Original Research Article

Species composition, relative abundance, and diversity of termites (Blattodea: Insecta: Isoptera) in the Kwara State Univerity Campus, Malete, Kwara State, Nigeria

Abubakar Abdullahi **Adeoye**[1*], Adeyemi Mufutau **Ajao**[1], James Adebayo **Ojo**[2]

[1] *Department of Zoology, Kwara State University, Malete, Kwara State, Nigeria*
[2] *Department of Crop Production, Kwara State University, Malete, Kwara State, Nigeria*

Correspondence to:
A.A. Adeoye, Department of Zoology, Kwara State University, Malete, Kwara State, Nigeria
e-mail: abubakar.adeoye@kwasu.edu.ng, Telephone +2348108855918.

Abstract

Termites are widely dispersed throughout the tropics and attain the highest diversity and abundance in the rainforests of Africa. Understanding their diversity in areas with human activities can provide insights into the local biodiversity and health of the ecosystem. The present study investigated the abundance and diversity of termite species at the Kwara State University campus. The study area was divided into five zones, and thorough examinations of all microhabitats were conducted to detect termite presence. Random handpicking and transect sampling methods were employed to evaluate termite diversity. There were 353 instances of termites encountered between May 2021 and August 2022. The analysis revealed eight termite species in seven genera and three subfamilies. Among these, Trinervitermes geminatus had the highest relative abundance at 48.7%, whereas *Fulleritermes tenebricus* had the lowest at 1.98%. All identified species belonged to the family Termitidae, with subfamilies Nasutitermitinae accounting for 50.7%, Macrotermitinae for 37.7%, and Termitinae for 11.6% of the species. Grass-feeding *Trinervitermes geminatus* was the most frequently collected species, followed by fungus-growing *Macrotermes subhyalinus*; both were found across all five campus zones. The species diversity and richness indices observed in the five zones were moderately high. The considerable abundance of termites within the university campus suggests their significance in the ecosystem. There is a need to document termite species present in an ecosystem with human activities because it helps to monitor biodiversity loss in the environment.

Keywords: Monitoring; biodiversity; Termitidae; relative abundance; zones; transect sampling method

INTRODUCTION

Termites are eusocial insects of great benefit and economic importance to humans, and they play a crucial role in soil formation processes, particularly in tropical regions. In conjunction with ants, termites act as decomposers, aiding in nutrient cycling thereby regulating soil fertility through biophysical and chemical processes (Vrsansky and Aristov, 2014). Termites are widely dispersed throughout tropical and some temperate regions and attain the highest diversity and abundance in the rainforests of Africa, South America, and Southeast Asia (Rahman and Tawatao, 2003).

Generally, termites nest in different microhabitats, and most epigeal termites have mound nests occupying approximately 10% of the land surface area in forested or tropical savanna regions (Lavelle, 1997). Globally, over 2958 termite species have been

described within 271 genera and seven families (Engel et al., 2009). However, the Treatise on the Isoptera of the World suggests the presence of 3105 living and fossil species classified into 12 families and 330 living and fossil genera (Krishna et al., 2013). Identification and classification of termite species rely predominantly on the soldier castes, and worker castes for soldier-less termites frequently encountered during foraging activities away from the nests and are often associated with wood damage (Kirton, 2005).

In Africa, economically significant termite genera in agricultural and forest regions include *Macrotermes*, *Allodontermes*, *Amitermes*, *Pseudacanthotermes*, *Odontotermes*, *Ancistrotermes*, *Trinervitermes*, *Hodotermes*, and *Microtermes* (Christopher et al., 2013) and were reported to have impacted different ecosystems in Africa.

Only a few studies have been conducted on the diversity of termites in Nigeria. On the University of Port Harcourt campus, Ugbomeh et al. (2019) discovered termite species in the families Kalotermitidae (*Glyptotermes* sp.) and Termitidae, with two subfamilies present: Amitermitinae and Nasutitermitinae (*Amitermes* sp., *Globitermes* sp., *Microcerotermes* sp., and *Nasutitermes havilandi*). In a study of species richness, diversity, and relative abundance of termites in the University of Lagos campus, eight genera were found in two families (Rhinotermitidae and Termitidae), and six subfamilies (Rhinotermitinae, Amitermitinae, Macrotermitinae, Microcerotermitinae, Nasutitermitinae, and Termitinae), (Kemabonta and Balogun 2014). In the Kwara State University campus and its environs, a previous survey of termite mounds showed a high abundance of *Macrotermes bellicosus* (Ajao et al., 2018). Also, in the diversity study of termite species in *Eucalyptus* plantations in Afaka, three subfamilies: Macrotermitinae, Nasutitermitinae, and Termitinae were found (Alamu et al., 2018).

Termites possess distinguishing morphological characters that aid morphological identification studies. Morphological analysis of termites is crucial for the identification of the species and is used as the method available when molecular identification is not accessible, especially in developing countries. Thus, the current survey aims to assess the abundance and diversity of termites in the Kwara State University campus, in Malete, Nigeria. We hypothesise that termite diversity and abundance differ between different zones based on the intensity of human activities on the campus. Therefore, there will be differences in the assemblage of termite in all the selected zones on the campus.

MATERIALS AND METHODS

Study area

The present study was conducted within the Kwara State University campus, Malete, Ilorin, Kwara State, Nigeria. The campus environment comprises various structures such as administrative and faculty buildings, classrooms, hostels, as well as open areas including farms. The campus was divided into five distinct zones based on the anthropogenic activities carried out in the areas, as illustrated in Figure 1. Zone 1 is composed of administrative and faculty buildings and is a disturbed area with frequent human activities. Zone 2 is an area with buildings and fewer human activities while Zone 3 is composed of student residential areas. Zone 4 has faculty buildings and has more open areas with fewer human activities while Zone 5 is an open grassland with farming activities.

Termite sampling and identification

Two distinct sampling methods were implemented across the sampling zones from May 2021 to August 2022. Random sampling by searching and handpicking was employed in areas exhibiting infrastructural development, whereas the open areas and farmlands were subjected to transect sampling, following the protocol outlined by Jones and Eggleton (2000) with minor adjustments. A team of three individuals conducted searching and sampling activities for 30 minutes. This duration was extended to one hour in regions with a high frequency of termite encounters. Within each zone, nests were sought out in various locations, including soil galleries, decaying wood, live and deceased trees, leaf litter, wooden structures, and buildings all within a radius of 200 meters. Termites were carefully collected and preserved in 70% ethanol in 30 ml glass vials. Morphological identification of the collected specimens was carried out using the identification keys provided by Ahmad (1965), Uys (2002), and Sornnuwat et al. (2004).

Data analysis

Data analysis was conducted utilising PAST 4.03 Software (Hammer et al., 2001) and Microsoft Excel (2013) to compute ecological indices, including species diversity, species richness, dominance, and evenness or equitability indices. The termite diversity examined in this study pertains to α-diversity, which encompasses the diversity of species within

a specific community or habitat. To assess diversity, the Shannon–Wiener diversity index and Simpson's diversity index were employed. Species richness was quantified using Margalef's index, while the dominance index was determined using the formula for Relative dominance. Additionally, the evenness or equitability of a species was evaluated using the Evenness Index (Ojija and Kavishe, 2016). The formulas for the Shannon-Weiner index (H') and Simpson's Dominance Index (D) are as follows:

$$\text{Shannon diversity Index (H)} = -\sum_{i=1}^{s} p_i \ln p_i$$

Shannon diversity Index, **p** is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), **ln** is the natural log, Σ is the sum of the calculations, and is the number of species.

$$\text{Simpson's Dominance Index} = -\sum_{i=1}^{1} pi2$$

In the Simpson index, **p** is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), Σ is still the sum of the calculations and is the number of species.

RESULTS

Termite species abundance

The survey conducted within the Kwara State University campus recorded a total of 353 termite encounters, identifying eight distinct species in seven genera within the family Termitidae. Three subfamilies were represented: Nasutitermitinae, which included *Trinervitermes geminatus* and *Fulleritermes tenebricus*; Macrotermitinae, consisting of *Macrotermes bellicosus*, *Macrotermes subhyalinus*, *Odontotermes* sp. and *Ancistrotermes cavithorax*; and Termitinae, composed of *Amitermes* sp. and *Microcerotermes* sp. (Table 1; Figure 2). Nasutitermitinae species accounted for 50.7% of the total species collected, while Macrotermitinae and Termitinae constituted 37.7% and 11.6% respectively (Figure 3). Members of the subfamily Nasutitermitinae exhibited both the highest and lowest abundance across all surveyed zones. *Trinervitermes geminatus* comprised 48.7% of the total sampled species, whereas *F. tenebricus* made up 1.98%.

Distribution of termites in different microhabitats and feeding groups

During our survey, termites inhabited different microhabitats in leaf litter, dead trees, woods, epigeal mounds, soil surfaces, and living trees. Most of the termites identified in this study were also found within foraging galleries built in the soil. All Macroterminae species were found in dead wood microhabitat. *Amitermes* sp, *Microcerotermes* sp., and *A. cavithorax* were found in living trees (Table 2). *Macrotermes subhyalinus* and *M. bellicosus* were present in four out of the five microhabitats, while the dominant species, *T. geminatus*, was solely found in mounds on the soil surface. Epigeal mound builders identified on campus included *M. subhyalinus*, *M. bellicosus*, and *T. geminatus*. *Macrotermes subhyalinus* and *M. bellicosus* were noted to be destructive within the study zones, as they were observed consuming wooden structures and trees. *Ancistrotermes cavithorax* predominantly occupied fallen small branches of trees and twigs.

Donovan et al. (2001) feeding group classification was used to classify termite assemblage and the termites encountered were in the category of the three feeding divisions in group II (Table 2). Group II fungus-grower species predominated, encompassing four species, namely *M. subhyalinus*, *M. bellicosus*, *A. cavithorax* and *Odontotermes* sp. while Group II wood feeders had three species (*Microcerotermes* sp., *Amitermes* sp. and *F. tenebricus*). *Trinervitermes geminatus* is the only grass feeder species in Group II.

Species richness and diversity of termite species

The species diversity indices varied between zones. Zone 4 exhibited the highest Shannon-Wiener diversity index (1.71), whereas Zone 2 recorded the lowest (1.39). Similarly, Simpson's diversity index was highest in Zone 4 (0.75) and lowest in Zone 2 (0.67).

Regarding species richness, the Margalef index indicated the highest value in Zone 5 (1.69), contrasting with the lowest value observed in Zone 2 (1.35) (Table 3). Pielou's evenness indices revealed variations across the sampled zones, with Zones 1 and 2 demonstrating higher evenness (0.82) compared to Zone 3, which displayed the lowest evenness (0.73).

DISCUSSION

The survey conducted at the Kwara State University campus identified eight termite species belonging to seven genera in the family Termitidae, encompassing the subfamilies Nasutitermitinae, Macrotermitinae, and Termitinae. Species in the genus *Trinervitermes* dominated while *Fulleritermes tenebricus* was the least

Table 1. Termite taxa and relative abundance of species encountered within the five zones in the Kwara State University Campus

FAMILY	SUB-FAMILY	TERMITE SPECIES	Zone 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	Total encounter	% Occurrence
Termitidae	Nasutiterminae	*Trinervitermes geminatus*	17	21	68	35	31	172	48.7
		Fulleritermes tenebricus	0	0	2	4	1	7	1.98
	Macrotermitinae	*Macrotermes bellicosus*	2	3	8	7	5	25	7.1
		Macrotermes subhyalinus	7	5	26	13	9	60	16.9
		Odontotermes sp.	2	0	5	3	4	14	3.9
		Ancistrotermes cavithorax	3	8	11	9	3	34	9.6
	Termitinae	*Amitermes* sp.	2	1	7	5	2	17	4.8
		Microcerotermes sp.	4	3	6	4	7	24	6.8
		Taxa_S	7	6	8	8	8		
		Individuals	37	41	133	80	62		

Table 2. Feeding group and occurrence of termite species in different microhabitats in five zones in the Kwara State University Campus

Termite species	Feeding Group	Epigeal mound	Leaf litter	Microhabitats soil	Wood/dead tree	Living tree
Trinervitermes geminatus	II (G)	+	-	+	-	-
Fulleritermes tenebricus	II (W)	-	-	+	+	-
Macrotermes bellicosus	II (F)	+	+	+	+	-
Macrotermes subhyalinus	II (F)	+	-	+	+	-
Odontotermes **sp.**	II (F)	-	-	+	+	-
Amitermes **sp.**	II (W)	-	-	+	+	+
Ancistrotermes cavithorax	II (F)	-	+	+	+	+
Microcerotermes **sp.**	II (W)	-	-	-	+	+

(Feeding groups: II(W) = wood feeders, II(G)= Grass feeders, II(F)= Fungus growers). Present (+), Absent (-).

Table 3. Species diversity and richness indices as calculated for termites encountered within the five zones in the Kwara State University Campus

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Dominance_D	0.27	0.33	0.32	0.25	0.30
Simpson_1-D	0.73	0.67	0.68	0.75	0.70
Shannon_H	1.59	1.39	1.52	1.71	1.58
Evenness_e^H/S	0.70	0.67	0.57	0.69	0.60
Margalef	1.66	1.35	1.43	1.59	1.69

frequent of the total number of species sampled. A similar survey of arboreal termites in the Port Harcourt University environment revealed termites identified as *Amitermes* sp., *Nasutitermes havilandi*, *Odontotermes* sp., *Microcerotermes* sp., *Glyptotermes* sp., and *Globitermes* sp. (Ugbomeh et al., 2019) but with little difference in species composition. *Amitermes* sp. was found in the trees and was dominant in the Port Harcourt University campus environment. Furthermore, the termites identified on the University of Lagos campus showed that *Amitermes* sp. was dominant, followed by *Ancistrotermes* sp. while *Capritermes* sp. was found to be the least abundant (Kemabonta and Balogun, 2014) as opposed to the present study where *T. geminatus* was the most abundant.

In *Eucalyptus* plantations, Alamu et al. (2018) reported that members of Nasutitermitinae constituted 14% of the total encountered termites which was lower than the Nasutitermitinae of the present survey, 50.7%. Macrotermitinae in the *Eucalyptus* plantations was the highest and was higher than that in the present study, 37.7%.

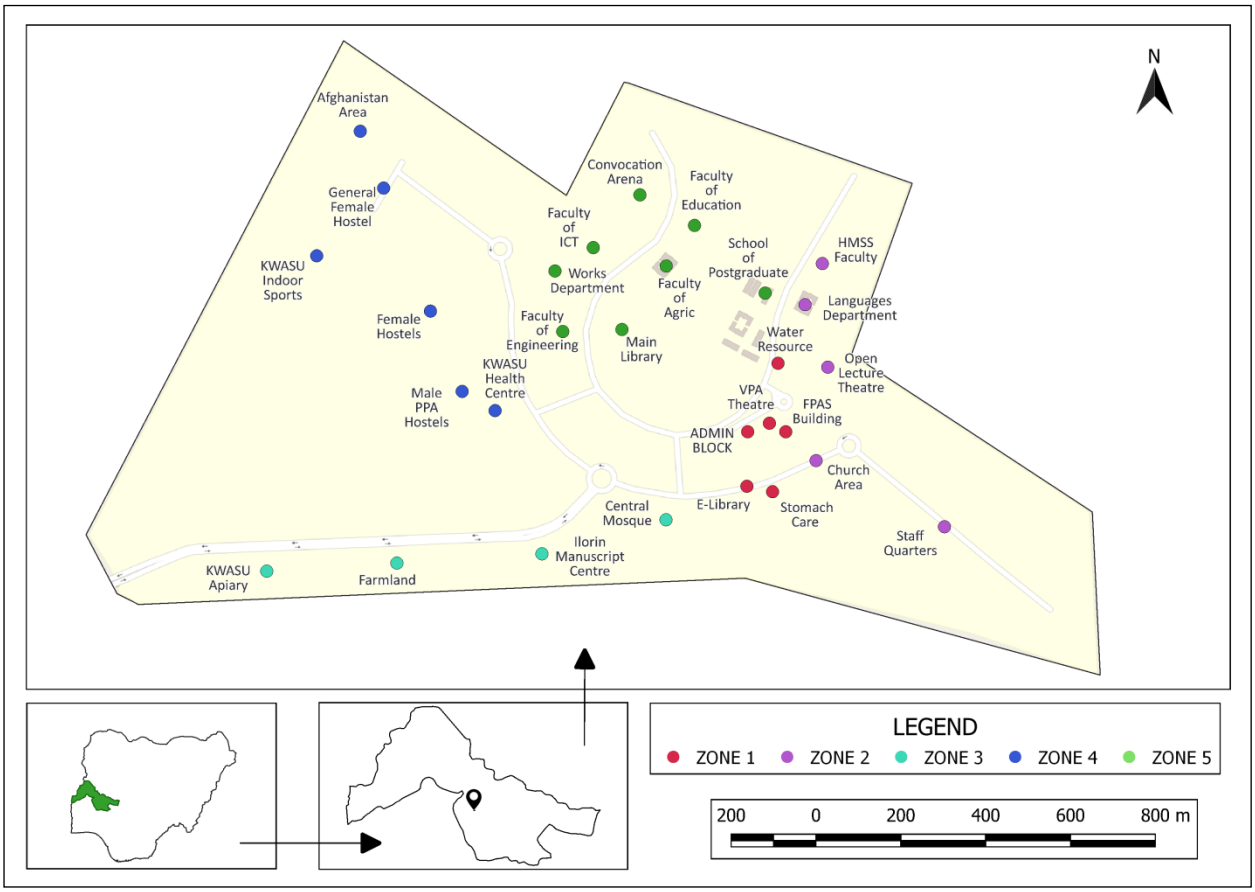

Figure 1. Map of Kwara State University campus, Malete (Nigeria) showing the five different zones of termite collection. Zone 1 is composed of administrative and faculty buildings. Zone 2 is an area with buildings and fewer human activities while Zone 3 is composed of student residential areas. Zone 4 has faculty buildings and has more open areas with fewer human activities and Zone 5 is an open grassland with farming activities.

The occurrence and the dominance of the termite species found in this study indicate that the microhabitats on the campus favor their survival. Most termites were mostly in the microhabitats either wood or epigeal nesting sites. The occurrence of epigeal mound builders was lower than the wood nesting species. Based on zone dominance, it was also observed that *T. geminatus* had the highest number of occurrences in all five zones on the campus. This could be due to the vegetation type which is a Derived Savanna comprising a larger percentage of grass vegetation with some trees. A similar report was given that *Trinervitermes* sp. occurred frequently in the southern arid region in the sampling site because *Trinervitermes* sp. are grass-feeders that occur more frequently in open grass savanna (Schyra et al., 2018).

In the present study, the termites were sampled from different microhabitats such as mounds, living and/or dead trees, and soil galleries. *Microcerotermes* sp. in the present study was found nesting within living trees, and this was also reported by Olugbemi and Malaka (1994) in which *Microcerotermes fuscotibialis* gathered its food within living trees. Also, the species reported from Western Ghats in India were found nesting in dead wood, soil galleries on forest trees, and closed mounds (Vidyashree et al., 2018).

The diversity index on the Kwara State University campus indicated a moderate diversity, ranging from 1.39 to 1.71 at different zones. These results were also similar to the results of the research conducted on the University of Lagos campus where eight genera were found during dry and rainy seasons (*M. natalensis*, *M. subhyalinus*, *Ancistrotermes* sp., *Nasutitermes* sp., *Microcerotermes* sp., *Capritermes* sp., *Amitermes* sp., and *Coptotermes* sp.), and the species diversity index ranged from 1.51–1.66 (Kemabonta and Balogun, 2014).

The Pielou's index of evenness was also calculated for the sampled termite species in the present study. In general, Pielou's index of evenness falls between 0 and 1. The Pielou's index of termite species on the Pondicherry Engineering College campus, India was 0.76 and 0.85 (Anantharaju et al., 2014) which was closer to evenness values in the Kwara State University campus ranging from 0.73 to 0.82 across the five zones.

Figure 2. Termite species encountered in the Kwara State University campus, Malete, Nigeria (a) *Macrotermes bellicosus* / (b) *Macrotermes subhyalinus* / (c) *Odontotermes* sp. / (d) *Ancistrotermes cavithorax* (e) *Trinervitermes geminatus* / (f) *Fulleritermes tenebricus* / (g) *Amitermes* sp. / (h) *Microcerotermes* sp.

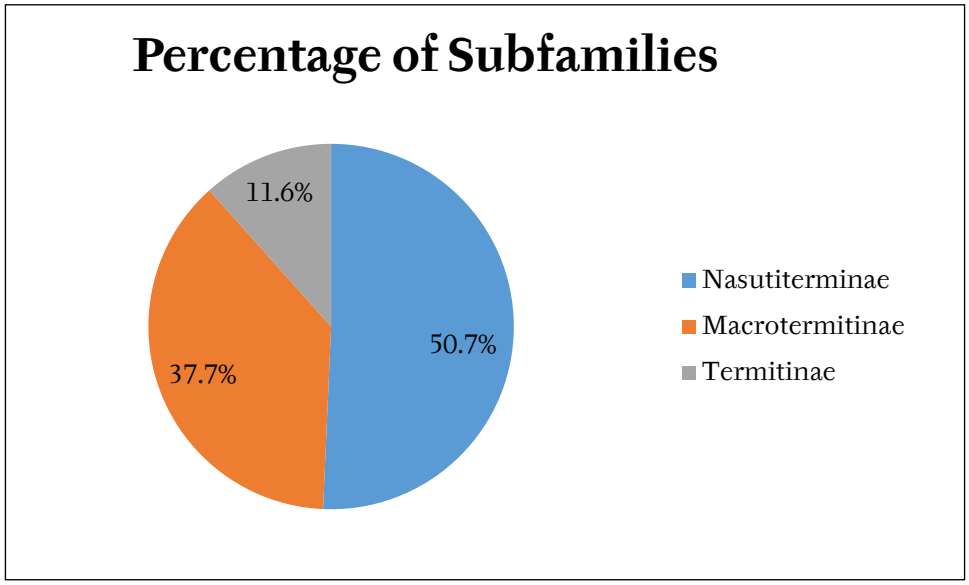

Figure 3. Subfamilies of Termitidae encountered in the Kwara State University campus, Malete, Nigeria

Evenness of termite assemblage in protected areas in central Côte d'Ivoire as reported by Dosso et al. (2013) ranged from 0.27 to 0.46 showing unevenness whereas the present study result shows relative evenness.

Generally, the identification of termites in Nigeria is difficult due to a lack of expertise and limited research carried out on this taxonomic group in the country, as Kemabonta and Balogun (2014) and Ugbomeh et al. (2019) also noted. In general, identifying West African termites is problematic and most taxa need revision (Korb et al., 2019). This limitation underscores the need for further research to enhance the identification and classification of termites not only in Nigeria and across West African

countries, but throughout the continent. Addressing these knowledge gaps will contribute to a better understanding of termite ecology and facilitate more effective pest management strategies in the region.

In summary, the study area exhibited eight termite genera, with *T. geminatus* predominating as grass-feeders, reflecting the Derived Savanna environment characterised by a significant presence of grasses alongside sparse tree cover. While moderate diversity of termite species was observed overall, areas impacted by human activities showed reduced diversity. Understanding the abundance of termite species is crucial for effective control measures, and studies on species diversity in areas with anthropogenic activities are crucial for monitoring biodiversity loss in the environment.

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CONFLICT OF INTEREST

The authors declared no conflicts of interest concerning the research, authorship, and publication of this article.

ETHICAL COMPLIANCE

The authors have followed ethical standards in conducting the research and preparing the manuscript.

REFERENCES

Ahmad M. (1965): Termites (Isoptera) of Thailand. American Museum of Natural History 131: 1–114.

Ajao A.M., Oladimeji Y.U., Oladipo S.O., Adepoju S.A. (2018): Activity of mound building *Macrotermes bellicosus* (Isoptera: Termitidae) around Kwara State University campus guinea Savannah ecozone, Nigeria. Animal Research International 15: 2918–2925.

Alamu O.T. Ewete F.K., Jimoh, S.O. (2018): Occurrence and diversity of termite species in *Eucalyptus* plantations in Afaka, Kaduna state, Nigeria. Journal of Research in Forestry, Wildlife and Environment 10: 33–38.

Anantharaju T., Kaur G., Gajalakshmi S., Abbasi S.A. (2014): Sampling and identification of termites in Northeastern Puducherry. Journal of Entomology and Zoology Studies 2: 225–230.

Christopher M., Jacob Y., Bruno N. (2013): Damage caused by termites (Isoptera: Termitidae) in coconut nurseries of Rufiji District, Tanzania. International Journal of Agricultural Science Research 2: 227–233.

Donovan S.E., Eggleton P., Bignell D.E. (2001): Gut content analysis and a new feeding group classification of termites (Isoptera). Ecological Entomology 26: 356–366.

Dosso K., Yeo K., Konate S., Linsenmair K.E. (2013): Importance of protected areas for biodiversity conservation in central Côte d'Ivoire: Comparison of termite assemblages between two neighboring areas under differing levels of disturbance. Journal of Insect Science 12: 121–131.

Engel M.S., Grimaldi D.A., Krishna K. (2009): Termites (Isoptera): their phylogeny, classification, and rise to ecological dominance. American Museum Novitates 3650: 1–27.

Hammer O., Harper D.A.T, Ryan P.D. (2001): PAST: Paleontological Statistics software package for education and data analysis. Palaeontologia Electronica 4: 1–9.

Jones D.T., Eggleton P. (2000): Sampling termite assemblages in tropical forests: testing a rapid biodiversity assessment protocol. Journal of Applied Ecology 37: 191–203.

Kemabonta K.A., Balogun S.A. (2014): Species richness, diversity and relative abundance of termites (Insecta: Isoptera) in the University of Lagos, Lagos, Nigeria. FUTA Journal of Research in Sciences 2: 188–197.

Kirton G.L. (2005): The importance of accurate termite taxonomy in the broader perspective of termite management. Proceedings of the Fifth International Conference on Urban Pests. P & Y Design Network, Malaysia.

Korb J., Kasseney B.D., TétéCakpo Y., CasallaDaza R.H., Gbenyedji J.N.K.B., Ilboudo M.E., Josens G., Koné N.A., Meusemann K., Ndiaye A.B., Okweche S.I., Poulsen M., Roisin Y., Sankara F. (2019): Termite Taxonomy, Challenges and Prospects: West Africa, A Case Example. Insects 10: 1–8.

Krishna K., Grimaldi D.A., Krishna V., Engel M.S. (2013): Treatise on the Isoptera of the world. Bulletin of the American Museum of Natural History 7: 2433–2705.

Lavelle P. (1997): Faunal activities and soil processes: adaptive strategies that determine ecosystem function. Advanced Ecological Research 27: 93–132.

Microsoft Corporation (2013): Microsoft Excel (Computer software).

Ojija F., Kavishe, R. (2016): A preliminary study on abundance and diversity of aquatic macro invertebrates of Nzovwe Stream, in Mbeya, Tanzania. International Journal of Life Sciences Research 4: 29–38.

Olugbemi B.O., Malaka S.L.O. (1994): Effects of food on recruitment activities in *Microcerotermes fuscotibialis*. Journal of Scientific Research and Development 1: 69–73.

Rahman H., Tawatao N. (2003): Isoptera. Introductory course to entomology 1: 121–133.

Schyra J., Hausberger B., Korb J. (2018): Phylogenetic community structure of southern African termites (Isoptera). Sociobiology 65: 15–23.

Sornnuwat Y., Vongkaluang C., Takematsu. Y. (2004): A Systematic Key to Termites of Thailand. Kasetsart Journal (National Science) 38: 349–368.

Ugbomeh A.P., Membere O., Efuka A., Bawo, D.D.S. (2019): A rapid survey of the arboreal termites in a university environment in Port Harcourt, Nigeria. The Journal of Basic and Applied Zoology 80: 1–8.

Uys V. (2002): A Guide to the Termite Genera of Southern Africa. Plant Protection Research Institute Handbook. Agricultural Research Council, Pretoria 5: 1–113

Vidyashree A.S., Kalleshwaraswamy C.M., Mahadeva–Swamy H.M., Asokan R., Adarsha S.K. (2018): Morphological, molecular identification and phylogenetic analysis of termites from western Ghats of Karnataka, India. Journal of Asia-Pacific Entomology 21: 140–149.

Vrsansky P., Aristov D. (2014): Termites (Isoptera) from the Jurassic/Cretaceous boundary: Evidence for the longevity of their earliest genera. European Journal of Entomology 111: 137–141. DOI: 10.14411/eje.2014.014.

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