# HABITAT DIVERSITY AND BENTHIC FUNCTIONAL TROPHIC GROUPS AT SERRA DO CIPÓ, SOUTHEAST BRAZIL

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(With 1 figure)

**ABSTRACT**

The assessment of the diversity of habitats and the characterisation of the functional trophic groups of benthic macroinvertebrate communities of some rivers of Serra do Cipó (MG) were the main objectives of this study. The available trophic resources and the types of substrata were characterised along with the structure and composition of their using functional trophic groups. Serra do Cipó is a watershed divisor of the São Francisco and Doce River basins, including a series of streams and rivers, of good water quality and well preserved ecological characteristics. Samples were collected in Cipó, Peixe and Preto do Itambé rivers, besides the Indaiá and Capão da Mata streams at 26 sampling stations, during the rainy (February) and dry (October) seasons of 1998, using "Kicking nets" of 0.125 mm mesh size. The group of collectors (Baetidae, Leptophlebiidae and Leptohyphidae) was the most abundant, followed by collector-predators (Hydrophilidae, Ceratopogonidae, Chironomidae-Tanypodinae), and detritivorous-herbivores (Oligochaeta). The riparian vegetation, together with the aquatic macrophytes, are the substrata containing the highest richness of functional trophic groups and the higher habitat diversity. The results suggest that the use of functional trophic groups, together with habitat evaluation, are efficient tools in the evaluation of the diversity of benthic macroinvertebrates, particularly in altitudinal lotic ecosystems.

*Key words*: benthic macroinvertebrates, functional trophic groups, bioindicators, river ecology, habitat diversity.

**RESUMO**

**Diversidade de habitats e grupos tróficos funcionais na Serra do Cipó, sudeste do Brasil**

Este trabalho teve por objetivo avaliar a diversidade de habitats e caracterizar os grupos tróficos funcionais das comunidades de macroinvertebrados bentônicos em alguns rios na Serra do Cipó, MG. Foram caracterizados os recursos tróficos disponíveis e os tipos de substrato nos habitats amostrados, a composição de grupos tróficos funcionais que os utilizam e a estrutura da comunidade de macroinvertebrados bentônicos. A Serra do Cipó constitui-se em um divisor de águas das bacias do Rio São Francisco e do Rio Doce e engloba uma série de córregos e rios, com características ecológicas ainda bem preservadas e águas de boa qualidade. Foram amostrados os rios Cipó, Peixe e Preto do Itambé, além dos córregos Indaiá e Capão da Mata ao longo de 26 estações amostrais. As amostras foram coletadas nos períodos de chuva (fevereiro) e seca (outubro) de 1998, utilizando-se "Kicking nets" com malha de 0,125 mm. Os resultados evidenciaram que o grupo dos coletores (Baetidae, Leptophlebiidae e Leptohyphidae) foi o mais abundante, seguido pelos coletores-predadores (Hydrophilidae, Ceratopogonidae, Chironomidae-Tanypodinae) e detritívoros-herbívoros (Oligochaeta). A avaliação da diversidade de habitats permitiu caracterizar a vegetação ripária, juntamente com as macrófitas aquáticas, como os substratos contendo a maior riqueza de grupos tróficos funcionais, por oferecerem maior diversidade de habitats. Os resultados sugerem que a utilização de grupos tróficos funcionais, juntamente com a avaliação de habitats, constituem eficientes ferramentas na avaliação da diversidade da macrofauna bentônica em ecossitemas lóticos de altitude.

*Palavras-chave*: macroinvertebrados bentônicos, grupos tróficos funcionais, bioindicadores, ecologia de rios, diversidade de habitats.

## INTRODUCTION

The distribution of benthic organisms in lotic ecosystems is directly related to the water current, quality and availability of food, type of substratum (sandy, stone, wood, aquatic macrophytes), water temperature, and the concentrations of dissolved oxygen and sulfidric gas (Palmer *et al.*, 1994; Quinn & Hickey, 1994; Townsend *et al.*, 1997).

Biomonitoring programs in a watershed should consider the diversity of available habitats, taking into account the population densities, taxonomic composition, and the structure of benthic communities or the function of the ecosystem (Rosenberg & Resh, 1993; Marques & Barbosa, 1997).

Benthic macroinvertebrates take part in the metabolism of freshwater ecosystems, participating in the nutrient cycling, reducing the size of organic particles (e.g. shredders), facilitating the action of micro-decomposers namely bacteria, fungi and yeast (Ward *et al.*, 1995; Callisto & Esteves, 1995) and transporting organic matter downstream (Whiles & Wallace, 1997). Moreover, macroinvertebrates are very important in the energy flux, constituting the major food source for other aquatic insects, fishes (Muñoz & Ojeda, 1997; Wong *et al.*, 1998; Batzer, 1998) and some insectivorous birds (Ward *et al.*, 1995).

Benthic macroinvertebrates functional groups constitute a good tool in biomonitoring programs particularly considering the evaluation of available trophic resources and its use in lotic ecosystems (Cummins & Klug, 1979; Mihuc, 1997; Callisto & Esteves, 1998). Moreover, this approach allows for evaluating the functional organisation of different communities (Odum, 1985).

Benthic macroinvertebrates in rivers present three types of morphologic and behavioural adaptations to the unidirectional flow: (1) those involving the position of the organism (e.g. locomotion, adhesion to the substratum, covering – as the burrowers); (2) adaptations associated to feeding (functional trophic groups – FTG); (3) those related to adaptations for reproduction (e.g. some Belostomatidae-Hemiptera, whose males protect the eggs on their back).

The approach of FTG proposed by Cummins (1973) is based on the association among a limited variety of feeding adaptations found among the benthic macroinvertebrates and the basic categories of food resources. According to this author the categories of food resources are: (1) debris: coarse (CPOM) or fine (FPOM), formed by particulate organic matter and the associated microbiota; (2) periphyton, formed by attached algae and associated material; (3) living aquatic macrophytes; and (4) preys. Serra do Cipó possesses a series of altitudinal streams, located between 800 and 1,200 meters. According to Ward (1992), the altitudinal streams represent valuable environmental resources, as primary points as water sources and formation of watersheds. In Brazil, river studies are still scarce, standing out the evaluation of the River Continuum Concept of Vannote *et al*. (1980) in the State of Rio de Janeiro by Baptista *et al*. (1998); evaluation of the riverine diversity grassland streams by Diniz-Filho *et al*. (1998), Oliveira & Froehlich (1996; 1997a), Oliveira *et al*. (1997), Bispo & Oliveira (1998), Froehlich & Oliveira (1997) and, in the State of São Paulo, Oliveira & Froehlich (1997b). Furthermore, at Serra do Cipó, a preliminary evaluation of aquatic biodiversity were made by Maia-Barbosa *et al*. (in press), Barbosa *et al*. (in press), Galdean *et al*. (in press), Galdean *et al.* (2000).

This study had as objective to evaluate the diversity of habitats and the available trophic resources, along with substrata types, the composition of functional trophic groups, and the structure of benthic macroinvertebrate community, in selected rivers of Serra do Cipó.

## STUDY AREA

The National Park of Serra do Cipó is located in the centre part of the Minas Gerais State (19°12'-34'S; 43°27'-38'W), at the southern part of Serra do Espinhaço, within the municipal districts of Jaboticatubas, Santana do Riacho, Morro do Pilar and Itambé do Mato Dentro. Its total area is 33,800 ha and a perimeter of c. 154 km (Fig. 1).

The local climate is the altitudinal tropical with fresh and rainy summers of the type Cwb and dry season well stablished (Köppen, 1931). The annual medium temperatures oscillate between 17$^{o}$ and 18.5$^{o}$C; the maximum precipitation between 1,450 and 1,800 mm, with an annual potential evapotranspiration from 700 to 850 mm.

Serra do Cipó corresponds to the meridional portion of the mountainous system of Espinhaço that extends from the north of the Ferrous Quadrilateral, in the longitudinal direction, going by the north of Minas Gerais and crossing Bahia State. This montaineous system contains the sources of the São Francisco River. Furthermore, Serra do Cipó is a natural water divisor between the São Francisco and Doce rivers, two of the major watersheds of Minas Gerais (Ab'Saber, 1990).

The vegetation of the area is varied although dominated by grasslands ("cerrado") at altitudes bellow 1,000 m and by rupestrian fields above 1,000 m. The area is also rich in endemic species which may account for c. 30%, according to Giulietti & Pirani (1988) and Pereira (1994).

## MATERIAL AND METHODS

Sediment samples were collected using "Kicking nets" (1 m$^{2}$) of 125 µm mesh, in 26 sample stations in February (rainy season) and October (dry season) of 1998 in the Cipó, Peixe and Preto do Itambé rivers and in the Indaiá and Capão da Mata streams. In the laboratory, they were rinsed through a 125 µm mesh sieve and sorted under a stereomicroscope.

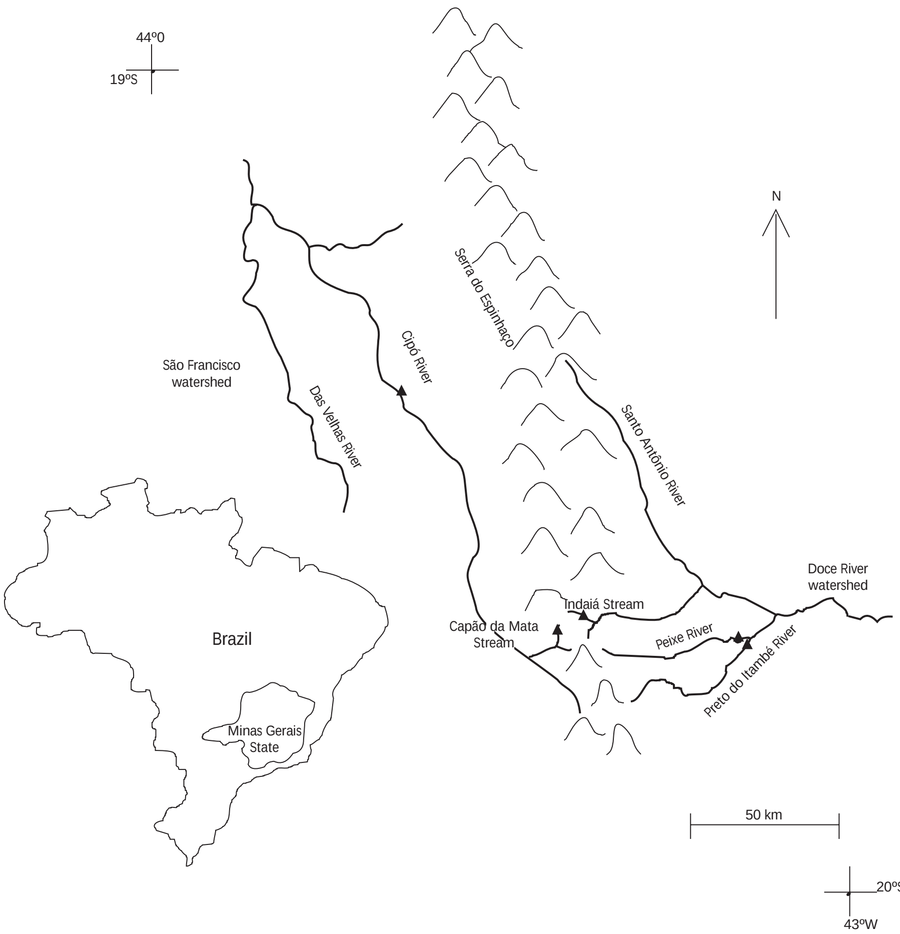


**Fig. 1 —** Map of the studied area with the studied ecosystems in Serra do Cipó.

The recorded organisms are deposited in the Reference Collection of Benthic Macroinvertebrates of ICB/UFMG, Brazil, following methodology described in Callisto *et al.* (1998). Using an Hydrolab multiprobe apparatus it were measured water temperature, pH, electrical conductivity, dissolved oxygen and redox potential.

The classification of the functional trophic groups was based in Wiederholm (1983), Merritt & Cummins (1988), Epler (1995) and Pescador (1997), considering the type of substratum, morphological characteristics of mouthparts and behavioural adaptations. The identified trophic groups were: (1) Collectors: Baetidae, Leptophlebiidae, Leptohyphidae, Caenidae (Ephemeroptera); Collembola; Hydroptilidae *Oxyethira* and *Ochrotrichia*, Philopotamidae *Chimarra* (Trichoptera) and Bivalvia; (2) Scrapers: Helicopsychidae (Trichoptera); (3) Filtering-Collectors: *Simulium* spp. (Simuliidae, Diptera); (4) Shredders: Tipulidae (Diptera); Odontoceridae *Marilia*, Calamoceratidae *Phylloicus* (Trichoptera); (5) Generalists: Leptoceridae (Trichoptera); (6) Herbivorous: Lepidoptera; (7) Predators: Heteroptera; Dytiscidae, Gyrinidae (Coleoptera); Perlidae, Gripopterygidae (Plecoptera); Tabanidae, Empididae (Diptera); Corydalidae (Megaloptera); Hydrobiosidae *Atopsyche* (Trichoptera); all Odonata ninphs; (8) Collectors-Scrapers: Ancylidae; (9) Collectors-Predators: Hydrophilidae (Coleoptera); Ceratopogonidae, Tanypodinae (Chironomidae, Diptera); (10) Collectors-Detritivorous: Elmidae (Coleoptera); (11) Detritivorous-Herbivorous: Oligochaeta; and (12) Filtering-Collectors: Hydropsychidae *Smicridea* (Trichoptera).

## RESULTS

### *Water characteristics*

The depths in the studied rivers varied from 0.40 m in Cipó River up to 1.45 m in Preto do Itambé River, typical of small to medium water bodies (3$^{rd}$ to 7$^{th}$ order), typical of altitudinal areas. The minimum temperature was of 11.5$^{o}$C in Capão da Mata Stream and maximum of 22.1$^{o}$C in Peixe River.

Dissolved oxygen varied between 6.41 mg/L (73.5% saturation) in Cipó River – Santana do Riacho and 8.28 mg/L (94.7% saturation) in Peixe River, and pH values ranged between 5.15 (Peixe River) and 6.05 (Cipó River). The waters show typically low electrical conductivity values (11.3 µS/cm and 18,2 µS/cm) in Peixe and Preto do Itambé rivers respectively, with a recorded maximum value of 45.2 µS/cm found in Cipó River and total alkalinity ranging considerably among the studied rivers, from 30.6 mEq/L in Peixe River to 381.4 mEq/L in Cipó River.

The major habitats found in the studied rivers were: organic matter on top of gravel, bed of fine particulate organic matter deposited in pools, stones, riparian vegetation, aquatic macrophytes and deposits of dry leaves (Table 1).

### *Benthic macroinvertebrates*

During the dry period collectors were the dominant organisms in the majority of the studied habitats (Table 2). These organisms use particulate organic matter in suspension and deposited in pools. As the rivers of Serra do Cipó are altitudinal ecosystems, in general small, the sampled habitats were rich in particulate organic matter of allochthonous origin, thus favouring the abundance of their trophic group.

On the other hand, during the rainy season the predominant organisms were collector-predators, mainly Chironomidae larvae that play an important role processing particulate organic matter (detritivorous) or eating preys (predators).

A high richness of predators was recorded (Coleoptera, Plecoptera, Diptera, Megaloptera, Trichoptera and Odonata), although with reduced density of organisms, except in these habitats showing high richness of functional trophic groups.

Furthermore, organic matter + gravel, organic matter in pools and deposited of leaves, were the habitats showing lower richness of functional trophic groups, which presented higher abundance of collector-predators and collectors. Moreover, a selection due to physical factors in the habitat of stones in the main channel of the rivers was evident. In this situation, the current is strong and only those organisms adapted to fix on and between the stones are able to maintain themselves, thus reducing competition for food and space (e.g. collectors).

Riparian vegetation and aquatic macrophytes presented a high number of functional trophic groups and high densities of organisms, being collectors the dominant organisms in numbers. Riparian vegetation was sampled in all the studied rivers, except in Indaiá Stream (Table 1).

**TABLE 1**

**Types of identified habitats on studied ecosystems in rainy and dry seasons of 1998.**

| Ecosystems | OM + gravel | OM in pools | Stones | Riparian vegetation | Aquatic macrophytes | Deposits of leaves |
|---|---|---|---|---|---|---|
| Cipó River (Faz. Chácara) | * | | * | * | | |
| Cipó River (Santana do Riacho locality) | | | * | * | | |
| Capão da Mata Stream | | * | | * | * | * |
| Indaiá Stream | | | * | | * | |
| Preto do Itambé River | | * | | * | * | |
| Peixe River | | * | * | * | | * |

**TABLE 2**

**Abundance of functional trophic groups in the sampled habitats in Serra do Cipó ecosystems in rainy and dry seasons of 1998.**

| Functional trophic groups | OM + gravel | OM in pools | Stones | Riparian vegetation | Aquatic macrophytes | Deposits of leaves |
|---|---|---|---|---|---|---|
| RAINY SEASON | | | | | | |
| Predators | 6.18 | 0.40 | 1.14 | 2.90 | 3.09 | 0.65 |
| Collectors | 18.54 | 21.51 | 10.83 | 62.91 | 21.14 | 96.40 |
| Scrapers | 1.12 | 0 | 0 | 0 | 0 | 0 |
| Filtering Collectors | 5.06 | 0 | 3.70 | 8.80 | 14.75 | 0 |
| Shredders | 2.81 | 0 | 7.41 | 0 | 19.41 | 0.33 |
| Collectors-Scrapers | 4.49 | 1.59 | 7.41 | 11.79 | 11.25 | 0.33 |
| Colletors-Predators | 55.62 | 76.10 | 67.80 | 12.93 | 30.13 | 1.96 |
| Detritivorous-Herbivorous | 6.18 | 0.40 | 1.71 | 0.67 | 0.23 | 0.33 |
| DRY SEASON | | | | | | |
| Predators | 0.84 | 14.26 | 0.65 | 9.90 | 1.61 | 2.67 |
| Collectors | 21.31 | 38.72 | 57.27 | 59.69 | 36.95 | 21.89 |
| Scrapers | 0 | 0.18 | 0.37 | 0 | 0.63 | 0.18 |
| Filtering Collectors | 0 | 1.94 | 16.45 | 1.20 | 1.61 | 0.18 |
| Scrapers | 0 | 0 | 0.05 | 0 | 0.75 | 0.53 |
| Generalists | 0 | 0 | 0 | 0.11 | 0.08 | 0 |
| Herbivorous | 0 | 0.18 | 0.32 | 0.11 | 0 | 0 |
| Collectors-Scrapers | 0.63 | 0 | 0.14 | 0.22 | 0 | 0 |
| Colletors-Predators | 61.39 | 37.32 | 22.12 | 20.95 | 9.75 | 72.77 |
| Collectors-Detritivorous | 5.49 | 4.58 | 1.57 | 3.50 | 4.48 | 1.25 |
| Detritivorous-Herbivorous | 10.34 | 2.82 | 1.06 | 4.32 | 44.14 | 0.53 |

This habitat offers larger protection against water current and higher diversity of conditions for the macroinvertebrates. At the pools with stony bottom, similar numbers and composition of numeric pattern in the functional trophic groups were recorded, as well as the same influence of sazonality. In the rainy season, the predator-collectors were the dominant organisms while during the dry season it was recorded an increase in the number of functional trophic groups.

## DISCUSSION

Comparing the rainy and dry seasons, in spite of the dominance of collectors, some functional trophic groups were absent, among which herbivores and collector-detritivores are examples. This difference can be related to the mixture of the habitats caused by the rains, thus reducing the richness of functional trophic groups. This reduction probably also changes the period of metamorphosis of the larvae and nymphs thus affecting the numbers of adults flying to the terrestrial environment.

On the other hand, comparing individual numbers, in the rainy season it was recorded c. 3,000 more individuals, corresponding to the filtering-collectors, shredders and collectors. These results allow to suggest that the largest contribution of organic matter was the decisive agent responsible for the recorded increase of individuals. Furthermore, during the rainy season, the macroinvertebrates search for new habitats capable to provide protection against the current and predators, thus creating over populated areas, while in the dry season these organisms are evenly distributed amongst the available habitats.

According to Robson & Barmuta (1998), the architecture and substratum type in a given habitat exert a direct influence upon the composition of its present macrofauna. Moreover, different rivers possessing similar habitats can also present similar benthic communities (Palmer *et al.*, 1993a; Mihuc & Minshall, 1995). As stated by these authors, the relationship between the composition of functional trophic groups and the sampled habitat types was evidenced in the studied ecosystems. Furthermore, in all habitats with riparian vegetation and stones in the main channel, a numeric dominance of predator-collectors and collectors were evident.

The relationships between benthic macroinvertebrates and environmental characteristics have been studied intensively to identify zones of grouping of invertebrates in headwaters of mountain rivers (Hawkes, 1975; Vannote *et al.*, 1980). The diversity of functional trophic groups is influenced by the characteristics of the available habitats, proving that different FTG explore different alimentary resources (Hawkins & MacMahon, 1989). The maintenance of habitats' diversity is of paramount importance for the conservation of biological diversity (Tundisi *et al.*, 1998).

In general terms, it was possible to relate the dominance of collectors with the selectivity of the habitats that can be positive or negative. A habitat can supply protection or impede the fixation of macroinvertebrates in a certain environment, thus favouring the occurrence of certain functional trophic groups. It is important to point out that these habitats besides minimise the action of the water current, also influence the availability of trophic resources for the benthic macroinvertebrates (e.g. in the deposits of leaves, only the collectors and some shredders larvae of Chironomidae were present).

Morphological and behavioural adaptations of macroinvertebrates allow exploring the categories of resources, dividing them in two categories: obligatory and optional. As pointed out by Cummins & Klug (1979), an obligatory relationship is that where a way of food acquisition will produce, at least, the minimum level of obligatory growth for the survival and reproduction. An obligatory specialist can be restricted morphologically (e.g. the mouthparts of a predator is inadequate to filter FPOM or UFPOM) or to present a behavioural pattern that needs a certain appropriate morphological structure to use an alternative food resource. An obligatory relationship between adaptation morpho-behavioural and a specific alimentary resource maximises the efficiency in the conversion of the food in growth. On the other hand, the generalists sacrifice the efficiency in using it narrows of a resource for the wide advantages of using a larger variety of alimentary resources. Feeding on CPOM the shredders ingest larger microbial biomass and a substratum altered biochemically, if compared to the one that just would be obtained by the scrapers.

Minshall (1988) and Palmer *et al*. (1993b) assume that the functional trophic group that prevail in benthic communities is the generalist, exactly because it is not specialised in the use of only few alimentary resources. According to Mihuc (1997), each functional trophic group possesses subdivisions, as for instance collectors, which can be detritivorous, herbivores or generalists. The classification used in the present study took in consideration the habitats where the macroinvertebrates were found. In this way, generalists are those organisms capable to use different available trophic resources; and specialists, those that use only specific trophic resource, identified by morphological characteristics and adaptations to the environment (e.g. predators).

The studied ecosystems, especially the headwaters, present typical characteristics as strong influence of the riparian vegetation and high content of CPOM in the riverbed. In these ecosystems, the collectors were dominant due to the physical characteristics of the rivers, narrow beds, rocky bottoms and well-developed riparian vegetation.

The results of this study allow concluding that the use of functional trophic groups and the colonisation of characteristic habitats, constitute a useful tool for the conservation of aquatic ecosystems. The adaptability of benthic communities to the environments reflects specificity but also the nature and intensity of the answers to different human impacts. Besides, reactions to environmental changes determine the predominant populations, the proportions of the functional trophic groups, and the different forms of use of the primary resources, avoiding, most of the time, the eutrofication process. Finally, these results provide a basic knowledge for the identification of policies and proposal for conservation and maintenance use of natural resources of a given area. Furthermore, as suggested by Barbosa & Galdean (1997), such typology emphasises the need for a larger integration between the taxonomic knowledge and the ecology of the involved organisms, thus demonstrating the possibility of using supra-specific categories for the identification of groups of organisms and their role in the maintenance of the general balance of the ecosystems.

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