Eurasia Specialized Veterinary Publication

Entomology Letters

ISSN:3062-3588

2021, Volume 1, Issue 1, Page No: 22-28

Available online at: www.esvpub.com/

Nest Design Capabilities of the Black Larger Ant (*Componotus* sp.)

Paramanandham Joothi[1]*, Ramya Pakkirisamy[1], Malini Subramaniyan[1], Jayakumar Samidurai[1], Krishnappa Kaliyamoorthy[1], Ronald Ross Pankirias[2]

[1]Department of Zoology and Wildlife Biology, A.V.C. College (Autonomous), Mannampandal- 609 305, Mayiladuthurai, Tamil Nadu, India.
[2]Department of Zoology, Govt. Arts College, Ariyalur- 621 713, Tamil Nadu, India.

***E-mail** ✉ paramusacon2010@gmail.com

ABSTRACT

This study evaluated the nest structure of the black larger ant using affordable white cement for modeling. Various parameters including the tunnel's length and width, the chamber's dimensions (length, width, and diameter), the depth of the nest, and the number of tunnels and chambers were measured. Standard tools and techniques were used to assess these factors. The nest's average circumference was 15.1 ± 4.30 cm and its depth was 13.1 ± 3.50 cm. The average number of tunnels was 9.0 ± 2.0, with an average tunnel length of 10.7 ± 5.60 cm and a width of 3.0 ± 1.0 cm. The number of chambers was 6.0 ± 2.0, with chamber lengths of 3.7 ± 1.6 cm and widths of 2.5 ± 1.3 cm, all showing significant variation. A positive correlation ($r = 0.54$, $n = 52$) was observed between the tunnel's length and width, indicating that as the tunnel length increases, its width tends to increase as well. The direction of the tunnels appeared to be influenced by environmental factors, such as the proximity to water sources. The majority of the tunnels were oriented to the west (29%), with the east and south directions also notable. Most of the nests observed were irregular in shape, although a few displayed rounded formations. While an initial description of the nest structure is valuable, a deeper examination is necessary to fully understand how the design of these nests contributes to the colony fitness. This includes analyzing how specific features support the colony's overall survival and the mechanisms behind these adaptive advantages.

Keywords: Tunnels, Nest, Ants, Architecture, Underground

Received: 17 March 2021
Revised: 23 May 2021
Accepted: 28 May 2021

How to Cite This Article: Joothi P, Pakkirisamy R, Subramaniyan M, Samidurai J, Kaliyamoorthy K, Pankirias RR. Nest Design Capabilities of the Black Larger Ant (*Componotus* sp.). Entomol Lett. 2021;1(1):22-8. https://doi.org/10.51847/WqHlJ1l4ph

Introduction

Nest construction plays a crucial role for many species, enabling colonies or individuals to create environments suited to their needs. Among these, ants are known for building underground nests by removing soil particles, unlike wasps or bees that use materials like wood or wax [1]. Different ant species construct elaborate subterranean nests that can range in size and complexity, designed to protect the colony from environmental fluctuations [2] and predators [3]. These nests also serve as critical environmental engineers [4], altering soil properties such as runoff [5], soil turnover [6], plant dynamics [7], and nutrient cycling. The architecture of social insect nests, particularly ants, is highly diverse, yet all nest designs share the common purpose of maintaining a stable internal temperature and providing a secure environment for the colony members. Ant nests can vary in depth and complexity, with some being shallow, while others extend several meters underground, connected by an intricate network of tunnels and chambers. The primary function of these nests is to protect the queen, brood, and worker ants from predators and dehydration. It has been observed that the microclimate inside the nest remains more stable than the external environment [8]. Variations in the number, arrangement, and connectivity of nest chambers lead to different architectural layouts [9, 10]. These differences may result from factors like the colony's developmental stage, seasonal changes [11], soil composition, and microclimatic conditions. Research into nest construction can offer valuable insights into the collective behaviors of ant colonies. However, the study of ant nest architecture is still in its early phases. While preliminary studies have started to highlight the diverse architectural designs among species, fully understanding the intentionality behind these variations remains a long-term goal. Despite recent advancements, much of the existing knowledge consists of descriptive reports or basic illustrations from excavation studies, with few offering comprehensive population data or detailed architectural analyses. The differences in nest architecture across species are primarily linked to the arrangement, distribution, and size of the various components. The review above was conducted to explore the nest excavation of the black larger ant.

This research examined the structural design of the black larger ant's nest by utilizing affordable white cement. Measurements were taken for the tunnel's length and width, as well as the width, length, and diameter of the chambers, the depth of the nest, and the total count of chambers and tunnels, all using standard measurement tools and techniques.

Materials and Methods

The black larger ant, classified under the Hymenoptera order, features wingless workers measuring between 4 and 6 mm in length. These ants are usually dark brown or black and are often observed in large groups. They are commonly seen near their underground nests or following scent trails on the ground and on different surfaces such as buildings and walls. Six black larger ant nests were randomly selected for study in Vadakarai Panchayat, Mayiladuthurai Taluk, Nagapattinam District, located in the coastal region of Tamil Nadu, amidst a garden filled with dense vegetation like bamboo, hibiscus, and citrus. The research was conducted between November 2017 and March 2018. Upon selecting the nests, a mixture of 3 kg of white cement and 10 liters of water was prepared to mark the nests [12]. This mixture was designed to prevent bubble formation from the cement’s setting process and limit water absorption into the soil. The nest entrances were cleaned using a portable vacuum cleaner, after which the cement mixture was carefully injected into the nest using a syringe, filling it until the nest overflowed. After three days, when the cement had fully hardened, the nests were excavated by hand with the help of dissection tools. The resulting chambers and tunnels were cleaned, measured, and then numbered, sketched, and photographed for documentation.

Nest characteristics

A trench was first dug around the perimeter of each nest, then excavation continued inward and downward as the chambers and tunnels became visible. The size of the chambers, including their depth, length, and width, were recorded for all 6 nests. Furthermore, the tunnels' length and diameter were measured for the nests that had been filled with markers. During the excavation process, measurements were taken using thread and a measuring scale. The following parameters were documented: the total number of tunnels, their width and length, the number of chambers, their diameter, width, and length, the overall depth of the nest, the total length of the tunnels, and the nest's outer circumference. Additionally, the direction of the tunnels was also observed and noted.

Statistical analysis

Statistical analysis was performed using correlation to examine the relationship between the width and length of the chambers and tunnels. ANOVA was also conducted to analyze the variations in the width and length of both chambers and the tunnels, using SPSS version 16 software.

Results and Discussion

Nest characters

Nest I had the highest number of tunnels (11), followed by nest III with 10, nests V and VI with 9, nest IV with 7, and nest II with 6. Similarly, nest I contained the most chambers (10), with nest III and VI both having 6, and nests V, II, and IV having 5, 4, and 3, respectively. The deepest nest was nest VI with a depth of 17.4 cm, followed by nest IV at 16.7 cm, nest III at 12.7 cm, nest I at 12.4 cm, nest II at 10.6 cm, and nest V at 8.3 cm. The outer circumference of the nests was largest in nest II at 21.7 cm, followed by nest VI at 17.6 cm, nest I at 15.4 cm, nest V at 14.6 cm, nest III at 11.3 cm, and nest IV at 9.8 cm. The total length of the tunnels was greatest in nest I at 105.1 cm, followed by nest VI at 101.4 cm, nest II at 95.6 cm, nest V at 90.2 cm, nest IV at 84.5 cm, and nest III at 60.3 cm **(Table 1)**.

Table 1. Nest characters of the nests studied during the study period (n = 6)

Nest number	No. of tunnel	No. of chambers	Depth of the nest (cm)	Outer circumference of the nest (cm)	Total length of the tunnel (cm)
Nest I	11	10	12.4	15.4	105.1
Nest II	6	4	10.6	21.7	95.6
Nest III	10	6	12.7	11.3	60.3
Nest IV	7	3	16.7	9.8	84.5
Nest V	9	5	8.3	14.6	90.2
Nest VI	9	6	17.4	17.6	101.4

The circumference of the nests of larger black ants ranged from 9.8 cm to 21.7 cm, with an average of 15.1 ± 4.30 centimeters (n = 6). Nest depths varied from 8.3 cm to 16.7 cm, averaging 13.1 ± 3.50 centimeters (n = 6). The number of tunnels in the nests ranged from 7 to 11, with an average of 9.0 ± 2.0 (n = 6). Tunnel lengths varied between 2.6 cm and 24.3 cm, with a mean of 10.70 ± 5.60 centimeters (n = 52). Tunnel width ranged from 1.2 cm to 4.6 centimeters, with an average width of 3.00 ± 1.00 centimeters. Correlation analysis between tunnel length and width showed a positive relationship (r = 0.54, n = 52), indicating that as tunnel length increased, the width also tended to increase **(Table 2)**. The number of chambers observed across all nests varied from 3 to 10, with an average of 6.0 ± 2.0 (n = 34). Chamber lengths ranged from 1.3 cm to 8.4 centimeters, with an average of 3.70 ± 1.60 centimeters. Chamber width varied from 1.8 cm to 5.6 centimeters, with an average of 2.50 ± 1.30 centimeters. A positive correlation between chamber length and width was also found (r = 0.69). The diameter of the chambers, when circular, ranged from 1.3 cm to 3.6 centimeters, with an average diameter of 2.60 ± 1.62 cm **(Table 2)**. Tunnel orientation was examined to understand environmental influences, such as water sources. The study showed that tunnel directions varied, with the majority directed west (29%), followed by east and south (25%), north (13%), southwest (6%), and northeast (2%). A total of 52 tunnels were recorded. In terms of chamber shape, 91% of the chambers were irregular, while 9% were round (n = 34). Based on the data from the table, the measured tunnel length, breadth, and chamber width were larger than the listed values. While there were important differences in nest characteristics, the chamber length did not significantly differ from the table values **(Table 2)**.

Table 2. Range, mean, and correlation of the overall nest (n = 6) (cm)

Variables	Range	Mean ± SD	Correlation (r)	P-value	F
Nest circumference (cm)	9.8- 21.7	15.1 ± 4.3			
Nest depth (cm)	8.3-16.7	13.1 ± 3.5			
No. of tunnels	7.0- 11.0	9.0 ± 2.0			
Tunnel length (cm)	2.6- 24.3	10.7 ± 5.6	0.54	0.053	2.377
Tunnel width (cm)	1.2-4.6	3 ± 1.0		0.108	1.925
No. of chambers	3.0-10.0	6 ± 2.0			
Chamber length (cm)	1.3-8.4	3.7 ± 1.6	0.69	0.827	0.424
Chamber width (cm)	1.8-5.6	2.5 ± 1.3		0.450	0.978
Chamber diameter (cm)	1.3-3.6	2.6 ± 1.2			

The results of regression analysis indicate a direct relationship between the width and length of the tunnel. As the tunnel width increases, the tunnel length also tends to increase significantly. A similar pattern was observed for the chambers, where the width was found to be directly related to the length of the chambers. An increase in the chamber width led to a corresponding increase in the tunnel length **(Figures 1 and 2)**. During the excavation of each nest, a pencil sketch was created to predict the nest structure, which was later transferred to a computer model. This sketch served as a basis for visualizing the nest's architecture digitally, revealing considerable variation in the characteristics of the nests. In the computer-generated model, the number of tunnels and chambers was also recorded.

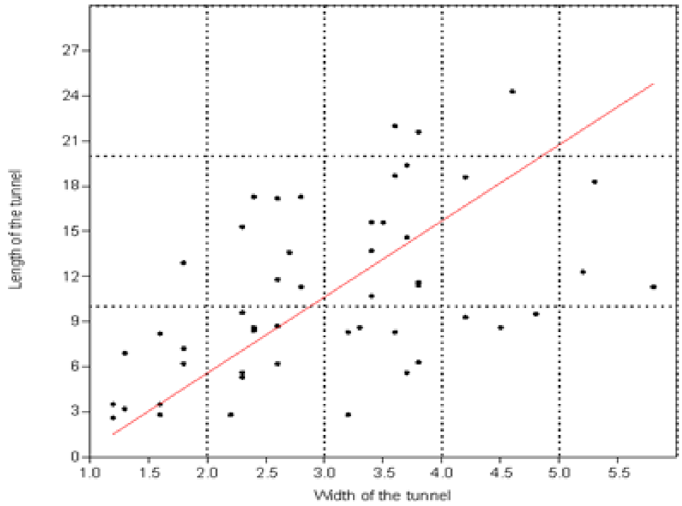

Figure 1. Regression analysis of the width of the tunnel against the length tunnel (n = 6).

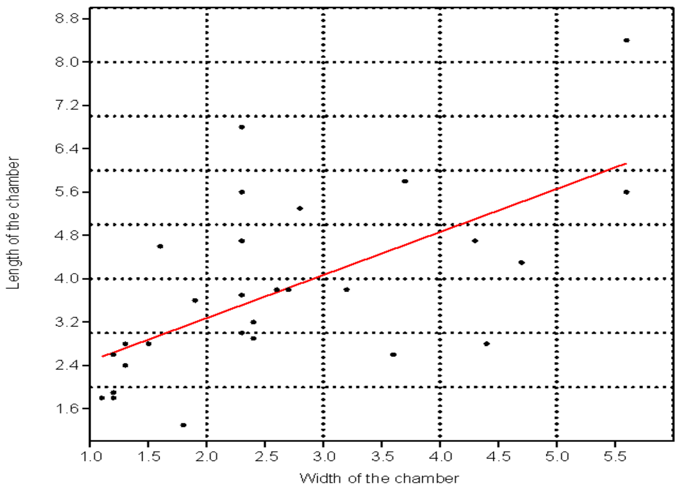

Figure 2. Regression analysis of the width of the chamber against the length of the chamber (n = 6).

The design of a nest requires a significant investment of energy and time, offering benefits such as shelter, microclimate stability, and reliability [13]. Additionally, the nest structure plays a key role in organizing the colony members, contributing to the colony's function as a highly coordinated superorganism. Although considerable resources are devoted to nest construction, this investment enhances the colony's fitness, which could otherwise have been directed toward other tasks that support survival. A major challenge remains in understanding how specific features of the nest's design fulfill particular roles within the colony and how these roles influence the colony's overall fitness. For instance, the towers built by various tropical termite species are critical for aeration and temperature control, showcasing their adaptability [14]. However, there is limited comparable knowledge about the complex nests constructed by ants.

In this study, *Componotus* sp. nests were found in the soil beneath bushes. This contrasts with previous research, which indicated that the *Componotus* genus is most commonly associated with natural bamboo or bamboo traps [15-17]. Among the 6 nests excavated, variations were observed in the number of tunnels, chambers, nest depth, and the overall length of the tunnels. These differences were attributed to factors such as the colony's size and maturity. This finding aligns with Tschinkel [18] observations, which suggested that larger colonies tend to construct larger nests because of the concurrent processes of deepening the nest, expanding chambers, and developing a new vertical arrangement of chambers. The casts of small, medium, and large nests reveal distinct architectural variations linked to colony growth.

A strong positive correlation was observed between the length and width of the tunnels. The linear regression analysis indicated that both the length and width could be predicted based on the maturity and size of the colony. The outer circumference of the nest varied across different nests, likely influenced by the size and shape of each nest. This study did not assess the number of ants within the nest, as it was not part of the research objectives. However, the abundance of ants could potentially affect nest characteristics, such as the number of chambers, tunnels, and the dimensions of the chambers.

The intricate nests of the black larger ant, *Camponotus* sp., exhibit clear, consistent, and species-specific structural patterns. The size and form of the chambers vary independently in each nest. The lack of size restrictions allows for the chambers' shapes to be independent of the nest's overall size, as observed in *Pogonomyrmex badius* and *Camponotus socius* [19]. This suggests that workers follow simple, localized guidelines to create nests with similar shapes, regardless of their size. Jesovnik *et al*. [20] excavated four nests of *Mycetagroicus inflatus*, each featuring a single, small, inconspicuous entrance around 2-3 millimeters in diameter. Unlike the entrance of *M. cerradensis* [21], these nests did not have a mound of excavated soil around the entrance. In contrast, the present study observed notable variations in the tunnels and chambers of the nests.

In the current study, several tunnels were found to connect the chambers, influencing their size. A similar observation was made by Jesovnik *et al*. [20], who documented nests containing 2-4 chambers, with widths ranging from 2 to 8 cm. The deepest chamber they encountered had a depth of 310 centimeters, but it contained only ants and no queen. The shallowest chamber observed had a depth of 22 centimeters and consisted solely of loose sand, with no ants present. Some nests also exhibited tunnels linking the chambers, which were notably straight and perpendicular to the surface. Forti *et al*. [22] reported that the number of chambers in the nests they studied ranged from four to fourteen, with chambers distributed perpendicularly across a depth of 101 to 509 cm. In contrast, the present study found that the average depth of the black larger ant's nest was 13 cm.

The current study revealed that the nests of *O. brunneus* featured simple vertical shafts connecting various chambers. These findings suggest that the nests of *O. brunneus* are composed of basic vertical shafts that link simple, horizontal chambers, a common design in underground ant nests. The ancestors of these ants likely created these burrows, which would have initially contained only a few chambers or perhaps just one [23]. In this study, all six nests also exhibited horizontal chambers. Forti *et al*. [22] described the nests of Atta capiguara, which were characterized by several mounds of loose soil, forming cone-like shapes with distinctive features. A similar investigation was carried out on the Florida harvester ant nests by Tschinkel [18], who noted that their nests had two primary components: shafts and chambers. These shafts were elongated, circular, oval, or sometimes flattened-oval in shape. They generally had a long axis inclined at an angle of 20° to 70° from the vertical, rarely reaching 90°. The typical diameter of these shafts was slightly under one cm. In the upper parts of the nest, the shafts were wider and sometimes had a flattened-oval shape, reaching up to 2 cm in width. However, in the present study, these shafts were referred to as tunnels. Tschinkel [18] also observed that nests typically had a single entrance, though in some cases, two or three openings were noted. From the entrance, there was a downward slope in the shaft, inclined at around 20-30° from the horizontal. As one moved deeper, the angle gradually increased to 45-60° at depths around fifty cm and beyond. A similar pattern was observed in the current study, where a single entrance led to a tunnel that descended at an angle of 20-30° from the horizontal. Additionally, some helical tunnels were also identified in this investigation.

Conclusion

The current study highlighted the nesting behavior and structural features of the black larger ant (*Componotus* sp.). In India, limited research has focused on ant nest excavation, with some studies originating from the southern regions. These studies have shown that nest structure and characteristics are influenced by the colony's maturity and size, indicating a need for further detailed research in the future.

Acknowledgments: We express our gratitude to the Principal and Head of the Department of Zoology and Wildlife Biology, A.V.C. College (Autonomous), Mannampandal, Mayiladuthurai, Tamil Nadu, India, for granting permission to conduct this important research.

Conflict of Interest: None

Financial Support: None

Ethics Statement: None

References

1. Yang G, Zhou W, Qu W, Yao W, Zhu P, Xu J. A review of ant nests and their implications for architecture. Buildings. 2022;12(12):2225. doi:10.3390/buildings12122225
2. Jones JC, Oldroyd BP. Nest thermoregulation in social insects. Adv Insect Physiol. 2006;33:153-91. doi:10.1016/S0065-2806(06)33003-2
3. Powell S, Clark E. Combat between large derived societies: a subterranean army ant established as a predator of mature leaf-cutting ant colonies. Insectes Soc. 2004;51(4):342-51. doi:10.1007/s00040-004-0752-2
4. De Almeida T, Mesleard F, Santonja M, Gros R, Dutoit T, Blight O. Above-and below-ground effects of an ecosystem engineer ant in Mediterranean dry grasslands. Proc R Soc B. 2020;287(1935):20201840. doi:10.1098/rspb.2020.1840
5. Cammeraat LH, Willott SJ, Compton SG, Incoll LD. The effects of ants' nests on the physical, chemical and hydrological properties of a rangeland soil in semi-arid Spain. Geoderma. 2002;105(1-2):1-20.
6. Wills BD, Landis DA. The role of ants in north temperate grasslands: a review. Oecologia. 2018;186(2):323-38. doi:10.1007/s00442-017-4007-0
7. Bieber AG, Oliveira MA, Wirth R, Tabarelli M, Leal IR. Do abandoned nests of leaf-cutting ants enhance plant recruitment in the Atlantic forest? Austral Ecol. 2011;36(2):220-32.
8. Sankovitz M, Purcell J. Ant nest architecture is shaped by local adaptation and plastic response to temperature. Sci Rep. 2021;11(1):23053. doi:10.1038/s41598-021-02491-w
9. O'Fallon S, Drager K, Zhao A, Suarez A, Pinter-Wollman N. Foraging behaviour affects nest architecture in a cross-species comparison of ant nests. Philos Trans R Soc B. 2023;378(1884):20220146. doi:10.1098/rstb.2022.0146
10. Moreira A, Forti LC, Andrade AP, Boaretto MA, Lopes J. Nest architecture of atta laevigata (F. Smith, 1858) (Hymenoptera: Formicidae). Stud Neotrop Fauna Environ. 2004;39(2):109-16.
11. Lapointe SL, Serrano MS, Jones PG. Microgeographic and vertical distribution of Acromynnex landolti (Hymenoptera: Formicidae) nests in a Neotropical savanna. Environ Entomol. 1998;27(3):636-41.
12. Moreira AA, Forti LC, Boaretto MA, Andrade AP, Lopes JF, Ramos VM. External and internal structure of Atta bisphaerica forel (Hymenoptera: Formicidae) nests. J Appl Entomol. 2004;128(3):204-11.
13. Michielsen RJ, Ausems AN, Jakubas D, Pętlicki M, Plenzler J, Shamoun-Baranes J, et al. Nest characteristics determine nest microclimate and affect breeding output in an Antarctic seabird, the Wilson's storm-petrel. PLoS One. 2019;14(6):e0217708. doi:10.1371/journal.pone.0217708
14. Korb J. Thermoregulation and ventilation of termite mounds. Naturwissenschaften. 2003;90(5):212-9.
15. Manthey JD, Girón JC, Hruska JP. Impact of host demography and evolutionary history on endosymbiont molecular evolution: a test in carpenter ants (genus Camponotus) and their Blochmannia endosymbionts. Ecol Evol. 2022;12(7):e9026. doi:10.1002/ece3.9026
16. Cobb M, Watkins K, Silva EN, Nascimento IC, Charles Delabie JH. An exploratory study on the use of bamboo pieces for trapping entire colonies of arboreal ants (Hymenoptera: Formicidae). Sociobiology. 2006;47(1):215-24.
17. Fagundes R, Terra G, Ribeiro SP, Majer JD. O bambu merostachys fischeriana (Bambusoideae: Bambuseae) Como habitat para formigas de floresta tropical Montana. Neotrop Entomol. 2010;39(6):906-11. doi:10.1590/S1519-566X2010000600009
18. Tschinkel WR. The nest architecture of the Florida harvester ant, Pogonomyrmex badius. J Insect Sci. 2004;4(1):21.
19. Tschinkel WR. The nest architecture of the ant, Camponotus socius. J Insect Sci. 2005;5(1):9. doi:10.1093/jis/5.1.9
20. Jesovnik A, Sosa-Calvo J, Lopes CT, Vasconcelos HL, Schultz TR. Nest architecture, fungus gardens, queen, males and larvae of the fungus-growing ant Mycetagroicus inflatus Brandão & Mayhé-Nunes. Insectes Soc. 2013;60(4):531-42. doi:10.1007/s00040-013-0320-8

21. Solomon SE, Lopes CT, Mueller UG, Rodrigues A, Sosa-Calvo J, Schultz TR, et al. Nesting biology and fungi culture of the fungus-growing ant, Mycetagroicus cerradensis: new light on the origin of higher attine agriculture. J Insect Sci. 2011;11(1):12.
22. Forti LC, Camargo RS, Fujihara RT, Lopes JF. The nest architecture of the ant, Pheidole oxyops forel, 1908 (Hymenoptera: Formicidae). Insect Sci. 2007;14(5):437-42.
23. Cerquera LM, Tschinkel WR. The nest architecture of the ant Odontomachus brunneus. J Insect Sci. 2010;10(64):64. doi:10.1673/031.010.6401