English Version

Architecture of nests of *Acromyrmex (Moellerius) balzani* (Formicidae: Myrmicini: Attini) in pasture[1]

Katiane Santiago Silva[2]*, Maria Aparecida Castellani*[3]*, Luiz Carlos Forti*[4]*, Aldenise Alves Moreira*[3]*, Odair Lacerda Lemos*[3]*, Rita de Cássia Silva Carneiro*[5]*, Camila Rodrigues Khouri*[3]*, Ana Elizabete Lopes Ribeiro*[6]

Abstract

Leaf-cutter ants *Acromyrmex* (*M.*) *balzani* (Emery), specialized in the cutting of gramineae are very common in pastures and agricultural crops of the South West of Bahia, with high density of nests. The objective of this work was to study aspects of nest architecture of *A. balzani*, located in pastures in the Southwest of Bahia, in order to search for the improvement of pest control strategies. Ten nests located in the cities of Vitoria da Conquista, Itapetinga, Tremedal and Itambé, BA were selected for study. Externally, the area, the volume of loose soil and the distance between the mount of loose soil and the tower were evaluated. The excavation was complete, opening gutters and cuttings in the soil profile. Afterwards, the measure of the height, width, depth, and the chambers height, regarding to the soil surface and to the coordinates of an orthogonal axis previously established were performed. The area and volume varied from 325 cm^2 to 1880 cm^2 and from 0.15 L to 5.88 L respectively. The distances between the loose soil mount and the tower varied from 2 to 37 cm. The total number of chambers per nest varied from 3 to 14, predominantly of chambers containing fungus, adult ants, and young forms. The higher concentration of chambers was at the first 30 cm and near the soil mount, but not under its projection.

Key words: Attini; chambers; leaf-cutter ants

Introduction

The tribe Attini (Formicidae, Myrmicinae) groups the ants which cultivate fungi and comprehend approximately 190 species (MAYÉ-NUNES and JAFFÉ, 1995), divided in 12 genus (HOLLDOBLER and WILSON, 1990), of which 95% of the species are neotropical and only 5% are found in the Neartic Region (MAYAHÉ-NUNES and JAFFÉ, 1995).

Leaf-cutter ants, genus *Atta* and *Acromyrmex*, more known as saúvas and quenquéns, respectively, have wide geographic distribution, appear in all the American continent, except Canada, some islands in the Center America and Chile (MARICONI, 1970).

They are considered plagues in agricultural, silvicultural and pastoralist areas, since they use vegetal substrates to the fungi cultivation, with which they live in association to obtain part of the food they need (WILSON, 1971). Genus *Acromyrmex* has approximately 63 nominal species (DELLA LUCIA, 1993), grouped in two subgenus, *Acromyrmex* e *Moellerius*, being the former of considerable interest, mainly because the ranges which comprehend this subgenus generally are specialized in grass cutting (FOWLER, 1988). It is noteworthy, for the loss that they determine in pasture, the species *Acromyrmex balzani*, *Acromyrmex landolti*, *Acromyrmex striatus* and *Acromyrmex heyri* (FORTI and BOARETTO, 1997). The first two species are very similar considering the morphological, ethological aspects and the construction of their nests, considering that *A. balzani* was inicially described as a subspecies of *A. landolti* and, later, raised to the category of species by FOWLER (1988).

Injuries caused by leaf-cutting ants in pastures include reduction of the capacity of pasture (FORTI,

Received on: 05 jan. 2010. Accepted for publication on: 02 apr. 2010.

1 Financial support: PRODOC/FAPESB,UESB e CNPq.

2 Professor in Vegetal Production, Universidade Estadual de Mato Grosso do Sul (State University of Mato Grosso do Sul) / Unidade Universitária de Aquidauana, Caixa Postal 25, Aquidauana-MS.

3 Professor in Plant Production, Universidade Estadual do Sudoeste da Bahia (State University of the South of Bahia) - UESB, Caixa postal 95, CEP 45083-900, Vitória da Conquista-BA, e-mail: castellani.uesb@gmail.com

4 Professor in Entomology, Department of Vegetal Production. /FCA – UNESP, Botucatu- SP.

5 Post-graduated in Agronomy (Crop Science), UESB, Vitória da Conquista,BA.

6 Agronomic engineer, DSc. In Entomology;

1985; FOWLER et al., 1990; GALLO et al., 2002), infestation of the pastures by weeds (AMANTE, 1967; FOWLER and ROBINSON, 1977), soil impoverishment, land devaluation and competition with the cattle. Besides that, according to DELLA LUCIA (1993), *A. landolti* and *A. balzani* cause severe damage since they cut the pasture close to the soil and due to the fact that they carry grass seeds, making the formation of pasture difficult.

Acromyrmex species present lower nests than saúvas, which are found in high densities, aspects which make the control difficult and contribute to increase the importance of these ants (ZANETTI et al., 2003). For *A. balzani* there are registers in literature of 120 nests ha^{-1} (GONÇALVES, 1967), of .058 nests ha^{-1} in pasture of *Panicum laxum* and 2.441 nests ha^{-1} in areas with predominance of *Cynodon dactylon* and *Paspalum notatum* (MENDES et al., 1992). For the state of Bahia, Brazil, there are registers of occurrence of *A. balzani* in nest density variable from 800 to 900 ha^{-1} (LEWIS, 1975) and from 25 to 1.900 ha^{-1}, with higher values in pastures with predominance of *Panicum maximum* and of *Paspalum* sp. and reduced densities in pastures of *Brachiaria decumbens* (SILVA et al., 2003).

Another aspect which influences in the efficiency of the techniques of chemical control of the leaf-cutting ants is the architecture of the nests, achieving great structural complexity in the species of *Atta* (MOREIRA et al., 2004 a). *Atta* nests can reach 8 m of depth, with more than seven thousand chambers (MOREIRA et al., 2004 a). By contrast, *Acromyrmex* nests are less deep and with lower number of chambers (GONÇALVES, 1964; ANDRADE, 1991). *A. balzani* nests in opened, sunny places and in soils with low humidity (ANDRADE, 1991), presenting nests characterized by a tower built from fragments of straw and other vegetal waste which protect them.

Close to the towers land mounts are found in a semicircular form and besides it, the waste brought from the interior of the nests. According to GONÇALVES (1961), nests of *A. balzani* present from two to four superposed chambers, with 4 to 10 cm of diameter, considering that the last rarely overcomes 60 cm of depth. MENDES et al. (1992) found from 3 to 6 chambers, being the fist ones at 11.4 cm, with maximum depth from 53 to 124 cm, while PIMENTA et al. (2007) verified that the nests of this ant present four or five chambers, always superposed with maximum depth of 95.0 cm.

Several factors interfere in the spatial distribution of the nests and in aspects of their architecture. In *A. landolti* nests there were seasonal ranges in the number and depth of chambers, according to what was proved by LAPOINTE et al. (1998).

The architecture of the nests and the distribution of substrates in fungi chambers are aspects which may interfere in the results of leaf-cutter ant control (MOREIRA et al., 2002; MOREIRA et al., 2003; MOREIRA et al., 2004 a e b).

The present work had as objective to study the aspects of the architecture of nests of *A. balzani* in pastures of the Southeast region of the State of Bahia, Brazil, searching for subsidies for the perfecting of control strategies.

Material and methods

For the studies, ten nests of *A. balzani* were selected in the Southeast region of Bahia, in which three (N_1, N_2 and N_3) in Vitória da Conquista (14º 50' of South latitude and 40º 50' of West longitude), three (N_4, N_5 and N_6) in Itapetinga (15° 15' of South latitude and 40° 15' of West longitude), two (N_7 and N_8) in Itambé (15° 14' of South latitude and 40° 37' of West longitude) and two in Tremendal (N_9 and N_{10}) (14° 58' of South latitude and 41° 24' of West longitude).

Before initiating the work, strings were stretched out forming an orthogonal axis (x, y), used for the localization of all the external and internal measures of the nest, with point of intersection coincident with the tower of straw, following the procedures described by MOREIRA et al. (2003, 2004 a and b). Initially, it was estimated the area of the mount of loose soil, taking the largest width and the highest length; the volume of the loose soil, by land sampling and stowage in recipients of known volume; and the distance between the tower and the mount of loose soil.

After the measurement of the external

parameters, the nests were completely excavated, opening furrows in the side of the nest and cutting the soil profile following the channels. They were marked with neutral talc to facilitate the excavation. To the characterization of the chambers, it was taken the measures of width, height, length and depth in relation to the soil surface and the orthogonal axis x, y. With the dimensions of the chambers of three nests, it was calculated their volume, comparing them to the geometric figures cylinder and ellipsoid, trough the formulae $V= \pi/4\ [(l + h)/2]^2.p$ and $V= \pi/6\ .\ l.\ h.\ p$, respectively, where 1 = chamber width, h = chamber height and p = chamber length.

In order to obtain the real volume of the chambers, after being opened, it was removed their content (registering the presence of winged, larvae, pupae, adults, fungi sponge and soil), its interior was cover with plastic back of low thickness, containing water, with volume adjusted until the complete filling of the chambers. Later, the volume of the water was measured with a beaker. So the volume of the chambers was estimated according to the model which was better adapted to the data.

For the data of the internal architecture it was calculated the average, standard deviation and regression, using the program SAEG version 4.0.

Results and discussion

All the excavated nests presented a single orifice, used either for supply or for removal of soil coming from the excavation, under which it was found a tower built with dry grass, similar to the descriptions of the external part of nests of *A. balzani* done by several authors (BONDAR, 1924; IHERING, 1928; ANDRADE, 1991; MENDES et al., 1992; PIMENTA et al., 2007). However, it was seen in the studied pasture the presence of nests with more than one tower, generally two, very close and connected with each other and with the same orifice, similarly to a forked tower. On the other hand, the typical straw tower may be absent in the entrance of the nests in the driest periods of the year, as it was observed by PIMENTA et al. (2007) in the months of August, September and October in Ipameti, GO. The structure in form of tower build with vegetal material is probably made to avoid or minimize the entrance of water in the nests in the rainy periods of the year (ANTONIALLI-JUNIOR e GIANNOTTI, 1997).

The average distance between the orifices of access to the colony, over which it is placed the straw tower, and the mount of loose soil of *A. balzani* nests was 13.7 cm, ranging from 2.0 cm to 37.0 cm (Table 1). The amplitude of variation was slightly superior to the one obtained by ANDRADE (1991), who observed distances of 8.0 to 30.0 cm in nests of *A. balzani* located in the State of São Paulo.

The total depth of the nests varied from 57 to 210 cm, with minimum number of three, and maximum of 14 chambers, considering that most of nests (70%) presented depth above 70 cm and more than five chambers (Table 1). The data obtained in this work are slightly superior to those reported by other authors. In the *A. balzani* nest characterization made by BONDAR (1924) and IHERING (1928), the authors affirm that the maximum number of chambers is six. In Minas Gerais, MENDES et al. (1992) found from three to six chambers in nests of *A. balzani,* with total depth from 53 to 124 cm and PIMENTA et al. (2007), studying the same species of ant in Goiás, observed nests with four and five chambers and depth from 72 to 95 cm. For the conditions of the state of Sergipe, PODEROSO et al. (2009) found nests containing one to five chambers, with maximum depth of 50 cm.

The range in depth and the number of chambers observed in different works may be related to several factors as nest age, type of soil, place of nesting, and periods of the year, among others. PODEROSO et al. (2009) verified that *A. balzani* nests, excavated in the rainy season present more superficial chambers, fact that, according to the authors, may be explained as a mechanism to supply the exigencies of water of the workers, eggs, larvae, pupae and symbiotic fungus. According to the same authors, behavioral changes from the individuals of the same colony indicate to workers the necessity of temperature regulation, trough the reduction or increase of the excavation. The excavated nests in the present work were placed in municipalities with semi arid climate in the Southeast region of Bahia, characterized for presenting annual average rainfall inferior to 800 millimeters, index of aridity

Table 1. Distance of the tower (cm), area of loose soil (cm²), volume of loose soil (L), total volume of chambers (L) and total number of chambers and total depth (cm) in ten nests of *Acromyrmex balzani*, in pasture in the Southeast region of Bahia, Brazil.

Nests	Distance of the tower (cm)	Area of loose soil (cm^2)	Volume of loose soil (L)	Total volume of the chambers (L)	Total number of chambers	Total depth (cm)
N1	15.0	1600	1.1	2.2	06	210
N2	31.0	1628	2.2	2.5	10	181
N3	10.0	900	4.1	0.7	05	87
N4	17.0	1880	5.9	2.8	09	90
N5	02.0	1692	4.2	1.6	04	72
N6	15.0	1147	5.3	4.5	13	62
N7	10.0	1260	1.3	1.2	09	87
N8	37.0	896	1.8	2.9	14	183
N9	04.0	325	0.1	0.1	03	57
N10	05.5	4171	3.7	1.8	14	84
Average	13.7	1,549.9	2.9	2.1	8.6	111.3

of until 0.5 and risk of drought more than 60% (MINISTÉRIO DA INTEGRAÇÃO SOCIAL, 2011). Thus, it is likely that the highest number of chambers and higher nest depth, observed in the present work, may be related to the adaptation of *A. balzani* to the lasting conditions of drought.

Considering the other data that were evaluated and presented in Table 1, it is observed that the nest N_9 presented a lower number of chambers (3), lower area (325 cm^2), lower volume of loose soil (0.1 L) and lower total volume of chambers (0.1 L), while the nest N6 presented higher total volume of chambers (4.5 L). On the other hand, nest N10 presented highest area of loose soil (4171 cm^2) and larger number of chambers (14).

The linear regressions performed among the parameters presented in Table 1 (volume of loose soil and total volume of chambers, volume of loose soil and total number of chambers, area of loose soil and volume of loose soil, area of loose soil and total volume of chambers, area of loose soil and total number of chambers and total volume of chambers with total number of chambers) did not indicate significant correlation. Significant correlation was obtained only between total volume of chambers and total number of chambers (R^2 = 0.4816). The importance of studying these relations is in the perfecting of the calculation of the dosage of insecticide baits to the control of the leaf-cutter ant colonies.

The area of loose soil has been used as parameter to calculate dosages of insecticide to control the nests of saúvas, with recommendation of 8 to 10 g of nests m^{-2} of loose soil. Yet, it has been demonstrated that the area and the volume of loose soil are not good indicators of the real size of the nests of saúvas, and this may lead to the use of under dosage of baits to the nest control. Loss of loose soil by leaching and compaction, besides the fact that there are in the interior of the chambers soil stored inside the chambers (MOREIRA et al., 2002; MOREIRA et al., 2003; MOREIRA et al., 2004 a e b). For the species of *Acromyrmex*, which present smaller nests than saúvas, the manufacturers recommend from 8 to 10 g $nest^{-1}$, i.e., the same dosage to one m^2. Considering that in this work 70% of the nests presented area of loose soil superior to one m^2, the standard dosage established probably would not be sufficient to cause the mortality of the nest.

The larger concentration of chambers (54.0%) occurred in the first 30 cm (Figure 1). From the total of 87 registered chambers, there was predominance of chambers with fungi (86.2%), occurring, also, chambers only with soil (5.7%) and empty (6.9%), which indicate, probably, activity with nest expansion. The average depth of the first chamber was 9.9 cm, ranging from 0.0 cm (close to the orifice) (N_5); 1.0 cm (N_8); 2.0 (N_6); 4.5 cm (N_7); 6.5 cm (N_4); 9.0 cm (N_{10}); 12 cm (N_2); 13 cm (N_3), 20.5 cm (N_9); and 30.0 cm (N_1). Concerning the average depth of the first chamber, the data of the present work are close to those presented by MENDES et al. (1992), in which the authors found the first chambers of this same species of ant at 11.4 cm of depth, in average. On the other hand, PIMENTA et al. (2007) observed the first chambers of *A. balzani* at depths 1.0; 1.2 and 1.3 cm from the soil surface in the three nests excavated by the authors. It is likely that this smallest range of depth of first chamber observed in the work of PIMENTA et al. (2007) is related to the smallest number of excavated nests.

The nest N_6 presented the largest chamber, with dimensions of 20.0 x 11.0 x 10.0 cm of length, height and width, respectively. The smaller chamber was found in the nest N_9, with dimensions of 4.5 x 2.0 x 1.5 cm of length, height and width, respectively.

In mean terms, the larger length, height and width were 8.9 cm, 9.4 cm and 8.7 cm, respectively (Table 2). PIMENTA et al. (2007) found, to the same species of ant, chambers with maximum size of 13.0 x 13.0 x 12.0 cm of length, height and width, respectively. According to MOREIRA et al. (2004 a e b), the ranges in the dimensions of the chambers of the same leaf-cutter ant may come from the necessity of the colony in increasing the cultivation of the fungi in function of the growth of the colony or of a behavior in particular.

Comparing the real volume to the chambers with the estimated volume trough the similarity with geometric figures, it was found more similarity of the chambers with ellipsoidal form (Table 3), being in

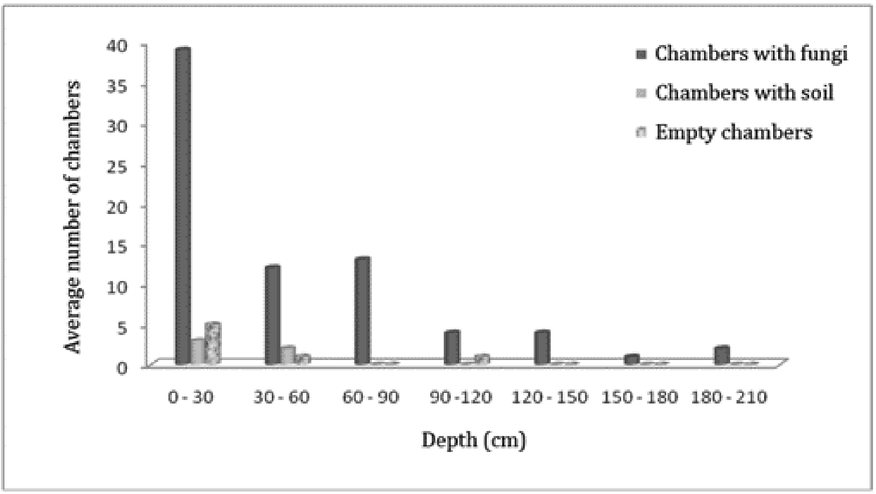

Figure 1. Average number of chambers with fungi, with soil and empty of 10 nests of *Acromyrmex balzani* in different depths. In pastures of the Southeast region of Bahia, Brazil.

Table 2. Average, standard deviation (s), maximum value (Max.) and Minimum (Min.) of the dimensions of the chambers (length, height and width) of the nests of *Acromyrmex balzani*, in pastures of the Southeast region of Bahia, Brazil.

Nests	Number of chambers	LENGHT (cm)				HEIGHT (cm)				WIDTH (cm)			
		Average	S	Max.	Min.	Average	S	Max.	Min.	Average	S	Max.	Min.
N1	06	8.0	3.4	13.0	4.0	9.4	2.9	13.0	4.5	7.8	1.9	10.0	05.5
N2	10	7.1	2.8	12.0	3.5	7.5	2.2	10.5	4.5	6.5	1.9	09.5	04.0
N3	04	5.5	2.8	10.0	3.0	6.4	2.9	09.5	4.0	5.0	2.3	08.5	03.0
N4	09	7.9	2.3	12.0	4.5	8.9	2.0	11.5	6.0	7.5	2.5	12.0	04.0
N5	04	6.5	4.6	11.0	2.0	6.4	6.1	15.0	1.5	7.5	6.5	15.0	02.0
N6	13	8.9	4.5	20.0	2.0	7.7	3.2	11.0	1.0	6.9	2.9	11.0	01.5
N7	09	6.2	2.5	10.5	3.0	5.7	2.6	10.0	3.0	5.0	2.7	09.0	15.0
N8	14	6.2	1.8	11.0	4.5	6.3	1.8	10.0	4.0	8.7	4.7	21.0	04.0
N9	03	4.3	0.3	04.5	4.0	3.8	2.0	06.0	2.0	2.2	0.8	03.0	01.5
N10	14	6.0	2.4	12.5	3.5	5.6	2.1	09.5	2.5	5.5	2.8	12.0	02.5

Table 3. Real measured and estimated volume (mL) for similaty with geometric figure of the ellipsoid and cylinder and relation between real and estimated volume (V1/V2 and V1/V3) of the chambers of the nests of *Acromyrmex balzani* in pastures in the Southeast region of Bahia, Brazil.

Nests	Chambers	Real volume (V1)	Ellipsoid volume (V2)	Cylinder volume (V3)	V1/V2	V1/V3
N1	1	150.0	192.0	382.2	0.8	0.4
	2	302.0	376.0	585.9	0.8	0.5
	3	31.0	37.6	56.3	0.8	0.5
	4	115.0	131.0	195.4	0.9	0.6
	Minimum	31.0	37.6	56.3	0.8	0.4
	Maximum	302.0	376.0	585.9	0.9	0.6
	‘S	113.3	142.8	230.0	0.0	0.5
	Average	149.5	184.1	304.9	0.8	0.5
N2	1	208.0	188.0	286.6	1.1	0.7
	2	199.0	166.0	248.4	1.2	0.8
	3	325.0	335.0	500.5	0.9	0.6
	4	37.0	37.6	56.1	0.9	0.6
	Minimum	37.0	37.6	56.1	0.9	0.6
	Maximum	325.0	335.0	500.5	1.2	0.8
	‘S	118.3	121.8	182.2	0.1	0.6
	Average	192.2	181.6	272.9	1.1	0.7
N3	1	306.0	261.0	398.1	1.2	0.8
	2	105.0	105.0	129.7	1.0	0.8
	Minimum	105.0	105.0	129.7	1.0	0.8
	Maximum	306.0	261.0	398.1	1.1	0.8
	‘S	142.1	110.3	189.8	0.1	0.7
	Average	205.5	205.5	263.9	1.1	0.8

‘S: Standard deviation

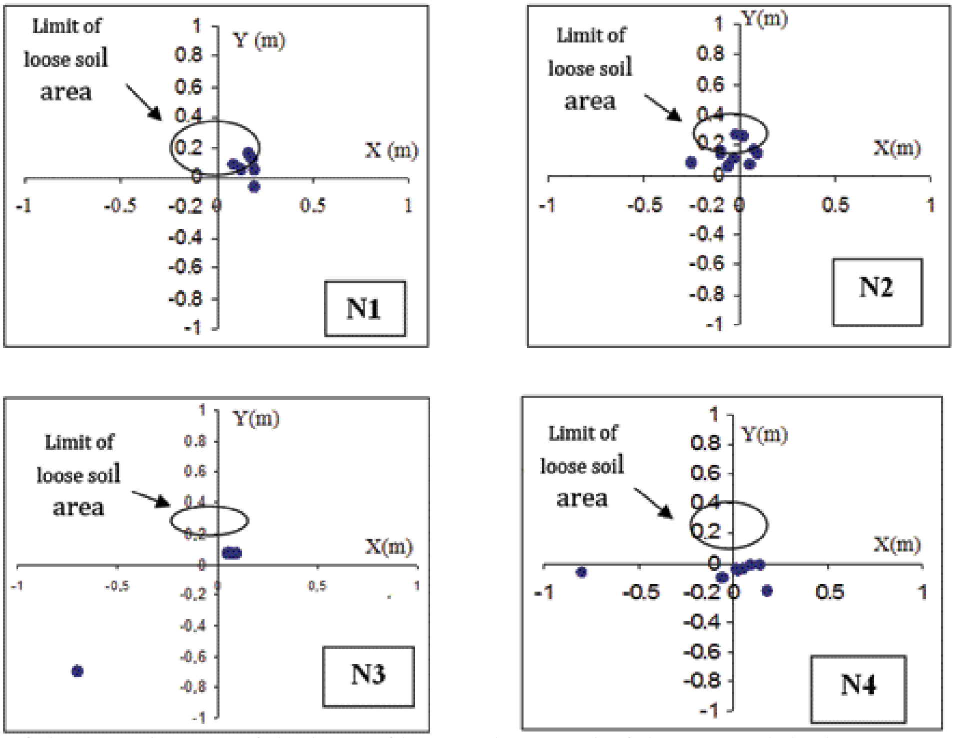

Figure 2. Schematic drawing of the limit of loose soil area and of the area with higher concentration of chambers of four nests (N1, N2, N3, N4) of *Acromyrmex balzani*, in pasture of the Southeast region of Bahia, Brazil.

accordance with the data presented by PODEROSO et al. (2009) and differing from other species, i.e. *Acromyrmex rugosus* which presents ovoid or reniform format (SOARES et al., 2006).

Most of the chambers of the nests of *A. balzani* are located between the projections of the straw tower and the mount of loose soil; there is, though, larger distance of them in the nests N_3 and N_4 (Figures 2 and 3). Considering that *A. balzani* nests present a single orifice, this positioning of the chambers may be an adaptation to the protection of the chambers of fungi, avoiding contamination and flooding, for example.

The architecture of nests of other grass leaf-cutting ants revealed nest strategies different among themselves and, mainly, among those which cut preferentially dicotyledonous. Considering two important species of saúvas specialized in grass

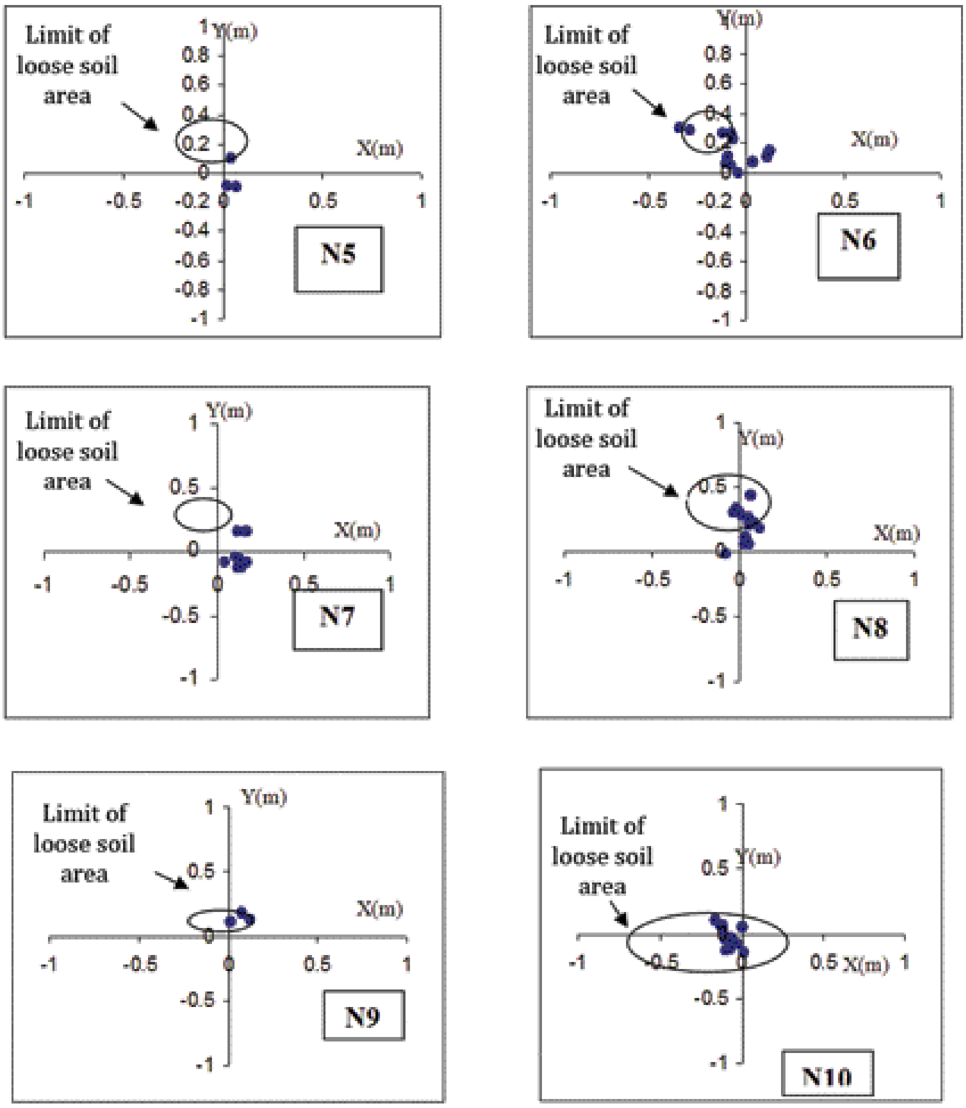

Figure 3. Schematic drawing of the limit of loose soil area and of the area with higher concentration of chambers of six nests (N5, N6, N7, N8, N9, N10) of *Acromyrmex balzani*, in pasture of the Southeast region of Bahia, Brazil.

cutting, *Atta bisphaerica* and *Atta capiguara,* the internal architectures are sensibly different. In the first species, the chambers of fungi are placed under the projection of the loose soil (MOREIRA et al., 2004 a), while in *A. capiguara* nests, the chambers of fungi are placed outside the apparent seat of the nest, distanced and laterally distributed under the soil level (AMANTE, 1967; FORTI, 1985).

Concerning the control, the position of the chambers of fungi has a great importance for the species of saúvas when toxic baits and fogging are used. For *A. bazani,* the displacement of the chambers in relation to the orifice of entrance of the nest, may difficult the use of insecticides in the formulation dry powder, technique used for quenquéns, reducing the efficiency of control in field.

Conclusions

A. balzani nests may present until 14 chambers of fungi;

The largest number of chambers in *A. balzani* nests is found to 30 cm of depth;

Most of the chambers of *A. balzani* nests is found between the projections of the orifice and the mount of loose soil;

There is a significant correlation between the volume and the total number of chambers in *A. balzani* nests.

References

ANTONIALLI-JUNIOR, W.F.; GIANNOTTI, E. Nest architecture and population dynamics of the Ponerinae ant *Ectatomma opciventre* Roger (Hymenoptra: Formicidae). **Journal of Advanced Zoology**, v. 18, p. 64-71, 1997.

AMANTE, E. *Atta capiguara*, praga das pastagens. **O Biológico**, v. 33, n. 6, p. 113-120, 1967.

ANDRADE, M.L. **Bionomia e Distribuição Geográfica do Gênero Acromyrmex Mayr, 1865 (Hymenoptera: Formicidae) no Estado de São Paulo, Brasil**. 1991. 120f. Tese (Doutorado em Zoologia) – Universidade Estadual Julio de Mesquita Filho – UNESP, Botucatu.

BONDAR, G. Insetos daninhos e moléstias das plantas e dos animais. **Correio Agrícola**, v. 2, p .111-112, 1924.

DELLA LUCIA, T.M.C. **As formigas cortadeiras**. 1. ed.Viçosa: Folha de Viçosa, 1993. 252p.

FORTI, L.C. Relação entre plantas atacadas e a saúva *Atta sexdens rubropilosa* (Formicidae: Hymenoptera). **Boletim do GTEC**, v.2, p.11-13, 1985.

FORTI, L.C.; BOARETTO, M.A.C. **Formigas cortadeiras**: biologia, ecologia, danos e controle. Botucatu: Universidade Estadual Paulista, 1997. 61p.

FOWLER, H.G.; ROBINSON, S.W. Foraging and grass selection by the grass-cutting ant *Acromyrmex landolti fracticornis* (Forel) (Hymenoptera, Formicidae) in habitats of introduced forage grasses in Paraguay. **Bulletin Entomological Research**, v.67, p.659-666, 1977.

FOWLER, H. G. A organização das comunidades de formigas no Estado do Mato Grosso, Brasil. **In:** ACTA X CONGRESSO LATIOAMERICANO DE ZOOLOGIA, Valparaízo, Chile. 1988. Anais, p. 85.

FOWLER, H.G.; BERNARDI, S.V.E.; DELABIE, J.H.C.; FORTI, L.C.; SILVA, V.P. Major ant problems of South America. In: VANDER MEER, R.K.; JAFFE, K.; CEDERO, A. (Org.). **Applied Myrmecology: a world perspective**. Boulde: Westview Press. 1990. p.3-14.

GALLO, D.; NAKANO, O.; SILVEIRA NETO, S.; CARVALHO, R.P.L.; BAPTISTA, G.C.; BERTI FILHO, E.; PARRA, J.R.P.; ZUCHI, R.A.; ALVES, S.B.; VENDRAMIM, J.D.; MARCHINI, L.C.; LOPES, J.R.S.; OMOTO, C. **Entomologia Agrícola**. 3.ed. Piracicaba: FEALQ, 2002. 920p.

GONÇALVES, C.R. O Gênero *Acromyrmex* no Brasil. **Studia Entomologica,** v.1, p.113-180, 1961.

GONÇALVES, C. R. As formigas cortadeiras. **Boletim de campo**, v. 22, p. 7-23, 1964.

GONÇALVES, C.R. As formigas cortadeiras da Amazônia, dos gêneros "*Atta*" Fabr. = "*Acromyrmex*" Mayr (Hym., Formicidae). A**tlas do Simpósio sobre a Biota Amazônica: Zoologia**, v. 5, p. 181-202, 1967.

HÖLLDOBLER, B.; WILSON, E. O. **The ants**. Cambridge: Harvard University Press., 1990. 732p.

IHERING, R.V. Catálogo popular das espécies mais notórias de formigas brasileiras. **Almanaque Agrícola Brasileiro**, v. 17, p. 292–300, 1928.

LAPOINTE, S.L.; SERRANO, M.S.; JONES, P.G. Microgeographic and vertical distribution of *Acromyrmex landolti* (Hymenoptera: Formicidae) nests in a neotropical savanna. **Environment Entomology**, v.27, n.3, p.636-641, 1998.

LEWIS, T. Colony size, density and distribution of the leaf-cutting ant *Acromyrmex octospinosus* (Reich) in cultivated fields. **Transactions of Royal Entomological Society of London**, v. 127, n. 1, p. 51-64, 1975.

MARICONI, F. de A.M. **As Saúvas**. São Paulo: editora Agronômica Ceres, 1970, 167p.

MAYHÉ-NUNES, A.J.; JAFFÉ, K. Filogenia dos Attini. In: ENCONTRO DE MIRMECOLOGIA, São Leopoldo. 1995. **Anais...** São Leopoldo. 1995, v.12. p.55-59.

MENDES, W.B.A.; FREIRE, J.A.H.; LOUREIRO, M.C.; NOGUEIRA, S.B.; VILELA, E.F.; DELLA LUCIA, T.M.C. Aspectos ecológicos de *Acromyrmex* (Moellerius) *balzani* (Emery, 1890) (Formicidae: Attini) no município de São Geraldo, Minas Gerais. **In:** Anais da Sociedade Entomológica Brasileira, v. 21, n. 2, p. 155-68, 1992.

MINISTÉRIO DA. INTEGRAÇÃO NACIONAL. SECRETARIA DE POLÍTICAS DE. DESENVOLVIMENTO REGIONAL. **Nova Delimitação do Semi-Árido Brasileiro**. Disponível em: <www.integracao.gov.br/download/download.asp>. Acesso em: 20 de abril 2011.

MOREIRA, A.A.; FORTI, L.C.; ANDRADE, A.P.P.; BOARETTO, M.A.C.; RAMOS, V.M.; LOPES, J.F.S. Comparação entre parâmetros externos e internos de ninhos de *Atta bisphaerica* Forel, 1908 (Hymenoptera: Formicidae). **Acta Scientiarum**, v.24, n.2, p.369-373, 2002.

MOREIRA, A.A.; FORTI, L.C. ; BOARETTO, M.A.C. ; ANDRADE, A.P.P. ; ROSSI, M.N. Substrate distribution in fungus chambers in nests of *Atta bisphaerica* Forel, 1908 (Hymenoptera: Formicidae). **Journal of Applied Entomology**, v.127, p.96-98, 2003.

MOREIRA, A.A.; FORTI, L.C.; BOARETTO, M.A.C.; ANDRADE, A.P.P.; LOPES, J.F.S.; RAMOS, V.M. External and internal structure of *Atta bisphaerica* Forel (Hymenoptera, Formicidae) nests. **Journal of Applied Entomology**, v.128, n.1, p.200-203, 2004a.

MOREIRA, A.A.; FORTI, L.C.; ANDRADE, A.P.P.; BOARETTO, M.A.C.; LOPES, J.F.S. Nest Architecture of *Atta laevigata* (F. Smith, 1858) (Hymenoptera: Formicidae). **Studies Neotropical Fauna Environment**, v. 39, n. 2, p. 109-116, 2004b.

PIMENTA, L.B.; ARAÚJO, M.S.; LIMA, R.; SILVA, J.M.S.; NAVES, V.G.O. Dinâmica de forrageamento e caracterização de colônias de *Acromyrmex balzani* (Emery, 1890) (Hymenoptera: Formicidae) em ambiente de cerrado goiano. **Revista Científica Eletrônica de Engenharia Florestal**, n.9, p.1-12, 2007.

PODEROSO, J.C.M.; RIBEIRO, G.T.; GONÇALVES, G.B.; MENDONÇA, P.D.; POLANCZYK, R.A.; ZANETTI, R.; SERRÃO, J.E.; ZANUCIO, J.C. Nest and foraging characteristics of *Acromyrmex landolti balzani* (Hymenoptera: Formicidae) in Northeast Brazil. **Sociobiology**, v.54, n.2, p. 361-371, 2009.

SILVA, K.S.; BOARETTO, M.A.C.; FORTI, L.C.; MOREIRA, A.A.; KHOURI, C.R.; LEMOS, O.L.; RIBEIRO, A.E.L.; VIANA, A.E.S. Arquitetura de ninhos de *Acromyrmex (Moellerius) balzani* (Hymenoptera, Formicidae). In: XVI SIMPÓSIO DE MIRMECOLOGIA, Florianópolis. 2003. **Anais...** Florianópolis. 2003. p. 165-167.

SOARES, I.M.F.; DELLA LUCIA, T.M.C.; SANTOS A.A.; NASCIMENTO; I.C.; DELABIE, J.H.C. Caracterização de ninhos e tamanho de colônia de *Acromyrmex rugosus* (F. Smith) (Hymenoptera, Formicidae, Attini) em restingas de Ilhéus, BA, Brasil. **Revista Brasileira de Entomologia**, v. 50, n. 1, p. 128-130, 2006.

WILSON, E.O. **The insect societies**. Cambridge: Harvard University Press, 1971. 548p.

ZANETTI, R.; ZANUNCIO, J.C.; MAYHÉ-NUNES, A.J.; MEDEIROS, A.G.B.; SOUZA-SILVA, A. Combate sistemático de formigas-cortadeiras com iscas granuladas, em eucaliptais em cultivo mínimo. **Revista Árvore**, v.27, n.3, p.387-392, 2003.