## Discussion

Our results indicated that invertebrate morphotype abundance in tank bromeliads increases with both detrital mass and water volume. However, detrital mass was the best predictor of invertebrate abundance. Thus, if the amount of detritus, and therefore nutrient levels, had not increased proportionally to increases in volume, larger bromeliads may not have supplied the resources needed to support greater invertebrate abundance.

Variation in invertebrate richness remains unexplained. Greater habitat heterogeneity can create more niches, increasing species richness. However, increases in volume, energy and nutrients do not necessarily increase heterogeneity. Furthermore, if invertebrate colonization of bromeliad tanks in the Monteverde elfin forest is rare, or the species pool of colonizers is small, morphotype richness would not necessarily increase with water volume and detrital mass.

## Literature Cited

Begon, M., J.L. Harper, and C. R. Townsend. 1990. *Ecology: Individuals, Populations and Communities*. Blackwell Scientific Publications: Boston.

Forsyth, A, and K. Miyata. 1984. Tropical Nature. Charles Scribners Sons: New York.

Jenkins, B., R. L. Kitching, and S. L. Pimm. 1992. Productivity, disturbance, and food web structure at a local scale in experimental container habitats. Oikos 65. Pp. 249-255.

Kitching, R. L. 2001. Food webs in phytotelmata: "bottom-up" and "top-down" explanations for community structure. Annual Review of Ecology and Systematics 62. Pp. 729-760.

Yanoviak, S. P. 2001. Predation, resource availability, and community structure in neotropical water-filled tree holes. Oecologia 126. Pp. 125-133.





# Benthic macroinvertebrate community composition changes at two sites in the Quebrada Maquina

R. Mitchell Ermentrout, Joel Wickre, Kathleen Theoharides and Benjamin Guidi

*Abstract:* The Quebrada Maquina originates in the Monteverde forest preserve and runs through the town of Monteverde, Costa Rica. We hypothesized that various sources of pollution draining into the stream would affect macroinvertebrate community composition. We found higher overall abundance, but lower evenness among species downstream. There is no clear indication as to whether pollution or other factors contributed to these differences.

*Key Words: anthropogenic inputs, nutrient loading, pollution, stream diversity, stream flow, stream succession*

## Introduction

Anthropogenic inputs of petrochemicals, insecticides, heavy metals, nutrients, and sediment may affect invertebrate communities within stream systems. Indications of damaged stream ecosystems often include reduced diversity, the elimination of certain pollution-sensitive species and increased abundance and dominance of more tolerant species.

We conducted a study of macroinvertebrate communities in the Quebrada Maquina above and below several potential sources of pollution, including roads, hotels, a gas station, a laundromat, a dance club, horse and cattle pasture, and several houses with garbage pits that ended in the stream itself. Similar studies in the area suggested that pollution reduces diversity in disturbed stream communities (Anderson, 1996; Severino, 2001). We hypothesized that pollution from point and non-point sources would affect invertebrate communities in microhabitats downstream from development. We predicted that these inputs would raise abundance of invertebrates downstream versus the upstream reference site, due to nutrient loading, but that diversity would decline downstream. There are two major reasons for expected lower diversity downstream. First, species that are especially pollution sensitive are likely to die off if water is contaminated, and, second, species that are more pollution tolerant may be able to dominate in these disturbed ecosystems.

## Methods

We sampled two sites on Quebrada Maquina downstream of the Monteverde Biological station. The upstream reference site was approximately 50 m upstream from the road to Cerro Amigos, while the downstream site was about 100 m downstream of the Monteverde highway. We measured river width and velocity at each site. We measured depths every 20 cm along the width line. For each site we measured the velocity by timing a floating orange as it traveled 5 m down the stream. We calculated the stream discharge at each site by multiplying the cross-sectional area of the stream by the velocity.

At both sites we chose two 1 $m^2$ plots in rocky riffle areas. Plots were approximately equivalent in substrate type, depth and vegetation cover. To collect macroinvertebrate samples, we held nets downstream from the selected plots. We then manually agitated the benthos and scrubbed all rocks to remove attached organisms. All debris from the disturbance flowed into the nets. We separated invertebrates from organic and inorganic debris and preserved them in ethanol. We identified them to morphotype (which we as-

sumed were species), and determined the family when possible (Thorpe and Covich 1991, Merritt and Cummins 1978). We calculated diversity and evenness for each plot with both Simpson's and Shannon's indices.

## Results

Stream velocity downstream was 72% higher, and discharge 193% higher, than upstream. Macroinvertebrates were more abundant in the downstream site (Fig. 1; F = 14.4, df = 1, 3, P = 0.06), although this difference was only marginally significant. Species (morphotype) richness was approximately the same in both sites (F = 0.20, df = 1, 3, P = 0.70). However, morphotypes differed between sites. Only eight of the 19 morphotypes counted were found in both sites. Three were found only in the reference site, and eight only in the downstream site.

Indices of macroinvertebrate diversity were significantly higher upstream (Fig. 2; Shannon's, F = 93.3, df = 1, 3, P = 0.01; Simpson's, F = 59.4, df = 1, 3, P = 0.02). Higher evenness upstream accounted for the higher diversity there (Fig. 3; Shannon's, F = 242.7, df = 1, 3, P = 0.004; Simpson's, F = 20.1, df = 1, 3, P = 0.05).

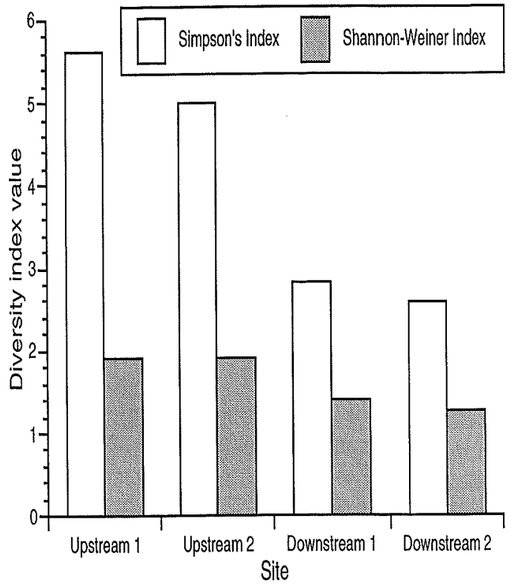


FIG. 2. Macroinvertebrate diversity in 1 $m^2$ plots in the Quebrada Maquina, Monteverde, Costa Rica.

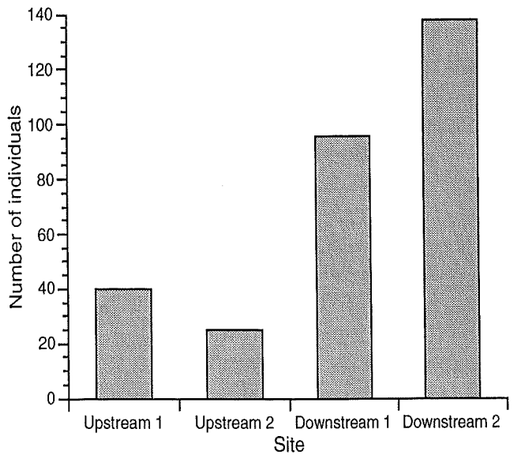


FIG. 1. Total abundance of macroinvertebrates from 1 $m^2$ plots in upstream and downstream sites on the Quebrada Maquina, Monteverde, Costa Rica.

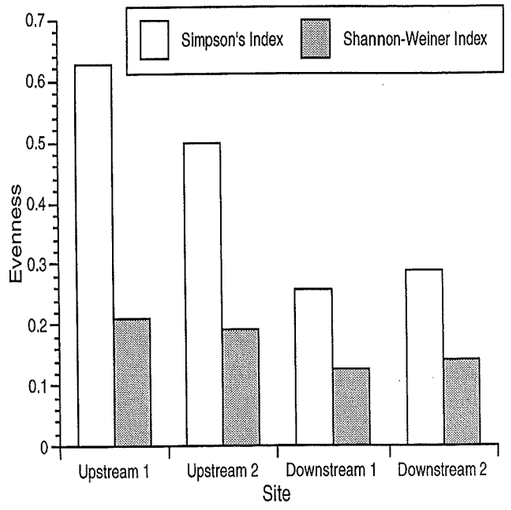


FIG. 3: Evenness of species in each 1 $m^2$ site in the Quebrada Maquina, Monteverde, Costa Rica.





## Discussion

We found changes in macroinvertebrate communities between sites that could have been induced by reduction in water quality resulting from pollution inputs.

Higher abundance of invertebrates downstream may be due to higher nutrient load in runoff from developed areas. However, the lower evenness downstream may result from factors other than anthropogenic inputs, such as increased discharge downstream. Lower diversity downstream was due to a decrease in evenness, rather than a decrease in richness, reflecting the dominance of two families, Hydropsychidae (Trichoptera) and Simuliidae (Diptera). The family Hydropsychidae are web-spinning insects that rely on high flow to wash food material into their webs.

Similar richness upstream and downstream suggests that anthropogenic inputs may not have seriously harmed macroinvertebrate populations. The particular changes in species assemblages we observed can be explained by pollution or by other factors. More study is necessary to determine the influence of development on macro-invertebrate assemblages in Quebrada Maquina.

## Literature Cited

Anderson, Katie. Point source pollution and local stream invertebrates. *in* Tropical Ecology and Conservation. Spring and Fall 1996. CIEE: Monteverde, CR.

Merritt, R. W., and K. W. Cummins. 1978. *in* Introduction to the Aquatic Insects of North America. 3rd Ed. Kendall/Hunt Pub. Co: Dubuque.

Severino, Michael J. The effects of pollution on benthic macroinvertebrate community structure and composition. *in* Tropical Ecology and Conservation. Spring 2001. CIEE: Monteverde, CR.

Thorp, James H. and Alan P. Covich. 1991. Ecology and Classification of North American Freshwater Invertebrates. Academic Press, Inc: San Diego.