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Small-scale Macroinvertebrate Distribution in a Riffle of a Neotropical Rainforest Stream (Río Bartola, Nicaragua)

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Abstract.—Streams are highly heterogeneous environments in which habitat characteristics vary drastically over small distances, but little information is available in this context about Neotropical systems. In this work, we analyse the relationship between taxonomical composition and functional organization of stream benthic communities and some environmental variables in a single riffle of the Río Bartola, Nicaragua. Current velocity, position in the streambed, and substratum composition evidently influence invertebrate density and taxonomical richness. We investigate the functional organisation of the communities, reporting that collectors are the most represented functional feeding group, while shredders are almost absent.

Keywords.—stream invertebrates, Nicaragua, micro-distribution, riffle.

There is a growing interest in the study of Neotropical lotic systems, because of their enormous ecological and economic importance, and knowledge about the benthic macroinvertebrates of Central America is making rapid progress. After a long period of sporadic studies, many taxonomical works are describing the variety and richness of aquatic invertebrates in Central America (Wills Flowers 1992; Maes 1998; Springer 1998). In Neotropical regions, different aspects of stream benthos ecology have received more attention (Jackson and Sweeney 1995), such as structural composition (Paaby et al. 1998) and functional organization (Graça et al. 2001), drift (Pringle and Ramírez 1998), allochtonous material processing (Benstead 1996), food chain interactions (Rosemond et al. 1998), secondary production (Ramírez and Pringle 1998), and use of macroinvertebrate communities in biological monitoring of running waters (Fenoglio et al. 2002).

Environmental variability in time and space shapes the distribution of organisms; this variability is a basic characteristic of running water systems (Poff and Ward 1990). Stream invertebrates are generally thought to be distributed according to environmental factors that operate at different spatial scales (Heino et al. 2003).

Analysing the importance of spatial scale in the organization of macroinvertebrate communities, some authors take into account only large spatial scales, considering stream reach as the lowest unit of replication (Cooper et al. 1998), while others give great importance to small scale variations, analysing diversity among sampling points in the same stream reach (Downes et al. 1993). In small scale studies, variations of chemical-physical parameters, such as pH, temperature and water chemistry are of minor importance; local variations of other abiotic factors, such as current velocity, substratum composition, water depth, and biotic elements, such as competition and predation, shape the distribution of invertebrates at the scale of microhabitat within a single riffle (Minshall 1984; Malmqvist and Mäki 1994; Downes et al. 1998).

The aim of this study was to describe the micro-distribution of stream invertebrates in a single riffle of a tropical stream, examining the local variations of density, richness and functional composition in relation to selected environmental characteristics, that present great relevance at small-scale: current velocity (v), water depth (h), distance from the nearest riverbank (d; i.e. position in the riverbed) and relative composition of the substratum.

The study was conducted near Charro Gaitan, in a 15 m riffle of the Río Bartola, a small tributary of Río San Juan, Nicaragua. The Río San Juan district, situated in the extreme southeast of Nicaragua, is one of the areas of greatest ecological integrity of Central America. Río Bartola is a small river, located in a primary forest, with no evidence of anthropic alterations.

We collected 13 Surber samples (area 0.06 m^2, mesh 250 μm) from the riffle in a single date (4 January 2002), to minimize temporal variation of invertebrate distribution. Samples were fixed in ethyl alcohol (70°) and subsequently examined in the laboratory with a stereoscopic microscope (20/60 X). Identification of the taxa was performed using the following texts: Roldán (1988), Merritt and Cummins (1996) and Wills Flowers (1992). Invertebrates were grouped into Functional Feeding Groups (FFG), according to Merritt and Cummins (1996): collectors-gatherers (Cg), filterers (F), predators (P), scrapers (Sc) and shredders (Sh).

Water temperature was 24-26 °C. Current velocity, water depth and distance from the nearest bank were measured at each Surber sample. Percentages of different substratum sizes (boulders > 25 – 45 cm, cobble > 6 – 25 cm, gravel > 6 – 60 mm, sand 0.06 – 6 mm, silt < 0.06 mm) were recorded at each point, by using a gravelometer. Current speed was determined by using a Eijkelkamp current-meter. Statistical analysis of the relationships between invertebrate abundance, taxonomical richness, biodiversity, functional composition and the selected environmental parameters was performed with correlation analyses (Spearman and Pearson tests) and correspondence analyses (CORANA).

We collected 342 organisms, belonging to 25 taxa (Table 1). No keys are available for species-level identification of great part of stream insects and invertebrates in Central America and particularly in Nicaragua. In our study site, aquatic insects represented the dominant component of stream benthos (98% of organisms). Ephemeroptera was the most represented insect order in the riffle, and within this group the most abundant family was that of the Leptophlebiidae. Diptera was the second major group of invertebrates collected in the riffle, of which Simuliidae was the main family, followed by Chironomidae. Trichoptera was represented by two caseless filterer families: Hydropsychidae (*Leptonema* sp.) and Philopotamidae (*Chimarra* sp.). Members of Elmidae were the dominant Coleoptera. Odonata was represented by two families of Zygoptera (Coenagrionidae and Platystictidae) and one of Anisoptera (Libellulidae).

Faunal composition of riffle riverbed was quite similar to the one reported in studies about Costa Rican lowland streams (Pringle and Ramírez 1998), both for taxonomical and functional composition. However, invertebrate densities were lower (mean: 420.92 individuals/m^2 ± 223.75 SD) than

TABLE 1. List of taxa, with main Functional Feeding Groups (FFG) (collectors-gatherers—Cg, filterers—F, predators—P, scrapers—Sc, shredders—Sh).

Taxa		FFG
Plecoptera		
Perlidae	*Anacroneuria* sp.	P
Ephemeroptera		
Heptageniidae	*Stenonema* sp.	Sc
Baetidae	*Camelobaetidius* sp.	Cg
	Baetis sp.	Cg
Leptohyphidae	*Leptohypes* sp.	Cg
Leptophlebiidae	*Thraulodes* sp.	Cg
	Traverella sp.	Cg
Trichoptera		
Hydropsychidae	*Leptonema* sp.	F
Philopotamidae	*Chimarra* sp.	F
Coleoptera		
Elmidae		Cg
Haliplidae		Sh
Diptera		
Chironomidae		Cg
Simuliidae		F
Odonata		
Libellulidae	*Macrothemis* sp.	P
	Miathyria sp.	P
Coenagrionidae	*Argia* sp.	P
Platystictidae	*Palaemnema* sp.	P
Hemiptera		
Belostomatidae	*Abedus* sp.	P
Naucoridae	*Cryphocricos* sp.	P
Lepidoptera		
Pyralidae	*Limnophila* sp.	Sc
Tricladida		
Planariidae		P
Crustacea		
Pseudothelphusidae		Sh
Macrobrachium sp.		Sh-Cg
Annelida		
Lumbriculidae		Cg

the ones reported in other studies (Pringle and Ramírez 1998; Paaby et al. 1998; Boyero and Bailey 2001). Stream invertebrate assemblages varied consistently within the riffle. Both invertebrate density and taxonomical richness increased with the increasing of current velocity (Table 2), but also the position in the streambed was important: communities in the lateral shallow parts of the stream showed lowest density and richness. Substratum percentage composition influenced invertebrate abundance (N) and taxonomical richness (S), with boulders and cobbles richer than sandy microhabitats (Fig. 1).

Analysing the functional composition of the assemblages, we found that collector-gatherers were the most abundant FFG (51.5%), followed by filterers (28.9%), predators (9.6%) and scrapers (8.8%). Shredders were the less represented, at only 1.2%. Current velocity affected the relative abundance of collectors negatively (Spearman correlation test, $r = -0.707$, $P < 0.01$) and the relative abundance of scrapers ($r = 0.789$, $P < 0.01$) and filterers ($r = 0.800$, $P < 0.01$) positively. Distance from the nearest bank also affected the distribution of FFG: scrapers were more abundant in the central part of the river ($r = 0.739$, $P < 0.01$) and collectors in the banks ($r = -0.722$, $P < 0.01$).

We found that the number and taxa diversity of stream benthos greatly varied among different microhabitats in a single riffle. This pattern was long known for temperate regions (Mackay and Kalff 1969), but few data are available for Neotropical environments. As previously stated, current velocity was an important factor in shaping benthic communities, both in structural and functional composition: higher velocities were associated with a richer and more abundant invertebrate assemblage. It is

TABLE 2. Relationships between macroinvertebrate density (N) and richness (S) and velocity (v), distance from the nearest bank (d) and water depth (h) (Pearson's correlation test).

	v	d	h
N	0.832***	0.562*	0.530
S	0.875***	0.833***	0.760**

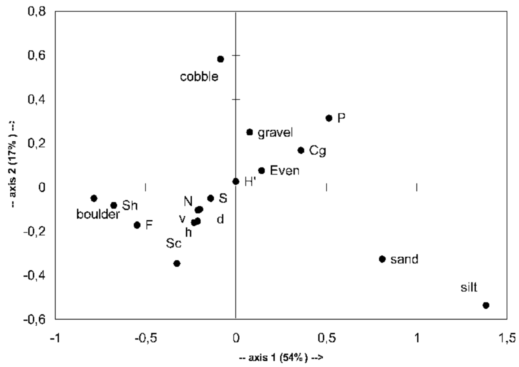

FIG. 1. Correspondence analysis (h = height above bed; v = current velocity; d = distance from the nearest bank; N = invertebrate abundance; S = taxonomical richness; H′ = Shannon-Wiener diversity; Even = Evenness).

likely that current is related to water oxygenation and also plays a key role in the functional feeding of some groups, such as filterers. Moreover, it is well established that micro-flow dynamics play a key role in the small-scale distribution of benthic communities (Statzner and Holm 1982; Hart et al. 1996). Considering the substratum composition, our results agree with previous findings in temperate streams: sand was a poor substrate, probably for its instability and also because tight packing of sand grains reduces the trapping of organic detritus and limits the availability of oxygen.

Macroinvertebrate shredders were nearly absent in our samples while collectors-gatherers and filterers (both feeding on fine particulate organic matter) were dominant. This result supports an emergent hypothesis about allochtonous coarse particulate organic matter processing in tropics: in tropical lotic systems, the lack of insect shredders suggests that the decomposition of plant material in fine particulate organic matter is operated either by macroconsumers, such as crustaceans and fish, or by enhanced microbial activity (Pringle et al. 1993; Graça et al. 2001; Dobson et al. 2002).

Understanding community structure and function and their determinants is one of the main objectives of ecology. In Nicaragua, except for some studies on aquatic insects (Maes 1998; Maes et al. 1988; Maes and Flint 1988; Fenoglio 1999; Dominique et al. 2001; Maes and Fenoglio 2002), benthic macroinvertebrate fauna is poorly known. Results from such studies can be used to predict taxa distribution at local small-scale and identify factors that can influence micro-distribution patterns in the lotic systems of this area.

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Literature Cited

Benstead, J. P. 1996. Macroinvertebrates and the processing of leaf litter in a tropical stream. *Biotropica* 28:367-375.

Boyero, L., and R. C. Bailey. 2001. Organization of macroinvertebrate communities at a hierarchy of spatial scales in a tropical stream. *Hydrobiologia* 464:219-225.

Cooper, S. D., S., Diehl, K., Kratz, and O. Sarnelle. 1998. Implications of scale for patterns and processes in stream ecology. *Austr. J. Ecol.* 23:27-40.

Dobson, M., A. Magana, J. M. Mathooko, and F. K. Ngdegwa. 2002. Detritivores in Kenyan highland streams: more evidence for the paucity of shredders in the tropics? *Freshwat. Biol.* 47:909-919.

Dominique, Y., A. Thomas, and S. Fenoglio. 2001. Redescription de *Camelobaetidius musseri* (Traver & Edmunds, 1968) (Ephemeroptera, Baetidae). *Ephemera* 3:33-41.

Downes, B. J., P. S. Lake, and S. G. Schreiber. 1993. Spatial variation in the distribution of stream invertebrates: implications of patchiness for models of community organization. *Freshwat. Biol.* 30:119-132.

Downes, B. J., P. S. Lake, E. S. G. Schreiber, and A. Glaister. 1998. Habitat structure and regulation of local species diversity in a stony, upland stream. *Ecol. Monog.* 68:237-257.

Fenoglio, S. 1999. Entomofauna acuatica de ambientes loticos: observaciónes ecológicas en el Refugio Bartola y nuevos taxa para el Nicaragua. *Rev. Nica. Ent.* 4:29-43.

Fenoglio, S., G. Badino, and F. Bona. 2002. Benthic macroinvertebrate communities as indicators of river environment quality: an experience in Nicaragua. *Rev. Biol. Trop.* 50:1125-1131.

Graça, M. A. S., C. Cressa, M. O. Gessner, M. J. Feio, K. A. Callies, and C. Barrios. 2001. Food quality, feeding preferences, survival and growth of shredders from temperate and tropical streams. *Freshwat. Biol.* 46:947-957.

Hart, D. D., B. D. Clark, and A. Jasentuliyana. 1996. Fine-scale field measurement of benthic flow environments inhabited by stream invertebrates. *Limnology and Oceanography* 41:297-308.

Heino, J., T. Muotka, and R. Pascola. 2003. Determinants of macroinvertebrate diversità in headwater streams: regional and local influences. *J. Anim. Ecol.* 72:425-434.

Jackson, J. K., and B. W. Sweeney. 1995. Research in tropical streams and rivers: Introduction to a series of papers. *J. N. Am. Benthol. Soc.* 14:2-4.

Mackay, R. J., and J. Kalff. 1969. Seasonal variation in standing crop and species diversity of insect communities in a small Quebec stream. *Ecology* 50:101-109.

Maes, J. M. 1998. *Insectos de Nicaragua*. Vol. I, Print-Leon, Nicaragua.

Maes, J. M., J. P. Desmedt, and V. Hellebuyck. 1988. Catálogo de los Odonata de Nicaragua. *Rev. Nica. Ent.* 4:29-43.

Maes, J. M., and O. S. Flint. 1988. Catálogo de los Trichoptera de Nicaragua. *Rev. Nica. Ent.* 2:1-11.

Maes, J. M., and S. Fenoglio. 2002. Un contributo alla conoscenza dell'entomofauna acquatica del Nicaragua, Atti XIX Congresso Società Italiana di Entomologia, pag. 47.

Malmqvist, B., and M. Mäki, 1994. Benthic macroinvertebrate assemblages in north Swedish streams: environmental relationships. *Ecography* 17:9-16.

Merritt, R. W., and K. W Cummins. 1996. *An introduction to the aquatic insects of North America, 3rd ed.*, Dubuque, IO:Kendall / Hunt.

Minshall, G. W. 1984. Aquatic insect—*substratum* relationships In *The ecology of aquatic insects*, ed., V. H. Resh and D. M. Rosemberg, 358-400. New York: Praeger Publ.

Paaby, P., A. Ramirez, and C. M. Pringle 1998. The benthic macroinvertebrate community in lotic systems draining the South Caribbean zone in Costa Rica. *Rev. Biol. Trop.* 46:185-199.

Poff, N. L., and J. V. Ward. 1990. Physical habitat template of lotic systems: recovery in the context of historical pattern of spatio-temporal heterogeneity. *Env. Manag.* 14:629-645.

Pringle, C. M., G. A. Blake, A. P. Covich, K. M., Buzby, and A. Finley. 1993. Effects of omnivorous shrimp in a montane tropical stream: sediment removal, disturbance of sessile invertebrates and enhancement of understory algal biomass. *Oecologia* 93:1-11.

Pringle, C. M., and A. Ramírez. 1998. Use of both benthic and drift sampling techniques to assess tropical stream invertebrate communities along an altitudinal gradient, Costa Rica. *Freshwat. Biol.* 39:359-373.

Ramirez, A., and C. M. Pringle. 1998. Structure and production of a benthic insect assemblage in a neotropical stream. *J. N. Am. Benthol. Soc.* 17:443-463.

Roldan, G. 1988. Guía para el estudio de los macroinvertebrados acuáticos del Departamento de Antioquia. Colombia: Universidad de Antioquia—CIEN.

Rosemond, A. D., C. M. Pringle, and A. Ramirez. 1998. Macroconsumer effects on insect detritivores and detritus processing in a tropical stream. *Freshwat. Biol.* 39:515-523.

Springer, M. 1998. Genera of aquatic insects from Costa Rica, deposited at the Museo de Zoologia, Universidad de Costa Rica. *Rev. Biol. Trop.* 46:137-142.

Statzner, B., and T. F. Holm. 1982. Morphological adaptations of benthic invertebrates to stream flow-an old question studied by means of a new technique (Laser Doppler Anemometry). *Oecologia* 53: 290-292.

Wills Flowers, R. 1992. Review of the genera of Mayflies of Panama, with a checklist of Panamaniam and Costa Rican species (Ephemeroptera) In *Insects of Panama and Mesoamerica*, ed., D. Quintero and A. Aiello, 37-51. Oxford: Oxford University.