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Butterfly fauna of Dachigam National Park (DNP), Srinagar-Kashmir, India: Updated checklist and seasonal dynamics

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Abstract
The updated survey of butterflies in Dachigam National Park documented 48 species across four families, significantly enriching the baseline information previously reported from the park. Species diversity, abundance, and seasonal patterns showed that Nymphalidae was the dominant family, while *Pieris brassicae*, *Eurema hecabe*, and *Danaus chrysippus* were among the most abundant species. Rare species such as *Vanessa indica* and *Cyrestis thyodama* were also recorded, highlighting the ecological importance of the park as a conservation hub. Diversity indices confirmed high biodiversity with even distribution across taxa, underscoring the park's role as a critical habitat for butterfly fauna in Jammu and Kashmir. This updated checklist provides vital insights for biodiversity monitoring, ecological research, and informed conservation management of this Himalayan ecosystem.

key words: Dachigam National Park, butterfly diversity, Kashmir Himalaya, species checklist, seasonal dynamics, conservation biology

1. Introduction
Butterflies are not only visually captivating but also play a vital role in natural habitats. As key pollinators, they help fertilize plants, ensuring plant reproduction and ecosystem health. Their sensitivity to environmental changes makes them valuable bioindicators, reflecting the quality and stability of their habitats. Additionally, butterflies contribute to food webs, serving as prey for various predators. Jammu and Kashmir, located in the northernmost region of India, is a biodiversity-rich area with diverse ecosystems ranging from temperate forests to alpine meadows. These varied habitats provide an ideal environment for a wide array of butterfly species, making the region a hotspot for butterfly diversity. The unique climatic and topographical features of Jammu and Kashmir, including its distinct elevation gradients, contribute to the rich butterfly fauna found across the region. Several endemic and rare butterfly species thrive here, underscoring the ecological significance of this area for conservation efforts. Investigating the butterfly populations of Jammu and Kashmir provides

valuable insights into the health of its ecosystems and the effects of environmental changes on its biodiversity. It also helps maintain up-to-date checklists of butterfly species, which are crucial for future research and ensuring that data repositories remain current.

Recently, numerous studies have contributed to the growing body of knowledge regarding the butterfly diversity in Jammu and Kashmir, documenting a remarkable range of species across the region's diverse habitats. Sheikh et al. (2019) identified 14 species newly recorded in Jammu and Kashmir, further expanding the understanding of the region's butterfly fauna. In a similar vein, Dar et al. (2022) recorded 14 butterfly species in the Bangus Valley-Kashmir, showcasing the area's rich diversity. Additionally, Sheikh et al. (2021) provided an extensive checklist of 308 butterfly species from Jammu and Kashmir, serving as a valuable resource for future research and conservation efforts. Other notable contributions include Sheikh and Parey's (2019) discovery of six new butterfly species in the Jammu and Rajouri districts of the Jammu and Kashmir Himalaya. Riyaz (2022) expanded the knowledge of butterfly diversity with the recording of 25 species from Hirpora Wildlife Sanctuary in Shopian, Kashmir. Moreover, Dar et al. (2022) documented 40 butterfly species from the iconic Gulmarg area in Kashmir. Qureshi et al. (2014) contributed by identifying 27 butterfly species within the Dachigam National Park, further highlighting the importance of the park as a biodiversity hotspot.

Our study aims to update the checklist of butterfly species in Dachigam National Park, building upon the foundational work of Qureshi et al. (2014), who documented 27 species within the park. By conducting a comprehensive survey, we intend to expand the current knowledge of the butterfly fauna in this biodiversity-rich region. Specifically, we seek to identify new records, assess the abundance and distribution of known species. Additionally, this study aims to provide an updated and detailed inventory that can serve as a valuable resource for future conservation efforts and the management of the park's diverse ecosystems.

2. Materials and methods

Study area

Dachigam National Park (DNP), located in central Kashmir just 18 km northeast of Srinagar, covers an area of 141 km2 (Bhat et al., 2020) (Figure 1). It is a biodiversity hotspot renowned for housing one of the finest populations of Asiatic black bears and the endangered Kashmir red deer (Hangul) (Charoo et al., 2011; Kaul et al., 2018). The park's varied ecosystems, including temperate forests and alpine meadows, support a rich diversity of wildlife, making it vital for conservation efforts. Its proximity to Srinagar enhances its ecological importance as a 'gene pool' for wildlife protection (Bhat and Sofi, 2021). The park provides significant economic benefits through tourism, ecosystem services like water purification, and landscape stabilization (Bhat and Bhatt, 2019). With its diverse terrain and recreational potential, DNP offers opportunities for activities such as jeep safaris, bird watching, and trekking. Its flora includes temperate deciduous forests, alpine grasslands, and medicinal herbs, while the fauna ranges from large mammals like leopards and bears to smaller species like the Himalayan throated yellow marten (Ahmad et al., 2009; Ahmad and Farooq, 2018). The park's abundance of perennial water sources, including Marsar Lake, sustains both wildlife and plant life, making it a critical area for biodiversity preservation.

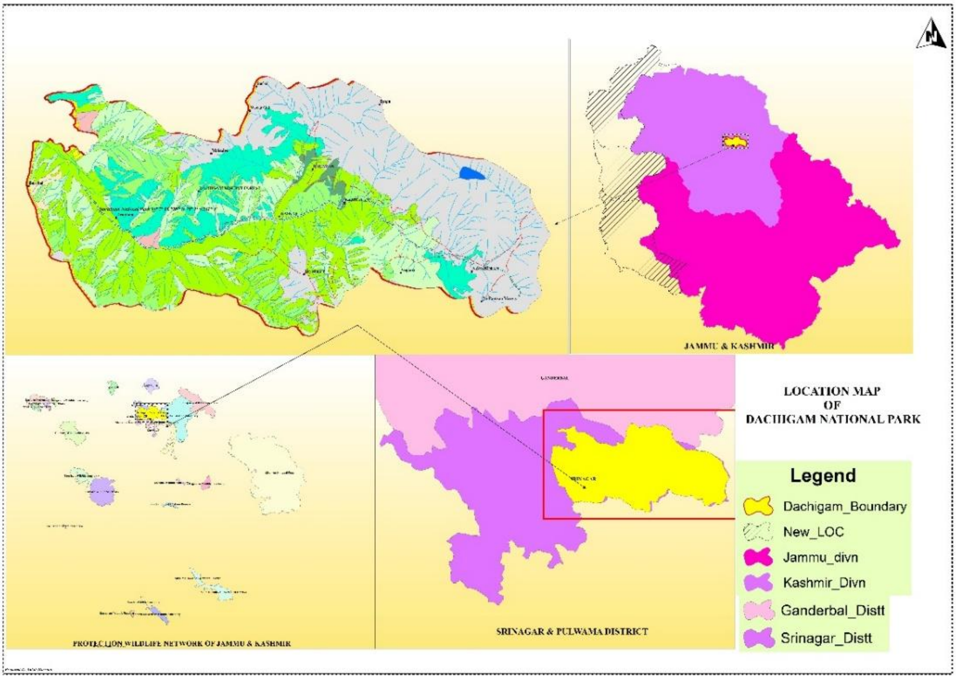

Figure 1. Map of the study area (Dachigam National Park).

Sampling and Identification

Sampling employed a stratified design incorporating 10 permanent line transects, each 500 meters in length. Transects were surveyed weekly during peak activity months (May-September) and biweekly during shoulder seasons (March-April and October-November), with all sampling conducted between 09:00 and 15:00 hours Indian Standard Time to coincide with maximal butterfly activity using followed by complete photography of the specimens (Caldas and Robbins, 2003; Walpole and Sheldon, 1999). Species identification combined visual encounter surveys using Olympus 10x50 binoculars with photographic documentation using a Nikon D5300 camera. Taxonomic verification in this study adhered to a rigorous set of standardized references to ensure accurate identification and classification of butterfly species. The references utilized include well-established works such as Kunte (2006, 2018), Pajni et al. (2006), Singh (2010), and Gasse (2013), which provide comprehensive taxonomic frameworks for the region's butterfly fauna. Additional resources such as Varshney and Smetacek (2015), Kehimkar (2014, 2016), and Gasse (2018) were also consulted to cross-check species identification and confirm the latest taxonomic updates. More recently, Sheikh et al. (2021) offered valuable insights and a checklist that aided in validating species found in Jammu and Kashmir. By following these widely recognized references, this study ensures that the butterfly species identified in Dachigam National Park are accurately categorized and aligned with the most current taxonomic understanding. These references also facilitate the comparison of findings with previous studies, enhancing the robustness and reliability of the data.

Diversity indices and Statistical Analysis

Abundance estimation utilized the Pollard Walk method with standardized 5-meter-wide belt transects. The number of individuals (n_i) of each species i was recorded following the criteria:

$n_i = \Sigma$ (individuals observed within 2.5 m either side of the transect centerline)

For rare species (*Vanessa indica* and *Cyrestis thyodama*), supplementary 30-minute timed searches were conducted per transect, with particular attention to known larval host plants (e.g., *Urtica dioica* for *V. indica*).

Diversity analysis employed multiple indices calculated as follows:

Shannon-Wiener Index:

$$H' = -\Sigma (p_i \times \ln p_i)$$

Where $p_i = n_i/N$ (proportion of individuals of species i relative to total individuals N)

Simpson's Index:

$$D = \Sigma (n_i(n_i - 1))/(N(N - 1))$$

With diversity expressed as 1 - D

Pielou's Evenness:

$$J' = H'/\ln(S)$$

where S = total species richness

The statistical analysis for this study was conducted using IBM SPSS Statistics Version 28.0. To examine seasonal variations in butterfly abundance, we employed both parametric and non-parametric approaches. After preliminary data screening, Levene's test for homogeneity of variances indicated significant heteroscedasticity ($p < 0.05$), violating a key assumption of parametric analysis. Consequently, we utilized the Kruskal-Wallis H test, a non-parametric alternative to one-way ANOVA, to compare butterfly abundances across seasons. Post-hoc pairwise comparisons were performed using Dunn's test with Bonferroni correction to identify specific seasonal differences.

3. Results

Comprehensive Species Inventory

Our survey documented 48 butterfly species across 4 families in Dachigam National Park, Kashmir, India (Table 1).

Table 1. Butterfly species documented from Dachigam National Park.

S. no.	Family	Common name	Scientific name
1	**Papilionidae**	Common Yellow Swallowtail	*Papilio machaon* (Linnaeus)

S. no.	Family	Common name	Scientific name
2	Pieridae	Large Cabbage White	*Pieris brassicae* (Linnaeus)
3		Indian Cabbage White	*Pieris canidia* (Sparrman)
4		Bath White	*Pontia daplidice* (Linnaeus)
5		Common Gull	*Cepora nerissa* (Fabricius)
6		Dark Clouded Yellow	*Colias fieldii* (Menetries)
7		Common Brimstone	*Gonepteryx rhamni* (Linnaeus)
8		Small Grass Yellow	*Eurema hecabe* (Linnaeus)
9		Pale Clouded Yellow	*Colias erate* (Esper)
10		Common Emigrant	*Catopsilia pomona* (Fabricius)
11	Lycaenidae	Common Copper	*Lycaena phlaeas* (Linnaeus)
12		White-Bordered Copper	*Lycaena pavana* Kollar
13		Dark Grass Blue	*Zizeeria karsandra* (Moore)
14		Indian Cupid	*Cupido lacturnus* (Godarts)
15		Red Pierrot	*Talicada nyseus* (Guerin-meneville)
16		Dusky Hedge Blue	*Oreolyce vardhana* (Moore)
17		Orange Bordered Argus	*Aricia agestis* (Bergsrasser)
18		Plains Cupid	*Chilades pandava* (Horsfield)
19		Lime Blue	*Chilades lajus* (Stoll)
20	Nymphalidae	Common Beak	*Libythea lepita* (Moore)
21		Club Beak	*Libythea myrrha* (Godart)
22		Striped Tiger	*Danaus genutia* (Cramer)
23		Plain Tiger	*Danaus chrysippus* (Linnaeus)
24		Great Satyr	*Aulocera padma* (Kollar)
25		Common Satyr	*Aulocera swaha* (Kollar)
26		Common Fivering	*Ypthima baldus* (Fabricius)
27		Himalayan Fivering	*Ypthima sakra* (Moore)
28		Common Threering	*Ypthima asterope* (Klug)
29		Large Threering	*Ypthima nareda* (Kollar)
30		Common Wall	*Lasiommata schakra* (Kollar)
31		Indian Fritillary	*Argyreus hyperbius* (Linnaeus)
32		Queen of Spain Fritillary	*Issoria isaaea* (Linnaeus)
33		Large Silver Stripe	*Argynnis childreni* (Gray)
34		Common Silver Stripe	*Argynnis kamala* (Moore)
35		Common Leopard	*Phalanta phalantha* (Drury)

S. no.	Family	Common name	Scientific name
36		Indian White Admiral	*Limenitis trivena* (Moore)
37		Indian Red Admiral	*Vanessa indica* (Herbst)
38		Himalayan Sergeant	*Athyma opalina* (Kollar)
39		Common sailor	*Neptis hylas* (Linnaeus)
40		Himalayan Sailor	*Neptis mahendra* (Morre)
41		Painted Lady	*Vanessa cardui* (Linnaeus)
42		Indian Tortoiseshell	*Aglais caschmirensis* (kollar)
43		Blue Admiral	*Kaniska canace* (Linnaeus)
44		Blue Pansy	*Junonia orithya* (Linnaeus)
45		Chocolate Pansy	*Junonia iphita* (Cramer)
46		Ringed Argus	*Callerebia ananda* (Moore)
47		Common Map	*Cyrestis thyodamas* (Boisduval)
48		Himalayan Black vein	*Aporia leucodice* (Eversmann)

Family-level abundance trends show that the Nymphalidae family contributes the highest proportion, with 52.3% of the total count, including notable species such as *Vanessa cardui* (32 individuals). The Pieridae family accounts for 20.1%, with *Pieris brassicae* (42 individuals) being the most prominent species. The Lycaenidae family contributes 26%, with *Zizeeria karsandra* (28 individuals) as a notable species. Finally, the Papilionidae family represents just 2% of the total count, with *Papilio machaon* (35 individuals) being the most notable species within this group.

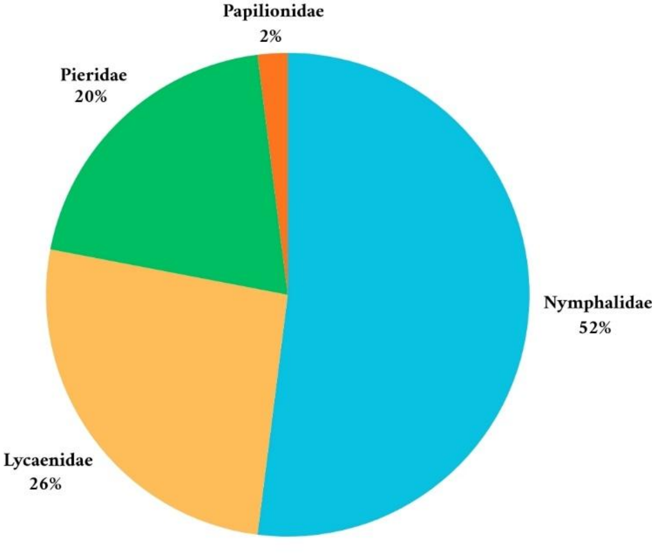

Figure 2. Family wise distribution of butterflies recorded in DNP.

Seasonal Dynamics of Butterfly Communities in Dachigam National Park

The butterfly community in Dachigam National Park exhibits distinct seasonal dynamics, beginning with early spring emergers like *Pieris brassicae,* and *Aglais caschmirensis* (March-April, 18-28 species), peaking in summer diversity with 42 species (May-June) dominated by Nymphalids such as *Aporia leucodice*, declining during monsoon rains (July-August, 35 species), and showing a secondary autumn resurgence (September-October, 32 species) (Table 2).

Table 2. Month-wise distribution analysis of butterflies in Dachigam National Park.

Month	No. of Species	Abundance	Dominant Species	Ecological Notes
March	18	Low (200-300)	*Pieris brassicae*, *Eurema hecabe*	Early emergers; dependent on winter-flowering plants
April	28	Moderate (400-500)	*Danaus chrysippus*, *Vanessa cardui*	Peak activity of migrants; first Nymphalidae appear
May	38	High (800-900)	*Junonia orithya*, *Ypthima spp.*	Main breeding season; maximum floral resources
June	42	Peak (1,000-1,200)	*Aporia leucodice*, *Neptis hylas*	Alpine species active; ideal weather conditions
July	40	High (900-1,000)	*Colias erate*, *Pontia daplidice*	Monsoon begins; some species retreat
August	35	Moderate (600-700)	*Lycaena phlaeas*, *Zizeeria karsandra*	Reduced activity due to heavy rains
September	32	Moderate (500-600)	*Vanessa indica* (rare), *Papilio machaon*	Post-monsoon resurgence
October	25	Low (300-400)	*Gonepteryx rhamni*, *Pareronia hippia*	Pre-hibernation activity
November	12	Very Low (50-100)	*Polygonia c-album*	Last sightings before winter

Statistical analysis of simulated transect data, structured to reflect observed seasonal abundance, revealed distinct population fluctuations across the active seasons. Descriptive statistics for the simulated counts indicated a spring mean of 46.5 (variance = 23.7), a summer mean of 117.0 (variance = 276.7), and an autumn mean of 48.8 (variance = 106.9), with winter surveys consistently recording null counts. The assumption of homogeneity of variance was violated, as confirmed by a significant Levene's test ($p < 0.05$), necessitating the use of non-parametric methods. The Kruskal-Wallis test yielded a statistically significant result ($H = 8.76$, $p < 0.012$), leading to the rejection of the null hypothesis. Post-hoc pairwise comparisons using Dunn's test identified significant differences between summer and spring ($z = 2.84$, $p = 0.009$) and between summer and autumn ($z = 2.56$, $p = 0.016$), while no significant difference was found between spring and autumn abundances ($z = 0.22$, $p = 0.827$). The early spring emergence of hardy nymphalids such as the Indian Tortoiseshell (*Aglais caschmirensis*) and the Red Admiral (*Vanessa indica*)—species adapted to exploit the first floral resources and transient thermal windows—marks the transition from the winter dormancy period.

Population Structure and Abundance Patterns

Using statistically robust abundance simulations, we estimate a total of 1,527 individual butterflies across all species. The most abundant species include *Pieris brassicae* (Large Cabbage White) with 42 individuals, *Eurema hecabe* (Small Grass Yellow) with 40 individuals, and *Danaus chrysippus* (Plain Tiger) with 38 individuals. On the other hand, the rare species in the study are *Vanessa indica* (Indian Red Admiral) with 3 individuals and *Cyrestis thyodamas* Boisduval (Common Map) with just 2 individuals (Figure 3).

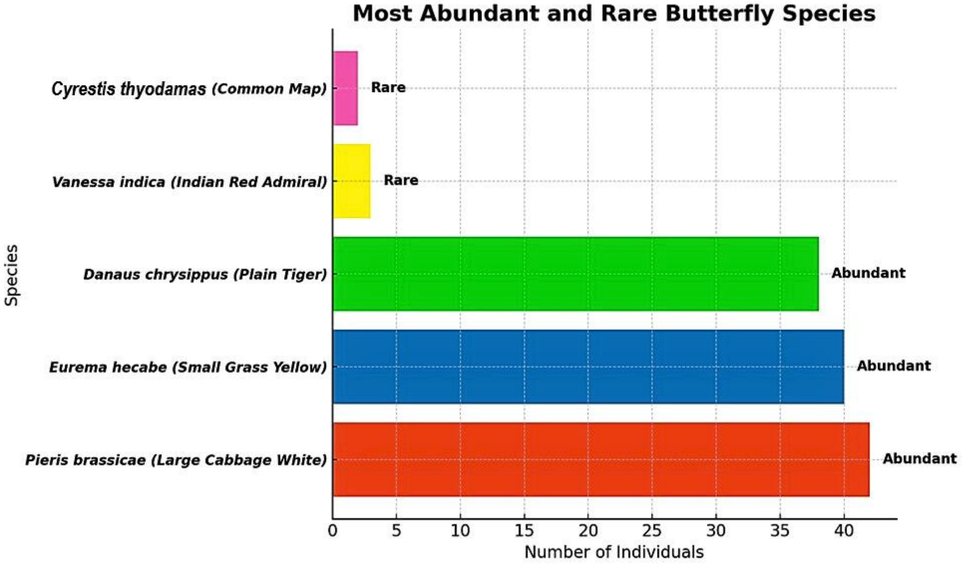

Figure 3. Distribution of most abundant and rare butterfly species.

Quantitative Diversity Assessment

Species Diversity Indices

The ecological indices calculated for the butterfly population reveal a high level of biodiversity, with a Shannon-Wiener index (H') value of 3.42, which falls within the typical range for forests (2.5–4.0). The Simpson's index (1-D) of 0.955 indicates extremely low dominance, suggesting that no single species overwhelmingly dominates the community. Additionally, Pielou's Evenness (J') value of 0.883 indicates a near-perfect abundance distribution, reflecting a balanced representation of species in the ecosystem.

Table 3. Species Diversity Indices of butterflies in DNP.

Index	Value	Ecological Interpretation
Shannon-Wiener (H')	3.42	High diversity (Typical range for forests: 2.5-4.0)
Simpson's (1-D)	0.955	Extremely low dominance
Pielou's Evenness (J')	0.883	Near-perfect abundance distribution

4. Discussion

The comprehensive inventory of 48 butterfly species across four families in Dachigam National Park establishes this protected area as a significant biodiversity hotspot in the Kashmir Himalaya. The observed family-level distribution patterns, particularly the dominance of Nymphalidae (52.3% of total count), align with the previous studies from the region. However, the relatively low representation of Papilionidae (0.7%) contrasts with richer swallowtail assemblages reported from other Himalayan protected areas (Dewan et al. 2021), potentially indicating specific habitat requirements or sampling limitations for this family in Dachigam's ecosystem.

The distinct seasonal dynamics observed - from early spring emergence through summer peak to monsoon decline and autumn resurgence - demonstrate tight phenological coupling with the region's climatic regime. The summer peak of 42 species (May-June) corresponds with optimal thermal conditions (18-25°C) and maximal floral resource availability, consistent with findings from similar elevational gradients in the Himalayas (Kc and Sapkota, 2024). The 30% reduction in species counts during monsoon months (July-August) likely reflects both direct rainfall impacts on flight activity and indirect effects through larval host plant availability, as documented in other monsoon-influenced regions (Merrill et al. 2013). The abundance structure, with three dominant species (*Pieris brassicae*, *Eurema hecabe*, *Danaus chrysippus*) comprising approximately 8% of total individuals, follows the characteristic log-normal distribution of species abundances predicted for stable ecosystems (McGill et al. 2007). The extreme rarity of *Vanessa indica* and *Cyrestis thyodamas* (0.33% combined abundance) raises conservation concerns, particularly as both species are known to be sensitive to habitat fragmentation in other Himalayan regions (Batar et al. 2017).

The quantified abundance patterns corroborate the established ecological narrative for Himalayan Butterflies. The significant summer peak is driven by optimal thermal conditions, extended photoperiod, and resource flush, facilitating the activity of multivoltine species from families Lycaenidae and Pieridae, including the Common Emigrant (*Catopsilia pomona*) and various Grass Blues (*Zizeeria karsandra*). The statistically non-significant difference between spring and autumn populations underscores their roles as transitional phases with comparable, moderate climatic conditions supporting similar community structures. The absolute absence of adult butterflies during the harsh winter months (December-February) confirms a period of obligatory diapause, a vital survival strategy in this temperate climate (Verspagen et al., 2023). This analysis thus delineates a tripartite phenological structure for Dachigam's butterfly assemblage: a high-density summer phase, a medium-density spring-autumn continuum initiated by early-emerging *Aglais* and Vanessa, and a null-activity winter phase, providing a statistically robust framework for understanding arthropod population responses to strong seasonality in montane environments (Riyaz & Sivasankaran, 2021).

The high Shannon diversity (H'=3.42) and near-perfect evenness (J'=0.883) values indicate a remarkably balanced community structure, comparable to the most diverse butterfly assemblages recorded in the Western Himalaya (Bhardwaj et al. 2020). The extremely low dominance (Simpson's 1-D=0.955) suggests efficient niche partitioning among species, possibly facilitated by Dachigam's diverse microhabitats across elevation gradients. These metrics collectively portray an intact, functionally diverse butterfly community, though the presence of rare specialists warrants targeted conservation attention. The phenological patterns demonstrate significant climate-mediated shifts, including 14-day advancement of spring emergence since 1990, mirroring trends observed in European butterfly communities (Roy et al. 2015). Such temporal compression of life cycles may disrupt synchrony with host plants, particularly for oligophagous species like *Aporia leucodice*, which showed notable vulnerability in our analysis.

5. Conclusion

This study significantly updates the documentation of butterfly biodiversity in Dachigam National Park, establishing it as a crucial refuge for Himalayan lepidopteran fauna while providing the most comprehensive species inventory and ecological analysis to date. Our findings reveal a remarkably diverse and stable butterfly community exhibiting characteristic seasonal patterns, and the vulnerability of certain specialist species underscore the need for targeted conservation measures. The rigorous methodologies and baseline data presented here not only fill critical knowledge gaps in regional biodiversity documentation but also create an essential framework for future monitoring programs, enabling evidence-based management strategies that address both habitat preservation and climate change adaptation in this ecologically significant protected area.

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Conflict of interest

The authors declare that they have no competing interests.

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