Benthic macroinvertebrates in mesohabitats of different spatial dimensions in a first order stream (São Carlos - SP)

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RESUMO: Macroinvertebrados bentônicos em mesohabitats de diferentes dimensões espaciais de um córrego de primeira ordem, São Carlos – SP. O Córrego do Fazzari reúne características espaciais que possibilitam a identificação de diferentes mesohabitats, tanto logitudinalmente (no leito principal do córrego) quanto lateralmente (zona ripária marginal). Com o objetivo de analisar a estrutura taxocenótica e funcional dos macroinvertebrados bentônicos foram realizadas coletas em 6 mesohabitats de um trecho próximo à nascente desse córrego. As coletas foram realizadas, com o auxílio de um cilindro coletor, retirando 10 unidades de amostragem em cada mesohabitat. Após a identificação, os organismos foram agrupados segundo categorias de alimentação. Foram identificados 60 táxons de macroinvertebrados, sendo que as maiores riquezas foram encontradas nos mesohabitats localizados no leito principal do córrego. Os resultados indicaram diferenças na estrutura taxocenótica e funcional dos macroinvertebrados, com correspondência entre a distribuição das comunidades e características físicas e químicas do ambiente, demonstrando a importância de variações em mesoescala para o estudo da distribuição dos macroinvertebrados em ambientes lóticos.

Palavras chaves: Macroinvertebrados bentônicos, sistemas lóticos, grupos funcionais de alimentação, mesohabitats

ABSTRACT: Benthic macroinvertebrates in mesohabitats of different spatial dimensions in a first order stream, São Carlos – SP. Fazzari Stream has spatial characteristics which allow identification of different mesohabitats in the main bed and the marginal riparian zone. With purpose of analyzing the taxocenotic and functional macroinvertebrate community structure, a collection program was developed in 6 mesohabitats close to the spring of the stream. In each mesohabitat 10 samples were taken using a cylindrical collector. After identification, the organisms were grouped according to feeding groups. Sixty macroinvertebrate taxa were identified, their greatest abundance found in the main bed of the stream. Results indicate differences in taxocenotic and functional macroinvertebrate structure, and their relation in the distribution of the community and chemical and physical characteristics of the environment, demonstrating the importance of variations in mesoscale for the study of macroinvertebrate distribution in lotic environment.

Key words: benthic macroinvertebrates, lotic systems, functional feeding groups, mesohabitats.

Introduction

The influence of physical and chemical features in macrobenthonic community structure in lotic systems has been one of the dominant subjects in benthos ecology research (Death, 1995). Many general models of space distribution, in small scales (Hynes, 1970; Minshall & Minshall, 1977; among others) and in large scales (Vannote et al, 1980, Townsend, et al. 1983; Stazner & Higler, 1986; Corkum, 1989, Junk, et al., 1989, among others), try to explain the distribution of this community in the environment. However, the integration between the biotic and abiotic processes, in multiple scales, still remains unknown.

The evaluation of the community structure of macroinvertebrates, considering a hierarchic relation among habitats, landscape and features of rivers (Frissell et al, 1986; Giller et al., 1992) in a different space dimension (Ward, 1989), and related to mesohabitats analysis (Armitage & Pardo, 1995) has been indicated as an important approach to interpret the integration between the organisms and the environment (Pardo & Armitage, 1997).

Mesohabitats, defined as visually distinct habitat units with apparent physical uniformity, have been pointed out as a structural ecological unit adjusted to study the dynamics of the macroinvertebrates community in lotic environments (Pardo & Armitage, 1997).

The objective of this study was to analyze the taxonomical and feeding groups of benthic macroinvertebrates that populate different mesohabitats in a first-order stream.

Study area

The Fazzari Stream, located on UFSCar campus, in São Carlos - SP (21°59'S - 47°54'W) is an affluent of the Monjolinho River, which is an affluent of the Jacaré-Guaçu River, that flows into Tietê River, in Ibitinga - SP. It is a stream of small ratio that flows through an area with riparian vegetation (a path of 300m, approximately). The region is characterized by the existence of seasonality, emphasizing two periods: a dry season (April - November) and a rainy season (December - March).

Several kinds of mesohabitat were found in the main bed and the marginal riparian zone of the stream. Six mesohabitats were chosen as the most expressive of the path, 2 in the side areas (MH3 and MH4) and 4 in the main bed (MH 1, MH2, MH5 and MH6). The general features of each mesohabitat are presented in Tab.I.

Table I: General features of the mesohabitats of Fazzari Stream.

	MH_1	MH_2	MH_3	MH_4	MH_5	MH_6
Localization	Channel	Channel	Riparian zone	Riparian zone	Channel	Channel
Hydraulic feature	Run	Riffle	Pool	Pool	Pre- pool	Pool
Water Velocity ($cm.s^{-1}$)	10.0	15.0	< 0.50	< 0.50	2.80	1.10
Water depths (cm)	20.0	20.0	10.0	10.0	25.0	20.0
Oxygen ($mg.l^{-1}$)	5.52	5.70	1.19	1.17	5.52	4.87
Inorganic Substrate	Coarse sand	Coarse sand	Mud	Mud	Sand and Mud	Mud
Organic Substrate	(CPOM)	(CPOM)	Fungus d bacterium (CPOM>FPOM)	(CPOM>FPOM)	(CPOM>FPOM))	FPOM>>CPOM))

(Roque, 1997)

Methodology

At the end of the rainy season (04/96 to 06/96), benthic macroinvertebrates were collected with help of a cylindrical collector (0.025 m^2 in area and 0.1 m in height) in 10 randomly chosen spots in each one of the 6 mesohabitats. The samples were washed in water and the restrained material passed through a sieve with a 0.21 mm mesh; the organisms were sorted in transparent trays, fixed in a 4% formol solution and preserved in 70% alcohol

Identification of the fauna was made with help of identification manuals (McCafferty, 1981; Merritt & Cummins, 1984; Brinkhurst & Marchese, 1989). The Chironomidae larvae (Diptera) were identified up to the genus and/or morphotype level (Wiederholm, 1983; Trivinho-Strixino & Strixino, 1995). The feeding groups were defined according to Merritt & Cummins' classification (1984).

The Principal Components Analysis was carried out as an ordination method, processed by NTSYS-pc Program (version 2.02, Applied Biostatistics, Inc., 1997). Data were processed after [log (x+1)] transformation of the abundance of each taxon. Furthermore, a cluster analysis using Euclidean distance measure and the method of grouping UPGMA was applied; the obtained dendrogram was tested for its consistency from the cofenetic correlation.

Results and Discussion

Composition and taxa participation

The analysis of 1681 specimes collected in 6 mesohabitats indicated the presence of 61 taxa of macroinvertebrates, in which Chironomidae, Tipulidae, Culicidae and Dytiscidae were the most abundant (Tab. II). Some taxa had been restricted to certain mesohabitats; among the most expressive, the Plecoptera nymphs of Gripopterygiidae and Perlidae, the Simuliidae larvae (Diptera) and some Orthocladiinae larvae (Chironomidae) in mesohabitat 2 (MH2); Culicidae and *Chironomus* larvae (Chironominae

Table II: Benthic macroinvertebrates in different mesohabitats of Fazzari Stream.

	Mesohabitats					
Taxa	**MH1**	**MH2**	**MH3**	**MH4**	**MH5**	**MH6**
Chironomidae	♦	■	■	■	■	■
Simuliidae		■				
Tipulidae type 1					○	♦
T. type 2			■			
Tabanidae		○	♦			
Ceratopogonidae	○	♦	●	●	♦	♦
Culicidae			○	■		
Chaoboridae				♦		
Trichoptera						
Calamoceratidae	♦	○	○		♦	○
Polycentropodidae		♦				♦
Hydropsychidae		●				○
Leptoceridae						○
Odontoceridae	♦	○			♦	
Philopotamidae		♦				
Hydroptilidae		○				
Odonata						
Coenagrionidae	○	○	○		○	♦
Corduliidae		○			○	
Libellulidae			○	○	○	
Ephemeroptera						
Leptophlebiidae	○	♦			♦	♦
Plecoptera						
Gripopterygiidae		○				
Perlidae		○				
Coleoptera						
Elmidae		♦	○		♦	♦
Dytiscidae type 1		♦	♦			♦
D. type 2	♦	♦			♦	■
Hemiptera						
Gerridae					○	
Naucoridae	○	○			♦	○
Oligochaeta						
Gr. Megadrilo type 1		♦	♦		○	○
Gr. Megadrilo type 2			♦		○	♦
Lumbricidae	○	○				
Tubificidae	○		○		○	♦
Naididae				○		○
Specimes	51	264	655	270	179	262
Richness	10	21	14	6	16	17

○ < 5 Specimes ♦ < 25 Specimes 25 > ● < 50 Specimes ■ > 50 Specimes ı mesohabitats MH3 and MH4, and Tipulidae type 2 in MH3 (Tabs. II and III). According ɔ Ward (1992), the association between certain taxa and the physical features of the nvironment were identified in some lotic habitats (ex. Simuliidae).

Some authors, like Logan & Brooker (1983); Minshall & Minshall (1977); Argermeier ι Karr (1984) and Paprocki (1997), had verified greater abundance of benthic nacroinvertebrates in riffle when compared to pool. Kikuchi & Uieda (1998) had found ıigher frequency. In this study, a greater richness of fauna in mesohabitat MH2 was 'erified, in accordance to the above mentioned annotations. Such results suggest that 'ariables like substratum heterogeneity, greater water velocity and greater oxygen content, :haracteristic for riffle, must perform an important role in the maintenance of greater ichness in these areas.

Like the participation of Chironomidae in several mesohabitats, a similar result to the one ›btained by Sanseverino (1998) in Atlantic forest streams in the State of Rio de Janeiro was 'erified; there was a predominance of the Tanypodinae and Chironominae subfamily in mesohabitats 4H5 and MH6 (deposition area) and Orthocladiinae in MH2 (erosion area) (Tab. III).

'able III: Chironomidae in different mesohabitats of Fazzari Stream.

	Mesohabitats					
Chironomidae	**MH1**	**MH2**	**MH3**	**MH4**	**MH5**	**MH6**
Ablabesmyia	○	♦	♦	♦	♦	●
ıear *Brundiniella*		○	○	♦	○	
Coelotanypus					○	○
Denopelopia				○		
Djalmabatista	♦	♦	○	○	♦	♦
Fittkauimyia					○	
Labrundinia			○		○	
Larsia	○	♦	●	♦	♦	♦
near *Macropelopia*				♦		○
Monopelopia				○		
Procladius						○
Zavrelimyia			○			
Beardius	○				○	○
Harnischia Complex. type 1	○					
H. Complex. type 2	○					○
Chironomus			●	■		
Cladopelma					♦	
Goeldichironomus		○				
Polypedilum		♦			○	
Stempellinella						♦
Stenochironomus	♦	○	○		○	♦
Endotribelos					♦	♦
Tanytarsini type 1		♦			○	♦
T. type 2		♦				○
T. type 3		○			○	○
T. type 4		○	○	○	♦	♦
Cricotopus	○	○			○	○
Nanocladius		○				
Parakiefferiella		♦				
Paraphaenocladius		♦				
Specimes	24	95	92	150	95	123
Richness	8	15	9	9	16	16

○ < 5 Specimes •< 25 Specimes 25> ● < 50 Specimes ■ > 50 Specimes

The main component analysis demonstrated that the two first components explained 60% of the total variability of the sampled data (35% and 25%, respectively).

The mesohabitats graphical representation of the two first components and the dendrogram of similarity (Fig. 1A and 1B) enable the identification of 2 mesohabitat groups: those situated in the marginal riparian zone (MH3 and MH4), in the quadrant of negative values, and those situated in the main bed of the stream (MH1, MH5 and MH6), located in the quadrant under the higher influence of the positive fraction of component 2. Though, comparing to the others, MH2 was different in component analysis (Fig. 1A). These results suggest that axis 2 is related to water speed, once the negative values have been associated to the reofilical taxa like Perlidae, Gripopterygiidae, Hydroptilidae, Philopotamidae and Simuliidae.

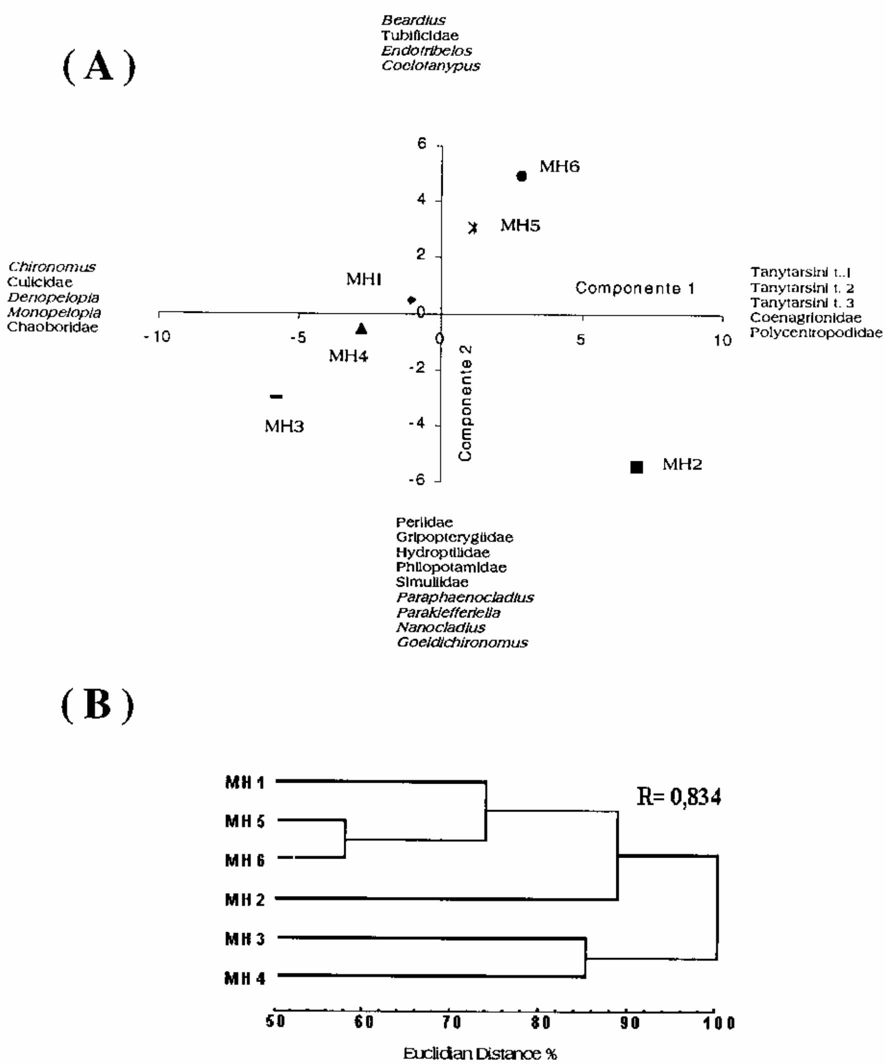

Figure 1: (A) Diagram of Principal Component Analysis. The taxa presented in the each axes contributed by correlation < -0.144 in negative portion and > 0.183 in positive portion of component 1, and < - 0.173 in negative portion and 0.213 in positive portion of component 2. 2B) Mesohabitats (MH) Similarity Dendrogram in Fazzari Stream.

The low similarity of mesohabitat MH2 in relation to the others of the stream bed contributes to the comments of Brussock & Brown (1991) that call attention to riffle distribution in streams in lowlands, which can ecologically be compared with "islands" for certain macroinvertebrates. Another relevant aspect, in the present study, was the differentiation of the community that lives in the marginal riparian zone (MH3 and MH4), whose features must mainly be related to the intermittent character of these areas (Roque et. al., 2000).

Functional feeding groups

The participation of functional feeding groups considering all the mesohabitats indicated predator predominance (39%), followed by collector-gatherers (29%), filter-feeders (15%), shredders (11.5 %) and grazers (3.5%). This low shredder participation, as opposed to comments on streams of regions with temperate climate suggested in the River-Continuum-Concept *(CCR)"* (Vannote et al. 1980), coincides with other studies on tropical streams (Winterbourn et al., 1981 (New Zealand), Durton & Sivaramakrishnan, 1993 (India), Dudgeon, 1994 (New Guinea), Wantzen, 1997 (Brazil). On the other hand, results of this *CCR* prediction have also observed in tropical streams (Nair et al., 1989 and Baptista et al., 1998), indicating that the subject is still controversial and need new studies and methodological approaches.

The analysis of functional feeding groups in each mesohabitats indicated expressive differences (Fig. 2 A). Only in MH2, a distribution of feeding groups according to the CCR prediction was verified, showing that in riffle in forested low-order streams there is a significant participation of shredders. Such results indicate that specific characteristics in the mesohabitat scale can play an important role in the feeding groups distribution, corroborating with Barbara et al. (1993) who emphasizes the necessity of considering variations in a small scale for the better comprehension of dynamics in lotic systems. Some studies have demonstrated that, depending on the stream's geomorphology, a regular alternation (Model of Pseudo-cyclical Alternation) between erosion areas with high water speed and substratum characterized by coarse particles and depositional areas with low speed and fine particle predominance (Knigton, 1984 apud Giller et al., 1992) exists. In the Fazzari Stream, the longitudinal sequence of mesohabitats (1-2-5-6) (Fig. 2b and 2c) seems to be in accordance with this model of pseudo-cyclical alternation; the differential participation of functional groups showed correspondence with the physical and chemical features of each mesohabitat, reflecting a possible connection among several mesohabitats as schematized in Fig. 2B and 2C.

The high water speed and the location of MH2 (downstream of the MH6), explains probably the expressive participation of filter-feeders (Fig. 2A), in particular of Simuliidae larvae, which can benefit of transported matter (FPOM).

The MH1 showed predominance of shredder groups (Fig. 2A). The particle fragmentation (CPOM) for these groups contributes probably to the accumulation of FPOM deposits present in mesohabitats 5 and 6.

Mesohabitats 5 and 6 presented predominance of predators (Fig. 2A), with expressive Tanypodinae (Diptera, Chironomidae) participation. The high number of predators in these mesohabitats, is probably related to the fact that these regions are areas of low water speed with accumulation of organic matter and organisms (Arunachalam et. al., 1991). The collectors have also revealed to be expressive in these mesohabitats, and play an important role in the processing of small organic particles (Fig 2).

Different from the others, Mesohabitats 3 and 4 presented predominance of collectors and absence of shredders (Fig. 2A). This result is probably related to physical and chemical variables, as low oxygen, lower water speed and greater deposits of organic matter of these mesohabitats in the riparian region (Tab. 1). The numerical supremacy of the *Chironomus* larvae in these mesohabitats, a low-oxygen tolerant group, reflects clearly the special features of these environments. Therefore, it is important to consider the riparian zone

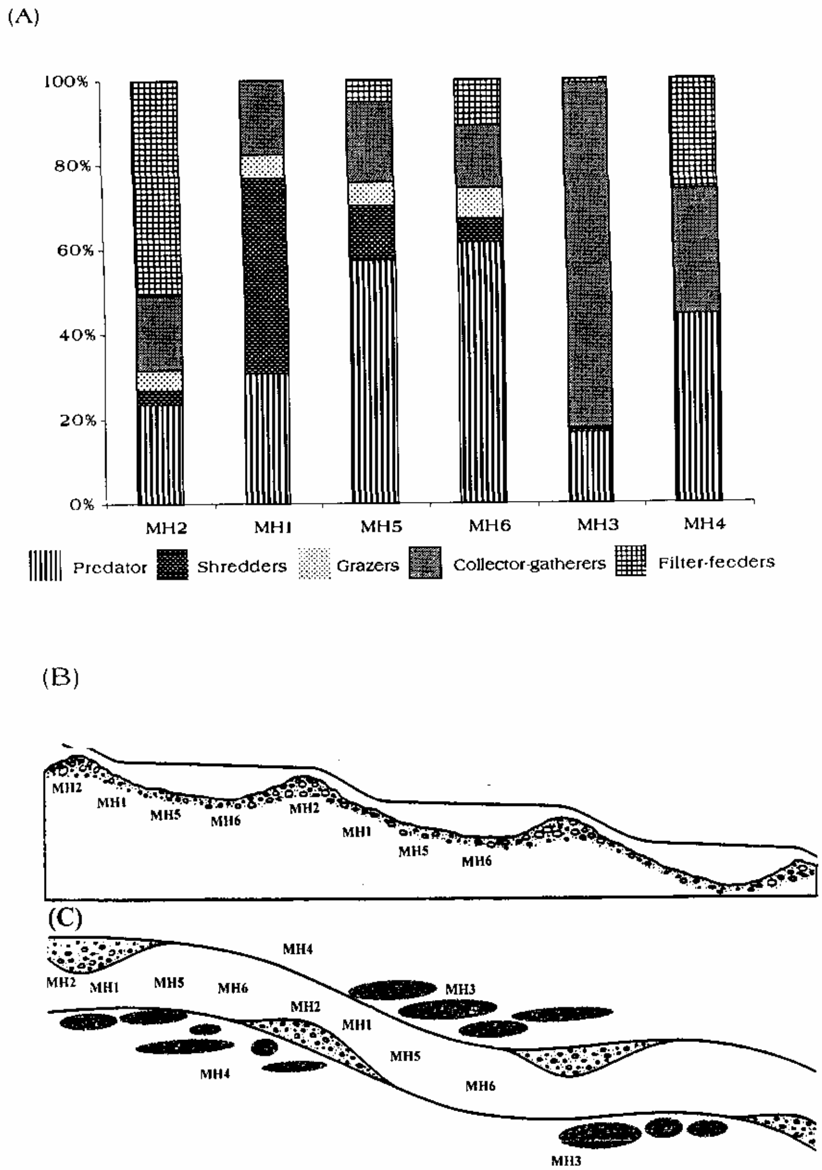

Figure 2: (A) Relative feeding groups participation on differents mesohabitats. (B and C) Schematic profile of the mesohabitats distribution in a gradient longitudinal pseudo-cyclic: riffle (MH2) – run (MH1) – pre-pool (MH5) – pool (MH6). (Modificated of Knigton, 1984 apud Giller et al., 1992).

(or other wetland) in the ecology of a stream (Wantzen & Junk, 2000), but functional characteristics of streams became more complex, because some first order streams (as the Fazzari) can present a proportionally bigger occupied area of wetlands with a difficult delimitation between aquatic and terrestrial environment in the mesohabitat scale. Works carried out in flooded areas of great rivers also suggest differences in community and functional feeding groups of macroinvertebrates in the transversal rection: main stream bed – marginal areas (Marchese & Ezcurra De Drago, 1992; essimian et al, 1998).

This proposal of pseudo-cyclical longitudinal distribution of mesohabitats and the nctional feeding groups in mesoscale and the inclusion of marginal areas in the functional ream characterization is still preliminary, as it was restricted to a spatial analysis. owever, the results indicated differences in the taxocenotic and functional structure of ie macroinvertebrates, with interrelation the physical and chemical features of the nvironment and the distribution of organisms, demonstrating the importance of variations i mesoscale for the study distribution of the macroinvertebrates in lotic environments.

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