Geo-Eco-Trop, 1977, 1 (2), 139-148

POPULATIONS OF TERMITES (ISOPTERA) IN NATURAL AND AGRICULTURAL ECOSYSTEMS IN SOUTHERN GUINEA SAVANNA NEAR MOKWA, NIGERIA *

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RÉSUMÉ

Les populations de Termites (Isoptères) des écosystèmes naturels et des agro-écosystèmes de la savane sud-guinéenne, près de Mokwa, Nigéria.

Des études qualitatives et quantitatives des populations de Termites ont été effectuées en savanes boisées naturelle et secondaire, en pâturage et en cultures de maïs. La diversité en Termites y est respectivement de 23, 22, 20 et de 4 à 8. La culture amène la disparition rapide des espèces édificatrices de monticules épigés ainsi que celle plus lente des espèces lignivores. Par contre *Amitermes evuncifer* et *Microtermes* spp. augmentent en nombre et deviennent, au Nigéria, un fléau pour les récoltes.

ABSTRACT

Qualitative and quantitative studies have been made on termite populations in tropical savanna woodland on red Ferrisols witq a sandy clay loam topsoil and sandy clay subsoil. The sites included undisturbed savanna woodland, secondary woodland regenerating for 15 years after 1 year of cultivation and 9 years of fallow, first year grazed pasture and first year maize derived from this secondary woodland and maize grown on land mechanically cultivated for up to 24 years.

A total of 23 identifiable species occurred in undisturbed woodland, 22 in secondary woodland, 20 in grazed pasture, 8 in first year maize and 4 in maize grown on land cultivated for up to 24 years. Mechanised cultivation necessitates the destruction of the large mounds of *Macrotermes bellicosus* and the process of cultivation destroys the mounds of *M. subhyalinus*, those of 5 species of *Trinervi-*

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termes and the nests of *Cubitermes* and *Promirotermes* which occupy abandoned *Trinervitermes* mounds.

Species with subterranean nests are less drastically affected by cultivation although continious cultivation results in the loss of the wood-feeding *Microcerotermes*, *Ancistrotermes* and *Odontotermes* and of all of the soil-feeders except *Adaiphrotermes*. Two species increase in abundance under continuous cultivation. One, *Amitermes evuncifer* has a very under-dispersed distribution and the population data has a high variance. The second, *Microtermes* (a complex of 5 unidentified species) has a population density of 820/m2 in grazed pasture, 925/m2 in first year maize and 4425/m2 in maize grown on land cultivated for up to 24 years. *Microtermes* spp. and *Amitermes evuncifer* are the principal termite pests of crops in Nigeria.

INTRODUCTION

Termites are one of the dominant groups of arthropods in many tropical soils. Certain species cause damage to agricultural and tree crops (HARRIS, 1969, SANDS 1973), and pastures (WATSON and GAY , 1970 ; WOOD and OHIAGU, 1975) but the majority of species are not pests. Although different groups of termites with a variety of nesting habits and food sources, such as living and dead wood, grass, plant litter, dung and soil, have a significant role in decomposition processes (WOOD, 1975) the question of whether their presence has an overall beneficial or harmful effect on soils and plant growth remains unanswered (LEE and WOOD , 1971b). One of the major problems in assessing the effects of termite damage to crops or their effects on soils is that of sampling populations which are cryptic, highly mobile and strongly aggregated (LEE and WOOD , 1971b ; SANDS 1972). Consequently there is no information on the relationship between population density and crop damage or the factors which influence the abundance of pest and non-pest species. This paper presents preliminary results of a project, commenced in 1974, which aims to answer some of these questions, in particular those relating to the economic significance of termites in crops and pastures.

SITES

The experimental sites are located between 6 and 16 km north of Mokwa at elevations between 180 and 230m. Mokwa (90° 18'N, 5° 5'E) is close to the southern boundary of the Southern Guinea Savanna and has a mean annual rainfall of 1175 mm and a pronounced wet and dry season, with the latter extending approximately from mid-October to mid-April. The general area is gently undulating with broad interfluves and is occupied by soils of the Kulfo Association which are developed on coarse — grained Nupe Sandstone (VALETTE, 1973). The sites themselves occupy mid — to upper — slope positions on undifferentiated red Ferrisols which have a sandy surface layer with low water retention capacity

and clay content gradually increasing with depth to form a textural B horizon at 30 — 64cm (Dangappe Series) or 64 — 150cm (Kulfo Series). The natural vegetation is closed savanna woodland, 12-15m high, characterised by the presence of *Afzelia africana* Smith ex Perr., *Detarium microcarpum* Guill. and Perr. and *Burkea africana* Hook f.

The area has a complex agricultural history. Between 1949 and 1953 it was incorporated into the Niger Agricultural Project and some land was cleared and mechanically cultivated. When the scheme collapsed (BALDWIN, 1957) the project was taken over by the Northern Nigerian Government and cultivation was continued on some areas until 1959 when some of the land was handed over to Ahmadu Bello University to be run as an Agricultural Research Station. Much of this land reverted to bush after 1959 while some has been maintained in cultivation up to the present time. The sites which form the subject of the present paper can be grouped as follows, according to their history of land use :

(1) Undisturbed Woodland : plots 13 and 14.

(2) 15 — years old secondary woodland : plots 1 and 2. Cleared in 1949 and cultivated for 1 year with subsequent regeneration being prevented by cutting until 1958 when the area was left undisturbed.

(3) Grazed pasture : plots 4 and 5. Derived from 15 — year old secondary woodland by clearing and cultivating in 1974.

(4) Maize : Plots 7 and 9. Derived from 15 — year old secondary woodland by clearing and cultivating in 1974.

(5) Maize : Plot 97. On land mechanically cultivated and cropped from 1949 to the present time.

(6) Maize : Plot 98. On land mechanically cultivated from 1949 to 1952 untouched from 1952 to 1965 from which time it has been continuously cultivated.

Plots 1,12,4,5,9, and 7 form part of a randomised block experiment started in 1974 which includes other crops not considered here. Plot 97 is located 1.5 km SW, plot 98 1.5 km NE and plots 13 and 14,8.5 km NE of these experimental plots.

METHODS

Details of the methods used for sampling and extracting termites are described elsewhere (WOOD, JOHNSON and OHIAGU, unpubl.) The sampling area in each plot measured 30 m by 80 m and a total of 96 sampling units (cores of soil 10 cm diameter, 100 cm deep) were taken from each plot : 48 during the period 11th. June —23rd. July 1974 and 48 during the period 4th. September — 15th. November, 1974. Plots 97 and 98 were not sampled during the first period so that only 48 sampling units were taken from each of these plots.

RESULTS

Diversity of Species

The spatial distribution of the nest-systems of the species found in undisturbed woodland is shown in Fig. 1 Nests of *Coptotermes* are invariably associated with trees and may be above or below ground level. The mound — buiding species

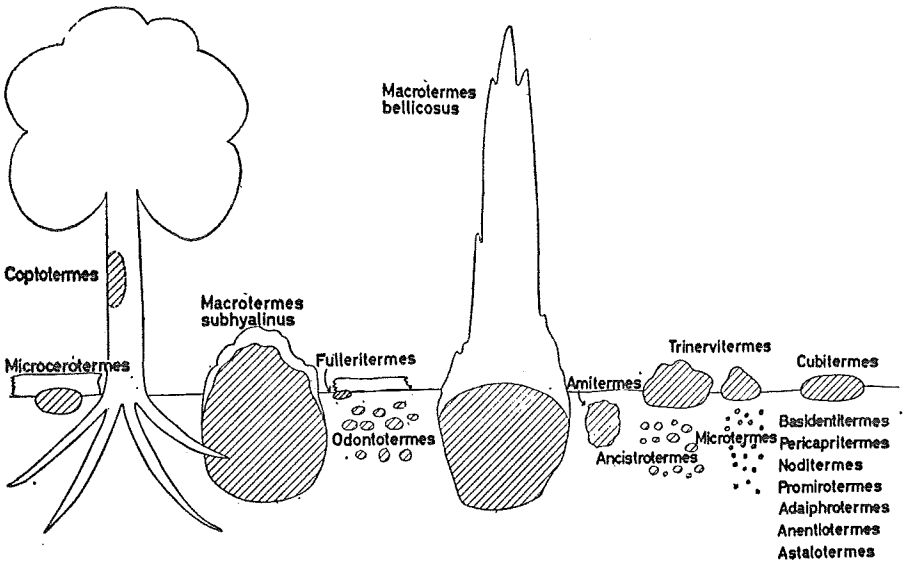

Fig. 1. Diagrammatic representation of the spatial distribution of the nests of different species of Termites in savanna woodland near Mokwa.

include *Trinervitermes geminatus*, T. *oeconomus* and *T. trinervius*, the abandoned mounds of which are often occupied and re-built by *T. occidentalis*, *T. togoensis* and *Cubitermes*. *Macrotermes bellicosus* builds large (up to 8 m high), « cathedral » — shaped mounds whereas *M. subhyalinus* builds low, irregularly domed mounds or may have a completely subterranean nest. Certain genera, such as the soil-feeding *Cubitermes* and *Promirotermes* are closely associated with abandoned mounds of *Trinervitermes*. The other soil-feeders either live in diffuse subterranean galleries (*Adaiphrotermes*, *Anenteotermes*, *Astalotermes*, *Basidentitermes* and *Pericapritermes*) or build a distinct nest just below the soil surface (*Noditermes*). The nests of the wood feeding *Microtermes* and *Fulleritermes* are located just below the soil surface, often in association with tree roots or logs. *Amitermes* is also completely subterranean but its nests are not as deep as those of the fungus — growing *Ancistrotermes*, *Odontotermes* and *Microtermes*, which in the case of the latter genus extend below depths of 2 metres.

The occurence of these species in the different sites is shown in Table 1. The greatest number of species occurs in undisturbed woodland, the total number being

TABLE 1. Distribution of Termites under different systems of land management.

Species	Undisturbed woodland	Secondary woodland (since 1959)	Secondary Woodland (since1959) Cleared 1974		Cultivated since 1949 Maize
			Grazed pasture	Maize	
RHINOTERMITIDAE-COPTOTERMITINAE					
Coptotermes sp.	+	+			
TERMITIDAE-MACROTERMITINAE					
Ancistrotermes sp.	+	+	(+)	+	(+)
Macrotermes bellicosus (Sm.)	+				
Macrotermes subhyalinus (Rambur)	+	(+)	(+)		
Microtermes spp.	+	+	+	+	+
Odontotermes pauperans (Silv.)	+	(+)	(+)		
Odontotermes smeathmani (Full.)	+	(+)	(+)	+	
— TERMITINAE					
Amitermes evuncifer Silv.	+	+	+	(+)	+
Basidentitermes sp.	(+)	(+)	+		
Cubitermes sp.	+	+	+		
Microcerotermes spp.	+	+	+	+	+
Noditermes sp.	(+)	+	(+)		
Pericapritermes sp.	(+)	+	+		
Promirotermes sp.	(+)	+	(+)		
— APICOTERMITINAE					
Adaiphrotermes sp.	+	+	+	+	+
Anenteotermes sp.	+	+	+	+	
Astalotermes sp.	(+)	+	(+)	+	
— NASUTITERMITINAE					
Fulleritermes sp.	+	(+)			
Trinervitermes geminatus (Wasm.)	+	+	+		
Trinervitermes occidentalis (Sjost.)	+	(+)	(+)		
Trinervitermes oeconomus (Trag.)	+	+	(+)		
Trinervitermes togoensis (Sjost.)	+	+	+		
Trinervitermes trinervius (Rambur)	+	(+)	(+)		
TOTAL SPECIES	23	22	20	8	4

(+) Not recorded on sampling area but present in adjacent areas.

more than the 23 shown in Table 1 due to the presence of several (at least 5) species of the taxonomically difficult genus *Microtermes*. In secondary woodland and grazed pasture the species composition is similar to that in undisturbed woodland. The absence of *M.bellicosus* from these sites is due to the fact that all mounds of this species were destroyed on land cleared and cultivated by the Niger Agricultural Project (BALDWIN , 1957). Although there are viable mounds in the vicinity, the species has failed to re-establish itself. The tree — dependent *Coptotermes* and *Fulleritermes* are eliminated by clearing and are absent from grazed pasture and cultivated sites.

Cultivation results in a rapid elimination of species as there is a decrease from a total of 20 species in grazed pasture to 8 in maize during the first year of cultivation. The five mound — inhabiting species of *Trinervitermes*, species associated with these mounds (*Cubitermes*, *Promirotermes*) and *M. subhyalinus* all disappear. The three soil-feeding genera, *Noditermes*, *Pericapritermes* and *Basidentitermes*, have not been found in cultivated soils and it is likely that they are also rapidly eliminated. Long term cultivation (up to 24 years) results in a further reduction in the number of species.

Abundance of Species

In undisturbed and secondary woodland total abundance issimilar (approximately 3000/m2, Table 2) but there is a difference in the relative abundance of the dominant species. In undisturbed woodland *Microcerotermes* (33.4 %), *Ancistrotermes* (26.4 %) and *Microtermes* (25.2 %) form the bulk of the population (85 %) whereas in secondary woodland *Microtermes* (62.2 %), *Adaiphrotermes* (20.0 %) and *Microtermes* (17.2 %) make up virtually the entire (99.4 %) population The three latter genera are also dominant in grazed pasture and first — year maize. However, in the latter there is a decline in total abundance to approximately 1500/m2 largely due to a decrease in the numbers of *Microtermes* and *Adaiphrotermes*. Long term cultivation leads to the disappearance of *Microcerotermes* (virtually depended on dead wood for food) and *Adaiphrotermes* is alsmost eliminated. Only *Microtermes* and *Amitermes evuncifer* survive and their abundance may be several times that in undisturbed woodland, secondary woodland and grazed pasture. In fact the abundance of *Microtermes* in the sites with a long history of cultivation exceeded that of all species in undisturbed woodland.

DISCUSSION

These results clearly indicate that clearing and cultivation have a marked effect on the termite fauna. Further effects brought about by the planting of different crops will not be apparent until the experiments have been continued for several years. The only other studies of the effects of land use on termite populations are the surveys by SANDS (1965) in northern Nigeria and WOOD and LEE (1971) in northern Australia which relate to the effects of clearing alone and clearing and grazing (WOOD, in press).

TABLE.2 Abundance (numbers/m2) of Termites under different systems of land management.
(96 cores, 10 cm diameter, 100 cm deep, per plot ; 97 & 98, 48 cores per plot).

Species	Undisturbed woodland		Secondary woodland (since 1959)		Secondary woodland cleared in 1974				Cultivated since 1949 Maize	
					Grazed pasture		Maize			
	13	14	1	12	4	5	9	7	97	98
WOOD-FEEDERS										
Amitermes evuncifer	74				13	9			1690*	3090
Microcerotermes sp.	915	1253	302	717	419	315	467	499		
WOOD-and LITTER-FEEDERS										
Ancistrotermes	1165	550	6				89			
Macrotermes bellicosus	6+	32+								
M. subhyalinus										
Microtermes spp.	1141*	497	2850*	827	1309	1150	1381	467	4507*	4345
Odontotermes spp.	446	19					16			
GRASS-FEEDERS										
Trinervitermes spp.	116+	181+					3			
SOIL-FEEDERS										
Adaiphrotermes sp.	92	49	413	769	486	220	121	57		17
Anenteotermes sp.		7		2		41	3	2		
Astalotermes sp.				4						
Basidentitermes sp.					6	16				
Cubitermes sp.	131	270								
Pericapritermes sp.			21			36				
TOTAL	4086	2858	3592	2319	2233	1787	2080	1025	6197	7452
MEAN FOR SITE	3472		2956		2010		1553		6825	

* These population figures are over estimates biased by the presence of more than 500 individuals in one core.

\+ These species are mound-inhabiting and total populations exceed these figures. Provisional estimates are 680/m2 for *Trinervitermes* (OHIAGU, personal communication) and 180/m2 for *Macrotermes bellicosus* (COLLINS, personal communication).

It is apparent from our experiments and the literature quoted above that clearing of woodland and removal of tree roots has two major environmental effects on termite populations, namely the removal of nestings sites and removal of food. Species depending on trees for nesting (eg. *Coptotermes*) are immediately eliminated and the removal of woody vegetation severely limits the sources of food for the wood-feeding *Microcerotermes* and some of the wood— and litter-feeding fungus-growing species. However, in these experiments the effects of clearing are confounded with the effects of cultivation except in the grazed pasture where long term effects will not be apparent for several years.

Mechanical cultivation necessitates the destruction of the large mounds of *M. bellicosus* and results in the destruction of small mounds (eg. *Trinervitermes*) and the elimination of species associated with them. Shallow subterranean nests (eg. *Noditermes*) are also destroyed and surface or near-surface foraging galleries are disrupted. Long term cultivation results in the elimination of all but one species of soil-feeder (*Adaiphrotermes*) which continues to survive in low numbers. It is interesting that the abundance of this species is greater in secondary woodland where *Cubitermes* are rare (having been subjected to cultivation in 1949 with consequent loss of available nesting sites) than in undisturbed woodland. As little is known of the feedings and nesting habits of soil-feeding termites (WOOD, in prep.) it is not possible to say whether or not there is competition between these species which results in the increase in abundance of *Adaiphrotermes* in the absence or near-absence of *Cubitermes*. It does seen likely, however, that the near elimination of soil feeders under long term cultivation is due to the low content of organic matter in cultivated soils. The low numbers of *Ancistrotermes* and *Odontotermes* in secondary woodland and the grazed pasture and maize plots derived from this woodland presents problems, currently unanswerable, which are being investigated. Both species have relatively deep nests and like *Microtermes*, which increases in abundance under long term cultivation, feed on fresh dead wood and other plant debris. It is possible, but unlikely, that cultivation has a damaging effect on their nest system while not damaging that of *Microtermes*. It is more likely that the contrasting effect of cultivation on *Microtermes* on the one hand and *Ancistrotermes* and *Odontotermes* on the other is due to removal of food preferred by the latter and its replacement by crops and their residues which favour the survival of *Microtermes*.

The specific effect of different crops on termite populations has never been studied but is one of the long term aims of the present experiments. Whatever these effects are it is apparent that in the sites we have studied long term cultivation leads to the elimination of the majority of species present in undisturbed woodland and the survival, at high population densities, of *Amitermes evuncifer* and *Microtermes* spp. These species are the principal termite pests of crops in Nigeria (SANDS, 1960) and it appears that their pest-status is a direct result of agricultural operations. These operations result in reduction in diversity of vegetation, increase in production : biomass ratio of vegetation and reduction in heterogeneity of the habitat and produce agro-ecosystems which have all the characteristics of

immature ecosystems in which species diversity is low and one or a few species are of high dominance (SOUTHWOOD and WAY, 1970 ; van EMDEN and WILLIAMS, 1974). In such situations it is appropriate to investigate the factors leading to the development of populations of pest-status and to consider the possibility of their suppression by appropriate pest-management procedures. However, such procedures require far more knowledge than is currently available on the ecology of termite populations.

Acknowledgements

This work is part of the Termite Research Project organised jointly by the Centre for Overseas Pest Research, U.K. (Ministry for Overseas Development) and the Institute for Agricultural Research (Ahmadu Bello University, Nigeria). We would like to acknowledge the invaluable help of Malan M. LAWAL and his assistants in the field and Malan M.C. SHITTU in the laboratory. Acknowledgements are due to the Directors of the Institute for Agricultural Research and the Centre for Overseas Pest Research for permission to publish this paper.

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