

Decayed Wood Affecting the Attraction of the Pest Arboretum Termite *Nasutitermes corniger* (Isoptera: Termitidae) to Resource Foods

by

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ABSTRACT

Nasutitermes corniger shows preferential feeding for the wood of different tree species, but it is not known whether attractiveness is a function of the state of decay. This study examined the foraging behavior of *N. corniger* towards wood in different stages of decay. Wood was exposed to weather for durations of 0, 3, 6 or 9 months. Then the wood was placed in a standard foraging arena with termites. Exploration and recruitment behavior were recorded for 1 h. Separate bioassays were conducted for three species: *Pinus elliottii*, *Eucalyptus grandis* and *Manilkara huberi*. In the tests with *P. elliottii* and *E. grandis*, more individuals were recruited to wood decayed for 6 months (191 and 185, respectively) than to undecayed wood (12 and 69, respectively). Similarly, more individuals were recruited to decayed *M. huberi* wood than undecayed, but only after 9 months (249 and 7, respectively). Decayed wood has therefore been demonstrated to be more attractive to *N. corniger* than undecayed wood. The different decomposition rates necessary to increase attractiveness may be explained by differences in wood density.

Key words: decaying wood, foraging behavior, *Nasutitermes*, recruitment, termites, wood-decomposition.

INTRODUCTION

The termite *Nasutitermes corniger* (Motschulsky) is one of the most harmful arboreal species in Brazil, where it causes damage to wood on buildings and

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indoor structures. Control is difficult owing to the construction of polycalic nests, which are often some distance from the point of infestation (Mill 1991; Costa-Leonardo 2002; Vasconcellos & Bandeira 2006).

Existing methods to reduce damage in urban areas are based on backfill barriers of potent residual insecticides as well as chemical wood treatment (Su & Scheffrahn 1998). Alternative methods based on baits impregnated with small amounts of insecticide are preferred to reduce the risk of accidental poisoning and environmental contamination (Su & Scheffrahn 1993; Su & Scheffrahn 1998; Rojas & Morales-Ramos 2001). These have been used successfully in the control of subterranean termites of the genera *Coptotermes* and *Reticulitermes*, but have so far been ineffective with *Nasutitermes* termites (Su 1994; Costa-Leonardo 2002). Originally, *N. corniger* was assumed not to discriminate between the wood of different plant species (Bustamante 1998). However, Gazal *et al.* (2010) showed that *Eucalyptus grandis* was more heavily attacked than *Pinus elliottii* and *Manilkara huberi* wood, when offered simultaneously. Another factor that could influence the choice of *N. corniger* is the degree of wood decomposition. A positive effect of wood decay on attractiveness has been demonstrated in other termite species (Lenz *et al.* 1980; Lenz *et al.* 1991; Bustamante 1998).

This study aimed to investigate the attractiveness of wood altered by decomposition processes to *N. corniger*, with the intention of developing more suitable baits.

MATERIAL AND METHODS

Maintenance of Termites in the Laboratory

Twenty mature colonies of *N. corniger* (with alates termites present) were collected from trees located in different non-urban areas. The colonies were established in glass containers 50 × 40 × 60 cm and maintained under laboratory conditions of 25 ± 5°C, 85 ± 5% relative humidity (R.H.) and 10:14 h light:dark cycle (Gazal *et al.* 2010). Each colony was connected by a silicone tube (8 mm in diameter) to an exclusive foraging arena consisting of a 50 × 50 cm glass plate with a 5 cm high perimeter wall. To avoid pre-conditioning to the wood types used in the experiments, prior to the experiments the termites were fed with cedar wood, *Cedrela odorata* L. (Meliaceae) and *Hymenolobium elatum* Ducke (Fabaceae).

Wood

In the experiments, wood from the following trees was used: pine, *Pinus elliottii* Engelm. (Pinaceae); eucalypt, *Eucalyptus grandis* Hill (ex Maiden) (Myrtaceae); and massaranduba, *Manilkara huberi* Ducke (ex Chevalier) (Sapotaceae). These woods have very different densities (0.55, 0.81 and 1.10 g/cm³, respectively) and geographic origin: *Pinus elliottii* originated from the United States, where it is considered a forest species of great importance (Drescher *et al.* 2001); *E. grandis* is native to the east coast of Australia; and *M. huberi* originated from Brazil's Amazon region (Azevedo *et al.* 2007).

The wood densities were calculated after determining the dry mass of a piece of freshly fallen wood of known volume. The three wood species were cut into pieces of 5 × 2 × 2 cm and a part of these wood was stored in a room at 15±5°C and 50±5% R.H. for a duration of 9 months to prevent decomposition (undecayed wood or control). The other part of the wood was exposed to weathering for 3, 6 or 9 months (decayed wood), respectively. The wood was exposed to weather as a monolayer on the terrace of the laboratory. The 9-month decay period began in June 2006, the 6-month period in September and the 3-month period in December of the same year, so they ended on the same date in March 2007 when the tests began. Rainfall, temperature, relative humidity and radiation data were recorded.

Bioassays

The bioassays were carried out separately for each of the three wood species. All the tests were carried out between 1:00 and 6:00 PM since a preliminary test in laboratory conditions demonstrated that *N. corniger* does not have a daily activity rhythm. Before beginning the tests, the linking tube from the nest to the foraging arena was obstructed with mineral cotton for 15 minutes to prevent the entrance of insects into the arena. Immediately, the maintenance food was removed and the termites within it were transferred to the nest. Then, the treatments (decayed pieces of wood of the same species by 3, 6 and 9 months) and the control (one undecayed piece of wood) were placed in the arena on separate glass plates of 5 × 2.5 cm, 10 cm apart from each other, equidistant (20 cm) from the point of access. For each test, the position of the treatment and control wood in the arena was randomized. The tests began when the access of the termites to the arena was reopened. Each experiment was carried out on twenty colonies of termites (n = 20).

The tests started when the first termite contacted one of the wood samples. We then recorded the occurrence of: a) initial exploration, b) initial recruitment and c) massive recruitment behavior.

Initial exploration was considered to be when the first soldier made contact with a piece of wood, pressed its abdomen against it and then returned to the nest. Initial recruitment was considered to be when the first workers arrived at the wood source. Massive recruitment was considered to be when a large number of workers arrived at the wood source via a trail (Gazal *et al.* 2010).

After 1 h of observation, the plates containing wood and the termites present on them were removed and the termites present on each plate were counted.

The proportions in which the behaviors initial exploration, initial recruitment and mass recruitment occurred in the tests were compared between the decayed wood treatments and the undecayed wood (control) with Chi-square tests. The number of termites recruited at the end of the tests was compared by ANOVA and the means compared by Tukey's test ($p < 0.05$). Due to the lack of normal distribution these data were log-transformed (Ln).

RESULTS

The climatic conditions to which the wood types were exposed are presented in Table 1. Only one of the climatic variables differed between treatments. Solar radiation was highest in the 3-month treatment (Kruskal–Wallis, $H_{1,350} = 11.97, P < 0.001$). This treatment was performed in the summer months only, when radiation is invariably higher. The mean of other variables (rainfall, relative humidity and temperature) did not differ significantly between treatments (Kruskal–Wallis test). Therefore, the time of exposure to weather was assumed to be the main factor causing differences between the treatments.

The first contact of the termites with one of the wood pieces generally occurred a few minutes after opening the access to the arena. Initial exploration, initial recruitment and mass recruitment were observed to undecayed wood as well as to decayed wood, regardless of the treatment and species wood type (Table 2).

The proportion of initial exploration and initial recruitment did not differ between undecayed and decayed wood. However, the proportion of

Table 1. Mean daily rainfall (frequency and volume), temperatures (minimum and maximum), relative humidity and solar radiation during weather exposure of wood decomposition treatments (3, 6 and 9 months).

Treatment (months)	Rainfall		Temperature		Relative humidity (%)	Solar radiation (Wm ⁻²)
	Frequency (n)	Volume (mm)	min. (°C)	max. (°C)		
0 (control)	0.0±0.0	0.0	10.0±0.3	20.0±0.2	50.0±5.0	0.0
3	0.5±0.1	6.3±1.5	21.4±0.1	30.2±0.3	84.0±0.7	237.0±8.0
6	0.5±0.1	5.2±1.0	20.2±0.2	28.6±0.3	83.0±0.6	218.0±6.0
9	0.4±0.1	3.8±0.6	19.0±0.2	28.3±0.2	81.2±0.5	204.4±4.7

*significant difference in Kruskal–Wallis tests, $P < 0.01$.

Table 2. Percentage of tests with occurrence of the three phases of foraging behavior (exploration, initial recruitment and massive recruitment) of *Nasutitermes corniger* on wood exposed to ambient conditions for 0 (control), 3, 6 and 9 months (treatments). The tests were replicated five times on four termite colonies ($n = 20$). Experiments were performed separately with wood of *Pinus elliottii*, *Eucalyptus grandis* and *Manilkara huberi*.

Wood species	Treatment (months)	Behavioral event		
		Initial exploration (%)	Initial recruitment (%)	Massive recruitment (%)
<i>P. elliottii</i>	0 (control)	95	80	10
	3	90	65	30 ^{ns}
	6	85	85	60*
	9	90	75	40 ^{ns}
	0	95	80	15
<i>E. grandis</i>	3	90	75	25 ^{ns}
	6	95	90	65*
	9	95	70	45 ^{ns}
	0	80	65	10
<i>M. huberi</i>	3	85	65	20 ^{ns}
	6	80	75	30 ^{ns}
	9	95	80	50*

*significant difference from the control in χ^2 tests, $P < 0.05$.

massive recruitment of termites to decayed wood was always greater than to undecayed wood.

In the tests with *P. elliottii*, recruitment was highest to wood exposed to weather for 6 months (12/20 vs 2/20 to undecayed wood, $\chi^2=8.90$, $P < 0.01$). A similar result was observed in tests with *E. grandis* (13/20 vs 3/20

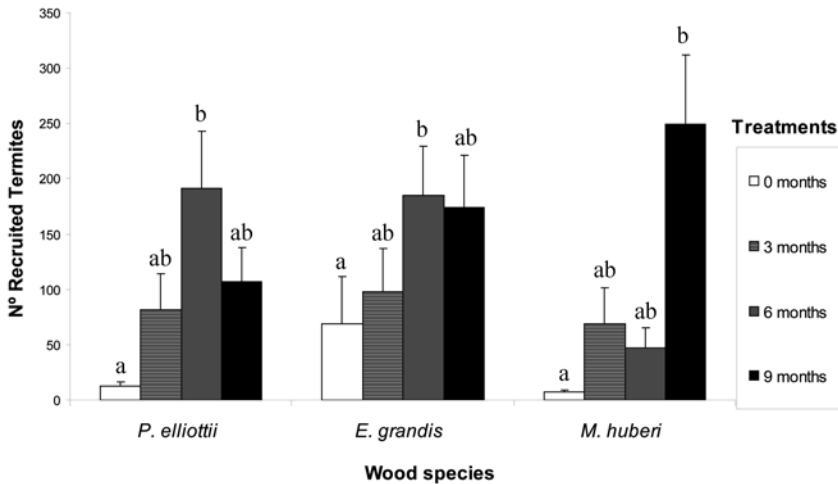


Figure 1. Number of *Nasutitermes corniger* termites recruited [Ln] (mean \pm SE) after 60 min to undecayed and decayed wood (3, 6 and 9 months) in a foraging choice arena. Separate experiments were conducted with the wood of *Pinus elliottii*, *Eucalyptus grandis* and *Manilkara huberi*. Different letters indicate significant differences between wood treatments in Tukey tests, $P < 0.05$.

undecayed wood, $\chi^2 = 8.44$, $P < 0.01$). The total number of termites recruited to decayed wood (6 months) at the end of the tests was also higher than to undecayed wood, both for *P. elliottii* (191.4 ± 51.9 vs 12.4 ± 4.1 , $F_{3,76} = 3.44$, $P < 0.05$) and for *E. grandis* (185.2 ± 44.6 vs 69.0 ± 42.8 , $F_{3,76} = 3.82$, $P < 0.05$). This behavior was similar among the different replications ($F_{19,220} = 0.97$, $P = 0.41$).

In tests with *M. huberi* mass recruitment happened more times on decayed wood than on undecayed wood (10/20 tests vs 2/20 tests, $\chi^2 = 5.83$, $P < 0.05$), but in this case to the wood exposed to weather for 9 months (Table 2). Similarly, more termites were also recruited to decayed wood exposed for 9 months than to undecayed wood (249.4 ± 62.9 vs 7.3 ± 2.1 , $F_{3,76} = 2.91$, $P < 0.05$, Fig. 1).

DISCUSSION

Attacks by *N. corniger* to the undecayed wood of *Pinus elliottii*, *Eucalyptus grandis* and *Manilkara huberi* were recently described by Gazal *et al.* (2010). Given that the termites attacked the undecayed wood of all three species, even in situations in which decayed wood was also available, decay may not be a

prerequisite for termite attacks (Esenther *et al.* 1961). On the other hand, the occurrence of mass recruitment to decayed wood of the three species indicates that the decay process was not restrictive to exploitation of wood as a resource. In our experiments, pine and eucalypt wood decayed for 6 months and massaranduba wood decayed for 9 months recruited more termites than the undecayed wood. Increase attractiveness of decomposed wood to termites may be a consequence of changes in nutritional value due to the action of fungi. The wood decomposition process can release toxic compounds, but can also increase nutrient availability (Waller & La Fage 1987). Further, changes in the physical structure caused by depolymerization of cellulose, including cell wall thinning, bore hole formation and rounded pit erosion, may ease fiber removal (Erwin *et al.* 2008). In addition, allelochemicals that influence the foraging behavior of termites may also be released (Cornelius *et al.* 2002), some of which, for example, may trigger trail following (Esenther & Beal 1979; Rust *et al.* 1996). Extracts from decayed wood have been used to direct subterranean termite foraging toward a bait station (Su 2005).

In this study, *P. elliotii* and *E. grandis* wood was most attractive to termites after a decay period of 6 months, but *M. huberi* wood was most appealing after a decay period of 9 months. This difference may be due to lower rates of water retention of dense wood resulting in slower decomposition (Bultman & Southwell 1976). Wood with higher density, such as *M. huberi*, may need to be exposed to the weather for longer to undergo chemical or physical changes equivalent to that occurring in eucalypt or pine wood.

Contrary to expectation, *E. grandis* and *P. elliotii* decayed for 9 months were not preferred to undecayed wood. This indicates a drop in attractiveness at a certain point in the decomposition process. A similar response was found in studies with the termites *Coptotermes formosanus* Shirak and *Reticulitermes flavipes* Kollar, when wood decayed for 8 weeks was preferred to the undecayed wood, but wood decayed for 12 weeks was not (Cornelius *et al.* 2003). Perhaps the ease of fiber removal or gains in nutritional quality in the short term do not compensate indefinitely for nutrient losses associated with the decomposition process longer. Alternatively, increased attractiveness may be offset by the simultaneous production of toxic or repellent chemicals.

Wood is often used as a bait substrate to facilitate the distribution of insecticide within termite colonies. In this study, we found that undecayed

and decayed wood offered together are attractive food sources for *N. corniger*. However, differences in the mass recruitment of foragers suggested that this termite species is more attracted to decayed wood. Therefore, it may be beneficial to use decayed wood when preparing insecticide-impregnated baits for *N. corniger* termites.

Future research is needed to determine whether increased recruitment to decayed wood is a result of physical or chemical changes in the wood, and also to investigate the role of different decomposing agents in this process.

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