STREAM WATER QUALITY OF QUEBRADA MÁQUINA AT MONTEVERDE, COSTA RICA

NATHAN H. RAINES, ANDREW R. CARRERAS,
SCOTT W. SCHWARTZ, AND WILLIAM F. J. STORK

Research advisors: Faculty and graduate students. Faculty editor: David R. Peart

Abstract: Ecotourism has increased substantially in recent years for many Costa Rican towns, bringing potential human impacts to formerly pristine areas that attract visitors. We examined benthic macroinvertebrate communities and physical/chemical factors at 6 sites along the Quebrada Máquina stream in Monteverde to test for evidence of anthropogenic pollution. We hypothesized that stream water quality, assessed through the Hilsenhoff Biotic Index, would decrease immediately below a human development near the stream. We found no directional trend in this index, indicating that there is no direct impact of ecotourism development on stream water quality. However, both benthic macroinvertebrate species richness and Shannon-Weiner diversity decreased as the stream flowed downstream. More detailed study is needed to determine the reasons for this trend.

Key Words: Quebrada Máquina, *pollution, water quality, stream invertebrates, diversity*

INTRODUCTION

Ecotourism in Costa Rica is an important and growing part of many local economies. Monteverde alone hosts over 187,000 visitors yearly (M. Hidalgo, *pers. comm*). Rapid development in Monteverde and other ecotourism hotspots has changed in land use and may be increasing local stream pollution.

The Quebrada Máquina stream passes through areas of development as it flows from the cloud forest through the town of Monteverde. Ermentrout et al. (2003) showed that the macroinvertebrate community in a nearby stream changed substantially between upstream and downstream sites, possibly a result of changes in water quality. We hypothesized that inputs from development sites decrease Quebrada Máquina water quality as it flows through the town of Monteverde. We expected evidence of increased pollution in stream sites just below a development compared to sites just above it.

METHODS

We surveyed six sites along Quebrada Máquina in Monteverde, Costa Rica, on 20-21 January 2006: in the cloud forest (site 1); before (2) and after (3) passing a major hotel; before (4) and after (5) passing an input from a discotheque, a gas station, a residential neighborhood and road on the eastern side of town, and after an input from development on the western side of town (6). We determined the elevation and distance downstream from site 1 for each site (site 1= 1510 m above sea level; site 2= 1390 m above sea level, 900 m downstream from site 1; site 3= 1380 m, 1050 m; site 4= 1365 m, 1275 m; site 5= 1300 m, 1875 m; site 6= 1240 m, 2225 m). All sites

had approximately the same canopy composition and cover.

At each site we chose three sample spots with homogeneous rocky riffle substrates, the preferred habitat for benthic macroinvertebrates. We measured the pH, temperature, conductivity, and dissolved oxygen at each spot and kick-net sampled the benthic macroinvertebrates by disturbing the substrate in a 0.5 x 0.5 m area in front of the net for one minute. We calculated discharge at each site using stream width, depth at 11 intervals along its width, and flow (measured by timing how fast the stream carried an apple for 5 meters). We counted and identified all invertebrates collected, to family.

We estimated stream pollution levels at each site with the Hilsenhoff Biotic Index, which uses invertebrate family richness and abundance coupled with pre-assigned pollution tolerances for each family (Lehmkuhl 1979). We also calculated the Shannon Diversity Index (SDI) of invertebrate families for each site (Begon et al. 1990).

RESULTS

We collected and identified a total of 726 invertebrates representing 23 taxa. Some groups were common across all sites (two Ephemeteropteran taxa: Heptogeniidae and Siphlonuridae; and one Trichopteran taxon; Hydropsychidae). Other groups were found more commonly or exclusively upstream (two Ephemeropteran taxa: Trycorythidae and Ephemerellidae; one Plectopteran taxon: Chloropeltidae; two Coleopteran taxa: Dytiscidae and Psephenidae; and one Crustacean). No invertebrate families were found in noticeably higher numbers in downstream sites than upstream sites (Appendix A).

Hilsenhoff Biotic Index did not differ significantly between stream sites (ANOVA, $F_{5, 13} = 0.36$, $P = 0.86$; Fig.1). Abiotic conditions were also relatively constant across sites (Table 1). We found no trend in water discharge rate across sites. SDI and family richness decreased with distance downstream from site 1 (Fig.1).

Table 1: Values (mean ± SE) of selected abiotic factors across six sample sites along the Quebrada Máquina, Monteverde, Costa Rica. Measurements were taken at 3 points for each site except site 5, which had 4 measurement points.

	Temperature (°C)	DO (mg/L)	Conductivity (mV)	pH
Site 1	15.67 ± 0.09	8.83 ± 0.09	36.40 ± 1.20	6.43 ± 0.05
Site 2	16.20 ± 0.00	8.63 ± 0.03	30.90 ± 7.35	6.40 ± 0.03
Site 3	16.30 ± 0.00	8.47 ± 0.26	35.40 ± 1.00	6.42 ± 0.10
Site 4	16.00 ± 0.00	8.33 ± 0.26	42.57 ± 0.35	6.31 ± 0.03
Site 5	16.10 ± 0.00	8.88 ± 0.08	44.00 ± 0.37	6.76 ± 0.15
Site 6	15.53 ± 0.03	8.43 ± 0.07	48.40 ± 0.46	6.47 ± 0.08

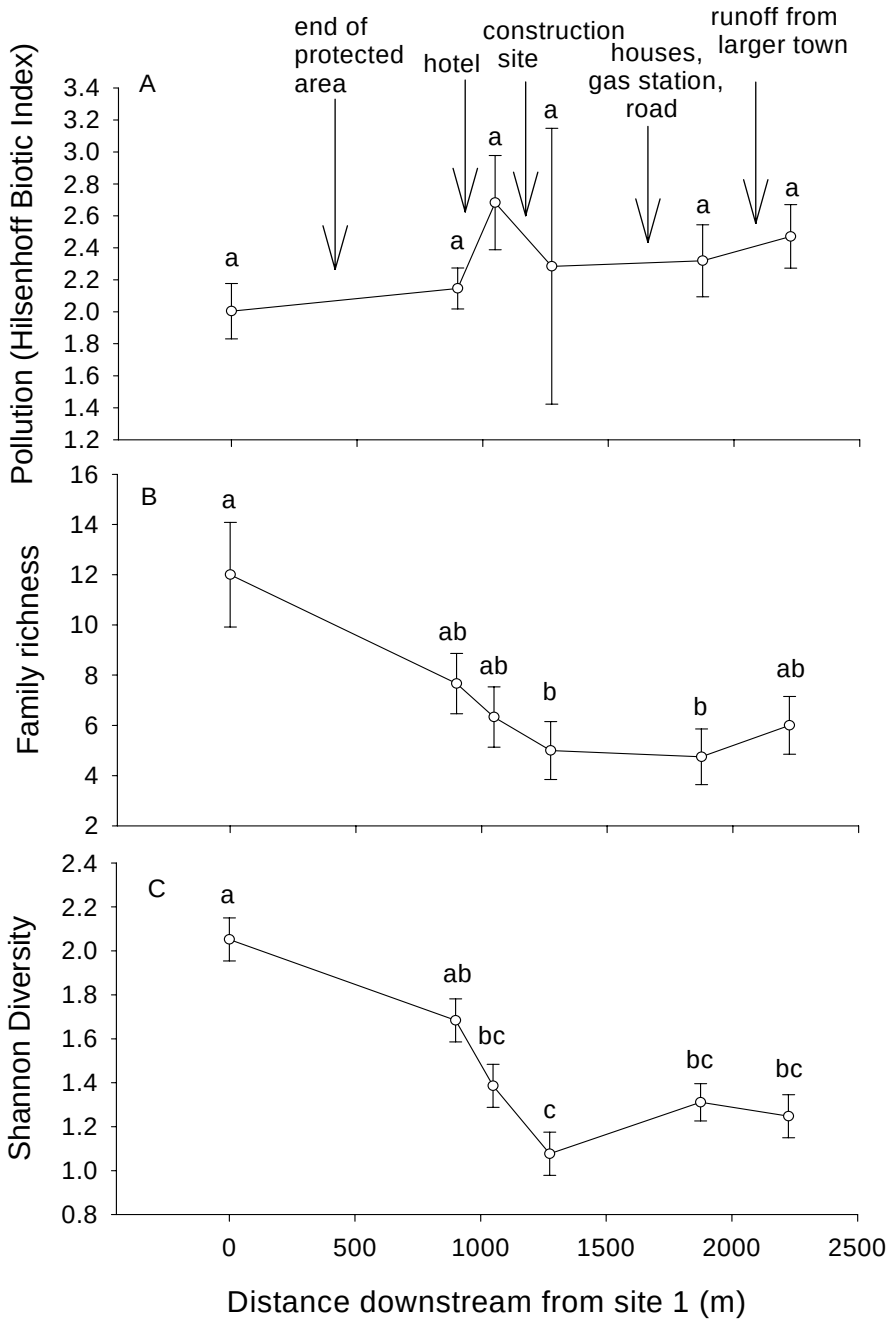

Figure 1. Comparison of trends in (A) pollution (Hilsenhoff Biotic Index), (B) family richness and (C) Shannon Diversity Index of benthic macroinvertebrates in Quebrada Maquina by sampling site, presented in distance downstream from site 1. Points and error bars represent mean ± 1 SE. Points not sharing a letter are significantly different ($p < 0.05$, with Tukey-Kramer HSD). Possible sources of pollutants into the stream are denoted with arrows

DISCUSSION

Development along the Quebrada Máquina did not obviously decrease water quality in the stream. It may be a factor in producing the decreased stream invertebrate family richness and SDI by changing habitats surrounding the stream, but there are several other possible mechanisms. Although elevation changed by 270 m across all sites, abiotic features of the stream (pH, conductivity, temperature, and dissolved oxygen) were quite stable throughout our study site (Table 1) (for review see Flowers, 1991). However, a change in elevation of that magnitude would certainly have effects on air temperature and the riparian environments surrounding the stream, which could alter allochthonous inputs. Factors such as primary production or non-benthic predators (excluding fish, which are absent) within the stream might also affect invertebrate family richness and SDI.

To identify mechanisms behind the observed changes in stream invertebrate community we recommend measuring autochthonous primary production and predation and examining riparian vegetation at each site. Another more rigorous test might involve sampling multiple streams for comparison or sampling the stream at numerous discrete intervals and comparing intervals that have a given factor that might affect water quality or invertebrate communities with intervals that do not.

LITERATURE CITED

Begon, M., J.L. Harper, and C.R. Townsend. 1990. Ecology: Individuals, Populations and Communities, 2nd edition. Blackwell Scientific Publications, Boston.

Ermentrout, R.M., J. Wickre, K. Theoharides, and B. Guidi. 2003. Benthic macroinvertebrate community composition changes at two sites in the Quebrada Máquina. Dartmouth Studies in Tropical Ecology 2003. pp. 59-61.

Flowers, R. 1991. Diversity of stream-living insects in northwestern Panama. Journal of the North American Benthological Society. **10**: pp. 322-334.

Lehmkuhl, D.M. 1979. How to Know the Aquatic Insects. William C. Brown Company Publishers, Dubuque.

Pouliot, N.D., A.V. Barnhorst, V.R. Levesque, and J.L. Mitchell. 1995. The recovery of Quebrada Guacimal. Dartmouth Studies in Tropical Ecology 1995, pp. 48-50.