



Butterflies (Lepidoptera) of district Lucknow: Species diversity and seasonal dynamics

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Abstract

This study comprehensively examines the diversity and seasonal variation of butterfly populations across five families—Pieridae, Nymphalidae, Lycaenidae, Hesperidae, and Papilionidae in the district Lucknow from 2022 to 2024. A total of 39,151 individual butterflies representing 90 species were recorded. The Nymphalidae family exhibited the highest abundance (12,648 individuals), followed by Lycaenidae (12,399), Pieridae (8,077), Hesperidae (3,603), and Papilionidae (2,424). In this research, we examined the seasonal diversity patterns of butterfly populations, constantly observing the highest butterfly diversity during rainy seasons, with peak diversity values documented in the years 2023–2024. The Lycaenidae family showed the highest overall diversity throughout all seasons, peaking at 3.087 in the 2023–2024 and in 3.069 in the year 2022–2023 in rainy season, while the Papilionidae family repeatedly exhibited the lowest diversity in both years. The family Pieridae exhibited relatively stable species richness patterns throughout the study period, compared to all other families, while Nymphalidae and Lycaenidae showed increased richness in the winter seasons 3.855 and 4.008 respectively. In contrast, the Hesperidae and Papilionidae families showed a stability in richness through all seasons. This research examined the crucial impact of seasonal variations on the diversity and species richness of butterfly populations, emphasizing the adaptive responses of different families to climatic and environmental variations. This study focuses on the significance of seasonal monitoring to understand the butterfly ecology and supporting conservation initiatives.

Keywords: Seasonal variation, butterfly ecology, richness, abundance, conservation initiatives

Introduction

All over the world, butterfly populations are declining because of environmental changes and anthropogenic activities. It is necessary to understand the significance of butterflies, as these attractive creatures are crucial for the ecosystem. In our ecosystem, the existence of Lepidoptera (Butterflies) serve as an ecological indicator of a healthy environment and plays a critical role in pollination, both of which are essential for achieving sustainability and conserving the diversity of flora and fauna as well. Nearly 28,000 species of butterflies exist globally, approximately 80% found in tropical regions. The Indian subcontinent is home to 1,379 species of butterflies that are well-known for their diverse topography, climate, and vegetation (Varshney and Smetacek, 2015; Van Gasse, 2021) [30, 28]. They are the second-largest, most prevalent, and most recognizable arthropods, coming under the phylum Arthropoda and making up the insect order Lepidoptera. Butterflies have frequently taken on a central role in biodiversity monitoring actions and are considered umbrella species in conservation efforts (New, 1997) [13]. The appearance of butterflies is seasonal, observable sometimes, rare, and not visible at other times (Kunte, 2000) [11]. The population of butterflies is significantly affected if even minor changes occur in environmental conditions such as temperature, precipitation, humidity, and other factors (Prakash *et al.*, 2024a) [16]. Butterflies are a very well-studied group of insects. Because they are so sensitive to changes in their environment, they make a great model to study the effects of climate change, since ectotherms physiological processes depend on temperature a lot (Dennis, 1993; Parmesan, 2003; Illan *et al.*, 2012) [4, 14, 6]. A broad range of factors pose significant threats to the important natural habitats of butterflies, and

the conservation of these natural habitats is crucial for the future survival of endangered species (Boriani *et al.*, 2005; Van Swaay *et al.*, 2006) [3, 29]. Dry and wet seasons are key determinants that affect species diversity and seasonality (Wolda 1988; Groton *et al.*, 2012) [31, 5]. This paper highlights the diversity, richness, and impact of seasonal variations on the butterfly population of the district Lucknow.

Materials and Methods

We conducted this research from November 2022 to October 2024, during three distinct seasons: summer (March to June), rainy season (July to October), and winter (November to February). Lucknow has a humid subtropical climate. The southwest monsoon arrives in Lucknow, that is, it comes from the third week of June to August. Lucknow receives an average annual rainfall of 827.2 mm. On the basis of weather parameters of two years of data of Lucknow, maximum temperatures reach 24°C in January 2024 to 46°C in June 2024, and minimum temperatures from 3°C in January 2024 to 26°C in both July 2023 and June 2024. The relative humidity recorded 88%, the highest in January 2023, and dropped to a low of 32% in April 2024. We recorded variations in air pressure between 1018 mbar in January 2024 and 998 mbar in July 2024 (Fig; 2).

Study sites: We have conducted the present study on the diversity and seasonal dynamics of butterflies at three selected sites in the district Lucknow. The selected sites are: Site-1: Kukrail Reserve Forest is a tropical dry deciduous forest located approximately 9 km northeast direction to the city center that covers a 5000-acre area. It is located on the geographical coordinates of 26° 54' 45.5" N and 80° 59'

32.0'' E. Site-2: Rasoolpur Iduria Reserve Forest lies on the coordinates 26° 44' 40.9'' N and 80° 56' 01.6'' E, covering 113.026 acres of forest areas near SGPGIMS. Site-3: Musabagh Reserve Forest covers 284.171 acres and lies on the coordinates 26° 52' 26.1'' E and 80° 52' 12.8'' N (Fig;1). The selected sites are rich in vegetation, aspects a diverse range of floral species, including distinct types of herbs, shrubs, grasses, and woody plants.

based on the specific features of each forest. During the survey in the Kukrail reserve forest, we covered an 800-meter length and a 5-meter-wide strip on either side of the transect. In Rasoolpur Iduria, the reserve forest covers 1000 meters in length, with a width of 5 meters on either side of the transect during documentation. In Musabagh reserve forest, we traversed a length of 600 meters and a width of 5 meters on either side of the transect.

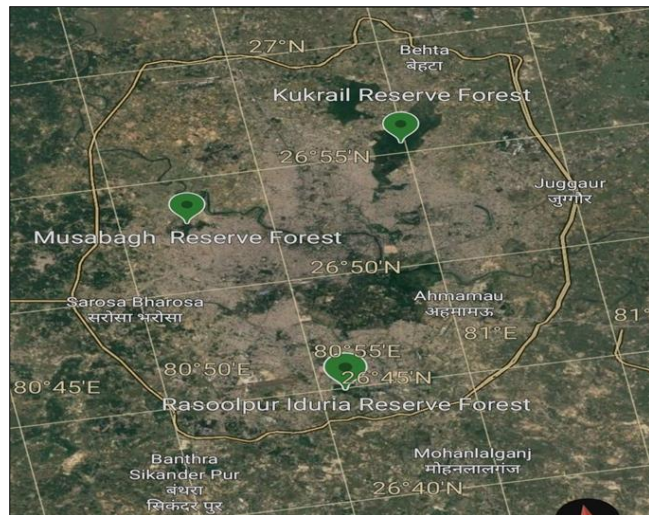


Fig 1: Satellite view of the study site, (Courtesy: Google Earth).

For the documentation of butterfly populations at all selected sites, we applied the (Pollard, 1977) [15] strip transect method. Every transect varied in length and width,

Sampling techniques: Observations and data collection of butterflies have been done continuously every ten days at all three sites in each month. Every observed butterfly species had its identification documented. The authors used an aerial sweep hand net to capture and release butterflies from species that were not identifiable through direct observation. The authors documented the butterflies through photographs, using a Nikon D5600 mounted with a 70-300 mm lens. The authors identified butterflies using available field guide such as (Smetacek, 2016; Kehimkar, 2016; Bhakare and Ogale, 2018) [25, 7, 2]. We conducted the butterfly survey early in the morning, from 8:30 AM to 11:30 AM, and at mid-noon, from 1:30 PM to 3:30 PM.

Data analysis: The Shannon Diversity index is applied to evaluate the species diversity of butterflies from all the sites (Shannon and Wiener, 1949) [20]. The analysis of dominance of diversity of butterfly families using Simpson Dominance index (Simpson, 1949) [24] and (Margalef Richness index, 1958) [12] to evaluate the richness of butterfly across different seasons.

Table 1: Observation of list of seasonal status of butterfly population of district Lucknow.

S.N.	Common Name	Scientific Name	SS	RS	WS
Family: Pieridae Genus (9) Genus% (16.07) Species (14) Species % (15.55%)					
1.	Common Emigrant	<i>Catopsilia pomona</i> (Fabricius)	+	+	+
2.	Mottled Emigrant	<i>Catopsilia pyranthe</i> (Linnaeus)	+	+	+
3.	Common Gull	<i>Cepora nerissa</i> (Fabricius)	+	+	+
4.	Pioneer	<i>Belenois aurota</i> (Fabricius)	+	+	+
5.	One-Spot Grass yellow	<i>Eurema andersoni</i> (Moore)	-	+	+
6.	Common Grass Yellow	<i>Eurema hecabe</i> (Linnaeus)	+	+	+
7.	Small Grass Yellow	<i>Eurema brigitta</i> (Stoll)	+	+	+
8.	Three-spot Grass Yellow	<i>Eurema blanda</i> (Boisduval)	+	+	+
9.	Yellow Orange Tip	<i>Ixias pyrene</i> (Linnaeus)	-	+	+
10.	White Orange Tip	<i>Ixias marianne</i> (Cramer)	+	+	-
11.	Common Jezabel	<i>Delias eucharis</i> (Drury)	-	+	+
12.	Common Wanderer	<i>Pareronia hippia</i> (Fabricius)	+	+	+
13.	Psyche	<i>Leptosia nina</i> (Fabricius)	+	+	+
14.	Indian Cabbage White	<i>Pieris canidia</i> (Linnaeus)	+	-	+
Family: Lycaenidae Genus (20) Genus% (35.71%) Species (31) Species% (34.44%)					
15.	Common Silverline	<i>Cigaritis vulcanus</i> (Fabricius)	+	+	-
16.	Common Shot Silverline	<i>Cigaritis ictis</i> (Hewitson)	+	-	-
17.	Scarce Shot Silverline	<i>Cigaritis elima</i> (Moore)	+	+	-
18.	Large Oakblue	<i>Arhopala amantes</i> (Hewitson)	+	-	+
19.	Indian Oakblue	<i>Arhopala atrax</i> (Hewitson)	+	+	-
20.	Gram Blue	<i>Euchrysops cnejus</i> (Fabricius)	+	+	+
21.	Pea Blue	<i>Lamipdes boeticus</i> (Linnaeus)	+	+	+
22.	Zebra Blue	<i>Leptotes plinius</i> (Fabricius)	+	+	+
23.	Common Ciliate Blue	<i>Anthene emolus</i> (Godart)	+	+	-
24.	Bright Babul Blue	<i>Azanus ubaldus</i> (Stoll)	-	+	-
25.	Dull Babul Blue	<i>Azanus uranus</i> (Butler)	-	+	-
26.	Common Lineblue	<i>Prosotas nora</i> (C. Felder)	+	+	-
27.	Tailless Lineblue	<i>Prosotas dubiosa</i> (Semper)	+	-	-
28.	Lime Blue	<i>Chilades lajus</i> (Stoll)	+	+	+

29.	Small Cupid	<i>Chilades parrhasius</i> (Fabricius)	-	+	+
30.	Plain Cupid	<i>Chilades pandava</i> (Horsfield)	+	+	+
31.	Forget- me-not	<i>Catochrysops strabo</i> (Fabricius)	+	+	+
32.	Common Pierrot	<i>Castalius rosimon</i> (Fabricius)	+	+	+
33.	Red Pierrot	<i>Talicauda nyseus</i> (Guérin-Méneville)	-	+	+
34.	Striped Pierrot	<i>Tarucus nara</i> (Kollar)	+	+	-
35.	Black-spotted Pierrot	<i>Tarucus balkanicus</i> (Freyer)	-	+	+
36.	Indian Pierrot	<i>Tarucus indica</i> (Evans)	+	+	+
37.	Dark Cerulean	<i>Jamides bochus</i> (Stoll)	+	+	-
38.	Slate Flash	<i>Rapala manea</i> (Hewitson)	-	+	+
39.	Indian Red Flash	<i>Rapala iarbus</i> (Fabricius)	-	-	+
40.	Indian Sunbeam	<i>Curetis thetis</i> (Drury)	+	+	-
41.	Tiny Grass Blue	<i>Zizula hylax</i> (Fabricius)	-	+	+
42.	Pale Grass Blue	<i>Pseudozizeeria maha</i> (Kollar)	+	+	+
43.	Dark Grass Blue	<i>Zizeeria karsandra</i> (Moore)	+	+	+
44.	Oriental Grass Jewel	<i>Freyeria putli</i> (Kollar)	+	+	-
45.	Grass Jewel	<i>Freyeria trochylus</i> (Freyer)	+	+	-
Family: Nymphalidae Genus (19) Genus% (33.92%) Species (32) Species% (35.55%)					
46.	Plain Tiger	<i>Danaus chrysippus</i> (Linnaeus)	+	+	+
47.	Common Tiger	<i>Danaus genutia</i> (Cramer)	+	+	+
48.	Common Crow	<i>Euploea core</i> (Cramer)	+	+	+
49.	Blue Tiger	<i>Tirumala limniace</i> (Cramer)	+	+	-
50.	Glassy Tiger	<i>Parantica aglea</i> (Stoll)	+	+	-
51.	Common Leopard	<i>Phalanta phalantha</i> (Drury)	+	+	+
52.	Painted Lady	<i>Vanessa cardui</i> (Linnaeus)	+	-	+
53.	Danaid Eggfly	<i>Hypolimnas misippus</i> (Linnaeus)	+	+	+
54.	Great Eggfly	<i>Hypolimnas bolina</i> (Linnaeus)	+	+	+
55.	Peacock Pansy	<i>Junonia almana</i> (Linnaeus)	+	+	+
56.	Blue Pansy	<i>Junonia orithya</i> (Linnaeus)	+	+	+
57.	Yellow Pansy	<i>Junonia hierta</i> (Fabricius)	+	+	-
58.	Grey Pansy	<i>Junonia atlites</i> (Linnaeus)	+	+	+
59.	Chocolate Pansy	<i>Junonia iphita</i> (Cramer)	+	-	+
60.	Lemon Pansy	<i>Junonia lemonias</i> (Linnaeus)	+	+	+
61.	Common Castor	<i>Ariadne merione</i> (Cramer)	+	+	+
62.	Angled Castor	<i>Ariadne ariadne</i> (Linnaeus)	-	+	+
63.	Tawny Coster	<i>Acraea violae</i> (Fabricius)	+	+	+
64.	Common Nawab	<i>Polyura athamas</i> (Drury)	+	+	+
65.	Anomalous Nawab	<i>Polyura agrarius</i> (Swinhoe)	-	+	-
66.	Black Rajah	<i>Charaxes solon</i> (Fabricius)	+	+	-
67.	Common Baron	<i>Euthalia aconthea</i> (Cramer)	+	+	+
68.	Gaudy Baron	<i>Euthalia lubentina</i> (Cramer)	+	+	-
69.	Commander	<i>Moduza procris</i> (Cramer)	+	+	-
70.	Common Palmfly	<i>Elymnias hypermnestra</i> (Linnaeus)	+	-	+
71.	Common Evening Brown	<i>Melantis leda</i> (Linnaeus)	+	+	+
72.	Bamboo Treebrown	<i>Lethe europa</i> (Fabricius)	-	+	+
73.	Common Three-ring	<i>Ypthima asterope</i> (Klug)	+	+	+
74.	Common Four-ring	<i>Ypthima huebneri</i> (Kirby)	+	-	+
75.	Lesser Three-ring	<i>Ypthima inica</i> (Hewitson)	+	+	+
76.	Common Bushbrown	<i>Mycalasis perseus</i> (Fabricius)	-	+	+
77.	Dark Branded Bushbrown	<i>Mycalasis mineus</i> (Linnaeus)	-	+	+
Family: Hesperidae Genus (5) Genus % (8.92%) Species (9) Species% (10%)					
78.	Rice Swift	<i>Borbo cinnara</i> (Wallace)	+	+	+
79.	Bevan's Swift	<i>Borbo bevani</i> (Moore)	+	+	-
80.	Dark Palm-Dart	<i>Telicota bambusae</i> (Moore)	-	+	+
81.	Indian Skipper	<i>Spialia galba</i> (Fabricius)	+	+	-
82.	Small Branded Swift	<i>Pelopidas mathias</i> (Fabricius)	+	+	+
83.	Pale Small Branded Swift	<i>Pelopidas thrax</i> (Heubner)	+	+	+
84.	Large Branded Swift	<i>Pelopidas subochracea</i> (Moore)	-	+	+
85.	Conjoined Swift	<i>Pelopidas conjuncta</i> (Herrich-Schäffer)	-	+	+
86.	Common Banded Awl	<i>Hasora chromus</i> (Cramer)	+	+	-
Family: Papilionidae Genus (3) Genus% (5.35%) Species (4) Species% (4.44%)					
87.	Common Mormon	<i>Papilio polytes</i> (Linnaeus)	+	+	+
88.	Common Rose	<i>Pachliopta aristolochiae</i> (Fabricius)	+	+	-
89.	Lime Butterfly	<i>Papilio demoleus</i> (Linnaeus)	+	+	+
90.	Common Jay	<i>Graphium doson</i> (C. & R. Felder)	+	+	+

Abbreviations: SS: Summer Season, RS: Rainy Season, WS: Winter Season, "-" not recorded, "+" recorded.

Table 2: Family-wise diversity and dominance of butterfly population over two years from 2022-2024.

Family	Pieridae		Lycaenidae		Nymphalidae		Hesperiidae		Papilionidae	
	H	D	H	D	H	D	H	D	H	D
SS22-23	2.027	0.142	2.693	0.084	2.845	0.073	1.473	0.270	1.198	0.344
SS23-24	2.038	0.141	2.758	0.078	2.917	0.068	1.580	0.233	1.156	0.365
RS22-23	2.305	0.119	3.069	0.053	3.012	0.062	1.923	0.192	1.306	0.285
RS23-24	2.358	0.110	3.087	0.052	3.086	0.054	1.935	0.188	1.308	0.286
WS22-23	2.310	0.111	2.451	0.096	2.728	0.080	1.104	0.401	0.945	0.405
WS23-24	2.335	0.108	2.472	0.093	2.848	0.070	1.232	0.359	0.962	0.401

Abbreviations: H: Shannon diversity index, D: Simpson Dominance index, SS: Summer Season, RS: Rainy Season, WS: Winter Season.

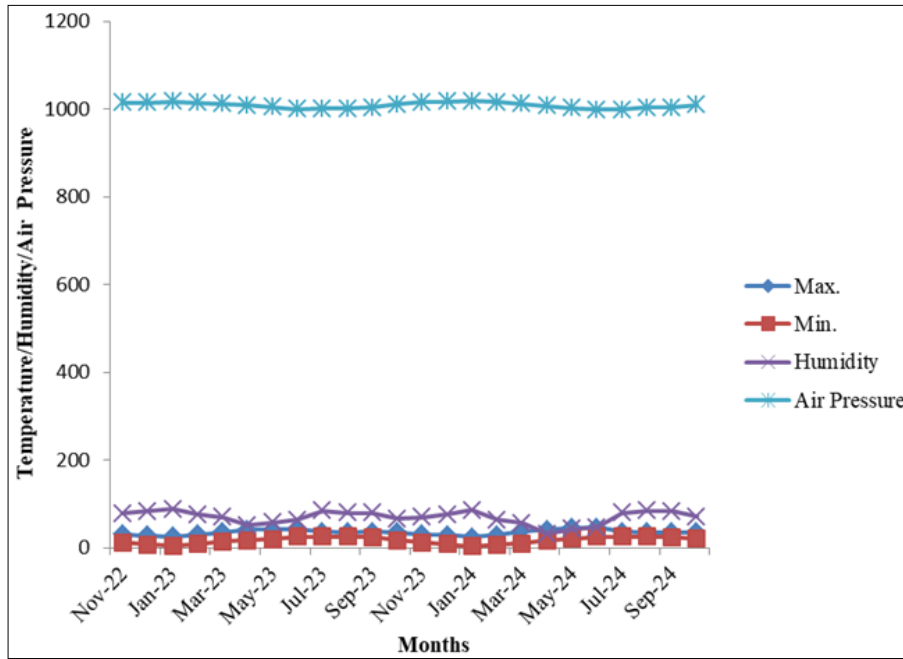


Fig 2: Weather parameters (temperature, humidity, and air pressure) of Lucknow across months from 2022- 2024

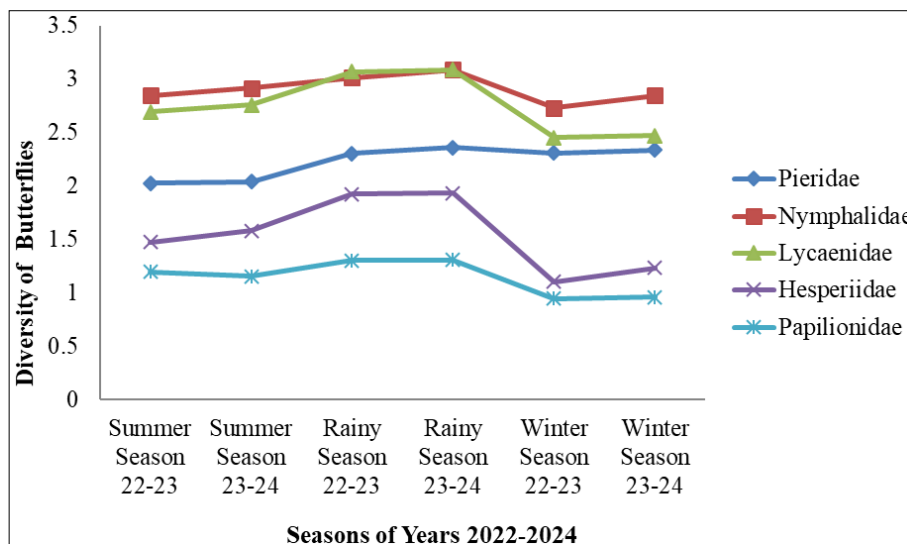


Fig: 3 Diversity of butterfly families across different seasons from 2022-2024

Results and Discussion

During the two year study period we recorded total 39,151 individuals, representing 90 species from three different selected study sites of district Lucknow. The Nymphalidae family recorded the highest number of butterfly individuals, 12648, followed by the Lycaenidae family with 12399, the Pieridae family with 8077, the Hesperiidae with 3603, and the lowest number of butterfly recorded shows in Papilionidae family with 2424. The study examined the

diversity of butterflies from all five families, Pieridae, Nymphalidae, Lycaenidae, Hesperiidae, and Papilionidae during the summer, rainy (including pre- and post-monsoon), and winter seasons, over two years from 2022 to 2024 (Fig: 3). The diversity of butterflies is influenced due to seasonal variations, which significantly impact their visibility and abundance. The season-wise weather data for Lucknow showed temperature variations, with mainly high temperatures and lower humidity in the summer season and

lower temperatures and higher humidity in the winter season (Fig; 2). During the summer season, butterflies are primarily active and visible, their diversity increases during the rainy season, and decreases in the winter. The findings indicate that the overall diversity of the family Nymphalidae is relatively high compared to the butterfly families. However in rainy season, the family Lycaenidae exhibits greater diversity than Nymphalidae and all other families. With the highest value recorded, 3.069 in the rainy season of 2022-2023 and 3.087 of 2023-2024. During the winter seasons, the diversity diminishes, reaching its lowest at 2.451 in the winter season of 2022–2023 and 2.472 in 2023-2024. The family Hesperidae exhibits the highest diversity in the rainy season, reaching a value of 1.923 in 2022-2023 and 1.935 in 2023-2024. Apart from this, the winter seasons show the lowest diversity in Hesperidae family, with the least value of 1.104 recorded in the winter season of 2022–2023. Family Papilionidae shows the highest diversity in rainy seasons, with the highest value of 1.308 in the year 2023-2024 and the lowest diversity recorded during the winter seasons, with the least value of 0.945 in the 2022-2023. In family Pieridae, we observed a relatively consistent level of diversity across all seasons, despite not being the most diverse. The Pieridae family of 2023–2024 exhibits the highest diversity, with a value of 2.358 in the rainy season, and the summer season of 2022–2023 observed the lowest diversity, at 2.027 (Table 2). Overall, five families of butterflies in the rainy season (pre- and post-monsoon) had the highest dominance of butterflies observed in Lycaenidae and Nymphalidae in the years 2023–2024 and the lowest dominance observed in Papilionidae family in the years 2022–2024 (Table 2).

The analysis of seasonal patterns of species richness among different families of butterfly population across two years in each of the three seasons: summer, rainy, and winter. The Pieridae family possesses constant species richness in all of the seasons, with values around 1.614 in the rainy season to 1.677 in the summer and 1.652 in winter. The Nymphalidae family has significant variation in species richness, with a slight increase in winter (3.855) compared with the summer (3.661) and rainy (3.657) seasons. This indicates that this family expands throughout all seasons, with a slight increase during winter. The Lycaenidae family encompasses a substantial increase in species richness in winter (4.008) compared with summer (3.538) and rainy seasons (3.461). This indicates that winter could provide healthier conditions for this family. The Hesperidae family exhibits a decline in species richness during the rainy season (1.033) compared to winter (1.196) and summer (1.286). This result shows that rainy weather might be less favorable for this family. At last, the Papilionidae family has the lowest species richness among all families, with a slight rise in winter (0.613) instead of rainy season (0.428) and summer seasons (0.423). This suggests a generally constrained presence throughout the year, with a slight rise in the winter. Changes in weather patterns, temperature variations, and shifts in flowering seasons directly influence their development, life cycle, migration patterns, and overall survival of butterflies. In analysis of observation the authors recorded 56 genera and 90 species in all five families of butterflies. In terms of genera and species, the Nymphalidae and Lycaenidae families represent the most diverse, while the Papilionidae family is the least diverse (Table1).

In previous years, the diversity, distribution, and habitat status of butterflies have been studied in Lucknow and neighboring districts (Kumar *et al.*, 2016; Kumar and Rana, 2018; Kumar, 2020; Sharma *et al.*, 2024; Prakash *et al.*, 2024d) [8, 9, 10, 21, 17]. Several new records of butterfly species have been documented in Lucknow and other parts of Uttar Pradesh recently, (Sushmita *et al.*, 2021; Sharma *et al.*, 2021; Sushmita *et al.*, 2022; Sheikh *et al.*, 2023; Antil *et al.*, 2024) [26, 22, 27, 23, 1]. (Prakash *et al.*, 2024b; 2024c) [18, 19] have also identified some butterfly species according to their genitalia. These new records indicate an increasing number of studies on butterflies in Uttar Pradesh compared to previous years. This growing research interest highlights a significant shift towards understanding the Lepidoptera diversity of the region. To build upon these findings, it is crucial to further advance and systematic research efforts, enabling a comprehensive understanding of species distribution, ecological roles, and population dynamics.

Conclusion

We analyzed all the observed diversity data of butterfly families over the two years, and we found that the families Lycaenidae and Nymphalidae exhibited the highest diversity in rainy seasons (including pre- and post-monsoon), indicating that butterflies generally prefer wet climate conditions for appearance during these seasons despite the summer and winter seasons. From a conservation perspective, it is necessary to understand the study of seasonal impacts on butterfly populations. Monitoring seasonal variations in butterflies yields positive result that inform strategies to mitigate the effects of climate change. These studies enable researchers to more accurately predict population trends and create effective conservation plans.

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