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# Invertebrates Colonization on Native Tree Leaves in a Neotropical Stream (Brazil)

key words: invertebrate assemblages, leaf breakdown, mixed packs, functional feeding groups, Brazilian Cerrado

### Abstract

We evaluate the composition and structure of invertebrate assemblages during leaf breakdown of five native tree species (*Myrcia guyanensis*, *Ocotea* sp., *Miconia chartacea*, *Protium brasiliense* and *Protium heptaphyllum*) and a mixture of them in a headwater stream, Southeastern Brazil. Coarse mesh litter bags were used over a 120-day period. *P. heptaphyllum* showed the slowest breakdown rate, while *Myrcia* showed the fastest. Total densities and biomass values of associated invertebrates were different among leaf types and incubation periods. The highest values of total abundance were found in *P. heptaphyllum*, while *Ocotea* sp. and *Miconia* were few colonized. Gathering-collectors feeding group dominated all leaf types, followed by predators and shredders. Shredders were more abundant in *Myrcia* than in *Miconia* and the mixed pack.

## 1. Introduction

Forested streams are heterotrophic ecosystems, where the main energy resource is the allochthonous organic matter from the riparian vegetation (VANNOTE *et al.*, 1980; WALLACE *et al.*, 1997). In these streams, leaves form small patches on the streambed (KOBAYASHI and KAGAYA, 2004) that can be used as food resource and/or shelter by benthic invertebrates (RICHARDSON, 1991; DOBSON and HILDREW, 1992).

The influences of the riparian vegetation on the availability of food resources (allochthonous and autochthonous) to the aquatic organisms are potentially reflected on the trophic structure of the invertebrate assemblages and on the relative composition of functional feeding groups (GREGORY *et al.*, 1991; TOWNSEND and HILDREW, 1988; WALLACE *et al.*, 1997; 1999). Therefore, the abundance and composition of detritivore assemblages in shadow reaches are mostly determined by the composition of plant species on the riparian zone (VANNOTE *et al.*, 1980; CUMMINS *et al.*, 1989).

There are many evidences of the role of invertebrates on the leaf breakdown process in aquatic ecosystems of temperate regions, related to the direct feeding process or by their capacity to influence the microbial metabolism (WEBSTER and BENFIELD, 1986; GRAÇA, 2001; JONSSON *et al.*, 2001). Moreover, it is also important to consider that shredders, when feeding, may choose some leaf species and reject others (CANHOTO and GRAÇA, 1995). According to GRAÇA (2001), this preference can be related to differences on the leaf physical structure, nutrient concentration and also the presence of secondary compounds, such as polyphenolics and tannins.

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Contrasting to the existing information from temperate regions, few studies evaluated the importance of decomposer organisms in the tropics (GRAÇA *et al.*, 2001; MATHURIAU and CHAUVET, 2002). Although, as suggested by IRONS *et al.* (1994), there is a belief that the importance of the microorganisms is higher in lower latitudes, where invertebrate participation is less effective. Recently, MATHURIAU and CHAUVET (2002) observed an increased activity of aquatic hyphomycetes and a low participation of shredders while studying the decomposer assemblages in an altitudinal stream in Colombia. Besides, studies performed by BENSTEAD (1996) in Costa Rica, DUDGEON and WU (1999) in Hong Kong, DOBSON *et al.* (2002) in Kenya and GONÇALVES *et al.* (2006a, b) in Brazil, showed a low participation of shredders in the invertebrate assemblages associated with decomposing leaf litter, when compared to data obtained in temperate streams.

The main goal of this study was to verify if the composition and structure of invertebrate assemblages would vary during the breakdown of Brazilian Cerrado native tree leaves. A mixed pack composed by all studied leaf species was also included to verify if a more heterogeneous resource would be more attractive to invertebrates and, consequently, result in a faster breakdown. Therefore, the following questions were asked: (1) Are the breakdown rates from the studied leaves different? (2) Do the composition and structure of the associated invertebrate assemblages vary according to leaf type and incubation periods?

## 2. Methods

## 2.1. Study Area

This study was performed at Serra do Cipó National Park, Southeastern Brazil. It has a total area of 33,800 ha and is located on the South portion of the Espinhaço Mountain range, in the State of Minas Gerais. The region climate type is tropical of altitude (Cwb) and the rainy season is from October to April. The experiment was conducted in a 3<sup>rd</sup> order reach of Indaiá stream (19°16.4' S – 43° 31.2' W), in an altitude of 1,450 m. During the experiment (low waters period), this reach was 2 m wide, 35 cm deep and presented a water discharge of approximately 0.23 m<sup>3</sup> s<sup>-1</sup>. Waters were well oxygenated (4.1 mg L<sup>-1</sup>) and presented an average temperature of 16.1 °C, low values of pH (5.9) and electric conductivity (76  $\mu$ S cm<sup>-1</sup>). According with CALLISTO *et al.* (2004), this reach also presents low values of total phosphorous (14.5–20.25  $\mu$ g L<sup>-1</sup>) and total nitrogen (145.1–234.0  $\mu$ g L<sup>-1</sup>) in this period. The dense riparian vegetation of this reach is composed mainly by *Augusta longifolia* (SPRENG), *Erythroxylum pelletarianum* ST. HIL, *Miconia chartacea* TRIANA, *Miconia cyathanthera* TRIANA, *Myrcia guyanensis* AUBL., *Ocotea* sp. AUBL. and *Protium brasiliense* ENGL.

## 2.2. Experimental Design

In this experiment we used leaves from the five most representative riparian species in the vertical input in this reach of Indaiá stream (GONÇALVES *et al.*, 2006). Leaves from *Myrcia guyanensis* AUBL. (Myrtaceae), *Ocotea* sp. AUBL. (Lauraceae), *Miconia chartacea* TRIANA (Melastomataceae), *Protium brasiliense* ENGL. and *Protium heptaphyllum* MARCH. (Burseraceae) were collected using four nets (1 m<sup>2</sup>, 10 mm mesh size) that had been previously fixed 1.5 m above ground on both sides of the stream. Monthly, from February to June 2003, leaves retained in each net were taken to the laboratory in plastic bags, dried at room temperature, separated, identified and placed in thermal boxes. These five tree species are native from the Brazilian Cerrado and their leaves present low concentrations of nitrogen and phosphorous (MORETTI *et al.* in press).

Leaves from each species, including the mixed pack, were placed separately in  $15 \times 20$  cm (10 mm mesh size) litter bags. In the single species bags, there was  $1 \pm 0.005$  g of leaves (air dry mass) and, in the bags with the mixed pack, we used  $2 \pm 0.005$  g of leaves (air dry mass). The proportion of leaves from each species that composed the mixed pack was determined by the vertical input of these species in the studied reach of Indaiá stream (*P. heptaphyllum*: 0.70 g, *Myrcia*: 0.58 g, *P. brasiliense*: 0.32 g,

*Ocotea* sp.: 0.20 g and *Miconia*: 0.20 g). During the period from June 12<sup>th</sup> to October 10<sup>th</sup>, 2003, a total of 144 litter bags were incubated next to the stream's substrate, tied to the marginal vegetation and also to submersed rocks, under similar flow and turbulence conditions. Four replicates of each treatment were collected randomly after 7, 15, 30, 60, 90 and 120 days of incubation. In each sampling date, the replicates were placed individually in plastic bags and transported in a thermal box with ice to the laboratory at the Federal University of Minas Gerais.

Leaves from each litter bag were carefully washed with running water over a 120  $\mu$ m mesh sieve. The invertebrates were preserved in 70% alcohol and then sorted and identified, up to family level, in a Zeiss stereomicroscope (20×), using specific identification keys (CostA *et al.*, 2006; FERNÁNDEZ and DOMÍNGUEZ, 2001; MERRITT and CUMMINS, 1996; ROLDAN PÉREZ, 1988). The Chironomidae larvae were identified using a Zeiss optic microscope (200×) (EPLER, 2001; TRIVINHO-STRIXINO, 1995). Each found organism was counted, grouped by taxon, dried at 60 °C for 72 hours, weighted with a 0.1 mg precision equipment and classified in the following functional feeding groups (CUMMINS *et al.*, 2005; MER-RITT and CUMMINS, 1996): gathering-collectors, filtering-collectors, predators, shredders and scrapers. For the *taxa* that could belong to more than one functional group, the identified organisms were evenly divided among each possible trophic category. After washing, leaves were placed in the oven for 72 hours at 60 °C to determine the remaining dry mass.

## 2.3. Data Analysis

Breakdown rates were determined adjusting the data from leaf remaining dry mass (leaf DM) to the exponential negative model  $W_t = W_0 e^{-kt}$ , where  $W_t$  is the remaining mass at time *t* (in days),  $W_0$  is the initial mass, and *k* is the breakdown rate (WEBSTER and BENFIELD, 1986). Slopes (*k*) were compared by Covariance Analysis (ANCOVA) followed by Tukey HSD Test (ZAR, 1999), to test for differences in the breakdown rates of leaf types. The relative abundance of each invertebrate taxon was calculated. Total density values (ind. g<sup>-1</sup> leaf DM), densities of each functional feeding group, biomass (mg g<sup>-1</sup> leaf DM) and taxon richness values were compared by Variance Analysis (ANOVA two-way), using as factors the leaf type and the incubation periods, also followed by Tukey HSD Test (ZAR, 1999). All data were log transformed and the statistical analyses were performed using Statistica 5.5 (StatSoft Inc., Tulsa, USA).

## 3. Results

## 3.1. Leaf Breakdown

A fast mass loss was observed for *Myrcia* during the first 7 days of incubation (18% mass loss, Fig. 1). *Ocotea* sp. and the mixed pack showed high rates of mass loss until the 15<sup>th</sup> day of incubation. But we also observed an increase on these samples' mass at the 30<sup>th</sup> day. Every leaf type showed a slower breakdown process after the first month of incubation, with the exception of *Myrcia*. However, *Ocotea* sp. and *Miconia* showed a fast mass loss on the last 30 days. After 120 days of incubation, the detritus that decomposed faster were *Myrcia* (49% remaining mass, k = 0.0063 day<sup>-1</sup>) and *Ocotea* sp. (57% remaining mass, k = 0.0043 day<sup>-1</sup>). *Miconia* and the mixed pack presented intermediary breakdown rates (k = 0.0033 day<sup>-1</sup> and k = 0.0020 day<sup>-1</sup> and k = 0.0019 day<sup>-1</sup>, respectively) showing approximately 80% remaining mass at the end of the experiment (Fig. 1).

Studied leaf types presented different breakdown rates (ANCOVA,  $F_{(5,130)} = 22.26$ ; P < 0.001). Considering their breakdown rates, leaf types may be ordered as following: *P. heptaphyllum*, *P. brasiliense < Miconia*, *Ocotea* sp., mixed pack < *Myrcia* (Tukey HSD Test).



Figure 1. Percentage of mass loss (mean  $\pm$  SE) and breakdown rates (k day<sup>-1</sup>) of five tropical species and a mixed pack in Indaiá Stream.

#### 3.2. Associated Invertebrates

The density values of invertebrates associated with decomposing leaves were relatively low in the first month of incubation (Fig. 2A). *Myrcia* and *P. brasiliense* showed the highest density values after 60 days of incubation ( $32.4 \pm 4.0$  and  $22.7 \pm 17.9$  ind. g<sup>-1</sup> leaf DM, respectively). *Ocotea* sp. presented the highest density value at the end of the experiment, reaching  $47.1 \pm 20.6$  ind. g<sup>-1</sup> leaf DM after 120 days. *P. heptaphyllum* also reached its highest density value ( $38.7 \pm 8.6$  ind. g<sup>-1</sup> leaf DM) on the fourth month of incubation while *Miconia* and the mixed pack showed low values during the whole experiment. The total density values were different among every leaf type and incubation periods (ANOVA, leaf type:  $F_{(5,101)} = 8.11$ , P < 0.001; incubation period:  $F_{(5,101)} = 40.95$ ; P < 0.001).

In general, the biomass of invertebrates associated with the leaf types increased with time (Fig. 2B), with *Ocotea* sp. and *Myrcia* presenting the highest values after 60 (37.9 ± 40.9 and 20.1 ± 5.3 mg g<sup>-1</sup> leaf DM, respectively) and 120 days of incubation (33.6 ± 27.5 and 28.6 ± 11.2 mg g<sup>-1</sup> leaf DM, respectively). The biomass of associated invertebrates was also different among leaf types and incubation periods (ANOVA, leaf type:  $F_{(5,101)} = 2.48$ , P < 0.05; incubation period:  $F_{(5,101)} = 102.13$ , P < 0.001).

Taxon richness values were not significantly different among leaf types (ANOVA,  $F_{(5,101)} = 1.98$ , P > 0.05). However, they were different between incubation periods (ANOVA,  $F_{(5,101)} = 18.31$ , P < 0.001). The mixed pack presented intermediary values of taxon richness during the whole experiment (Fig. 2C). When adding all associated invertebrates identified in each incubation period, *P. heptaphyllum* showed the highest total number of organisms (329 individuals) and taxon richness (33 taxa) while *Ocotea* sp. and *Miconia* were the ones less colonized (169 and 181 individuals; 26 and 22 taxa, respectively) (Table 1). The composition of the invertebrate assemblages associated with the six different leaf types was similar and mainly composed by *Corynoneura* sp. (Diptera, Chironomidae), Leptoceridae (Trichoptera) and Leptophlebiidae (Ephemeroptera). These three taxa repre-



Figure 2. Total density (mean  $\pm$  SE, A), biomass (mean  $\pm$  SE, B) and taxon richness (mean  $\pm$  SE, C) of associated invertebrates during the breakdown of leaf detritus in Indaiá Stream.

Table 1. Relative abundance of invertebrate taxa associated with leaf detritus (% of total numbers cumulated over the study period) in Indaiá Stream. FFG = Functional Feeding Groups, Mg = Myrcia, Oc = Ocotea sp., Mc = Miconia, Pb = P. *brasiliense*, Ph = P. *heptaphyllum*, Mixed = mixed pack, Ga-Co = gathering-collectors, Fil-Co = filtering-collectors, Pr = predators, Shr = shredders, Scr = scrapers, (-) = absent.

Taxon	FFG	Mg	Ос	Мс	Pb	Ph	Mixed
Lentophlebiidae	Ga-Co/Scr	9 70	14 79	12 71	12.65	973	20.16
Baetidae	Ga-Co/Scr	0.75	0.59	2 21	2 45	0.91	1.98
Lentohynhidae	Ga-Co	0.75	1 77	0.55	1.63	0.30	1.50
ODONATA	Oa-Co		1.//	0.55	1.05	0.50	1.50
Coenagrionidae	Dr	0.37	0.50	0.55	0.82	0.61	0.30
PLECOPTERA	11 D	0.57	0.59	0.55	0.62	0.01	0.59
Perlidae	Pr	-	-	-	0.41	_	-
HETEROPTERA							
Naucoridae	Pr	0.75	0.59	_	-	0.91	_
Notonectidae	Pr	-	_	-	-	_	0.39
COLEOPTERA							
Elmidae	Ga-Co/Scr	0.37	0.59	1.10	0.41	1.22	0.39
Hydroscaphidae	Scr	-	0.59	-	-	-	-
Hydrophilidae	Ga-Co/Pr	_	0.59	_	_	1.22	_
Psephenidae	Scr	0.37	_	_	-	0.30	_
Gyrinidae	Pr	_	_	_	-	0.91	_
Dryopidae	Ga-Co/Scr/Shr	_	-	_	-	0.30	-
TRICHOPTERA							
Leptoceridae	Ga-Co/Shr/Pr	25.37	13.02	19.34	29.39	24.01	9.49
Calamoceratidae							
Phylloicus sp.	Shr	_	1.18	0.55	_	0.30	1.19
Polycentropodidae							
Polycentropus sp.	Fil-Co/Pr	1.12	1.18	_	2.04	1.82	3.56
Helicopsychidae	Scr	_	_	1.66	0.41	_	1.58
Hydropsychidae	Fil-Co/Pr	_	_	_	_	_	0.39
DIPTERA	111 00,111						0.07
Chironomidae							
Tanypodinae							
Pentaneurini	Pr	_	_	_	0.41	_	_
Ablabesmvia sp	Pr	2.61	3 55	3 87	1 22	273	0.39
Larsia sp.	Dr	2.01	5.55	5.07	0.41	0.30	0.57
Labrundinia sp.	Dr	1.86	173	2.21	4.08	1.82	3 16
Zavrelimvia sp.	Dr	1.00	4.75	0.55	4.08	0.30	5.10
Zavieuniyia sp.	Dr	_	_	0.55	0.41	0.30	_
<i>Tanypus</i> sp.	FI	1.06	1 77	2 21	2.26	5.47	474
(amall)		1.80	1.//	5.51	5.20	3.47	4.74
(Siliali)							
Orthocladiinae	C - C -	25 75	21.00	10.24	21 (2	10.24	15 01
Corynoneura sp.	Ga-Co	25.75	21.89	19.34	21.03	18.24	15.81
Thienemanniella sp.	Ga-Co	_	-	1.10	-	_	_
Cricotopus sp.	Ga-Co/Shr	-	-	0.55	0.82	-	_
Nanocladius sp.	Ga-Co	2.98	5.92	0.55	2.86	2.73	—
Chironominae							
Beardius sp.	Ga-Co	0.75	1.18	0.55	0.41	0.30	_
Chironomus sp.	Ga-Co/Shr	-	—	—	-	0.30	—
Dicrotendipes sp.	Ga-Co/Fil-Co	-	_	-	-	0.61	_
Kiefferulus sp.	Ga-Co	-	0.59	-	-	-	_
Nilothauma sp.	Nilothauma sp. Ga-Co				-	_	0.39
Parachironomus sp.	Ga-Co/Pr	_	1.77	_	-	1.22	0.79

Taxon	FFG	Mg	Ос	Мс	Pb	Ph	Mixed	
Phaenopsectra sp.	Scr/Ga-Co	7.46	2.37	5.52	3.67	1.52	9.09	
Polypedilum sp.	Ga-Co/Shr/Pr	4.48	1.77	1.66	_	0.61	1.19	
Stenochironomus sp.	Ga-Co/Shr	-	2.37	_	-	1.22	1.98	
Tribelos sp.	Ga-Co	2.24	6.51	8.84	0.82	3.04	13.04	
Rheotanytarsus sp.	Fil-Co	-	2.37	_	0.41	1.22	0.39	
Tanytarsus sp.	Ga-Co/Fil-Co	4.48	2.96	4.97	4.90	5.47	1.58	
undetermined		6.34	4.73	8.29	4.08	9.73	5.93	
(small)								
Culicidae	Ga-Co/Fil-Co	0.37	-	_	-	_	-	
COLLEMBOLA	Ga-Co	_	-	-	0.41	_	0.39	
ACARINA								
Hydracarina	Pr	_	_	-	_	0.30	-	
Total number of taxa		20	26	22	25	33	25	
Total number of organisms		268	169	181	245	329	253	

Table 1. (continued)

sented together more than 45% of the total number of organisms identified in each leaf type, with the relative abundance of Chironomidae larvae varying from 49 to 64% (Table 1).

Functional feeding groups composition of the associated invertebrate assemblages varied among leaf types (Fig. 3). Gathering-collectors were dominant in every leaf type (52-59%) while filtering-collectors presented the lowest values of abundance (2-6%). Predators presented the highest abundance values in *P. heptaphyllum*, *P. brasiliense* and *Myrcia* (22, 20 and 17\%, respectively) while scrapers were more representative in the mixed pack and *Miconia* (19 and 14\%, respectively). Shredders were less abundant (6–11%), presenting higher values in *P. heptaphyllum*, *P. brasiliense* and *Myrcia*.

The density values observed for gathering-collectors, predators and shredders were different among leaf types and incubation periods (Table 2). *Myrcia* presented higher densities of gathering-collectors and shredders than *Miconia* and the mixed pack (Tukey HSD Test).

Table 2. Functional feeding groups densities (mean  $\pm$  SE) of invertebrates associated with leaf detritus in Indaiá Stream and ANOVA two-way results using leaf type and incubation time as factors. Mg = Myrcia, Oc = Ocotea sp., Mc = Miconia, Pb = P. brasiliense, Ph = P. heptaphyllum, Mixed = mixed pack. \* P < 0.05; \*\* P < 0.01; \*\*\* P < 0.001.

		Density (ind. g <sup>-1</sup> leaf DM)					F and P values		
Functional-Feeding Groups	Mg	Oc	Мс	Pb	Ph	Mixed	Leaf	Time	Leaf-Time Interaction
Gathering-Collect.	$10.5 \pm 1.9$	$8.5 \pm 2.3$	$4.0 \pm 0.7$	$6.3 \pm 1.5$	$7.4 \pm 1.1$	$3.7 \pm 0.5$	6.90***	30.01***	2.49***
Filtering-Collect.	$0.6 \pm 0.1$	$0.6 \pm 0.2$	$0.2 \pm 0.1$	$0.5 \pm 0.2$	$0.9 \pm 0.4$	$0.2 \pm 0.1$	1.77	5.83***	1.16
Predators	$3.2 \pm 0.7$	$2.6 \pm 1.0$	$1.1 \pm 0.3$	$2.4 \pm 0.6$	$3.1 \pm 0.8$	$0.8 \pm 0.2$	8.03***	33.62***	2.20**
Shredders	$1.9 \pm 0.4$	$1.1 \pm 0.4$	$0.6 \pm 0.1$	$1.3 \pm 0.3$	$1.6 \pm 0.3$	$0.4 \pm 0.1$	7.21***	27.28***	1.85*
Scrapers	$1.7\pm0.3$	$1.6\pm0.6$	$1.1\pm0.3$	$1.3\pm0.2$	$1.2\pm0.4$	$1.3\pm0.3$	1.67	17.20***	1.59

206



Figure 3. Functional feeding groups composition (%) of invertebrate assemblages associated with decomposing leaf detritus in Indaiá Stream.

However, the densities of predators observed in the mixed pack were lower than the values found for *Myrcia*, *P. heptaphyllum* and *P. brasiliense*. The density values observed for filtering-collectors and scrapers differed only among incubation periods.

# 4. Discussion

Invertebrates colonized the decomposing leaf types differently. *P. heptaphyllum* and *Myrcia* presented the highest values of associated invertebrates, indicating that these resources were more attractive. However, the colonization process was slow and a low number of

organisms was found associated to the leaves when compared to other studies performed on tropical streams (see DUDGEON and WU, 1999; MATHURIAU and CHAUVET, 2002) that found more than 2,000 associated individuals in the first weeks of incubation.

Every type of leaf used in this study presented breakdown rates that are among the lowest ones observed on tropical environments, that ranged from 0.001 to 0.559 day<sup>-1</sup> in studies performed, respectively, in Kenya and Costa Rica (see ABELHO, 2001; DOBSON *et al.*, 2003; GONÇALVES *et al.*, 2006b). The physical-chemical characteristics of the studied species, that present a low nutritional value, associated to low flow and nutrient values in the Indaiá stream, are probably related to the low breakdown rates observed on this study (SUBERKROPP, 1998; ROSEMOND *et al.*, 2002). Breakdown rates are mainly a result of microorganisms and aquatic invertebrates activity. Therefore, they probably constitute an indirect measure of the potential use of leaf detritus as food resource (DOBSON *et al.*, 2003).

*Myrcia* showed higher density values on the second month of the experiment, emphasizing the existing relationship between invertebrate colonization and leaf conditioning by the microbial community (GESSNER and DOBSON, 1993; GONÇALVES *et al.*, 2006a). *P. heptaphyllum*, due to its requirement for a longer decomposition period, acted as a more durable resource to the aquatic invertebrate fauna, supporting an abundant and rich assemblage at the end of the experiment. These colonization patterns are in agreement with the conclusions obtained by GONÇALVES *et al.* (2004) indicating that the degradative ecological succession (*sensu* BEGON *et al.*, 1996) is the main force determining the structure of the invertebrate community associated with decomposing leaf litter.

The mixed pack presented intermediary values of taxon richness, and, not as expected, also presented low density values during the whole incubation period. Therefore, the breakdown rate of this resource resulted from an interaction of the individual breakdown rates from each leaf species and not from a greater colonization by aquatic invertebrates. These results could be different if the benthic patches of the studied stream did not present a great variety of leaves (CHARÁ, 2003), which would turn the mixed pack more attractive to the invertebrates.

Gathering-collectors presented the highest relative abundances in every type of resource, suggesting a continuous accumulation of FPOM on detritus surface that could either be produced inside the litter bag or captured from the seston (GRUBBS *et al.*, 1995). However, the distribution of scrapers is probably related to the biofilm growth on detritus surface (ALLAN, 1995). The low presence of shredders in the invertebrate assemblages reinforces the smaller influence of these organisms on the decomposition process of leaf litter in tropical streams.

The Chironomidae larvae are usually numerically dominant in invertebrate assemblages associated with leaf detritus on different climatic regions (GRUBBS *et al.*, 1995; GONÇALVES *et al.*, 2004). However, these organisms present multiple feeding habits and their trophic classification is still uncertain. Although few genera are considered as shredders, the Chironomidae can interfere on the decomposition process by scraping or mining the leaf surface (ROSEMOND *et al.*, 1998). Therefore, some authors consider the chironomids as an important link in the energy flow and in the secondary production of lotic ecosystems, specially in ecosystems that present leaf litter with low nutritional values and absence of shredders (OERTLI, 1993; CALLISTO *et al.*, unpublished).

Although organisms classification in functional feeding groups is a very useful tool on analyzing patterns or to elaborate predictions on ecological studies (GRUBBS *et al.*, 1995), the feeding habits of most tropical invertebrates are not completely clear. Therefore, it is possible that many organisms classified as collectors or scrapers eventually behave as shredders during a specific period of their life cycle (MATHURIAU and CHAUVET, 2002), reinforcing the conclusions obtained by COVICH (1988) on the dominance of generalist consumers on the trophic chains of small neotropical streams.

The results obtained in this experiment corroborate others performed on the Tropical region (BENSTEAD, 1996; DUDGEON and WU, 1999; DOBSON et al., 2002; GONÇALVES et al.,

2006a, b) on the reduced presence of shredders in tropical streams. All these studies found shredders abundance values lower than 20% of total invertebrates recorded. However, the existing differences on the temperate and tropical regions seem to be more complex than the simple direct effect of temperature, as suggested by IRONS *et al.* (1994). The absence of seasonality on the allochthonous input of leaf litter, associated to great variations on the headwaters flow, reduces the predictability of leaf detritus as food resource on most tropical streams (DOBSON *et al.*, 2002). Besides, while temperate streams support riparian species that present soft leaves with high nutritional values (GRAÇA *et al.*, 2001), many species that are common to tropical riparian vegetation present leaves with thick cuticles that are probably refractory, high concentrations of toxic compounds (MARQUES *et al.*, 2000) and also demand longer conditioning periods by microorganisms (GONÇALVES *et al.*, 2006a).

In conclusion, the data here presented demonstrate a small participation of invertebrates on leaf litter breakdown in the Indaiá stream, suggesting that the breakdown mediated by the microbial community would be the main responsible for the observed mass losses. So far, we come to the conclusion that the aquatic invertebrate community uses the leaf litter accumulated on the streambed of this reach as shelter, indirect food resource (FPOM and biofilm) and, in a smaller scale, as a direct carbon and other nutrients resource.

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