Assessment of Butterfly Diversity of a Tropical Forest Division of Maharashtra, India

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ABSTRACT

A study was conducted to estimate the butterfly diversity in the Pandharkawada Forest Division of Maharashtra, India. The study revealed presence of 103 species of butterflies belong to 5 family dominated by family Nymphalidae (34.95 %), Lycaenidae (27.18 %) followed by Pieridae (18.45 %), Hesperiidae (12.62 %) and Papilionidae (6.80 %). On the basis of Occurrence of species in study area 28.155 % species was categorized as abundant species whereas 36.89 % species was common, 11.65 % species was frequent, 18.44 % was occasional, and 4.85 % species was rare. On the basis of level of protection provided by Indian Wildlife Protection Act, 1972, 16 species recorded from study area belong to different Schedules of this act of which 3 species are in schedule 1. 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 the nectar and changes in temperature and humidity of the habitats concerned. The results of the study prove that the Pandharkawada forest division, Maharashtra has a healthy environmental setup that accommodates rich butterfly diversity.

KEY WORDS: ABUNDANCE, BUTTERFLY, DIVERSITY, OCCURRENCE, PANDHARKAWADA.

INTRODUCTION

Pandharkawada forest division is situated in Yavatmal District of Indian state of Maharashtra. This area lies at south eastern part of the district, located between the geographical confines of east longitude $78^0 14'$ and $79^0 13'$ East and $19^0 45'$ and $20^0 20'$ North, spread over the area of 655.336 sq. km. 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). Area constitutes honey comb pattern with compact patches of vegetation, meadows, open-scrubs, waterbodies and seasonal wetlands intersperse with agriculture. These varied ecosystems show great utility for conservation of biological diversity. Varied habitats and seasonal variation in floral composition of this dry deciduous forest attract verities of insect species. The diversity of insects plays an important role in the terrestrial and aquatic ecosystems by providing ecosystem services such as pollination, pest control, nutrient decomposition, and maintenance of ecosystem (Koh and Sodhi 2004; Losey and Vaughan 2006). Among insects, butterflies are the most attractive elements of the universe. They perform prominent roles in pollination (Tiple et al., 2006; Tiple 2018).

Adult butterflies are dependent on nectar and pollen as their food while the caterpillars are dependent on specific host plants for foliage (Nimbalkar et al., 2011), this facilitate pollination. Butterflies are considered as the best indicators of the health of any kind of ecosystem. They bear a history of long-term co-evolution with plants. (Thomas 2005; Bonebrake et al., 2010). Butterflies are therefore treated as an important model group to study ecology of any landscape and its conservation status (Watt and Boggs 2003; Ehrlich and Hanski 2004; Mukherjee et al., 2015). Temperature and relative humidity are the important factors in distribution and assemblage of Butterfly species (Gupta et al., 2019)

Many butterfly species are vulnerable due to the habitat loss caused by modern agricultural practices and urbanisation, other major negative impacts are due to the widely increasing global environmental change. In the view of this changing scenario to ensure essential ecosystem services rendered by butterflies, it is essential to document these ecologically important vividly hued winged beauties. This study is design to estimation butterfly diversity in the Pandharkawada forest division, Maharashtra, India. This will work as biological instrument in devising sustainable conservation strategies for these beautiful creatures and to understand their role in maintaining ecological dynamics of this landscape.

MATERIAL AND METHODS

Study Area: Study was conducted at Shibla Forest (canopy covered with associated grassy belts), Gopalpur Nursery (Forest Nursery), Shindola Forest (Scrub with Sandy Soil), Nilgiri Ban (Eco-Park), Saykheda (Water Reservoir and Seasonal Wetland). Ecological conditions are as every study sight is different than other.

Survey method: The butterflies were observed and photographed in the sampling sites for a period of 1 year between January 2019 and December 2019. 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/Study site from morning 8 AM to afternoon 11 AM during good weather periods.

Species identification: After detection, a specimen was photographed (Nikon D7100; 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=Ni × 100/Nt] where, Ni is number of individuals of species and Nt is total number of individuals all species (Basavarajappa 2006; Joshi 2014). Relative

Occurrence (RO) of family was calculated as [RO= Ns × 100/Nt] where, Ns is number of species of each family and Nt is total number of all species (Basavarajappa 2006; Joshi 2014). Mean percent occurrence (M%) for month was calculated as [M% = Nm × 100 /Nt] where, Nm is number of individuals in each month and Nt is total number of individuals during complete study tenure (Basavarajappa 2006; Joshi and Tantarpale 2016). The mean values of the pooled species occurrence data were used to calculate the monthly diversity and to categorize the local status of species.

The diversity assessment enabled highlighting the observed species richness pattern of the butterfly species. The diversity indices were quantified with the help of PAST Version 1.60 software (Palaeontological Asso., Norway; Hammer et al., 2001). The species diversity was calculated using Shannon diversity index that calculated as $[H' = - \sum_{i=1}^{R} Pi \log Pi]$, where Pi is proportion of the first species which is given by $Pi= ni/N$ (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= N1/N0] where N1 is Number of abundant species in the sample and N0 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 analysed 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, 103 butterfly species under five families were recorded in study area (Table 1). Based on value of butterfly relative dominance in study area, 28.155 % species was categorized as abundant species whereas 36.89 % species was common, 11.65 % species was frequent, 18.44 % was occasional, and 4.85 % species was rare (Figure 1). The maximum number of butterfly species were recorded under family Nymphalidae (34.95 %), Lycaenidae (27.18 %) followed by Pieridae (18.45 %), Hesperiidae (12.62 %) and Papilionidae (6.80 %) (Figure 2).

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 changes in temperature and humidity of the habitats concerned

Mean percent abundance of butterflies was significantly different (F = 145.5, df = 11, p < 0.05); Shannon diversity values of butterflies were significantly different (F= 189.2, df = 11, p < 0.05); species evenness among different months was significantly different (F= 196.3, df = 11, p < 0.05) while species richness among the study months was significantly different (F = 188.3, df = 11, p < 0.05). A trend in mean % abundance, Shannon diversity, species richness and species equitability showed the contradictory patterns (Figure 4).

Table 1. Diversity of Butterflies during January 2019 to December 2019 in the Pandharkawada Forest Division, Maharashtra, India

Common Name	Scientific Name	Relative Dominance	Local Status	IUCN Status	WPA Status
Family: Papilionidae					
Tailed Jay	*Graphium agamemnon* (Linnaeus, 1758)	1.163	Common	NE	
Common Jay	*Graphium doson* (Felder and Felder, 1864)	1.098	Common	NE	
Common rose	*Pachliopta aristolochiae* (Fabricius, 1775)	0.994	Common	LC	
Crimson rose	*Pachliopta hector* (Linnaeus, 1758)	0.941	Common	NE	Sch.I
Lime Butterfly	*Papilio demoleus* (Linnaeus, 1758)	1.321	Abundant	NE	
Common Mormon	*Papilio polytes* (Linnaeus, 1758)	1.237	Abundant	NE	
Spot Swordtail	*Graphium nomius* (Esper, 1793)	0.599	Occasional	NE	
Family: Pieridae					
Common Albatross	*Appias albino* (Fabricius, 1775)	1.039	Common	NE	Sch.II
Indian Pioneer	*Belenois aurota* (Fabricius, 1793)	1.407	Abundant	NE	
Common Emigrant	*Catopsilia pomona* (Fabricius, 1775)	1.220	Abundant	NE	
Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus, 1758)	0.920	Common	NE	
Common Gull	*Cepora nerissa* (Fabricius, 1775)	1.368	Abundant	NE	Sch.II
Small salmon Arab	*Colotis amata* (Butler, 1870)	0.604	Occasional	NE	
Large Salmon Arab	*Colotis fausta* (Olivier, 1804)	0.531	Occasional	NE	
Crimson Tip	*Colotis danae* (Fabricius, 1775)	0.578	Occasional	NE	
Small Orange Tip	*Colotis etrida* (Boisduval, 1836)	1.051	Common	NE	
White Orange Tip	*Ixias Marianne* (Cramer, 1775)	1.024	Common	NE	
Yellow Orange Tip	*Ixias pyrene* (Linnaeus, 1764)	0.712	Occasional	NE	
Common Jezebel	*Delias eucharis* (Drury, 1773)	1.114	Common	NE	
One Spot Grass Yellow	*Eurema andersoni* (Moore, 1865)	1.148	Common	LC	
Three Spot Grass Yellow	*Eurema blanda* (Boisduval, 1836)	1.003	Common	NE	
Small Grass Yellow	*Eurema brigitta* (Stoll, 1780)	1.131	Common	LC	
Common Grass Yellow	*Eurema hecabe* (Linnaeus, 1758)	1.294	Abundant	NE	
Spotless Grass Yellow	*Eurema laeta* (Boisduval, 1836)	1.359	Abundant	NE	
Psyche	*Leptosia nina* (Fabricius, 1793)	0.703	Occasional	NE	
Common Wanderer	*Pareronia valeria* (Cramer, 1776)	1.116	Common	NE	
Family: Nymphalidae					
Tawny Castor	*Acraea violae* (Fabricius, 1775)	0.976	Common	NE	
Angled Castor	*Ariadne ariadne* (Linnaeus, 1763)	1.157	Common	NE	
Common Castor	*Ariadne merione* (Cramer, 1779)	1.077	Common	NE	
Common Sergeant	*Athyma perius* (Linnaeus, 1763)	0.502	Occasional	NE	
Plain Tiger	*Danaus chrysippus* (Linnaeus,1758)	1.389	Abundant	NE	
Striped Tiger	*Danaus genutia* (Cramer, 1779)	1.270	Abundant	NE	
Common Crow	*Euploea core* (Cramer, 1780)	1.439	Abundant	LC	
Double Branded crow	*Euploea Sylvester* (Fabricius, 1793)	0.490	Occasional	NE	
Baronet	*Euthalia nais* (Cramer, 1779)	0.935	Common	NE	
Common Baron	*Euthalia aconthea* (Cramer, 1777)	0.304	Rare	NE	
Great Eggfly	*Hypolimnas bolina* (Linnaeus, 1758)	1.065	Common	NE	
Danaid Eggfly	*Hypolimnas misippus* (Linnaeus, 1764)	0.959	Common	NE	Sch.II
Peacock Pansy	*Junonia almana* (Linnaeus, 1758)	1.312	Abundant	LC	

Grey Pansy	*Junonia atlites* (Linnaeus, 1763)	1.056	Common	NE	
Yellow Pansy	*Junonia hierta* (Fabricius, 1775)	1.110	Common	LC	
Chocolate Pansy	*Junonia iphita* (Cramer, 1779)	0.970	Common	NE	
Lemon Pansy	*Junonia lemonias* (Linnaeus, 1758)	1.184	Abundant	NE	
Blue Pansy	*Junonia orithya* (Linnaeus, 1764)	1.418	Abundant	NE	
Common Evening Brown	*Melanitis leda* (Linnaeus, 1758)	1.249	Abundant	NE	
Dark Evening Brown	*Melanitis phedima* (Cramer, 1780)	0.724	Occasional	NE	
Common Bush Brown	*Mycalesis perseus* (Fabricius, 1775)	0.947	Common	NE	
Dark Brand Bush Brown	*Mycalesis mineus* (Linnaeus, 1758)	0.788	Frequent	NE	
Common Sailer	*Neptis hylas* (Linnaeus, 1764)	0.929	Common	NE	
Common Leopard	*Phalanta phalantha* (Drury, 1773)	1.032	Common	LC	
Blue Tiger	*Tirumala limniace* (Cramer, 1775)	1.213	Abundant	NE	
Commander	*Moduza procris* (Cramer, 1777)	1.140	Common	NE	
Painted Lady	*Synthia cardui* (Linnaeus, 1764)	0.911	Common	NE	
Joker	*Byblia ilithyia* (Drury, 1773)	0.902	Common	NE	
Common Three Ring	*Ypthima asterope* (Klug, 1832)	1.143	Common	NE	
Large Three Ring	*Ypthima nareda* (Kirby, 1871)	0.831	Frequent	LC	
Common Four Ring	*Ypthima huebneri* (Kirby, 1871)	0.782	Frequent	LC	
Common Five Ring	*Ypthima baldus* (Fabricius, 1793)	0.791	Frequent	NE	
Anomalous Nawab	*Polyura agrarian* (Linnaeus, 1764)	0.674	Occasional	NE	
Common Nawab	*Polyura athamas* (Drury, 1773)	0.481	Occasional	NE	Sch.II
Black Rajah	*Charaxes solon* (Fabricius, 1793)	0.546	Occasional	NE	Sch.II
Towny Rajah	*Charaxes bernardus* (Fabricius, 1793)	0.680	Occasional	NE	Sch.II
Family: Lycaenidae					
Pointed Ciliate Blue	*Anthene lycaenina* (C. Felder, 1868)	0.758	Frequent	NE	Sch.II
Large Oak Blue	*Arphopala amantes* (Hewitson, 1862)	0.368	Rare	NE	
Dull Babool Blue	*Azanus uranus* (Butler, 1886)	0.795	Frequent	NE	
Bright Babool Blue	*Azanus ubaldus* (Stoll, 1782)	1.023	Common	NE	
Lime Blue	*Chilades lajus* (Stoll, 1780)	1.430	Abundant	NE	
Gram Blue	*Euchrysops cnejus* (Fabricius, 1798)	1.199	Abundant	NE	Sch.II
Pea Blue	*Lampides boeticus* (Linnaeus, 1767)	1.229	Abundant	NE	Sch.II
Zebra Blue	*Leptotes plinius* (Fabricius, 1793)	1.377	Abundant	NE	
Dingy Line Blue	*Petrelaea dana* (de Niceville, 1884)	1.033	Common	NE	
Tailless Line Blue	*Prosotas dubiosa* (Semper, 1879)	1.018	Common	NE	Sch.II
Common Line Blue	*Prosotas nora* (Felder, 1860)	1.125	Common	NE	
Guava Blue	*Virachola isocrates* (fabricius, 1793)	0.659	Occasional	NE	Sch.I
Dark Grass Blue	*Zizeeria karsandra* (Moore, 1865)	1.258	Abundant	NE	
Lesser Grass Blue	*Zizina otis* (Fabricius, 1787)	1.181	Abundant	NE	
Tiny Grass Blue	*Zizula hylax* (Fabricius, 1775)	1.318	Abundant	NE	
Plum Judy	*Abisara echerius* (Moore, 1901)	0.688	Occasional	NE	
Common Pierrot	*Castalius rosimon* (Fabricius, 1775)	0.786	Frequent	NE	Sch.I
Forget-Me-Not	*Catochrysops strabo* (Fabricius, 1793)	1.282	Abundant	NE	
Plains Cupid	*Luthrodes pandava* (Horsfield, 1829)	0.864	Frequent	NE	
Indian cupid	*Cupido lacturnus* (Godart, 1824)	0.985	Common	NE	
Grass Jewel	*Freyeria trochylus* (Freyer, 1845)	1.344	Abundant	NE	
Common Cerulean	*Jamides celeno* (Cramer, 1775)	1.359	Abundant	NE	
Indian Red Flash	*Rapala airbus* (Fabricius, 1787)	0.305	Rare	NE	
Slate Flash	*Rapala manea* (Hewitson, 1863)	0.229	Rare	NE	
Common Silverline	*Spindasis vulcanus* (Fabricius, 1775)	0.755	Frequent	NE	
Common Shot Silverline	*Spindasis ictis* (Hewitson, 1865)	0.567	Occasional	NE	
Rounded Pierrot	*Tarucus extricates* (Kollar, 1848)	1.175	Abundant	NE	
Peacock Royal	*Tajuria cippus* (Fabricius, 1775)	0.163	Rare	NE	Sch.II
Family: Hespiridae					
Brown awl	*Badamia exclamationis* (Fabricius, 1775)	1.338	Abundant	LC	
Plain Banded Awl	*Hasora vita* (Cramer, 1780)	0.792	Frequent	NE	SchIV

Bevan's Swift	*Borbo bevani* (Moore, 1878)	0.534	Occasional	NE	
Rice swift	*Borbo cinnara* (Wallace, 1866)	1.427	Abundant	NE	
Blank Swift	*Caltoris kumara* (Moore, 1878)	0.543	Occasional	NE	
Small branded swift	*Pelopidas mathias* (Fabricius,1798)	1.226	Abundant	NE	
Conjoined Swift	*Pelopidas conjuncta* (Moore, 1878)	0.878	Common	NE	
Paintbrush Swift	*Baoris farri* (Moore, 1878)	0.810	Frequent	NE	SchIV
Common Straight Swift	*Parnara guttatus* (Bremer and Gray, 1853)	1.104	Common	LC	
Indian Palm bob	*Suastus gremius* (Fabricius, 1798)	0.896	Common	NE	
Dark Palm-Dart	*Telicota ancilla* (Moore, 1878)	1.045	Common	NE	
Indian skipper	*Spialia galba* (Fabricius, 1793)	0.751	Frequent	LC	
Grass Demon	*Udaspes folus* (Cramer, 1775)	0.635	Occasional	NE	

Rare Species recorded from Pandharkawada Forest Division

Peacock Royal   Red Flash   Common Baron   Large Oak Blue   Slate Flash
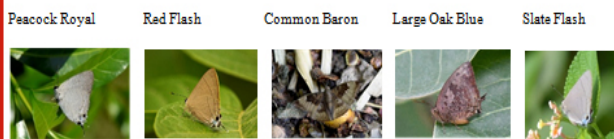
Schedule I Species recorded from Pandharkawada Forest Division

Crimson Tip   Guava Blue   Common Pierrot
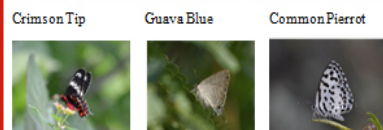
Figure 1: Relative occurrence of butterfly Species in Pandharkawada forest division
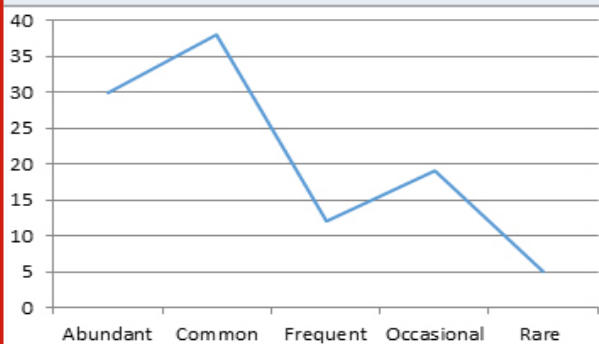
Abundant- 29 (28.155%), Common-38 (36.89%), Frequent-12 (11.65%), Occasional-19 (18.44%), Rare- 05 (4.85%)

Figure 2: Relative dominance of butterfly families in the Pandharkawada forest division, Maharashtra, India
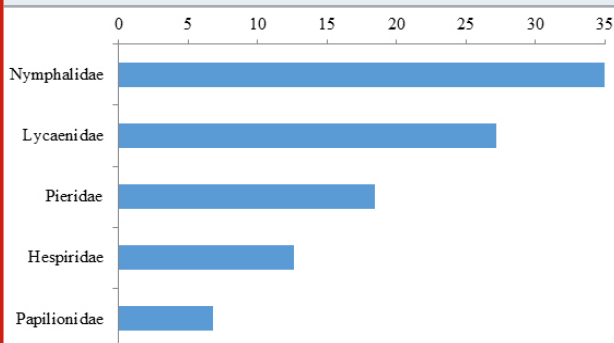
Figure 3: Dendrogram showing similarity in number of butterfly species composition among the studied month during January 2019 to December 2019
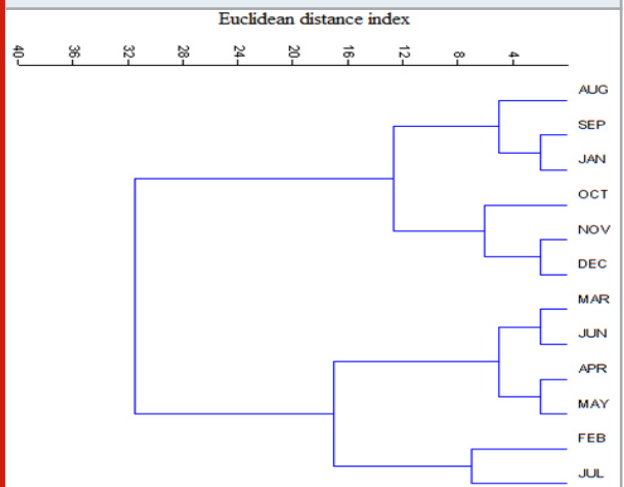
Figure 4: The values of the diversity indices in different months observed through the random sampling of butterflies in the Pandharkawada forest division, Maharashtra, India
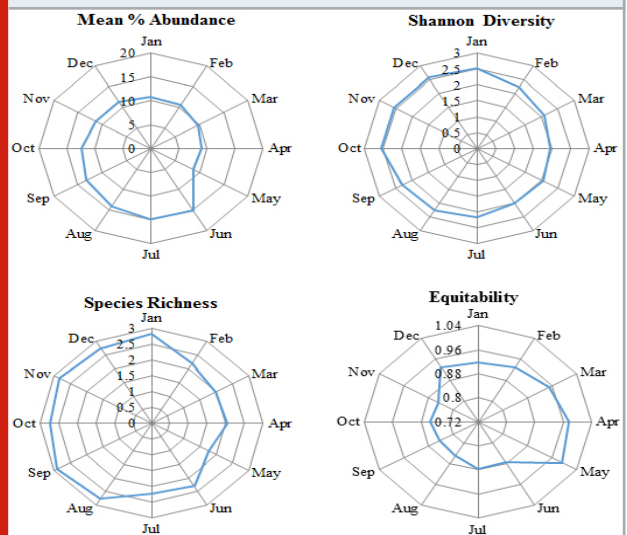
The butterflies are the ecologically important creature that serves as indicators of environmental conditions (Stefanescu et al., 2004). Observations on the butterfly

diversity provide the information about variations in the species richness and the abundance in relation with the vegetation along the landscape and the species interactions (Öckinger and Smith 2006; Öckinger et al 2006; Mutmainnah and Santosa 2019). In this context, the diversity of Butterflies in the Pandharkawada forest division, Maharashtra, India was studied during January 2019 to December 2019. The study area was dominated by the dense vegetation with variety of plant species that host the butterfly populations. 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).

Studies on the butterfly diversity in the forest 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 103 species belonging to five families from study area.The maximum number of butterfly species was recorded under family Nymphalidae, Lycaenidae followed by Pieridae, Hesperiidae and Papilionidae. Among these 103 species Based on value of butterfly relative dominance in study area, 28.155 % species was categorized as abundant species whereas 36.89 % species was common, 11.65 % species was frequent, 18.44 % was occasional, and 4.85 % species was rare. The rare species recorded are *Rapala airbus Rapala manea Tajuria cippus Euthalia aconthea Arphopala amantes.*

Out of these 103 butterfly species, 16 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 *Hasora* vita and *Baoris farri* are categorized as Schedule IV. It is established that the butterfly abundance increased in monsoon as population is at its peak in June and July. It decreased in the summer and pre-monsoon possibly due to the unavailability of nectar and the changes in temperature and humidity of the habitats concerned, as 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 species encounter indicates peak from August to November and December while 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 number of species observed in the present study remained similar to the 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). As revealed through the present study, 103 butterfly species are available in different numbers across the study area. Dominance of the butterflies of the family Nymphalidae is similar to that observed in other parts of the world (Mutmainnah and Santosa 2019).

In parity with the species diversity observed in Pandharkawada Forest Division, 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 wetlands and allied factors render stability to the butterfly population and assemblages in the landscapes, these are possibly important contributors to the observed variations in the butterfly species recorded in the present study. The observations on the diversity of the butterflies in the study area suggested that the intensive conservation management is required to ensure sustenance of ecosystem services derived from the butterflies. The present diversity study was 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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