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Research Letters

Assessing the importance of riparian zones conservation for leaf decomposition in streams

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ABSTRACT

Because of changes in riparian zones and water properties, human disturbances in terrestrial ecosystems can affect the decomposition of organic matter and invertebrate assemblages in forest streams. The aim of this study was to evaluate how changes in the riparian zones influenced leaf breakdown rates and colonization by invertebrate shredders. Leaves of *Miconia chartacea* were incubated in four streams of the same watershed that presented different conservation levels in the riparian zones. Leaf breakdown rates were higher in the presence of shredders and in the most preserved stream. In terms of abundance and biomass, shredders differed among streams, and the importance of these organisms on leaf decomposition decreased in altered streams. These results suggest the conservation level in the riparian zones influenced leaf decomposition mediated by shredders, and the observed decrease in breakdown rates was probably due to the high sensitivity of shredders to changes in the availability of food resources and habitat.

Introduction

The increase in human population and environmental impacts has caused many changes in both terrestrial and aquatic ecosystems (Allan, 2004). Because of the linkages between these environments, changes in the riparian zones, such as deforestation to create grazing areas and the replacement of native species by monocultures (Vorosmarty et al., 2010), also affect aquatic communities and important ecological processes occurring in stream ecosystems (Landeiro et al., 2010).

Changes in the riparian zones can modify the quality and quantity of leaf litter produced (Silva-Junior et al., 2014). Given that allochthonous material is an important energy source to heterotrophic organisms (Vannote et al., 1980), changes in the inputs of leaf litter can influence aquatic invertebrate assemblages by modifying the distribution and abundance of different taxa (Masese et al., 2014) and functional feeding groups (Encalada et al., 2010). Among these, invertebrate

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shredders, which feed on leaves imported from the riparian vegetation, are mainly affected. Through their activity, these organisms transform the coarse particulate organic matter into fine particles, feces and dissolved organic matter, exerting an important role in the detritus chain (Cummins, 1973). Therefore, changes affecting the distribution of shredders can modify the availability of resources along the food chain and stream ecosystem functioning (Dudgeon, 2006).

Traditionally, the assessment of stream integrity used structural indicators, i.e., monitoring aquatic communities and the physical and chemical parameters of water (Callisto et al., 2004). More recently, the evaluation of ecological processes, such as leaf decomposition, has been used as an additional tool for stream assessment (Graça et al., 2015). The decomposition process is an important functional indicator of stream ecosystems (Gessner and Chauvet, 2002), as it comprises both the riparian vegetation and biotic and abiotic components of the aquatic environment (Cummins, 1974). The use of functional indicators is widespread in Europe and North America. In Brazil, few studies have used this approach (see Silva-Junior and Moulton, 2011; Silva-Junior et al., 2014), and the leaf decomposition process was normally used to compare the functioning of ecosystems that were clearly different, such as preserved and impacted streams (Gonçalves et al., 2014).

Herein, the leaf decomposition process was evaluated in four streams of the same watershed that presented different conservation levels in the riparian zones. The aim of this study was to evaluate how changes in the riparian zones influenced leaf breakdown rates and colonization by invertebrate shredders. Assuming that changes in the abundance and species composition of the riparian vegetation decrease the diversity and availability of leaf litter on streambed, we hypothesized that breakdown rates, and the importance of invertebrate shredders on this process, would decrease in altered streams, i.e., the most preserved stream would present the highest breakdown rates and invertebrate assemblages with high proportions of shredders in terms of abundance and biomass.

Materials and methods

Study area

The four streams studied (Norte, Luxemburgo, Macuco and Banana) belong to the Santa Maria da Vitória River Basin and are located in the State of Espírito Santo, Southeastern Brazil. Norte Stream (20°01′43.9″ S–40°32′00.8″ W) presents a high level of human disturbance. The native vegetation was completely removed in one of the margins, and a narrow line of trees remained along the other margin. Both margins had signs of erosion, and the predominant substrate types were sand banks and leaf patches. Luxemburgo (20°08′15.6″ S–40°35′44.4″ W) is the second most disturbed stream. Despite the presence of the riparian vegetation in both margins, exotic fruit trees (banana and jackfruit) replaced the majority of native species. The studied reach had a rocky substrate dominated by large sand banks and some leaf patches. Macuco (20°01′23.1″ S–40°32′58.6″ W) and Banana (20°02′22.1″S–40°31′53.9″W) streams are located in fragments of Atlantic Forest and are more preserved. However, a monoculture of *Eucalyptus globulus* Labill. (1000 m^2) and a small rural property were located close to one of the margins of Macuco. The streambed of these streams was heterogeneous, with the presence of pebbles, gravel and leaf patches. More information about the studied streams and the physical and chemical properties of water (Table S1) is available in the supplementary material.

Experimental design

Senescent leaves of *Miconia chartacea* Triana (Melastomataceae) were collected in the riparian zone of Macuco Stream using 4 litter traps fixed at 1.5 m height and dried at room temperature. This species was chosen because it was abundant in the riparian vegetation of the studied streams, and shredders were frequently observed consuming these leaves. Portions of 2.00 ± 0.05 g of leaves were placed in litter bags (10 cm × 15 cm) of fine (0.5 mm) and coarse (10 mm) meshes and incubated in the four streams, in reaches with similar conditions of depth and flow. Thirty-six litter bags of each mesh were incubated per stream, totaling 288 samples. Four replicates of each mesh were collected in each stream at the intervals of 3, 7, 15, 30, 45, 60, 90, 120 and 150 days of incubation. Additional litter bags (time 0) were used to correct mass loses that occurred during sample handling and transport and to determine an oven dry mass/air dry mass correction factor.

In the laboratory, the leaves of each sample were washed over a 250 μm mesh and dried (60° C, 72 h) to determine the remaining mass. Invertebrates found in the coarse mesh bags were fixed in 70% ethanol and posteriorly identified and assigned to functional feeding groups using specific identification keys. Individuals were then separated by taxon, counted, dried (60° C, 72 h) and weighed in an analytical balance (0.1 mg) for the determination of biomass.

Data analysis

A negative exponential model was used to evaluate the decomposition process. The regression of the natural logarithm of the proportion of the remaining leaf dry mass and the time elapsed (days) was calculated, and the regression slope was used as the breakdown rate (k). Separate models were used to calculate the breakdown rates in fine (k_f) and coarse mesh bags (k_c) and to compare them, as well as the k_c/k_f ratios, among the studied streams (Gessner and Chauvet, 2002). The differences in the taxa composition of shredders among the streams were tested by an Analysis of Similarities (ANOSIM), based on the abundance data. General linear models (GLMs) were used to compare the proportion of shredders in terms of abundance (number of individuals per litter bag) and biomass (total dry mass per litter bag) among streams and incubation times ($\ln[x+1]$ transformed data). We tested normality on residuals from GLMs for each response variable. When a model was significant, Tukey tests were used for post hoc comparisons among streams and incubation times. All of the statistical analyzes were performed using SPSS (version 23.0 for Macintosh, SPSS, Chicago, Illinois) and Primer 6 (Primer-E Ltd.).