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Intra-colonial Population of *Macrotermes bellicosus* (Smeathman) [Isoptera: Termitidae] in Sokoto, Semi-Arid Zone of North-Western Nigeria.

[*1]H. M. Bandiya, [1]Q. Majeed, [2]N.D. Ibrahim,[1]M.M. Yahaya and [1]M.A. Yahaya
[1]Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria
[2]Department of Crop Science, Usmanu Danfodiyo University, Sokoto, Nigeria
[*Corresponding author, e-mail: hbandiya68@yahoo.com; ☎: +234(0)8065911577]

ABSTRACT: The intra- colonial population of individuals within the mounds of mound- building termite, *Macrotermes bellicosus* (Smeathman) occurring in some selected Local Government Areas of Sokoto State were studied. A total of 72 cone shaped mounds were selected based on their heights. Populations were estimated by randomly collecting and counting core samples from the mounds using a small bucket as the mounds were being excavated. At the end of the excavation, the total sand removed from the mound was crushed and measured using the same bucket. Total number of termites from a mound was extrapolated from the above estimates. Results indicate the presence of five different castes; reproductives, workers, minor and major soldiers and nymphs. The population of individuals per mound apart from the reproductives, ranged between 14158.00 and 24777.67 with an average of 18,795.49 termites per mound. The nymphs were the largest (5,942.60) closely followed by the workers (5,547.70), while the minor soldiers are the least with 3,279.38. Significant difference ($p<0.05$) occurred between minor soldiers and nymphs, major soldiers and nymphs, minor soldiers and workers and minor soldiers and nymphs in some of the studied areas. The present study show *M. bellicosus* to have high population within individual mounds enough to cause damage if ignored. Being a pestiferous species that could promote erosion, appropriate control strategies are required for its control.
Key words: *Macrotermes bellicosus*, Mounds- building termites, intra-colonial Population, Mounds, Castes.

INTRODUCTION

Macrotermes bellicosus (Smeathman) is a fungus-growing and mound-building polymorphic social insect. It lives in colonies and their numbers vary from several hundred to several million individuals per mound. They are a prime example of decentralized, self-organized systems that use swarm intelligence to exploit food sources and environments that could not be available to any single insect acting alone (Skaife *et al.*, 1979).

A colony of *M. bellicosus* shelter approximately 360,000 neuters in Nigeria (Collins, 1981) and was reported by Ekpo and Onigbinde (2007) as a popular termite in Nigeria. It is a pest of several crops in Nigeria that include Sugarcane (Boboye, 1986), Maize (Wood *et al.,* 1980), Groundnut (Johnson and Gumel, 1981) and Cocoa (Ndubuaku and Asogwa, 2006). The mounds of *Macrotermes* to affect the tree flora of several ecosystems being a source of heterogeneity in the landscape (Traore *et al.,* 2008). Aisagbonhi (1989) reported that 10.8% of 1300 coconut seedlings were attacked by *M. bellicosus* in nursery at the Nigerian Institute for Oil Palm Research, Benin City. Ndubuaku and Asogwa (2006) reported *M. bellicosus* among significant pests of cocoa in Nigeria. It serves as food to countless predators and are pivotal in nutrient cycling and hence an important component of the ecosystem (Logan *et al.,* 1990; Meyer *et al.,* 1999; Braide *et al.,* 2011*)*. Bandiya *et al.* (2012) reported a density of 10.08 mounds per hectare in Sokoto State. Being a pestiferous species and an important component of the ecosystem this research was carried out to determine the intra-colonial population of various castes of *M. bellicosus* within the mounds in Sokoto State.

MATERIALS AND METHODS

The Study Area

The research was carried out in Sokoto State, located in the Northwest of Nigeria ($11^0$30'N and $14^0$00'N and $4^0$00'E and $6^0$40'E). The state covers a total land area of 32,000 km^2 (Abdu *et al.,* 1982; Mamman *et al.,* 2000; Tureta *et al.*, 2006), 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 with mean monthly temperatures varying between 13^{o}C in December/ January and 42^{o}C in April while the average annual temperature is 34^{o}C (Kowal and Knabe, 1972; SERC, 2010). In the present study Four (4) Local Government Areas in the State were selected, namely; Shagari, Wamakko, Wurno and Yabo.

Selection of Sample Plots

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

Survey of Mounds of *Macrotermes bellicosus* and Population Estimation

A transect walk survey was done on foot in each of the selected sample plots to identify the mounds of *M. bellicosus* in each Local Government Area. Seventy-two cone- shaped mounds identified as belonging to *M. bellicosus* within the sample plots were selected as follows; nine mounds from fadama and nine mounds from upland plots of each of the selected Local Government Area based on their heights. Among the nine mounds, three mounds were small, measuring 0.30 to 1.49 m in height, three were medium-sized, measuring 1.50 to 2.49 m in height and the other three were large, measuring 2.50 m and above as was done by Meyer (2001). Considering the number and sizes of the mounds involved, and the difficulties of digging and counting, estimation of population was based on methods used by Hartwig (1956) and Sands (1965) with some modifications. In their methods, core samples were taken by digging up bases of the mounds and calculating the volume of the sample area. In this study, each mound was fully excavated and known samples were taken randomly as the excavation was going-on, using a small bucket as core sample, from which number of termites in each bucket was counted. At the end of the excavation, the total sand removed from the mound was crushed and measured using the same bucket. Total number of termites from a mound was extrapolated from the above estimates by multiplying the number of termites per bucket with the number of buckets per mound.

Before excavating a mound, a circular trench was made around the mound by digging up areas near the bases of the mound, starting from a distance of about 0.5 m from the mound and extending it very close to the mound. This was with a view to preventing the termites from escaping through the underground tunnels. After the trenching, the excavation started from the top to the bottom, samples were collected regularly as the mounds were being excavated as described above. Collection of samples was done in the morning, when foraging activity was low as reported by Ratcliffe and Greaves (1940). The soil samples were transferred into labelled plastic bags and transported to the laboratory for examination. The separation of the termites from mound material was done in the laboratory by floatation methods as described by Collins (1981).

During the separation process, the collected soils were first transferred into buckets separately and then water poured unto each. The resulting slurry was stirred with a pipe connected to a running tap. Floating individuals were skimmed off using sieves, while sunken individuals were collected by pouring the fluid through sieves. All individuals extracted were counted in living, dead or damaged forms; only termite heads were counted when found dead to avoid counting an individual twice. Population of the various castes was estimated by counting the proportion of the various castes in the colony.

Statistical Analysis

Data generated was subjected to one-way analysis of variance, where significant differences were observed, means separation was carried out using Duncan Multiple Range Test (DMRT). Observations were considered significant where $p<0.05$. All the analyses were done using SAS 9.3 Statistical package (SAS, 2003®).

RESULTS AND DISCUSSION

The mean population of individuals within the termite mounds was presented in Table 1. It show Yabo fadama as having the highest mean number of 24,775.67 individuals per mound, while Wamakko upland has the lowest with 14,156. The population of nymphs and workers per mound is higher in Yabo fadama with 8,775.78 and 7,374.67 respectively while Wamakko upland had the least with 3,491.80 and 3,914.40 respectively.

The minor soldiers had their highest population in Wamakko fadama with 3,882.44 and the lowest in Shagari upland with 2,525.11, while the major soldiers had their highest mean in Yabo fadama with 5,057.44 and the least at Shagari upland with 3,324.22. The average population of the termite per mound was found to be 18,795.49. The nymphs had the highest mean of 5,942.60 followed by the workers with 5,547.70, while the minor soldiers had the lowest with 3,279.38.

Table 1: Mean Population of Various Castes of *M. bellicosus* per Mound

LGA	Land Type	Mean Population				Total Population
		Major Soldiers	Minor Soldiers	Workers	Nymph	
Shagari	Fadama	3647.11	3066.67	6019.44[a]	6501.56[a]	19234.78
	Upland	3324.22	2525.11	4530.22	823.44	14202.99
Wamakko	Fadama	4706.78	3882.44	5355.56	4624.22	18569.00
	Upland	3738.20	3011.60	3914.40	3491.80	14156.00
Wurno	Fadama	3752.44	3871.00	5961.33	7694.01	21278.78
	Upland	3735.89	2996.56	4221.22	5301.89	16255.56
Yabo	Fadama	5057.44	3567.78	7374.67	8775.78	24775.67
	Upland	4244.33	3313.89	7004.78	7328.11	21891.11
Total Means		**4025.80**	**3279.38**	**5547.70**	**5942.60**	**18795.49**
SE (±)		**209.29**	**167.11**	**450.28**	**681.02**	**1341.80**

LGA = Local Government Area

Figure 1 depicts the nymphs as having the highest population followed by workers in all the land types except in Shagari upland, Wamakko fadama and upland where population of workers was the highest. The figure also shows minor soldiers as having the lowest population in all the land types except in Wamakko fadama where they are depicted as being higher than the major soldiers.

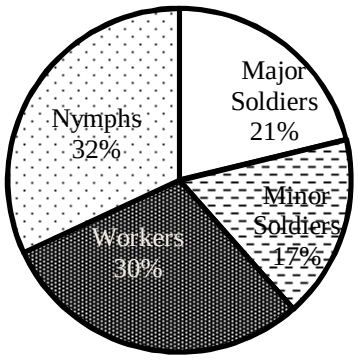

Figure 1: Proportion of Various Castes Members within the Mounds of *M. bellicosus* in the Study Areas.

The 18,795.49 mean population per mound recorded is comparatively much lower than what was reported earlier where Darlington (1991) estimated 1.3million neuters in a mature mound of *Macrotermes michaelseni* (Sjöstedt) in Kenya, Collins (1981) observed about 360,000 neuters in the mounds of *M. bellicosus* in Nigeria and Meyer (2001) estimated 45,835 neuters for medium- sized mounds of *M. natalensis* in South Africa.

The difference may be due to the efficiency of the sampling method employed in the present work where estimates were based on total excavation of the mounds as against earlier studies where the mounds were not fully excavated and populations were estimated. It may also be because the period of sampling that was between February and May when reproductive activities were high in preparation for the swarming and food resource was highly available as most plant material were dried at the time. Another explanation may be that the ring trenching technique before excavation prevented emigration from the mounds as reported by Meyer (2001), but also prevented the coming back of foraging individuals to the mound.

The observed higher nymphal population within the mounds in the present study may be attributed to the fact that the worker and soldier castes were migratory, while the bulk nymphal population resides within the mound. Also, the period of the collection reflected a period of active development in preparation for the coming raining season, but

contrary to this, Meyer (2001), Collins (1981) and Darlington (1991) estimated the worker population to be higher.

Significant difference ($p<0.05$) occurred between minor soldiers and nymphs in Shagari fadama, between major soldiers and nymphs in Wurno fadama, between minor soldiers and nymphs in Yabo fadama and between major soldiers and workers, major soldiers and nymphs, minor soldiers and workers and minor soldiers and nymphs in Yabo upland.

The proportion of the various castes of *M. bellicosus* per mound excluding the reproductive pair is presented in Figure 1. The figure shows nymphs being highest with 32%, followed by the workers (30%) while the two soldier castes collectively show 38%, with the major and minor soldiers as 21% and 17% respectively.

CONCLUSION

The present study show *M. bellicosus* to have high population of their various castes within an individual mound both in fadama land type and uplands with higher prevalence in fadama land type that is used throughout the year for farming activities. These populations, if ignored, cause economic damage, being a pestiferous species that could promote erosion, therefore, appropriate control strategies are required for its control.

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