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Nest Architecture Ability of Black Larger Ant (*Componotus* Sp.)

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ABSTRACT

This study assessed the nest architecture of Black Larger Ant using low-cost white cement. Length and width of the tunnel, length, width, and diameter of the chamber, deepness of nest, and number of tunnels and chambers assessed by standard measuring tools and techniques. The average nest circumference (15.1 ± 4.30 cm), Depth of nest (13.1 ± 3.50 cm), number of tunnels (9.0 ± 2.0), tunnel length (10.70 ± 5.60 cm), width of the tunnel (3.00 ± 1.00 cm), number of chambers (6.0 ± 2.0), chamber length (3.70 ± 1.60 cm), chamber width (2.50 ± 1.30 cm) varied significantly. The correlation performed with the length and width of the tunnel showed a strong positive correlation ($r = 0.54$, $n = 52$). It also noticed that, whenever increasing the tunnel length simultaneously width of the tunnel also increased. Tunnel direction was identified in favor of identifying the other environmental factors like water sources of the nest. It was noticed that, the nest tunnel direction maximum in the west (29%) followed by east and south directions. The majority of the nests studied were irregular, while a few noticed round shapes. Initially, it is essential to provide a description. However, comprehending the intricate structure of the nest necessitates a more extensive analysis. This analysis should encompass how specific structures enhance the overall fitness of the social organism and the underlying mechanisms via which this enhancement occurs within the colony.

Keywords: Nest, Architecture, Ants, Underground, Tunnels.

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INTRODUCTION

Nest construction is vital for a variety of organisms for which their colony or individual could be stylish. Among the organisms, the ant fauna constructs bottomless nests that are made by removing soil particles somewhat rather than being constructed with wood or wax, as in the case of wasps and bees [1]. Various ant species build underground nests, which can be both large and sophisticated, to guard their colony from hostile environment variation [2] and predators [3]. Therefore be imperative for soil engineers [4] who distress their local environment by changing soil properties such as runoff [5], turning over soil [6], altering plant dynamics [7], or enhancing soil nutrients. Nest Architecture of social organisms particularly insects varies extremely in their construction and resources, but the different plans all have a unique goal to maintain a more constant internal temperature in their soil and to offer a familiar environment for the colony associates. Ant nests vary in their deepness and internal complexity and they can be shallow or reach up to a few meters down into the soil, with lots of chambers linked by tunnels. The main function of the nest is to guard the queen, brood, and workers against natural opponents and dehydration. It has been shown that the microclimate within the nest differs less than the outside climate [8]. The number and arrangement of nest chambers and the way they are linked to one another by tunnels [9, 10] also differ resulting in different nest configurations.

These differences may be due to the stage of the colony, sudden seasonal changes [11], microclimatic conditions, or differences in soil composition. Studying nest construction has the potential to provide valuable insights into the collective efforts of ant colonies. Unfortunately, the study of incomprehensible ant-nest construction is still in its early stages. While some preliminary research is starting to delineate the various architectural variations within and across species, comprehension of the intentional features of this variation is still a long way off. The recent circumstances have improved, nevertheless, the majority of the available information consists solely of verbal accounts or simple illustrations derived from excavations. Only a small number of these sources give a comprehensive population count or detailed quantitative data regarding the architectural structures. The architectural variation among species mostly arises from differences in the configuration, distribution, and dimensions of these components. The above literature review was initiated to interest in the nest excavation of Black Larger Ant.

This study assessed the nest architecture of Black Larger Ant using low-cost white cement. Length and width of the tunnel, length, width, and diameter of the chamber, deepness of nest, and number of tunnels and chambers assessed by standard measuring tools and techniques.

MATERIALS AND METHODS

The Black Larger Ant, belonging to the class Hymenoptera, is characterized by its wingless workers that measure 4-6 mm in length. These ants are typically black or dark brown and are often found in huge numbers. They can be observed either around their nests in the soil or following scent trails across the ground and along various surfaces such as walls and buildings. Six nests of Black Larger Ants randomly located in Vadakarai Panchayat, Mayiladuthurai Taluk, Nagapattinam District, Tamil Nadu province in the coastal region of Tamil Nadu and the garden which occupies high vegetation ie., Bamboo, *Hypiscus*, goa, citrus, etc. The study was carried out from November 2017 to March 2018. After the selection of nests, the marker was prepared with a mixture consisting of three kg of white cement and 10 L of water [12]. The mixture can prevent the bubble formations that appear due to cement tightening and water infiltration into the soil. The nest entry was cleared with a portable vacuum cleaner and the mixed slurry of indicator was poured into the nest by using a syringe until the overflow of the nest. After three days, as the white cement became entirely hardened; the ant nest was excavated smoothly by the hand with the help of dissection tools. The excavated tunnels and chambers were cautiously cleaned for measuring and the structure was numbered, sketched, and photographed.

Nest characteristics

Within each nest, a trench was dug around the perimeter, then subsequently excavated inward and downward as chambers and tunnels emerged. The dimensions of the chambers, including their length, depth, and width, were measured for all six nests. Additionally, the diameter and length of the tunnels were measured for the nests that were filled with markers. While the marker poured nest excavation the following characters were measured by using thread and measuring scale. Number of tunnels (by count), Tunnel width and length, Number of chambers (by count), chamber width, diameter and length, depth of whole nest, total length of tunnels, and outer circumference of the nest were measured. Finally, the direction of the tunnels was also noticed.

Statistical analysis

For statistical analysis, the correlation was executed for the length and width of the tunnels and chambers, and the ANOVA was executed for the length and width of tunnels and chambers by using SPSS version 16 software.

RESULTS AND DISCUSSION

Nest characters

The number of tunnels shows high numbers in nest I (11) followed by nest III (10), nest V and VI (9), nest IV (7), and nest II (6). Likewise, the number of chambers shows a maximum number in nest I (10) followed by nest III and VI (6) and nest V, II, and IV shows 5, 4, and 3 respectively. The depth of the nest shows in maximum in nest VI (17.4) followed by nest IV (16.7), nest III (12.7), nest I (12.4), nest II (10.6), and nest V (8.3). The outer circumference of the nest shows, a maximum in nest II (21.7) followed by nest VI

(17.6), nest I (15.4), nest V (14.6), nest III (11.3), and nest IV (9.8). Likewise, the total length of the tunnel was calculated and shows the maximum in nest I (105.1) followed by nest VI (101.4), nest II (95.6) nest V (90.2), nest IV (84.5), and nest III (60.3) **(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 nests of larger black ants had a circumference ranging from 9.8 to 21.7 cm, with an average circumference of 15.1 ± 4.30 cm (n = 6). The depth of the nests ranged from 8.3 to 16.7 cm, with an average depth of 13.1 ± 3.50 cm (n = 6). The number of tunnels varied from 7.0 to 11.0, with an average of 9.0 ± 2.0 (n = 6). The length of the tunnels ranged from 2.6 to 24.3 cm, with an average length of 10.70 ± 5.60 cm (n = 52). The tunnel's width was measured to be between 1.2 and 4.6 cm, with an average width of 3.00 ± 1.00 cm. The correlation analysis conducted on the length and width of the tunnel revealed a significant positive connection (r = 0.54, n=52). It also noticed that, whenever increasing the tunnel length simultaneously width of the tunnel also increased **(Table 2)**. The number of chambers in all the nests that were analyzed ranged from 3.0 to 10.0, with an average of 6.0 ± 2.0 (n = 34). The observed range of chamber length was 1.3 to 8.4 cm, with an average length of 3.70 ± 1.60 cm. The chamber width was measured within the range of 1.8 to 5.6 cm, with an average value of 2.50 ± 1.30 cm. The positive correlation was executed between the length and width of the chamber (r = 0.69). The chamber diameter was measured if it was circular. It shows 1.3 to 3.6 cm in diameter and an average diameter was calculated as 2.60 ± 1.620 **(Table 2)**. Tunnel direction was identified in favor of identifying the other environmental factors like water sources of the nest. In the studied nests water sources were noticed in the several directions in different nests. The observation revealed that the majority of the nest tunnels were oriented towards the west (29%), followed by the east and south (25%), north (13%), southwest (6%), and northeast (2%) directions. The total number of tunnels observed was 52. The shape of the chamber was also determined in the nests that were analyzed. The data indicates that 91% of the chamber shape was irregular, while the remaining 9% exhibited a round form (n = 34). Based on the information provided in the table, the calculated measurements for the length, breadth of the tunnel, and width of the chamber were found to be larger than the values listed in the table. There were significant differences between nests and the length of the chambers was less than the table value so there is no significant difference between nests **(Table 2)**.

Table 2. Range, Mean, and Correlation of the overall Nest (n = 6) (cm)

Variables	Range	Mean± SD	Correlation (r)	P (0.05)	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			

Regression analysis shows that the width of the tunnel is directly proportional to the tunnel length. Increasing the width of the tunnel greatly influences the length of the tunnel and also induces increasing length. Similarly, the width of the chambers was directly proportional to the length of the chambers. Increasing the width of the chambers influences and increases the length of the tunnel **(Figures 1 and 2)**. During the excavation of each nest, a pencil drawing was made to predict the nest architecture with the help of a computer. The pencil drawing helped to draw the model of the nest architecture on a computer. It shows that, great variance among the nest characters. In the computer-aided drawing, the tunnel and chamber numbers were noted.

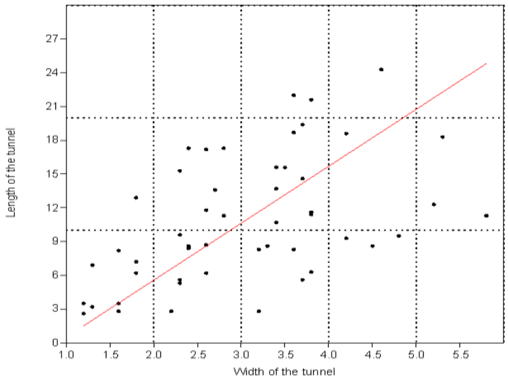

Figure 1. Regression analysis of the width of the tunnel against the length tunnel (n = 6).

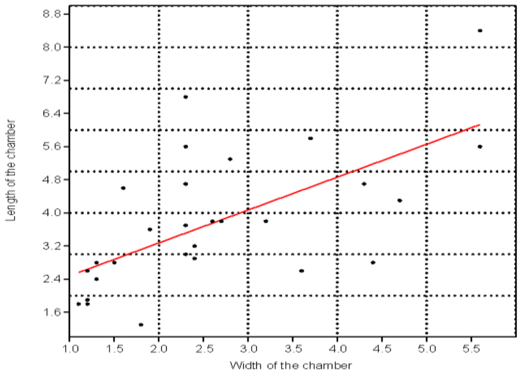

Figure 2. Regression analysis of the width of the chamber against the length of the chamber (n = 6).

The nest's planning represents a considerable asset of energy and time and provides shelter, microclimate, and dependability [13]. Furthermore, the nest structure design is anticipated to serve as a method for integrating the colony members into a highly organized and functional entity known as the superorganism. The substantial investment of time and effort dedicated to nest construction undoubtedly yields benefits in terms of fitness, as this energy could have been allocated to other duties that enhance fitness instead. An outstanding problem is to determine how specific characteristics of the structural design contribute to specific functions within a colony, and how this contribution affects the overall fitness of the colony. The towers constructed by several tropical termite species serve as a means of aeration and temperature regulation, making them highly adaptable [14]. However, there is currently a lack of comparable knowledge regarding the intricate nests built by ants.

In the present investigation, the *Componotus* sp. nests were located in the ground with bushes. However, most of the previous studies coded that in controversy against the present investigation, the *Componotus* genus was most common in natural bamboo or bamboo traps [15-17]. Among the six nests excavated it showed variation in the numbers of tunnels, chambers, nest deepening, and total length of the tunnel due to the colony size and their maturity of the colony. A similar type of statement was arrived at by Tschinkel [18]. This study has discovered that larger colonies excavate larger nests due to the simultaneous processes of nest deepening, chamber magnification, and the creation of a new vertical sequence of chambers. The casts of small, medium, and big nests exhibit several architectural modifications that are linked to colony expansion.

Tunnel length and width showed a strong positive correlation. It also showed the linear regression which states that length and width were predictable with the colony size and maturity of the colony. The nest's outer circumference varies from nest to nest and it might be based on the nest's size and shape also. This present investigation does not carry out an abundance of ants in the nest due to the objectives mentioned earlier. The abundance of ants in the nest may influence the nest characters such as the number of tunnels, chambers, and chambers length and width.

The unfathomable nests of the Black larger ant, *Camponotus* sp., show obvious, reliable, and species-typical structural patterns. The size and shape of the chamber are also independent in each nest. The absence of size constraints allows for the manifestation of shape independence from overall size in the nests of *Pogonomyrmex badius* and *Camponotus socius* [19]. This implies that workers only need to adhere to uncomplicated, localized iterative guidelines to construct a nest with a comparable shape, regardless of its size. Jesovnik *et al*. dug four nests of *Mycetagroicus inflatus* [20]. Each nest included a solitary, uncomplicated, and inconspicuous entrance orifice of roughly 2-3 mm in diameter. The entrance of no nest was encircled by a mound of excavated soil particles, which distinguishes it from the entrance of the congeneric *M. cerradensis* [21]. But in this present study nest showed variations in tunnels and chambers.

In this present investigation, the nest showed several tunnels have adjoined the chambers and also influenced chamber size. A similar kind of study has been revealed by Jesovnik *et al*. who noticed nests enclosed 2–4 chambers, which varied from 2–8 cm in width [20]. The most profound chamber encountered had a depth of 310 cm and had ants, but no queen. The most superficial chamber observed had a depth of 22 cm and had no ants, simply unconsolidated sand. Some nests were found to have tunnels connecting their chambers, which were reported to be remarkably straight and perpendicular to the surface. Forti *et al*. have observed the number of chambers varied from 4 to 14 among the studied nests, perpendicularly distributed through a depth from 101-509 cm [22]. The present investigation showed the depth of the black larger ants' nest noticed as an average was 13 cm.

The present investigation showed simple vertical shafts connecting the chambers. These results show that the nests of *O. brunneus* consist of straightforward vertical shafts that connect simple, horizontal chambers. This architectural design is commonly found in subterranean ant nests. The predecessors of ants likely excavated these burrows, but they likely had only one or a few chambers [23]. In this present investigation also horizontal chambers have been reported in all nests (n = 6). Forti *et al*. revealed the nest characteristics of the *Atta capiguara* nests and had the characteristic shape consisting of several mounds of loose soil with unique features resembling a conic section [22]. Similar kinds of studies were made in Florida harvester ant nest by Tschinkel [18]. He explained that nests consist of two distinct components: shafts and chambers. Shafts are elongated structures with a circular, oval, or flattened-oval shape. They often have a long axis that is inclined at an angle of 20° to 70° from the vertical, although it is rarely inclined at 90°. The normal shaft diameters are a little smaller than 1 cm. In the higher regions of the nest, the shafts tend to be larger and can have a flattened-oval shape with a width of up to around 2 cm. But in the present investigation shafts were named as tunnels. He also suggested that nests typically included a solitary entrance, although occasionally two or three openings were observed. Starting from the entrance, there is a downward shaft that slopes at an angle of approximately 20-30° from the horizontal. As you walk further down, the inclination gradually increases to 45-60° at a depth of around 50 cm and lower. A similar type of observation was made in the present investigation showing a single entrance and tunnel go down at an angle of 20-30° from horizontal. Some helical tunnels were also observed in the present investigation.

CONCLUSION

The present investigation revealed the nest architecture ability and the characteristics of the Black Larger Ant (*Componotus* sp.). In India, a few studies revealed nest excavation of ants and its very primitive start-up of ant nest excavation from the southern part of India. It revealed that the nest structure and their attributes were based on the maturity and colony size and the study also needs more informative research in the near future.

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