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Community Composition and Dynamics of Butterflies in Different Microhabitats of Central Aravalli Hill Regions of Ajmer District, Rajasthan, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Aims: Butterflies are the symbol and target species for conservation in many parts of the world, and are key indicators of an environment's ecological status. The abundance, brief generation time, quick movement, and sensitivity to climatic changes of the butterfly fauna make it a significant predictor. It is crucial for effective and suitable butterfly protection to conduct research on biodiversity, ecology, and habitat suitability.

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Place and Duration of Study: The study was conducted in Ajmer City, Rajasthan, India. The four sites for butterfly collection were Open Land, Scrub Land, Aravalli Hills, and MDS University Campus to reflect the variety of environments in Ajmer. Scrub land makes up 1.5 km^2, open ground 1.3 km^2, the MDS University campus 0.5 km^2, and the Aravalli hills 2 km^2 of the 5.3 km^2 research regions.
Methodology: For butterfly studies, the Pollard walk technique was used, with 20 fixed transects placed stratified and randomly across four environments. Adult butterfly individuals were noted while walking at a slow, steady speed within a assumptive 5 m radius and Alpha and Beta diversity analysis was performed using PAST 4.06 and Microsoft Excel 2010
Results: During the study, 54 butterfly species from five groups were identified. The most diverse families were Nymphalidae and Pieridae, then Lycaenidae, Hesperiidae, Papilionidae.
Conclusion: It is essential to track changes in the butterfly population as an indicator for climate and human impacts because they are sensitive to changes in their surroundings, they perform functions like pollinating various plant species. However, by planting appropriate trees, plants, and other vegetation that will support the organisms' continued health, we can at least try to lessen them. At a minimum, this attempt will prevent the common species from facing extinction.

Keywords: Butterfly; community composition; microhabitat; Rajasthan; conservation.

1. INTRODUCTION

Ecosystems and habitats are always transforming, and some of these alterations are fueled by human influences. As a result, continuous ecological monitoring is required to assess the status of the ecosystem and biodiversity [1]. We study biological indicators to better understand the role of biodiversity in management of ecosystems [2]. The human development process is one of several elements proven to have an impact on biodiversity in many regions. Construction operations such as road construction, power transmission line construction, energy development, and waterway excavation and impoundment for development have been shown to have an impact on land cover and on variety of species including butterflies [3].

Butterflies are a flagship and target species for conservation in many parts of the world, particularly for invertebrates [4]. Butterflies are simple to examine because of their fairly large size and distinctiveness, as well as their well-known taxonomy [5]. They are a key component of biodiversity in natural environments due to their strong complicated linkages in the food web [6]. The adult forms consume nectar and pollinate, which is essential for the ecological functioning [7] and larval forms serve as primary consumers and prey to species at higher trophic levels. Therefore, butterflies provide dual functions as pollinators and energy transferors. Butterflies are key indicators of an environment's ecological status and biotope quality [8,9] as prospective pollinators of their nectar plants and indicators of the health and quality of their host plants and the ecosystem as a whole. The butterfly fauna is an important indicator because it is abundant, its generation is short, its migration is fast, and it is very sensitive to environmental changes [10].

Many species are habitat specific and are extremely vulnerable to habitat degradation, which includes changes in microclimate, vegetation structure, and the co-occurrence of plant types on a local scale [6,9] Seasonal factors, in addition to habitat types, play an important role in defining the spatiotemporal patterns of butterfly species richness and diversity [11-13]. Temperature and rainfall patterns impact the similarity and variety of local butterfly populations [14,15].

Butterflies are extremely sensitive to fractional fluctuation in climatic conditions and disturbance in their habitats due to their short life spans, host plant specialization, and limited dispersion capabilities in majority of species [16]. The undisturbed natural flora and seasonal flowering plantation provide promising habitat for butterfly populations if there are no development operations or contamination from industrial hazardous waste [17].

In this context, studies on diversity, ecology, and habitat appropriateness are critical for successful and proper butterfly conservation [9]. Studies are vital for understanding butterfly diversity, ecology, and numerous functions in an ecosystem, as well as for investigating the influence of disturbance and land use changes on them Bhardwaj et al, [18]. All of these characteristics make them a viable model for ecological and conservation research, emphasizing the importance of establishing good conservation approaches [19]. As an outcome of our current work, an inventory of butterfly faunal diversity and abundance is developed.

2. MATERIALS AND METHODS

2.1 Study Area

All of the investigation locations were in the Central Aravalli Hill Ranges of Ajmer City, Rajasthan, India. Ajmer has semi-arid climate with bushy and thorny vegetation [20]. The average annual rainfall in Ajmer is 525 mm, with 90% of it falling between June and September, while the average yearly temperature is 30-40°C. Four microhabitats for butterfly sampling were chosen to represent the diverse landscapes of Ajmer. The four ecologically diverse study landscapes were Open Land, Scrub Land which also includes some water bodies, Aravalli Hills, and MDS University Campus, which were located between the latitude and longitude of 26.50°N and 74.68°E.

Open Lands include areas near university with scattered vegetations which are chiefly grasses and herbs. Scrub Lands were dominated by dense scrubs and trees like *Prosopis juliflora, Calotropis procera, Prosopis cineraria, Lantana camara, Capparis decidua* and *Acacia senegal.* The rocky terrain of Aravalli Hill regions encompassing the regions of ancient central aravallies in Rajasthan, the chief vegetations are *Acacia arabica, Prosopis juliflora, Cynodon dactylon* etc. MDS University Campus is area with highest human activities among all and is most diverse in terms of both natural and ornamental flora that include *Azadirachta indica, Alstonia macrophylla, Acacia acacia, Calotropis gigantean, Ziziphus nummularia, Adhatoda vasica, Bougainvillea sp.* and invasive flora such as *Prosopis juliflora, Lantana sp.* and *Parthenium sp*. The total study area is 5.3 km^2 approximately, in which scrub land accounts for 1.5 km^2, open land for 1.3 km^2, MDS University campus for 0.5 km^2, and Aravalli Hills for 2 km^2.

2.2 Data Collection and Analysis

Sampling was carried out for a period of one year between November 2021 and October 2022. Pollard walk method was used for butterfly surveys [21]. At each site, a road transect method was followed to collect the data. Each site was visited twice a month (N=96) and on each day sampling was carried out for 3 hours in morning (07:00 to 10:00 hrs) and 3 hours in evening (16:00 to 19:00 hrs).

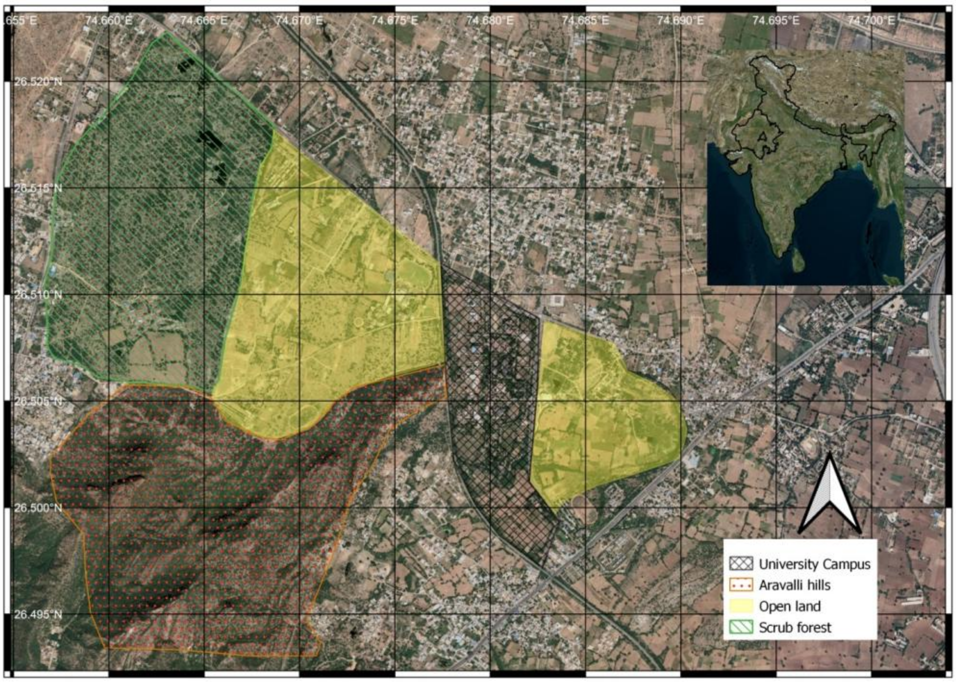

Fig. 1. Four studied microhabitats in study area located at Ajmer district, Rajasthan India

The study area was explored during three seasons: summer (March-June), monsoon (July-October) and winter (November-February). Twenty permanent transects (N = 20), each of 300m in length were laid in a stratified and random manner across four habitats (N = 5 each) in the study area. The consecutive transects in a habitat were spaced 50m apart from each other. Individuals of adult butterflies were recorded and counted around an imaginary 5m radius while walking with a slow, constant pace in each permanent transect. Ten transects (N = 10) were covered in each sampling day, mostly during cloudless and sunny weather conditions in order to spot maximum butterflies [22].

The identification of butterflies was done in the field based on morphological and behavioral descriptions with reference to Kehimkar [23] followed by photography using DSLR Canon-EOS 1300D and Nikon D5300 (55-300mm).

Alpha and beta diversity were calculated using the following indices: Shannon Weiner Index, Simpson Index, Evenness Index, Berger Parker Index of Dominance, Margalef's Index for Richness, Whittaker's Beta Diversity was also compared pairwise for each of the four locations. Microsoft Excel 2010 and PAST 4.06 [24] were used for all statistical analysis.

3. RESULTS AND DISCUSSION

From the four study sites, 54 butterfly species from five families were identified over the course of the investigation (Table 1). With 16 species (29.6%), Nymphalidae had the highest species richness, followed by Pieridae (14 species, 25.9%), Lycaenidae (11 species, 20.3%), Hesperiidae (7 species, 12.9%), and Papilionidae (6 species, 11.1%). Pairwise comparison of Whittaker's Beta Diversity index showed highest value of 0.36842 between University Campus and Aravalli Hills (Table 3). Two species of Lyncaenidae, *Azanus uranus* and *Rapala jarbus* were found only in one study area that was University campus with mixed vegetation. One species of Hesperidae (*Suastus gremius*) was only found at open land with very low vegetation and one species of Nymphalidae (*Acraea violaei*) was only found at scrub forest dominated with scrubby vegetation. According to Table 2, there is more species richness species in scrub forest with water bodies than in open land with little vegetation followed by university campus with a variety of vegetation, and the Aravalli hills in that order. Alpha species diversity (α) is highest at university campuses with mixed vegetation have high Simpson (0.9637) and Shannon (3.556) indices values, while Aravalli Hills have the lowest diversity according to both indices (0.9084 and 2.661). However, Aravalli Hills (0.09157) exhibits higher Dominance than other locations.

Table 1. Distribution of the different butterfly species observed at the four study sites

S.No	Family	Scientific Name	Study sites and number of sightings			
			Aravalli Hills	Scrub Forest	University Campus	Open Land
1	Hesperiidae	*Hasora chromus*	0	10	30	22
2		*Sarangesa purendra*	18	31	40	22
3		*Spialia galba*	5	10	40	30
4		*Suastus gremius*	0	0	0	5
5		*Parnara guttata*	0	20	30	23
6		*Borbo cinnara*	0	0	20	11
7		*Pelopidas mathias*	12	20	31	11
8	Papilionidae	*Graphium doson*	0	2	3	2
9		*Graphium aganemnon*	1	5	10	20
10		*Pachliopta aristolochiae*	0	10	40	44
11		*Pachliopta hector*	0	10	40	33
12		*Papilio polytes*	20	25	70	55
13		*Papilio demoleus*	0	5	30	50
14	Pieridae	*Eurema brigitta*	0	22	30	27
15		*Eurema hecabe*	5	30	44	32
16		*Eurema laeta*	0	12	30	20
17		*Catopsilia pomona*	7	29	40	33
18		*Catopsilia pyranthe*	0	32	70	60
19		*Colotis amata*	0	19	49	33

S.No	Family	Scientific Name	Study sites and number of sightings			
			Aravalli Hills	Scrub Forest	University Campus	Open Land
20		*Colotis etrida*	20	40	80	44
21		*Colotis fausta fausta*	2	20	30	13
22		*Ixias marianne*	0	20	33	14
23		*Ixias pyrene*	1	2	5	2
24		*Pieris canidia*	0	2	12	8
25		*Cepora nerissa*	5	11	28	22
26		*Delias eucharis*	0	4	1	0
27		*Belenois aurota*	0	10	55	33
28	Lycaenidae	*Catochrysops strabo*	1	40	55	22
29		*Leptotes plinius*	0	15	45	33
30		*Tarucus nara*	5	20	100	91
31		*Zizeeria karsandra*	0	0	4	7
32		*Zizula hylax*	0	10	50	44
33		*Azanus uranus*	0	0	*3*	0
34		*Freyeria putli*	2	20	66	29
35		*Freyeria trochylus*	0	10	18	11
36		*Chilades pandava*	0	12	44	20
37		*Chilades parrhassius*	11	66	90	70
38		*Rapala iarbus*	0	0	10	0
39	Nymphalidae	*Trimala limniace*	5	20	5	15
40		*Danaus genutia*	0	0	3	1
41		*Danaus chrysippus*	50	59	130	40
42		*Euploea core*	0	3	5	11
43		*Melanitis leda*	0	0	1	1
44		*Melanitis phedima*	0	5	1	2
45		*Ypthima asterope*	20	100	200	140
46		*Acraea violae*	0	1	0	0
47		*Phalanta phalantha*	10	11	5	2
48		*Vanessa cardui*	50	43	30	37
49		*Junonia orithya*	77	60	140	108
50		*Junonia hierta*	50	16	70	33
51		*Junonia almana*	30	28	120	100
52		*Junonia lemonias*	23	33	56	43
53		*Hypolimnas bolina*	0	19	28	25
54		*Hypolimnas misippus*	0	6	20	10

Table 2. Alpha diversity indices of butterflies recorded at four study sites

	Aravalli Hills	Scrub Forest	University Campus	Open Land
Total Sightings	430	998	2190	1564
Species Richness				
Species	24	47	52	50
Margalef's Richness	3.793	6.661	6.631	6.662
Evenness				
Pielou's Evenness Index	0.5965	0.7095	0.6738	0.6969
Dominance				
Dominance_D	0.09157	0.03873	0.03627	0.03673
Berger-Parker	0.1791	0.1002	0.09132	0.08951
Diversity				
Simpson_1-D	0.9084	0.9613	0.9637	0.9633
Shannon_H	2.661	3.507	3.556	3.551

Table 3. Pairwise comparison of whittaker's beta diversity of butterflies recorded in four study sites

	Aravalli Hills	Scrub Forest	University Campus	Open Land
Aravalli Hills	0	0.32394	0.36842	0.35135
Scrub Forest	0.32394	0	0.070707	0.072165
University Campus	0.36842	0.070707	0	0.039216
Open Land	0.35135	0.072165	0.039216	0

The highest Whittaker's Beta diversity is between the university campus and the Aravalli hills (0.36842), and the lowest is between the university campus and open land (0.039216) (Table 3).

Butterflies are an important part of the food chain therefore, they serve as markers of environmental changes in their surroundings. They have greater sensitivity than a lot of other biological groups [25] Because of high availability of food plants, 24 species (44.4% of total), 3 of Hesperidae, 4 of Lycaenidae, 9 of Nymphalidae, 2 of Papillionidae and 6 of Pieridae were noticed in all study sites, There are 9 species of Nymphalidae, 5 species of Pieridae, 5 species of Lycaenidae, 3 species of Hesperiidae, 2 species of Paplioniidae that use every study habitat, which suggests that they are strong, energetic flyers that may aid them in looking for resources over wide regions [26,27].

Under Wild Life Protection Act, 1972 one specie *Pachliopta hector* (Crimson rose) of Papillionidae family is classified in Schedule-I. Two species *Hypolimnas misippus* (Danaid eggfly) of family Nymphalidae and *Cepora nerissa* (Common gull) of Pieridae family in Schedule-II and one species *Euploea core* (Common crow) of Nymphalidae in Schedule-IV are valuable from conservation point of view.

4. CONCLUSION

From the study sites, a total of 54 species of butterflies have been documented. Among the five recorded butterfly families in the four studied microhabitats, Nymphalidae appears to be the most diverse not only in abundance but also in species richness (n=16, 29.6%), followed by Pieridae (n=14, 25.9%), Lycaenidae (n=11, 20.3%), while families with lowest species richness are Hesperiidae (n=7, 12.9%)and Papilionidae (n=6, 11.1%). The diversity of Nymphalidae and Pieridae is greater in terms of species abundance in the study area, according to our present outcomes, which are followed by Lycaenidae. The two families Hesperiidae and Papilionidae showed the least diversity. The information gathered in this study's data could prove invaluable as a resource for monitoring changes in butterfly populations, as an indicator for climate changes in the area in the future. The depicted butterfly family and species list is not final and comprehensive, so long-term research work with periodic surveys of the vegetation cover and tracking of the diversity of butterflies may be performed in the study area with a focus on ecological aspects. Due to their sensitivity to environmental changes they act as natural indicator of disturbances in the ecosystems. Insects play an important role in the structure of a society by providing services like pest control, nutrient depletion, and decomposition, as well as pollinating different plant species. To protect them we can promote planting suitable vegetations like host plants that will help the organisms stay healthy. By making such an attempt, at the very least, the common species won't be on the verge of extinction.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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