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Abundance and Diversity of Fruit-Feeding Butterflies in Federal University of Lafia, Nasarawa State, Nigeria

Goodness Johnny[1]✉, Akwashiki Ombugadu[1], James Ishaku Maikenti[1], Innocent Abimiku Polycarp[1], Eche Onah Otakpa[2], Isaac Affiku Joshua[1], Joseph Ibrahim Izang[3] & Yananret Daen[1]
[1]Department of Zoology, Federal University of Lafia, Nasarawa State, Nigeria
[2]Department of Zoology, Applied Entomology & Parasitology Unit, University of Jos, Plateau State, Nigeria
[3]A.P. Leventis, Ornithological Research Institute, University of Jos
Biological Conservatory, Laminga, Plateau State, Nigeria
✉jonnygoodness6@gmail.com

Abstract: Fruit-feeding butterflies, an ecologically significant group, play a key role in maintaining biodiversity and ecosystem functions, particularly in tropical and subtropical regions. Thus, this study aimed at comparing the abundance and diversity of fruit-feeding butterflies in two habitats in Federal University of Lafia (FULafia) Permanent Site, Nasarawa State, Nigeria, from July to August, 2024. Butterflies were trapped across two habitats using rotten banana fermented in palm wine which was placed in a dish and suspended in the butterfly trap and allowed to stand between the hour of 7:00 am and 6:00 pm for each survey day. Temperature and relative humidity were recorded when trap was set-up and as at the time traps were removed. A total of 35 fruit-feeding butterflies were recorded in this study which belong to family Nymphalidae and spread across three species namely; *Charaxes epijasius* (48.6%), *C. varenes vologeses* (28.6%), and *C. boueti boueti* (22.8%). The species *Charaxes epijasius* accounted for the highest butterfly population in both gallery forest and savannah woodland habitats and differences between species was significant (χ^2 = 10.993, df = 2, P = 0.004102). There was a significant difference (χ^2= 4, df = 1, P = 0.0455) in butterfly abundance between the two habitat types. Temperature and humidity had a positive influence on butterfly abundance across the two habitat types. In conclusion, this research contributes to a better understanding of the ecological dynamics of fruit-feeding butterflies in FULafia Permanent Site in wet season period. Hence, felling of trees within the premises of FULafia should be discouraged in order to conserve butterflies.

Keywords: Butterflies, habitats, weather conditions, wet season

Introduction

The rapid loss of humid tropical forests over the past decades and the continuing degradation of remaining tropical forests [1] have led to widespread declines in biodiversity, which greatly comprises ecosystem functioning. Climate projections suggest that variations in temperature and precipitation will significantly impact the potential distribution areas of different species of tropical high mountain butterflies, with scenarios that estimate a significant contraction (between 30 and 56%) of suitable climatic areas [2, 3, 4]. Butterfly richness and diversity in different tertiary institutions in Nasarawa State and Nigeria at large have also been explored, reporting Nymphalidae, Papilonidae, Pieridae, Lycaenidae and Hesperidae as the dominant butterfly family [3, 5, 6, 7]. Again, Yager *et al.* [5] reported that abundance and diversity in the surveyed institutions favoured the areas with little or no human disturbance.

Studies considering both phylogenetic and functional diversity show that evolutionary history cannot explain community structure alone. In open canopy environments, such as Savannahs, fruit feeding butterflies often exhibit specific traits associated with this habitat, including lighter scoloration, camouflage, and enhanced flight capabilities [8, 9, 10]. Conspicuous butterflies with limited flight capabilities may be more vulnerable to predation by natural enemies in open habitats like savannah woodlands [9, 10]. As a result, other defensive traits, such as wing, eyes and iridescence, may also be associated with habitat conditions. The gallery forests is characterized by higher levels of taxonomic, functional and phylogenetic diversity among fruit- feeding butterflies compared to savannah woodlands [10].

Butterfly diversity

Orimaye *et al.* [11] understudied butterfly diversity in the protected area (PA) and unprotected area (UPA) of Ise Forest Reserve, IseEkiti, Ekiti State where the family of Nymphalidae was the most abundant (39.0%) while Hesperidae had the lowest composition (0.4%).. Similarly, Ombugadu *et al.* [3] reported a higher butterfly diversity in the undisturbed habitat (H′=2.6) than the disturbed habitat (H′ =2.5) of Federal University of Lafia Permanent Site, Lafia, Nasarawa State. Nigeria is endowed with various biodiversity; butterfly diversity is also one of the listed insect group. Recently, a species inventory of the Cross River National Park was taken which included butterflies checklist sequel to the fact that national park is the largest area of tropical forest in Nigeria [12]. Butterfly communities are expected to be influenced by expanding environmental disturbances, which are most common in urban landscapes [13–16], slight changes in urban landscape management such as improving habitat connectivity, have been suggested to increase butterfly richness, diversity and abundance in these systems [13, 17–20]. Despite the occurrence of fruit feeding butterflies in patches of urban habitats [3].

The role of savannah woodland and gallery forest habitats on the abundance of butterflies is obvious, however, changes in environmental conditions play critical roles in structuring the community of species across ecosystems [21–24]. Environmental changes has influence on community composition and structure of species on a global, regional and local scale, respectively. Across heterogeneous urbanization gradients in areas facing growing human influence the environmental changes that influence adaptation strategies have been of great interest to community composition, structure, and species distributions [20, 25, 26]. A study of butterfly diversity in and around Southern Nigeria revealed a higher abundance and diversity index in relatively protected site than unprotected area [11], indicating that human-related activities are negatively impacting butterfly communities. Thus, urban landscapes experiencing increasing environmental perturbation may be experiencing significant declines in species richness, diversity, and abundance [27, 28, 29]. Research on biodiversity conservation while promoting landscapes sustainability in urban areas, primarily in tropical climates, is needed to improve ecosystem services in these landscapes [20, 30]. To this end, this study compared the abundance and diversity of fruit-feeding butterflies in two habitats in Federal University of Lafia Permanent Site, Nasarawa State, Nigeria.

Materials and Methods

Study area

The study was carried out at the Permanent Site of the Federal University of Lafia (FULafia), Nasarawa State, Nigeria (Figure 1). The university is situated in the derived guinea-savanna vegetation zone of Central Nigeria within the coordinates of latitude 8°28´ N and longitude 8° 32´ E and an elevation 158 meters above sea level. The average temperature of Lafia is 32℃, and the annual rainfall is 165 mm. The permanent site is characterized by grassland savannah and scrub woodland interspersed by strips of gallery forests [3]. Common plant species found within the campus include: *Parkia biglobosa*, *Magnifera indica*, *Citrus* sp., *Isorbelinia* sp., *Anacardium occidentale*, *Tridax procumbens*, *Senna occidentalis*, *Ixora* sp., *Bambusa* sp., *Ficus* sp., and various grass and palm trees for collection of butterflies.

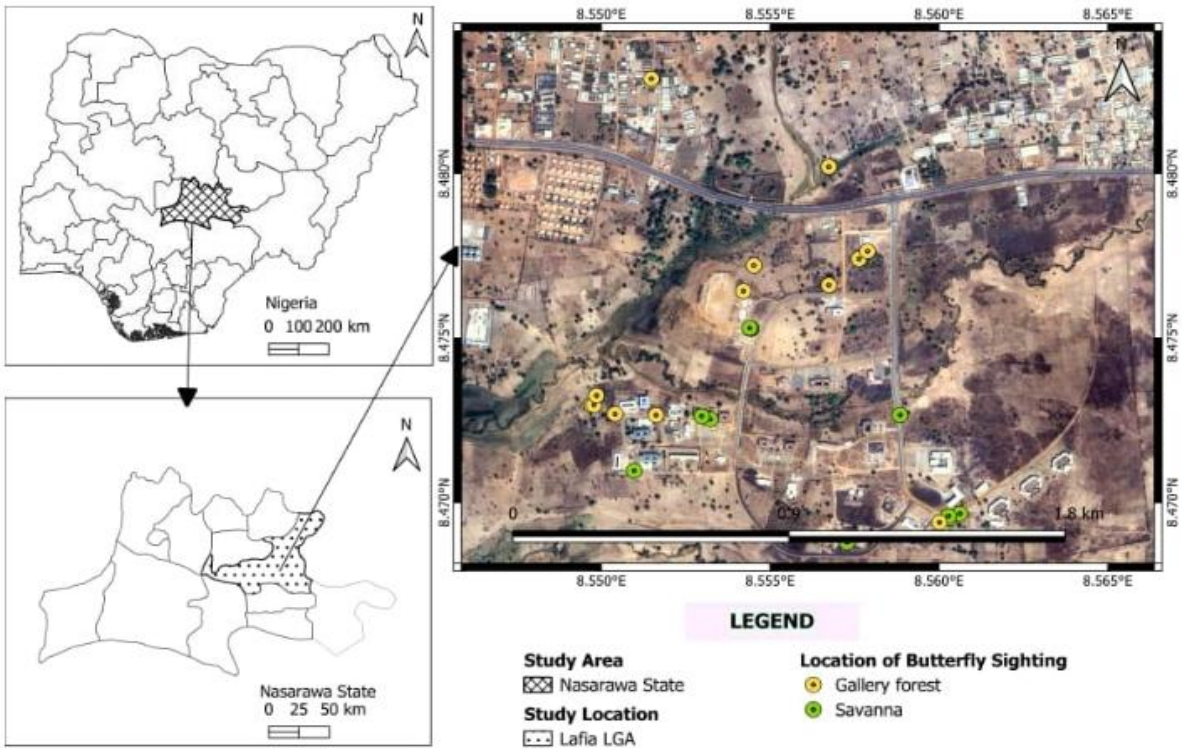

Figure 1: Sites surveyed in the two habitat types in Federal University of Lafia, Nasarawa State, Nigeria

Sample collection and processing

Butterfly collection was conducted within the months of July and August, 2024. The study spanned 6 weeks in total. Systematic random points were generated and marked with the aid of a geographic positioning system across the two habitats, 6 points (3 points in each habitats type) spread at least 100 meters depending on the availability of strong trees that can suspend the traps from dropping on the generated weekly. Butterfly traps were then mounted on these trees for collection of butterflies (Plate 1). New points at least 100 meters away from previous point's locations were generated after every week during the study period to ensure that a significant portion of the study areas was covered. In total, 36 points were generated from the focal habitats; 18 points each from the Savannah woodland and the gallery forest.

Butterfly traps were laced with fermented palm wine and mashed rotten banana (this was fashioned to attract fruit-feeding butterflies mainly) [31, 32, 33]. The traps with fresh baits were mounted in the morning (0700 h) and then inspected once daily, usually at dusk (1800 h). After eating the bait, the butterflies usually hung quietly from the traps top or sides. Handling frequently caused them to fly around the trap and occasionally escape. As a result, the trap was kept closed immediately after newly captured butterflies were extracted, until all of the butterflies were resting again. Inspections involved extracting trapped butterflies, identifying and recording their abundance.

All collected butterflies were immobilized in two separate specimen bottles (one for savannah woodland habitat and the other for gallery forest habitat), containing cotton wool with chloroform soaked to prevent random movement and displacement of wings. Butterflies were identified using identification guides by Larsen [34], Brattstrom [35] and Singh [36], respectively.

Plate 1: Butterfly baited trap hung on a tree in Gallery forest

Statistical analysis

Data obtained were expressed in simple percentages and analyzed using Python software while the R Console software package was used to plot the various charts. Pearson's Chi-square test was used to compare the proportions of butterflies between species as well as in relation to habitat types. The association between butterflies' abundance in both habitats and corresponding interaction with weather variables was determined using Pearson's product-moment correlation. Level of significance was set at $P < 0.05$.

Results and Discussion

Butterfly composition in permanent site of Federal University of Lafia

A total of 35 individual fruit-feeding butterflies was recorded in this study which belong to the family Nymphalidae that spread across three species namely; *Charaxes epijasius* (48.6%), *C. varenes vologeses* (28.6%), and *C. boueti boueti* (22.8%) which are present in both habitats as shown in Table 1. The species *Charaxes epijasius* accounted for the highest butterfly population in both gallery forest and savannah woodland habitats and differences between species was significant (χ^2= 10.993, df = 2, P = 0.004102). There was a significant difference (χ^2= 4, df = 1, P = 0.0455) in butterfly abundance between the two habitat types. Plate 2 shows the three butterfly species caught.

Table 1: Checklist of butterflies in gallery and savannah woodland habitats

Species	No. Caught Across Habitats (%)		Total Count (%)
	Gallery Forest	Savannah Woodland	
C. boueti boueti	5 (62.5)	3 (37.5)	8 (22.8)
C. epijasius	10 (58.2)	7 (41.2)	17 (48.6)
C. varenes vologeses	6 (60)	4 (40)	10 (28.6)
Total (%)	21 (60)	14 (40)	35

Plate 2: Nymphalidae butterflies collected from the two habitats in Federal University of Lafia

Investigating the weather parameters that predict butterfly species diversity and abundance

Figure 2 shows that temperature had a strong significant positive relationship with butterfly abundance (r =0.65, P=0.04315). Also, butterfly abundance showed a strong positive and significant association with relative humidity (r =0.68, P =0.04052, Figure 3).

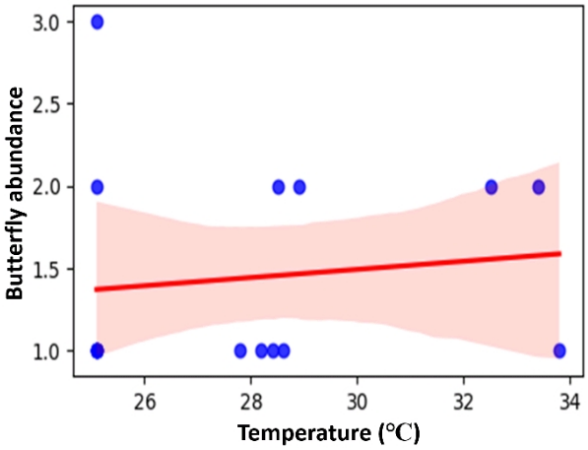

Figure 2: Relationship between butterfly abundance and Temperature (℃)

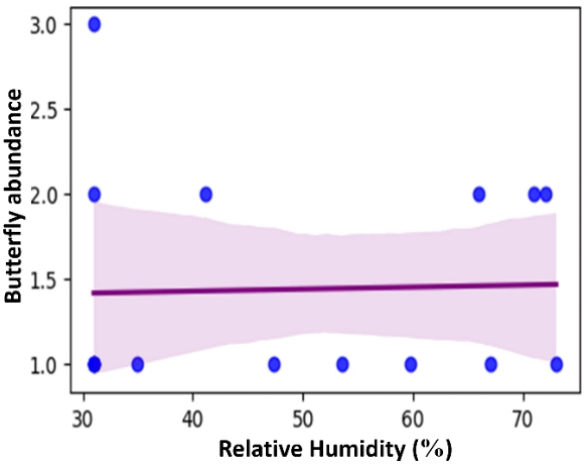

Figure 3: Relationship between butterfly abundance and humidity

The outcome of this study reveals that Federal University of Lafia (FULafia) Permanent Site has a low population and diversity of frugivorous butterfly possibly due to the period in which this research was conducted which happened to be transition months (July and August) between early and late wet seasons based on the high amount of rainfall at such period as well as the action of other microclimatic conditions that would have limited butterflies population in the area. Our finding of three fruit-feeding butterfly species in the area suggests that FULafia's Permanent Site is still eco-friendly host environment for butterflies. The high occurrence of *Charaxes* species in this study agrees with Ombugadu *et al.* [3] who also reported the *Charaxes* butterflies as the most abundant member of the family Nymphilidae.

Habitat preference of fruit-feeding butterflies

The high number of butterflies in gallery forest in this research could be due to availability of resources. This is consistent with the studies by Orimaye *et al.* [11] who reported high abundance of butterfly species in the Ise forest Reserve, Ibadan, Nigeria. Orimaye and colleagues also suggested that the grassland habitat had a negative impact on butterfly communities. Interestingly, previous studies by Yager *et al.* [5] opined that gallery forest is rich in butterfly species due to their complex vegetation structure and stable micro-climate. Closed canopy layer provide niches for different species and this tallies with the studies conducted by [37] in South Eastern Nigeria. Studies from tropical forest regions have demonstrated that butterfly diversity reaches peak in stable environments due to continuous availability of resources which includes dense forest structure that allows for coexistence of multiple species thereby reducing competition for food and space [16, 38].

The increased functional diversity observed in the gallery forest can be attributed to the heightened structural and environmental heterogeneity in contrast to open habitat such as the savanna [39]. The assemblages in the gallery forest exhibit higher functional redundancy compared to savannah, despite the fact that certain butterfly clades, especially those with robust thoraces, mainly Charaxinae and Nymphalinae, exhibit a preference for forest canopies [40, 41]. Gallery forest with their unique climatic condition may provide a refuge favouring numerous species of insects and other animals [42]. Scriven *et al.* [43] elucidated that flower density is more important to a site for butterfly diversity and abundance than the presence of specific habitats.

Predictors of butterflies abundance

Butterflies are affected in various aspects by changes in climatic conditions because of their high sensitivity to their environment. Ourstudy revealed that both temperature and relative humidity had a strong positive influence on fruit-feeding butterfly abundance, thus, could serve as good butterfly predictors during field surveys. A study of butterfly and effect of temperature and humidity gradient on butterfly assemblage by Gupta *et al.* [44] also reported a relationship between butterfly abundance and the variation in temperature. Temperature among other environmental factors was reported to have an influence of butterflies of the forest ecosystem of the Research Park, Gazipur, Bangladesh [45, 46] found a positive relationship between fruit-feeding butterflies species richness and abundance in Brazil.

The individual responses of specific butterfly species to weather conditions from previous studies have shown that varying temperature ranges can influence overall oviposition output [47] while relative humidity serve as an important predictor of butterfly diversity and species richness, although extremely dry and hot conditions can exceed the tolerance limits of butterflies and their activity will significantly decline [48]. Relative humidity is critical for the survival of many species,

particularly early life stages [49]. These findings are in line with our study which has clearly demonstrated that temperature and relative humidity are pivotal predictors of butterfly population.

Conclusion

This study recorded a low population of butterflies (35 individuals) all from the same family Nymphalidaeal though spread across three species during early and late wet season's transition months (July and August). Also, this research reveals positive influence of temperature and relative humidity on the abundance of fruit-feeding butterflies, thus, could serve as key predictors during butterflies' survey in the area. Butterflies abundance in gallery forest was slightly higher than what was recorded in savannah woodland area. Hence, the two habitats should be well protected in order to support butterflies diversity in the fast developing urban landscape.

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