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SEASONAL DIVERSITY AND ABUNDANCE OF SUBTERRANEAN TERMITE SPECIES IN *EUCALYPTUS* PLANTATIONS IN AFAKA, NIGERIA

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ABSTRACT

Termites are important components of the soil insect biomass and contribute substantially to effective functioning of the ecosystem. Diversity and abundance of termites are always negatively affected by anthropogenic activities and climatic factors. This study evaluates the seasonal variation in the diversity and abundance of termite species in *Eucalyptus* plantations in Afaka, Kaduna State, Nigeria. Termite diversity and abundance were monitored in four *Eucalyptus* species (*Eucalyptus camaldulensis*, *Eucalyptus citriodora*, *Eucalyptus cloeziana* and *Eucalyptus tereticornis*) plantation during the dry and rainy seasons for over a period of two years. Termite samples were collected using wood board of *Terminalia ivorensis* measuring 30cm x 20 cm x 2 cm in dimension. Termite species diversity and evenness in the four *Eucalyptus* plantations were determined using Shannon-Weiner diversity and Pileou's (evenness) indices. The result showed that two termite species: *Microtermes* and *Ancistrotermes* species were prevalent in the four *Eucalyptus* species plantation, while *Macrotermes* species were the least. There were variations in the abundance of termite species at different season across the plantation. The highest (1561.30/0.6 m^2) population abundance of *Microtermes* sp. was recorded in *E. camaldulensis* plantation in January, 2013, while the lowest (35.00/0.6 m^2) was recorded in *E. citriodora* plantation in January, 2014. Similarly, the highest (495.85/0.6 m^2) population of *Ancistrotermes* sp. was recorded in *E. camaldulensis* plantation in January 2013, and the least (5.65/0.6 m^2) was recorded in *E. cloeziana* plantation in August, 2012. The Shannon-Weiner diversity (0.27 – 1.15) and Pileou's (evenness) (0.24 – 0.99) indices recorded for termites in different *Eucalyptus* species were generally low. The appropriate plantation management needs to be practiced to avoid biodiversity loss of important termite species in the ecosystem.

Keywords: Termite population, Diversity indices, *Eucalyptus*, Ecosystem, Afaka

Introduction

Deforestation is one the major environmental challenges relating to the survival and welfare of man globally and Nigeria in particular (Abdullahi *et al*., 2017; Ogunwale, 2015). In sub-Saharan African countries, the degradation of forest resources has led to the advancement of climate change culminated into different natural hazards (Lemenih, 2004). To overcome the environmental challenges and save the remaining natural forest, planting of fast growing tree species is the solution in order to satisfy the ever increasing demand for forest products. These fast growing exotic species is a viable opportunity to solve the current dilemma between conservation and livelihood needs.

Eucalyptus is an exotic tree species and a large genus of the Myrtaceae family, consisting of 900 species and subspecies. It is an evergreen tall tree that originated

from Australia and Tasmania. *Eucalyptus* is highly explored by man for medicinal purposes because of its anti-microbial, anti-inflammatory and antioxidant properties (Vecchio *et al*., 2016). In addition, the plant is used in forestry for timber, fuel and paper pulp; and environmentally, in the control of wind erosion. It is a fast-growing tree species with short rotation, tolerance to desiccation and drought, and of high economic benefits (Liu and Li, 2010). However, one of the major constraints in the plantation establishment of *Eucalyptus* worldwide is the problem of termite infestation.

Termites are described as ubiquitous insects in tropical, subtropical, and warm temperate regions and known to play an important role in ecosystems; and often referred to as ecosystem engineers (Buczkowski and Bertelsmeier, 2017). In tropical ecosystems, termites were reported to constitute over 10% of the total animal biomass and 95% of soil insect biomass (Jones and Eggleton, 2000) and are considered to enhance ecosystem productivity (Bourguignon *et al*., 2016). Their activities affect the processes and properties of soil structure and hydrology, nutrient availability, and organic matter decomposition (Ahmad *et al*., 2018). They are major contributors to the productivity and composition of plant communities through tunneling, breakdown and deposition of organic materials and soil movement within their natural habitats (Wickings and Grandy 2011; Maynard *et al*., 2015).

Some termite species are also significant economic pests in urban areas where they attack human-made structures and also in natural forest habitats. They are polyphagous in nature and are highly destructive pests of crop plants, and cause damage to green foliage, seedlings, wood, fibers including household cellulose-based materials, and postharvest stored products (Upadhyay, 2013). They infest roots and woody tissues of tree seedlings both in the nursery and field.

Termites' population, species richness and their distribution are important tools for determining environmental integrity. Their richness and abundance may be severely affected by habitat fragmentation, fire occurrence, cropping patterns, topography, and bioclimatic factors (Kalleshwaraswamy *et al*., 2018, Davies *et al*., 2012) which are leading causes of biodiversity loss. Termite population is dependent on environmental variables such as rainfall, soil moisture content, availability of food, soil texture and soil temperature. Termite diversity and abundant studies at the University of PortHacourt, Nigeria reported five termite species from two families: Termitidae (Amitermes spp1, Amitermes spp2, and Globitermes spp) and Macrotermitidae (Macrotermes gilvus and Macrotermes spp.) with Amitermes spp being the most abundant (Wekhe, 2019). Another study on species richness, diversity and relative abundance of termites in the University of Lagos, Nigeria recorded two families and six sub families (Rhinotermitinae, Amitermitinae, Macrotermitinae, Nasutitermitinae, Termitinae and Microcerotermitinae with *Amitermes* spp as the most abundant and widely distributed species (Kemabonta, 2014). The occurrence of seven termite species, *Macrotermes bellicosus*, *Macrotermes subhyalinus*, *Odontotermes obesus*, *Nasutitermes germinatus*, *Amitermes evuncifer*, *Microtermes* sp., and *Ancistrotermes* sp., all belonging to the family Termitidae have been reported foraging in different *Eucalyptus* plantations in Nigeria (Alamu *et al*.,

2017). However, there are no information on the abundance and seasonality of occurrence of termite species foraging on the plantation floor of Eucalyptus species in Afaka, Nigeria. This study therefore, seeks to put on record the abundance and seasonal occurrence of termite species in some *Eucalyptus* species plantation in Afaka, Nigeria.

Materials and methods

Description of the study area

The study area, Afaka, Kaduna State, Nigeria is located between latitude 10. 33° N – 10. 41° N and longitude 07. 26° E – 07. 28° E. The climate of Afaka is characterized by a clear distinction between dry and rainy seasons which last from late October to early April and mid-April to early October, respectively. The mean annual rainfall is 1266.0 mm based on annual rainfall record of forty-three years (1969 – 2012) (NIMET 2012). The main indigenous forest species are *Pakia biglobolsa* (Dorawa), *Ceiba petandra* (Silk Cotton), and *Andasonia digitata* (Kuka) while the exotic forest species include *Azadiracta indica* (Neem), *Tectona grandis* (Teak), *Eucalyptus* spp., *Gmelina* spp., and *Pinus caribea* (pine).

Seasonal variation in the abundance of termite species in *Eucalyptus* plantations

Estimate of termite diversity and abundance was carried out using wood board prepared from, *Terminalia ivorensis*, as bait. The dimension of each board was 30 cm long, 20 cm wide and 2 cm thick.. Twenty wood boards were arranged in each *Eucalyptus* plantation along transect lines (consisting of two diagonals) across a 100 m x 100m plot sample. The wood boards were placed in each plantation during the rainy season in August, 2012 and dry season in January, 2013 and repeated during the rainy season in August, 2013 and January, 2014. In each season, at 15 days after installation, the wood boards were gently lifted up and transferred into a polythene bag together with the termites attached to it and the soil excavated underneath the board up to a depth of 5cm with the aid of a spade and a hand trowel. All the polythene bags with the content were carried to the laboratory where the termites were sorted out and counted. Correlation analysis was carried out between the population abundance and soil parameters.

Determination of termite species diversity index

Termite species diversity and evenness in the four *Eucalyptus* plantations were determined using Shannon-Weiner diversity and Pileou's (evenness) indices.
Shannon-Weiner diversity index was calculated using the formula:
$H = -\sum P_i(\ln P_i)$
Where, P_i = proportion of each species in the sample
lnPi = natural logarithm of the proportion of each species in the sample.
Evenness index was calculated as follows:
J = H/lnS, where H = Shannon-Weiner diversity index;
S = number of species in the habitat.

Results

Seasonal abundance of termite species in *Eucalyptus* plantations

The most abundant termite species in August 2012 and January, 2013 in *E. camaldulensis* was *Microtermes sp*. representing 75.56% and 75.90%, respectively of the entire termite populations (Table 1). *Ancistrotermes* sp. was more in abundance than other termite species in August 2013 and January, 2014 with relative abundance of 69.18% and 65.56%, respectively. The abundance of

Macrotermes sp. recorded was the least in all seasons studied. Generally, the Shannon-Weiner diversity index was low across the seasons and it ranged between 0.48 and 0.69 while evenness was between 0.45 and 0.89. In *E. citriodora* plantation, with a relative abundance of 73.04% and 87.06%, *Microtermes* sp was more in abundance than *Ancistrotermes* sp. and *Macrotermes* sp. in August, 2012 and January, 2013, respectively. On the contrary, the number of *Ancistrotermes* sp was more in abundance than other termite species in August, 2013 and January, 2013. *Macrotermes* species, though present in all the seasons recorded the least abundance. The highest value of 1.09 was recorded for Shannon-Weiner index in August, 2013 while the value was less than one in the other seasons. The evenness value was between 0.42 and 0.99 (Table 2).

Table 3 showed that the abundance of *Microtermes* sp was more than other termite species in *E. cloeziana* plantation during the rainy and dry seasons from 2012 to 2014. The species of *Macrotermes* and *Ancistrotermes* were more in abundance than *Amitermes evuncifer* which was only detected in January, 2013 and August, 2013. The values of Shannon-Weiner index and evenness were in the range of 0.27 to 1.15 and 0.27 to 0.92, respectively. In *E. tereticornis* plantation, with an average of 205.65/0.6m^2 representing a relative abundance of 51.95% and 596.50/0.6m^2 representing a relative abundance of 71.30%, *Microtermes* sp was more in abundance than other termite species during the rainy season in August, 2012 and dry season in January, 2013 respectively. In August, 2013 and January, 2014 *Ancistrotermes sp.* was greater in number than *Macrotermes* and *Microtermes* species. Shannon-Weiner index and evenness were in the ranges of 0.62 to 1.00 and 0.44 to 0.91, respectively (Table 4).

Table 1: Seasonal abundance (per 0.6m^2) and diversity index of termites in *Eucalyptus camaldulensis* plantation in Afaka, Kaduna State.

Termite species	August 2012		January 2013		August 2013		January 2014	
	Abundance	Relative abundance (%)	Abundance	Relative abundance (%)	Abundance	Relative abundance (%)	Abundance	Relative abundance (%)
Macrotermes sp.	10.90	5.53	0.00	0.00	0.00	0.00	14.15	7.81
Ancistrotermes sp.	37.65	19.11	495.85	24.10	482.20	69.18	118.80	65.56
Microtermes sp.	148.45	75.56	1561.30	75.90	214.80	30.82	48.25	26.63
Total	197		2057.15		697.00		181.20	
Shannon-Weiner index (H')	0.69		0.55		0.62		0.48	
Evenness (J)	0.62		0.79		0.89		0.45	

Table 2: Seasonal abundance (per 0.6 m^2) and diversity index of termites in *Eucalyptus citriodora* plantation in Afaka, Kaduna State

Termite species	August 2012		January 2013		August 2013		January 2014	
	Abundance	Relative abundance (%)	Abundance	Relative abundance (%)	Abundance	Relative abundance (%)	Abundance	Relative abundance (%)
Macrotermes sp.	4.80	5.32	25.95	5.34	58.10	15.97	6.96	3.34
Ancistrotermes sp.	19.50	21.63	36.90	7.60	197.10	54.19	166.50	79.87
Microtermes sp.	65.85	73.04	422.75	87.06	108.50	29.83	35.00	16.79

Total	90.15	485.60	363.70	208.46
Shannon-Weiner index (H')	0.64	0.47	1.09	0.58
Evenness (J)	0.58	0.42	0.99	0.53

Table 3: Seasonal abundance (per 0.6m^2) and diversity index of termites in *Eucalyptus cloeziana* plantation in Afaka, Kaduna State

Termite species	August 2012		January 2013		August 2013		January 2014	
	Abundance	Relative abundance (%)	Abundance	Relative abundance (%)	Abundance	Relative abundance (%)	Abundance	Relative abundance (%)
Macrotermes sp.	12.25	4.41	23.20	3.91	33.40	8.02	136.85	21.98
Ancistrotermes sp.	5.65	2.03	87.70	14.79	74.10	17.80	152.85	24.55
Microtermes sp.	259.95	93.56	256.55	43.27	278.70	66.96	332.9	53.47
Amitermes sp.	0.00	0.00	225.40	38.02	30.00	7.21	0.00	0.00
Total	277.85		592.85		416.20		622.60	
Shannon-Weiner index (H')	0.27		1.15		0.97		1.01	
Evenness (J)	0.24		0.83		0.70		0.92	

Table 4: Seasonal abundance (per 0.6m^2) and diversity index of termites in *Eucalyptus tereticornis* plantation in Afaka, Kaduna State

Termite species	August 2012		January 2013		August 2013		January 2014	
	Abundance	Relative abundance (%)	Abundance	Relative abundance (%)	Abundance	Relative abundance (%)	Abundance	Relative abundance (%)
Macrotermes sp.	15.85	4.00	6.45	0.77	56.50	12.31	0.05	0.01
Ancistrotermes sp.	174.4	44.05	233.70	27.93	266.90	58.14	377.20	68.45
Microtermes sp.	205.65	51.95	596.50	71.30	135.70	29.56	173.80	31.54
Total	395.90		836.65		459.10		551.05	
Shannon-Weiner index (H')	0.83		0.64		1.00		0.62	
Evenness (J)	0.76		0.58		0.91		0.44	

Discussion

Termite population in terms of abundance varied among the four *Eucalyptus* plantations in different seasons. The population of *Macrotermes* species was low in all the plantations compared to the populations of *Microtermes* and *Ancistrotermes* species being mainly attributed to the destruction of epigeal termite mounds by farmers in order to reduce termite infestation on crops in the adjacent farmlands. This is similar to the report of Ogedegbe and Ogwu (2015) that farmers destroy termite mounds as a means of controlling termites in Ugoniyekorhionmwon Community, Edo State, Nigeria. However, termite mounds in the adjacent lands to the plantation may serve as sources of *Macrotermes* species foraging in the plantations. The populations of *Microtermes* and *Ancistrotermes* were generally higher than that of *Macrotermes* species. Species of *Microtermes* and *Ancistrotermes* are subterranean nesters and are thus difficult to be discovered and destroyed unlike epigeal mounds built by *Macrotermes* species. This confirmed the reports by some scientists that subterranean termites are more abundant than the mound builders in tropical regions (Abbadie and Lepage, 1989; Abensperg-Traun and De Boer, 1990).

Low values of Shannon-Weiner index indicates that the population of termite species in *Eucalyptus* plantations in the study area were unevenly distributed. It showed the dominance of one or two species over the other termite species. This is clearly evident in the abundance of *Ancistrotermes* and *Microtermes* species than the remaining termite species encountered in the plantations. The generally low diversity of termite recorded in the plantations could be as a result of habitat disturbances such as unchecked felling of trees, indiscriminate annual bush burning by the Fulani herdsmen and continuous grazing of their cattles in the plantation which are associated with *Eucalyptus* plantations in Afaka. Indiscriminate felling of trees and bush burning may cause depreciation of canopy closure which could lead to direct sunlight on the soil surface thereby leading to an increase in environmental temperature. The level of habitat disturbance and its influence had been reported to have significant negative correlation to the structure of termite communities (Pribadi *et al*., 2011; Gathorne-Hardy *et al*., 2002). Fire occurrence has been described to indirectly impact the diversity, relative abundance, and distribution of termites especially in the savanna ecosystems (Davies *et al*., 2012). This was further confirmed that the distribution and abundance of termites were found to be significantly correlated with a set of environmental variables such as fire occurrence, herbaceous species richness, woody plant species richness, woody plant diversity, woody plant families' diversity, and organic carbon (Kone *et al*., 2018). However, fire occurrence was identified to be the most important disturbance factor, modeling termite assemblage's characteristics within habitats. In agreement with this statement, the development of species richness within different habitats may be explained by the fact that the annual burning characterizing the savannah ecosystems could lead to relatively high habitat instability, with less diversified food availability (Kone *et al*., 2018). Hence, this burning disturbance activity allows the persistence of only disturbance-adapted species (Dosso *et al*., 2010).

Variation in termite diversity across different habitats has also been attributed to

anthropogenic disturbance, cropping patterns, topography, and bioclimatic factors (Kalleshwaraswamy *et al*., 2018). Habitat loss also has been confirmed to have negative impacts on species richness, population abundance and genetic diversity (Aguilar *et al*., 2008; Laurance *et al*., 2002). Habitat loss can as well shorten trophic chain length, alter species interactions; and reduce successful foraging, breeding, and dispersal of organisms (Fahrig, 2003). The use of fire in *Eucalyptus* plantation should be discouraged as it negatively impacts termite diversity in the plantation. Not all termites are destructive, a larger percentage of them are important component of ecosystem and enhances effective ecosystem functioning.

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