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Aquatic invertebrates increase litter breakdown in Neotropical shallow semi-arid lakes

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ABSTRACT

The feeding behavior of shredders and scrapers (invertebrates) is important for litter processing in aquatic ecosystems. We assessed the importance of invertebrate activity for organic matter breakdown in shallow lakes (macrophyte covered or macrophyte free), testing whether the abundance of scrapers was greater than that of shredders, and if macrophytes increased scraper density and consequently, the rate of leaf litter breakdown. We used litter bags with senescent leaves to assess the density, richness and biomass of invertebrates and assessed the mass loss of litter after oven drying. The mean decomposition coefficient (k = -0.0037day^{-1}) was lower than reported rates for other semi-arid lakes. We observed greater leaf breakdown in litter bags with coarse mesh, indicating the importance of scrapers, but potentially also microbes. However, leaf-associated invertebrates (averaged across both types of lakes) had low densities (4.7 ind.g^{-1}), biomass (8.3 mg g^{-1}) and richness (12 *taxa*), which may explain similar breakdown rates between lakes. Semi-aquatic Coleoptera and Mollusca were the most diverse *taxa* because they are capable of tolerating high hydrological stress associated with shallow lakes in semiarid areas. Planorbidae, which are intermediate hosts for the human parasitic trematode *Schistosomamansoni*, were almost absent in the macrophytic lake, suggesting that macrophytes may reduce the Planorbidae density and play an important role in human health.

1. Introduction

Shallow lakes are small water bodies, with dominance particularly in semi-arid regions as the Australian “Mallee” and “Mulga”, the Chilean and Argentinean “Chacos” and the Brazilian “Caatinga”, that often provide water and habitat for biota (Barbosa et al., 2012; Casco et al., 2016; Neiff et al., 2006). For example, shallow artificial lakes (called “açudes”) and small dams provide most of the water storage within Brazilian semi-arid regions. Apart from water storage, shallow lakes also provide water recharge, water purification and recreational fisheries to their adjacent communities (Sayer et al., 2016). Although most studies published worldwide have highlighted the importance of deep lakes, shallow lakes cover a larger area of Earth's surface and often have greater biological activity per unit area than deep lakes (Downing et al., 2006). Despite the clear importance of these small lakes, ecological aspects such as nutrient cycling and energy flow through leaf litter breakdown are still poorly understood.

The diversity of aquatic communities may be influenced by environmental factors such as rainfall and water pollutants (Mooney et al., 2009), biological interactions (e.g. predation and competition; Padial et al., 2014; Ziegler et al., 2015) and ecological processes (e.g. input and decomposition of organic matter; Carvalho et al., 2015; Song et al., 2013). The effects of these factors (environmental, interactions process conditions) may be evaluated through the analysis of leaf litter breakdown (Graça et al., 2015; Rezende et al., 2014). Although many studies have examined the processes of autochthonous litter and/or dead macrophytes breakdown (Carvalho et al., 2015; Li et al., 2013; Song et al., 2013; Ziegler et al., 2015), we still have a poor understanding of breakdown dynamics (mainly allochthonous leaf litter; Rezende et al., 2010) in shallow lakes (Ilmavirta, 1980; Telöken et al., 2011).

Dead macrophytes (a type of autochthonous litter), provide food and refuge to fish and invertebrates, contribute to habitat heterogeneity, and increase habitat productivity and biodiversity (Thomaz and Cunha, 2010). The contribution of allochthonous litter may be more important in shallow than deep lakes because of their greater

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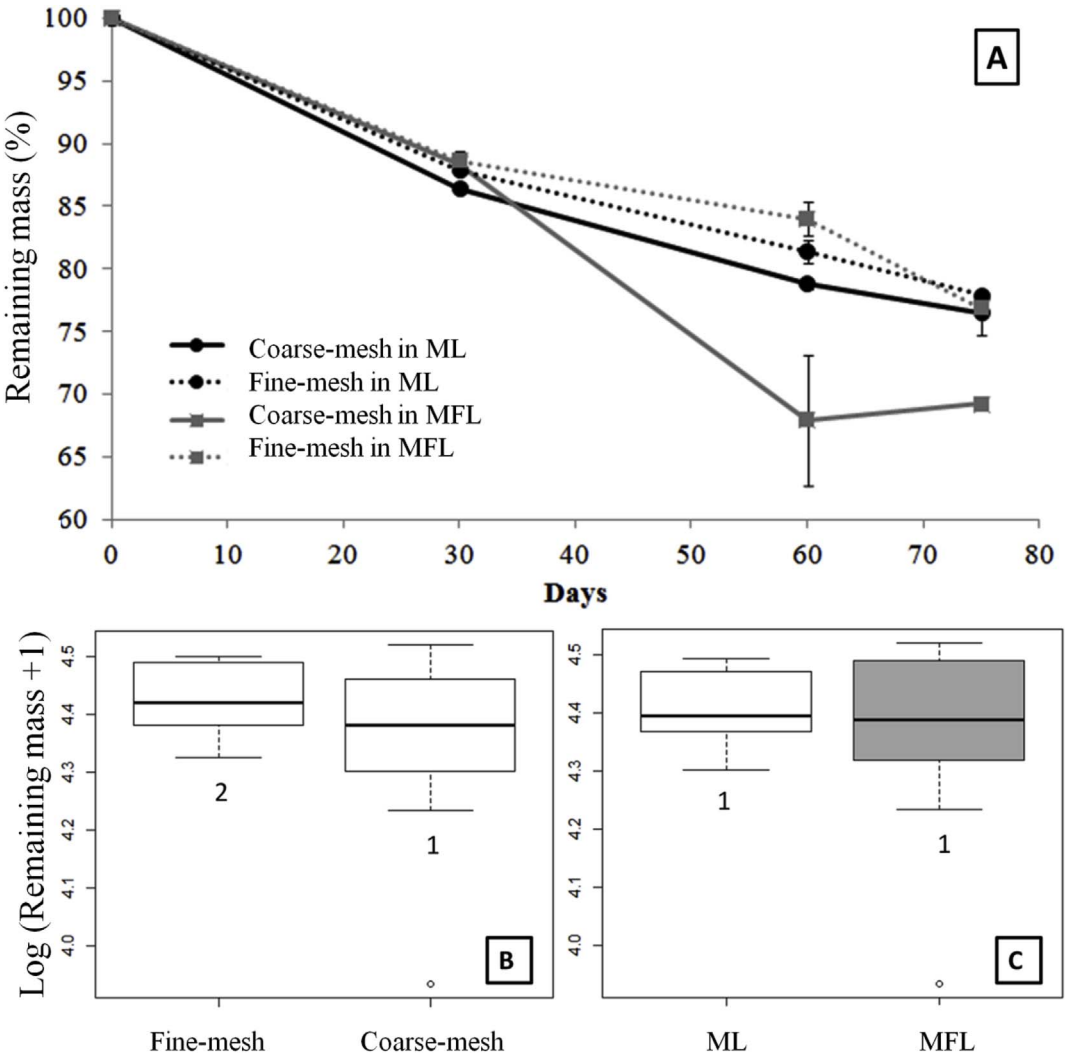

Fig. 1. Mean values and standard errors for the remaining mass in the ML (black line) and MFL (grey line) from fine mesh (dotted line) and coarse mesh (continuous line) litter bags (A). For B (remaining mass between litter bags mesh sizes) and C (remaining mass between lake types), the upper and lower lines of the boxes represent the quartiles, the bold line represents the median, the dashed lines represent the upper and lower limits, and the circles represent outliers. Different numbers (1 and 2) indicate significant differences.

surface-area (Ilmavirta, 1980). Also, allochthonous litter influences the production of methane, which is an important greenhouse gas, in the sediments of shallow lakes (Furlanetto et al., 2012). Therefore, allochthonous input (i.e., driven by rain and wind) and subsequent decomposition processes should be better studied to understand the ecology of semi-arid shallow lake sand interactions within the associated decomposer communities (Telöken et al., 2011). Leaf litter breakdown can also be influenced by many factors, such as physical and chemical variables of water and detritus and decomposers such as micro-organisms and aquatic invertebrates (Carvalho et al., 2015; Li et al., 2013; Quintão et al., 2013; Rezende et al., 2010; Song et al., 2013).

Aquatic fungi (hyphomycetes), mineralize leaf litter through enzymatic action, and drive the breakdown of structural and recalcitrant compounds such as lignin and cellulose (Graça et al., 2015; Quintão et al., 2013). Bacteria then decompose labile molecules as secondary metabolites (Graça et al., 2015; Quintão et al., 2013). Microbial communities are also responsible for the nutritional enrichment of leaf litter, increasing their palatability and enabling the colonization and consumption of leaves by invertebrates (Graça et al., 2015; Quintão et al., 2013; Rezende et al., 2010). The density and richness of shredders are low, and often absent, in semi-arid Brazilian lakes (Barbosa et al., 2012), but the relative abundance of scrapers is high (Barbosa et al., 2012; Rodríguez-Lozano et al., 2015, 2016).The high abundance of scrapers is important for leaf breakdown, once leaves are fragmented when the consumption of periphyton in litter tissues (Rezende et al., 2010). The role of aquatic organisms in breaking down allochthonous litter in tropical shallow lakes is not well studied (Barbosa et al., 2012; Carvalho et al., 2015) and there are no published studies of these dynamics in Brazilian semi-arid regions.

Our objective was to assess the importance of the invertebrate community in leaf breakdown of *Inga laurina*in two Brazilian semi-arid shallow lakes (covered by macrophytes or macrophyte-free), specifically testing two working hypotheses: (1) scrapers will be relatively more abundant than shredders (which are generally absent in lentic systems; Rezende et al., 2010), resulting in a high importance of scrapers in leaf breakdown; and (2) increase in the density of macrophytes in shallow lakes will lead to a high density of invertebrates (mostly scrapers) indirectly increasing leaf breakdown rates. We tested these hypotheses by comparing the invertebrate colonization and the rate of leaf breakdown in litter bags with different mesh sizes, allowing us to remove the effects of invertebrates on decomposition using a fine mesh size.