CROP PROTECTION

Termites in Sugar Cane in Northeast Brazil: Ecological Aspects and Pest Status

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Cupins em Cana-de-Açúcar no Nordeste Brasileiro: Aspectos Ecológicos e seu Potencial Como Praga

RESUMO - A distribuição espacial, a abundância e os hábitos alimentares dos cupins foram estudados em uma plantação de cana-de-açúcar do Nordeste brasileiro e, com base nesses parâmetros ecológicos, o potencial praga das espécies foi discutido. Quatro espécies foram encontradas: *Amitermes nordestinus* Mélo & Fontes, *Cylindrotermes nordenskioeldi* Holmgren, *Nasutitermes coxipoensis* (Holmgren) e *Syntermes nanus* Constantino, todas registradas pela primeira vez em associação com cana-de-açúcar. A abundância e a distribuição espacial (vertical e horizontal) dos cupins foram influenciadas principalmente pela biomassa de raízes da cultura e pela quantidade de matéria orgânica no solo. Constatou-se que *C. nordenskioeldi* causa danos à cultura da cana-de-açúcar, *A. nordestinus* tem potencial como praga, enquanto *N. coxipoensis* e *S. nanus* não apresentam potencial como praga. A importância dos cupins para manutenção da fertilidade, aeração e porosidade dos solos tropicais deixa evidente que estudos básicos sobre a biologia reprodutiva e dinâmica populacional de *C. nordenskioeldi* e *A. nordestinus* devem ser estimulados, na perspectiva do desenvolvimento de agentes de controle e técnicas de manejo espécie-específicos.

PALAVRAS-CHAVE: Isoptera, riqueza de espécies, abundância, distribuição espacial, hábito alimentar

ABSTRACT - The spatial distribution, abundance, and feeding habits of termites in a sugar cane plantation in Northeast Brazil were studied, and based on these ecological parameters, the pest status of the species was evaluated. Four species were found: *Amitermes nordestinus* Mélo & Fontes, *Cylindrotermes nordenskioeldi* Holmgren, *Nasutitermes coxipoensis* (Holmgren) and *Syntermes nanus* Constantino, which we reported by the first time in association to sugar cane. The abundance and spatial distribution (vertical and horizontal) of the termites were influenced mainly by the plant root biomass and soil organic matter. *C. nordenskioeldi* is harmful to sugar cane, *A. nordestinus* is a potential pest, while *N. coxipoensis* and *S. nanus* are not potential pests. The importance of termites for maintaining the fertility, aeration and porosity of tropical soils is an evidence that basic investigations on reproduction biology and population dynamics of *C. nordenskioeldi* and *A. nordestinus* must be encouraged aiming to develop pest control agents and species-specific management techniques.

KEY WORDS: Isoptera, species richness, abundance, spatial distribution, feeding habit

Termites are abundant in tropical ecosystems acting on decay of plants debris in soil, with an important role in nutrients cycling and soil fertilization (Bignell & Eggleton 2000). Their participation in the decomposition process starts with the fragmentation of the plant necromass which is then mineralized by fungi and bacteria and transformed in inorganic nutrient compounds that will be absorbed by plants (Holt 1987). Termites also have a marked effect on tropical soil structure and properties, where many species move the organic matter from the surface to deeper layers of the soil, improving and maintaining its porosity and aeration (Garnier-Sillam & Harry 1995, Lavelle *et al*. 1997).

About 10% of termite species have been pointed out as agents of some kind of harm to crops or buildings (Edwards & Mill 1986, Constantino 2002). In agricultural systems, they have been reported as harmful to many crops, like maize, yam, cassava, eucalyptus, peanut, rice, and cotton (Sands 1973, Fowler & Forti 1990). Termites have been reported as one of the most important causes of damage to sugar cane plantations in Northeast Brazil (Novaretti & Fontes 1998). The functional importance of termites in ecosystems leads us to the need of a better knowledge on the reproduction biology, behaviour, and ecology of pest potential species. Such knowledge may be a useful tool for estimating the pest status. Besides, it is a prerequisite to develop control agents or alternative management techniques appropriate for each species, period of the year, and region, as well as to adop less injurious maintenance procedures to agroecosystems (Logan *et al*. 1990, Martius 1998).

The present work aimed to evaluate the richness, abundance, spatial distribution (vertical and horizontal), and feeding habits of termite species found in a sugar cane plantation in Northeast Brazil. An overall analysis of these ecological parameters was additionally performed as a contribution to estimate the pest status of the species here investigated.

Material and Methods

The investigation was carried out at the Japungu distillery, in the Municipality of Santa Rita, Paraíba State, Brazil, where sugar cane plantations cover an area of 18,000 ha. Two formation-types, the Atlantic forest and the Cerrado, were originally predominant in that area. The local climate is the type AS' of Köppen classification, hot, humid with rains in autumn and winter (Atlas Geográfico da Paraíba 1985). Rotation of crops and chemical control of insects have never been practised in our study area. The sugar cane cultivar in the area was SP 70-1143, which lasts one year from the day it is planted to harvest (from August to March). The average distance between two contiguous ridges with sugar cane was 1m.

Two plots measuring 50 x 50 m were delimited in the middle of the plantation and 240 sampling sites were chosen, of which 120 were along the ridges and 120 were along the furrows. The sampling sites were 5 m apart from each other. Collections of termites were performed from December/1997, immediately after sugar cane harvest, up to September/1998 throughout the crop growth period. Every three months, five sites on the ridges and five in the furrows of one plot were chosen by chance, totalling 40 collections (20 on the ridges and 20 in the furrows). A monolith of soil (25 x 25 x 40 cm) was collected from each sampling site, which was sliced in four layers measuring 25 x 25 x 10 cm, for manual extraction of termites (adapted from Anderson & Ingram 1987). After collecting the termites, the roots were removed from each layer by using a 50 cm diameter sieve with a 2 mm mesh size. The roots were taken in paper bags to the laboratory, where they were oven-dried at 105°C for 72h and weighed afterwards. The temperature of the soil from which the monolith was collected was measured with a mercury column thermometer, in the adjacent layers at 0-10 cm, 10-20 cm, 20-30 cm, and 30-40 cm deep. Soil samples from these four layers were also collected to determine soil humidity, pH, and organic matter content. The sample collections were always performed in the morning (between 7:30h and 11:30h), before soil temperature increased, which would cause migration of termites to deeper layers of the soil.

The termite feeding habits were evaluated through field observations (Constantino 1992, Bandeira & Vasconcellos 2002). The mandibles morphology (Sands 1965, Deligne 1966, Fontes 1982, Bandeira 1989) and maceration of bowels content of at least 10 workers from each species were analized, by using a light microscope (Bandeira 1989), in order to detect the existence of sand and silt particles and plant fragments. Seven hundred and fifty pieces of sugar cane stems were collected at random and sliced in search of termites. Other sugar cane plantation areas were observed with respect to the presence of termites, mainly at places where plants were apparently less developed.

The aggregate distribution and the large amount of soil samples with no termites were a major obstacle to normalize the data for a parametrical statistical analysis, even after the transformation to log (x + 1), which led us to choose the application of nonparametric statistics. The U-test of Mann-Whitney was used to compare the difference between abundance of termites in the ridges and in the furrows. The test of Kruskal-Wallis was used to determine the preference of termites for the soil layers. The test of Wilcoxon was used *a posteriori* to determine possible significant differences among the soil layers. The Spearman correlation was applied to investigate the relations between abundance of termites and the abiotic factors.

Results

The four species of termites we found belong to the family Termitidae (Table 1). *Cylindrotermis nordenskioeldi* Holmgren occurred exclusively on the ridges of the sugar cane plantation, representing more than half of all collected individuals (Table 1). *Amitermes nordestinus* Mélo & Fontes and *Nasutitermes coxipoensis* (Holmgren) were also more abundant on the ridges, though occurring in the furrows as

Table 1. Richness and abundance of termites (individuals m^{-2}) in sugar cane plantation in Paraíba State, Northeast Brazil.

Species	Ridges					Furrows					Feeding habit	Microhabitat
	Dec	Mar	Jun	Sep	Mean	Dec	Mar	Jun	Sep	Mean		
A. nordestinus	529	600	1410	326	716.2	-	36	6	2590	658.0	Intermediate	s, r
C. nordenskioeldi	4732	3081	3793	2026	3408.0	-	-	-	-	-	Xylophagous	lv, ds, r, s
N. coxipoensis	-	4322	2374	842	1884.5	-	3	-	-	0.7	Xylophagous	ds, s
S. nanus	26	-	-	-	6.5	-	-	32	-	8.0	Phyllophagous	s
Total	5287	8003	7577	3194	6015.2	-	39	38	2590	666.7	-	-
Monthly relative bundance (%)	22.0	33.3	31.5	13.2	-	-	1.5	1.4	97.1	-	-	-

Microhabitats: lv, living stem; ds, dead stem; r, roots; s, soil well. *Syntermes nanus* Constantino was slightly more abundant in the furrows than on the ridges, but with a less significant density. *A. nordestinus* was the most common species in the furrows, representing 97.1% of the termites in those sites. The abundance of termites on the ridges was 6,015.2 individuals m^{-2} and in the furrows was only 666.7 individuals m^{-2}, a difference nine times larger in favour of the former sites ($U = 33.0$; $P < 0.01$).

A gradient of termite abundance was observed in the soil layers on the ridges. The largest concentration of individuals was found in the 0-10 cm layer, decreasing gradually deeper in the soil. The test of Kruskal-Wallis showed a significant difference in the layers on the ridges ($P < 0.001$), but not in the layers in the furrows ($P < 0.27$). The significance levels for the soil layers on the ridges, as determined *a posteriori* by the test of Wilcoxon, are shown in Table 2. The abundance of termites correlated significantly with the biomass and necromass of roots ($r_s = 0.67$; $P < 0.01$) and also with the soil organic matter content ($r_s = 0.40$; $P < 0.05$), both on the ridges and in the furrows.

Table 2. Test of Wilcoxon *a posteriori* for a comparison between the abundance of termites at the soil layers investigated on the ridges of the sugar cane plantation, in Paraíba State, Northeast Brazil.

Soil layers	Ridges		
	10-20 cm	20-30 cm	30-40 cm
0-10 cm	P < 0.05	P < 0.05	P < 0.05
10-20 cm		P < 0.05	P< 0.05
20-30 cm			P = 0.46

The xylophagous termites *C. nordenskioeldi* and *N. coxipoensis* were the most abundant species in the sugar cane plantation. *C. nordenskioeldi* individuals were found feeding mainly on dead sugar cane stems, but also on apparently healthy stems, as well as on plant roots. This species had larger amount of individuals (though not quantified) in gaps of the plantation with shorter and yellowish plants. *N. coxipoensis* had individuals feeding generally on dead stems, but occasionally feeding also on living stems (less than 1%) which were previously attacked by larvae of *Diatraea saccharalis* (Fabricius) (Lepidoptera: Crambidae). Individuals of *A. nordestinus* were found feeding on fallen leaves and dead roots, but also on some living roots. Individuals of *S. nanus* were also feeding on recently fallen leaves and also on living leaves, when there were no dead leaves on the soil, in the beginning of the sugar cane sprouting.

Discussion

The richness of the termite species in the sugar cane plantation we studied represented one fifth of the species richness we found in a remnant of the Atlantic forest 20 km away; however, the density of individuals in the plantation was twice as large as in the forest (Silva & Bandeira 1999). This inverse relationship between species richness and abundance of individuals in cultivated areas, contrasting with the natural vegetation, had already been reported elsewhere (Wood *et al.* 1977). The richness of termite species we found in our study area represented one fourth of the richness of species we determined in a Cerrado remnant 5 km distant from the sugar cane plantation (Sena *et al.* 2003). The increased climatic instability and the decreased habitat heterogeneity, caused by deforestation followed by cultivation, certainly eliminated the most susceptible species to disturbance, contributing to a biological situation characterized by a low biodiversity with few dominant species (Begon *et al.* 1990). Black & Okwakol (1997) suggested that the reduction of termite diversity may have a negative impact on ecological processes of agroecosystems, chiefly on those related to plant necromass decomposition.

The four species studied here are included in genera that have already been reported in association with sugar cane in Northeast Brazil (Novaretti & Fontes 1998, Malagodi & Veiga 1994), but the termites they studied were not identified at species level. In Southeast Brazil, where more studies on termites in association with sugar cane have been performed, 14 species were registered by Arrigoni *et al.*(1988), although none of them belonged to the genera *Amitermes* and *Cylindrotermes* (Macedo 1995, Pizano 1995). Among 14 species reported by Arrigoni *et al.* (1988), only four species have been considered as of economic injury to crops, *viz. Heterotermes tenuis* (Hagen), *Procornitermes triacifer* (Silvestri), *Neocapritermes parvus* (Silvestri), and *Cornitermes cumulans* (Kollar), being the former the most important (Macedo 1995, Novaretti & Fontes 1998). We did not find any species of *Heterotermes* in the sugar cane plantation, but in northeastern Atlantic forest remnants *H. longiceps* has been reported as one of the commonest species living in decomposing tree trunks (Bandeira *et al.* 1998; A. Vasconcellos, unpub.); and *H. sulcatus* was reported inside buildings at several urban areas of João Pessoa, capital of Paraíba State (Vasconcellos *et al.* 2002).

The spatial distribution of termites on the soil of the sugar cane plantation was clearly influenced by the available resources, like biomass and necromass of roots and soil organic matter content. No migration of termites was noticed from the upper surface layers to lower layers of the soil as the climate changed from dry to rainy season. Termites in the Atlantic forest showed a uniform distribution in the soil profile, with a tendency to concentrate in the 10-25 cm layer (Silva & Bandeira 1999).

Our field observations and our studies of feeding habits of *C. nordenskioeldi* in the laboratory showed that this species is the only one that causes injuries to plants in the sugar cane plantation, since its individuals feed on living roots and stems. We were unable to evaluate the economic injury level this species caused to the crop. However, the injuries were noticeable in gaps of the crop with less developed plants with their yellow leaves, and where the individuals of *C. nordenskioeldi* were found in more than 70% of the clumps of roots.

In Northeast Brazil, species of *Amitermes* were observed feeding on stems of sugar cane plants (Novaretti & Fontes 1998). As individuals of *A. nordestinus* were observed feeding on wood and humus, we suggest that this species feeds mainly on dead roots and leaves, both mixed into the soil as a result of the decomposition. However, as we also observed an intensive grazing activity of individuals close to living roots of sugar cane, the plants could be weakened by injuries in their root system, an aspect that must be investigated with an appropriate method. This species has been recently reported as harmful to roots of pineapple (*Ananas comosus*, Bromeliaceae) (Mélo & Fontes 2003). Individuals of *A. nordestinus* have also been reported in roots of bromeliads and cacti in two ecosystems of Northeast Brazil, 'caatinga' (Mélo 2002) and 'cerrado' (A. Vasconcellos, unpub.).

Species of *Nasutitermes* have also been reported as pests of sugar cane (Malagodi & Veiga 1994). In our study, individuals of *N. coxipoensis*, though very frequent, seemed to be feeding on necromass (dead stems and leaves), being then considered as beneficial to the crop. Its individuals were rarely found in living stems which were previously attacked by larvae of *D. saccharalis*. Thus, the presence of *N. coxipoensis* in living stems seems to be only possible when mediated by lesions on plant tissue caused by that caterpillar.

Some species of *Syntermes*, as reported by Guagliumi (1969), are more harmful to sugar cane plantation because they attack new and old leaves. Reduction of leaf area of a plant alters its photosynthetic rate affecting its growth (Speight *et al.* 1999). Constantino (1995) also observed that species of *Syntermes* feed chiefly on leaves. Pereira *et al.* (1977) observed individuals of *S. molestus* and *S. grandis* attacking roots and newly planted stem internodes. Living leaves of sugar cane had clear signs of cuts made by individuals of *S. nanus*, but the attacked leaves had a frequency of only 1%, which represents a negligible loss of crop yield.

In conclusion, *C. nordenskioeldi* causes damage to sugar cane plantation; *A. nordestinus* is a potential pest, while *N. coxipoensis* and *S. nanus* are not potential pests. Even though some species of termites are harmful to crops, their participation in the necromass decomposition and soil formation reinforce the need to investigate the reproduction biology and population dynamics of *C. nordenskioeldi* and *A. nordestinus*, in order to obtain effective control agents or species-specific management techniques useful to integrated pest control.

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