International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2020): 7.803

Morphological Structure of Termite Mounds and Vertical Distribution of Royal Lodges of *Pseudacanthotermes spiniger* (Sjostedt) (Isoptera: Macrotermitinae) in Sugarcane Plantations of the Niari Valley (Republic of Congo)

Valentin DIBANGOU[1]*, Mireille BELLE MBOU OKASSA[1, 2], Grâce NIANGA BIKOUTA[1]

[1]Laboratoire de Biodiversité et Écologie Animales, Faculté des Sciences et Techniques, Université Marien Ngouabi, BP 69, Brazzaville, République du Congo
[2]Rectorat de Limoges, 13 Rue Francois Chénieux, 87000 Limoges, France
*Auteur Correspondent, E-mail: dibangou[at]hotmail.com; Tel: +242-05-586-54-34

Abstract: ***Termites are social insects belonging to the order Isoptera. Some species, including Pseudacanthotermes spiniger, build nests or habitats. Observation of several nests of this termite has shown that they consist of an epigeal part with the characteristic shape of a cone. The cone has the particularity of being rebuilt in a short period of time during the swarming process, even if it has recently been razed. It is only occupied by termites during this same swarming period. It is thus a swarming cone. The hypogeum part or endoecy or habitacle is permanently inhabited. In addition to the termites, it contains fungus-comb chambers and a royal lodge or royal chamber. Several of these lodges contain several reproducers, in this case physogasters queens, and are distributed vertically at varying depths. The results of the analysis of variance indicate significant differences (P<0.001) in the number of lodges according to the depth. The depth range with the highest average number of royal lodges is between 21 and 30 cm with 20.15 lodges but the deepest lodges belong to polygynous colonies. The combination of several breeders would allow for deeper and perhaps faster digging in order to protect the royal lodge from potential predators.***

Keywords: Fungus-growing termites, Macrotermitinae, nest structure, polygyny

1.Introduction

Termites build organo-mineral structures (galleries, casts, mounds, fungus-comb chambers) which are generally called biogenic structures and have specific physical, chemical and microbiological properties [1]. Some researchers define up to 8 different forms of termite mounds. The nests or termite mounds can be totally endogeous or hypogeous. On the other hand, some species of termites erect constructions that constitute epigeous nests. Among the epigean nesting termites is *P. spiniger* Sjostedt. The buildings of this termite have two parts: an epigenetic part which can reach 3 metres in height and which overhangs the underground part. Knowing that in termites, the type of termite mound is closely linked to the species, what is the characteristic shape of the *P. spiniger nest*? Do both the epigeal and subterranean parts constitute the nest or only one of the two parts? These constructions are created by a pair of swarmers who, when founding the colony, burrow into the ground to a certain depth and create a copularium in which the young queen lays the first eggs. From these eggs, larvae emerge which will produce, among others, the first workers who will build the nest. The presence of numerous reproducers (polygyny) is often mentioned by several authors [2], [3], [4]. In *Nasutitermes*, Thorne [5] described two mechanisms by which polygyny can occur: pleometrosis and reproductive replacement. In the case of pleometrosis, several pairs of sexed individuals reproduce and form a colony together. Thorne [5] argues that their nests can thus grow faster, have a higher probability of survival and a lower age of first reproduction than monogynous colonies. It can also be assumed that if several reproducer work together to dig a copularium it will be deeper than in the case of monogyny. Is there a link between the number of queens and the vertical location of the royal lodge? What is the preferential depth of location of royal lodges?

2.Material and Methods

2.1 Studied area localization

The ground data's were obtained in the sugar cane plantations of the Niari valley south-east of the Congo Republic. The Niari Valley is framed by the 12°21 and 14°57 west meridians and lies astride the 04°00 south.

2.2 Sampling

The nests of P. spiniger are very recognisable. They can be distinguished from the nests of other species by the cone shape of the epigeal part. The study of the internal morphology was carried out by making longitudinal sections of the nests. The cone is excavated with a sharp machete. Pieces of the wall are meticulously cut away to the base of the nest. The goal is to keep half the cone in place. On the ground, and following the same plan, blocks of earth are gradually cleared in depth, until they no longer meet with fungus-combs chambers. The depths to which the royal lodges are located once located are noted, as well as the number of physogaster queens present.

Because of their mobility, it was excluded to take into account the number of kings in this study.

2.3 Statistical procedures

A two-factor analysis of variance (ANOVA) [6] was used. It was carried out using SPSS software version 26.0 to evaluate the distribution of the number of queens on the one hand and the number of lodges on the other hand as a function of the depth. The separation of the means for the different parameters measured was performed by the Student Newman and Keuls test [7] at the 5% significance level. The linear association between the variables was assessed by Pearson's correlation [8]

3.Results

3.1 Description of the nest structure

The nests observed in this study have two distinct parts: an erect part with the appearance of a cone (figure 1), which can be up to 1.60 m high and have a base diameter of around 2 m. It is the main cone. All around the main cone, there are secondary cones which are simple upwellings of earth. Below the main cone is the hypogeous part of the termite mound. It is made up of a more or less dense and crumbly clayey layer at its base: This is the endoecy or habitacle. Sub-spherical in shape, the habitacle can be up to 2 metres in diameter and 1 metre deep. The royal lodge and most of the fungus-comb can be found here. Fungus-comb chambers are located all around the endoecy and contain supplies of 'sawdust', dark coloured plant debris. Some of them are scattered and communicate with each other and with the endoecy through a network of underground galleries. Other large galleries start at the base of the cone and run vertically and transversely to the outside.

3.2 Number of physogasters queens and vertical location of royal lodges.

One hundred and eighteen (118) nests were sliced open, which also corresponds to one hundred and eighteen listed royal lodges. The number of physogaster queens found in each royal lodge, as well as their location depths are shown in Figure 2.

Figure 1: Photo of a *P. spiniger* cone that during its erection blocked sugarcane leaves around it

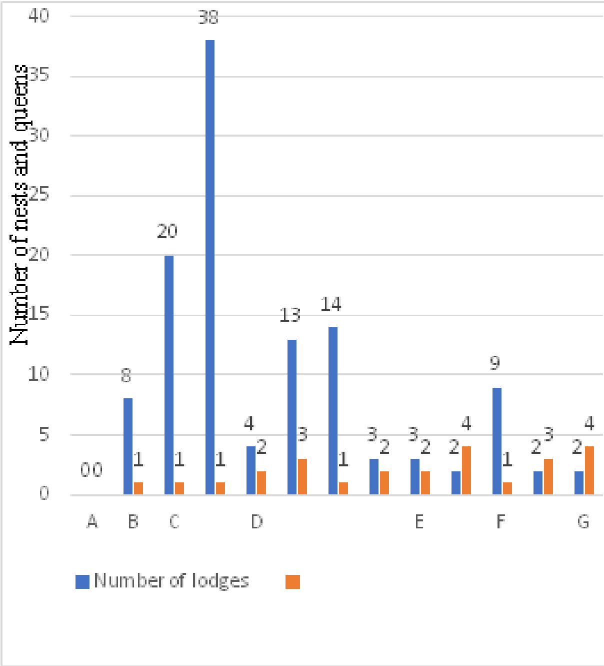

Figure 2: Number of queens per lodge and their vertical location

The x-axis letters indicate the depth range at which the sampled lodges are located.

Depths (cm): **A**: 00-10; **B**: 11-20; **C**: 21-30; **D**: 31-40; **E**: 41-50; **F**: 51-60; **G**: 61-70

3.3 Statistical analysis

The results of the analysis of variance indicate significant differences (P<0.001) in the number of lodges according to depth (Table 1). Three depth equal parts have a high average number of lodges: 20, 15 lodges for part C (21-30cm); 18, 33 lodgges, for part **D** (31-40 cm) et 8, 23 lodges for part **B** (11-20 cm). However, the number of lodges is not significantly different between depthsrs **A** (00-10cm); **E** (41-50cm); **F** (51-60 cm) and **G** (61-70cm).

Table 1: Variation in the number of lodges as a function of depth

Dependent variable*	depth (cm) *	Average*	CV (%) *
NL	A	0a	0, 12
	B	8, 23ab	0, 71
	C	20, 15c	0, 97
	D	18, 33c	0, 65
	E	5, 51a	0, 43
	F	5, 5a	0, 62
	G	2, 36a	1, 15

Legend. **Dependent variable*.** NL: Number of lodges; **Depth (cm) *. A**: 00-10; **B**: 11-20; **C**: 21-30; **D**: 31-40; **E**: 41-50; **F**: 51-60; **G**: 61-70. **CV (%) *:** coefficient of variation;

Average*: Numbers with different letters in the column are significantly different according to the Student-Newman-Keuls T-test at the p<0.05 threshold.

3.4 Number of queens

3.5 Linear correlation between study variables (Table 3)

The results of the analysis of variance also show significant differences (P<0.005) in the number of queens according to depth. The analysis revealed two groups of averages: the first group marked by low averages and the second group marked by higher averages (Table 2).

The highest average number of queens per depth range is obtained at the following depths: 3, 20 queens (31-40 cm); 3, 61 queens (41-50 cm); 4, 093 queens (51-60 cm) et 5, 28 queens (61-70 cm).

Table 2: Variation in number of queens as a function of depth

Dependant variable *	Depth (cm) *	Average*	CV (%) *
NQ	A	0, 0a	0, 02
	B	1, 163a	1, 71
	C	1, 301a	0, 87
	D	3, 206b	0, 67
	E	3, 617b	0, 83
	F	4, 093b	0, 92
	G	5, 280C	1, 15

Legend. **Variable dependant*. NQ**: Number of queens; **Depth (cm) *. A**: 00-10; **B**: 11-20; **C**: 21-30; **D**: 31-40; **E**: 41-50; **F**: 51-60; **G**: 61-70. **CV (%) *:** coefficient of variation.

Average*: Numbers with different letters in the column are significantly different according to the Student-Newman-Keuls T-test at the p<0.05 threshold.

The Pearson test revealed a strong positive linear correlation between the number of queens (NQ) and depth (D). That is, the number of queens is correlated with

depth: r= 0.641; P <0.05. There is also a positive correlation between the number of lodges (NL) and depth: r= 0.426; P < 0.05. Furthermore, no correlation was observed between the number of queens and the number of lodges P > 0.005
.

Table 3: Linear correlation between the study variables

	NL	NQ	D
NL	**1**	**0.059 ns**	**0.426***
NQ	**0.059 ns**	**1**	**0.641****
D	**0.426***	**0.641****	**1**

Legend: *: = significant at 5%.; ** = very significant at 5%.; **ns** = not significant. **NL:** Number of lodges; **NQ**: Nombre of Queens; **D**: depth (cm).

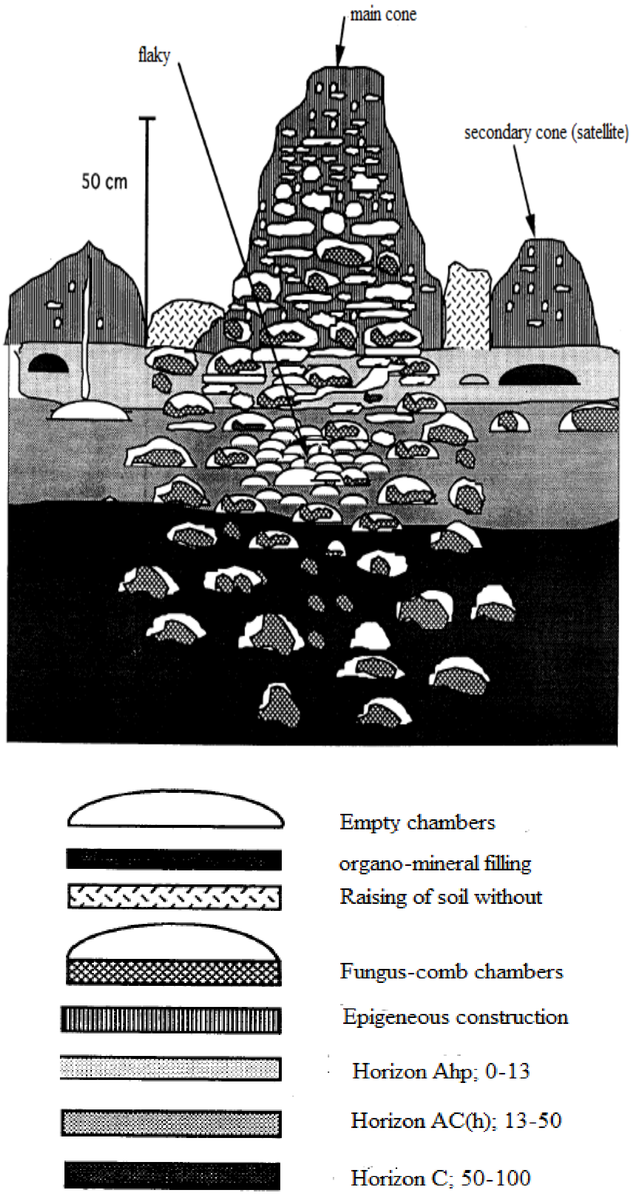

Figure 3: Longitudinal section of a nest of *Pseudacanthotermes spiniger* and its satellites (From Renoux et al, 1990)

4.Discussion

The nest structure of *P. spiniger* has been described by several authors. For Tano [9] this nest is hypogeous. This author does not refer to the epigeal part that Renoux et al. [10], Mora [11] and Dibangou [12] reported. Renoux et al [13] qualified this part as a main cone and attributed to it a role in swarming (figure 3). Indeed, Dibangou [12] notes that the main cone is occupied by termites only during the swarming period. It is during this period that the workers rearrange it by rebuilding a new cone in a few days if the previous one is broken. During its erection the cone can even trap sugarcane leaves that may be in its path (Figure 1). About an hour before the swarming starts, holes are made along the cone. These holes communicate with the internal galleries. The adults emerge through these holes and, for the most part, climb to the top of the cone to gain momentum and fly away [10]. Outside the swarming periods, the entire population is confined to the hypogeous part. This hypogeous part also contains the Fungus-comb chambers, most of which are located under the main cone. According to Darligton [14] this organisation is also found in *Macrotermes michaelseni*, the epigeal part of the nest is not a habitation for the colony. The queen, workers and fungus-combs chambers are located in the hypogeous part. However, as with *P. militaris*, there are fungus-comb chambers isolated that can be located several metres from the main nest [15]. They are connected to the latter by a network of underground galleries: this is the periecy. Several authors have reported polygyny in termites **[2]**; Atkinson & Adams, [16] in *Nasutitermes corniger*; Darlington [3], [4] in *Macrotermes michaelseni* and *M. herus*; DeHeer & Vargo [17] in *Reticulitermes flavipes*. Our results also report cases of polygyny in *P. spiniger*. Darlington [18] also found that 23.3% of *M. michaelseni* nests had multiple queens and Scott Turner **[**19] associates the presence of multiple breeders in a colony with an adaptive strategy to ensure successful colony foundation. In the present study, there is a strong positive linear correlation between the number of queens and the depth of location of the royal lodges. The deepest lodges correspond to polygynous colonies. This could be interpreted as a defence strategy for the future young colony. Indeed, the association of several reproducers would constitute an advantage to dig the copularium more quickly and, above all, to reach a greater depth in order to escape the predatory ants. Indeed, on the ground, ants are formidable predators of termites [20], [21]. Wilson [22] identified at least six genera of ants specialised in termite predation. Of these 6 genera, the ant *Megaponera analis* is a specialised predator of termites, particularly those of the subfamily *Macrotermitinae* of which the genus *Pseudocanthotermes* is a part [21]

5.Conclusion

In the sugar cane plantations of the Niari valley, the nests of P. spiniger consist of two distinct parts, one epigeal and the other hypogeal. The epigee part is often damaged by harvesting machinery or any other agricultural activity. On the other hand, the underground part is preserved because even the turning of the soil during ploughing cannot affect the survival of the colonies. Indeed, royal lodges are mostly located at depths greater than 10 cm with a higher concentration between 21-30 cm (18.33 royal lodges). Royal pairs survive and keep the colonies alive. Thus, each year, when the swarming period arrives and thanks to the workers' ability to rebuild, cones reappear. In addition, with the particularity of some sexed to form polygynous couples, which would be a strategy to fight against predatory ants, the number of termite mounds is increasing.

Acknowledgements

We would like to express our sincere thanks to the Congo Sugar Company and more particularly to the agronomic department for their assistance and help during this work.

References

[1] Lavelle P. D., Bignell M., Lepage M., Wolters V. and Roger P.1997. Soil function in a changing world. The rôle of invertebrate ecosystem engineers. *Eur. J. Soil Biol.*, 33 (4) p.159-193

[2] Thorne, B L.1984. Polygyny in the Neotropical termite *Nasutitermes corniger:* life history consequences of queen mutualism. Behav. Ecol. Sociobiol.14: 117–136.

[3] Darlington, JPEC 1987b Primary reproductives and royal cells of the termite *Macrotermes michaelseni*. Insect Sci. Appl.8: 121–128

[4] Darlington, JPEC 1988. Multiple reproductives in nests of *Macrotermes herus* (Isoptera: Termitidae). Sociobiology 14: 347–351.

[5] Thorne, B. L.1982. Polygyny in termites: Multiple primary queens in colonies of*Nasutitermes corniger* (Motschuls) (Isoptera: Termitidae). *Ins. Soc* **29,** 102–117

[6] Ross A. and Willson V., One-Way ANOVA, In: Basic and Advanced Statistical Tests, E-Book Publisher: Brill—Sense, 21–24, 2017**.**

[7] Abdi H., Williams LJ (2010). Newman-Keuls Test and Tukey Test. In Neil Salkind (Ed.), Encyclopedia of Research Design Thousand Oaks, CA: Sage.

[8] Dagnelie P.2008. De la régression simple et l'analyse de la variance aux modèles linéaires généralisés: synthèse et chronologie. Rev. MODULAD 39, 107-136

[9] Tano Y., 1993. Les termitières épigées d'un bassin versant en savane soudanienne: répartition et dynamique des nids, rôle sur les sols et la végétation. Thèse d'état ès Sciences. Université Abidjan, Côte-d'Ivoire.249 pp.

[10] Renoux J. Rouland C., Mora Ph., Dibangou V.1991. Les constructions du termite *Pseudacanthotemes spiniger* dans les champs de canne à sucre, essai de lutte spécifique.1st Int. Coll. on sugar cane, afcas, 131-1 34.

[11] Mora, P.1992. Dégâts des termites champignonnistes "*Pseudacanthotermes spiniger*" et "*Microtermes subhyalinus*" dans les plantations de canne à sucre: mise au point d'une lutte spécifique. Thèse d'Université. Université Paris XII-Val de Marne, 176 pp

[12] Dibangou, V.1993. Étude comparée de la biologie et du métabolisme digestif de deux espèces de termites (*Pseudacanthotermes spiniger* et *P. milititaris*) des plantations de canne à sucre de la vallée du Niari (Congo) ». Paris 12. http://www.theses.fr/1993PA120039

[13] Renoux J., Rouland C., mora Ph., 1990. Une modification du peuplement en termites par la transformation d'un écosystème naturel en un agrosystème. REED-SRETIE info, 30, 2-5

[14] Darlington, JPEC.1987a. How termites keep their cool. *The Entomological Society of Queensland News Bulletin* **15**: 45-46.

[15] Dibangou V., Mora P., Célini L. Rouland-Lefevre.2012. Spatial distribution and density of fungus-growing termite *Pseudacanthotermes militaris* (Isoptera: Macrotermitinae) in the Congo republic. Asian Journal of Biological Sciences 5 (8): 406-416

[16] Atkinson L, Adams ES (1997) The origins and relatedness of multiple reproductives in colonies of the termite *Nasutitermes corniger*. *Proceedings of the Royal Society of London*. *Series B, Biological Sciences*, **264**, 1131–1136.

[17] DeHeer CJ, Vargo EL (2004) Colony genetic organization andcolony fusion in the termite *Reticulitermes flavipes* as revealed by foraging patterns over time and space. *Molecular Ecology*, **13**, 431–444.

[18] Darlington JPEC.1985 Multiple Primary Reproductives in the Termite *Macrotermes michaelseni* (Sjöstedt). Caste Differentiation in Social Insects. Pages 187-200. https://doi.org/10.1016/B978-0-08-030783-1.50018-5

[19] Scott Turner J.2000. Architecture and morphogenesis in the mound of *Macrotermes michaelseni* (Sjöstedt) (Isoptera: Termitidae), Macrotermitinae) in northern Namibia Cimbebasia 16: 143-175

[20] Koné N'golo A., Youan BDC., Kolo Y., Konaté S.2019. Mort précoce des nids du termite du genre Macrotermes dans la Réserve Scientifique de Lamto en Côte d'Ivoire: compétition interspécifique ou action de fourmis prédatrices ? Journal of Applied Biosciences 141: 14406-14418

[21] Gonçalves TT, Ronaldo Reis Jr., DeSouza Og, Pontes Ribeiro S.2005. Predation and Interference Competition Between Ants (Hymenoptera: Formicidae) and Arboreal Termites (Isoptera: Termitidae). Sociobiology Vol.46, No.2,

[22] Wilson, E.1971. The Insects Societies. Harvard University Press, Massachusetts