

A comparative study on the abundance and diversity of butterflies in disturbed and undisturbed habitats in a tertiary institution in central Nigeria

Abstract

Butterflies are among the most widely spread taxa whose distribution cut across all the continents of the world except the Antarctica. Many butterfly species are comparatively easy to sample and recognize both as individuals and as species than many other insect groups. They are extremely sensitive to changes in vegetation composition and structure in the environment. As a result of this; butterflies have widely been used as a model species to evaluate the health of the environment and changes in the environment. We investigated and compared the butterfly abundance and diversity within a newly established tertiary institution in Central Nigeria in April, 2016 using transects with the aid of sweep nets. Four transects were laid in each of the disturbed and undisturbed habitats of Federal University of Lafia (FULafia). Transects were visited in the morning and evening. An overall total of three hundred and one butterflies were seen. However, only 160 were caught which spread across 5 families, 21 genera and 25 species. The most abundant family of butterflies caught was Pieridae 49 (30.63%) followed by Lycaenidae 42 (26.25%), Nymphalidae 34 (21.25%), Papilionidae 34 (21.25%), while Hesperidae 1 (0.63%) was the least and scarce in the study area. The most abundant genera of butterflies recorded were *Eurema* 29 (18.13%), *Papilio* 27 (16.88%) and *Hypolycaena* 23 (14.38%). The mean abundance of butterflies seen in relation to disturbed and undisturbed habitats showed a very high significant difference ($t = -4.1952$, $df = 94.682$, $P < 0.0001$). Time of day showed a very high significant difference ($t = 6.2208$, $df = 82.469$, $P < 0.0001$) in the mean abundance of butterflies. The undisturbed habitat was more diversified ($H' = 2.6$) in butterfly diversity than the disturbed habitat ($H' = 2.5$). This study being the first effort in exploring the butterfly wealth of FULafia clearly shows that the ongoing building construction in the Permanent Site of the University may have some impact on the abundance and diversity of butterflies. Hence, the Management of the Institution should ensure that the area designated for Zoological Garden is well safe guarded for biodiversity conservation amidst ongoing sustainable development.

Keywords: butterflies, abundance, diversity, disturbed and undisturbed habitats, time of day

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Introduction

Insects are important components in both natural and transformed landscapes. They play crucial roles in the maintenance of a healthy environment. They provide various ecosystem services which are important for some aspects of human livelihood such as agriculture, tourism and natural resource use.^{1,2} Butterflies are insects in the order Lepidoptera; they are found all the continents of the world and in almost all habitat types.³ Butterflies populations are strongly influenced by local weather and are highly sensitive to changes in vegetation composition and structure. This among many other attributes makes them good bio-indicators of environmental health.⁴ Therefore, their population trends over time are frequently used as indices of ecosystem health and as surrogates for whole biodiversity in different landscapes.⁵ Studies have shown that increased urban features such as roads, buildings and mowed lawns correlates with decrease in butterfly species richness, diversity and abundance. As might be predicted, butterfly species that specialized on particular plant species for oviposition and disturbance sensitive species are more affected by urbanization than generalist species.⁶ Human population and society has made a very great impact on mass distribution and global extinction of existing species.³

Today, butterflies (Rhopalocera) are one of the planet's most diverse, abundant and successful insects. The roles insects play in

nature require us to understand how insects and other organisms living in a biological community interact with living and non-living environment. Drivers of biodiversity loss act at local, regional and global scales,⁷ hence the need for a holistic approach in conservation research and practice, especially for highly mobile groups such as insects which move across local, regional and in some cases across national boundaries. Though insect loss is a global challenge, inventories assessments and development of conservation strategies may be better targeted at local or regional scales.

In West Africa, over one thousand species of butterfly (about 50% of the region's butterflies' population) abound in Nigeria.⁸ Recently, studies have suggested a range of factors that affects the pattern of distribution of butterflies, these includes competition, predation, numerical abundance of species, food web structure, genetic factors, short and long term aspects of evolutionary rate and size of the insect.^{9,10} More works have attempted to specifically pin down the factors that affect the biodiversity of butterflies.⁵ However, rising human influence and associated degrees of pressure and shocks on the ecosystem have resulted into changes, which many creatures (including butterflies) cannot adapt to. When the change involves the composition of species and major structuring processes of the ecosystem which could have negative implications on the ability of such ecosystem to provide economically valued ecological services.¹¹ Therefore, this necessitates the need to develop sustainable

resource management policies for these ecosystems based on an understanding and appreciation of the ecological processes involved. In Madagascar, disturbed forest habitat and edges were found to be richer in butterfly species than undisturbed area.¹² Also, higher butterfly diversities were recorded in unprotected tropical forest by Thomas,¹³ Hill, Kramer, Lace and Banham,¹⁴ Brown¹⁵ and Hammer and Hill.¹⁶ The above records show that butterfly diversity varies from one location to another and provide the rationale for locating specific analysis to inform biodiversity status/control measures (or policies). Further investigation is necessary based on the fact that habitat type determines richness and kinds of butterfly.¹⁷

Habitats loss can take many forms including conversion of natural habitats to agricultural lands, logging or fragmentation. Habitat loss due to agricultural activities greatly threatens lepidopterans.^{18,19} Though such definitive claims about the impact of habitat disturbance effects on butterfly species diversity is difficult to establish given the variety of responses butterflies' exhibit to disturbance.²⁰ Koh²⁰ reviewed 20 studies that examined the impacts of land use changes and habitat loss on butterfly communities in South-east Asia. Seven of the studies showed decreased diversity in anthropogenic disturbed sites as compared to protected forests, but interestingly, some studies have shown the opposite trend. Bonebrake et al.²¹ also reviewed 20 more studies from the neotropics and afrotropics and found similarly that six of the studies reported decreased in diversity with disturbance, but four found increased. Much of the confusion stems from methodological differences among studies, which make comparisons difficult.²⁰ Spatial scale (extent and grain) and regional differences can have important consequences for species richness relationships²² and likely further obscure habitat loss effects on butterfly diversity. One of the consistent patterns found in most of these studies, however, is that species with narrow ranges tend to be the most vulnerable to the impacts of habitat loss and usually require natural forest to persist.^{13,23,24} Spatial and temporal scales are complicating factors that must be considered when comparing effects of habitat loss on butterflies. For example, studies at small spatial scales are more likely to report increases in diversity when comparing disturbed and undisturbed sites than are studies at larger spatial scales.²⁵

Nigeria is an afro-tropical country endowed with rich flora and fauna biodiversity, typical of most tropical countries of the world. The tropics which has been reported to be home to about 70% of global biodiversity is also a treasure trove of insect diversity which is estimated to parallel the extent of plant diversity of this region.²⁶ Nigeria's tropical rainforest and savannah vegetation zones lie within the Guinea Forests of West African Biodiversity Hotspots (27). This region is identified as one of the most severely threatened forests in the world, being left with just 15% of its original forest cover.²⁸

Human activities have caused drastic global increase in extinction rate.²⁹ Species populations are disappearing even more quickly and at a faster pace than ever.³⁰ The Permanent Site of Federal University of Lafia (FULafia) is undergoing rapid construction without necessarily taking into account the impact on butterfly species composition and distribution which are good indicators of habitat biodiversity. Also, some butterflies are endemic to the guinea savanna area. Butterflies respond quickly to environmental changes and are highly diverse taxon, which has proven as a vital group for developing the conceptual framework of terrestrial biodiversity.³¹ Studies on butterflies have been particularly important for understanding tropical insect diversification, ecology, evolution and conservation.^{17,21,31} To this end, this study generated the first checklist of butterflies in the Permanent Site of Federal University of Lafia, which will help in the sustainable development of the area.

Materials and methods

Study Area

The study was carried out in Federal University of Lafia (FULafia) Permanent Site, Nasarawa State, Nigeria as shown in Figure 1. The school is located in latitude 8°28'N and longitude 8°32'E and elevation of 158 metres above sea level. The average temperature of Lafia is 26.8-27.0° and the annual rainfall is 165 mm. The Permanent Site is characterized by grassland savannah, scrub woodland and interspersed by gallery forest.

Two sites were selected for survey. The sites were categorized as:

- The undisturbed site: This was defined as the area characterized with tall trees, minimal anthropogenic activities such as grazing activities, construction, farming etc.
- The disturbed site: These are sites that are fast changing due to construction activities. The site is characterized by grassland with space shrubs.

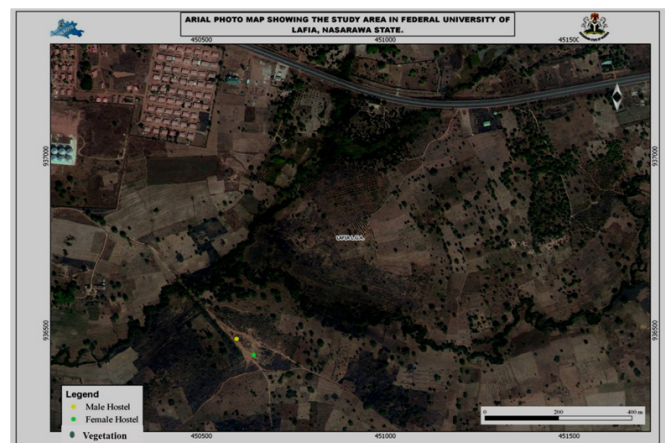


Figure 1 Aerial Photo Map of Federal University of Lafia, Nasarawa State showing the habitats and infrastructure.

Data collection

Butterflies survey was carried out between 15th and 30th April, 2016. Four 700 metres transects were marked using a geographic positioning system (GPS) etrex GARMIN-12. Transects were placed at least 100 metres apart. Yellow ribbons were used to define the start and end of each transect. Two line transects were walked on the disturbed as well as undisturbed site twice (morning [0600 to 1000 hours] and evening time [1500 to 1800 hour]) in every sampling day. Each transect was visited a total of 28 times and a total of 56 visitations in each of the habitat types in fourteen rounds (days). Butterflies were collected using a sweep net.^{14,32,33} The Pollard Transect Walking Technique (PTWT) was modified to include captures with a sweep net. Butterflies seen or caught that fell within 25 metres on either side of the transect route were counted, described and recorded.

All the captured butterflies were immobilized in two separate specimen bottles (one for disturbed site and the other undisturbed site), containing cotton wool with chloroform soaked, to prevent random movement and displacement of wings. Butterflies were identified using identification key by Larsen.³⁴ The samples were preserved by injecting 75% ethanol into the abdomen to prevent other insect infestations and then allowed to air dry and were pooled from both the disturbed and undisturbed site respectively to avoid mix up.

Data analysis

Data was analyzed using R Console software version 3.2.2. Two sample t-test were used to compare the abundance of butterflies seen as well as those collected between disturbed and undisturbed sites in the Permanent Site of Federal University of Lafia. Also, it was used to compare the abundance of butterflies in relation to time of day. Pearson’s Chi-square test was used to compare diversity index in relation to the two sites. Level of significance was set at $P < 0.05$.

Results

Butterfly species checklist generated at the end of this study is shown in Table 1. An overall total of three hundred and one (301) individuals of butterflies were seen. Of the 301 butterflies seen, only one hundred and sixty (160) were caught and they spread across five (5) families, twenty-one (21) genera’s and twenty-five (25) species were seen, caught and identified from both disturbed and undisturbed site of Federal University of Lafia (Table 1). The highest number

of individuals were recorded in the family Pieridae 49 (30.63%); Lycaenidae 42 (26.25%); Nymphalidae 34 (21.25%) and Papilionidae 34(21.25%) while family Hesperidae recorded the lowest number of individuals with 1 (0.63%).

Three genera from three different families were found to be more abundant in both disturbed and undisturbed sites of the study, and they are as follows: *Eurema* (Pieridae) 29 (18.13%); *Papilio* (Papilionidae) 27 (16.88%) and *Hypolycaena* (Lycaenidae) 23 (14.38%) followed by *Catopsilia* (Pieridae) 10 (6.25%) while in the remaining nineteen genera from the total recorded in this study had low occurrence with less than ten individuals. A genus in the family Hesperidae (*Abantis*) was only seen in the undisturbed sites while the disturbed site had greater number in the family Lycaenidae 24 (15%). In the family Pieridae, there was no much difference as undisturbed site had 29 (18.13%) while the disturbed site had 20 (12.5%). Most of the captured butterflies were identified to species level. However, a lycaenid and some few species were not identified beyond the genus levels (Table 1).

Table 1 Checklist of butterflies in Federal University of Lafia Permanent Site across disturbed and undisturbed habitats

Family	Species	Habitats		Total (%)
		Disturbed (%)	Undisturbed (%)	
Hesperidae	<i>Abantis nigeriana</i>	0(0.00)	1(0.63)	1(0.63)
		0(0.00)	1(0.63)	1(0.63)
Lycaenidae	<i>Azanas jesous</i>	3(1.88)	2(1.25)	5(3.13)
	<i>Deudorix dinochares</i>	2(1.25)	0(0.00)	2(1.23)
	<i>Hypolycaena anara</i>	14(8.75)	9(5.63)	23(14.38)
	<i>Cupidopsis cissus</i>	5(3.13)	4(2.5)	9(5.63)
	<i>Lolasa sp.</i>	0(0.00)	3(1.88)	3(1.88)
		24(18.14)	18(11.25)	42(26.25)
Nymphalidae	<i>Acraea serena</i>	3(1.88)	0(0.00)	3(1.88)
	<i>Bicyclus campa</i>	3(1.88)	1(0.63)	4(2.5)
	<i>Byblia anvatara crameri</i>	1(0.63)	1(0.63)	2(1.25)
	<i>Charaxes sp.</i>	0(0.00)	2(1.25)	2(1.25)
	<i>Danaus chrysippus</i>	3(1.88)	6(3.75)	9(5.63)
	<i>Hamanumida daedalus</i>	0(0.00)	5(3.13)	5(3.13)
	<i>Hypolimnas misippus</i>	1(0.63)	0(0.00)	1(0.63)
	<i>Junonia chorimene</i>	0(0.00)	1(0.63)	1(0.63)
	<i>Ypthima spp.</i>	2(1.25)	0(0.00)	2(1.25)
		0(0.00)	5(3.13)	5(3.13)
		13(8.15)	21(13.15)	34(21.25)
Papilionidae	<i>Graphium angolarus baronis</i>	2(1.25)	5(3.13)	7(4.38)
	<i>Papilio demodocus</i>	7(4.38)	20(12.5)	27(16.88)
		9(5.63)	25(15.63)	34(21.25)
Pieridae	<i>Belenois creona creona</i>	2(1.25)	1(0.63)	3(1.88)
	<i>Catopsilia florella</i>	1(0.63)	9(5.63)	10(6.25)
	<i>Colitis spp.</i>	3(1.88)	0(0.00)	3(1.88)
	<i>Eurema brigitta brigitta</i>	9(5.63)	11(6.88)	20(12.50)
	<i>Eurema hecabe solifera</i>	5(3.13)	4(2.5)	9(5.63)
	<i>Mylothris aburi</i>	0(0.00)	3(1.88)	3(1.88)
	<i>Mylothris chloris</i>	0(0.00)	1(0.63)	1(0.63)
		20(12.5)	29(18.13)	49(30.63)
Total		66(41.25)	94(58.75)	160(100)

The distribution of butterflies between the disturbed and undisturbed habitats shows that there are more butterflies in the undisturbed site 94 (58.75%) than the disturbed site 66 (41.25%). Therefore, the mean abundance of butterflies in relation to disturbed and undisturbed habitats showed a very high significant difference ($t = -4.1952$, $df = 94.682$, $P = 0.00006143$, Figure 2). Butterflies were more abundant in the morning session over the evening session. Thus, there was a very high significant difference in butterfly abundance in relation to time of day ($t = 6.2208$, $df = 82.469$, $P < 0.0001$, Figure 3).

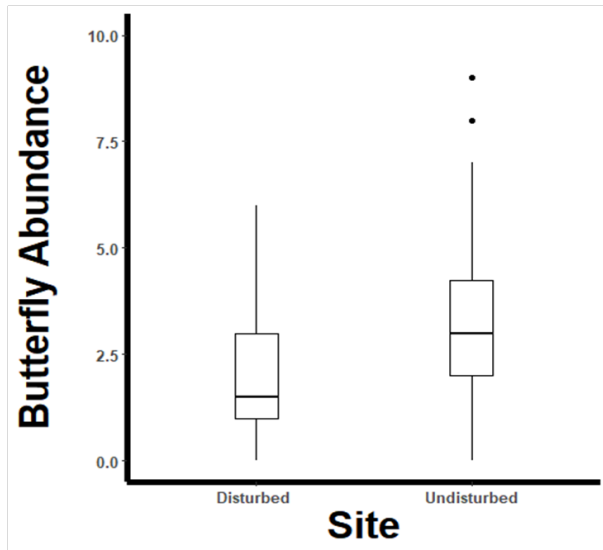


Figure 2 Butterfly abundance in relation to the level of disturbance.

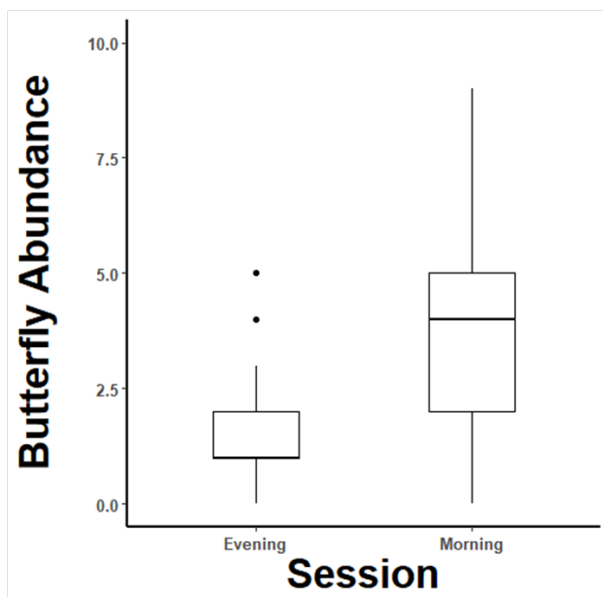


Figure 3 Butterfly abundance in relation to the time of day.

The diversity index recorded in Table 2 and Table 3 clearly shows that butterfly diversity in the disturbed and undisturbed sites was relatively high. Though diversity was higher in undisturbed site ($H' = 2.615$) than the disturbed site ($H' = 2.547$). However, diversity index variation between the two sites showed no significant difference ($\chi^2 = 0.00089578$, $df = 1$, $P = 0.9761$).

Discussion

The analysis of the results obtained clearly showed that butterflies

composition from both the undisturbed and disturbed habitats of the Federal University of Lafia (FULafia) Permanent Site, Nasarawa State, Nigeria spreads across five families, twenty-five genera and twenty-seven species which is a good indicator that the area would be of interest for a well-planned ex-situ biodiversity conservation programme, most especially in the Zoological Garden area of the Institution. The higher number of Pieridae and Lycaenidae is supported by the studies of Bernard³⁵ who reported the two families as the largest of the order Lepidoptera that can be seen almost everywhere. The genera *Eurema* (Pieridae) and *Hypolycaena* (Lycaenidae) were found to be more abundant in both the undisturbed and disturbed site, while the genera *Papilio* (Papilionidae) was far more abundant in the undisturbed site of FULafia. *Abantis*, a member of the family Hesperidae minimally occurred, and were seen on rare occasions in the undisturbed site, but were not found at all in the disturbed site at the time of this study. Most butterfly species found in the undisturbed site were having shaper and more attractive colours and were not high flyers though very energetic and hence making them more difficult to catch using the sweep net as when compared to the disturbed site, of which reasons could be as a result of more food component such as plant nectar for the nectar-sucking butterflies, and fruits, for the fruit-feeding butterflies.

The undisturbed site was found to be more abundant and diverse probably due to low level of anthropogenic activities such as the effect of construction, habitat loss and disturbance in the environment. The site had more species of the family Papilionidae (*Papilio demodocus*) which is commonly known as the citrus swallow tail, and are considered very scarce and difficult to find as a result of harvest by individuals but were found in reasonable and well flourishing amount in FULafia's site. The findings of this study is further supported by Hill et al.,¹⁴ Brown,¹⁴ Bonebrake et al.²¹ and Akwashiki et al.³³ who reported great abundance of butterfly species in less disturbed habitats. Higher abundance and diversity in the undisturbed site could be because the site provides wider resources for the butterflies to utilize compared to the disturbed area where both vegetation and activities of other taxa are minimal because of both destruction of microhabitats and depletion of necessary resources needed for the daily activities of all living things. Many butterfly larval stage depends on specific plant or sort of host plants, a little disturbance to the abundance of such plants could have a resultant negative effects on the population. Also, Koh²⁰ reviewed 20 studies that examined the impacts of land use changes and habitat loss on butterfly communities in South-east Asia in which seven of the studies showed decreased diversity in anthropogenic disturbed sites as compared to protected forests, but interestingly, nine studies showed the opposite trend. Bonebrake et al.²¹ also reviewed 20 more studies from the neotropics and afrotropics and found similarly that six of the studies reported decreases in diversity with disturbance, but four found increased abundance. The other ten studies were equivocal on this point.

Butterflies population in relation to time of day was more abundant in the morning session over the evening, and the observed result was supported by the study of Koh²⁰ who found butterflies to be more energetic during the day as the sun rises. Abundance of butterflies in relation to time of day showed a high significant difference as more species were increasing as sun rises, to the peak of the afternoon and abundance drops drastically as evening falls. The occurrence of these species at the early hours of the afternoon could possibly be as a result of the role they play in the ecosystem, as plant pollinators, and hence requires sunlight to make them energetic in order to carry out their daily activities.

Table 2 Butterfly species diversity index for the disturbed site in Federal University of Lafia Permanent Site

Family	Species	No. in disturbed area	Pi	Ln(Pi)	Pi*Ln(Pi)
Lycaenidae	<i>Azonus jesous</i>	3	0.0455	-3.09	-0.1406
	<i>Deudorix dinochares</i>	2	0.0303	-3.4966	-0.1059
	<i>Hypolycaena anara</i>	14	0.2121	-1.5507	-0.3289
	<i>Lepidochrysops vera</i>	5	0.0758	-2.5797	-0.1955
Nymphalidae	<i>Acraea serena</i>	3	0.0455	-3.09	-0.1406
	<i>Bicyclus campa</i>	3	0.0455	-3.09	-0.1406
	<i>Byblia anvatara crameri</i>	1	0.0152	-4.1865	-0.0636
	<i>Danaus chrysippus</i>	3	0.0455	-3.09	-0.1406
	<i>Hypolimnas misippus</i>	1	0.0152	-4.1865	-0.0636
Papilionidae	<i>Ypthima albida</i>	2	0.0303	-3.4966	-0.1059
	<i>Graphium angolanus baronis</i>	2	0.0303	-3.4966	-0.1059
	<i>Papilo demodocus</i>	7	0.1061	-2.2433	-0.238
Pieridae	<i>Belenois creona</i>	2	0.0303	-3.4966	-0.1059
	<i>Catopsilia florella</i>	1	0.0152	-4.1865	-0.0636
	<i>Colotis spp</i>	3	0.0455	-3.09	-0.1406
	<i>Eurema brigittabrigitta</i>	9	0.1364	-1.9922	-0.2717
	<i>Eurema hecabe solifera</i>	5	0.0758	-2.5797	-0.1955
Total		66			-2.547
		∴ H' = -(-2.547) = +2.547			

Table 3 Butterfly species diversity index for the undisturbed habitat in Federal University of Lafia Permanent Site

Family	Species	No. in undisturbed area	Pi	Ln(Pi)	Pi*Ln(Pi)
Hesperiidae	<i>Abantis nigeriana</i>	1	0.0106	-4.5469	-0.0482
Lycaenidae	<i>Azonus jesous</i>	2	0.0213	-3.849	-0.0819
	<i>Hypolycaena anara</i>	9	0.0957	-2.3465	-0.2246
	<i>Lepidochrysops vera</i>	4	0.0426	-3.1559	-0.1344
Nymphalidae	<i>Lolais spp</i>	3	0.0319	-3.4451	-0.1099
	<i>Bicyclus campa</i>	1	0.0106	-4.5469	-0.0482
	<i>Byblia anvatara crameri</i>	1	0.0106	-4.5469	-0.0482
	<i>Charaxes spp</i>	2	0.0213	-3.849	-0.0819
	<i>Danaus chrysippus</i>	6	0.0638	-2.752	-0.1756
	<i>Hamanumida Daedalus</i>	5	0.0532	-2.9337	-0.1561
	<i>Junonia chorimene</i>	1	0.0106	-4.5469	-0.0482
	<i>Ypthima Spp</i>	5	0.0532	-2.9337	-0.1561
Papilionidae	<i>Graphium angolanus angolanus</i>	5	0.0532	-2.9337	-0.1561
	<i>Papilo demodocus</i>	20	0.2128	-1.5474	-0.3293
Pieridae	<i>Belenois creona</i>	1	0.0106	-4.5469	-0.0482
	<i>Catopsilia florella</i>	9	0.0957	-2.3465	-0.2246
	<i>Eurema brigitta brigitta</i>	11	0.117	-2.1456	-0.251
	<i>Eurema hecabe solifera</i>	4	0.0426	-3.1559	-0.1344
	<i>Mylothris aburi</i>	3	0.0319	-3.4451	0.1099
	<i>Mylothris chloris</i>	1	0.0106	-4.5469	-0.0482
Total		94			-2.615
		∴ H' = -(-2.615) = +2.615			

Conclusion

The findings of the present study underline the importance of Federal University of Lafia undisturbed site as a preferred habitat for butterflies. Also, a high number of butterflies were recorded in the morning period than in the evening hours. If the landscaping and maintenance of gardens are carefully planned, the diversity of butterflies may increase in the University campus providing a rich ground for butterfly conservation as well as for research. This study will also add to our future attempts in understanding the complex nature of mutualistic interaction between butterflies and flowering plants that is essential for continuity of ecosystem services. This is the first effort in exploring the butterfly wealth of Federal University of Lafia. The present list of butterfly species is not conclusive and

exhaustive and future exploration will be continued to update this checklist.

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Conflicts of interest

All author listed here declare no conflict of interest exists.

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