Research in Zoology 2012, 2(1): 1-4
DOI: 10.5923/j.zoology.20120201.01

Density and Dispersion Pattern of Mounds of *Macrotermes bellicosus* [Isoptera: Termitidae] in Some Local Government Areas of Sokoto, Semi-arid Zone of Nigeria

Bandiya H. M.[1], Majeed Q.[1], Ibrahim N. D.[2,*], Shindi H. A.[3]

[1]Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto
[2]Department of Crop Science, Usmanu Danfodiyo University, Sokoto
[3]Department of Science, College of Agriculture, Zuru

Abstract Studies were carried out to determine the density and dispersion pattern of the mounds of *Macrotermes bellicosus* in fadama and upland areas of some Local Government Areas of Sokoto state. Mounds were counted manually and distance between mounds was measured using measuring tape. Results indicated that an average of 10.08 mounds ha^{-1} and there is significant difference ($p<0.05$) in number of mounds between fadama and uplands, in most of the areas. The dispersion coefficient ranged from 0.03 to 0.71 with most of the population showing a clump pattern of distribution.

Keywords Density, Dispersion, *Fadama*, *Macrotermes bellicosus* Pattern, Upland

1. Introduction

Macrotermes bellicosus (Smeathman) belongs to group of insects commonly called termites. Termites are polymorphic social insects that live in self-constructed mounds called Termitarium. The individual termites within the termitarium constitute a colony that comprises several castes that are morphologically and functionally distinct (Lee and Wood, 1971; Richards and Davies, 1977). They are soft-bodied, moderate to small size insects with biting mouthparts. Body of flying individuals is dark, but those that remain in the nest are whitish with only their heads being pigmented heavily (Krishna and Weesner, 1969; Richards and Davies, 1977). The wings in termites are temporary, long and slender and in two pairs that are similar to each other. They are deciduous and are quickly shed with a single flick when the swarming termites find a new nest site, pair up and dig in (Collins, 1981; Ekpo and Onigbinde, 2007). *M. bellicosus* is a fungus-growing termite that cultivates symbiotic fungi in their nest (Binate *et al.*, 2008) and was considered a popular termite in Nigeria (Ekpo and Onigbinde, 2007). It was reported as pest of several crops such as Maize (Wood *et al.,* 1980), Groundnut (Johnson and Gumel, 1981), Sugarcane (Boboye, 1986), Rice (Alam, 1992) and Cocoa (Ndubuaku and Asogwa, 2006). Termite mound is one of the common features of most agro- ecosystem in tropical Africa (Wood and Sands, 1978; Collins, 1983; Yamada *et al.*, 2005). The mounds of Macrotermes were found to affect the tree flora of several ecosystems being a source of heterogeneity in the landscape (Traore *et al.,* 2008).

The population of the mounds tend to prevent farmers from utilising land masses for cultivation where their densities were high (Ehi*et al.,* 2007). Trapnell *et al.* (1976) estimated a density of 3-4 mounds ha^{-1} in Zambia for Macrotermitinae, Pomeroy (1978) reported 1-4 mounds ha^{-1} for Macrotermes in Uganda, Abe *et al*. (2009) reported a 3- 10 mounds ha^{-1} for *M. bellicosus*. Studies by Collins (1981) and Eggleton *et al.* (1996) on pattern of distribution of mounds of *M. bellicosus* revealed a random and clump distribution pattern in Southern Guinea Savanna of Nigeria and Cameroun, respectively.

The present research is undertaken to study the density and distribution pattern of mounds of *M. bellicosus* being a popular and most prevalent mound- building termite species in Sokoto State, Nigeria.

2. Materials and Methods

The Study Area

The research was carried out in Sokoto State, located in the Northwest of Nigeria, between latitudes 11°30'N and 14°00'N and longitudes 4°00'E and 6°40'E. Sokoto State covers a total land area of 32,000 km^2 (Abdu *et al.,* 1982; Mamman *et al.,* 2000; Tureta *et al.*, 2006). The State has a tropical continental climate and entirely falls within the semi-arid climatic environment. The annual rainfall is between 500 and 750 mm with a high peak in August and mean monthly temperatures varying between 13°C in December/

* Corresponding author:
dolegoronyo@yahoo.com (Ibrahim N. D.)
Published online at http://journal.sapub.org/zoology

January and 42°C in April, while the average annual temperature is 34°C (Kowal and Knabe, 1972; SERC, 2010).

Four (4) Local Government Areas in the State were selected following preliminary studies of areas with high number of termite mounds, namely; Shagari, Wamakko, Wurno and Yabo.

Selection of Sample Plots

In each Local Government Area, six (6) sample plots of 1 hectare (500 m x 20 m) were selected, from which three (3) plots each, from both fadama and upland were chosen by applying the standardised protocols of Jones and Eggleton (2000).

1) Survey of Mounds of *M. bellicosus*in the Sample Plots

A transect survey was done on foot in each of the selected sample plots to identify the mounds of *M. bellicosus* in each Local Government Area. Mounds belonging to *M. bellicosus* within the sample plots encountered were counted. Similarly, distance between mounds was measured using a measuring tape. The method used by Collins (1981) and Lepage (1984) for determining spatial distribution using the dispersion coefficient was employed in the study for determination of spatial distribution pattern of the mounds. The dispersion coefficient of the mounds was calculated using the Clark and Evans (1954) formula for assessing the dispersion coefficient;

$$a = m.d^2$$

Where, **a** is the dispersion coefficient, **m** is the real density and **d** is the average distance between mounds. The real density was determined using the formula;

$$d = n/s$$

Where, **n** is the number of mounds sampled and **s** is the area sampled in m^2 as applied by Meyer (1997). Values where a=0 are described as having clump distribution, a= 0.25 as random distribution and a= 1.158 as regular distribution (Collins, 1981).

2) Statistical Analysis

Data generated were subjected to one-way analysis of variance where significant differences between means were separated using Least Significant Difference (LSD) at $p<0.05$. Analysis was done using SAS 9.3 Statistical package (SAS, 2003®).

3. Results and Discussion

Densities of mounds of *M. bellicosus* in the study area are shown in Table 1. A total of 242 mounds with a mean density of 10.08 were observed in the 24 plots. Wurno Local Government Area had the highest mean of 18 mounds ha^{-1}, while Shagari had the least 4.67 mounds ha^{-1}(Table 1). The observed mean density of 10.08 mounds ha^{-1} appeared to be higher than earlier reports of Lee and Wood (1971), which indicated that large mounds of Macrotermitinae that supports large number of individuals are usually less than 10 mounds ha^{-1}. Similarly, Pomeroy (1978) reported a density of 1- 4 mounds ha^{-1} for Macrotermes in Uganda, Trapnell *et al.* (1976) also, estimated a density of 3- 4 mounds ha^{-1} in Zambia for Macrotermitinae and Abe *et al.* (2009) reported a density of 3-10 mounds ha^{-1} for *M. bellicosus* in an upland site of central Nigeria and attributed the variation to anthropogenic disturbance. The observation in the present study may be because of the favourable environmental conditions and non-destruction of the mounds by people due to the spiritual believes that the mounds house evil spirits.

Figure 1 showed mean number of mounds of *M. bellicosus* in different land types. It revealed that Wurno upland had the highest mean, followed by Shagari upland while Wamakko upland was the least. Also, fadama lands have more mounds than the uplands in all the Local Government Areas except in Shagari Local Government Area where uplands had higher mounds than the fadama lands (Figure 1). The Figure also showed significant difference ($p<0.05$) between fadama lands and uplands in the number of mounds in all the Local Government Areas.

Table 1. Abundance of Mounds of *M. bellicosus* per hectare in the Study Area

Sample Plot	Land Type	Local Govt. Area	No. of Mounds Per Hectare	Mean No. of Mounds Per Land Type In a LGA
1	Fadama	Shagari	9	
2	Fadama	Shagari	6	7.67
3	Fadama	Shagari	8	
4	Upland	Shagari	10	
5	Upland	Shagari	11	9.67
6	Upland	Shagari	8	
7	Fadama	Wamakko	14	
8	Fadama	Wamakko	7	10.33
9	Fadama	Wamakko	10	
10	Upland	Wamakko	5	
11	Upland	Wamakko	3	4.67
12	Upland	Wamakko	6	
13	Fadama	Wurno	16	
14	Fadama	Wurno	20	18.00
15	Fadama	Wurno	18	
16	Upland	Wurno	8	
17	Upland	Wurno	14	10.00
18	Upland	Wurno	8	
19	Fadama	Yabo	17	
20	Fadama	Yabo	13	14.00
21	Fadama	Yabo	12	
22	Upland	Yabo	7	
23	Upland	Yabo	6	6.33
24	Upland	Yabo	6	
		Total	242	10.08
			SE±	1.51

The significant difference observed between the density of mounds in the fadama and upland areas, with the fadama having higher number of mounds in all the Local Government Areas except in Shagari Local Government Area, could be attributed to the moisture content in the fadama land type. But in Shagari, probably because of the pestiferous activities of the termites, there were various attempts to control the termites from the fadama as it is the major farming area in the community, this might have influenced the mound density. This is in agreement with the report by Pomeroy (1978) that the abundance of mounds of *M. bellicosus* was strongly correlated with moisture, but disagreed with Abe *et al.* (2009) which reported that the number and volume of termite mounds are lower in lowlands than the uplands and attributed interference with shallow water table in poorly drained soil as a possible factor responsible for the difference.

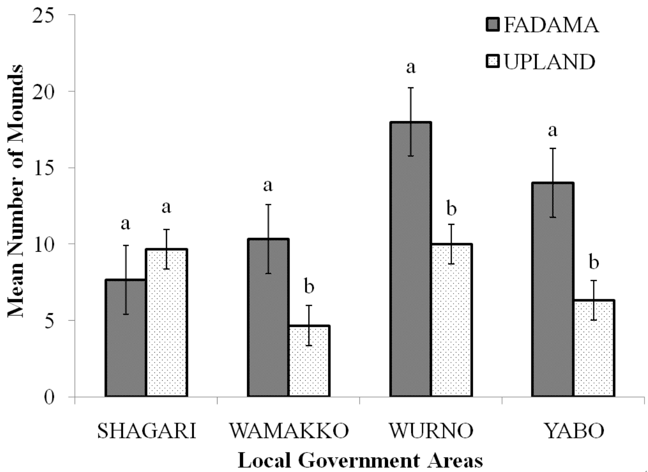

Figure 1. Mean Number of Mounds of *M. bellicosus* per hectare in Different Land Types in the Study Area. Bars followed by the same letter at the top were not significantly different ($p > 0.05$). LSD (SAS, 2003®)

Dispersion coefficient as presented in Table 2 ranges from 0.03 (Wamakko upland) - 0.71 (Wurno upland). This showed that the mounds were clumped in distribution in all the fadama lands and Wamakko upland, randomly distributed in Yabo upland and Shagari upland, while in Wurno upland the distribution indicated a degree of over-dispersion. The clumped distribution patterns observed among the fadama lands could be because of sufficient plant material in the land type, also the random distribution observed among the uplands implied that intraspecific competition was not a key factor regulating the distribution of mounds in those areas. This pattern implied that a few major factors are dominant in regulating the distribution of the mounds in the area, which could be one of the reasons for the unexplained observed variation in some areas in the study with apparently no difference in the environmental variables.

The observed over-dispersion in Wurno upland may be because of rocky nature of the area making it difficult for mound construction by the termite. The observed clump dispersion in Wamakko upland could have resulted because of the low density of the mounds in the most of the land type with few mounds aggregating in one area possibly because of its richness in plant materials due to improved soil quality. This was in line with Collins (1981) which reported a random distribution pattern of *M. bellicosus* in Southern Guinea Savanna of Nigeria and Eggleton *et al.* (1996) in Cameroun that termite abundance was highly clumped.

Table 2. Dispersion Coefficient of Mounds of *M. bellicosus* in the Local Government Areas

LGA	Land Type	Average Distances Between Neighboring` Mounds (m)± S. E.	Dispersion Coefficient
Shagari	Fadama	41.56± 9.22	0.04
Shagari	Upland	54.58± 6.68	0.16
Wamakko	Fadama	47.58± 6.24	0.05
Wamakko	Upland	37.89± 11.89	0.03
Wurno	Fadama	43.96± 4.60	0.04
Wurno	Upland	61.21± 5.67	0.71
Yabo	Fadama	48.13± 4.75	0.10
Yabo	Upland	34.49± 4.78	0.22

4. Conclusions

M. bellicosus have high mound density in Sokoto State. The insect being a pestiferous species could promote erosion; appropriate control strategies are required for its control. The clump distribution pattern of the termite suggests that they are aggregated in a more favourable environment, thus paving a way for their control.

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