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Seasonal Variations in the Diversity and Abundance of Butterflies in the Forest of Champaner-Pavagadh, Gujarat

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ABSTRACT

Butterflies are one of the most potent pollinators and ecological indicators existing today. Their presence indicate the health of an ecosystem. Thus a research work was conducted in the forest area of Champaner-Pavagadh to study the diversity, abundance and seasonal distribution of butterflies. Champaner - Pavagadh is a UNESCO recognized world heritage site which attracts number of pilgrims and tourists throughout the year. Pavagadh hill comprises forest vegetation with different types of flowering plants. A total of 52 butterfly species belonging to 5 different families namely Nymphalidae, Pieridae, Papilionidae, Lycaenidae and Hesperidae were recorded during the study period July 2016 to June 2018. Maximum diversity of species were observed in Nymphalidae and Pieridae. Least diversity of species was observed in Hesperidae. The maximum favorable season for flourishing of butterflies were post-monsoon and the post-monsoon season includes months of September, October and November because of the frequent

rains received during monsoon period promotes the growth of the flowering plants which provide nectar resource for the butterflies. Some butterflies such as *Catopsilia pomona*, *Catopsilia pyranthe*, *Eurema brigitta*, *Delias eucharis*, *Belenois aurota*, *Ixias marianne*, *Acraea terpsicore*, *Ariadne merione*, *Danaus chrysippus*, *Hypolimnas misippus*, *Euchrysops cnejus* were existed throughout the year while species like *Curetis thetis*, *Hasora chromus*, *Pelopidas mathias*, *Telicota bambusae*, *Colotis danae* were observed only during post-monsoon and winter seasons.

Keywords Butterfly, Diversity, Pavagadh, Seasonal variation.

INTRODUCTION

Butterflies are one of the most fascinating insects belonging to the order Lepidoptera. Members of this group are attracted by their peculiar coloration and beauty. Approximately 17, 200 species of butterflies have been reported worldwide and out of which 1,501 species of them are inhabiting in India (Kunte 2000). Adults and larvae of butterflies depend on specific host plants for foliage, nectar and pollens. The occurrence of butterflies is seasonal and their appearance become common for only a few months and remain rare or absent for rest of the year. They become rare or inactive as adults and usually spend their life either as caterpillar or pupae during unfavorable seasons.

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Seasonal changes are influenced by ecological and biological factors such as temperature, humidity, rainfall, photoperiod, availability of food plants and larval host plants.

Champaner-Pavagadh is a very good site for studying the diversity of the butterflies because it is an undisturbed unique area comprising a large number of floristic elements. The major plant species found in the forest area includes *Annona squamosa*, *Ficus benghalensis*, *Pongamia pinnata*, *Tamarindus indica*, *Mangifera indica*, *Wrightia tinctoria*, *Cassia fistula*, *Lantana camara*, *Ziziphus mauritiana*, *Calotropis procera*, which act as excellent nectar resources as well as larval host plants in the forest area.

Diversity of butterflies in a habitat highly depends upon the flora diversity of that area (Sharma 2014). The richness of biodiversity is directly proportional to the climatic conditions of that area. Details of biodiversity is a measure to explain the diversity in the existing organisms of that area. Butterflies are good indicators of environmental changes as they are sensitive and are directly affected by changes in habitats, atmosphere temperature and the weather conditions (Kunte 1997). Butterflies play an important role in pollinating flowers and most of the agricultural crops. The abundance of butterflies usually indicates a healthier ecosystem (Fernandes et al. 2016) due to the fact that butterflies are an important component of a food chain. Since no work was done in this area on the butterfly diversity, this study was taken up for a period of two years. Hence the objective of this research work is to study the seasonal variations in the diversity and abundance of butterflies in the Champaner-Pavagadh Archaeological Park, Gujarat.

MATERIALS AND METHODS

Study area

The study was carried out in Champaner - Pavagadh Archaeological Park. It is 53 km North-East of Vadodara situated in Panchmahal district of Gujarat. It spreads over an area of more than 1,329 hectares which includes Pavagadh hill, garden, various monuments, agricultural fields, temples, mosques,

palaces. Pavagadh hill has a height of 820 m which is surrounded by dense forest having a large number of trees, shrubs, herbs, grasses and climbers. At the base of the hill there is the presence of a public garden which is a place of tourist attraction.

Considering the floral diversity and uniqueness of the forest area, it is identified and selected for studying the seasonal variations, diversity and abundance of butterflies. Forest area covers the base of the hill and extends up to the top of Pavagadh hill. It is a dry deciduous forest having different types of vegetation which attract a large number of butterflies there. Data collected from forest area presented in this study were restricted to the elevation of 413 m only.

Sampling protocol

Pollard walk

A systematic approach was followed to monitor the diversity of butterflies in the study area. Butterflies were sampled following Pollard walk method (Pollard and Yates 1993) on fixed paths in different habitats covering all the seasons from July 2016 to June 2018. The length of transect varied from 500 m to 1000 m depending on the length of the study site and 5 m on either side is covered in an hour walking at a constant pace. Counts were made twice in a month for both the area of study. The observations were made from 08 : 00 AM to 12 Noon because it is the peak time for the butterfly activities. Butterfly species were identified directly in the field or in difficult cases following photography and identification with the help of field guides. No capture or collection of specimens were made during the entire study period.

Photography

The best time for photographing butterflies is soon after sunrise when they come out for basking. In this research butterflies were photographed with the help of camera, Canon EOS 750 D.

Identification

Identification of butterflies were done with the help

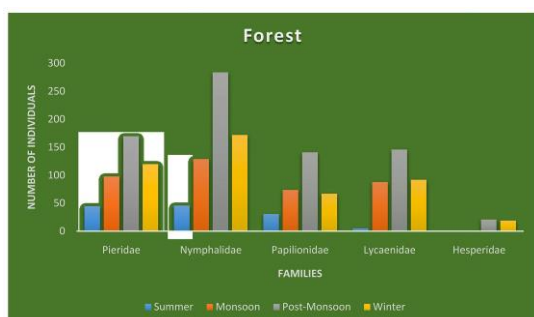


Fig. 1. Graphical representation of seasonal variation of butterfly families in Champaner - Pavagadh.

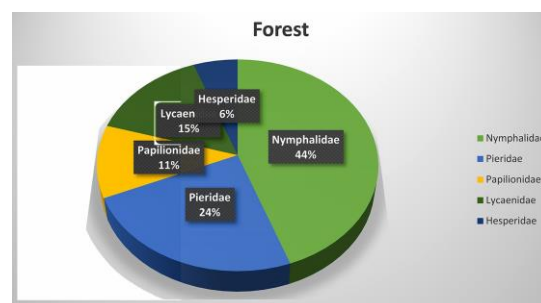


Fig. 2. Percentage - wise distribution of butterfly families at forest.

of identification books (Bhakare and Ogale 2018, Smetacek 2016).

Seasonal bifurcation

For the convenience of data collection and interpretation the whole year were divided into four seasons namely Summer, Monsoon, Post-Monsoon and Winter (Figs. 1 and 2), (Table 1).

Sampling of butterflies

The observed butterflies were categorized into 5 categories on the basis of their abundance in the study area. VC-Very Common (Above 75 sightings), C-Common (75–50 sightings), NR-Not Rare (50–25 sightings), R-Rare (25–10 sightings) and Very Rare (Below 10 sightings). This categorization of butterflies is completely depending on the local availability of them.

Statistical analysis

To analyse the seasonal diversity of the selected hab-

Table 1. Seasons with respect to months.

Sl. No.	Seasons	Months
1	Summer	March, April and May
2	Monsoon (Rainy)	June, July and August
3	Post-monsoon	September, October and November
4	Winter	December, January and February

itat, diversity indices were calculated using statistical software PAST.3.exe. The diversity indices such as Shannon–Weiner and Simpson diversity indices, Evenness Index for the butterfly diversity for different seasons were calculated. Shannon–Weiner Index measures the number of species within a habitat relative abundance of each species, whereas Simpson’s diversity Index is a measure of diversity which takes into account the number of species present as well as the relative abundance of each species. Pielou’s Evenness Index was calculated, it states the evenness of the individuals which are distributed among the different species.

RESULTS AND DISCUSSION

A total of 52 butterfly species belonging to 5 families were recorded from the forest area of Champaner - Pavagadh. Tables 2 and 3 depicts the list of butterflies identified from the study area with their seasonal occurrence. The result of the present study shows that post-monsoon season is the most appropriate time and summer season is the least preferred season for the flourishing of butterflies. The maximum species diversity was observed during post-monsoon season

followed by monsoon season and winter season and least diversity of species was observed during summer season. The butterfly population showed highest population sightings during the months from August to November and butterflies population showed a decline from the month of February and reached to the bottom level during March to April. Most of the butterflies were encountered during monsoon and post-monsoon seasons because of the frequent rains which promote the growth of vegetation. Butterflies

Table 2. Season wise availability of butterflies in forest. ** S stands for summer season, M stands for monsoon season, PM stands for post-monsoon season and W stands for winter season. + sign represents presence and – sign represents absence of butterfly species.

Sl. No.	Common name	Scientific name	S	Seasons			W
				M	PM		
Family : Pieridae							
1	Common Emigrant	<i>Catopsilia pomona</i> Fabricius, 1775	+	+	+		+
2	Mottled Emigrant	<i>Catopsilia pyranthe</i> Latreille, 1758	+	+	+		+
3	Small Grass Yellow	<i>Eurema brigitta</i> Stoll, 1780	+	+	+		+
4	Common Grass Yellow	<i>Eurema hecabe</i> Linnaeus, 1758	+	+	+		+
5	Common Jezebel	<i>Delias eucharis</i> Drury, 1773	+	+	+		+
6	Common Gull	<i>Cepora nerissa</i> Fabricius, 1775	+	+	+		+
7	Pioneer	<i>Belenois aurota</i> Fabricius, 1793	+	+	+		+
8	White Orange Tip	<i>Ixias marianne</i> Cramer, 1779	+	+	+		+
9	Yellow Orange Tip	<i>Ixias pyrene</i> Linnaeus, 1764	+	+	+		+
10	Crimson Tip	<i>Colotis danae</i> Fabricius, 1775	—	—	+		+
11	Small Samon Arab	<i>Colotisamata</i> Fabricius, 1775	—	+	+		+
12	Common Wanderer	<i>Pareronia hippia</i> Fabricius, 1787	—	+	+		+
13	Psyche	<i>Leptosia nina</i> Fabricius, 1793	—	+	+		+
Family : Nymphalidae							
14	Tawny Coster	<i>Acraea terpsicore</i> Linnaeus, 1758	+	+	+		+
15	Common Castor	<i>Ariadne merione</i> Cramer, 1777	+	+	+		+
16	Black Rajah	<i>Charaxes solon</i> Fabricius, 1793	—	+	+		+
17	Painted Lady	<i>Vanessa cardui</i> Linnaeus, 1758	+	+	+		+
18	Plain Tiger	<i>Danaus chrysippus</i> Linnaeus, 1758	+	+	+		+
19	Striped Tiger	<i>Danaus genutia</i> Cramer, 1779	+	+	+		+
20	Common Indian Crow	<i>Euploea core</i> Cramer, 1780	—	+	+		+
21	Common Baron	<i>Euthalia aconthea</i> Cramer, 1777	—	+	+		+
22	Great Eggfly	<i>Hypolimnas bolina</i> Linnaeus, 1758	+	+	+		+
23	Danaid Eggfly	<i>Hypolimnas misippus</i> Linnaeus, 1764	+	+	+		+
24	Peacock Pansy	<i>Junonia almanac</i> Linnaeus, 1758	+	+	+		+
25	Grey Pansy	<i>Junonia atlites</i> Linnaeus, 1763	+	+	+		+
26	Yellow Pansy	<i>Junonia hierta</i> Fabricius, 1798	+	+	+		+
27	Chocolate Pansy	<i>Junonia iphita</i> Cramer, 1779	+	+	+		+
28	Lemon Pansy	<i>Junonia lemonias</i> Linnaeus, 1758	+	+	+		+
29	Common Evening Brown	<i>Melanitis leda</i> Linnaeus, 1758	+	+	+		+
30	Common Bushbrown	<i>Mycalesis perseus</i> Fabricius, 1775	+	+	+		+
31	Common Sailer	<i>Neptis hylas</i> Linnaeus, 1758	—	+	+		+
32	Glassy Tiger	<i>Parantica aglea</i> Stoll, 1782	+	+	+		+
33	Common Leopard	<i>Phalanta phalantha</i> Drury, 1773	—	+	+		+
34	Baronet	<i>Symphaedra nais</i> Forster, 1771	—	+	+		+
35	Blue Tiger	<i>Tirumala limniace</i> Cramer, 1775	+	+	+		+
Family : Lycaenidae							
36	Common Pierrot	<i>Castalius rosimon</i> Fabricius, 1775	—	+	+		+
37	Lime Blue	<i>Chilades lajus</i> Stoll, 1780	—	+	+		+
38	Indian Sunbeam	<i>Curetis thetis</i> Drury, 1773	—	—	+		+
39	Gram Blue	<i>Euchrysops cnejus</i> Fabricius, 1798	+	+	+		+
40	Common Silverline	<i>Spindasis vulcanus</i> Fabricius, 1775	—	+	+		+
41	Dark Grass Blue	<i>Zizeeria karsandra</i> Moore, 1865	—	+	+		+
42	Lesser Grass Blue	<i>Zizina otis</i> Fabricius, 1787	—	+	+		+
43	Tiny Grass Blue	<i>Zizula hylax</i> Fabricius, 1775	—	+	+		+

Table 2. Continued.

Sl. No.	Common name	Scientific name	S	Seasons		
				M	PM	W
Family : Papilionidae						
44	Common Jay	<i>Graphium doson</i> Felder & Felder, 1864	+	+	+	+
45	Tailed Jay	<i>Graphium agamemnon</i> Linnaeus, 1758	+	+	+	+
46	Common Rose	<i>Pachliopta aristolochiae</i> Fabricius, 1775	+	+	+	+
47	Crimson Rose	<i>Pachliopta hector</i> Linnaeus, 1758	+	+	+	+
48	Common Mormon	<i>Papilio polytes</i> Linnaeus, 1758	+	+	+	+
49	Lime Butterfly	<i>Papilio demoleus</i> Linnaeus, 1758	+	+	+	+
Family : Hesperidae						
50	Common Banded Awl	<i>Hasora chromus</i> Cramer, 1780	–	–	+	+
51	Rice Swift	<i>Pelopidas mathias</i> Fabricius, 1798	–	–	+	+
52	Dark Palm Dart	<i>Telicota bambusae</i> Moore, 1878	–	–	+	+

show a seasonal trend in their presence in all habitats. Family Nymphalidae has got the maximum diverse species of butterflies.

During summer months majority of the forest area becomes dry which keeps most of the butterflies away from feeding. Herbs and shrubs start their life cycle in the beginning of the monsoon and complete it by the end of the post-monsoon season.

Pavagadh is a hilly area belonging to the Panchmahal District of Gujarat. It is a dry deciduous forest

receives annual rainfall from June to September. The maximum temperature experienced during summer months which induced the land become dried up and thereby most of the nectar and larval host plants disappeared. Hence the number of butterflies observed during summer season were less compared to other seasons such as pre-monsoon, monsoon and winter. When it starts receiving monsoon the disappeared plants start reappearing. Maximum rainfall of this season received were during August which was a boon to the entire habitat. After the monsoon the quantity and quality of the vegetation increases. Rainfall influences

Table 3. Abundance of butterflies in forest. **VC-Very Common (> 75), C-Common (75-50 sightings), NR-Not Rare (50-25 sightings), R-Rare (25-10 sightings) and Very Rare (<10 sightings) **VC-Very Common (> 75 sightings), C-Common (75-50 sightings), NR-Not Rare (50-25 sightings), R-Rare (25-10 sightings) and Very Rare (< 10 sightings).

Sl. No.	Common name	Scientific name	Abundance
Family : Papilionidae			
1	Common Jay	<i>Graphium doson</i> Felder & Felder, 1864	VC
2	Tailed Jay	<i>Graphium agamemnon</i> Linnaeus, 1758	VC
3	Common Rose	<i>Pachliopta aristolochiae</i> Fabricius, 1775	VC
4	Crimson Rose	<i>Pachliopta hector</i> Linnaeus, 1758	C
5	Common Mormon	<i>Papilio polytes</i> Linnaeus, 1758	C
6	Lime Butterfly	<i>Papilio demoleus</i> Linnaeus, 1758	C
Family : Nymphalidae			
7	Tawny Coster	<i>Acraea terpsicore</i> Linnaeus, 1758	NR
8	Common Castor	<i>Ariadne merione</i> Cramer, 1777	NR
9	Black Rajah	<i>Charaxes solon</i> Fabricius, 1793	C
10	Painted Lady	<i>Vanessa cardui</i> Linnaeus, 1758	C

Table 3. Continued.

Sl. No.	Common name	Scientific name	Abundance
9	Black Rajah	<i>Charaxes solon</i> Fabricius, 1793	C
10	Painted Lady	<i>Vanessa cardui</i> Linnaeus, 1758	C
11	Plain Tiger	<i>Danaus chrysippus</i> Linnaeus, 1758	VC
12	Striped Tiger	<i>Danaus genutia</i> Cramer, 1779	C
13	Common Indian Crow	<i>Euploea core</i> Cramer, 1780	NR
14	Common Baron	<i>Euthalia aconthea</i> Cramer, 1777	NR
15	Great Eggfly	<i>Hypolimnys bolina</i> Linnaeus, 1758	NR
16	Danaid Eggfly	<i>Hypolimnys misippus</i> Linnaeus, 1764	NR
17	Peacock Pansy	<i>Junonia almanac</i> Linnaeus, 1758	NR
18	Grey Pansy	<i>Junonia atlites</i> Linnaeus, 1763	R
19	Yellow Pansy	<i>Junonia hierta</i> Fabricius, 1798	R
20	Chocolate Pansy	<i>Junonia iphita</i> Cramer, 1779	NR
21	Lemon Pansy	<i>Junonia lemonias</i> Linnaeus, 1758	VC
22	Common Evening Brown	<i>Melanitis leda</i> Linnaeus, 1758	C
23	Common Bushbrown	<i>Mycalesis perseus</i> Fabricius, 1775	NR
24	Common Sailer	<i>Neptis hylas</i> Linnaeus, 1758	NR
25	Glassy Tiger	<i>Parantica aglea</i> Stoll, 1782	C
26	Common Leopard	<i>Phalanta phalantha</i> Drury, 1773	NR
27	Baronet	<i>Symphaedra nais</i> Forster, 1771	NR
28	Blue Tiger	<i>Tirumala limniace</i> Cramer, 1775	NR
Family : Pieridae			
29	Common Emigrant	<i>Catopsilia pomona</i> Fabricius, 1775	VC
30	Mottled Emigrant	<i>Catopsilia pyranthe</i> Latreille, 1758	C
31	Small Grass Yellow	<i>Eurema brigitta</i> Stoll, 1780	VC
32	Common Grass Yellow	<i>Eurema hecabe</i> Linnaeus, 1758	VC
33	Common Jezebel	<i>Delias eucharis</i> Drury, 1773	C
34	Common Gull	<i>Cepora nerissa</i> Fabricius, 1775	C
35	Pioneer	<i>Belenois aurota</i> Fabricius, 1793	C
36	White Orange Tip	<i>Ixias marianne</i> Cramer, 1779	C
37	Yellow Orange Tip	<i>Ixias pyrene</i> Linnaeus, 1764	C
38	Crimson Tip	<i>Colotis danae</i> Fabricius, 1775	NR
39	Small Samon Arab	<i>Colotis amata</i> Fabricius, 1775	NR
40	Common Wanderer	<i>Pareronia hippia</i> Fabricius, 1787	NR
41	Pysche	<i>Leptosia nina</i> Fabricius, 1793	NR
Family : Lycaenidae			
42	Common Pierrot	<i>Castalius rosimon</i> Fabricius, 1775	C
43	Lime Blue	<i>Chilades lajus</i> Stoll, 1780	C
44	Indian Sunbeam	<i>Curetis thetis</i> Drury, 1773	NR
45	Gram Blue	<i>Euchrysops cnejus</i> Fabricius, 1798	C
46	Common Silverline	<i>Spindasis vulcanus</i> Fabricius, 1775	C
47	Dark Grass Blue	<i>Zizeeria karsandra</i> Moore, 1865	VC
48	Lesser Grass Blue	<i>Zizina otis</i> Fabricius, 1787	VC
49	Tiny Grass Blue	<i>Zizula hylax</i> Fabricius, 1775	VC
Family : Hesperiidae			
50	Common Banded Awl	<i>Hasora chromus</i> Cramer, 1780	NR
51	Small Branded Swift	<i>Pelopidas mathias</i> Fabricius, 1798	R
52	Dark Palm Dart	<i>Telicota bambusae</i> Moore, 1878	NR

Table 4. Diversity indices of forest.

Diversity index	Sum- mer	Mon- soon	Post-	
			Mon- soon	Winter
Shannon-Weiner Index (H)	2.724	3.638	3.807	3.744
Simpsons's Index of Diversity (1—D)	0.9267	0.9692	0.9748	0.972
Pielou's Evenness Index	0.8469	0.8091	0.8655	0.8127

the area from dry deciduous to moist deciduous type for some point of time. Significant amount of rainfall makes the soil fertile and nutrient rich helping the growth of larval food plants and nectar plants. Thus highest number of butterfly species were observed during post-monsoon and monsoon seasons as compared to other seasons. A study conducted by Gandhi and Kumar (2016) at Dangs of Gujarat also found highest numbers of butterfly species were observed in post-monsoon season as compared to summer, winter, pre-monsoon and monsoon seasons which also supports that the distribution and abundance of butterflies at a locality are influenced by the rainfall condition of that region. The diversity distribution of butterflies also coincide with the rainy season of the region. A study conducted by Deepika and Sowmya (2014) indicated that there are several factors such as temperature, day length, relative humidity and total rainfall collectively influence the abundance of butterflies of different families. However, more than half of the total butterfly species were encountered during wet seasons. A similar kind of study conducted by Revathy and Mathew (2014), also find that the Shannon diversity Index and species richness were found to be higher in monsoon and post-monsoon seasons. Study conducted by Gandhi and Kumar (2016), also find that post-monsoon season is the best suitable time for the existence of butterflies. This result is also supporting the present study that maximum number of butterflies recorded during post-monsoon and monsoon seasons and during summer months the number of species observed were very less. It was noticed that some butterfly species such as Dark Grass Blue, Lesser Grass Blue, Tiny Grass Blue were completely disappeared during summer season. However some of the species like Common Emigrant, Mottled Emigrant, Small

Grass Yellow, Common Grass Yellow, Plain Tiger, Danaid Eggfly, Common Jay, Tailed Jay, Common

Rose were present throughout the year.

Butterflies exhibit seasonal variation in their distribution and more species diversity observed in monsoon than in winter and summer (Manwar and Wankhade 2014). During summer season most part of the forest becomes dried up and the larval host

plants and nectar plants also gets vanish. Pavagadh receives its maximum rainfall during the monsoon season and it is a boon for the entire flora. They start appearing during these months. Significant amount of rainfall increases the soil fertility which in turn help the floral growth. The result of the study conducted by Nimbalkar et al. (2015) inferred that the occurrence of species of different families were highly diversified during monsoon (June to September) followed by post-monsoon and the species showed least diversification during pre-monsoon season.

Highest number of species diversity and abundance were observed in Habitat I that is the forest area. Though it is a dry deciduous forest and most of the vegetation gets dried up during summer season, some of the shrubs flower during summer season too. There are plants that bear flowers throughout the year also. These plants support the diversity of butterflies during this time.

Shannon-Weiner and Simpson diversity indices and Evenness Index were calculated for four seasons (Table 4). Shannon - Weiner Index (H) for the study area ranged between 2.724 and 3.807. It indicates that highest butterfly species diversity occurred during post-monsoon season and least diversification of species occurred during summer season. In habitat I also post-monsoon is the most favorable season for the diversity of butterfly species. Typical values of Shannon Index in most of ecological studies range between 1.5 and 3.5 and the index is rarely greater than 4. The Shannon Index increases when the richness and the evenness of the community increases and Shannon Index decreases when richness and evenness of the community decreases.

When calculated Simpson's Index of diversity (1-D), the values ranged between 0.9267 to 0.9748. This Index showed that lowest abundance of butterfly species were obtained during summer months and highest species abundance were obtained during post-monsoon months. Mali et al. (2014) reported that butterfly fauna depends on the floristic elements, climate, rainfall, temperature and being highly sensitive butterflies get easily affected by changes in environment. A study conducted by Shrestha et al. (2018) also concluded that maximum plant diversity with availability of sufficient nectars and food plants always favor high butterfly diversity.

Pielou's Evenness Index of the two habitats were calculated. The calculated values of Pielou's Evenness Index at forest area (Habitat I) across seasons ranged from 0.8091 (monsoon) and 0.8655 (post-monsoon) indicating that butterflies are distributed more evenly during monsoon and post-monsoon months. Similarly Pielou's Evenness Index for garden area (Habitat II) across seasons was calculated and the values ranged from 0.8079 (monsoon) to 0.8509 (post-monsoon), which indicate that in Habitat I also monsoon and post-monsoon seasons are supporting more evenness in butterfly species distribution. The results of the two habitats show that forest area is supported with more evenness in butterfly species distribution than garden area. Values close to 1 indicate that high evenness in species abundance and values close to 0 indicating low evenness among butterfly species distribution. The area of forest composed of a mixed vegetation where all kinds of plants such as grasses, herbs, shrubs, trees are available while garden area is composed of planted vegetation like ornamental plants and other plants. The most preferred plant resources utilized by butterflies in the garden area include *Bougainvillea spectabilis*, *Vinca rosea*, *Ixora coccinea* and *Nerium oleander* while in forest area butterflies preferred to visit *Annona squamosa*, *Calotropis gigantea*, *Cassia fistula*, *Azadirachta indica*, *Tamarindus indica*, *Lantana camara*. Sharma et al. (2014) also mentioned that butterflies require all kinds of vegetation for the survival of larval, pupal and adult stages and their ideal habitat should be a mixture of grasslands, herbs, shrubs and flowering plants.

CONCLUSION

The present study is the first of this type of study in this area. Therefore it is very difficult to say whether the diversity of the butterflies in this area is decreasing or increasing. So it is suggested that there is a need of continuous monitoring of butterflies because any change in the diversity only be identified through a continuous monitoring and analyzing the data every year. Champaner - Pavagadh is recognized as a world heritage site by UNESCO in 2004 and it is also a famous pilgrimage site due to the presence of Kali Mata temple at the top of the hill. So there is a continuous flow of tourists and pilgrims throughout the year. As the area is undergoing constructional activities, there are chances of habitat destruction like cutting of trees and habitat degradation. These activities will affect the shelter of many butterflies. In spite of the dry weather condition of the Pavagadh area, occurrence of 52 butterfly species is a good sign of biodiversity and habitat health. In order to maintain the health of the habitat and biodiversity the concerned authorities should take necessary actions to conserve the biodiversity for achieving sustainable development.

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REFERENCES

- Bhakare M, Ogale H (2018) A Guide to Butterflies of Western Ghats (India) Includes Butterflies of Kerala, Tamilnadu, Karnataka, Goa, Maharashtra and Gujarat State. 1st edn. Milind Bhakare, Somwar Peth: Satara, Maharashtra.
- Deepika DS, Sowmya LK (2014) Seasonal patterns in butterfly diversity and abundance in relation to weather parameters at Kambalakonda eco-tourism park, Vishakhapatnam. Int J Pl An and Environ Sci 4 : 146—155.
- Fernandes B, Kini A, Varkey J, Subramanian S, Achary P (2016) Study of diversity and current status of butterflies (Rhoptalocera) at Vasai Fort, Dist-Palghar, India. Int Res J Biol Sci 5 : 11—19.
- Gandhi S, Kumar D (2016) Seasonal diversity of butterflies in the fragmented habitats of Waghai Botanical Garden of The Dangs - Gujarat. IJBR 4 : 237—244.

- Kunte KJ (1997) Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in Northern Western Ghats. *J Biosci* 2 : 593—603.
- Kunte KJ (2000) *Butterflies of Peninsular India*. 1st edn. University Press (India) Limited : Hyderabad, pp 2000.
- Mali M, Khokhariya BP, Dabgar YB (2014) Biotic inter relationship of plants and butterflies in surrounding of Gandhinagar, Gujarat. *IJSR* 3 : 420—422.
- Manwar N, Wankhade V (2014) Seasonal variation in diversity and abundance of butterfly at Sawanga Vithoba Lake area District Amravati, Maharashtra India. *J Biol Sci* 14 : 485—493.
- Nimbalkar RK, Chandekar SK, Kunte SP (2015) Butterfly diversity in relation to nectar food plant from Bhore tahsil, Pune District, Maharashtra, India. *JoTT* 3 : 1601—1609.
- Pollard E, Yates TJ (1993) *Monitoring Butterflies for Ecology and Conservation*. Chapman & Hall : London, UK.
- Revathy VS, Mathew G (2014) Seasonal fluctuations of butterfly population : A study in butterfly garden at Peechi, Kerala, India. *IJAEB* 7 : 29—35.
- Sharma S, Mandloi R, Chariya D (2014) Diversity of butterflies in Omkareshwar Region nearby area of Narmada river bank, Madhya Pradesh India. *IJLSCI* 3 : 144—148.
- Shrestha BR, Sharma M, Magar KT, Gaudel P, Gurung MB, Oliet B (2018) Diversity and status of butterflies at different sacred forests of Kathmandu valley, Nepal. *JEZS* 6 : 1348—1356.
- Smetacek P (2016) *A Naturalist's Guide to the Butterflies of India, Pakistan, Nepal, Bhutan, Bangladesh and Sri Lanka*. John Beaufoy Publishing Ltd : New Delhi.