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Diversity and Seasonal Dynamics of Arthropods in Okomu Forest Reserve

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Case Study

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ABSTRACT

A field survey was conducted in Okomu Forest Reserve Edo State, to assess the diversity and seasonal dynamics of arthropod species in selected land use systems (Okomu national park, Okomu rubber plantation and Okomu oil palm plantation). Samplings of arthropods were carried out between February and September 2020, arthropods were collected by hand picking and sweep net in each sampled plots at 25 m x 25 m in the study area. Insects encountered were killed and preserved by chloroform. Arthropods samples were taken to the laboratory for oven dry and identification. A total of 382 arthropods spread across 15 orders, 34 families and 81 species were recorded. The most dominant orders were *Hymenoptera* (Ants) followed by *Odonta* (dragonfly) and *Lepidoptera* (butterfly and Moth) during dry season while highest abundance of orders were *Spirostreptida* (millepde) followed by *Hymenoptera* (Ants) and *Araneae* (spider) during rainy season. Okomu National Park has the highest (220) insect species abundance follow by Okomu Rubber Plantation (136) while the least was Okomu Oil Palm Plantation (72) in the study area. Study revealed that Okomu Rubber Plantation has no record of *Scolopendromorphra* (centipede) and*Hemiptera* (bug) while in Okomu Oil Palm Plantation no record of *Scolopendromorphra* (centipede), *lepidoptera* (butterfly), also there were norecord of blattodea (crockroach) order of insect species in Okomu National Park. The highest species diversity and evenness was observed

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in Okomu National Park (H' = 3.03 and E'= 0.83) follow by Okomu Oil Palm Plantation (H'=1.89 and E'=0.86) while Okomu Rubber Plantation was the least (H' = 1.53 and E'= 0.60). ANOVA showed significant (P≤0.05) different on diversity and abundance between land use systems while there is nosignificant (P≥0.05) different seasons in the study area. Observation was made on seasonal variation of arthropods species in different land use systems and dominant species as bio-indicators in the study area.

Keywords: Diversity; abundance; arthropod; seasons and land use system.

1. INTRODUCTION

Tropical forests play a prominent role in the maintenance of global biodiversity and ecosystem processes [1,2]. Their canopies are known to support an incredible diversity of animal species, in particular that of arthropods [3,4]. Ground arthropods and their diversity are of considerable significance during the recovery process of degraded ecosystems [5,6] since variations in diversity are presumably correlated with the stability of various biotic and abiotic components of ecosystems [7,8] Soil biodiversity has become an important measure for the evaluation of ecosystems [7] though the role of species diversity in ecosystem function is disputed [9] In terrestrial ecosystems, arthropods are one of the most important components in biodiversity [10] and their interactions with plants are essential for terrestrial food webs [11]. Many modern ecological studies are focusing on these interactions between vegetations and arthropods but interpretations may be limited, therefore a combination with studies focused on the fossil record is necessary [12] Studies on fossil insect herbivory have provided a variety of ecological and evolutionary information over the years, such as climate and anthropogenic activities [13,14]. Seasonal change in climatic conditions, especially the availability of water, has not only strong effects on the vegetation [15] but is probably also crucial for dynamics in the assemblage of arthropod communities, food web dynamics [16] extinction patterns [17,18] and ecosystem recovery after extinction events [17,19]. They have also shown that biodiversity loss may greatly affect trophic interactions and change the overall food web structure of ecological systems [20]. Moreover, there is increasing concern about the loss of biological diversity from ecosystems [21]. The movements of individual arthropods can be affected by the structural complexity of the surrounding vegetation [22]. Few studies concentrate on the seasonal change of forest arthropods between distinct seasons. The aim of the study was to examine seasonal variation of arthropod abundance and diversity at three land use systems in Okomu Forest Reserve. In this study, the arthropods collected were compared between dry and wet seasons.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out in Okomu Forest Reserve comprises Okomu National Park (ONP), Okomu Rubber Plantation (ORP) and Okomu Oil palm Plantation (OOP). However, the study areas were geographically located on longitude 5^0 00'E - 5^o 30'E and latitude 6^o 00'N - 6^o 30'N, Longitude 5° 07'E- 5° 25'E and Latitude 6^o 18'N-6^o 26'N for ONP, ORP and OOP respectively. Okomu forest reserve is set within the 1,082km² in Udo, Ovia south-west Local Government Area of Edo State. The topography is gentle ranging between 30 and 60 m above sea level. The mean annual rainfall is 2100 mm and a mean monthly temperature of 27°C. The mean monthly humidity is between 30.2% and 65% during the afternoon. Soils are acidic, with nutrients poor sandy loam, pH of 5.0 [23]. The Okomu National Park initially managed as a wildlife sanctuary by the Nigerian Conservation Foundation; it was gazetted as a national park in May 1999 and administered by the Nigerian National Parks Service (Ezealor, 2002). The Park covers a land mass of 202.24 km² [24]. The forest has a small rich fragment that once covered the region, but which has continued to shrink owing to numerous encroachments on it. It is characterized by swamp-forest, high forest, secondary forest, and open scrub. It serves as habitat for many endangered species of flora and fauna. Okomu Oil Palm Plantation as well as rubber Plantation was established in 1976 as a Federal Government of Nigeria pilot project covering an area of 15,580 hectares out of which 12,500 hectares could be planted with oil palm. In 1979 the company was incorporated as a private company with limited liability and in 1990, within a Structural Adjustment Programme, it was converted to a Public Limited Company (PLC). It

is a member of the Belgian Socfin, a global player group in the cultivation of oil palm as well as rubber, coffee and tropical flowers. Socfin owns 62.69% of Okomu Oil Palm's shares.

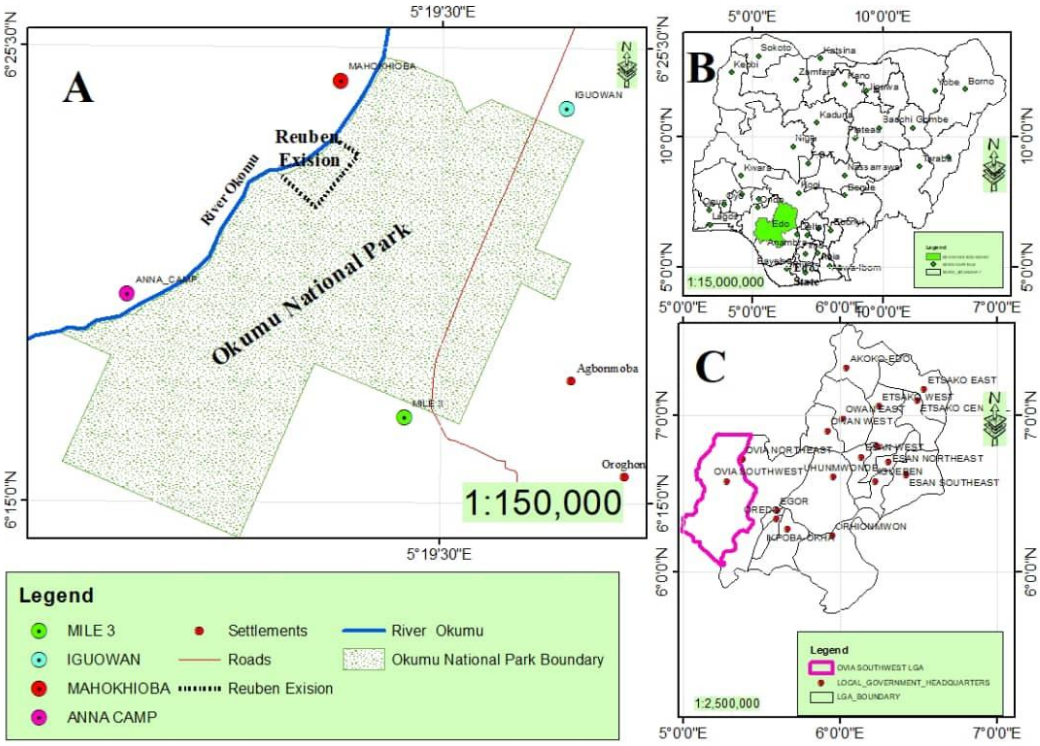

Fig. 1. Map of Okomu National Park

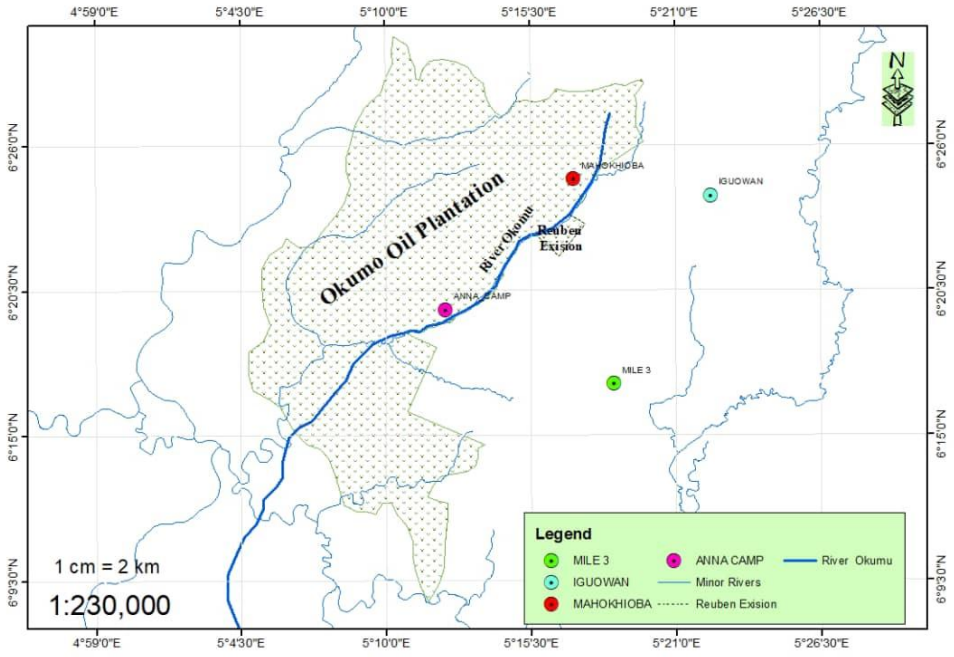

Fig. 2. Map of Okomu Oil Palm Plantation

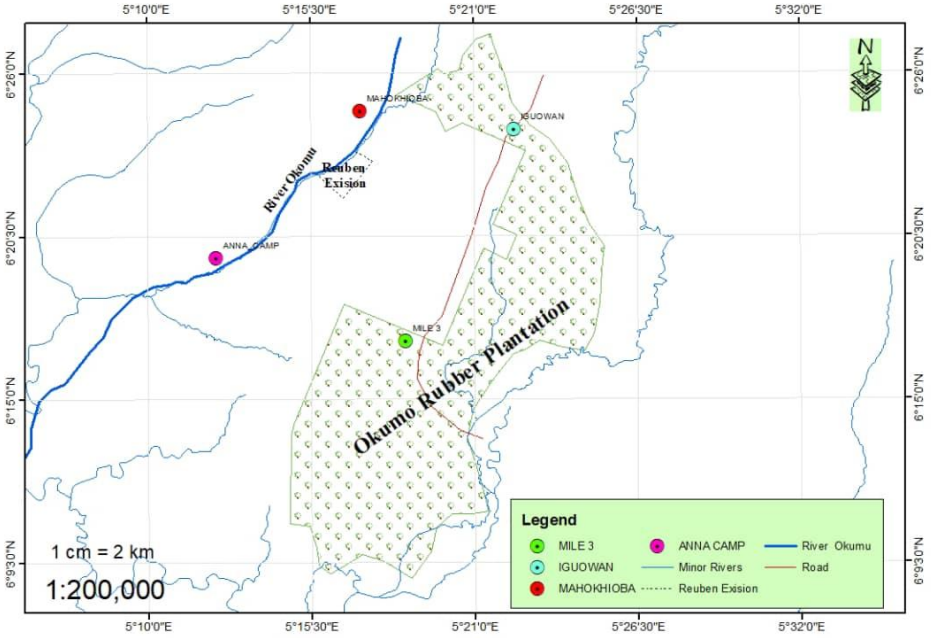

Fig. 3. Map of Okomu Rubber Plantation

2.2 Sampling Technique

A systematic sampling technique was adopted, line transects method [25] was conducted in each land use system and plots were laid to allows easy data assessement and enumeration to ensures a wide coverage of the population sampled in the study area was achieved.

2.3 Data Collection

Study was conducted between two seasons in February, 2020 (dry season) and September, 2020 (rainy season). Insect collection was carried out within each of the demarcated sample plots in the three land use systems and the sampling was focused on free living insects in the study area during raining and dry season. Eight sampled plots were cut in each of the three land use system for insect's collection. Two transect were cut in each ecosystem habitat while four plots were laid adjacent to other plot along a line transect of about 200m with the plots size of 25m x 25m and 20m interval from edge effect at 500m distance parallel to other transect line demarcation. Insects were collected by sweep net while those on forest floor were handpicked. An average of at least 30 minutes was spent at the collection plot [26]. A total of 382 arthropods species were collected in the study areas. 154, 115 and 113 arthropods species were encountered in Okomu national park, Okomu rubber plantation and Okomu oil palm plantation respectively.

2.4 Insects Collection, Preservation and Identification

Insects on the trees and forests floor were collected with sweep net as well as those flying around with average of 30 minutes spent in each sampled plots, all collected arthropod species were killed and preserved by Chloroform in a closed container. Sampled arthropods collected were mounted on thick card board in the laboratory and oven dried. An insects Taxonomy skill was engaged to identify insects sample as represented in the three land use areas after oven dry in the laboratory. Insects were identified and classified into order and families and their occurrence were recorded to confirm their diversity and abundance [27] and later were kept in the box.

2.5 Data Analysis

All insect species encountered in each community were classified into families and order; frequencies of occurrence were obtained for species abundance, evenness and relative density. The following biodiversity indices were used among the three land use systems.

(i) 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 ecosystem [28].
The equations used are

$$H^{I} = -\sum_{i=1}^{S} PiLn(Pi)$$

H^i = Shannon diversity index s
S = the total number of species in the habitat
Pi = proportion S (species in the family) made up of the 1th species

(ii) Species evenness (E)

In each ecosystem will be calculated by adopting Shannon's equitability index (EH) of Kent and Coker (1992):

$$H_{E} = \frac{\sum_{i=1}^{S} PiLn(Pi)}{Ln(S)}$$

HE= Species evenness
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

3. RESULTS

3.1 Diversity and Abundance of Insects in the Study Area

The distribution of arthropod species as order, family, scientific names and common names of all species encountered in the study area are presented in Table 1. A total of 382 species across 15 Orders, 54 family and 81 species were encountered. The land use system with highest arthropod species abundance is Okomu national park of 108 at dry season followed by Okomu oil palm plantation of 85 at raining season and Okomu oil palm plantation of 68 at dry season. While the land use system with highest arthropod species diversity presented is Okomu National Park of 41 at dry season followed by Okomu rubber plantation of 22 at dry season and Okomu oil palm plantation of 18 at rainy season. 39 species abundance accounted for *Atta spp* (Ants) during dry season followed 34 *Zinophora brevilobata* (millipedes) during rainy season and 21 *Formica spp* (Ants) during dry season.

Table 2 presents the diversity, abundance and evenness of arthropod species during dry and rainy seasons in the study area. A highest abundance of 108 individual insect species were encountered in Okomu National Park during the dry season follow by Okomu Oil Palm Plantation has 85 during the raining season while Okomu Rubber Plantation has the least 46 arthropod species abundance during dry season respectively. Diversity index of arthropods in the study area during dry season shows that land use system in Okomu National Park have the highest diversity (H' = 3.03) and evenness (E'= 0.83), while Okomu Rubber Plantation has the least (H'=1.53) and Evenness (E'= 0.60). During rainy season the highest insect species with diversity index (H'=2.58) and evenness (E'=0.84) are recorded in Okomu National Park, while the least (H'=2.23) and (E'= 0.77) is Okomu Oil Palm Plantation.

Results present the abundance of arthropod orders during dry and rainy seasons in the study areas. Fig. 4A showed a total number of 11 orders of insect species encountered during the dry season. The highest abundance of species is recorded in order *Hymenoptera* (Ants) followed by *Odonta* (dragonfly) and *Lepidoptera* (butterfly and Moth). Meanwhile, the land use systems with highest abundance of insect orders are recorded in Okomu National Park while the least abundance insect orders are recorded in Okomu rubber plantation. Result also revealed in Okomu Rubber Plantation that no present of *Scolopendromorphra* (centipede), *Mantodae* (Antfly), *Diptera* (cranyfly), *Araneae* (spider) and *Dermaptera* (Earwig), also Okomu oil palm plantation record no orders of *Scolopendromorphra* (centipede), *Mantodae* (Antfly), *Hemiptera* (bug) and *Diptera* (cranyfly) order of insect species during dry season. In Fig. 4B a total number of 10 orders accounted to arthropod species during the rainy season, order with highest abundance is recorded in *Spirostreptida* (millepde) followed by *Hymenoptera* (Ants) and *Araneae* (spider). Result has revealed in Okomu Rubber Plantation that no record of *Scolopendromorphra* (centipede) and *hemiptera* (bug) was observed while Okomu Oil Palm Plantation had no record of *Scolopendromorphra* (centipede), *lepidoptera* (butterfly) and Okomu National Park had no record of blattodea (crockroach) order of insect species.

Table 1. Distribution of insect diversity and abundance species in the habitats during dry and rainy seasons

					ONP		ORP		OOP		
	ORDER	**Family**	**Scientific Name**	**Common Name**	**Freq dry**	**Freq rain**	**Freq dry**	**Freq rain**	**Freq dry**	**Freq rain**	**Sum**
1	Araneae	Theraphosidea	*Euathlus smithii*	Spider	2	0	0	0	0	0	**2**
2	Areneae	Thomisidae	*Gasteracantha spp*	Orb spider	0	0	0	0	0	14	**14**
3	Arenea	Amaurobiidae	*Callobius spp*	Spider	0	0	0	1	0	0	**1**
4	Araneae	Sparassidae	*Heteropoda venatoria*	Spider	0	0	0	0	1	0	**1**
5	Araneae	Pholcidae	*Pholcus phalangioide*	Spider	0	1	0	0	0	0	**1**
6	Areneae	Lycosidae	*Hogna carolinensis*	Spider	0	0	0	0	0	1	**1**
7	Araneae	Araneidae	*Philodromus marxi*	Spider	0	1	0	0	0	4	**5**
8	Araneae	Desidae	*Metattella simony*	Spider	3	1	0	0	0	0	**4**
9	Blattodea	Ectobiidae	*parcoblatta americana*	Crockroack	0	0	0	1	0	1	**2**
10	Coleoptera	Histeridae	*Acritus spp*	Beetle	2	0	0	0	0	0	**2**
11	Coleoptera	Meloidae	*Lytta aenea*	Beetle	0	0	0	6	0	0	**6**
12	Coleoptera	Carabidae	*Harpalus rufipe*	Beetle	1	0	0	0	0	0	**1**
13	Coleoptera	Tenebrionidae	*Various spp*	Beetle	0	0	1	0	0	3	**4**
14	Coleoptera	Erotylidae	*Megalodacne heros*	Beetle	0	0	0	0	0	1	**1**
15	Coleoptera	Scolopendridae	*Anomala spp*	Beetle	0	0	0	0	1	0	**1**
16	Coleoptera	Lucanidae	*Lucanus capreolus*	beetle larva	0	0	0	4	0	0	**4**
17	Coleoptera	Psephenidae	*Psephenus spp*	Beetle	0	1	0	0	0	1	**2**
18	Coleoptera	Lycidae	*Calopteraon discripens*	Beetle	1	0	0	0	0	0	**1**
19	Coleoptera	Tenebrionidae	*Eleodes spp*	Beetle	2	1	0	0	0	0	**3**
20	Dermaptera	Anisolabididae	*Anisolabis maritime*	Earwig	1	2	0	0	0	0	**3**
21	Diptera	Calliphiphoridae	*Lucilia sericata*	Fly	1	1	0	0	0	0	**2**
22	Hemiptera	Reduviidae	*Zelus longipes*	assassin bug	0	1	0	0	0	3	**4**
23	Hemiptera	Plataspidae	*Megacopta cribraria*	Bug	2	1	0	0	0	0	**3**
24	Hemiptera	Coreidae	*Anasa tristis*	Bug	0	0	5	0	0	0	**5**
25	Hemiptera	Lygaeidae	*Arocatus melanophalus*	Bug	0	1	0	0	0	0	**1**
26	Hemiptera	Reduviidae	*Pselliopus spp*	Assassin bug	0	0	0	0	0	2	**2**
27	Hemiptera	Lygaeidae	*Nysius raphanus*	Bug	1	0	0	0	0	0	**1**
28	Hemiptera	Aphididea	*Dysaphis plantaginea*	Aphid	1	0	0	0	0	0	**1**
29	Hymenoptera	Formicidae	*Camponotus*	Ants/Fly	14	0	1	0	0	0	**15**

					ONP		ORP		OOP		
	ORDER	**Family**	**Scientific Name**	**Common Name**	**Freq dry**	**Freq rain**	**Freq dry**	**Freq rain**	**Freq dry**	**Freq rain**	**Sum**
			pennsyluanicus								
30	Hymenoptera	Formicidae	*Solenopsis invicta*	Ant	0	15	0	2	0	0	**17**
31	Hymenoptera	Formicidae	*Pogonmyrmax occidentalis*	Ant/fly	0	0	0	0	11	0	**11**
32	Hymenoptera	Formicidae	*Atta spp*	Ants/Fly	0	0	39	0	0	0	**39**
33	Hymenoptera	Specidae	*Sphex lucae*	Ant/fly	0	0	0	0	1	0	**1**
34	Hymenoptera	Formicidae	*Plectroctena melanophalus*	Ant	0	1	0	2	0	8	**11**
35	Hymenoptera	Vespidae	*Polistes fuscatus*	Ants/Fly	0	0	2	0	0	0	**2**
36	Hymenoptera	Formicidae	*Formica spp*	Ants/Fly	21	0	0	0	0	0	**21**
37	Hymenoptera	Lygacidae	*Nysius raphanus*	Ant	1	3	0	0	0	0	**4**
38	Hymenoptera	Siricidae	*Urocerus gigasflavicornis*	Ants/Fly	1	1	0	0	0	0	**2**
39	Hymenoptera	Apidae	*Apis mellifera*	Bee	1	0	0	0	1	0	**2**
40	Lepidoptera	Pieridae	*Pieris rapae*	Butterfly	4	0	0	1	0		**5**
41	Lepidoptera	Lycaenidae.	*Satyrium calanus*	Butterfly	1	0	0	0	0	0	**1**
42	Lepidoptera	Erebidae	*Celiptera frustulum*	Moth	1	0	0	0	0	0	**1**
43	Lepidoptera	Pieridae	*Pontia protodice*	Butterfly	2	0	0	0	0	0	**2**
44	Lepidoptera	Crambidae	*Hahncappsia spp*	Moth	1	0	0	0	0	0	**1**
45	Lepidoptera	Noctuidae	*Chlorida virescens*	Butterfly	0	0	1	0	0	0	**1**
46	Lepidoptera	Erebidae	*Pyrrharctia isabella*	Butterfly	0	0	1	0	0	0	**1**
47	Lepidoptera	Saturniidae	*Citheronia regalis*	Moth	1	0	0	0	0	0	**1**
48	Lepidoptera	Lasiocampidae	*Macrothylacia rubi*	Catapilar	0	0	0	1	0	0	**1**
49	Lepidoptera	Erebidae	*Orygia dectrita*	Moth	1	0	0	0	0	0	**1**
50	Lepidoptera	Torticidae	*Adoxophy furcatana*	Butterfly	0	0	0	0	6	0	**6**
51	Lepidoptera	Noctuidae	*Cucullia convexipennis*	Moth	1	0	0	0	0	0	**1**
52	Lepidoptera	Nymphalidae	*Heliconius charithonia*	Butterfly	1	0	0	0	0	0	**1**
53	Lepidoptera	Hesteridae	*Ancyloxphya numitor*	Butterfly	1	0	0	0	0	0	**1**
54	Lepidoptera	Pieridae	*Eurema mexicana*	Butterfly	1	0	0	0	0	0	**1**
55	Lepidoptera	Hesteridae	*Erynnia lucilius*	butterfly/moth	1	0	0	0	0	0	**1**
56	Lepidoptera	Crambidae	*Hymena perspectail*	butterfly/moth	1	0	0	0	0	0	**1**
57	Mantodae	Mantidae	*Mantis religiosa*	Ants/Fly	1	0	0	0	0	0	**1**

					ONP		ORP		OOP		
	ORDER	**Family**	**Scientific Name**	**Common Name**	**Freq dry**	**Freq rain**	**Freq dry**	**Freq rain**	**Freq dry**	**Freq rain**	**Sum**
58	Odonata	Libellulidae	*Pantale flavescens*	DragonFly	2	0	2	0	0	0	**4**
59	Odonata	Coenagrionidae	*Argia apicalis*	DragonFly	4	0	0	0	0	0	**4**
60	Odonata	Aeshnidae	*Anax walsinghami*	DragonFly	0	0	1	0	0	0	**1**
61	Odonata	Coenagrionidae	*Enallagma exsulans*	DragonFly	15	0	0	0	0	0	**15**
62	Odonata	Libellulidae	*Pantala flavescens*	Dragonfly	3	0	1	0	0	0	**3**
63	Odonata	Gemphidae	*Progomphus obscures*	*DragonFly*	2	1	1	0	0	0	**4**
64	Odonata	Aeshnidae	*Anax junius*	DragonFly	2	1	0	0	0	0	**3**
65	Odonata	Libllulibidae	*Sympetrum spp*	DragonFly	1	1	0	0	0	0	**2**
66	Orthoptera	Acrididae	*Melanoplus femurrubrum*	Grasshopper	1	0	10	0	0	6	**17**
67	Orthoptera	Acrididae	*Melanoplus ponderosus*	Grasshopper	0	0	0	0	3	0	**3**
68	Orthoptera	Acrididae	*Melanoplus differetialis*	Grasshopper	0	0	3	0	0	1	**4**
69	Orthoptera	Acrididae	*Melanophus bivittatus*	Grasshopper	0	0	1	0	0	2	**3**
70	Orthoptera	Gryllidae	*Gryllus spp*	Criket	0	0	0	5	0	1	**6**
71	Orthoptera	Lycosidae	*Strenopelmatus nigrocapitatus*	Criket	0	0	0	0	0	2	**2**
72	Orthoptera	Acrididae	*Dissosteira carolina*	Grasshopper	0	0	0	0	4	0	**4**
73	Orthoptera	Rhaphidophoridae	*Centhophilus spp*	Grasshopper	1	1	0	0	0	0	**2**
74	Orthoptera	Tettigoniidae	*Anabrus simplex*	Grasshopper	3	5	0	0	0	0	**8**
75	Polydesmida	Trichocomaceae	*Crystallomus thyridotus*	Millipede	0	1	0	1	0	4	**6**
76	Polydesmida	Xystodesmidae	*Aphehoria virginiensis*	Millipede	0	1	0	0	0	0	**1**
77	Polydesmida	Polydesmidae	*Tymbodesmus figinus*	rough millipede	0	0	0	2	0	0	**2**
78	Scolopendromorphra	Scolopendridae	*Scolopendra gigantea*	Centipede	1	0	0	0	0	0	**1**
79	Spirostreptida	Odontopygidae	*Spinotarsus silvarum*	Millipede	0	3	0	10	0	1	**14**
80	Spirobolida	Spirostreptidae	*Pelmatojulus excisus*	Millipede	0	0	0	7	0	0	**7**
81	Spirostreptida	Harpagophoridae	*Zinophora brevilobata*	Millipede	0	1	0	4	0	30	**35**
				Abundance	**108**	**46**	**68**	**47**	**28**	**85**	**382**
				Diversity	**41**	**22**	**12**	**14**	**10**	**18**	

ONP: Okomu National park; ORP: Okomu rubber plantation; OOP: Okomu Oil Palm Plantation; freq. dry:frequency of insect during dry season; freq. rainy:frequency of insect during rainy season

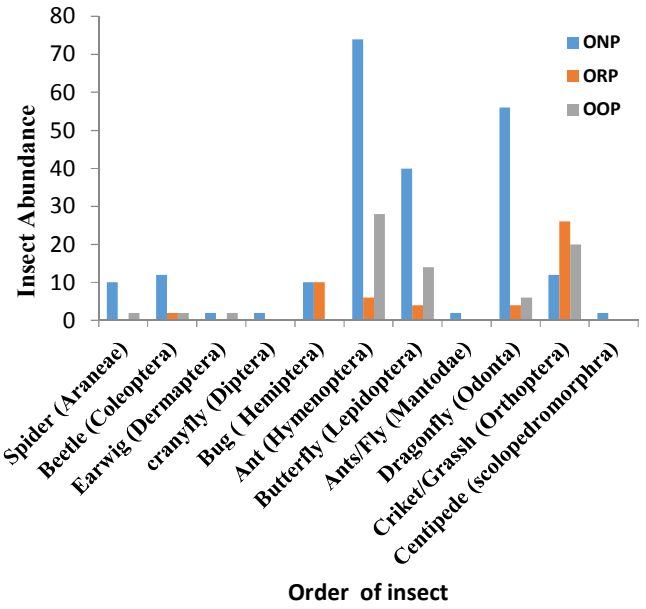

Fig. 4A. Abundance of arthropod Order during Dry Season in the study Area

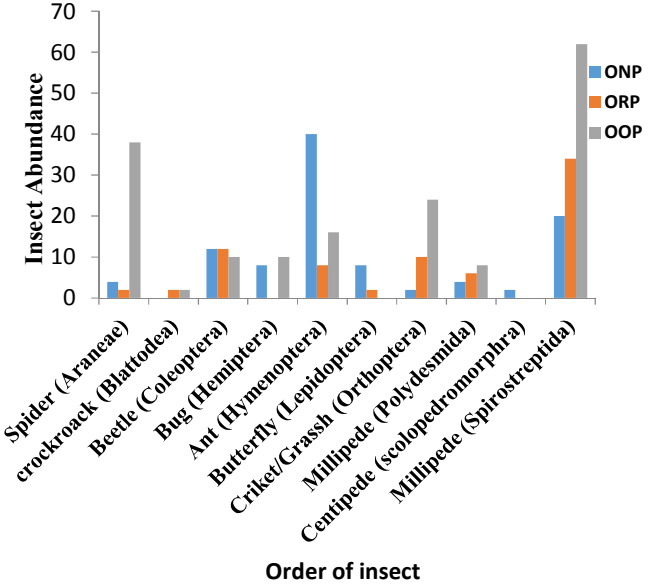

Fig. 4B. Abundance of arthropod Order during Rainy Season in the study area

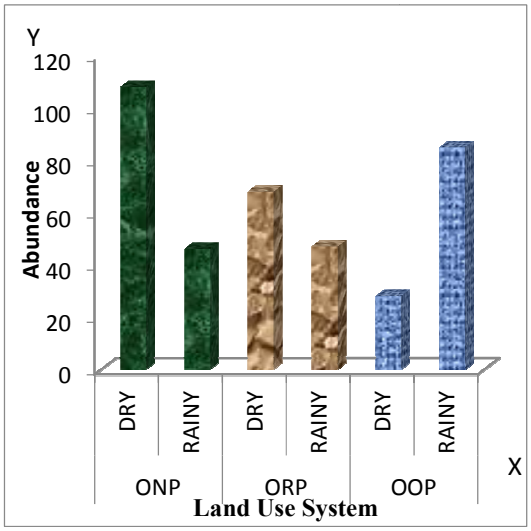

Fig. 5A. Abundance of insect species during rainy seasons in each land use system

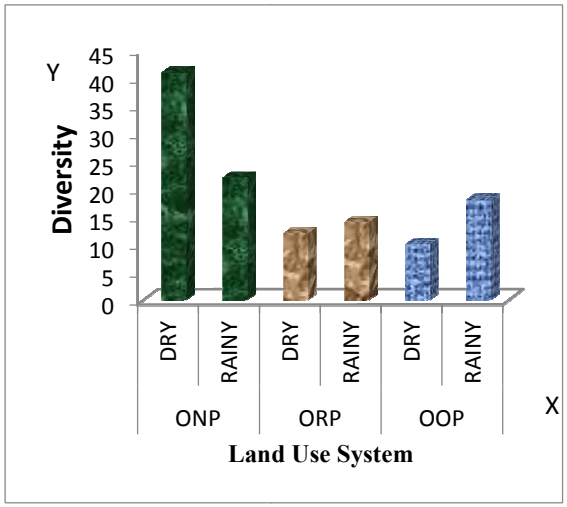

Fig. 5B. Diversity of insects species during dry rainy seasons in each land use system

Fig. 5. Diversity and Abundance of insect species during dry and rainy seasons in each land use system

Table 2. Diversity and Abundance of insect species during dry and rainy season in the study area

	Dry Season			Rainy Season		
Location	**Abund/ hectare**	**Hi**	**E**	**Abund/ hectare**	**Hi**	**E**
ONP	108	3.03	0.83	47	2.58	0.83
ORP	46	1.53	0.60	28	2.32	0.90
OOP	68	1.89	0.86	85	2.23	0.77

H^{i} index: Shannon Weiner index; E: Evenness;Abund/hectare: Aundance Per Hectare; ONP: Okomu National park; ORP: Okomu rubber plantation; OOP: Okomu Oil Palm Plantation

Fig. 5 revealed that, the seasonal diversity and abundance of arthropod species across the land use systems in the study area. Okomu National Park had the highest arthropod abundance species during dry season followed by Okomu oil palm plantation during rainy season and Okomu Rubber Plantation during dry season (Fig. 5A). The least abundance is Okomu oil palm plantation during dry season followed by Okomu Rubber Plantation during rainy season and Okomu national park during raining season. However, the result revealed some gaps in arthropod abundance between Okomu National Park and Okomu Oil Palm Plantation and fewer gaps between Okomu Oil Palm Plantation and Okomu Rubber Plantation. Moreover, Okomu national park during dry season had the highest diversity of arthropod species followed by Okomu rubber plantation during dry season and Okomu oil palm plantation during rainy season (Fig. 5B). The least diversity is Okomu national park during raining season followed by Okomu oil palm plantation during dry season and Okomu rubber plantation during rainy season.

Table 3 showed the effect of land use system and season on diversity and Abundance of insect species in the study area. The diversity of insect species has significant (P≤0.05) effect in Land use system, while abundance of insect species has no significant (P≥0.05) effect in the study areas. Therefore, diversity of insect speciesis higherin Okomu National Park than Okomu rubber plantation and Okomu Oil Palm Plantation, though there is no significant (P≤0.05) effect between Okomu rubber plantation and Okomu Oil Palm Plantation. Diversity and Abundance of insects species is not significantly P≥0.05 different on seasons in the study areas.

4. DISCUSSION

4.1 Influence of Land Use Systems and Seasons on Arthropod Diversity and Abundance

The study showed significant (P≤0.05) different among land use system and seasons in the study area. Okomu National Park has the richest insect species diversity and abundance during dry season. Okomu Oil Palm Plantation was second during rainny season and Okomu Rubber plantation was third during dry season (Fig. 5A and 5B). Rich insect species diversity and abundance in Okomu national park could be attributed to the fact that there are more desirable tree species, vegetation cover and the environmental condition is very conducive as insect habitat compare to Okomu oil palm plantation and Okomu rubber plantation. Murdoch, [29] reported that physical complexity of an environment could affect arthropods abundance and diversity. The understory layer in natural forest could also attract more insects species compare to oil palm plantation and rubber plantation. This is similar to the findings of Novotony *et al*. [30] who noted that the greater the tree species in the tropics, the higher the insect diversity. Also Alarape et al. [31] revealed that the structural complexity of habitat and diversity of vegetation forms have been shown to be correlated with animal and arthropod species diversity.

Table 3. Effect of land use system and season on diversity and Abundance insects species in the study area

Land use system	Diversity	Abundance
ONP	0.014±0.002[a]	0.97±2.665 [a]
ORP	0.013±0.003[b]	0.68±3.418 [a]
OOP	0.013±0.003[b]	0.73±2.955 [a]
P- Value	0.026	0.672

Values with the same alphabet along column has no significant difference while values with the same alphabets in the same row are significantly different with one another at P≥0.05

During dry season, the result obtained showed that Hymenoptera is the most dominant order, Lepidoptera and odonata were also dominant orders based on individual species (Fig. 4A). Result was similar to Naman *et al*. [32] who reported that Odonta was most dominant Order followed by Lepidoptera and Hymenoptera in Kaduna State University forest habitat. This findings support the [33] who reported Hymenoptera as the dominant insect order in Gulbarga District, Karnataka, India. The study equally revealed that Lepidoptera was the second dominated order and Odonta third dominat order, as agreed with the findings of Nwosu and Iwu [34] who observed more order of Lepidoptera in protected area of Okwu Ogbaku forest reserve in Imo State. Many adult dragonflies may require forest for hunting, and it is known that many gomphids and females of other families spend much of their time in the canopy [35] Largely, diversity and abundance of ants, butterflies and dragonflies contribute to the growth, maintenance and expansion of flora in the tropical regions [36,37]. While this contradicts Adeduntan and Olusola who recorded Orthoptera as the most dominated arthropod order in different forest vegetation types in Ondo state. This may be attributed to the variation in ecological zone.

Result obtained during rainy season shows that Spirostreptida, Hymenoptera and Araneae were the most dominant species (Fig. 4B). This revealed that various environmental factors such as temperature, humidity, rainfall, vegetation and food sources directly affecting the diversity and distribution of insects' population [38,39]. Thus, influence of rainfall in the form of humidity on density and diversity in environment is likely to be an indirect effect on food availability. Millipede feeding activity is specialized on dead organic matter, or on saprophytic organism consumption [40]. Millipedes till the soil, mix it with the leaf litter, draw them inside the soil to the burrows and bring the organic matter from underneath to the top soil, to transform it into proper type of humus [41]. This activity is much during rainy season.

5. CONCLUSION

The study reveals that the higher the tree species, the higher the diversity and abundance of insect species. Meanwhile, the land use system that has the highest flora and fauna (Plant and insect) is Okomu national park, and then followed by Okomu Oil Palm Plantation and Okomu Rubber plantation respectively. The variation in insect diversity and abundance were significant during dry seasons in each of the ecosystem selected for this study. There should be consideration for arthropods collection during dry to ensured richness in variation and abundance of species in their habitats. Meanwhile, collection of millipede and centipede are more diverse and abundant during rainy season, hence subsequence collection should be more during rainy season. Also, study has showed that habitat with understory layer, diversity and abundance of tree species informed diversity and abundance of insect species, therefore it should be noted that diversity and abundance of arthropods species in the natural forest is far more than an even-aged plantation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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