Acta Limnologica Brasiliensia, 2015, 27(4), 394-410 http://dx.doi.org/10.1590/S2179-975X3215

Diversity and composition of Trichoptera (Insecta) larvae assemblages in streams with different environmental conditions at Serra da Bocaina, Southeastern Brazil

Diversidade e composição da Assembléia das larvas de Trichoptera (Insecta) em riachos com diferentes condições ambientais na Serra da Bocaina, Sudeste do Brasil

Ana Lucia Henriques-Oliveira[1], Jorge Luiz Nessimian[1] and Darcílio Fernandes Baptista[2]

[1]Laboratório Entomologia, Departamento Zoologia, Instituto de Biologia, Universidade Federal do Rio de Janeiro – UFRJ, Ilha do Fundão, CP 68044, CEP 21970-944, Rio de Janeiro, RJ, Brazil
e-mail: anahenri@biologia.ufrj.br; jnessimian@gmail.com

[2]Laboratório de Avaliação e Promoção da Saúde Ambiental – LAPSA, Instituto Oswaldo Cruz – IOC, Fundação Oswaldo Cruz – Fiocruz, Av. Brasil, 4365, Manguinhos, CEP 21045-900, Rio de Janeiro, RJ, Brazil
e-mail: darcilio@ioc.fiocruz.br

Abstract: Aim: The goal of this study is to examine the composition and richness of caddisfly assemblages in streams at the Serra da Bocaina Mountains, Southeastern Brazil, and to identify the main environmental variables, affecting caddisfly assemblages at the streams with different conditions of land use. **Methods:** The sampling was conducted in 19 streams during September and October 2007. All sites were characterized physiographically by application of environmental assessment protocol to Atlantic Forest streams and by some physical and chemical parameters. Of the 19 streams sampled, six were classified as reference, six streams as intermediate (moderate anthropic impact) and seven streams as poor (strong anthropic impact). In each site, a multi-habitat sampling was taken with a kick sampler net. The sample was composed by 20 units, each one corresponded to 1 m^2 of collected substrate, corresponding 20 m^2 of sampling area. The material was placed in a plastic container (500 µm of mesh), washed, homogenized and sub-sampled. For each stream, 6 subsamples were randomly sorted. **Results:** Were collected 2,113 caddisfly larvae, belonging to 12 families and 28 genera. Hydropsychidae and Leptoceridae were the most abundant families, and *Smicridea* was the most abundant genus. Sorensen's index results showed that the streams studied were grouped according to environmental integrity. The Indicator Species Analysis showed only characteristic taxa to reference streams. Canonical Correspondence Analysis showed that caddisfly assemblage was strongly influenced by nitrate concentration, pH and condition of riparian vegetation. Multiple regression analysis indicated significant correlations to five genera with some environmental parameters, besides total abundance of Trichoptera. **Conclusions:** Ours results showed that degree of environmental impact, mainly the nitrate concentration, pH, and condition of cover vegetation acted as a major factor in determining the Trichoptera assemblages present in the stream of the Serra da Bocaina, separating streams along an environmental gradient.

Keywords: caddisflies; biomonitoring; riparian vegetation; community; impacted streams; Atlantic Forest.

Resumo: Objetivo: Este trabalho teve como objetivo examinar a composição e riqueza da assembleia de larvas de Trichoptera em rios na Serra da Bocaina, Sudeste do Brasil, e identificar as principais variáveis ambientais, que afetam os mesmos rios com diferentes condições de uso da terra. **Métodos:** As amostragens foram feitas em 19 riachos em setembro e outubro de 2007. Cada riacho foi caracterizado fisiograficamente, através da aplicação de um protocolo de avaliação ambiental para rios de Mata Atlântica, e parâmetros físicos e químicos. Dos 19 rios amostrados, seis foram classificados como referência, seis como intermediários (moderado impacto antrópico) e sete como pobres (forte impacto antrópico). Em cada riacho, foi feita uma amostragem multi-habitat com uma rede de "kick". Cada amostra foi composta por 20 unidades, sendo cada uma correspondente a 1 m^2 de substrato coletado, totalizando 20 m^2 de área amostrada. O material coletado foi colocado em um organizador, lavado, homogeneizado e sub-amostrado, sendo retiradas seis sub-amostras aleatoriamente. **Resultados:** Foram coletadas 2.113 larvas de Trichoptera, pertencentes a 12 famílias e 28 gêneros. Hydropsychidae e Leptoceridae foram as famílias mais abundantes e *Smicridea* o gênero mais abundante. O índice de Sorensen mostrou que os rios estudados foram agrupados de acordo com a integridade ambiental. Análise de Espécies Indicadoras mostrou táxons característicos apenas para os rios preservados. A CCA mostrou que a assembleia de Trichoptera foi influenciada pela concentração de nitrato, pH e condição da vegetação ripária. A regressão múltipla mostrou correlação significativa da abundância de cinco gêneros com alguma variável ambiental, além da abundância total de Trichoptera. **Conclusões:** Nossos resultados indicaram que o grau de impacto ambiental, principalmente a concentração de nitrato e a condição da cobertura vegetal, agiram como um dos principais fatores em determinar a assembléia de Trichoptera presente nos riachos da Serra da Bocaina, separando os rios ao longo de um gradiente ambiental

Palavras-chave: biomonitoramento; vegetação ripária; comunidade; rios impactados; Mata Atlântica.

1. Introduction

The lotic ecosystems in the Atlantic forest of Southeastern region of Brazil have suffered severe man-induced stress and are threatened by pollution, development of urban areas and loss of riparian vegetation. According to Dean (1997), the Atlantic Forest is known for its high species diversity, the high degree of endemism of its biota. The destruction of this forest has been occurring since the European colonization of Brazil. Deforestation has not only altered physical habitat, but it has also led to increased peak flows and water volumes during flood events in some pasture catchments. These land-use impacts constitute a press disturbance and also can to affect stream community structure and function over the long-term (Harding et al., 1998).

Macroinvertebrate as indicators of human disturbance have a long history for use in evaluating sewage pollution in rivers, among then Trichoptera larvae are often a major component of the invertebrate fauna in lotic ecosystems worldwide (Ward, 1992), corresponding about 8-13% of total abundance. They are fundamental components of the trophic dynamics and energy flow in lakes, rivers, and streams, forming a link between basal resources (organic debris and primary production and secondary consumers such as fishes (Resh & Rosenberg, 1984; Angrisano, 1995; Wiggins, 1996).

Trichoptera, along with Ephemeroptera and Plecotera, is one of the integrant groups of EPT index (Rosenberg & Resh, 1993). The caddisflies stand out in the monitoring of water quality because they have high species richness and abundance, varying levels of sensitivity to physical and chemical changes, and pollution of aquatic ecosystems (Rosenberg & Resh, 1993; Wiggins, 1996). These traits make the order a good indicator of water quality (Collier et al., 1997).

Caddisfly communities have been useful to detect land use impacts and water pollution effects, by changes in community composition, diversity of taxa or morphological asymmetries in the pollution-tolerant species (*e. g.* Cereghino et al., 1997; Bonada & Williams, 2002; Bonada et al., 2005; Hughes, 2006; Miserendino & Brand, 2007; Houghton & Holzenthal, 2010).

In Brazil, studies on Trichopteran fauna have been growing in the last years (e.g. Bispo et al., 2004; Spies et al., 2006; Spies & Froehlich, 2009; Maltchik et al., 2009; Barbosa et al., 2011; Nogueira et al., 2011; Massoli & Callil, 2014), but few relate caddisflies with environmental pollution. For instance, Bispo et al. (2004) have discussed the role of some physical habitat feature, such as canopy cover and anthropogenic influence, on caddisflies larvae distribution in streams.

The aim of the present study was to examine the composition and richness of caddisfly assemblages in streams at the Serra da Bocaina Mountains, Southeastern Brazil, and to identify the main environmental variables, including riparian vegetation, affecting caddisfly assemblages in streams subjected to different conditions of land use.

2. Material and Methods

2.1. Study area

This study was carried out in 19 streams of the Serra da Bocaina Mountains. The Serra da Bocaina territory is partly preserved in a conservation unit, the Parque Nacional da Serra da Bocaina (PNSB) with an area of 1 000 km^2, located between 22°40'-23°20'S and 44°24'-44°54'W), with 60% of native vegetation and the remainder consisting of a 30-y regenerated (secondary) forest. The climate is classified as temperate super humid with annual precipitation of 1,800 mm. Average temperature is around 16 °C but with a high variation between lowland areas (36-38 °C, around 200 m.a.s.l.) to upper areas (0-4 °C, with a maximum altitude of 2,132 m.a.s.l.) (Guimarães et al., 2000). The studied streams are located in the municipalities of Angra do Reis, Mangaratiba, Parati, Rio Claro (Rio de Janeiro State), and São José do Barreiro (São Paulo State), located both in conservation and urban areas (Figure 1).

2.2. Sampling sites

The sampling was conducted in September and October 2007. In each sampling site, it was conducted a visual environmental assessment protocol (EP) based on the RCE - Riparian Channel Environment protocol (Petersen, 1992). The environmental assessment protocol (EP) was obtained by summing 10 individual metrics based on visual assessment of riparian vegetation cover, stream margins, habitats, substrates or bank conditions. For each parameter a score is given, summed, and the final score is compared to determine one of the five classes of environmental integrity (Appendix 1).

The following environmental parameters were measured at each site: altitude (using a Garmin GPS76), river mean depth (m), width (m), acidity (pH, using LabConte mPA-210p), current velocity ($m.s^{-1}$), discharge ($m^3.s^{-1}$), and water temperature

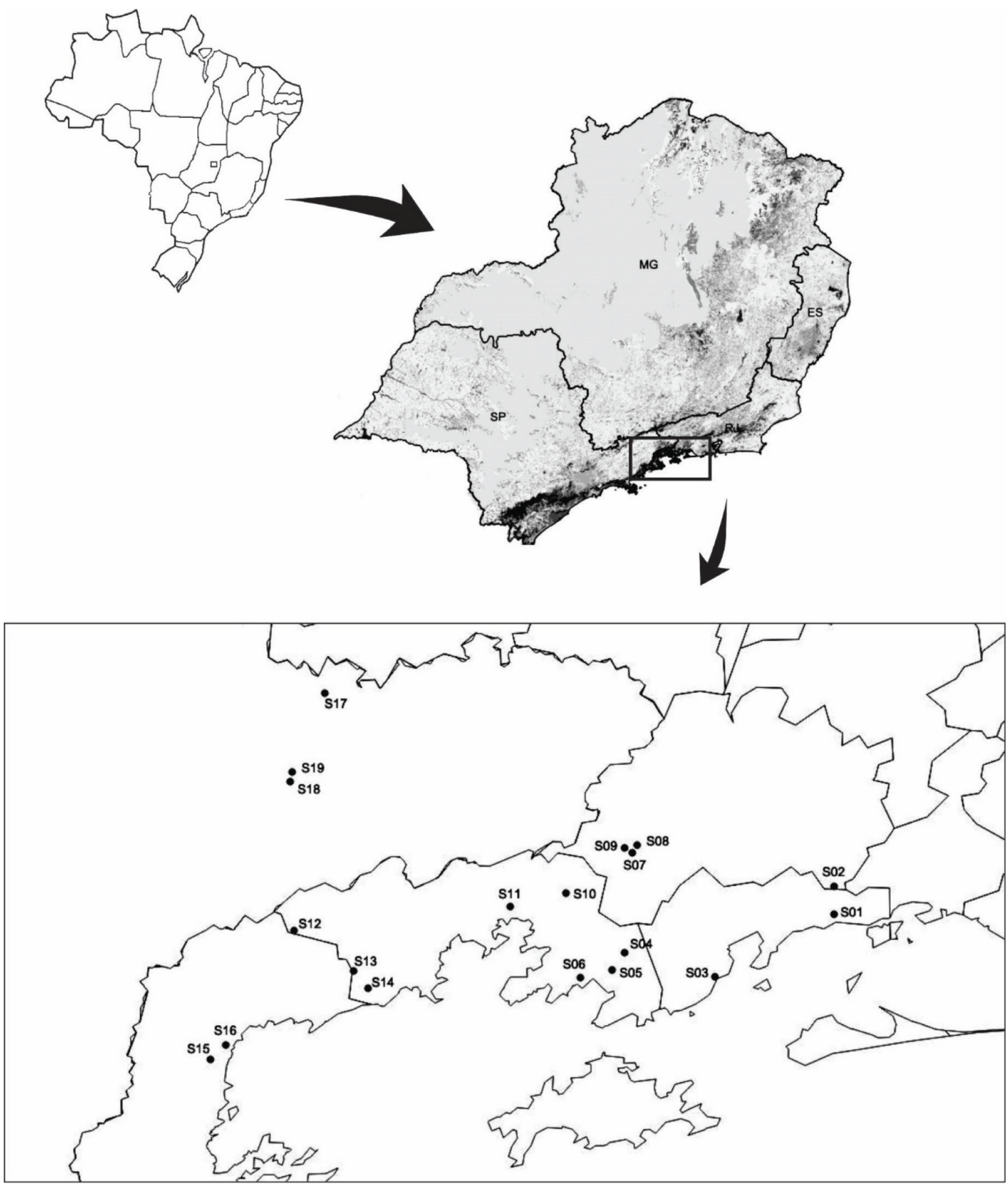

Figure 1. Map of Southeastern Brazil region highlighting the Southern of Rio de Janeiro state and the North of São Paulo state with the sampling sites.

(°C). Water was sampled for further physical and chemical analysis in laboratory: Conductivity (CE, µS/cm^{-1}), Total Alkalinity (mg/L) – (FEEMA, 1979), % Dissolved Oxygen (%DO), Ammonia (mg/L), Nitrate (mg/L), Nitrite (µg/L), and Fecal Coliform (NCP).

The mean width (in meters) per stream was determined from two sections (10 m apart) perpendicular to the main stream flow. The current velocity was estimated by the head rod method (Waterwatch Australia Steering Committee, 2002), using a stainless steel ruler. In each section, we measured the depth of the stream in meters, (D1, with the thin edge of the ruler into the flow), and (D2, with the flat side face into the flow, creating a standing wave or 'head'). These measures were taken at every 30 cm across the stream section. The difference between D1 and D2 is the head. The average head (h) were calculated from these measurements. The average velocity of the stream was determined by the formula: $V (m/s) = \sqrt{}^2 (2x9.81xh)$, where 9.81 is the gravitational constant. The current velocity of each stream was the average of velocities measured in each sampling year. Stream orders were determined by the study of the tributaries of each stream using the cartographic charts of IBGE (1973a, b, c, 1974 a, b) (scale 1:50 000).

Before biological sampling, the sites were classified into three levels of impairment: reference sites, moderately impaired sites (intermediate), and severely impaired sites (poor). Reference sites were considered as streams minimally disturbed by meeting located in forested areas, land use with maximum of 20% of the basin area urbanized and ≥ 75% of the upstream basin area forested; width of the riparian zone > 18 m; no visible sign of channelization; and "very good" classification according to the environmental assessment protocol. Major impacts at 'impaired' sites were removal of riparian vegetation and alterations of physical characteristics of streams with 'intermediate' or 'poor' classification. For the 'intermediate' condition, the following a priori conditions should be met: deforestation of 50-70% of the upstream area; silting in riffle mesohabitats covering 30-50%.

In each site, a multi-habitat sampling was taken with a kick sampler (500 µm mesh), the sampling was proportional to substrate availability in the stream stretches studied. The sample was composed of 20 units, corresponding to total sampling area of 20 m^2 substrates, and each one corresponds to 1 m^2 of collected substrate. The sample was combined and preserved in 80% ethanol. In laboratory, the sample of each stream was washed, homogenized and placed in a plastic container with total size 64 x 36 cm, divided into 24 quadrats of aluminum with mesh of 500 µm. Each quadrat measures 10.5x8.5cm, with an area of approximately 90 cm^2. For each stream, 6 subsamples were randomly removed (representing each subsample one quadrat) that were sorted in white trays (Oliveira et al., 2011). Caddisfly larvae were identified with aid of the taxonomic keys by Angrisano (1995), Pes et al. (2005) and Wiggins (1996).

2.3. Data analysis

Community diversity and evenness were calculated using the Shannon-Wiener and Pielou indexes, respectively (Elliot, 1977; Ludwig & Reynolds, 1988). Taxonomic richness was estimated as the total number of different taxa found in each sample and by rarefaction method (Gotelli & Colwell, 2001) using the program Past, version 1.40 (Hammer et al., 2001).

Sorensen's Similarity Index was used for analyzing similarities between taxonomic composition of Trichoptera fauna based on a presence-absence matrix for the genera. The Sorensen's Index matrix was submitted to a cluster analysis through the average association method (UPGMA). Characteristic groups of each stream type were determined through Indicator Value Method – IndVal (Dufrêne & Legendre 1997). This method matches information on species abundance and frequency of occurrence among groups. A Monte Carlo permutation test was employed to test significant associations of taxa and groups of sites ($p < 0.05$).

A Canonical Correspondence Analysis (CCA) was used to determine the factors that might be influencing the caddisfly fauna abundance and distribution. The total abundance data of all streams were log-transformed (n + 1). Environmental features included were: pH, Conductivity, width, depth, velocity, discharge, Dissolved Oxygen, Ammonia, Nitrate, Nitrite, Total Alkalinity, fecal coliform, besides the degree preservation of riparian vegetation (RV) using the score of EA item 9. CCA, Sorensen's Similarity index and Indicator Value Method were performed using PC-ORD program version 4.14 (Mccune & Mefford, 1999).

Multiple regression analysis was performed to evaluate the relation between environmental features (independent variable) to species distribution and abundance of the same (dependent variable). The dependent variables considered in this analysis were abundance of each taxa in each site, total abundance and total richness. This analysis was performed using STATISTICA 7.0 (Statsoft, 2004).

3. Results

3.1. Environmental parameters of streams

Of the 19 streams sampled, six were classified as reference (score > 16), and the other streams were classified as impaired, being six streams as intermediate, with moderate anthropic impact (score > 9.0 < 16) and seven streams as poor, strong anthropic impact (score > 0 < 9.0) (Table 1). The environmental parameters recorded from the studied streams are shown in Table 2. Temperature values do not varied significantly among the streams. Stream S03 show the lowest pH values (5.70) while S17 the highest (8.04). The stream S06 classified as poor, showed the highest values of Conductivity (140.8μS.cm^{-1}), Ammonia (> 2.5), and Alkalinity (123.2 mg/L). The values of dissolved oxygen (DO) do not showed significant variation because some poor streams obtained high values.

3.2. Trichoptera community composition

A total of 2,113 individuals of Trichoptera larvae belonging to 12 families and 28 genera were collected. Hydropsychidae and Leptoceridae were the most abundant families with 916 and 535 specimens respectively. The taxonomic richness (rarefactions and observed), Shannon's diversity, Pielou's evenness index, and total abundance are shown in Table 3. The richness in reference streams was standardized for 63 individuals, intermediate for 9 individuals and poor streams for 18 individuals by the rarefaction richness. This value represents the stream with lowest abundance. Although, the S06 and S08 had lower abundance values than site S02, these two sites were not considered in rarefaction analysis because both had only one genus with one and four individuals respectively. The highest values of richness and diversity were found in sites S18 and S19 both located in preserved areas.

Smicridea was the genus with higher abundance in all streams, with 786 individuals. In reference sites, besides *Smicridea* (19%), were also abundant *Grumichella* (16.5%), *Phylloicus* (15.9%), *Nectopsyche* (12.8%), and *Grumicha* (9.5%). In impaired sites, *Smicridea* was the main genus of Trichoptera, representing more than 63% of the fauna composition.

Cluster Analysis results based on the Sorensen's index (Figure 2) show the presence of three principal

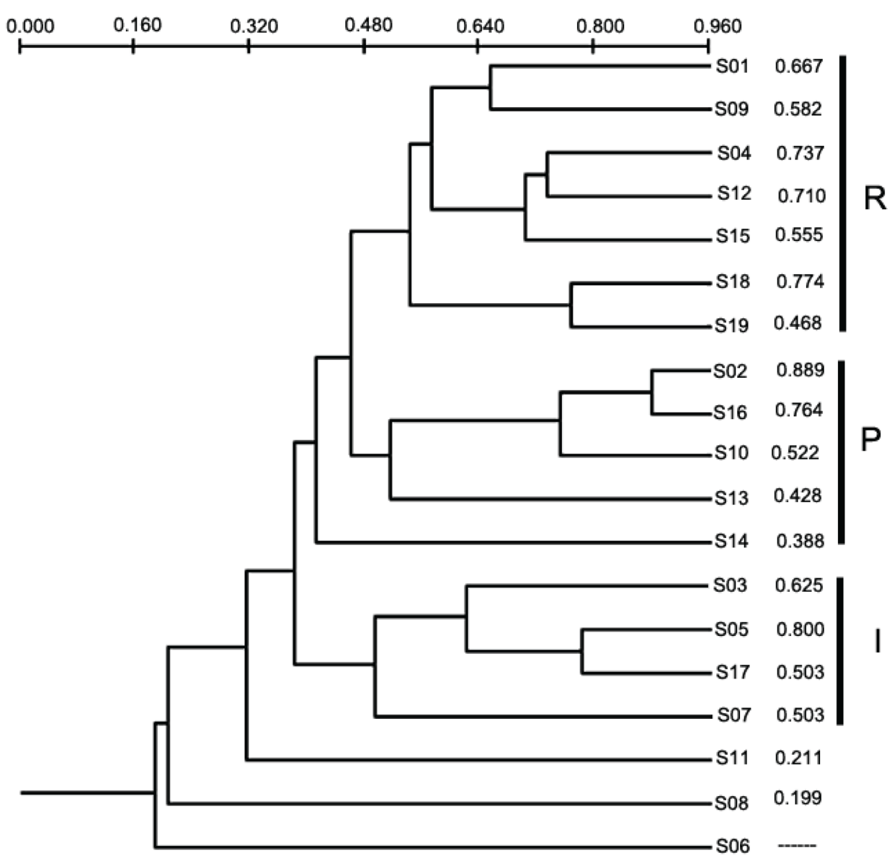

Figure 2. Cluster Analysis (UPGMA method) based on Sorensen's Index values for 19 streams in Serra da Bocaina Mountain. R – Reference sites; I – Intermediate sites; P – Poor sites.

groups of streams: one group formed by reference sites, one formed by the majority of intermediate sites and one group formed by poor sites. The results of the Indicator species analysis (Table 4) showed only characteristic taxa to reference streams: *Atopsyche* (50.5 ± 14.23, $p < 0.05$), *Phylloicus* (25.7 ± 11.98, $p < 0.05$) and *Triplectides* (30.2 ± 12.38, $p < 0.05$). Intermediate and poor streams do not showed characteristic taxa.

In the CCA the three first axis explained 0.350, 0.280, and 0.230 respectively of variation, and were strongly influenced by nitrate concentration, pH and condition of riparian vegetation, separating streams with good ecological condition from impaired streams (Figures 3 and 4).

Multiple regression analysis showed significant correlations of the abundance of five genera with some environmental parameters. The total abundance

Table 1. Localization, score of Environmental Assessment Protocol (EP) and Environmental classification for each studied stream in Serra da Bocaina Mountains.

	Site	Latitude	Longitude	Altitude (m)	EP	Classification
S01	Rio Muriqui	22°55'00.06" S	43°57'10.59" W	32	19.9	reference
S02	Rio do Saco	22°52'59.43" S	43°57'11.48" W	355	7.0	poor
S03	Rio Grande	22°59'35.91" S	44°05'54.40" W	25	15.2	intermediate
S04	Rio Caputera	22°57'49.64" S	44°12'31.14" W	111	16.7	reference
S05	Rio Jacuecanga	22°59'05.92" S	44°13'27.95" W	5	9.6	intermediate
S06	Rio Camorim	22°59'41.44" S	44°15'47.72" W	2	3.8	poor
S07	Rio Piraí	22°50'28.26" S	44°11'57.88" W	498	12.2	intermediate
S08	Rio Parado	22°49'58.27" S	44°11'36.13" W	506	3.2	poor
S09	Rio Cotia	22°50'08.37" S	44°12'31.68" W	553	14.1	intermediate
S10	Rio da Guarda	22°53'28.44" S	44°16'49.44" W	35	5.8	poor
S11	Rio Florestão	22°54'27.79" S	44°20'57.40" W	25	16.6	reference
S12	Rio Santo Antônio	22°56'12.46" S	44°36'49.53" W	110	19.4	reference
S13	Rio Itapicú	22°59'10.36" S	44°32'27.53" W	17	9.5	intermediate
S14	Rio Perequê	23°00'25.15" S	44°31'21.62" W	17	5.1	poor
S15	Rio Barra Grande	23°05'38.69" S	44°42'57.30" W	26	10.3	intermediate
S16	Rio São Roque	23°04'36.36" S	44°41'50.83" W	16	5.3	poor
S17	Ribeirão Barreiro	22°38'45.86" S	44°34'34.75" W	506	3.8	poor
S18	Ribeirão do Boqueirão	22°45'16.59" S	44°37'06.22" W	1364	16.7	reference
S19	Rio Mambucaba	22°44'34.29" S	44°36'56.41" W	1488	18.4	reference

Table 2. Environmental features measured for 19 rivers studied in Serra da Bocaina Mountains.

	T °C	Width cm	Depth cm	Vel $m.s^{-1}$	Dis $m^3.s^{-1}$	pH	CE $\mu S.cm^{-1}$	% DO $mg.L^{-1}$	Ammonia $mg.L^{-1}$	Nitrate $mg.L^{-1}$	Nitrite mg,L^{-1}	Alk $mg.L^{-1}$	FCO	RV
S01	19.8	8.7	14.43	0.2993	0.3917	7.61	31.60	87.0	0.05	1.7	0.006	34.92	1	20
S02	21.1	7.9	17.39	0.2198	0.2156	6.93	30.70	82.8	0.05	1.1	0.002	32.86	10	2
S03	20.0	8.5	28.74	0.3618	0.8828	5.70	43.50	80.7	0.04	0.8	0.009	30.81	13	13
S04	19.3	12.24	27.78	0.2814	0.9260	7.35	27.57	79.2	0.02	0.6	0.007	30.81	4	15
S05	20.4	12.85	14.42	0.4772	0.8814	7.78	31.31	75.3	0.02	0.8	0.006	39.03	38	9
S06	21.2	2.35	9.68	0.3944	0.0820	7.09	140.80	28.9	2.50	0.4	0.006	123.24	97	4
S07	19.7	15.20	35.55	0.2164	1.1559	7.94	24.73	89.7	0.00	0.5	0.002	41.08	0	11
S08	21.4	7.45	12.49	0.3111	0.2733	7.70	31.28	94.7	0.10	1.0	0.000	44.00	136	2
S09	19.8	11.00	14.26	0.4461	0.6986	7.05	22.54	89.3	0.01	1.3	0.020	43.13	8	14
S10	22.1	8.25	28.70	0.1393	0.3124	7.45	33.47	77.9	0.13	0.6	0.033	50.00	16	3
S11	20.6	9.78	35.95	0.1466	0.5133	7.94	21.13	80.9	0.03	0.8	0.008	36.97	3	18
S12	21.8	13.15	16.68	0.2574	0.5826	7.36	23.10	95.1	0.06	1.0	0.000	49.30	0	19
S13	22.6	6.50	15.01	0.21075	0.1823	7.56	21.69	94.1	0.03	0.8	0.000	32.86	19	10
S14	25.0	12.00	11.08	0.4225	0.5637	7.29	22.38	96.4	0.06	0.5	0.003	39.03	11	4
S15	19.7	17.85	23.63	0.3124	1.2339	7.48	17.80	89.1	0.04	0.5	0.001	34.92	2	8
S16	19.5	7.50	13.15	0.3814	0.4124	7.59	16.79	77.2	0.02	1.1	0.004	36.97	0	4
S17	24.4	6.95	17.11	0.1615	0.1626	8.04	35.26	57.7	0.05	1.2	0.001	53.40	18	1
S18	20.6	5.38	14.75	0.2885	0.2266	7.74	20.16	64.0	0.06	1.0	0.002	34.92	6	18
S19	19.2	6.11	18.07	0.3810	0.4311	6.25	9.08	57.9	0.08	0.9	0.004	36.97	0	18

Vel= Current velocity; Dis = Discharge; CE = Electric conductivity; DO = % Dissolved oxygen; Alk = Total Alkalinity; FCO= fecal coliform; RV = riparian vegetation.

Table 3. Trichoptera taxa collected in 19 streams in Serra da Bocaina Mountains, Southeastern Brazil.

	TAXA	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19
	Anomalopsychidae																			
Con	*Contulma* Flint, 1969																			1
	Calamoceratidae																			
Phy	*Phylloicus* Müller, 1880	135	1		10					2	3	11	14	1		1	4		16	13
	Glossosomatidae																			
Mor	*Mortoniella* Ulmer, 1906							19			1				1				3	5
Pro	*Protoptila* Banks, 1904							5										1		
	Helicopsychidae																			
Hel	*Helicopsyche* Siebold, 1856				2			6				1	7						1	1
	Hydrobiosidae																			
Ato	*Atopsyche* Banks, 1905	12								4			1						1	10
	Hydroptilidae																			
Leu	Leucotrichini	1																		
Ali	*Alisotrichia* Flint, 1964										1									
Hyd	*Hydroptila* Dalman, 1819			7		8				5		5								
Met	*Metrichia* Ross, 1938.	3		1	7	8		1		4			3					3		43
Neo	*Neotrichia* Morton, 1905							1				1							2	
Oxy	*Oxyethira* Eaton, 1873																			10
	Hydropsychidae	1																		
Smi	*Smicridea* McLachlan, 1871	5	10		20	371	1	1		81	75	39	3		4	4	31	48	34	59
Lep	*Leptonema* Guérin, 1843							3				21	2	65	14	10	4		2	6
Mac	*Macronema* Pictet, 1836											2								
	Leptoceridae																			
Ata	*Atanatolica* Mosely, 1936	2																		

Table 3. Continued...

	TAXA	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19
Grl	*Grumichella* Müller, 1879	1											12		4				32	163
Nec	*Nectopsyche* Müller, 1879	16	1	1	2	1		9	4	31	1			2			1	4	68	45
Not	*Notalina* Mosely, 1936												1						9	46
Oec	*Oecetis* McLachlan, 1877							2												4
Tri	*Triplectides* Kolenati, 1859	1			18					1			16			1			7	29
	Odontoceridae																			
Mar	*Marilia* Müller, 1880	1																	4	1
	Philopotamidae																			
Chi	*Chimarra* Stephens, 1829	1	6	1	47		1		1	5		3		1	3	1		1		
	Polycentropodidae																			
Cyr	*Cyrnellus* Banks, 1913										12									
Poc	*Polycentropus* Curtis, 1835								1					5					1	
Pop	*Polyplectropus* Ulmer, 1905													2						4
	Sericostomatidae																			
Gru	*Grumicha* Müller, 1879			3								112	13	1	3				2	3
	Total Abundance	**180**	**18**	**9**	**63**	**435**	**1**	**48**	**4**	**130**	**86**	**92**	**174**	**81**	**32**	**22**	**41**	**57**	**182**	**443**
	Total Richness	12	4	3	8	5	1	10	1	9	6	8	11	4	8	6	5	5	14	17
	Rarefaction	7.3	4.0	3.0	8.0	2.0	-	5.0	-	3.0	2.8	7.2	8.5	2.2	6.5	4.4	3.7	3.2	10.3	11.3
	Shannon H'	1.002	1.014	0.684	1.688	0.537	0.000	1.805	0.000	1.153	0.557	1.560	1.340	0.616	1.670	1.493	0.847	0.628	1.861	2.052
	Eveness Pielou	0.403	0.731	0.622	0.812	0.334	0.000	0.784	0.000	0.525	0.311	0.750	0.559	0.444	0.803	0.833	0.526	0.390	0.705	0.724

Table 4. Taxa with significant values of Indication ($p < 0.05$, 1000 permutations) for each site group (reference, intermediate and poor streams) studied at Serra da Bocaina Mountain, Southeastern Brazil. Where Max Group 1: reference; max group 2 – intermediate and max group 3 – poor.

Taxon	Max group	Value (IV)	Mean	S. Dev	*p*
Contulma	1	12.5	15.7	3.09	1.0000
Phylloicus	**1**	**81.9**	**50.5**	**14.23**	**0.0276**
Mortoniella	3	14.8	27.6	12.67	0.8504
Protoptila	3	17.1	18.6	8.83	0.5116
Helicopsyche	1	34.7	28.0	12.16	0.2563
Atopsyche	**1**	**62.5**	**25.7**	**11.98**	**0.0151**
Alisotrichia	2	16.7	15.8	3.08	0.5833
Hydroptila	3	28.2	21.9	10.43	0.1367
Metrichia	1	46.9	38.8	13.68	0.2631
Neotrichia	1	16.3	19.5	10.74	0.6124
Oxyethira	1	12.5	15.7	3.09	1.0000
Smicridea	3	33.8	54.1	11.31	0.9793
Leptonema	3	41.6	37.1	13.45	0.3306
Macronema	1	12.5	15.9	3.10	1.0000
Atanatolica	1	12.5	15.8	3.08	1.0000
Grumichella	1	48.7	29.6	13.13	0.0997
Nectopsyche	1	51.3	46.0	13.05	0.3041
Notalina	1	37.5	22.5	10.77	0.1402
Oecetis	3	8.9	17.0	9.58	0.8535
Triplectides	**1**	**73.4**	**30.2**	**12.38**	**0.0079**
Marilia	1	37.5	21.0	10.68	0.0922
Chimarra	3	46.1	51.6	14.33	0.6508
Cyrnellus	1	12.5	15.9	3.10	1.0000
Polycentropus	2	12.8	21.4	10.71	0.7936
Polyplectropus	1	7.5	16.9	9.66	1.0000
Grumicha	1	40.8	38.5	14.52	0.4429

of Trichoptera was significantly correlated with the degree of preservation of riparian vegetation (r^2=0.627; p=0.000). *Smicridea* showed significate correlation with five environmental parameters (r^2=0,791; p<0,05), positively with stream width, current velocity, and nitrite concentration, and negative with stream discharge and dissolved oxygen (%). *Notalina* correlated negatively with dissolved oxygen and conductivity (r^2=0,722; p=0,05). *Grumicha* showed positive correlation with riparian vegetation (RV) and negatively with stream depth, current velocity and nitrate concentration. *Grumichella* and *Triplectides* showed positive correlation with degree of preservation of riparian vegetation (RV), Total richness did not obtain a significant correlation with any environmental parameters.

4. Discussion

Biodiversity loss in freshwaters is a mounting threat from widespread human disturbances, and benthic macroinvertebrates are key indicators in determining patterns of stream ecosystem degradation (Pond, 2011). In our study, we observed a great loss of diversity in intermediate and poor streams when compared with the reference ones. The low diversity of Trichoptera at impaired sites is related to loss of habitats by urbanization and deforestation, causing the increase of sedimentation on rocky substrates and reduced litter input in the stream (Allan et al., 1997; Townsend et al., 1997; Bispo & Oliveira, 2007).

Hydropsychidae and Leptoceridae were the main families found in this study. These data confirm the greater abundance of these families in Tropical regions, as reported by Flint et al. (1999). According Bonada et al. (2004), Hydropsychidae is regarded as a very tolerant family all over the world, with species being segregated within different water quality characteristics along the river. In our study, *Smicridea* was the most abundant in all sites, mainly in the impaired sites, where represented more than 60% of the specimens. This result denotes a high tolerance of this genus to small impacts as absence of riparian vegetation, sedimentation, or small input of organic matter, and corroborates the results found by Righi-Cavallaro et al. (2010) and Massoli & Callil (2014) for other regions of the country.

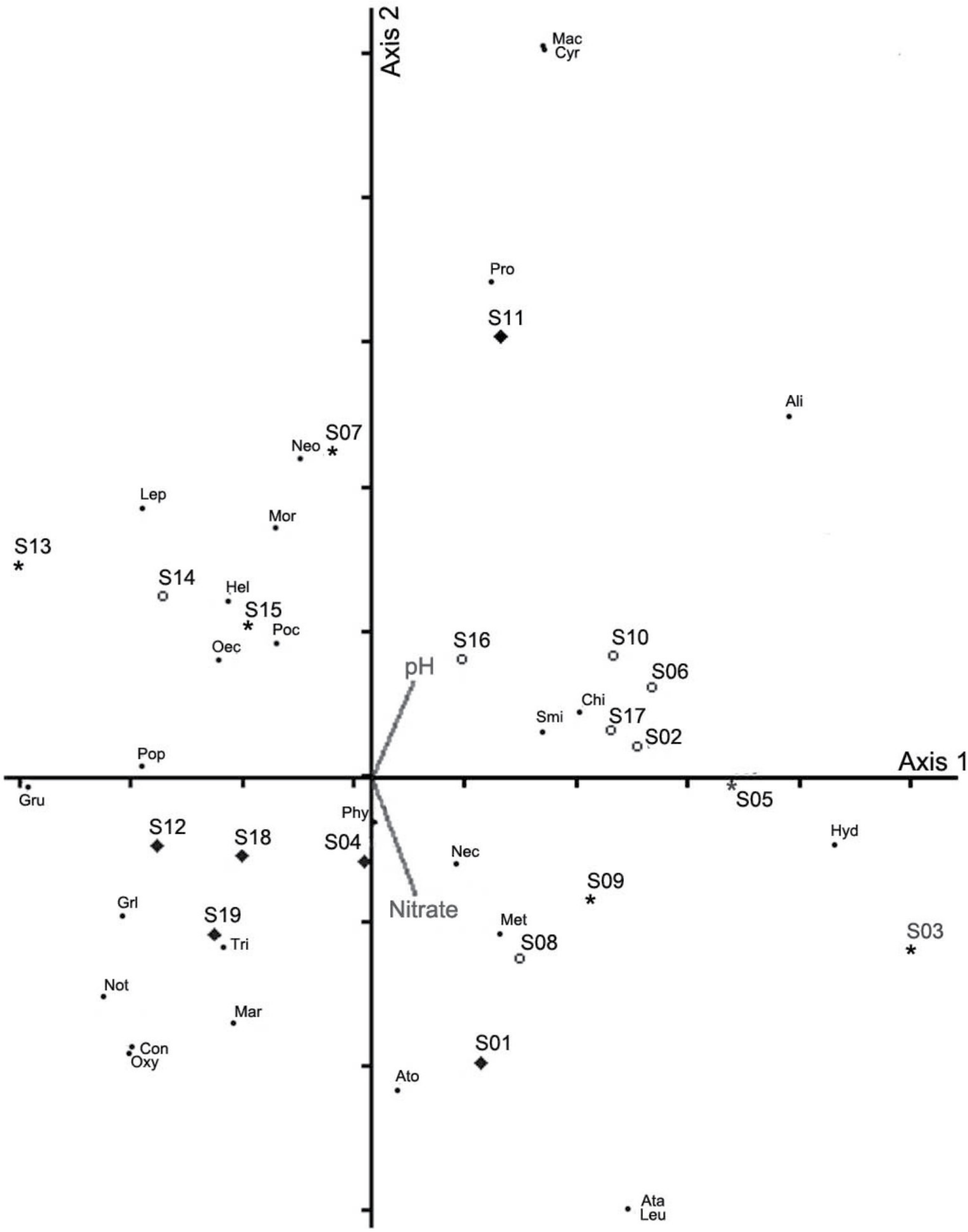

Figure 3. Canonical Correspondence Analysis (CCA) performed to 19 sites studied and environmental parameters at Serra da Bocaina Mountain. Axis 1 and 2. ♦ reference streams, * intermediate streams, ○ poor streams.

According Bentes et al. (2008), *Smicridea* is a water quality bioindicator with generalist habit which can be found in environments with different degrees of preservation. *Smicridea* larvae are found in rocky substrates in moderate or high current velocity and its main source of food is fine particulate organic matter (FPOM) that is trapped in the capture nets they build (Wiggins, 1996; Merritt & Cummins, 1996).

The results of Sorensen's index showed the presence of different communities, characteristic to each degree of environmental impact. According to Allan (2004) the land use patterns are considered one of main determining factors in macrofauna

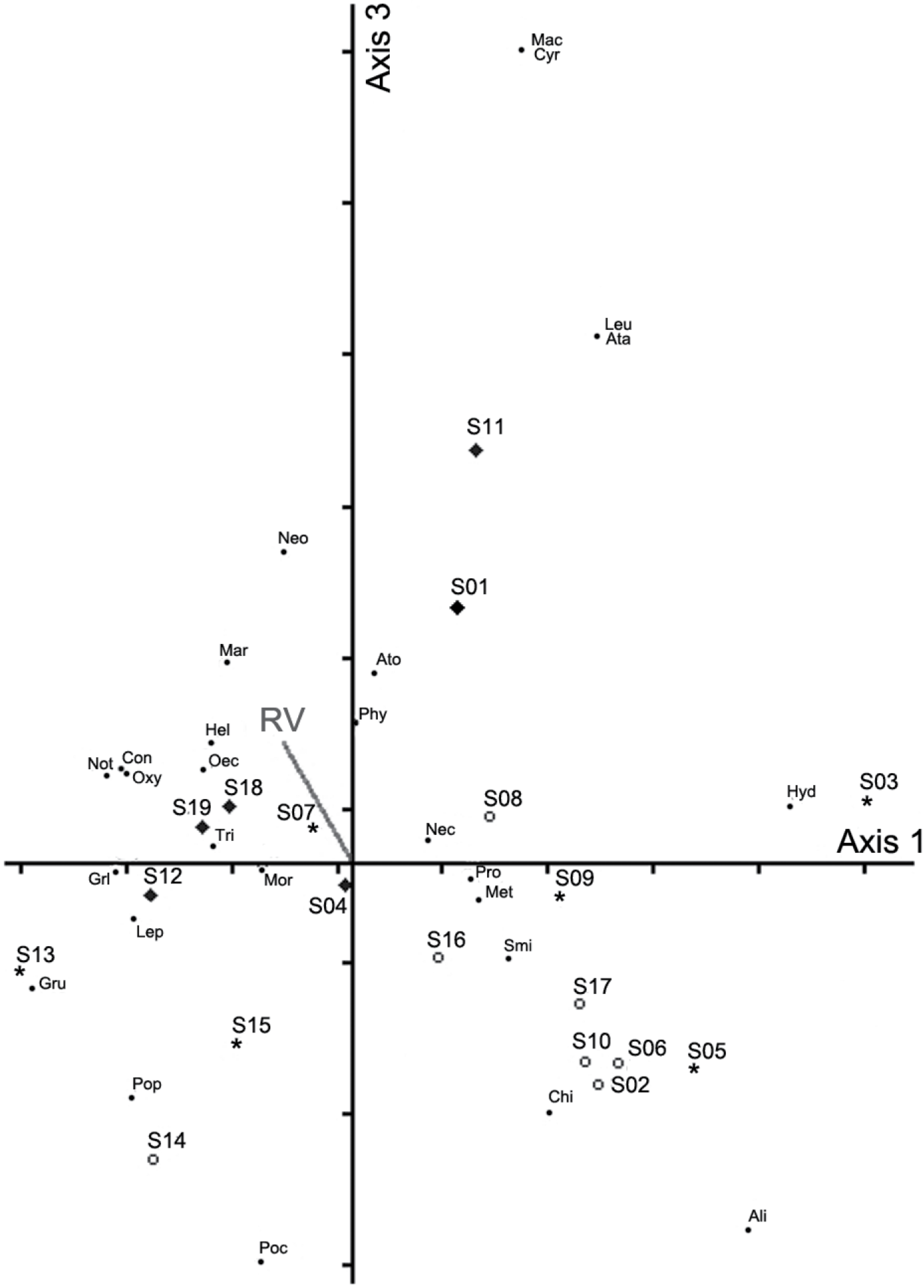

Figure 4. Canonical Correspondence Analysis (CCA) performed to 19 sites studied and environmental parameters at Serra da Bocaina Mountain. Axis 1 and 3. ♦ reference streams, * intermediate streams, ○ poor streams, RV- riparian vegetation.

distribution. According Bonada et al. (2004), certain caddisfly families and species are sensitive to some variables but more tolerant to others, making the Trichoptera good tools for biomonitoring. *Atopsyche*, *Helicopsyche*, *Phylloicus* and *Triplectides* were characteristic to reference streams, corroborated by results of multiple regression for caddisfly total abundance that showed positive correlations with preservation of riparian vegetation. *Helicopsyche*, *Phylloicus* and *Triplectides* are primarily leaf eaters (shredders or scrapers) having strong association with degree of preservation of riparian zone, that provides food and material for shelters. Nogueira et al. (2011) found that species highly dependent to leaf bags as *Phylloicus,* showed significant declines in impaired streams or without riparian vegetation. Pereira et al. (2012) found *Helicopsyche* and *Phylloicus* as good indicators of preserved environments. *Atopsyche* larvae are predators and their main food items are larvae of Diptera, Trichoptera, Ephemeroptera and Oligochaeta (Reynaga & Rueda Martín, 2010). Ours results could prove that some taxa may be sensitive to changes in the quality of the stream and riparian vegetation, and might be good candidates for using as indicator taxa in bioassessment programs.

Canonical Correspondence Analysis showed that degree of environmental impact, directed by the change in nitrate concentration, pH and condition of riparian vegetation, were the main influencing factors that separated the stream along with an environmental gradient. Strieder et al. (2006) observed that the concentration of nitrate and nitrite had leading role in the distribution of species of *Simulium* in rivers in the Rio Grande do Sul state separating streams according to the degree of environmental impact. Hepp et al. (2013) studying EPT distribution in urban streams with different environmental impacts found that BOD, nitrate and phosphorous affected particularly Trichoptera and Plecoptera.

Nogueira et al. (2011) observed that the flow, vegetation and conservation of the environment were determining factors in the species composition at the Suiá-Miçú River basin, Mato Grosso, Brazil. Allan et al. (1997) found that land use was a strong predictor of biological and habitat integrity. The riparian vegetation plays an important role in the dynamic of water bodies, influencing directly or indirectly in the process and system of community (Vannote et al., 1980). Also, a higher amount of sediment was found on the stones as a consequence of the large areas of land recently denuded. Rodrigues-Filho et al. (2015) analyzing the alterations in land uses based on amendments to the Brazilian Forest Law and their influences on water quality of a watershed found that even the suppression of only 20% of vegetation cover in the watershed is not compatible with sustainable practices and would result in losses of important ecosystem services and increase of loading nutrients in watersheds. According Whittier & Van Sickle (2010) quantifying an overall human disturbance gradient is probably the least tractable part of the process of determining taxon and assemblage tolerance.

Our study represents first investigations about assemblages of Trichoptera larvae and environmental quality in Serra da Bocaina streams, and confirms previous studies conducted to same area about environmental quality, that degree of environmental impact, mainly the condition of cover vegetation and amount of fecal coliform, act as a major factor in determining the distribution of Trichoptera assemblages present in the stream. The identification of which environmental factors were influencing the composition of aquatic insect fauna is very important to guide programs of assessment and conservation of biodiversity in rivers of Southeastern Brazil.

Acknowledgements

The authors would like to thank the financial support of CNPq (Edital CNPq/PROEP 400107/2011-2 and CT-Hidro/PDJ), ICMBIO-MMA and Serra da Bocaina National Park for collect permits, and the colleagues Valdinei Valin and Denise Borges Assunção (LAPSA/IOC/FIOCRUZ) for the water analysis of this study.

References

ALLAN, J.D. Landscapes and riverscapes: the influence of land use on stream ecosystems. *Annual Review of Ecology and Evolution System*, 2004, 35, 257-284. http://dx.doi.org/10.1146/annurev.ecolsys.35.120202.110122.

ALLAN, J.D., ERICKSON, D. and FAY, J. The influence of catchment land use on stream integrity across multiple spatial scales. *Freshwater Biology*, 1997, 37(1), 149-161. http://dx.doi.org/10.1046/j.1365-2427.1997.d01-546.x.

ANGRISANO, E.B. *Insecta Trichoptera*. In E.C. LOPRETTO and G. TELL, eds. *Ecosistemas de aguas continentals*. La Plata: Ed. Hemisferio Sur, 1995, pp. 1199-1242.

BARBOSA, F.F, GODOY, B.S and OLIVEIRA, L.G. Trichoptera Kirby (Insecta) immature fauna from Rio das Almas Basin and Rio Paranã, Goiás State, Brazil, with new records for some genera. *Biota Neotropica*, 2011, 11, 21-25. http://dx.doi.org/10.1590/S1676-06032011000400001.

BENTES, S.P.C., PES, A.M.O., HAMADA, N. and KEPPLER, R.L.M.F. Larvas de *Synoestropsis* sp. (Trichoptera: Hydropsychidae) são predadoras? *Acta Amazonica*, 2008, 38(3), 579-582. http://dx.doi.org/10.1590/S0044-59672008000300023.

BISPO, P.C. and OLIVEIRA, L.G. Diversity and structure of Ephemeroptera, Plecoptera and

Trichoptera (Insecta) assemblages from riffles in mountain streams of Central Brazil. *Revista Brasileira de Zoologia*, 2007, 24(2), 283-293. http://dx.doi.org/10.1590/S0101-81752007000200004.

BISPO, P.C., OLIVEIRA, L.G., CRISCI-BISPO, V.L.C. and SOUSA, K.G. Environmental factors influencing distribution and abundance of trichopterans in Central Brazilian mountain streams. *Studies on Neotropical Fauna and Environment*, 2004, 39(3), 233-237. http://dx.doi.org/10.1080/0165052041 2331271710.

BONADA, N. and WILLIAMS, D.D. Exploration of the utility of fluctuating asymmetry as an indicator of river condition using larvae of the caddisfly *Hydropsyche morose* (Trichoptera: Hydropsychidae). *Hydrobiologia*, 2002, 481(1/3), 147-156. http://dx.doi.org/10.1023/A:1021297503935.

BONADA, N.V., RIERADEVALL, M. and PRAT, N. Relationship between pollution and fluctuating asymmetry in the pollution-tolerant caddisfly *Hydropsyche exocellata* (Trichoptera, Insecta). *Archiv für Hydrobiologie*, 2005, 162(2), 167-185. http://dx.doi.org/10.1127/0003-9136/2005/0162-0167.

BONADA, N.V., ZAMORA-MUNOZ, C., RIERADEVALL, M. and PRAT, N. Ecological profiles of caddis fly larvae in Mediterranean streams: implications for bioassessment methods. *Environmental Pollution*, 2004, 132(3), 509-521. http://dx.doi.org/10.1016/j.envpol.2004.05.006. PMid:15325467.

CEREGHINO, R., BOUTET, T. and LAVANDIER, P. Abundance, biomass, life history and growth of six Trichoptera species under natural and hydropeaking conditions with hypolimnetic releases in a Pyrenean stream. *Archiv für Hydrobiologie*, 1997, 138, 307-328.

COLLIER, K.J., SMITH, B.J. and BAILLIE, B.R. Summer light-trap catches of adults Trichoptera in hill-country catchments of contrasting land use, Waikato New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 1997, 3(5), 623-634. http://dx.doi.org/10.1080/00288330.1997.9516794.

DEAN, W. *With broadax and firebrand: the destruction of the Brazilian Atlantic Forest.* California: University of California Press, 1997, 504 p.

DUFRÊNE, M. and LEGENDRE, P. Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs*, 1997, 67, 345-366.

ELLIOT, J.M. *Some methods for statistical analysis of samples of benthic invertebrates*. 2th ed. London: Freshwater Biological Association, 1977, 160 p. Scientific Publication, no. 25.

FLINT, O.S., HOLZENTHAL, R.W. and HARRIS, S.C. *Catalog of the Neotropical Caddisflies (Insecta: Trichoptera)*. Ohio: Ohio Biological Survey, 1999, 239 p.

FUNDAÇÃO ESTADUAL DE ENGENHARIA DO MEIO AMBIENTE – FEEMA. *Métodos de análise físico-química da água.* Rio de Janeiro: DICOMT, 1979, vol. 3.

GOTELLI, N.J. and COLWELL, R.K. Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters*, 2001, 4(4), 379-391. http://dx.doi.org/10.1046/j.1461-0248.2001.00230.x.

GUIMARÃES, A.E., GENTILE, C., LOPES, C.M., SANT'ANNA, A. and JOVITA, A.M. Ecologia de mosquitos (Diptera: Culicidae) em áreas do Parque Nacional da Serra da Bocaina, Brasil. I - Distribuição por hábitat. *Revista de Saude Publica*, 2000, 34(3), 243-250. http://dx.doi.org/10.1590/S0034-89102000000300006. PMid:10920446.

HAMMER, Ø., HARPER, D.A.T. and RYAN, P.D. PAST: Paleontological Satatistic software package for education and data analysis. *Paleontologia Eletronica,* 2001, 4(1), 1-9.

HARDING, J.S., BENFIELD, E.F., BOLSTAD, P.V. and HELLFMAN, G.S. HARDING, J.S., BENFIELD, E.F., BOLSTAD, P.V., HELFMAN, G.S. and JONES 3RD., E.B. Stream biodiversity: the ghost of land use past. *Proceedings of the National Academy of Sciences of the United States of America*, 1998, 95(25), 14843-14847. http://dx.doi.org/10.1073/pnas.95.25.14843. PMid:9843977.

HEPP, L.U., RESTELLO, R.M., MILESI, S.V., BIASI, C. and MOLOZZI, J. Distribution of aquatic insects in urban headwater streams. *Acta Limnologica Brasiliensia*, 2013, 25(1), 1-9. http://dx.doi.org/10.1590/S2179-975X2013005000014.

HOUGHTON, D.C. and HOLZENTHAL, R.W. Historical and contemporary biological diversity of Minnesota caddisflies: a case study of landscape-level species loss and trophic composition shift. *Journal of the North American Benthological Society*, 2010, 29(2), 480-495. http://dx.doi.org/10.1899/09-029.1.

HUGHES, S.J. Temporal and spatial distribution patters of larval Trichoptera in Madeira streams. *Hydrobiologia*, 2006, 553(1), 27-41. http://dx.doi.org/10.1007/s10750-005-0627-1.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA – IBGE. *Carta Topográfica Cunhambebe: SF-23-Z-A-V-3, Escala 1:50.000*. Rio de Janeiro: IBGE, 1973a.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA – IBGE. *Carta Topográfica Parati: SF-23-Z-C-I-2, Escala 1:50.000*. Rio de Janeiro: IBGE, 1973b.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA – IBGE. *Carta Topográfica*

Mangaratiba: SF-23-Z-A-V-4, Escala 1:50.000. Rio de Janeiro: IBGE, 1973c.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA – IBGE. *Carta Topográfica Rio Mambucaba: SF-23-Z-C-II-I, Escala 1:50.000*. Rio de Janeiro: IBGE, 1974a.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA – IBGE. *Carta Topográfica São José do Barreiro: SF-23-Z-A-IV-2, Escala 1:50.000*. Rio de Janeiro: IBGE, 1974b.

LUDWIG, J.A. and REYNOLDS, J.F. *Statistical ecology: a primer on methods and computing*. New York: John Wiley and Sons, 1988, 337 p.

MALTCHIK, L., STENERT, C., SPIES, M.R. and SIEGLOCH, A.E. Diversity and Distribution of Ephemeroptera and Trichoptera in Southern Brazil Wetlands. *Journal of the Kansas Entomological Society*, 2009, 82(2), 160-173. http://dx.doi.org/10.2317/JKES808.04.1.

MASSOLI, E.V. and CALLIL, C.T. Hierarchical analysis of the diversity of Trichoptera in the headwaters of the Cuiabá River Basin, Brazil. *International Review of Hydrobiology*, 2014, 99(3), 236-243. http://dx.doi.org/10.1002/iroh.201301627.

MCCUNE, B. and MEFFORD, M.J. *Multivariate analysis of ecological data. Version 4.14* [software]. Oregon: Gleneden Beach, 1999.

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

MISERENDINO, M.L. and BRAND, C. Trichoptera assemblages and environmental features in a large arid Patagonian river. *Fundamental and Applied Limnology*, 2007, 169(4), 307-318. http://dx.doi.org/10.1127/1863-9135/2007/0169-0307.

NOGUEIRA, D.S., CABETTE, H.S.R. and JUEN, L. Estrutura e composição da comunidade de Trichoptera (Insecta) de rios e áreas alagadas da bacia do rio Suiá-Miçú, Mato Grosso, Brasil. *Iheringia. Série Zoologia*, 2011, 101, 173-180. http://dx.doi.org/10.1590/S0073-47212011000200004.

OLIVEIRA, R.B.S., MUGNAI, R., CASTRO, C.M. and BAPTISTA, D.F. Determining subsampling effort for the development of a rapid bioassessment protocol using benthic macroinvertebrates in streams of Southeastern Brazil. *Environmental Monitoring and Assessment*, 2011, 175(1-4), 75-85. http://dx.doi.org/10.1007/s10661-010-1494-4. PMid:20495956.

PEREIRA, L.R., CABETTE, H.S.R. and JUEN, L. Trichoptera as bioindicators of habitat integrity in the Pindaı'ba river basin, Mato Grosso (Central Brazil). *International Journal of Limnology*, 2012, 48, 295-302. http://dx.doi.org/10.1051/limn/2012018.

PES, A.M.O., HAMADA, N. and NESSIMIAN, J.L. Chaves de identificação de larvas para famílias e gêneros de Trichoptera (Insecta) da Amazônia Central, Brasil. *Revista Brasileira de Entomologia*, 2005, 49(2), 181-204. http://dx.doi.org/10.1590/S0085-56262005000200002.

PETERSEN, R.C. The RCE: a Riparian, Channel and Environmental Inventory for small streams in the Agricultural Landscape. *Freshwater Biology*, 1992, 27(2), 295-306. http://dx.doi.org/10.1111/j.1365-2427.1992.tb00541.x.

POND, G.J. Biodiversity loss in Appalachian headwater streams (Kentucky, USA): Plecoptera and Trichoptera communities. *Hydrobiologia*, 2011, 679(1), 97-117. http://dx.doi.org/10.1007/s10750-011-0858-2.

RESH, V. H. and ROSENBERG, D.M. *The ecology of aquatic insects*. New York: Praeger Publishers, 1984, 625 p.

REYNAGA, C.M. and RUEDA-MARTÍN, P. Trophic analysis of two species of *Atopsyche* (Trichoptera: Hydrobiosidae). *Limnologica*, 2010, 40(1), 61-66. http://dx.doi.org/10.1016/j.limno.2008.07.004.

RIGHI-CAVALLARO, K.O., SPIES, M.R. and SIEGLOCH, A.E. Ephemeroptera, Plecoptera e Trichoptera assemblages in Miranda River basin, Mato Grosso do Sul State, Brazil. *Biota Neotropica,* 2010, 10(2), 253-260. http://dx.doi.org/10.1590/S1676-06032010000200028.

RODRIGUES-FILHO, J.L., DEGANI, R.M., SOARES, F.S., PERIOTTO, N.A., BLANCO, F.P., ABE, D.S., MATSUMURA-TUNDISI, T., TUNDISI, J.E. and TUNDISI, J.G. Alterations in land uses based on amendments to the Brazilian Forest Law and their influences on water quality of a watershed. *Brazilian Journal of Biology = Revista Brasileira de Biologia*, 2015, 75(1), 125-134. http://dx.doi.org/10.1590/1519-6984.08813. PMid:25945629.

ROSENBERG, D.M. and RESH, V.H. *Freshwater biomonitoring and benthic macroinvertebrates.* New York: Chapman & Hall, 1993, 488 p.

SPIES, M.R. and FROEHLICH, C.G. Inventory of caddisflies (Trichoptera: Insecta) of the Campos do Jordão State Park, São Paulo State, Brazil. *Biota Neotropica,* 2009, 9(4), 211-218. http://dx.doi.org/10.1590/S1676-06032009000400021.

SPIES, M.R., FROEHLICH, C.G. and KOTZIAN, C.B. Composition and diversity of Trichoptera (Insecta) larvae communities in the middle section of the Jacuí River and some tributaries, State of Rio Grande do Sul, Brazil. *Iheringia. Série Zoologia*, 2006, 96, 389-398.

STATSOFT. *Statistica: data analysis software system*. Version 7 [online]. Cary, 2004. [viewed 19 July 2003]. Available from: www.statsoft.com

STRIEDER, M.N., SANTOS, J.E. and VIEIRA, E.M. Distribuição, abundância e diversidade de Simuliidae (Diptera) em uma bacia hidrográfica impactada no sul do Brasil. *Revista Brasileira de Entomologia*, 2006, 50(1), 119-124. http://dx.doi.org/10.1590/S0085-56262006000100018.

TOWNSEND, C.R., ARBUCKLE, C.J., CROWL, T.A. and SCARSBROOK, M.R. The relationship between land use and physicochemistry, food resources and macroinvertebrate communities in tributaries of the Taieri River, New Zealand: a hierarchically scaled approach. *Freshwater Biology*, 1997, 37(1), 177-191. http://dx.doi.org/10.1046/j.1365-2427.1997.00151.x.

VANNOTE, R.L., MINSHALL, G.W., CUMMINS, K.W., SEDELL, J.R. and CUSHING, C.E. The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences*, 1980, 37(1), 130-137. http://dx.doi.org/10.1139/f80-017.

WARD, J.V. *Aquatic insect ecology.* New York: John Wiley & Sons, 1992, 438 p.

WATERWATCH AUSTRALIA STEERING COMMITTEE. Module 4: physical and chemical parameters. In *Waterwatch Australia National Technical Manual* [online]. Canberra: Environmental Australia, 2002. [viewed 19 July 2003]. Available from: http://www.waterwatch.org.au/libray/

WHITTIER, T.R. and VAN SICKLE, J. Macroinvertebrate tolerance values and assemblage tolerance index (ATI) for Western USA streams and rivers. *Journal of the North American Benthological Society*, 2010, 29(3), 852-866. http://dx.doi.org/10.1899/09-160.1.

WIGGINS, G.B. *Larvae of the North America caddisfly genera (Trichoptera).* 2nd ed. Toronto: University of Toronto Press, 1996, 457 p.

Received: 13 November 2015
Accepted: 16 March 2016

Appendix 1. Environmental Assessment Protocol to Atlantic Forest adapt from RCE (Petersen, 1992).

Environmental Assessment Protocol				
	Very good	**Good**	**Regular**	**Bad**
1. Substrate available to benthic animals / forest cover	Environment with >70% favorable to colonization of benthic animals and shelter for fish; presence of twigs and woods; margin without breaks in vegetation.	40-70% of the stable environment favorable to colonization; great presence of newly fallen leaves.	20-40% of the stable environment with lower habitats availability; substrate frequently removed or disturbed.	Environment with less than 20% stable; absence of favorable habitats for colonization; substrates unstable or deficient.
score	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Features of river bottom	Gravels, pebbles and stones are 0-25% covered by fine sediment.	Gavel, pebbles and stones are 25-50% covered by fine sediment.	Gravel, pebbles and stones are 50-75% covered by fine sediment.	Gravel, pebbles and stones are more than 75% covered by fine sediment.
score	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/ bottom regime	All 4-velocity/bottom regime present: bottom deep slow, bottom deep fast, shallow slow, shallow fast (slow = < 0.3m/s /deep = > 0.5m)	Only 3 of the 4 regime are present (if shallow fast is missing take a smaller value than if had missing any other)	Only 2 of the 4 regime are present.(if shallow fast or shallow slow are missing take a smaller value)	Dominate by a regime (usually bottom deep slow)
score	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment deposition	Small or without island magnification or sand barriers; less than 5% of river bottom affected by sediment deposition.	Some stretches with increase in the formation of barriers; the most of part formed by sand and fine sediment; 5-30% of the bottom affected, small deposition in pools.	Moderate deposition of sand or fine sediment on the barriers; 30-50% of bottom affected; moderate deposition in pools.	Great deposition of fine sediment, high development of barriers; more than 50% of the bottom instable; almost all pools absents due to high deposit of sediment.
score	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel status of running water	Reach of water within their normal bed and minimal exposed substrates.	Water fills > 75% of the available channel or < 25% of substrate exposed.	Water fills 25-75% of the available channel, and/or almost all riffle substrates exposed.	Little water in the channels and most of present in permanent pools.
score	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel changes	Absence of channelization or drainage, river with normal patterns.	Some channelization present, generally in area near bridges; may be evidence of past channelization.	Great channelization stretches, formation of sand barriers on both margins; 40-80% of river channelized or modified.	Cemented margins; more than 80% of the river channelized and modified. Most part of the aquatic habitats removed.
score	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Rapids frequency	Frequent rapids; in rivers where the rapids are continuous, verify the presence of large rocks or other natural mechanisms of obstruction.	Rapids occurrences uncommon; there are diversity of habitats to fauna; presence of rapids separated by pools of various sizes.	Occasional rapids or curves; long pools separated by short rapids; river bottom in curves provided some sort of habitat for aquatic fauna	Usually calm waters or shallow rapids; poor habitats.
score	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Margin stability	Stable margin; absence of erosion or gaps in margin; < 5% of margin affected.	Moderate stability; short erosional areas, with sign of recovery. 5-30% of margin with eroded area.	Margin with moderate instability; 30-60% of margin in the stretch has eroded, great potential of erosion during floor.	Margin instable; many eroded areas, frequently bare areas along the stretch. 60-100% of margin with erosion..
Right margin (RM)	10 9	8 7 6	5 4 3	2 1 0
Left margin (LM)	10 9	8 7 6	5 4 3	2 1 0

Appendix 1. Continued...

Environmental Assessment Protocol				
	Very good	**Good**	**Regular**	**Bad**
9. Riparian vegetation	>90% of margin and riparian forest compound by native vegetation, with large trees, shrubs and macrophytes; absence of pastures and fields in the stretch.	70-90% of margin and riparian forest compound by native vegetation. Modifying of vegetation evident.	50-70% of margin covered by vegetation; obvious modification of vegetation; patches of soil bare or with pasture.	< 50% of margin surface covered by vegetation; much altered vegetation; absence of native vegetation.
Score RM	10 9	8 7 6	5 4 3	2 1 0
Score LM	10 9	8 7 6	5 4 3	2 1 0
10. Extension of riparian forest	Width of riparian forest large than 18 m; human activities do not impact the area.	Width of riparian forest about 12-18 m; human activities cause minimal impacts to the area.	Width of riparian forest about 6-12m; human activities cause major impacts to the area.	Width of riparian forest less than 6 m; human activities eliminated the riparian forest or reduce it drastically.
Score RM	10 9	8 7 6	5 4 3	2 1 0
Score LM	10 9	8 7 6	5 4 3	2 1 0
TOTAL SCORE				

Result: Divide Total Score by 10, and the value obtained is Average Score. Average Score: between 20 and 16 (Reference stream); between 15 and 9, (Intermediate stream); less than 9 (Poor stream).