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Research Article

A Field Assessment of *Macrotermes bellicosus* Mound Physical Characteristics across Diverse Topographies in Zuru, Kebbi State

* Hassan Ajayi Shindi and Mujtaba Haruna

Department of Biology, Federal University of Agriculture Zuru, Nigeria.

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***Corresponding Author: Hassan Ajayi Shindi**
Department of Biology, Federal University of Agriculture Zuru, Nigeria.

Abstract

The physical characteristics of mounds constructed by Macrotermes bellicosus*, the most dominant mound-building termite species in Zuru Local Government Area, Kebbi State, Nigeria, were investigated. The study assessed mound height, shape, location, exposure, and colony activity status across selected upland and Fadama areas. Mound heights and basal circumferences were measured using a measuring tape, while mound shapes and exposure conditions were observed and recorded. The colony activity status of each mound was determined by partially opening the mound with a hoe or shovel to confirm the presence or absence of live termites. Results showed that mound height ranged from 0.983 ± 0.1091 m to 4.133 ± 0.088 m, while basal circumference was found to record an average mean of 4.45 m (Senchi Upland) to 10.50 (Senchi fadama). The observed mound shapes included irregular, conical, spherical, and dome-shaped forms, with irregular and conical shapes being the most dominant across the study locations. More mounds were found under canopy cover and shaded microhabitat than in areas that are directly exposed to sunlight, although the degree of exposure varied remarkably across land types and locations. Upland areas generally recorded a higher number of living mounds expose to sunlight compared to Fadama areas and is as the result of farming activities, which more is done in areas expose to sunlight than canopy cover and shaded microhabitat. This is found out to be because of types of crops are being cultivated in the study area. Among the study locations, Rikoto and Manga had the highest number of canopy cover and shaded microhabitat compare to other areas; Dabai, R/Zuru, Senchi and Ushe. The findings indicate that termite mounds are common landscape features within the study area, which exhibits considerable variation in height, canopy cover and shaded microhabitat, and exposure conditions, with many occurring under canopy cover and shaded microhabitat environments.*

Keywords: Macrotermes bellicosus*, termite mounds, upland, and Fadama.*

Introduction

Termite mounds are among the most conspicuous and ecologically important features of tropical and savanna landscapes. Termites are eusocial insects belonging to the order *Blattodea* (formerly *Isoptera*), and they play vital roles in decomposition, nutrient cycling, soil modification, and ecosystem engineering (Krishna *et al.*, 2013). Based on their feeding habits and habitats, termites are generally classified into four groups: dry-wood termites, damp-wood termites, harvester termites, and subterranean termites. Through their activities, termites contribute significantly to soil formation and improvement, thereby enhancing soil quality in tropical agro ecosystems (Jones and Eggleton, 2000; Fall *et al.*, 2001).

Termite mounds are common features of agricultural landscapes throughout tropical Africa and are often sufficiently/very abundant to influence vegetation patterns and the overall appearance of the landscape (Aiki *et al.*, 2013; *Apori et al.*, 2020). Different termite species construct different types of nests depending on environmental conditions, feeding habits, and soil characteristics. While some species build underground nests, others construct large epigeal mounds that may reach several metres in height. Among the mound-building termites, *Macrotermes bellicosus* is one of the most dominant and widely distributed species in the West African savanna. This species builds large and permanent mounds consisting of intricate networks of chambers, galleries, ventilation systems, and fungus combs used for cultivating symbiotic fungi (Jones and Eggleton, 2000; Fall *et al*., 2001).

The soils of *M. bellicosus* mounds are generally enriched with clay particles, organic matter, calcium, and exchangeable cations compared with the surrounding soils. This enrichment results from the continuous biological activities of the termites within the mound (Apori *et al*., 2020; Momah and Okieimen, 2020; Yamada *et al*., 2005). Consequently, termite mound soils contribute significantly to soil fertility and are widely utilized in local agricultural practices. The mounds are constructed from soil particles that are bound together by saliva and organic materials, forming stable structures capable of resisting erosion and withstanding adverse environmental conditions (Jouquet *et al.*, 2004; Abe *et al*., 2009).

The physical characteristics of termite mounds, particularly their siz and shape, vary considerably according to termite species, climatic conditions, vegetation cover, and soil type. Mounds may be conical, dome-shaped, spherical, or irregular in appearance. Such variations in mound architecture are regarded as adaptive responses that promote efficient drainage, enhance temperature regulation, and facilitate adequate ventilation within the colony. For example, cone-shaped and dome-shaped mounds are believed to improve water runoff and minimize the damaging effects of rainfall on mound surfaces (Karibi-Botoye *et al*., 2024). Recent studies have further demonstrated that mound structures play an important role in maintaining favourable microclimatic conditions within termite colonies.

In Nigeria, termite mounds are widely distributed across the savanna regions and are particularly common in cultivated fields and fallow lands (Abe *et al*., 2009). Their presence may positively influence agricultural productivity by improving soil fertility, although they may also hinder farming operations, especially in areas where mechanized farming is practiced. Previous studies conducted in various parts of Nigeria have shown that termite abundance and mound distribution are strongly influenced by land use patterns, soil properties, and environmental conditions (Jouquet *et al*., 2006; Akpan *et al*., 2020).

Despite the considerable ecological and agricultural importance of termite mounds, information on the physical characteristics of *Macrotermes bellicosus* mounds in Zuru Local Government Area of Kebbi State, Nigeria, remains limited. Therefore, the present study was undertaken to assess the physical characteristics of termite mounds, including mound size, shape, exposure, and living status, across upland and fadama land types in selected locations within the study area.

Methodology

The study was conducted in Zuru Local Government Area ~~of~~ Kebbi State, Nigeria, located within the Guinea–Sudan savanna ecological zone. Geographically, the area lies approximately between latitudes 11°15′N and 11°35′N and longitudes 4°45′E and 5°15′E in the southeastern part of Kebbi State (Madu and Ibrahim, 2022). The area experiences a tropical savanna climate characterized by two distinct seasons: a wet season extending from April to October and a dry season from November to March. Annual rainfall in the area ranges between 850 and 1200 mm, while average mean temperatures vary from 24°C to 39°C Tureta *et al.,* 2006). The area also experiences Harmattan conditions between November and February, which are characterized by cool, dry, and dusty winds. Vegetation within the study area consists mainly of savanna woodland trees with grasses, shrubs, and scattered economic trees such as *Parkia biglobosa*, *Vitellaria paradoxa*, and *Daniellia oliveri* (Aiki *et al.,* 2013; Abubakar *et al.,* 2021).

Six villages within Zuru Local Government Area were purposively selected for the study based on the abundance and widespread occurrence of termite mounds observed during preliminary field reconnaissance. Sample plots of 1 hectare (500m) x 20m) in each were selected two (2) plots both according to Jones and Eggleton, (2000) method. Global fixes of the selected plots as shown in (Table 1) were taken using Global Positioning System (GPS) receiver, e-Trex, Garmin Hand- Held Receiver. The selected villages were Dabai, Rafin Zuru, Rikoto, Senchi, Manga, and Ushe. These locations represent different land-use systems, including upland farms, fadama lands, fallow areas, and open landscapes, thereby providing adequate representation of termite mound distribution within the study area.

A transect walk survey method was employed to assess the physical characteristics of *Macrotermes bellicosus* mounds within the selected sample plots. Individual termite mounds identified as belonging to *M. bellicosus* were counted and recorded accordingly. Measurements of mound height and basal circumference were taken using a measuring tape, while mound shape, exposure to sunlight, and surrounding vegetation conditions were visually observed and documented following standard field procedures for termite mound characterization (Bandiya *et al.,* 2016.; Bandiya and Jatau, 2018 and Akpan *et al.,* 2020). The living status of each mound was determined by carefully opening a portion of the mound using a hoe or shovel to examine the internal activity of termites. Mounds in which active termite caste members such as workers, soldiers, or reproductives were present were classified as living mounds, whereas mounds without visible termite activity were regarded as dead mounds. Similar procedures have been applied in recent termite ecology studies for evaluating colony activity and mound occupancy (Apori *et al.,* 2020).

Data obtained from the field survey were subjected to analysis of variance (ANOVA) to determine significant differences among treatments and locations. Where significant differences occurred, means were separated using the Least Significant Difference (LSD) test at 5% probability level. Statistical analyses were carried out using SAS statistical software version 9.4 (SAS Institute, 2021).

Results and Discussion

The spatial distribution of termite mounds exhibited considerable variation across the study locations and land types. In the upland areas, Rikoto recorded the highest mean mound abundance (13.0 ± 0.6), followed by Manga (11.7 ± 0.7), while Dabai had the lowest (8.3 ± 0.9). A similar trend was observed in the fadama areas, Rikoto had the highest mean number of mounds (12.667 ± 0.882), whereas Dabai recorded the lowest mean value (6.667 ± 1.2~~02~~) as presented in Table 2. The high abundance of termite mounds observed in Rikoto and Manga may be associated with favorable environmental conditions, vegetation cover, and soil characteristics that support termite survival and mound establishment. Similar observations were reported by Aiki *et al.* (2013) and Akpan *et al.* (2020), who noted that termite mound abundance is strongly influenced by soil properties and ecological conditions. In respect to mound height, the highest mean values in upland areas were recorded in Ushe (4.133 ± 0.088 m) and Manga (4.090±0.046 m), while the lowest value was observed in Senchi (0.983 ± 0.109 m). In fadama areas, Senchi recorded the highest mean mound height (1.720 ± 0.057 m), whereas Dabai had the lowest mean height (1.353 ± 0.173 m). Variations in mound height across the study areas may be linked to soil fertility, moisture availability, and the intensity of farming activities, which influence termite foraging and mound construction. According to Jouquet *et al*. (2004) a, termite mound growth and structural development are often enhanced in nutrient-rich and moist environments.

In respect of basal circumference of the mounds also varied across locations and land types. In the upland areas, Dabai recorded the highest mean basal circumference (9.920 ± 0.210 m), while the lowest value was observed in Senchi (4.450 ± 0.104 m). In fadama locations, Senchi had the highest mean basal circumference (10.500 ± 0.289 m), whereas Rafin Zuru recorded the least value (4.847 ± 0.327 m). The wider basal circumference observed in Senchi fadama may indicate greater colony age and stability, as larger mound dimensions are often associated with long-established termite colonies and favorable environmental conditions Bandiya and Jatau, (2018) and (Momah and Okieimen, (2020).

Generally, the results indicated that termite mounds of *Macrotermes bellicosus* were widely distributed across all study locations and land types. However, none of the observed mounds exceeded 5 m in height, suggesting moderate mound development compared with larger mound systems reported in some African savanna ecosystems. Figure 1 further confirms the widespread occurrence of termite mounds throughout the study area. The abundance of mounds observed align with the finding of Apori *et al*. (2020), who reported that termite mounds are common and ecologically important features in tropical agro ecosystems due to their role in soil modification and nutrient cycling.

Results showed that the termite mounds observed in the study area were predominantly irregular, conical, dome-shaped, and spherical. Irregular and conical mound shapes were the most dominant across both upland and fadama land types. Statistical analysis indicated no significant difference ($p > 0.05$) in mound shapes across the study locations. The dominance of irregular and conical mound forms may represent adaptive structural modifications that facilitate effective drainage and minimize the destructive effects of rainfall on mound surfaces. Similar findings were reported by Ehi et *al.* (2007) and Karibi-Botoye *et al.* (2024), who noted that mound architecture in termites contributes to environmental regulation, drainage efficiency, and ventilation within termite colonies.

It was further observed that irregular mound shapes had the highest mean occurrence in both upland (3.25 ± 0.30) and fadama (3.17 ± 0.21) land types, followed by conical mound shapes with mean values of 3.00 ± 0.27 and 2.75 ± 0.21, respectively. Dome-shaped and spherical mounds recorded comparatively lower mean values in both land types. The predominance of irregular and conical mound forms suggests that these mound structures may provide better protection against environmental stress and rainfall intensity. Similar report by Bandiya and Jatau (2018).confirmed these same findings.

The study also revealed variations in mound exposure to sunlight and canopy cover and shaded microhabitat across the different locations. Most of the mounds encountered were found under tree shades rather than in open sun-exposed areas. Rikoto and Manga fadama recorded the highest number of mounds located under shade. In upland areas, canopy cover and shaded microhabitat locations had a higher mean number of mounds (37.00) compared to sun-exposed areas (28.00). Similarly, fadama areas recorded more mounds under shade (29.00) than in exposed locations (22.00). The preference for shaded environments may be attributed to favorable microclimatic conditions such as reduced temperature fluctuations and improved soil moisture retention, which enhance termite survival and colony establishment. Akpan *et al*. (2020) similarly observed increased termite activity and mound abundance in shaded environments with higher organic matter accumulation.

The degree of mound exposure to direct sunlight varied considerably across the study locations and land types, suggesting that exposure may not be the primary factor influencing mound site selection. Furthermore, the number of live mounds was significantly higher than dead mounds across all locations. Dead mounds were relatively few and showed no significant differences among the sampled plots. The high number of living mounds observed in the study area indicates active termite colonization and favorable environmental conditions for termite survival.

The low occurrence of dead mounds may be associated with anthropogenic activities within the study area. In many local communities, soils from abandoned termite mounds are commonly utilized for house construction and soil amendment because of their high clay content and nutrient status. In addition, farmers often destroy dead mounds because they are believed to harbor reptiles such as snakes and other potentially harmful organisms. Similar observations regarding the utilization and ecological importance of termite mound soils were reported by Momah and Okieimen (2020).

Table 1: Global Positioning System (GPS) Coordinates of Sample Plots

Plot No.	Location	Land Type	Latitude (°N)	Longitude (°E)
1	Dabai	Upland	11°26′27.9″	5°15′38.2″
2	Dabai	Upland	11.4123768°	5.2510424°
3	Dabai	Fadama	11.4558173°	5.2625682°
4	Dabai	Fadama	11.4607104°	5.2634466°
5	Rafin Zuru	Upland	11.457915°	5.260582°
6	Rafin Zuru	Upland	11.428581°	5.259466°
7	Rafin Zuru	Fadama	11°25′45.0″	5°16′43.6″
8	Rafin Zuru	Fadama	11°25′24.3″	5°16′46.5″
9	Senchi	Upland	11.372810°	5.234387°
10	Senchi	Upland	11.304123°	5.213786°
11	Senchi	Fadama	11.304259°	5.213701°
12	Senchi	Fadama	11.324719°	5.228426°
13	Rikoto	Upland	11.428581°	5.259466°
14	Rikoto	Upland	11.436252°	5.276182°
15	Rikoto	Fadama	11.429603°	5.241840°
16	Rikoto	Fadama	11.4500228°	5.2607802°
17	Manga	Upland	11.061439°	5.207363°
18	Manga	Upland	11.399768°	5.244774°
19	Manga	Fadama	11.404063°	5.243039°
20	Manga	Fadama	11.403323°	5.244860°
21	Ushe	Upland	11.263959°	5.228243°
22	Ushe	Upland	11.258545°	5.219435°
23	Ushe	Fadama	11.258968°	5.219632°
24	Ushe	Fadama	11.263950°	5.224210°

Source: Field survey (2026).

Note: Coordinates were obtained using a handheld Global Positioning System (GPS) receiver. Upland areas represent well-drained terrestrial environments, whereas fadama areas represent seasonally flooded lowlands. For consistency in journal presentation, all coordinates should preferably be reported in either decimal degrees (DD) or degrees, minutes, and seconds (DMS), but not both.

Table 2: Mean Number of Mounds, Height and Basal Circ. per land type in Study locations

Location	Land Type	No. of Mounds	Height (m)	Basal Circ. (m)
Dabai	Upland	8.333 ± 0.882	1.637 ± 0.184	9.920 ± 0.210
Dabai	Fadama	9.333 ± 0.667	1.353 ± 0.173	8.447 ± 0.457
Rafin Zuru	Upland	9.000 ± 1.155	1.373 ± 0.197	6.107 ± 0.316
Rafin Zuru	Fadama	8.000 ± 1.155	1.347 ± 0.164	4.847 ± 0.327
Senchi	Upland	11.333 ± 0.882	0.983 ± 0.109	4.450 ± 0.104
Senchi	Fadama	6.667 ± 1.202	1.720 ± 0.057	10.500 ± 0.289
Rikoto	Upland	13.000 ± 0.577	1.540 ± 0.180	7.340 ± 0.083
Rikoto	Fadama	12.667 ± 0.882	1.417 ± 0.088	7.243 ± 0.137
Manga	Upland	11.667 ± 0.667	4.090 ± 0.046	6.273 ± 0.139
Manga	Fadama	9.000 ± 1.155	1.487 ± 0.041	6.503 ± 0.055
Ushe	Upland	10.000 ± 0.577	4.133 ± 0.088	6.183 ± 0.235
Ushe	Fadama	9.000 ± 0.577	1.627 ± 0.076	5.870 ± 0.271

Table 3: Mean Number of Mound Shapes per Land type in the study locations

Land Type	Irregular	Conical	Dome	Spherical
Upland	3.25 ± 0.30	3.00 ± 0.27	2.00 ± 0.32	1.50 ± 0.28
Fadama	3.17 ± 0.21	2.75 ± 0.21	2.33 ± 0.33	1.33 ± 0.19

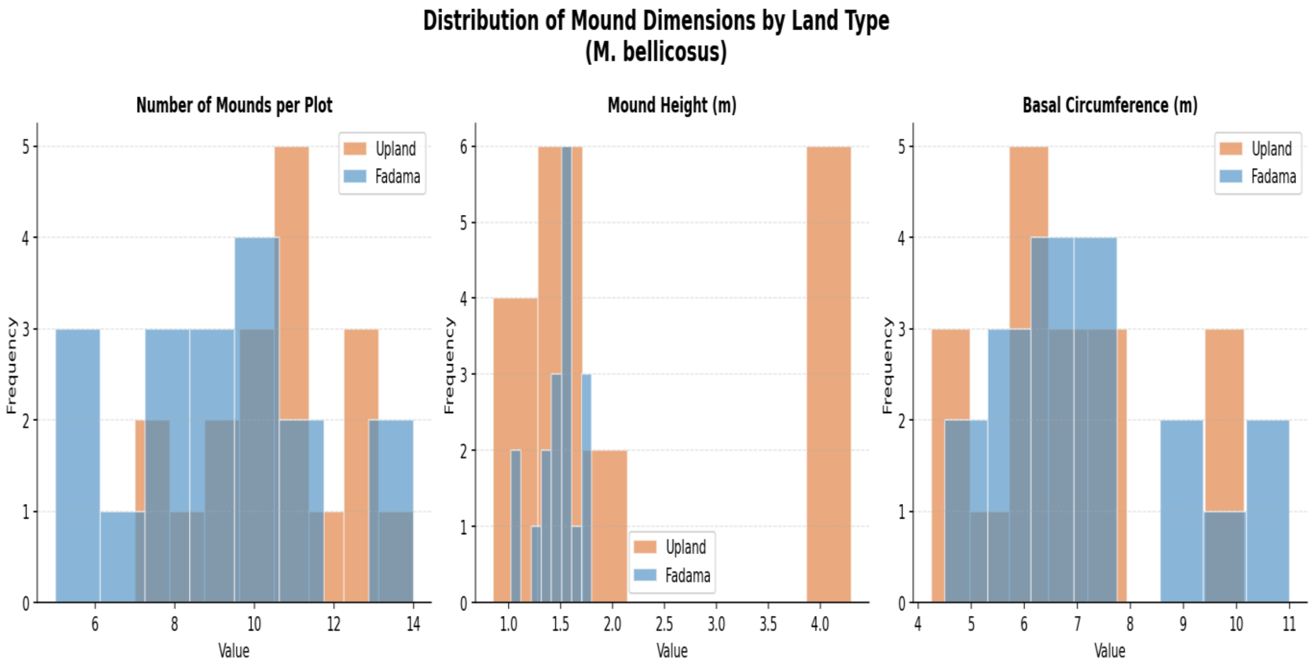

Figure 1: Mean Number of Mounds, Height and Basal Circ. Base on land type in Study locations

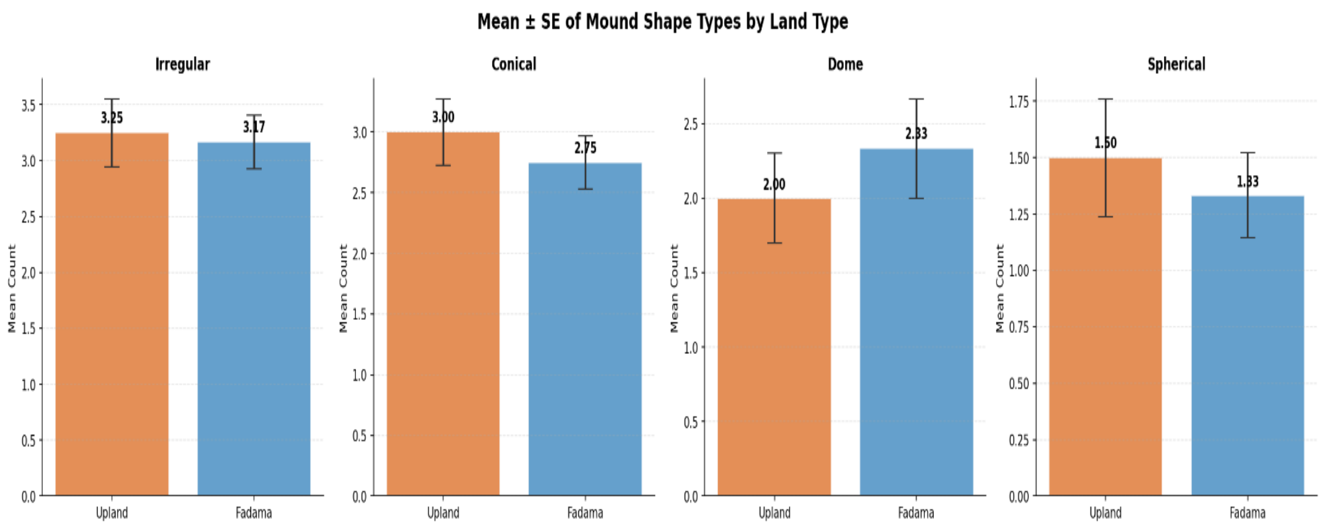

Figure 2: Shapes of mounds of *M. bellicosus* in different land types found in the different Study areas. Bars followed by the same colour in a location were not significantly different (p> 0.05).

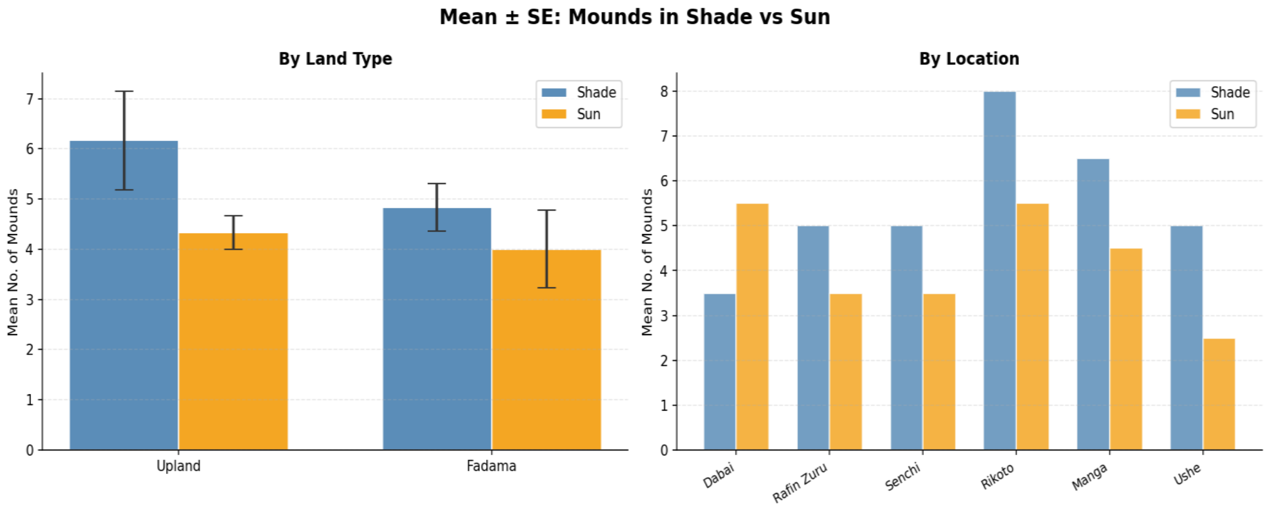

Figure 3. Number of Mounds of *M. bellicosus* located under tree shades/exposed to sunlight in different land types and location in the study area.

Conclusion

The current study demonstrated that termite mounds of *Macrotermes bellicosus* are common features across the study location of Zuru Local Government Area of Kebbi State. These mounds varied in size/height, shape, and exposure conditions, meaning some are expose to sunlight while others in canopy cover and shaded microhabitat. This study confirms that land type and environmental topography exert a strong influence on the physical characteristics and spatial distribution of *Macrotermes bellicosus* mounds in Zuru LGA, Kebbi State. Uplands promote dense, highly elevated spires, whereas seasonally flooded fadama areas encourage broader basal bases and lower heights to maintain structural integrity. These findings underline the ecological flexibility of *M. bellicosus* as a major soil engineer in savanna biomes. Future studies should evaluate clay content, organic matter, and specific hydrological regimes in these plots to further clarify the soil-mechanic drivers of termite architecture.

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