Journal of Research in Forestry, Wildlife & Environment Vol. 15(4) December, 2023
E-mail: jrfwe2019@gmail.com; jfewr@yahoo.com
http://www.ajol.info/index.php/jrfwe
jfewr ©2022 - jfewr Publications
ISBN: 2141 – 1778
Turshak et al., 2023

VEGETATION AND WEATHER AS DRIVERS OF BUTTERFLY SPECIES RICHNESS AND ABUNDANCE IN A CONSERVATORY, CENTRAL NIGERIA

[*1,2]Turshak, L. G., [1]Emmanuel, P., [2]Ibrahim, J. I., [2]Chaskda, A. A. [2]Mwansat, G.S.

[1]Biological Sciences Unit, Department of Science Laboratory Technology, University of Jos.
[2]A.P. Leventis Ornithological Research Institute, Department of Zoology, University of Jos.
***Corresponding Author:** longtee2008@gmail.com; +234 803 966 4891

ABSTRACT

This study investigated butterfly species richness and abundance in Amurum Forest Reserve. The effects of weather and vegetation as drivers on butterfly diversity was also determined. Pollard walk method for butterfly survey was used in three habitats namely the savanna scrub, gallery forest and the rocky outcrop. The pollard method was used to sample butterflies. Vegetation variables namely the number of shrubs, number of plants in fruits, average grass height, number of plants in flower, percentage litter cover and number of plants were measured within a 10 x 10 m plot placed randomly. There were 57 butterfly species recorded belonging to 5 families. Of the 5 families, Pieridae had the highest abundance while the lowest is that of Papilionidae. Weather parameters (wind speed and temperature) significantly affected butterfly abundance negatively. This means that as wind and temperature increases, the number of butterflies correspondently decreased. As vegetation parameters increased (Number of shrubs, number of plants in fruits, average grass height, number of plants in flower and percentage litter cover), abundance of butterflies significantly increased. However, as number of plants in fruits increased, the abundance of butterflies decreased. Similarly, butterfly's species significantly increased with increase in the number of trees and percentage litter cover. We concluded that some vegetation and weather parameters are predictors of butterfly species abundance and richness.
Keywords: Butterflies, Conservation, Habitat, Vegetation and Weather

Correct Citation of this Publication
Turshak, L. G., Emmanuel, P., Ibrahim, J.I., Chaskda, A. A. Mwansat, G.S. (2023). Vegetation and weather as drivers of butterfly species richness and abundance in a conservatory, Central Nigeria. *Journal of Research in Forestry, Wildlife & Environment,* 15(4): 209 - 215

INTRODUCTION

Butterflies are insects in the macrolepidopteran clade rhopalocera from the order Lepidoptera which also include moths (Emily, 2010). Larson *et al*., (2001), estimated that there are more than 28,000 species of butterflies with about 80% in tropical region. Africa as a whole has about 4,000 species (Larsen, 2015). West Africa has about 2,000 species of butterflies, and an estimated over 1,400 species of in Nigeria. Butterflies have been recognized as useful biodiversity indicator group of tropical land-use systems because they are sensitive and react quickly to subtle changes in environmental and habitat conditions (Larsen 2008). Due to their short life cycle, narrow niches and relatively low mobility, they are more sensitive to land-cover and land-use changes than long-lived animals. Butterflies are relatively easy to capture, manipulate and identify (Thomas, 2005), which makes them important candidates for monitoring changes in habitat, biodiversity and environmental conditions (Nowicki, *et al*., 2008), including the impact of landscape and habitat management practices and disturbance regimes in terrestrial ecosystems.

Butterfly activities are closely controlled by weather and many species are constrained by climate, mostly occupying a small part of the range of their host plants (Ibrahim, 2021). In addition, butterflies are food to birds and other predators and are hosts to several parasitoids that suppress crop pests (Summerville *et al*., 2001). Consequently, their conservation is essential to sustaining the productivity of natural landscapes. Despite their diversity, ubiquity and ecological importance, butterflies remain relatively under studied, particularly with regard to their ecology, behaviour and functional roles as indicators of environmental health (Marchiori and Romanowski 2006; Stireman *et al*., 2009). Butterflies are important pollinators of wild and cultivated crop species (Munyuli 2010). Roughly, 90% of butterfly species live in the tropics (Bonebrake *et al*., 2010). However, knowledge of butterflies inhabiting habitat types is fairly good in Mediterranean regions compared with the sub-Saharan Africa. The relative scarcity of data on tropical butterfly populations hampers the ability to effectively conserve them, particularly as bio-indicator species and pollinating agents (Bonebrake *et al*., 2010) in different land systems.

Butterflies have been used successfully as indicator species in several studies. Their abundance and richness change in response to environmental conditions such as plant composition and structure, humidity and degree of disturbance of vegetation. Hence, the need to investigate how these vegetation and weather parameters influence butterfly species richness and abundance. The goal of this study was to investigate the vegetation and weather parameters that predict butterfly species richness and abundance at the Amurum Forest Reserve.

Butterflies are one of the most charming and easily recognizable insects that belong to order Lepidoptera. They have a fairly clear taxonomy, and their life history and biology are well defined (Nelson and Anderson, 1994; Wood and Gillman, 1998). Their ability to adapt to virtually any climate, has made them some of the most successful creatures on earth. Butterflies are considered important flagships for insect conservation (New *et al*., 1995; Smetacek, 1996). More attention is paid throughout the world, because of their important service in environmental quality assessment under terrestrial ecosystem (Ghazoul, 2002). They are considered to be one of the several insects that are a potential ecological indicator of forest condition.

Materials and Methods

Study site

This research was carried out at the Amurum Forest Reserve (Figure 1). The reserve is a small protected area located about 15km east of Jos, Nigeria. The reserve covers a landscape of about 300 hectares (Ezealor, 2002) and serves as refuge to many plants and animal species in north-central Nigeria. The reserve is one of Nigeria's Important Bird Areas with at least 300 bird species, over 130 butterfly species and many mammals, reptiles, amphibians and plant species. The site holds populations of both endemic species and other species of conservation concern, for example Amurum holds a viable population of the range restricted birds such as the Rock Firefinch (*Lagonosticta sanguinodorsalis*) and its brood parasite, the Jos-Plateau Indigobird (*Vidua maryae*) (Daru, *et al*., 2015). The region is also home to some endemic butterfly taxa (*Alaena exotic, Capys sp, Charaxes chevrot*i and *Mylothris rueppellii josi*) and the only known site in Nigeria with a population of *Monile gemmifera maculate.* The reserve is typical savannah woodland dominated by grasses, with scattered rocky outcrop, and strips of riparian forest along streams (Vickery and Jones, 2002). In the savannah woodland, common trees and shrubs include *Dichrostachys cinerea, Adenodolichos paniculatus, Jasminum dichotomum, Combretum fragran, Lophira lanceolota, Securidaca longepedunculata Alophyllus africanus* and *Piliostigma thoningii*. The rocky outcrops are dominated by plants such as: *Acacia ataxacantha*, *Ficus* spp, *Euphorbia desmondii*, *Croton zambesicus* and *Senna singuaena* whereas the most frequent woody plant species in the gallery forest include *Boscia angustifolia, Harungana madagascariensis*, *Syzygium guineense* and *Ochna schweinfurthiana*.

The minimum and maximum temperatures in the region ranges between 8–15°C during the coldest months (November– February) and rise to 30–38°C during the warm and dry months (March–April). Mean annual rainfall is around 1,400 mm, falling mainly between April and October (Ezealor, 2002). The forest reserve is surrounded by farmlands, human settlements and fallow lands and has been under protection with little human disturbance for over 15 years.

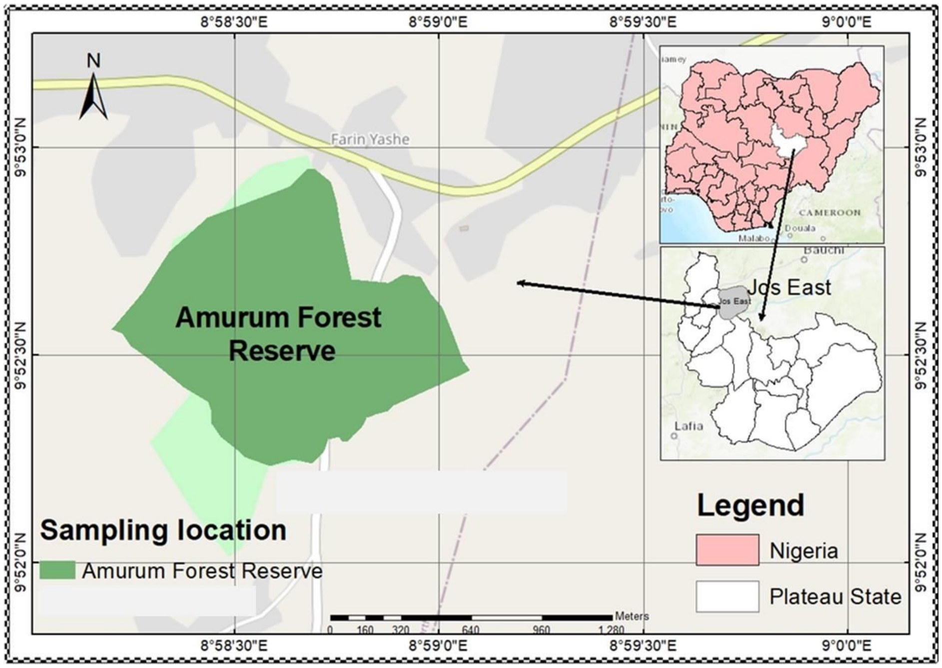

Figure 1. Map of the Amurum Forest Reserve, Plateau State.

Study design and data collection

There are many butterfly survey methods, however, for this study; Pollard walk method of butterfly survey was used. Pollard walks entail counting both the number and species of butterfly along a fixed route on a regular interval (e.g. weekly) throughout a given period. The method was adopted because it is a transect based method that sample almost the entire butterfly community rather than a guild or group. Below are the simplified procedures in undertaking a standard Pollard walk. Pollard walks or transect counts are the most widely used field protocol for monitoring butterfly populations (Van Swaay *et al*., 2008). The protocol is well tested and the approach has become the standard for many butterflies monitoring especially in Europe

The Amurum Forest Reserve is stratified into three different habitat types: the rocky outcrop, savannah woodland, and the gallery forest. Six transects of 600m were laid in each habitat type along pre-existing routes. Each transect was visited once. Along the transect, all butterfly seen and identified within 3m to the left and right hand side of the observer as the observer walk along the transect, were recorded. Field data were collected from July to August, 2021.

Vegetation and weather parameter measurement

The following vegetation parameters were measured for each section of transects: tree density, shrub density, number of plants in fruits, number of plants in flower, percentage grass cover, percentage litter cover, and average grass height. To determine tree and shrub densities, a 5m X 5m quadrat was made at the beginning of each section of a transect and number of trees shrubs, number of plants in fruits, and flower were counted. To estimate percentage grass cover, average grass height and litter cover, four 1m x 1m quadrat were laid randomly within the 5m x 5m larger quadrat and these parameters were measured. At the centre of each grid, percentage canopy cover was estimated by viewing the sky through the canopy from the wrong side of a pair of binoculars (Manu, 2002; Jones *et al*., 1996).

Three average daily weather parameters (temperature, wind speed and humidity) were collected on each sampling day from the A. P. Leventis Ornithological Research Institute weather station. The weather data during survey periods were extracted and those were the data used for analyses.

Data analyses

All data collected were entered into Microsoft Office Excel 2010 and analyses were carried out in R software, version 4.0.2 (R Development Core Team, (2020-06-22)). To investigate the vegetation and weather drivers of butterfly species richness and abundance, butterfly species richness and abundance were modeled against vegetation parameters (tree density, shrub density, number of plants in fruits, number of plants in flower, percentage grass cover, percentage litter cover, and average grass height) and weather parameters (temperature, humidity, and wind speed). Before models were developed, visual inspection of all explanatory variables against the response variables was carried out by means of plotting each explanatory variable against all the response variables. Where a variable showed a curvilinear relationship with butterfly species richness or abundance, a polynomial term (quadratic and/or cubic) were fitted.

RESULTS

General overview

A total of 683 individual butterflies consisting of 57 species in 5 families were recorded in this study. The family Nymphalidae had the highest number of species (21) followed by the family Pieridae (17). Papilionidae had the least number of species (2); others are Lycaenidae (14), and Hespiriidae (7) species. The family Pieridea had the highest number of species (333) the families Nymphalidae, Lycaenidae, Hespiriidae and Papilionidae had 211, 108, 17, and 14 individuals respectively (Figure 2). *Belenois aurota* (family Pieridae) had the highest number of individuals (138).

Effect of vegetation parameters on butterfly species richness and abundance

Among the eight vegetation parameters measured, only number of shrubs, number of plants in flowers, number of plants in fruits, average grass height, and percent litter cover predicted butterfly abundance significantly (Table 1). Whereas all the above vegetation parameters had a positive relationship with butterfly abundance i.e increased in the vegetation parameters results in corresponding increase in butterfly abundance, number of plants in fruits had a negative relationship with butterfly abundance (Table 1). Butterfly species richness was predicted by only two vegetation parameters; number of trees and percent litter cover which both had a positive relationship with butterfly species richness (Table 2).

Effects of weather parameters on butterfly species richness and abundance

For all the weather parameters, only temperature and wind speed had significant effect on butterfly abundance (Table 3). Temperature had a negative correlation with butterfly abundance. In other words, at very high temperature, butterfly abundance decreases. Similarly, wind speed had negative relationship with butterfly abundance. At very high wind speed, butterfly abundance decreases and vice-versa. However, for butterfly species richness, only wind speed significantly predicted it. The relationship was a negative one as in the case of abundance (Table 4).

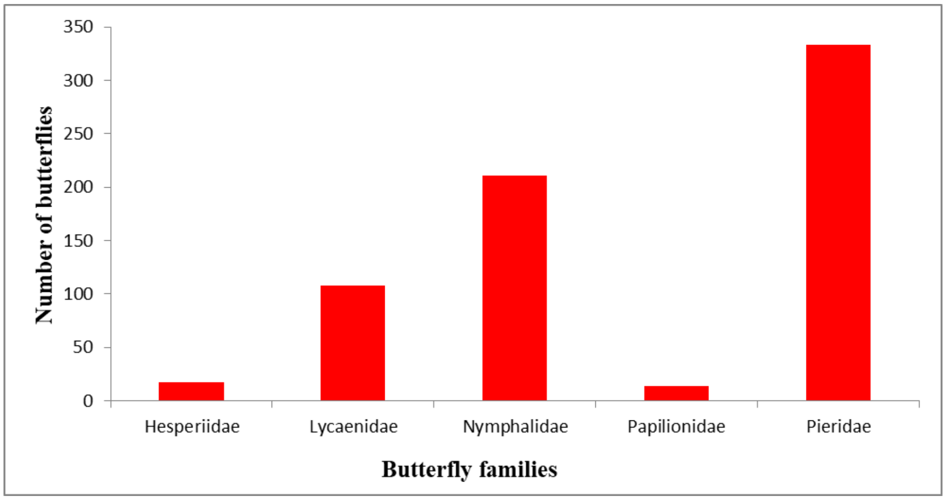

Figure 2. Number of individual butterflies recorded in each family

Table 1. Effects of vegetation parameters on butterflies' abundance

Parameters	Estimate	Std. Error	z value	p-value	Sig
(Intercept)	1.413357	0.090919	15.545	< 2e-16	***
Number of shrubs	0.009814	0.003113	3.153	0.001616	**
Number of plants in flowers	0.017918	0.007128	2.514	0.011948	*
Number of plants in fruits	-0.038003	0.012201	-3.115	0.001841	**
Average grass height	0.456388	0.12904	3.537	0.000405	***
Percent litter cover	0.006073	0.001809	3.357	0.000787	***

Table 2. Effects vegetation parameters on butterfly species richness

Parameters	Estimate	Std. Error	z value	p-value	Sig
(Intercept)	1.741675	0.056494	30.829	<2e-16	***
Number of trees	0.00941	0.004669	2.016	0.0438	*
Percent litter cover	0.003709	0.001448	2.561	0.0104	*

Table 3. Effects of weather parameters on butterfly abundance

Parameters	Estimate	Std. Error	z value	p-value	Sig
(Intercept)	16.53958	3.38998	4.879	1.07E-06	***
Temperature	-0.57666	0.13625	-4.232	2.31E-05	***
Wind speed	-0.23226	0.06087	-3.815	0.000136	***

Table 4. Effects of weather parameters on butterfly species richness

Parameters	Estimate	Std. Error	z value	p-value	Sig
(Intercept)	2.18336	0.09543	22.879	< 2e-16	***
Wind speed	-0.18758	0.05968	-3.143	0.00167	**

DISCUSSION

Vegetation parameters: number of shrubs, number of plants in fruits, average grass height, number of plants in flowers and percentage litter cover significantly affected both butterfly abundance, with butterfly abundance positively correlated with all the above excepts number of plants in fruits which had a negative correlation. This could be because most of the fruit feeding butterflies are canopy species or ground dwelling butterflies e.g. *Charaxes* and *Bicyclus* respectively, and are mostly missed when using transect methods. This sis further evident in the data we collected, with just few record of *Charaxes* species even though it is one of the mot species rich genus in Amurum Forest Reserve (Ibrahim, 2021). It has been established that butterfly abundance is positive influence by plant diversity because many species developmental stage depend directly on these diverse plants (Munyili, 2010). This study found the same relationship. The strong relationship between plants in flowers and butterfly abundance is because flowers provide essential sources of carbohydrates for nectar feeding adult butterflies. Hence, areas with higher number of plants in flower had both high number of individual butterflies and a higher variety of butterfly species. Similar result was recorded in central Uganda (Munyuli, 2010). Percentage canopy cover, which strongly correlated positively with number of trees and shrub, significantly affected butterfly abundance and species richness respectively. The relationship was curvilinear and indicated that butterfly abundance peak in moderate canopy cover. It was observed in the field that areas with high canopy cover also had high plant species richness, and these plant species can potentially serve as host-plants for larvae and create microhabitats providing shelter to numerous butterfly species. However, butterflies may avoid very thick canopy cover because of higher predation risk. This might have caused the drop in butterfly abundance in high percentage canopy cover. Also, low butterfly abundance at high percentage canopy cover could be due to poor detectability during Pollard walks

It is generally accepted that weather factors regulate most insect species 'life cycles (Sparks *et al.*, 2007). Weather variables may therefore be important in determining adult emergence (van Asch and Visser, 2007; Saastamoinen and Haski, 2008), foraging, reproduction and breeding activities of many butterfly species in sub-Saharan Africa (Munyuli, 2010). Munyuli, (2010), observed that temperature is a key factor regulating daily activities (flight and foraging movements) of butterflies. Butterflies like all other insects are affected by these dynamics; at low and very high temperature, their activities are hampered. Both wind speed and temperature significantly affected butterfly abundance negatively and this could be because at high wind speed, butterflies are easily displaced because of their light body weight and are easily carried around. Consequently, butterflies end to stay around natural wind breakers on days that are not favourable. Similarly, at very high temperature, butterflies' activities are greatly reduced to conserve energy. The trend above was the same for butterfly species richness except that only wind speed had a significant effect.

CONCLUSION

A record of 57 species of butterflies in a short-term study as this clearly shows that the study area is rich in butterflies. The conservation implications for butterflies at the Amurum Forest Reserve suggests that vegetation variable of number of shrubs, number of plants in flower, number of plants in fruits, average grass height and percentage litter cover predicted positive butterflies' abundance and richness. These are important information for management decisions.

REFERENCE

Bonebrake TC, Ponisio LC, Boggs CL, Ehrlich PR. (2010). More than just indicators: a review of tropical butterfly ecology and conservation. *Biology and Conservation*, 143(9): 1831–1841.

Cowlishaw, G., Pettifor, R.A. and Isaac, N.J.B. (2009). High variability in patterns of population decline: the importance of local processes in species extinctions. Proceedings of the Royal Society of London Series, *Biological Sciences*, 276: 63–69.

Daru, B., Yessoufou, K., Nuttman, C., and Abalaka, J. (2015). A preliminary study of bird use of fig Ficus species in Amurum Forest Reserve, Nigeria. *Malimbus*, 37: 1-15.

Ezealor, A. U. (2002). *Critical Sites for biodiversity conservation in Nigeria.* Nigerian Conservation Foundation (NCF)., Lagos. 110 pp.

Ghazoul, J. (2002). Impact of logging on the richness and diversity of forest butterflies in a tropical dry forest in Thailand. *Biodiversity and Conservation*, 11: 521–541.

Ibrahim J. I. (2021). Developing an effective protocol for butterfly monitoring in West African savannah region (Unpublished master ‘s thesis). A. P. Leventis Ornithological Research Institute, University of Jos, Jos, Nigeria

Larsen, L. (2015). Urban climate and adaptation strategies. *Front Ecol Environ,* 13(9): 486–492.

Larsen, T.B. (2008). Forest butterflies in West Africa have resisted extinction… so far (Lepidoptera: Papilionoidea and Hesperioidea). Biodiversity and Conservation, 17: 2833–2847.

Larson, B. M., Kevan, P. G., & Inouye, D. W. (2001). Flies and flowers: taxanomic diversity of anthophiles and pollinators. *The Canadian Entomologist*, 133(4): 439-465.

Manu, S. (2002). Effects of habitat fragmentation on the distribution of forest birds in South Western Nigeria with particular reference to Ibadan Malimbe and other Malimbes, PhD Thesis, University of Oxford, UK.

Marchiori OM, Romanowski HP. (2006). Specie s composition and diel variation of a butterfly taxocene (Lepidoptera, Papilionoidea and Hesperioidea) in a restinga forest at Itapua State Park, Rio Grande de Sul, Brazil. *Rev Bras Zool*. 23(2): 443–454.

Munyuli TMB. (2010). Pollinator biodiversity and economic value of pollination services in Uganda [PhD dissertation]. [Kampala (Uganda)]: Makerere University. 431 p.

Nelson, S.M. and Anderson, D.C. (1994). An assessment of riparian environmental quality by using butterflies and disturbance susceptibility scores. *The Southwestern Naturalist*, 39: 137-142.

New, T.R., Pyle, R.M., Thomas, J.A., Thomas, C.D. and Hammond, P.C. (1995). Butterfly conservation management. *Annual Review of Entomology*, 40: 57-83.

Nowicki, P., Settele, J., Henry, P. Y., & Woyciechowski, M. (2008). Butterfly monitoring methods: The ideal and the real world. *Israel Journal of Ecology and Evolution*, *54*(1): 69–88. https://doi.org/10.1560/IJEE.54.1.69

Smetacek, P. (1996). Restoring past glory. *Santuary Asia* XVI, 6: 26-29.

Stireman J.O., Greeney, H.F., Dyer, L.A. 2009. Species richness and host associations of Lepidoptera-attacking Tachinidae in the northeast Ecuadorian Andes. *Journal of Insect Science*. 9(39):1–19.

Summerville, K.S., Metzler,E.H., and Crist, T.O. (2001). Diversity of Lepidoptera in Ohio Forests at Local and Regional Scales: How Heterogeneous is the Fauna? *Annals of the Entomological Society of America,* 94 (4): 584-591

Thomas, J. A. (2005). Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. *Philosophical Transactions of the Royal Society of London, Biological Sciences*, 360:339–357.

Van Swaay, C., Regan, E., Ling, M., Bozhinovska, E., Fernandez, M., Marini-Filho, O. J., and Pe‘er, G. (2015). Guidelines for standardised global butterfly monitoring. Group on Earth Observations Biodiversity Observation Network, Leipzig, Germany. GEO BON Technical Series, 1, 32.

Vickery, J. & Jones, P. J. (2002). A new ornithological institute in Nigeria. Bull. African Bird Club 9(1): 61–62.

Wood, B. and Gillman, P. (1998). The effects of disturbance on forest butterflies using two methods of sampling in Trinidad. *Biodiversity and Conservation*, 7: 597-616.