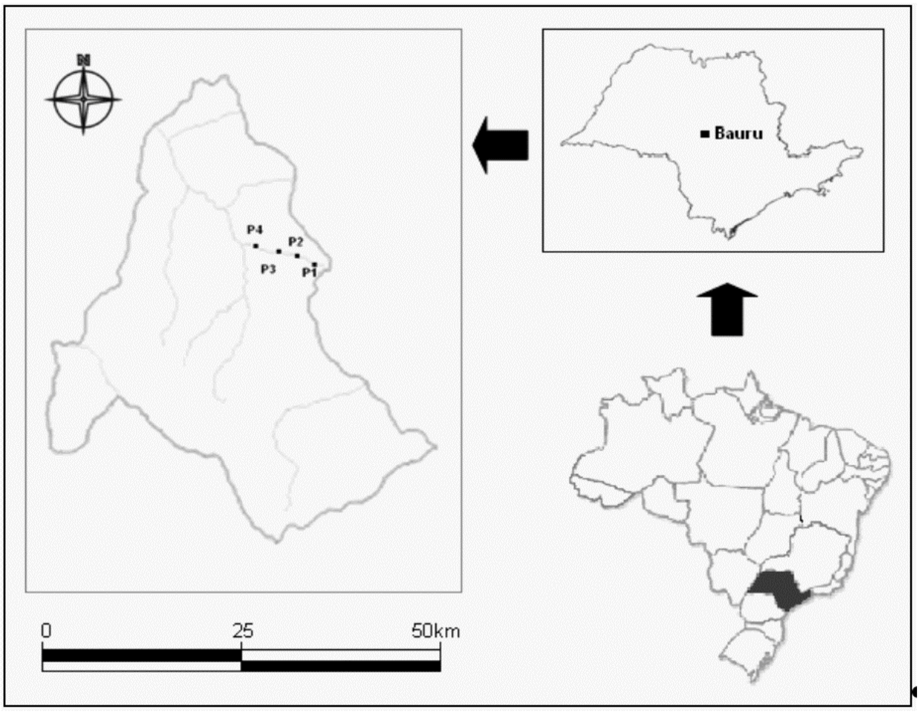

Figure 1. Map of the municipality of Bauru (SP), showing the location of sample sites in the córrego Vargem Limpa area.

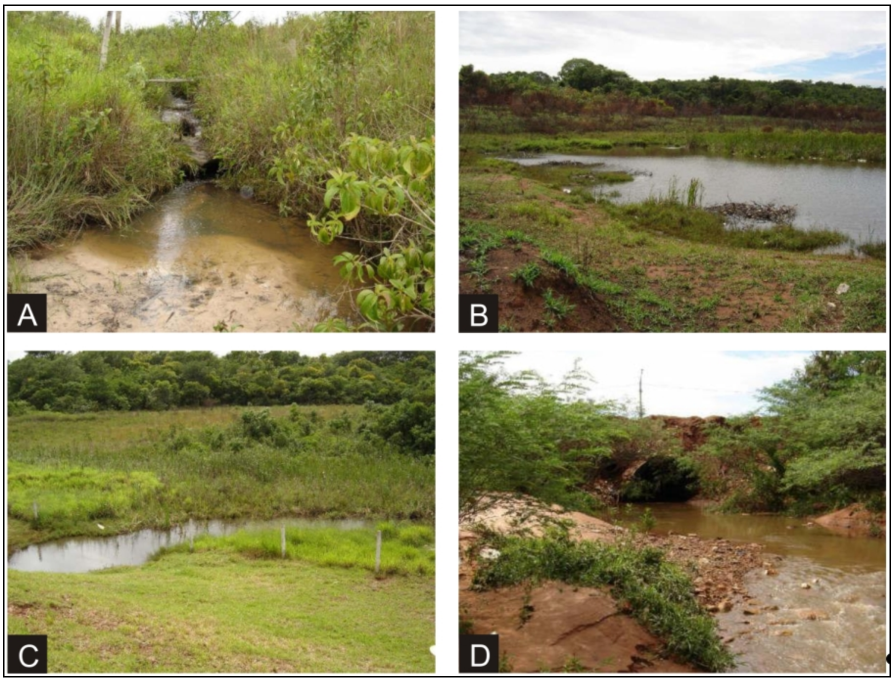

Figure 2. Sampling points of Córrego Vargem Limpa, Bauru (SP): A) Point 1, B) Point 2, C) Point 3, D) Point 4.

3. RESULTS AND DISCUSSION

In this study, 3,068 specimens belonging to 25 macroinvertebrate taxa and 9 families were collected (Table 1). The results indicate a predominance of organisms pertaining to the families Chironomidae and Tubificidae, as well as significant values of Naididae and Glossiphoniidae, in all sampling points. The high densities of these families may indicate an input of organic matter in the system, since they have a distinguished high tolerance to organic enrichment, compared to other organisms (Fusari and Fonseca-Gessner, 2006). In P1, the constant input of allochthonous material from riparian vegetation might be responsible for these values. P2 and P3 receive organic matter from the Zoo's reservoir, derived from the cleaning of the animals' cages. The situation in P4 is probably a consequence of the increase of organic matter due to discharges of domestic sewage.

Within Chironomidae, *Polypedilum* was the dominant genus in P1 and P2 (Table 1). This genus is composed of grazer-collectors (Coffman and Ferrington, 1996) and belongs to a group of psammophilic Chironomidae (Barton and Smith, 1984), generally associated with sandy bottoms. The silting process and formation of sediment deposits in P2 may have contributed to the predominance of this genus. In P3, where the bottom shows similar characteristics as P2, the most abundant genus within the family was *Cladopelma* (10.6%), which is also composed of grazer-collectors, associated with sandy substratum.

Table 1. Absolute abundance (N) and relative abundance (ni) of benthic macroinvertebrates in the four sampling sites along Vargem Limpa stream, in December 2004.

Taxa	**P1**		**P2**		**P3**		**P4**	
	N	**ni**	**N**	**ni**	**N**	**ni**	**N**	**ni**
Diptera								
Chironomidae								
Ablabesmyia	19	4.83	11	0.98	2	0.47	1	0.09
Beardius	1	0.25	1	0.09	1	0.24		
Caladomyia	3	0.76	10	0.89				
Chironomus	2	0.51	1	0.09			437	38.81
Cladopelma					45	10.64		
Clinotanypus					1	0.24		
Corynoneura	1	0.25						
Cricotopus	4	1.02	1	0.09				
Cryptochironomus	1	0.25			6	1.42		
Dicrotendipes			7	0.62				
Endotribelos					1	0.24		
Fissimentum	2	0.51	12	1.07	9	2.13	1	0.09
Harnischia complex	47	11.96	5	0.44				
Lopescladius	1	0.25						
Polypedilum	109	27.74	13	1.15	20	4.73	2	0.18
Tanypus			1	0.09				
Tanytarsus	24	6.11	1	0.09				
Ceratopogonidae	1	0.25		0.00				
Tabanidae			1	0.09				
Tipulidae	2	0.51	1	0.09				
Hirudinea								
Glossiphoniidae	6	1.53	40	3.55	7	1.65		
Psicolidae			1	0.09				
Oligochaeta								
Tubificidae	158	40.20	912	80.99	302	71.39	601	53.37
Naididae	11	2.80	108	9.59	29	6.86	84	7.46
Trichoptera								
Limnephilidae	1	0.25						

Chironomus was the dominant genus in P4 with 38.8% of relative abundance (Table 1). According to Marques et al. (1999), *Chironomus* exhibits high tolerance to eutrophic conditions, showing significant increase in abundance in response to anthropogenic organic enrichment and consequent water quality deterioration, being considered a reliable environmental indicator. The predominance of this genus in P4 may be associated with discharges of domestic sewage, which causes the increase of organic matter and reduction of dissolved oxygen levels, making the environment more adequate for these organisms.

Shannon diversity index values indicated little variation between sampling points (Table 2) displaying an increase only in P1, which can be explained by the relation between richness and relative abundance of macroinvertebrates in this site. In P4, however, the predominance of Tubificidae and *Chironomus* resulted in a smaller diversity and richness.

Table 2. Values of richness (S), number of individuals (N) diversity (H'), equitability (J) and dominance (D) of benthic macroinvertebrates registered along Vargem Limpa stream, in December 2004.

	S	**N**	**H'**	**J**	**D**
P1	18	393	1.71	0.59	0.26
P2	17	1,126	0.81	0.28	0.67
P3	11	423	1.09	0.45	0.53
P4	7	1,126	0.92	0.47	0.44
Total	25	3,068			

Pielou evenness values produced a similar pattern, with the highest values in P1 and the smallest in P4 (Table 2). The high value in P1 can be attributed to the homogenous distribution of individuals among the taxa collected. Simpson's dominance (D) index was highest in P2 (D = 0.67) and lowest in P1 (0.26). The large number of individuals (highest among all four points), mainly belonging to the family Tubificidae, and the low richness, explain these results in P2.

According to Esteves (1998), most aquatic ecosystems exhibit pH values varying from 6 to 8. The pH measured in Vargem Limpa stream ranged from 5.7 to 6.9 (Table 3), characterizing the water system as acidic. This variable is influenced, amongst others, by concentrations of carbon dioxide and organic acids dissolved in the water, which reduce pH.

Table 3. Values of pH, electrical conductivity (CE), water temperature (T) and dissolved oxygen (OD) registered along Vargem Limpa stream, in December 2004.

	pH	**CE (µs/cm)**	**T (ºC)**	**OD (mg/L)**
P1	6.0	35.14	21.64	6.41
P2	5.7	51.57	24.79	2.86
P3	6.3	44.14	23.86	4.88
P4	6.9	312.86	25.07	1.29

The lowest electrical conductivity values were registered in P1 and the highest in P4: 35.14 µs/cm and 312.86 µs/cm, respectively. Electrical conductivity is more influenced by physical (climate, hydrology) and chemical (geology, minerals solubility) factors, as well as anthropogenic impacts (deforestation, silting process), than by biologic factors (Pedrosa and Rezende, 1999). However, high concentrations of decomposing organic matter increase the quantity of ions dissociated in the water, which results in an elevated electrical conductivity such as the values registered in P4, where a large quantity of allochthonous material may have played a significant role (see Table 3). P2 and P3 presented intermediate values, 51.57µs/cm and 44.14 µs/cm respectively, since they have a more restricted access than P4, yet still suffer anthropogenic impact. In addition, P2 is also an area of more intense draught, enhancing the transport of materials from this site to others, resulting in a smaller local conductivity.

Pearson's correlation ($p<0.05$) indicates only positive (significant) correlations between descriptors and physical and chemical parameters (Table 4). Such results suggest that the environmental variables are favoring the fauna in regards to density and composition. Considering the high tolerance of organisms collected in this study to organic matter and the alterations evidenced by physical and chemical variables, Pearson's correlation analysis serves as additional evidence.

Table 4. Significant Pearson correlations (r) between descriptors of benthic macroinvertebrates and environmental variables in Vargem Limpa stream, in December 2004.

Descriptors	**Environmental variables**			
	pH	CE	T°C	OD
Chironomus	0.60	0.60	0.60	0.60
Polypedilum	0.60			
Harnischia				
Cladopelma	0.74	0.74	0.74	0.74
Ablabesmyia				
Tanytarsus				
Fissimentum		0.80	0.80	0.80
Caladomyia		0.79	0.79	0,79
Cryptochironomus	0.89			
Dicrotendipes		0.74	0.74	0.74
Cricotopus				
Beardius				
Clinotanypus	0.74	0.74	0.74	0.74
Corynoneura	0.74			
Endotribelos	0.74	0.74	0.74	0.74
Lopescladius	0.74			
Tanypus		0.74	0.74	0.74
Ceratopogonidae	0.74			
Tabanidae		0.74	0.74	0.74
Tipulidae				
Glossiphoniidae		0.80	0.80	0.80
Psicolidae		0.74	0.74	0.74
Tubificidae	0.80			
Naididae	0.80			
Limnephilidae	0.74			
Richness				
Diversity	0.80			
Equitability	0.60	0.60	0.60	0.60
Dominance	0.60	0.60	0.60	0.60

Dissolved oxygen concentrations (OD) depend on two main factors: water temperature and atmospheric pressure. As temperature and pressure decrease, the water oxygenation increases. OD levels diminish mainly due to consumption by organic matter decomposition, losses to the atmosphere, breathing of aquatic organisms, and metallic ion (iron and manganese) oxidation (Esteves, 1998). The lowest values for this parameter were registered in P4, located in an urban zone, with great alterations in the water's physical and chemical characteristics (Table 3). In contrast, the highest values were registered in P1, where restricted access to the spring, within JBMB, reduces the possibility of human influence.

4. CONCLUSIONS

An overall analysis of the results (physical, chemical, and biological) indicates the predominance of organisms tolerant to organic matter, associated with environmental alterations in the aquatic system, which allow attributing a low quality status for Vargem Limpa stream water. This data reaffirms the importance of using aquatic macroinvertebrates as bioindicators in environmental diagnoses.

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