EFFECTS OF LAND USE ON LOTIC CHIRONOMID COMMUNITIES OF SOUTHEAST BRAZIL: EMPHASIS ON THE IMPACT OF SUGAR CANE CULTIVATION

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With 1 figure and 3 tables

ABSTRACT: In a study to evaluate impacts in low order streams of the State of São Paulo, 4 streams in areas of sugar cane cultivation, 2 in pasture and 3 in preserved natural habitat were sampled. From the 51 Chironomidae species collected, 42 were observed in preserved streams, 27 in sugar cane and 11 in pasture. The results indicated that deforestations of riparian vegetation results in the loss of the faunistic diversity.

RESUMO: Em um estudo de avaliação de impacto em córregos de baixa ordem do Estado de São Paulo foram analisados 4 córregos em áreas de cana de açúcar, 2 em pastagem e 3 em áreas preservadas. Das 51 espécies de quironomídeos, 42 foram observadas nos córregos preservados, 27 em áreas de cana e 11 em pastagem. Os resultados indicaram que a retirada da mata ripária resultou na perda da diversidade faunística.

KEY WORDS: chironomids, sugar cane, land use.

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INTRODUCTION

Brazilian colonization occurred without specific planning and, as a consequence, natural resources, particularly forests, were greatly affected by economic development. During colonization, native land cover vegetation was cleared to make way for agriculture, in particular sugar cane cultivation and pasture. Brazilian sugar cane cultivation has passed through different periods, but always with steady rise in the total cultivated area. In the last 15 years, sugar cane cultivation has continued to expand (CARVALHO FILHO, 2000) including the southeastern region, mainly in the State of São Paulo. Studies in this region of Brazil have demonstrated that in areas without riparian vegetation, chemical toxic products (fertilizers, herbicides and insecticides) used in sugar cane cultivation are rapidly transported to streams as contaminated water and sediment runoff (CORBI *et al*., 2006), impacting the hydrological resources of adjacent areas. This is exacerbated by riparian vegetation clearance. It is extremely important to understand the effect of land use on stream macroinvertebrate communities in order to develop and implement suitable regulatory policies (OMETO *et al*., 2000). In this study we assessed the influence of agricultural activity, in particular sugar cane culture, on lotic Chironomidae fauna.

MATERIAL AND METHODS

The 9 streams sampled were all located in the Jacaré-Guaçu River Basin, State of São Paulo, Brazil (Table 1). All streams were of low order, located at low altitude between 500m to 700m above sea level. 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. Sites C1 to C4 were located in extensive areas with sugar cane cultivation; sites M1 to M3 were located on forested areas and sites P1 and P2 in pasture, with no riparian vegetation.

Chironomid larvae were surveyed in three periods: March/April, 2002; June/July/August, 2002; November/December, 2002. A total of 27 samples were collected: 12 in streams with sugar cane culture, 9 in streams with riparian vegetation and 6 in pasture areas. Samples were taken using a D-frame hand net (250 µm) covering riffle and pools areas over a 5 minute period (FONTOURA, 1985). In the laboratory, samples were washed in a sieve of 0.25 mm mesh, sorted on an illuminated tray and fixed with 70% alcohol. Chironomid larvae were separated into morphotypes (TRIVINHO-STRIXINO & STRIXINO, 1995).

TABLE 1. Streams localization and general information about land use.

Legend	Stream	City	Land use	Coordinates
C1	Água Sumida	Araraquara	Sugar cane	21º56' (S) 48º16' (W)
C2	São João	Guarapiranga	Sugar cane	21º57'(S) 48º15'(W)
C3	Ouro	Araraquara	Sugar cane	21º47'(S) 48º0.7'(W)
C4	Chibarro	Araraquara e Ibaté	Sugar cane	21º52'(S) 48º0.5'(W)
M1	Espraiado	São Carlos	Riparian vegetation	21º53' (S) 47º52' (W)
M2	Fazzari	São Carlos	Riparian vegetation	21º59' (S) 47º54' (W)
M3	Monjolinho	São Carlos	Riparian vegetation	22º00' (S) 47º50' (W)
P1	Água Preta	Ribeirão Bonito	Pasture	22º00' (S) 48º12'(W)
P2	Andes	Araraquara	Pasture	21º55' (S) 48º11'(W)

In the State of São Paulo, Brazil, there is no index relating lotic chironomids to the local environmental conditions, nor any water-quality index using chironomid fauna. Consequently, in this study, lotic chironomids were analyzed for the occurrence (or presence) of each taxonomic group and for the total of organisms collected. The following metrics were used to evaluate stream community characteristics in relation to stream integrity: richness index (Margalef), diversity index (Shannon), BMWP (with regional adaptations), the Belgian Biotic Index, the ratio between the number of EPT taxa (sensitive) and Chironomids (tolerant) (EPT/Chironomidae X 100), the ratio between chironomid number and the total of individuals of aquatic macroinvertebrates collected (Chironomidae/total X 100), the ratio between the number of *Chironomus* larvae and the total Chironomidae number (*Chironomus*/Chironomidae). The EstimateS Program (Version 6) was used to calculate the richness index (Margalef) and the diversity index (Shannon). Cluster analysis was used to identify groups of similar sites (with UPGMA, and Bray-Curtis similarity measure method).

RESULTS

A total of 51 chironomid taxa were identified: 42 in forested streams, 27 in sugar cane areas and 11 in pasture areas (Table 2). Cluster analysis clearly separated streams located on preserved areas from streams located in impacted areas (Fig. 1). The community indices applied to the chironomid fauna were high in streams with riparian vegetation. The biotic indexes (BMWP and IBB), applied to the total macroinvertebrate fauna of the 9 streams, showed good ecological quality in the preserved streams (M1-M3) and low ecological quality in streams associated with agricultural activity and pasture (Table 3). Larvae of *Chironomus* species were the most frequent and abundant taxa in streams located on agricultural areas. In contrast, streams in forested areas had greater taxon richness, with *Beardius* sp., *Stenochironomus* spp., *Endotribelos* spp. and *Caladomyia* spp. larvae occurring exclusively at these sites.

TABLE 2. Chironomidae taxa participation (specimens) in 9 low order streams of Jacaré-Guaçu River Basin, State of São Paulo, Brazil. Legends as Table 1.

Chironomidae/streams	C1	C2	C3	C4	M1	M2	M3	P1	P2
Ablabesmyia gr. annulata sp.			◆	●	○	○	◆		
Ablabesmyia (Karellia) sp.		◆			◆	■	○		◆
Alotanypus (?) sp.			○						
Clinotanypus sp.			◆	◆				●	◆
Coelotanypus sp.	○			◆					
Djalmabatista spp.				◆	◆	●	○		○
Fittkauimyia sp.						○			
Labrundinia sp.				●	○	◆			
Larsia sp.			○	○	○	○			
Pentaneura sp.				○	◆	○	◆	○	
Procladius sp.		○	○	○					
Thienemannimyia sp.				○					
Zavrelimyia sp.								○	
Beardius sp.					◆	◆			
Chironomus spp.	■	■	●	■	○		○	■	■
Cladopelma sp.						○			
Cryptochironomus sp.		○	◆		○				○
Endotribelos sp. 1					◆	■	◆		
Endotribelos sp. 2					◆	◆			
Endotribelos sp. 3					○	○	○		
Fissimentum sp.					○				
Goeldichironomus sp.				○					
Harnischia (complexo) spp.				○	○	◆	●		
Lauterborniella sp.							○		
Nilothauma sp.						○			
Oukuriella sp.					○				
Polypedilum spp.				◆	●		■	○	
Stenochironomus spp.					◆	●	○		
Zavreliella sp.							○		
Caladomyia sp. 1				○	◆	◆	○		
Caladomyia sp. 2						○			
Rheotanytarsus spp.		◆	■	◆	◆	○	●	○	
Stempellinella sp.		○			◆	○			
Stempellina sp.			○						
Tanytarsus sp. 1						◆	◆		
Tanytarsus sp. 2			○		○	○	◆		
Tanytarsus sp. 3						○			
Tanutarsus sp. 4		○	●	○				○	◆
Tanytarsus sp. 5						◆			
Tanytarsus sp. 6							○		
Tanytarsus sp. 7					◆				

TABLE 2. (Cont.)

Chironomidae/streams	C1	C2	C3	C4	M1	M2	M3	P1	P2
Cardiocladius sp.							○		
Cricotopus sp.		○			◆				
Corynoneura sp.					◆		○		
Gymnometriocnemus sp.			○				○		
Lopescladius sp.					○				
Nanocladius sp.		○	○	◆	○		○		
Parakiefferiella sp.					○				
Parametriocnemus sp.					○		◆		
Thienemanniella sp. 1			○		◆		○		
Thienemanniella (?) sp. 3			○		◆		◆	◆	

Specimens =? **■ > 50 20< ● <50 5< ◆<20 ○ <5**

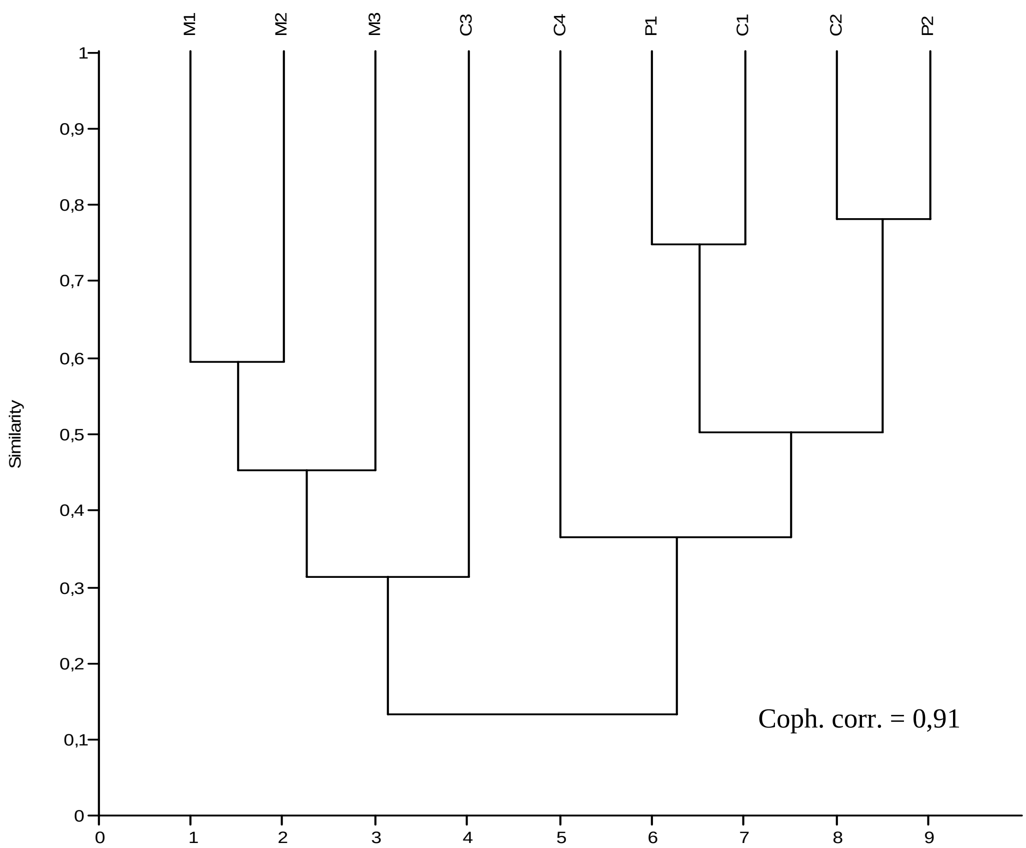

Fig. 1. Dendogram of the Cluster analysis (UPGMA; Bray-Curtis similarity) applied for the Chironomidae community of the 9 low order streams of Jacaré-Guaçu River Basin, State of São Paulo, Brazil. Legends as Table 1.

TABLE 3. Main community characteristics and evaluation measurements of the fauna of the 9 low order streams of Jacaré-Guaçu River Basin, State of São Paulo, Brazil. Legends as Table 1.

Community metrics	**C1**	**C2**	**C3**	**C4**	**M1**	**M2**	**M3**	**P1**	**P2**
Number of Chironomidae taxa	2	9	15	16	30	23	24	8	6
(Chironomidae/total) x 100	90	74	84	83	54	65	63	64	88
(*Chironomus*/Chironomidae) x 100	98	65	16	35	3	0	2	88	89
(EPT/Chironomidae) x 100	0	6	1	5	46	28	21	1	2
Diversity index Shannon (H’)	0.2	1.7	2.1	2.7	3.5	3.2	3.3	1.3	1.4
Richness index Margalef (I_{Mg})	0.7	2.7	4.7	5.1	8.7	6.8	7.9	2.3	2.4
Biotic index (BMWP)	6.0	23	55	53	130	94	130	35	31
Biotic index (IBB)	3.0	6.0	5.0	6.0	10	9.0	8.0	5.0	5.0

Class	**“score” IBB**	**“score” BMWP**	**Water quality**
1	9-10	≥ 81	Excelent
2	7-8	80 - 61	Good
3	6	60 - 41	Regular
4	4-5	40 - 26	Poor
5	≤ 3	≤ 25	Very poor

DISCUSSION

Riparian organic input, in the form of dissolved organic matter, leaf litter, fruits, woody debris and invertebrates, is a vital food source for aquatic food webs in many systems (LYNCH *et al,* 2002). Several studies have also shown the importance of the riparian canopy cover for lotic chironomid community structure and diversity (MCKIE & CRANSTON, 2001, BENSTEAD & PRINGLE, 2004, BOJSEN & JACOBSEN, 2003) and that a decline in riparian canopy cover reduces litter detritus input to the streambed and increases periphyton biomass, because of the light-related factors. In this study, deforested streams had homogeneous and depauperate chironomid communities, in contrast to streams in forested areas.

The results of this study clearly show the importance of riparian vegetation, which coincides with higher taxa richness in the forested streams (M1 – M3) including the presence of chironomid shredders such as *Stenochironomus* and *Endotribelos*. In contrast, lower taxon richness and a greater number of *Chironomus* spp larvae was observed in the deforested streams, indicating environmental degradation caused by sugar cane cultivation and pastures for grazing. *Chironomus* larvae are widely known to tolerate urban and industrial discharge (KLEINE & TRIVINHO-STRIXINO, 2005).

Our results indicated that riparian vegetation clearance resulting from agricultural activity was the principal impact influencing lotic chironomid communities and diminishing chironomid faunal diversity. This highlights the need to develop suitable hydrological resource management procedures in the southeast Brazil, particularly in São Paulo state where agriculture, especially sugar cane culture, has drastically reduced natural vegetation cover. Moreover, the use of fertilizers containing metals during different periods of sugar cane cultivation could cause, in the future, further impacts on the lotic chironomid community (CORBI, *et al*., 2006).

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BIBLIOGRAPHY

BENSTEAD, J. P. & C. M. PRINGLE:
2004. Deforestation alters the resource base and biomass of endemic stream insects in eastern Madagascar. *Freshwater Biology*, **49**, 490-501.

BOJSEN, B. H. & D. JACOBSEN:CARVALHO FILHO, S. M.:
2000. *Colheita mecanizada: desempenho operacional e econômico em cana sem queima prévia*. ESALQ (USP), Piracicaba – SP, 108 pp.

CORBI, J. J., S. TRIVINHO-STRIXINO, A. DOS SANTOS & M. DEL GRANDE:
2006. Environmental diagnostic of metals and organochlorinated compounds in streams near sugar cane plantations activity (São Paulo State, Brazil). *Química Nova*, **29**(1): 61-65.

FONTOURA, A. P.:
1985. *Manual de vigilância da qualidade das águas superficiais. Avaliação biológica da qualidade da água.* Instituto de zoologia "Dr. Augusto Nobre". Faculdade de Ciências – Universidade do Porto. Porto – Portugal, 38 pp.

KLEINE, P. & S. TRIVINHO-STRIXINO:
2005. Chironomidae and other aquatic macroinvertebrates of a first order stream: community

response after habitat fragmentation. *Acta Limnologica Brasiliensia*, **17** (1): 81-90.

LYNCH, R. J., S. E. BUNN & C. P. CATTERALL:
2002. Adult aquatic insects: Potential contributors to riparian food webs in Australia's wet-dry tropics. *Austral Ecology*, **27**, 515-526.

MCKIE, B. & P. CRANSTON:
2001. Colonisation of experimentally immersed wood in south eastern Australia: responses of feeding groups to changes in riparian vegetation. *Hydrobiologia***,** **452**: 1–14.

OMETO, J. P. H. B., L. A. MARTINELLI., M. V. BALLISTER., A. GESSNER., A.V. KRISCHE & R.L. VICTORIA:
2000. The effects of land use on water chemistry and macroinvertebrates rates in two streams of the Piracicaba river basin South-east Brazil. *Freshwater Biology*, **44** (2): 327-337.

TRIVINHO-STRIXINO, S. & G. STRIXINO:
1995. *Larvas de Chironomidae (Diptera) do Estado de São Paulo: Guia de identificação e diagnose de gêneros*. São Carlos: UFSCar, 227 pp.

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