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Leaf breakdown in two tropical streams: Differences between single and mixed species packs

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Abstract

We assessed leaf breakdown of five native riparian species from Brazilian Cerrado (*Myrcia guyanensis*, *Ocotea* sp., *Miconia chartacea*, *Protium brasiliense*, and *Protium heptaphyllum*), incubated in single and mixed species packs in two headwater streams with different physico-chemical properties in the Espinhaço Mountain range (Southeastern Brazil). Leaves were placed in plastic litter bags (15 cm × 20 cm, 10 mm mesh size) and the experiments were carried out during the dry seasons of 2003 and 2004. Leaf nitrogen and phosphorus contents were similar in all species, but polyphenolic contents were different ($P<0.001$). *M. guyanensis* showed higher polyphenolics content (8.48% g^{-1} dry mass) and leaf toughness. Individually, higher breakdown rates were found in *M. guyanensis* at Indaiá stream ($k = 0.0063 \pm 0.0005\ d^{-1}$) and in *Ocotea* sp. at Garcia stream ($k = 0.0088 \pm 0.0006\ d^{-1}$). However, *P. brasiliense* and *P. heptaphyllum* showed lower breakdown rates at Indaiá and Garcia streams (Indaiá: $k = 0.0020 \pm 0.0002$ and $0.0019 \pm 0.0001\ d^{-1}$; Garcia: $k = 0.0042 \pm 0.0001$ and $0.0040 \pm 0.0002\ d^{-1}$). Single and mixed breakdown processes of each species were not statistically different on both streams. However, all species showed higher breakdown rates at Garcia stream ($P<0.01$). These results suggest that leaf breakdown is not altered when litter benthic patches are composed by a mixture of species in the same proportions that they occur on riparian leaf falls.

Keywords: Breakdown rates; Leaf toughness; Nutrients; Polyphenolics; Brazilian Cerrado

Introduction

Allochthonous organic matter input is the main energy source to aquatic communities in streams where the stream bed is shaded by riparian vegetation (Minshall, 1967; Vannote, Minshall, Cummins, Sedell, & Cushing, 1980; Webster & Meyer, 1997). Studies on the decomposition process of organic detritus in lotic ecosystems have received considerable attention since the late 1960s, due to their role in the energetic metabolism of these environments (Abelho, 2001). However, equivalent studies on tropical streams are scarce and little is known about the processing of organic matter in these ecosystems. Recent studies at lower latitudes include those of Mathuriau and Chauvet (2002) and Chará (2003) in Colombia, Dobson, Mathooko, Ndegwa, and M'erimba (2003) in Kenya, Abelho, Cressa, and Graça (2005) in Venezuela, and Moulton and Magalhães (2003), Wantzen, Rosa, Neves, and Da Cunha (2005), and Gonçalves, França, Medeiros, Rosa, and Callisto (2006b) in Brazil.

Leaf breakdown rates may vary in a wide scale of magnitude among species (Cornelissen, 1996; Petersen &

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Cummins, 1974). They are influenced by internal (leaf physical and chemical characteristics) and external factors (e.g., water chemical composition, temperature, discharge, dissolved oxygen, and biotic communities) (Abelho, 2001; Kaushik & Hynes, 1968; Webster & Benfield, 1986). Lower breakdown rates are associated to leaf toughness, which is influenced by lignin and tannin contents (Hoorens, Aerts, & Stroetenga, 2003; Ostrofsky, 1997; Pereira, Graça, & Molles, 1998). These traits may affect leaf breakdown due to their influence on the activity of decomposing microorganisms and invertebrate shredders (Canhoto & Graça, 1996; Gessner & Chauvet, 1994; Rosemond, Pringle, Ramírez, Paul, & Meyer, 2002).

In headwaters, leaf breakdown is a critical process that affects availability of food to aquatic webs (Cummins, Wilzbach, Gates, Perry, & Talaiferro, 1989; Minshall, 1967; Wallace, Eggert, Meyer, & Webster, 1997). Studying the breakdown of a single species is not sufficient to understand the energy flow through the ecosystem (Hoorens et al., 2003), especially in tropical ecosystems where riparian corridors are composed of many tree species. In such environments, leaves are found in mixed species packs on the stream beds. As leaf structure and chemical composition may differ considerably among species (Webster & Benfield, 1986), species composition of mixed leaf packs may affect the breakdown rate of each species individually (Leff & McArthur, 1989; Petersen & Cummins, 1974). Thus, the breakdown of mixed packages may result from the characteristics of all the component species (additive effects) or be determined by a dominant species in the process (key-species) (Hoorens et al., 2003; Swan & Palmer, 2004; Wardle, Bonner, & Nicholson, 1997). In Savannah-like ecosystems such as the Brazilian Cerrado, a main trait of the vegetation is its sclerophylly, with species differing in toughness, lignin, and tannin content (Madeira, Ribeiro, & Fernandes, 1998; Marques, Garcia, & Fernandes, 1999). Therefore, studies in such environment should be important in an attempt to bridge the gap existing in our understanding of the decomposition process in a more broad scale.

Knowing that Brazilian Cerrado leaves may differ in their chemical and physical characteristics, we hypothesized that leaf breakdown rates would be different in single and mixed species leaf packs. We expected that leaf processing of different species would affect each other when incubated on mixed packages, altering the individual breakdown rates. So, the main goal of this study was to assess the breakdown rates of five native Brazilian Cerrado riparian leaves (*Myrcia guyanensis* Aubl., *Ocotea* sp. Aubl., *Miconia chartacea* Triana, *Protium brasiliense* Engl., and *Protium heptaphyllum* March.) when incubated in single and mixed species leaf packs. To verify the influence of stream characteristics on leaf breakdown in tropical ecosystems, experiments were conducted in two headwater streams that present different landscape cover, use, and water properties.

Material and methods

Study area

The Cerrado Biome of Tropical South America covers about 2 million km^2, representing ca. 22% of the land surface of Brazil, plus small areas in eastern Bolivia and northwestern Paraguay (Oliveira & Marquis, 2002). The riverine forests following the drainage throughout the Cerrado Biome cover probably less than 10% of its total area but harbor an enormous floristic and faunal diversity (Da Silva & Bates, 2002). Some databases contain more than 600 species of trees for riverine forests of the Cerrado Biome and it is certain that they contain more, once there are still relatively few surveys of these forests (Fonseca, Sousa-Silva, & Ribeiro, 2001; Oliveira & Marquis, 2002).

Indaiá and Garcia streams belong to the headwaters of the Doce river basin and are located in the southern Espinhaço Mountain range (Southeastern Brazil), a water divisor of the Brazilian basins of São Francisco and Doce rivers (Fig. 1). According to the Koppen Climate Classification System, the climate type of this area is Tropical of Altitude (Cwb) with cool summers and dry winters. During the experiments (dry season), monthly means of precipitation and air temperature at study streams ranged from 5 to 20 mm and 18 to 22 °C (www.simge.mg.gov.br).

Indaiá stream is located in the Serra do Cipó National Park (33,800 ha), a well-preserved landscape consisting of rocky grasslands at higher elevations and highly diverse riverine forests in the valleys and canyons. The experiment was carried out in a third order reach (19° 16.4′S–43° 31.2′W), at the altitude of 1459 m a.s.l, where waters present total N and total P contents of 0.19 and 0.02 mg L^{-1}, respectively. The riparian corridor at the study site is 7 m wide, shading most of the stream bed, and is mainly composed of *Augusta longifolia* (Spreng) Rehder (Rubiaceae), *Erythroxylum pelletarianum* St. Hil (Erythroxylaceae), *M. chartacea*, *Miconia cyathanthera* Triana (Melastomataceae), *M. guyanensis* (Myrtaceae), *Ocotea* sp. (Lauraceae), and *P. brasiliense* (Burseraceae) (Gonçalves, França, & Callisto, 2006a).

Garcia stream is located in Serra do Ouro Branco, where the landscape consists of grasslands, grazing areas, and forest fragments of different areas. The study was carried out in a third order reach (20° 21′S–43° 41′W) inside a forest fragment, at the altitude of 1300 m a.s.l. In this reach, waters present higher nutrient contents (total N: 1.0 mg L^{-1}, total P: 0.026 mg L^{-1}) and the stream bed is totally shaded by the riparian