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SOIL MACROFAUNA IN FOUR DIFFERENT AGROECOSYSTEMS IN AGO-IWOYE, SOUTH-WEST NIGERIA

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Abstract

Four different agro-ecosystems (Kola, banana, cassava and fallow ground) were surveyed for macrofauna population. A population explosion of the macrofauna was noticed during the August break (a period of break in rainfall sandwiched between the two rainfall peaks) in all agro-ecosystems. Cassava agroecosystem shows the highest population. The growth was optimum under the survival conditions such as moisture level, relative humidity, temperature and minimal dislodgment of the organisms. Among the animal taxa recovered, four groups are of great importance to soil fertility-Insecta, Oligochaeta, Diplopoda and Arachnida. Cassava agro-ecosystem has the highest earthworm population (39.2%), and habours 33% of beetles, 59% of the Blatter, 53% of the *Chelonethi*, 39% of the *Formica*, 40% of the nematodes, 34% of the *Pachybolus*, the only record of *Spirostreptus*, 41% of the termites, and 29% of all organisms recorded. The fallow agroecosystem, next in population size, tops the records for Camponotus (69%), the only record of grasshopper, isopods (36%), *Pheidole* (37%), *Scutigerrella*, (38%), slugs and snails (59%), and (28)% of all the organisms recovered. The banana agroecosystem comes third in the series supporting 25% of all the macrofauna collected. It is the richest agroecosystem in *Diplura* (35%, *Habrodesmus* (39%), *Lithobius* (45%), maggot (59%) *Meteipera* (92%), *Prepodesmus* (62%). The kola agroecosystem is the least supportive of the four agroecosystems studied. It harbours the highest population of caterpillar (71%), the only record of lcheium, mesostigmatic mite (43%, spider (46%), and 18% of the macrofauna. The mites predate on many other macro and mesofauna, rendering the ecosystem less effective in terms of bio-degradation. A combination of these factors account for the comparatively higher litter layer under kolanut agroecosystems than under others.

Introduction

The macrofunal groups are very important in soil fertility and pedological consideration. Numerous works have been carried out on soil macrofauna in different regions (Wightrman & Wightrman, 1994). These include Temperate Region, Equatorial Region and other semi-arid Region in the continent of Africa. Though a dark ecosystem, the soil is a world full of caverns, tunnel and crevices inhabited by various organisms of importance (John 1976). These organisms are classified based on their body width into three ecological groups: microfauna. Mesofauna and macrofauna. The microfauna comprise all soil inhabiting protozoans and some nematodes; the mesofauna include the primitive aptergote insects, acarines, pauropods and symphylids; the macrofauna include large-sized arthropods, annelids and molluscs. Varied and abundant faunal group enhance soil fertility and thus high soil productivity (Edwards et al, 1970: Madge, 1981). In many agro-ecosystem, especially abandoned farmland, there are keen interactions among animals and micro-organisms which form which form and integrated system for the decomposition of organic matters and mineral nutrients recycling (Edwards & Lofty, 1975; Wallwork, 1976; Blevings et al., 1984, Seastedt, 1984).

Conscious of the need for genomic preservation and for maintaining life sustaining system of the biosphere, and being concerned that biological diversity is being significantly reduced by physical development on the permanent site of Ogun State University started in the 1980s. The development in already modifying the biodiversity and abundance of fauna and flora on the site. This study was carried out at a new university site (the Permanent site of Ogun State University) whose development is already modifying the biodiversity and abundance of the fauna and flora on the site and also of its immediate neighbors since physical development on the permanent site of Ogun State University started in the 1980s.

This study is carried out with a view to obtaining baseline information on the macrofauna of the new location (the Permanent Site of Ogun State University) the species composition, the relative abundant, monthly changes, and their responds to climatological factors. This will facilitates the future assessments of the impacts of the development of the University on its environment. The preservation of biodiversity is a high priority among biologist, ecologist and environmentalist a few studies had focused on the importance of biodiversity in natural and agricultural ecosystem.

Materials and Methods

This field research was conducted on the Main Campus of Ogun State University (New Permanent Site) Ago-Iwoye Ogun State, Nigeria latitude 6^o48^1N and longitude 3^050^1E. The environment represents a typical tropical lowland rainforest climate having a high mean monthly temperature of 27.6^0C and a minimum temperature of 25^0C Climatological characteristic of Ago-Iwoye are given in Table 1.

Table 1. mean monthly rainfall and temperature

Date	Jan	Feb	Mar	Apr	May	Jun
Rainfall (mm)	7	23	102	152	198	250
Temperature (^{0}C)	26.1	27.6	27.6	26.7	26.6	25.5
Date	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall(mm)	280	108	155	170	235	15
Temperature (^{0}C)	25.1	24.5	24.9	25.6	26.6	26.6

Data obtained from Weather Station, Department of Geography and Regional Planning, Ogun State University, Ago-Iwoye.

Each agro-ecosystem, (about one year old) and of about 1 hectare area was divided into 3 plots and 6 replicates. Samples were taken in each micro-habitat using a 10 cm x 10 cm quadrant (6 quadrant) every fortnight, throughout January to December 1996.

The samples were taken into the laboratory, the soil samples were observed under the microscope and the organisms sorted out by hands, counted, recorded, and preserved in 70% alcohol.

Differences in results were tested by ANOVA. Batches which differ significantly were identified by Duncan Multiple Range Test.

Results and Discussions

Fauna Record: Nominal list of the macrofauna recovered during the study and their relative frequencies are given in Table 2. Not at all the organisms are encountered at each occasion.

Earthworms (of several genera were the most frequent (12.2%), followed by beetles (9%) and *Habrodesmus* (9%). In all, the records includes over 39 genera, (noting that some organism could not be identified to generic level), over 31 families, 9 classes and 6 phyla.

Monthly Record: Table 3 shows their distribution during the months of the year. Earthworms have the most regular frequency, followed by Beetles and Millipedes (*Habrodesmus*, and *Prepodesmus* respectively). The highest records were recorded during the months of July, which coincides with the

Table 2. Macrofauna Recovered and their relative frequencies.

Organisms	Density	as percentage of all fauna
Aphis	2	0.5
Beetle	40	9.0
Blatter	4	0.9
Camponotus	13	2.9
Carabus	1	0.2
Caterpillar	2	0.5
Cheloneth	13	2.9
Diplura	29	6.6
Dolometh	2	0.5
Earthworm	54	12.2
Formica	14	3.2
Glomeris	1	0.2
Grasshopper	2	0.5
Habrodesmus	40	9.0
Ichneum	2	0.5
Isopods	13	2.9
Lithobius	21	4.8
Maggot	8	1.8
Mesostigmatic mite	7	1.6
Meteiperia	2	0.5
Millipede	4	0.9
Myzus	1	0.2
Nematodes	21	4.8
Nemobius	1	0.2
Neuroptera larva	1	0.2
Pachybolus	14	3.2
Pheidole	21	4.8
Phlegra	2	0.5
Prepodesmus	29	6.6
Psilida	1	0.2

Organisms	Density	as percentage of all fauna
Reduvid	1	0.2
Scarabeus	1	0.2
Scutigerrela	26	5.9
Slug	1	0.2
Snail	8	1.8
Spider	9	2.0
Spirostreptus	1	0.2
Staphilinidae	3	0.7
Termite	18	4.1
Unidentified	5	1.1

peak of the raining season. The population dwindles towards either side of that peak. In terms of aggregate population, the population is generally lowest at the beginning and end of year (the dry season). From about March the population builds up and reaching a peak about August and then drops noticeably towards the harmattan dry season. There is a significant variations from month to month (Table 3). The months with significant differences are shown in Table 4. The lowest records are from October to February of the following year: the harmattan and dry season.

Table 3. Dynamics of monthly record of the macrofauna in all the agroecosystem

Organisms	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Row Total	as % of all fauna
Aphis				1			2						3	0
Beetle		16.0	81	3	20	33	18	36		11	14	2	234	9
Blatter			17				2	15					34	1
Camponotus		12		37			5	51					105	4
Carabus								1					1	0
Caterpillar		1			6								7	0
Cheloneth		1	10			5	4	1	37	6		10	74	3
Diplura		4	10	2		17	49	5	14		3		104	4
Dolometh							1		1				2	0
Earthworm		3	10	83	71	21	100	16	18	8	12	3	345	13
Formica		3	1	6	23	15	12	26	15		6		107	4
Glomeris		1						16					17	1
Grasshopper			15										15	1

Habrodesmus		5	6	11	65	24	75	79	55				320	12
Ichneum				10									10	0
Isopods					6	2	7	9	7				31	1
Lithobium		10	4	13	5	5	8	2	3				50	2
Maggot			5	1		1	7	13	2		5		34	1
Mesostigmatic mite		1			8		1	6	6	6	6		30	1
Meteiperia				11					1				12	0
Millipede		5											5	0
Myzus		1											1	0
Nematodes		11	2	1	41	16	8	108					187	7
Nemobius		1											1	0
Neuroptera larva		1											1	0
Pachybolus		4		110	6	19				19			158	6
Pheidole	26	6			122		21	20	11			15	221	8
Phlegra		14		9	18	30	28	33	1				133	5
Prepodesmus								3					3	0
Psilida							1						1	0
Reduvid			18				1		1			1	21	1
Scarabeus		1	6										7	0
Slug/Snail		9	6				1	19					35	1
Scutigerrela		7		8		2	43	33	10				103	4
Spider		1	1	1	5		3	1	5				17	1
Spirostreptus						9							9	0
Termite	2	31	30		58	14	1	53	2	1		19	211	8
Unidentified					17							1	18	1
Wireworm		1								5			6	0
Monthly Total	28	150	122	307	471	204	398	543	197	56	46	54	2673	100
Monthly Percentage	1	6	8	11	18	8	15	20	7	2	2	2	100	

Of the organisms recorded, 1% occurred in January, and 6% in February. July (15%) and August (20%) have the highest percentage record. Pearson Test shows that the distribution of the organisms is not uniform (at $p<0.05$).

Distribution among the agroecosystems: Macrofaunal density is not uniform under the four different agroecosystems (Table 5). The highest record was from under cassava, fallow and banana, in that order, and the least under Kola.

Table 4: Duncan Multiple Range Test indicating which months have significantly different records(*)

		Sep -03	Feb -02	Feb -16	Mar -15	Jul -26	Nov -13	Apr -19	Aug -9	Jun -12	Jun -21	Oct -25	Jun -02	Mar -29	Jan -26	Sep -12	May -24	Aug -21	Apr -26	May -03
Mean	Date																			
8.727	Jun-02	*	*	*																
8.750	Mar-29		*	*																
9.333	Jan-26																			
12.23	Sep-12	*	*	*	*	*	*	*	*	*	*									
12.75	May-24	*	*	*	*	*	*	*	*	*	*	*	*	*						
15.00	Aug-21	*	*	*	*	*	*	*	*	*	*	*		*						
15.75	Apr-26	*	*	*	*	*	*	*	*	*	*	*	*	*						
20.53	May-03	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			

Table 5. Aggregates of the macrofaunal types under different agroecosystems

Organisms	Banana	Cassava	Fallow	Kola	Row Total	as % of all fauna
Aphis			1.00	2.00	3	0.5
Beetle	4.33	7.46	6.11	5.00	22.9	4.0
Blatter	2	15.00		8.5	25.5	4.5
Camponotus		3.5	12.57	2.5	18.57	3.2
Carabus		1.00			1	0.1
Caterpillar	1		1	5	7	1.2
Cheloneth	4	12.33	4.25	2.67	23.25	4.1
Diplura	5.17	3.33	5.14	1.17	14.81	2.6
Dolometh				1	1	0.1
Earthworm	6.18	9.79	5.27	3.57	24.99	4.4
Formica	9.5	13	8.25	3	33.75	5.9
Glomeris			16		16	2.8
Grasshopper			8		8	1.4
Habrodesmus	12.9	6.5	8.3	5.09	32.79	5.7
Ichneum				5	5	0.8

Isopods	1.67	2	3.5	2.5	9.67	1.7
Lithobius	4.67	2.5	1	2.13	10.3	1.8
Maggot	13	5	3	1	22	3.8
Mesostigmatic mite	5.5	1	1	5.67	13.7	2.3
Meteiperia	11			1	12	2.1
Millipede	1.33	1			2.33	0.4
Myzus		1			1	0.2
Nematodes	5	12.78	7	6.88	31.66	5.6
Nemobius			1		1	0.2
Neuroptera larva			1		1	0.2
Pachybolus	12.2	15.5	7	11.3	45.95	8.1
Pheidole	5	10.75	15	9.33	40.08	7.1
Phlegra		5.33	2	1	8.33	1.5
Prepodesmus	9.33		3.86	1.8	14.99	2.6
Psilida			1		1	0.2
Reduvid	9.5	1		1	11.5	2.0
Scarabeus	1				1	2.0
Scutigerrela	4.67	3	6.5	3	17.17	3.0
Slug/Snail	1	2	5.8	1	9.8	1.3
Spider	1	1	1	2.6	5.6	1.0
Spirostreptus		9			9	1.6
Termite	11.3	18.5	8.75	6.20	44.78	7.9
Unidentified			9		9	1.6
Wireworm	1		5		6	1.1
Column Total	143.3	163.3	158.3	101	565.89	100
% per Agro ecosystem	25	29	28	18	100	

The cell entries are means of record of the organism under the corresponding agroecosystems

The distribution of each organismic type was not uniform under the four agroecosystems (Table 6). Aphids are more distributed under little disturbed agroecosystems. Among those found under all agroecosystems are False scorpion (*Chelonethi)*, Diplura, earthworms, formicid ants, (Pheidole), Millipede *(Habrodesmus, Pachybolus, Prepodesmus)*, Wood lice (isopods), Centipede *(Lithobius, Scutigerrella)*, dipteran larvae (maggots), nematodes, snails and slug, soil spiders and termites. For most of these the distribution is fairly even among the agroecosystem. But beetles are more common under cassava and fallow than under kola. Similarly, earthworms are more common under banana and cassava than under kola.

Table 6: Test of Difference in Macrofaunal Abundance among the different Agroecosystems

Agroecosystem	Mean	Std. Dev.
Banana	6.5758	7.9835
Cassava	7.4811	8.9912
Fallow	6.6552	9.5718
Kola	4.0088	5.0877
Total	6.1448	8.1679

On ANOVA these differences are significant at P = 0.0095
On Duncan Multiple Range Test the difference exist between **Kola** and each of **Banana, Fallow, Cassava.**
Correlation between macrofaunal abundance and climatic factors: A significant and positive Pearson correlation (r = 0.1084, p = 0.024) exist between the macrofauna density and the rainfall.
Spearman Rank correlation coefficient is significant between macrofauna density and both of rainfall and temperature. Between macrofaunal density and rainfall Spearman rank correlation coefficient is 0.2094, (p = 0.01) and between macrofauna density and temperature-0.1057 (p = 0.05).

Regression Model: Macrofaunal population can be predicted from rainfall. From stepwise regression analysis only rainfall enters the regression equation whose regression coefficient is 0.010022 ± 0.004417 (S.E), which is significant at (p=0.05) and the constant of regression equation is 4.626386 ± 0.774509. therefore the relationship between amount of rainfall and the number of macrofauna can be represented by the equation:

$$M = 4.63 + 0.01R$$

Where M = macrofaunal populations
R = rainfall (in mm)

Discussion

Although soil fauna of natural terrestrial ecosystems influences organic matter decomposition and mineralization processes such as nutrient release rates (Crossley, 1977; Petersen & Luxton, 1982; Seastedt, 1984), this catalytic role has not been demonstrated for the soil fauna of agricultural system. However, House &Parmelee (1985) speculated that under condition of continuos no-tillage (fallow), earthworm and micro-arthropods will assume a more dominant role in organic matter decomposition, but the cassava agroecosystem has the highest density of earthworm followed by banana agroecosystem.

Although, house and Parmelee (1985) opined that elimination of soil disturbance and stratification of organic matter contributed to the higher densities of soil arthropods and earthworms under no tillage (fallow), it is not the case in this study.

Furthermore, according to House & Ali (1981); Crossley et al 1984, House & Parmelee, 1985), no-tillage provides a more favourable environment for soil and surface residue dwelling organism by reducing moisture loss, ameliorating temperature extremes and fluctuations, and supplying a relatively continuous substrate for decomposers. This study proves that the cassava agroecosystem provides a more favourable environment for soil and surface residue-dwelling organisms when the abundance and incidence are taken into consideration. Moreover, the rate at which these plant shed their leaves and allow undergrowth is higher than other agroecosystems to allow population build up of soil-dwellers.

However, the paucity of soil dwellers in kola agroecosystem is thought to be due to the low decomposition of kola leaves which may result from the chemical constituent of the leaves which may be having inhibitory effect on the macrofauna. Perhaps an additional cause may be the relatively higher abundance of the carnivorous macrofauna which conceivably predate on, and lower the population of the detritus macrofauna.

According to House and Permelee (1985) continuous no-tillage stratifies the soil, concentrating organic matters, nutrients and microbial activities near the surface. In contrast, conventional tillage, through implements mixes crop residues with soil, and thereby generates more homogenous condition as found out in similar study by Coleman (1983), House et al 1985, and Odum, (1984).

House and Permelee (1985) reported a similar study in temperate zone that tillage indirectly accelerates decomposition of organic matter by stimulating microbial activity and lowering the diversity of the soil fauna community.

Earthworms have long been associated with the maintenance of soil fertility through their degradation of organic matter and their incorporation of humus into the soil. These activities are recognized as improving soil structure aggregation and drainage (House and Permelee, 1985). Many soil micro-arthropods such as mites and Collembola have well developed mouth parts capable of fragmenting organic matter while feeding on bacteria and fungi that adhere to plant residue (Wallwork, 1976, 1981). The fragmentation of plant material increases its surface area and thus accelerates microbial activity, which in turn enhances organic matter breakdown and mineralization (Seastedt & Crossley, 1980; Seastedt, 1984).

The emergence of macrofaunistic group follows aggregated distribution and follows rainfall pattern. The earthworms and millipedes preferred moist weather while the arachnids emerged through rainy season to late dry season. This is in accordance with Debauche (1962).

Conclusion

These soil fauna are said to be vital component of different agroecosystem; in that they have an indirect catalytic role in surface crop residue decomposition. Tillage accelerates crop residue decomposition by generating homogenous soil litter-condition and increasing soil-litter contact, both of which stimulate microbial activities. Soil fauna have to be guarded in the subsequent planning of the University Campus. Indiscriminate felling of trees will enhance rapid water run off. Use of pesticides and herbicides in the near future may tamper with the soil fauna.

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