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Diversity of butterflies in Victoria Park Reserve Forest, Bhavnagar, Gujarat, India

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Abstract

Documentation of biodiversity is crucial for examining the health of ecosystems. Many species act as an ecological indicator due to their susceptibility to changes in a particular environment. Butterflies, providing vital ecosystem services, respond uniquely to urbanization and can be a good tool for the assessment of the well-being of the habitat. The present study, one of its first kind in the particular habitat, provides a comprehensive outlook on the species diversity and abundance of butterflies at Victoria Park Reserve Forest, an urban forest area in Bhavnagar, Gujarat, India. The survey was conducted from March 2018 to February 2019 across all seasons. A total of 69 species belonging to 45 genera and five different families were recorded. The most diverse family was Lycaenidae (33.33%), followed by Nymphalidae (31.88%), Pieridae (21.74%), Papilionidae (7.25%), and Hesperiidae (5.80%). *Junonia* , was the dominant genus with six species. Out of the total recorded species,12 species are listed under the Least Concern category of the IUCN red list and 57 species are Not Evaluated. Seasonal variation in the number of species was observed, which shows the highest number of species in September (n=63) and the lowest in May (n=22). The abundance of the butterfly community was found to be highest during August (26.37%) and the lowest during February (1.85%). This study provided an understanding of the butterfly community in the habitat and would encourage further research for habitat restoration in the reserve forest.

Keywords: abundance; butterflies; diversity; reserve forest; urbanization

Introduction

Biodiversity documentation is crucial for assessing the overall health of ecosystems and creating appropriate action plans, especially for ecologically sensitive organisms like butterflies (Chowdhury and Soren, 2011). Many species serve as biological indicators because of their susceptibility to climate change and habitat fragmentation (Kunte, 2000) and reflect the changes in the environment and ecosystem (Thomas, 2005; Posa and Sodhi, 2006; Koh, 2007). Butterflies respond uniquely to urbanization depending on their habitat of distribution, historical background of the city as well as their taxonomic identity (Brown and Freitas, 2002;

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Soga and Koike, 2012a, 2012b). Local extinctions of rare, specialist, and less abundant butterfly species can occur due to urbanization (Shapiro and Shapiro, 1973; Corke, 1999; Fattorini, 2011b; Soga and Koike, 2012a).

Among the insects, Butterflies are best studied and play a crucial ecological role such as pollinating a large variety of plants, including urban agriculture (Garratt *et al*., 2014; Potter and LeBuhn, 2015). Along with birds, Butterflies are among the most charismatic and eye-catching wildlife groups that have been comprehensively used for educational objectives because of their aesthetic values (Kellert, 1993; Schlegel *et al*., 2015). Indeed, urban butterflies are suggested to be an ideal group of wildlife to reconnect people with nature (Soga and Gatson, 2016).

Biodiversity inventories provide important baseline data for future ecological and conservation research. Such species lists at different stages of the urbanization process can aid to sense the shifts in species composition during a particular period. In the past century, many researchers carried out studies on the ecology and conservation of butterflies in various habitats of India (Bingham, 1905; Bingham, 1907; Evans, 1932; Talbot, 1938; Talbot, 1947; Wynter-Blyth, 1947; Larsen, 1987; Kunte, 2000). There have been many studies documenting butterfly fauna in protected areas in different parts of India (Singh *et al*., 2001; Sreekumar and Balakrishna, 2001; Sharma, 2009; Raut and Pendharkar, 2010; Kunte *et al*., 2012; Tewari and Rawat, 2013; Quareshi *et al*., 2014; Kannan and Chandrasekaran, 2022) and from Gujarat (Bhalodia *et al*., 2002a, 2002b, 2002c; Sharma and Sharma, 2013; Gandhi *et al*., 2017; Suthar *et al*., 2019). Previously Mosse (1929) surveyed the butterflies of Kathiawar with special reference to Bhavnagar state. Since then, there is a lack of information on the butterfly fauna of the Bhavnagar region. Therefore, the present survey is undertaken in Victoria Park Reserve Forest to determine the trends in species composition and status of the butterfly community. The present study on the butterflies of Victoria Park Reserve Forest is the first of its kind in this particular habitat.

Materials and Methods

Study area

Bhavnagar is located on the western coast of the Gulf of Khambhat in the Saurashtra peninsula of Gujarat, India. The present study was carried out in Victoria Park Reserve Forest (21°44'48"N 72 08'26"E), situated about 3 km south of the centre of Bhavnagar city, Gujarat, India (Figure 1). Historically, it was designed under the guidance of Councillor and Chief Engineer Mr. Proctor Sims of the erstwhile Bhavnagar State under the governance of Maharaja Takhtasinhji Gohil (Patel, 1982). The study area covers about 2.02 km^2 of reserve forest which is triangular in shape. Most of the forest areas are plain but the western part is hilly and rugged and some low-lying areas are also present. There is a small lake present in the forest known as 'Krishna-Kunj Talav'. The study area is situated in a semi-arid zone with temperatures ranging between 11.2 °C to 39.4 °C and an average rainfall of about 610.4 mm.

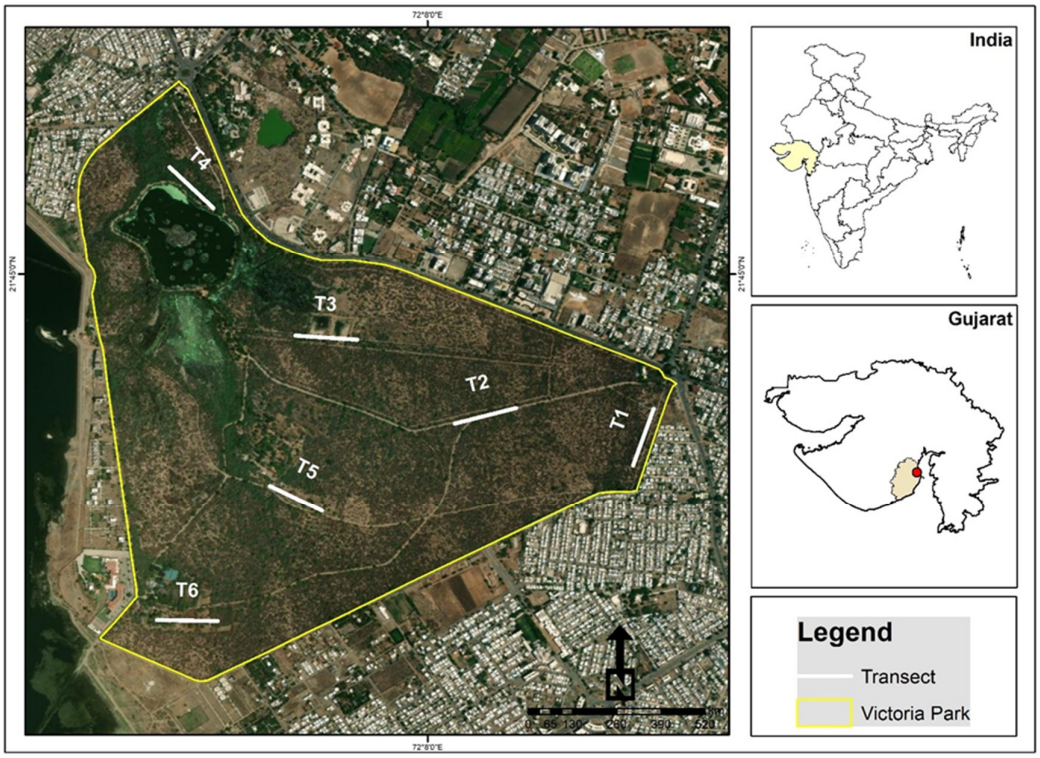

Figure 1. Map of the study area

Data collection

The survey was conducted between March 2018 to February 2019. The study period was divided into four seasons [i.e., winter (December-February), summer (March-May), monsoon (June-August), and post-monsoon (September-November)]. Field observations were carried out in the early mornings from sunrise to 10:30 AM and in the evenings from 04:00 PM to sunset, except for extreme weather conditions like heavy rains and high winds. Occasional surveys were also conducted to explore species diversity. The Pollard walk method (Pollard, 1977, 1991) was followed to record the butterflies twice a month. A total of six transects were evenly laid throughout the study area. Each transect had a fixed route of 200 m in length and butterflies were recorded from both the sides up to the distance of 5 m to ensure consistency in the observation field. Transects were walked at a stable pace with short halts during the walk to document the butterflies for proper identification. Visual observations in the field were aided by Olympus 8×42 binoculars and Nikon B 700 Point and Shoot Camera. Butterflies were photo-documented and identified with the help of previous scientific literature (Mosse, 1929; Evans, 1932; Wynter-Blyth, 1957; Gay *et al*., 1992; Lewington, 1999; Kunte, 2000; Parasharya and Jani, 2007; Singh, 2011; Kehimkar, 2016). Recorded species were categorized under IUCN Red List (IUCN, 2022) and their status in the Wildlife Protection Act (WPA) 1972 of India (Anonymous, 2006).

Statistical analysis

Different diversity indices were analysed with the assistance of Microsoft Excel 2019 and PAST software (Hammer *et al*., 2001) to understand the butterfly community structure in the study area. The rank-abundance curve or Whittaker plot is a graphical representation of relative species abundance in ecological studies. The x-axis signifies the abundance rank of the species and the y-axis signifies the relative abundance. It is also used to visualize species richness and evenness (Whittaker, 1965).

Results

Species richness

A total of sixty-nine species belonging to five different families were reported (Figure 2; Table 1, 2). The present findings reveal that the diversity of Lycaenidae (33.33%) was highest followed by Nymphalidae (31.88%), Pieridae (21.74%), and Papilionidae (7.25%) while, Hesperiidae (5.8%) has the least diversity. Lycaenidae was the most diverse family comprising 23 species of 17 genera, followed by Nymphalidae (22 species, 14 genera), Pieridae (15 species, 7 genera), Papilionidae (5 species, 3 genera), and Hesperiidae (4 species, 4 genera). Among the 45 genera recorded, 31 had only one species, while the *Junonia* Hübner, [1819] of the family Nymphalidae was the genus with the highest number of species (n=6) (Figure 3).

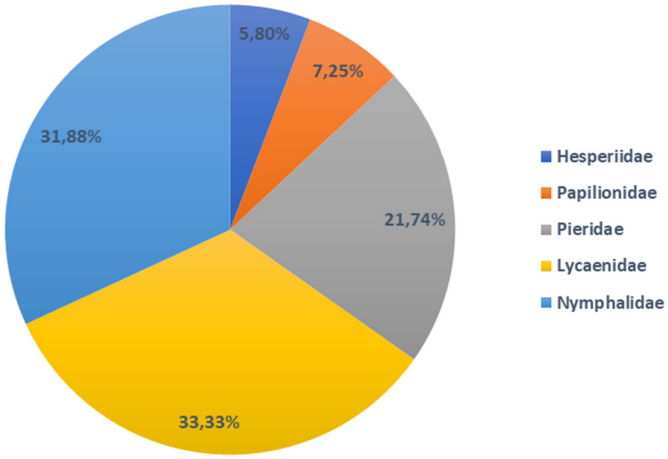

Figure 2. Family-wise distribution of butterfly species in the study area

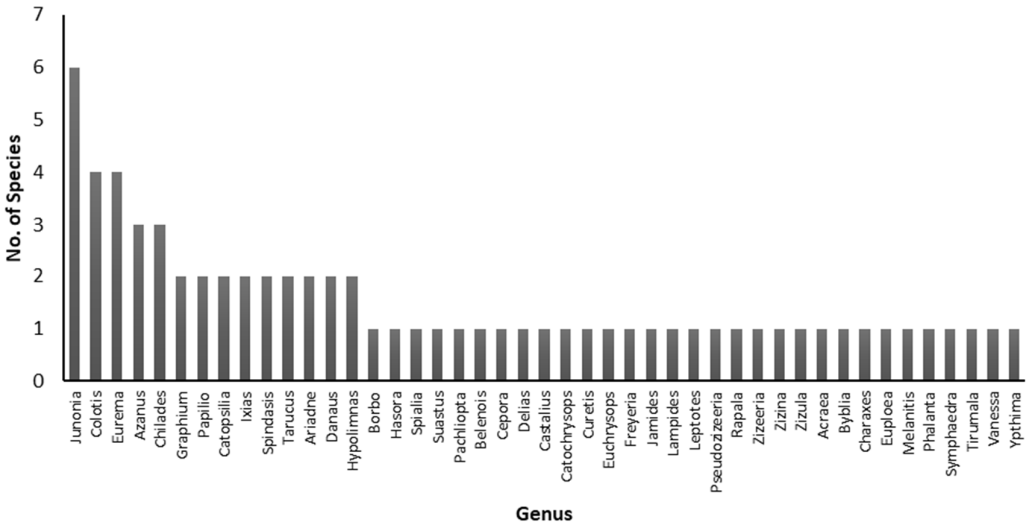

Figure 3. Distribution of butterfly species belonging to different genera in the study area

Table 1. Family-wise composition of butterfly community in the study area

Family	Genus	Species	No. of Individuals				
			Summer	Monsoon	Post-monsoon	Winter	Total
Hesperiidae	04	04	2	39	57	29	127
Papilionidae	03	05	49	146	137	30	362
Pieridae	07	15	163	875	503	127	1668
Lycaenidae	17	23	121	815	735	133	1804
Nymphalidae	14	22	127	465	653	159	1404
Total	**45**	**69**	**462**	**2340**	**2085**	**478**	**5365**

Table 2. Family-wise checklist of butterflies observed in the study area with its status in IUCN and WPA 1972

Sr. No.	Scientific name	Common name	IUCN
Family: Hesperiidae			
1	*Borbo cinnara* (Wallace, 1866)	Rice Swift	NE
2	*Hasora chromus* (Cramer, 1780)	Common Banded Awl	NE
3	*Spialia galba* (Fabricius, 1793)	Indian Skipper	NE
4	*Suastus gremius* (Fabricius, 1798)	Indian Palm Bob	NE
Family: Papilionidae			
5	*Graphium agamemnon* (Linnaeus, 1758)	Tailed Jay	NE
6	*Graphium nomius* (Esper, 1799)	Spot Swordtail	NE
7	*Pachliopta aristolochiae* (Fabricius, 1775)	Common Rose	LC
8	*Papilio demoleus* (Linnaeus, 1758)	Lime Butterfly	NE
9	*Papilio polytes* (Linnaeus, 1758)	Common Mormon	NE
Family: Pieridae			
10	*Belenois aurota* (Fabricius, 1793)	Pioneer	LC
11	*Catopsilia pomona* (Fabricius, 1775)	Common Emigrant	NE
12	*Catopsilia pyranthe* (Linnaeus, 1758)	Mottled Emigrant	NE
13	*Cepora nerissa* (Fabricius, 1775)	**Common Gull	NE
14	*Colotis amata* (Cramer, 1775)	Small Salmon Arab	NE
15	*Colotis danae* (Fabricius, 1775)	Crimson Tip	NE
16	*Colotis etrida* (Boisduval, 1836)	Small Orange Tip	NE
17	*Colotis fausta* (Olivier, 1804)	Large Salmon Arab	NE
18	*Delias eucharis* (Drury, 1773)	Common Jezebel	NE
19	*Eurema blanda* (Boisduval, 1836)	Three-spot Grass Yellow	NE
20	*Eurema brigitta* (Stoll, 1780)	Small Grass Yellow	LC
21	*Eurema hecabe* (Linnaeus, 1758)	Common Grass Yellow	NE
22	*Eurema laeta* (Boisduval, 1836)	Spotless Grass Yellow	NE
23	*Ixias marianne* (Cramer, 1779)	White Orange Tip	NE
24	*Ixias pyrene* (Linnaeus, 1764)	Yellow Orange Tip	NE
Family: Lycaenidae			
25	*Azanus jesous* (Guérin–Méneville, 1849)	African Babul Blue	LC
26	*Azanus ubaldus* (Stoll, 1782)	Bright Babul Blue	LC
27	*Azanus uranus* (Butler, 1886)	Dull Babul Blue	NE
28	*Castalius rosimon* (Fabricius, 1775)	*Common Pierrot	NE
29	*Catochrysops strabo* (Fabricius, 1793)	Forget-me-not	NE

30	*Chilades lajus* (Stoll, 1780)	Lime Blue	NE
31	*Chilades pandava* (Horsfield, 1829)	Plains Cupid	NE
32	*Chilades parrhasius* (Fabricius, 1793)	Small Cupid	NE
33	*Curetis thetis* (Drury, 1773)	Indian Sunbeam	NE
34	*Euchrysops cnejus* (Fabricius, 1798)	**Gram Blue	NE
35	*Freyeria putli* (Kollar, 1844)	Small Grass Jewel	NE
36	*Jamides celeno* (Cramer, 1775)	Common Cerulean	NE
37	*Lampides boeticus* (Linnaeus, 1767)	**Pea Blue	LC
38	*Leptotes plinius* (Fabricius, 1793)	Zebra Blue	NE
39	*Pseudozizeeria maha* (Kollar, 1844)	Pale Grass Blue	NE
40	*Rapala iarbus* (Fabricius, 1787)	Indian Red Flash	NE
41	*Spindasis ictis* (Hewitson, 1865)	Common Shot Silverline	NE
42	*Spindasis vulcanus* (Fabricius, 1775)	Common Silverline	NE
43	*Tarucus indica (*Evans, 1932*)*	Pointed Pierrot	NE
44	*Tarucus nara* (Kollar, 1848)	Rounded Pierrot	NE
45	*Zizeeria karsandra* (Moore, 1865)	Dark Grass Blue	LC
46	*Zizina otis* (Fabricius, 1787)	Lesser Grass Blue	NE
47	*Zizula hylax* (Fabricius, 1775)	Tiny Grass Blue	NE
Family: Nymphalidae			
48	*Acraea violae* (Fabricius, 1793)	Tawny Coster	NE
49	*Ariadne ariadne* (Linnaeus, 1763)	Angled Castor	NE
50	*Ariadne merione* (Cramer, 1777)	Common Castor	NE
51	*Byblia ilithyia* (Drury, 1773)	Joker	NE
52	*Charaxes solon* (Fabricius, 1793)	**Black Rajah	NE
53	*Danaus chrysippus* (Linnaeus, 1758)	Plain Tiger	LC
54	*Danaus genutia* (Cramer, 1779)	Striped Tiger	NE
55	*Euploea core* (Cramer, 1780)	***Common Crow	LC
56	*Hypolimnas bolina* (Linnaeus, 1758)	Great Eggfly	NE
57	*Hypolimnas misippus* (Linnaeus, 1764)	**Danaid Eggfly	NE
58	*Junonia almana* (Linnaeus, 1758)	Peacock Pansy	LC
59	*Junonia atlites* (Linnaeus, 1763)	Gray Pansy	NE
60	*Junonia hierta* (Fabricius, 1798)	Yellow Pansy	NE
61	*Junonia iphita* (Cramer, 1779)	Chocolate Pansy	NE
62	*Junonia lemonias* (Linnaeus, 1758)	Lemon Pansy	NE
63	*Junonia orithya* (Linnaeus, 1758)	Blue Pansy	NE
64	*Melanitis leda* (Linnaeus, 1758)	Common Evening Brown	NE
65	*Phalanta phalantha* (Drury, 1773)	Common Leopard	NE
66	*Symphaedra nais* (Forster, 1771)	Baronet	NE
67	*Tirumala limniace* (Cramer, 1775)	Blue Tiger	NE
68	*Vanessa cardui* (Linnaeus, 1758)	Painted Lady	LC
69	*Ypthima asterope* (Klug, 1832)	Common Three-ring	LC

(IUCN status: NE = Not Evaluated, LC = Least concern)

(Wildlife Protection Act 1972: *Schedule I (Part IV), **Schedule II (Part II), ***Schedule IV)

The number of species were varying throughout the year representing the month-wise distribution of butterflies (Figure 4). Highest number of species were recorded during September (n=65) followed by August (n=63), October (n=58), July & November (n=52), and December (n=43) respectively while, the least number of species were recorded in the months of May (n=22), February (n=24), January & March (n=25), April (n=30), and June (n=32) respectively. Some of the species like *Papilio demoleus* (Linnaeus, 1758), *Belenois aurota* (Fabricius, 1793), *Colotis amata* (Cramer, 1775), *and Danaus chrysippus* (Linnaeus, 1758) were found throughout the study period.

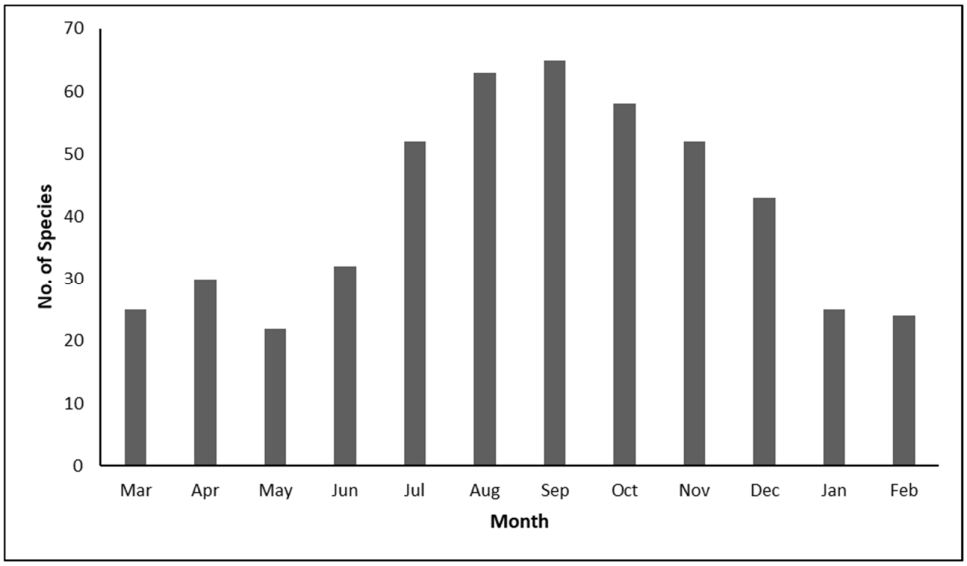

Figure 4. Month-wise composition of butterfly species in the study area

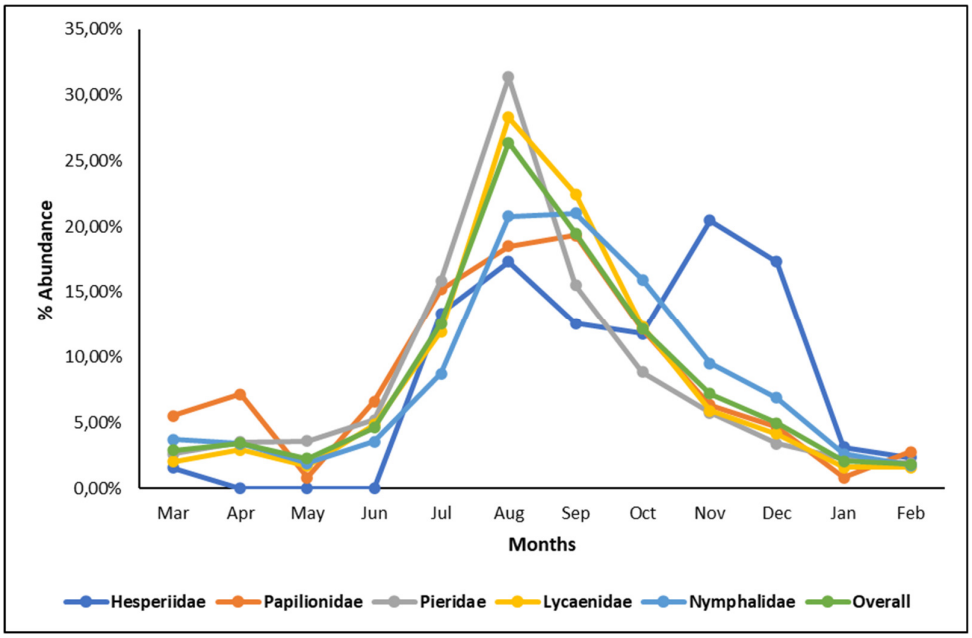

Figure 5. Family-wise abundance of butterfly species in the study area

The family-wise abundance of species (Figure 5) was highest during August for the family Hesperiidae (17.32%), Pieridae (31.35%), and Lycaenidae (28.33%) while for Nymphalidae (21.01%) and Papilionidae

(19.34%), it was highest during September. The overall abundance of butterflies was highest during August (26.37%) and the lowest during February (1.85%).

Threat status

Out of the total 69 species, 12 were categorized under the Least Concern (LC) status as per the IUCN Red List (IUCN, 2022): *Pachliopta aristolochiae* (Fabricius, 1775), *Belenois aurota* (Fabricius, 1793), *Eurema brigitta* (Stoll, 1780), *Azanus jesous* (Guérin–Méneville, 1849), *Azanus ubaldus* (Stoll, 1782), *Lampides boeticus* (Linnaeus, 1767), *Zizeeria karsandra* (Moore, 1865), *Danaus chrysippus* (Linnaeus, 1758), *Euploea core* (Cramer, 1780), *Junonia almana* (Linnaeus, 1758), *Vanessa cardui* (Linnaeus, 1758), *Ypthima asterope* (Klug, 1832). The remaining 57 species were marked as Not Evaluated (NE). Seven species were protected under the Wildlife Protection Act (WPA), 1972 including *Castalius rosimon* (Fabricius, 1775) under Schedule I of Part IV; *Cepora nerissa* (Fabricius, 1775), *Euchrysops cnejus* (Fabricius, 1798), *Lampides boeticus* (Linnaeus, 1767), *Charaxes solon* (Fabricius, 1793), and *Hypolimnas misippus* (Linnaeus, 1764) under Schedule II of Part II; and *Euploea core* (Cramer, 1780) under Schedule IV of the act.

Rank abundance curve/ Whittaker plot

The evenness of the butterfly community in the study area is depicted on the rank abundance curve (Figure 6A) which shows relatively low steep inclination suggesting high evenness in the community as the higher-ranked species have lower abundances than the lower-ranked species. According to the Whittaker plot, family Pieridae, Lycaenidae, and Nymphalidae have relatively higher species evenness than Papilionidae and Hesperiidae (Figure 6B).

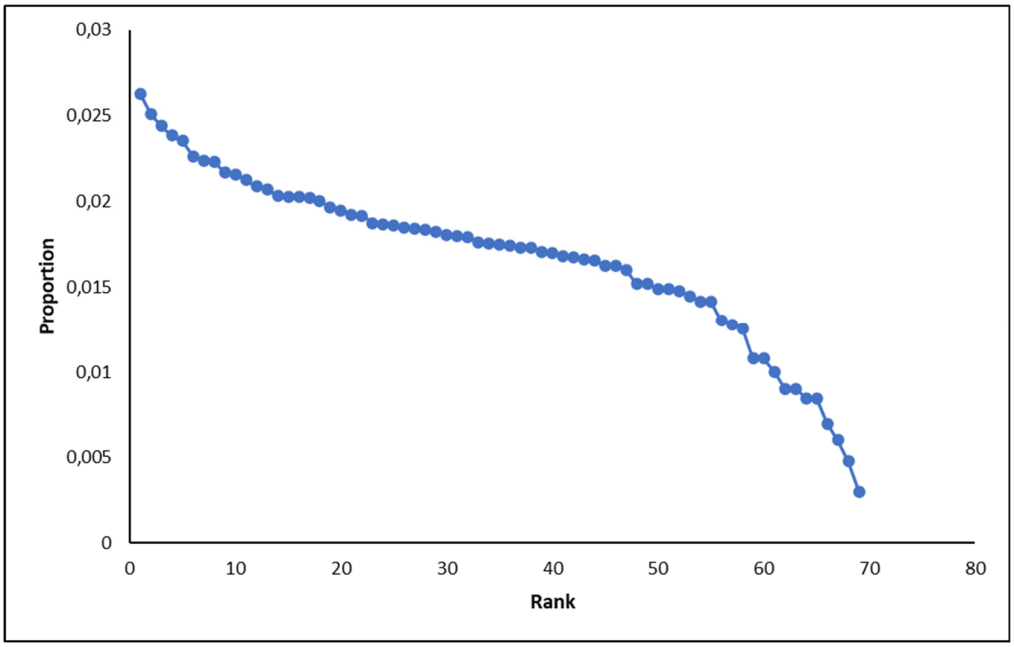

Figure 6A. Rank-abundance curve or Whittaker plot of butterfly community in the study area

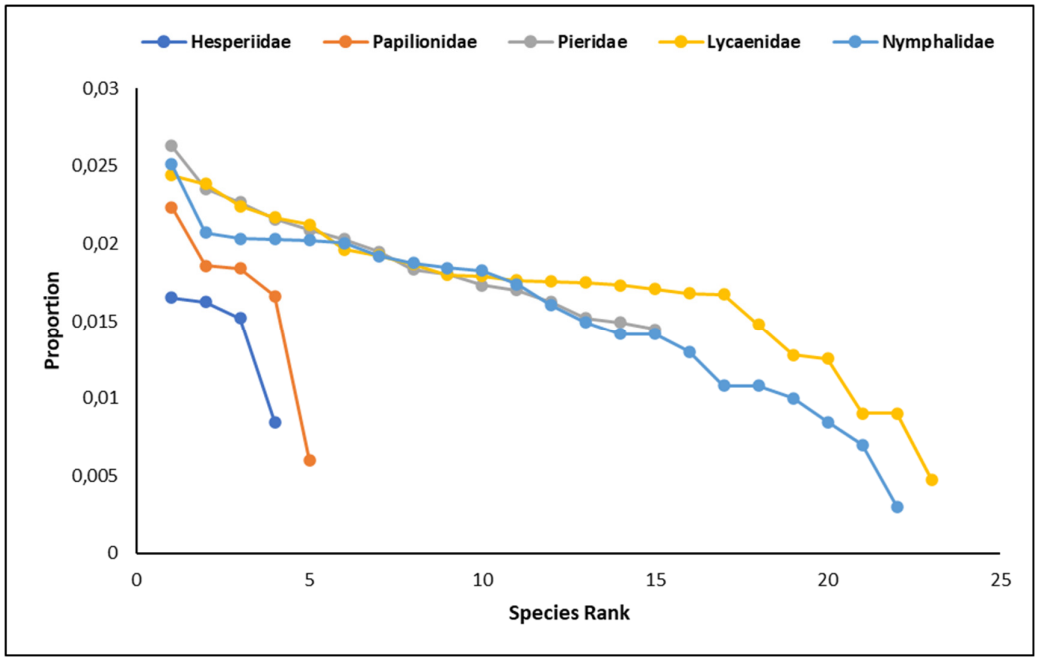

Figure 6B. Family-wise Rank-abundance curve or Whittaker plot of butterfly community in the study area

Discussion

In the present study, 69 species of butterflies from 45 genera and five families were found in a semi-arid habitat with dominant scrub and thorny vegetation. Family Lycaenidae has the highest number of species (23 species), accounting for 33.33 % of overall butterfly diversity in the study area with the highest abundance (1804 individuals). With 22 species, Nymphalidae was the second most species rich family, followed by Pieridae with 15 species. The Hesperiidae and Papilionidae were poorly represented harbouring 4 species, 127 individuals and 5 species, 362 individuals respectively. Maximum sightings were recorded for *Eurema hecabe* (426 individuals), *Danaus chrysippus* (324 individuals) and *Azanus ubaldus* (275 individuals). Many researchers (Bhalodia *et al*., 2002a, 2002b, 2002c; Sharma *et al*., 2017, Sharma and Sharma 2017; Suthar *et al*., 2019) had recorded butterfly diversity of different protected areas in Gujarat. In a drought prone habitat of Narayan Sarovar Wildlife Sanctuary Bhalodia *et al*. (2002c) had reported 34 species of which Nymphalidae had the highest species diversity (13 species, 38.23 %). In the Vansda National Park, a moist deciduous forest of the northern western ghats, Bhalodia *et al*. (2002a) had reported 62 butterfly species of which Nymphalidae (17 species, 27.41 %) was the most diverse family. Suthar *et al*. (2019) reported 32 species from the Piplaidevi Forest Range of Dangs, Gujarat. Bhalodia *et al*. (2002b) had reported 44 species of butterflies from Ratanmahal Wildlife Sanctuary, the only large dense forest pocket of Dahod district in Gujarat, where Nymphalidae (14 species, 31.82 %) was the most dominant butterfly family. In a dry deciduous forest of Gir Wildlife Sanctuary Sharma and Sharma (2017) had reported 53 species of butterflies of which the highest number of species (16) were belonged to the Pieridae family. Another study from Gir Protected Area (Sharma *et al*., 2017) had reported 67 butterfly species out of which 23 species (34.32%) were belonged to the family Nymphalidae. The distribution of butterflies on spatio-temporal scale is broadly determined by the seasonal variations (Kunte, 1997). In the present study, the number of butterflies varied significantly throughout the study period. The occurrence of the butterflies was comparatively higher during the monsoon (2340 individuals) to post-monsoon (2085 individuals) season possibly due to an increase in the vegetation cover, wet climate and humidity compared to the winter and summer months. These conditions suffice their food, refuge and other

associated requirements. On the contrary, the winter months witness dry conditions and lower temperature coupled with reduced biomass and scarcity of food sources which result in lower numbers of butterflies. Jaramillo *et al*. (2019) and Sharma and Sharma (2021) had observed the similar patterns of butterfly distribution in the mountain range of Mexico and in a sub-tropical zone of Jammu shiwaliks respectively. Assemblage of the families Nymphalidae and Hesperiidae was highest during the post monsoon season while it was highest in the Monsoon season for Papilionidae, Pieridae and Lycaenidae (Table 1). These results suggest the importance and uniqueness of habitat underlying its conservation value for an indicator taxa like butterflies.

Conclusions

Butterflies are sensitive to alteration in the landscape, loss of vegetation structure and habitat degradation. Urbanization imperils butterfly diversity with the deterioration of environmental conditions. Butterflies, an ecological indicator serves many ecosystem services, therefore, attention should be given to conserving and protecting the butterfly diversity especially, in urban habitats. The recorded data from the present study can establish important information in the form of a scientific reference for assessing the environmental changes in the locality, in upcoming times. Long-term ecological studies of the butterfly diversity with reference to vegetation cover in the habitat should be carried out as the list is not final and exhaustive. This study can inculcate interest among students and local citizens and can promote conservation efforts by establishing butterfly-friendly plantations with the help of the local authorities.

Authors' Contributions

DT and VMM conducted the fieldwork, PPD and AHS designed and supervised the study. The manuscript was prepared by VMM and reviewed by DT, AHS, and PPD. All Authors read and approved the final manuscript.

Ethical approval

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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