Stream community structure and the role of allochthonous inputs in Quebrada Moquina at Monteverde

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Abstract: Allochthonous inputs may be important in structuring stream invertebrate communities, particularly in streams with low primary productivity. This study examined the invertebrate community in Quebrada Moquina, a densely shaded headwater stream in Monteverde, Costa Rica. I hypothesized that (1) the stream had low primary production, and therefore low scraper abundances, and (2) a strong relationship existed between allochthonous inputs and invertebrate distribution, represented by collector abundances relative to localized sources of forest debris ("debris dams"). As predicted, the abundance of collectors was linked to the location of debris dams. However, scraper abundances were relatively high in all locations, suggesting surprisingly high primary productivity.

Key words: functional feeding groups, large woody debris, primary production

Introduction

Stream invertebrate communities can be structured by resource availability. Streams in tropical forests generally have very low primary productivity due to low light and low nutrients. Thus, allochthonous resources may be especially influential in structuring the invertebrate community. The Quebrada Moquina stream in the Monteverde biological station appears to have low in-stream primary productivity. The stream is covered by dense canopy which blocks almost all direct sunlight. Allochthonous inputs may be the main resource for stream invertebrates. Within the stream, large woody debris often blocks the passage of other coarse particulate organic matter (CPOM) like leaves and sticks. The majority of allochthonous material in the stream is localized in these "debris dams," making the distribution of resources spatially heterogeneous.

If there is low in-stream primary productivity and patchy allochthonous material this should be reflected in the structure of the stream invertebrate community, as defined by the relative abundance of different function feeding groups (FFGs). For example, scrapers, which utilize periphyton, should be in low abundance within most reaches. Shredders, which rely on CPOM, should be aggregated in the vicinity of debris dams. Collectors (both filterers and gatherers of fine particulate organic matter, or FPOM), should decrease in abundance with increasing downstream distance from debris dams. I tested these predictions by sampling the Quebrada Moquina invertebrate community.

Methods

I sampled two to three invertebrate communities downstream from each of five debris dams in the Quebrada Moquina, a cloud forest, first-order stream at Monteverde biological station, Costa Rica. I haphazardly chose runs or riffles and sampled invertebrates with a 20 cm-wide kick-net. I repeated sampling three times at each run or riffle. I measured the distance of each sample site from the nearest debris dam upstream.

I identified organisms using aquatic insect keys (Lehmkuhl 1979 and Merrit et al. 1996) and categorized them into functional feeding groups using information from Merrit at al.

(1996). I examined abundances of all FFGs and correlated collector abundances with distance of sample sites from debris dams. I evaluated patterns in collector abundance with a general linear model (ANCOVA) that included debris dams (categorical variable) and distance below the nearest debris dam (continuous variable).

RESULTS

I identified 16 invertebrate taxa, which included representatives from the five generally recognized functional feeding groups (Table 1). Scrapers and collectors were among the most abundant groups (Table 2). Abundance of collector-filterers, collector-gatherers, and all collectors decreased with increasing distance from debris dams (Fig. 1), significantly so for collector-filterers and collectors combined (Table 2). Surprisingly, the abundance of collectors associated with each debris dam seemed to be related to their position along the stream, with the highest abundance upstream and the lowest downstream. Shredders, although rare overall, also decreased with distance from debris dam (Table 3).

DISCUSSION

The high abundance of scrapers suggests that primary production was higher than I expected in the Quebrada Moquina. The overall structure of the invertebrate community in this cloud forest stream may therefore be less de-

Table 1. Invertebrate morphotypes, their mean abundance, and their functional feeding group (after Merrit et al. 1996).

Invertebrate morphotype		Mean # per sample ± SD	Functional feeding group
Tricoptera	Polycentropidae	1.82 ± 3.9	Collector-filterer
	Hydrocychidae	3.27 ± 3.1	Collector-filterer
	Odontoceridae	0.09 ± 0.3	Shredder
Plecoptera	Perlidae	2.82 ± 2.5	Predator
Ephemeroptera	Beatidae	8.64 ± 5.0	Collector-gatherer
	Heptageniidae	15.36 ± 10.7	Scraper
	Leptophlebeidae	0.36 ± 0.7	Collector-gatherer
Coleoptera	Psephenidae	0.36 ± 0.5	Scraper
	Dytiscidae	1.18 ± 2.2	Predator
	Elmidae	4.0 ± 0.4	Collector-gatherer
Diptera	Tipulidae	0.45 ± 0.5	Predator
	Chironomidae	1.45 ± 1.4	Collector-gatherer
	Simulidae	19.36 ± 22.3	Collector-filterer
Odonata		0.45 ± 1.2	Predator
Amphipoda		1.82 ± 1.7	Collector-gatherer
Crab		0.64 ± 0.5	Shredder

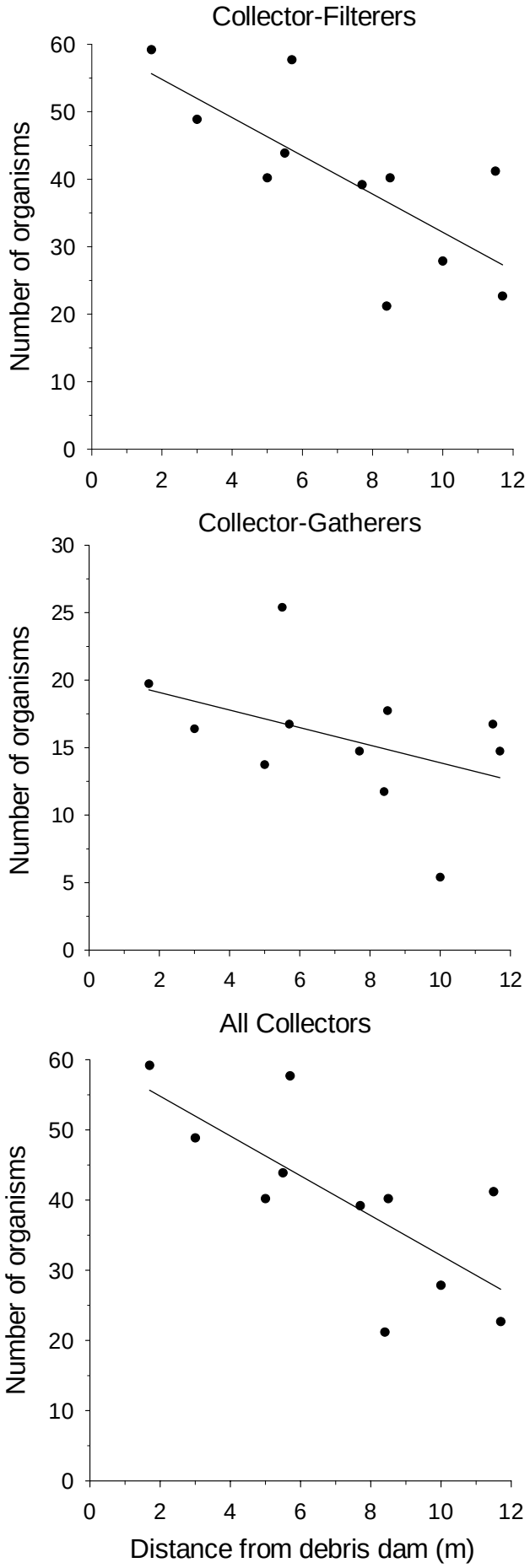

Table 2. Results of ANCOVAs testing for effects of debris dams (categorical variable) and distance from dams (continuous variable) on abundance and richness of different functional feeding groups.

	F-statistic		
Independent variable	Debris dams[a]	Distance from dam[b]	Mean ± SE
Collector-gatherers	1.30	1.71	16 ± 2
Collector-filterers	9.10*	8.69*	24 ± 7
All collectors	13.50**	15.02*	40 ± 8
Scrapers	0.91	1.24	16 ± 3
Predators	1.05	0.83	4 ± 1
Shredders	3.00	9.39*	1 ± 0.3
All organisms	22.29**	8.91*	60 ± 9
Family richness	2.68	1.37	10 ± 0.5

* $P < 0.05$, ** $P < 0.01$
[a] df = 4,10 [b] df = 1,10

Table 3. Mean collector abundance with respect to debris dam order, from upstream (1) to downstream (5). Least square means adjusted for variation in distances from debris dams.

Debris dam order	Least square mean	Standard error
1	69.85	6.29
2	23.47	5.22
3	53.48	6.46
4	42.51	6.73
5	10.43	6.62

Figure 1. Abundance of collector organisms as a function of distance downstream of debris dams. Numbers of organisms have been adjusted for the effects of overall stream position, relative to debris dam order. Collector-gatherers ($r^2 = 0.19$, $P = 0.19$); Collector-filterers ($r^2 = 0.55$, $P < 0.01$); All collectors ($r^2 = 0.46$, $P = 0.02$).

pendent on allochthonous inputs than postulated. Collector abundances, however, showed the predicted decline with distance from debris dams, supporting the hypothesis that consumer community structure was influenced by distance relative to debris dams. It appears that allochthonous inputs may play a key role in community structure, and debris dams represent the primary sites of this resource within the stream.

Because collector abundance depends on FPOM, the relationship between debris dam order and collector abundance suggests that FPOM concentrations may be higher upstream. There may be a relationship between elevation and the role of runoff inputs: if increased elevation and higher air moisture causes higher soil moisture, runoff carrying FPOM from soil may increase. The relationship between collector abundance and debris dam order may reflect a FPOM gradient as this effect diminishes downstream. This hypothesis could be tested by comparing FPOM concentrations, based on dry weights of filtered samples, along an elevational gradient in the stream.

Evidence of substantial in-stream primary production was unexpected, but allochthonous inputs still appear to strongly influence the invertebrate community. This negative correlation between collector abundance and distance downstream of debris dams highlights the role of large woody debris in resource retention in headwater streams.

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