INFLUENCE OF ENVIRONMENTAL FACTORS ON THE DISTRIBUTION OF FAMILIES OF AQUATIC INSECTS IN RIVERS IN SOUTHERN BRAZIL

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Introduction

The focus of conservation science is changing from protecting individual species and protected areas isolated (POIANI *et al*., 2000) for preservation of whole communities within regions (CHANDY *et al*., 2006). For this, it is necessary to know the structure of communities and how they are influenced by abiotic factors at different scales (regional and local), both on a stretch of one river, as in microbasins, aim of understanding the dynamics of communities in basin as a whole.

Macroinvertebrate communities may be influenced by variables related to either the local spatial scale (eg substrate, water chemistry, habitat conditions) or regional (latitude, biome, continent) (VINSON & HAWKINS, 1996), as well as temporal scales (BROSSE *et al*., 2003), suffering interference of biotic and abiotic variables and their interactions, which determine the structure of the community that is established. A change in one of these factors can influence the composition and distribution of aquatic organisms (WEIGEL *et al*., 2003).

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Studies conducted in different orders rivers show that both the composition and richness increase from the headwater to the mouth of a river, but also the width, depth, temperature and also the production/respiration, which directly influence the composition and distribution of macroinvertebrates (VANNOTE *et al.*, 1980; JACOBSEN, 2004). However, Statzner & Higler (1986) and Statzner *et al.* (1988) support the idea that hydric stress associated with the geomorphology of the stream bed is the main factor structuring lotic communities, and that these factors do not always vary in a predictable way along, so that there is the possibility of finding a pattern in the distribution of macroinvertebrates from the headwater to the mouth. Cornell (1999) argues that processes regional (biogeographic) and historical (evolutionary) scales are probably more important than the interactions between species.

In a study in northern Ecuador, in four microbasins, it was found that when communities of aquatic insects are analyzed along a longitudinal gradient, based on altitudinal zones, the identification to the family level is satisfactory because the same family aquatic insects can occur in different regions, with different influences of abiotic factors. The same is not verified for species that have high turnover in wider ranges (JACOBSEN, 2004). The use of the family level for taxonomic identification can also reduce problems of identifying and subsampling, increasing the reliability and robustness of the patterns revealed in longitudinal and environmental independent gradients of regions (RAHBEK, 1995). Furthermore, in studies in France (BOURNAUD *et al.*, 1996), Denmark (FRIBERG & JACOBSEN, 1997) and in Britain (WRIGHT *et al.*, 1998) it was found that the richness of families of aquatic insects is highly correlated with species richness.

In Brazil, studies on the diversity of benthic macroinvertebrates communities in lotic environments have generally focused on composition and spatial distribution in local scale, i.e., covering a stretch of river or a unique microbasin (e.g. TAKEDA *et al.*, 1991; BAPTISTA *et al.*, 2001; KIKUCHI & UIEDA, 2005; AYRES-PEREZ *et al.*, 2006; BALDAN, 2006; HEPP & SANTOS, 2008; NESSIMIAN *et al.*, 2008; RIBEIRO *et al.*, 2009).

In the state of Rio Grande do Sul, only four studies were conducted along a longitudinal gradient: (i) in the Sinos River basin, for the analysis of water quality through the biomonitoring of aquatic insect communities in three streams second order (BIEGER *et al.*, 2010.); (ii) in sixteen streams without specific hydrologic order (STRIEDER *et al.*, 2006.); (iii) in two microbasins Jacuí River and one in Ibicuí in sites from 1st to 4th orders (SALVARREY *et al.*, 2014) and (iv) in the Ibicuí River basin in four microbasins in sites from 1st to 4th orders, to analyze the distribution of communities of mollusks (FREITAS *et al.*, 2011).

In this context, the aim of this study is to provide information about the spatial composition and structure of aquatic insect community along a longitudinal gradient (from 1st to 4th orders) in four microbasins in southern Brazil.

Materials and Methods

The Ibicuí River basin is located in the Pampa biome, on the western border of the State of Rio Grande do Sul, with 36,397.69 km^2 drainage area, the largest basin of the Uruguay River Basin (www.comiteibicui.com.br – accessed 07.04.2012). The study area covers two of the three morphological units in the Ibicuí River basin is inserted: Planalto da Serra Geral; Depressão Central and grasslands, which dominate this space with the exception of riparian forests along rivers (LETURCQ *et al*., 2012). In plain, is characterized by vegetation consisting of grasses, creeping plants, some trees and shrubs found near watercourses (MARCHIORI, 2002).

The climate in the region is subtemperado with distinct seasons and an annual mean temperature of 18.1 °C to 22 °C and 13 °C the average temperature of the coldest month. Rainfall is well distributed and reaches higher annual values to 1400 mm (MALUF, 2000). Considering this hydric balance, the region is included between sub-humid and humid climate classes (MALUF, 2000).

The economic basis of the region is agriculture, especially the cultivation of rice, which is the main water use (90% of the use of surface water). Water quality is affected by the lack of treatment of domestic and industrial sewage with heavy discharge of organic matter. Addition to agriculture, there are livestock and extraction of sand (www.comiteibicui.com.br – accessed 07.04.2012).

Sampling sites

Sampling was conducted at eight sites in the four microbasins belonging to the Ibicuí River basin: Inhacundá-Caraí Passo (IC), Miracatu-Taquari (MT), Lajeado Grande (LG) and Sanga Santo Antônio (SA) (Figure 1). The MT and IC microbasins are located north of the main channel, with the highest altitudes reaching 285 m to 358 m and the lower altitudes, 145 m to 77 m, respectively. The microbasins LG and SA are located south of the Ibicuí River, with altitudes ranging 48 to 161 and 36 m to 98 m, respectively (Table 1). The longest linear distance is 81 km between the SA1 and MT1 points, and the closest features 7 km between the MT1 and IC1 points.

In each microbasin, sites of orders 1st, 2nd, 3rd and 4th were sampled, with two replications were pooled in a single sample, due to the low N of aquatic insects in each replicate, with four sampling sites per microbasin, totaling 16 sites sampling.

For each site, we measured environmental factors, such as geographic coordinates (UTM) and altitude (m), using GPS, shading, river width, presence of macrophytes and land use, with the help of topographic maps (Table 1).

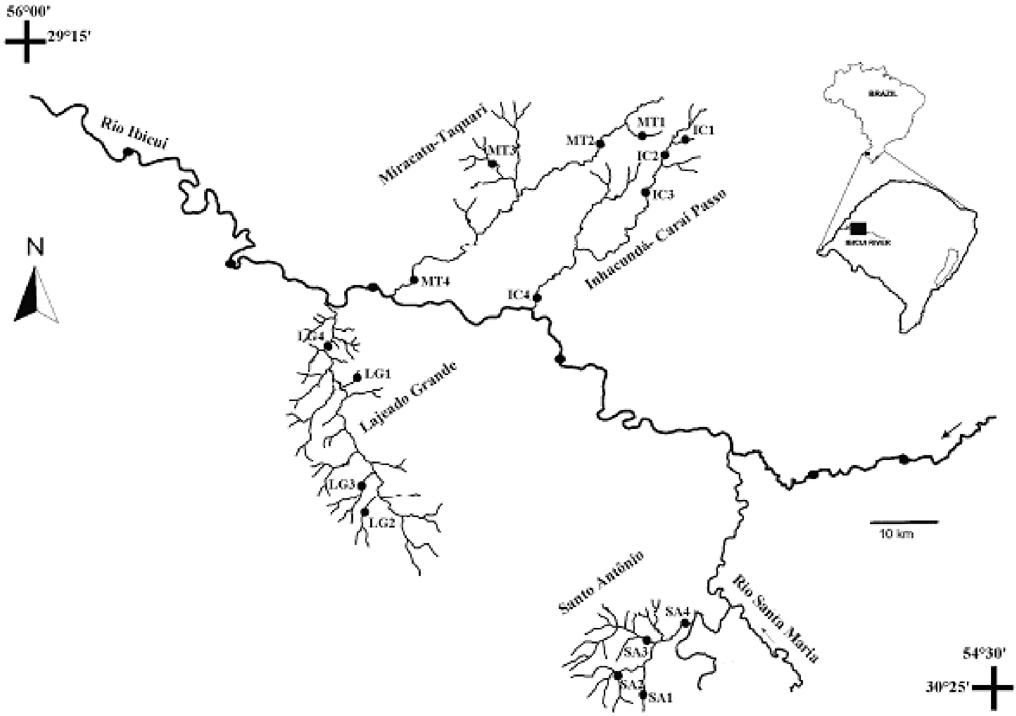


Figure 1. Location of the study area with the four microbasins studied, and sampling sites in the middle course of the Ibicuí River, RS, Brazil.

Sampling and identification

Samplings were conducted in April and May 2010. At each site, macroinvertebrates were collected with the help of a Surber sampler with an area of 30 cm x 30 cm. Individuals collected were preserved in 70% ethyl alcohol in plastic containers and taken to the laboratory for analysis. In the laboratory, individuals were counted and identified to taxonomic family level, with the help of specialized literature (MERRIT & CUMMINS, 1996; BORROR & DELONG, 2005; DOMÍNGUES & FERNÁNDEZ, 2009; MARIANO & FROEHLICH, 2010).

Abiotic factors were also measured, such as: air temperature (°C) water temperature (°C), dissolved oxygen (mg/L), water velocity (m/s), pH, electric conductivity (μS) with the help of thermometer, oximeter, peagameter and conductivity, *in situ*. In addition to these variables, also the concentration of Ca and Fe (mg/L), biochemical oxygen demand (mg/L), chemical oxygen demand (mg/L) were analyzed. Analyses of dissolved solids and chemical oxygen demands and biochemistry were performed at the Laboratory of Rural Water (LAR/UFSM). To analyze the granulometry of the sediments, we used the method of screening based on the Wentworth grain-size scale.

Statistical analysis

The variation between environmental factors (temperature of air and water, dissolved oxygen, calcium, iron, biochemical and chemical oxygen demand, altitude, water velocity, pH, electrical conductivity and grain size) between different orders of rivers and between different microbasins was verified through an analysis of variance (ANOVA).

To verify the existence of significant differences between the abundance of aquatic insects, among the different orders of the sampling sites and also for the richness an Analysis of Variance (ANOVA) was performed. The same was done to verify the existence of significant difference in abundance and richness in communities of aquatic insects between the microbasins.

To evaluate whether the communities that inhabit different orders are similar or if the similarity is greater among microbasins non-metric multidimensional scaling (NMDS) was performed. The Bray-Curtis dissimilarity was used (LEGENDRE & LEGENDRE, 1998).

Canonical Correspondence Analysis CCA was used to detect how much of the variability in taxonomic composition is explained by environmental variables (LEGENDRE & LEGENDRE, 1998). To transform the geographical coordinates in a matrix of Euclidean distance, was made a Principal Coordinate Analysis of Neighbor Matrices (PCNM) (BORCARD *et al.*, 2002). The spatial covariate was used as a spatial matrix in CCA through the manual variable selection (forward stepwise) procedure, whereby only significant variables are added ($p < 0.05$ by Monte Carlo permutation test with 999 randomizations).

The biotic data were logarithmized [log10 (x +1)] and environmental variables (water temperature, dissolved oxygen, biochemical oxygen demand and chemical oxygen demand, altitude, water velocity, conductivity, river width and grain size) were transformed by square root and standardized by standard deviation. Data were logarithmized to stand homoscedastic (SOKAL & ROHLF, 1995). The standardization of environmental data was performed to homogenize the scale of different units of measure included in the environmental matrix (eg, μS for electrical conductivity and mg/L for dissolved oxygen) (CLARKE & GORLEY, 2006).

After the result of the CCA, the partition of variance was applied, with the aim of identify what percentage of variation of environmental, spatial factors and environmental factors and their influence on the structure of aquatic insect community (BORCARD *et al.*, 2002).

Results

Among the environmental factors analyzed (Table 1), only four showed a significant variation between microbasins and a factor ranged between orders of the rivers. The air temperature ranged between MT and SA microbasin (ANOVA, $F_{(3.12)} = 3545$, p=0.040). The water temperature ranged between LG and SA microbasins (ANOVA $F_{(3.12)} = 5.884$, p=0.019) and between MT and SA microbasins (ANOVA $F_{(3,12)} = 5.884$, p=0.014).

The quantity of Fe ranged between microbasins SA and IC, LG and MT (ANOVA $F_{(3.12)}$= 24,658, p=0.001). The biochemical oxygen demand ranged between IC and LG (ANOVA F $F_{(3.12)}$= 5.759, p=0.011). There was no significant difference between the analyzed factors and the orders of the rivers, except the very fine sand factor ranging between 4th order and other (ANOVA $F_{(3.12)}$= 7.312, p= 0.011, 1st order; p= 0.040, 2nd order; p= 0.006, 3rd order).

In total 9,135 individuals were collected, distributed in 26 families of aquatic insects. The microbasin with the highest number of families was Inhacundá-Caraí Passo (IC), with 24 families of aquatic insects, followed by Miracatu-Taquari (MT), with 21 families, Lageado Grande (LG), with 15 families and Santo Antônio (SA) with ten families. There was no significant difference in species richness (Anova, $F_{(3.12)}$= 2.805, p = 0.085) and abundance (Anova, $F_{(3.12)}$= 1.095, p>0.05) between microbasins. When we analyzed the richness and abundance of aquatic insect communities between orders, no significant differences were found (ANOVA, $F_{(3.12)}$= 2.244, p>0.05) and (ANOVA, $F_{(3.12)}$=2.522, p>0.05), respectively. The only family of aquatic insect that occurred in all sampled sites was Chironomidae, followed by Baetidae, which not only occurred in one site. Other families of aquatic insects were also representative as Elmidae, which occurred in 11 of the 16 sites sampled, Calopterygidae and Hidropsychidae that occurred exactly in half of the sites sampled (Table 2).

Table 1. Abiotic factors of the sampling sites and characterization of the Ibicuí River basin: Santo Antônio (SA1, SA2, SA3, SA4), Lajeado Grande (LG1, LG2, LG3, LG4), Inhacundá-Caraí Passo (IC1, IC2, IC3, IC4) and Miracatu-Taquari (MT1, MT2, MT3, MT4).

	SA1	SA2	SA3	SA4	LG1	LG2	LG3	LG4	MT1	MT2	MT3	MT4	IC1	IC2	IC3	IC4
Hydrologic order	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Altitude (m)	98	36	98	96	93	161	117	48	297	145	149	285	358	230	166	77
Shadow (%)	0	0	0	100	0	0	100	0	100	50	100	50	0	50	50	0
Width (m)	5	2	4	7	3	3	3	12	1	5	6	14	1.5	6	8.5	12
Macrophytes	1	1	1	1	1	0	0	0	1	0	0	1	1	0	0	0
Land use	Pasture Plantation	Pasture Plantation	Pasture	Pasture	Plantation	Pasture	Pasture	Pasture	Pasture	Pasture	Pasture	Pasture	Pasture	Pasture	Pasture	Pasture
Latitude (UTM)	6642825.73	6643478.12	6644855.86	6648485.47	6710761.51	6689646.91	6696356.83	6715961.89	6746917.9	6738186.9	6744453.9	6725936.7	6747653.7	6743542.3	6744041.3	6725219.4
Longitude (UTM)	692813.29	690551.1	692600.76	696349.84	643534.77	645577.69	645990.46	640353.84	686713.62	664692.57	663651.56	652730.11	692593.91	688582.33	687169.29	671072.46
Air temp. (ºC)	16.5	16.5	16	17	22	20	22	28	29	24	16.5	32	19	22	23	17
Water temp. (°C)	16.8	16	16	13	21	21	16	23	19	20	21	22	19	20	17.5	20
DO (mg/L)	5.7	7.4	7.16	6.7	6.64	6.43	8.17	5.9	6.96	8.79	7.5	6.7	7.8	8.49	8.96	5.72
Ca (mg/L)	0.9	2.32	7.29	1.29	1.74	0.02	0.02	2.06	0.77	0.84	1.74	0.8	9.1	1.16	4.65	0.77
Fe (mg/L)	1.57	1.94	0.91	0.89	0.03	0.09	0.04	0.04	0.02	0.02	0.01	0.12	0.02	0.02	0.01	0.03
BOD (mg/L)	5	1	8	4	1.75	2	3	3.5	3	4	5.5	4.5	6	8.2	7	11
COD (mg/L)	14	61	254	195	0.9	37	8	28	4	2	40	18	23	34	37	142
Water velocity (m/s)	0	0.3	0.2	0.17	0.16	0.18	0.28	0.17	0	0.4	0	0.4	0.24	0.11	0.4	0.31
pH	6.68	7.2	7.32	7.35	6.12	6.62	7.06	6.92	7.25	6.8	7.13	6.42	6	6.92	6.92	6.82
CE (µS)	16.46	34.23	91.31	46.85	20.67	11.48	11.38	24.46	190.04	20.25	103.5	17.87	26.22	40.28	43.62	18.7
Boulder (%)	0	0	0	0	0	50.95	0	0	33.33	38	64.1	0	61.14	78.2	66.66	0
Cobble (%)	0	0	0	0	0	25.47	5.6	0	4.81	43.25	12.81	0	26.14	8.2	14.26	0
Pebble (%)	50	0	0	0	0	6.11	3.6	0	1.75	0.5	2.5	0	2.6	6.95	1.8	0
Granule (%)	6.9	0	0	0.12	0	5.6	4.72	1.33	9.3	0.35	3	0	4.25	4.7	2.6	0
Very coarse sand (%)	11.85	0.55	1.01	0.12	0	2.16	2.5	3.61	7.4	0.3	3.45	0	2.63	0.8	3	0
Coarse sand (%)	10	1.5	14.1	3.51	0	2.16	6.7	2	4.72	2.2	3.52	0.72	1.7	0.6	5.36	0
Fine sand (%)	13.25	67.07	83.73	83.93	86.85	3.05	72.54	46.85	8.51	10.2	7.75	63.17	0.91	0.4	4.2	70.3
Very fine sand (%)	3.25	24.18	1.01	11.2	7.8	1.4	2.36	33.5	3.8	4.8	1.72	29.72	0.3	0.05	1.25	22.8
Silt (%)	4.75	6.7	0.15	1.12	5.35	3.1	1.98	12.71	26.38	0.4	1.15	6.39	0.33	0.1	0.87	6.9

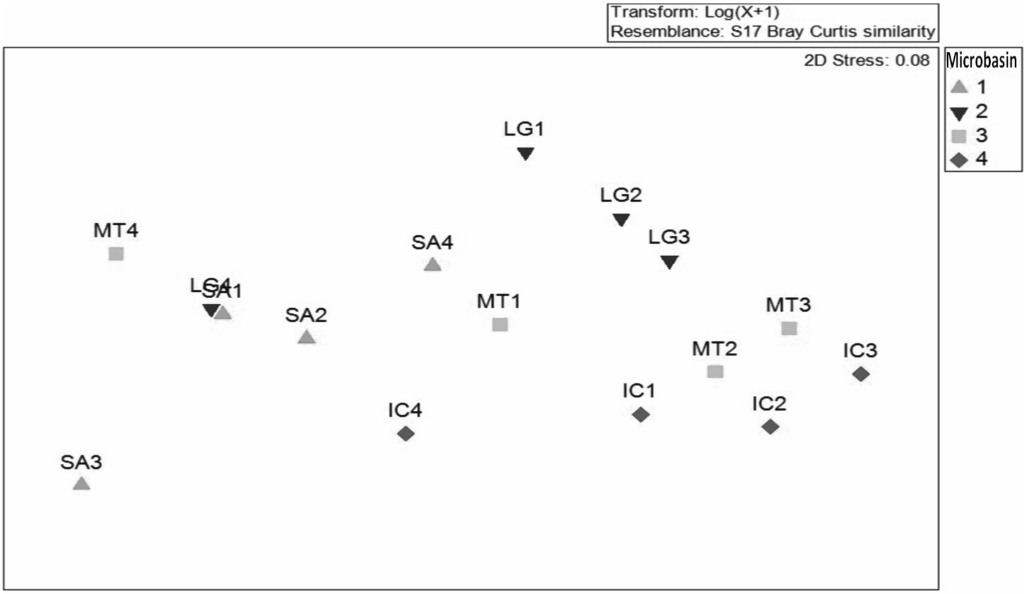
Note: shadowing (0= absent; 50= partly; 100= fully); macrophytes (0= absent; 1= present); Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), DO (dissolved oxygen), Ca= cálcio, Fe= ferro, EC= Electrical Condutivity.

Table 2. Abundance and richness found on the sampling sites in microbasins Santo Antônio (SA), Lajeado Grande (LG), Miracatu-Taquari (MT) and Inhacundá-Caraí Passo (IC)

Order	Family	Abbeviation	SA1	SA2	SA3	SA4	LG1	LG2	LG3	LG4	MT1	MT2	MT3	MT4	IC1	IC2	IC3	IC4	Total
Collembola	Osotomidae	Osot	0	0	0	0	19	1	2	0	0	1	0	0	0	0	0	0	23
Ephemeroptera	Caenidae	Caen	0	1	0	0	0	0	0	0	10	15	26	0	8	76	40	11	187
	Leptohyphidae	Leptoh	0	0	0	0	12	0	15	0	0	325	0	0	5	45	104	0	465
	Leptophlebiidae	Leptop	0	0	0	0	0	0	1	0	2	20	247	0	3	15	74	0	362
	Tricorythidae	Tric	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	4
	Baetidae	Baet	1	4	1	42	17	193	89	1	6	42	42	0	6	95	538	1	1078
Odonata	Calopterygidae	Calo	0	0	0	0	2	1	14	0	2	5	5	0	1	0	5	0	35
	Gomphidae	Gomp	0	0	0	0	0	0	8	0	2	1	0	0	3	3	11	0	28
	Cordullidae	Cord	0	1	0	0	0	0	1	0	0	0	0	0	0	6	1	0	9
	Coenagrionidae	Coen	0	0	0	1	0	0	0	0	0	0	3	0	0	7	26	2	39
	Libellulidae	Libe	0	0	0	0	1	0	2	1	4	16	0	0	0	0	1	0	25
Plecoptera	Perlidae	Perl	0	0	0	2	0	0	0	0	0	0	6	0	1	4	16	0	29
	Grypopterygidae	Gryp	0	0	0	0	0	0	1	0	5	1	2	0	0	0	0	0	9
Megaloptera	Corydalidae	Cory	0	0	0	0	0	0	0	0	0	0	4	0	0	7	4	0	15
Trichoptera	Hydroptilidae	Hydt	0	0	0	0	0	0	0	0	0	13	0	0	17	12	4	0	46
	Philopotamidae	Phil	0	0	0	0	18	0	2	0	0	0	87	0	0	13	71	0	191
	Hidropsychidae	Hidp	0	0	0	5	0	157	20	0	0	5	196	0	3	5	260	0	651
	Polycentropodidae	Poly	0	0	0	0	0	0	0	0	0	0	64	0	0	0	17	0	81
	Helicopsychidade	Heli	0	0	0	0	0	0	0	0	0	0	0	0	0	15	115	0	130
Coleoptera	Dytiscidae	Dyti	1	2	0	1	0	0	0	0	0	0	0	0	0	1	0	3	8
	Elmidae	Elmi	0	1	0	0	1	3	8	0	5	14	16	0	2	11	73	1	135
	Hydrophilidae	Hydr	0	0	2	0	0	0	0	0	0	8	2	0	0	13	8	1	34
	Psephenidae	Psep	0	0	0	0	0	0	0	0	0	1	14	0	25	8	32	0	80
Diptera	Chironomidae	Chir	35	15	2	65	29	1576	198	18	121	916	426	14	364	643	768	149	5339
	Ceratopogonidae	Cera	0	0	0	0	0	1	6	0	1	14	1	0	6	0	67	0	96
	Empididae	Empi	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	5
Abundance			37	24	5	116	99	1936	367	20	148	1397	1141	14	445	979	2239	168	9135
Richness			3	6	3	6	8	8	14	3	9	16	16	1	14	18	22	7	26

Through the NMDS, we obtained a stress value equal to 0.08, representing proper adjustment (KRUSKAL & WISH, 1978), verifying a standard ordering between microbasins, especially in Inhacundá-Caraí Passo and Santo Antônio and between local orders 1st, 2nd and 3rd of microbasins Lageado Grande and Inhacundá-Caraí Passo. We can observe this same pattern between the first three orders of the microbasin Inhacundá-Caraí Passo and the 1st and 2nd orders of the microbasin Miracatu-Taquari. The sites 4th orders have a tendency to stay separate (Figure 2).

Figure 2. NMDS of microbasins.

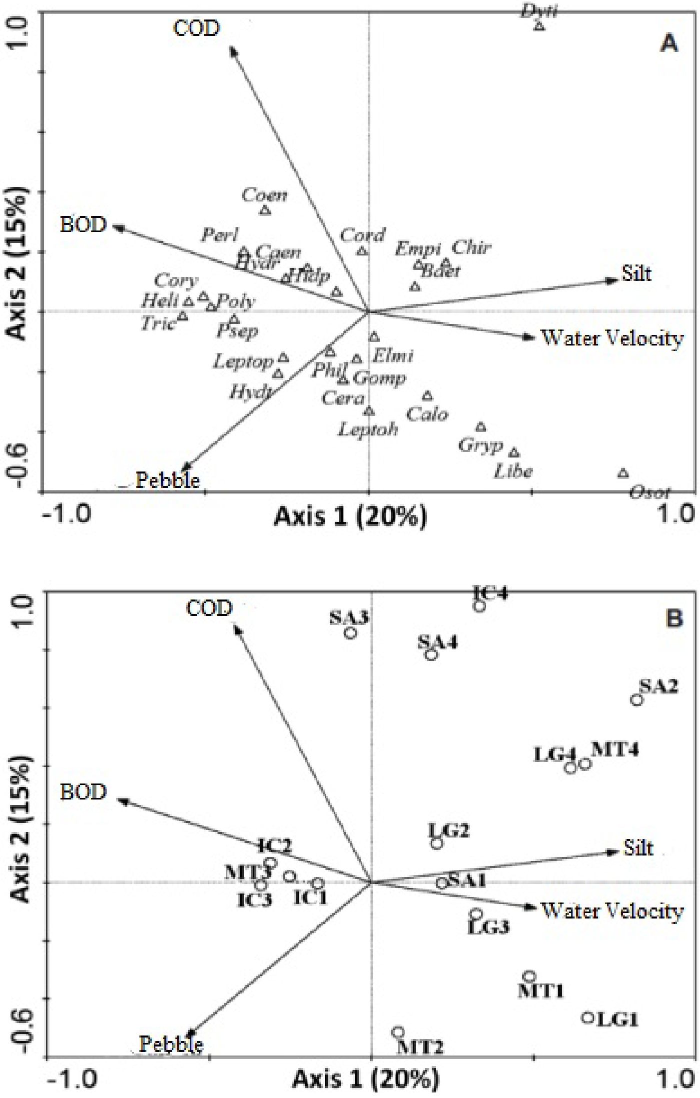


Legend: Sanga Santo Antônio – SA (▲), Lajeado Grande - LG (▼), Miracatu-Taquari – MT (■) and Inhacundá-Caraí Passo – IC (◆). Orders: 1st order= SA1, LG1, MT1, IC1; 2nd order= SA2, LG2, MT2, IC2; 3rd order= SA3, LG3, MT3, IC3; 4th ordem= SA4, LG4, MT4, IC4.

The canonical correspondence analysis (CCA) has revealed that families of aquatic insects are influenced by five environmental variables (Figure 3A): biochemical oxygen demand (BOD), chemical oxygen demand (COD), water velocity, cobble and silt (CCA, F=2.212, p=0.0010). Families are influenced by the BOD: Hydrophilidae, Hydroptilidae, Caenidae, Perlidae, Corydalidae, Helicopsychidae and Polycentropodidae. Cordullidae was influenced by COD, while Baetidae, Chironomidae and Empididae were by silt. The water velocity influenced families: Elmidae, Calopterygidae, Grypopterygidae, Libellulidae and Osotomidae. The pebble influenced families: Philopotamidae, Gomphidae, Ceratopogonidae, Leptophlebiidae and Hydroptilidae.

Similarity occurred in the distribution of the families of aquatic insects when the environmental variables were related to sampling sites through the CCA. These variables that significantly influence differ between microbasins and rivers in different orders. The first axis of the CCA showed positive correlation with silt and water velocity and negative with COD, BOD and pebble. The second axis was positively correlated with silt, COD and BOD and negative correlation with pebble and water velocity. In general, the axis 1 segregated sites of 1st and 3rd orders of the IC, LG and MT microbasins and in total microbasin SA. The axis 2 segregated sites 2nd and 4th orders of microbasins IC, LG and MT (Figure 3B).

Figure: 3A) e 3B): 3A)Canonical correspondence analysis with 26 families and 24 environmental variables. 3B) Canonical correspondence analysis with 16 sampling sites and 24 environmental variables.



Legend: 3A) Osot: Osotomidae, Caen: Caenidae, Leptoh: Leptohyphidae, Leptop: Leptophlebiidae, Tric: Tricorythidae, Baet: Baetidae, Calo: Calopterygidae, Gomp: Gomphidae, Cord: Cordullidae, Coen: Coenagrionidae, Libe: Libellulidae, Perl: Perlidae, Gryp: Grypopterygidae, Cory, Corydalidae, Hydt: Hydroptilidae, Phil: Philopotamidae, Hidp: Hidropsychidae, Poly: Polycentropodidae, Heli: Helicopsychidae, Dyti: Dytiscidae, Elmi: Elmidae, Hydr: Hydrophilidae, Psep: Psephenidae, Chir: Chironomidae, Cera: Ceratopogonidae, Empi: Empididae. 3B) SA: Santo Antônio (1 to 4= 1st, 2nd, 3rd and 4th), LG: Lajeado Grande (1 to 4= 1st, 2nd, 3rd and 4th), MT: Miracatu-Taquari (1 to 4= 1st, 2nd, 3rd and 4th) and IC: Inhacundá-Caraí Passo (1 to 4= 1st, 2nd, 3rd and 4th).

Based on the analysis of partition, it is found that only 31% of the parameters that influence the distribution of aquatic insects were not included in this study, and that the distribution of families of aquatic insects in the Ibicuí River basin is strongly influenced by environmental variables (environment = 44%; spatial = 11%; environment + spatial = 14%).

Discussion

The significant results for the environmental variables between the microbasins studied demonstrate the need to understand that the rivers of the same basin suffer different influences, and evidence the need for analyzes in broader scales, such as microbasins and basins to infer the distribution of aquatic communities. This study demonstrates the need for individual assessments of anthropogenic effects in each microbasin demonstrating the fragility of decisions related to an aquatic system based on studies in different microbasins.

The families richness of aquatic insects found in this study is similar to that found in the Rio das Antas Basin and Gravataí River basin, totaling 25 families of aquatic insects (BUENO *et al.*, 2003), and the Jacutinga River basin, with 27 families (HEPP & SANTOS, 2005). However, the richness found here is higher than that found in the Pelotas River basin and Taquari-Antas basin, with 18 families (BUCKUP *et al.*, 2007), and lower than that found in the Tigre River basin and the Campo River basin, with 32 families (KÖNIG *et al.*, 2008). Thus, the sampling carried out contemplates the results found in other studies, with satisfactory to the conclusions obtained.

The study area is inserted in an environmental matrix that is characterized by agriculture and livestock activities across its extension (Table 1). The land use is strongly related to patterns of large-scale (geographic), but patterns in the levels of land use influence water chemistry and subsequently biotic assemblages (eg communities of invertebrates and fish) (WILEY *et al.*, 1990; ALLAN *et al.*, 1997; TOWNSEND *et al.*, 1997). The community structure can be more sensitive to disturbances of local land use than the ecosystem processes that incorporate both biotic and abiotic components in spatial scales broader (SPONSELLER *et al.*, 2001).

The abundance of organisms collectors at all sampling sites, mainly Chironomidae, indicating an enrichment of organic matter in the sediment (DÉVAI, 1990). The entry of particulate organic matter depends of place characteristics and riparian vegetation, while the hydrological regime (which affects the distribution of sediment and channel conditions) is the result of regional climate and geology (ALLAN & JOHNSON, 1997). The Baetidae family is known for its ability to colonize and presents rapid growth (CALLISTO *et al.*, 2001), which makes possible its presence in water bodies with different land uses.

The larvae and adults of Elmidae are common in regions of high water velocity and high oxygen content (BRIGHAM & WHITE, 1996), this aspect may explain its occurrence in the sampling sites. In this study, Elmidae was correlated with the water velocity and amount of pebble. Calopterygidae presented distribution in temperate and tropical environments and was present in 65% of sampling sites (CÓRDOBA-AGUILAR

& CORDERO-RIVERA, 2005). Studies indicate that the adaptations of the larvae are related to biotic and abiotic factors (CORBET, 1999). Hydropsychidae can also be considered of high environmental tolerance (BUSS *et al.*, 2002), and occurs in most studies with biomonitoring, such as Biasi *et al.* (2008) and Hepp & Santos (2009).

The microbasin Inhacundá-Caraí Passo was presented the highest richness. However there was no significant difference between the number of families present with other microbasins. In cluster analysis it is found that this microbasin is separated from the others, probably by higher levels of dissolved oxygen and water velocity. In addition to a neutral at all the sampling sites, and availability of refuge, with the presence of boulder and pebble. Greater abundance and richness found in areas with currents have already been widely discussed in the literature (ALLAN & CASTILLO, 1995; UIEDA & GAJARDO, 1996), for environments with rapid flow generally have more oxygen and food availability (MERRITT & CUMMINS, 1996).

There was a separation between microbasins and between sites from 1st to 3rd order with the 4th order based on NMDS. The components and processes that occur in a river can be seen as part of an interconnected system (VANNOTE *et al.*, 1980; CORKUM, 1989). Most studies have assumed, at least implicitly, that local patterns are primarily determined by local processes (PALMER *et al.*, 1996).

In the present study, local rivers of orders intermediate would provide the presence a greater abundance of organisms, mainly local first order. This pattern could be explained by the presence of macrophytes at all sites of first orders, and this vegetation hosts a community of insects varied and abundant due to support conditions that provide (ROSINE, 1955; GLOWACKA *et al.*, 1976; MASTRANTUONO, 1986).

The segregation of the microbasins in this study also occurred in the Yakima River basin in the United States in 60 sites distributed in stretches from 1st to 6th order (CARTER *et al.*, 1996). This distribution of species correlated with environmental variability and not the order of the rivers (CARTER *et al.*, 1996). The same pattern was found for Boyero (2003), in two basins in central region of Spain, and Donald & Anderson (1977), in Canada, where the richness varied considerably among microbasins. The larger the scale of the study, the environment is more heterogeneous (FORMAM & GODRON, 1986), and spatial heterogeneity in rivers is complex and evident when examining multiple spatial scales (SCHLOSSER, 1991).

Among the environmental variables, pebbles and silt influenced the distribution of families of aquatic insects in the Ibicuí River basin. These variables were related to microbasins and not the orders of rivers. The texture, the degree of compaction, particle size and surface area of the sediment may influence the composition and abundance of species (NAKAMURA & KIKUCHI, 1996). Although the composition of the substrate is similar within each microbasin, it appears that the water velocity also varies and is determinant in the distribution of families. The velocity of the water exerts a direct physical force to organisms, but this variable also affects other factors within the river as substrate composition, distribution of nutrients and oxygen content (CORKUM, 1989; WIBERG-LARSEN et al., 2000). Some environmental variables such as nutrients, sediment and hydrology are more influenced by regional-scale features, while others are more controlled variables at the local scale (eg vegetation cover on a site) (ALLAN *et al.*, 1997).

Addition to the importance of the substrate as habitat, as protected from currents and predators (ALLAN & CASTILLO, 1995), deposition of fine sediments, in the case of silt, often due to human activities, can have major consequences for aquatic organisms (LUEDTKE & BRUSVEN, 1976; NEWCOMBE & MACDONALD, 1991). In Trichoptera, Hydropsychidae mainly for family, fine sediment is deposited on the nets of captures produced by these individuals, causing damage and increasing energy expenditure for maintenance and reconstruction (STRAND & MERRIT, 1997).

Biochemical oxygen demand and chemical oxygen demand were decisive factors for the distribution of families of aquatic insects in the Ibicuí River basin. Larsen *et al.* (2009) found that BOD values are greater in pastures with lower richness of aquatic insects, and small variations in this parameter are sufficient to affect the community of these individuals (CLEWS & ORMEROD, 2008). In the present study, the BOD influenced the distribution of aquatic insects in the Inhacundá-Caraí Passo basin, in sites of 1st, 2nd and 3rd order, and the Miracatu-Taquari basin in site of 3rd order.

The chemical oxygen demand is negatively related to the distribution of aquatic insects in sites of 1st and 3rd order microbasin in the Lageado Grande and sites of 1st and 2nd order in microbasin Miracatu-Taquari. The COD is directly related to the presence of untreated effluents in water bodies (ALLAN & CASTILLO, 1995; PIEDRAS *et al.*, 2006). In relation to eutrophication, some macroinvertebrates feature sensitivity (BACEY & SPURLCK, 2007) while others have a high tolerance, an increase of abundance in their communities as a response to organic enrichment caused by human activity (MARQUES *et al.*, 1999; CALLISTO *et al.*, 2005). In addition, the study conducted in microbasins with naturally acidic waters in New Zealand, was also not found correlation between the variables richness and pH (WINTERBOURN & COLLIER, 1987).

Through the partition observe the interaction of spatial and environmental factors explained only 14% of the distribution of families of aquatic insects, and spatial, only 11% and the environmental variables that most influence (44%) along the Ibicuí River basin. Although some studies have shown that landscape factors such as geology and surface area or geographic factors (latitude and distance of sampling sites in the river) are as important as the physical and chemical characteristics of the river (e.g. CORKUM, 1989; LAMMERT & ALLAN, 1999), the present study these variables were less explanatory.

Overall, the geographic distance also contributes to the increased diversity (MYKRÄ *et al.*, 2007), such that, in the Ibicuí River basin, the greater the geographical distance between microbasins (e.g. SA and MT), the greater the possibility of increasing the occurrence of families of aquatic insects. The effect of geographic distance appears at small spatial scales (DIXO & VERDADE, 2006), as in Miracatu-Taquari and Inhacundá-Caraí Passo microbasins that even nearby showed some differentiation in the richness and occurrence of families of aquatic insects. Studies have shown that factors at large scales can excellent predictors of community structure (e.g. CORKUM, 1989; RICHARDS *et al.*, 1996). However, little attention has been given to the relative influence of environmental variables measured at different spatial scales on local diversity of aquatic macroinvertebrates

(VINSON & HAWKINS, 1998). Disregarding the spatial scale may arise ecological incorrect conclusions (WIENS *et al.*, 1987; THOMAS & TAYLOR, 1990). The analysis in broader scales are a promising approach to discovery of patterns in the distribution families and aquatic insects which results at a local should not be extrapolated to others.

References

ALLAN, J.D. & CASTILLO, M.M. **Stream ecology: structure and function of running waters**. London: Chapman & Hall, 1995. 388 p.

ALLAN, J.D. & JOHNSON, L.B. Catchment-scale analysis of aquatic ecosystems. **Freshwater Biology**, v. 37, p. 107-111, 1997.

ALLAN, J.D., ERICKSON, D.L. & FAY, J. The influence of catchment land use on stream integrity across multiple spatial scales. **Freshwater Biology**, v. 37, n. 1, p. 149-161, 1997.

AYRES-PERES, L., SOKOLOWICZ, C.C. & SANTOS, S. Diversity and abundance of the benthic macrofauna in lotic environments from the central region of Rio Grande do Sul State, Brazil. **Biota Neotropica**, v. 6, n. 3, p. 1-10, 2006.

BACEY, J. & SPURLOCK, F.F.F. Biological of urban and agricultural streams in the California Central Valley. **Environmental Monitoring and Assessment**, v. 130, p. 483-493, 2007.

BALDAN, L.T. **Composição e diversidade da taxocenose de macroinvertebrados bentônicos e sua utilização na avaliação de qualidade de água no Rio de Pinto Morretes, Paraná, Brasil**. Dissertação (Mestrado em Ecologia e Conservação) – Universidade Federal do Paraná, Curitiba. Dados não publicados, 2006.

BAPTISTA, D.F., DORVILLÉ, L.F.M., BUSS, D.F. & NESSIMIAN, J.L. Spatial and temporal organization of aquatic insects assemblages in the longitudinal gradient of a tropical river. **Revista Brasileira de Biologia**, v.61, n. 2, p. 295-304, 2001.

BIASI, C., MILESI, S.V., RESTELLO, R.M. & HEPP, L.U. Ocorrência e distribuição de insetos aquáticos (Ephemeroptera, Plecoptera, Trichoptera) em riachos de Erechim/RS. **Revista Perspectiva**, v. 32, p. 171-180, 2008.

BIEGER, L., CARVALHO, A.B.P., STRIEDER, M.N., MALTCHIK, L. & STENERT, C. Are the streams of the Sinos River basin of good water quality? Aquatic macroinvertebrates may answer the question. **Brazilian Journal of Biology**, v. 4, n. 70, p. 1207-1215, 2010.

BORCARD, D., LEGENDRE, P. & DRAPEAU, P. Partialling out the spatial component of ecological variation. **Ecology**, v. 73, p. 1045-1055, 2002.

BORROR, D.J. & DELONG, D.M. **Introduction to the Study of Insects.** 7.ed. Thomson Brooks/ Cole, 2005. 864p.

BOURNAUD, M., CELLOT, B., RICHOUX, P. & BERRAHOU, A. Macroinvertebrate community structure and environmental characteristics along a river: congruity of patterns for identification to species or family. **Journal of the North American Benthological Society**, v. 15, n. 2, p. 232-253, 1996.

BOYERO, L. Multiscale patterns of spatial variation of stream macroinvertebrate communities. **Ecological Research**, v.18, p. 365-379, 2003.

BROSSE, S., ARBUCKLE, C.J. & TOWNSEND, C.R. Habitat scale and biodiversity: influence of catchment, stream reach and bedform scales on local invertebrate diversity. **Biodiversity and Conservation**, v. 12, p. 2057- 2075, 2003.

BUCKUP, L., BUENO, A.A.P., BOND-BUCKUP, G., CASAGRANDE, M. & MAJOLO, F. The benthic macroinvertebrate fauna of highland streams in southern Brazil: composition, diversity and structure. **Revista Brasileira de Zoologia**, v. 24, n. 2, p. 294-301, 2007.

BUENO, A.P., BOND-BUCKUP, G. & FERREIRA, B.D.P. Estrutura da comunidade de invertebrados bentônicos em dois cursos d'água do Rio Grande do Sul, Brasil. **Revista Brasileira de Zoologia**, v. 20, n. 1, p. 115-125, 2003.

BUSS, D.F., BAPTISTA, D.F., SILVEIRA, M.P., NESSIMIAN, J.L. & DORWILLÉ, L.F. Influence of water chemistry and environmental degradation on macro invertebrate assemblages in a river basin in southest Brazil. **Hidrobiologia**, v. 481, p. 125-136, 2002.

CALLISTO, M., MORETTI, M. & GOULART, M. Macroinvertebrados bentônicos como ferramenta para avaliar a saúde de riachos. **Revista Brasileira de Recursos Hídricos**, v.6, n. 1, p. 71-82, 2001.

CALLISTO, M., GONÇALVES, J.F. & MORENO, P. **Invertebrados Aquáticos como Bioindicadores**. In: GOULART, E.M.A. (Ed.). Navegando o Rio das Velhas das Minas Gerais. Belo Horizonte: UFMG, 2005.

CARTER, J.L., FEND, S.V. & KENNELLY, S.S. The relationships among three habi-tat scales and stream benthic invertebrate community structure. **Freshwater Biology**, v. 35, p. 109-24, 1996.

CHANDY, S., GILBSON, D.J. & ROBERTSON, P.A. Additive partitioning of diversity across hierarchical spatial scales in a forest landscape. **Journal of applied ecology**, v. 43, p. 729-801, 2006.

CLARKE, K.R. & GORLEY, R.N. **Primer v.6: User Manual/Tutorial**. PRIMER-E, Plymouth, UK, 2006.

CLEWS, E. & ORMEROD, S.J. Improving bio-diagnostic monitoring using simple combinations of standard biotic indices. **River Research and Applications**, in press, 2008.

CORBET, P.S. **Dragonflies: Behaviour and ecology of Odonata**. Essex: Harley Books, 1999. 829p.

CÓRDOBA-AGUILAR, A. & CORDERO-RIVERA, A. Evolution and ecology of Calopterygidae (Zygoptera: Odonata): status of knowledge and research perspectives. **Neotropical Entomology**, v. 34, n. 6, p. 861-879, 2005.

CORKUM, L.D. Patterns of benthic in-vertebrate assemblages in rivers of north-western North America. **Freshwater Biology**, v. 21, p. 191-205, 1989.

CORNELL, H.V. Unsaturation and regional influences on species richness: a review of the evidence. **Ecoscience**, v. 6, p. 303-315, 1999.

DEVÁI, G. Ecological background and importance of the change of Chironomid fauna in shallow Lake Balaton. **Hidrobiologia**, v. 191, p. 189-198, 1990.

DIXO, M. & VERDADE, V.K. Leaf litter herpetofauna of the Reserva Florestal de Morro Grande, Cotia (SP). **Biota Neotropica**, v. 6, n. 2, 2006.

DOMINGUEZ, E. & FERNÁNDEZ, H. **Macroinvertebrados bentônicos sudamericanos: sistemática y biología**. Tucumán: Fundación Miguel Lillo, 2009. 656p.

DONALD, D.B. & ANDERSON, R.S. Distribution of the stoneflies (Plecoptera) of the Waterton River drainage, Alberta, Canada. **Syesis**, v. 10, p. 11-20, 1977.

FORMAN, R.T.T. & GODRON, M. **Landscape Ecology**. Wiley & Sons. New York, 1986. 619p.

FREITAS, S.L., MARTELLO, A.R. & KOTZIAN, C.B. **Influência da ordem e da microbacia, e de alguns fatores ambientais de escala local, na estrutura e na distribuição espacial de comunidades de moluscos**. Trabalho de Conclusão de Curso. Universidade Federal de Santa Maria – Dados não publicados, 2011.

GLOWACKA, I., SOSZKA, G.J. & SOSZKA, H. **Invertebrates associated with Macrophytes. In: Selected problems of lake littoral ecology**. Widawnictwa Uniwersytetu Warszawskiego, Warszawskiego, Warszawa, p. 97-122, 1976.

HEPP, L.U. & SANTOS, S. Estrutura trófica de invertebrados aquáticos no Rio Jacutinga. **Revista Perspectiva**, v. 105, n. 29, p. 69-74, 2005.

HEPP, L.U. & SANTOS, S. Benthic communities of streams related to different land uses in a hydrographic basin in southern Brazil. **Environmental Monitoring and Assessment**. 2008. [doi: 10.1007/s10661-008-0536-7]

HEPP, L.U. & SANTOS, S. Benthic communities of streams related to different land uses in a hydrographic basin in southern Brazil. **Environmental monitoring and Assessment,** v. 157, p. 305-318, 2009.

JACOBSEN, D. & FRIBERG, N. **Macroinvertebrate communities in Danish streams: the effect of riparian forest cover. Freshwater Biology -Priorities and Development -** in Danish Reserch Gad, Kobenhavn. (SAND-JENSEN, K. & PEDERSEN. 0. eds.). GEC Gad Publishers Ltd. DK-1161. Copenhagen., pp: 208-222, 1997.

JACOBSEN, D. Contrasting patterns in local and zonal family richness of stream invertebrates along an Andean altitudinal gradient. **Freshwater Biology**, v. 49, p. 1293-1305, 2004.

KIKUCHI, R.M. & UIEDA, V.S. Composição e distribuição dos macroinvertebrados em diferentes substratos de fundo de um riacho no município de Itatinga, São Paulo, Brasil. **Entomologia y Vectores**, v. 12, n. 2, p. 193-231, 2005.

KÖNIG, R., SUZIN, C.R.H., RESTELLO, R.M. & HEPP, L.U. Qualidade das águas de riachos da região norte do Rio Grande do Sul (Brasil) através de variáveis físicas, químicas e biológicas. **PanAmerican Journal of Aquatic Sciences**, v. 3, p. 84-93, 2008.

KRUSKAL, M.A. & WISH, M. **Multidimensional scaling**. Beverly Hills: Sage Publication, 1978.

LAMMERT, M & ALLAN, J.D. Assessing biotic integrity of streams: Effects of scale in measuring the influence of land use/ cover and habitat structure on fish and macroinvertebrates. **Environmental Management**, v. 23, p. 257-270, 1999.

LARSEN, S., VAUGHANI, P. & ORMEROD, S.J. Scale-dependent effects of fine sediments on temperate headwater invertebrates. **Freshwater Biology**, v. 54, p. 203-219, 2009.

LEGENDRE, P. & LEGENDRE, L. **Numerical ecology**. 2.ed. Amsterdam: Elsevier, 1998.

LETURCQ, G., LAURENT, F. & MEDEIROS, R. **Perception et gestion de l'érosion et des ressources en eau par les agriculteurs et les éleveurs du bassin versant de l'ibicuí (RS, Brésil).** Confins [Online], 4 | 2008. Disponível em: <http://confins.revues.org/index4793.html>. Acesso em: 19 de abril de 2012.

LUDTKE, R.L. & BRUSVEN, M.A. Effects of sand sedimentation on colonization of stream insects. **Journal of the Fisheries Research Board of Canada**, v. 33, p. 1881-1886, 1976.

MALUF, J.R.T. Nova classificação climática do Estado do Rio Grande do Sul. **Revista Brasileira de Agrometereologia**, v. 8, n. 1, p.141-150, 2000.

MARCHIORI, J.N.C. **Fitogeografia do Rio Grande do Sul. Enfoque Histórico e Sistemas de Classificação**. Porto Alegre: EST Edições, 2002. 118p.

MARIANO, R. & FROEHLICH, C.G. Ephemeroptera. In: **Guia on-line: Identificação de larvas de Insetos Aquáticos do Estado de São Paulo**, 2010.

MARQUES, M.M.G.S.M., BARBOSA, F.A.R. & CALLISTO, M. Distribution and abundance of Chironomidae (Diptera, Insecta) in an impacted watershed in south-east Brazil. **Revista Brasileira de Biologia**, v. 59, n. 4, p. 553-561, 1999.

MASTRANTUONO, L. Community structure of the zoobentos associated with submerged macrophytes in a eutrophic Lake Nemi (Central Italy). **Bolletino di Zoologia**, v. 53, p. 41-47, 1986.

MERRITT, R.W. & CUMMINS, K. **An introduction to the aquatic insects of North America**. 3.ed. Dubuque: Kendall/Hunt, 1996. 862p.

MYKRÄ, H., HEINO, J. & MUOTKA, T. Scale-related patterns in the spatial and environmental components of stream macroinvertebrate assemblage variation. **Global Ecology and Biogeography**, v. 16, p. 149-159, 2007.

NAKAMURA, F. & KIKUCHI, S. Some methodological developments in the analysis of sediment transport processes using age distribution of foodplain deposits. **Geomorphology**, v. 16, p. 139-145, 1996.

NESSIMIAN, J.L., VENTICINQUE, E.M., ZUANON, J., DE MARCO, P.J.R., GORDO, M., FIDELIS, L., BATISTA, J.D. & JUEN, L. Land use, habitat integrity, and aquatic insect assemblages in Central Amazonian streams. **Hydrobiologia**, v. 614, n. 1, p. 117-131, 2008.

NEWCOMBE, C.P. & MACDONALD, D.D. Effects of Suspended Sediments on Aquatic Ecosystems. **North American Journal of Fisheries Management**, v. 11, p. 72-82, 1991.

PALMER, M.A., ALLAN, J.D. & BUTMAN, C.A. Dispersal as a regional process affecting the local dynamics of marine and stream benthic invertebrates. **Trends in Ecology and Evolution**, v. 11, p. 322-326, 1996.

PIEDRAS, S.R.N., OLIVEIRA, J.L.R., MORAES, P.R.R. & BAGER, A. Macroinvertebrados bentônicos como indicadores de qualidade de água na Barragem Santa Bárbara, Pelotas, RS, Brasil. **Ciência Rural**, v. 36, n. 2, p. 494-500, 2006.

POIANI, K.A., RICHTER, B.D., ANDERSON, M.G. & RICHTER, H.E. Biodiversity conservation at multiple scales: Functional sites, landscapes, and networks. **BioScience**, v. 50, n. 2, p. 133-146, 2000.

RAHBEK, C. The elevational gradient of species richness – a uniform pattern. **Ecography**, v. 18, p. 200–205, 1995.

RIBEIRO, L.O., KONIG, R., FLORES, E.M.M. & SANTOS, S. Composição e distribuição de insetos aquáticos no rio Vacacaí-Mirim, Santa Maria, Rio Grande do Sul. **Ciência e Natura**, v. 31, n. 1, p. 79-93, 2009.

RICHARDS, C., JOHNSON, L.B. & HOST, G.E. Landscape-scale influences on stream habitats and biota. **Canadian Journal of Fisheries and Aquatic Sciences**, v. 53, n. 1, p. 295-311, 1996.

ROSINE, W.N. The distribution of invertebrates on submerged aquatic plant surfaces in Muskee Lake, Colorado. **Ecology**, v. 36, p. 308-314, 1955.

SALVARREY, A.V.B., KOTZIAN, C.B., SPIES, M.R. & BRAUN, B. The influence of natural and anthropic environmental variables on the structure and spatial distribution along longitudinal gradient of macroinvertebrate communities in southern Brazilian streams. **Journal of Insect Science**, v. 14, n. 13, p 1-23, 2014.

SCHLOSSER, I.J. Stream fish ecology: a landscape perspective. **BioScience**, v. 41, p. 704–712, 1991.

SOKAL, R.R. & ROHLF, F.J. **Biometry: the principles of statistics in biological research**. New York, Freeman, 1995. 887p.

SPONSELLER, R.A., BENFIELD, E.F. & VALETT, H.M. Relationships between land use, spatial scale and stream macroinvertebrate communities. **Freshwater Biology**, v. 46, p. 1409-1424, 2001.

STATZNER, B. & HIGLER, B. Stream hydraulics as a major determinant of benthic invertebrate zonation patterns. **Freshwater Biology**, v. 16, p. 127-39, 1986.

STATZNER, B., GORE, J.A. & RESH, V.H. Hydraulic stream ecology: observed patterns and potential applications. **Journal North American Benthological Society**, v. 7, p. 307-60, 1988.

STRAND, M.R. & MERRITT, R.W. Effects of episodic sedimentation on the net-spinning caddisies *Hydropsyche betteni* and *Ceratopsyche sparna* (Trichoptera: Hydropsychidae). **Environmental Pollution,** v. 98, p. 129 - 134, 1997.

STRIEDER, M.N., RONCHI, L.H., STENERT, C., SCHERER, R.T. & NEISS, U.G. Medidas biológicas e índices de qualidade da água de uma microbacia com poluição urbana e de curtumes no sul do Brasil. **Acta Biologica Leopondensia**, v. 28, n. 1, p. 17-24, 2006.

TAKEDA, A.M., BÜTTOW, N.C. & MELO, S.M. Zoobentos do canal Corutuba-MS (Alto do Rio Paraná- Brasil). **Revista Unimar**, v. 13, n. 2, p. 353-364, 1991.

THOMAS, D.L. & TAYLOR, E.J. Study designs and tests for comparing resource use and availability. **Journal of Wildlife Management**, v. 54, n. 2, p.v322-330, 1990.

TOWNSEND, C.R., SCARSBROOK, M.R. & DOLEDEC, S. The intermediate disturbance hypothesis, refugia, and biodiversity in streams. **Limnology and oceanography**, v. 42, p. 938-949, 1997.

UIEDA, V.S. & GAJARDO, I.C.S.M. Macroinvertebrados perifíticos encontrados em poções e corredeiras de um riacho. **Naturalia**, v. 21, p. 31-47, 1996.

VANNOTE, R.L., MINSHALL, G.W., CUMMINS, K.W.L., SEDELL, J.R. & CUSHING, C.E. The River Continuum Concept. **Canadian Journal of Fisheries and Aquatic Sciences**, v. 37, p. 130-137, 1980.

VINSON, M.R. & HAWKINS, C.P. Effects of sampling area and subsampling procedure on comparisons of taxa richness among streams. **Journal North American Benthological Society**, v. 15, n. 3, p. 392-399, 1996.

VINSON, M.R. & HAWKINS, C.P. Biodiversity of stream insects: Variation at Local, Basin, and Regional Scales. **Annual Review of Entomology**, v. 43, p. 271-93, 1998.

WEIGEL, B.M., WANG, L., RASMUSSEN, P.W., BUTCHER, J.T., STEWART, P.M. & WILEY, M.J. Relative influence of variables at multiple spatial scales on stream macroinvertebrates in the Northern Lakes and Forest ecoregion, U.S.A. **Freshwater Biology**, v. 48, p. 1440-1461, 2003.

WHITE, D.S. & BRIGHAM, W.U. **Aquatic Coleoptera**, p. 399-473. *In*: MERRIT, R.W. & CUMMINS, K.W. (eds). An Introduction to the Aquatic Insects of North America. 3.ed. Kendall/Hunt Publishing Company, Dubuquer, Iowa, 1996.

WIBERG-LARSEN, P., BRODERSEN, K.P., BIRKHOLM, S., GRON, P.N. & SKRIVER, J. Species richness and assemblage structure of Trichoptera in Danish streams. **Freshwater Biology**, v. 43, p. 633-647, 2000.

WIENS, J.A., ROTENBERRY, J.T. & VAN HORNE, B. Habitat occupancy patterns of North American shrubsteppe birds: the effects of spatial scale. **Oikos**, v. 48, p.132-147, 1987.

WILEY, M.J., OSBORNE, L.L. & LARIMORE, R.W. Longitudinal structure of an agricultural prairie river system and its relationship to current stream ecosystem theory. **Canadian Journal of Fisheries and Aquatic Sciences**, v. 47, p. 373-384, 1990.

WINTERBOURN, M.J. & COLLIER, K.J. Distribution of benthic invertebrates in acid, brown water streams in the South Island of New Zealand. **Hydrobiologia**, v. 153, p. 277- 286, 1987.

WRIGHT, J.F., FURSE, M.T. & MOSS, D. River classification using invertebrates: RIVPACS applications. **Aquatic Conservation – Marine and Freshwater Ecosystems**, v. 8, p. 617-631, 1998.

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INFLUENCE OF ENVIRONMENTAL FACTORS ON THE DISTRIBUTION OF FAMILIES OF AQUATIC INSECTS IN RIVERS IN SOUTHERN BRAZIL

Abstract: Neotropical rivers suffer effects of human actions. Conservation measures are based on data from other regions because few studies in this region and limnology knowledge. But it´s often inability to realize differences in the environmental variables answer at different scales about aquatic communities. This study aimed: to know aquatic insects richness in a neotropical watershed to check the environmental variables influence on the distribution of aquatic insects families in four tributaries of this microbasin and to check the rate distribution pattern of aquatic insects families between different rivers orders and different microbasins, according to environmental and spatial variables influence. We found 9,135 individuals belonging to 26 macroinvertebrates families. The communities structure were differed between microbasins. The aquatic insects families were influenced by different spatial and environmental variables in each microbasin.

Keywords: Macroinvertebrates, Lotic, Spatial scale, Microbasin, Distribution.

Resumo: O rios neotropicais sofrem os efeitos das ações humanas. Medidas conservacionistas, pela escassez de estudos na região e do conhecimento límnico, baseiam-se em dados referentes a outras regiões, sendo muitas vezes ineficazes pela inobservância das diferenças nas respostas das comunidades aquáticas às variáveis ambientais em escalas distintas. Este estudo teve como objetivos: conhecer a riqueza de insetos aquáticos em uma bacia neotropical; verificar qual a influência das variáveis ambientais na distribuição das famílias de insetos aquáticos em quatro tributários dessa bacia e observar se o padrão de distribuição das famílias de insetos aquáticos varia entre as ordens dos rios ou entre microbacias, de acordo com a influência de variáveis ambientais e espaciais. Foi encontrado um total de 9.135 indivíduos distribuídos em 26 famílias de macroinvertebrados. A estrutura das comunidades foi distinta entre as microbacias. As famílias de insetos aquáticos foram influenciadas pelas variáveis ambientais e espaciais diferentes em cada microbacia.

Palavras chave: Macroinvertebrados, Lótico, Escala espacial, Microbacia, Distribuição.

Resumen: Ríos neotropicales sufren los efectos de las acciones humanas. Las medidas de conservación debido a la falta de estudios en la región y de conocimiento límnico, se basan en datos de otras regiones, siendo muchas veces ineficaces por no permitir observar las diferencias en las respuestas de las comunidades acuáticas a las variables ambientales en escalas diferentes. Este estudio tuvo como objetivo: conocer la riqueza de insectos acuáticos en una cuenca neotropical, verificar la influencia de las variables ambientales en la distribución de las famílias de insectos acuáticos en cuatro afluentes de esta cuenca, y observar si el patrón de distribución de las famílias de insectos acuáticos varia entre las ordenes de los ríos y/o entre microcuencas, según la influencia de las variables ambientales y espaciales. Fueron encontrados un total de 9135 individuos distribuidos en 26 famílias de macroinvertebrados. La estructura de las comunidades fue diferente entre las microcuencas. Las famílias de insectos acuáticos fueron influenciadas por las variables ambientales y espaciales diferentes en cada microcuenca.

Palabras clave: Macroinvertebrados, Lótico, Escala espacial, Microcuenca, Distribución.

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