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Insect diversity and abundance in three forest areas of Lagos State

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Abstract

Mangrove forest ecosystem preserves diversity of species, which includes insects. Insects serve as bioindicators, pollinators and nutrient recyclers in the forest. However, the number of insects decline as the forest fades. We conducted this field survey to assess the diversity and abundance of insect species in three selected mangrove swamp forests located in Lagos State, Nigeria. Samples were collected fortnightly using different techniques, for a period of three months. Insects collected were preserved in 70% alcohol, but butterflies and moths were preserved dry. Representative samples were identified with picture insect mobile application V1.0.8 and confirmed using standard identification keys. Vegetation cover was quite similar in all the areas sampled comprising of *Alchornea cordifolia*, *Eragrosis racemose*, *Paspalum dilatatum* and *Avicennia germania*. A total of 182 insects were collected belonging to seven Orders, 18 Families and 38 species. The most dominant Order was Coleoptera with relative abundance of 66.48% and the least was Hemiptera (0.59%). The Order Odonata was the most diverse (H^{l}=1.09), and the most dominant species were *Pantala flavescens* and *Sympetrum fonscolombii*, having relative abundance of 8.24% each, followed by *Palpopleura lucia* (7.69%), *Ceriagrion glabrum* (7.14%) and *Lestinogomphus africanus* (6.04%). *Psedagrion kersteni* was rare with relative abundance < 0.5%. Iba site had the highest species diversity (H^{l}=1.24) but lowest number of individuals. This study documents the diversity and abundance of insects in the fast-disappearing mangrove forest of Lagos State, Nigeria.

Introduction

The abundance and diversity of insect species in forest ecosystems hold significant importance for entomologists due to their crucial roles within these ecosystems (Weisser and Siemann 2004). Not only do these species contribute to ecological dynamics, but they also play a vital role in the survival of life on Earth (Bommarco *et al* 2013). Unfortunately, worldwide declines in insect populations have become alarming, attributed to habitat fragmentation, loss or simplification, as well as increased pesticide use (Powney *et al* 2019; Ellis 2012; Zattara and Aizen 2021). It is evident from numerous studies that human activities, among other factors, have been the primary drivers of these population declines, with a consistent correlation between human interference and reductions in the diversity and abundance of insect species in forest ecosystems (Tscharntke *et al* 2005; Le Féon *et al* 2010; Adeduntan *et al* 2005).

Heterogeneity of landscapes and quality of habitats can significantly influence insects across various scenarios and scales (Kennedy *et al* 2013; Tscharntke *et al* 2005). This is particularly important for insects with lower mobility, limited diet range, and lower fertility (Gámez-Virués *et al* 2015; Hall *et al* 2019; Rader *et al* 2020; Steffan-Dewenter and Kuhn 2003). Deforestation and urbanization of forested areas lead to the degradation of forest habitats, resulting in reduced habitat quality and heterogeneity. These changes can have profound effects on the well-being and diversity of insect populations inhabiting forest ecosystems. However, the impacts vary among species and depend on the level of stress experienced by each species (Tscharntke *et al* 2005). Insect herbivores, for instance, are directly influenced by the concentration of resources in plant species and are more likely to be found in areas where their host plants are abundant. Similarly, the concentration of host plant species directly affects insect herbivores, as they are more likely to establish populations or persist in areas with a higher concentration of host plants (Kareiva 1983).

Nigeria is located in tropical African within the Guinea forests of the West African biodiversity hotspots, making it an area of significant ecological importance (Anwadike 2020; Ajayi *et al* 2022). Regrettably, Tropical Africa has gained notoriety for having some of the world's most severely threatened forests, with approximately 55.7% of its primary forest lost mainly due to anthropogenic activities (Leisher *et al* 2022). The continuous depletion of forest regions in Nigeria is primarily driven by inappropriate and indiscriminate extraction of economically important trees, as well as encroachment for urbanization, industrialization, and large-scale agriculture. Deforestation, whether partial or complete, poses a major threat to insect diversity and abundance (Khan *et al* 2017).

Estimating insect diversity has become a topic of global interest as it plays a crucial role in developing effective conservation strategies. However, for more precise and targeted outcomes, it is essential to focus these efforts at local and regional scales (Kehinde *et al* 2014). Adopting a local-scale approach to insect conservation helps reduce ambiguity resulting from a global perspective (Tscharntke *et al* 2007), while also providing a better understanding of the variation in insect composition and abundance across diverse sites (Bonebrake *et al* 2010).

In Nigeria, very little is known about the diversity and abundance of forest insect populations, despite these species accounting for the greatest amount of biodiversity in forest ecosystems. In this study, we investigated the diversity and abundance and also provide a checklist of the insect species in three selected forest areas in Lagos State, Nigeria.

Materials and methods

Study location

This study was conducted in three mangrove swamp forest sites namely; Ijanikin, Iba (both in Ojo) and Ikotun (in Alimosho Local Government Areas of Lagos State, Nigeria) (Figure 1). Ojo is a Local Government Area and town in Lagos State, Nigeria, located on the eastern section of the Trans West African coastal highway, about 37km west of Lagos with a population of 609,173, density of 3,300/km^2, and it is part of the Lagos Metropolitan Area (Hutchison 2009).

Iba community stretches over 15km^2 with a population of over 5,000 people (Olatunbosun 2018). Iba is between Badagry and FESTAC Town. It also has a close proximity to the ocean hence having a coastal weather condition. Vegetation cover includes: ferns, black mangrove, and few palm trees.

Ijanikin is a suburb of Lagos, which lies along Badagry express way and in close proximity to Agbara, Ojo, Igbesa and Ijegun. Its vegetation is characterized by mangrove forest randomly mixed with grasses and shrubs, and heavily populated by coconut trees, raffia palms, red mangrove, black mangrove and Dryopteris ferns, which are the main plants found in the area.

Ikotun lies in Alimosho, this is the largest local government area in Lagos State with a land mass of 138.7 km^2 and a population of 2,047,024 inhabitants. It is comprised of residential area and small commercial activities with markets, schools and businesses. The area sampled is also a mangrove swamp forest with Dryopteris ferns and mangrove plants. Ikotun is in Alimosho Local government bounded in the north by Abeokuta express way from the boundary of Ikeja Local Government, to the south by Isheri Olofin and Shasha community in Idimu, to the east by Ikeja Local Government and to the west by Isheri-Iyana Ipaja road up to the second bridge on Abeokuta express road (Ayeni and Ogunyemi, 2015). The dominant vegetation of Alimosho Local Government is the mangrove swamp forest consisting of fresh natural water. The swamp forest is combination of mangrove forest and coastal vegetation developed under the brackish condition of the coastal areas, and swamp of the freshwater lagoons and estuaries.

Sampling zones

The study location was divided into sampling zones, based on density of forest cover (Hojas-Gascon *et al* 2015). Three zones were identified in each sampling location. The geographic position of each zone was taken during the first visit (Figure 1).

Sample collection

Adult insects were collected from Iba, Ijanikin and Ikotun forest areas. Each site was randomly sampled fortnightly and collection was done once a day between the hours of 10:00 am to 2:00pm. Insects were collected for three months (October-December 2019), from towards the end of the wet season to the beginning of the dry season. Several techniques were adopted for collection and these include the use of sweep net, beating sheet, hand picking, and pit fall trap. The vegetation cover in the sites were also collected and identified. Identification was done by plant taxonomist in the herbarium of Lagos State University, Ojo. Lagos.

Insect collection techniques

Sweep net: Sweep net with 90cm handle and a 38cm net diameter, was used for sampling insects such as dragonflies, butterflies, moths, bees, wasps, flies and some smaller insect species. An average of five sweeps was done within twenty-five minutes sampling time. Sweeping was done back and forth through dense and rough vegetation, up and down tree trunks, grasses and abandoned fields.

Hand collection: Slow moving and crawling insects were collected manually by hand- picking from under logs, loose bark, on timber, in dung, on different parts of plants and within tight spaces.

Beating sheet: Beating sheet was made with a white cloth, attached to a frame about 1m^2, with two pieces of light wood crossing each other and fitted into pockets at each corner of the cloth. This technique was used to collect arboreal insects by placing the sheet under a tree or shrub

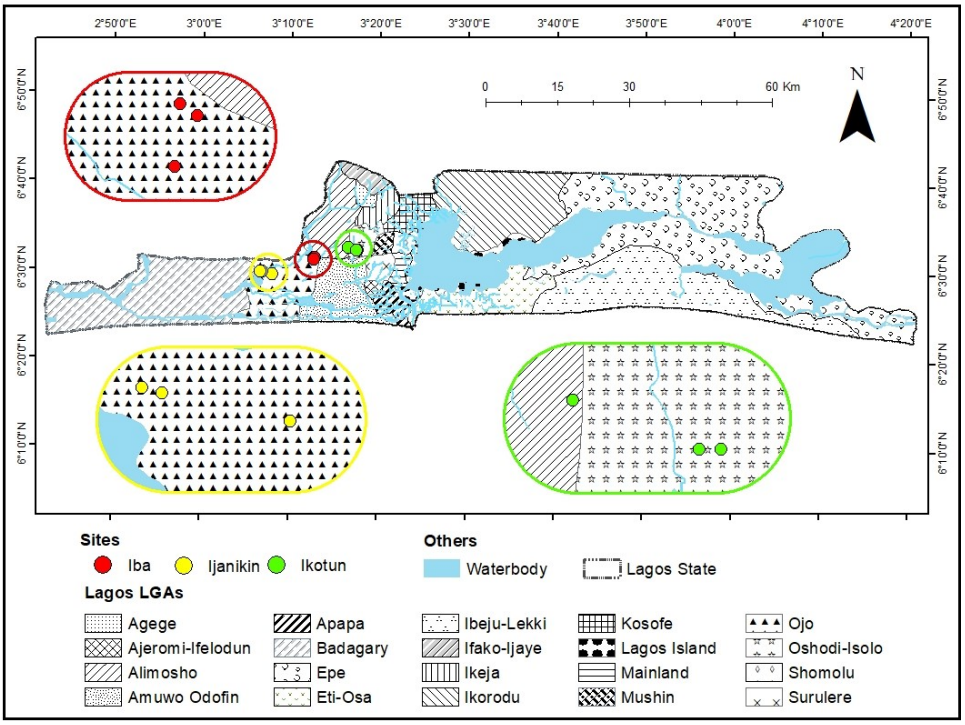

Figure 1. Map of Lagos State showing the sampling sites in Iba, Ikotun and Ijanikin.
(Big oval circles indicate sampling zone, while the small circles inside are the sampling points)

and beating the tree branches with a stick, causing insects on tree branches and leaves to fall on the sheet. Locating tiny specimens on the sheet was sometimes a problem because of leaves or other unwanted materials dropping onto the sheet. Watching for movement helped to locate specimens, as well as tilting the sheet so that the debris is displaced or even allowed to fall off, with the insects and mites left clinging to the cloth. This method was used once in each site during each visit.

Pitfall trap: This was made with a can sunk into the earth. A cover mounted on sticks was placed over the open top of the can to exclude rain, debris and small vertebrates. The plastic can was partly filled with 70% ethanol, which acts as a preservative and a killing agent. Crawling and nocturnal insects were collected with this method. Pitfall trap were sunk in ground and emptied the next day and was done during each sampling session in each site.

Preservation and identification

Butterflies and moths were preserved in a handmade triangular envelope to prevent washing off of the scales on contact with alcohol. With the use of pen, these envelopes were carefully labelled with date and location of sites where they were collected. All other insect groups collected were separated into transparent plastic sample bottles which were also labelled with date and location of sites from which they were sampled. All samples except odonatans and lepidopterans were soaked in 70% alcohol to kill them and afterwards, air dried for 72 hours to preserve them (Ojija *et al* 2016). The triangular envelopes holding the odonatans and lepidopterans were placed in airtight plastics containing acetone for 24 hours (to retain their colours for proper identification), they were thereafter placed in another envelope prior to identification. Insects were identified using type specimens. Further clarification and identification were done with the aid of insect identification keys (Dijkstra and Clausnitzer, 2014 for odonatans; Goulet and Huben, 1993 for hymenopterans; Corbet and Tams, 1943 for lepidopterans; other species were identified with type specimens).

Data analysis

Data from insect survey were analysed by estimating species richness, diversity and correlation. Species richness and diversity were calculated, using Shannon-Wiener Index (Shannon, 1948), Simpsons index (Simpson, 1949) and Margelef's index (Clifford and Stephenson, 1975). Pearson correlation coefficient was also determined.

Results

Vegetation types in the study areas

A total of fifteen plant species were collected from the three areas under study. The list of mangrove plants species is shown in Table 1. *Alchornea cordifolia*, *Eragrosis racemose*, *Paspalum dilatatum, Avicennia germania*, *Conocarpus erectus* and *Drepanocarpus lanatus* were present in all the sites. While Ijanikin had some unique species, *Erythrinia speciosa A and Rhizophora mangle*.

Composition and abundance of insects in the study areas

A list of all the insect species collected from the three study areas is presented in Table 2. A total of 182 individual insects belonging to 38 species, 18 families and 7 orders were found in the mangrove swamp forest surveyed in Lagos State. They include insects of the Orders Coleoptera, Diptera, Hymenoptera, Lepidoptera, Hemiptera, Orthoptera and Odonata. Of the 38 species collected only 23 were identified to species level, 12 of the collected species (e.g., *Palpopleura lucia, Pantala flavescens, S. fonscolombii* and *Ceriagron glabrum*) were common to all the studied sites. The largest number of insect species (67) was collected from Ijanikin site, and the least was (56) from Iba site. Relative abundance of the insect species is shown in Table 2. Odonata had the highest relative abundance of 66.48%, while the least was Hemiptera, 0.59%. In all sampled sites, two odonatans of the Family Libelullidae, *Pantala flavescens* and *S. fonscolombii* had the highest relative abundance of 8.24% each, closely followed by another odonatan, *Palpopleura lucia* with relative abundance of 7.69%, and *Ceriagrion glabrum* with 7.14%. Lepidopterans such as *Leptophobia aripa*, *Agraulis vanillae*, and odonatans such as *Erythrodiplax sp.* were rarely found, having relative abundance of 0.5% each (Table 2). The diversity indices of the insect Orders are shown in Table 3. Odonata had the highest diversity index (H=1.09) and the least species dominance (D=0.34), while Hemiptera had the least diversity index (H=0) and the highest species dominance (D=1.00). The richest of the seven insect Orders was Coleoptera (d=0.96).

Of the three sampled sites, Iba had the least number of individuals (56) and the highest diversity of species (H'=1.24). Ikotun had the highest insect species dominance (D=0.53), and the lowest species diversity (H'=1.00). Of all sites sampled, the richest was Ijanikin (d=1.43; Table 4).

Linear relationships between insect abundance and pled sites.

The correlation statistics is shown in Table 5. Although the three sites had high correlation values, Ikotun and Iba had the highest correlation value (r=0.99). All correlation values were above 0.90 with similar orders and species diversity.

Discussion

The insect population collected in the three areas studied were positively correlated, which could be attributed to similarity in the vegetation type. As opined by Dutra and De Marco (2015), the abundance of many species of dragonflies has been taken as an indication of good ecosystem quality; this may indicate that Ijanikin site has better environment and resource to support more Odonata species which was higher in Ijanikin than the other sites. Forest complexity provides odonates habitats where they may shelter at night, safety against adverse weather conditions (rain or strong wind) and predation. When farm sites are near forest, the latter can function as a refuge or buffer that allows establishment of odonate species (Paulson 2006). However, in Iba and Ikotun, the land is utilized for agriculture, pasture and, residential and industrial buildings compared to Ijanikin. These areas are prone to environmental degradation and pollution due to anthropogenic activities such as deforestation, indiscriminate refuge disposal, release of automobile exhaust fumes, erosion, agrochemical runoff and deposition of domestic waste and sewage on sites. As a result, forest ecosystem disturbance abounds in such industrial areas and this could be another reason for the less insect diversity in these areas.

Rarity of Hemiptera in this study contrasts Yager *et al* (2018) report of Hemiptera dominance in the Forestry Nursery of the Federal University of Agriculture, Makurdi,

Table 1: Checklist of plants encountered in mangrove forest at Iba, Ijanikin and Ikotun areas of Lagos State

S/N	Plant Species	Common/Local name	Iba	Ijanikin	Ikotun
1	*Alstonia scholaris L.*	Devils tree	Present	Present	Absent
2	*Alchornea cordifolia*	Christmas bush	Present	Present	Present
3	*Erythrinia speciosa A.*	Coral tree	Absent	Present	Absent
4	*Eragrosis racemose T.*	Love grass	Present	Present	Present
5	*Paspalum dilatatum P.*	Dallis grass	Present	Present	Present
6	*Laguncularia racemose*	White mangrove	Present	Absent	Absent
7	*Avicenia germines*	Black Mangrove	Present	Present	Present
8	*Rhizophora mangle*	Red mangrove	Absent	Present	Absent
9	*Conocarpus erectus*	Green buttonwood	Present	Present	Present
11	*Acrostichum aurenum*	Golden leather fern	Present	Present	Present
12	*Thespesia* (*Calotropis*) *procera*	Ewe bomu bomu	Present	Present	Present
13	*Raphia hookeri*	Raffia palm	Present	Present	Absent
14	*Jathropha curcas*	Ewe lapaa lapaa	Present	Present	Present
14	*Drepanocarpus lunatus*		Present	Present	Present
15	*Dryopteris sp*	Ferns	Present	Present	Present

Table 2: The distribution and relative abundance of insect species in all the sites

Order	S/N	Family	Genus/Species	IKT	IBA	IJK	Relative Abundance (%)
Lepidoptera	1	Shingidae	*Cephonoidses hylas* (Linnaeus, 1771)	-	2	-	1.09
	2	Nymphalidae	*Acraea acerata* (Hewitson, 1874)	6	5	1	6.59
	3	Pieridae	*Leptophobia aripa* (Biosduval, 1836)	-	-	1	0.54
	4	Hesperiidae	*Polites vibex*	-	-	2	1.09
	5	Nymphalidae	*Agraulis vanillae* (Linnaeus, 1758)	-	-	1	0.54
Diptera	6	Stratiomyidae	*Hermetia illucens* (Linnaeus, 1758)	1	2	-	1.64
	7	Calliphoridae	*Calliphora vicina* (Jean, 1830)	-	2	1	1.64
	8	Calliphoridae	*Chrysomya putoria* (Wiedemann, 1830)	5	-	-	2.74
Odonata	9	Libellulidae	*Palpopleura lucia* (Drury, 1773)	1	3	1	7.69
	10	Libellulidae	*Pantala flavescens* (Fabricus, 1798)	11	3	1	8.24
	11	Libellulidae	*Orthetrum julia* (Kiby 1900)	3	2	1	3.29
	12	Libellulidae	*Plathemis lydia* (Drury, 1773)	3	5	2	5.49
	13	Libellulidae	*Erythrodiplax* sp (Drury, 1773)	-	1	2	1.64
	14	Libellulidae	*Sympetrum fonscolombii* (Selys, 1840	3	4	8	8.24
	15	Libellulidae	*Libellula forensic* (Hagen, 1874)	2	1	7	5.49
	16	Libellulidae	*Pseudolon superbus* (Hagen, 1861)	3	3	1	0.38
	17	Libellulidae	*Dythemis velox* (Hagen, 1861)	-	3	-	1.64
	18	Libellulidae	*Erythrodiplax minuscula* (Rambur, 1842)	-	-	1	0.54
	19	Libellulidae	*Orthetrum caledonicum*	3	2	1	0.54
	20	Libellulidae	*Pachydiplax longipennis* (Brauer, 1868)	1	-	-	0.54
	21	Libellulidae	*Sympetrum flaveolum* (Linnaeus, 1758)	1	-	-	0.54
	22	Libellulidae	*Crocothemis erythraea* (Drury, 1773)	1	-	-	0.54
	23	Libellulidae	*Hemistigma albipunctum* (Rambur, 1842)	-	1	-	0.54
	24	Aeshnidae	*Anax imperator* (Leach, 1815)	-	-	2	1.09
	25	Aeshnidae	*Gynacantha nigeriensis* (Gambles, 1956)	-	-	1	0.54
	26	Coenagrionidae	*Ceriagrion glabrum* (Burmeister, 1839)	5	3	5	7.14
	27	Gomphidae	*Lestinogomphus africanus* (Fraser, 1926)	5	4	2	6.04
Coleoptera	28	Nitidulidae	*Brassicogethes aeneus* (Fibricius, 1775)	-	1	-	0.54
	29	Chrysomelidae	*Plagiometriona clavata* (Fabricius, 1798)	-	1	-	0.54
	30	Chrysomelidae	*Monocesta coryli*	-	2	1	1.64
	31	Chrysomelidae	*Crioceris duodecimpunctata*	1	-	1	1.09
	32	Lycidae	*Caena dimidiate* (Fibricius, 1801)	-	-	1	0.54
Hymenoptera	33	Scoliidae	*Scolia dubia* (Say, 1837)	-	1	-	0.54
	34	Apidae	*Bumbus auricomus* (Frison, 1917)	2	2	7	6.04
	35	Apidae	*Apis cerena* (Fabricius, 1793)	-	-	1	0.54
	36	Vespidae	*Dolichovespuca maculata (Linnaeus, 1763)*	-	-	3	1.64
Hemiptera	37	Pentatomidae	*Oebalus pugnax* (Fibricius, 1775)	-	-	1	0.54
Orthoptera	38	Acrididae	*Mermiria bivittata (Serville, 1839)*	2	3	2	0.38
Total				59	56	67	182

IKT= Ikotun; IJK= Ijanikin, IBA = Iba

Benue State, Nigeria.

Lepidoptera was the second most abundant insect Order collected, with highest occurrence in Ijanikin site. Shrubs and grass habitats have a high proportion of butterfly species with a wide geographical distribution range (Vu 2009). This is in conformity with the vegetation type found in Ijanikin, a swampy wetland, there is greater butterfly diversity in the wet sites than in the dry sites. In addition, the stream sides in the forest have openings which support more butterflies. Gaps in the forest have higher butterfly diversity than closed forests (Van 2011).

This study was conducted during the dry season and in sites with little diversity of ornamental and flowering plants as observed during sampling. A result of butterfly abundance surveyed across several habitats suggests that there is greater insect diversity in wet sites and in sites with diverse flowering plants, than in dry sites (Van 2011). This difference in habitats could have led to little butterfly

Table 3: Diversity indices of insect orders

Orders	Relative Abundance (%)	No of Individuals	Dominance (D)	Simpson (1-D)	Shannon (H)	Margalef (d)
Lepidoptera	9.89	I8	0.34	0.66	1.01	0.69
Diptera	6.04	11	0.44	0.56	0.92	0.83
Odonata	66.48	121	0.34	0.66	1.09	0.42
Coleoptera	4.39	8	0.4	0.59	0.97	0.96
Hymenoptera	8.79	16	0.52	0.48	0.83	0.72
Hemiptera	0.59	1	1	0	0	0
Orthoptera	3.84	5	0.52	0.48	0.67	0.62

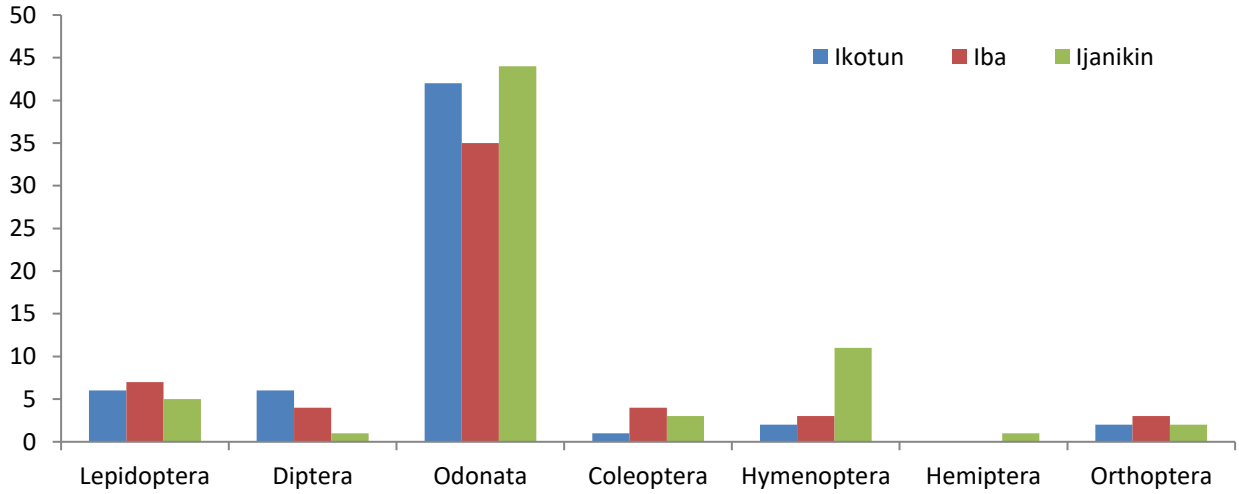

Figure 2. Distribution of insect orders across the three sampled locations

Table 4: Diversity indices of insect orders in the three sample sites

Diversity Indices	Ikotun	Iba	Ijanikin
Taxa (s)	6	6	7
Individual	59	56	67
Dominance (D)	0.53	0.42	0.47
Simpson (1-D)	0.47	0.58	0.53
Shannon (H)	1	1.24	1.13
Margalef (d)	1.23	1.24	1.42
Relative abundance (%)	32.41	30.76	36.81

Table 5: Correlation coefficients of insect's abundance between sampling sites

	Ikotun	**Iba**	**Ijanikin**
Ikotun	1		
Iba	0.99	1	
Ijanikin	0.96	0.97	1

abundance in the sampled sites. The result of diversity indices across habitats showed that, even though Iba area had the highest insect diversity values, Ijanikin was the most specious. This implies that the availability of different plants influences the diversity and abundance of insect species. This is in agreement with the findings of Gatson (1991) and Cheng and Kirton (2007), whose reports stated that plants and insects interact by way of mutualism and phytophagy. Also, Alarape*, et al* (2015) revealed that the structural complexity of habitat and diversity of vegetation forms correlate with animal and insect species diversity.

Comparatively, similarity in the plant diversity in all the sites was also followed by positive correlation with insect diversity; although evidence of human interference was more prominent in Ikotun and Iba. The r value shows a positive linear relationship indicating a higher rate of simultaneous increase or decrease in diversity between Ikotun and Iba.

Conclusion

This study showed that the fast-disappearing mangrove forest of Lagos State at Ikotun, Iba and Ijanikin contains rich insect fauna. This calls for cooperative efforts to protect the mangrove forest in order to preserve this rich biodiversity.

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