Nest and Foraging Characteristics of *Acromyrmex landolti balzani* (Hymenoptera: Formicidae) in Northeast Brazil

by

Júlio César Melo Poderoso[1], Genésio Tâmara Ribeiro[1], Gláucia Barretto Gonçalves[1], Paula Daniele Mendonça[1], Ricardo Antonio Polanczyk[2], Ronald Zanetti[3], José Eduardo Serrão[4] & José Cola Zanuncio[5,6]

ABSTRACT

The objective of this study was to survey leaf-cutting ants in the Campus of the Federal University of Sergipe in Sergipe State, Brazil, and to analyze characteristics of nests and foraging dynamics of the most frequent species. Six transects with 20 meters wide by 50 meters long were cast every 150 meters where leaf-cutting ants were collected . Eighty-three ant nests were found in the six transects. In 88% *Acromyrmex landolti balzani* (Hymenoptera: Formicidae) was the only species of this genus found, with the other 12% composed of *Atta* spp. Seven nests of *A. landolti balzani* were evaluated after its identification and observed during the photophase (07:00 A.M. to 06 P.M.) for periods of 20 min at intervals of 50 minutes during five days. The depths of nests ranged from 12cm to 140cm in the rainy and dry seasons, respectively, and their vaulted chambers have an elliptical shape. The foraging behavior of this species increases, gradually, from 10:00 A.M. to 02:00 P.M. and reached a peak, which is related to the sensitivity of the ant workers to microclimatic gradients, time and space. These gradients affect the nesting and foraging behavior of this insect.

Key words: ecology, insect pests, leaf cutting ants

[1]Universidade Federal de Sergipe – Núcleo de Engenharia Florestal, Avenida Marechal Rondon s/n, 49100-000, São Cristóvão. Estado de Sergipe, Brasil

[2]Núcleo de Desenvolvimento Científico e Tecnológico em Manejo Fitossanitário de Pragas e Doenças (NUDEMAFI), Centro de Ciências Agrárias (CCA), Universidade Federal do Espírito Santo, 29500-000, Alegre, Estado do Espírito Santo, Brasil. E-mail: rapolanc@yahoo.com.br.

[3]Departamento de Entomologia, Universidade Federal de Lavras, Caixa Postal 37, 37.200-000, Lavras, estado de Minas Gerais, Brasil. e-mail: zanetti@ufla.br

[4]Departamento de Biologia Animal, Universidade Federal de Viçosa, 36571-000, Viçosa, estado de Minas Gerais, Brasil.

[5]Author correspondent: zanuncio@ufv.br

INTRODUCTION

Leaf-cutting ants are the major insect pest in forest plantations in Brazil in commercial areas, reforestation, landscaping or restoration areas (Zanetti *et al.* 2003). These species have broad geographical distribution and, if not properly controlled, can reach a large number of colonies per area (Zanuncio *et al.* 2002).

Procedures for leaf-cutting ant control have been developed (Zanetti *et al.* 2008), but the ants' spatial distribution and behavior are largely unknown (Reis *et al.* 2008). The spatial distribution and behavior of leaf-cutting ant nests may be affected by environmental factors and it should be studied for *Atta* and *Acromyrmex* species (Zanuncio *et al.* 2004). The spatial distribution of ants may be a response to factors as light, temperature, humidity, host plants, behavior, reproduction and interaction with other organisms (Fowler *et al.* 1986) as well as the presence of areas with native vegetation (Zanetti *et al.* 2000).

Loose soil at entrance holes is indicative of leaf-cutting ant nests but it is important to evaluate ecological characteristics such as the internal architecture of these nests (Verz *et al.* 2007) and foraging peaks (Alves *et al.* 1997) to develop methods of controlling these pests. The nests of leaf-cutting ants are usually formed by chambers and tunnels that connect one chamber to another or to the external area. The nests of *Atta* and *Acromyrmex* have chambers with fungi, workers, brood and queen, empty or with soil or waste (waste from vegetables, depleted fungi and ant bodies) (Mariconi 1970).

Foraging includes selection, cutting and transport of plant fragments through chemically or physically marked trails into the nest and it may vary during the year and for each species of leaf-cutting ant (Della Lucia & Oliveira 1993). This process is complex and the social and individual behavior determines the loading of a substrate to the breeding colony with maximum yield (Rocco & Hölldobler 1994) and the season, temperature, relative humidity, development stage of the colony and release of reproductive individuals can influence foraging (Lewis *et al.* 1974a, 1974b; Rockwood 1975, 1976). The space, quantity and quality, competition with other colonies, and predation are the main ecological factors that determine the foraging strategy of ants (Traniello, 1989). For this reason, the analysis of spatial distribution of colonies of leaf-cutting ants is important to understand the interaction of insects with substrate (Underwood & Chapman, 1996). The objective was to survey ants of the tribe Attini and analyze characteristics of the nest and foraging dynamics of the more frequent species.

MATERIAL AND METHODS

Characterization of the study area

The municipality of São Cristóvão, Sergipe State, Brazil is located at 11º00'54"S, 37º12'21"W with a hot and humid climate, a rainy season from March to August, average temperature of 26 °C and annual rainfall of 1490mm. January, February and March are the warmest months with an average temperature of 27 °C, average maximum 30° C and minimum of 24° C while the coldest months are July and August with an average temperature of 24° C and average maximum below 27 °C. The soils are mainly sandy clay, acidic, deep and loose. Moreover, they have low fertility, high porosity (draining rainfall), high acidity and salinity, which make them difficult to use for agriculture. Sandy clay soils have red color from iron released from rock and are low in nutrients (Simese 2007).

Survey of leaf-cutting ants at the UFS

The Attini fauna considered in the survey was collected in six transects 20 m wide and 50 m long (Sossai *et al.* 2005) established according to a map of the Federal University of Sergipe (UFS) campus at every 150 m. All ant species were manually collected and stored in 70% ethanol labeled with information about the sample, place, predominant vegetation, type of construction, date of collection and collector. Ant species were identified by external morphology of their workers and soldiers with a stereomicroscope (Leica Wild MPS 05) and taxonomic keys (Mayhé-Nunes 1991). Twenty specimens of each nest per species were sent to Dr. Jacques Delabie of the Myrmecologie Laboratory of CEPEC/CEPLAC in Itabuna, Bahia State for confirmation of the identification. Voucher specimens were deposited in the laboratory of Agricultural and Forest Pests of the Forest Department of UFS.

Internal architecture of the nest

Seven nests of *Acromyrmex* were sampled in June 2005 (rainy season) and five from November 2005 to February 2006 (dry season) after being identified and its area of loose soil (the largest length and largest width) obtained. Each nest had only one entrance and, therefore, a survey of their outside parameters was not necessary. Trenches of variable width and depth were excavated by hand tools to study the internal architecture of the nests of this leaf-cutting ant by removing layers of soil up to the last chamber. The number, width (l), height (h) length (p) and depth of the chambers of the nests excavated were determined.

The geometric figures of the chambers were defined as spheres, cylinders or ellipsoids to determine their volume with the formula: $V= 1/6\pi\ [(1 + h + p) / 3]\ 2$ for spheres, $V= \pi/6.lhp$, for ellipsoids and $V= \pi /4\ [(l + h) / 2]\ 2.p$ for the cylinders, where l= width of the chamber, the chamber height h=the chamber height and p= length of the chamber.

Foraging dynamics

Three colonies of *A. landolti balzani* were selected and observed during the photophase (7:00 A.M. to 06:00 P.M.) for periods of 20 min at intervals of 50 min during five days at the UFS in April 2006. The number of workers returning to the nest with plant material was observed and measured during this period. The design was completely randomized and the averages analyzed with the program SISVAR (version 4.3) and compared with the Tukey test at a significance level of $p < 0.05$.

RESULTS

Ant species

Eighty-three ant nests were found in the six transects with 88% composed of *Acromyrmex* spp. and 12% of *Atta* spp. corresponding to an average of 121.7 and 16.6 *Acromyrmex* spp and *Atta* spp. nests and a total of 138.3 nests per hectare. The nests of *Atta* spp. were 69.00% *Atta sexdens sexdens* L., 15.26% *Atta sexdens rubropilosa* and 15.76% *Atta leavigata* F. Smith (Hymenoptera: Formicidae). These nests were under trees such as *Clitoria fairchildiana* R. Howard (Fabaceae), *Anacardium occidentale* L. and *Schinus terebinthifolius* Raddi (Anacardiaceae). *Atta* species forage leaves of these trees and can reduce growth and cause mortality of plants. This was evidenced by totally defoliated trees and ornamental plants damaged by leaf-cutting ants. *Acromyrmex landolti balzani* (Emery) was the only species found in all transects (Fig. 1) with its nests mainly in open areas like lawns.

Nest architecture

The chambers and the external area of the nests of *A. landolti balzani* are connected by channels that do not fall directly to the chamber, but have mild slopes. The number of chambers of ant nests ranged from one to five in June 2005 with the shortest and longest in between 12 and 50cm depth, respectively, and in most cases with ellipsoidal shape and diameter of 12 to 30cm.

The architecture of the nests of *A. landolti balzani* shows a single entrance hole formed by a tube of straw and other vegetable waste and one or more exits with an average height of 3.8 cm. Furthermore, mounds of loose soil with semi-circular shapes and average areas of 18.95 cm^2 ($32cm^2$ to 2.7 cm^2) were found next to this hole (Fig. 2).

Ant nests of *A. landolti balzani* evaluated had two to five chambers, the first at a few centimeters from the surface of the soil (15cm) up to 140cm depth and a diameter from three to 12cm. The length of the tunnels between chambers ranged from 12 to 28cm and they were vertical or inclined, leading

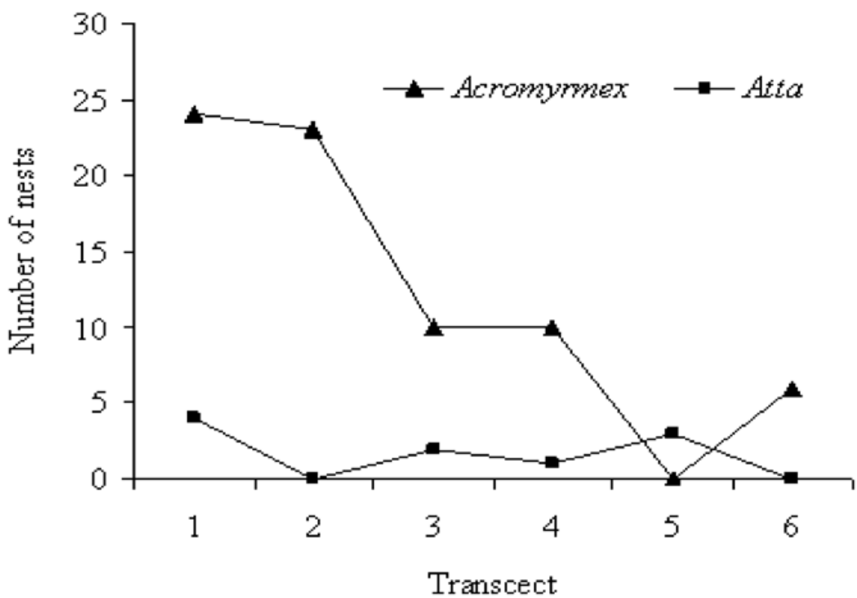

Fig. 1. Frequency of nests of *Acromyrmex* and *Atta* species (Hymenoptera: Formicidae) in transects at the campus of the Federal University of Sergipe, Municipality of São Cristóvão, Sergipe State, Brazil.

to the chambers. Green plant fragments found in the chambers may serve as a food reserve for the fungus.

Dynamics of foraging

Acromyrmex landolti balzani forage without trails and with a radial distribution of individuals from 60 to 250cm around the entrance hole of the nest. The number of individuals of *A. landolti balzani* foragers increased from 10:00 A.M. and reached a peak at 02:00 P.M. (Fig. 3) when the temperature and relative humidity were 31.40 ± 1.30 °C and 63.90 ± 0.91%, respectively. The foraging of this ant decreased until 06:00 P.M. when the average temperature and relative humidity were 26.00 ± 0.98 °C and 80.00 ± 0.95%, respectively. The plant fragments used as substrate for the fungi cultivation by *A. landolti balzani* were mainly leavess of *Paspalum notatum* Flügge (Poaceae), *Cynodon dactylon* L. (Poaceae) and the flowers *Richardia brasiliensis* Gomes (Rubeaceae).

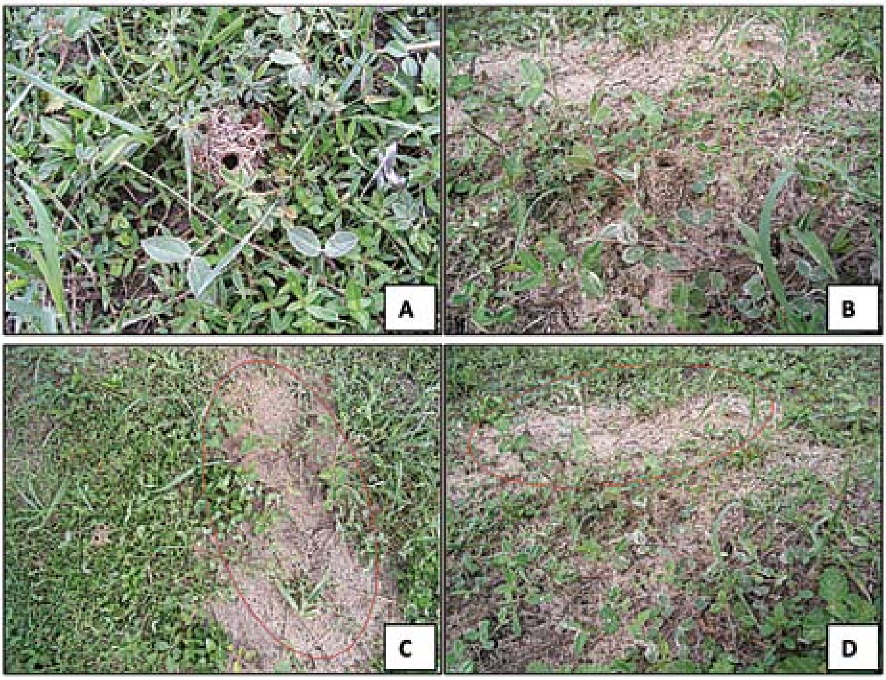

Fig. 2. Hole of nest entrance of *Acromyrmex landolti balzani* (A, B) and mound of loose soil with semicircular shape (C, D), campus of the Federal University of Sergipe, Municipality of São Cristóvão, Sergipe State, Brazil.

DISCUSSION

Acromyrmex landolti balzani occurs in São Paulo, Minas Gerais, Santa Catarina, Goiás and Mato Grosso do Sul States (Mayhé-Nunes 1991) and this is the first report of this ant in Sergipe State, Brazil. Ants of this species are more abundant in the grassland and reforested areas and *Acromyrmex* spp. occupy 98.00% of the nests of leaf-cutting ants in areas of *Pinus* sp. plantation (Cantarelli *et al.* 2006).

The architecture of the nests of *A. landolti balzani* varied with weather conditions. Ants nests excavated in the rainy season (July 2005) had more superficial chambers with fungi, which may be explained by the ideal water requirement of workers, eggs, larvae or pupae and the fungus of this leaf-cutting ant. Change in this behavior shows the responsiveness of workers of *Acromyrmex* sp. to temperature with increasing or decreasing excavation activity depending on this parameter as suggested by Bollazzi *et al.* (2008).

The chambers and the external area values observed in this research are similar to nests of *A. landolti balzani* in the region of Viçosa, Minas Gerais State, Brazil with three to six chambers up to 11.4 cm in depth and superimposed and connected by a vertical channel (Mendes *et al.* 1992).

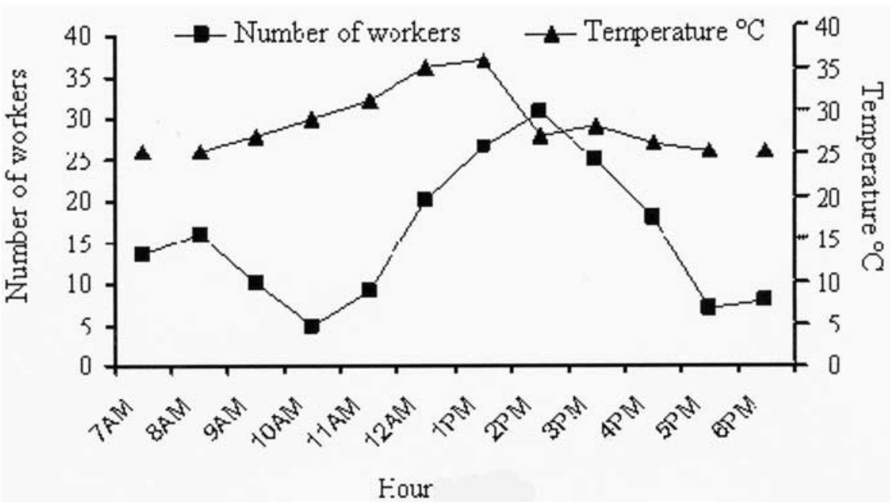

Fig. 3. Pattern of daily foraging of a nest of *Acromyrmex landolti balzani* (Hymenoptera: Formicidae) in April 2006 in the campus of the Federal University of Sergipe, Municipality of São Cristóvão, Sergipe State, Brazil.

Queen, eggs, larvae and pupae were found in the last and penultimate chamber of the nests of *A. landolti balzani* which is similar to that observed for *Acromyrmex rugosus rugosus* in the coast north and south of Ilhéus, Bahia State, Brazil (Soares *et al.* 2006). The behavior of colonies of *A. landolti balzani* in the UFS campus may be related to the sensitivity of this species to microclimatic gradients, time and space and its ability to change behavior with the deepening of chambers and transfer of fungal mass to deeper and more humid areas during the dry season (Bollazzi *et al*. 2008). This behavior can affect the control of *A. landolti balzani* which is usually accomplished with powdered insecticide because ant baits are not well-accepted and carried by these ants. Thus, dry powder should be used, preferably, in the rainy season when the chambers with fungi are closer to soil surface. The area of each chamber was lower as the number of chambers increased in the same nest. The largest total volume of chambers in this study was 2.27 liters and the lowest was 0.3 liters in a colony with only one chamber.

Acromyrmex landolti balzani forage without trails and with a radial distribution of individuals. The lack of trails in some species of *Acromyrmex* is explained by their dependence on ephemeral or homogeneously dispersed resources which makes main trails unnecessary (Vasconcelos & Fowler 1990. This behavior may also be explained by the direct transfer of leaves cut by the workers, which allows the exploitation of various food sources with less time and energy (Lopes *et al.* 2003).

The foragers were the largest workers of *A. landolti balzani,* similar to other species of this genus such as *Acromyrmex volcanus* and *A. octospinosus* where the division of labor is based on a bimodal distribution of size of the population of a colony (Wetterer *et al.* 1998), with minor workers remaining inside the nest caring the fungus garden and constructing the nest entrance while the major workers leave the nest to forage (Wetterer 1999).

Activities outside the nest require larger and older individuals due to the presence of predators and competitors (Rao 2000). The tasks of a colony are based on the morphology and age of workers (Evison *et al.* 2008) because the larger ants have more experience and behavioral flexibility to survive outside the nest (Camargo *et al.* 2007). On the other hand, brood and fungi garden care are performed by the smaller ones but it may vary between *Acromyrmex* species depending on the environment and food received (Lopes *et al.* 2005). This is related to increasing mortality risk in external activities during foraging and increasing life expectancy for young workers engaged in tasks inside the colony (Wakan *et al.* 1998). Complex behavior involving changes in the nest architecture, change and transporting the brood to places with better temperature and variations in the depth of the chambers requires a high degree of individual specialization and may be necessary to maintain the balance in a colony.

The temperature can be used to predict the occurrence and density of leaf cutting ants (Farj-Brener 1994), and the workers are sensitive to this parameter, as it affects the behavior of nesting, replacement of fungus (Bollazzi and Roces 2002) and search for food (Kleineidam *et al.* 2007).

The behavioral responses of leaf cutting ants vary with environmental conditions and this should be considered when choosing the best method of controlling these pests. The foraging activity of *A. landolti balzani* varies with temperature and humidity and therefore the ant baits should be applied in the morning just before 02:00 P.M. to control this ant because its foraging activity decreases from that time until ceasing around 06:00 P.M.

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