Regular Article
pISSN: 2288-9744, eISSN: 2288-9752
Journal of Forest and Environmental Science
Vol. 37, No. 3, pp. 243-250, September, 2021
https://doi.org/10.7747/JFES.2021.37.3.243

JFES
Journal of Forest and Environmental Science

Butterfly Diversity, Distribution, and Abundance in the University of Port Harcourt River State, Nigeria

Ogaga Dean Efenakpo[1,*], Usman Zakka[2] and Dokubo ThankGod Omanoye[1]
[1]*Department of Forestry and Wildlife Management, University of Port Harcourt, P.M.B. 5323 Port Harcourt 50005, Nigeria*
[2]*Department of Crop and Soil Science, University of Port Harcourt, P.M.B. 5323 Port Harcourt 500004, Nigeria*

Abstract

Information on butterflies in the Niger Delta Region is relatively scanty because monitoring of their activities and distribution has not been fully documented and these are paramount to establish their conservation protocols. The study therefore aimed at evaluating the species richness distribution pattern, and relative abundance of butterflies in the University of Port Harcourt. The University Park was purposively selected for this study. The park was stratified into three different habitat types (secondary forest, farmland, and residential/garden). A sampling of each stratum was done three times; twice in the morning between 8:00 am and 12:00 pm as well as once in the evening between 4:00 pm and 6:00 pm along a 100 m line transects for 16 months (May 2017-August 2018). Data collected were analyzed for species diversity indices, evenness, and similarity index. A total of 1,932 individual butterflies belonging to 28 species, 18 genera, and five 5 families were identified in the study area. Species diversity and evenness were higher on farmland (1-D=0.909; H'=2.615; E=0.833), and least in the residential area/gardens (1-D=0.744; H'=1.975; E=0.659). The family Nymphalidae (39.0%) had the highest number of species occurrence while Hesperidae (0.4%) had the lowest composition. Anthene larydas (24.12%) had the highest relative abundance in the entire study area, followed by Acraea serena (17.49%). The study, therefore, recommends continuous monitoring of butterfly species diversity and composition also in other regions.

Key Words: lepidoptera, ecology, butterfly, forest, diversity

Introduction

Butterflies belong to a subdivision (phylum) of the animal kingdom arthropoda in the order lepidoptera (Sundufu and Dumbuya 2008; Ojianwuna 2015). Over 273,000 species of lepidoptera (butterflies (28,000) and moths (245,000)) exist in the world today contributing to one-quarter of all named species on the earth (Emmel 2012; Nair et al. 2014; MCLB 2021). Lepidoptera is important to man and the health of the environment. Butterflies play a significant role in the pollination of crops and as aesthetics (Ramesh et al. 2010; Ghazanfar et al. 2016). They also provide raw materials such as silks in the textile industry and are indicators of good health and quality in plants, climatic change and a healthy environment (Kocher and Williams 2000). Butterflies, in particular, are known to be an excellent group for investigating the loss of traditional pastures and the resulting effects of vegetation encroachment (Koch et al. 2015; Ubach

Received: August 7, 2020. Revised: May 24, 2021. Accepted: May 27, 2021.

Corresponding author: Ogaga Dean Efenakpo
Department of Forestry and Wildlife Management, University of Port Harcourt, P.M.B. 5323 Port Harcourt 50005, Nigeria
Fax: +23408020531957, E-mail: ogaga.efenakpo@uniport.edu.ng

et al. 2020).

Lepidoptera communities are greatly influenced by species richness and composition of local plant communities in tropical rainforest (Novotny et al. 2002; Kurylo et al. 2020; Delabye et al. 2021). Consequently, there is much fear that many species of butterflies will go into extinction due to the fast rate of disappearance of their natural habitats such as swamps and forests. This was supported by Gascon et al. (1999) who reported that modified habitats and anthropogenic activities are often influencing butterfly species and their dynamics. The increasing number of landscape fragmentation and destruction of natural habitat for the establishment of structures without deliberate attempts to maintain or re-establish pristine eco-habitat are detrimental to native butterfly species, which could be gradually disappearing (Gascon et al. 1999; Alarape et al. 2015; Kurylo et al. 2020; Pignataro et al. 2020).

Lepidoptera community and the factors which influence their species composition have long been a topic of interest to ecologist and conservationists to form baseline information for environmental quality and biodiversity monitoring (Nwosu and Iwu 2011; Alarape et al. 2015). Their role as an indicator group has prompted their use in recent decades in extensive ecological monitoring programmes (Ubach et al. 2020). The knowledge about butterfly's richness, diversity, and distribution in the Niger Delta is relatively scanty with little documentation made by Larson (1997), Nwosu and Iwu (2011) as well as Ojianwuna (2015). The study, therefore, aims to provide the butterfly species checklist and abundance in the University of Port Harcourt Park and to evaluate the butterfly species richness and diversity by ascertaining their family composition and species distribution pattern with the view to providing baseline data for other studies in River State and Niger Delta Region.

Methodology

Study area

The study was carried out at the University Park, University of Port Harcourt, Rivers State, Nigeria. The University of Port Harcourt covers an approximately 461 ha of land and extends from 04°52'30" to 04°55'00" North latitude and from 06°54'40" to 06°55'40" East longitude (Eludoyin et al. 2015). The University of Port Harcourt lies in the humid tropical zone with an annual rainfall ranging from 2,000 mm to 2,470 mm, with annual temperature ranging from 23°C minimum to 32°C maximum and a high relative humidity amounting to 70.90% (NDES 2001). The peak of the rainy season in the study area is usually from June to October.

Materials and Methods

Protocol

The work was based on a field survey (involving visual spotting) and laboratory analysis. The University of Port Harcourt was stratified into three habitat types on the bases of vegetation, land use, and fragmentation. The fragmented sites were also chosen to reflect varying land use/land cover types and the degree of disturbance. Butterfly species were assessed quantitatively across the different habitats and cultivated land areas with an adjustable handheld sweep net, a global positioning system (GPS) and a digital camera. Butterflies were collected on a line transects at a distance of 100 meters on each transect. A total of 15 line transects measuring 50 meters apart were used in each habitat type and unidentified butterflies were caught using a sweep net having 150 cm handle and 25 cm orifice to identify the species and sex of each individual. The sampling covered a period of 16 months from "May 2017-August 2018".

Each survey was carried out twice between 8:00 am and 12:00 pm and once between 4:00 pm and 6:00 pm in order to establish butterfly diversity, distribution and abundance. The unidentified butterfly specimens were collected from several microhabitats within the location sites; grasses, flowers, hedges, and walls. Each of the specimens collected was kept in a well-labeled Ziploc showing location, habitat type and date of collection. Collected specimens were euthanized by a ball of cotton wool soaked in chloroform solution. The specimens were further air-dried and photographed. Identification was done using taxonomical keys of Sáfián and Warren (2015), as well as online identification platforms such as the Virtual Museum of South (vmus.adu.org.za), last Access on 18th September 2019.

Data analysis

Data collected were analyzed using the Statistical Package for the Social Scientist (SPSS 17). Butterfly spe-

cies, individual diversity, and abundance were calculated using the Shannon Weiner index (H), Simpson index (1-D), Relative abundance, and evenness (Magurran and McGill 2011). The species richness (S) was counts of the species number. Sorensen's coefficient index was used to calculate community similarity, which is also mathematically shown below:

Shannon Weiner index (H') $H' = -\sum p_i(\ln)(p_i)$ i

H'=Shannon index

$$Pi = \frac{\text{Number of individuals of species}}{\text{Total number of samples}}$$

In=natural log

Simpson's Dominance index (D) is a measure of diversity that takes into accounts both richness (the number of species per sample) and evenness (abundance of the different species making up the richness of an area).

Simpson's Dominance index (D): $D = 1 - \frac{\sum n(n-1)}{N(N-1)}$ ii

D=Dominance index

ni=number of individuals in the i^{th} species

N=total number of entities in the dataset

Table 1. Checklist and abundance of the University Park

S/N	Family	Species	Common name	Abundance
1	Hesperidae	*Pardaleodes edipus*	Common Pathfinder Skipper	7
2	Lycaenidae	*Anthene larydas*	Spotted Hairtail	466
3	"	*Hypolycaena philippus*	Purple-brown Hairstreak	68
4	"	*Leptotes pirithous*	Common Zebra Blue	7
5	Nymphalidae	*Acraea alciope*	Hewitson's Acraea	36
6	"	*Acraea bonasia*	Bonasia Acraea	43
7	"	*Acraea encedana*	Pierre's Acraea	31
8	"	*Acraea serena*	Dancing Acraea	338
9	"	*Amauris niavius*	Friar	21
10	"	*Amauris tartarea*	Monk or Dusky Friar	17
11	"	*Danaus chrysippus*	Plain Tiger	13
12	"	*Euphaedra medon*	Widespread Forester	3
13	"	*Euphaedra themis*	Common Themis Forester	8
14	"	*Bicyclus dorothea*	Light Bush Brown	3
15	"	*Bicyclus safitza*	Common Bush Brown	25
16	"	*Bicyclus taenias*	Grey Bush Brown	4
17	"	*Junonia oenone*	Blue Pansy	207
18	Papilionidae	*Graphium policenes*	Common Swordtail	18
19	"	*Papilio dardanus*	Mocker Swallowtail	15
20	"	*Papilio demodocus*	Citrus Swallowtail	182
21	"	*Papilio nireus*	Blue-banded Swallowtail	3
22	Pieridae	*Appias phaola*	Dirty Albatross	116
23	"	*Belenois calypso*	Calypso White	77
24	"	*Catopsilia florella*	African Emigrant	9
25	"	*Colotis euippe*	Round-winged Orange Tip	5
26	"	*Eurema senegalensis*	Forest Grass Yellow	6
27	"	*Mylothris chloris*	Western Dotted Border	166
28	"	*Mylothris rhodope*	Rhodope	38
	5 Families	18 Genera; 28 Species	Grand total	1,932

Source: Field Survey 2018.

Calculation of Relative abundance:

$$\text{Species relative abundance} = \frac{\text{Species abundance} \times 100}{\text{Total abundance}}$$

Evenness Index (E) which refers to how close in numbers each species is in an environment, calculated as:

$$E = \frac{H}{H_{max}} \quad \text{iii}$$

E=evenness index

H'=Shannon Weiner index

H_{max}=the highest value of Shannon Weiner index

Sorensen's coefficient index calculates community similarity (species common in each community). The index value ranges between 0 and 1 and the closer the value to 1, the higher the probability of species number common to each community and a value equal to 1 indicates complete community overlap while 0 index indicates complete dissimilarity.

$$\text{Sorensen's Coefficient (CC)} = \frac{2C}{S_1 + S_2} \quad \text{iv}$$

Where: C=the number of species of two communities have in common

S_1=the total number of species found in community 1.

S_2=the total number of species found in community 2.

Results

Butterfly checklist and abundance

The result of the checklist and abundance of butterfly species across the different habitat is presented in the Table 1. A total of 28 species belonging to 18 genera and 5 families of butterflies were recorded amounting to 1,932 individuals. *Anthene larydas* had the highest occurrence (466), while *Euphaedra medon*, *Bicyclus dorothea* and *Papilio nireus* had the least occurrence (3).

Species richness and diversity indices

The result of species diversity indices, richness and evenness are presented in the Table 2, and the results of similarity indices are presented in the Table 3. The study revealed that species diversity indices were higher on farmland (1-D=0.909; H'=2.615), followed by secondary forest (1-D=0.865; H'=2.256) (Table 2) and the least diversity occurred in residential area/gardens (1-D=0.744; H'=1.975) (Table 2). But species evenness was higher in farmland habitats (E=0.833), than secondary forest and in residential area/garden (E=0.659). However, the species richness was higher on farmlands (S=26), than residential area/gardens (S=20) and secondary forest (S=15). Table 3 shows that similarity or overlap was high between farmland and residential area/garden (SI=0.87) and the overlap was low between secondary forest and residential area/garden (SI=0.51).

Table 3. Sorensen's similarity indices of butterflies in the three habitats

	Residential/ gardens	Farmlands	Secondary forests
Residential/gardens	*	0.8696	0.5142
Farmlands		*	0.6341
Secondary forests			*

Source: Field Survey 2018.

Table 2. Diversity indices of butterflies in the different habitat types sampled over 16 months in the University of Park

Parameter	Residential/gardens	Farmlands	Secondary forests
Species S	20	26	15
Individuals	946	872	114
Simpson 1-D	0.744	0.909	0.865
Shannon H'	1.975	2.615	2.256
Evenness E	0.659	0.803	0.833

Source: Field Survey 2018.

Family composition and species distribution pattern in the study area

In Fig. 1 the family composition of butterflies of the study area is presented, while the results of species distribution pattern across the different habitats are shown in Fig. 2. Fig. 1 shows that the family Nymphalidae (39.0%) had the highest species number, followed by Lycaenidae (28.0%), while Hesperidae (0.4%) had the lowest family composition. Fig. 2 shows that species distribution was at maximum on farmland (26), followed by residential area/gardens (20) and secondary forest (15).

Relative abundance of butterflies species in the study area

The relative abundance of butterfly species in the different habitat types are presented in the Table 4, while the relative abundance of the entire study area is presented in the Table 5. Table 4 shows that *Papilio demodocus* had the highest relative abundance (22.81%) while *Amauris niavius* and *Danaus chrysippus* had the lowest relative abundance (0.88% and 0.88%) in the secondary forest. Also, *Anthene larydas* had the maximum relative abundance (38.25%) while *Bicyclus dorothea* (0.11%), *Bicyclus taenias* (0.11%) and *Eurema senegalensis* (0.11%) had the minimum relative abundance in residential areas/gardens.

Furthermore, the study (Table 4) revealed that the species *Junonia oenone* had the highest relative abundance (13.30%) while *Papilio nireus* has the lowest relative abundance (0.11%) on farmlands. However, *Anthene larydas* had the highest relative abundance (24.12%) in the entire study area, while *Bicyclus dorothea* (0.16%), *Euphaedra medon* (0.16%), and *Papilio nireus* (0.16%) exhibited the least relative abundance (see Table 5).

Discussion

The 28 species belonging to 5 families recorded in the study area were lower compared with the findings of the survey made by Ojianwuna (2015) survey in Okomu National Park, Edo State, Nigeria, who recorded 76 species belonging to 5 families. More also, the survey of Alarape et al. (2015) at the University of Ibadan Botanical Garden, Nigeria, who identified 57 butterfly species belonging to 9 families. This disparity in Ojianwuna (2015) and Alarape et al. (2015) could be attributed to differences in vegetation at the different sampling sites, vegetation cover, and ecological zones, species abundance and methods of identifications. However, the result was higher compared with the study of Kemabonta et al. (2015) who recorded a total of 1105 individual butterflies belonging to 11 genera and 4 families (Nymphalidae, Papilionidae, Pieridae and Lycaenidae), Nwosu and Iwu (2011) found 201 individual butterflies belonging to 28 genera and 5 families (Lycaenidae, Pieridae, Nymphalidae, Papilionidae and Satyridae),Yager et al. (2016) recorded a total of 337 individuals representing 17 butterfly species belonging to 5 families (Papilionidae, Pieridae, Nymphalidae, Lycaenidae, and Hesperidae) and Elanchezhyan et al. (2017) who recorded a total of 721 individuals of butterflies belonging to 5 families (Nymphalidae, Pieridae, Lycaenidae, Papilionidae and Hesperiidae) in Asia, the variation especially to the collections made in Asia with similar microhabitat may be due to species richness and diversity, abundance and ecological zones. Also, the methods of collection and duration by the surveyors may have contributed to such significant differences in number.

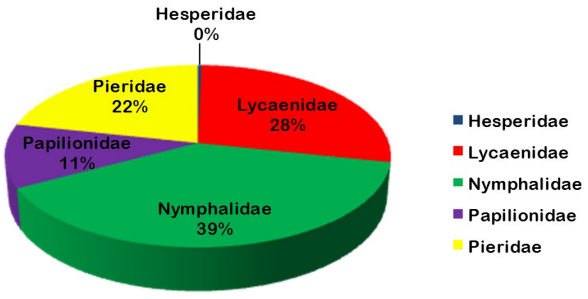

Fig. 1. Family composition of butterfly in the study area.

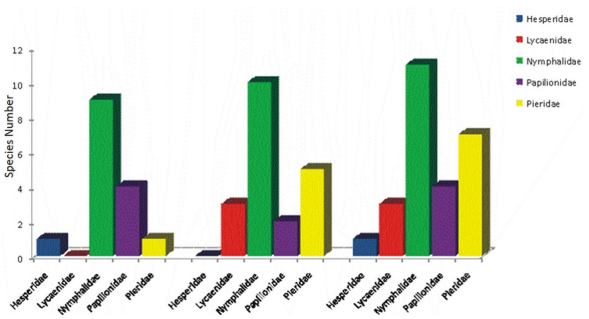

Fig. 2. Distribution of butterflies family in the study area.

Table 4. Relative abundance of butterfly in each habitat type

S/N	Species	Common name	Secondary forest		R. area/ gardens		Farmland	
			A	R.A%	A	R.A%	A	R.A%
1	*Pardaleodes edipus* (Stoll 1781)	Common Pathfinder Skipper	5	4.39	-	-	2	0.23
2	*Anthene larydas* (Cramer 1780)	Spotted Hairtail	-	-	362	38.23	104	11.93
3	*Hypolycaena philippus* (Fabricius 1793)	Purple-brown Hairstreak (Plate 2)	-	-	6	0.63	62	7.11
4	*Leptotes pirithous* (Linnaeus 1767)	Common Zebra Blue	-	-	5	0.53	2	0.23
5	*Acraea alciope* (Hewitson 1852)	Hewitson's Acraea	5	4.39	19	2.01	12	1.38
6	*Acraea bonasia* (Fabricius 1775)	Bonasia Acraea	2	1.75	25	2.64	16	1.83
7	*Acraea encedana* (Pierre 1976)	Pierre's Acraea	-	-	9	0.95	22	2.52
8	*Acraea serena* (Fabricius 1775)	Dancing Acraea	17	14.91	215	22.73	106	12.16
9	*Amauris niavius* (Linnaeus 1758)	Friar	1	0.88	14	1.48	6	0.69
10	*Amauris tartarea* (Mabille 1876)	Monk or Dusky Friar	-	-	13	1.37	4	0.46
11	*Danaus chrysippus* (Linnaeus 1758)	Plain Tiger	1	0.88	2	0.21	10	1.15
12	*Euphaedra medon* (Linnaeus 1763)	Widespread Forester	3	2.63	-	-	-	-
13	*Euphaedra themis* (Hübner 1807)	Common Themis Forester	8	7.02	-	-	-	-
14	*Bicyclus dorothea* (Cramer 1779)	Light Bush Brown	-	-	1	0.11	2	0.23
15	*Bicyclus safitza* (Westwood 1850) (Plate 3)	Common Bush Brown	2	1.75	-	-	23	2.64
16	*Bicyclus taenias* (Hewitson 1877)	Grey Bush Brown	-	-	1	0.11	3	0.34
17	*Junonia oenone* (Linnaeus 1758)	Blue Pansy	19	16.67	72	7.61	116	13.30
18	*Graphium policenes* (Cramer 1775)	Common Swordtail	16	14.04	-	-	2	0.23
19	*Papilio dardanus* (Brown 1776)	Mocker Swallowtail	5	4.39	1	0.11	9	1.03
20	*Papilio demodocus* (Esper 1798)	Citrus Swallowtail	26	22.81	54	5.71	102	11.70
21	*Papilio nireus* (Linnaeus 1758)	Blue-banded Swallowtail	2	1.75	-	-	1	0.11
22	*Appias phaola* (Doubleday 1847)	Dirty Albatross	-	-	44	4.65	72	8.26
23	*Belenois calypso* (Drury 1773)	Calypso White	2	1.75	19	2.01	56	6.42
24	*Catopsilia florella* (Fabricius 1775)	African Emigrant	-	-	-	-	9	1.03
25	*Colotis euippe* (Linnaeus 1758)	Round-winged Orange tip	-	-	-	-	5	0.57
26	*Eurema senegalensis* (Boisduval 1836)	Forest Grass Yellow	-	-	1	0.11	5	0.57
27	*Mylothris chloris* (Fabricius 1775)	Western Dotted Border	-	-	72	7.61	94	10.78
28	*Mylothris rhodope* (Fabricius 1775)	Rhodope	-	-	11	1.16	27	3.10

NB: R.area, residential areas; A, abundance; R.A, relative abundance.
Source: Field Survey 2018.

Species diversity and evenness indices were least in residential area/gardens and highest on farmlands. The variation may be attributed to the fact that a large proportion of different flowering and non-flowering plant species including crops which serve as food sources for butterflies that are present in the latter habitat and where there may also be relatively undisturbed forest habitat unlike in residential areas. Butterfly family composition of the study area revealed that the family Nymphalidae had the highest number of species, followed by Lycaenidae, Pieridae, and Papilionidae while Hesperidae had the lowest family composition in the study area. This may be as a result of family adaptation to fragmented habitat. The result agrees with the finding of Ojianwuna (2015), Kemabonta et al. (2015) and Elanchezhyan et al. (2017) who also reported Nymphalidae to have the highest family composition in their studies. However, it disagrees with Alarape et al. (2015) and Yager et al. (2016) who found that Pieridae composition is higher compared to Nymphalidae.

Sorensen's similarity index showed that similarity was highest between farmland and residential area/garden, followed by secondary forest and residential area/garden and overlap was low between secondary forest and residential area/garden. This may be due to the shared vegetation char-

Table 5. Relative abundance of butterfly in the entire study area

S/N	Species	Common name	Abundance	R. Abundance%
1	*Pardaleodes edipus* (Stoll 1781)	Common Pathfinder Skipper	7	0.36
2	*Anthene larydas* (Cramer 1780)	Spotted Hairtail	466	24.12
3	*Hypolycaena philippus* (Fabricius 1793)	Purple-brown Hairstreak (Plate 2)	68	3.52
4	*Leptotes pirithous* (Linnaeus 1767)	Common Zebra Blue	7	0.36
5	*Acraea alciope* (Hewitson 1852)	Hewitson's Acraea	36	1.86
6	*Acraea bonasia* (Fabricius 1775)	Bonasia Acraea	43	2.23
7	*Acraea encedana* (Pierre 1976)	Pierre's Acraea	31	1.60
8	*Acraea serena* (Fabricius 1775)	Dancing Acraea	338	17.49
9	*Amauris niavius* (Linnaeus 1758)	Friar	21	1.09
10	*Amauris tartarea* (Mabille 1876)	Monk or Dusky Friar	17	0.88
11	*Danaus chrysippus* (Linnaeus 1758)	Plain Tiger	13	0.67
12	*Euphaedra medon* (Linnaeus 1763)	Widespread Forester	3	0.16
13	*Euphaedra themis* (Hübner 1807)	Common Themis Forester	8	0.41
14	*Bicyclus dorothea* (Cramer 1779)	Light Bush Brown	3	0.16
15	*Bicyclus safitza* (Westwood 1850) (Plate 3)	Common Bush Brown	25	1.29
16	*Bicyclus taenias* (Hewitson 1877)	Grey Bush Brown	4	0.21
17	*Junonia oenone* (Linnaeus 1758)	Blue Pansy	207	10.71
18	*Graphium policenes* (Cramer 1775)	Common Swordtail	18	0.93
19	*Papilio dardanus* (Brown 1776)	Mocker Swallowtail	15	0.78
20	*Papilio demodocus* (Esper 1798)	Citrus Swallowtail	182	9.42
21	*Papilio nireus* (Linnaeus 1758)	Blue-banded Swallowtail	3	0.16
22	*Appias phaola* (Doubleday 1847)	Dirty Albatross	116	6.00
23	*Belenois calypso* (Drury 1773)	Calypso White	77	3.99
24	*Catopsilia florella* (Fabricius 1775)	African Emigrant	9	0.47
25	*Colotis euippe* (Linnaeus 1758)	Round-winged Orange Tip	5	0.26
26	*Eurema senegalensis* (Boisduval 1836)	Forest Grass Yellow	6	0.31
27	*Mylothris chloris* (Fabricius 1775)	Western Dotted Border	166	8.59
28	*Mylothris rhodope* (Fabricius 1775)	Rhodope	38	1.97

Source: Field Survey 2018.

acteristic of the habitats, the relative proximity of the habitats and activities level of inhabitants in the study sites. The result of species distribution count was highest on farmland followed by residential area/gardens and was very low in the secondary forest. This result may be attributed to the relatively large landmass of habitat types and adaptations to land use type of the University Park. *Anthene larydas* was observed to have the highest relative abundance in the entire study area, followed by *Acraea serena* (Plate 1), *Junonia oenone* (Plate 4), *Bicyclus dorothea*, *Euphaedra medon*, and *Papilio nireus*. This observation disagrees with the findings of Yager et al. (2016), but partially agrees with that of Kemabonta et al. (2015), who ranked *Acraea serena* as highest. The *Anthene larydas* prefers open lawns and were the most frequently observed butterfly and this could be as a result of their habitat requirement and adaptation to the modified human environment and fragmented habitat.

This research forms the most rudimental baseline for butterfly taxonomy and distribution in the Niger Delta Region. However, based on the limited numbers of species richness and diversity in residential areas/gardens, it becomes imperative to recommend that the University Port Harcourt should be reforested especially with flowering plants including trees and edge-plants in addition to conserving the remaining secondary forest and a periodic monitoring of the abundance and diversity of butterflies in the study area should be prioritized.

References

Alarape AA, Omifolaji JK, Mwansat GS. 2015. Butterfly Species Diversity and Abundance in University of Ibadan Botanical Garden, Nigeria. Open J Ecol 5: 352-360.

Delabye, S, Maicher, V, Sáfián, S, Doležal J, Altman J, Janeček Š, Kobe IN, Murkwe M, Šebek P, Tropek R. 2021. Butterfly and moth communities differ in their response to habitat structure in rainforests of Mount Cameroon. Biotropica 53: 567-580.

Elanchezhyan K, Samraj JM, Reuolin SJ. 2017. Butterfly diversity at the agricultural collegecampus, Killikulam, Tami Nadu, India. J Entomol Zool Stud 5: 1389-1400.

Eludoyin OS, Oladele AT, Iyanda OM. 2015. Mapping and Assessment of Ethno-Medicinal Trees in Built Up Areas - University of Port Harcourt, Nigeria. South-East Eur For 6: 129-140.

Emmel TC. 2012. Veterinary pediatrics of butterflies, moths, and other invertebrates. Vet Clin North Am Exot Anim Pract 15: 279-288, vii.

Gascon C, Lovejoy TE, Bierregaard RO, Malcolm JR, Stouffer PC, Vasconcelos HL, Laurance WF, Zimmerman B, Tocher M, Borges S. 1999. Matrix habitat and species richness in tropical forest remnants. Biol Conserv 91: 223-229.

Ghazanfar M, Malik MF, Hussain M, Iqbal R, Younas M. 2016. Butterflies and their contribution in ecosystem: a review. J Entomol Zool Stud 4: 115-118.

Kemabonta KA, Ebiyon AS, Olaleru F. 2015. The butterfly fauna of three varying habitats in South Western Nigeria. FUTA J Res Sci 11: 1-6.

Koch B, Edwards PJ, Blanckenhorn WU, Walter T, Hofer G. 2015. Shrub Encroachment Affects the Diversity of Plants, Butterflies, and Grasshoppers on Two Swiss Subalpine Pastures. Arct Antarct Alp Res 47: 345-357.

Kocher SD, Williams EH. 2000. The diversity and abundance of North American butterflies vary with habitat disturbance and geography. J Biogeogr 27: 785-794.

Kurylo JS, Threlfall CG, Parris KM, Ossola A, Williams NSG, Evans KL. 2020. Butterfly richness and abundance along a gradient of imperviousness and the importance of matrix quality. Ecol Appl 30: e02144.

Larson TB. 1997. Butterflies of the Cross River National Park- diversity writ large. In: Proceedings of the Workshop: Essential Partnership- the Forest and the People; Calabar, Nigeria; Oct 23-28, 1997. pp 229-235.

Magurran AE, McGill BJ. 2011. Biological Diversity: Frontiers in Measurement and Assessment. Oxford University Press, Oxford, 345 pp.

McGuire Center for Lepidoptera and Biodiversity (MCLB). 2021. https://www.floridamuseum.ufl.edu/index.php/mcguire/home/. Accessed 16 Dec 2019.

Nair AV, Mitra P, Bandyopadhyay SA. 2014. Studies on the diversity and abundance of butterfly (Lepidoptera: Rhopalocera) fauna in and around Sarojini Naidu college campus, Kolkata, West Bengal, India. J Entomol Zool Stud 2: 129-134.

Niger Delta Environmental Survey (NDES). Biological Environment Research Report, River State University of Science and Technology (RSUST), Port Harcourt. Vol. 46: 251.

Novotny V, Miller SE, Basset Y, Cizek L, Drozd P, Darrow K, Leps J. 2002. Predictably simple: assemblages of caterpillars (Lepidoptera) feeding on rainforest trees in Papua New Guinea. Proc Biol Sci 269: 2337-2344.

Nwosu LC, Iwu C. 2011. A comparative study of diversity of species of butterflies in protected and unprotected habitats of Okwu Ogbaku forest reserve in Mbaitoli L.G.A., Imo State, Nigeria. J Environ Issues Agric Dev Ctries 3: 129-136.

Ojianwuna CC. 2015. Climatic Variables as Factors Affecting Diversity and Abundance of Butterflies in Okomu National Park, Edo State, Nigeria. J Nat Sci Res 5: 70-76.

Pignataro T, Bressan P, Santos AL, Cornelissen T. 2020. Urban gradients alter the diversity, specific composition and guild distribution in tropical butterfly communities. Urban Ecosyst 23: 723-730.

Ramesh T, Hussain KJ, Selvanayagam M, Satpathy KK, Prasad MVR. 2010. Patterns of Diversity, Abundance and Habitat Associations of Butterfly Communities in Heterogeneous Landscapes of the Department of Atomic Energy (DAE) Campus at Kalpakkam, South India. Int J Biodivers Conserv 2: 75-85.

Sáfián S, Warren RD. 2015. Common Butterflies of IITA. International Institute of Tropical Agriculture (IITA), Ibadan, 117 pp.

Sundufu A, Dumbuya R. 2008. Habitat preferences of butterflies in the Bumbuna Forest, Northern Sierra Leone. J Insect Sci 8: 1-17.

Ubach A, Páramo F, Gutiérrez C, Stefanescu C. 2020. Vegetation encroachment drives changes in the composition of butterfly assemblages and species loss in Mediterranean ecosystems. Insect Conserv Divers 13: 151-161.

Yager GO, Agbidye FS, Okoh AO. 2016. Diversity and abundance of butterfly species (Lepidoptera) fauna in Federal University of Agriculture, Makurdi Forestry Nursery, Benue State, Nigeria. J Res For Wildl Environ 8: 83-89.