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Variation in the Abundance of Tree and Insect Species in Selected Forest Reserves in Ondo State, Nigeria

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ABSTRACT: This study was carried out to examine the variation in the abundance of tree and insect species in some selected forest reserves in Ondo State Nigeria. The study also examined the relationship between soil mesofauna, tree and the insect species. Eight sample plots (20 m by 40 m) were demarcated where enumeration of trees species, sampling of insets, and collection of soil samples were carried out. A total number of 1167 woody trees species were encountered from all forest reserves, distributed in to 360, 371, 274, and 162 in Akure/Ofosu, Oluwa, Akure Queen's forest and Owo forest reserves respectively. Shannon-Wiener diversity index values are 3.60, 3.57, 3.34 and 3.31 for Oluwa, Akure/Ofosu, Owo and Akure Queen's forest reserves respectively. Trees species richness was higher in Oluwa forest reserve (61), and the least was found in Owo (38). Then were nine hundred and fifty six (956) insects' species with 123, 234, 236 and 363 in Owo, Akure/Ofosu, Oluwa and Akure (Queen) forest reserve respectively. Shannon-Weiner diversity index values for the reserves were 3.07, 3.08 3.17 and 3.31 for Owo, Akure/ Ofosu, Oluwa and Akure Queen's forest reserves were respectively. Insects' species richness was highest in Akure Queens forest (36) while the least was found in Owo (26). The results of soil mesofauna shows that 309 mesofauna were recorded in the Oluwa forest, 250, 233 and 115 were encountered in Akure/ Ofosu, Akure Queen's and Owo forest reserves respectively. The correlation coefficient between insects and mesofauna was positive and high (0.7747). However the correlation coefficient between trees and insects abundance was negative (-0.3800) while those of trees and mesofauna abundance was positive but low (0.1120). Suggestions were made on how our forest can be managed sustainably.

Keywords: Ecosystems, Diversity, Mesofauna, Abundance.

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INTRODUCTION

One of the greatest assets of tropical forest is the richness of floral and fauna species. According to FAO, (1993) the tropical forest contains at least 50% of the total living species on earth. The richness in biological diversity of tropical forest is partly responsible for the continued pressure under which it has been subjected for centuries. The demand for forest and forest products in Nigeria has risen astronomically, resulting in increased pressures on the existing natural forest. The natural forest in Nigeria is increasingly being depleted through the indiscriminate extraction of economic trees and encroachment on forestland for other purposes like agriculture, urbanization and industries. Deforestation has been attributed to be the aftermath of various activities of man in the bid for economic development (Anon, 2001a 2010).

Nigeria ecological zone can be broadly divided into savanna and rainforest. The savanna region covers an area of 75,297 km^2 and is made up of

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Sudan, Sahel, Guinea and Derived savanna. The rainforest which accounts for only 2% of the country's forest area is located in the southern part of the country and it is composed of humid lowland forest, fresh water swamp and mangrove forest (Adeduntan, 2009). Each of these ecological zones has its own peculiarities and supports a wide range of plant and animals species. But the tropical rainforest has been the richest in abundance and diversity of plant and animal species. The occurrence of soil arthropods this zone outnumbers the arthropods of all other compartments of many biomes (Badejo and Ola-Adams, 2000).

Out of all the forests and forest reserves in Nigeria that remained relatively undisturbed until the 1980s, significant portions of these remaining forest and forest reserve ecosystems have been lost in the last two decades. As these natural forest ecosystems disappear, so do many of the goods and services, like timber, fuel wood, watershed, charcoal, pharmaceuticals, erosion control and prevention, soil stabilization, food, fruits and nuts, e.t.c, which they provide are disappearing. According to FAO (1997), Nigeria's total forest area in 1990 stood at 14,387,000 hectares. But in 1995, it stood at 13,780,000 hectares with a total change, 1990 – 1995, of –607,000 hectares at an annual change of –121,000 hectares (i.e. –0.9%). Adedoyin, (1995) describes the current situation as deplorable. The rate of forest degradation is increasing all over the world due to the rapid increase human population thereby resulted into community expansion. Therefore, this development lead to exploitation of the biological plants in our ecosystems as well as some of the beneficial insects that is present in our environment. Also, this effects resulted into which causes many of the plants species, and insect species to go into extinction while many are highly endangered, which could be attributed to the failure or weakness of current conservation measure or implementation failure as well as over exploitation of land within and outside reserves. It is therefore very important to examine the variation that exists in the abundance and variation of trees, insects and mesofaunna species in some selected forest reserves in Ondo State, Nigeria, to look at variation that exist among various forest reserves in the states.

METHODOLOGY

Study Area

This study was carried out in Ondo State Nigeria. The State lies between latitudes 5°45' and 7°52'N and longitudes 4°20' and 6°05'E. Ondo State is bounded on the east by Edo and Delta States, on the west by Ogun and Osun States, on the north by Ekiti and Kogi States and to the south by the Bight of Benin and the Atlantic Ocean.

The following are the study sites; Akure-Ofosu forest reserve, Akure Queens forest, Owo forest reserve and Oluwa forest reserve and all lies within rainforest zone of Ondo State. Stratified random sampling was adopted to select four forest reserves in Ondo State, Nigeria. The State is one of the most forested states in Nigeria, with 16.4% of the total area demarcated as forest reserves (Omoluabi *et al.,* 1990).The State has forest reserves total area of 3,370 km^2 although 12% of the reserved area had been converted to government plantations by the early 1990s (Agbelusi 1994). The trees were dominated by broadleaved hardwood trees that form dense, layered stands. The mean annual temperature is about 26 ºC (minimum 19 ºC and maximum 34 ºC) and the rainy season lasts for 9 months annually, between March and November (about 2500 mm with bimodal rainfall pattern) while the dry seasons usually last for 3 months, between December and February. The climate of Ondo is humid tropical with seasonal variation. The mean annual rainfall is about 2000 mm with double maximum in the months of July and September and a short relatively dry period in August. December through to February constitutes the

major dry season while January and February are the driest months with each having less than 30 mm rainfall (Ola-Adams and Hill, 1987). The mean monthly relative humidity is about 70%. Ondo State has a temperature which a range from about 20.6°C to 33.5°C, with monthly mean temperature is about 27°C, a condition that is conducive to the development of tropical rainforest.

The soils of Ondo State are predominantly ferruginous tropical soils and are typical of the variety found in the intensively weathered areas of basement complex formations in the rainforest zone of southwest in Nigeria (Onyekwelu *et al.,* 2005). The soils of Ondo State were derived from the basement complex rocks which are mostly well drained, with a medium texture. The soils, classified as Ondo association, are of high agricultural value for both tree and arable crops. The swamp flats are characterized by swampy organic and flooded organic soils, while the major part consists of decomposed and partly decomposed organic matter; whereas areas affected by tide bear saline soils. The latter soils are mostly useless for agricultural practices.

Data collection and Tree species Identification

Eight sample plot of sizes 20 m X 40 m were demarcated in each of the forest reserves where enumeration took place. Two transects lines of 1000 m in length parallel to each other with at a distance of 500 m between them were laid in each of the study sites and each transect has four plots to make a total of eight (8) samples plots in each of the study sites. The botanical name of every living tree encountered in the sample plots of each forest reserve with dbh greater or equal to 10 cm were identified and recorded. Where a tree botanical name is not known, such was identified by its common name. A tree that cannot be identified was referred to as unknown, and part of such tree (such as leaves, bark and flower) was collected for identification in the herbarium.

Insects Collection

Insect collection was carried out within each of demarcated sample plots in each Forest Reserve and the sampling was targeted on free living insect herbivore foraging during the day time of the each selected forest reserves. These insects include leaf-chewing and sap sucking insects. Sampling of the insects was carried on daily basis for the period of one month, and during the collection all insects encountered were collected alive with hand and sweep net and were gently killed inside a bottle contain chloroform to preserve them. Sweep net was used for all flying insect while hand picking was used for the entire crawling insects found on the ground and on the trees. Average of at least 30 minutes was spent at each collecting station (Adeduntan, 2007). All insects were classified into their family and orders. An insect Para Taxonomist was employed and field assistant was used for the recording on the field. The frequency was obtained to ascertain species abundance / richness and species evenness.

Mesofaunna Isolation and Identification

Collection of soil samples: The soil samples were collected at three different points diagonally in each plot and bulked. The bulked samples from each plot were taken to the laboratory to determine the soil mesofauna in each forest ecosystem.

The isolation of soil mesofauna was done in the laboratory using the flotation method. About 100 g of the bulked soil was placed in a Petri-dish and mixed with water (this helped in coagulation of the soil constituents so that the soil mesofauna can be viewed). The soil was then viewed under microscope to identify the various species and abundance of soil mesofauna present in the soil sample.

Data Analysis

Tree species Classification and Diversity Indices

All tree species that were encountered in each forest reserve were classified into families and their frequencies of occurrence were also obtained to ascertain species abundance richness and species evenness. The following biodiversity indices were used to obtain species richness and evenness in each of the selected forest reserves. They were also used as indices for comparing biodiversity among the different forest ecosystems.

(i) Species relative diversity (RD) (%): Species relative diversity refers to the number of individual of a given species divided by the total number of individual of all species. It is given by equation 1

$$RD = \frac{n_i}{N} * 100 \qquad \text{(eqn 1)}$$

Where:

RD = relative density of the species
ni = number of the individual of species i
N = total number of individual in the entire population.

(ii) Shannon – Wiener diversity index: This was used to calculate the ecosystem's diversity index which takes into account the species richness and abundance of each species in the different ecosystems (Kent and Coker, 1992). The equation that was used is:

$$H^1 = - \sum_{i=1}^{s} PiLn(Pi) \qquad \text{(eqn 2)}$$

H^1 = Shannon diversity index
S = the total number of species in the habitat
Pi = proportion S (species in the family) made up of the 1th species
Ln = natural logarithm.

(iii) Species evenness (E) in each ecosystem was calculated by adopting Shannon's equitability index (E_H) of Kent and Coker (1992):

$$E_H = \frac{\sum_{i=1}^{s} p_i \ln(p_i)}{\ln(S)} \qquad \text{(eqn 3)}$$

RESULTS AND DISCUSSION

Tree species diversity and abundance

One thousand, one hundred and sixty seven (1,167) individual trees were encountered in all the study sites. These were distributed into ninety-four (94) tree species falls into twenty-nine (29) families per hectare. Tables 1 and 2 show that, Oluwa forest reserve had the highest species abundance of three hundred and seventy-one (371) distributed within 59 species, followed by Akure-Ofosu with 360 stems in 58 species, and Akure (Queen) plot has two hundred and seventy four (274) in fifty (50) species. The least was recorded in Owo forest reserve with one hundred and sixty two (162) individual in thirty eight (38) species. The diversity values obtained for Oluwa forest reserve, Akure-Ofosu forest reserve, Owo forest reserve and Akure (Queen Plot), were 3.60, 3.57, 3.34, and 3.31, respectively.

In Oluwa forest reserve, *Diospyros spp* has the highest number of occurrence among all the fifty-nine trees encountered with a relative frequency of 9.97% followed by *Celtis zenkerii* (7.01%) and *Strombosia pustulata* (7.01%), while *Baphia sapida, Perpulchrum clanidoxa, Dracaena mannii, Erythroxylum mannii* and *Ficus goliath* have the least frequency and relative frequency of 2.43 and 0.27; and 0.27 and 0.27 respectively. *Diospyros spp* has the highest value of occurrence in Akure-Ofosu forest reserve with thirty seven (37) individual. Some of the tree species encountered are as follows; *Steculia*

Table 1: Tree species diversity and relative abundance in the study sites

TREE SPECIES	FAMILY	Akure/Ofosu forest reserve		Akure queen's forest		Owo forest reserve		Oluwa forest reserve	
		Freq. (Ha)	R.Freq.	Freq. (Ha)	R.Freq.	Freq. (Ha)	R.Freq.	Freq. (Ha)	R.Freq.
Afzelia africana	Caesalpinioideae	-	-	1.56	0.36	-	-	-	-
Albizia zygia	Mimosoideae	-	-	3.13	0.73	-	-	-	-
Alstonia boonei	Apocynaceae	1.56	0.28	4.69	1.09	-	-	1.56	0.27
Baphia nitida	Papilionoideae	14.1	2.5	-	-	9.38	3.7	14.1	2.43
Blighia sapida	Sapindaceae	3.13	0.56	-	-	-	-	3.13	0.54
Bombax bounopozense	Bombaceae	1.56	0.28	1.56	0.36	-	-	3.13	0.54
Bosqueia angolensis	Moraceae	6.25	1.11	6.25	1.46	3.13	1.23	4.69	0.81
Brachystegia eurycoma	Caesalpinioideaee	12.5	2.22	10.9	2.55			12.5	2.16
Bridelia ferruginea	Euphorbiaceae	10.9	1.94	4.69	1.09	1.56	0.62	10.9	1.89
Buchholzia coriacea	Violaceae	10.9	1.94	-	-	4.69	1.85	20.3	3.5
Canarium schweinfurthii	Burseraceae	4.69	0.83	1.56	0.36	1.56	0.62	4.69	0.81
Ceiba pentandra	Bombacaceae	1.56	0.28	3.13	0.73	4.69	1.85	1.56	0.27
Celtis mildbraedii	Ulmaceae	3.13	0.56	3.13	0.73			3.13	0.54
Celtis zenkeri	Ulmaceae	40.6	7.22	42.2	9.85	14.1	5.56	40.6	7.01
Chrysophyllum albidum	Sapotaceae	15.6	2.78	14.1	3.28	1.56	0.62	14.1	2.43
Chrysophyllum perpulchrum	Sapotaceae	-	-	3.13	0.73	-	-	1.56	0.27
Clanidoxa garbonensis		1.56	0.28	-	-	-	-	1.56	0.27
Cleistopholis patens	Annonaceae	6.25	1.11	1.56	0.36	-	-	6.25	1.08
Cola acauminata	Sterculiaceae	21.9	3.89	3.13	0.73	6.25	2.47	21.9	3.77
Cola gigantean	Sterculiaceae	20.3	3.61	18.8	4.38	29.7	11.73	20.3	3.5
Cola hipsida	Sterculiaceae	3.13	0.56	1.56	0.36			3.13	0.54
Cola millenii	Sterculiaceae	4.69	0.83	9.38	2.19	20.3	8.02	4.69	0.81
Cola nitida	Sterculiaceae	3.13	0.56	3.13	0.73	-	-	3.13	0.54
Cola spp	Sterculiaceae	-	-	1.56	0.36	-	-	-	-
Cordia millenii	Bignonaceae	4.69	0.83	1.56	0.36	-	-	4.69	0.81
Desplatsia dewevrei	Tiliaceae	3.13	0.56	6.25	1.46	7.81	3.09	3.13	0.54
Diospyros crassiflora	Ebenaceae	6.25	1.11	-	-	-	-	6.25	1.08
Diospyros dendo	Ebenaceae	-	-	-	-	4.69	1.85		
Diospyros spp	Ebenaceae	57.8	10.28	1.56	0.36	7.81	3.09	57.8	9.97
Discoglypremna caloneura	Euphorbiaceae	7.81	1.39	-	-	7.81	3.09	7.81	1.35
Dracaena mannii	Agavaceae	1.56	0.28	-	-	-	-	1.56	0.27
Drypetes floribunda	Euphorbiaceae	1.56	0.28	-	-	-	-	1.56	0.27
Drypetes spp	Euphorbiaceae	-	-	4.69	1.09	6.25	2.47	-	-
Ekan aja		-	-	1.56	0.36	-	-	-	-
Enantia chlorantha	Annonaceae	-	-	1.56	0.36	-	-	-	-
Entandrophragma angolense	Meliaceae	3.13	0.56	9.38	2.19	-	-	3.13	0.54
Erythrophleum africanum	Mimosoideae	1.56	0.28	-	-	3.13	1.23	1.56	0.27
Erythroxylum mannii	Erythroxylaceae	1.56	0.28	3.13	0.73	-	-	1.56	0.27
Euphorbia deightonii	Euphorbiaceae	-	-	3.13	0.73	-	-	-	-
Fagara macrophylla	Rutaceae	7.81	1.39	-	-	4.69	1.85	7.81	1.35

Ficus goliath	Moraceae	1.56	0.28	-	-	4.69	1.85	1.56	0.27
Funtumia elastica	Apocynaceae	15.6	2.78	18.8	4.38	3.13	1.23	15.6	2.7
Hannoa klaineana	Simaroubaceae	-	-	6.25	1.46	-	-	-	-
Holoptelea grandis	Moraceae	4.69	0.83	-	-	3.13	1.23	4.69	0.81
Hunteria umbellata	Apocynaceae	14.1	2.5	-	-	3.13	1.23	14.1	2.43
Khaya grandifoliola	Meliaceae	4.69	0.83	-	-	-	-	4.69	0.81
Lovoa trichilioides	Meliaceae	3.13	0.56	-	-	4.69	1.85	3.13	0.54
Mansonia altissima	Sterculiaceae	28.1	5	50	11.68	3.13	1.23	28.1	4.85
Melicia regia	Moraceae	3.13	0.56	-	-	-	-	3.13	0.54
Mitragyna stipulosa	Rubiaceae	1.56	0.28	1.56	0.36	-	-	1.56	0.27
Mussanga cecropiodes	Moraceae	1.56	0.28	-	-	4.69	1.85	1.56	0.27
Myrianthus arboreus	Moraceae	14.1	2.5	1.56	0.36	7.81	3.09	14.1	2.43
Napoleonaea imperialis	Lecythidaceae	6.25	1.11	6.25	1.46	1.56	0.62	6.25	1.08
Pachystela delevoyi	Sapotaceae	1.56	0.28	-	-	-	-	1.56	0.27
Parinari robusta	Chrysobalanaceae	-	-	1.56	0.36		-	-	-
Pausinystalia johimbe	Rubiaceae	10.9	1.94	1.56	0.36	1.56	0.62	10.9	1.89
Pausinystalia macroceras	Rubiaceae	1.56	0.28	-	-	-	-	1.56	0.27
Pentaclethra macrophylla	Mimosoideae	3.13	0.56	-	-	-	-	3.13	0.54
Phyllanthus discoideus	Euphorbiaceae	6.25	1.11	-	-	4.69	1.85	10.9	1.89
Piptadeniastrum Africana	Mimosoideae	-	-	1.56	0.36	-	-	-	-
Pterocarpus angolensis	Papilioniodeae	3.13	0.56	25	5.84			3.13	0.54
Pterygota macrocarpa	Sterculiaceae	4.69	0.83			12.5	4.94	4.69	0.81
Pycnanthus angolensis	Myristicaceae	20.3	3.61	7.81	1.82	4.69	1.85	20.3	3.5
Rhizophora racemosa	Rhizophoraceae	-	-	3.13	0.73	-	-	-	-
Ricinodendron heudelotii	Euphorbiaceae	15.6	2.78	10.9	2.55	9.38	3.7	15.6	2.7
Sterculia oblonga	Sterculiaceae	7.81	1.39	14.1	3.28	1.56	0.62	7.81	1.35
Sterculia rhinopetala	Sterculiaceae	28.1	5	26.6	6.2	3.13	1.23	28.1	4.85
Strombosia grandifolia	Olacaceae	-	-	1.56	0.36	-	-	-	-
Strombosia pustulata	Olacaceae	40.6	7.22	23.4	5.47	21.9	8.64	40.6	7.01
Terminalia superba	Combretaceae	4.69	0.83	10.9	2.55	4.69	1.85	7.81	1.35
Treculia africana	Moraceae	7.81	1.39	1.56	0.36	-	-	7.81	1.35
Triplochiton scleronxylon	Sterculiaceae	23.4	4.17	40.6	9.49	12.5	4.94	23.4	4.04
Unknown		-	-	1.56	0.36	1.56	0.62	-	-
Total Abundance		563	100.00	428	100.00	253	100.00	580	100.00

Table 2: Trees species diversity indices in the selected forest reserves

Habitat	Species Richness	H^1 Diversity index	Evenness (E)	Abundance (per hectare)
Akure Ofosu	58	3.57	0.61	360
Akure Queen plot	50	3.31	0.59	274
Owo	38	3.34	0.66	162
Oluwa	59	3.60	0.61	371
Total	205	13.82	2.47	

H^1= Shannon Weiner diversity index.

Table 3: ANOVA table for comparing variation in abundance of tree species with Forest Reserves

Sources of variation	Df	Sum of Squares	Means of Squares	F-Cal.	F-Tab
Treatment (Forest reserves)	3	0.860	0.287	2.66	0.6
Error	28	2.903	0.104		
Total	31	3.763			

Table 4: Follow up of the influence of forest reserves on abundance of tree species encountered

Sources of Variation	Means per hectare
Akure Queens Plot	360[a]
Oluwa Forest Reserve	274[b]
Akure-Ofosu	162[b]
Owo Forest Reserve	371[c]

Means that follow with the different alphabet are significantly different (P<0.05)

rinopetala, Celtis zenkerii, Cola milenii, Steculia oblonga, Funtumia elastica, Mansonia altisima e.t.c. with the following frequencies; 28.1, 40.6, 4.69, 7.81, 1.56, 28.1 respectively.

In Akure-Queen forest, *Mansonia altissma* has the highest frequency (28.1), this is followed by *Celtis zenkerii*, and *Triplochiton scleroxylon* with 40.16 and 23.4 respectively. But in Owo forest reserve, *Cola gigantean* has the highest number of occurrence (23.3) followed by *Strombosia pustulata* and *Cola millenii* with 40.6, and 4.69 respectively *Bridelia ferruginea*, *Chrysophyllum perpulchrum*, and *Napoleoneae imperialis* has one species each with least the relative frequency.

ANOVA table (Table 3) shows that there was significant difference (Pd" 0.05) between the tree species encountered in the four selected forest reserves. The follow up analysis shows that the tree species in Akure-Queen forest is significantly higher than tree species in the other forest reserves. Tree species diversity was significantly (Pd" 0.05) lower in Owo forest reserve but there was no significant difference between Akure-Ofosu and Oluwa forest reserves diversity (Table 4).

Insect herbivores diversity richness and abundance

Table 5 shows the diversity, richness and abundance of insects in the selected forest reserves. A total of 956 individual insects were encountered in all the studied sites in 45 different species distributed within 18 families. Akure Queen's forest reserve has the highest abundance of 363 in 36 different species. *Orthetrum chrysositigma* species has the highest number of occurrence 51 species per hectare within this forest reserve with 9.09% relative frequency, 29.69 species per hectare were recorded in Oluwa forest reserve with 8.08% relative frequency and eight species in Owo forest reserve with 4.07% relative frequency. *Orthetrum chrysositigma* species was not present at all in Akure/Ofosu forest reserve. Some of the species that were present with high relative frequency are: *Shinjonotus octofaciatus* (8.82 %), *Colias philodise* (6.68%), *Riticulitermes spp* (6.61 %) and *Pantala flallescens* (5.79%). Oluwa forest reserve has the next highest abundance of 236 in 27 species. *Orthetrum chrysositigma*, and *Anaphaesis aurota* have the highest frequency within the forest reserves with 8.05% and 6.7% relative frequency respectively, some of the species encountered with high frequency and relative frequency in the reserve are *Tomares nesimachus* (23.44), *Pantala flallescens* (23.44), *Oedipoa coerulans* (20.31). But in Akure-Ofosu, 234 was recorded with 27 different species and the least was encountered in Owo forest reserve with 123 individual in 26 species (Table 5). The diversity of insects in the study sites follows this order; Akure (Queen's plot), Oluwa forest reserve, Akure-Ofosu forests and Owo forest reserve (3.31, 3.17, 3.08 and3.07) respectively (Table 6).

The results of analysis of variance (Table 7) show that there were significant (P<0.05) differences in insects' species that was encountered in the selected four forest reserve. Also, result of follow up shows that there are no significant (P>0.05) difference between Akure-Ofosu and Oluwa forest reserve. However, there are significant (P< 0.05) differences between the insect's species in Owo forest reserve and Akure Queen Plot (Table 8).

Table: 5 Insect species abundance in the forest reserves

INSECTS SPECIES	FAMILY	AKR-OFOSU FRT RS		AKURE FRT RS		OWO FRT RS		OLUWA FRT RS	
		Freq. (Ha)	R.Freq.	Freq. (Ha)	R.Freq.	Freq. (Ha)	R.Freq.	Freq. (Ha)	R.Freq.
Alypia octomaculate	Noctuideal	9.38	2.56	-	-	-	-	-	-
Ameles heldreichi	Mantisdes	1.56	0.43	-	-	-	-	-	-
Ameles heldreichi	Mantisdes	-	-	1.56	0.28	3.13	1.63	-	-
Anacridium aegyptium	Orthoptera	6.25	1.71	1.56	0.28	-	-	-	-
Anaphaeis aurota	Pieridae	35.94	9.83	3.13	0.55			25.00	6.78
Apis malilifera	Apidae			3.13	0.55	4.69	2.44	-	-
Aporia cratagei	Pieridae	10.94	2.99	7.81	1.38	-	-	-	-
Archan apollinus biellgus	Papilionidea	10.94	2.99	-	-	-	-	-	
Aychispirostreptus syriacus	Diptopoda	1.56	0.43	3.13	0.55	-	-	-	
Brachythemis leucosticta	Odonata	31.25	8.55	17.2	3.03	1.56	0.81	15.63	4.24
Camponotus pennsyuanicus	Forchicidae	20.31	5.56	12.5	2.2	7.81	4.07	7.81	2.12
Catopsilla florella	Pieridae	9.38	2.56	23.4	4.13	9.38	4.88	12.50	3.39
Chrysonga abliceps	Diptera	18.75	5.13	17.2	3.03	12.5	6.5	15.63	4.24
Chrysotoxum sp	Diptera	7.81	2.14	9.38	1.65	-	-	-	-
Colias philodise	Pieridae	9.38	2.56	39.1	6.89	9.38	4.88	14.06	3.81
Colotis phisadia phsadia	Pieridae	4.69	1.28	23.4	4.13	4.69	2.44	9.38	2.54
Episyron quinquenotatus	Pompilidae	-	-	15.6	2.75	9.38	4.88	-	-
Gryllus pennsyluanicus	Gryllidae	17.19	4.70	10.9	1.93	3.13	1.63	-	-
Hippanchia fatua sidiaea	Satyridae	4.69	1.28	12.5	2.2	4.69	2.44	6.25	1.69
Hyalophora cecropia	Saturmudea	12.50	3.42	7.81	1.38			12.50	3.39
Ischnura elegans ebneri	Odonata	31.25	8.55	17.2	3.03	6.25	3.25	18.75	5.08
Lesiominate orientalis	Satyridae	4.69	1.28	17.2	3.03			17.19	4.66
Lucilia sericata	Diptera	6.25	1.71	10.9	1.93	6.25	3.25	14.06	3.81
Lycaena thorsamon oniphate	Lycanidea	15.63	4.27	7.81	1.38	7.81	4.07	-	-
Madais fausta fausta	Pieridae	17.19	4.70	4.69	0.83	1.56	0.81	14.06	3.81
Maniola tulmassia	Satyridae	12.50	3.42	14.1	2.48	4.69	2.44	14.06	3.81
Mantis religiosa	Mantisdes	-	-	-	-	7.81	4.07	3.13	0.85
Melanoplus sangninipes	Acrididae	-	-	14.1	2.48	-	-	4.69	1.27
Oedipoa coerulans	Orthoptera	-	-	21.9	3.86	7.81	4.07	20.31	5.51
Oedipoa miniata	Orthoptera	-	-	12.5	2.2	6.25	3.25	14.06	3.81
Orthetrum chrysositigma	Odonata	-	-	51.6	9.09	7.81	4.07	29.69	8.05
Pantala flallescens	Odonata	-	-	32.8	5.79	1.56	0.81	23.44	6.36
Riticulitermes sp	Phinotermitidea	-	-	37.5	6.61	-	-	10.94	2.97
Sarcophagidea	Diptera	-	-	6.25	1.1	-	-	4.69	1.27
Sceliphron spirifore	Hymenoptera	-	-	18.8	3.31	10.9	5.69	3.13	0.85
Shinjonotus octofasciatus	Orthoptera	10.94	2.99	50	8.82	9.38	4.88	6.25	1.69
Tomares nesimachus	Lycanidea	18.75	5.13	23.4	4.13	18.8	9.76	23.44	6.36
Zegris eupheme	Pieridae	9.38	2.56	10.9	1.93	3.13	1.63	14.06	3.81
Zizeena kasandra kasandra	Lycanidea	26.56	7.26	6.25	1.1	21.9	11.38	14.06	3.81
		365.63	100.00	567	100	192	100	368.75	100.00

Table 6: Diversity indices of Insects Species in the forest reserves

Habitat	Species Richness	H^1 Diversity	Evenness	Abundance per hectare
Akure-Ofosu	27	3.08	0.56	234
Akure (Queen)	35	3.31	0.56	363
Owo	26	3.07	0.64	123
Oluwa	27	3.17	0.58	236

Table: 7 ANOVA table for comparing variations in insect species abundance with forest reserves

Sources of variation	df	Sum of Squares	Means of Square	F Cal.	F Tab
Treatment (Forest reserves)	3	1.219	0.406	2.726	0.63
Error	28	4.176	0.146		
Total	31	5.395			

Table: 8 Comparison of insect species abundance in the study area

Sources of Variation	Means
Akure Queens Plot	234[a]
Oluwa Forest Reserve	363[a]
Akure-Ofosu	123[b]
Owo Forest Reserve	236[c]

Mesofauna Abundance, Diversity and Richness

The results of mesofauna diversity and abundance of the study sites are presented in Table 9. It was discovered that 907 individual mesofauna were extracted in all the sites under the study and distributed within 62 species. A total of 309 different species of soil mesofauna were recorded in Oluwa forest reserve with diversity value of (2.57) which is the highest value compared with other studied habitats. This was followed by Akure-Ofosu forest reserve with mesofauna abundance species of 250, with diversity value of 2.30 followed by Akure-Queen's forest reserve with 233 abundance and diversity value of 2.52 while the least was recorded at Owo forest reserve with abundance value of 115 and diversity of 2.30. Mesofauna diversity was significantly higher in Oluwa forest reserve and Akure (Queen's plot) forest reserves than the remaining forest reserve. The correlation coefficient between insects and mesofauna was positive and high (0.7747). However the correlation coefficient between trees and insects abundance was negative (-0.3800) while that those of trees and mesofauna abundance was positive but lower (0.1120) respectively.

DISCUSSIONS

Diversity of tree species in the study area

Species richness and distribution are the most important characteristics of tropical rainforest ecosystem. Regardless of plot size, the number of tree species is far greater in tropical rainforest than in any other forest community (Adekunle, 2006). However, The Nigeria rainforest ecosystem is dominated by members of Sterculiaceae (e.g. *Cola spp., Sterculia spp.*,) Ulmaceae (e.g. *Celtis spp., Holoptelea grandis*), Meliaceae (e.g. *Entandrophragma spp., Khaya ivorensis*) and species like *Terminalia superba, Erythrophleum spp., and Brachystegia eurycoma* (Richards 1939, Isichei 1995 and Were 2001), which is consistent with our findings (Table 1). Also our study revealed that members in the of families Apocynaceae (*Funtumia elastic, Hunteria umbellate*) and Euphorbiaceae (*Bridelia spp., Drypetes spp*., and *Strombosia pustulata)* are also important tree species composition of the study areas. The presence of different tree species of high quality across different forest reserves under the study site could be attributed to forest exploitation and degradation, due to richness of forest reserve. The results of our findings on species richness, which is one of the indices of biodiversity assessment, shows that Oluwa and Akure Queen's forest reserves had higher richness than Akure-Ofosu and Owo forest reserves. This indicated that species richness decreased as the intensity of forest degradation increases. The variation in species richness in Akure-Ofosu and

Table 9: Mesofauna abundance in the study area

MESOFAUNA SPECIES	AKR-OFOSU FRT RS		AKURE FRT RS		OWO FRT RS		OLUWA FRT RS	
	Freq. (Ha)	R.Freq.	Freq. (Ha)	R.Freq.	Freq. (Ha)	R.Freq.	Freq. (Ha)	R.Freq.
Acrobeloides sp	23.44	6.00	-	-	10.94	6.09	34.38	7.12
Allolobophora trapezoides	9.38	2.40	-	-	31.25	17.39	9.38	1.94
Alomeus marginata	-	-	-	-	-	-	7.81	1.62
Aporrectoda caliginosa	-	-	-	-	-	-	9.38	1.94
Araneus diadematus	59.38	15.20	21.88	6.42	9.38	5.22	14.06	2.91
Caenohabditis elegans	-	-	-	-	-	-	3.13	0.65
Calpoda steinii	-	-	28.13	8.26	-	-	28.13	5.83
Dorylus fimbriatus	81.25	20.80	67.19	19.72	6.25	3.48	54.69	11.33
Earwig	7.81	2.00	9.38	2.75	3.13	1.74	17.19	3.56
Folsomia candida	29.69	7.60	23.44	6.88	7.81	4.35	14.06	2.91
Isopod sp	45.31	11.60	3.13	0.92	29.69	16.52	42.19	8.74
Mesodiplogaster inheriter	-	-	20.31	5.96	-	-	-	
Microtermitinae	25.00	6.40	12.50	3.67	14.06	7.83	-	-
Myrmicania striata	9.38	2.40	53.13	15.60	23.44	13.04	121.88	25.24
Oniscus asellus	-	-	-	-	-	-	9.38	1.94
Polyzonium sp	9.38	2.40	4.69	1.38	17.19	9.57	7.81	1.62
Porcelliio scober	-	-	-	-	-		43.75	9.06
Rhabditis sp	-	-	10.94	3.21	-	-	-	-
Ricinoides cassipalpe	40.63	10.40	17.19	5.05	-	-	26.56	5.50
Scolopendra hero	-	-	46.88	13.76	-	-	7.81	1.62
Spirostreptus sp	7.81	2.00	12.50	3.67	6.25	3.48	14.06	2.91
Tullbergia gramilata	42.19	10.80	32.81	9.63	20.31	11.30	17.19	3.56
	390.63	100.00	364.06	100.00	179.69	100.00	482.81	100.00

Table 10: Diversity indices of Mesofauna Species in the study area

Habitat	Species Richness	H^1 index	Evenness	Abundance per hectare
Akure-Ofosu	13	2.30	0.42	250
Akure-Queen	15	2.52	0.46	233
Owo	12	2.30	0.48	115
Oluwa	19	2.57	0.45	309

H^1= Shannon-weinner index

Table 11: ANOVA Table for comparing variations in Mesofauna Species with forest Reserve

Sources of variation	df	Sum of Squares	Means of Square	F Cal.	F Tab
Treatment (Forest reserve)	3	0.542	0.181	4.179	0.015
Error	28	1.209	0.043		
Total	31	1.751			

Table 12: Mean separation showing the influence of the study area on Mesofauna Species abundance

Sources of Variation	Means
Akure Queens Plot	250[a]
Oluwa Forest Reserve	233[a]
Akure-Ofosu	115[a]
Owo Forest Reserve	309[b]

Means that follow with the different alphabet are significantly different (P<0.05)

Owo forest reserves could be attributed to the effect of repeated logging and exploitation at the two sites (Onyekwelu *et al.,* 2008, Webb and Peralta, 1998). Species richness values in Oluwa and Akure Queen's forests are comparable with that of some rainforest sites in Nigeria, e.g. 56, 55, and 54 tree species ha^{-1} were found in Sapoba, Shasha and Ala forest reserves respectively (Lowe 1997, Adekunle 2006 and Adeduntan *et. Al.*. 2005). The trend of Shannon-Weiner diversity indices (H^1) showed that Oluwa forest reserve was the most diverse among the four forest ecosystems, followed by Akure-Ofosu, Owo forest reserve and the least was Akure Queen's forest. Adekunle (2006), reported that the H^1 values that ranged from 3.34-3.66 for some rainforest sites in Nigeria. The findings of this study are similar to the report of Adekunle (2006) except Akure Queen's forest reserve which is a little lower compared to the range but still falls within the general limit of 1.5- 3.5 recommended by Kent and Coker (1992). This is an indication that species distribution is also affected by level of forest exploitation across different forest reserves.

Diversity of insect's species herbivores in the study area

The diversity of insects in Akure-Queen reserve is significantly higher (P d" 0.05) than what we observed in the other selected forest reserves. This is similar to the study of Hill *et al.*, (1995) who reported a reduction in diversity of insect species due to the form and structure of forest ecosystems. He further observed that species richness, abundance and evenness of butterflies were significantly higher (Pd" 0.05) in unlogged forest than in the logged forest. Novotany *et al.,* (2006) reported that the greater the number of tree species in the tropics the higher the insect diversity. Adeduntan (2007) also reported that the higher the tree species diversity, the higher is also the insect's diversity of an ecosystem. This could be as a result of closed canopy of undisturbed forest which forms different layers that allowed regeneration over time. This could have contributed greatly to. Owo forest reserve has scattered tree that encourage the growth of shrubs and grasses, this could affect or reduce the diversity of insect in the habitat. This agrees with the finding of (Mordoch *et al,* 1972 South wood 1979) who reported that physical complexity of an environment affects arthropods abundance and diversity.

Diversity and Abundance of Soil Mesofauna

From the results of this study, it was observed that Oluwa forest reserve has the highest abundance of soil mesofauna than the other forest reserves. This is similar to the works of *Kampicher et al.*, (2000), who reported that

Table13: Relationship that exist between Trees, Insects and Mesofauna in the study area.

Relationship	R	Comment
Trees and insects	-0.379999402	Negative correlation
Insects and Mesofauna	0.774708399	Positive high correlation
Trees and Mesofauna	0.111905404	Positive low correlation

mesofauna was the most abundant in the soil that attain high densities of up to 100,000 individuals per m^2. This is because they live in wet as well as in the dry ecosystems and contribute to different tropic levels within the terrestrial food web (Rusek, 1998). Various factors such as soil types; plant cover and intensity of soil cultivation directly influence the soil mesofauna with respect to number and composition (Farrar and Crossely, 1983). Also the results of Shannon-Weiner diversity values of mesofauna indicate that Oluwa forest reserve had the higher diversity index than the other forest reserves. The results of this are similar to the findings of Adeduntan (2009). He reported that Akure forest reserve was one of the forest reserves with the highest diversity index in southwestern Nigeria. This might be due to its location, types of vegetation covers and condition.

CONCLUSION

The high values obtained for species diversity and abundance of trees and insects in this study shows a typical characteristic of a tropical rainforest, within which large portion of Ondo State is found. The results show that there are negative relationship between trees abundance and insect's abundance, while there are strong positive relationship between Insects' abundance and mesofauna abundance in the selected forest reserve. The higher the tree species abundance the higher the Arthropod species abundance. This is because arthropod can only be found where their food is available.

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