ACTIVITY OF MOUND-BUILDING *MACROTERMES BELLICOSUS* (ISOPTERA: TERMITIDAE) AROUND KWARA STATE UNIVERSITY CAMPUS GUINEA SAVANNAH ECOZONE, NIGERIA

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ABSTRACT

This study was designed to investigate Macrotermes bellicosus, nesting mounds, abundance and activity in the savannah ecological zone of Kwara State, North-Central, Nigeria. The research was conducted at four randomly selected villages around and including Kwara State University. A systematic survey of visible mounds of M. bellicosus was carried out over the entire study area. Also, the heights of mounds were measured using a measuring tape. M. bellicosus collection was conducted using baited traps consisting of cardboard, toilet tissue, wooden stakes and wood shaving. These were embedded or placed on ground within plots at a regular distance of 10 m and checked twice weekly. The samples collected per baited trap per plot per location were preserved in 90 % ethanol and identified. Similarly, survey of physically damaged items was conducted and recorded to observe termite activity. The result from the four different locations of the study showed that the number of M. bellicosus mounds in urban area was the highest in urban site (74.33 ± 5.93) and was significant when compared to the other locations. Farmland had the tallest M. bellicosus mound (17.3 cm) followed by uncultivated land mass (15 cm), while the least mean height (12 cm) was encountered at the urban area. The abundance and distribution of the M. bellicosus showed no significant difference when comparing the study locations except in urban site. Proper precautions on protection of the building and barns are recommended.

Keywords: *Macrotermes bellicosus*, Nesting mounds, Importance, Savannah ecological zone, Damage

INTRODUCTION

Macrotermes bellicosus is a species of *Macrotermes*, which is the largest termite known. The queen measures about 110 mm long, workers about 3.6 mm and soldiers between 18 – 19 mm for the major soldier, as there is sexual dimorphism for both workers and soldiers. About 2000 species are distributed in tropical countries. Termites are predominantly tropical in distribution and are at the ecological center of many tropical ecosystems (Backwell and d'Errico, 2001). Most species are abundant and diverse in many tropical soils, and particularly in forests (Eggleton, 2000). They are major agents of decomposition, and play an important part in nutrient and carbon fixation (Bignell, 2006). The recycling of soils organic matter, improve soil physical and chemical properties and improve water-absorbing capacity (Eggleton, 2001; Korb and Linsenmair, 2001). Termites are a source of vegetation and

tree diversity. Their sensitivity to habitat disturbance causes changes in their species richness, composition and functional characteristics (Aanen *et al.,* 2002; Binate *et al.,* 2008; Engel *et al*., 2011).

The forests of West Africa have been reported to have the highest termite species richness (Donovan *et al.,* 2000; Eggleton, 2000). For example, in the forests of southern Cameroon, termites are one of the most common of all arthropod groups (Tilahun *et al*., 2012). In cultivated systems derived from woodland and savanna in West Africa, *Macrotermes* is an abundant pest. In the wet season, *Macrotermes* were usually concentrated in the upper 25 cm, whereas the proportion of the population below 50 cm greatly increased in the dry season as they moved deeper in the soil (Gessner and Leuthold, 2001).

In Nigerian riparian forest, report have shown that most termites were in the top 25 cm of the soil profile and had no significant difference in abundance across seasons (Sileshi *et al*., 2010). In drier or more seasonal habitats, vertical distribution varies with species, soil type and season. This effect was probably less pronounced in tropical forests where the canopy limits fluctuations in soil temperature. Movement of termites may also be linked to rainfall events. In a seasonal humid forest in Cameroon, Korb (2003) found that both species richness and abundance in 10 cm deep soil samples were generally higher in dry periods compared with wet periods. Termite activity, such as mound building, subterranean tunneling and soil feeding, improves soil structure and quality. They feed on dead plant material at different stages of decomposition (Abe *et al.,* 2009a). They live predominantly in tropical regions, where they are by far the most important decomposer animal. They cause damage to trees, wooden structures, earthen dams, underground electrical cables, wooden buildings, wooden furnishings and items made of paper (Yamada *et al.,* 2005; Ekpo and Onigbinde, 2007).

Termites have a wide range of dietary, foraging and nesting habits, with many species showing a high degree of resource specialization. The vast majority of species feed on dead plant material, while relatively few species feed on living plant tissue (Lesnik, 2014).

Many studies have focused on mounds because they are relatively easy to locate and they can be dominant feature of the landscape, particularly in savanna (Abe *et al.,* 2009b). Very large intra-specific variations in mound density across seemingly homogenous savanna systems are often observed, like for *Macrotermes bellicosus* in central Africa (Lys and Leuthold, 1991).

Approximately 2,650 species of termites have been described to date, and less than 3 % of these cause significant economic damage to buildings or related manmade structures. Similar proportions are serious pests of crops. The termite fauna of urban environments is usually highly depauperate and characterized by wood-feeding species, unlike natural habitats that often support much greater species and functional diversity. The influence of termites' on ecosystem processes at any site depends on the species composition and abundance of the local termite assemblage (Eggleton, 2000; Obi and Ogunkunle, 2009). However, studies on termite species, nesting mounds, abundance and their activity are scanty for the savannah ecological zone of Nigeria particularly around Kwara State University campus Guinea savannah, Kwara State, North-Central, Nigeria. This research was therefore designed to fill this gap in knowledge.

MATERIALS AND METHODS

Study Area: The study was conducted at the Kwara State University (KWASU) Malete and its environs. Malete in Moro Local Government Area is situated within Longitude 8°42'0" N and Latitude 4°28'0" E (Figure 1) (Ajao, 2017). The State is located in the tropical zone of North-Central Nigeria with a land area of 36,825 square kilometers and a population of 2,591,555 (KWADP, 2008). The area experiences two seasons, tropical wet and dry climate. The dry season is from October to March and the wet season is from March to September. Kwara State has an annual rainfall range of 1000 mm to 1500 mm.

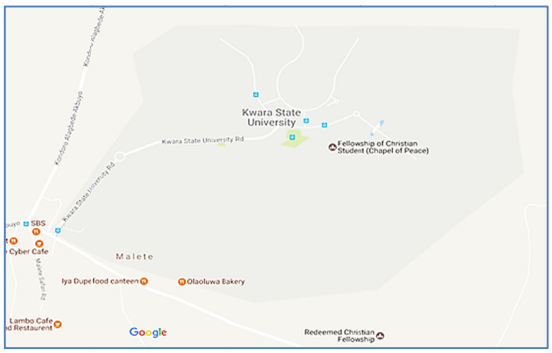

Figure 1: Map of Kwara State University, Malete showing the study area (Ajao, 2017)

Temperature is uniformly high and ranges between 25 °C and 30 °C in the wet season throughout the season except in July – August when the cloud of the sky prevents direct heatstroke while in the dry season; it ranges between 33 °C to 34 °C. The annual temperature ranges from 22.8 °C to 34.9 °C and the rainfall is about 107.3 mm per month.

Research Design and Sampling Techniques: The experimental design was an ecological survey carried out in four locations; KWASU campus Malete (urban), Jenkunu (uncultivated area), Apodu (forested) and Sunkuso (farmland). Three sampling points were taken and was carried out randomly in each of the localities including Kwara State University campus. These locations were grouped based on nature of vegetation and human activity.

Survey of *Macrotermes bellicosus* Mounds in the Sampled Plots: A systematic survey of visible mounds and arboreal nests of *M. bellicosus* was carried out over the entire study area. A transect survey was done on foot in each of the selected sample plots to identify the mounds of *M. bellicosus* in each of the study area. Mounds within the sampled plots were counted, measured with a measuring tape and recorded between months of April to October 2016 and November 2016 to April 2017.

Sample Collection and Identification: *M. bellicosus* collection was conducted using baited traps consisting of cardboard, toilet tissue, wooden stakes and wood savings. Each was embedded or placed on ground within plots at a regular distance of 10 m. Traps were checked twice weekly for the next six weeks. The termites collected per baited trap per plot per location were preserved in preserved in 90% ethanol, in vials, sorted, counted and identified. Identification of the collected samples was done with the aid of a hand lens and a dissecting microscope based on the morphology of the soldier caste. Features of importance include: colour, appearance, shape of mandibles, shape of head capsule, number of abdominal segments, type of mandible and presence of teeth on mandibles based on established keys (Ahmad, 1950; Chhotani, 1997; Engel *et al.*, 2007; Lawal and Banjo, 2007). Similarly, survey of *M. bellicosus* activity was conducted and recorded on physically damaged or currently fed upon items as evidenced by mud tunnel, half consumed and trees with observable outer and underground termite activity.

Data Analysis: Data analyses were carried out using the Statistical Package for Social Sciences (SPSS) version 20.0. Descriptive statistics (frequencies and percentages) was used to summarize the occurrence of *M. bellicosus* in study areas. Analysis of variance was used to compare the occurrence of *M. bellicosus* in different site location.

RESULTS

The result from the four different locations in the study showed that the number of *M. bellicosus* mounds in urban area was the highest and was significant when compare to the other locations. Farmland had the tallest *M. bellicosus* mound (17.3 cm) with 43.33 ± 4.40 termites, followed by uncultivated land mass (15 cm) with 45.00 ± 2.89 termites, while the least mean height (12 cm) with 74.33 ± 5.93 termites was encountered at the urban area (Table 1, Figure 2). Different superscripts along the same column are significant ($p \leq 0.05$).

The abundance and occurrence of the *M. bellicosus* showed no significant difference when compared by studied locations (Figures 2 and 3 a, b and c), although abundance of *M. bellicosus* in urban site (74.33 ± 5.93) was

higher than that of other studied sites (Table 1, Figure 3c). This gave an indication that more damage was done by *M. bellicosus* in the developed areas than in the farmland area. However, the tallest mounds (17.3 cm) was encountered in the farmland followed by uncultivated area with 15 cm, while the least mean height was encountered at urban area (12 cm).

Table 1: Abundance and height of mounds of *Macrotermes bellicosus* around Kwara State University Campus, Nigeria

Sites	Height of mounds		Abundance
	Nature of location	Height (cm)	
Site A	Farmland	17.3	43.33 ± 4.40[a]
Site B	Urban area	12.0	74.33 ± 5.93[b]
Site C	Forested area	13.0	39.00 ± 2.65[a]
Site D	Uncultivated area	15.0	45.00 ± 2.89[a]

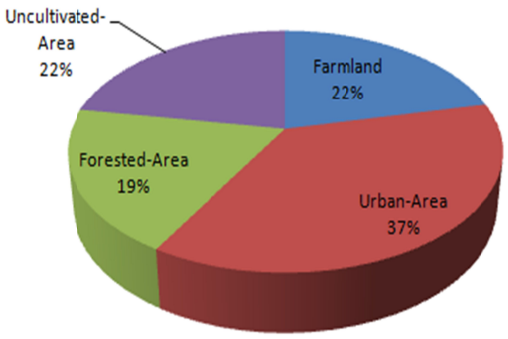

Figure 2: Percentage occurrence of *Macrotermes bellicosus* mounds around Kwara State University Campus, Nigeria

Table 2, Figure 3 d and e presents the prevalence of *M. bellicosus* through bait collection. Out of 17,699 termites collected, 5,524 was recorded from cardboard, 4,547 from toilet tissue, 3,834 from wooden stakes while 3,794 the least was recorded from wood savings (Table 3). 4,741 *M. bellicosus* was recorded from the four bait types for urban area, followed by the uncultivated area (4,588), 4,240 from forested area, while 4,110 was recovered from the farmland respectively. Table 4, Figure 3 f and g presents *M. bellicosus* feeding and damaging activities in the studied locations.

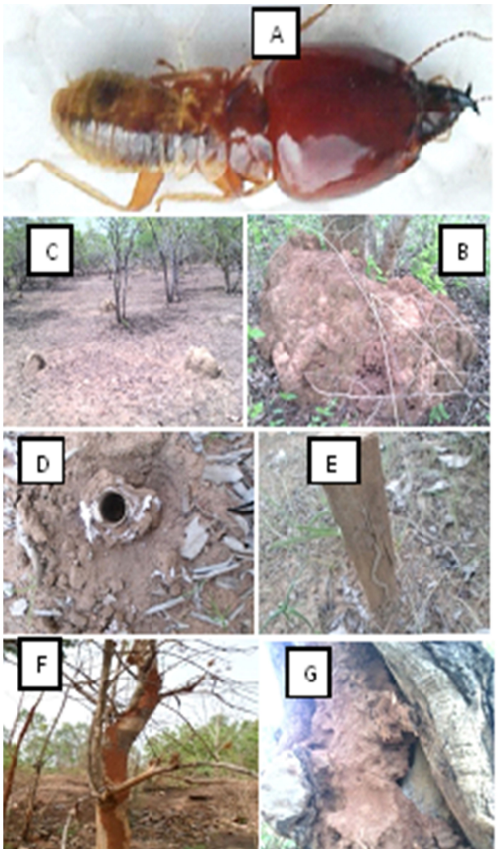

Figure 3: Occurrence of *Macrotermes bellicosus,* nest mounds, baiting traps and damages done at study area (a) Soldier of *Macrotermes bellicosus,* (b) Distribution of nest mounds (c) Nature of termite built-nest (d) Toilet tissue as baiting trap (e) Wooden stake bait (f) Living plant damage and (g) Dry/dead plant damage

From farmland, 43.66 ± 8.51 was encountered and 26.67 ± 6.01 on grain barn/ produce while 265.00 ± 47.98 and 509.00 ± 29.50 from trees at the forested areas respectively.

DISCUSSION

The soil that is available in a particular locality has an effect on the type, shape, size and height of the mound. Termites of the genus *Macrotermes* and other family of *Macrotermitidae,* as found in the study area use only the subsoil in their mound building operations. The physical properties of the soil and the climate are especially important in relation to mound building.

Table 2: Occurrence of *Macrotermes bellicosus* by bait types around Kwara State University Campus, Nigeria

Sites	Bait types								Total
	Cardboard		Toilet tissue		Stake (wooden)		Wood savings		
	F	%	F	%	F	%	F	%	
Farmland	1350	24.4	1135	25.0	824	21.5	801	21.1	4110
Urban area	1554	28.1	1177	25.9	1005	26.2	1005	26.5	4741
Forested area	1257	22.8	1075	23.6	980	25.6	948	25.0	4260
Uncultivated area	1363	24.7	1160	25.5	1025	26.7	1040	27.4	4588
Total	5524	100.0	4547	100.0	3834	100/0	3794	100.0	17699

Table 3: Mean occurrence of *Macrotermes bellicosus* by bait types around Kwara State University Campus, Nigeria

Sites	Bait types			
	Cardboard	Toilet tissue	Stake (wooden)	Wood savings
Farmland	450 ± 15.28^{a}	378.33 ± 10.14^{a}	274.67 ± 6.06^{a}	267.00 ± 39.31^{a}
Urban area	518 ± 11.24^{b}	392.33 ± 12.20^{a}	335.00 ± 17.32^{b}	335.00 ± 16.74^{a}
Forested area	419 ± 13.20^{a}	358.33 ± 6.06^{a}	326.67 ± 5.78^{b}	316.00 ± 5.20^{a}
Uncultivated area	454.33 ± 6.39^{a}	386.67 ± 19.40^{a}	341.67 ± 23.67^{b}	346.67 ± 26.00^{a}

Different letter superscript along the same column is significantly different ($p \leq 0.05$)

Table 4: Activity of *Macrotermes bellicosus* on physically damaged and fed upon items around Kwara State University Campus, Nigeria

Sites	Buildings planks	Trees	Farm grain barn/ produce
Farmland	0.33 ± 0.33^{ab}	43.66 ± 8.51^{b}	26.67 ± 6.01^{b}
Urban area	6.67 ± 1.76^{b}	2.00 ± 1.15^{a}	0.00 ± 0.00^{a}
Forested area	0.00 ± 0.00^{a}	265.00 ± 47.98^{c}	0.00 ± 0.00^{a}
Uncultivated area	0.00 ± 0.00^{a}	509.00 ± 29.50^{d}	0.00 ± 0.00^{a}

Different letter superscript along the same column is significantly different ($p \leq 0.05$)

Hinze *et al.* (2002) similarly observed that under similar climatic condition, areas where the subsoil has high clay content will have *M. bellicosus* mounds tall and steep-like than areas where the subsoil is sandy. When a mound-building termite, such as *M. bellicosus* occurs over a wide range of soil types and climatic conditions, many styles of superficial architecture result. These are modifications of a pattern of building acted upon by local conditions and do not necessarily indicate any fundamental change in behavior and activity.

M. bellicosus play an important role in the ecosystem balance and certainly improve the fertility of soil (Abe *et al.,* 2006). Termite activity, such as tunneling, soil feeding and mound building, helps to maintain macro pore structure, redistributes organic matter and improves soil stability and quality (Obi and Ogunkunle, 2009).

The influence of termites' on ecosystem processes may depend on the species abundance of the local termite assemblage and certain extensive damage to woodworks in buildings, agricultural crops and other wooden materials have been reported (Yamada *et al.,* 2005).

The present study revealed that *M. bellicosus* at the studied locations causes damage to trees, wooden structures, wooden buildings, wooden furnishings and items made of paper (Yamada *et al.,* 2005; Ekpo and Onigbinde, 2007). In addition, they have a wide range of dietary, foraging and nesting habits, with many species showing a high degree of resource specialization. The vast majority of species feed on dead plant material, while relatively few species feed on living plant tissue (Lesnik, 2014).

Baits attract foraging termites, and it helps to give estimates of relative intensity of foraging activity rather than relative population density. Baiting has been useful in studying inter- and intra-specific foraging activity (Donovan, 2000), size of foraging territory (Lobry de Bruyn and Conacher, 1990) and rates of food consumption (Abe *et al.*, 2009b). Likewise, it has also been used to estimate local species richness (Wood *et al.,* 1982). However, this can be problematic because not all species are attracted to bait. Arboreal species that do not forage on the ground, and other species that do not forage close to the soil surface, may be excluded during the sampling. Food preference trials have also shown that not all termite species are attracted to the same bait materials (Engel and Delclos, 2010), implying that using a single bait type will under-sample the local species richness. The current work has shown different baiting method in estimating the abundance of the termite present in different locations.

The abundance showed that termites infest the university environment. This in contrast to the work that maintains that the termite fauna of urban environments is usually highly depauperate and characterized by wood-feeding species, unlike natural habitats that often support much greater species and functional diversity the more (Eggleton, 2000). Therefore, proper precautions need to be taken to ensure the protection of the building in the university community. The damage done to the farm product giving a need for proper harvesting and processing of farm output to ensure adequate availability of food to the community.

Conclusion: The result revealed that *M. bellicosus* mounds in urban area was the highest and was significant when compare to the other locations. The abundance of *M. bellicosus* in urban site was higher than that of other study sites which was an indication that more damages can be done by *M. bellicosus* in the developed areas than the farmland area. The abundance shows that the university environment is highly prone to termite's infestation and proper precautions needs to be taken to ensure the protection of the building in the school community.

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