Morphological Identification and Molecular Characterization of Termites in Selected Areas in Keffi, Nasarawa State, Nigeria

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ABSTRACT

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 study aimed to determine the morphological identification and molecular characterization of termites in selected areas in Keffi, Nasarawa State. Ten (10) soldiers and ten (10) worker termites were randomly sampled for identification from each study locations. In this study, head color, size, and shape, number of antennae segments, mandible shape, pronotum shape, and gula shape were considered as morphological characters and compared with identification keys. Species richness, dominance, and evenness or equitability indices were determined using Shannon–Wiener diversity index and Margalef's index. A total of one hundred and twenty-one (121) termite was in this study. Three subfamilies were represented: Nasutitermitinae, which included Trinervitermesgeminatus (58). Macrotermitinae, consisting of Macrotermesbellicosus (43), and Macrotermessubhyalinus (11). Termitinae, composed of Microcerotermessp (9). Macrotermitinae and Macrotermessubhyalinus constituted 35.5% and 9.1% respectively. Microcerotermessp recorded the list percentage occurrence of 7.4%. The species diversity indices varied between locations. GRA exhibited the highest Shannon-Wiener diversity index (1.168), whereas Angwan Lambu recorded the lowest (0.6364). Similarly, Simpson's diversity index was highest in GRA (0.64) and lowest in Angwan Lambu (0.44). Regarding species richness, the Margalef index indicated the highest value in GRA (1.001), contrasting with the lowest value observed in El- Kabir (0.3338). 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.

Keywords: Termite, Isoptera, DNA Extraction, Gel Electrophoresis, Keffi, Nigeria

INTRODUCTION

Termites are social insects living in colonies. They are sometimes called white “ants”, however they are not ants, because the true ants belong to the Order Hymenoptera, while termites belong to the Order Isoptera (Grimaldi and Engel, 2015). Engel and Krishna (2014), grouped termites into 6 families, 170 genera and about 2600 species, of which 300 species are said to be of economic importance. Termites can be divided into three general categories based on their habitat: damp wood, dry wood and subterranean (Paul and Rueben, 2013). According to Paul and Rueben (2013), damp wood termites do not present wide spread pest problems, but can be problematic under certain conditions, dry wood termites are significant and costly pests, while the subterranean termites are the major urban pests. Termites are essential members of the soil ecosystem and are found throughout the world (Abdel and Skai, 2011). They are the most important fauna in nutrient recycling, improving soil fertility and serving as food sources for other animals. On the other hand, termites are highly destructive and polyphagous pests of cropplants, which damage green foliage, seedlings, forests, pasture, wooden structures, fibers including household cellulose-based materials, and postharvest stored products (Upadhyay 2013).

The interaction of termite with man arises as a result of man’s interference with natural food supply of termite and with its environment (Edwards and Mill, 2011). However, since their food supply is mainly wood and

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woody tissues of plant, they do come into direct competition with man resulting in great loss of properties and amenities. Termites are one of the main types of destructive insects attacking buildings in tropical areas (Ghaly and Edwards 2011). The destructive activities of termites as a result of their feeding habits cannot be over emphasized

MATERIALS AND METHODS

3.1 Sampling Design.

Samples were collected from New Market, El-Kabir, Pyanku, AngwanLambu, Government Residential Area (G.R.A) and G.S.S Yelwa. From each survey region, two to three districts would be selected for sampling based on their accessibility and proximity to roads. From each site, 10 soldiers and 10 worker termites were randomly sampled for identification. Samples were collected by opening termite nests.

Samples were collected from available mould in the morning and late evening. Termites were extracted from the sample soil by hand-sorting using a moistened preserved in 97% alcohol.

3.2 Morphological Identification

Soldiers were used for identification to species level using morphological characters. In this study, head color, size, and shape, number of antennae segments, mandible shape, pronotum shape, and gula shape were considered as morphological characters in the identification keys. Species determination was made based on previous descriptions of morphological identification using taxonomic key by Krishna et al., (2013) for Macrotermitinae; key described by Bagine (1986) wasused to characterize the genus Odontotermes; morphological characters described by Rambur (1842) and Grassé (1937) wereused for Macrotermes; and descriptions used by Chhotani (1997) was used for Microtermes. Samples containing only workers will be subjected to molecular identification. Coordinates of each collection location was be taken.

3.3 Molecular Characterization

3.3.1 DNA Extraction Using Nimr Biotech Kit

Extraction of the termite tissues of individual mosquitoes using genomic DNA purification kit for isolation of DNA. All of each individual termites were placed in 2ml Eppendorf tube with pestle.Homogenized in 500µl lysis buffer and vortex the mixtures and incubate at 56℃ for 10min then centrifuge at 10,000 rpm for 1 minutes. After spinning, 200µl of absolute ethanol was added to the tube. The mixture was transfer into spin column and centrifuge at 10,000rpm for 30 sec, discard the flow-through and blot the collection tube on a tissue paper. 500µl of wash buffer 1 was added to the spin column, then centrifuge at 10,000 rpm for 30 sec follows the discard of flow-through and blots the collection tube on a tissue paper. the spin column was centrifugeagain at 12,000rpm for 3minutes to remove all the traces of ethanol, thereafter; the spin column is placed in another microcentrifuge tube. 50µl of elution buffer was added to the Centre of the column then incubate at room temperature for 1 to 2 mins and centrifuge at 10,000rpm for 1 minute to elute the DNA. It was repeated 7 times for increased DNA yield.

3.3.2 Gel Electrophoresis

1.5g of agarose gel with 100ml of Tris-acetate- Ethylene-diamine tetra acetic acid (EDTA) was used in electrophoresed of the PCR product. The agarose was melted in a microwave for about 2mins until and allowed to cool satisfactorily. The gel was stained with 5µl Ethidium Bromide for the visualization and detection of amplified DNA fragment, after cooling, the gel was poured into a clean well casting chamber and electrophoresis comb had been inserted to create wells into which amplicons were loaded. The cast was placed in the electrophoresis tank containing 1X to cover the gel and wells follows by the removal of the comb from the well. Molecular ladder (5µl) was dispensed into the first well followed by 7µl of each amplicon were appropriately loaded and run at 80v with 150mA for an hour. The gel was viewed and taken under UV transilluminator for documentation.

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3.4 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 equ-

itability 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:

H - Shannon diversity index;

pi - proportion of individuals of the species in a whole community; or proportion of total sample represented by species. Divide no. of individuals of species n by total number of samples N (pi=n/N)

S = No of species/species richness

∑ - sum symbol; and

ln - natural logarithm, but the base of the logarithm is arbitrary (10 and 2 based logarithms are also used).

n - individuals of a given type/species; and

N - total number of individuals in a community,

Hmax = ln(S) = maximum diversity possible

Evenness (E)= H/Hmax

Table 1: Termite taxa and relative abundance of species encountered within the study areas in Keffi, Nasarawa State, Nigeria.

FAMILY	SUB-FAMILY	TERMITE SPECIES	New market	El-Kabir	Pyanku	AngwanLambu	G.R.A	G.S.S Yalwa	Total Encounter (%)
Termitidae	Nasutiterminae	*Trinervitermesgeminatus*	5 (8.6)	10 (17.2)	19 (32.8)	8 (13.8)	10 (17.2)	6 (10.3)	58 (49.3)
	Macrotermitinae	*Macrotermesbellicosus*	10 (23.3)	10 (23.3)	3 (7.0)	4 (9.3)	6 (14.0)	10 (23.3)	43 (35.5)
		Macrotermessubhyalinus	5 (45.5)	0 (0.0)	0 (0.0)	0 (0.0)	2 (18.2)	4 (36.4)	11 (9.1)
	Termitinae	*Microcerotermes* sp.	0 (0.0)	0 (0.0)	7 (77.8)	0	2 (22.2)	0 (0.0)	9 (7.4)
Total			20 (16.5)	20 (16.5)	29 (24.0)	12 (9.9)	20 (16.5)	20 (16.5)	121 (100)

The survey of termite conducted within the Keffi recorded a total of one hundred and twenty-one (121) termite encounters, identifying four distinct species in three genera within the family Termitidae. Three subfamilies were represented: Nasutitermitinae, which included Trinervitermesgeminatus(58, 49.3%).Macrotermitinae, consisting of Macrotermesbellicosus(43, 35.5%), and Macrotermessubhyalinus(11, 9.1%).Termitinae, composed of Microcerotermes sp. (Table 1). Nasutitermitinae species accounted for the highest(49.3%) of the total species collected, while Macrotermitinae and Macrotermessubhyalinus constituted 35.5% and 9.1% respectively.Microcerotermessp recorded the list percentage occurrence of 7.4%.

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Table 2: Species diversity and richness indices as calculated for termites encountered

Parameters	New market	El-Kabir	Pyanku	AngwanLambu	G.R.A	G.S.S Yalwa
Dominance_D	0.375	0.5	0.4982	0.5556	0.36	0.38
Simpson_1-D	0.625	0.5	0.5018	0.4444	0.64	0.62
Shannon_H	1.04	0.6931	0.8548	0.6365	1.168	1.03
Evenness_e^H/S	0.9428	1	0.7837	0.9449	0.8041	0.9334
Margalef	0.6676	0.3338	0.5939	0.4024	1.001	0.6676

The species diversity indices varied between locations. GRA exhibited the highest Shannon-Wiener diversity index (1.168), whereas AngwanLambu recorded the lowest (0.6364). Similarly, Simpson's diversity index was highest in GRA (0.64) and lowest in AngwanLambu (0.44). Regarding species richness, the Margalef index indicated the highest value in GRA (1.001), contrasting with the lowest value observed in El- Kabir (0.3338) (Table 2). Pielou's evenness indices revealed variations across the sampled locations.

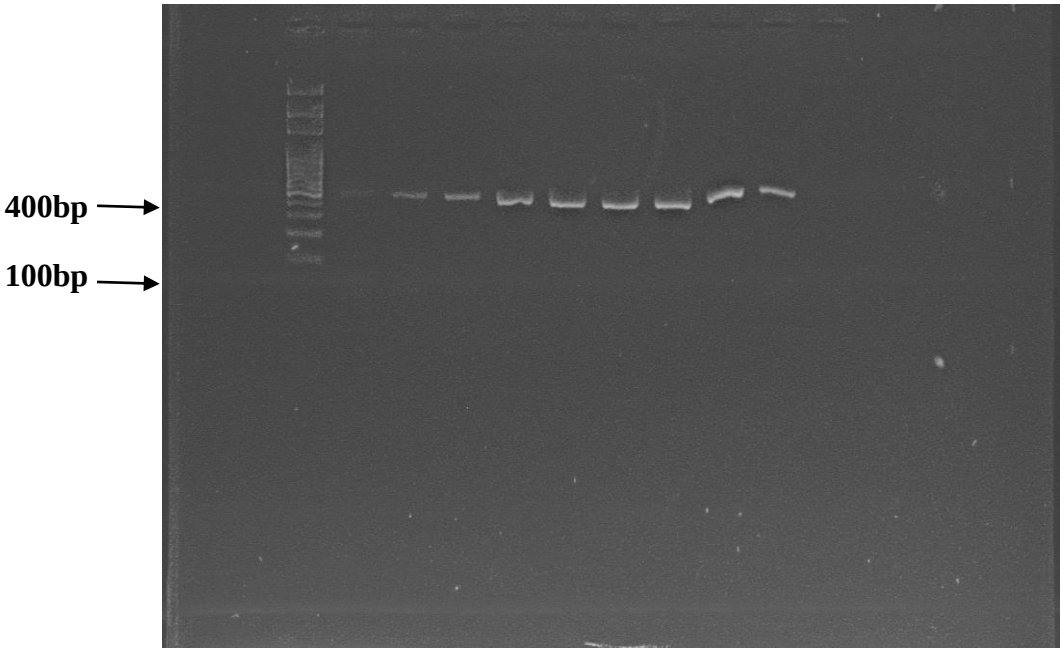


Fig. 2 Lane M= molecular DNA ladder; Lane 1-9= DNA of termite 1, 2, 3 -Trinervitermes geminates, 5, 6, 7-Macrotermes bellicosus 4, 8, 9- Microtermes sp ; Lane NC=Negative Control

DISCUSSION

The survey of termite conducted within the Keffi recorded a total of 121 termite encounters, identifying four distinct species in three genera within the family Termitidae. Three subfamilies were represented: Nasutitermitinae, which included Trinervitermesgeminatus. Macrotermitinae, consisting of Macrotermesbellicosus, and Macrotermessubhyalinus. Termitinae, composed of Microcerotermes sp. Nasutitermitinae species accounted for 49.3% of the total species collected, while Macrotermitinae and Termitinae constituted 44.6% and 7.4% respectively.

A similar survey of arboreal termites in the Port Harcourt University environment revealed termites identified as Amitermes sp., Nasutitermeshavilandi, Odontotermes sp., Microcerotermes sp., Glyptotermes sp., and Globitermes sp. (Ugbomehet 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, 2022) as opposed to the present study where T. geminatus was the most abundant.

Alamu et al., (2018) reported that members of Nasutitermitinae constituted 14 % of the total encountered termites in Eucalyptus plantations, 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, 44.6%.

The diversity index recorded within Keffi indicated a moderate diversity, ranging from 0.36 to 1.2 at different areas. 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 0.51–1.66 (Kemabonta and Balogun, 2022).

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 (Anantharajuet al., 2019) which was closer to evenness values in the Keffi ranging from 0.4 to 1.0 across the locations.

CONCLUSION

The study area exhibited four termite genera, with T. geminatus predominating as grass-feeders, reflecting the Derived Savanna environment characterized 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.

REFERENCES

1. Abdel G, Skai E (2011). Termite Damage to Buildings: Nature of Attacksand Preventive Construction Methods. American Journal of Applied Sciences 4(2):187-200.
2. Abe, T., Bignell, D.E., and Higashi, M. (2020).Termites: Evolution, Socially, Symbioses, Ecology. Kluwer Academic Publishers. 256pp.
3. Ackerman IL, Constantino R, Gauch HG, Lehmann J, Riha SJ, Erick CMF (2019) Termite (Insecta: Isoptera) Species Composition in a Primary Rain Forest and Agroforests in Central Amazonia. The Association for Tropical Biology and Conservation Biotropica41(2):226– 233
4. Ahmad, S. S and Yaacob, A.W. (2015).Termites from Selected Building Premises in Selangor Peninsular Malaysia. Malaysian Forester 60: 203 – 215.
5. Alamu, O.T. Ewete, F.K., and 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.
6. Anantharaju T., Kaur G., Gajalakshmi S., Abbasi S.A. (2019): Sampling and identification of termites in Northeastern Puducherry. Journal of Entomology and Zoology Studies 2: 225–230.
7. Bignell, D. E. (2010). Introduction to symbiosis.In:Termites: Evolution, Sociality and Ecology. Kluwer Academic Publishers, Dordrecht, The Netherlands. 189 – 208pp.
8. Bignell, D. E., & Eggleton, P. (2011). Termites in ecosystems. In T. Abe, D. E. Bignell, &H. Higashi (Eds.), Termites: Evolution, sociality, symbiosis, ecology (pp. 363–387). Dordrecht: Kluwer Academic Publishers.
9. Bignell, D. E., Roisin, Y., & Lo, N. (2011).Biology of termites: A modern synthesis (p. 576). Dordrecht: Springer.
10. Chouvenc, T., Su, N.-Y., 2010.Apparent synergy among defense mechanisms insubterranean termites (Rhinotermitidae) against epizootic events – The limitsand potential for biological control. Journal of Economic Entomology 103,1327–1337
11. Culliney, T.W., Grace, J.K., (2010). Prospects for the biological control of subterraneantermites (Isoptera: Rhinotermitidae), with special reference to Coptotermesformosanus. Bulletin of Entomological Research 90, 9–21.

12. Davies AB, Berndt JV, Rensburg, Eggleton P, Parr CL (2012). Assessing the efficiency of termite sampling methods in southern African savannas. Journal of insect conservation University of Van Pretoria 76-77
13. Davis, P. (2019). "Termite Identification". Entomology at Western Australian Department of Agriculture.Archived from the original on 2009-06-12.
14. Dawes, T.Z., 2010. Reestablishment of ecological functioning by mulching and termite invasion in a degraded soil in an Australian savanna. Soil Biol. Biochem., 42: 1825-1834.
15. Dean, S., & Gold, R. (2014). Sex ratios and development of the reproductive system in castesofReticulitermes flavipes (Kollar) (Isoptera: Rhinotermitidae). Annals of the Entomological Society of America, 97, 147–152.
16. Donovan, S.E., P. Eggleton, W.E. Dubbin, M.Batchelder and L. Dibong, (2011). The effect of asoil-feeding termite, Cubitermesfungifaber(Isoptera: Termitidae) on soil properties: Termitesmay be an important source of soil microhabitatheterogeneity in tropical forests. Pedobiologia, 45:1-11.
17. Edwards, R. and Mill, A.E. (2011).Termites in Buildings.Their Biology and Control.Rentokil Ltd., West Sussex, U.K. 54 – 67pp.
18. Eggleton, P. (2017). Biological Letters, June 7, cited in Science News Vol. 171, p. 318.
19. Engel, M.S. and Krishna, K. (2014).“Family-group names for Termites (Isoptera)”. American Museum Novitates 3432: 1-9.
20. Fei, H. & Henderson, G. (2014) Effects of temperature, directionalaspects, light conditions, and termite species on subterranean termiteactivity (Isoptera: Rhinotermitidae). Environmental Entomology, 33,242–248.
21. Forschler, B. T. (1999a). Biology of subterranean termites of the genus Reticulitermes. Part II, pp. 31-50. In National pest control association research report on subterranean termites. National Pest Control Association Publications.DunanLoring, VA.
22. Forschler, B. T. and Jenkins, T. M. (2000). Subterranean Termites in the Urban Landscape: Understanding their social structure is the key to successfully implementing population management using bait technology. Urban Ecosystems 4: 231 – 251pp.
23. Ghaly, A.; and Edwards, S. (2011). Termite damage to buildings: Nature of attacks and preventive construction methods.Ame. Journal of England and Applied Sciences, 4, 187–200.
24. Grace, J.K., 2003. Approaches to biological control of termites. Sociobiology 41, 115–121.
25. Grace, J.K., Ewart, D.M., 1996. Recombinant cells of Pseudomonas fluorescens: ahighly palatable encapsulation for delivery of genetically engineered toxins tosubterranean termites (Isoptera: Rhinotermitidae). Letters in Applied Microbiology 23, 183–186.
26. Grimaldi, D. and Engel, M.S. (2015).Evolution of the Insects.Cambridge University Press. 145pp.
27. Hamilton, C. and Bulmer, M.S. (2012) Molecular antifungal defensesin subterranean termites: RNA interference reveals in vivo rolesoftermicins and GNBPs against a naturally encountered pathogen.Developmental and Comparative Immunology, 36, 372–377.
28. Hemachandra J, Edirisinghe P, Karunaratne WAIP, Gunatilleke CVS (2010). Distinctiveness of termite assemblages in two Fragmented Forest types in Hantane hills in the Kandy district of Sri Lanka. Ceylon Journal of Science (Biological Sciences); 39(1):11-19
29. Hinze, B., Crailsheim, K., &Leuthold, R. H. (2012).Polyethism in food processing and socialorganization in the nest of Macrotermesbellicosus(Isoptera, Termitidae). Insectes Sociaux,49, 31–37.
30. I.L. Ackerman, W.G. Teixeira, S.J. Riha, J. Lehmann, E.C.M. Fernandes, The impact of mound-building termites on surface soil properties in a secondary forest of Central Amazonia, Appl. Soil Ecol. 37 (2007) 267e276.
31. Imamura, Y., &Fujii, Y. (1995). Analysis of feeding activities of termites by AE monitoring ofinfested wood (in Japanese). Wood Preservation, 21, 11–19.
32. Inward, D. J. G., Vogler, A. P., &Eggleton, P. (2007a). A comprehensive phylogenetic analysisof termites (Isoptera) illuminates key aspects of their evolutionary biology. MolecularPhylogenetics and Evolution, 44, 953–967.
33. J.A. Holt, M. Lepage, Termites and soil properties. in: T. Abe, D.E. Bignell,M. Higashi (Eds.), Termites: Evolution, Sociality, Symbioses, Ecology. KluwerAcademic Publishers, Dordrecht, 2000, pp. 389e407.

34. Jones, S.C. and Nutting, W. L. (2009).Foraging Ecology of Subterranean Termites in the Sonoran Desert. In: Special Biotic Relationships in the Arid Southwest. University of New Mexico Press, Albuquerque, N.M. 79 – 106pp.
35. Kemabonta, K.A., and Balogun, S.A. (2022): 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.
36. Korb, J. and K. Hartfelder, (2018). Life history and development-a framework for understanding developmental plasticity in lower termites. Biol.Rev., 83: 295-313. DOI: 10.1111/j.1469-185X.2008.00044.x
37. Lee, C. Y. (2012). Subterranean Termite Pest and their Control in the Urban Environment in Malaysia. Sociobiology 40: 3 – 9.
38. Lee, K. E. and Wood, T. G. (2010).Termites and Soils.CABI Publishing. New York, N.Y. Pp. 1-24, 65-71.
39. Light, S. F. (1994).The Damp- Wood Termite, Paraneotermitessimplicicornis. In: Termites and Termite Control. University of California Press, Berkeley, C. A. 311 – 313pp.
40. Myles, T. G. (2015). Termite biology, urban entomology programme. Online at http://www.utoronto.ca/forest/termite/termite.htm
41. Nakayama, T., Yoshimura, T., & Imamura, Y. (2005).Feeding activities of CoptotermesformosanusShiraki and Reticulitermessperatus(Kolbe) as affected by moisture content of wood.Journal of Wood Science, 51, 60–65.
42. Nalepa, C. A., and C. Bandi. (2010). Characterizing the ancestors: paedomorphosis and termite evolution, pp. 53-76. In T. Abe, D.E. Brignell, and M. Higashi [eds.]. Termites: evolution, sociality, symbiosis, ecology.Kluwer Academic Pub. Dordrecht, The Netherlands.
43. Neoh, K.B.; Lee, C.Y. (2011). "Developmental stages and caste composition of a mature and incipient colony of the drywood termite, Cryptotermesdudleyi (Isoptera: Kalotermitidae)". Journal of Economic Entomology. 104 (2): 622–8. doi:10.1603/ec10346. PMID 21510214.
44. Noirot, C. (2010). Formation of Castes in the Higher Termites. In: Biology of Termites. Vol. 1.Academic Press, New York, N. Y. 311 – 350pp.
45. Noirot, C. and J.P.E.C. Darlington. 2000. Termite Nests: Architecture, Regulation and Defence, pp.121-139. In: T. Abe, D.E. Bignell and M. Higsahi, eds., Termites: Evolution, Sociality, Symbioses, and Ecology. Kluwer Academic Publishers, Dordrecht, The Netherlands.
46. Ohiagu, C.E. (1999). Nest and Soil population of Trinervitermes Spp. with particular References to Trinervitermesgerminatus (Wasmann) Isoptera in Southern Guinea Savanna, near Mokwa, Nigeria. Ecologia40 : 167-178.
47. Ohtoko, K., M. Ohkuma, S. Moriya, T. Inoue, R. Usami, and T. Kudo. 2000. Diverse genes of cellulase homologues of glycosyl hydrolase family 45 from the symbiotic protists in the hindgut of the termite Reticulitermessperatus. Extremophiles 4: 343-349.
48. Omkar, & Pervez, A. (2002). Influence of temperature on age specific fecundity of a ladybeetle,Micraspis discolor(Fabricius). International Journal of Tropical Insect Science, 22, 61–65.
49. Omkar, & Pervez, A. (2004).Temperature dependent development and immature survival of an aphidophagous ladybeetle, Propyleadissecta(Mulsant).Journal of Applied Entomology, 128, 510–514.
50. Paul, B. B. and Rueben, J. M. (2013).Arizona Termites of Economic importance. University of Arizona Press, Tucson, AZ. 9 – 17pp.
51. Pawson, B. M., and R. E. Gold. 1996. Caste differentiation and reproductive dynamics of the three subterranean termites in the genus Reticulitermes (Isoptera: Rhinotermitidae). Sociobiology 28: 241-251.
52. Pearce, M. J. (1997). Termites: Biology and Pest management. CABI Publishing. New York, N.Y. 86 – 92pp.
53. Piper, R. (2007). Extraordinary Animals: An Encyclopedia of Curious and Unusual animals. Greenwood Press. 125pp.