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Comparison of two sampling methods for biomonitoring using aquatic macroinvertebrates in the Dos Novillos River, Costa Rica

Heide Stein[a], *Monika Springer*[b,*], *Bert Kohlmann*[c]

[a] *AG Grundwasserökologie, Universität Koblenz-Landau, Fortstr.7, 76829 Landau, Germany*
[b] *Escuela de Biología, Universidad de Costa Rica, 2060 San José, Costa Rica*
[c] *EARTH University, A.P. 4442-1000, San José, Costa Rica*

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ABSTRACT

Benthic macroinvertebrates are the most commonly suggested group of organisms for freshwater biomonitoring and have been extensively studied in temperate areas. On the other hand, the methodology and theoretical background of biomonitoring have not yet been sufficiently adapted to tropical aquatic environments. The main focus of this study was the testing and comparison of two different collection methods in order to determine water quality and possible anthropogenic influences on the river Dos Novillos, Limón, Costa Rica. For the first method, aquatic invertebrates were collected for 120 min with a strainer, from different microhabitats, picked from the substrate and preserved directly in the field with 70% alcohol. For the second method, organic and inorganic materials, including benthic organisms, were gathered from different microhabitats with a D-shaped net for 10 min, with separation and sorting done in the laboratory. Results from five sampling campaigns showed that each sampling method differed in the composition of the fauna collected (Sørensen similarity index = 80%), although water quality categories obtained from the BMWP-CR index showed no differences between the two methods. The advantages and disadvantages of each method are discussed, and according to the results obtained from this study, further testing for an adequate methodology in tropical rivers is still necessary.

1. Introduction

Ecological engineering has been used for successful management and restoration of all kinds of aquatic ecosystems, including streams and rivers, mangrove forests, and other wetlands, especially in temperate and subtropical regions, but more recently also in tropical countries such as Costa Rica (Dallas et al., 2004; Nahlik and Mitsch, 2006). The application of biomonitoring is an important tool for assessing the effectiveness of stream and river restoration, as well as conservation activities (Bockelmann et al., 2004; Day et al., 2006; Tullo et al., 2006).

The use of the benthic macroinvertebrate fauna as an indicator for a qualitative classification of freshwater systems has increased in many regions of the world within the last years (Roldán, 2003). One of the major advantages of biomonitoring with benthic macroinvertebrates is the possibility to detect changes in water quality that occur at the time of sampling as well as changes that have occurred within a longer period before sampling, due to the relatively sedentary life style

* *Corresponding author*. Fax: +506 207 4216.
E-mail address: springer@biologia.ucr.ac.cr (M. Springer).
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and long life spans of these organisms (Rosenberg and Resh, 1996; Schwoerbel, 1999). In comparison, chemical and physical analysis might be more accurate, but these only reflect the actual conditions in the water body at the time of sampling (Alba-Tercedor, 1996). Furthermore, macroinvertebrates show sensitivity towards various factors that are responsible for changes in water quality, and they are less expensive to work with than chemical and physical analysis (Pontasch and Cairns, 1991).

Aquatic macroinvertebrates can be used for the evaluation of water quality in two ways. Firstly, the taxonomic diversity of a benthic invertebrate community reflects the water quality conditions, since generally a high diversity indicates a high water quality (Hynes, 1984). Secondly, specific taxonomic groups can be used as bioindicators, which are characteristic for certain habitat and water quality conditions. Compared to temperate zones such as Europe and North America, where the use of aquatic macroinvertebrates in water quality monitoring programs is well established, the knowledge of the ecology and distribution of the benthic macroinvertebrate fauna in the Neotropics is still incomplete (Roldán, 2003). Although the necessity for these studies has been realized and consequently there has been a notable increase in the research of the freshwater fauna of Costa Rica and other Central American countries in the last years, only a few publications about biomonitoring exist for these regions (Charpentier and Tabash, 1985; Springer, in press). Furthermore, the high species diversity generally found in the tropics and the lack of inventory lists for different aquatic ecosystems make an adaptation of evaluation systems developed in temperate zones more difficult. As a consequence, a standard method for Central America has not yet been developed.

The present study was conducted within the context of the research project "Monitoreo de la calidad de agua y el uso de bioindicadores acuáticos en la microcuenca del Río Dos Novillos, Guápiles, Limón" ("Monitoring of water quality and the use of bioindicators in the watershed of the Dos Novillos River"). The primary objective of this paper is to discuss the usefulness of two different sampling methods which have been tested in the course of the aforementioned program in order to find the most efficient collecting technique. The data obtained from the investigation meet the increased need for control programs and basic studies, which have become even more urgent with the introduction of a new (not yet signed) law in Costa Rica, which states the use of benthic macroinvertebrates as bioindicators in addition to chemical and physical analysis as default testing methods for water quality (Ministerio de Ambiente y Energía, Propuesta de Ley del Recurso Hídrico 14.845, 2006).

2. Material and methods

2.1. Study area

The Dos Novillos River drains from the Costa Rican central mountain range, at an elevation of approximately 2380 m towards the Atlantic lowlands of the province of Limón, in Guácimo, Costa Rica (10°N, 83°W). This region in Costa Rica is characterized by a humid tropical climate with a mean annual temperature of 25.8 °C (Coen, 1983) and annual precipitation averages of 5000–8000 mm, without a pronounced dry season (Benstead, 1996).

For the collection of aquatic macroinvertebrates, six sampling sites at the Río Dos Novillos were chosen (Fig. 1). All stations were sampled five times in total. The first sampling site – "Don Eladio" (site 1) (elevation 441 m)–served as a reference site, as it is a part of the rhithral region located 8 km upstream of the human settlement of Pocora (5660 inhabitants); minimal anthropogenic disturbances were assumed. Thus, natural conditions characterizing good water quality (e.g. high taxa richness, community composition dominated by organisms sensitive to pollution) were expected to be found. "La Argentina" (site 2) (elevation 187 m, 1400 inhabitants) is located approximately 5.5 km downstream from Don Eladio (site 1) and 2.5 km upstream from Pocora. The samples were taken from one of three arms with decreased current, which the Dos Novillos River formed at this site. This site was chosen in order to examine the extent to which livestock farming and human settlement might influence the water quality of the river. At the third sampling site, "Chiquitín" (site 3) (elevation 90 m), the highest anthropogenic influence was expected, since the communities of La Argentina and Pocora were located on the river upstream from Chiquitín (site 3). In March 2005, the river-bed was artificially straightened at this site as a measure of protection against flooding of houses close to the river. "La Hamaca" (site 4) (elevation 51 m) is located within the property of EARTH University (1000 inhabitants), approximately 2 km downstream of Chiquitín (site 3). As the Dos Novillos River drains through areas covered by forest between Chiquitín (site 3) and La Hamaca (site 4), this sampling point was chosen in order to examine whether water quality was improved by filtering processes in the forest. "Quebrada Mercedes" (site 5) (elevation 45 m) is situated at one arm of the Dos Novillos River, which runs through a forested part of the EARTH University campus. This site is located approximately 2 km downstream of Chiquitín (site 3) and was chosen to examine if a small effluent drain with water from a plantation (of EARTH University) had any influence on the brook. The last site, "Desembocadura" (site 6) (elevation 40 m), is located approximately 500 m upstream from the union of the Dos Novillos River with the Parismina River. The sampling site Desembocadura (site 6) was selected to study the influence of banana plantations on the water quality. Table 1 shows the exact location, depth, width, and current conditions for each site. Samples were taken at each site every 15 days from December 2004 to March 2005.

2.2. Sampling methods

For the collection of aquatic macroinvertebrates two different semi-quantitative methods were used. For the first method, macroinvertebrates were collected directly from their habitats in the river using tweezers and a plastic strainer with a diameter of 19 cm and 1 mm mesh size as a hand net. The strainer was used in three ways: (1) To collect organisms living in the water column or close to the river bank as well as macroinvertebrates living on submerged vegetation were extracted by pulling the strainer through the water. (2) The strainer was