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Litterfall and nitrogen turnover in an Amazonian blackwater inundation forest

Caida de horajasca y ciclo de nitrógeno en un bosque de innundación en la región amazonica de aguas negras

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Abstract In 1976/77 energy flow and nutrient cycling in an Amazonian blackwater inundation forest were studied. The major part of the litter biomass turnover occurred during the emersion phase. 95% decomposition rate for nitrogen was measured with 15 mm mesh litter bags and was 4.7 years. Over 30 per cent of the annual leaf-fall was decomposed by soil-dwelling arthropods.

Resumen Durante los años 1976 y 1977 se estudiaron los flujos de energía y nutrimentos en un bosque de innundación en la región de aguas negras del Amazonas. La mayor parte de la caida de hojarasca ocurre durante la fase de aguas altas mientras que la mayor descomposición ocurrió durante la fase de aguas bajas. La tasa de descomposición para el nitrógeno en bolsas de 15 mm de malla, fue de 4.7 años para el 95%. Cerca del 30% de la caida anual de hojas fue descompuesta por artrópodos del suelo.

Introduction

The valleys of the Amazonian rivers are seasonally inundated. Water levels and inundation periods (which average about 6 months) change gradually within the inundation forest depending on the distance from the river bank. During the year of study inundation at the investigation site occurred from April to July. Most of the inundated areas are forested and these forests are affected by the chemical and physical conditions of the adjacent rivers. In 1976/77, we studied energy flow and nutrient cycling in an Amazonian blackwater inundation forest situated at Tarumã Mirím River about 15 km north of Manaus, Brazil. Litterfall, litter decomposition and energy flow and nutrient turnover in a soil-dwelling cockroach population were quantified. I present here the results concerning litterfall, litter decomposition, and N-cycling in this system.

Methods

Litterfall was measured using 1-m^2 open-top samplers. During the submersion phase, samplers were placed both at water surface and at ground levels in order to measure both litterfall and the net proportion of fresh litter that is lost *via* water flow.

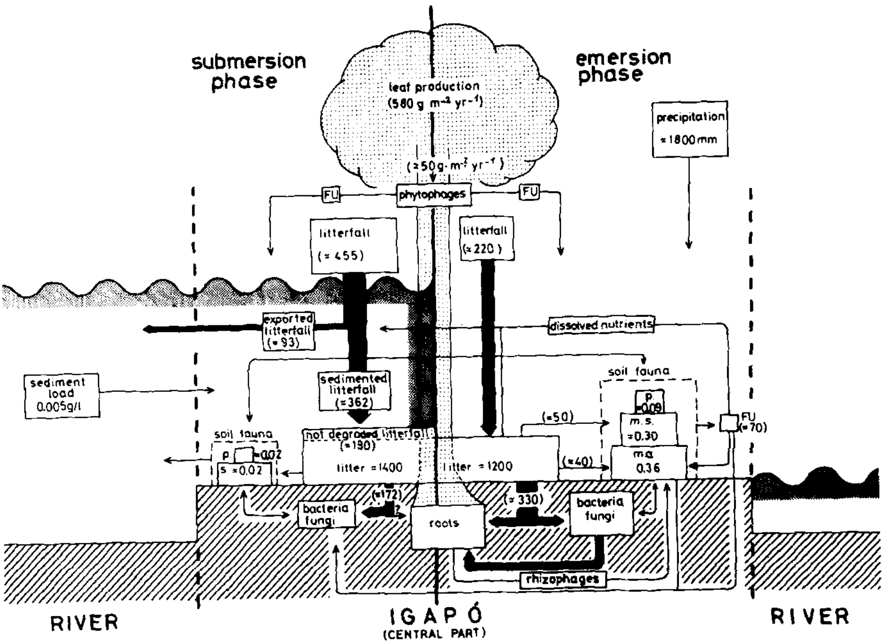

Fig. 1. Standing-crop biomass and production in the emersion and submersion phases of an Amazonian blackwater inundation forest. Values in parentheses refer to dry matter production, values without parentheses refer to standing biomass; p = predators, s = saprophagous fauna, ms = macro saprophagous fauna, ma = microarthropods. (From Irmler[2]).

Leaf litter decomposition was studied directly by monitoring weight and N loss from freshly-fallen leaves placed in 15-mm mesh bags and incubated on the forest floor for 100 days of the emersion phase[4]. Decomposition rates were also studied indirectly by feeding experiments with cockroaches[3]. Nitrogen was determined by Kjeldahl methods.

Results and discussion

Energy flow and nutrient turnover were investigated for both the submersion phase (SP) and the emersion phase (EP). Fig. 1 presents standing biomass, litterfall, and production data for each phase. The major part of the litterfall occurred during the inundation phase[1], although the major part of the litter turnover occurred during the emersion phase. 455 g dry litter m^{-2} fell during the submersion phase; of this, 93 g was lost *via* river flow and 172 g was decomposed during the submersion phase. Litterfall during the emersion phase was 220 g dry litter m^{-2}. The saprophagous fauna consumed about 90 g dry leaf litter m^{-2} during the emersion phase, or over 30% of the annual leaffall (not total litterfall) available to it; the remainder was presumably decomposed by bacteria or fungi[2].

Nitrogen was distributed in and transferred between the different components of the inundation forest ecosystem as listed in Tables 1 and 2. The input of nitrogen to the system *via* rainwater and water of the inundations was extremely

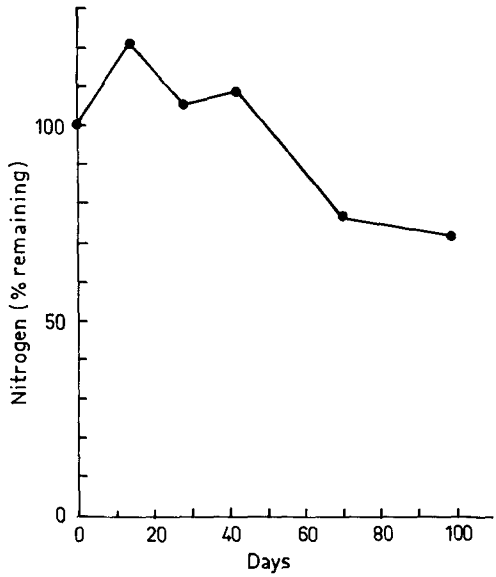

Fig. 2. Release of nitrogen from fresh leaf litter in 15 mm mesh bags during incubation on the forest floor for 100 days of the emersion phase in the blackwater inundation forest.

low. A major part of the system's total nitrogen content is in the standing vegetation, not investigated in this study. 13 g N m^{-2} was in the standing litter. Leaf-production resulted in a net apparent N-uptake of 11.25 g N m^{-2} yr^{-1}, of which 3.57 g N m^{-2} yr^{-1} was translocated back to the twigs before leaffall. Litterfall transferred 9.67 g N m^{-2} yr^{-1} to the forest floor. 1.31 g N m^{-2} yr^{-1} was lost by leaf export *via* river current during the inundation phase. The remaining 8.36 g N m^{-2} yr^{-1} in the litter was presumably mineralized. 95% decomposition for N was 4.7 years; Olson's[5] decomposition rate (k) was 0.64.

Fig. 2 shows the loss of litter-N from mesh bags during 100 days of the emersion phase. The N-concentration of the litter was between 1.2 and 1.5% N initially, and over 100 days, decreased to 1.0% N.

Investigations with cockroaches showed that litter was assimilated when it contained 1.4–1.5% N but not when it contained 1.0% N. This suggests that cockroaches feed mainly on fresh rather than older litter. Older leaf litter is probably assimilated only with dead animal biomass (*ca.* 14%N). The N-concentration of the cockroach feces was 1.5% N when cockroaches were fed animal biomass plus old litter (1.0% N), or about the same N-content as fresh litter, indicating that cockroaches may effectively redistribute nitrogen in the litter.

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Table 1. Nitrogen in litter and soil invertebrates of the blackwater inundation forest, and in river water at time of peak flooding. Biomass values are on dry-weight basis

Component	Mass $g\,m^{-2}$	Nitrogen	
		%	$g\,N\,m^{-2}$
Litter	1300	1.0	13.0
Soil invertebrates	0.75[b]	13.9	0.11
River water	3×10^6	40×10^{-6}[a]	1.2

[a] 0.40 mg N l^{-1}.
[b] From Irmler[2].

Table 2. Nitrogen fluxes in various parts of the blackwater inundation forest. Exported litter is the difference between submerged and nonsubmerged litter traps during the submersion phase

	Mass $g\,m^{-2}\,yr^{-1}$	N-content %	N-flux $g\,N\,m^{-2}\,yr^{-1}$
Bulk precipitation	2.2×10^6[a]	44×10^{-6}[b]	1.0
Leaf production	580[c]	1.94	11.3
Litterfall	675	1.44	9.72
Exported litter	93	1.44	1.31
Soil-invertebrate feces	90[c]	1.52	1.37

[a] 2200 mm.
[b] 0.44 mg Kjeldahl-N l^{-1}.
[c] From Irmler[2].
[d] Emersion phase values are 1.8×10^6 g H_2O $m^{-2}\,yr^{-1}$, and 0.8 g N $m^{-2}\,yr^{-1}$.

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