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# *Nests architecture of Dinoponera gigantea Perty, 1833, (Hymenoptera:Formicidae) in Cerrado North Northeast of Brazil*

Ants build nests on different substrates, above ground occupying tree trunks, occupying them internally and externally. On the ground, ants build nests with a range of structural and architectural variation. The structural and architectural diversity of ant nests in soils results from the manifestation of intrinsic factors (colony size, rhythm of internal activity of the anthill, among others) and extrinsic factors such as seasonality intends to describe the architecture of nests of Dinoponera gigantea, Perty, 1833, in two soil orders in an area of Cerrado in the Northeast of Brazil. Twelve anthills of Dinoponera gigantea, Perry,1833, six in a Xanthic Hapludox and six in an Oxyaquic Udipsamments were selected. The selected nests were molded with cement and then excavated to obtain measurements of the diameter of the hole at the entrances to the nests, the depth of the anthills, the measurements of height, width and length of the chambers and galleries. The nests molded in Oxyaquic Udipsamments have a depth ranging from 14.5 cm to 43 cm, with an average of 9 chambers and an average volume of 322.61 cm³, all with 2 to 3 access openings. In the nests molded in the Xanthic Hapludox, the depth varied between 29 cm and 62 cm and presented an average number of 9 chambers, with a total average volume of 103.01 cm³, and with 2 access openings. Ellipsoid-shaped input and output with diameters between 2 cm and 3 cm. Data analysis showed that the nests of D. gigantea in the studied soils are statistically similar. However, it was possible to observe that the nests found in the Xanthic Hapludox are deeper and present a pattern with greater geometric regularity, while the nests found in the Oxyaquic Udipsamments are less deep and with less geometric regularity. The differences in design and depth of D. gigantea nests in these two soils are related to the conditions of vegetation cover, temperature and stability and aggregate indices of these two soils.

**Keywords:** Nesting; Soil; Ponerinae.

# *Arquitetura de ninhos de Dinoponera gigantea Perty, 1833, (Hymenoptera:Formicidae) no Cerrado Norte Nordeste do Brasil*

As formigas constroem ninhos em diferentes substratos, acima do solo ocupam tronco de árvores, ocupando-os interna e externamente. No solo as formigas constroem ninhos com uma amplitute de variação estrutural e arquitetônica. A diversidade estrutural e arquitetônica dos ninhos de formigas nos solos é resultante da manifestação de fatores íntrinsecos (tamanho da colônia, ritmo de atividade interna do formigueiro, dentre outros) e de fatores extrínsecos como sazonalidade pretende descrever a arquitetura de ninhos de Dinoponera gigantea, Perty, 1833, em duas ordens de solo em área de Cerrado do Nordeste do Brasil. Foram selecionados 12 formigueiros de Dinoponera gigantea, Perry,1833, seis um Latossolo Amarelo e seis em um Neossolo Flúvico. Os ninhos selecionados foram moldados com cimento e em seguida escavados para obtenção das medidas de diâmetro do orifício de entradas dos ninhos, da profundidade dos formigueiros, das medidas de altura, largura e comprimento das câmaras e galerias. Os ninhos moldados no Neossolo Flúvico têm profundidades que variam de 14,5 cm a 43 cm, com média de 9 câmaras e volume médio de 322,61 cm³, todos com 2 a 3 aberturas de acesso. Os ninhos moldados no Latossolo Amarelo a profundidade variou entre 29 cm e 62 cm e apresentou um número médio de 9 câmaras, com volume médio total de 103,01 cm³, e com 2 aberturas de acesso de entrada e saída de formato elipsoide de diâmetros entre 2 cm a 3 cm. A análise dos dados mostrou que os ninhos de D. gigantea dos solos estudados são estatisticamente semelhantes. No entanto, foi é possível observar que os ninhos encontrados no Latossolo são mais profundos e apresenta um padrão com maior regularaidade geométrica, enquanto os ninhos encontrados no Neossolo Flúvico são menos profundos e com menor regularidade geométrica. As diferenças de design e de profundidade dos ninhos de D. gigantea nesses dois solos estão relacionadas às condições de cobertura vegetal, de temperatura e dos índices de estabilidade e agregados desses dois solos.

**Palavras-chave**: Nidificação; Solo; Ponerinae.

Topic: **Ciências do Solo**

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## INTRODUCTION

Ants build nests in different substrates, such as decaying wood trunks, in the canopy of trees and in the soil (CARVALHO et al., 2009). Ants that inhabit the litter and soil are known as hypogeic, and participate more actively in processes that change the physical and chemical conditions of the soil with the construction of their nests (SILVA et al., 2004; PEREIRA, 2012).

Ants alter the edaphic environment and soil quality, modifying the soil structure through excavation activities, construction of galleries and nests, in addition to transporting mineral and organic material to different depth levels of the pedological horizons, affecting density, the concentration of nutrients and the degradation of organic matter (BRIESE, 1982; DOSTAL et al., 2005; CERDÁ et al., 2008; MELO et al., 2009).

Most ant nests have similar traits to the nests of other social insects, as they house many individuals within a single colony, sharing routine nest tasks such as care for pupae and young individuals, foraging and colony maintenance (BOLTON, 2003). The nests of social insects, such as ants, are considered the best architecturally designed. The architecture of these nests can contain from simple to more complex structures, which can vary significantly in volume and shape between species (HASIOTIS, 2003; TSCHINKEL, 2003).

The ant nests present in the ground, for the most part, do not an architectural edification patterrn, however the Ectatomini ants build nests with relatively simple structures and patterned with tunnels and chambers with regular shapes (ANTONIALLI JUNIOR et al., 1997; LAPOLA et al., 2012.)

Studies involving structure and architecture of ant nests generate relevant information about the biology of these social insects, as it is possible, with these studies, to know how to use the internal spaces of the studied nests, to record the events and/or interactions that occur inside the nests. The information obtained from these studies is also useful in the control of ants of economic interest, as shown by the large number of works of this nature with leaf-cutting ants of the Attini tribe (SUDD et al., 1987; THERAULAZ et al., 1998; HASIOTIS, 2003; TSCHINKEL, 2003; MELO et al., 2009).

Ants from the Attini tribe have concentrated much of the work on nest architecture in the taxonomic section of the *Atta* genus, with the purpose of seeking more efficient methods to control these ants, considered pests in agriculture and forestry cultures (MARINHO et al., 2006; ADLA MÉRCIA CAROBENSE DA PALMA, 2016). Despite the economic impacts that leaf-cutting ants produce on plant production systems (LEAL et al., 2011), the ecological services that these and other excavator ants generate can often exceed the pricing of agricultural commodity markets, prompting increased studies of these edaphic ants and the Formicoid precursor clade. The Poneroid, despite being little studied, have from structurally simple and homogeneous nests to complex and heterogeneous structures.

Poneroid nests can show variations that date to the Mesozoic as verified (HASIOTIS, 2003) in fossilized nests of these social insects. In studies with *D. quadricipes* Vasconcellos (2004) also observed variation in the nest architecture of this ant genus. The differences are more pronounced in the number of chambers, number of openings and depth. These architectural and structural differences may be related to the heterogeneity of physical and chemical attributes of the soils used by these ants.

Poneromorph nests have been studied, even though they are in the rear of the Atinni. Despite most of the studies pointing out the nesting environments of these ants, as well as the association of these ants' nests with soil and vegetation cover attributes (BRANDÃO, 1999; FOURCASSIE et al., 2002; SILVA et al., 2017) and Moreira et al. (2020) who described the general pattern of the internal structure of nests of *Dinoponera giagantea* in the Cerrado southeast of Maranhão.

Ant species of the genus *Dinoponera* use the soil as the main substrate for the formation of their colonies (FEITOSA et al., 2012; SCHMIDT et al., 2013; LIMA et al., 2020b). Studies involving nests of ants of the *Dinoponera* genus relate the presence of these ants' nests to soil types, vegetation cover, and chemical and physical soil attributes (SILVA et al., 2017). Other studies show that *Dinoponera* nests in arid environments are built on the base of trees, which commonly present differences in the number of openings and diameter (FOURCASSIE et al., 2002).

The study about *D. gigantea* biology in area with Amazonian transition from semiarid have a high value, as it can show the capacity of this ant species to adjust to the different pedological and phytophysiognomic domains of an area of Cerrado North Northeast of Brazil, which is in the limit of the Brazilian pre-Amazon, where ecological conditions are conspicuously different from the humid forests of the Amazon where this species of ant is traditionally found. In this work, it was proposed to describe the architecture of *D. gigantea* nests in two orders of soils and different phytiophysiognomic covers of the Cerrado North Northeast of Brazil.

## METHODOLOGY

### Study area

The study was carried out in two environmentals of Cerrado, located in North North of Brazil, Chapadinha city, State of Maranhão. (3°44'4.92"S 43°19'10.59"O) and (3°43'14"S - 43°18'54.4"O). at an altitude of approximately 100 m. According to Thornthwaite climate classification, the regional climate is sub-humid B1WA'a, with an annual temperature of 29±1 °C, an annual rainfall of about 1,600 to 2,000 mm, and distinct dry (July-November) and wet (December - June) seasons (NOGUEIRA et al., 2012). The predominant vegetation is typical of the Cerrado, with greater indecency of creeping plants and small shrubs (OLIVEIRA FILHO et al., 2002).

### Sample design

It was selected 12 anthills of *Dinoponera gigantea*: six in an Oxyaquic Udipsamments covered by Mesophilic forest on secondary growth with dense vegetationand leaf litter, and six in a Xanthic Hapludox – covered by Cerrado with Shrub and trees. Anthills were selected with the aid of protein baits (sardines) and carbohydrates (bread with honey). Four 200 m transects were plotted in each sampling environment, where 10 sets of baits 20 m equidistant were distributed, with the purpose of attracting and identifying the nests of *D. gigantea.*

**Anthill Modeling**

The internal molding of the anthills was carried out using a 1:2 ratio of water and cement (water and cement). The modeling solution was introduced into the anthill with the aid of a 20 mm diameter hose. The dilution of the modeling solution and the fluidity tests were carried out at the moment of molding each nest.

The nests saturated with the modeling solution were excavated four days after being saturated with the water and cement solution. A circular trench of 50 cm in depth and 30 cm away from one of the nest openings was opened, in order to leave a cylinder containing the nest, which was excavated laterally until all chambers were exposed (ANTONIALLI JUNIOR et al., 1997).

The diameter of the openings of each nest, the depth of the nests, the depth of each chamber, the measures of width, height and length of the chambers were measured (ANTONIALLI JUNIOR et al., 1997; 2001). The galleries were measured as chambers, as the galleries have similar geometric dimensions to the chambers.

The measurements obtained in loco were plotted on graph paper, generating images that were adjusted to a 3D scale to capture all the dimensions of the anthill. Area and volume measurements were compiled using SketchUp Version 2016.

The soils were classified according to parameters described by Santos et al. (2013). In each environment, soil samples with preserved structure were collected in the layers of 00 - 0.1 m, 0.1 - 0.2 m and 0.2 -0.3 m, with the aid of the Uhland sampler, totaling 16 rings of 5 x 5 cm in each layer per environment. In samples with preserved structure, total porosity (TP), macroporosity (Ma), microporosity (Mi) and soil density (Ds) were determined using a tension table, according to procedures described by Claessen et al. (1997). Additionally, in each soil layer of the two environments, 24 deformed samples were collected with the aid of hoe. In samples with deformed structure, the contents of sand, silt and clay were determined according to (GEE et al., 2002).

**Statistical Analysis**

The data obtained received descriptive statistical treatment, generating measures of: maximum and minimum, medians, means and coefficient of variation, and were also tested for normality, showing homoscedastic behavior that allowed the purchase of averages between data from the anthills of the two environments by the *t* test paired, with the help of Infostat software (DI RENZO, 2020). The physical parameters of the soils were associated with the structural measures of the nests, using the Principal Component test in order to show the physical parameters of the soils most strongly related to the structure and design of the studied nests, using the Infostat software (DI RENZO, 2020).

**RESULTS**

The maximum depth of *D. gigantea* nests studied in the Oxyaquic Udipsamments was 43 cm and the minimum depth was 14 cm. An average of 9 chambers per nest of *D. gigantea* was found in this soil (Table

1), with 50 to 60 individuals. The number of chambers in the nests in this soil was not statistically greater than the number of chambers in the nests found in the Oxyaquic Udipsamments (Table 2). The internal area of the nests of the two soils studied did not show statistical differences. The average of the internal area of the nests in the Oxyaquic Udipsamments is 450 $cm^2$ and in the Xanthic Hapludox it is 262 $cm^2$ (Table 2). The average volume of chambers per nest was 3294.02 $cm^3$ in the Oxyaquic Udipsamments, being significantly higher than the average volume of the Xanthic Hapludox, which recorded an average of 878.51 $cm^3$ (Table 2).

**Table 1:** Area ($cm^2$) and volume ($cm^3$) of the chambers of anthill nests of *Dinoponera gigantea* in Oxyaquic Udipsamments and Xanthic Hapludox soil of North Northeast of Brazilian Cerrado

| Nests | Soils | Geometric measures | Number of Chamber for nests | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** |
| **1** | **Oxyaquic Udipsamments** | **Area** | 396,12 | 1,23 | 1,2 | 7,25 | - | - | - | - | - | - | - | - | - | - |
| | | **Volume** | 2306,72 | 2,46 | 3,6 | 21,7 | - | - | - | - | - | - | - | - | - | - |
| **2** | | **Area** | 13,92 | 362,3 | 16,6 | 44,9 | 5,05 | 3,1 | 2,2 | 47 | - | - | - | - | - | - |
| | | **Volume** | 139,15 | 3985 | 166 | 270 | 25,3 | 15 | 6,6 | 189 | - | - | - | - | - | - |
| **3** | | **Area** | 1,52 | 263 | 1,65 | 27 | - | - | - | - | - | - | - | - | - | - |
| | | **Volume** | 3,04 | 1841 | 3,3 | 162 | - | - | - | - | - | - | - | - | - | - |
| **4** | | **Area** | 132,52 | 14,07 | 288 | 18,5 | 118 | 14 | 107 | 12 | 6,47 | 15 | 1,8 | - | - | - |
| | | **Volume** | 530,08 | 70,35 | 288 | 55,4 | 354 | 41 | 537 | 17 | 19,4 | 45 | 7,3 | - | - | - |
| **5** | | **Area** | 192,99 | 360,8 | 41,5 | 19,5 | 51,2 | 62 | 31,6 | 40 | 33,1 | 12 | 2,7 | 1,1 | 24 | 4,9 |
| | | **Volume** | 1736,87 | 2525 | 166 | 58,6 | 205 | 247 | 158 | 121 | 215 | 75 | 8 | 3,3 | 73 | 17 |
| **6** | | **Area** | 82,17 | 28,34 | 10,7 | 39,9 | 2,65 | 1,2 | 123 | 1,9 | 25,6 | 4,1 | 3,2 | - | - | - |
| | | **Volume** | 164,34 | 42,51 | 21,5 | 79,9 | 7,94 | 3,5 | 493 | 5,5 | 76,6 | 4,1 | 3,2 | - | - | - |
| **1** | **Xanthic Hapludox** | **Area** | 50,99 | 49,39 | 18,1 | 10,1 | 8,26 | 4,5 | 26,2 | 19 | 9,72 | 1,9 | 1,8 | 48 | - | - |
| | | **Volume** | 153 | 123,5 | 54,4 | 35,2 | 33 | 23 | 105 | 57 | 9,72 | 1,9 | 1,8 | 240 | - | - |
| **2** | | **Area** | 20,93 | 14,94 | 60,8 | 6,61 | 4,42 | 4,5 | 11,1 | 14 | 7,13 | 8,5 | 14 | 39 | 1,5 | 5,4 |
| | | **Volume** | 31,4 | 29,87 | 152 | 9,91 | 6,62 | 14 | 22,2 | 27 | 14,3 | 17 | 29 | 78 | 2,3 | 16 |
| **3** | | **Area** | 3,92 | 50,57 | 2,04 | 114 | 51 | 98 | 63,9 | 49 | 18,7 | 19 | 15 | - | - | - |
| | | **Volume** | 11,76 | 101,1 | 4,08 | 345 | 128 | 295 | 192 | 147 | 74,8 | 56 | 44 | - | - | - |
| **4** | | **Area** | 129,1 | 62,78 | 8,72 | 77,2 | - | - | - | - | - | - | - | - | - | - |
| | | **Volume** | 387,3 | 188,3 | 34,9 | 309 | - | - | - | - | - | - | - | - | - | - |
| **5** | | **Area** | 107,7 | 25,31 | 2,05 | - | - | - | - | - | - | - | - | - | - | - |
| | | **Volume** | 538,7 | 75,93 | 6,14 | - | - | - | - | - | - | - | - | - | - | - |
| **6** | | **Area** | 48,7 | 2,65 | 4,83 | 41,2 | 32,8 | 41 | 87,8 | 9,7 | 4,08 | 4,3 | 115 | - | - | - |
| | | **Volume** | 146,1 | 3,98 | 14,5 | 206 | 65,6 | 145 | 307 | 19 | 4,08 | 8,5 | 520 | - | - | - |

The *D. giantea* nests in Oxyaquic Udipsamments had two to three ellipsoid-shaped openings with diameters of 2 to 4 cm, projecting vertically above ground level together with the first chamber of the respective nests and always facing the rising sun. The anthills molded in this soil showed polydomic condition, with adjacent nests with only one opening and diameter similar to the openings of standard nests.

**Table 2:** Number, volume and area of ant chambers of *Dinoponera gigantea* in two soils of Cerrado North Northeast of Brazil

| **Variables** | **Oxyaquic Udipsamments** | | | | **Xanthic Hapludox** | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of chambers | Area ($cm^2$) | Volume ($cm^3$) | Depth cm | Number of chambers | Area ($cm^2$) | Volume ($cm^3$) | Depth cm |
| N | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Mean | 8.83 A | 520.51 A | 3294.02 A | 23,25A | 9.17 A | 291.81 A | 944.32B | 40 A |
| S.D. | 4.36 | 234.87 | 1903.88 | 10,99 | 4.54 | 126.77 | 403.34 | 11,64 |
| S.E. | 1.78 | 95.88 | 777.26 | 4,49 | 1.85 | 51.75 | 164.66 | 4,75 |
| CV | 49.3 | 45.12 | 57.8 | 47,27 | 49.47 | 43.44 | 42.71 | 29,11 |
| Minimum | 4 | 293.17 | 902.09 | 14 | 3 | 135.06 | 449.6 | 37 |
| Maximum | 15 | 878.89 | 5610.27 | 43 | 14 | 485.13 | 1439.76 | 62 |

Means with different letters on the same line differs stastically $p \leq 0,05$. CV. Coefficient of variation, S.D. Standard deviation, standard error, N - number of anthills.

The anthills of the Oxyaquic Udipsamments soil had fewer chambers and no regular shape (Figures 1, 2 and 3). Anthills 1, 2 and 3 of the Oxyaquic Udipsamments were the least deep (Table 1) and with the greatest irregularity of the chambers, but presented a mean absolute volume greater than the mean absolute volume of the chambers of anthills 4, 5 and 6 of this soil (Table 1). The Principal Component Analyze (PCA) multivariate associations show that *D. gigantea* nests have greater internal volume when they are built in soils with higher clay contents, higher percentage of macropores and higher aggregate stability indexes, higher atmospheric humidity, lower temperatures and lower soil density values (Figure 4) as occurs in Oxyaquic Udipsamments (Table 3).

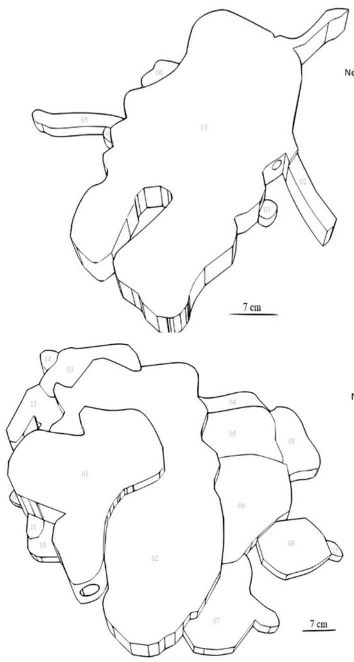


**Figure 1:** Nests 01 and 02 of *Dinoponera gigantea* in a Oxyaquic Udipsamments in the Cerrado North Northeast of Brazil.

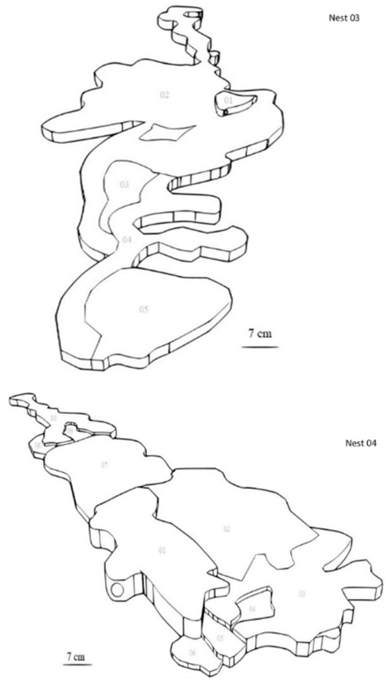


**Figure 2:** Nests 03 and 04 of *Dinoponera gigantea* in a Oxyaquic Udipsamments in the Cerrado North Northeast of Brazil.

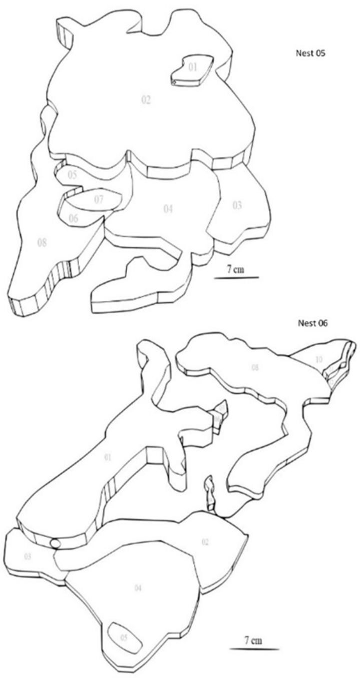


**Figure 3:** Nests 05 and 06 of *Dinoponera gigantea* in a Oxyaquic Udipsamments in the Cerrado North Northeast of Brazil.

The Principal Component Analyze (PCA) multivariate associations show that *D. gigantea* nests have greater internal volume when they are built in soils with higher clay contents, higher percentage of macropores and higher aggregate stability indexes, higher atmospheric humidity, lower temperatures and lower soil density values (Figure 4) as occurs in Oxyaquic Udipsamments soil (Table 3).

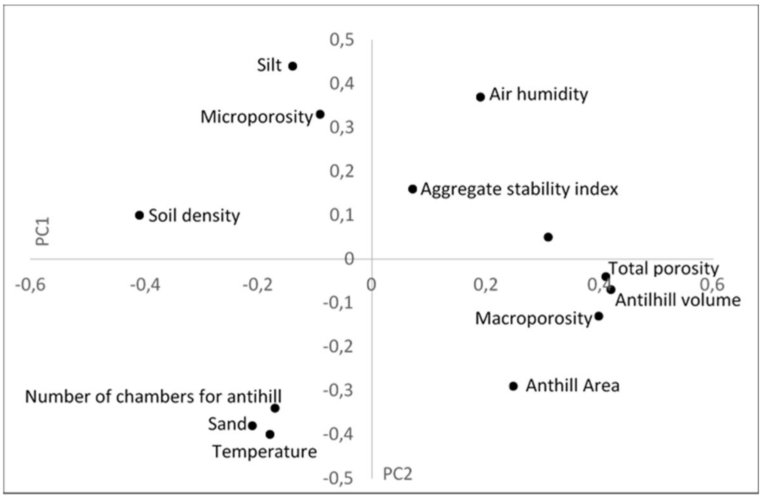


**Figure 4:** Analysis of principal components of soil attributes and climatic variables related to the occurrence of nests of *Dinoponera gigantea* in Udipsamments Oxyaquic and Hapludox Xanthic from Cerrado, North Northeast Brazil. 71.0% system inertia in the second principal component.

The depth of D. gigantea nests studied in the Xanthic Hapludox ranged from 29 to 62 cm in depth. The average number of chambers found in these nests was equal to 9 (Table 1 and 2) (Figures 5, 6 and 7), with 15 to 30 individuals of *D. gigantea* in the studied nests in this soil.

The depth of the Xanthic Hapludox nests was not statistically different from the depth recorded for the Oxyaquic Udipsamments nests. However, in absolute values, the nests are deeper than the Oxyaquic Udipsamments soil nests. The deepest nest of *D. gigantea* in the Xanthic Hapludox reached 62 cm in depth and the shallowest ones, 29 cm in depth.

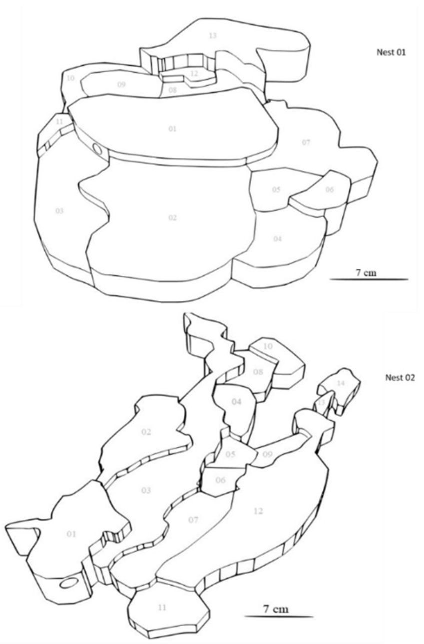


**Figure 5:** Nests 01 and 02 of *Dinoponera gigantea* in a Xanthic Hapludox in the Cerrado North Northeast of Brazil.

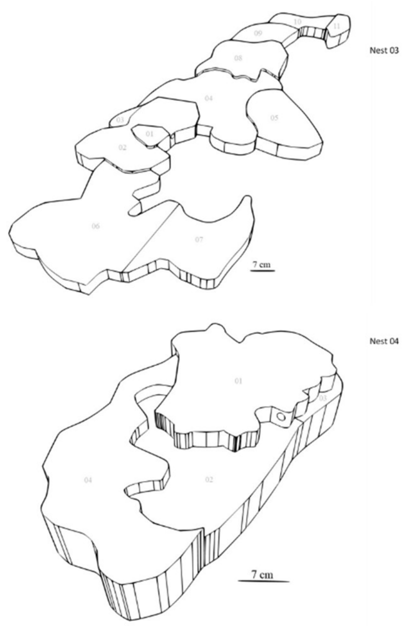


**Figure 6:** Nests 03 and 04 of *Dinoponera gigantea* in a Xanthic Hapludox in the Cerrado North Northeast of Brazil.

All nests in the Xanthic Hapludox had two openings with a diameter varying between 2 and 3 cm and ellipsoid shape, forming an acute angle that rises about 10 cm above ground level along with the first chamber of each nest, always facing the rising sun.

The PCA associations (Figure 4) show that *D. giantea* nests will have smaller volume, more chambers and will be deeper in soils with higher micropore area contents, with lower aggregate stability indexes, with smaller measurements atmospheric humidity, with higher temperatures that characterize the Xanthic Hapludox (Table 3).

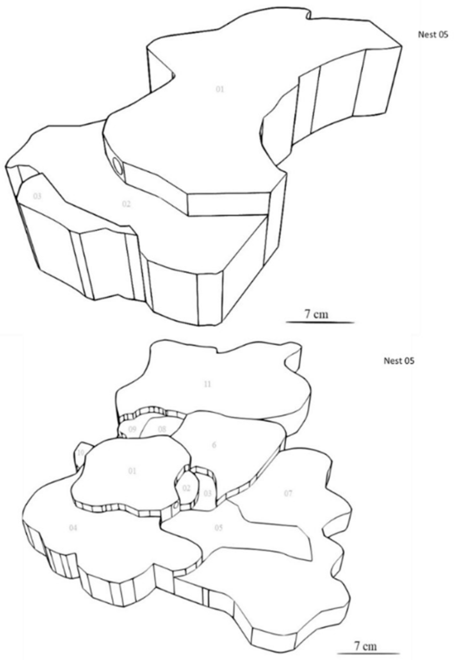


**Figure 7:** Nests 05 and 06of *Dinoponera gigantea* in a Xanthic Hapludox in the Cerrado North Northeast of Brazil.

## DISCUSSION

The smaller depth of *D. giantea* ant nests in the Oxyaquic Udipsamments is possibly related to the phytophysiognomic domain found in this soil. The structure of the forest in this environment is arboreal with strong shading in the soil that is covered by a dense layer of litter Silva et al. (2017). In this forested environment, the treetops limit the incidence of sunlight directly on the ground, keeping the pedological environment at lower temperatures than what is observed in environments with shrubby vegetation cover. Ants of the species *D. gigantea* prefer wetter environments with low temperatures (FOURCASSIE et al., 2002; SILVA et al., 2017). When ants of this genus are found in shrub or xerophytic formations, nests are preferably built at the base of tree and shrub trunks in order to minimize the effects of strong insolation and desiccation.

The phytophysiognomic domain of the Oxyaquic Udipsamments environment created thermal and humidity conditions for the construction of *D. gigantea* nests near the soil surface. The higher clay content in depth in Oxyaquic Udipsamments, especially in the relief depression forms, can create water saturation zones in the deeper layers of these soils, which may have conditioned the construction of nests in the layer from 00 to 43 cm deep, as ants of the species *Dinoponera gigantea* do not build nests in hydromorphic soils Silva et al. (2017). The concentration of *D. gigantea* nests in the superficial layers of the studied Oxyaquic Udipsamments reduced the number of chambers, but amplified the volume and internal area of the chambers of these anthills.

Although the internal area of *D. gigantea* anthills in the Oxyaquic Udipsamments and the Xanthic Hapludox nests are statistically similar, there are numerical differences that show that the *D. gigantea* nests in the Oxyaquic Udipsamments surpass on average 58% the inner area of this ant's nests in the Xanthic Hapludox of the xerophytic environment of the Cerrado. The superficialization of the water table in Oxyaquic Udipsamments limited the deepening of *D. gigantea* nests in this soil to a maximum of 43 cm.

The superficialization of these nests in the soil profile was compensated with the amplification of the inner area of these nests, where the ants built large chambers with more than 2300 $cm^3$. The construction of large and voluminous galleries and chambers is associated with the structural stability conditions of this soil, which has the highest aggregate stability indexes (greater than 90%), and the predominance of water-conducting macropores, which quickly drain water from the first layers of soil (ASSIS JÚNIOR et al., 2012). Especially in the sites where *D. gigantea* nests, which also has high root density.

The arboreal vegetation that covers the Oxyaquic Udipsamments provides root structures that amplify the stability of these nests. The roots compose a network of mooring the walls of chambers and galleries, Zaleski et al. (2005). The structuring of the first layers of the Oxyaquic Udipsamments created conditions for *D. gigantea* to build nests with large chambers and galleries rich in macropores that efficiently drain water even during periods of higher rainfall in the region.

The nests studied in this pedological cover had 2 to 3 entry and exit holes, ellipsoid, with a diameter of 2 to 4 cm, in a vertical position in relation to the ground level, which is common among ants of this genus. The verticalization of the openings is most likely due to the level of shading characteristic of a forested environment, which homogenizes the level of insolation at different times of the day. This number of openings is also common for polydomic anthills. The variation in the number of openings is a function of the nesting environment, being also observed by an author, who found anthills with the same number of openings and oriented to the east, both in the forest environment and in the semiarid.

The anthills molded in Oxyaquic Udipsamments showed polydomism, as they all had a secondary nest nearby, with only one entry and exit hole. The polydomic condition of these attachments can be seen as individuals from the main nest passively occupied this attachment, during the molding process of the main nest with cement solution. Another relevant aspect found in polydomic anthills was the number of ants per colony, in this case an average of 50 to 60 individuals were counted, a number in absolute values superior to those found in monodomic anthills of the pedological cover of the Xanthic Hapludox, where a population of ants was recorded, with an average of 15 to 30 individuals. These results confirm data obtained by Hooldobler et al. (1990), Fourcassie et al. (2002), who deal with a possible degree of polydomism for the genus *Dinoponera* and by Lapola et al. (2003), who obtained results similar to those of this study, when evaluating the population size and volume and architecture of nests of the ant *Ectatomma brunneum*.

The correlation matrix of the Oxyaquic Udipsamments's physical attributes confirms the close relationship that the superficial, voluminous and irregularly-architectured nests of *D. giantea* have with clay-rich soils, organic matter with a higher percentage of macropores and higher levels of aggregate stability, higher atmospheric moisture, lower temperatures and lower soil density values as occurs in Oxyaquic Udipsamments. Silva et al. (2017) verified that *D. gigantea* nests are strongly associated with the physical attributes listed in this work, and these same authors add that organic matter and litter also strongly affect the distribution of *D. gigantea* nests.

The *D. gigantea* nests built in Hapludox Xanthic were deeper than the nests of this ant species found in the Udipsamments Oxyaquic. In the Hapludox Xanthic, the phytophysiognomic domain of the Cerrado allows more light to enter the understory and soil (LIMA et al., 2020a). The greater penetration of sunlight into this environment increases the temperature at the litter/soil interface. This increase in temperature should be considered a determining factor for the occurrence of deeper nests of *D. gigantea* in the Cerrado Hapludox Xanthic.

The greater depth of *D. gigantea* nests in the Hapludox Xanthic increased the number of chambers in this soil. This adjustment of size, volume and depth of the nests in the Hapludox Xanthic should be considered as a strategy of this ant species to reduce the internal temperature of the nests in the sampled Cerrado environment.

In northeastern Brazil where high temperature and low humidity measurements are recorded, VASCONCELOS et al. (2004) identified *D. quadriceps* nests at 1.2 m depth and with more than 15 chambers, all of geometrically regular shape, showing that in less humid environments and with higher temperatures such as the Cerrado sampled in this work, the nests of *Dinoponera* tend to deepen, to increase the number of chambers, but chambers of smaller volume.

The construction of deeper ant nests in hot forest soils is also observed in ant species that are more phylogenetically distant from *D. gigantea*, as shown by the results obtained by Lapola et al. (2003) for *Ectatomma brunneum* and Antonialli Júnior et al. (1997) who found 90 cm deep *E. opavicentre* nests.

The smaller number of openings of *D. gigantea* nests in the Hapludox Xanthic and the smaller diameter of these angularly acute openings are in agreement with the monodomic condition of these *D. gigantea* nests. The acute angulation of the opening of these nests shows the effect of vegetation cover on the orientation of the openings of edaphic ant nests, which, depending on the species, can magnify the number of openings and their respective angulations, as verified by Paiva et al. (1997) for *D. quadriceps*, *D. australis* and *D. lucida*, and Vieira et al. (2007) who recorded only one orifice with an ellipsoid shape and 2.5±0.71 cm in diameter larger by 1.4±0.23 cm in diameter for the anthills of *Ectatomma vizottoi*. These last authors related this variation to the structure of the nesting environment of *E. vizottoi*, highlighting the type of vegetation cover, litter volume, among others, as also observed by Antonialli Junior et al. (1997), when they described the architecture of *E. opaciventre* nests in an urban Atlantic Forest.

The architectural difference between the nests of *D. gigantea* in the Oxyaquic Udipsamments and the Hapludox Xanthic may be associated with the magnification of differences in the structural stability of these soils. In the studied Hapludox Xanthic, the aggregate stability indexes are smaller and they decrease even more when these soils are moistened under field conditions. Ant nests in coastal Hapludox Xanthicin Brazil should be analyzed considering the cohesion (GIAROLLA et al., 2009) and the structural compliance

(LIMA et al., 2005; SILVA et al., 2006) of these soils formed in the lithostratigraphic unit of the Barreiras Formation, which extends from the Southeast to the North of Brazil (WEST et al., 2020). The cohesive soils of the Barreiras formation are friable when moistened and strongly dense when dry.

The friability of these soils when wet, at the beginning of the rainy season, reduces the effort and energy expenditure with the excavation (BOLLAZI et al., 2008), allowing the construction of nests with deeper chambers that are more thermally comfortable.

The chambers and galleries built on this soil have a regular shape and are smaller and less bulky and, therefore, more stable and resistant to the instability that these soils experience during the rainy season in the region. During the dry season, these soils change their behavior drastically, reaching high levels of densification and natural compaction. This amphoterism of the physical attributes of cohesive Hapludox Xanthic (JACOMINE, 1996; BOTELHO, 2001) especially affects aggregate stability and soil density (GUERRA et al., 1996).

The multivariate associations showed that, in addition to soil density and aggregate stability, microporosity and sand contents in Hapludox Xanthic are added to define the structure, architecture, depth and number of chambers of *D. gigantea* anthills in the Hapludox Xanthic studied, while the highest indices of soil macroporosity, water-stable aggregates, clay and soil organic matter are crucial for *D. gigantea* to build structurally and architecturally different nests in the studied Oxyaquic Udipsamments.

## CONCLUSIONS

In Oxyaquic Udipsamments, vegetation cover, physical attributes (macroporosity, aggregate stability, clay content), lower temperatures and dense vegetation cover affected the structure and architecture of nests of *D. gigantea* in this soil. The nests of *D. giantea* from Oxyaquic Udipsamments did not show a defined architectural pattern, the chambers are superficial, voluminous and without geometrical regularity. In Hapludox Xanthic, vegetation cover, physical attributes (microporosity, aggregate stability, clay content, soil density), high temperatures and erratic vegetation cover affected the structure and architecture of *D. gigantea* nests in this soil. In the Hapludox Xanthic, *D. gigantea* nests are deeper, have greater geometric regularity, greater number of chambers and are less voluminous.

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