

## Association between *Constrictotermes cyphergaster* (Silvestri, 1901) (Isoptera: Termitidae) with *Pilosocereus gounellei* (Weber ex Schum) Byles & Rowley (Cactaceae) at the Northeastern Brazil

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**Abstract.** Termites are important components of tropical ecosystems, as decomposers and for their outstanding role in feeding guilds. There are about 2,800 species of termites in terrestrial ecosystems, organized into seven families. Factors that determine abundance in termite colonies are soil type, quality of microhabitat, humidity, and availability of food resources. The species *Constrictotermes cyphergaster* (Silvestri, 1901) belongs to the Family Termitidae and to the Subfamily Nasutitermitinae. Termites in this taxon are characterized by building their nests in arboreal environments and rocks. Ecological interactions of termites and cactaceans are still scarcely studied. The research was done during the year of 2014, at the Experimental Station of the Federal University of Paraíba, located in the Municipality of São João do Cariri, State of Paraíba, Brazil. A quadrant with a total area of 2,500 m<sup>2</sup> was delimited. Fifteen random samples of *Pilosocereus gounellei* (Weber ex Schum) Byles & Rowley containing termites, and 15 random samples without termites, were chosen. We report a previously unreported relationship between these organisms, and analyze the relationship existing between the size of the cactaceans and the occurrence of termite mounds. We conclude that the relationship between the cactacean *P. gounellei* and the termite *C. cyphergaster* is one of herbivory of the later over the former. After consuming all the living tissues of the plants, the termites abandon the plant, because these cactaceans no longer

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provides the necessary conditions for the survival of termites. Xique-xique associated with termite mounds show visual signs of suffocating debilitation, leading to the total collapse of the cactaceans.

**Keywords:** Caatinga; Termite mounds; Xique-xique.

**Resumo.** *Associação entre o cupim Constrictotermes cyphergaster (Isoptera: Termitidae) com Pilosocereus gounellei (Weber ex Schum) Byles & Rowley (Cactaceae) no Nordeste do Brasil.* Os cupins ou térmitas tem grande a importância nos ecossistemas tropicais por seu papel nos processos de decomposição e sua posição na cadeia alimentar. Existem cerca de 2.800 espécies de cupins em ecossistemas terrestres, organizados em sete famílias. O tipo de solo, a qualidade do microambiente, a umidade e a disponibilidade de recursos alimentares influenciam na abundância das colônias dos térmitas. *Constrictotermes cyphergaster* (Silvestri, 1901) pertence à Família Termitidae e à Subfamília Nasutitermitinae. Os cupins destes grupos são caracterizados por construir seus ninhos em ambientes arborícolas e em rochas. As pesquisas sobre a relação ecológica entre cupinzeiros e cactáceas ainda são bastante escassas. A pesquisa foi realizada no ano de 2014, na Estação Experimental da Universidade Federal da Paraíba, localizada no Município de São João do Cariri, estado da Paraíba, Brasil. Foi delimitado um quadrante com área de 2.500 m<sup>2</sup>. Foram escolhidos de forma aleatória 15 pontos nos quais se encontravam o xique-xique *Pilosocereus gounellei* (Weber ex Schum) Byles & Rowley com cupinzeiro e 15 sem o termiteiros. Estamos registrando uma relação anteriormente não relatada entre esses organismos, e analisamos a relação existente entre o tamanho das cactáceas e a ocorrência dos termiteiros. Concluímos que a relação entre o cupim *C. cyphergaster* e a cactácea *P. gounellei* é um tipo de herbivoria. Depois de consumir todos os tecidos vivos das plantas, os cupins abandonam a planta, porque essas cactáceas já não fornecem as condições necessárias para a sobrevivência destes. Os xique-xique associados com os termiteiros mostram sinais visuais de debilitação sufocante, levando ao colapso total das cactáceas.

**Palavras-chave:** Caatinga; Termiteiros; Xique-xique.

## Introduction

Termites are important components of tropical ecosystems, as decomposers and for their outstanding role in feeding guilds (Coles, 1980). In many tropical ecosystems, termites dominate the landscape with their nests and termite mounds. They often surpass almost all other insect groups in numbers of individuals and biomass (Bandeira and Vasconcellos, 1999).

According Constantino and Acioli (2006), there are about 2,800 species of termites in terrestrial ecosystems, organized into seven families and the Families

Termitidae, Serritermitidae, Kalotermitidae, and Rhinotermitidae are reported in Brazil. Factors that determine abundance in termite colonies are soil type, quality of microhabitat, humidity, and availability of food resources (Constantino and Acioli, 2006).

*Constrictotermes cyphergaster* (Silvestri, 1901) belongs to the Family Termitidae and to the Subfamily Nasutitermitinae. Termites in this taxon are characterized by building their nests in arboreal environments and rocks. They inhabit Argentina, Bolivia, Brazil, and Paraguay (Constantino, 1999; Torales et al.,

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2005; Lucena, 2016). According to Bandeira et al. (2007), *C. cyphergaster* feeds almost exclusively on wood (e.g., trunks, twigs, and branches). In some cases, these may include other types of available vegetation, such as cactuses and bromeliads.

The Cariri Region in the State of Paraíba is inserted in the Caatinga Biome. This formation presents 396 species of plants, organized into 90 families. Ten of these belong to the Cactaceae (Barbosa et al., 2007). The cactaceans occurring in this region are xerophilous and similar to the crassulaceans regarding water economy (Barreto and Barbosa, 2001). These families are very resistant in dry climates. Being well adapted to the semiarid region, they become important as food sources for animals, mainly during period of drought (Campos et al., 2017).

Ecological interactions of termites and cactaceans are still scarcely studied (e.g. Marín et al., 2004; Silva, 2014). However, among ecological relations established between termites and plants, the following have been recognized: (1) a harmonic but indifferent relationship, when the host plant furnishes mechanical support, without being otherwise affected by the presence of these insects (Cesar et al., 1986); (2) a non-harmonic or negative relationship, when the termites damage the plant species (Cesar et al., 1986), usually by feeding on certain plant tissues (Lee and Wood, 1971); and (3) a harmonic or positive relationship, when the plants benefit from the presence of the termite mounds (Cesar et al., 1986). Additionally, we may relate the negative indirect impact caused by termites, which may modify some proprieties of the soil, that will influence the development of plant species (Cesar et al. 1986).

The cactaceans *Pilosocereus gounellei* (Weber ex Schum) Byles & Rowley inhabits the Region of Caatinga, at Northeast Brazilian, on shallow, rocky or sandy soils (IUCN Red List, 2017).

The hypotheses in this paper are (1) termites of the species *C. cyphergaster* are potential herbivores of the cactacean “xique-xique”; (2) termites of this species

prefer cactaceans of larger perimeter; (3) the field methods used in the present paper are efficient for analyzing relationships between termites and cactaceans.

So, the aim of the present study is to evaluate the heterotypic relationship between termites and “xique-xique” in the Municipality of São João do Cariri, State of Paraíba, Northeastern Brazil.

## Material and methods

### Study area

The research was done during the year of 2014, at the Experimental Station of the Federal University of Paraíba, located in the Municipality of São João do Cariri. The area is located within the Caatinga Biome, in the Semiarid Region of the State of Paraíba, Northeastern Brazil. This region belongs to the Planalto da Borborema, between the coordinates of 7° 23' 30" S and 36° 31' 59" W (Figure 1). The altitude varies from 400 to 600 m above sea-level (Araujo et al., 2013). Soil types are Neossolo Lítico, Vertissolo and Luvisolo Crômico Vértico (Chaves et al., 2000). This region is characterized by semi-arid climate (Couto et al., 2015).

A quadrant with a total area of 2,500 m<sup>2</sup> was delimited. Fifteen random samples of *P. gounellei* containing termites, and 15 random samples without termites, were chosen (Figure 1).

### Data collecting

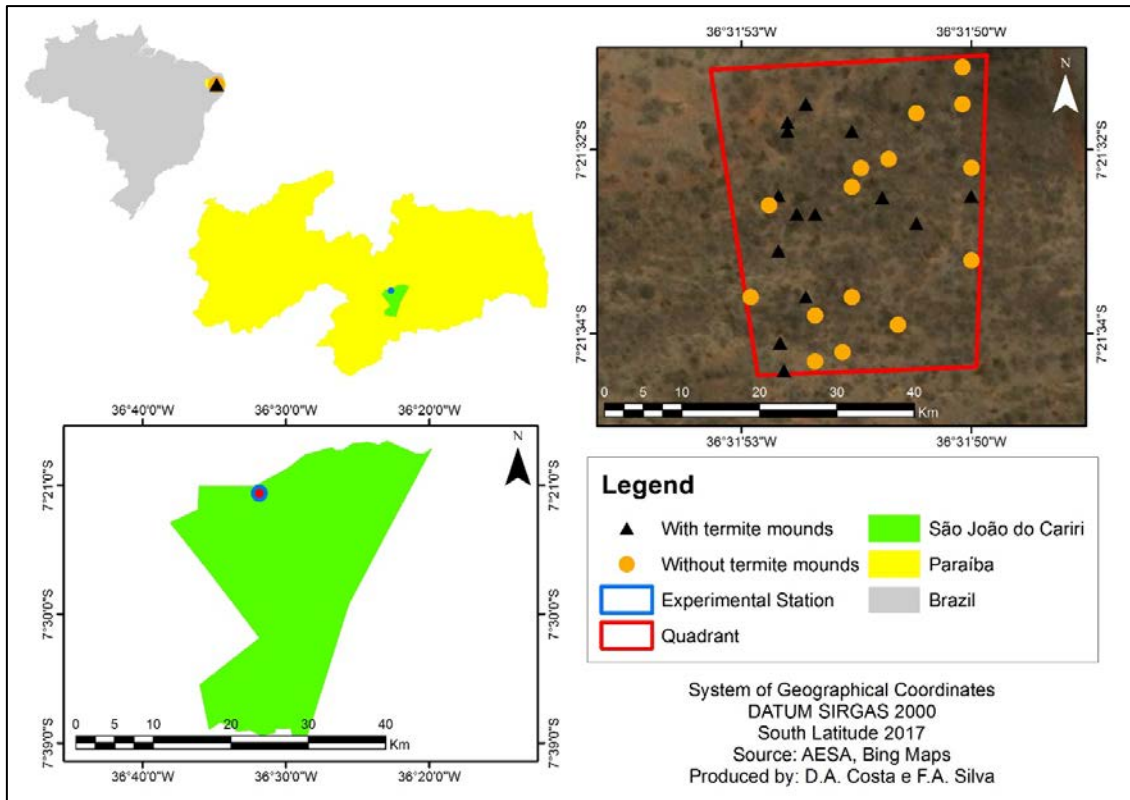
The perimeters of the termite mounds and of the cactaceans were measured, using the following formula:  $P=2 \times \pi \times r$ , in which **P** is the Perimeter,  $\pi$  corresponds to the value of Pi ( $\cong 3,14$ ), and **r** refers to the radius of the circle.

The activity in the termite mound was analyzed, being classified into Active and Inactive. In Active mounds the presence of termites was noted, while Inactive mounds did not show signs of the presence of termites.

Cactaceans with termite mounds were classified into Stage 1 plants (living plants), with less than 50% of the plant surface covered by the termite mound, Stage 2 plants (debilitated plants), with more than 50% of the plant surface covered

by the termite mound, and Stage 3 plants (dead plants), for rotting plant individuals with virtually the whole surface covered by the termite mound.

For the analysis of pH, ten soil samples containing cactaceans were collected, five of which contained termite mounds and five without mounds.



**Figure 1.** Map indicating the location of samples at Experimental Station of the Federal University of Paraíba, Municipality of São João do Cariri, State of Paraíba.

Excursions to the collecting site were made both during the day and night. Termites are nocturnal. Soldiers of this species collect food and also defend their termite mounds during the night (e.g. Moura et al., 2006).

In order to capture termites, mounds were sectioned longitudinally with a machete during daytime. Sections were 5 cm deep and 10 cm long. Termites were then captured with entomological pincers. Termites were preserved in alcohol at 70%. They were identified under an Olympus stereomicroscope with the identification key of Constantino (1999), and the species

was confirmed based on Cunha et al. (2015).

Soil samples were dried at environmental conditions, fragmented, processed, and then analyzed at Laboratório de Ecologia Química (LEQ), Universidade Federal da Paraíba, according to the norms of “Empresa Brasileira de Pesquisa Agropecuária” (EMBRAPA, 1997). Chemical analyses for evaluation of soil fertility and soil acidity (pH) were conducted.

Statistical analyses were performed with programs PAST (Hammer et al., 2001) and R (R Development Core Team, 2011).

## Results and discussion

In the present study we detected a strong presence of termite mounds in the

local cactaceans (xique-xique), corroborating the possible preference of termites for this species of plant (Figure 2).

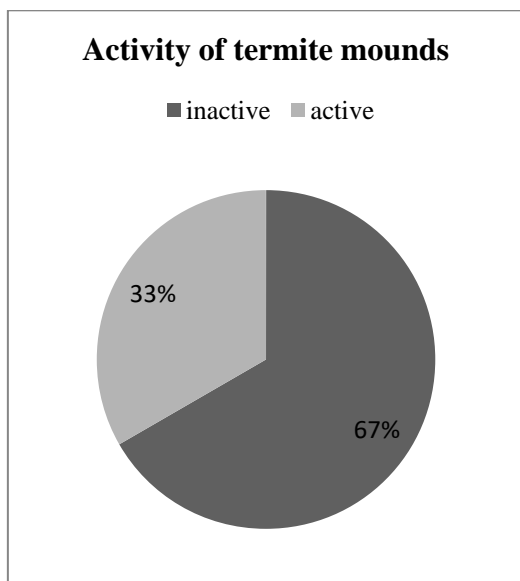


**Figure 2.** Xique-xique cactaceans with a termite mound of *C. cyphergaster*.

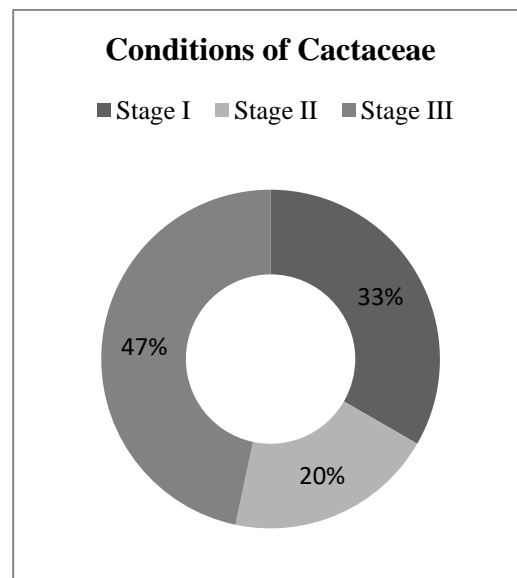
A total of 67% of termite mounds occurring on xique-xique were inactive (Figure 3).

We quantified 33% in Stage I (living), and 20% in Stage II (debilitated) and 47% of cactaceans as in Stage III

(dead) (Figure 4). We recorded most inactive termite mounds as occurring in Stage III (dead) cactaceans. This demonstrates that, after consuming all the living tissues of the plants, the termites abandon the plant, because these cactaceans no longer provides the necessary conditions for the survival of termites.



**Figure 3.** Proportion of active and inactive termite mounds.



**Figure 4.** Proportion of Stage I (living), Stage II (debilitated), and Stage III (dead) cactaceans.

The experiments indicated that mean pH in soil containing healthy cactaceans and cactaceans with termite mounds is 6.9 and 6.4, respectively (Table 1). We may conclude that soil containing cactuses with termites is more acid relative to soils containing only cactaceans.

**Table 1.** Mean pH in soil samples with healthy cactaceans and with termite mounds in Estação Experimental, Bacia Escola de São João do Cariri.

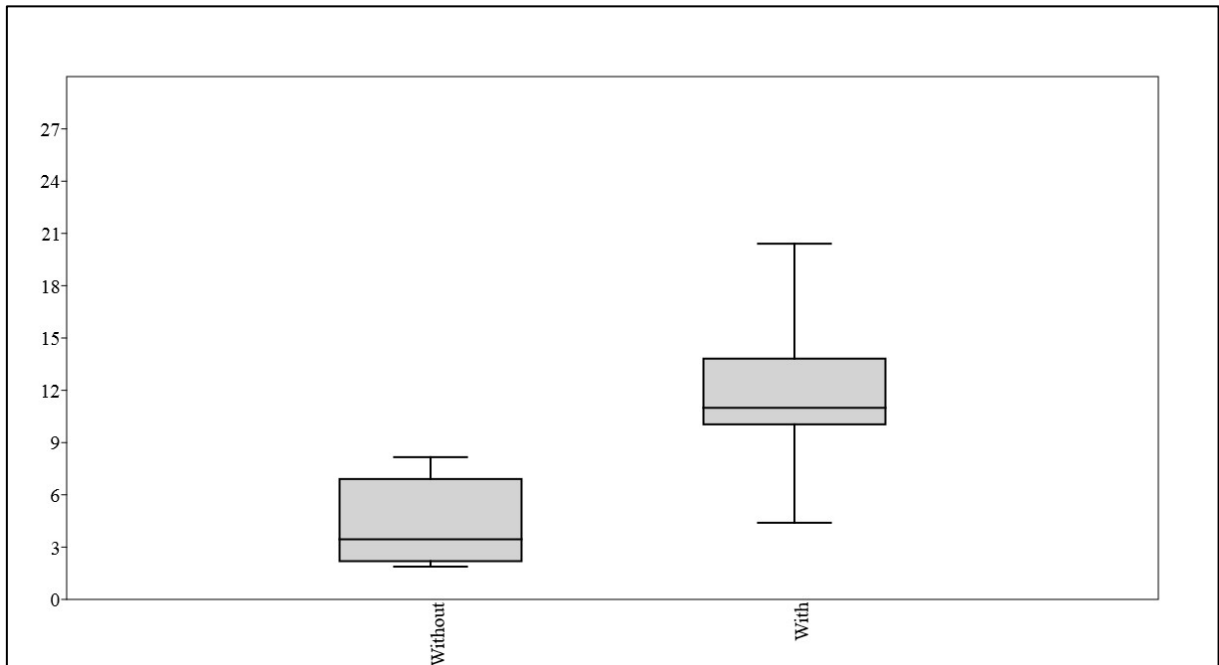
	Healthy cactaceans	Cactaceans with termite mounds
Sample 1	7.05	6.2
Sample 2	6.16	6.42
Sample 3	6.63	6.24
Sample 4	6.68	6.27
Sample 5	7.87	7.06
Mean	6.9 ± 0.64	6.4 ± 0.34

We recorded that the mean perimeter of xique-xique with termites is larger than those without termites, 11.93 m ( $\pm$  4.11 m) and 4.38 m ( $\pm$  2.33) m, respectively (Figure 5). The Test of Shapiro-Wilk indicated that cactaceans without termites do not present normal

distribution ( $W = 0.842$ ,  $p = 0.0134$ ). On the other hand, for plants with termites, the data are normal ( $W = 0.9597$ ,  $p = 0.6868$ ). As the set of data are not parametric, we conducted the Wilcoxon Test. We found a significant difference between the perimeters of xique-xique with and without

termites ( $W = 120$ ,  $p = 6.5331 \times 10^{-4}$ ). The data reveal that termites prefer larger plants. These provide more food and furnish better

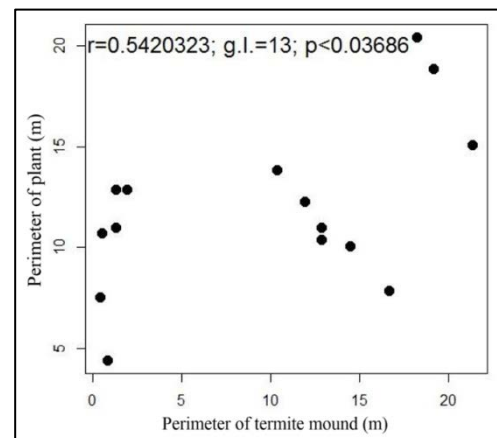
structural conditions for the building of the mounds.



**Figure 5.** Perimeter of xique-xique without and with termites.

Similar results were described by Lima-Ribeiro et al. (2006), who associated *C. cyphergaster* with arboreal species in the Cerrado formation. Gonçalves et al. (2005) find that in the Atlantic Forest the presence of termites in trees is positively related to the size of the trees.

Finally, the perimeters of the cactaceans were correlated to the perimeter of the termite mounds. The Test of Shapiro-Wilk indicated that the data present normal distribution, both for the variable “vegetal” ( $W = 0.9597$ ,  $p = 0.6868$ ), and for the variable “termite mound” ( $W = 0.9568$ ,  $p = 0.6378$ ). The Pearson’s Correlation indicated a significant positive correlation ( $r = 0.542$ ,  $p < 0.05$ ) between the perimeters of xique-xique and of termite mounds (Figure 6). Thus, the bigger the cactacean, the bigger will be the termite mound.



**Figure 6.** Pearson’s Correlation between the perimeter of the cactacean *Pilosocereus gounellei* and the termite mound.

## Conclusions

The relationship between the cactacean *P. gounellei* and the termite *C. cyphergaster* is one of herbivory of the later over the former. Xique-xique associated with termite mounds show visual signs of suffocating debilitation, leading to the total collapse of the cactacean.

We suggest that this species of termite presents a case of adaptive feeding, in which the termites show preference for larger cactaceans. Large cactaceans provide a better source of food for the termites and better mechanical support for the construction of their mounds.

The field work used in this study was sufficient for testing the above hypotheses and was successful for reaching novel ecological results pertaining to the interactions of termites and cactaceans.

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## Conflicts of interest

Authors declare that they have no conflict of interests.

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