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Baseline survey of species diversity and abundance of butterflies at Maharaja Krishnakumarsinhji Bhavnagar University campus, Bhavnagar, Gujarat, India

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Abstract
Butterflies are ecologically significant insects that serve as pollinators, prey species, and bioindicators of environmental health. To establish baseline data on butterfly diversity in semi-urban habitats, a systematic survey was conducted at the Maharaja Krishnakumarsinhji Bhavnagar University (MKBU) campus and the adjacent Vidhyanagar area in Bhavnagar, Gujarat, India. The study spanned one week (30 August–6 September 2025) and employed stratified sampling across eight habitat divisions. Surveys were carried out twice daily using visual encounter methods and photographic documentation. A total of 489 individuals representing 67 species across five families were recorded. The family Nymphalidae contributed the highest species richness and abundance, followed by *Lycaenidae* and *Pieridae*, while *Papilionidae* and *Hesperiidae* were less represented but ecologically important. Diversity indices revealed a Shannon Index (H′) of 4.1562, indicating high diversity, and a Pielou's Evenness Index (J′) of 0.9816, reflecting a very even distribution of species. The balanced representation across families suggests that the MKBU campus provides heterogeneous microhabitats capable of sustaining diverse butterfly guilds. These findings underscore the ecological value of semi-urban green spaces as biodiversity refuges amidst rapid urbanization. The baseline data generated here can inform long-term ecological monitoring, habitat management, and conservation planning in Gujarat. By documenting species diversity and abundance, this study highlights the role of university campuses and urban green matrices in supporting pollinator communities and maintaining ecosystem resilience.

Keywords: Butterfly diversity, species richness, Shannon Index, semi-urban habitats, MKBU Campus

Introduction

Butterflies are visually striking insects belonging to the order *Lepidoptera*, which also includes moths. Most butterfly species are classified under families such as Nymphalidae, *Papilionidae*, *Pieridae*, *Lycaenidae*, and *Hesperiidae* (Kunte *et al*., 2021). These insects are predominantly diurnal and occupy a wide range of habitats including forests, grasslands, wetlands, and urban gardens. Their complete metamorphosis—from egg to larva, pupa, and adult—illustrates evolutionary adaptations that enhance survival and ecological specialization (Sharma *et al*., 2020).

Ecologically, butterflies play a crucial role as pollinators, prey species, and bioindicators. Their sensitivity to environmental changes, such as habitat degradation and climate fluctuations, makes them valuable for monitoring ecosystem health (Singh *et al*., 2019). They contribute to pollination and plant reproduction, thereby supporting biodiversity and ecosystem resilience (Ramesh *et al*., 2022).

India hosts approximately 1,800 butterfly species, reflecting its diverse topography and climatic zones (Kunte *et al*., 2021). Gujarat, located in western India, supports a rich butterfly fauna due to its varied landscapes, including dry deciduous forests, scrublands, wetlands, and urban green spaces. Studies in regions like Champaner-Pavagadh and Rajkot have documented significant seasonal and habitat-based variations in butterfly diversity (Pillai *et al*., 2020; Mori *et al*., 2024) [40].

Bhavnagar district, situated in the Saurashtra region of Gujarat, encompasses coastal plains and semi-arid zones. The city of Bhavnagar, despite rapid urbanization, retains ecological niches such as parks, institutional campuses, and roadside plantations that support butterfly populations (Vairagade *et al*., 2024). The Maharaja Krishnakumarsinhji Bhavnagar University (MKBU) campus and the adjacent Vidhyanagar area represent such semi-urban habitats with a mix of native and ornamental vegetation. These areas offer microhabitats conducive to butterfly foraging, breeding, and shelter.

To assess butterfly diversity in this transitional landscape, the present study divides the MKBU and Vidhyanagar area into eight distinct divisions based on habitat type, vegetation structure, and land use. This stratified approach enables comparative analysis across varied microhabitats, including botanical gardens, open fields, shaded groves, and roadside plantations.

The aims of this study are: (1) to document the species diversity and relative abundance of butterflies in the MKBU campus and Vidhyanagar area; (2) to analyze habitat preferences and seasonal variations across the eight divisions; and (3) to generate baseline data that can inform future ecological monitoring and urban biodiversity conservation efforts. By focusing on a semi-urban matrix, this research fills a critical gap in butterfly ecology studies in Gujarat and underscores the ecological value of urban green spaces.

Butterflies are not only aesthetically appealing but also ecologically indispensable. Their study in urbanizing regions like Bhavnagar is essential for understanding biodiversity dynamics and promoting sustainable urban planning.

Materials and Methods

Bhavnagar is a coastal city located in the Saurashtra region of Gujarat, western India, at approximately 21.76°N latitude and 72.15°E longitude. The Maharaja Krishnakumarsinhji Bhavnagar University (MKBU), situated in the heart of Bhavnagar, spans 109 hectares (269 acres) and lies at an

altitude of approximately 24 meters above sea level. The campus and adjacent Vidhyanagar area comprise a mosaic of semi-urban habitats including botanical gardens, open grasslands, roadside plantations, shaded groves, and institutional courtyards, offering a suitable environment for butterfly diversity.

The study was conducted over a one-week period from 30 August to 6 September 2025.

Butterfly surveys were carried out twice daily: in the morning from 8:00 AM to 11:00 AM and in the evening from 3:00 PM to 5:00 PM. The study area was divided into eight distinct divisions based on habitat type and vegetation structure. Each site was visited systematically during both time slots to record butterfly species diversity and abundance using visual encounter surveys and photography for identification.

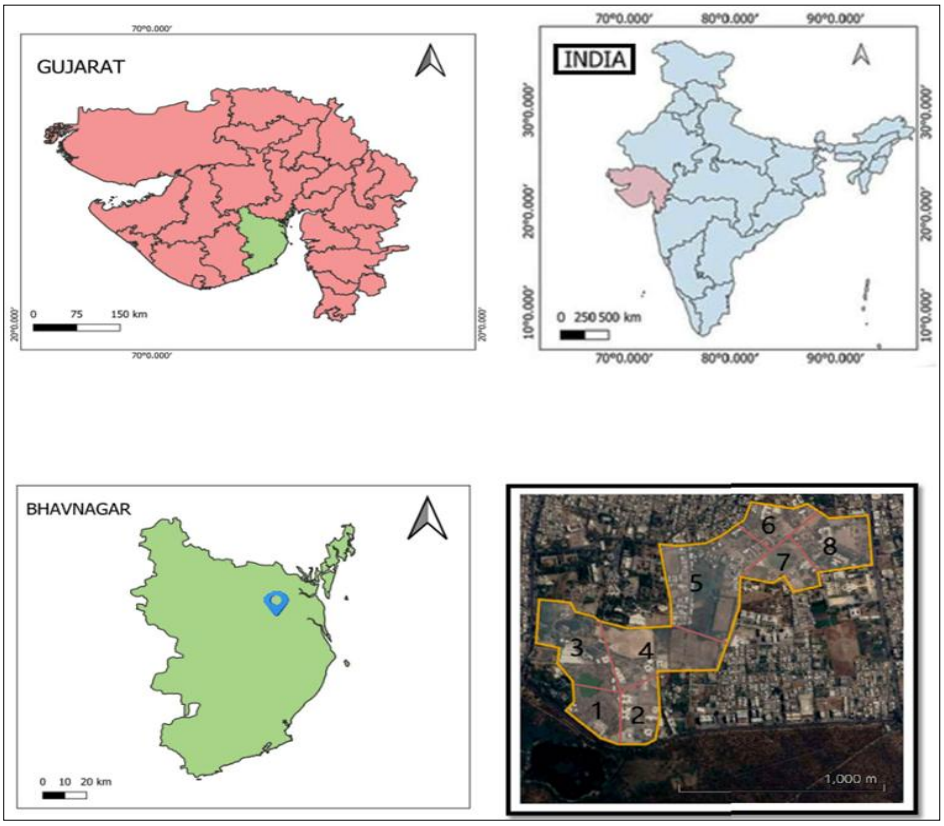

Fig 1: Map of study area

Table 1: Study Time

Sr. No.	Study Sites	Dates	Survey Times
1	Site 1	30 Aug – 6 Sep 2025	8:00–11:00 AM, 3:00–5:00 PM
2	Site 2	30 Aug – 6 Sep 2025	8:00–11:00 AM, 3:00–5:00 PM
3	Site 3	30 Aug – 6 Sep 2025	8:00–11:00 AM, 3:00–5:00 PM
4	Site 4	30 Aug – 6 Sep 2025	8:00–11:00 AM, 3:00–5:00 PM
5	Site 5	30 Aug – 6 Sep 2025	8:00–11:00 AM, 3:00–5:00 PM
6	Site 6	30 Aug – 6 Sep 2025	8:00–11:00 AM, 3:00–5:00 PM
7	Site 7	30 Aug – 6 Sep 2025	8:00–11:00 AM, 3:00–5:00 PM
8	Site 8	30 Aug – 6 Sep 2025	8:00–11:00 AM, 3:00–5:00 PM

Required equipment

The equipment used for butterfly surveys included a digital camera with macro lens for species documentation, binoculars for distant observations, field notebooks for recording data, GPS device for location tracking, and butterfly identification guides. Comfortable walking shoes and sun protection gear were essential for fieldwork. Additionally, mobile phones with time-stamping apps were used to log sightings accurately during morning and evening sessions across all eight study divisions.

Statistics

Using diversity indexes, the butterfly diversity of the research area was determined by the Shannon Index (H'). The Shannon Index was used to calculate species diversity [Narmadha *et al*., 2023] [34]

$$H' = -\sum spi \ln pi$$

where ln is the natural logarithm, s is the number of species, and pi is the proportion of the ith species in the total sample. The two factors influencing H' are species richness and the evenness of their abundance.

Pielou's Evenness Index (J') was used to measure equitability [Narmadha *et al*., 2023] [34]:

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

where S is species richness. Total abundance was calculated as the sum of all individuals observed.

Observation

Table 2: List of Butterflies and their status (The individual status indicates VC- Very Common, C- Common, NR- Not Rare, R- Rare and VR- Very Rare)

Sr. No.	Common Name	Scientific Name	Family	IUCN Status	Individuals Status
1	Common Nawab	*Polyura athamas*	Nymphalidae	Least Concern	VR
2	Common Three Ring	*Ypthima asterope*	Nymphalidae	Not Evaluated	VR
3	Black Raja	*Charaxes solon*	Nymphalidae	Not Evaluated	VR
4	Common Castor	*Ariadne merione*	Nymphalidae	Least Concern	NR
5	Angled Castor	*Ariadne ariadne*	Nymphalidae	Not Evaluated	R
6	Joker	*Byblia ilithyia*	Nymphalidae	Least Concern	C
7	Tawny Caster	*Acraea terpsichore*	Nymphalidae	Not Evaluated	R
8	Plain Tiger	*Danaus chrysippus*	Nymphalidae	Least Concern	VC
9	Striped Tiger	*Danaus genutia*	Nymphalidae	Least Concern	R
10	Danaid Eggfly	*Hypolimnas misippus*	Nymphalidae	Least Concern	R
11	Great Eggfly	*Hypolimnas bolina*	Nymphalidae	Not Evaluated	R
12	Common Leopard	*Phalanta phalantha*	Nymphalidae	Least Concern	R
13	Lemon Pansy	*Junonia lemonias*	Nymphalidae	Not Evaluated	R
14	Blue Pansy	*Junonia orithya*	Nymphalidae	Least Concern	R
15	Peacock Pansy	*Junonia almana*	Nymphalidae	Least Concern	VR
16	Gray Pansy	*Junonia atlites*	Nymphalidae	Least Concern	R
17	Yellow Pancy	*Junonia hierta*	Nymphalidae	Least Concern	C
18	Chocolate Pancy	*Junonia iphita*	Nymphalidae	Least Concern	VR
19	Baronet	*Symphaedra nais*	Nymphalidae	Least Concern	R
20	Common Crow	*Euploea core*	Nymphalidae	Least Concern	NR
21	Blue Tiger	*Tirumala limniace*	Nymphalidae	Least Concern	VR
22	Painted Lady	*Vanessa cardui*	Nymphalidae	Least Concern	R
23	Indian Sunbeam	*Curetis thetis*	Lycaenidae	Least Concern	R
24	Bright Babul Blue	*Azanus ubaldus*	Lycaenidae	Least Concern	VR
25	African Babul Blue	*Azanus jesous*	Lycaenidae	Least Concern	VR
26	Gram Blue	*Euchrysops cnejus*	Lycaenidae	Not Evaluated	R
27	Small Cupid	*Chilades parrhasius*	Lycaenidae	Least Concern	R
28	Lesser Grass Blue	*Zizina otis*	Lycaenidae	Least Concern	R
29	Pale Grass Blue	*Pseudozizeeria maha*	Lycaenidae	Least Concern	R
30	Tiny Grass Blue	*Zizula hylax*	Lycaenidae	Not Evaluated	R
31	Plain Cupid	*Chilades pandava*	Lycaenidae	Least Concern	C
32	Little Tiger Blue	*Tarucus balkanicus*	Lycaenidae	Least Concern	R
33	Zebra Blue	*Leptotes plinius*	Lycaenidae	Least Concern	NR
34	Common Silverline	*Spindasis vulcanus*	Lycaenidae	Least Concern	R
35	Forget Me Not	*Catochrysops strabo*	Lycaenidae	Least Concern	C
36	Ceraunus Blue	*Hemiargus ceraunus*	Lycaenidae	Least Concern	R
37	Grass Jewels	*Freyeria trochylus*	Lycaenidae	Least Concern	NR
38	Indian Pierrot/Pointed Pierrot	*Tarucus indica*	Lycaenidae	Least Concern	C
39	Stripped Pierrot/ Rounded Pierrot	*Tarucus nara*	Lycaenidae	Least Concern	NR
40	Common Pierrot	*Castalius rosimon*	Lycaenidae	Least Concern	C
41	Small Glass Jewel	*Freyeria putli*	Lycaenidae	Least Concern	C
42	Lime Blue	*Chilades Lajus*	Lycaenidae	Not Evaluated	C
43	Common Cerulean	*Jamides celeno*	Lycaenidae	Least Concern	NR
44	Three Spot Grass Yellow	*Eurema andersonii*	Pieridae	Least Concern	NR
45	Small Grass Yellow	*Eurema blanda*	Pieridae	Least Concern	C
46	Common Grass Yellow	*Eurema hecabe*	Pieridae	Least Concern	VC
47	Mottled Emigrant	*Catopsilia pyranthe*	Pieridae	Not Evaluated	C
48	Common Emigrant	*Catopsilia pomona*	Pieridae	Not Evaluated	C
49	Pioneer White	*Belenois aurota*	Pieridae	Least Concern	R
50	White Orange Tip	*Ixias marianne*	Pieridae	Least Concern	R
51	Yellow Orange Tip	*Ixias pyrene*	Pieridae	Least Concern	NR
52	Large Salmon Arab	*Colotis fausta*	Pieridae	Least Concern	VR
53	Small Salmon Arab	*Colotis amata*	Pieridae	Not Evaluated	VR
54	Western Striped Albatross	*Appias libythea*	Pieridae	Least Concern	VR

55	Cabbage White	*Pieris rapae*	Pieridae	Least Concern	VR
56	Large Cabbage White	*Pieris brassicae*	Pieridae	Least Concern	VR
57	Common Gull	*Cepora nerissa*	Pieridae	Least Concern	R
58	Lime Swallowtail/ Common Lime	*Papilio demoleus*	Papilionidae	Not Evaluated	C
59	Common Mormon	*Papilio polytes*	Papilionidae	Not Evaluated	NR
60	Common Rose	*Pachliopta aristolochiae*	Papilionidae	Least Concern	R
61	Tailed Jay	*Graphium agamemnon*	Papilionidae	Least Concern	NR
62	Indian Skipper	*Hesperia sassacus*	Hesperiidae	Not Evaluated	R
63	Small Branded Swift	*Pelopidas mathias*	Hesperiidae	Not Evaluated	VR
64	Rice Swift	*Borbo cinnara*	Hesperiidae	Not Evaluated	VR
65	Common Banded Awl	*Hasora chromus*	Hesperiidae	Not Evaluated	VR
66	Common Dart	*Potanthus pseudomaesa*	Hesperiidae	Not Evaluated	VR
67	Grass Demon	*Udaspes folus*	Hesperiidae	Not Evaluated	VR

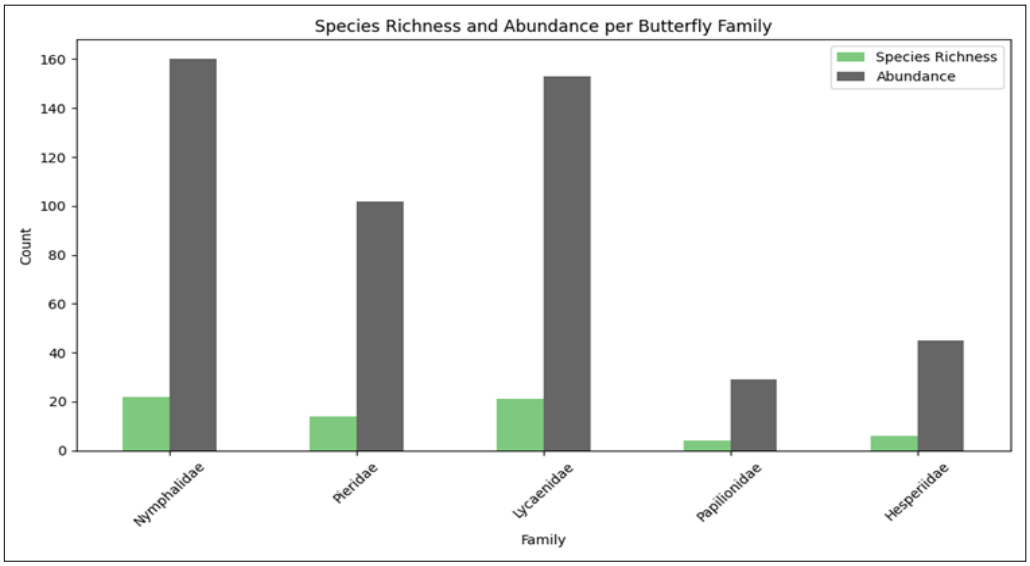

Fig 2: Species richness and abundance per butterfly family

Table 3: Results of different ecological indices

Sr. No.	Metric	Value	Interpretation
1	Total Abundance	489	Overall individuals observed
2	Species Richness (S)	67	Number of species present
3	Shannon Index (H′)	4.1562	High diversity
4	Pielou's Evenness (J′)	0.9816	Very even distribution

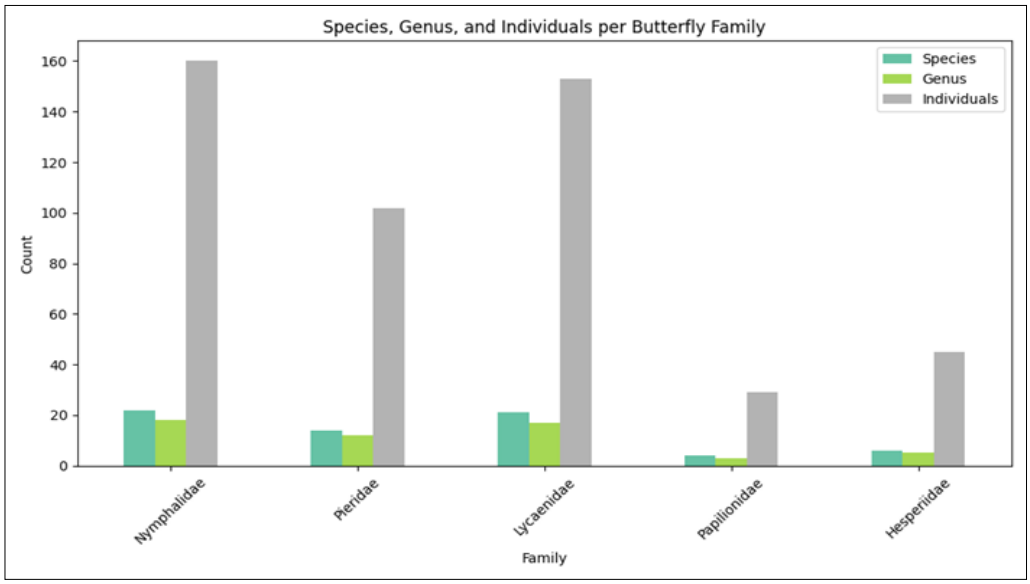

Fig 3: Species, genus and individual per butterfly family

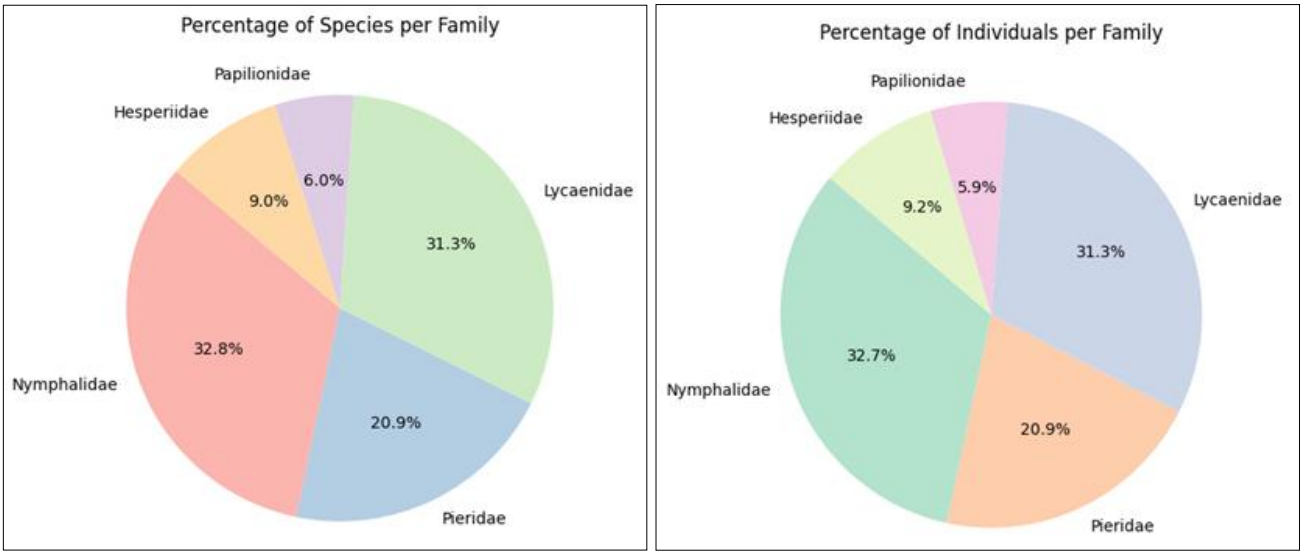

Fig 4: Percentage of individuals and species per butterfly family

Discussion

The present survey documented 67 butterfly species across five families, with a total abundance of 489 individuals. The calculated Shannon Index (H′ = 4.1562) indicates high diversity, while the Pielou's Evenness Index (J′ = 0.9816) demonstrates a very even distribution of species. These values suggest that the study site supports a stable and balanced butterfly community. Similar surveys in Gujarat have reported comparable richness but slightly lower diversity indices. For example, a study at Saurashtra University Campus, Rajkot recorded 52 species with a Shannon Index of 3.2 (Boricha *et al*., 2021). Another survey at Junagadh, Gujarat documented 45 species with seasonal fluctuations in abundance, yielding diversity values around 3.0 (Chauhan *et al*., 2023). Compared to these, the present site shows higher richness and evenness, indicating that semi-urban habitats can sustain butterfly diversity at levels comparable to or exceeding protected areas.

Studies from other parts of India also highlight similar patterns. Research at Indira Gandhi National Tribal University, Amarkantak (Madhya Pradesh) reported 41 species with moderate diversity indices (Sharma *et al*., 2019). The higher values observed in the current study may be attributed to the heterogeneous vegetation structure, availability of host plants, and reduced pesticide use in the surveyed area.

Nymphalidae dominated both richness and abundance, consistent with findings from Rajkot and Junagadh surveys (Boricha *et al*., 2021; Chauhan *et al*., 2023), where this family was also most represented. Their adaptability to varied habitats and host plants explains their dominance. *Pieridae* contributed significantly to abundance, reflecting their preference for open scrublands and agricultural fields (Kunte *et al*., 2000). *Lycaenidae* showed strong representation in richness, highlighting host plant diversity and microhabitat heterogeneity (Kehimkar *et al*., 2016). *Papilionidae* and *Hesperiidae*, though less represented, added ecological breadth, with *Papilionidae* serving as indicators of healthy larval host plants and *Hesperiidae* representing grassland specialists (Magurran *et al*., 2004) [28].

Among the families, Nymphalidae contributed the highest species richness, followed by *Lycaenidae* and *Pieridae*, reflecting their ecological adaptability and wide distribution in semi-urban habitats. The high evenness value suggests that the campus provides heterogeneous habitats—including gardens, open fields, and tree cover—that support diverse butterfly guilds. This diversity is consistent with findings from other semi-urban ecosystems in India, where green spaces act as refuges for pollinators amidst urbanization pressures.

The high diversity and evenness indices suggest that the study site is ecologically resilient. The balanced distribution of species across families indicates that no single taxon dominates, which is a hallmark of a stable ecosystem. The presence of indicator species such as *Papilio demoleus*, *Danaus genutia*, and *Hypolimnas bolina* further underscores the ecological health of the habitat.

Conclusion

This study demonstrates that semi-urban green spaces can act as biodiversity refuges, supporting high butterfly diversity comparable to larger protected areas. The results highlight the importance of conserving such habitats amidst urban expansion. Future research should focus on seasonal monitoring, host plant mapping, and long-term population dynamics to better understand the ecological drivers of butterfly diversity. Integrating these findings with regional surveys will strengthen conservation strategies and contribute to the broader understanding of butterfly ecology in Gujarat and India.

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