The benthic macroinvertebrate fauna of highland streams in southern Brazil: composition, diversity and structure

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ABSTRACT. Benthic macroinvertebrate in four rivers, three in the Pelotas River basin (Divisa, Marco and Silveira rivers, in the headwaters of the Uruguai River) and one in the Taquari-Antas system (Antas River), a tributary in the Guaíba basin, in the state of Rio Grande do Sul, were identified. Two samples were collected in summer, autumn and spring, with one replicate in each river. The total of 28,961 specimens included members of Platyhelminthes, Annelida, Acarina, Insecta, Crustacea and Mollusca. The Silveira and Marco rivers showed significant differences in the indices of Shannon-Weaver (H'), Simpson's Reciprocal (1/D), Margalef (DMg) and Equitability (E). The Silveira River showed the highest means of diversity and the EPT index (Ephemeroptera, Plecoptera, Trichoptera). Comparison among the diversity indices, considered individually, were insufficient to show differences in community structure, for the purpose of ecological characterization of the rivers. The EPT values characterized the Divisa River as having the highest abundance (73%), followed by the Marco (71%), Antas (48%) and Silveira (36%). These results suggest that the Silveira River is subject to moderate environmental stress, from human impact, although it showed the highest diversity of the major macrobenthic groups.
KEY WORDS. Aquatic invertebrates; community structure; diversity indices; Rio Grande do Sul.

RESUMO. **Fauna de macro-invertebrados bentônicos de rios de montanha no sul do Brasil: composição, diversidade e estrutura.** Os macro-invertebrados bentônicos que ocorrem em quatro rios, três pertencentes à bacia do Rio Pelotas (Rios Divisa, Marco e Silveira nas cabeceiras do Rio Uruguai) e um ao sistema Taquari-Antas (Rio Antas), tributário da bacia do Guaíba, no Estado do Rio Grande do Sul, foram identificados. Duas amostras foram coletadas no verão, outono e primavera, com uma réplica em cada rio. Foram coletados 28961 espécimes de macro-invertebrados compreendendo Platyhelminthes, Annelida, Acarina, Insecta, Crustacea e Mollusca. Na comparação entre os rios, Silveira e Marco mostraram diferenças significativas nos índices de Shannon-Weaver (H'), no Recíproco de Simpson (1/D), de Margalef (DMg) e na Equitabilidade (E). O rio Silveira possui os maiores índices médios de diversidade e de EPT (Ephemeroptera, Plecoptera, Trichoptera). Os valores de EPT caracterizaram o rio Divisa com a maior abundância (73%), seguido pelo Marco (71%), Antas (48%) e Silveira (36%), Estes resultados sugerem que o rio Silveira sofre um moderado *stress* ambiental, de origem antrópica, embora mostre uma maior diversidade da macrofauna bentônica.
PALAVRAS-CHAVE. Estrutura da comunidade; índices de diversidade; invertebrados aquáticos, Rio Grande do Sul.

The world's continental surface-water resources are receiving special attention from ecologists and governmental authorities, in many countries including Brazil (SALATI *et al.* 1999, TUNDISI *et al.* 1999). The environmental impacts that are threatening aquatic ecosystems necessitate immediate and profound expansion of our knowledge of the biotic structure of limnetic systems and the implementation of effective methods of monitoring.

On the world scene, Brazil occupies a special position because of the enormous freshwater discharge of its rivers, representing 53% of all limnetic water production in South America (334,000 m³/s) and 12% of global production (1,488.000 m³/s) (REBOUÇAS 1999). The highlands of southern Brazil contain re-markable freshwater resources, whose quality, chiefly in the headwater areas, is mostly acceptable. These areas are of high biological importance (MMA 2000).

Several drainage basins have their headwaters in the highlands of Rio Grande do Sul; the largest, the Pelotas River, a tributary of the Uruguai River, defines the border with Argentina. A second basin, Taquari-Antas, is part of the Guaiba system, which drains into the Patos Lagoon. The grassy landscapes in these highlands contain enclaves of *Araucaria* (Juss , 1789) (Araucariaceae) forest, which are undergoing severe environmental impact from the intensive cultivation of exotic tree species, especially *Pinus* (Linnaeus, 1753) (Pinaceae). These trees

provide timber and cellulose for industries in Brazil and other countries.

Some streams in these basins are beginning to suffer strong impacts from forestry activities, mainly from uncontrolled discharge of the timber sawmills and destruction and/or replacement of the native gallery forests. The effects can be seen in the elevation and silting of the streams, and the decrease in their biological diversity. In aquatic ecosystems of Scotland and South Island in New Zealand, the negative consequences of overexpansion of exotic conifer plantations on the benthic macroinvertebrate communities were elucidated by HARRIMAN & MORRISON (1982) and FRIBERG et al. (1997).

Moreover, the unregulated application of pesticides in potato and apple agriculture is an increasingly preferred alternative to traditional practices. The introduction of exotic fish species, such as the rainbow trout *Oncorhynchus mykiss* (Walbaum, 1792), constitutes an additional menace to the native aquatic biota of the small streams of the drainage basins of the highland mountain meadows of Rio Grande do Sul.

Knowledge of benthic macroinvertebrates has been used by many researchers, such as the characterization of trophism and the functionality of aquatic environments (LENAT 1993, KIKUCHI & UIEDA 1998, MELO & FROEHLICH 2001, GALDEAN et al. 2001, BUENO et al. 2003) as well as the understanding of the trophic dynamics of food webs (ROSI-SHALL & WALLACE 2002, BUENO & BOND-BUCKUP 2004, MOTTA & UIEDA 2005). Macroinvertebrates have also been much utilized as biotic indicators in monitoring (LENAT 1993, CHARVET et al. 1998, MARQUES & BARBOSA 2001, LORENZ et al. 2004) and in evaluation of water quality (CALLISTO et al. 2001 a, b). Human influence on the areas surrounding the streams has provided incentive for the study of impacts from organic pollution and/or water acidification caused by changes in agricultural practices (HARRIMAN & MORRISON 1982, LENAT & CRAWFORD 1994, SPONSELLER et al. 2001), and estimation of the consequences of introduction of exotic plant species (FRIBERG et al. 1997). Additionally, many projects have been developed to compare streams at different altitudes and latitudes (JACOBSEN et al. 1997), describe the physical and chemical conditions in stream systems (REMPEL et al. 2000, WHITING 2002), set priorities and policies for land conservation (WRIGHT et al. 1993), and also evaluate the influence of the range of variation in streams on the macroinvertebrate faunas (PARDO & ARMITAGE 1997, BEISEL et al. 1998, BOYERO 2003), among other subjects.

Our objectives included a comparison between biodiversity and community structure in four highland streams, considering that until now no research on this subject has been done in the region.

MATERIAL AND METHODS

Study area and sampling stations

Local altitudes are over 1,200 meters, with low air temperatures and sporadic snowfall in the winter and mild temperatures during the summer. The regional climate is charac-

terized as mesothermal and humid, with mild summers (LEMOS & SANTOS 1986), super humid, or super humid to humid (IPAGRO 1989). The annual rainfall during the study period ranged from 1,700 to 1,800 mm, with little precipitation during autumn and winter and more in spring and summer. Mean low temperatures were below 0ºC during both years. Mean annual high temperatures were 19.69 and 20.14 ºC, with the highest single values of 28 to 30 ºC during summer months (Tab. I).

The study site is located in the geomorphic area called the Planalto das Araucarias (*Araucaria* Plateau), the easternmost segment of the Morphostructural Domain Basin and Sedimentary Deposits (Domínio Morfoestrutural das Bacias e Coberturas Sedimentares), in acidic rocks of the Serra Geral Formation in southern Brazil (GOVERNO DO ESTADO DE SANTA CATARINA 1986). Wide areas are covered by grassy fields of *Andropogon lateralis* (Nees , 1753) (Poacea), a dominant and locally important species; the other principal vegetation types are the *Araucaria* forests and highland peat bogs.

The headwater regions of the Taquari-Antas (28º49'S - 50º00'W) and of the Pelotas River system (28º36'S -49º58'W) are subject to torrential rains, with rapid surface outflow and abrupt variations in discharge, resulting from the steeply sloped landscape; dense, radial drainage; sparse vegetation cover; and the relative shallowness and low permeability of the soils. The zones with less energy and accumulation of fine sediments are well spaced, representing a Rithral section, with low autochthonous production, and the typical, crystal-clear oligotrophic water of mountain streams.

Macroinvertebrate collection and environmental measurements

Three of the rivers sampled, Silveira, Marco and Divisa, belong to the Pelotas River basin; the Antas River is in the Antas-Taquari basin (Fig. 1).

Two samples were collected monthly, in each stream, using a Surber sampler (1,089 cm² area), with 250 mm mesh netting, in different types of sediment and current speeds. Samples were grouped according to season, *i.e.*, austral autumn 2000 (April and June), spring 2000 (September and October) and summer 2000-2001 (December and February), resulting in 12 samples. The intense rains in winter prevented sampling in that season. Sampling methods followed the recommendations of MERRIT & CUMMINS (1984) and BUENO et al. (2003).

The following physical and chemical water parameters were measured: a) water temperature; b) oxygen content, with a hand-held Dissolved Oxygen Meter (OXI 330/SET-WTW; c) pH, with a portable Cole & Parmer pH Meter and d) conductivity, with a portable Model 33 S-C-T-Meter.

In the laboratory, the specimens were sorted and identified to family level, following the recommendations of JACOBSEN et al. (1997), DOLÉDEC et al. (2000) and MELO (2005). Because of the paucity of taxonomic descriptions of Brazilian benthic invertebrates, it was difficult to identify the specimens to species level. Taxonomic identification was based on MACAN (1975) and ROLDAN-PÉREZ (1988).

Table I. Air temperature, rainfall, and relative humidity in São José dos Ausentes, Rio Grande do Sul State, Brazil, in 2000 and 2001.

| Meteorological data	Year 2000	Year 2001
Mean lowest air temperatures (°C)	8.83	9.92
Absolute lowest air temperature during the period (°C)	-8.20	-4.20
Mean highest air temperatures (°C)	19.69	20.14
Absolute highest air temperature during the period (°C)	28.80	30.00
Rainfall (mm)	1,738.00	1,885.40
Lowest and highest Rainfall during the period (mm)	54.6 (May), 307.3 (October)	34.7 (August), 253.6 (September)
Mean air humidity (%)	77.66	77.75
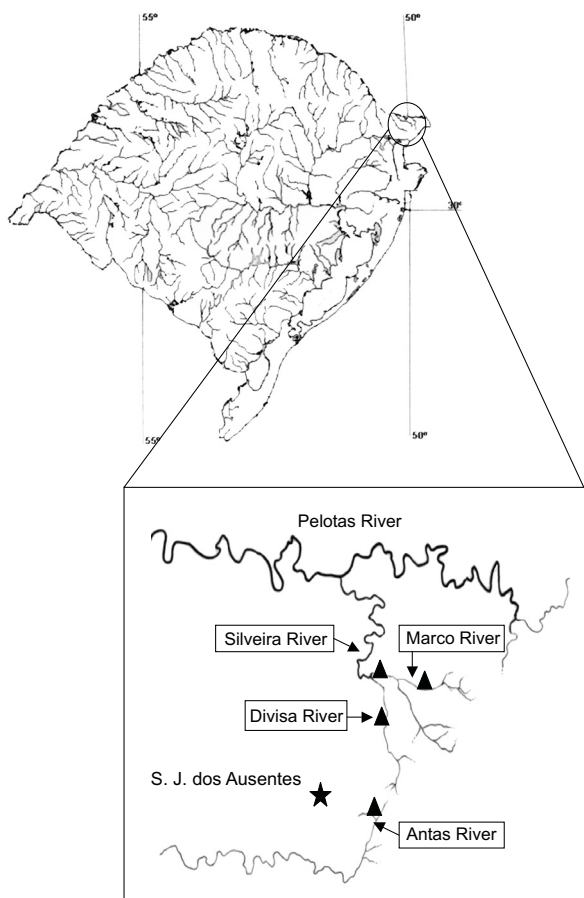
Figure 1. Map of Rio Grande do Sul, southern Brazil, showing the sample sites (▲) in Pelotas, Silveira, Marco, Divisa and Antas Rivers.

Data analysis – community structure

The following variables were analyzed: abundance – number of individuals per sample (N); richness- number of families per sample (S); diversity – Shannon-Weaver index (H'), Margalef's index (D_{Mg}), Simpson's reciprocal index (1/D); evenness (E) or equitability; and number of families of EPT (Ephemeroptera, Plecoptera, Trichoptera), which is commonly utilized as an indicator of disturbance in stream communities

(SPONSELLER *et al*. 2001). The EPT proportion was calculated by dividing the number of individuals belonging to the EPT-Group by the total abundance in each stream.

The diversity in each stream was compared by season, and analyzed using One-Way ANOVA (SPSS for Windows version 10.0).

RESULTS

Physical and chemical characteristics

The four rivers are very similar in their characteristics as headwaters of mountain rivers, with bed sediments composed mainly of pebbles and, in some places, continuous basaltic flagstone, and stretches of swift current alternating with still water sections. Water temperature variation was very similar in the four streams during the year; the widest range, from 8.8 to 25 °C, was measured in the Silveira River. The pH was neutral or slightly alkaline at all stations, 6.5 in the Divisa River and 8.5 in the Silveira River. Mean conductivity was also low: 15 mS/cm in Silveira, 20 µS/cm in Marco, 13 µS/cm in Divisa and 17 µS/cm in Antas. The dissolved oxygen percent saturation remained above 80%, usually around 100% in all streams.

No statistically significant correlation was found between the abundance of organisms and the abiotic variables. This can be explained by the non-continuous point measurements of the physical and chemical conditions.

Community Structure and Composition

A total of 28,961 specimens, primarily immature insects, were collected during the sampling period. Of this total, 6,318 specimens were collected from the Rio Silveira, 9,570 from Marco, 8,222 from Divisa, and 4,851 from Antas (Tab. II).

The majority of the families identified were present in all four streams, but some particularities were observed; for example, Trichoptera (Philopotamidae), Diptera (Tipulidae), Hemiptera (Veliidae), Megaloptera (Corydalidae) and Collembola (Sminthuridae) occurred only in the Antas River. Annelida (Histriobdellidae) were found only in the Divisa River.

Seasonal and Spatial Variation

The Rio Marco contained the highest mean number of specimens, but the lowest richness and diversity (Tab. III).

Table II. Absolute (n) and relative (%) frequency of benthic macroinvertebrates in Silveira, Marco, Divisa and Antas Rivers, during the sampling period.

Macroinvertebrates	Family	Silveira		Marco		Divisa		Antas	
		n	%	n	%	n	%	n	%
Platyhelmintes	Planariidae	6	0.09	335	3.50	50	0.61	81	1.67
	Temnocephalida	41	0.65	0	0.00	18	0.22	4	0.08
Annelida	Hirudinea	48	0.76	0	0.00	2	0.02	1	0.02
	Oligochaeta	32	0.51	0	0.00	1	0.01	2	0.04
	Histriobdellidae	0	0.00	0	0.00	16	0.19	0	0.00
Mollusca	Ancylidae	100	1.58	0	0.00	0	0.00	3	0.06
	Hydrobiidae	166	2.63	0	0.00	137	1.67	0	0.00
	Ampullariidae	60	0.95	0	0.00	8	0.10	0	0.00
	Bivalvia	5	0.08	1	0.01	1	0.01	0	0.00
Arthropoda									
Acarina		463	7.33	282	2.95	264	3.21	185	3.81
Hexapoda									
Collembola	Isotomidae	0	0.00	0	0.00	1	0.01	5	0.10
	Entomobyidae	0	0.00	0	0.00	1	0.01	0	0.00
	Smynthuridae	0	0.00	0	0.00	0	0.00	1	0.02
Trichoptera	Hydropsychidae	481	7.61	19	0.20	25	0.30	13	0.27
	Hydroptilidae	120	1.90	114	1.19	77	0.94	6	0.12
	Hydrobiosidae	29	0.46	13	0.14	24	0.29	29	0.60
	Glossosomatidae	12	0.19	20	0.21	13	0.16	27	0.56
	Leptoceridae	29	0.46	102	1.07	48	0.58	89	1.83
	Philopotomidae	0	0.00	0	0.00	0	0.00	1	0.02
Diptera	Chironomidae	1,919	30.37	1,313	13.72	1,127	13.71	1,538	31.70
	Simuliidae	600	9.50	100	1.04	66	0.80	146	3.01
	Psychodidae	3	0.05	9	0.09	1	0.01	10	0.21
	Tipullidae	0	0.00	0	0.00	0	0.00	1	0.02
Lepidoptera	Pyralididae	27	0.43	236	2.47	137	1.67	5	0.10
Coleoptera	Elmidae	114	1.80	353	3.69	191	2.32	335	6.91
	Psephenidae	89	1.41	7	0.07	2	0.02	34	0.70
	Ptilodactylidae	5	0.08	27	0.28	34	0.41	7	0.14
Ephemeroptera	Baetidae	878	13.90	6,179	64.57	4,873	59.27	1,165	24.02
	Leptophlebiidae	294	4.65	178	1.86	625	7.60	392	8.08
	Leptohyphidae	437	6.92	181	1.89	273	3.32	441	9.09
Plecoptera	Gripopterygidae	70	1.11	44	0.46	22	0.27	90	1.86
	Perlidae	5	0.08	6	0.06	17	0.21	97	2.00
Odonata	Calopterygidae	12	0.19	0	0.00	1	0.01	1	0.02
	Libelullidae	1	0.02	0	0.00	0	0.00	0	0.00
	Coenagrionidae	7	0.11	2	0.02	4	0.05	9	0.19
Hemiptera	Gerridae	4	0.06	0	0.00	0	0.00	4	0.08
	Naucoridae	10	0.16	5	0.05	1	0.01	12	0.25
	Veliidae	0	0.00	0	0.00	0	0.00	1	0.02
Megaloptera	Corydalidae	0	0.00	0	0.00	0	0.00	1	0.02
Crustacea	Copepoda	53	0.84	2	0.02	49	0.60	45	0.93
	Cladocera	112	1.77	13	0.14	12	0.15	0	0.00
	Ostracoda	86	1.36	29	0.30	93	1.13	65	1.34
	Amphipoda	0	0.00	0	0.00	0	0.00	1	0.02
	Decapoda Aeglidae	0	0.00	0	0.00	8	0.10	4	0.08
Total		6,318	22.00	9,57	33.00	8,222	28.40	4,851	16.60

Table III. Diversity indices of benthic macro invertebrates community based on samples collected during 2000-2001, in four rivers (N: total and mean abundance in parenthesis; S: richness; H': Shannon's index; 1/D Simpson's reciprocal index; DMG Margalef's index; EPT: number of family of Ephemeroptera, Plecoptera, Trichoptera; E: eveness).

Stream	Season	N		S	H'	1/D	DMg	EPT	E
Silveira	Autumn	1,788	(894)	20	1.91	4.98	2.93	8	0.64
	Spring	1,363	(681)	20	1.82	4.38	2.99	9	0.60
	Summer	3,167	(1,583)	26	2.43	8.36	3.49	9	0.74
Marco	Autumn	3,227	(1,613)	12	1.39	2.78	1.58	6	0.55
	Spring	1,342	(671)	12	1.05	1.79	1.79	6	0.42
	Summer	5,001	(2,500)	19	1.16	1.82	2.30	7	0.40
Divisa	Autumn	1,469	(734)	11	1.24	2.56	1.56	5	0.52
	Spring	3,724	(1,862)	18	1.11	1.91	2.34	6	0.38
	Summer	3,029	(1,514)	24	2.01	4.50	3.15	8	0.63
Antas	Autumn	1,846	(923)	19	1.80	4.35	2.63	8	0.61
	Spring	2,371	(1,185)	20	1.70	3.94	2.96	7	0.57
	Summer	634	(317)	12	1.66	4.07	2.08	5	0.66

The Silveira and Antas rivers did not show significant seasonal differences in the diversity indices, although most indices were higher during summer season, for both rivers. However, significant seasonal differences were found to the Marco River in $D_{Mg.}$ (F = 18.99) and S (F = 9.39), and to the Divisa River in richness (F = 17.62), H' (F = 9.44) and $D_{Mg.}$ (F = 10.89).

The result of the comparison between the diversities in the streams was significant. The Silveira and Marco rivers were dissimilar regarding H' (F = 4.91), 1/D (F = 3.60), DMg (F = 5.47) and E (F = 4.47). The Silveira River had higher mean indices of diversity during the sampling period, followed by the Antas and Divisa rivers, and last by the Marco River.

The highest percentage of EPT occurred in the Divisa River (73.69%), followed by the Marco (71.64%), Antas (48.75%) and Silveira (36.44%) rivers.

DISCUSSION

The composition and the structure of the community of benthic invertebrates in the high-altitude mountain streams in southern Brazil have been little studied up to now, a circumstance that obstructs any attempt to compare the present results with those previously reported for this region. Investigations in streams in Ecuador and Denmark, identified as lowland streams by Jacobsen *et al.* (1997), showed lower richness indices than those obtained in the present study. Results reported by Baptista *et al.* (2001) from streams in southeastern Brazil indicated that the highest abundance and richness of benthic invertebrates occurred during a period of drought. The Tainhas River, also a part of the Taquari-Antas basin, however, shows consistently higher richness, reaching 36.67 in winter and 23.67 in spring (Bueno *et al.* 2003). The Silveira River had greater richness during the summer months (26), compared to the other streams. These results are similar to the richness levels of the families found in other South American streams.

The use of diversity indices in the analysis is appropriated and recognized as a good tool in preliminary evaluations of hydrographic drainages (Charvet *et al.* 1998). In this sense, the value for D_{Mg} in the Silveira River, as it describes the richness weighted against sample size, is very close to the data abtained from a nonpolluted stream in Lyon, France (Charvet *et al.* 1998). However, the use of diversity indices alone, can mask the results, leading to misinterpretations, notwithstanding the display of high diversity indices, as in the Silveira River. The use of other parameters such as the EPT can result in other explanations about what is occurring in the community structure.

The effect of stability of the limnetic environment and its relation with the structure of the community, more specifically the equitability, has been admitted as a key factor for the identification of biodiversity (Jacobsen *et al.* 1997, Jacobsen & Encalada 1998). Values of E were higher during an unstable wet season in eight Ecuadorian highland streams (Jacobsen & Encalada 1998). In comparison to the equitability index values of the four sampled streams with the Tainhas River, a typical upland stream (Bueno *et al.* 2003), a stronger similarity to the Silveira River can be observed, followed by the Antas River. Our results showed a higher equitability in the Silveira River during the summer months, when rain was copious, surpassing 115 mm in December, typifying the instability of the environment.

Other investigations have described reductions in richness of non-tolerant EPT groups (Ephemeroptera, Plecoptera and Trichoptera) in agricultural streams (*sensu* Lenat & Crawford 1994) in connection with increases of richness and abundance of other taxa (Vuori & Joensuu 1996, Sponseller *et al.* 2001). In three streams in the Piedmont ecoregion of North Carolina, U.S.A., the abundance of macroinvertebrates was greater in the summer, suggesting that input from energy sources was important for the sites where autochthonous productivity was

considered an important energy source in agricultural streams (LENAT & CRAWFORD 1994). Furthermore, an increase in the abundance of Diptera Simuliidae was accelerated by an increase in organic and inorganic emissions (VUORI & JOENSUU 1996). High abundance of these organisms has been followed by the increase of Oligochaeta and other Diptera in contaminated streams (LENAT & CRAWFORD 1994). In polluted streams in southeastern Brazil, the prevalence of the dipterans *Chironomus,* known as indicators of environmental stress, was reported (MARQUES *et al.* 1999). Dipterans are tolerant organisms (LENAT 1993), and their abundance may indicated degraded conditions (MAUL *et al.* 2004). Our results confirm this information, because Diptera (Simuliidae and Chironomidae) predominated in the Silveira River, which suffers environmental stress from untreated runoff from the nearby Silveira village.

Among the constituents of the EPT groups, the family Baetidae was the most abundant during the spring and summer months. The second most abundant family of EPT was Leptohyphidae. On the other hand, the analysis of the benthic community showed that Chironomidae was the predominant family, during all sampling seasons. Again, these results confirm those for highland streams in Equador by JACOBSEN & ENCALADA (1998). Baetidae and Chironomidae are good colonizers and grow rapidly, becoming dominating groups and adapting to changeable environments such as the Silveira River (JACOBSEN & ENCALADA 1998, CALLISTO *et al.* 2001b).

The *Araucaria* forests along some banks of the Silveira and Antas Rivers stabilize water temperatures, which is not the case in the Marco and Divisa Rivers, which are bare of bordering vegetation. Variations in temperature influence the life cycle of aquatic insects and can be the cause of reduction of their diversity. These fluctuations in temperature are directly associated with streams in non-forested areas, where waters may reach higher temperatures (SPONSELLER *et al.* 2001). Riparian vegetation can influence the physical processes in a stream, erosion, or the diversity of habitats (WHITING 2002). Our results seem to confirm those conclusions, since the Silveira and Antas Rivers did not show significant differences between the diversity indices through the seasons, emphasizing the importance of the natural marginal vegetation for the water courses. The input of plant material to the streams and the presence of macrophyte habitats in the substrata provide an ideal mesohabitat for the aquatic macroinvertebrates. This feature contributes to the increase of diversity and influences the distribution of invertebrates, as observed in a brook in the Paranapanema basin in Brazil (UIEDA & GAJARDO 1996). These streams show, on the other hand, deeper stretches, with slow flow, and, therefore, continuous habitat transitions that affect the composition of their communities (PARDO & ARMITAGE 1997).

The lack of historical information about the benthic macrofauna does not permit any firm conclusion of the effect of rainbow trout, an exotic species introduced and re-introduced yearly in this region since 1983, on the biodiversity in the

streams. Our results did not indicate any perceptible impairment of diversity or abundance of benthic macroinvertebrates in the Silveira River. In addition to the possible predacious influence of the rainbow trout, this stream is subject to combined pressures from land-use practices and from urban and agricultural effluents. The input of organic matter to the watercourse may have favored the benthic macrofauna. The conservation of the native riparian vegetation along the banks of the Silveira River may also be responsible for the richness of macroinvertebrates observed during the sampling period.

The deficient documentation about freshwater biota in southern Brazil, combined with our inability to predict the structure of the benthic macroinvertebrate communities, is associated with our lack of knowledge about the historical utilization of the soil locally (SPONSELLER *et al.* 2001). The region is dominated by basalt and high organic matter content near the surface; low quantities of calcium, magnesium and potassium; low pH values and high content of changeable aluminum (FAO 1988). These characteristics result from the cold, wet climate, which favors buildup of organic matter. At the same time, the high rate of mineralization impoverishes the soil, which has been extensively used for cultivation of potatoes and apple trees. Stream headwater areas are susceptible to changes in the utilization of the surrounding areas and soil management in the drainage basin, as reported by researchers in North American and European countries (LENAT & CRAWFORD 1994, VUORI & JOENSUU 1996). Information is still lacking about possible changes in the chemical content of waters in southern Brazil resulting from the large-scale introduction of *Pinus* plantations which replaced the natural vegetation, especially along the Divisa and Marco Rivers.

The relationship between the faunal composition and the functions of aquatic ecosystems is variable over both temporal and spatial scales, necessitating large-scale, long-term investigations (LACROIX & ABBADIE 1998). The variations examined here provide a preliminary characterization of the aquatic macrofaunal population dynamics, taking into account that species richness is a function of local and regional processes, the relative influence of which varies over time, as shown by MOUQUET *et al.* (2003) and VINSON & HAWKINS (2003). Studies in boreal forests in Finland clarified the important role of macroinvertebrates in processing allochthonous material, contributing to local decay, as well in the metabolic activity of streams and the transfer of energy from aquatic to terrestrial consumers (VUORI & JOENSUU 1996). Therefore, the application of biomonitoring methods focusing on benthic macroinvertebrates is strongly recommended (CHARVET *et al.* 1998) in streams, as an important tool for the evaluation of the biodiversity of terrestrial ecosystems in the region of "campos de cima da serra"in southern Brazil.

Our results show that highland streams in southern Brazil exhibit a diversity which is quite similar to other streams previously investigated. Although the diversity indices considered separately did not show a well-defined profile of the community structure, the EPT, examined in combination with those

indices, demonstrated that the Silveira River, with its high diversity, and the next-most-diverse Antas River are dominated by tolerant macroinvertebrate groups. This information suggests that these rivers are subject to moderate environmental stress, which requires further investigation.

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