Diversity Pattern of Swallowtails Butterflies in Okomu National Park Edo State in Nigeria

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Abstract

Swallowtail diversity sampling in Okomu National Park was carried between July 2012 and June 2014 using butterfly nets and pollard methods (Pollard, 1977) along 1 km by 0.005 km of eight (8) transects in the various ranges (Igwonwan, Arakhuan, Julius Creek, Babui) of the park. Five hundred and fifty five (551) individuals grouped into two genera of twelve species were collected from the ranges of the park. Four rare species notably: *Papilio sosia sosia, Papilio nierus nireus, Papilio garienus* and *Graphium angolanus* (Family: Papilionidae) were observed in the park. *Papilio garienus* and *Graphium angolanus* recorded for the first time in the park. Most of the *Graphium* species confined in large congregations around areas with streams and mud puddling. The MOF transect had the highest diversity and was closely related to the CC transect. While the SHR transect had the lowest diversity (H) and was closely related to GRA transect. Swallowtail butterflies were found throughout the months of sampling and significantly higher ($p<0.05$) during the rainy seasons compared to the dry seasons. Okomu National Park is rich in Swallowtail butterflies.

Keywords: Swallowtails, diversity, Okomu, *Papilio, Graphium*

Introduction

Natural habitats in the tropics are globally threatened and this cause a serious loss of species (Aduse-Poku et al., 2012). In Africa especially

Nigeria, less attention is given to small animal taxa in most protected areas but these animals are important for ecological and conservation monitoring and are highly lost from both outside and within protected areas. Arthropods are good indicators of habitats biodiversity because they respond

quickly to environmental changes, and are highly diverse taxon. Lepidoptera (butterflies and moths) are the second largest order of Arthropods and, making them particularly useful for biodiversity survey (Tiple, Khurad & Dennis 2009; Inuoye, 2001; Kremen, 1994; Erhardt, 1985). Butterflies occur in a wide range of situations but are particularly characteristics of humid tropical forests, in which the known species occur (Alarape, Omifolaji & Mwausat, 2015).

Butterflies in general and swallowtails in particular are important ecological indicators (Tumuhimbise, Okwakol, & Kanggwagye, 2001; Kremen, 1994; Brown, 1991; Howard, 1991). Taxonomically, swallowtail butterfly more detailed compared to other groups of tropical insects. The adults of many species can be easily identified in the field, they have a rapid lifecycle with close association with plant resources, and their populations are sensitive to local weather, microclimates and light level (De Vries, Murray, & Lande, 1997; Beccalloni & Gaston, 1995; Hill, Hammer, Lace, & Banham, 1995;). Largely, butterflies contribute to the growth, maintenance and expansion of flora in the tropical regions where these insects show high abundance and species diversity (Majumder, Lodh, & Aganwala, 2012; Bonebrake, Ponisio, Boggs, & Ehrlick, 2010.

New (1992) and Prendergast et al. (1993) have described swallowtail butterflies as important flagship species for invertebrate conservation. A number of them have been threatened (Tumuhimbise et al., 2001; Collins & Morris, 1985). Swallowtail butterflies have been widely used in fine art design and decorations commercially. Swallowtail ranching has been carried out in Kenya (J. Kaddu, personal communication) and Papua New Guinea (Hutton, 1990) to reduce the exploitation in the wild due to commercial pressure. Tumuhimbise et al. (2001), Larsen (1991) have worked on the diversity of swallowtails communities in different habitat in Africa. There have not been many studies on the diversity of swallowtails within different habitat types in the Nigerian forests. Also, in an effort to obtain baseline data on the indicator species, this research is on diversity of Swallow tails from one of the remaining Nigeria's secondary forest in National Park (Okomu) where no qualitative data has been collected in recent time

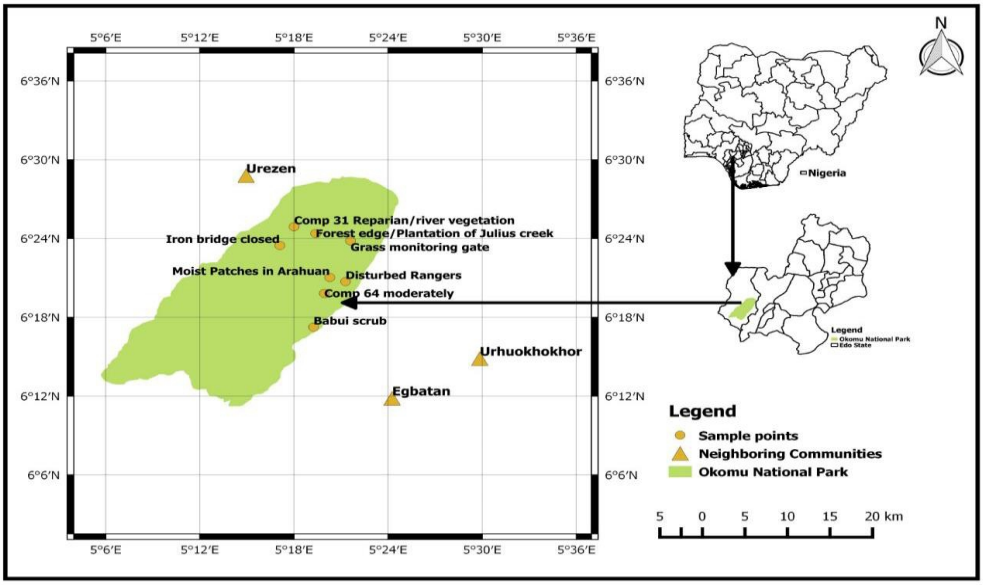
Reliable biodiversity assessment is needed to document changes in species composition and abundance and to focus on conservation efforts of the insects (Aduse-Poku et al., 2012). For effective conservation of insects globally, understanding their ecology is very important and this puts a spotlight on butterflies because they are probably the best known (Thomas, 2005). Knowledge of tropical butterflies is limited when compared to the temperate species. This difference in knowledge has serious implications for their conservation (Bonebrake et al., 2010). Hence, it becomes pertinent to establish baseline data on swallowtail butterflies species' abundance and distribution, for further surveys and consideration of conservation efforts.

Materials and methods

Location

The 200 km2 Okomu National Park is in Ovia South West Local Government Area of Edo State, Southern Nigeria. It lies within Latitude 060 20′ N and Longitude 0.050 16′ E (Figure 1).

Figure 1. A Map of Okomu National Park showing sampling point



Sampling Areas

Sampling was carried out between July 2012 and June 2014, using butterfly nets and pollard walk methods (Pollard, 1977) in selected sites of the four (4) Ranges in the Park Igwonwan. Arakhuan, Julius Creek and Babui Range, based on visual level of disturbance and degree of canopy closure (Barau, Slowik, Bobo, & Muehlenberg, 2010), the ranges grouped as follows:

1. Scattered/Open Forest (SOF) which shows features of selective logging in disturbed forests and agricultural activities (plantation).
2. Closed Forest (CF), which represents moderately disturbed forests, trees in closed canopies and dense vegetation.
3. Swamp Forest(SF) which represents moist patches along road and riparian habitats
4. Scrub (S) which represents grasses and herbaceous plants (Shrub).

The line transect method (Barau et al., 2010) was adopted where eight (8) transects were selected in the range with the following features;

i. T1 (disturbed forest at compactment 54 Arakhuan (DIS) at Latitude 06^0 20′ 43″N, Longitude 0.005^0 21′ 17″ E of 62 m above sea level and

T2 (Forest Edge/Plantation Compartment 29 Julius Creek (FE/P) at Latitude 06^0 24′ 23″ N, Longitude 0.05^0 19′ 23″ E of 82 m above sea level for SOF,

ii. T3 (Moderately Disturbed habitat at Compartment 64 Arakhuan (MOF) at Latitude 06^0 24′ 54″ N, Longitude 0.005^0 19′ 56″ E of 64 m above sea level and T4 (Closed Forest at Julius Creek Compartment 30 (CC) at Latitude 06^0 23′ 28″N, Longitude 0.005^0 17′ 06″ E of 39 m above sea level for CF.

iii. T5 (Moist Patches on Road at compartment 54 Arakhuan (FAR/MP) at Latitude 06^0 21′ 02″ N, Longitude 0.005^0 20′ 27″ E of 53 m above sea level and T6 (Riparian Habiat at Compactment 31 Julius Creek RIP) at Latitude 06^0 24′ 54″N, 0.005^0 18′ 00″ E of 10m above sea level for SF.

iv. T7 (Grassland at compactment 28 Igwonwan Range GRA) at Latitude 06^0 23′ 49″N, Longitude 0.005^0 21′ 36″E of 82 m above sea level and T8 (Shrub at compartment 89 Babui Range (SHR) at Latitude 06^0 17′ 15″N, Longitude 0.005^0 21′ 36″E of 40 m above sea level for S.

Each transect measured 1 km in length and 0.005 km in width took about thirty (30) minutes for two observers to walk a transect counting and obtaining butterfly specimen Barau et al. (2010). All butterflies obtained were set at the Zoology laboratory of Delta State University, Abraka and identified using standard keys by Larsen (2005).

Statistical Analysis

Results were analysed using Analysis of variance. The computer BASIC program SP DIVERS (Ludwig & Reynolds, 1988) adopted to calculate Species/ Taxa richness, diversity, evenness indices and dominance of swallowtail butterflies Community. The relationship between the butterflies in the eight transects analysis using Cluster Analysis.

Results

Collected Swallowtail Butterflies and abundance.

Five hundred and fifty one (551) individuals grouped into two genera of twelve species were collected (table 1). *Graphium policenes*; 197, was the most abundance of the swallowtail butterflies species collected and identified. The swallowtail butterfly species, *P. gallienus* was the least of the species collected.

Table 1. Species and abundance of Swallowtails in different habitats.

S/N	**Scientific Name**	**Habitats**								Total
		DIS	FE/P	MOF	FAR/MP	RIP	CC	GRA	SHR	
1	*Papilio danaus* (Linnaeus, 1758)	3	4	2	1	0	0	6	8	24
2	*P. chrapkowskoides nurettini* (Kocak, 1983)	4	4	9	20	27	14	2	3	83
3	*P. menestheus menestheus* (Drury, 1773)	4	1	6	15	6	24	0	2	58
4	*P. nireus nireus* (Linnaeus, 1758)	0	2	0	5	0	0	0	0	7
5	*P. sosia sosia* (Rothschild & Jordan, 1903)	0	0	2	3	3	0	0	0	8
6	*P. cyproeofila cyproeofila* (Butler, 1868)	4	0	25	8	3	28	1	2	71
7	*P. gallienus* (Distant, 1879)	0	0	1	0	0	1	0	0	2
8	*P. demodocus demodocus* (Esper, 1798)	2	5	4	4	2	2	6	5	30
9	*Graphium policenes* (Cramer, 1775)	2	9	12	57	102	4	5	6	197
10	*G. leonidas leonidas* (Fabricius, 1793)	1	2	7	14	20	0	1	1	46
11	*G. antheus* (Cramer, 1779)	2	0	5	11	5	0	0	0	2
12	*G. angolanus* (Goeze, 1779)	0	0	2	0	0	0	0	0	2
	Total	22	27	75	138	168	73	21	27	551

Key: DIS- Disturbed Habitat; FE/P- Forest Edge/ Plantation; MOF- Moderately Open Forest; FAR/MP- Forest along Road/ Moist Patches; RIP- Riparian Forest; CC- Closed Canopy; SHR-Shrub; GRA-Grassland.

Diversity indices

The diversity indices of the Swallowtail butterflies species calculated showed that MOF had the highest species index (D) and diversity index (H)

values of 2.31 and 2.02 respectively, followed by DIS with D; 2.27 and H; 1.99, and RIP the least with D and H values of 1.37 and 1.27 respectively (table 2).

Table 2. Diversity indices of Swallowtail butterflies in the eight different habitats in Okomu National Park

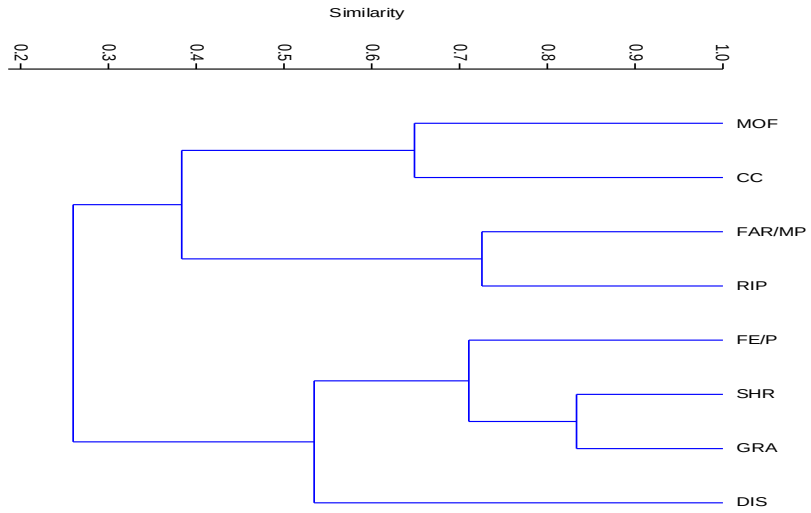
Habitat types	Species No(S)	Individual No(N)	Species Richness Index (D)	Evenness Index (J)	Diversity Index(H)
DIS	8	22	2.27	0.92	1.99
FE/P	7	27	1.82	0.82	1.75
MOF	11	75	2.31	0.69	2.02
FAR/MP	10	138	1.82	0.62	1.83
RIP	8	168	1.37	0.45	1.27
CC	6	73	1.17	0.65	1.37
GRA	6	21	1.64	0.80	1.57
SHR	7	27	1.82	0.83	1.76

Key: DIS- Disturbed Habitat; FE/P- Forest Edge/ Plantation; MOF- Moderately Open Forest; FAR/MP- Forest Along Road/ Mosit Patches; RIP- Riparian Forest; CC- Closed Canopy; SHR- Shrub; GRA- Grassland.

Similarity relationship of the swallowtail butterflies

The similarities relationship between the various of the swallowtail butterfliese colleceted in the various transects are represented in fig. 2.

Fig 2. Similarities reveled by the cluster analysis from the eight transects in Okomu National Park, Edo State.



Seasonal sampling of Swallowtail butterflies

The result of butterflies samplied within the period of June 2012 and July 2014 (rainy and dry seasons) are represented in Table 3. Butterflies were colleceted in the two seasons, rainy and dry season. In the month of August

2102 (rainy season), eleven species of the swallowtail butterflies were collected, while in the month of January 2014 (dry season) four of the species of the swallowtail butterflies identified were colleceted.

Table 3. The butterflies collected from Okomu National Park from the period of July 2012 to June 2014

S/N	Species	Number of individual species per Months(2012to2014)																							
		Jul 12	Aug	Sept	Oct	Nov	Dec	Jan 13	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan 14	Feb	Mar	Apr	May	Jun
1	*P. chrapkowskoides nurettini*	4	8	7	6	4	4	3	7	0	3	2	3	2	4	5	3	3	2	2	2	1	2	2	4
2	*P. menestheus menestheus*	2	4	5	4	3	3	6	3	1	3	2	2	2	4	4	4	2	0	0	0	2	1	1	0
3	*P. demodocus demodocus*	4	2	2	2	3	0	1	2	0	1	0	0	1	2	1	1	1	1	0	0	1	1	3	1
4	*P. sosia sosia*	0	1	1	0	0	0	0	1	0	1	1	0	0	0	1	1	0	0	0	1	0	0	0	0
5	*P. nireus nireus*	0	1	1	0	0	0	0	0	0	0	0	1	1	0	1	1	1	0	0	0	0	0	0	0
6	*P. danaus*	1	2	2	1	4	3	1	0	0	1	0	0	0	1	1	1	2	1	1	1	0	1	0	0
7	*P. gallienus*	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
8	*P. cyproeofil cyproeofila*	7	5	3	4	3	6	11	4	1	1	1	1	3	4	1	1	2	1	2	3	3	1	0	3
9	*G. policenes*	9	32	17	15	10	12	11	12	0	5	6	1	2	8	6	5	7	3	4	10	7	3	7	5
10	*G. leonidas leonidas*	1	4	2	4	2	3	5	2	0	5	1	1	0	1	0	6	0	0	0	2	4	0	0	3
11	*G. illyris illyris*	2	3	1	1	1	0	0	4	1	0	0	0	1	1	0	0	0	0	0	3	5	1	0	0
12	*G. angolanus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0
	Total/Month	8	11	10	8	8	6	7	8	3	8	6	6	8	8	9	9	8	5	4	7	7	7	4	5

$p<0.05$

Discussion

Twelve species of swallowtail butterflies: *Papilio danaus, P. chrapkowskoides nurettini, P. menestheus menestheus, P. nireus nireus, P. sosia sosia, P. cyproeofila cyproeofila, P. gallienus, P.demodocus demodocus, Graphium policenes, G. leonidas Leonidas, G. antheus, G. angolanus* were recorded from eight habitats in Okomu National Park, Edo State. It was observed that, that most of the *Papilio* species where found in damp shady places in forest interior covered by canopy of tall trees, dense undergrowth near water sources, nectar sources and MOF with relative openness allows penetration of sunlight to make the environment suitable and make them very active. Larsen (1991) states that swallowtail butterflies will not be observed on dull day periods.

The two genera: *Papilio* and *Graphium*, marked the only genera of which the swallowtail butterflies in the Park belonged to. This result agrees with Larsen (2005), who recorded *Papilio* and *Graphiums* as the two most abundance genera of which most swallowtail butterflies species of West Africa are grouped.

Two species *P. gallienus* and *G. angolanus* were recorded for the first time in the Park during the study in Moderately Open Forest (MOF) and Closed Canopy (CC), and MOF respectively. The two species with *P. sosia sosia* and *P. nierus nireus* were rare. According to Thomas (1995), butterfly short-term abundance across season result from variation in weather, whereas long-term abundance changes are due to modification of habitat quality and availability of food. The later explains the reason for the rare abundance of *P. gallienus, P. sosia sosia, P. nierus nireus* and *G. angolanus* in the period of which this research was conducted. As noted by Ogedegbe A. B., Ogedegbe A. U., & Rotimi (2014) the habitats where the species were observed have lesser diversity of *Tridax, Ricinus communis, Leucas aspera, Mimosa pudica, Gomphrena serrata, Vernonia cinerea, Chromolaena odorata, Anisomelous* sp. and *Lantana camara* flower vegetations, which are the most suitable flowering plants for the swallowtail butterflies. Besides, from the result, it is obvious that the Park; Okomu National Park, is quite rich in swallowtail butterflies (Beccaloni & Gaston, 1995; Larsen, 1991) and has specific set of microenvironment suitable for the species (Ogedegbe et al., 2014).

The low species diversity (H) and species richness in the GRA and SHR indicates that extreme openness' that exposes them to dryness and predation were avoided. Tumuhimbise et al. (2001) also observed similar findings. However, *Graphium* species mud puddle along water stream in RIP. The natural preference for these swallowtails for forest areas that are shady particularly midday seemed to be controlled by humidity and rainfall of the specific area. Water sources were also an important factor that enabled the

butterflies' mud puddle in large congregation on a sandy patch and rocks along streams.

The low diversity index in CC and RIP sites is because of high canopies associated with the area, specialist and rare species restricted to the area. Despite the fact that diversity was low, species abundance was high. The streamside had natural forest with different layers along the streamside's, openings, and wet sand and rocks, which are important environment for the conserving of large abundance of butterflies and specialist species.

The diversity result of this research study corresponds with the hypothesis of intermediate disturbance by Blair and Launer (1997); Bobo et al. (2006), which states that butterfly diversity is low in the natural closed forests, but when the natural forests are highly disturbed, the diversity decreases.

The Bray-Curtis cluster analysis also explains the relationship between the various transects. The similarity result shows that more than 50% of the butterfly species recorded in all transects were the same despite differences in habitat characteristics. This high similarity value of butterfly species may be an indicator of beta diversity (Whittaker, 1960) which in turn indicates availability of niches and more microhabitats on the ground areas in each of the study habitats. Studies by Novotny et al. (2007), Majumde et al. (2012) reported that tropical forests show low beta diversity of herbivorous insects. From the result, it was also observed that the swallowtail butterflies in the habitats of GRA and SHR shared more similarities probably because of the openness of transects and dissimilarities with the CC and MOF which contained trees in canopies and dense forests.

The abundance patterns with respect to season (dry and wet) indicate that *Papilio* species seen all year round and were significantly higher in the rainy season than in the dry season at $p < 0.05$. This may be because of high rainfall, availability of food sources and host plants and less predation during the season, which ensured survival of larvae and adult butterflies.

Conclusion

Okomu National park is a park rich in swallowtail butterflies and efforts geared towards conserving the species legalized in order to preserve the biotas, which are good bio-indicator of the environment.

References:

1. Alarape, A. A., Omifolaji, J. K. & Mwausat, G. S. (2015). Butterfly species diversity and abundance in University of Ibadan Botanical garden, Nigeria. *Open Journal of Ecology 5*: 352-360. doi: 10.4236/oje.2015.58029

2. Aduse-Poku, K., William, O., Oppong, S. K., Larsen, T., Ofori-Boateng, K., & Molleman, F. (2012). Spatial and temporal variation in butterfly diversity in a West African forest: Lessons for establishing efficient rapid monitoring programmes. *Africa Journal of Ecology 50*: 326-334. doi: 10.1111/j.1365-2028.2012.01328.x
3. Barau, K., Slowik, J., Bobo, K. S., & Muehlenberg, M. (2010). Correlations of Rain Forests and Forest Type with Papilionid Assemblages in Assam in North-East India. *Psyche 10* (1155): 560396. doi: 10.1155/2010/560396
4. Beccaloni, G. W., & Gaston, K. J. (1995) Predicting the Species Richness of Neotropical Butterflies Ithomiinae (Lepidoptera: Nymphalidae) as Indicators. *Biological Conservation 71*: 77-86. doi: 10.1016/0006-3207(94)00023-J
5. Blair, R. B., & Launer, A. E. (1997). Butterfly diversity and human land use species assemblage along an urban gradient. *Biological Conservation 80*: 113-125: doi: 10.1016/S0006-3207(96)00056-0 In: Ogedegbe, A. B. O. Ogedegbe, A. U., & Rotimi, J. (2014). Diversity of Lepidopteran Assemblages in five habitat-types in the Niger Delta, Nigeria. *European International Journal of Science and Technology 3*(8): 45-57.
6. Bobo, K. S., Waltert, M., Fermon, H., Njokagbor, J., & Muhlerberg, M. (2006). From forest to Ffarmland: butterfly diversity and habitat associations along a gradient of forest conversion in Southwestern Cameroon. *Journal of Insect Conservation 10*: 29-42. doi: 10.1007/s10841-005-8564-x
7. Bonebrake, T. C., Ponisio; L. C., Boggs, C. L., & Ehrlick, P. R. (2010). More than just indicators: A review of tropical butterfly ecology and conservation. *Biological Conservation 143*: 1831-1841. doi: 10.1016/j.biocon.2010.04.044
8. Brown, K. S. (1991). Conservation of Neotropical Environments. Insects as Indicators In: The Conservation of Insects and their habitats (Eds N.M Collins and J.A Thomas) Academic Press London.
9. Collins, M., & Morris, M. (1985). Threatened Swallowtail butterflies of the World. He I.U.C.N Red data Book. International Union for Conservation of Nature and Natural Resources, Gland.
10. De Vries, P. J., Murray, D., & Lande, R. (1997). Species diversity in the vertical, horizontal, and temporal dimensions of a fruit feeding butterflly community in an ecoudorian forest. *Biology Journal of Linnean Society 62*: 343-364. doi: /10.1006/bijl.1997.0155
11. Erhardt, A. (1985) Diurnal Lepidoptera: Sensitive Indicators of Cultivated and Abandoned Grassland. *Journal of Applied Ecology 22*: 849-861. doi: 10.2307/2403234

12. Fitzherbert, E., Gardner, T., & Davenport, T. R. B. (2006). Butterfly Species Richness and Abundance in the Katavi Ecosystem of Western Tanzania, *African Journal of Ecology 44*(3): 353-362. doi: 10.1111/j.1365-2028.2006.00655.x
13. Hill, J. K., Hammer, K. C., Lace, L. A., & Banham, W. M. T. (1995). Effect of selective logging on tropical butterflies on Buru, Indonesia. *Journal of Applied Ecology 32*: 454-460.
14. Howard, P. C. (1991) Nature Conservation in Uganda's Tropical Forest Reserves. International Union for Conservation of Nature and Natural Resources, Gland.
15. Hutton, P. (1990). Butterfly farming and Conservation in Papau NewGuinea In:Conservation in Developing Countries, Problems and Prospects.Natural History Society,Oxford University Press.
16. Inuoye, D. W. (2001). Role of Pollinator in Encyclopedia of Biodiversity 4. Academy Press, London, 732-730.
17. Kremen, C. (1994). Biological Inventory Using Target Taxa: A Case Study of Butterflies in Rainforest of Madagascar. *Journal of Ecological Applications 4*: 407-422. doi.org/10.2307/1941946
18. Kunte, K. (1997). Seasonal Patterns in Butterfly abundance and Species Diversity in Four Tropical Habitats in North Western Ghats. *Journal of Bioscience* 22: 283-287.
19. Larsen, T. B. (1991). *Butterflies of Kenya*. Oxford University Press, Oxford.
20. Larsen, T. B. (2005). Butterflies of West Africa Appolo books publishers, Stenstrup. 1-595 pp.
21. Ludwig, J.A. & Reynolds, J.F. (1988) Statistical Ecology: A Primer on Methods and Computing. Wiley-Interscience Pub., New York.
22. Majumder, J., Lodh, R., & Aganwala, B. K. (2012). Variation in Butterfly Diversity and Unique Species richness along different habitats in Trishna Wildlife Sactuary, Tripura, Northeast India. *Check list 8*(3): 432-436.
23. New, T. R. (1992). The Swallowtail Butterflies Action Plan Species. I.U.C.N no 18. International Union for Conservation of Nature and Natural Resources, Gland.
24. Novotny, V., Miller, S. E., Hulcr, J., Drew, R. A. I., Basset, Y., Janda, M., Setliff, G. P., Darrow, K., Stewart, A. J. A., Auga, J., Isua, B., Molem, K., Manumbor, M., Tamtiai, E., Mogia, M. & Weiblen, G. D. (2007). Low beta diversity of herbivorous insects in tropical forests. *Nature*, *448*(7154), 692-695. doi:10.1038/nature06021
25. Ogedegbe, A. B. O., Ogedegbe, A. U., & Rotimi, J. (2014). Diversity of Lepidopteran Assemblages in five habitat-types in the Niger Delta,

Nigeria. *European International Journal of Science and Technology 3*(8): 45-57.

26. Pollard, E. (1977) A method for Assessing Changes in Abundance of Butterflies. *Biological Conservation 12*:115-134. doi: 10.1016/0006-3207(77)90065-9
27. Prendergast, J. R., Qulnn, R. M., Lawton, H. H., Eversham, B. C., & Gbbons, D. W. (1993). Rare Species the Coincidence of Diversity Hotspots and Conservation Strategies. *Nature 365*: 335-337. doi: 10.1038/365335a0
28. Thomas, J. A. (2005). Monitoring Changes in the abundance and Distribution of Insects Using Butterflies and other indicators, *Philosophical Transactions of the Royal Society 360*: 339-357. doi: 10.1098/rstb.2004.1585
29. Tiple, A. D., Khurad, A. M. & Dennis, R. L. H (2009). Adult butterfly feeding-nectar flower associations: Constraints of taxonomic affiliation, butterfly, and nectar flower morphology. *Journal of Natural History 43*(13-14): 855-884. doi: 10.1080/00222930802610568
30. Trueman, J. W. H., & Cranston, P. S. (1997). Prospects for the rapid assessment of terrestrial invertebrate biodiversity. *Memoirs of Museum Victorial 56*: 349-348.
31. Tumuhimbise, G., Okwakol, M. J. N., & Kanggwagye, N. (2001). Species diversity of swallowtail butterflies (Papilionidae: Lepidoptera) in North Maramagambo Forest. *African Journal of Ecology 39*(1): 113-115. doi: 10.1111/j.1365-2028.2001.00228.x
32. Whittaker, R. H. (1960) Vegetation of the Siskiyou Mountains, Oregon and California. *Ecological Monographs 30*: 279-338. doi: 10.2307/1943563