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The influence of physical instream spatial variability on Chironomidae (Diptera) assemblages in Neotropical streams

Gustavo Rincon Mazão, Pitágoras da Conceição Bispo*

Laboratório de Biologia Aquática, Departamento de Ciências Biológicas, Faculdade de Ciências e Letras de Assis, Universidade Estadual Paulista, Assis, São Paulo State, Brazil

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ABSTRACT

In this study, the Chironomidae assemblages were studied in order to test the following hypotheses: a) mesohabitat type and substrate complexity affect the richness, abundance, and composition of the fauna; b) mesohabitat type is a good predictor for Chironomidae composition. To test the hypotheses, experiments were carried out in two mesohabitats (riffle and pool) using two substrate complexities (high and low) in 12 streams from Central Brazil. The mesohabitat type and substrate complexity did not affect the richness and abundance of the local fauna. The mesohabitat affected the faunistic composition. The assemblages of riffles and pools were distinct. Indicator Species Analysis showed that *Paratendipes* sp., *Polypedilum* sp. 2, *Pentaneura* sp., *Rheotanytarsus* sp. 1, *Corynoneura* sp. 2, *Cricotopus* sp. 2, *Lopescladius* sp., *Nanocladius* sp. 2, *Parametriocnemus* sp., and *Thienemanniella* sp. had preference for riffles and *Chironomus* sp., *Ablabesmyia* sp. 1, *Ablabesmyia* sp. 2, *Djalmabatista* sp., *Fittkauimyia* sp., and *Labrundinia* sp. for pools. Our results highlight the importance of physical instream variability on fauna structure, suggesting that habitat homogenization due to anthropic action may cause drastic effects on the diversity of chironomids and, probably, other benthic macroinvertebrates. Therefore, maintaining instream morphology, including the different mesohabitats, is fundamental for biodiversity conservation in streams.

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1. Introduction

Streams are ecosystems with high spatial variability on different scales, creating mosaics with different environment conditions and resource availability. This variability is responsible for spatial variation of abundance and high alpha and beta diversity in these ecosystems (Taniguchi and Tokeshi, 2004; Clarke et al., 2008; Costa and Melo, 2008). Therefore, understanding the influence of environmental variability on stream biota is critical to understand the ecological processes that determine the biodiversity in these ecosystems.

High instream spatial variability can be observed in meso and microhabitat scales (Frissell et al., 1986; Pardo and Armitage, 1997). This variability affects biotic structure and ecological dynamics in streams (Pardo and Armitage, 1997; Brooks et al., 2005; Ortiz et al., 2006; Brown, 2007; Costa and Melo, 2008). A simple visual inspection of these ecosystems allows to identify many mesohabitats (Pardo and Armitage, 1997), among these, riffles and pools. Riffles are erosive habitats with predominance of rock and gravel sediment beds, characterized by rapid, turbulent, and irregular water currents. On the other hand, pools have low water velocity and are deposition habitats with organic debris, sand, and fine sediment. Due to the great environmental differences between these two mesohabitats, their faunal assemblages generally are also different. Thus, many studies indicate that mesohabitat types can be a good predictor of stream macroinvertebrate fauna (Pardo and Armitage, 1997; Buss et al., 2004; Silveira et al., 2006; Crisci-Bispo et al., 2007).

Inside each mesohabitat, the specific substrate characteristics also affect aquatic macroinvertebrate assemblages. For example, type, localization, presence of refuges, and substrate complexity influence the role of predation, faunal composition, body size, species richness, and abundance of aquatic macroinvertebrates (Dudgeon, 1996; Lancaster, 1996; Taniguchi et al., 2003; Taniguchi and Tokeshi, 2004; Gibbins et al., 2005; Costa and Melo, 2008; Thomaz et al., 2008). Thus, the experimental manipulation of substrate characteristics, such as the substrate complexity, has been used to understand their effects on macroinvertebrate assemblages (Taniguchi et al., 2003; Taniguchi and Tokeshi, 2004).

* Corresponding author at: Laboratório de Biologia Aquática, Departamento de Ciências Biológicas, Faculdade de Ciências e Letras de Assis, Universidade Estadual Paulista. Avenida Dom Antônio 2100, Assis, SP, 19806-900, Brazil.
E-mail address: pitagoras@assis.unesp.br (P.C. Bispo).

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Riffle substrates are composed of different size rocks, which create interstitial spaces with distinct sizes and a complex mosaic of water currents. On the other hand, pool substrates are composed of fine and coarse organic deposits as well as soft inorganic sediments. Thus, on riffles, substrate and hydraulic conditions are apparently more complex than on pools, which could explain the greater fauna diversity in riffle mesohabitats often observed in streams (Buss et al., 2004; Brooks et al., 2005). However, riffle and pool substrates present distinct natures; thus, this factor requires control. One way to solve this question is to make experimental studies manipulating the substrate characteristics in both mesohabitats. Our experiment was based on the premises that substrate complexity may affect the aquatic macroinvertebrates (Taniguchi et al., 2003; Taniguchi and Tokeshi, 2004) and that it is possible to manipulate the complexity by the disposition of particles with different shapes and sizes, mimicking the natural substrate of the stream.

The Chironomidae family distinguishes itself from other freshwater macroinvertebrates regarding high richness (Ferrington, 2008) and a wide range of feeding behaviors represented by predators, detritivores, and filterers, in addition to leaf, wood, and fruit miners (Berg, 1995; Trivinho-Strixino and Strixino, 1995; Nessimian and Sanseverino, 1998). Another characteristic is its wide geographic distribution and different preferences for specific microhabitats (e.g. litter, fine sediment, rocks, mosses, macrophytes among others) (Sanseverino and Nessimian, 1998, 2001; Sodré et al., 2010). High diversity and fast colonization of Chironomidae make them an ideal faunal group for testing ecological theories using an experimental approach. Thus, the Chironomidae family was used to evaluate the following hypotheses on the role of physical instream variability for aquatic insects: 1) mesohabitat type and substrate complexity affect the taxa richness, abundance and composition of the fauna; 2) mesohabitat type is a good predictor for Chironomidae composition. These hypotheses were tested experimentally in two mesohabitats (riffle and pool), using substrates with two complexities (high and low) in streams from Central Brazil.

2. Materials and methods

2.1. Study area

This study was carried out during the dry season (August and September) in 12 streams (classified as first and second order according to Strahler, 1957) of municipalities of Iporá, Ivolandia, and Amorinópolis, between 50°54′ W 16°39′ S and 51°3′ W 16°40′ S, in the Southwest region of Goiás State, Brazil (Fig. 1). This region presents Cerrado (Brazilian Savanna), a biome that comprises the headwaters of three important Brazilian hydrographic basins (Paraná, São Francisco, and Amazônica Basins). The seasonality is well defined with two periods: dry (May to October) and rainy (November to April).

2.2. Environmental characterization

The following environmental variables were recorded in the studied streams: water temperature (°C), current (m/s), discharge (m^3/s), potential hydrogen (pH), electrical conductivity (μS/cm), dissolved oxygen (mg/l), and turbidity (NTU). The water current was measured using a current meter (Swoffer model 3000) and the discharge was calculated by multiplying water current average by stream section area (Lind, 1979). A multi-parameter probe (Horiba) was used to measure water temperature, pH, electric conductivity, and dissolved oxygen. Turbidity was measured with Hach probe (model 2100P). The characterization of studied mesohabitats of the streams is presented in Table 1.

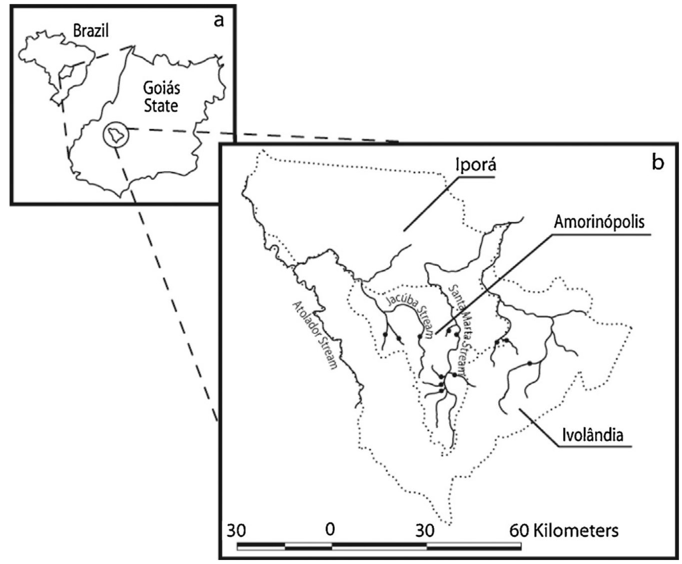

Fig. 1. a- Study region in the southwest of Goiás State, Brazil. b- Points marking the stations where the experiments were performed. Dotted lines delineate limits of Amorinópolis, Iporá, and Ivolândia Municipalities.

Table 1
Means and standard deviations (sd) of physical-chemical variables measured in riffle and pool mesohabitats, and of discharge of 12 streams of Iporá, Amorinópolis, and Ivolândia Municipalities, Goiás State, Brazil.

	Pool		Riffle	
	Mean	sd	Mean	sd
Dissolved oxygen (mg/l)	7.26	1.25	8.24	0.94
Turbidity NTU	7.33	5.47	5.08	1.88
pH	6.65	0.94	6.52	0.97
Temperature (°C)	23.79	2.44	23.8	2.35
Water current (m/s)	0	0	0.46	0.18
Electrical conductivity (μS/cm)	<6.0		<6.0	
	Mean	sd	Min	Max
Stream discharge (m^3/s)	0.08	0.1	0.003	0.257

2.3. Experimental design

This experiment was carried out in riffles and pools of 12 streams. Riffle habitats had water currents greater than 0.255 m/s, and pools had absence of currents (considering the current meter used). Streams were used as blocks and substrates were put in one riffle, and in one pool on each stream. Two samplers were fixed in each mesohabitat, one with high and another with low complexity substrate. The position of samplers in relation to stream margins was selected randomly.

Samplers were composed by a substrate in trays with 228 cm^2 of basal area. To mimic natural substrate, different shapes and sizes of substrate particles were combined to create similar (low complexity) or distinct (high complexity) spaces. The low complexity substrate was composed by marbles (glass) (2 cm diameter) and two concrete plaques (13 × 3.5 × 1 cm) arranged in parallel to each other. The high complexity substrate was composed by two size marbles (2 and 4 cm diameter) and three concrete cylinders (4 cm height and 4 cm diameter) randomly arranged. The sum of marbles and concrete objects was similar in both treatments in order to exclude area bias in posterior statistical analyses. Marbles were sandblasted to make them rough prior to the experiment.

As Chironomidae larvae are fast colonizers, an exposure time of 20 days on the mesohabitats was considered enough (Carvalho and Uieda, 2004). After the colonization period, samplers were removed with the help of a D net (0.250 mm) to avoid organisms loss. In the

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