Distribution of Chironomidae larvae fauna (Insecta: Diptera) on different substrates in a stream at Floresta da Tijuca, RJ, Brazil.

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ABSTRACT: Distribution of Chironomidae larvae fauna (Insecta: Diptera) on different substrates in a stream at Floresta da Tijuca, RJ, Brazil. **In a study conducted between 1994 and 1995 in the Rio da Fazenda, Parque Nacional da Tijuca (Tijuca National Park), Rio de Janeiro, Brazil, five samples were taken each season from each of the following substrates found in the area: litter from pools, litter from riffles, sand, and stones. All samples were taken with the aid of a Surber sampler. A total of 7,395 chironomid larvae were collected, distributed in 46 taxa belonging to three subfamilies. Regarding the substrates, litter from riffles present the highest amount of specimens although litter from pools exhibited the highest values of diversity and evenness. According to a correspondence analysis the three major factors acting upon the chironomid fauna distribution were current flow (distinguishing erosional from depositional areas), amount of organic matter available in the substrate, and the rainfall regime.**
Key-words: **Chironomid larvae; spatial distribution; aquatic insects; Tijuca Forest.**

RESUMO: Distribuição da fauna de larvas de Chironomidae (Insecta: Diptera) em diferentes substratos em um riacho da Floresta da Tijuca, RJ**. Em estudo realizado no rio da Fazenda, Parque Nacional da Tijuca, Rio de Janeiro, foram feitas amostragens entre 1994 e 1995 em quatro tipos diferentes de substratos (folhiço depositado em remanso, areia, folhiço em correnteza e pedra). As coletas foram feitas em cada estação utilizando um coletor do tipo Surber. Foram encontradas 7395 larvas de Chironomidae, pertencentes a 46 táxons e distribuídas em três subfamílias. O substrato com maior número de indivíduos foi o folhiço em correnteza, mas os maiores valores de riqueza, diversidade e equitabilidade foram encontrados no folhiço depósito em remanso. De acordo com a análise de correspondência os principais fatores que estão influenciando na distribuição da fauna de Chironomidae são: a velocidade da correnteza, separando áreas de erosão e depósito, a quantidade de matéria orgânica disponível no substrato para alimentação e abrigo, e o regime de chuva.**
Palavras-chave: **Chironomidae, larvas, distribuição espacial, Floresta da Tijuca.**

Introduction

The spatial distribution of aquatic insects is directly related to stream flow velocity, water temperature, amount of dissolved oxygen, pH, substrate particle size, food availability, among other factors (Cummins & Lauff, 1969). Furthermore, most aquatic insects are closely associated with the substrate type they are found on, this factor being one of the major determinants in the distribution and abundance of their populations (Minshall, 1984). Among the most ecologically important variables related to the substrate, the following ones must be stressed: physical structure, organic matter content, stability, and heterogeneity (Minshall, 1984; Ward, 1992). Regarding stability in aquatic environments,

the particle diameter is directly related to the degree of resistance to movement. Substrate stability will generally be proportional to the size of the particle because smaller rocks can be disturbed or overturned more frequently (Minshall, 1984).

The habitat structure may act upon the species diversity in a local scale, where more complex habitats offer a greater variety of microhabitats and is causally associated with a higher species richness (Downes et al., 1998). These spatially heterogeneous habitats support a higher variety of species than homogeneous ones, since species tend to replace each other very often in the space, therefore making the spatial component of the diversity much higher (Pianka, 1982).

Chironomid larvae are an important component in stream benthic communities, both in density as well as in diversity (Fend & Carter, 1995), being found colonizing several types of habitats and living in a wide variety of environmental conditions (Pinder, 1986).

There are few studies concerning chironomid communities at a generic or specific level in the State of Rio de Janeiro, Southeastern Brazil, especially those of Sanseverino et al. (1998), Sanseverino & Nessimian (1998), and Henriques-Oliveira et al. (1999a). The aim of this paper was to describe and study the chironomid fauna spatial distribution in the rythral section of the Rio da Fazenda, a small stream crossing the Parque Nacional da Tijuca (Tijuca National Park), State of Rio de Janeiro.

Material and methods

Study Area

The Parque Nacional da Tijuca (Tijuca National Park) is entirely located inside the urban perimeter of the city of Rio de Janeiro (Drummond, 1997), between S22°55'-S23°00' and W43°11'-W43°19', with a forested area of approximately 32km². The local vegetation is mainly represented by secondary tropical Atlantic Rain Forest, due to extensive logging for the establishment of coffee plantations during the eighteenth and nineteenth centuries. Although many exotic species were introduced for reforestation of the area (Mattos et al., 1976), the secondary forest is still typical of the Atlantic Forest found along the Brazilian coast.

The Rio da Fazenda, also known as Rio Humaitá, is a small stony stream that, in the studied site (first order), is located at 400 m a.s.l., being on average 2m wide and 20cm depth. In the studied site the river has a modest slope (around 6°) and distinction between riffles and pools areas is not very clear. In the sampling period the stream was almost entirely covered by riparian vegetation, with very little incidence of direct sunlight.

Sampling was done along a 20 m long section, delimited by marks in the ground. Therefore, all samples were always taken from the same area, minimizing the differences that might be found along the stream.

Methodology

All samples were taken with the aid of a Surber sampler (900 cm² area, 350μm mesh size) during months of August and November 1994 and February and May 1995. For each type of substrate five random samples were taken each month from the four major microhabitats found in the stream: litter from pools, sand, litter from riffles and stones.

All samples were fixed in ethanol 100% and after being washed, preserved in ethanol 80%. The collected material was sorted with the aid of a stereoscopic microscope with 50x maximum increase. The chironomid larvae were sorted in morphotypes, and identified up to genus level under a microscope (1000X) from permanent slide mounted larvae in Euparal, with the aid of the taxonomic keys of Cranston et al. (1983), Pinder & Reiss (1983), Epler (1995), and Trivinho-Strixino & Strixino (1995).

The plant material from samples of litter from pools and riffles was dried, weighted, and sorted into components: leaves, branches, roots, flowers and fruits. The degree of particulation of each sample was measured with a transect of 20cm or 10cm that was placed ten times randomly over the material to record the number of interruptions, i.e., the switch from one component to another. In this way, the more fragmented substrate shows the higher number of interruptions (Nessimian, 1985).

Concurrent with the biotic collection, the following water abiotic parameters were measured: dissolved oxygen, electric conductivity, and pH, both in riffle and pool areas, with the mean value registered for each season. The amount of dissolved oxygen was assessed using the method of Winkler (Brower & Zarr, 1977). Electric conductivity and pH were measured by portable Corning meters. Stream depth and width, as well as its temperature and flow were also recorded. The latter was measured with the aid of a floater (Lind, 1979). Air temperature and pluviosity data were kindly provided by the Instituto Nacional de Meteorologia (National Institute of Meteorology) and taken from the Estação Meteorológica do Alto da Boa Vista (Alto da Boa Vista Meteorological Station), near the studied area.

The structure of the chironomid community in different substrate types were analysed by means of its taxonomic composition, species richness, and by the Shannon's diversity index and Pielou's evenness index (Ludwig & Reynolds, 1988).

Associations among the chironomid taxa were inferred by the Spearman's rank correlation coefficient (Siegel, 1975) and the obtained values were submitted to a multivariate Cluster Analysis (UPGMA).

In order to know which taxa would be more characteristic of each studied substrates, the Indicator Species Analysis of Dufrêne & Legendre (1997) was employed. This method combines information about the abundance of a species in a particular habitat with its frequency of occurrence in that habitat. The statistical significance of the provided values was checked by a Monte Carlo test with 1,000 random permutations.

For a final analysis of the variation gradient in the structure of the chironomid fauna, a multivariate Correspondence Analysis (CA) was used as an ordination technique between the samples from each substrate-month and the number of chironomid taxa in each sample. In this way, it was possible to infer the relation between some environmental factors and the presence of some chironomid taxa, as well as their major substrates and months.

Results

Environmental variables

The recorded values of air temperature, flow speed, and water physico-chemical parameters taken in the months studies are shown in Table I. Water temperature changed from 18°C to 25°C in February, without major significant changes throughout the year. Water was acid with a mean pH value of 5.8. The amounts of dissolved oxygen varied from 8.08 $ml.l^{-1}$ in August to 4.18 $ml.l^{-1}$ in May. Electric conductivity changed little, with its highest value in November. The largest mean width was found in February, with 2.82 m, and the maximum depth in August, 30 cm.

Table I: Environmental variables at the Rio da Fazenda, Tijuca National Park, Rio de Janeiro, RJ, measured during the study period

	August/94	November/94	February/95	May/95
Air temperature (°C)	18	18	25	20
Mean air temperature (seasonal*) (°C)	19.7	22.4	26.0	22.8
Water temperature (°C)	18	18	24	18
Mean depth (cm)	30	25	23	24
Mean width (m)	2.37	2.38	2.82	2.80
Dissolved Oxygen (ml/l)	8.08	6.15	6.64	4.18
pH	4.6	6.0	6.3	6.4
Electric conductivity ($ms.cm^{-1}$)	50.2	67.4	---	46.1
Current velocity (m/s)	0.36	0.40	0.34	0.26

* Mean of temperatures recorded in months related to the season. [i.e. August (winter) = å (T-June + T-July + T-August)/3].

The analysis of the stream flow and rainfall during the period of the study allows us to distinguish the condition of the Rio da Fazenda in August 1994 from those observed in the others months. Mean rainfall amount in August was not higher than in November 1994 and May 1995 (Fig. 1). The highest stream flow was recorded in November, with 0.395 m/s, and the smallest was found in May, with 0.260 m/s, while the highest mean amount of rainfall was registered in May (299.6 mm) and the smallest in February (150.8 mm).

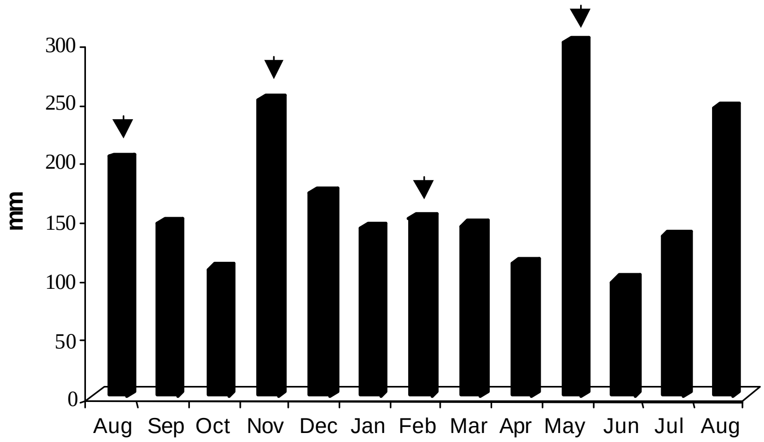

Figure 1: Total precipitation values recorded to Parque Nacional da Tijuca, by Estação Meteorológica do Alto da Boa Vista, from August 1994 to August 1995. The arrows points the months studied.

Litter Composition

The components of the plant material found in the litter samples are shown in Table II. The major components were twigs and especially leaves. Flowers and fruits were represented in smaller amounts. The largest amount of leaves was found in November in the litter from riffles, while the smallest was from the litter from pools in August, when a higher amount of twigs was recorded.

Table II: Composition and weight of litter samples collected in depositional areas (litter from pools) and erosional areas (litter from riffles) at the Rio da Fazenda, Tijuca National Park, Rio de Janeiro, RJ, in the month studied.

Litter from pools

	% Leaf	% Wood	% Flower	% Fruit		Dry weight (g)
August	61.08	37.38	0.34	1.20		74.28
November	84.54	14.68	0.20	0.58		110.80
February	83.76	15.24	0.40	0.58		113.90
May	71.20	25.62	1.08	2.10		50.85
Mean	75.15	23.23	0.50	1.12	Total	349.83

Litter from riffles

	% Leaf	% Wood	% Flower	% Fruit		Dry weight (g)
August	83.98	15.96	0.06	-		95.08
November	94.50	5.50	-	-		74.12
February	89.08	10.38	0.24	0.30		84.35
May	77.08	22.62	0.02	0.28		119.25
Mean	86.16	13.61	0.08	0.14	Total	372.75

The highest litter mean dry weight was found in February (113.90 g) and November (110.80 g) in the samples of litter from pools, while in the litter from riffles the highest weight was found in May (119.25 g). The degree of fragmentation of the plant material (Fig. 2) proved to be very homogeneous, although its highest values were recorded in February and May and the smallest in August and November.

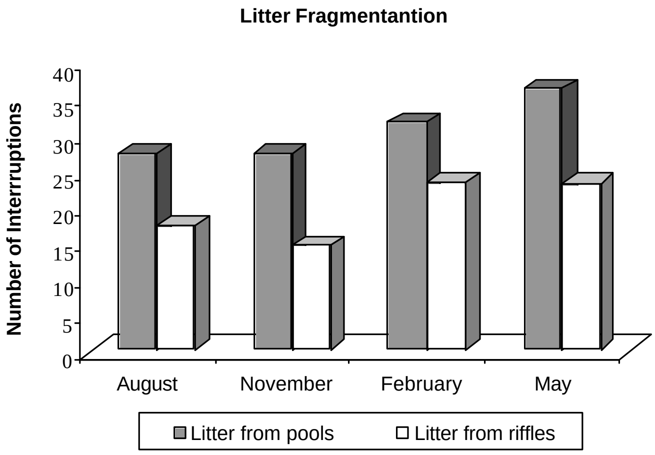

Figure 2: Mean values of fragmentation in number of interruptions of litter from pools and litter from riffles in the Rio da Fazenda, Parque Nacional da Tijuca, RJ.

Chironomid Fauna Composition

A total of 7,395 chironomid larvae were present in the samples, distributed in 46 taxa (Tab. III) belonging to the subfamilies Tanypodinae (10 taxa), Chironominae (23 taxa), and Orthocladiinae (13 taxa). The Orthocladiinae was the most abundant subfamily with 3,766 individuals (50.92%), prevailing in almost all types of substrate, especially in sand (72.76%) and litter from riffles (58.68%).

Among the analysed substrates, litter from riffles presented the highest amount of larvae, with 3,525 specimens (47.67%) and sand the lowest one (481 or 6.50%). In the litter from riffles, *Thienemanniella* was the most numerous genera (750 individuals), followed by *Corynoneura* sp.2, *Parametriocnemus*, Chironomini type 1 and aff. *Omisus*. Besides these, *Corynoneura* sp.1, *Endotribelos* sp.2, aff. *Parakiefferiella*, aff. *Pentaneura*, *Polypedilum*, *Rheotanytarsus*, *Stenochironomus*, and *Tanytarsus* were also abundant in this substrate.

In litter from pools, Chironominae, with 40.00% of the larvae, predominated a little over Orthocladiinae (37.70%), especially in February samples, in which they represented 63.00% of larvae. In this month, Tanypodinae presented their highest number among the substrates (22.30%). The most representative genera found in this substrate were *Lopescladius*, *Chironomus*, *Endotribelos* sp.2, *Labrundinia*, *Corynoneura* sp.2, *Phaenopsectra*, *Ablabesmyia*, and cf. *Djalmabatista* sp.1.

In sandy substrate, Orthocladiinae was the major group, and Chironominae was slightly predominant over Tanypodinae in November. *Lopescladius* was the most abundant genus, with 62.60% of larvae, followed by cf. *Djalmabatista* sp.1 and *Tanytarsus*, both with 35 specimens in this substrate.

In rocky substrate, Chironominae was the most numerous group, with 51.40%. Besides *Lopescladius*, this substrate had *Rheotanytarsus*, *Thienemanniella,* and aff. *Omisus* as representative taxa, which are characteristics of erosional areas.

According to the results obtained by the Indicators Species Analysis (Tab. IV) only the organic substrates presented characteristic taxa. *Ablabesmyia*, cf. *Djalmabatista* sp.1, *Labrundinia*, cf. *Larsia*, *Chironomus*, *Endotribelos* sp.2, *Phaenopsectra*, *Stempellinella*, aff. *Tribelos*, and *Nanocladius* were characteristic taxa of litter from pool, while Chironomini type 1, aff. *Omisus*, and *Parametriocnemus* were typical of litter from riffles samples.

Table III: Distribution of chironomid fauna in each type of substrates studied in the Rio da Fazenda, Parque Nacional da Tijuca, Rio de Janeiro.

	L. from pools	Sand	L. from riffles	Rock	Total
Tanypodinae					
Ablabesmyia	**61**	**1**	**1**	**7**	**70**
cf. *Djalmabatista* sp.1	**135**	**35**	**2**	**6**	**178**
cf. *Djalmabatista* sp.2	**2**	**1**	**-**	**4**	**7**
Labrundinia	**91**	**10**	**6**	**1**	**108**
cf. *Larsia*	**142**	**5**	**13**	**12**	**172**
Nilotanypus	**-**	**1**	**-**	**1**	**2**
aff. *Pentaneura*	**86**	**5**	**68**	**26**	**185**
Pentaneurini (not identified)	**18**	**8**	**11**	**4**	**41**
Pentaneurini type 1	**2**	**-**	**5**	**-**	**7**
Pentaneurini type 2	**4**	**2**	**1**	**-**	**7**
Subfamily total	**541**	**68**	**107**	**61**	**777**
(%)	**22.2**	**14.1**	**3.0**	**6.4**	**10.5**
Chironominae					
Beardius	**-**	**-**	**2**	**1**	**3**
Chironomus	**160**	**-**	**3**	**-**	**163**
Cryptochironomus	**2**	**2**	**-**	**-**	**4**
***Endotribelos* sp.1**	**2**	**-**	**3**	**1**	**6**
***Endotribelos* sp.2**	**152**	**2**	**42**	**1**	**197**
Complex *Harnischia* spp.	**8**	**2**	**-**	**-**	**10**
Lauterborniella	**11**	**-**	**3**	**1**	**15**
Nilothauma	**13**	**-**	**15**	**9**	**37**
Nimbocera	**5**	**-**	**20**	**3**	**28**
aff. *Omisus*	**27**	**4**	**317**	**145**	**493**
Oukuriella	**3**	**-**	**-**	**-**	**3**
Paratendipes	**6**	**-**	**-**	**-**	**6**
Phaenopsectra	**135**	**-**	**1**	**1**	**137**
***Polypedilum* sp.1**	**43**	**1**	**191**	**4**	**239**
***Polypedilum* sp.2**	**7**	**-**	**1**	**4**	**12**
Rheotanytarsus	**19**	**5**	**142**	**114**	**280**
Stempellina	**1**	**1**	**-**	**1**	**3**
Stempellinella	**120**	**8**	**19**	**25**	**172**
Stenochironomus	**77**	**-**	**92**	**36**	**205**
Tanytarsus	**89**	**35**	**130**	**86**	**340**
aff. *Tribelos*	**46**	**-**	**9**	**2**	**57**
Xestochironomus	**12**	**-**	**13**	**6**	**31**
Chironomini type 1	**37**	**3**	**348**	**23**	**411**
Subfamily total	**975**	**63**	**1,351**	**463**	**2,852**
(%)	**40.1**	**13.1**	**38.3**	**48.4**	**38.6**
Orthocladiinae					
***Corynoneura* sp.1**	**137**	**15**	**114**	**17**	**283**
***Corynoneura* sp.2**	**79**	**5**	**504**	**62**	**650**
Cricotopus	**1**	**-**	**2**	**1**	**4**
aff. *Limnophyes*	**11**	**-**	**30**	**-**	**41**
Lopescladius	**285**	**301**	**41**	**108**	**735**
aff. *Mesosmittia*	**9**	**-**	**6**	**-**	**15**
aff. *Metriocnemus*	**1**	**-**	**24**	**-**	**25**
Nanocladius	**118**	**5**	**50**	**15**	**188**
aff. *Parakiefferiella*	**112**	**5**	**126**	**16**	**259**
Parametriocnemus	**61**	**7**	**385**	**64**	**517**
Pseudosmittia	**55**	**2**	**30**	**8**	**95**
Rheocricotopus	**2**	**-**	**5**	**4**	**11**
Thienemanniella	**44**	**10**	**750**	**138**	**942**
Subfamily total	**915**	**350**	**2,067**	**433**	**3,765**
(%)	**37.6**	**78.2**	**58.6**	**45.2**	**50.9**
TOTAL	2,432	481	3,525	957	7,395

Table IV: Values found in the Indicator Species Analysis of the chironomid fauna at the Rio da Fazenda, Parque Nacional da Tijuca, RJ. In bold are the significant values ($p \leq 0,05$).

	L. from pools	Sand	L. from riffles	Rock	*p*
Ablabesmyia	87	0	0	38	0.004
cf. *Djalmabatista* sp.1	76	20	1	3	0.005
cf. *Djalmabatista* sp.2	7	4	0	29	0.548
Labrundinia	84	7	4	0	0.008
cf. *Larsia*	83	2	8	5	0.000
Nilotanypus	0	13	0	13	0.999
aff. *Pentaneura*	46	2	37	14	0.287
Pentaneurini (not identified)	44	20	13	7	0.252
Pentaneurini type 1	7	0	18	0	0.999
Pentaneurini type 2	29	14	4	0	0.709
Beardius	0	0	33	8	0.503
Chironomus	74	0	0	0	0.050
Cryptochironomus	25	13	0	0	0.550
Endotribelos sp.1	8	0	13	4	0.999
Endotribelos sp.2	77	1	21	0	0.035
Complex *Harnischia* spp.	60	10	0	0	0.085
Lauterborniella	55	0	10	2	0.096
Nilothauma	35	0	30	12	0.438
Nimbocera	13	0	54	3	0.104
aff. *Omisus*	4	0	64	29	0.024
Oukuriella	50	0	0	0	0.185
Paratendipes	50	0	0	0	0.205
Phaenopsectra	99	0	0	0	0.003
Polypedilum sp.1	18	0	80	1	0.273
Polypedilum sp.2	44	0	2	17	0.164
Rheotanytarsus	5	0	51	41	0.130
Stempellina	8	8	0	8	0.999
Stempellinella	70	2	8	11	0.010
Stenochironomus	28	0	45	18	0.249
Tanytarsus	26	10	38	25	0.476
aff. *Tribelos*	81	0	12	1	0.005
Xestochironomus	29	0	21	15	0.580
Chironomini type 1	7	1	85	6	0.000
Corynoneura sp.1	48	5	40	6	0.301
Corynoneura sp.2	9	1	78	5	0.087
Cricotopus	6	0	13	6	0.999
aff. *Limnophyes*	13	0	37	0	0.365
Lopescladius	39	41	6	15	0.401
aff. *Mesosmittia*	45	0	30	0	0.134
aff. *Metriocnemus*	1	0	48	0	0.213
Nanocladius	63	1	27	8	0.005
aff. *Parakiefferiella*	43	1	49	5	0.353
Parametriocnemus	6	1	74	12	0.025
Pseudosmittia	43	1	32	8	0.294
Rheocricotopus	9	0	23	9	0.772
Thienemanniella	2	0	60	15	0.337

The indexes of taxonomic richness, Shannon's diversity, and Pielou's evenness (Tab. V) presented their highest values for the litter from pools, especially in November. On the other hand, sandy substrate showed the smallest average values for these parameters.

According to the Cluster Analysis based upon the Spearman's rank correlation coefficient (Fig. 3) three groups of taxa are detected. Group A, formed by cf. *Djalmabatista* sp.1 and *Lopescladius*, that occurred in the pool areas, mostly on sand. Group B, formed by those taxa that occurred in the riffle areas, especially in litter, forming two small subgroups: b1 – the Orthocladiinae, which showed high numbers in August (dry period),

Table V: Values of Taxonomy Richness (R) Shannon's Diversity (H'), Pielou's Evenness (E) of the chironomid fauna in four substrates sampled at the Rio da Fazenda, Parque Nacional da Tijuca, RJ.

	Litter from Pools			Sand			Litter from Riffles			Rock		
	R	H'	E	R	H'	E	R	H'	E	R	H'	E
August	36	2.75	0.77	17	1.76	0.62	30	2.16	0.64	22	2.21	0.72
November	38	3.21	0.88	19	1.82	0.62	26	2.36	0.72	28	2.44	0.73
February	33	2.72	0.78	14	1.09	0.41	29	2.74	0.81	24	2.60	0.82
May	23	2.46	0.79	10	1.63	0.71	23	2.60	0.83	15	2.28	0.84

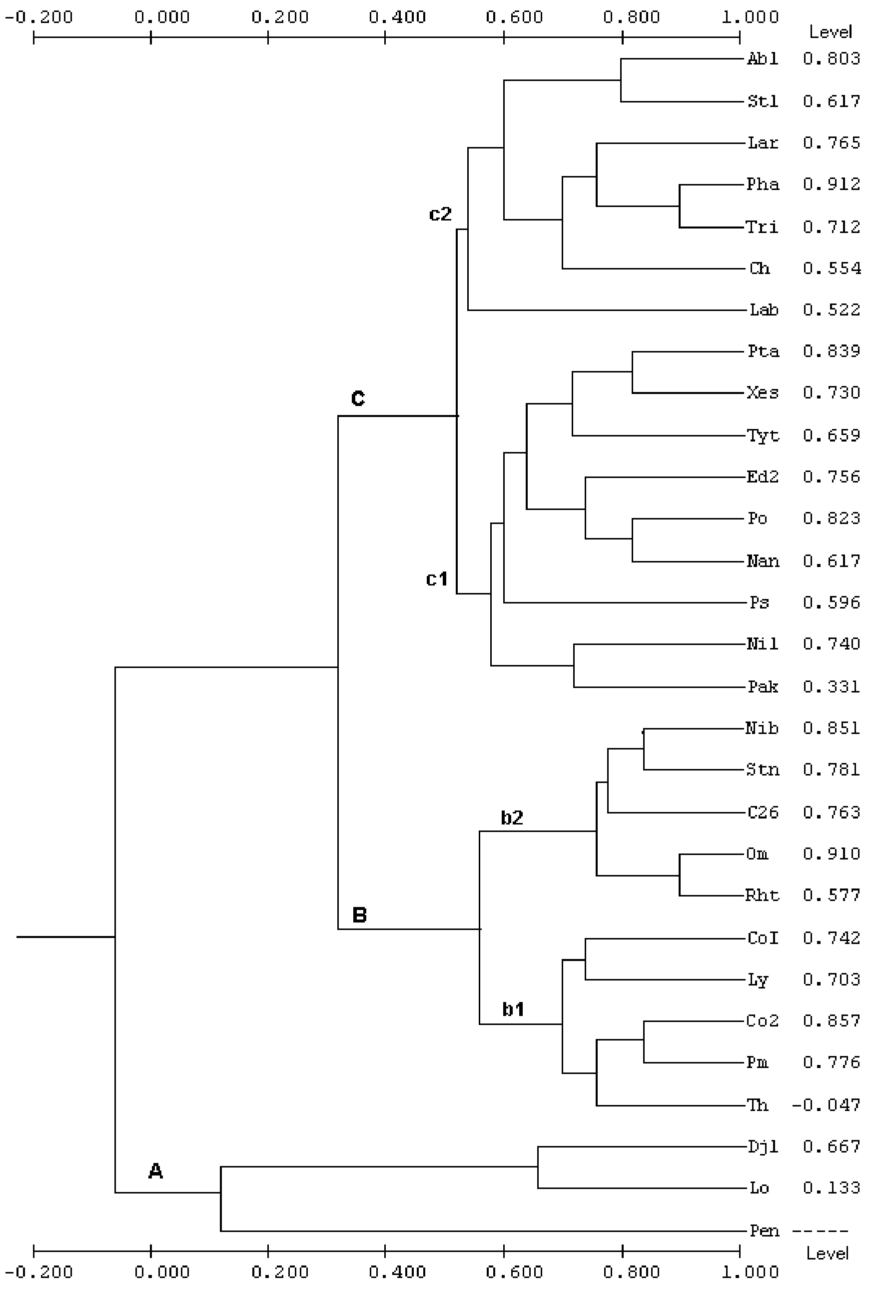

Figure 3: Cluster analysis of more abundant taxa based upon values of Spearman's rank correlation coefficient using the UPGMA method. Abl- *Ablabesmyia*, Ch- *Chironomus*, Col- *Corynoneura* sp.1, Co2- *Corynoneura* sp.2, C1- Chironomini type 1, Djl- *Djalmabatista* sp.1, Et2- *Endotribelos* sp.2, Lab- *Labrundinia*, Lar- cf. *Larsia*, Ly- aff. *Limnophyes*, Lo- *Lopescladius*, Mt- aff. *Metriocnemus*, Nan- *Nanocladius*, Nil- *Nilothauma*, Nib- *Nimbocera*, Om- aff. *Omisus*, Pak- aff. *Parakiefferiella*, Pm- *Parametriocnemus*, Pta- aff. *Pentaneura*, Pha- *Phaenopsectra*, Po- *Polypedilum* sp.1, Ps- *Pseudosmittia*, Rht- *Rheotanytarsus*, Stl- *Stempellinella*, Stn- *Stenochironomus*, Tyt- *Tanytarsus*, Th- *Thienemanniella*, Tri- aff. *Tribelos*, Xes- *Xestochironomus*.

and b2 – the Chironominae, with high numbers in February (rainy period). Group C, formed by the taxa associated to litter in general, but with predominance in the litter from pool areas. In this group two small subgroups are also found: c1 – formed by the taxa that occurred both in the litter from pools as well as in the litter from riffles, in February and November samples, and c2 – formed by the taxa that occurred in February but were more restrict to litter from pool areas. The major associations occurred between *Phaenopsectra* and aff. *Tribelos,* and aff. *Omisus* and *Rheotanytarsus*.

Factors determining larval distribution

In the Correspondence Analysis the first three axes explained 73.8% of the variation. Axis I (35.5% of the variation) might be interpreted as the gradient flow (Fig. 4).

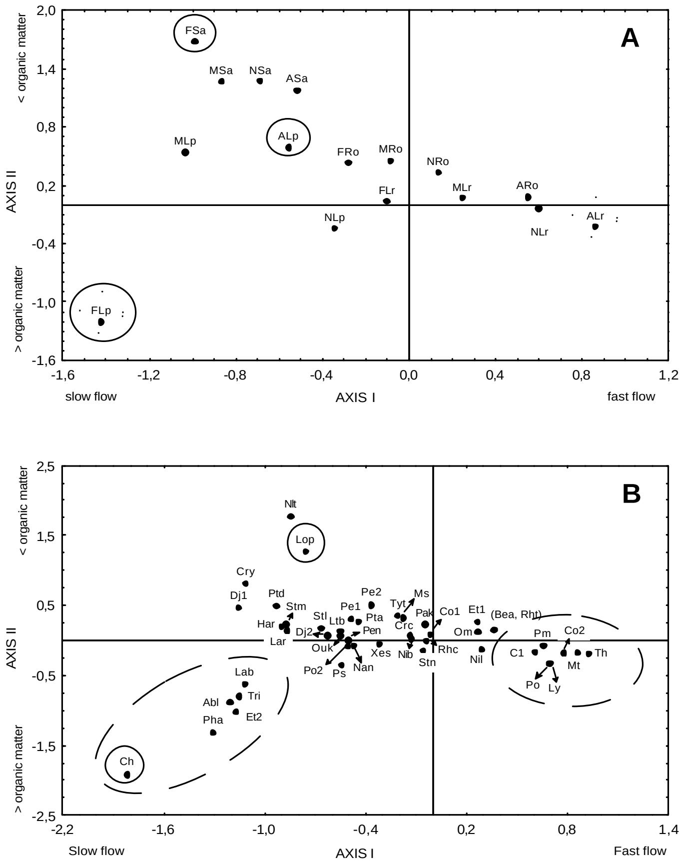

Figure 4: **Correspondence Analysis (axis I and II) of the samples in each type of substrate and season.** A **– substrates and months collected. (A – August; N – November; F – February; M – May; Lp – Litter from pools; Sa - sand; Lr – litter from riffles; Ro – rock).** B **– Chironomidae larvae (Abl- *Ablabesmyia*, Bea- *Beardius*, C1- Chironomini type 1, Ch- *Chironomus*, Col- *Corynoneura* sp.1, Co2- *Corynoneura* sp.2, Crc- *Cricotopus*, Cry- *Cryptochironomus*, Djl- *Djalmabatista* sp.1, Dj 2-*Djalmabatista* sp.2, Etl-*Endotribelos* sp.1, Et2-*Endotribelos* sp.2, Har-*Harnischia* Complex spp., Lab-*Labrundinia*, Lar- cf. *Larsia*, Ltb- *Lauterborniella*, Ly- aff. *Limnophyes*, Lo- *Lopescladius*, Ms- aff. *Mesosmittia*, Mt- aff. *Metriocnemus*, Nan- *Nanocladius*, Nlt- *Nilotanypus,* Nil- *Nilothauma*, Nib- *Nimbocera*, Om- aff. *Omisus*, Ouk- *Oukuriella*, Pak- aff. *Parakiefferiella*, Pm- *Parametriocnemus*, Ptd- *Paratendipes*, Pta- aff. *Pentaneura*, Pen- Pentaneurini, Pel- Pentaneurini sp.1, Pe2- Pentaneurini sp.2, Pha- *Phaenopsectra,* Po- *Polypedilum* sp.1, Po2- *Polypedilum* sp.2, Ps- *Pseudosmittia,* Rhc- *Rheocricotopus*, Rht- *Rheotanytarsus*, Stn-*Stempellina*, Stl-*Stempellinella*, Stn-*Stenochironomus*, Tyt-*Tanytarsus*, Th- *Thienemanniella,* Tri- aff. *Tribelos*, Xes- *Xestochironomus*). (In dotted line are main contributors to axis I, and in full line to axis II.)**

The distribution of chironomid larvae among the substrates varied according to the stream flow, with the greatest contribution for this axis coming from the samples of litter from pools in February (35.0%) and litter from riffles in August (35.0%). In the areas with slow flow, ***Chironomus*** (12.0%) was found, together with ***Phaenopsectra***, ***Endotribelos*** **sp.2,** and ***Lopescladius,*** larva that occurred mainly in litter from pools or sand. In the erosional areas, ***Thienemanniella*** (20.0%) was the main genus together with the larvae that were found especially in litter from riffles and rock habitats, like ***Corynoneura*** sp.2, aff. ***Omisus***, and ***Rheotanytarsus***.

Axis II (22.2% of the variation) might be seen as a gradient of the amount of organic matter present in the substrates (Fig. 4). The major contribution for this axis was made by the samples of litter from pools in February (40.0%) in the negative side of the axis - with a predominance of ***Chironomus*** (22.0%). The sand samples in February (21.1%) and litter from pools in August, in the positive side - with high numbers of ***Lopescladius*** (45.0%).

Axis III (16.1% of the variation) might be interpreted as the influence of the rainfall seasonality, being most evident in the erosional areas (Fig. 5). In this axis, the major contributions came from samples of litter from riffles in February (28.0%) and rock in November (20.0%), in which ***Rheotanytarsus*** and aff. ***Omisus*** showed the greatest contribution in the negative side of the axis, and litter from riffles in August (18.0%) with ***Thienemanniella*** (15.0%) as the most important taxon in the positive side.

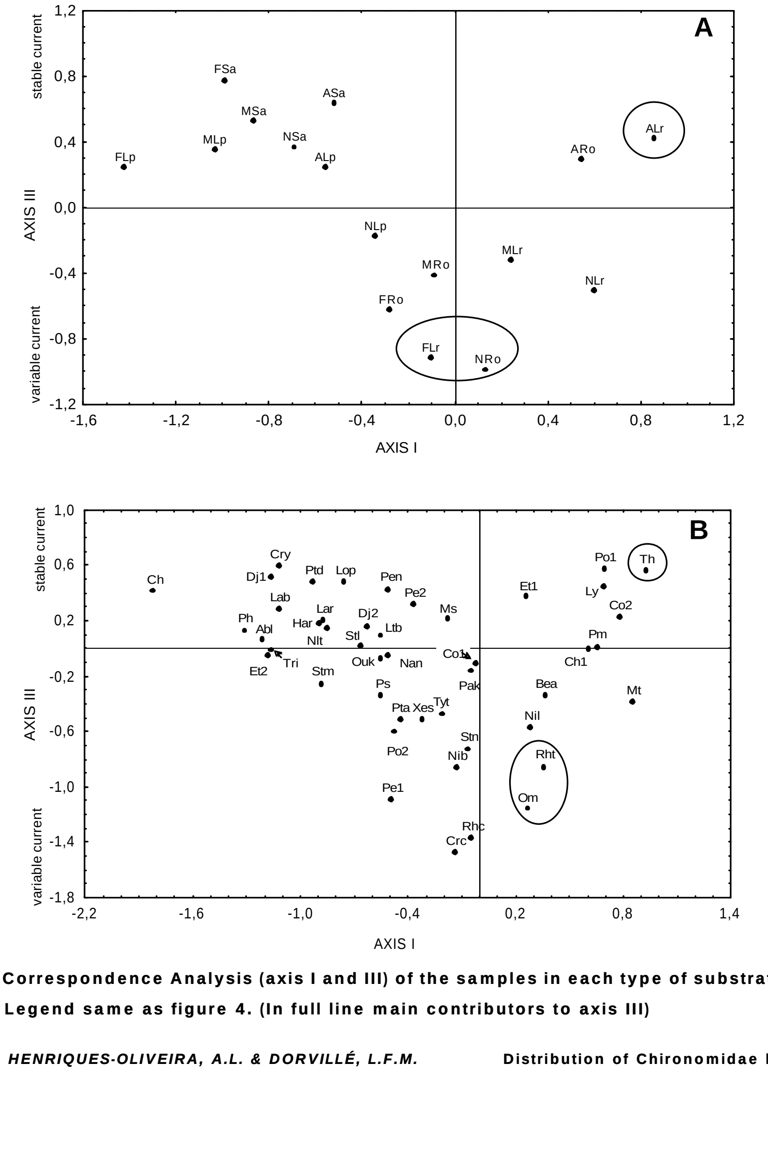

Figure 5: **Correspondence Analysis (axis I and III) of the samples in each type of substrate and season. Legend same as figure 4. (In full line main contributors to axis III)**

Discussion

Environmental variables

Temperature is one of the major environmental factors regulating rates of growth and development in aquatic insects (Anderson & Cummins, 1979 apud Pinder, 1986; Tokeshi, 1995), having an indirect effect upon the quality and amount of available food (Sweeney & Vannote, 1978 apud Pinder, 1986). According to Allan (1995 apud Kikuchi & Uieda, 1998) the temperature of flowing waters usually changes both seasonally, daily, and spatially, due to weather, altitude, extent of the riparian vegetation, and subterranean waters. Neither a seasonal nor a daily analysis of the water temperature change was made in the Rio da Fazenda but the recorded values of the air temperature showed a seasonal increase in temperature, with the highest values in February (26.0°C) and the lowest in August (19.7°C). This variation is reflected on the composition and structure of the Chironomid fauna found in the different months.

The electric conductivity values were related to the amount of rain. The highest value registered in November (Spring) is a reflection of the high rainfall values during this season, which introduces many particles to the river system and increase conductivity.

Leaf composition

Allochthonous organic matter is an important source of energy for many streams and the major energy source for woodland streams or streams with well-developed riparian corridors of vegetation (Cummins et al., 1983 apud Benfield, 1997). According to Benfield (1997), in temperate deciduous forests the peak of litterfall occurs in autumn, but organic material may continue to be introduced throughout the year, principally by lateral movement, being carried from forest soil into the stream during the year. In the tropics, the litterfall is usually non-synchronous and leaves enter streams relatively evenly over the entire year (Stout, 1980 apud Benfield, 1997), being dependent on the rain seasonal distribution, storm events, and the type of the forest (Covich, 1988).

In the stream studied, the highest amount of leaves was found in litter from riffles, mainly in November. This is probably due to the fact that when leaves fall in the river channel they are transported by the flow, being retained by stones and trunks existing in the channel, especially in erosional zones. In November, this transport could have also been increased by the higher amount of rainfall, which carried the litter accumulated in the forest soil during the winter to the river channel. The higher current velocity might have carried part of the leaves downstream explaining the higher amount of leaves in riffles than in pool areas. In litter from pools a higher amount of twigs was recorded mainly in August (37.4%). Since this month correspond to the dry period, the slightly reduced discharge does not allow the twigs that fall into the stream to be transported downstream, remaining concentrated in the depositional zone. According to Wohl et al. (1995), an increase of woody material into the stream might enhance its retaining capacity; promote substrates and refuges for invertebrates, and provide a higher stability to the channel.

In spite of homogeneous values, the highest degree of fragmentation was recorded in February and May for litter from pools probably because the dominant conditions found in the previous months (slow flow and low rainfall) allowed the deposited material to be better used by the shredders. Another factor that might have favoured the high degree of particulation recorded in May was the amount of woody material present in the stream, acting like a trap to the smaller leaf particles, which therefore could not be carried downstream. According to Bilby & Likens (1980), the organic debris dams are the most important structural components of small stream ecosystems, these dams acting in the retention of the organic matter into the systems, and permitting its transformation into smaller fractions on the tributaries of headwaters. The smallest fragmentation recorded in November, especially in the litter from riffles, might have been the result of very recent leaves, brought to the stream by the spring rainfall.

These results are in accordance to studies made in the Paquequer River (Teresópolis, Rio de Janeiro State, Brazil) (Huamantinco, 1998; Sanseverino, 1998), where the highest amount of leaves occurred in riffles and highest amount of wood in litter from pools, especially in the dry period.

Structure and composition of the Chironomid fauna

The structure and composition of the chironomid fauna from Rio da Fazenda showed variable during the year among the substrates. Although Orthocladiinae was the most abundant in almost all substrates and months studied, Chironominae showed to be the most diverse, being represented by 23 taxa.

The pattern of distribution of Chironomidae larvae on the four types of substrates studied can be related to the current flow that characterize the riffle and pool areas. Orthocladiinae was the most representative subfamily in litter from riffles, a result in agreement with Coffmam & Ferrington (1996), who consider this group as primarily of lotic environments and more frequent in high stream flow areas.

In litter from pools it was observed a slight dominance of the Chironominae, as well as a higher participation of Tanypodinae. Most of members of these two subfamilies are thermophilous and adapted to living in standing or running water in warm regions (Oliver, 1971). Besides *Lopescladius* (the most abundant genus), characteristic genera found in this substrate were *Chironomus*, *Endotribelos* sp.2, *Phaenopsectra* and *Ablabesmyia*. The occurrence of the Orthocladiinae *Lopescladius* in high numbers in litter from pools might be attributed to the mixture of this substrate with sand, since this genus is more typical in sandy substrate (Coffmam & Ferrington, 1996; Sanseverino, 1998). In previous studies carried out in highland streams of Rio de Janeiro State (e.g. Sanseverino 1998, Sanseverino et. al., 1998), this genus was commonly found in depositional areas, mainly in litter deposited in areas of little current velocity. In Rio da Fazenda, these larvae were more abundant mainly in February, when the stream was shallow and the pluviosity was low.

The lowest amount of chironomids in sandy substrate might be explained by the fact it usually offers little amount of organic detritus available to nourishment, and bigger instability. Studies conducted in others streams (e.g. Henriques-Oliveira et al., 1999b) have shown that usually sand tends to be colonized by few individuals. The chironomid fauna of this substrate is usually composed of predators and collectors of fine particles. The predominance of *Lopescladius* in depositional areas with sand is corroborated by supports previous studies (Sanseverino & Nessimian, 1998; Sanseverino *et al.* 1998; Sanseverino & Nessimian, 2001).

Mainly *Thienemanniella*, *Corynoneura* sp.2, *Parametriocnemus*, Chironomini type 1 and aff. *Omisus* inhabited the litter from riffles. According to Epler (1995), the larvae of these genera are usually found in rivers and streams, especially in erosional zones (Coffman & Ferrington, 1996). Sanseverino et al. (1998), studying a stream at Serra dos Órgãos (Rio de Janeiro State, Brazil) considered *Thienemanniella* and *Corynoneura* as the major members of the fauna in riffle substrates (rocks in waterfall and litter from riffles).

In rocky substrate, the most representative chironomid genera were aff. *Omisus*, *Rheotanytarsus* and *Thienemanniella. Rheotanytarsus* species are commons in rock surface, where they fix their detritus tube to filter the food carried by the current. Henriques-Oliveira et al. (1999a), studying the chironomid fauna from rocky substrate in two mountain streams in Rio de Janeiro State found *Rheotanytarsus* as the most important genus inhabitant the rocks in the erosional zone.

The results of Indicators Species Analysis show that the chironomid fauna from Rio da Fazenda appears to prefer especially the litter substrate, since ten taxa were indicatives of litter from pools and three indicatives of litter from riffles. Although this analysis has not presented significant results for the rocks and sand substrates, studies conducted in others rivers showed that genera like *Rheotanytarsus* and *Lopescladius* are typical of rock substrates in riffle areas and sand in pool areas, respectively. Perhaps the size of the studied area of Rio da Fazenda might have made difficult the easy distinction among the habitats, therefore promoting a mixture of the faunas of some substrates.

The values of taxonomic richness, diversity, and evenness varied along the year and among the substrates. The major values observed to litter from pools can indicate higher resource availability (food and protection) and substrate heterogeneity. The leaf litter is an important source of food, acting also as a trap for organic detritus and very fine particulate organic matter (Short et al., 1980), which can serve as habitat and food for the collectors and shredders (Kikuchi, 1996).

The low values of richness, diversity and evenness recorded to sand samples might reflect the instability of this substrate, which besides offering little food for the macroinvertebrate fauna is usually removed and washed in heavy rainfalls. According to Mackay & Kalf (1969 apud Kikuchi, 1996) the sandy substrate offers a small variety of microhabitats and a small number of species due to its instability.

The results of the Cluster Analysis performed upon the values of the Spearman's rank correlation coeficient support those from the indicator species analysis and previous observations. In this way, three groups of taxa were found associated to the substrates. Most chironomids preferred substrates with high amounts of organic matter, i.e. litter from pools and litter from riffles.

Factors determining the larvae distribution

Chironomid larvae, as many aquatic insects, select a particular limit of the current velocity according to their physiological requirements. Axis I of the Correspondence Analysis might be interpreted as a flow gradient, distinguishing groups from pool and riffle areas. This is better seen in the sample of litter from pools in February, where the low rainfall allowed the predominance of chironomid genera typical of more lentic habitats, like *Ablabesmyia*, *Chironomus, Endotribelos* sp.2, *Phaenopsectra* and aff. *Tribelos*. Also, the litter from riffles in August showed a predominance of chironomid genera characteristics of erosional habitats, like *Corynoneura* sp.2, aff. *Omisus*, *Parametriocnemus*, *Rheotanytarsus*, *Thienemanniella,* and Chironomini type 1.

The samples of rock and litter from riffles in February are found in an intermediate position, between pool and erosion samples. These samples have also suffered influence of the flow, since, besides presenting typical groups from erosional areas, also showed a great quantity of groups normally present in lentic environments, especially in pool areas like *Lopescladius*, *Stempellinella* and *Stenochironomus*.

The current velocity, distinguishing riffles and pools, is one of the major factors structuring several aquatic macroinvertebrate communities (*e.g.* Kikuchi & Uieda, 1998; Huamantinco & Nessimian, 1999; Buss, 2001). Rossaro (1991), studying six streams in Italy, recorded that the chironomid fauna was distributed according to a crenon-rhithron gradient as a function of water speed, which separated the taxa living in running waters from those living in terrestrial habitat or in standing waters.

The second factor that probably influenced the distribution of chironomid larvae in Rio da Fazenda was the amount of organic matter present in the substrate available for colonization and feeding. Related to this characteristic, the Correspondence Analysis axis II separated the samples of litter from pools in February and November, (which presented a higher amount of leaves), from those of sand. In summer, the large deposition of organic matter from the riparian forest in pools, together with the lowest rainfall of the year, could be favouring shredders and detritivores that processes the coarse particulate organic matter, such as *Chironomus, Endotribelos, Phaenopsectra* and aff. *Tribelos* (Henriques-Oliveira et al., in press). In November, the high input of new leaves into the system, brought by the heaviest rainfalls of the season, would also favour several groups of shredders. According to Cummins (1996), the allochthonous litter favours the occurrence of shredder groups, acting as their major food source, since aquatic microorganisms properly process it.

On the other hand, the sandy substrate is frequently washed, poor in organic matter, being mainly occupied by collector and predator genera, such as *Lopescladius and Tanytarsus* (collectors), and cf. *Djalmabatista* sp.2 (predator). According to Beisel et al. (1998) muddy, silty and sandy substrates are the most fluctuating habitats because hydraulic variation (i.e. floods) will be more likely to act as disturbances for such mineral habitats. Closely associated to the sand samples in the correspondence analysis are the litter from pools samples collected in May and August, both with high amount of twigs and sand, which reflected in the high numbers of *Lopescladius*. This component of the litter offer a low nutritive value and is considered as unpalatable, since there are very few true xilophagous species (Berg, 1995).

Also in the second axis, the samples of litter from riffles and rocks were found in an intermediate position in between the litter from pools and sand samples. In erosional areas, the stream discharge acts influencing the amount of organic matter retained, therefore favouring especially the collectors that use the current to filter or to collect food particles from the water column, as well as the scrapers. Food quality and amount have been identified as the main environmental factors influencing of rates of growth in aquatic animals, with consequent effects on duration of life cycle, size at maturity, fecundity, and survivorship (Pinder, 1986).

The third axis might be interpreted as the rainfall seasonality, and was more easily observed in erosional areas. The rock and litter from riffles sampled in August (Winter), with predominance of *Thienemanniella* and *Corynoneura* sp.2 and more stable current throughout the year, were placed opposite to samples of the same substrate in other months collected, which presented aff. *Omisus* and *Rheotanytarsus* as the major groups. In erosional substrates (rock and litter from riffles) the variation of current flow caused by the rainfall regime was higher, and affected the temporal distribution of some groups. In winter, there is a higher stability than at the other seasons, when the current flow may increase or decrease quickly. Kuhlmann (2000), studying of the chironomid fauna in artificial substrates at Rio Tietê (São Paulo State, Brazil) also a predominance of *Thienemanniella* and other Orthocladiinae during winter, and high numbers of *Rheotanytarsus* in summer months.

In samples from depositional areas, the seasonal variation among groups was not easily observed, since the fauna behaved in a very similar way thoughout the year, with the exception of the litter from pools samples in November, in which the heavy rains allowed the occurrence of groups typical of the erosional areas to occupy depositional areas. Therefore, these samples were positioned between the other two groups.

Beisel et al. (1998), analysing the structure of river communities regarding the spatial variation, found that the nature of substrate (influencing food available), water depth, and the current velocity were the main factors acting upon the mesohabitat and community structure. In this study, we also concluded that the mains factors determining the patterns of Chironomidae community distribution among the substrates could be related to current flow, which characterize riffle and pool areas, and rainfall seasonality, affecting the temporal distribution of some groups. These factors act upon the channel conditions and influence the amount of organic matter available in the substrates.

Acknowledgments

The authors wish to express their gratitude to: M.Sc. Daniela Maeda Takiya (Center for Biodiversity - Illinois Natural History Survey) to the review and suggestion concerning to this paper; CNPq and CAPES to the grants and support provided throughout this work. These results are part of the M. Sc. Dissertation of the first author in the Programa de Pós-Graduação em Ecologia–Universidade Federal do Rio de Janeiro (Brazil).

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Received: **20 September 2002**
Accepted: **29 April 2003**