FINE LITTER DEPOSITION WITHIN TREE CANOPY OF A TROPICAL RAINFOREST IN CENTRAL AMAZON

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INTRODUCTION

As growing concern for environmental issues accelerates, including the concerns related to the biosphere - atmosphere interactions, studies of forest canopies are essential to our understanding of biodiversity, global atmospheric changes, and conservation of forests. The development of new methods of canopy access has enabled scientists to conduct more quantitative research in tree crowns, shifting the biological canopy science from a descriptive autecology of individuals to a more complex ecosystem approach (Lowman & Wittman 1996).

Canopy habitats, unlike forest floor habitats, are usually described as "rigorous"because tree crowns presumably have more limited storage capacity for available nutrients and water, more sporadic and dilute nutrient inputs, less physical stability, and more patchy "safe sites"for establish - ment (Ackerman & Montalvo 1990).

Fine litter dynamics within the canopy may differ from litter dynamics on the forest floor for three reasons: (1) Canopy litter may be ephemeral, as it can be removed from branches by within - canopy disturbances such as wind, rain, and arboreal animal activities; (2) Leaf litter in the canopy may be deposited in smaller amounts due to lack of input from subcanopy and understory vegetation; and (3) Due to microclimate and substrate differences, as well as differences in community structure and density of macroinvertebrate detritivores and microbial decomposer that affects decomposition rates (Nadkarni & Matelson 1991).

Plant litterfall is one of the most important components of the biogeochemical cycles of forest ecosystems (Proctor 1983). Despite several studies evaluating litter accumulation on the forest floor had been published, we found just few works reporting measurements of the amounts, characteristics or dynamics of suspended leaf litter in subcanopy (Alvarez - Sanchez & Guevara 1999, Dearden & Wardle 2008) and within tree canopy crowns (Nadkarni & Matelson 1991, Nadkarni *et al.,* 2004). There is no published paper about fine litter deposition within tree canopy of Amazonian Tropical Rainforests.

OBJECTIVES

The main aims of this work were: (1) Quantify the fine litter deposition on inner branches of tree crown in a tropical rainforest in Central Amazon, in order to estimate the indirect nutrient and organic matter transport from canopy to forest floor, and determine the input of potential allochthonous sources of nutrients for canopy tropical epiphyte communities; (2) Evaluate vertical variation of litter retention comparing litter deposition on canopy and forest floor.

Particularly we intend to answer de following questions: (1) Which is the potential of biomass fine litter retention within tree canopy crown in an Amazonian tropical rainforest? (2) What's the difference between canopy and forest floor fine litter deposition, and its implication on nutrients cycling and ecosystem functioning? (3) How structural characteristics of tree canopy branches may have an effect on fine litter retention? And finally, (4) Does tree crowns with more complex structure shows larger epiphyte density?

MATERIAL AND METHODS

Study area

This study was carried out in the Cuieiras Reserve of the Instituto Nacional de Pesquisas da Amazônia (INPA), located 60 km north from Manaus ($2^{0}35^{'}$S, $60^{0}06^{'}$W), during the end of the dry season, from October to November 2008. Five trees with diameter at breath height (DBH) larger than 35 cm and possible to be climbed by rope techniques were selected. These trees belongs to the most common species presents in a 100 m2 plot, in a plateau area, near to the flux towers of LBA project where soil litterfall measurements have been done since 2002.

Canopy fine litter deposition

To estimate the standing crop of canopy fine litterfall we collected accumulated fine litter resting on 25 accessible branches segments within 3 m from the central trunk on five sample trees. The branch segments selected cover a wide variation on branch width, angle and epiphyte density

that exists within tree crowns. We separated the samples of each branch segment by components (leaves, stems < 2 cm, stems > 2 cm, reproductive parts, bryophytes, roots and miscellaneous) and than oven - dried at 60^{0} C for 50 hs, until constant weight, and weighted.

Soil fine litter deposition

To quantify litter - layer mass accumulated on the soil surface, we collected five compound samples under the crown area of each sampled tree using a 20 x 20 cm aluminum frame. Soil samples were separated and oven - dried as canopy samples.

Inner crown branches structural characteristics

The following characteristics of branch segments of canopy trees were analyzed: horizontal angle (degrees), width (cm), length (cm), perimeter (cm) and height from the soil. Number of epiphytes by branch was also recorded. The effects of branch structural characteristics on canopy fine litter deposition were tested with simple linear regressions.

RESULTS AND DISCUSSION

The mean fine litter mass accumulated in the tree canopies was 374 g.m - 2 of the branch surface area (3.74 t.ha $^{-1}$), while mean soil litter - layer mass were 833 g.m $^{-2}$ (8.32 t.ha $^{-1}$). These values are close to other studies for the same area developed by Monteiro (2005) that found the highest amount of litter - layer mass for plateau areas (mean= 5.8 t.ha $^{-1}$; range= 3.6 to 9.2 t.ha $^{-1}$)at the end of the dry season, in November. According to Luizão & Schurbart (1986) this is the period of greatest litter accumulation, and since we collected at this time of the year, we found high values of litterfall. For Costa Rican Cloud Forests, Nadkarni and Matelson (1991) found a mean canopy fine litter mass around 170 g.m $^{-2}$ of the branch surface area, which corresponds to c.a. 1% of soil litter - layer mass on that area.

Therefore, comparing these two types of forest formations, our study site in an Amazonian Tropical Rainforest area presents greater values of canopy fine litter deposition than Costa Rican Cloud Forests. These results were expected considering that (1) wind is one of the main within - canopy disturbances on canopy fine litter interception, besides rain and arboreal animal activities impact, and (2) winds are strongest and consequently a more important factor in the Cloud Forests than on Lowland Rainforests. In Costa Rican Cloud Forests the wind speed above the canopy reaches about 50 km.h $^{-1}$ (Nadkarni & Matelson 1991) while for the plateau areas of Cuieiras reserve on Central Amazon Araújo and collaborators (2002) reported that the mean daily wind speeds recorded by the sonic anemometers at the top of the flux towers were 6.8 km.h $^{-1}$ quite constant throughout the year.

When we compared vertical variation of accumulated litter composition we saw that the stem component with less than 2 cm diameter dominates the canopy (174 g.m $^{-2}$) while leaves components predominate in soil samples(353 g.m $^{-2}$); followed by stem component (273 g.m $^{-2}$). This result was also expected because leaves used to be the main fine litter component and presents high decomposition rate, contributing significantly to faster nutrient cycling process (Luizão 1989). Stems are less susceptible to winds influence than leaves, suggesting a slower decomposition rate in the canopy compared to the soil. The few leaves that do remain in the canopy decompose slower than in the soil. Canopy leaf litter turnover time for Costa Rican Tropical Forests (2.8 years) is twice the soil leaf litter turnover time (1.4 yr). According to Nadkarni and Longino (1990), this low decomposition rate should be due to dry environmental conditions and low densities of canopy macroinvetebrates in the tree crowns. The bryophyte component was found just in the canopy samples suggesting that the soft material of this component is quickly decomposed in the canopies and didn't reach the forest floor in a recognizable way.

The branch structural characteristics had a general influence on canopy litter deposition, and more structurally complex trees had greatest number of epiphytes. Number of epiphytes, branch perimeter and height from the soil had significant effects on canopy litter accumulation (P= 0.001; 0.002 and 0.05 respectively) while horizontal angle, branch width and length, despite a positive tendency, had no significant effects. The great amplitude of variation on the canopy fine litter (79 to 1049 g.m $^{-2}$) somehow could be explained by branch structural differences. Canopy litter variation associated to height from the soil could be related to vertical stratification of wind speed. Wind reaches higher speeds in the canopy than in lower forest strata, therefore it is easier to remove litter from higher canopy branches. To our study area in central Amazon, annual mean wind speed above the canopy (52 meters height) was about 5.4 km.h $^{-1}$ and just 1.2 km.h $^{-1}$ in sub - canopy (28 meters height) for the year 2008 (LBA flux tower unpublished data). Even more, lower *strata* have a substantial cumulative contribution of the input of fine litter from subcanopy and understory increasing the amounts of litter deposition at these forest heights.

More detailed studies about canopy fine litter turnover and decomposition rate in Amazonian tropical rainforests are essential to increase the knowledge on nutrient cycling at different forest layers. In the same way, long term studies addressing different vegetation types (primary and secondary forests) and topographic positions (plateau, slope and valley) are necessary to clarify the seasonal dynamic of canopy fine litter deposition and to make comparisons between different forest types possible.

CONCLUSION

The mean fine canopy litter mass accumulated in the tropical rainforest in the Cuieiras Reserve, central Amazon, at the end of the dry season was less than a half of that accumulated on soil surface. The fine wood component dominates the canopy fine litter suggesting a slower decomposition rate in the canopy compared to the soil. The Amazonian tropical rainforest studied in central Amazon supports very higher fine litter intercepted in the canopy contrasted to others forest formations with strongest winds as in Costa Rican Cloud Forests. More structurally complex trees accumulated more litterfall within canopy, indicating that some structural characteristics of tree crowns should be responsible for the large range of canopy litter accumulation.

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