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Leaf breakdown in a tropical stream: comparison between the exotic *Eucalyptus grandis* and two native species

Decomposição foliar em um riacho tropical: comparação entre a exótica *Eucalyptus grandis* e duas espécies nativas

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Abstract: Aim: We evaluated the leaf decomposition in a first order stream of the exotic *Eucalyptus grandis* and two native species *Lithraea molleoides* and *Maytenus aquifolium* common riparian trees in a tropical forest. Besides seasonal effects on leaf decomposition of the three species were evaluated. **Methods:** The dried leaves were incubated in litter bags" of 20 x 20 cm with 10 mm of mesh opening in two different treatments and at two times of the year (dry and rainy): i) 48 "litter bags" containing 4 g of leaves, being 24 "litter bags" with leaves of *L. molleoides* and 24 with *E. grandis* and ii) 48 "litter bags" containing 4 g of leaves, being 24 "litter bags" with of *M. aquifolium* and 24 with leaves of *E. grandis*. After 2, 7, 14, 21, 28 and 60 days of immersion, randomly removed four "litter bags" of each species to carry out the analyzes. **Results:** The weight loss in the first two days was between 20% and 40% in both experiments and in both seasons of the year. Leaf decomposition was higher in *L. molleoides* ($k=0.0062 \pm 0.0002$ day^{-1}) than in *E. grandis* ($k=0.0039 \pm 0.0005$ day^{-1}) in the dry season and higher in *L. molleoides* ($k=0.0185 \pm 0.0002$ day^{-1}) than *E. grandis* ($k=0.0164 \pm 0.0003$ day^{-1}) in the rainy season. In the second experiment the decomposition rates were higher in *M. aquifolium* ($k=0.0151 \pm 0.0009$ day^{-1}) than *E. grandis* ($k=0.0149 \pm 0.0006$ day^{-1}) in the dry season and higher in *M. aquifolium* ($k=0.0174 \pm 0.0001$ day^{-1}) than *E. grandis* ($k=0.0164 \pm 0.0002$ day^{-1}) in the rainy season. Besides, the results indicate that there is an effect of both the dry and rainy season and the native or exotic species on the decomposition rates. **Conclusions:** Our findings indicate that, the seasons are likely to influence leaf decomposition, and future studies should consider seasonality. Furthermore, the exotic species had a lower decomposition rate compared to native species, which reinforces that the replacement of native riparian vegetation by exotic species such as eucalyptus can interfere on the quality of allochthonous resources and on the cycling of nutrients in neotropical streams.

Keywords: leaf decomposition; riparian forest; seasonality; negative exponential model.

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Resumo: Objetivo: O objetivo deste estudo foi avaliar a decomposição foliar da espécie exótica *Eucalyptus grandis* e das espécies nativas *Lithraea molleoides* e *Maytenus aquifolium* (árvores ribeirinhas comuns em uma floresta tropical) em um riacho de primeira ordem. Além disso, foram avaliados os efeitos sazonais na decomposição foliar das três espécies. **Métodos:** As folhas secas foram incubadas em litter bags de 20 x 20 cm com 10 mm de abertura de malha em dois tratamentos distintos e em duas épocas do ano (seca e chuvosa): i) 48 "litter bags" contendo 4 g de folhas, sendo 24 "litter bags" com folhas de *L.molleoides* e 24 com folhas de *E. grandis* por estação e ii) 48 "litter bags", sendo 24 "litter bags" com folhas de *M. aquifolium* e 24 com folhas de *E. grandis*. Após 2, 7, 14, 21, 28 e 60 dias de imersão, foram retirados, aleatoriamente, quatro "litter bags" de cada espécie para a realização das análises. **Resultados:** A perda de peso nos primeiros dois dias esteve entre 20% e 40% em ambos os experimentos e épocas do ano analisadas. As taxas de decomposição foram: *L. molleoides* (k=0.0062 ± 0.0002 dia^{-1}) > *E. grandis* (k=0.0039 ± 0.0005 dia^{-1}) na época seca e *L. molleoides* (k=0.0185 ± 0.0002 dia^{-1}) > *E. grandis* (k=0.0164 ± 0.0003 dia^{-1}) na época chuvosa. No segundo experimento os resultados mostraram *M. aquifolium* (k=0.0151 ± 0.0009 dia^{-1}) > *E. grandis* (k=0.0149 ± 0.0006 dia^{-1}) na época seca e *M. aquifolium* (k=0.0174 ± 0.0001 dia^{-1}) > *E. grandis* (k=0.0164 ± 0.0002 dia^{-1}) na época chuvosa. Os resultados demonstraram ainda que há efeito tanto da época seca e chuvosa, quanto das espécies nativas ou exóticas no coeficiente de decomposição, indicando que no período chuvoso a taxa de decomposição mais alta. **Conclusões:** Nossos resultados indicam que a época do ano influencia a decomposição das folhas, e futuros estudos devem considerar a sazonalidade. Além disso, a espécie exótica apresentou taxa de decomposição mais baixa em comparação com as espécies nativas, o que reforça que a substituição da vegetação ripária nativa por espécies exóticas como o eucalipto pode interferir na qualidade dos recursos alóctones e na ciclagem de nutrientes em riachos neotropicais.

Palavras-chave: decomposição foliar; mata ripária; sazonalidade; modelo exponencial negativo.

1. Introduction

In a small forested stream, the vegetation cover inhibits the entry of light, thus inhibiting photosynthesis, and reducing the growth of primary producers (Encalada et al., 2010). These systems have a predominantly heterotrophic metabolism, relying on the riparian vegetation (mainly by the input of leaves) as a supplier of nutrients and energy for the aquatic communities (Wallace et al., 1997; Bueno et al., 2003). Originally from Australia, *Eucalyptus* species are cultivated in several regions of the world (Vital, 2007) due to easy adaptation in distinct locations and, thus they became the standard for the production of high yield and fast-growing forest material for different uses (Lima, 1996) and replace several native forests. Most studies evaluating the impacts of eucalypt plantations to streams, mainly in the northern hemisphere, have reported changes in the seasonality, quantity, and quality of organic matter entering streams (Abelho & Graça, 1996; Molinero & Pozo, 2004). This demonstrates that the replacement of the native deciduous vegetation by eucalypt monocultures may led to important changes in stream hydrology, organic matter dynamics, and litter quality (Canhoto & Laranjeira, 2007).

The leaf litter of *Eucalyptus* species is characterized by low quality due to the high concentration of secondary compounds and a thick cuticle that slows down detritivory (Moretti et al., 2007; Correa-Araneda et al., 2015). Thus, the *Eucalyptus* species present lower decomposition rates when compared to native species that are rich in nutrients and with low concentrations of secondary compounds (Gonçalves et al., 2012a; Tonin et al., 2014; Ferreira et al., 2019). On the contrary, when the native species leaves are of poor quality, we may expect *Eucalyptus* leaves to decompose faster than the natives. The decomposition process of exotic allochthonous foliar leaves has been subject of several studies several decades ago in the temperate ecosystems, knowledge on this topic in Brazil and tropical streams has been increasing in the last decade (Gonçalves et al., 2012b; Kiffer et al., 2018). Large areas with riparian vegetation are replaced by plantations of *Eucalyptus* (Canhoto & Graça, 1995), and the consequences for tropical streams need properly investigated.

Although litter decomposition in tropical streams is largely attributed to the macroinvertebrate community, decomposition rates can vary by stream, stream location, time of year, microbial activity, presence of shredders, and other specific factors (Benfield et al., 2017). It should also be taken into account the stream flow and seasonality that can influence the decomposition dynamics (Roberts et al., 2016). According to Tiegs et al. (2019), the extent of variability in bed decomposition patterns at multiple spatial and temporal scales should be considered if we want to understand the factors that control this process in tropical streams (Boyero et al., 2015). Decomposition rates depend on environmental characteristics and can show strong seasonal variation (Mora-Gomez et al., 2016) and higher decomposition rates are related to higher temperature values and water velocity which, in turn, acts directly on leaf decomposition, promoting physical fragmentation of leaf tissue (Gonçalves et al., 2014), reinforcing the seasonal influence.

According to the above, the present work will contribute to increasing the knowledge of the theme in streams and neotropical riparian forests, under the influence of the *Eucalyptus*. As Ferreira et al. (2019) suggested that the effects of plantations on litter decomposition are dependent on decomposer communities and the region where the stream is located, which reinforces the need to expand these studies in different biomes and regions of Brazil. The same consideration applies to the invasion of tropical riverside areas by exotic plants that can affect aquatic communities (Ferreira et al., 2012). In this paper, we investigate the decomposition dynamic of the exotic *Eucalyptus grandis* in comparison with two native species. Our hypotheses were: (a) the decomposition dynamics of the exotic *Eucalyptus grandis* W. Hill ex Maiden is slower than two most common natives tree species of Seasonal Semideciduous Forest – *Lithraea molleoides* (Vell.) Engl. and *Maytenus aquifolium* Mart.; (b) the decomposition rates are higher in the rainy season.

2. Material and Methods

2.1. Study sites

The study was carried out in a tropical stream located in the municipality of Sorocaba, SP, at 23º 23 ‘40”S and 47º 29’00”W at two times of the year (July at September 2014/dry season and from January at March 2015/rainy season). The altitude is 601 m, with annual mean temperatures of 16.1 °C and maximum of 27.9 °C and mean annual rainfall of 1300 mm. The site presents a strip of riparian vegetation in each of the banks, with the predominance of Seasonal Semi-Deciduous Forest or “Mata Mesófila” surrounded by plantations of *Eucalyptus grandis* (Sorocaba, 2012).

The environmental characterization of the *in situ* stream was also performed throughout the measurement of chemical (dissolved oxygen, pH, electrical conductivity and dissolved solids) and physical (temperature) using an OKATON multiparameter model PCD650. In addition, the width and depth of the stream were obtained using a measuring tape and current velocity, through the method of floating objects driven by the current.

The pH for both periods remained around neutrality between 7.17 ± 0.30 (dry season) and 7.40 ± 0.30 (rainy season). The electrical conductivity of the water in the dry period was 87.00 ± 5.00 µS cm^{-1}, while in the rainy period the conductivity was between 55.00 ± 17.00 µS cm^{-1} (Table 1). In the first experiment, the water in the dry season showed oxygen concentrations of 5.47 ± 0.10 mg L^{-1} and the rainy season had significant amounts of dissolved oxygen 6.00 ± 0 mg L^{-1}. The current velocity of the dry season was 0.90 ± 0.05 m s^{-1}, while in the rainy season the current velocity of the stream was 0.22 ± 0.10 m s^{-1}. In the dry period the flow rate was 0.02 ± 0.01 m^3 s^{-1} and in the rainy season the flow rate was slightly higher 0.09 ± 0.07 m^3 s^{-1} (Table 1).

Table 1. Physical and chemical characteristics of the Campininha stream, during the study period. The data represent mean values and the standard deviation.

	Period (Dry)	Period (Rainy)
Experiment	*E. grandis and L. molleoides/ E. grandis and M. aquifolium*	*E. grandis and L. molleoides / E. grandis and M. aquifolium*
Parameters		
pH	7.17 ± 0,30	7.40 ±0.30
Conductivity (µS cm^{-1})	87.00± 5.00	55.00 ± 17.00
Total solids dissolved (mg L^{-1})	54.00 ± 6.00	27.00 ± 8.00
Oxygen dissolved (mg L^{-1})	5.47 ± 0.10	6.00±0
Temperature (°C)	17.00 ± 0,50	26.00 ± 1.00
Width (m)	1.20 ± 0.30	1.24± 0.40
Depth (m)	0.21 ± 2.00	0.29 ±0.10
Current velocity (m s^{-1})	0.90 ± 0.05	0.22 ±0.10
Flow rate (m^3 s^{-1})	0.02 ± 0.01	0.10 ± 0.07

2.2. Experimental design and laboratory work

Leaves of the exotic species *E. grandis* and the two most abundant native species in the riparian forest of the stream, where the experiment was carried out (*L. molleoides* and *M. aquifolium)* were collected from the forest floor immediately after leaf fall in autumn (April 2014). The leaves were taken to the laboratory, air-dried at room temperature, and stored until needed. For the preparation of the samples, 4.0 g of leaves were placed in 20 × 20 cm litter bags with a 10 mm mesh (Canhoto et al., 2005; Leroy & Marks, 2006; Nin et al., 2009; Raposeiro et al., 2014). The dried leaves were incubated in two different treatments: i) 48 "litter bags" containing 4 g of leaves, being 24 "litter bags" with leaves of *L. molleoides* and 24 with *E. grandis* leaves and ii) 48 "litter bags", being 24 "litter bags" with of *M. aquifolium* and 24 with leaves of *E. grandis*. The plant material added to the "litter bags" was disposed in the stream at random, corresponding to the sample time by species, attached to the margins in roots with nylon string and submerged in the water. After 2, 7, 14, 21, 28 and 60 days of immersion, it was randomly removed four "litter bags" of each species to carry out the analyzes. In the laboratory, the collected leaves were washed with water on a sieve (with 0.21 mm mesh) to remove the attached sediment and dried at 50 °C for 48 hours (Canhoto & Graça, 2006).

2.3. Data analysis

To estimate the decomposition rates, the negative exponential model used was Wt = W_0. e^{-kt}, where Wt is the weight remaining at time t (in days), W_0 is the initial weight and k is the decomposition rate (Webster & Benfield, 1986). All statistical analyses were conducted in R (R Core Team, 2018) using the 'gnm' package (Turner & Firth, 2018). In order compare the weight decay of each species and each season, according to exposure days, we independently fit two non-linear models corresponding to the two datasets of the separate experiments and used the same initial structure, i.e.,

$$Y_{ijk} = \exp\left\{\beta_0 + \beta_{1i}d_k + \beta_{2j}d_k + \beta_{3ij}d_k\right\} + \epsilon_{ijkl} \tag{1}$$

where is the weight observed in the *i*-th season (dry or rainy) of the *j*-th species (native or exotic) after the *k*-th day of exposure (*k* = {2, 7, 14, 21, 28, 60} in base 2, logarithmic scale) of the *l*-th replicate (*l* = {1, 2, 3, 4}); and is the random variation, supposedly of normal distribution of zero mean and constant variance.

Note that the model of Equation 1 is, in fact, an extension of the negative exponential model, as in Webster & Benfield (1986), to allow the experimental structures used in this work. In this context, the parameter is the initial and known weight (offset, in statistical terminology), and the parameters and are, respectively, the decomposition rates associated with the *i*-th season and the *j*-th specie. To select the model, the terms of effect of the species and the time were successively removed (which is the same as testing the null hypothesis of a null effect in classical linear models), likelihood ratio tests were carried out at 5% of significance. The final models were validated by means of residue analysis and normal quantile-quantile graphs with simulated envelope (Flack & Flores, 1989).

3. Results

It was observed that in both experiments and in both seasons of the year, the weight loss in the first two days was between 20% and 40%. Leaf decomposition was higher in *L. molleoides* (k=0.0062 ± 0.0002 day^{-1}) than in *E. grandis* (k=0.0039 ± 0.0005 day^{-1}) in the dry season and higher in *L. molleoides* (k=0.0185 ± 0.0002 day^{-1}) than *E. grandis* (k=0.0164 ± 0.0003 day^{-1}) in the rainy season. In the second experiment the decomposition rates were higher in the order *M. aquifolium* (k=0.0151 ± 0.0009 day^{-1}) than *E. grandis* (k=0.0149 ± 0.0006 day^{-1}) in the dry season and higher in *M. aquifolium* (k=0.0174 ± 0.0001 day^{-1}) than *E. grandis* (k=0.0164 ± 0.0002 day^{-1}) in the rainy season. The Figure 1 represents all the observations made in the experiments, indicating a clear trend of weight loss over time. For experiments, a sub model of Equation 1 was selected, without the interaction parameter, according to the likelihood ratio tests (Model 2 of Tables 2 and 3). This provides evidence to affirm that there is an effect of both the dry and rainy season (i.e., the fact that the coefficient is important for the model fitting and is thus significantly different from zero) and the native or exotic species (i.e., the fact that the coefficient is important for the model fitting and is thus significantly different from zero) on the decomposition rates. In Table 4, we present the parameter estimates for each final model, respectively for the experiment with *L. molleoides* and with *M. aquifolium*. The decomposition rate was higher in the rainy season, mainly in the experiment *L. molleoides* x *E. grandis*. Furthermore,

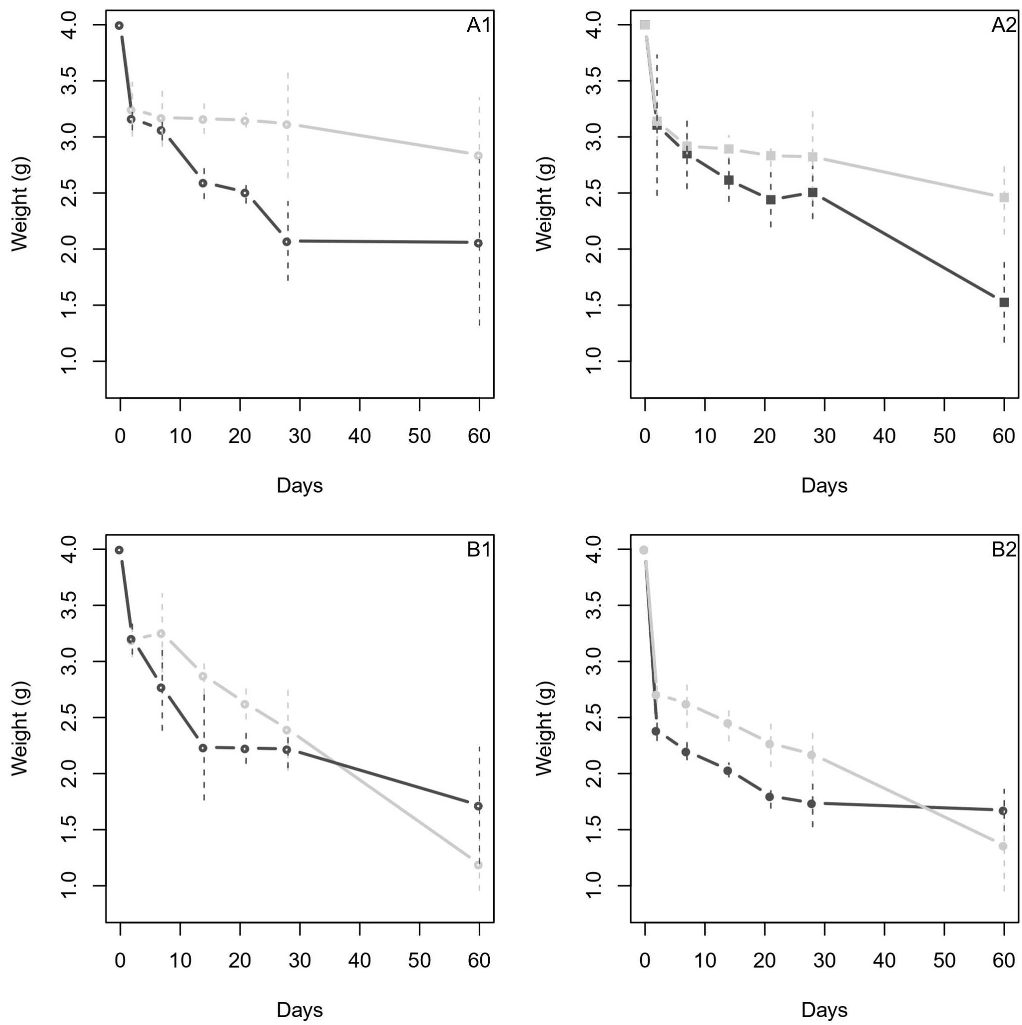

Figure 1. Mean (circles/squares) and standard deviation (vertical line segments) of the remaining weight observed over time. Panels A: experiment involving the species *E. grandis* (A1, open circles) and *L. molleoides* (A2, squares). Panels B: experiment involving the species *E. grandis* (B1, open circles) and *M. aquifolium* (B2, closed circles). In all panels, light gray denotes weights observed during the dry season and dark gray denotes weights observed during the rainy season.

Table 2. Likelihood ratio tests for the different models fitted to the experiment data involving *E. grandis* and *L. molleoides*.

Model	Predictor	-LogL	Test	χ^2	DF	p-value
1	$\exp\{\beta_0 + \beta_{1i}d_k + \beta_{2j}d_k + \beta_{3ij}d_k\}$	40.30	-	-	-	-
2	$\exp\{\boldsymbol{\beta_0 + \beta_{1i}d_k + \beta_{2j}d_k}\}$	**40.98**	1 vs. 2	1.35	1	0.2450
3	$\exp\{\beta_0 + \beta_{1i}d_k\}$	43.97	2 vs. 3	5.98	1	0.0145
4	$\exp\{\beta_0 + \beta_{2j}d_k\}$	59.05	2 vs. 4	36.14	1	<0.0001
5	$\exp\{\beta_0 + \beta_1 d_k\}$	60.92	2 vs. 5	39.87	2	<0.0001
6	$\exp\{\beta_0\}$	70.69	2 vs. 6	59.43	3	<0.0001

Log L: complementary to the logarithm of the model likelihood; χ^2: asymptotic chi-square statistic; DF: degrees of freedom for the comparison. Highlighted in bold the final model.

Table 3. Likelihood ratio tests for the different models fitted to the data of the experiment involving *E. grandis* and *M. aquifolium*.

Model	Predictor	-LogL	Test	χ^2	DF	p-value
1	$\exp\{\beta_0 + \beta_{1i}d_k + \beta_{2j}d_k + \beta_{3ij}d_k\}$	51.90	-	-	-	-
2	$\exp\{\boldsymbol{\beta_0 + \beta_{1i}d_k + \beta_{2j}d_k}\}$	**52.24**	1 vs. 2	0.69	1	0.4076
3	$\exp\{\beta_0 + \beta_{1i}d_k\}$	58.57	2 vs. 3	12.66	1	0.0004
4	$\exp\{\beta_0 + \beta_{2j}d_k\}$	55.50	2 vs. 4	6.52	1	0.0107
5	$\exp\{\beta_0 + \beta_1 d_k\}$	61.56	2 vs. 5	18.64	2	<0.0001
6	$\exp\{\beta_0\}$	84.35	2 vs. 6	64.21	3	<0.0001

LogL: complementary to the logarithm of the model's likelihood; χ^2: asymptotic chi-square statistic; DF: degrees of freedom for the comparison. The final model is highlighted in bold.

it is noted that in both cases, the exotic species had lower decomposition rates compared to native species (Figure 2).

4. Discussion

The weight loss in the first days presented by the three species in this paper is in the same order of magnitude with much research conducted in tropical streams (e.g., Gonçalves et al., 2012a, b), Tonin et al. (2014) and Tonello et al. (2014)). The rapid weight loss observed for leaf litter on the third day of incubation can be attributed to the metabolism of molecules and/or their leaching (molecules such as proteins, carbohydrates, and lipids) (Canhoto & Graça, 1996; Panhota et al., 2006). The remaining leaf litter is more resistant to decay and later weight loss is slower, also verified in studies conducted in Brazil (Rezende et al., 2010; Alvim et al., 2015).

Despite the above, we must be aware that sometimes *Eucalyptus* leaves present similar decomposition rates (Tonello et al., 2014) or higher than native species (Tonin et al., 2014). This is related to the studied leaf characteristics and, in some cases, some native species have leaves that can be comparatively less nutritious and less palatable than *Eucalyptus*. The results of the present study still showed that the species *E. grandis* had lower decomposition than native species that according to Hepp et al. (2009) it could be is due to the chemical composition of the detritus and the action of decomposers, such as the low content of nitrogen and phosphorus and the presence of refractory compounds such as lignin and hemicelluloses, thus inhibiting the decomposition and colonization of invertebrates (Gonçalves et al., 2012a, b; Tonin et al., 2014; Tonello et al., 2014).

Table 4. Estimates and standard errors of the parameters of the two final models.

Experiment	Paramter	Estimate	Standard error
E. grandis vs. *L. molleoides*	β_{11}	-0.0819	0.0061
	β_{12}	-0.1300	0.0070
	β_{22}	0.0179	0.0073
E. grandis vs. *M. aquifolium*	β_{11}	-0.1537	0.0092
	β_{12}	-0.1802	0.0099
	β_{22}	0.0378	0.0105

β_{11}: decomposition rates for the native species (either *L. molleoides* or *M. aquifolium*, depending on the experiment) during the dry season; β_{12}: decomposition rates for the native species (similarly, either *L. molleoides* or *M. aquifolium*, depending on the experiment) during the rainy season; and β_{22}: *E. grandis* effect over the decomposition rates of the native species in both seasons.

Eucalyptus spp. has a slower decomposition rate, possibly caused by the structural and chemical characteristics of leaves as verified by Gonçalves et al. (2006), Wantzen et al. (2008), Hepp et al. (2009), and Graça et al. (2015). Besides, the effects of *Eucalyptus* leaves on the aquatic ecosystem will depend on the type of community involvement in the decomposition process (microorganisms and macroinvertebrates), additionally, vary depending on the eucalyptus species and the geographic location of the stream (Ferreira et al., 2019). Numerous studies have shown that the leaves of *Eucalyptus* sp. when compared to native species have lower nutrients concentration (nitrogen and phosphorus) (Gonçalves et al., 2012a, b; Tonin et al., 2014; Tonello et al., 2014), higher hardness, and secondary metabolites which

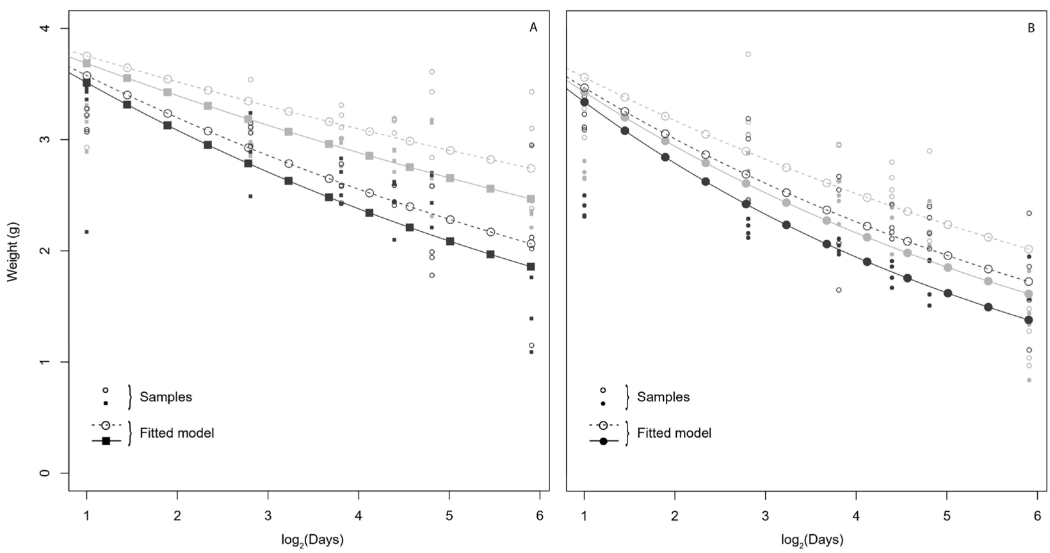

Figure 2. Final models fitted to the observed data. In both cases, time of the year and species influenced the decomposition rates. Panel A: first experiment, involving *E. grandis* vs. *L. molleoides*). Panel B: second experiment (*E. grandis* vs. *M. aquifolium*). In light gray: dry season; in dark gray: rainy season. Dashed lines: *E. grandis* (open circles in A and B); continuous lines: *L. molleoides* (squares in A) and *M. aquifolium* (closed circles in B).

inhibit the decomposing by microorganisms and benthic macroinvertebrate colonization, especially the shredders that directly consume leaf tissue (Bärlocher & Graça, 2002; Remor et al., 2013; Aragón et al., 2014; Kiffer et al., 2018).

The stream studied has high hydrodynamics (Vaz et al., 2017, 2019) and, according to these authors, it presents erosive processes upstream of the experiment area. This condition results in a large amount of inorganic material into its channel, causing an increase in fine granulometry and a simplification of the communities that inhabit the sediment, have contributed to the low decomposition of *E. grandis.* The sandy substrate after leaf deposition prevents weight loss and inhibits colonization of invertebrates (Telöken et al., 2014). Furthermore, there is strong evidence that degraded streams (silted and/or polluted) in tropical regions may have impaired decomposition processes (Gessner et al., 2010; Tagliaferro et al., 2019; Cionek et al., 2021). Besides, changes in tree species composition in riparian vegetation (due to changes in land use) may also affect the structure and functioning of streams due to variations in litter quality and quantity (Richardson et al., 2004; Kominoski et al., 2011) especially if the leaves are from *Eucalyptus*. In the present study, native species showed higher decomposition rates than exotic species, which reinforces these statements.

According to the classification for Brazilian streams proposed by Gonçalves et al. (2014), the decomposition rate in the dry period of the native species *Lithraea molleoides* was classified as intermediate while *Eucalyptus grandis* as low. The results of the decomposition rate of the experiment during the rainy season with the same species were classified as fast and intermediate respectively. In the experiments performed with the species *Maytenus aquifolium* and *Eucalyptus grandis* in the dry season they were classified as fast and intermediate, respectively, while in the rainy season they presented intermediate and intermediate decomposition rates. This is an important issue; decomposition rates appear to have been accelerated in the wet season for both experiments. The increase in abrasion and physical fragmentation in the rainy season seems quite plausible to explain the higher rates of decomposition in the rainy season observed in the experiments.

Kobayashi & Kagaya (2005) claim that the increase in flow during the rainy season probably increases physical abrasion and, consequently, has a strong effect on the disintegration of the leaf structure. According to Benfield et al. (2017), species-specific breakdown rates vary with the stream, location in the stream, time of year. Physical fragmentation caused by turbulence and water flow are key factors attributed by Gessner et al. (1999) and increase considerably in tropical streams in the rainy season due to the consequent increase in inflow and water turbulence. According to

Tiegs et al. (2019), temperature and precipitation are important variables that set limits on the breakdown rates, in rivers and riverside areas, which reinforces the influence of the rainy season. Gonçalves et al. (2014) claim that the highest decomposition rates are related to higher values of temperature. Under these conditions, the activity of microorganisms and shredders increases. The above report applies to the stream studied, because the mean values of the water temperature of the stream in the dry season were lower than the rainy season.

Thus, *Eucalyptus grandis* is a species with lower decomposition rates than native species, which may result in consequences for the supply of nutrients to neotropical streams, and the replacement of native species by eucalyptus plantations should be viewed with criteria, and preservation areas permanently used as a buffer against this possible impact. Although afforestation with *Eucalyptus grandis* can have consequences over time and in the quantity and quality of litter in streams, we can conclude based on the study carried out and on numerous others carried out in Neotropical streams that even low quality materials such as eucalyptus leaves can be used when under conditions that facilitate microbial activity, thus reducing the potential negative impact of such afforestation practices.

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