

Benthic macroinvertebrate diversity in the middle Doce River: the beginning of the Brazilian Long-Term Ecological Research (LTER) Program

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Introduction

Brazil is known as a megadiversity country (BARBOSA et al. 2000), which includes five biomes (Amazonia, Cerrado, Atlantic Forest, Caatinga and Pantanal), possessing c. 10–20% of the Earth's species. The freshwater ecosystems are prone to a high number of threats, because of the low level of knowledge available on the composition, processes and dynamics of their native species.

The Brazilian Long-Term Ecological Research (LTER) Program was established as a proposal for developing interdisciplinary scientific studies (including botany, zoology, ecology, microbiology, genetics, socio-economics, statistics, and environmental education) by monitoring of long-term trends. As suggested by BARBOSA et al. (2000), the North American LTER Program, now in its 17th year of activity, played an important role in the development of the Brazilian LTER network. The Brazilian LTER Program is coordinated by the Brazilian National Research Council (CNPq) who selected nine sites to initiate the program, a wide enough range of sites to deal with regional and local ecosystem diversity.

One of the nine established sites is localized in Minas Gerais State, in the middle Doce River valley, represented by the Atlantic Forest biome and one of the few places in Brazil where natural lakes (considering the geomorphological origin) can be found. The original Atlantic Forest was reported as having high levels of diversity and endemism (MULLER 1973, HAFFER 1974). Presently it is reduced to 3% of the original vegetation, of which less than 1% are primary forests (FONSECA 1985). The botanical diversity in the area is ca. 10,000 species, of which 53% of the trees, 74% of the bromeliads and 64% of the palms are endemic (BARBOSA et al. 1999). Of the present 940 species of birds, 214 are restricted to the area, as well as 73 out of the 260 recorded species of mammals, and 92% of the known amphibians. Apart from a few inventories of certain groups (e.g.

fish), information on the aquatic biodiversity of the majority of the area is very scarce (IEF 1994). The scientific information that supported the LTER site in the middle Doce River came from a previous inventory project carried out in 1993–1995 by BARBOSA et al. (1997).

The main objective of this study was to report the initial results of the benthic macroinvertebrate diversity within the perspective of the LTER Program in the middle Doce River basin, based on: (i) the ecological characterization of the sampling stations based on a protocol and the assessment of the sediment composition, and (ii) the assessment of the taxonomic composition and community structure of the benthic macroinvertebrate communities.

Study area

The Doce River basin is one of the most important watersheds in SE Brazil (83,000 km²; 3.1 million inhabitants; 124 inhabitants/km²) representing an important segment of the economy (mining, iron/steel plants, *Eucalyptus* plantations, cellulose industry), recently developed. The accompanying accelerated urbanization is almost completely lacking in basic sanitation, which results in an increasing degradation of the aquatic ecosystems (MARQUES et al. 1999). The economic activities moved from the initial gold-mining boom initiated in 1720, and coffee/sugar-cane plantations in 1861, to the implementation of iron/steel plants in the late 1930s, to the large reforestation projects, mainly with *Eucalyptus* spp., from the end of the 1970s. Nowadays, mining is one of the most important economic activities in the area, consuming considerable amounts of water and degrading extensive areas, including those containing the headwaters of the major rivers of the region.

Collections were carried out in the rainy period of 2000, in the middle Doce River area (19° 10'–20° 00' S, 41° 50'–43° 40' W) including seven sub-

basins (Caraça Stream, Santa Bárbara River, Piracicaba River, Peixe River, Severo Stream, Ipanema River and Doce River) and four lakes (Dom Helvécio, Amarela, Carioca and Águas Claras), at a total of 67 sampling stations, inside the Parque Estadual do Rio Doce and the surrounding areas.

Material and methods

Benthic samples were collected using a Petersen dredge (15 × 30 cm) in the rivers (triplicates) and with a corer sampler (0.025 cm³) in the lakes (five samples in each), and then fixed in 5% formalin. In the laboratory, the samples were washed through 2.00-, 1.00-, 0.50- and 0.250-mm mesh sieves and the organisms sorted and preserved in 70% ethanol and deposited in the Benthic Macroinvertebrate Reference Collection of the Institute of Biological Sciences, Federal University of Minas Gerais. The physical features of the sites were recorded on standard forms at the time of biological sampling, using the rapid characterization protocol for ecological conditions of the hydrographic basin stretches (CALLISTO et al. 2000).

Results and discussion

The use of the rapid characterization protocol of the ecological conditions (CALLISTO et al. 2000) on the sub-basins of the middle Doce River watershed constituted an important tool when evaluating the increasing level of impact along the studied sub-basins (Table 1). The results obtained indicated natural characteristics in Caraça Stream sub-basin, characteristics typical of altered sub-basins in Piracicaba River and Santa Bárbara River sub-basins, and all the others were classified as impacted.

The evaluation of the sediment granulometric composition showed individual patterns for each of the sampling stations. In Caraça Stream it was not possible to collect granulometric samples because the substratum was mostly rocks. The other sampling stations showed a varied mixture of granulometric particles and fractions of iron mining, with the predominance of sands (coarse, middle and fine particles of sand) as a result of the strong hydrodynamism present in the sub-basins. The analysis of the sediment granulometric composition of the lakes showed the prevalence of fine particles, typical of lentic ecosystems with intense sedimentation processes.

In total, 28 taxa were identified, 23 of which belonged to the Insect order, two were Annelids, and three belonged to other groups. Among the insects, the Chironomidae family (Diptera) was dominant, found at 16 sampling stations. Other families were also widely distributed along the middle Doce River basin: Elmidae (Coleoptera) and Baetidae (Ephemeroptera) at nine and seven sampling stations, respectively. The annelids were represented by two classes: Oligochaeta and Hirudinea, the former present at 14 sampling stations. The results obtained showed lower densities and diversity than those obtained in the 1993–1995 period, reported by BARBOSA et al. (1997). Simuliidae densities were higher in Caraça Stream, with a low amount of detritus in the samples. Chironomids (except the predators Tanypodinae) are mainly deposit feeders and were able to thrive in the prevailing conditions of reduced flows and silty stone surfaces, as were an Oligochaeta family (Tubificidae), as suggested by ARMITAGE et al. (1987). In South America, only two stonefly families are present, Perlidae and Gripopterygidae. The absence of stoneflies in the studied area is some indication that the middle Doce River basin is, in general, unsuitable for them, compared with other areas in Minas Gerais State, as suggested by GALDEAN et al. (2000).

The low diversity of benthic macroinvertebrates was probably related to low water quality and sandy substrata with high organic matter content, of anthropogenic origin, in the lotic sampling stations, where chironomids and Oligochaeta were abundant. In lentic habitats, the diversity was higher near the shore, mainly due to the presence of aquatic macrophytes, with a high density of gastropods (e.g. *Melanoidea tuberculata*).

The results show that the benthic macroinvertebrate diversity and density in the middle Doce River basin are decreasing compared with the 1993–1995 period (BARBOSA et al. 1997). Although in the present study, the sampling sites were analyzed together to demonstrate trends, it should be stressed that the Brazilian LTER Program must focus on individual sites, to be examined separately, and with emphasis on the aquatic macrophyte associated fauna.

Table 1. Results of the protocol of rapid characterization of the ecological conditions of the sub-basins of the middle Doce River, temperature (°C), dissolved oxygen (mg/L), pH, electrical conductivity ($\mu\text{S}/\text{cm}$), total alkalinity ($\text{mEq}/\text{L CO}_2$), turbidity (NTU), total nitrogen ($\mu\text{g}/\text{L}$), total phosphorus ($\mu\text{g}/\text{L}$), granulometric composition (R, rocky; S, sandy; F, fine sediment formed by sand, silt and clay), total density of benthic macroinvertebrate communities (mean and variance) and dominance (percentage of individuals) of Chironomidae, Oligochaeta, Simuliidae, Ephemeroptera and other groups (Trichoptera, Coleoptera, Odonata, Heteroptera, Lepdoptera, Diptera – Culicidae and Ceratopogonidae, Hirudinea and Gastropoda – *Melanoides tuberculata*) in the sample stations in the middle Doce River basin during the rainy season of 2000.

Variables	Caraça River	Santa Bárbara River	Piracicaba River	Peixe River	Severo Stream	Ipanema Stream	Doce River	Dom Helvecio Lake	Amarela Lake	Águas Claras Lake	Carioca Lake
Protocol of characterization	natural	altered	altered	impacted	impacted	impacted	impacted	not used	not used	not used	not used
Temperature	19.3	25.6	24.5	24.8	24.5	29.0	28.3	30.4	27.4	29.1	31.0
Dissolved oxygen	9.9	9.8	7.6	8.7	9.3	1.9	8.8	9.8	0.5	2.4	0.6
pH	4.02	6.6	7.05	6.35	6.5	7.39	6.3	8.13	6.15	5.49	5.69
Conductivity	16	39	75	62	26	283	54	37	317	42	116
Alkalinity	0.15	1.4	1.6	2.0	1.1	7.15	2.4	0.16	0.7	0.4	0.14
Turbidity	340	580	370	470	990	630	470	21	990	78	54
Total-N	461.3	590.0	1197.0	1358.5	1836.5	5341	1162	1181	474.1	524.9	421.6
Total-P	4.7	12.6	240.3	170.8	469.7	772.7	180.1	16.7	18.3	10.8	30.6
Granulometric composition	R	S	F	S	S	S	F	F	F	F	F
Total density	518 ± 1	30 ± 15	772 ± 706	116 ± 177	596 ± 760	811 ± 985	97 ± 114	4 ± 9	5 ± 10	79 ± 47	139 ± 163
% Chironomidae	10.6	18.0	1.9	46.5	6.0	8.0	45.0	100.0	0.0	6.0	87.0
% Simuliidae	58.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
% Oligochaeta	0.4	52.0	95.0	50.5	87.0	91.0	44.0	0.0	50.0	6.0	0.0
% Ephemeroptera	15.5	5.0	1.4	0.5	0.0	0.5	0.0	0.0	0.0	0.0	6.5
% other groups	15.5	25.0	1.7	2.5	6.4	0.5	11.0	0.0	50.0	88.0	6.5

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