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Subterranean termites associated to forest plantations in Southern Amazon, Brazil

Cupins subterrâneos associados a plantios florestais na Amazônia Meridional, Brasil

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Abstract

The growing demand for wood is being supplied through homogeneous forest plantations. However, large tracts of land cultivated with a single species are susceptible to insect pest attacks. Termites are one such insect pest, capable of destroying the root system of plants and harming their developments. The objective of the present study was to know the diversity of subterranean termites present in *Eucalyptus urograndis* (*Eucalyptus urophylla* S.T. Blake *x Eucalyptus grandis* Hill ex Maiden: Myrtaceae), *Tectona grandis* L.f.: (Lamiaceae) and *Bertholletia excelsa* Humb. & Bonpl. (Lecythidaceae) and *Hevea brasiliensis* (Willd. ex A. Juss.) Müll.Arg. (Euphorbiaceae) consortium, in Alta Floresta – MT state, and to verify the spatial distribution of termites in these locations and the influence of edaphic conditions on the diversity of termites in these areas. The survey used traps of corrugated cardboard, which were removed after 30 days and their individuals counted and identified. The soil was collected from the sampled plantations to test for any correlation that may exist between the edaphic variables and the species found. A total of 14,61 individual termites were collected, representing five termite species, the most commonly occurring species was *Heterotermes tenuis* (Hagen) (12,802 specimens). The spatial distribution of all species was aggregated. Most of the attacked traps were class 2 (between 101 and 500 termites collected), and correlation showed significance only between the factor clay x *H. tenuis*. The diversity of termites in the plantations is composed of five species, the aggregate distribution indicates preference for the most favorable areas of the environment and higher occurrence of *H. tenuis* in clay soils.

Keywords: Cellulosic trap; *Heterotermes tenuis*; Rhinotermitidae; Social insects

Resumo

A crescente demanda por madeira está sendo suprida através de plantios florestais homogêneos. No entanto, grandes extensões de cultivo com uma única espécie são suscetíveis a ataques de insetos-praga. Os cupins são uma dessas pragas, capazes de destruir o sistema radicular das plantas e prejudicar seu desenvolvimento. O objetivo do presente estudo foi conhecer a diversidade de cupins subterrâneos presentes em plantios de *Eucalyptus urograndis* (*Eucalyptus urophylla* S.T. Blake *x Eucalyptus grandis* Hill ex Maiden: Myrtaceae), *Tectona grandis* L.f.: (Lamiaceae) e consórcio de *Bertholletia excelsa* Humb. & Bonpl. (Lecythidaceae) e *Hevea brasiliensis* (Willd. ex A. Juss.) Müll.Arg. (Euphorbiaceae) no município de Alta Floresta - MT, além de verificar a distribuição espacial de cupins nesses locais e a influência das condições edáficas na diversidade de espécies nestas áreas. A pesquisa foi realizada com armadilhas de papelão ondulado, que foram removidas após 30 dias da instalação e seus indivíduos foram contados e identificados. Amostras de solo foram coletadas nos plantios para testar a correlação entre as variáveis edáficas e as espécies encontradas. Um total de 14.861 térmitas foram coletados, representando cinco espécies de cupins, sendo aquela com maior ocorrência *Heterotermes tenuis* (Hagen) (12.802 espécimes). A distribuição espacial de todas as espécies foi agregada. A maioria das armadilhas atacadas foi de classe 2 (apresentando entre 101 e 500 térmitas), e a correlação mostrou significância somente entre a quantidade de argila no solo e *H. tenuis*. A diversidade de térmitas nos plantios é composta por cinco espécies, e a distribuição agregada indica preferência pelas áreas mais favoráveis do ambiente, com maior ocorrência de *H. tenuis* em solos argilosos.

Palavras-chave: Armadilhas celulósicas; *Heterotermes tenuis*; Rhinotermitidae; Insetos sociais

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Introduction

Forestry is based on sustainability, and planted forests, supply the market demand for timber. However, while plantations benefit the environment by providing an alternative to deforestation, the expansion of forestry plantations across the landscape means an increase in phytosanitary problems (COSTA *et al.*, 2014). Brazilian forestry has, as one of its strength, the planting of eucalyptus (*Eucalyptus* sp. L Herit (Myrtaceae)), which began in the 1920s. However, nowadays, new species are emerging in the forest sector such as teak (*Tectona grandis* L.f.: Lamiaceae), an exotic species that were brought from India and also native species such as Brazil nut (*Bertholletia excelsa* Humb. & Bonpl.: Lecythidaceae) and rubber tree (*Hevea brasiliensis* (Willd. ex A.Juss.) Müll.Arg.: Euphorbiaceae) (REIS, PALUDZYSZYN FILHO, 2011; SHIMIZU; KLEIN; OLIVEIRA, 2007).

The state of Mato Grosso supports 187,090 hectares of eucalyptus plantations, 64,828 hectares of teak plantations (FAMATO, 2013) and 44,895 hectares of rubber tree (SHIMIZU; KLEIN; OLIVEIRA, 2007). The greater number of planted species is favorable for the maintenance of plant health, for some native species such as *Bertholletia excelsa* or *Hevea brasiliensis,* the homogeneous planting is not economically viable and mixed planting or intercropping is recommended (REIS, PALUDZYSZYN FILHO, 2011).

According to Fontes (2014), among the main groups of insect-pests that occur in Brazil are termites, social insects belonging to the order Blattodea: Termitoidea (previously order Isoptera). There are about 2,800 species of termites described worldwide; most of them are found in the tropics.

Ferreira *et al.* (2011) estimate that there are approximately 300 species of termites that occur in Brazil, in the families Kalotermitidae, Rhinotermitidae, Termitidae, and Serritermitidae. The main genera of the Kalotermitidae family are *Cryptotermes* Banks, 1906*, Neotermes* Holmgren, 1911, and *Rugitermes* Holmgren, 1911. In the Rhinotermitidae family, the genera *Coptotermes* Wasmann, 1896 and *Heterotermes* Froggatt, 1897, are dominant, and within the Termitidae family the genera *Cornitermes* Wasmann, 1897*, Nasutitermes* Dudley, 1890*, Syntermes* Holmgren, 1909, and *Anoplotermes* Müller, 1873 are the most prevalent ones.

According to Garlet, Costa and Boscardin (2016), population surveys are of fundamental importance, as they constitute the first stage of integrated pest management and provide information on population density, biological cycle and peaks of occurrence of the species present in the studied site. In addition, population surveys are necessary to identify which species are present on the site and have the potential to become pests, to provide information on site sustainability and to use as indicators of environmental quality (BERNARDI *et al.*, 2011).

Thus, the objective of the present study was to know the diversity of subterranean termites present in *Eucalyptus urograndis*, *Tectona grandis* and *Bertholletia excelsa* and *Hevea brasiliensis* consortium, in Alta Floresta – MT state, and to verify the spatial distribution of termites in these locations as well as the influence of the edaphic species conditions on the diversity of these areas.

Material and methods

The study was carried out in the municipality of Alta Floresta, in the state of Mato Grosso, Brazil. The climate is type Am, with two well-defined seasons (a rainy summer and a dry winter). The annual average temperature is approximately 26 ºC, and the average annual precipitation is 2800–3100 mm, according to the Köppen classification for Brazil (ALVARES *et al.*, 2013).

Four forest areas were evaluated. Field I, belonging to the farm Dois Irmãos, was a *Bertholletia excelsa* and *Hevea brasiliensis* plantation; the plantation was 9.56 ha in area, 20 years old, with a spacing of 20 m between rows of Brazil nut tree with a central line of rubber trees and 5 m spacing between trees. Field II was a 6.45 ha, composed of clones of the hybrid H13, *Eucalyptus urograndis* (*Eucalyptus urophylla* S.T. Blake *x Eucalyptus grandis* Hill ex Maiden); it belonged to Brasil Tropical Flats, was six years of age, with a tree spacing of 3 x 3 m. Fields III and IV were *Tectona grandis* plantations, belonging to the Farm IDC; both sites were 14 years of age, with a tree spacing of 3 x 2.2 m, and land area of 7.52 ha and 7.28 ha, respectively.

For the collection of the termites, the adapted methodology of Almeida and Alves (2009), corrugated cardboard traps were used. The traps were 25 cm in length and 5 cm in diameter and were rolled. The traps were installed in transects of 50 x 50 m, remaining in the ground for 30 days.

After the trapping period, the traps were collected and taken to the Didactic Laboratory of the State University of Mato Grosso for sorting. The termite specimens were counted and stored in bottles containing 70% alcohol. The termites were then sent to Professor Reginaldo Constantino, at the University of Brasilia, for identification.

Termite yields were classed according to the number of individuals collected in the trap: (0) absence of termites; (1) 1–100 termites; (2) 101–500 termites; (3) 501–1,000 termites; (4) 1,001–4,000 termites; and (5) over 4,001 termites.

In order to determine the spatial distribution of the individuals, the Dispersion Index (ID) (Formula 1) and Morisita Index (IϬ) (Formula 2) were calculated.

Formula 1:

$$ID = \frac{S^2}{x}$$

Where:
S^2 = sample variance.
X = average number of individuals/trap.

Formula 2:

$$I_6 = \mathrm{N}\frac{\sum x^2 - \sum x}{(\sum x)^2 - \sum x}$$

Where:
N = Number of sample units.
Σx = Sum of the individuals present in the sample units.
Σx^2 = Squared sum of the individuals present in the sample units.

According to Davis (1993), ID has the criterion of spatial distribution: I = 1, random distribution; I > 1, aggregate distribution; I < 1, regular distribution. According to the IϬ, when Iσ = 1 the distribution is random; when Iσ> 1 the distribution is aggregated and when Iσ < 1 the distribution is regular (MORISITA, 1962).

The soil from each site was analyzed to measure the levels of Ph, H_2O, Ca^{+2}, Mg^{+2}, P, K^+, and the sand, silt and clay content. A correlation analysis was performed (using the statistical program Assistat 7.6 Beta) to test for a relationship between soil properties and the number of termites present at each site.

Results and discussion

A total of 14,861 termite individuals were collected, with varied occurrence in the evaluated plantation stands. The termites belonged to five species, from the genera *Heterotermes, Anoplotermes,* and *Nasutitermes* (Table 1). The most frequent species was *Heterotermes tenuis*

(12,802 individuals), which was present in all of the sampled plots. The species with the lowest occurrence was *Anoplotermes* sp., of which only 50 individuals were collected and only from Field I.

Table 1 – Number of termites found in the evaluated areas.

Tabela 1 – Número de térmitas coletados nas áreas avaliadas.

Species	Fields					
	I	II	III	IV	Total (individuals / species)	Average (individuals / field)
***Heterotermes tenuis* (Hagen)**	115	2.427	3.002	7.258	12.802	3.200,5
***Nasutitermes dendrophilus* (Desneux, 1905)**	42	-	225	528	795	198,75
***Nasutitermes callimorphus* Mathews**	-	-	-	634	634	158,50
***Nasutitermes corniger* (Motschulsky)**	580	-	-	-	580	145,00
***Anoplotermes* sp. Müller, 1873**	50	-	-	-	50	12,50
Total (indivuals/field)	787	2.427	3.227	8.420	14.861	3.715,25

Fonte: Authors (2019)
Where: Field I = Consórcio *Bertholletia excelsa and Hevea brasiliensis*, Field II = *Eucalyptus urograndis*, Fields III e IV = *Tectona grandis*.

Termites were present in 21 traps of the 60 traps implanted in the plots. Nine of these traps received a class of 2 (101–500 termites), five received a class of 3 (501–1,000 termites), three were class 4 (1,001–4,000 termites), and only one trap received a class of 5, with 5,187 termites counted in this trap. Regarding the ID, all of the species presented an aggregate type of distribution (I > 1) in all studied plots (Table 2). The analysis verified that there was a positive correlation between soil clay content and the number of individuals of the species *Heterotermes tenuis.*

Table 2 – Dispersion rates for subterranean termites in forest plantations in Alta Floresta, Mato Grosso state.

Tabela 2 – Ìndices de dispersão para cupins subterrâneos em plantios florestais, em Alta Floresta, Mato Grosso.

Species	Fields							
	I		II		III		IV	
	ID	$I_б$	ID	$I_б$	ID	$I_б$	ID	$I_б$
Heterotermes tenuis	107,81	16	965,16	6,56	520,83	3,60	3475,08	8,18
Nasutitermes dendrophilus	39,38	16	-	-	210,00	15,00	492,80	15,00
Nasutitermes callimorphus	-	-	-	-	-	-	279,78	7,61
Nasutitermes corniger	543,75	16	-	-	-	-	-	-
***Anoplotermes* sp.**	46,88	16	-	-	-	-	-	-

Fonte: Authors (2019)
Where: The index of dispersion (ID) and index of Morisita ($I_б$) has as criterion of spatial distribution: I = 1, random distribution; I > 1, aggregate distribution; I < 1, regular distribution.

Like in this study, a high occurrence of *H. tenuis* individuals was also observed by Peres Filho *et al.* (2010), whose research showed a predominance of *H. tenuis* individuals in *Eucalyptus camaldulensis* Dehnh plantation in the city of Cuiabá (MT state), with 178,796 individuals collected (representing 79.93% of the total). The presence of *H. tenuis* was also observed in *H. brasiliensis* plantations in the municipality of El Doncello, Caquetá, Colombia, attacking 200 newly planted roots, along with three species of the genus *Nasutitermes* attacking three roots (CAMPO JUNIOR; STERLING; GOMÉZ, 2012).

The large number of individuals found in this study may be related to the presence of pastures in the vicinity of the plantations. According to Guerreiro and Oliveira (2011), the further from native forest areas it is, the higher the population of termites. Native termites become more susceptible to attack from natural predators such as ants.

The distribution was classed as aggregated for all species of sampled termites. A similar result was found by Peres Filho *et al.* (2012), where, using Iσ, they also found an aggregated distribution in *Cornitermes snyderi* Emerson, 1952, nests at Teca planting in the municipality of Porto Esperidião, in the state of Mato Grosso.

Dias *et al.* (2012) noted that several factors may determine species distribution. The distribution pattern is due to factors such as geographic distribution, soil physical and biological factors, and food distribution. Being in the aggregated or clustered form, the nests tend to be located in the most favorable parts of the habitat (SOUZA; COMINOTE; MORETTI, 2014). In the case of this study, it can be suggested that the sand and clay content in the soil are the main causes of the aggregate distribution. This was verified through the positive correlation between clay content and the presence of *H. tenuis* individuals. Peres Filho *et al.* (2012) also verified a positive correlation between the presence of *Cornitermes snyderi* and the soil clay content in *Tectona grandis* plantations in the municipality of Porto Esperidião.

Sandy soils generally provide low stability for the construction of subterranean tunnels and subterranean nests of termites, so termites tend to prefer clay-rich soils (PERES FILHO *et al.*, 2012), as we observed in the case of *Heterotermes tenuis*. Dias *et al.* (2012) argue that, as sandy soils have high permeability (retaining only 5% to 10% of the water) and clay soils can retain up to 30% water, termite preference for clay soils can be explained by the termite low resistance to desiccation (due to the low chitinization of the cuticle and low water retention capacity).

Conclusion

The termite diversity in forest plantations in the region is represented by five species, with *H. tenuis* being the most abundant, reinforcing its wide spatial distribution in the country. The aggregate spatial distribution indicates that these insects concentrate their populations in the most favorable areas of the environment, so the control can be directed in the area, avoiding economic damages.

Regarding the edaphic conditions, the positive correlation between the clay content and the number of *H. tenuis* individuals, indicates the preference of this species to this soil class, indicating the presence of these insects in areas with clay soils before planting.

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