THE RIVER CONTINUUM CONCEPT IN TROPICAL STREAMS

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Abstract. The River Continuum Concept (RCC) predicts that the composition of invertebrate communities in streams changes with shifts in abiotic factors from the headwaters of a stream to its mouth. We hypothesized that the changes in community composition predicted for temperate streams by the RCC would apply to tropical streams as well. We sampled the invertebrate communities in first, second, and third order streams and then identified and classified the organisms into functional feeding groups. Our data largely supported the RCC; physical characteristics of the stream changed with stream order as predicted. Further, the proportion of shredders, which break down coarse particulate organic matter, decreased with increasing stream order, and the proportion of collectors, which feed on fine particulate organic matter, increased.

Key Words: aquatic invertebrates, functional feeding groups, tropical aquatic communities

INTRODUCTION

The physical characteristics of a river change dramatically from headwaters to the mouth. These changes dictate the type and quantities of primary production that forms the base of the aquatic food webs. In headwaters, carbon inputs are dominated by terrestrially-derived leaf litter. Downstream a river becomes wider and deeper. As the percentage of overhead cover lessens, and the amount of the surface that receives direct solar radiation increases, the rate of instream algal production increases. These physical and biological changes are part of the River Continuum Concept (RCC), which provides a conceptual basis for the shifts that invertebrate fauna undergo as a result of downstream habitat changes (Covich 1991).

Invertebrates consume living and/or dead organic matter and process it characteristically according to "functional feeding groups." "Shredders," break up fallen leaf litter and coarse particulates. "Collectors" gather and filter fine particulates and/or drifting organisms. "Grazers" harvest algae attached to substrate. "Predators" are carnivores which feed on other invertebrates.

The RCC predicts that the invertebrate assemblages in headwater streams will be dominated by shredders and collectors, which are most adapted to live in waters with increased canopy cover and high detritus levels. Further downstream, where more light reaches the surface allowing higher production from algae and rooted macrophytes (Covich 1991), the proportion of shredders should diminish dramatically and be replaced by a predominately grazer fauna. Farther downstream, where the river bottom is below the photic zone and leaf litter is low, grazers diminish and collector-filterers are expected to dominate the fauna.

The RCC was originally developed from studies of North American temperate streams with forested headwaters. We decided to test the predictions of the RCC concerning the shifts in the invertebrate assemblages to see if they apply to streams occurring within the tropical cloud forest of Estación Biológica Monteverde, Costa Rica. We studied turbulent riffle sections of the river. The changes in invertebrate composition along the continuum are expected to occur to a greater extent in riffles than in the deeper, more stagnant waters of pools.

METHODS

Three sites were chosen, one in a first order stream, one in a second order stream, and one in a third order stream. In each site, five riffle habitats were randomly selected within which the aquatic invertebrate community was sampled. Organisms were collected in a 0.5 m2 area with a Surber sampler. The substrate and rocks were disturbed by hand in order to assure a complete sample. For each site, leaf litter in a 0.5 m2 area was collected at five different randomly-selected riffles. Width and depth were also measured in these areas, and percent cover was estimated for the entire site.

All invertebrate samples were sorted and identified to genus or sometimes family level. They were then categorized into the four functional feeding groups: grazers, shredders, collectors, and predators.

RESULTS

Stream width increased with increasing stream order (ANOVA, F=55.32, df=2, 12, P<0.001.) Each site differed from the other two significantly (Tukey-Kramer P<0.05.) The depth of the stream increased with increasing order as well (ANOVA, F=9.93, df=2, 12, P=0.003.) The depth of the first order site was lower than both the second and third order sites (Tukey-Kramer, P<0.05) but the depth of the second and third order sites did not differ. Allocthonous input from riparian vegetation decreased with increasing stream order (ANOVA, F=5.223, df=2, 12, P=0.023) and this difference was significant between the first and third order streams (Tukey-Kramer, P<0.05) Percent cover as estimated to be 75% at the first order stream, 50% at the second order stream, and 75% at the third order stream.

Community composition differed between the three sites. An ANOVA revealed that the relative proportions of the four feeding guilds changed with stream order (Pillai's trace, Approx. F=5.15, df=22, P=0.002, Figs. 1, 2, 3) The proportion of shredders decreased from the first and second order streams to the third (ANOVA, F=4.935, df=1, P=0.045). The proportion of collectors increased with increasing stream order (ANOVA, F=8.80, df=1, P=0.011). The greatest proportion of predators was found in the first order stream (ANOVA, F=5.663, df=1, P=0.033). There was no difference in the proportion of grazers between the three sites (ANOVA, F=1.314, df=1, P=0.272).

DISCUSSION

The River Continuum Concept proposes that as stream order increases, allochthonous input decreases in relative importance, and the bulk of carbon resources are autochthonous because of increased primary production (Covich, 1991, 24.) For this reason, it is predicted that shredders will be most abundant in headwater streams, and grazers will tend to dominate larger, high order streams. Further, collectors increase with increasing stream order due to the conversion of allochthonous materials into fine particulate organic matter (FPOM.) The first prediction, that allocthonous input and proportion of shredders would decrease with increasing stream order, was supported by our results. The RCC was further supported by the increase in relative proportion of collectors between our first and third order streams. The relative proportion of grazers in high and low order streams remained fairly constant. This may be explained by the consistently high percent cover by riparian vegetation; all of the sites were at least 50% covered. Without the increased sun exposure predicted by the RCC, algal primary production might not have increased enough to support a greater proportion of grazers, however the greatest relative proportion of grazers was found in the second order stream, which also had the lowest percent cover.

The RCC predicts that relative proportion of predators will remain constant between stream orders. In our study, a larger proportion of predators were found in the first order stream. This difference could have been due to the large number of odonates, classified as predators, that were found in the first order stream. This presents a possible problem with our system of classification. In some cases, we grouped invertebrate families into a single feeding guild, while in actuality, foraging strategies may be facultative.

Our study largely supported the predictions of the River Continuum Concept. These findings suggest that the RCC can be extended to tropical systems and is not limited to application in the temperate systems in which it was created.

LITERATURE CITED

Covich, A. P. and J. H. Thorp, eds. Ecology and Classification of North American Freshwater Invertebrates. Academic Press Inc., San Diego. 1991.

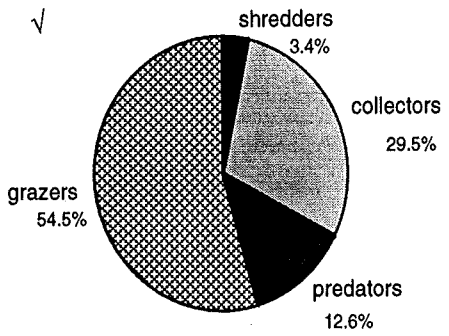

FIG. 1. Functional feeding groups in a first order stream at Monteverde Cloud Forest Preserve, Costa Rica. Cover by riparian vegetation was 75%, and mean weight of leaf litter occurring in the stream bed was 74.28 g.

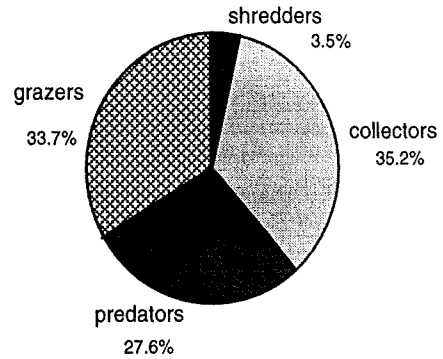

FIG. 2. Functional feeding groups in a second order stream at Monteverde Cloud Forest Preserve, Costa Rica. Cover by riparian vegetation was 50%, and mean weight of leaf litter occurring in the stream bed was 45.69 g.

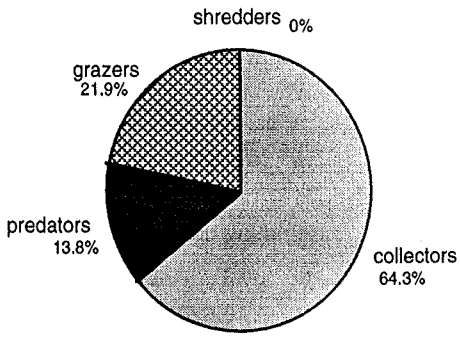

FIG. 3. Functional feeding groups in a third order stream at Monteverde Cloud Forest Preserve, Costa Rica. Cover by riparian vegetation was 75%, and mean weight of leaf litter occurring in the stream bed was 12.65 g.