ABUNDANCE AND DIVERSITY OF SOIL MITES OF FRAGMENTED HABITATS IN A BIOSPHERE RESERVE IN SOUTHERN NIGERIA[1]

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ABSTRACT - Soil samples were collected from the top 7.5 cm of soil in a Strict Natural Reserve (SNR), a surrounding buffer zone, a cassava farm and matured plantations of *Gmelina*, teak, and pine, so as to determine if plantation establishment and intensive cultivation affect the density and diversity of soil mites. Altogether, 41 taxonomic groups of mites were identified. The diversity and densities of mites in within the SNR, the buffer zone and the *Gmelina* were more than the diversity and densities in the cassava farm, teak and pine plantations. Each plantation had its own unique community structure which was different from the community structure in the SNR plot. The SNR plot and *Gmelina* were dominated by detritivorous cryptostigmatid mites unlike teak and pine which were dominated by predatory mesostigmatid and prostigmatid mites respectively. Low cryptostigmatid mite densities in the plantations and cassava farm were seen as a consequence of low fertility status of the soil, the evidence of which was revealed by soil pH and organic matter data.

Index terms: cassava, G*melina*, plantations, soil fauna, intensive farming.

ABUNDÂNCIA E DIVERSIDADE DE ÁCAROS DE HABITATS FRAGMENTADOS EM UMA RESERVA DE BIOSFERA NO SUL DA NIGÉRIA

RESUMO - Foram coletadas amostras de solo até a profundidade de 7,5 cm em uma reserva estritamente natural (SRN), em uma zona na vizinhança da SRN, e em plantações de mandioca, *Gmelina*, teca e pinheiros. O objetivo foi verificar se o estabelecimento de plantação e cultivo intensivo afetam a densidade e a diversidade de ácaros do solo. Ao todo, 41 grupos taxonômicos de ácaros foram identificados. A SNR, a zona vizinha da SNR e a plantação de *Gmelina* apresentavam maior densidade e diversidade de ácaros do que as plantações de mandioca, tecas e pinheiros. Cada plantação tinha sua própria estrutura de comunidade, diferente da estrutura existente na SNR. A SNR e a G*melina* eram dominadas por ácaros criptostigmatidas detritívoros, diferentemente das plantações de tecas e pinheiros, que eram dominadas por predadores mesostigmatidas e prostigmatidas, respectivamente. As baixas densidades de criptostigmatidas nas plantações de mandioca eram vistas como conseqüência da baixa fertilidade do solo, demonstrada pelos dados do pH baixo e pelos dados da matéria orgânica.

Termos para indexação: mandioca, G*melina*, plantações, fauna do solo, agricultura intensiva.

INTRODUCTION

Habitat fragmentation is associated with development, especially with the extension of various agricultural and silvicultural practices (Sgardelis & Usher, 1994). The Omo Biosphere Reserve in Nigeria is a fragmented habitat whose uniform agricultural landscape has been partitioned into a central Strict Natural Reserve (SNR), a buffer zone at the periphery of the SNR, many farm settlements and plantations of local and exotic trees. Each of these compartments are separated spatially either by footpaths, farm roads or hedgerows. The consequence of this is that each compartment has a more or less isolated soil microarthropod fauna, a phenomenon which increases the risk of local extinction due to deterministic, demographic, genetic or stochastic effects (Sgardelis & Usher, 1994).

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Soil tillage, application of biocides, reduction of vegetation cover and the consequent changes in microclimate have been reported to have negative effects on survival and reproduction of soil microarthropods in arable fields (Moore et al., 1984; Badejo & Lasebikan, 1988; Badejo & Akinyemiju, 1989, 1993; Badejo, 1990; Badejo & Straalen, 1993; Badejo & Olaifa, 1997; Badejo et al., 1997). When cultivation is done on a continuous basis, the period available for soil fauna to grow becomes shortened. Cryptostigmatid mites (Oribatida) in particular suffer deleterious effects because of their relatively long life span and ontogenic development, low fecundity, relatively poor dispersion ability and parental care regarding oviposition microsites (Murphy & Jalil, 1964; Jalil, 1965; Weigmann, 1975; Webb, 1977; Steinberger et al., 1990; Stamou & Asikids, 1992).

It is therefore expected that the structure of mite communities in the fragmented Omo Biosphere Reserve will vary between compartments depending on the degree of land use, type and extent of vegetation cover and extent of isolation from relatively undisturbed sites. Attention is being focused on soil mites in southwestern Nigeria because they account for about 50-60% of the soil microarthropod fauna (Badejo, 1987).

The aim of this study therefore is to investigate the diversity of soil mite populations in the fragmented habitats in Omo Biosphere Reserve so as to test the hypothesis that plantation establishment as well as intensive cultivation affect the density and diversity of soil mites.

MATERIAL AND METHODS

Site description

Omo Biosphere Reserve is one of the 31 Biosphere Reserves in 127 countries within the Afrotropical Realm. It is located between latitudes 6º 35' to 7º 5'N and 4º 19' to 4º 10'E in the Ijebu area of Ogun State in southwestern Nigeria. It is in the mixed moist, semi-evergreen rainforest zone in the Congolian sub-unit of the Guinea-Congolian Centre of Endemism or Phytochorion (Isichei, 1995). This reserve covers 130,500 ha of land about 20 km from the Atlantic coast 460 ha of land in the north central part of the reserve had been designated as a Strict Natural Reserve (SNR) since 1946. Plantations of local and exotic trees are present in the southernmost part of this Biosphere Reserve about 10 km away from the SNR and they are separated by farmlands and/or hedgerows. Detailed description of the physiognomy of the vegetation in the SNR and the plantations have been provided by Dike (1992) and Isichei (1995).

Geologically, the Biosphere reserve lies on crystalline rocks of the undifferentiated basement complex which in the southern parts is overlain by Eocene deposits of sand, clay and gravel. The terrain is undulating and the maximum elevation of 150 m above sea level is towards the west where this study was carried out. The soil of the area is characterized by low pH, high percentage organic matter and low water table that is characteristic of highly drained sandy soils that have perennial vegetation cover (Okali & Ola-Adams, 1987; Isichei, 1995).

For the purpose of this study, the Biosphere Reserve was divided into four zones. These zones are, the SNR, the buffer zone, the cassava farm and the plantations. On March 29 and 30, 1996, a 10 x 10 m plot was selected for sampling in each of the SNR and buffer zones. On April 12 and 13, 1996, the Biosphere Reserve was visited again and soil samples were taken from 10 x 10 m plots in each of the plantations of *Gmelina arborea* {all plant names after Lowe & Soladoye (1990)}, *Tectona grandis* (teak) and *Pinus caraba* (pine) which were between 20 and 25 years old, and in a cassava farm on the fringe of the buffer zone. From oral evidence, the cassava farm had been under cultivation for the past 20 years. The farm was usually left to fallow after every three years of cultivation. At the time of this study, the cassava farm had been established for just one year after three years of fallowing. Altogether, a total of six plots were sampled during this investigation. Without removing the litter cover, a bucket auger of mouth diameter 8.75 cm was pressed down to the soil to collect samples from the top 7.5 cm of the soil in six randomly selected points within each plot (10 x 10 m). Each sample unit was carefully pushed with a peg from the auger into a polythene bag which was securely tied at the mouth to prevent desiccation and spilling of soil before reaching the laboratory. Soil samples were collected from the top 0-7.5 cm layer of the soil in this study because previous studies have revealed that about 90% of soil microarthropods live in this layer in forests and cultivated plots (Chiba et al., 1975; Badejo & Akinyemiju, 1993).

On each sampling occasion, pH of the soil was determined in water (a soil/water ratio of 2:1) using a pH meter with glass electrode from each of the six sampling points in each plot. Soil samples were also collected from each sampling point for determination of soil organic matter in the laboratory using the adapted Walkley & Black (1934) method (International Institute of Tropical Agriculture, 1979).

Extraction procedure

In the laboratory, the Bukard model of Berlese-Tullgren funnel extractor (Lasebikan, 1974) was used to extract soil microarthropods from soil samples. Description of a unit of this extractor as well as the extraction details have been provided by Badejo (1996). After extraction which lasted for seven days, the extracted microarthropods were poured into a petri-dish from where the mites were sorted from the rest of the microarthropods and counted under a dissecting microscope. Temporary mounts of specimens were made and examined thoroughly for fine taxonomic details under the compound microscope but a large majority of the specimens were preserved in Koenike's fluid (Beirne, 1963). The mites were identified to family or generic levels using keys and illustrations provided in Baker & Wharton (1952), Evans et al. (1967), Norton (1990) and Woolley (1990) as well as comparing them with those already identified in the Laboratory for Systematics and Ecology of Microarthropods in Obafemi Awolowo University, Ile-Ife, Nigeria.

Statistical analysis

The Berger-Parker Dominance Index (D) (Southwood, 1978) was calculated to compare differences in the diversity and relative abundance of mites in all the plots.

RESULTS AND DISCUSSION

Data on soil pH, organic matter content and densities of cryptostigmatid mites are presented in Table 1. The soil of the area studied has a low pH but there is a tendency for the pH to be lower in the plantations than in the buffer and SNR. Low pH suggests acidity and consequently poor nutrient relations (Swift & Woomer, 1993). Although organic matter is relatively high in all the plots when compared with similar environments where organic matter as low as 2.0% have been recorded (Badejo & Akinyemiju, 1989), there is still an indication of lower organic matter in the plantations than in the SNR and buffer plots. Organic matter is a source and a sink for nutrient elements in the soil. It has appreciable influence on many soil properties, hence its significance in maintenance of soil fertility (Swift & Woomer, 1993). It can therefore be concluded that there are indications, from pH and soil organic matter data, that plantation establishment has reduced soil fertility in the study area.

TABLE 1. Soil pH, organic matter and cryptostigmatid mite densities in the experimental plots in the top 0-7.5 cm of soil (mean based on 6 samples).

Site	pH	Organic matter (%)	Cryptostigmatid mite density (no. per m^2)
Strict Natural Reserve	5.51	4.68	7,392
Buffer zone	5.95	5.15	12,912
Plantation of *Gmelina arborea*	5.11	3.50	4,950
Plantation of *Tectona grandis*	5.18	3.43	2,388
Plantation of *Pinus caraba*	5.32	3.35	2,760
Cassava farm	-	-	3,483

Only cryptostigmatid mite densities are presented in Table 1 because unlike other groups (mesostigmata and prostigmata) which contain predatory and parasitic forms, this group comprises of exclusively phytophagous and detritivorous feeders whose direct influence on decomposition processes and nutrient cycling in the soil has been documented (Wallwork, 1976). Many cryptostigmatid species feed directly on decomposing litter (saprophagous) while many others feed on soil fungi (mycophages). Cryptostigmatid mite densities in the SNR are three times as many as the densities in teak and pine and they are about twice as many as the numbers in *Gmelina* and cassava. The highest density was recorded in the buffer zone. If data on pH and organic matter which have been established as good indicators of soil fertility show a trend of fertility decline in the plantations, it follows therefore that low cryptostigmatid mite density indicates low fertility. The findings of Tian et al. (1998) that microarthropods have a buffering effect in regulating leaf decomposition and nutrient release, a process which is mediated by land-use history, lends credence to this conclusion. Previous studies in similar environments have also shown that soil disturbance during cultivation reduces soil microathropod densities (Badejo & Lasebikan, 1988; Badejo, 1990) and that recovery to precultivation levels occur during long fallow periods (Badejo, 1995). It is clearly shown in Fig. 1 that the plot investigated in the buffer zone contained more cryptostigmatid mites than the SNR plot which in turn contained more cryptostimatid mites than the *Gmelina* plot. These three plots contained more cryptostigmatid mites than the cassava, pine and teak plots.

The Berger-Parker Dominance Index for each genus/family of soil mites extracted from the experimental plots are presented in Table 2. This index is a measure of the percentage contribution of a taxonomic group to the total number of mites in each plot. Genera/families that provided 10% or more of the total density of mites in a plot are regarded as dominant and they are between two and four in all plots. The highest number of taxonomic groups was recorded from the buffer zone while the least was recorded from the cassava farm. The slight difference in the number of taxonomic groups between the SNR and buffer zone is probably due to the higher organic matter in the buffer zone (Table 1) which may be a consequence of more human activities other than soil tillage in the buffer zone. Such activities have been reported by Ola-Adams & Onyeachusim (1993) and Isichei (1995) as exploitation of wildlife and several non-timber forest products.

In the buffer and cassava plots, there was a large percentage of *Eremulus* which was hardly present in the SNR plot. Each of the plantations appears to have a unique mite community structure that is different from the community structures in the cassava farm, buffer zone and SNR. In *Gmelina*, *Scheloribates* was the most dominant. In teak, *Annectacarus*, and a mesostigmatid mite genus, *Rhodacarus*, were highly dominant. In pine, an unidentified prostigmatid

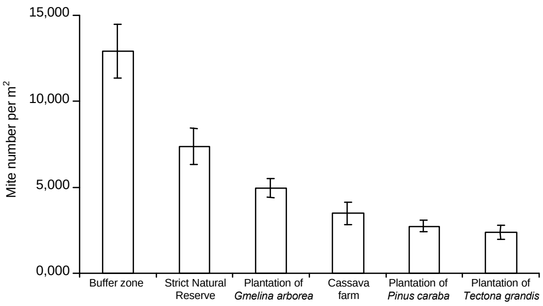

FIG. 1. The densities (no. per m^2 ± std. error) of cryptostigmatid mites in the experimental plots.

species belonging to the family Caeculidae was the most dominant. In the SNR and buffer plots, the dominant groups are all cryptostigmatid mites. The slight differences in the species composition of mites in these two plots may therefore not have a serious influence on the functioning of the mite segment of the soil ecosystem. The dominant shift in favour of *Eremulus* in the cassava farm, coupled with low diversity and density of mites suggests an effect of intensive cultivation on the mite community in this farm. In teak and pine, the dominance shift in favour of predatory mites suggest an alteration in ecosystem functioning. This dominance shift from cryptostigmatid to prostigmatid mites has also been observed during the transformation of a woodland into arable field in a temperate environment by Sgardelis & Usher (1994).

High diversity of mites in *Gmelina* coupled with dominance shift in favour of *Scheloribates*, a cryptostigmatid species, suggest that *Gmelina* is more favourable to cryptostigmatid mite populations than pine and teak. Conditions on the floor of *Gmelina* are similar to those on the floor of the SNR plot as a result of the dense cover of undergrowth and various other shrubs and tree species. This must have provided adequate shade and litter cover which has been reported to enhance the rapid growth of soil mite populations (Lasebikan, 1988; Badejo et al., 1995). The paucity of soil mites in pine despite the heavy cover of undecayed pine twigs and undergrowth might be due to the chemical composition of the litter. Studies in the same vegetation and climatic zone in Nigeria have revealed that chemical composition of litter can influence the abundance and diversity of soil microarthropods (Badejo et al., 1995). The low diversity of soil mites in teak might be due to the extensive erosion of the top soil in many areas. It is however interesting to note that *Annectacarus* accounts for 30% of the mites extracted from this plantation. This genus which has been found to recover quickly from herbicide treatment (Badejo & Akinyemiju, 1993) must have benefited from the conditions in the teak plantation. It is certain from these results that habitat fragmentation in the Biosphere Reserve has resulted in clear changes in the population structure of the soil-dwelling mites. The diversity data tend to agree

TABLE 2. The dominance index (species/number ratio expressed in percentage) of soil mites in the study area.

Mite group	Strict Natural Reserve	Buffer zone	Cassava farm	Plantation		
				Gmelina arborea	*Tectona grandis*	*Pinus caraba*
			Oribatida (Cryptostigmata)			
Annectacarus	0	1	0	2	30	0
Basilobelba	1	2	0	0	0	8
Belba	1	1	3	0	3	0
Carabodes sp.1	0	1	0	2	0	0
Carabodes sp.2	0	0	0	0	0	0
Dolicheremaeus	5.5	5	0	0	0	0
Epilohmannia	1	0	0	0	0	0
Eremulus	1	13	40	2	0	0
Galumna	3.5	2	0	0	0	0
Haplozetes	16	6	0	3	0	3
Hermannia	1	1	3	2	3	0
Indotritia	0	0	0	6	0	0
Machadobelba	0	3	3	5	3	18
Mesoplophora	0	0	0	0	0	0
Nothrus	0	0	0	0	12	12
Oppia	3	28	7	19	12	5
Oribates	9	0	3	5	3	3
Pilizetes	40	13	0	14	0	10
Platynothrus	1	0	7	2	1	0
Scheloribates	3	6	7	22	0	8
Tectocepheus	0	5	3	0	3	0
Teleioliodes	1	0	0	4	7	0
Cepheidae	0	0	10	0	0	0
			Gamasida (Mesostigmata)			
Macrocheles	0	0.5	0	0	0	0
Parasitus	0	0.5	10	0	0	0
Rhodacarus	0	0	0	0	18	0
Dermanyssidae	0	0	0	0	0	3
Polyaspididae sp.1	0	3	4	2	0	0
Polyaspididae sp.2	3	0	0	2	0	0
Protodinichidae	1	0.5	0	2	0	0
Uropodidae sp.1	6	4	0	2	1	0
Uropodidae sp.2	0	0	0	0	0	0
Uropodidae sp.3	1	0	0	2	0	0
Uropodidae sp.4	0	1	0	0	0	0
			Actinedida (Prostigmata)			
Bdellidae	0	3	0	0	0	3
Caeculidae	1	0	0	0	0	25
Cunaxidae	0	0.5	0	0	0	0
Rhagidiidae	0	0	0	2	4	0
Smarididae	0	0	0	0	0	0
Trombellidae sp.1	0	0	0	0	0	2
Trombellidae sp.2	1	0	0	0	0	0
No of taxonomic groups	20	22	12	19	13	13
No of dominant groups	2	3	3	3	4	4

with the trend seen in the densities (Fig. 1) in respect of the magnitude of the effect of disturbances on soil mite populations.

Previous studies on the ecology of soil microarthropods in similar environments have revealed that there are marked fluctuations in their population densities during the annual cycle. Some genera reach multiple peaks during the annual cycle while others reach single peak populations in the late wet season (Badejo, 1990).

This study was carried out in March/April during the early wet season when many mite species had just started recruiting their populations through reproduction. A more extensive sampling programme will provide more information on the diversity as well as absolute densities of mites in the fragmented habitats.

CONCLUSIONS

1. Habitat fragmentation in the Biosphere Reserve leads to fragmentation of the soil mite community and alteration of their densities and diversity.

2. Plantation establishment brings about a dominance shift to other mite species.

3. Type of vegetation cover and the resulting litter as well as intensive agriculture affect mite population densities and diversity in the soil.

4. Low soil cryptostigmatid mite densities signify poor fertility in cultivated soils.

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