FEEDING PREFERENCE OF SUBTERRANEAN TERMITES FOR FOREST SPECIES ASSOCIATED OR NOT A WOOD-DECAYING FUNGI

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ABSTRACT

This study was performed with the aim of determining the "natural" wood preferences of subterranean termites (Isoptera) in a field feeding experiment, giving a choice between a control (*Pinus* sp.) and test woods: three species of *Eucalyptus*. Feeding preference order of subterranean termites was *Pinus* sp. > *Eucalyptus robusta* ≅ *Eucalyptus urophylla* > *Eucalyptus pellita* by the percentage of subterranean termite-damaged wooden stakes at 30-, 45-, and 60-day exposure periods in the field. Three species of subterranean termites were identified: *Heterotermes longiceps* (Snyder) (Rhinotermitidae), *Coptotermes gestroi* (Wasman) (Rhinotermitidae), and *Nasutitermes jaraguae* (Holmgren) (Termitidae). This is the first record of occurrence of *H. longiceps* in the state of Rio de Janeiro. Unidentified fungi species of Basidiomycetes infected the wood stakes of all forest species tested; although none of them were attacked by subterranean termites.

Key words: wood-feeding termite, *Eucalyptus*, Basidiomycetes

INTRODUCTION

Termites are responsible for much of the degradation of wood and other celluloses in the terrestrial environment. So termite's feeding activity constitutes an important component of nutrient and energy cycling, especially in tropical ecosystems where termites are abundant (Wood & Sands, 1978; Schaefer & Whitford, 1981).

There are many factors affecting the feeding activity of termites on woods. Wood characteristics influence the feeding activity of termites. Depending on the characteristics of the wood species, initiation, maintenance or cessation of feeding by termites may follow their exposure to a wood species. Physical, mechanical and chemical properties of the wood are probably interdependent and results in variability in wood characteristics, which will ultimately cause variability in wood resistance to termites. For example, some antitermitic chemical compounds may be found in forest species like terpenoids and quinones that act as a natural repellent for termites (Nagnan & Clement, 1990; Scheffrahn, 1991; Grace, 1991).

Among the physical factors, the wood density influence the termite's ability to fragment the wood

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mechanically with its mandibles (Bultman et al., 1979).

The subterranean termite species are by far the most destructive, most widely distributed, and can cause serious damage to unprotected wood structures or to other cellulosic materials in a short time (Bultman & Southwell, 1976).

According to Sem-Sarma & Chatterjee (1970), termite resistance of wood can be tested by field and laboratory testing; however, field trials are realistic and meant only against subterranean termites. Also, in the field trials, the collective and cumulative effects of all kinds of abiotic and biotic deterioration factor can be evaluated.

In this context, we performed this study with the aim of determining the “natural” wood preferences of subterranean termites in a field feeding experiment, giving a choice between a control (*Pinus* sp.) and three *Eucalyptus* test species. Eucalyptus, because of their fast growth, climatic resistance and their desirable pulping properties (Malan, 1989), form the basis of commercial and rural forestry operations in many tropical and subtropical countries, including Brazil; however, they are particularly susceptible to attack by termites (Atkinson et al., 1992).

MATERIAL AND METHODS

The experiment was set from July 24, 2000 up to 60 days. It was carried out in a 2,000 m^2 backyard garden area in the residential area of the Universidade Federal Rural do Rio de Janeiro (UFRuralRJ) in Seropedica, state of Rio de Janeiro at which two subterranean termite infestation spots were found. This area was selected based on the studies of Bicalho (2000). The city of Seropedica is located in the southeast of Brazil at 22^o 46’S latitude, 43^o 41’W longitude and 33 m above sea level. According to Köppen classification, the climate is Cwa defined as humid-warm, with a dry winter (June-August) and summer rainy season (December-February), with mean annual temperature of 22.7^{o}C and yearly average rainfall of 1200 mm (FIDERJ, 1976).

Wooden pieces, 5.0 m long with a diameter of 10.5 cm, were supplied by the Department of Forest Products at the UFRuralRJ, and cut from heartwood or sapwood of 8-year-old trees of *Pinus* sp. and three species of *Eucalyptus*: *E. pellita* F. Muell. (red mahogany), *E. urophylla* S.T. Blake (Timor mountain gum), and *E. robusta* Sm. (swamp mahogany).

The wood density as a physical factor of the natural resistance of wood to termite was determined based on the method proposed by Vital (1984). Three wood samples of 3.5cm thick with a diameter of 10.5 cm were cut from the wooden pieces, and submerged in water for six weeks. After this period, each sample was submerged in water in a 1-L beaker, which was placed on a eletronic weighing machine to record the weights, and referred to the volumes. Subsequently the samples were oven-dried at 100ºC for four days, and then weighed in order to determined their dry weights. The wood density was defined as mean dry weight divided by the mean volume of the wood samples, and expressed as grams per cm^3. Based on the density values, the forest species were classified as softwood ($\geq$ 0.50 g/cm^3), wood of intermediate hardness (0.51-0.72g /cm^3) or hardwood ($\leq$0.73g/cm^3), according to Melo et al. (1990).

The experiment consisted of sixty stakes of each forest species that were used as termite bait. Stakes of 2.5 cm long by 3.0 cm of width and 2.5 cm thick were cut from the wooden pieces, and oven-dried at 100ºC for 24h. Afterwards, the stakes were submerged in water contained in 35-L plastic buckets for different immersion periods: 0, 24, 48 and 72 hours.

Before testing, the top of the eucalyptus stakes was painted in different colors to identify the wood species: black (*E. pellita*), white (*E. robusta*) and green (*E. urophylla*), and water immersion periods were marked down on the respective stakes.

The stakes were driven vertically into the soil approximately 1/5 of the total length protruded above ground level in a 260m^2 area of the backyard garden containing two infestation spots of *Coptotermes gestroi* (Wasnann). The soil was previously cleared of leaves, debris, spontaneous vegetation and weeds, and the stakes were installed in groups of four (one of each forest species) at 0.5m intervals. The stakes were removed from the soil at 30, 45 and 60 days after then installation for inspection of infestion by subterraean termites and other deterioration factors such as fungi and insect borers. Termite specimens were collected, preserved in labeled vials filled with 80% alcohol and sent to Prof. Reginaldo Constantino (Unb, Department of Zoology, Brasilia, DF, Brazil) for species identification. The stakes damaged by other wood-destroying organisms were taken to the laboratory of the Centro Integrado de Manejo de Pragas Urbanas e Rurais (CIMPUR) at UFRuralRJ for identifying the agents.

The experiment was installed in the field following a completely random design with 4 x 4 factorial selection of treatments (four forest species and four water immersion periods), basing on an arrangement in split-splot in the time (30, 45 and 60 days of exposition in the field), with five replicates. Each stake constituted an experimental unit.

Preference of subterranean termites among forest species was determined by the percentage of termite-damaged stakes within the different water immersion periods at each field exposure period.

Differences in wood preference among the forest species, the time of water immersion of the stakes and the exposure period of the stakes in the field were compared using analysis of variance (ANOVA) and Fisher's test ($\alpha = 0.05$). Average results were tested for significance at the 5% level, and separated using the Tukey's test. The statistical tests were performed using Sisvar v 4.3 software.

RESULTS AND DISCUSSION

The wooden stakes were mainly infested by the following subterranean termite species: *Heterotermes longiceps* (Snyder) and *Coptotermes gestroi* (Wasmann) (Isoptera: Rhinotermitidae). *H. longiceps* was collected 30 days after the experiment was started, while *C. gestroi* occurred at 45- and 60-day field exposure periods. This suggests that agonistic response may have occurred between colonies of these two species, which probably resulted in a takeover of *H. longiceps* foraging site by *C. gestroi*. Interespecific encounters among termite colonies resulting in agonistic response were observed by Springhetti & Amorelli (1982) and Thorne (1982). Field observation by Su & Scheffrahn (1988) revealed two incidents in which foraging sites of *Reticulitermes flavipes* (Kollar) was taken over by *Coptotermes formosanus* Shiraki. Additionally, food selection by *C. gestroi* is possibly influenced by thigmotaxic cues on the surface of wood stakes damaged by *H. longiceps*. Thigmotaxic attraction was documented by Usher (1974) for *Pseudacanthotermes militaris* (Hagen). Delaplane & La Fage (1989) observed that *C. formosanus* preferred wood damaged by *Reticulitermes virginicus* (Banks) over undamaged woods. However, wood previously damaged by conspecifics from another colony of *C. formosanus* was the most preferred wood. This is the first record of occurrence of *H. longiceps* in the state of Rio de Janeiro (Constantino, 2001).

Nasutitermes jaraguae (Holmgren) (Isoptera: Termitidae) also occurred at the end of the period of experimentation, i.e. at 60 days, but it attacked stakes other than those damaged by *C. gestroi*. These two subterranean termite species do not appear to compete heavily for wood species tested, maybe because they maintain mutually exclusive ecological niches through, for example, distinctive modes of attack and/or specific wood preferences.

However, there was not a significant difference on percentage of termite-damage stake of each forest species among the four times of water immersion at all field exposure periods. There was evidence of wood preference according to wood density and the field exposure period. *Pinus* sp. as softwood (0.43g /cm³) was significantly preferred over *Eucalyptus* species at all field exposure periods, and accounted for more than 42% of all termite-attacked stakes (Figure 1). The least preferred wood was *E. pellita*, a density of 0.53g /cm³, although not significantly when compared with *E. robusta* (0.41g /cm³) and *E. urophylla* (0.68g /cm³) at 30- and 45-day exposure periods (Figure 1). At the end of experimentation, i.e., 60 days after, none of the *E. pellita* stakes was damaged by termites (Figure 1). Laboratory studies conducted by Creffield et al. (1985) showed that the wood of *Pinus radiata* was more resistant to attack by *Coptotermes acinaciformis* than *E. regnans* for a period of 56 days. The results of the present study showed the opposite for *H. longiceps*, *C. gestroi* and *N. jaraguae*, i.e., the pine wooden stakes seemed to be more susceptible to attack by subterranean termite species than eucalyptus wooden stakes. Similar result was found by Tho (1974), who verified that *Pinus* spp. were highly susceptible to *Coptotermes* in Malaysia.

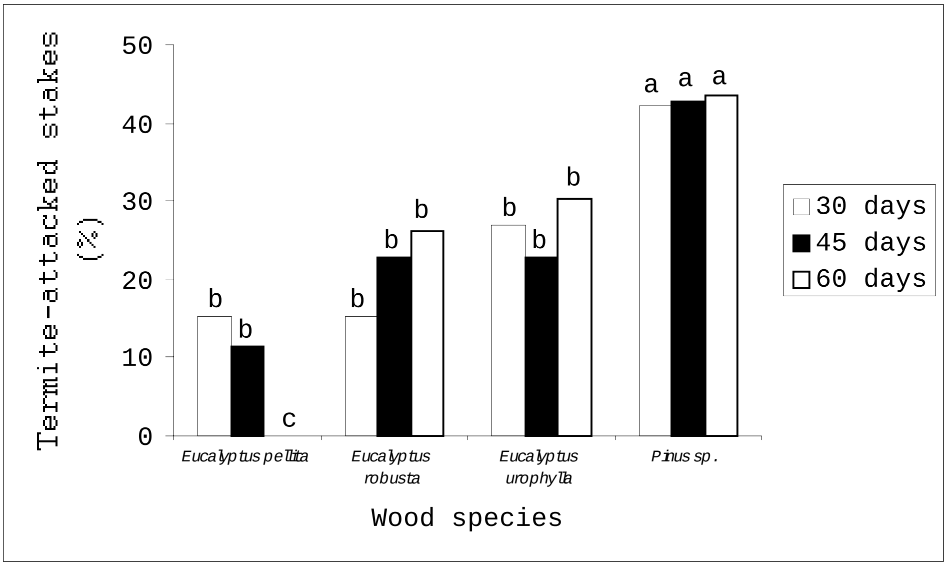

Figure 1. Percentage of stakes of each wood species attacked by subterranean termites at 30, 45, and 60 day exposure periods in the field in Seropedica, RJ. Averages within the same exposure period followed by the same letter are not significantly different as gauged by Tukey's test ($P \leq 0.05$).

Unidentified fungi species of Basidiomycetes were also found as a wood-decaying organism of the stakes in the ground infected all forest species tested. However, none of these wooden infested stakes were attacked by subterranean termites. There was not a significant difference on the percentage of fungi-infested stakes of each forest species among the four times of water immersion at all field exposure periods (Figure 2), however, there was a tendency for *Eucalyptus* species to more infected by wood-decaying fungi than *Pinus* sp. According to Sands (1969), the environment of subterranean termites normally includes a wide variety of fungi, some of them compete with termites for wooden material that provide their food. In general, the Rhinotermitidae benefits of the association with wood-rotting fungi. For example, *Lentinus pallidus* Berk. and Curt. breaks down toxic components to *Coptotermes niger* Snyder present in the heartwood of *Pinus caribaea* Morelet, which become the preferred feeding and nest site of this specie (Williams, 1965). On the other hand, some fungi produce breakdown products that are repellent or poisonous to termites (Sands, 1969). Ruyooka (1979) showed that wood decayed by *Gloeophyllum trabeum* (Pers. ex Fr.) Murr. was repellent to *Nasutitermes exitiosus* (Hill). In this context, in the present study, it seems that the wooden stakes infected by the basidiomycetous, saprophytic wood-rotting fungi were repellent or unattractive to *H. longiceps*, *C. gestroi* and *N. jaraguae*.

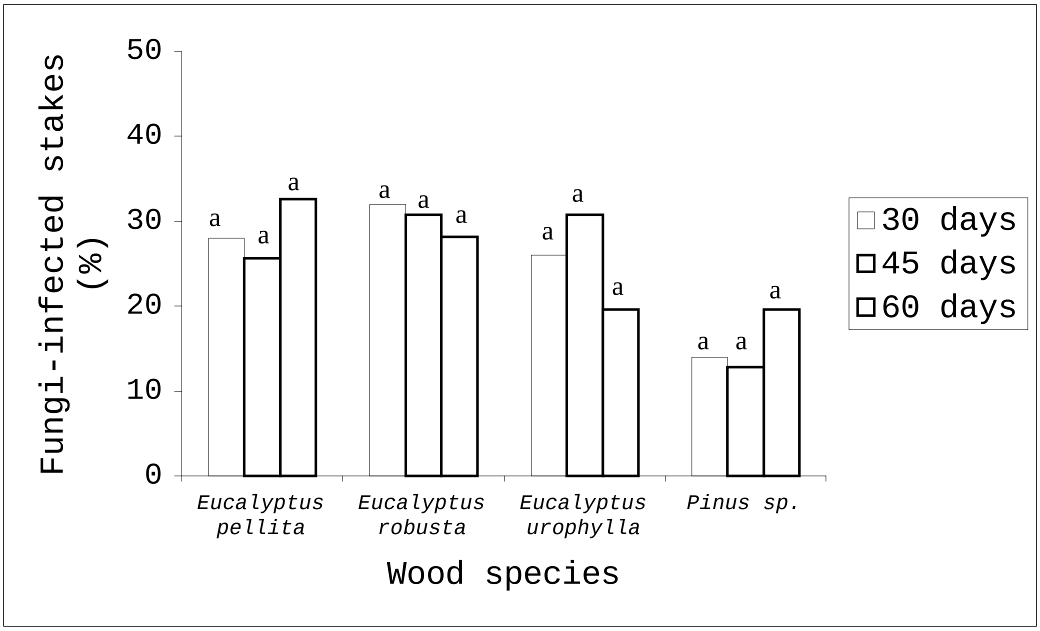

Figure 2. Percentage of stakes of each wood species infested by basidiomycetes fungi at 30, 45, and 60 day exposure periods in the field in Seropedica, RJ. Averages within the same exposure period followed by the same letter are not significantly different as gauged by Tukey's test ($P \leq 0.05$).

CONCLUSION

Wooden stakes of *Pinus* sp. was significantly preferred over *Eucalyptus* species by *Heterotermes longiceps* (Snyder), *Coptotermes gestroi* (Wasmann) and *Nasutitermes jaraguae* (Holmgren).

The least preferred wooden stakes by *Heterotermes longiceps* (Snyder), *Coptotermes gestroi* (Wasmann) and *Nasutitermes jaraguae* (Holmgren) was *Eucalyptus pellita*.

None of the infested wooden stakes by Basidiomycetes fungi were attacked by *Heterotermes longiceps* (Snyder), *Coptotermes gestroi* (Wasmann) and *Nasutitermes jaraguae* (Holmgren).

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REFERENCES

ATKINSON, P.R; NIXON, K.M.; SHAW, M.J.P. On the susceptibility of *Eucalyptus* species and clones to attack by *Macrotermes natalensis* Haviland (Isoptera: Termitidae). F**orest Ecology and Management**, V. 48, p.15-30, 1992.

BICALHO, A.C. **Aspectos comportamentais, taxa de consumo e marcação do cupim subterrâneo *Coptotermes havilandi* Holmgren, 1911 (Isoptera: Rhinotermitidae) em área residencial**. 2000. 82f. Dissertação (Mestrado em Agronomia/ Entomologia) – Universidade Federal de Lavras (UFLA), Lavras. MG.

BULTMAN, J.D; BEAL, R.H.; AMPONG, F.F.K. Natural resistance of some Tropical African woods to *Coptotermes formosanus* Shiraki. **Forest Products Journal**, V.29, n.6, p.46-51, 1979.

BULTMAN, .D. & SOUTHWELL, C. R. Natural resistance of tropical American woods to terrestrial wood-destroying organism. **Biotropica**, V.8, p.71-95, 1976.

CONSTANTINO, R. Key to the soldier of South American *Heterotermes* with a new species from Brazil (Isoptera: Rhinotermitittdae). **Insect Systematics & Evolution**, V.31, p.463-472, 2001.

CREFFIELD, J. W.; HOWICK C. D.; PAHL, P. J. Comparative wood consumption within and between mounds of *Coptotermes acinaciformis* (Froggatt) (Isoptera: Rhinotermitidae). **Sociobiology**, V.11, p.77-86, 1985.

DELAPLANE, K.S.; LA FAGE,J.P. Preference of the Formosan subterranean termite (Isoptera: Rhinotermitidae) for wood damaged by conspecifics. **Journal of Economic Entomology**, V.82, p.1363-1366, 1989.

FIDERJ. **Indicadores climatológicos: sistema de informação para o planejamento estadual.** Rio de Janeiro: FIDERJ/SECPLAN, 1976. 54p.

MALAN, F.S. The wood properties of South African grown *Eucalyptus grandis*. Some notes on their variation and association. **Wood South Africa**, V.14, p.61-67, 1989.

RUYOOKA, D.B.A. Response of *Nasutitermes exitiosus* (Hill) (Termitidae) do decay fungus- and fungal isolate "B 8"- infested wood. **Zeitschrift für Angewandte Entomologie**, V. 88, p.132-143,1979.

SANDS, W.A. The association of termites and fungi. *In*: KRISHNA, K.; WEESNER, T.M., eds. **The biology of termites.** New York: Academic Press, 1969. p.495-524.

SCHAEFER, D.A; WHITFORD, W.G. Nutrient cycling by subterranean termite *Gnathamitermes tubiformans* in a Chihuahuan Desert ecosystem. **Oecologia**, V. 48, p.277-283, 1981.

SEM-SARMA, P.K.; CHATTERJEE, P.N. Recent trends in laboratory evaluation of termite resistance of wood and wood products. **Journal of the Indian Academy of Wood Science**, V. 1, n.2, p.119-128, 1970.

SPRINGHETTI, A.; AMORELLI, M. Competitive behavior between two species of Isoptera: *Kalotermes flavicollis* and *Reticulitermes lucifugus*. **Sociobiology**, V. 7, p.155-164, 1982.

SNYDER, T.E. Annotated subject-heading bibliography of termites, 1350 B.C. to A.D. 1954. **Smithsonian Miscellaneous Collections**, V.130, p.1-305, 1956.

SU, N.-Y.; SCHEFFRAHN, R.H. Intra- and interspecific competition of the Formosan and eastern subterranean termite: evidence from field observations (Isoptera: Rhinotermitidae). **Sociobiology**, V.14, p.157-164, 1988.

THO, Y.P. Termite problem in plantation forestry in Peninsular Malaysia. **Malaysian Forester**, V.37, p.278-283, 1974.

THORNE, B.L. Termite-termite interactions: workers as an agonistic caste. **Psyche**, V.89, p.133-150, 1982.

USHER, M.B. Runway building and food exploration strategy of *Pseudacanthotermes militaris* (Insecta: Isoptera). **Biotropica**, V. 6, p.154-157, 1974.

WILLIAMS, R.M.C. **Termite infestation of pines in British Honduras.** London: H.M. Stationery Office, 1965. (Overseas Research Bulletin, 11).

WOOD, T.G.; SANDS, W.A. The role of termites in ecosystems, p.245-292.In: BRIAN, M.V., ed. **Production ecology of ants and termite**. Cambridge: Cambridge University Press, 1978.