

Diversity of Butterflies in Tipeswar Wildlife Sanctuary of Maharashtra, India

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ABSTRACT

Butterflies are considered as the best indicators of the health of any specified terrestrial ecosystem. They are key components in maintaining ecological dynamics of the protected areas and protected areas provides major support systems for maintaining their diversities. This scientific exercise is undertaken from 1 Dec. 2017 to 30 Nov. 2018 to explore butterfly diversity in Tipeswar Wildlife Sanctuary, a protected area spread over 148.63 km² and located at 78°20'22" to 78°47'56" East and 19°50'59" to 19°55'44" North situated in the Deccan peninsular of Central Indian landscape. Varieties of plant species of this dry deciduous forest and seasonal variation in floral composition of this wildlife sanctuary attract varieties of butterfly species. 97 species of butterflies belong to 64 genera of 5 families dominated by family Nymphalidae (34.02%), Lycaenidae (27.83%) followed by Pieridae (19.59%), Hesperidae (11.34%) and Papilionidae (7.21%) are recorded. It appears that the butterfly abundance increased from monsoon to winter while decreased in summer and pre-monsoon possibly due to the unavailability of nectar and the changes in temperature and humidity of this protected area. Butterflies are considered as an important model group in understanding ecology of a particular landscape. This research exercise will help in understanding ecology of this protected area and prove to be the important biological tool in devising the strategies for sustainable conservation of wildlife of this protected area and similar geographical regions

KEY WORDS: BUTTERFLY, BIOINDICATORS, DIVERSITY, POPULATION DYNAMICS, TIPESHWAR.

INTRODUCTION

The butterflies are the most attractive elements of the biological diversity of the universe (Losey and Vaughan 2006). They are beautifully coloured, ecologically important insects belong to order Lepidoptera of class insecta. There are 1.5 million identified animal species harbour on the earth, class insecta alone contributes near

about 0.8 million species whereas butterfly and moth shares 0.14 million species. More than 1700 species of butterflies are recorded from across the globe, of this India alone contributes 1504 (Gaonkar 1996; Smetacek 1992; Kunte 2009; Roy et al., 2010). Central India is home of 1400 species of butterfly (A Biodiversity Atlas- India Website), 167 amongst them are reported from Vidarbha, (Triple 2011). 111 species of butterfly are reported in and around Tadoba National Park of central India (Tiple 2010). Diversity of butterflies in Karhandla region of Umred-Karhandla wildlife sanctuary, studied by Gajbe (2016) and 53 species of butterflies belong to 34 genera of 5 families are recorded inhabiting in this protected area. Butterflies show co-evolutionary relationship with the plants and perform prominent roles in pollination (Tiple et al 2006; Tiple 2018).

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As pollinators butterflies are valuable creatures in maintaining the population dynamics of floral composition of natural and man-made ecosystems. Klein et al., (2008) have estimated that 35% of food use by human contributed from crop pollinated by insects (majorly by butterflies). As an integral part of prey-predator system they play major role in maintaining ecological balance in any type of ecosystem. As a bio-indicators, butterflies are useful in monitoring the ecological imbalance due to pollution, uncontrolled exploitation of natural resources, illegal encroachment and significant in studying the impact of rapid urbanisation on ecology in developing countries like India, (Khairunnisa et al., 2015). Global climate change has detrimental effect on butterfly diversity and its distribution as they are very specific in ecological requirements such as temperature, humidity, food plants and egg-laying habitats, (Forister and Shapiro 2003; Gonzalez-Megias et al., 2008).

Temperature and relative humidity are the important factors in distribution and assemblage of Butterfly species (Gupta et al., 2019). Butterflies are considered as the best indicators of the health of any specified terrestrial ecosystem (Thomas 2005; Bonebrake et al., 2010) and therefore treated as an important model group in understanding ecology of any landscape and to draw strategies for conservation accordingly (Watt and Boggs 2003; Ehrlich and Hanski 2004; Mukherjee et al., 2015). They are key components in maintaining ecological dynamics of the protected areas and protected areas are major support systems for maintaining their diversities. Distribution and variation in butterfly diversity changes in heterogeneous habitats with different ecological parameters (Suryanarayana et al., 2018).

This research exercise was aimed to estimate butterfly diversity in the Tipeshwar Wildlife Sanctuary, Maharashtra, India. Varieties of plant species of this dry deciduous forest and seasonal variation in floral composition of this wildlife sanctuary attract varieties of species of butterfly. The results of this research exercise will help in understanding ecology of Tipeshwar Wildlife Sanctuary and it will prove to be the important biological tool in devising the strategies conservation of wildlife of this protected area and similar geographical regions by understanding ecological role of these flying beauties.

MATERIAL AND METHODS

Study area: The Tipeshwar Wildlife Sanctuary situated in Yavatmal District of Indian state of Maharashtra. It is located between of 78°20'22" to 78°47'56" East and 19°50'59" to 19°55'44" North with total area of 148.63 sq. km. It constitutes compact patches of dense forest cover with meadows and a seasonal wetland. It has great utility from the point of view of wildlife and bio-diversity conservation. The main portion of this protected area constitutes the dry teak bearing forest. The climatic condition of this area is characterized by a hot summer, well-distributed rainfall during the south-west monsoon season and generally dry weather during rest of the year.

The cold season is from December to February (Yavatmal Gazetteer 2019).

Survey method: The butterflies were observed from the study sites for a period of 1 year between 1 Dec. 2017 to 30 Nov. 2018. During the survey, an efficient protocol was adopted. The survey was made using a "Pollard Walk" method (Pollard 1977; Pollard and Yates 1993) with necessary modifications. Study area was visited twice a month from early morning (8:00 AM) to afternoon (11:00 AM) during good weather periods.

Species identification: After detection, a butterfly was photographed in field (Nikon D7100+ Nikkor 105 micro lens; Nikon Inc., Tokyo, Japan) and identified with the help of visible structural features. For identification and comparative studies of observed specimens, keys and methods suggested by Evans (1932), Wynter-Blyth (1957), Haribal (1992), Kunte (2000) and Kehimkar (2008) were adopted.

Data analysis: Species occurrence analysis was carried out by Microsoft excel program with using the following formulas. Relative Dominance (RD) of species was calculated as $[RD = N_i \times 100 / N_t]$ where, N_i is number of individuals of species and N_t is total number of individuals all species (Basavarajappa 2006; Joshi 2014). Relative Occurrence (RO) of family was calculated as $[RO = N_s \times 100 / N_t]$ where, N_s is number of species of each family and N_t is total number of all species (Basavarajappa 2006; Joshi 2014). Mean percent occurrence (M%) for month was calculated as $[M\% = N_m \times 100 / N_t]$ where, N_m is number of individuals in each month and N_t is total number of individuals during complete study tenure (Basavarajappa 2006; Joshi and Tantarapale 2016). The mean values of the pooled species occurrence data were used to calculate the monthly diversity of and to categorize the local status of species.

The diversity assessment enabled highlighting the observed species richness pattern of the saurian species. The diversity indices were quantified with the help of PAST Version 1.60 software (Palaeontological As so., Norway; Hammer et al., 2001). The species diversity was calculated using Shannon diversity index that calculated as $[H' = - \sum_{i=1}^R P_i \log P_i]$ where P_i is proportion of the first species which is given by $P_i = n_i / N$ (Magurran 1988); species richness was obtained by using Margalef equation $[R = (S-1) / \log N]$, Where, R is Index of species richness, S is Total number of species and N is Total No. of individuals (Magurran 1988); while Species equitability was determined by equation of Pielou $[J = N_1 / N_0]$ where N_1 is Number of abundant species in the sample and N_0 is Number of species in the sample (Hammer et al., 2001). The similarity association matrix upon which the cluster based was computed using the nearest neighbour pair linkage algorithm of Euclidean distance index for presence and absence data (Hammer et al., 2001). The differences between the diversity and evenness indices of with species occurrence among different study months were statistically analyzed by using Analysis of variance (ANOVA). The statistical analyses were performed

following Zar (1999) using the SPSS version 10 (SPSS Inc., Chicago, IL, USA; Kinnear and Gray 2000).

RESULTS AND DISCUSSION

During this study, 97 butterfly species under five families were observed in study area (Table 1). Based on value of butterfly relative dominance in study area, 19.59 % species was categorized as abundant species whereas

44.32 % species was common, 12.37 % species was frequent, 15.46 % was occasional, and 8.24 % species was rare (Figure 1). The maximum number of butterfly species were recorded under family Nymphalidae (34.20 %), Lycaenidae (27.83 %) followed by Pieridae (19.58 %), Hesperidae (11.34 %) and Papilionidae (7.21 %) (Figure 2).

Table 1. Butterfly diversity in the Tipeswar Wildlife Sanctuary, Maharashtra, India during 1 Dec. 2017 to 30 Nov. 2018

Common Name	Scientific Name	Pictures	Local Status	IUCN status	Relative Dominance	
1 Family: Papilionidae						
Tailed Jay	<i>Graphium agamemnon</i> (Linnaeus, 1758)		Common	NE	1.115	
Common Jay	<i>Graphium doson</i> (Felder and Felder, 1864)		Common	NE	1.145	
Common rose	<i>Pachliopta aristolochiae</i> (Fabricius, 1775)		Common	LC	1.038	
Crimson rose	<i>Pachliopta hector</i> (Linnaeus, 1758)		Common	NE	0.980	SCH.I Part IV
Lime Butterfly	<i>Papilio demoleus</i> (Linnaeus, 1758)		Abundant	NE	1.379	
Common Mormon	<i>Papilio polytes</i> (Linnaeus, 1758)		Abundant	NE	1.291	
Spot Swordtail	<i>Graphium nomius</i> (Esper, 1793)		Occasional	NE	0.624	
Family: Pieridae						
Common Albatross	<i>Appias albino</i> (Fabricius, 1775)		Common	NE	1.084	SCH.II Part II
Indian Pioneer	<i>Belenois aurota</i> (Fabricius, 1793)		Abundant	NE	1.467	
Common Emigrant	<i>Catopsilia pomona</i> (Fabricius, 1775)		Common	NE	0.959	
Mottled Emigrant	<i>Catopsilia pyranthe</i> (Linnaeus, 1758)		Common	NE	0.917	

Table 1 Continue

Common Gull (Fabricius, 1775)	<i>Cepora nerissa</i>		Common	NE	0.931	SCH.II Part II
Small salmon Arab	<i>Colotis amata</i> (Butler, 1870)		Occasional	NE	0.531	
Large Salmon Arab	<i>Colotis fausta</i> (Olivier, 1804)		Rare	NE	0.237	
Crimson Tip	<i>Colotis danae</i> (Fabricius, 1775)		Occasional	NE	0.537	
Small Orange Tip	<i>Colotis etrida</i> (Boisduval, 1836)		Common	NE	1.096	
White Orange Tip	<i>Ixias Marianne</i> (Cramer, 1775)		Common	NE	1.072	
Yellow Orange Tip	<i>Ixias pyrene</i> (Linnaeus, 1764)		Occasional	NE	0.713	
Common Jezebel	<i>Delias eucharis</i> (Drury, 1773)		Common	NE	1.083	
One Spot Grass Yellow	<i>Eurema andersoni</i> (Moore, 1865)		Abundant	LC	1.298	
Three Spot Grass Yellow	<i>Eurema blanda</i> (Boisduval, 1836)	Observed in field	Frequent	NE	0.823	
Small Grass Yellow	<i>Eurema brigitta</i> (Stoll, 1780)		Common	LC	1.181	
Common Grass Yellow	<i>Eurema hecabe</i> (Linnaeus, 1758)		Abundant	NE	1.349	
Spotless Grass Yellow	<i>Eurema laeta</i> (Boisduval, 1836)		Abundant	NE	1.419	
Psyche	<i>Leptosia nina</i> (Fabricius, 1793)		Occasional	NE	0.734	
Common Wanderer	<i>Pareronia valeria</i> (Cramer, 1776)		Common	NE	1.163	
Family: Nymphalidae						
Tawny Castor	<i>Acraea violae</i> (Fabricius, 1775)		Common	NE	1.198	
Angled Castor	<i>Ariadne ariadne</i> (Linnaeus, 1763)		Abundant	NE	1.020	
Common Castor	<i>Ariadne merione</i> (Cramer, 1779)		Common	NE	1.123	

Table 1 Continue

Plain Tiger	<i>Danaus chrysippus</i> (Linnaeus, 1758)		Abundant	NE	1.449	
Striped Tiger	<i>Danaus genutia</i> (Cramer, 1779)		Abundant	NE	1.324	
Common Crow	<i>Euploea core</i> (Cramer, 1780)		Common	LC	1.134	
Double Branded crow	<i>Euploea Sylvester</i> (Fabricius, 1793)		Occasional	NE	0.549	
Baronet	<i>Euthalia nais</i> (Cramer, 1779)		Common	NE	0.974	
Common Baron	<i>Euthalia aconthea</i> (Cramer, 1777)		Rare	NE	0.204	
Great Eggfly	<i>Hypolimnas bolina</i> (Linnaeus, 1758)		Common	NE	1.111	
Danaid Eggfly	<i>Hypolimnas misippus</i>		Occasional	NE	0.713	
Common Jezebel	<i>Delias eucharis</i> (Drury, 1773) (Linnaeus, 1764)		Common	NE	0.999	SCH.II Part II
Peacock Pansy Grass Yellow	<i>Junonia almana</i> (Linnaeus, 1758)		Abundant	LC	1.167	
Grey Pansy	<i>Junonia atlites</i> (Linnaeus, 1763)		Common	NE	1.202	
Yellow Pansy	<i>Junonia hierta</i>		Common	LC	1.157	
Lemon Pansy	<i>Junonia lemonias</i> (Linnaeus, 1758)		Abundant	NE	1.364	
Spotless Grass Yellow	<i>Eurema laeta</i> (Boisduval, 1836)		Abundant	NE	1.419	
Psyche	<i>Leptosia nina</i> (Fabricius, 1793)		Occasional	NE	0.734	
Common Wanderer	<i>Pareronia valeria</i> (Cramer, 1776)		Common	NE	1.163	
Family: Nymphalidae						
Tawny Castor	<i>Acraea violae</i> (Fabricius, 1775)		Common	NE	1.198	
Angled Castor	<i>Ariadne ariadne</i> (Linnaeus, 1763)		Common	NE	1.020	

Table 1 Continue






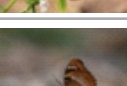
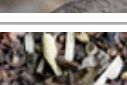
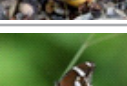
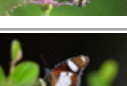
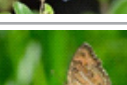
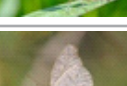
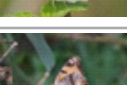

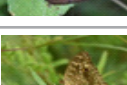
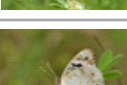
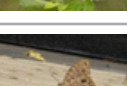
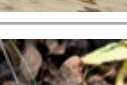
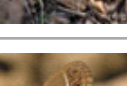
Common Castor	<i>Ariadne merione</i> (Cramer, 1779)		Common	NE	1.123	
Plain Tiger	<i>Danaus chrysippus</i> (Linnaeus, 1758)		Abundant	NE	1.449	
Striped Tiger	<i>Danaus genutia</i> (Cramer, 1779)		Abundant	NE	1.324	
Common Crow	<i>Euploea core</i> (Cramer, 1780)		Common	LC	1.134	
Double Branded crow	<i>Euploea Sylvester</i> (Fabricius, 1793)		Occasional	NE	0.549	
Baronet	<i>Euthalia nais</i> (Cramer, 1779)		Common	NE	0.974	
Common Baron	<i>Euthalia aconthea</i> (Cramer, 1777)		Rare	NE	0.204	
Great Eggfly	<i>Hypolimnas bolina</i> (Linnaeus, 1758)		Common	NE	1.111	
Danaid Eggfly (Linnaeus, 1764)	<i>Hypolimnas misippus</i>		Common	NE 0.999	Part II	SCH.II
Peacock Pansy	<i>Junonia almana</i> (Linnaeus, 1758)		Common	LC	1.167	
Grey Pansy	<i>Junonia atlites</i> (Linnaeus, 1763)		Common	NE	1.202	
Yellow Pansy	<i>Junonia hierta</i> (Fabricius, 1775)		Common	LC	1.157	
Chocolate Pansy	<i>Junonia iphita</i> (Cramer, 1779)		Common	NE	1.011	
Lemon Pansy	<i>Junonia lemonias</i> (Linnaeus, 1758)		Abundant	NE	1.364	
Blue Pansy	<i>Junonia orithya</i> (Linnaeus, 1764)		Abundant	NE	1.480	
Common Evening Brown	<i>Melanitis leda</i> (Linnaeus, 1758)		Abundant	NE	1.303	
Dark Evening Brown	<i>Melanitis phedima</i> (Cramer, 1780)		Occasional	NE	0.625	
Common Bush Brown	<i>Mycalesis perseus</i> (Fabricius, 1775)		Frequent	NE	0.789	

Table 1 Continue

Long Brand Bush Brown	<i>Mycalesis visala</i> (Moore, 1858)		Occasional	NE	0.703	
Common Sailor	<i>Neptis hylas</i> (Linnaeus, 1764)		Common	NE	0.968	
Common Leopard	<i>Phalanta phalantha</i> (Drury, 1773)		Common	LC	1.051	
Blue Tiger	<i>Tirumala limniace</i> (Cramer, 1775)		Common	NE	1.135	
Commander	<i>Moduza procris</i> (Cramer, 1777)		Common	NE	1.190	
Painted Lady	<i>Synthia cardui</i> (Linnaeus, 1764)		Common	NE	0.950	
Joker	<i>Byblia ilithyia</i> (Drury, 1773)		Common	NE	0.941	
Common Three Ring	<i>Ypthima asterope</i> (Klug, 1832)		Common	NE	1.193	
Large Three Ring	<i>Ypthima nareda</i> (Kirby, 1871)		Frequent	LC	0.868	
Anomalous Nawab	<i>Polyura agrarian</i> (Linnaeus, 1764)		Occasional	NE	0.703	
Common Nawab	<i>Polyura athamas</i> (Drury, 1773)		Occasional	NE	0.502	SCH.II Part II
Black Rajah	<i>Charaxes solon</i> (Fabricius, 1793)		Rare	NE	0.205	SCH.II Part II
Towny Rajah	<i>Charaxes bernardus</i> (Fabricius, 1793)		Rare	NE	0.276	SCH.II Part II
Family: Lycaenidae						
Pointed Ciliate Blue	<i>Anthene lycaenina</i> (C. Felder, 1868)		Occasional	NE	0.699	SCH.II Part II
Large Oak Blue	<i>Arphopala amantes</i> (Hewitson, 1862)		Rare	NE	0.197	
Dull Babool Blue	<i>Azanus uranus</i> (Butler, 1886)		Frequent	NE	0.831	
Bright Babool Blue	<i>Azanus ubaldus</i> (Stoll, 1782)		Common	NE	0.953	
Lime Blue	<i>Chilades lajus</i> (Stoll, 1780)		Common	NE	1.192	

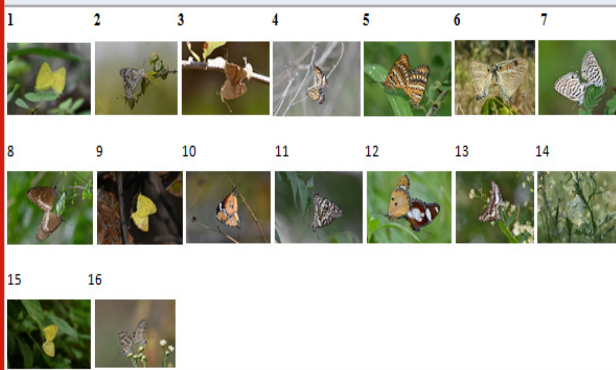
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Gram Blue	<i>Euchrysops cnejus</i> (Fabricius, 1798)		Common	NE	1.051	SCH.II Part II
Pea Blue	<i>Lampides boeticus</i> (Linnaeus, 1767)		Common	NE	1.136	SCH.II Part II
Zebra Blue	<i>Leptotes plinius</i> (Fabricius, 1793)		Abundant	NE	1.234	
Tailless Line Blue	<i>Prosotas dubiosa</i> (Semper, 1879)		Common	NE	1.062	SCH.II Part II
Common Line Blue	<i>Prosotas nora</i> (Felder, 1860)		Common	NE	1.172	
Guava Blue	<i>Virachola isocrates</i> (Fabricius, 1793)		Occasional	NE	0.688	SCH.I Part IV
Dark Grass Blue	<i>Zizeeria karsandra</i> (Moore, 1865)		Abundant	NE	1.312	
Lesser Grass Blue	<i>Zizina otis</i> (Fabricius, 1787)		Abundant	NE	1.233	
Tiny Grass Blue	<i>Zizula hylax</i> (Fabricius, 1775)		Common	NE	1.049	
Plum Judy	<i>Abisara echerius</i> (Moore, 1901)		Occasional	NE	0.718	
Common Pierrot	<i>Castalius rosimon</i> (Fabricius, 1775)		Frequent	NE	0.899	SCH.I Part IV
Forget-Me-Not	<i>Catochrysops strabo</i> (Fabricius, 1793)		Abundant	NE	1.336	
Plains Cupid	<i>Luthrodes pandava</i> (Horsfield, 1829)		Frequent	NE	0.854	
Indian cupid	<i>Cupido lacturnus</i> (Godart, 1824)		Frequent	NE	0.811	
Grass Jewel	<i>Freyeria trochylus</i> (Freyer, 1845)		Common	NE	1.153	
Common Cerulean	<i>Jamides celeno</i> (Cramer, 1775)		Frequent	NE	0.824	
Indian Red Flash	<i>Rapala airbus</i> (Fabricius, 1787)		Rare	NE	0.233	
Slate Flash	<i>Rapala manea</i> (Hewitson, 1863)		Rare	NE	0.137	SCH.I

Table 1 Continue

Common Silverline	<i>Spindasis vulcanus</i> (Fabricius, 1775)		Frequent	NE	0.829	
Common Shot Silverline	<i>Spindasis ictis</i> (Hewitson, 1865)		Occasional	NE	0.591	
Rounded Pierrot	<i>Tarucus extricates</i> (Kollar, 1848)		Abundant	NE	1.217	
Peacock Royal	<i>Tajuria cippus</i> (Fabricius, 1775)		Rare	NE	0.170	SCH.II Part II
Family: Hespiridae						
Brown awl	<i>Badamia exclamationis</i> (Fabricius, 1775)		Abundant	LC	1.397	
Common Banded Awl	<i>Hasora chromus</i> (Cramer, 1780)		Frequent	NE	0.828	
Rice swift	<i>Borbo cinnara</i> (Wallace, 1866)		Abundant	NE	1.489	
Small branded swift	<i>Pelopidas mathias</i> (Fabricius, 1798)		Abundant	NE	1.279	
Conjoined Swift	<i>Pelopidas conjuncta</i> (Moore, 1878)		Common	NE	0.916	
Paintbrush Swift	<i>Baoris farri</i> (Moore, 1878)		Frequent	NE	0.846	SCH. IV
Common Straight Swift	<i>Parnara guttatus</i> (Bremer and Gray, 1853)		Common	LC	1.151	
Indian Palm bob	<i>Suastus gremius</i> (Fabricius, 1798)		Common	NE	0.935	
Dark Palm-Dart	<i>Telicota ancilla</i> (Moore, 1878)		Common	NE	1.090	
Indian skipper	<i>Spialia galba</i> (Fabricius, 1793)		Frequent	LC	0.782	
Grass Demon	<i>Udaspes folus</i> (Cramer, 1775)		Occasional	NE	0.661	

Breeding Records of some butterflies from 1 Dec. 2017 to 30 Nov. 2018 in Tipeshwar Wildlife Sanctuary



- 1.Small Grass Yellow 2.Pioneer 3.Blue Pansy 4.Striped Tiger 5.Joker 6.Pea Blue 7.Rounded Pierrot 8.Common Crow 9.Yellow Orange tip 10.Plain Tiger 11.Lime Butterfly 12.Danied Egg fly 13.Common Jay 14.Common Emigrant 15.Common Grass Yellow 16.Zebra Blue

Figure 1: Relative occurrence of butterfly Species from 1 Dec. 2017 to 30 Nov. 2018 in Tipeshwar Wildlife Sanctuary

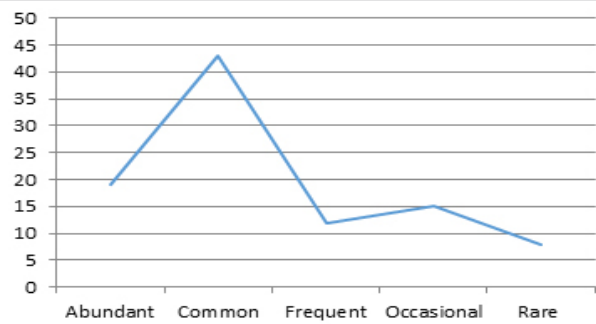
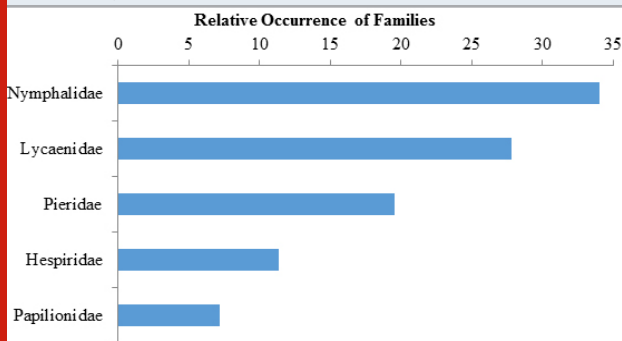


Figure 2. Relative dominance of butterfly families studied from 1 Dec. 2017 to 30 Nov. 2018 in the Tipeshwar Wildlife Sanctuary, Maharashtra, India



A dendrogram developed by Euclidean distance cluster analysis was observed to be multifaceted and showed variation in the level of similarity in the number of butterfly species in 12 months. The months with the minimum to moderate number of species belong to one cluster, whereas the rest of the months with moderate to maximum number of species formed another cluster

(Figure 3). It appears that the butterfly abundance increased from monsoon to winter while decreased in the summer and pre-monsoon possibly due to the unavailability of nectar and the change in temperature and humidity of the habitats concerned.

Figure 3: Dendrogram showing similarity in number of butterfly species composition among the studied month during 1 Dec. 2017 to 30 Nov. 2018

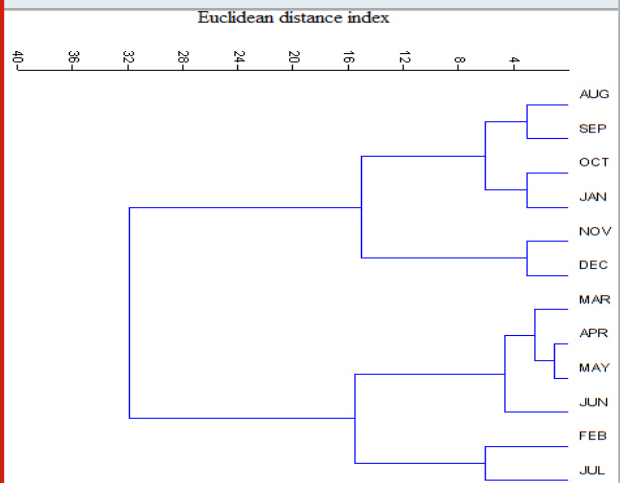
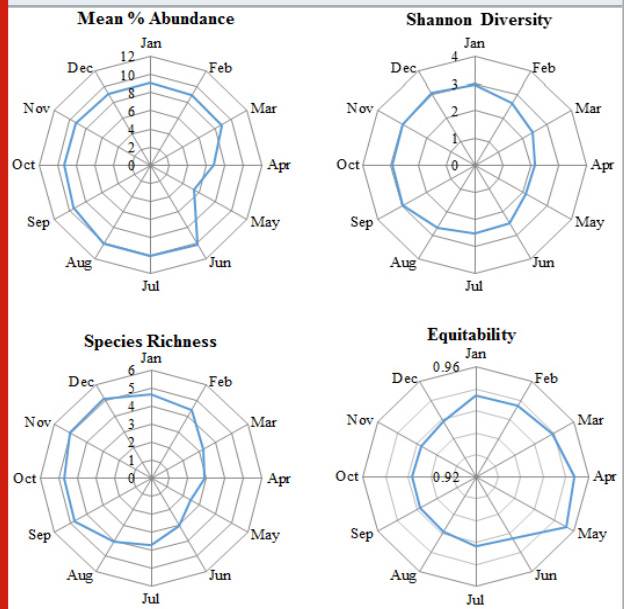


Figure 4: The values of the diversity indices in different months from 1 Dec. 2017 to 30 Nov. 2018 observed through the random sampling of butterflies in the Tipeshwar Wildlife Sanctuary, Maharashtra, India



Observations on the monthly variations of butterfly abundances indicate patterns of peak from June to November while a low from December May and from (Figure 3). Mean percent abundance of butterflies was significantly different ($F = 121.8, df = 11, p < 0.05$); Shannon diversity values of butterflies were significantly different ($F = 148.2, df = 11, p < 0.05$); species evenness among different months was significantly different

($F = 142.1$, $df = 11$, $p < 0.05$) while species richness among the study months was significantly different ($F = 156.4$ $df = 11$, $p < 0.05$). A trend in mean % abundance, Shannon diversity, species richness and species equitability showed the contradictory patterns (Figure 4).

The butterflies are the ecologically important organisms that serves as indicators of environmental conditions (Stefanescu et al., 2004). Observations on the butterfly diversity provide the information about variations in the species richness and the abundance in relation to the vegetation and associated landscapes (Öckinger and Smith 2006; Öckinger et al., 2006; Mutmainnah and Santosa 2019). In this context, the diversity of butterflies in the Tipeswar Wildlife Sanctuary, Maharashtra, India was studied during Dec. 2017 to 30 Nov. 2018. Varieties of plant species of this dry deciduous forest and seasonal variation in floral composition of this protected area attract varieties of species of butterfly. The earlier studies showed that heterogeneity of the habitats in terms of the available plant species supports the rich butterfly diversity (Kuussaari et al., 2007; Mukherjee et al., 2015). Butterfly diversity even in the agricultural landscape contrast to the urban and suburban regions show that the richness increased with the availability of the green space and the heterogeneity of the habitats in terms of the available plant species (Öckinger et al., 2009; Mukherjee et al., 2015).

Consistent with these studies the present observation records a total of 97 species belonging to five families. It was observed that the family Nymphalidae represented by 18 genera and 33 species was the most dominant followed by Lycaenidae (23 genera, 27 species), Pieridae (10 genera, 19 species), Hesperidae (10 genera, 11 species), and Papilionidae (3 genera, 7 species). The maximum number of butterfly species was recorded under family Nymphalidae and Lycaenidae followed by Pieridae, Hesperidae and Papilionidae. Relative dominance of butterfly species studied is, 19.58 % species was categorized as abundant whereas 44.32 % species as common, 12.37 % species as frequent, 15.46 % as occasional, and 8.24 % species was rare.

Out of these 97 butterfly species studied, 15 species specified under Indian Wildlife (Protection) Act, 1972 were encountered in good numbers. The butterflies *Pachliopta hector*, *Castalius rosimon* and *Virachola isocrates* are placed in Schedule I Part IV, the species *Appias albino*, *Cepora nerissa*, *Hypolimnas misippus*, *Polyura athamas*, *Charaxes bernardus*, *Anthene lycaenina*, *Charaxes solon*, *Euchrysops cnejus*, *Lampides boeticus*. *Prosotas dubiosa* and *Tajuria cippus* are protected under Schedule II Part II, while *Baoris farri* is categorized as Schedule IV. It is observed that the species diversity and its abundance is high from monsoon to early winter and decline from early summer onwards due to the reduction in moisture and scarcity of host plant species. Temperature and relative humidity are the important factors in distribution and assemblage of butterfly species (Gupta et al., 2019).

Observations on the monthly variations of butterfly encounters indicates that population is high in monsoon months and declining towards summer while diversity is at peak from August to December while a low from January to May. The present observations remain consistent with the records and views of the butterfly species in different parts of the world (Wilson et al., 2004; Tiple et al., 2006; Sodhi et al., 2010; Tiple 2018). The butterfly species observed in the present study remained similar to the available observations on the species in different parts of India bearing similar landscape patterns (Roy et al., 2012; Harsh 2014; Saikia 2014; Mukherjee et al., 2015). Dominance of the butterflies of the family Nymphalidae as revealed through the present study is similar to that observed in other parts of the country (Mutmainnah and Santosa 2019).

In parity with the species diversity observed in Tipeswar Wildlife Sanctuary, Maharashtra, India, it may be assumed that the butterflies play diverse functional roles for the sustenance of the ecosystems. The richness in species composition in study area was also prominent in present investigation. The availability of the vegetation, seasonal wetland and allied factors render stability to the butterfly population and assemblages in the landscapes are possibly important contributors to the observed variations in the butterfly species. The present diversity study is confined to a limited area and selected habitats. There is, in the future, a chance of more species being reported because of few pockets and habitats in the studied area requiring more extensive exploration.

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