Use of Baits for the Evaluation of Underground Termites (Blattodea: Rhinotermitidae) in Different Habitats of the Southern Amazon Region

Authors: Citadella, Felipe, Souza Maria, Luciano de, Miranda, Rafaela Pereira, Litter, Felipe Adolfo, Almeida Carneiro, Marcia de, et al.

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Use of baits for the evaluation of underground termites (Blattodea: Rhinotermitidae) in different habitats of the southern Amazon region

Felipe Citadella[1], *Luciano de Souza Maria*[1,]*, *Rafaela Pereira Miranda*[1], *Felipe Adolfo Litter*[1], *Marcia de Almeida Carneiro*[1], and *Juliana Garlet*[1]

Abstract

We investigated the effect of land use on the occurrence of termites during the rainy season in the southern Amazon region. We used Termitrap®-style cardboard baits to sample the termites in soils dominated by Marandu (*Urochloa brizantha* cv. 'Marandu' (Rich.) Webster; Poaceae) grassland, Mombasa (*Panicum maximum* cv. 'Mombasa' Jacq.; Poaceae) grassland, coffee (*Coffea canephora* Pierre ex A. Froehner; Rubiaceae), soybean (*Glycine max* (L.) Merr.; Fabaceae), or native forest. Five plots were randomly distributed in each area, and each plot contained 9 termite baits. At 45 d after introduction of the traps, the termites were collected, the species were identified, and the level of infestation (percentage of traps with termites) was determined. The areas with Mombasa, coffee, and native forest displayed the highest levels of termite infestation: 35.55, 29.36, and 23.47%, respectively. The areas cultivated with soybean and Marandu had lower levels of infestation: 2.50 and 2.22%, respectively. The baits seemed to be effective at monitoring the species *Heterotermes tenuis* (Hagen) and *Nasutitermes* sp. (both Blattodea: Rhinotermitidae).

Key Words: cardboard; *Heterotermes tenuis*; infestation; trap

Resumen

Nós investigamos o efeito do uso da terra na ocorrência de cupins durante a estação chuvosa na região sul da Amazônia. Usamos iscas de papelão Termitrap® para amostrar os cupins em solos dominados por pastagem Marandu (*Urochloa brizantha* cv. 'Marandu' (Rich.) Webster; Poaceae), pastagem Mombaça (*Panicum maximum* cv. 'Mombasa' Jacq.; Poaceae), café (*Coffea canephora* Pierre ex A. Froehner; Rubiaceae), soja (*Glycine max* (L.) Merr.; Fabaceae), ou foresta nativa. Cinco parcelas foram distribuídas aleatoriamente em cada área, e cada parcela continha 9 iscas de cupins. Aos 45 dias após a introdução das armadilhas, os cupins foram coletados, as espécies foram identificadas e determinou-se o nível de infestação (porcentagem de armadilhas com cupins). As áreas com Mombaça, café e mata nativa apresentaram os maiores níveis de infestação de cupins: 35,55; 29,36; e 23,47%, respectivamente. As áreas cultivadas com soja e Marandu apresentaram menores níveis de infestação: 2,50 e 2,22%, respectivamente. As iscas pareciam ser eficazes no monitoramento das espécies *Heterotermes tenuis* (Hagen) e *Nasutitermes* sp. (ambos Blattodea: Rhinotermitidae).

Palabras Clave:

Termites (Blattodea, formerly Isoptera) constitute 40 to 95% of the total soil macrofauna biomass, making them important in organic matter decomposition in tropical ecosystems (Calderón-Cortés et al. 2018). In the Brazilian Amazon, more than 238 termite species are known (Constantino 2018).

The major challenge to sampling termites is assessment of underground habitats. For example, Almeida and Alves (2009) noted that the population of *Heterotermes tenuis* (Hagen) (Blattodea: Rhinotermitidae) has a subterranean habitat, forages widely in the soil, and constructs a diffuse nest. Thus, it can be quite challenging to study their behavior.

Campos et al. (1998) reported that Termitrap® bait, a termite bait consisting of a roll of corrugated cardboard, can be used in monitoring termite populations. This trap was developed for monitoring of *H. tenuis*, but termites of the genera *Cornitermes*, *Procornitermes*, *Coptotermes*, *Neocapritermes*, and *Nasutitermes* (all Blattodea: Rhinotermitidae) also are attracted in the field, and the bait may be used for termite control with the addition of microbial or chemical insecticides (Almeida & Alves 2009).

Several studies conducted in the Amazon region showed that the suppression of forests and the introduction of agricultural systems resulted in changes in the composition, diversity, and distribution of soil fauna (Rousseau et al. 2014; Salazar et al. 2015). Peres-Filho et al. (2012) noted that termites are used commonly to carry out this type of study because they are quite sensitive to environmental changes, becoming pests when the environment is in imbalance. Acioli (2018) stated that *Nasutitermes* sp. and *Heterotermes tenuis* are favored for research, and become potential pests due to the replacement of primary vegetation with agricultural crops, such as cassava and palm. Sampling these subterranean crop habitats is difficult, due to the effort required for soil sampling. Thus, the objective of this work was to assess the effectiveness of Termitrap® cardboard baits for monitoring of subterranean termites in different environments in southern Amazonia.

[1]Universidade do Estado de Mato Grosso, Departamento de Ciências Biológicas e Agrárias, Alta Floresta, Mato Grosso, Brazil, E-mail: citadella@gmail.com (F. C.), tiolucio123@gmail.com (L. S. M.), pmiranda.rafaela@gmail.com (R. P. M.), felipe_gta@hotmail.com (F. A. L.), marciamac1995@gmail.com (M. A. C.), julianagarlet@yahoo.com.br (J. G.)
*Corresponding author; E-mail: tiolucio123@gmail.com

Materials and Methods

This study was carried out at Fazenda Yamashita, located in the municipality of Alta Floresta, Mato Grosso, Brazil (9.942777°S, 55.918638°W), in southern Amazonia. The regional climate, according to the Köppen classification, is defined as Awi with 2 well-defined seasons, with rainy summer and dry winter. The average temperature is approximately 26 °C, and the average precipitation is 2,200 to 2,500 mm per yr (Alvares et al. 2013). The soil of the area is characterized as Oxisol, with a predominance of clay (Benett et al. 2009). In this region, vegetation of the Ombrophylia Open Forest type predominates.

The termite fauna assessment was carried out in 5 environments in Southern Amazonia. The environments were Mombasa grassland (*Panicum maximum* Jacq.; Poaceae), with an area of 7.52 ha; coffee crop (*Coffea canephora* Pierre ex A. Froehner; Rubiaceae), with an area of 5.28 ha; forest fragment, with an area of 8.32 ha; soybean crop (*Glycine max* (L.) Merr.; Fabaceae), with an area of 9.6 ha; and the Marandu grassland (*Urochloa brizantha* (Rich.) Webster; Poaceae), with an area of 6.4 ha.

In order to maintain the edaphoclimatic factors as closely as possible, a maximum distance of 1,200 m between environments was maintained. Each type of environment was divided into plots measuring 40 × 40 m (0.16 ha). Five plots were randomly selected in each land use class for sampling with baits.

A total of 255 Termitrap® baits were constructed. Each trap was formed from a 20 × 50 cm strip of corrugated cardboard rolled up and fastened with an elastic band (number 18), according to methodology described by Campos et al. (1998). Distribution of the baits within the plot followed the spatial arrangement proposed by Peres Filho et al. (2012) (Fig. 1). The baits were arranged in the shape of a cross, 5 m apart, totaling 9 distribution points. A Garmin GPS model 76CSx (Garmin International Inc., Olathe, Kansas, USA) hand-held global positioning receiver was used to record the geographic location of the central point for the implantation and subsequent removal of the baits. With the aid of a Dutch soil auger (Sondaterra®, Piracicaba, São Paulo, Brazil) the baits were buried in the soil at a depth of 20 cm with the upper end level with the soil surface, avoiding depressions in the soil so there was no accumulation of water.

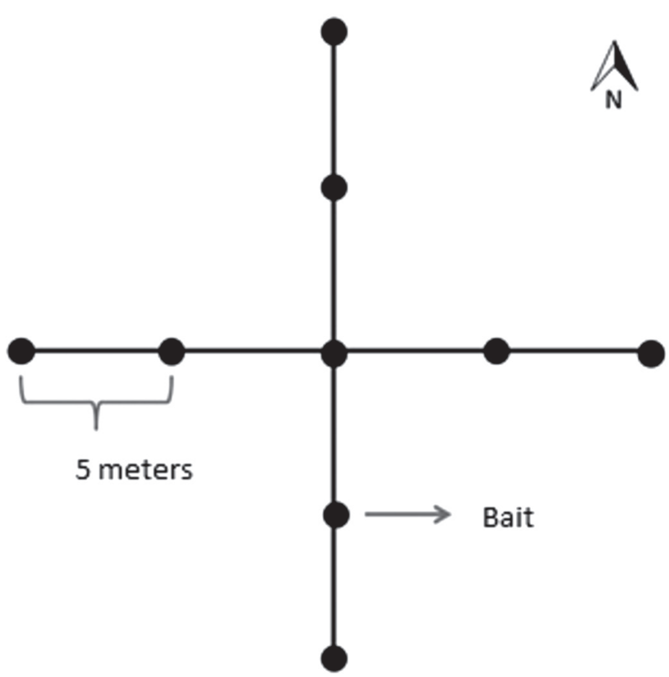

Fig. 1. Spatial arrangement of Termitrap® baits within plots for subterranean termite survey in different environments in southern Amazonia.

After 45 d in the field, the baits were removed from the soil, individually packed in plastic bags, identified, and taken to the Laboratory of Entomology of the State University of Mato Grosso, in Alta Floresta, Mato Grosso, Brazil, where the number of termites inside the baits was determined. Some termite specimens were stored in flasks containing alcohol at 70 °C and later identified with the aid of a stereoscope microscope (Leica EZ24, Carl Zeiss, Paris, France).

During an interview with the farm owner, the history of the termite activity in each class of soil was recorded, with the purpose of facilitating the interpretation and better understanding of the results obtained. The forest vegetation was characteristic of the region, and consisted of an area of forest fragment with no history of anthropic interference. The coffee crop was planted in 1996, and received frequent fertilization until 2010, without any type of fertilization or cultural treatments after this period. The soybean crop area had been used for several crops, including grazing, rice, miaze, and sorghum. The Mombasa grassland area was devoted to this forage plant since 2010. Marandu grassland was initiated in the early 1980s, with liming in 2009 and implementation of contour lines.

The statistical design was completely randomized, consisting of 5 treatments with 5 replicates, and 9 subsamples each. The data were submitted to analysis of variance (ANOVA) and the means were compared by the Duncan multiple range test at 5% probability using the Sisvar program (Ferreira 2011). The Lilliefors normality test showed that the data were not normally distributed, requiring transformation ($\sqrt{} \times + 0.5$).

Results

The degree of infestation of termite baits by subterranean termites in the 5 environments ranged from 35.55 to 2.22%, as shown in Table 1. The analysis of variance indicated a significant difference ($F = 3.39$; df = 2,25; $P < 0.05$) in the percentage of infestation among the habitats. Based on the termite bait sampling, the Mombasa, coffee, and forest fragment environments supported similar termite populations, resulting in 35.5, 29.36, and 23.47% infestation of baits, respectively. These were significantly higher levels of infestation than in the soybean and the signal Mombasa grass habitats, 20.5 and 2.22%, respectively. The termite infestation levels were not significantly different in the soybean and Marandu grass habitats.

Discussion

Variation in infestation among the environments likely are related to the conditions that each environment offers to the subterranean termites predominating in this study, *Nasutitermes* sp. and *Hetero-*

Table 1. Percentage of baits infested by subterranean termites in 5 environments in southern Amazonia.

Environment	Infestation (%)
Panicum (Mombasa) grassland	35.55 a
Coffee crop	29.36 a
Forest fragment	23.47 a
Soybean crop	2.50 b
Urochloa (Marandu) grassland	2.22 b
CV (%)	66.19

Original data: Analysis performed with the transformed data in ($\sqrt{} \times + 0.5$). Means followed by the same letter in a column do not differ by Duncan's multiple range test ($P > 0.05$).

termes sp. (Fig. 2). This would include quality and quantity of available food, but also temperature, humidity, light, and physical and chemical characteristics of the soil. Biotic factors such as competition and predation also may be important. This is consistent with Eggleton (2000), who stated that the species richness of a site is related to environmental characteristics, including altitude, temperature, rainfall, vegetation type, and structure, so that the frequency of occurrence of termites reflects the availability of resources and their intra- and interspecific environments.

Although not producing as high a bait infestation level, clearly the Mombasa grassland provides a food supply to termites, allowing them to settle in the area, as well as providing protection against predators, reducing brightness, increasing humidity, and reducing the soil surface temperature. Rodrigues et al. (2008) also noted that in well-managed areas with forage grasses, there is reduced soil compaction and vigorous growth of the root system and the aerial portions of the plants, contributing to an ample supply of food for termites. Thus, the management difference explains why baits in the Mombasa grassland had higher values of infestation relative to the Marandu grassland.

According to Marques and Galbiati (2008), the use of termite fauna as a bioindicator of environmental quality has proven to be an efficient instrument for the evaluation and monitoring of soil quality in pastures, because subterranean termites have a positive relationship with organic matter content. Thomazini and Thomazini (2002) reported that the predominant species in bait monitoring in the state of Acre was *H. tenuis*, reaching 99.8% of the termite fauna in the pasture environment. This species occurs most commonly in open areas, and can be found to cause high levels of infestation in Mombasa grassland.

The native forest area tends to be an equilibrium ecosystem, due to heterogeneity in species composition and high biodiversity. In this system there is a wide range of predators and competitors, as well as a diversity of food sources. Viana-Junior et al. (2014) observed the occurrence of termites of the genus *Nasutitermes* only in environments with trees or shrubs when they evaluated termite fauna in the Caatinga grassland environments, and in native and secondary native vegetation. Polatto and Alves-Junior (2009) reported that there is a positive relation between termites of the genus *Nasutitermes* and the density of trees.

Santos et al. (2010) found that *H. tenuis* was responsible for the damage of eucalyptus plants and sugar cane in Brazil, principally in the central-west and southeast regions of the country. In a study carried out in Cuiaba, Mato Grosso, Brazil, using the same methodology for monitoring termites in 3 areas (1, 10, and 17 yr without fire), the species *H. tenuis* was most abundant, consisting of 53.31% of the total specimens collected (Peres Filho et al. 2012).

Santos et al. (2010) reported that 1 of the factors that may be related to environmental heterogeneity is the amount of litter available, because the greater the vegetation cover, the greater the amount of litter and, therefore, the greater the termite richness. This occurs because termites have sedentary habits and do not forage in the open, so environments rich in organic material support greater richness of these insects. This was verified by the formation of colonies inside the baited cardboard, which contained a queen of *Heterotermes tenuis* (Fig. 3). The dense vegetation cover also provides greater protection to termites to the disadvantage of external climatic factors, such as desiccation caused by direct exposure to solar radiation.

In annual crops, the low rate of infestation is due to negative factors related to soil use, such as the application of pesticides for the protection of seeds and plants, which may have a residual effect, and directly or indirectly affect the soil community. The seeds used in planting soybean were treated with Fipronil-based insecticides. Crop rotation at the time of planting also may have contributed to destruction of the colonies and galleries, making it difficult to stabilize the soil and reducing the availability of food due to the rapid decomposition of organic material.

Giracca et al. (2003), studied the meso- and macrofauna of the soil in 2 systems of soybean planting, 1 organic and the other conventional, and reported that the number of edaphic organisms was greater in the organic system when compared to the conventional system. The authors stated that the management practices used in a production system may influence macrofauna directly via the mechanical action of plowing and weeding, along with the toxicity of agrochemicals, and indirectly through modifications in the structure of habitat and food resources. This was verified by Santos et al. (2010), who studied the foraging of *H. tenuis* through monitoring with Termitrap® baits in sugar cane plantations in the city of Piracicaba, São Paulo, Brazil. They reported a reduction in termite populations after land preparation in sugar cane plantations. According to the authors, land preparation causes disruption of the foraging tunnels of the termite colonies in the soil profile, thus having a negative effect on the subterranean termite population.

Marandu grassland in this study is being degraded due to overgrazing and compaction of the surface soil layer. Silva Filho et al. (2010)

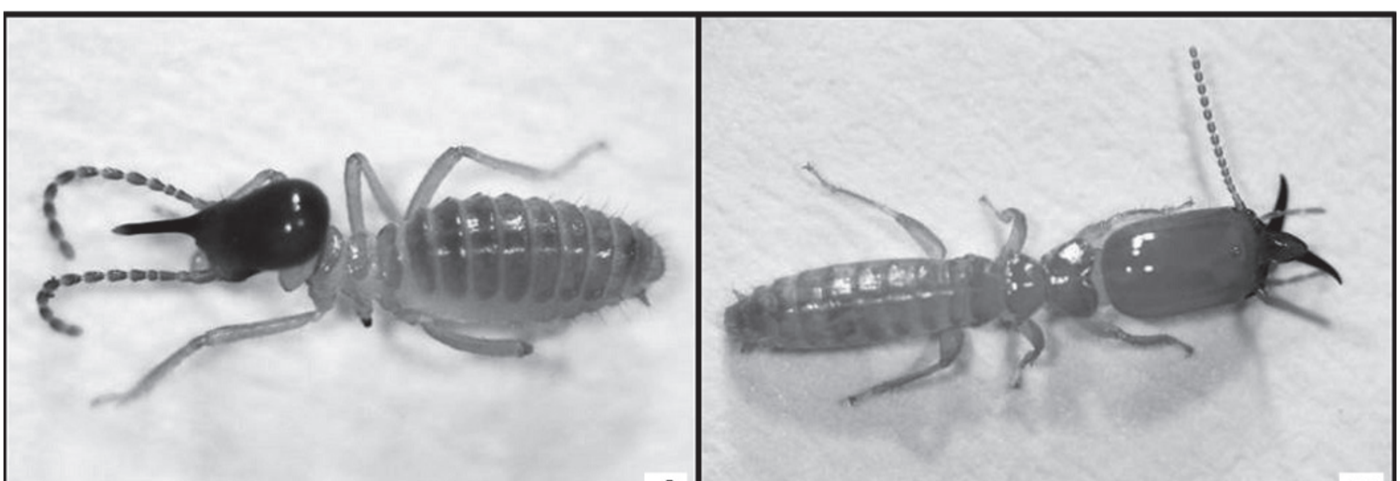

Fig. 2. Predominant termites in this study in southern Amazonia: (A) *Nasutitermes* sp. soldier; (B) *Heterotermes tenuis* soldier.

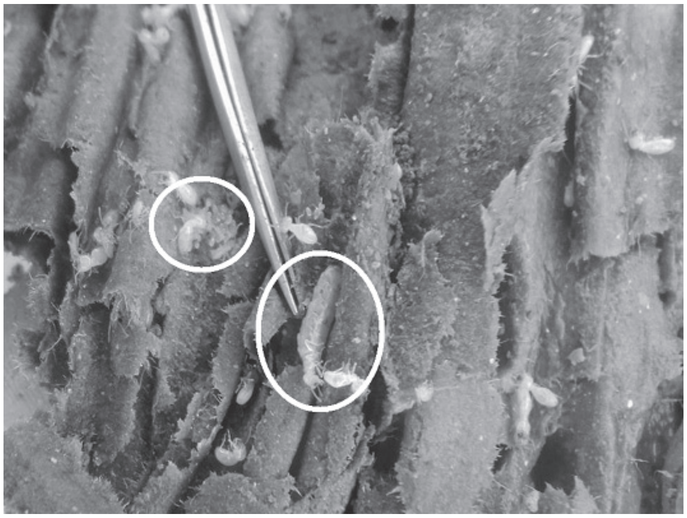

Fig. 3. Queen of *Heterotermes tenuis* (center circle) in early stage of egg production (circle on left), and colony formation inside the cardboard bait in southern Amazonia.

emphasized that areas subjected to grazing for 20 yr may be resistant to root penetration. Azevedo and Sverzut (2007) observed that animal trampling induces soil surface compaction, evidenced by increased soil density and resistance to penetration, with consequent decrease of macroporosity, total porosity, and hydraulic conductivity. With compaction of the surface layer and the decrease of macropores, the saturation point of the soil may occur more easily, becoming a limiting factor to subterranean termites. Junqueira et al. (2006) reported that poorly drained soils may be a factor for non-occurrence of termites on the baits. Ferreira et al. (2011) also emphasized that compaction hinders the movement of termites in the soil. Thus, soil compaction may explain the low level of infestation of Marandu grassland observed in this study.

Overall, termites infested baits most readily in the Mombasa grassland, coffee crop, and the forest fragment, suggesting higher densities, or more active foraging in these environments. In contrast, termite foraging in soybean and Marandu grassland was significantly lower. The dominant termite species was *H. tenuis*, and in open environments it was the only species found. The genus *Nasutitermes* was present in the forest area and in the coffee crop, which confirms its arboreal behavior requiring trees for nesting. We conclude that the baits were useful or monitoring populations of *H. tenuis* and *Nasutitermes* sp.

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