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Organic matter in termite mounds of an Amazonian rain forest

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ABSTRACT

This study investigates how termites alter the organic matter in rain forests near Manaus, Brazil. Samples were collected from the outer and inner parts of typical termite nests of *Nasutitermes, Termes, Embiratermes, Cornitermes, Anoplotermes,* and *Constrictotermes* genera, as well as from the surrounding topsoil (0-10 cm) and potential wooden food. The termite nests were significant sinks for organic matter and its associated nutrients. The organic C contents ranged between 100 and 500 g kg^{-1} in the nests, compared to 17 to 42 g kg^{-1} in the surrounding topsoils. As lignin contents of the mounds were higher than in wood, lignin may be accumulated in preference to other organic compounds. Our findings also suggest that the interior part of the nests is a region of higher organic matter turnover and lignin degradation.

RESUMO

Este estudo investiga como térmitas alteram a matéria orgânica em florestas tropicais perto de Manaus, Brasil. Foram colecionadas amostras das partes exteriores e internas de cupinzeiros típicos dos gêneros *Nasutitermes, Termes, Embiratermes, Cornitermes, Anoplotermes*, e *Constrictotermes*, como também da camada superior de solo na vizinhança (0-10 cm) e da madeira como potencial fonte alimentar. Os ninhos de térmitas foram significantes depósitos de matéria orgânica e dos nutrientes associados. Os conteúdos de C orgânico variaram entre 100 e 500 g kg^{-1} nos ninhos, comparados com 17 a 42 g kg^{-1} no solo. Como conteúdos de lignina eram mais altos nos cupinzeiros que em madeira, lignina pode ser acumulada nos ninhos em preferência a outros compostos orgânicos. Nossos achados também sugerem que a parte interior dos ninhos é uma região de processamento de matéria orgânica e de degradação de lignina acelerados.

ZUSAMMENFASSUNG

Diese Arbeit untersucht, wie Termiten die organische Substanz in Regenwäldern bei Manaus, Brasilien, verändern. Proben der äußeren und inneren Teile typischer Termitenester der Gattungen *Nasutitermes, Termes, Embiratermes, Cornitermes, Anoplotermes*, und *Constrictotermes*, sowie vom umliegenden Oberboden (0-10 cm) und von potentiell als Nahrungsquelle dienendem Holz wurden gesammelt. Die Termite-Nester waren signifikante Senken für organisches Material und seine assoziierten Nährstoffe. Die Gehalte an organischem C schwankten zwischen 100 und 500 g kg^{-1} in den Nestern, im Vergleich zu 17 bis 42 g kg^{-1} im umliegenden Oberboden. Da die Ligningehalte der Nesthügel höher

waren als im Holz, wird Lignin vielleicht mehr als andere organische Verbindungen akkumuliert. Unsere Ergebnisse suggerieren auch, daß der innere Teil der Nester ein Bereich mit höheren Umsatzraten organischer Substanz und schnellerer Ligninzersetzung ist.

INTRODUCTION

Termites play a key-role in organic matter cycles of tropical ecosystems. High densities of termite mounds are found in Amazonian rainforests (Martius, 1994). Since termites are unable to decompose lignin at a significant scale (Kuhnigk et al., 1994), lignin should accumulate in their mounds. This study was to investigate how termites alter the organic matter in the rain forest around Manaus, Brazil.

MATERIAL AND METHODS

Samples were collected from the outer and inner parts of typical termite nests of *Nasutitermes, Termes, Embiratermes, Cornitermes, Anoplotermes,* and *Constrictotermes* genera, as well as from the surrounding topsoil (0-10 cm; *Xanthic Ferralsol*; FAO-UNESCO, 1997) and potential wooden food. All nests were sampled in primary rainforest at the Embrapa Amazônia Ocidental near Manaus in Central Amazonia. One *Nasutitermes* nest was collected in a plantation at the Embrapa; some additional samples were taken in black-water floodplain forests (igapó) on the river Taruma Mirim, near Manaus and in a white-water floodplain forest on Ilha de Marchantaria, Rio Solimões/Amazonas. Present chemical analysis is still in progress but included the determination of organic C, N, and S by dry combustion (C/H/N/S analyzer, Elementar), and lignin-derived phenols (Hedges and Ertel, 1982; modified by Amelung et al., 1997)

RESULTS AND DISCUSSION

The organic C contents ranged between 100 and 500 g kg^{-1} in the nests, compared to 17 to 42 g kg^{-1} in the surrounding topsoils. The C and N contents in the nests exceeded those of topsoils by a factor of 6-18 and 4-5, respectively. Termite nests were thus significant sinks for organic matter and associated nutrients (Table 1). Lignin contents in wood (< 200 g kg^{-1}) were eventually even lower than in mounds (Figure 1), i.e., lignin is accumulated in preference to other organic compounds.

Except for *Nasutitermes sp.*, there was no significant difference in organic C between the samples from exterior and interior of the nests. In the mounds of the xylophagous *Nasutitermes sp.*, however, the nest interior had significantly lower C contents and C/N ratios than the exterior (Table 1). This seems to be accompanied by lower lignin contents and higher degree of lignin side-chain oxidation, as indicated by higher ratios of phenolic acids to phenolic aldehydes (Figure 1). Apparently organic matter turnover including oxidation of lignin is advanced in inner nest regions compared to external parts. As lignin oxidation might not have taken place in the gut of the termite itself, more research is required to clarify the role of symbiotic microorganisms to the biochemical transformations of organic matter. This might be achieved by future analyses of the nest material with respect to different enzyme activities and microbial biomarkers, such as amino sugars.

Table 1: Total C, N, and S contents in the mounds of *Nasutitermes* (n = 6; 2 nests each at Vàrzea, Igapó, Terra Firme), of other termite genera (2 nests each at Terra Firme), and in surrounding topsoils.

Genus	Nest region	C	N	S	C/N
			g kg^{-1} material		
Nasutitermes sp.	exterior (A) part	490 ± 18a[†]	12 ± 1.9h	1.7 ± 0.4m	42o
Nasutitermes sp.	intermediate (B) part	490 ± 12a	11 ± 1.7h	1.7 ± 0.4m	45o
Nasutitermes sp.	interior (C) part	450 ± 23b	12 ± 3.4h	1.7 ± 0.4m	39o
Embiratermes sp.	average A - C	199 ± 14ef	11 ± 3.1j	1.3 ± 0.1m	19p
Cornitermes sp.	C[‡]	380 ± 16c	17 ± 1.2i	2.4 ± 0.1*l*m	23p
Anoplotermes banksi	average A - C	168 ± 21f	11 ± 3.2j	1.2 ±0.1m	16p
Constrictotermes sp.	average A - C	303 ± 30d	17 ± 2.5i	3.1 ± 1.5*l*	18p
Termes sp.	average A - C	242 ± 52e	9 ± 2.9j	1.6 ± 0.3m	28op
Surface soil (0 - 10 cm)	-	27 ± 13g	2.3 ± 0.8k	0.4 ± 0.06n	12q

[†]Different letters within a column indicate that the corresponding values differed from another at the $p < 0.05$ level of significance (assessed by multivariate analysis of variance); [‡]A,B = soil material.

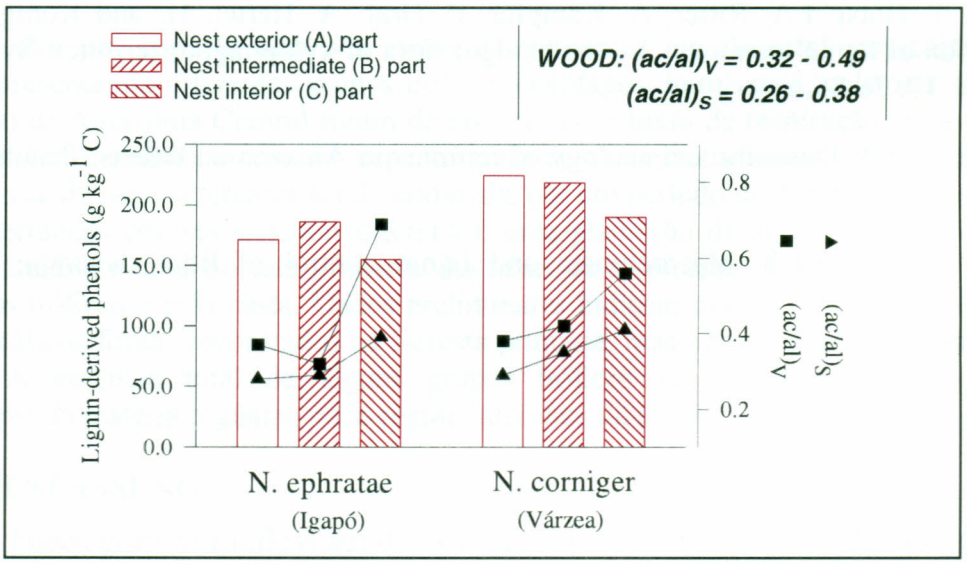

Figure 1: Lignin-derived phenols and ratios of phenolic acids to aldehydes (ac/al) of the vanillyl (V) and syringyl (S) structural units at different nest parts of *Nasutitermes* (N.). The ac/al values from our wood samples are given for comparison.

SUMMARY AND CONCLUSION

Termite mounds under study were preferred sinks for organic C and, to lesser extent, also for N and S. The termites selectively preserved lignin. As high lignin contents decelerate organic matter decomposition (Meentemeyer, 1978), this lignin accumulation could contribute to the stabilization of termite nests against microbial decay.

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