Spatial Distribution of Insect Diversity in Selected Locations within Forestry Research Institute of Nigeria, Ibadan, Nigeria

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ABSTRACT: With the increase in the rate of tree removal and construction of buildings within the Forestry Research Institute of Nigeria premises, there has been concomitant rise in habitat modification. These changes in habitat composition affect the insect population. This study therefore investigated the insect species diversity and abundance within some selected locations within FRIN with the view to determining different insect species available in FRIN premises. Sweep nets were used to trap the insects along a predetermined line transect. Data were analyzed using Microsoft Excel 2007 and Paleontological Statistics were used for the data analysis. Descriptive statistics, one-way analysis of variance (ANOVA) and species diversity and composition were all assessed. A total number of 1073 individual insects belonging to 6 orders, 27 families and 34 species were recorded across the three locations. Out of this, Order Lepidoptera had the highest relative abundance (53%), followed by Coleoptera (22%), then by Hymenoptera, Hemiptera, Heteroptera and Diptera with 10%, 9%, 4% and 2% relative abundance respectively. The result of ANOVA showed that there was no significant difference in species composition/richness across the locations at probability level of 5%. The insect species diversity, evenness and richness also varied across the locations. This study therefore, brings to the fore the diversity and abundance of insects within FRIN premises and highlighted the need for a more intensive study by the entomology section and for sustainable actions to be taken in conserving beneficial rare species while, managing the abundant pestiferous ones.

It is common knowledge among entomologists who have been engaging in insect collection that insect species diversity, abundance and composition vary greatly between adjacent locations. Sometimes, even between areas of great differences in the length and intensity of the seasons. Insects are important because of their diversity, ecological role, and influence on agriculture, human health and natural resources (Berenhaum, 1995; Adetundan *et al*., 2005; Premalatha et al., 2011).The total number of insect species on earth is estimated to be 1-3 million, probably represents more than 80-90% of all animal species (FAO, 2013; Yang *et al*., 2016; Jansson and Berggren, 2015 and Glick and Miller, 2016). Insects are the most populated organisms in the world (Speight *et al*., 2008). This can be because different species of the insect reproduces very fast and have large number of offspring. They are highly sensitive to changes in climate of their environment, such as rainfall, temperature, wind humidity and altitude (Khaliq *et al*., 2014). Insect are very important in natural as well as constructed landscapes. Insects are closely associated with human lives and have great impact on the welfare of humanity in diverse ways. They play crucial role in diverse ecosystem services especially in agriculture, tourism and in natural resource use (Choi and Miller, 2013). In the same vein,

large numbers of insect species, including those not known to science, continue to become extinct from local habitats world-wide (Miller and Rogo, 2001). The diversity of insect species is a function of the environmental condition (Yi *et al*., 2012). Habitat loss poses the greatest threat to the long-term survival of species on earth. Habitat fragmentation (the reduction of continuous habitat into several smaller spatially isolated remnants.), decreases area, increase edge. Jericho is a richly agrarian community in the southern part of Ibadan in Oyo state. The diversity and abundance of insects in this area has hardly been studied. Insect biodiversity studies conducted in Nigeria have largely been on the insects' diversity of specific orders and or species of insects. Few have considered the insect community altogether (Meddler, 1980). Aside inadequate taxonomic knowledge, the ecological knowledge of insects in Nigeria is not well understood as distribution and abundance of many insects species in the country are unknown and ecosystem services mostly assumed (Kato *et al*., 2000). Anthropogenic activities have contributed to the movement and spread of invasive insects into different habitats with many of them having Agricultural and Veterinary implications (Wardle, 2002). The total area vegetation of Forestry research institute of Nigeria has been seriously fragmented and

modified through the construction of buildings and road networks. The establishment and fencing of the herbal garden also has an impact on insect species distribution within FRIN. Even some of the fragmented areas are being further modified through the introduction of different land use and land cover types. This continues having serious impacts on FRIN landscape. However, little attention has been given to ascertain the impact of habitat fragmentation, modification and loss, on the composition and diversity of the insect populations. Disappearance of insects could lead to extinction of earth's animals because of the disappearance of so much plant life (Yager *et al.*, 2017). Today insects are by far the planet's most diverse, abundant and successful species (Zrzavy, 2018). The positive and negative roles of insects in nature require proper understanding on how they interact with living and non-living environment and their diversity (Miller, 2006). The current study is designed for the very first time to provide and document a checklist of the insects found in each of the locations, determine their composition and diversity pattern within the study locations. The

information that will be provided will be useful in giving an insight to insect species richness in the institute over the years, an information that is very useful for the management and conservation purposes (Mazon and Bordera, 2008).

MATERIALS AND METHODS

Study area: The study was carried out at different locations within the Forestry Research Institute of Nigeria Jericho Hill, Ibadan, Nigeria. The locations are Forestry Arboretum (FA), College of Forestry football field (COFF) and the Herbal Garden (HG)**.** FRIN is located between latitude 07° 25'N and 07° 55'N and longitude 3° 9'E and 53°E. The annual temperature ranges between 18.7°C and 34.4°C. The region is characterized with bimodal pattern of rainfall with peaks in July and September with mean annual rainfall of 1420.106mm. The mean relative humidity was 82% between June and September and 60% between December and February (FRIN meteorological station). The location of the study site is presented in figure 1.
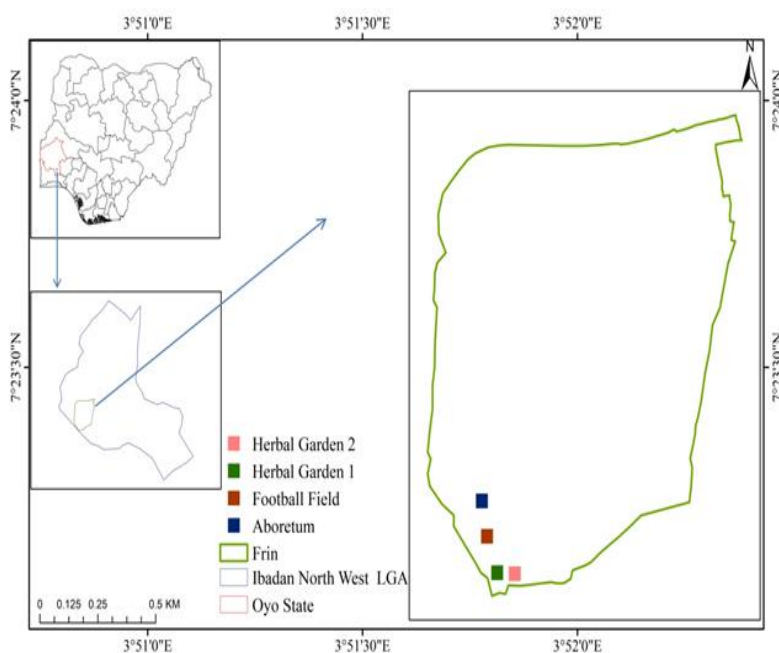

Fig.1: Map of the study areas

Sampling Procedure: The selected study areas were selected within the Forestry Research Institute of Nigeria premises based on the availability of tree species in the locations which can serve as host to these insect species. The areas included the forestry arboretum (FA), College of Forestry football field (COFF) and the herbal garden (HG).

Method of insect collection: This study made use of Sweep method of sampling technique across the three locations within FRIN. This method is suitable for sampling insects from ground layer vegetation. The sweeps were done during the early hours of the day

between 6 am to 10 am and evening from 4 pm to 7 pm twice in a week, along an established 200M transect line. The insects collected were killed using ethyl acetate and temporarily kept in polythene bags and plastic containers and later taken to the laboratory for identification and preservation.

*Preservation and Identification of insects collected***:** All insects collected were preserved by immersion in 70% ethanol. However, insects like moths that have scales on their wings were preserved dry in a tight container containing Silica gel. Representative samples were preserved in the Biological Laboratory

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of the Entomology section of the Forestry Research Institute of Nigeria for future reference. All insects collected were taken for identification at the Entomology section of the Forestry Research Institute of Nigeria.

Data Analysis: Data gathered for this research were analyzed using both descriptive and inferential statistics. Descriptive statistics like frequencies and percentages were used while One-way analysis of variance was employed as inferential statistics. Identified insects species were grouped into Order, Family and species. Species Diversity and Distribution were computed using diversity indices such as species diversity, species richness and evenness. However, insect species that couldn't be identified on the field was taken to Forestry Research Institute of Nigeria (FRIN) entomology department for proper identification. Data collected was put to statistical analysis to obtain meaningful information which can be used for managerial policy and decision making by the FRIN management. All the analyses in the study were done using Microsoft Excel 2007 (Microsoft Corp., Redmond, WA, USA) and Paleontological Statistics software package for education and data analysis (PAST).

RESULTS AND DISCUSSION

Diversity and Abundance of insects in the study locations: Table 1 show the diversity and abundance of insect species identified in the selected locations. A total of 1,703 individual insect samples were identified and collected for the study as presented in table 1 belonging 6 orders, 27 families and 34 species (Table 1). The largest number of insect species (27) for the study was observed from Forestry Herbarium (FH), followed by Herbal Garden (HG) (26) while the least was observed in College of Forestry Football Field (22). Across the locations, *Hypolimnus misippus* had the highest abundance (143) in the Order Lepidoptera and family Nymphalidae, followed by *Sinoxylon senegalense* (124) and *Bombyx mori* (108) while the least abundant (rare) insect species include *Trochalus gibbus*, *Pachnoda cordata* and *Xylopertheila picea*, all in the Order Coleoptera (Table 1). Table 2 shows the relative abundance of the insect species in the selected locations. *Hypolimnas misippus* had the highest relative abundance of (8.4%) followed by *Sinoxylon senegalense* with (7.28%) and *Bombyx mori* (6.34%) while insect with least relative abundance were *Trochalus gibbus* (0.53%), *Pachnoda cordata* and *Phryneta leprosa* having 0.59%.

Table 1: Diversity and Abundance Insect species in the study areas

S/N	Order	Family	Species	Host Plant	Location			TOTAL
					FH	COFF	HG	
1	**Coleoptera**	Scarabaeidae	Pachnoda cordata	Anacardium ocidentalis	10	0	0	10
2		Scarabaeidae	Trochalus gibbus	No name	9	0	0	9
3		Bostrichidae	Sinoxylon senegalense	bamboo	70	43	11	124
4		Bostrichidae	Xylopertheila picea	No name	11	0	0	11
5		Tenebrionidae	Alphitobius Spp	No name	2	55	12	69
6		Elateridae	Selasia unicolor	No name	10	77	9	96
7		cerambycidae	Phryneta leprosa	Modus alba	2	0	8	10
8		Platypodidae	Platypus hintzi	Antiaris africana	0	0	29	29
9		Scolytidae	Xyleborus perforans	Eucalyptus Spp	2	0	13	15
10		Bostrichidae	Apate monachus	Terminalia catappa	0	0	11	11
11	**Hymenoptera**	Vespidae	Belonogaster juncea	Anacardium ocidentalis	7	29	8	44
12		Formicidae	Camponotus Spp	Anacardium ocidentalis	22	0	31	53
13		Formicidae	Crematoguster depressa	No name	0	22	21	43
14		Apidae	Xylocopa Spp	No name	30	0	9	39
15								
16	**Diptera**	Stratiomyidae	Hermetia ilucens	No name	30	0	0	30
17								
18	**Heteroptera**	Cydidae	Cydnus Spp	Anacardium ocidentalis	30	11	7	48
19		Reduviidae	Physorhynchus distinctus	No name	0	11	1	12
20								
21	**Lepidoptera**	Nymphalidae	Phalanta phalantha	Populous euphratica	12	6	0	18
22		Crambidae	Haritalodes derogata	Hibiscus Spp	55	13	8	76
23		Nototindae	Anaphe venata	Triplochiton scleroxylon	21	80	3	104
24		Noctuidae	Magusa versicolorra	Triplochiton scleroxylon	11	2	3	16
25		Papilionidae	Papilio demodocus	Anacardium ocidentalis	80	14	0	94
26		Nymphalidae	Hypolimnas misippus	Anacardium ocidentalis	97	6	40	143
27		Geometridae	Zamara Spp	No name	32	8	51	91
28		Erebidae	Estigmene acrea	Pisum sativum	0	23	0	23
29		Bombycidae	Bombyx mori	Modus rubra	20	88	0	108
30		Erebidae	Crotema mentiens	Terminalia ivorensis	11	21	37	69
31		Erebidae	Euproctis Spp	Triplochiton scleroxylon	8	0	8	16
32		Pyralidae	Sylepta derogata	Solanum gilo	0	11	40	51
33		Limacodidae	Parade euchlora	No name	21	11	3	35
34		Nymphalidae	Acraea igola	No name	8	12	31	51
35	**Hemiptera**	Perrhocoridae	Dysdercus superstitious	Ceiba pentandra	8	32	15	55
36		Pentatomidae	Aspavia armigera	Modus alba	10	47	11	68
37		Coreidae	Leptoglossus membranaceus	Anacardium ocidentalis	0	0	32	32
				Total	**629**	**622**	**452**	**1703**

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Percentage frequency distribution of the individual insects and the species based on insect Order: According to the total number of species, the dominant order was the Lepidoptera with 11 families and 14 species (Fig. 1), followed by Coleoptera (7 families and 10 species), Hymenoptera (3 families and 4 species), Hemiptera (3 families and 3 species), Heteroptera (2 familes and 2 species) and the least was Diptera with 1 family and 1 species (Fig. 1). Also, table 2 revealed the percentage distribution of the individual insect and insect species in each of the study locations based on Order. In FA, the insect Order with the highest percentage distribution was Diptera (54%), followed by Lepidoptera (21%) while the Order with least percentage distribution was Heteroptera with 2%. In COFF, Lepidoptera had the highest percentage distribution (59%), followed by Coleoptera (14%), followed by Hemiptera, Heteroptera and Hymenoptera with 2% distribution each while Diptera had no representative. In HG, Lepidoptera had 38% distribution, followed by Coleoptera (27%), Hemiptera, Heteroptera and Hymenoptera had 12%, 8% and 15% distribution respectively while Diptera was not found in the location (Table 3). However, for the individual insect species, out of the 689 individual insect species found in Forestry Herbarium, 55% belongs to Lepidoptera, 17% belongs Coleoptera and Hymenoptera while the least was Hemiptera (3%). In COFF, Lepidoptera had the highest distribution with 46% followed by Coleoptera 27% while the least was Heteroptera (4%) with no representative for Diptera (Table 3). In the HG, out of the 460 insects identified,

Lepidoptera had the highest distribution (48%), followed by Coleoptera (20%) while the least was Heteroptera (2%).

Table 2: Relative abundance of the insect species identified across the study locations

| S/N	Speices	R A (%)
1	Pachnoda cordata	0.59
2	Trochalus gibbus	0.53
3	Sinoxylon senegalense	7.28
4	Xylopertheila picea	0.65
5	Alphitobius Spp	4.05
6	Selasia unicolor	5.64
7	Phryneta leprosa	0.59
8	Platypus hintzi	1.70
9	Xyleborus perforans	0.88
10	Apate monachus	0.65
11	Belonogaster juncea	2.58
12	Camponotus Spp	3.11
13	Crematoguster depressa	2.52
14	Xylocopa Spp	2.29
15	Hermetia ilucens	1.76
16	Cydnus Spp	2.82
17	Physorhynchus distinctus	0.70
18	Phalanta phalantha	1.06
19	Haritalodes derogata	4.46
20	Anaphe venata	6.11
21	Magusa versicolorra	0.94
22	Papilio demodocus	5.52
23	Hypolimnas misippus	8.40
24	Zamara Spp	5.34
25	Estigmene acrea	1.35
26	Bombyx mori	6.34
27	Crotema mentiens	4.05
28	Euproctis Spp	0.94
29	Sylepta derogata	2.99
30	Parade euchlora	2.06
31	Acraea igola	2.99
32	Dysdercus superstitious	3.23
33	Aspavia armigera	3.99
34	Leptoglossus membranaceus	1.88
	Total	**100.00**

Note: RA- Relative Abundance
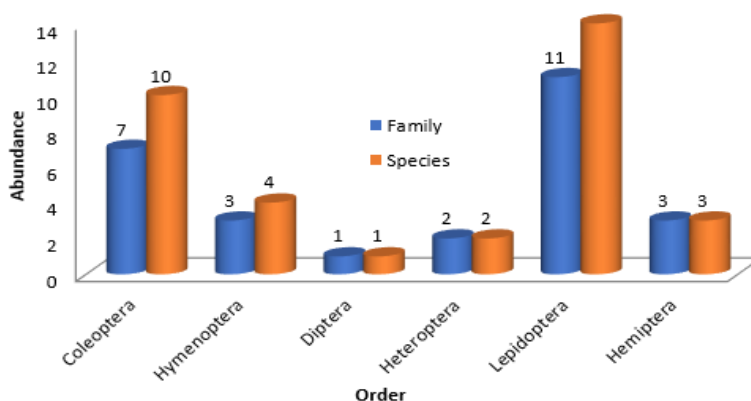
Fig. 1: Family and insect species abundance based on the insect Order

Table 3: Percentage distribution of individual insects (Frequency) and the species based on Order for the three study locations

S/N	Order	Species			Individual		
		FH	COFF	HG	FH	COFF	HG
1	Coleoptera	8 (14%)	3 (14%)	7 (27%)	116 (17%)	175 (27%)	93 (20%)
2	Diptera	30 (54%)	0 (0%)	0 (0%)	30 (4%)	0 (0%)	0 (0%)
3	Hemiptera	2 (4%)	2 (9%)	3 (12%)	18 (3%)	79 (12%)	58 (13%)
4	Heteroptera	1 (2%)	2 (9%)	2 (8%)	30 (4%)	22 (4%)	8 (2%)
5	Hymenoptera	3 (5%)	2 (9%)	4 (15%)	119 (17%)	73 (11%)	77 (17%)
6	Lepidoptera	12 (21%)	13 (59%)	10 (38%)	376 (55%)	295 (46%)	224 (48%)
	Total	**56 (100)**	**22 (100)**	**26 (100)**	**689 (100)**	**644 (100)**	**460 (100)**

Note: FH- Forestry Herbarium, COFF- College of Forestry Football Field, HG- Herbal Garden

*Relative abundance of the Orders***:** Across the study locations, Fig. 2 shows the pooled relative abundance of insects based on Orders. Out of the total insects identified, Order Lepidoptera had the highest relative abundance (53%), followed by Coleoptera (22%), then

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by Hymenoptera, Hemiptera, Heteroptera and Diptera with 10%, 9%, 4% and 2% respectively.
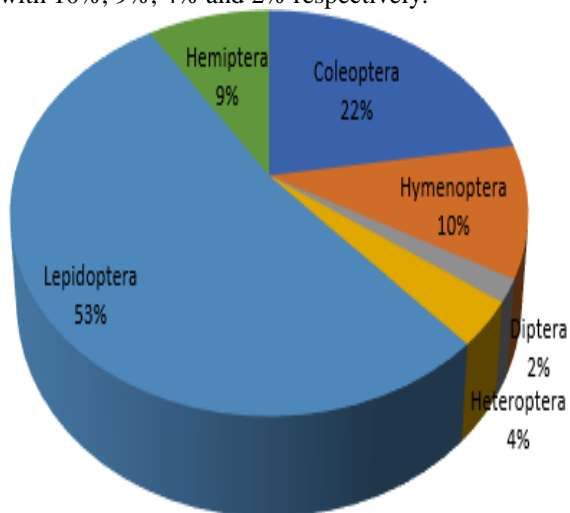

Fig. 2: Pooled percentage distribution of the insect orders across the selected locations

The result of the insect species diversity for the study locations as presented in (Table 4) revealed that the HG had the highest value for insect diversity (H'= 2.956), followed by FH (H'=2.866) and the least with (H'= 2.735) in COFF.

Table 4: Diversity indices of insects in the study locations

Variables	Locations		
	FA	**COFF**	**HG**
Number of species	27	22	26
Individuals	629	622	452
Shannon_H	2.866	2.735	2.956
Dominance_D	0.07675	0.0817	0.06262
Species eveness	0.6509	0.7007	0.7395
Margalef index	4.035	3.264	4.087

Note: FH- Forestry Herbarium; COFF- College of Forestry Football Field; HG- Herbal Garden

The highest species evenness was observed in HG (0.7395), followed by COFF (0.7007) and the least observed in FA (0.6509). The Shannon diversity t-test revealed that there is a significant difference ($P \leq 0.05$) between FA and COFF and between COFF and HG in terms of species diversity. However, there is no significant difference ($P > 0.05$) between FA and HG in term of species diversity (Table 5). The result of One-way ANOVA launched from the PAST revealed in Table 6 that there was no significant difference in species composition/richness across habitat at probability level of 5%.

Table 5: P-values for Shannon diversity t-test showing the level of difference in insect diversity between the study locations

	FH	**COFF**	**HG**
FH	1	0.0065*	0.0856 Ns
COFF		1	4.67 X 10^{-6*}
HG			1

*Note: FH- Forestry Herbarium; COFF- College of Forestry Football Field; HG- Herbal Garden; *- Significant at 5% level of probability; Ns- Non significant at 5% level of Probability*

Table 6: One-way ANOVA difference in species composition across habitat

Variables	Sum of Square	Degree of Freedom	Mean Square	F	P-Value
Between groups	590.961	2	295.480	0.6395	0.5297ns
Within groups	45742.6	99	462.047		
Total	46333.6	101			

Note: No significant difference at probability level of 5%

The results of this study showed that the Forestry Research Institute of Nigeria has high insect diversity within her perimeter fencing. The rich number of species available in the study areas could be mainly because of availability of different tree species that can serve as hosts for these insects. The study locations environment contains ornamental plants and seedlings as well as vegetation cover that mimic a forest suitable for the growth and development of these insect species. This is in agreement with the result of Yager *et al*., (2017) who reported the same in their study of insect diversity at the Federal University of Agriculture Makurdi, Benue State, Nigeria.

The result obtained for the study revealed that the Order Lepidoptera was the most dominating order based on the individual insect species. This finding is in contrast with the result of Nandini and Murali (2012) and Yager *et al*. (2017) who reported Hymenoptera as the most dominating order in their study of insect species in Gulbarga District, Kamataka, India and Hemiptera in their study of insect abundance in the Federal Unibersity of Makurdi, Benue State,

Nigeria respectively. Also, this result negate the findings of Adeduntan and Olusola (2013) who presented Orthoptera as the most dominating insect Order in different forest vegetation types in Ondo State. However, these variations can be attributed to the difference in study locations and in environmental characteristics/attributes, and also could be the availability of susceptible hosts n the study environments. The abiotic factors like the temperature, light and humidity do significantly influence the insects and the changes in their population trend, likewise the biotic factors (e.g. Host, crowding, diets etc.). Moreover, Heteroptera and Diptera Orders were the Orders with least number of individual insect species. This is in conformity with the report of Alarape *et al*., (2015) who stated that the abundance of individual insect species on a temporal scale was highly dependent on abiotic and biotic environment factors. The species of Lepidoptera identified in this study were typical of West African taxa. The species were in the families Nymphalidae, Papilionidae, Geometridae, Crambidae etc. This study revealed that

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the existence of tree species that can serve as host for these insects could make the Order Lepidoptera dominant in the study areas. Tree species that served as host to this order in the study areas included *Triplochiton scleroxylon, Anacardium ocidentalis, Terminalia ivorensis* etc. This is in line with the result of Nwosu and Iwu (2011) who observed more species of butterflies in the protected area of Okwu Ogbaku forest reserve in Imo State being attracted by the high presence of tree species in the reserve. Insect diversity indices of the study locations were examined to understand the insect diversity. The highest values of the Shannon-Weiner diversity observed in HG revealed a location with high insect species diversity and abundance. This Shannon-Weiner index compare favorably within the range of 2.87–3.20 reported by Yager *et al.*, (2017) for insect species diversity and abundance in and around Federal University of Agriculture, Makurdi Forestry Nursery, Benue State, Nigeria. The result of the diversity indices across the study locations revealed that herbal garden (HG) > Forestry Arboretum (FA) > College of Forestry football field (COFF). Although, the difference between Shannon-Weiner values of FA and the HG is not much. This might be as a result high number of tree species present in the two study locations that can serve as hosts to the insect species. The result of Shannon diversity t-test showed that there were significant differences between FA and COFF; and COFF and HG while there was no significant difference between FA and HG at probability level of 5%. However, this might be as a result of presence of trees between the two significant locations and vice-versa. Although, the FA and HG were more similar in insect species composition, the ANOVA showed there was no significant difference in species composition/ richness across the study locations. This is however, clearly understood from the perspective that both FA and HG contains high number of tree species and it is believed that plants co-evolve with their insect herbivores as opined by Hougen and Rausher (2007) and Tscharntke and Brand (2004). This can also be attributed to the continuous availability of growth and development resources in the study locations which makes the environment conducive for breeding unlike the college of Forestry Football filed that do not contain any tree. This finding agrees with the results of Adeduntan and Olusola (2013) and Samways (2007) who reported that insects are always present where there is a favorable condition for their survival.

Conclusion: FRIN is rich in insect species biodiversity. The study provides baseline information on insects' species for documentation and for more research to be built on. The present list of insects' species from this study is not exhaustive and so further exploration of insects species be continued taking into consideration other methods of insect collection and seasonal variations, as it affects insects' population dynamics. It is recommended that management strategies towards conservation of both flora and insects species should be intensified at the study locations within FRIN.

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