

Influence of taxonomic resolution of stream macroinvertebrate communities on the evaluation of different land uses.

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ABSTRACT: Influence of taxonomic resolution of stream macroinvertebrate communities on the evaluation of different land uses. Stream macroinvertebrate communities have been widely used as indicators of water quality. The knowledge of the stream macroinvertebrates structure provides fundamental information about the response of this fauna to impacts of chemical and/or physical perturbations resulting from different land uses, as deforestation for agricultural activity or input of domestic and industrial effluents. In Brazil, many studies have been conducted using the macroinvertebrate fauna as bioindicator of land use. However, there is a little information about which is the more adequate taxonomic resolution level for the best biological evaluation of these impacts. In this study we analyze the influence of sugar cane cultivation, pasture and presence of riparian vegetation on the aquatic macroinvertebrate communities of 9 streams located on Cerrado areas of the State of São Paulo (Brazil). This fauna was analyzed using two taxonomic levels: macroinvertebrates families and chironomid species. The community indices applied to these two taxonomic levels show, in general, similarity of results, that is, higher values of richness and diversity, and lower dominance for the communities living on streams protected by the riparian vegetation. These results allow concluding that for streams of the studied region, the family level of taxonomic resolution was enough to evaluate the effect of the agricultural land use.

Key-words: stream macroinvertebrates, land uses, taxonomic resolution, bioindicators.

RESUMO: Influência da resolução taxonômica das comunidades de macroinvertebrados de córregos na avaliação de diferentes usos do solo. Os macroinvertebrados aquáticos têm sido amplamente utilizados como indicadores de qualidade da água. A estrutura dessa comunidade pode fornecer informações a respeito de perturbações químicas e/ou físicas resultantes de diferentes usos do solo, como por exemplo, o desmatamento para atividade agrícola ou despejos de efluentes domésticos e industriais. No Brasil, vários estudos têm sido conduzidos utilizando os macroinvertebrados aquáticos como bioindicadores de qualidade da água. No entanto, pouca informação se tem a respeito de qual o nível de resolução taxonômica é mais adequado para se ter uma melhor avaliação biológica desses impactos. Neste estudo, foi analisada a influência do cultivo de cana-de-açúcar, da pastagem e da presença de vegetação ripária sobre a comunidade de macroinvertebrados aquáticos de 9 córregos de baixa ordem localizados em uma área de Cerrado do Estado de São Paulo (Brasil). Essa fauna foi analisada utilizando dois níveis de resolução taxonômica: famílias de macroinvertebrados e espécies de Chironomidae (Diptera). Os índices comunitários aplicados aos dois níveis taxonômicos mostraram, no geral, semelhança de resultados, ou seja, valores de riqueza e diversidade mais elevados, e de dominância mais baixos para as comunidades dos córregos protegidos por mata ripária. Estes resultados permitem concluir que, para os córregos da região, a resolução taxonômica em nível de famílias de macroinvertebrados foi suficiente para avaliar os efeitos dos usos do solo.

Palavras-chave: macroinvertebrados de córregos, usos do solo, resolução taxonômica, bioindicadores.

Introduction

In Brazilian history, during the colonization, the native land cover vegetation was removed, and substituted

by agriculture, mainly of sugar cane and pastures. These processes resulted in deforestation, especially in the Brazilian southeast region (Martins, 2001). These

mosaics of land uses, especially agriculture and pasture, in addition to the deforestation of riparian vegetation, have caused impacts on the hydric resources of the adjacent areas (Dudgeon, 1989; Nery, 2000; Martins, 2001; Angelotti-Netto et al., 2004; Corbi et al., 2006).

As the aquatic organisms may integrate effects of perturbations, numerous studies have been proposed to use the stream macroinvertebrate fauna to analyze the effects of different land uses. In studies using this fauna as indicators for monitoring rivers and streams, species level identifications in comparison with high resolution identifications can have greater information content and result in more reliable site classifications and better capacity to discriminate between sites, yet many of such monitoring programs identify specimens to family level rather than species. This is often because it is cheaper to obtain family level data than species level data. The choice of appropriate taxonomic resolution is a compromise between the cost of obtaining data at high taxonomic resolutions and the loss of information at lower resolutions. The optimum taxonomic resolution should be determined by the information required to address objective programs. In this perspective, some studies using stream macroinvertebrates have been conducted around the world to test the implications of taxonomic resolution and its influence as bioindicators of some environmental conditions (Hewlett, 2000; Thompson & Townsend, 2000; Guerold, 2000; Gabriels et al., 2005; Nahmani, et al., 2006).

In Brazil, many studies have attempted to relate the anthropic impacts on the stream macroinvertebrates. These studies have considered different environmental situations, such as: deforestations and impacts of agriculture (Roque et al., 2000; Ometo et al., 2000; Corbi et al., 2000; Cleto-Filho & Walker, 2001; Corbi, 2006), mining (Callisto & Esteves, 1998), organic enrichment and metals (Guereschi & Melão, 1997; Corbi et al., 2006) and impacts of reservoirs (Brandimarte, 1997; Anaya, 1997). In these studies distinct methodologies were used with different levels of taxonomic resolution, which make difficult the establishment of possible comparative analyses. There are a few studies that inferred the identification of the possible effects of taxonomic resolution of stream macroinvertebrates as bioindicators of land

uses. These points bring up the question of determining which is the more adequate taxonomical resolution level for the best biological evaluation of these impacts. In this context, the aim of this study is to verify if the changes in the taxonomic resolution are able to alter the value of stream macroinvertebrates as bioindicators of land use.

Material and methods

Study sites

The study was performed in 9 low order streams located on Jacaré-Guaçu River Basin, State of São Paulo, Brazil (Fig. 1). All streams are located in low altitude (500m to 700m) area of Cerrado vegetation and present low flow in predominant sand bed (Tab. 1). The average annual precipitation in the Jacaré-Guaçu River basin is about 1400 mm. The wet season occurs between October and March, while dry season occurs from April to September. Streams Água Sumida, São João, Ouro and Chibarro are located in extensive areas with sugar cane cultivation. Streams Fazzari, Espreado and Monjolinho (reference sites) are located on forested areas, while Água Preta and Andes are located in pasture areas, without riparian vegetation.

Stream macroinvertebrate communities

Macroinvertebrates were surveyed in three periods: March/April, 2002; June/July/August, 2002; November/December, 2002. Twenty seven samples were collected: 12 in streams with sugar cane culture, 9 in streams with riparian vegetation and 6 in pasture areas. The fauna was collected using a D-frame (Merritt & Cummins, 1996) aquatic net (250 mm) including riffle and pool areas, during 5 minutes, as recommended by Fontoura (1985). Three collections were combined into a single sample in each site. Samples were taken to the laboratory, washed in a sieve of 0.21mm of mesh, selected on an illuminated tray and fixed with 70% alcohol. Insects were dominant and the taxonomic identification was achieved at family level for most of them, on the basis of the available published data (Brinkhurst & Marchese, 1991; Merritt & Cummins, 1996). Because the Chironomidae (Diptera) family dominated all streams, the larvae of this group were analyzed to

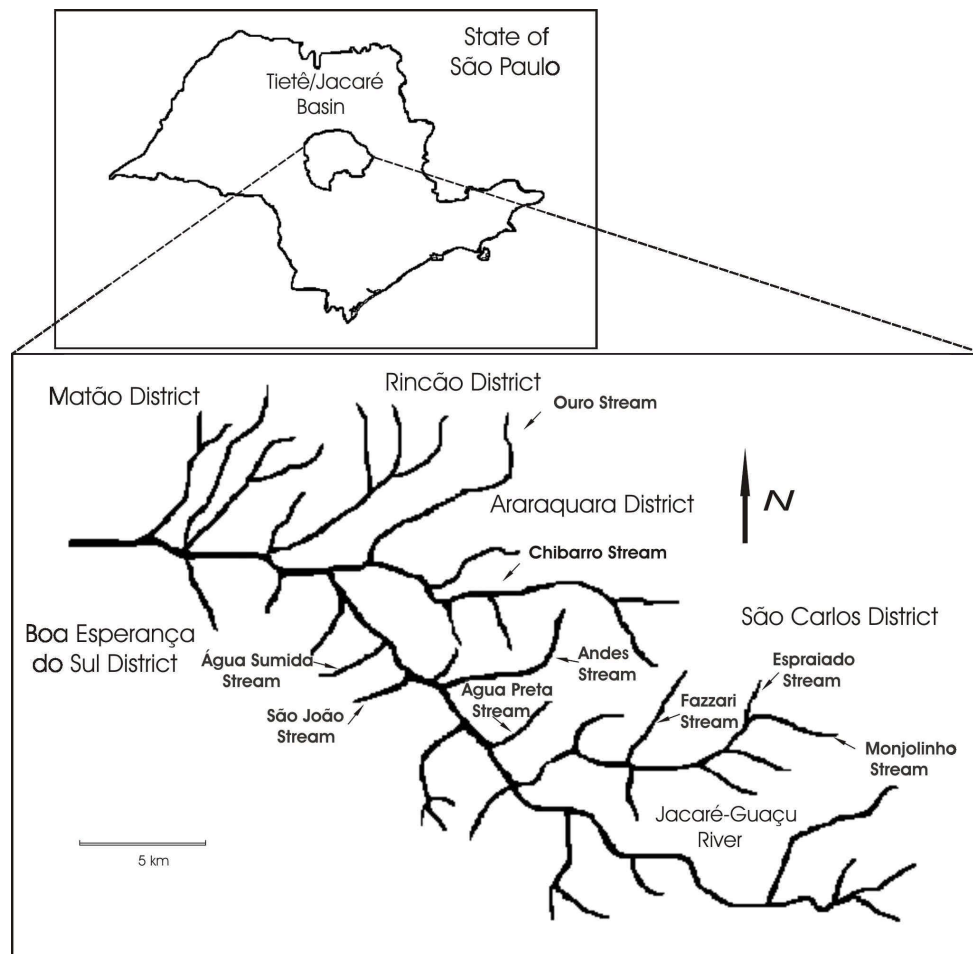


Figure 1: Location of the Jacaré-Guaçu River basin and the 9 stream sampling sites, State of São Paulo, Brazil.

Table 1: Streams localization and general information about land uses.

Legend	Stream	City	Land use	Coordinates
S1	Água Sumida	Araraquara	Sugar cane	21°56' (S) 48°16' (W)
S2	São João	Guarapiranga	Sugar cane	21°57'(S) 48°15'(W)
S3	Água Preta	Ribeirão Bonito	Pasture	22°00' (S) 48°12'(W)
S4	Andes	Araraquara	Pasture	21°55' (S) 48°11'(W)
S5	Ouro	Araraquara	Sugar cane	21°47'(S) 48°0.7'(W)
S6	Chibarro	Araraquara e Ibaté	Sugar cane	21°52'(S) 48°0.5'(W)
S7	Fazzari	São Carlos	Riparian vegetation	21°59' (S) 47°54' (W)
S8	Monjolinho	São Carlos	Riparian vegetation	22°00' (S) 47°50' (W)
S9	Espraiado	São Carlos	Riparian vegetation	21°53' (S) 47°52' (W)

species level (Trivinho-Strixino & Strixino, 1995).

Data analysis

Stream macroinvertebrates were identified and analyzed in two taxonomic resolutions: (I) family of macroinvertebrates

and (II) species of chironomids. The list of the macroinvertebrate families and chironomid species may be seen in Corbi (2006).

In the State of São Paulo there is no index correlating the macroinvertebrate

communities and the local environment, or any water-quality index using stream benthic fauna. Moreover, many assessment techniques adopt a multimetric approach using a suite of simple metrics to assess environmental degradation. The strength of this approach lies in its ability to integrate information from the various features of a community to give an overall classification of degradation without losing the information provided by individual metrics (Thorne & Williams, 1997). So, in order to evaluate the influence of the two taxonomic resolutions on use stream macroinvertebrates to assess the impacts of the land uses, and the integrity of each stream, the community characteristics were determined by the 6 following metrics: Taxa richness, Dominance index, Shannon's diversity index, Simpson's diversity index, Margalef's richness index and Coefficient of Community Loss (Courtemanch & Davies, 1987). The diversity/dominance indices were calculated using the Past Statistic Program (version 1.47). Data were analyzed by linear regressions, comparing the family taxonomic resolution versus chironomid species taxonomic resolution between the streams. Because of the high number of families, we used the preserved streams (S7, S8 and S9) as reference to make these analyses.

Results

Macroinvertebrate communities

In this study, 2622 specimens of 35

families of stream macroinvertebrates were identified. In all streams, the larvae of Chironomidae (Diptera) dominated, with 70% of the total macroinvertebrates collected. Other taxonomic groups like Libellulidae, Dytiscidae, Ceratopogonidae and Polycentropodidae were also frequently observed in many of the streams. In the streams without vegetation cover, especially in those located near to the area with sugar cane cultivation, a great amount of Odonata (Libellulidae family) and of Annelida, including the families Tubicidae, Naididae and Lumbricidae (Oligochaeta) and Glossiphoniidae (Hirudinea) were observed. The streams protected by riparian vegetation showed a greater variety of groups such as the Ephemeroptera, Plecoptera and Trichoptera families, and other Insecta.

At the two taxonomic levels analyzed, the values of the diversity indices (richness indices and diversity indices) were high in streams with riparian vegetation (reference sites). In contrast, the dominance indices showed smaller values in the reference streams. The analysis of the coefficient of the community loss showed high values in streams located in open areas (Tab. II).

The present study showed a strong correlation between family level of taxonomic resolution versus chironomid species level applied to the six community indices showing that the two taxonomic resolutions are correspondent (Fig. 2).

Table II: Values of the six community indices applied to the two taxonomic resolutions of the 9 streams. Legends as table 1.

Indices/Streams	S1	S2	S3	S4	S5	S6	S7	S8	S9
Family taxa richness	3.0	6.0	9.0	7.0	12	11	18	23	23
Chironomid taxa richness	2.0	10	8.0	7.5	15	19	23	24	28
Family dominance	0.9	0.5	0.5	0.6	0.5	0.6	0.4	0.4	0.3
Chironomid dominance	0.9	0.5	0.7	0.6	0.4	0.3	0.2	0.2	0.1
Family diversity (Shannon)	0.2	1.1	1.0	0.8	1.1	0.9	1.6	1.6	1.8
Chironomid diversity (Shannon)	0.1	0.9	0.5	0.7	1.6	2.1	2.4	2.4	3.0
Family diversity (Simpson)	0.1	0.4	0.5	0.4	0.4	0.3	0.6	0.6	0.6
Chironomid diversity (Simpson)	0.1	0.4	0.2	0.3	0.6	0.8	0.8	0.8	0.9
Family richness (Margalef)	0.5	1.1	1.2	1.1	2.1	1.9	2.8	3.8	3.8
Chironomid richness (Margalef)	0.1	1.7	1.1	1.2	2.8	3.2	4.0	4.4	5.1
Coefficient of community loss (Family)	10	3.0	2.8	3.0	1.7	1.8	0.4	0.0	0.0
Coefficient of community loss (Chironomid)	22	3.6	4.0	4.0	1.5	1.0	0.6	0.2	0.0

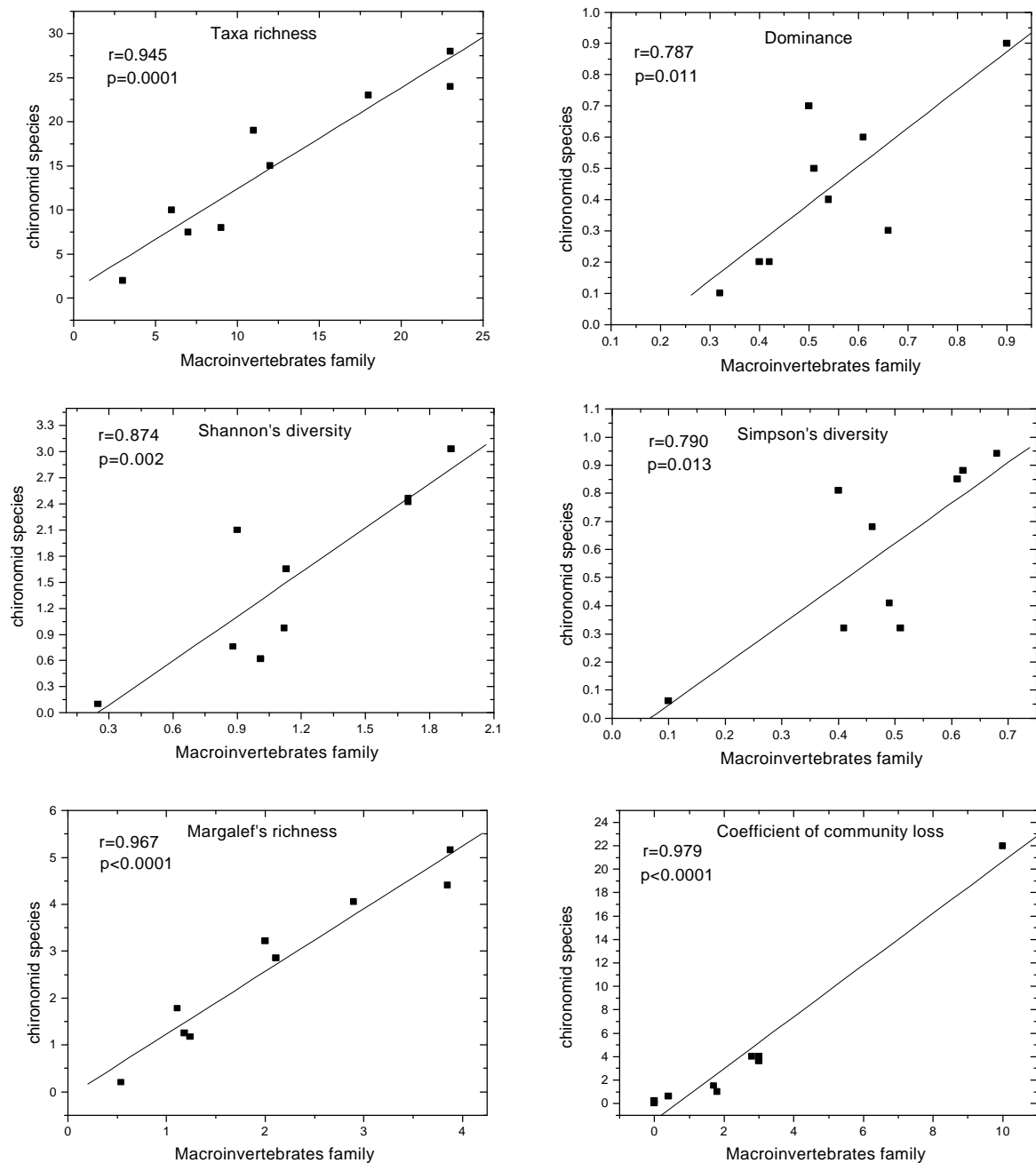


Figure 2: Linear regressions between family taxonomic resolution versus chironomid species applied to six community indices of the 9 streams.

Discussion

The appropriate taxonomic resolution for a particular study should be determined by the information required to address its objectives. As demonstrate by Resh et al. (1995) the choice of taxonomic resolution for monitoring is a compromise between the cost of obtaining data at high taxonomic resolutions and the loss of information at lower resolutions. As pointed out by

Nahmani et al., (2006), the scale of the taxonomical resolution to be used depends on the goals of the study. For some conservation purposes, the use of species level is required (Nahmani et al. 2006).

In Brazil, especially in the State of São Paulo, many streams are located in areas of Cerrado vegetation at low altitudes, low declivity and with predominance of sand substrates. As the result, a dominance of the Chironomidae fauna is observed (Corbi

et al., 2000; Roque & Trivinho-Strixino, 2001; Freire & Gessner, 2002; Kleine & Trivinho-Strixino, 2005). This fact was also observed in all streams of the present study. So, the use of lower taxonomic resolution using that family, as bioindicator of impacts of land uses can be considered, but costs/benefits and operational time required efforts should be examined (Marshall et al., 2006). However, in the Chironomidae, several species proved to be good indicators of open areas (without land cover) as pastures and agriculture, whereas other species were very sensitive to these impacts (Corbi, 2006). Clearly, gathering these species into a single taxonomic unit leads to loss of interesting information like, for example, the shredder species of Chironomidae (Guerold, 2000). To work out about this problem, we suggested that the use this of family as bioindicator of land uses can be good, but low taxonomic resolution is needed. Although, our results also point that the use of stream macroinvertebrates identified in level of family offered a good indicative of the impacts of land uses. Moreover, although dominant in the streams, the results showed that Chironomidae species identifications offered no substantial advantage over macroinvertebrate family-level identifications to discriminate the impacts of land uses. Simultaneously, time and cost savings may also be available for studies that require the detail provided by species-level data. Our results showed that all 9 streams data sets were similar when the two taxonomic resolutions (stream macroinvertebrates family or Chironomidae species) were used.

Overall, family identification appeared to be good for monitoring the effects of land uses on stream macroinvertebrates community in low order streams of the Cerrado's stream and could reduce taxonomic effort.

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