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Baseline assessment of butterfly taxonomic diversity in the Kadamgiri region, Talaja, Gujarat, India

Pratipalsinh Zala
Department of Zoology, Sir P. P. Institute of Science, Maharaja Krishnakumarsinhji Bhavnagar University, Bhavnagar, Gujarat, India

Abstract
Butterflies are ecologically significant insects that function as pollinators, prey species, and sensitive bioindicators of ecosystem health. To establish baseline data on butterfly diversity in hilly habitats, a systematic survey was conducted in the Kadamgiri region of Talaja, Gujarat, India. The study documented species occurrence and abundance through direct visual encounter surveys and photographic records across representative microhabitats. A total of 38 species belonging to five families—Nymphalidae, Pieridae, Lycaenidae, Papilionidae, and Hesperiidae—were recorded. Among these, Nymphalidae exhibited the highest richness, while Pieridae and Lycaenidae contributed substantially to overall abundance. Papilionidae and Hesperiidae, though less represented, added ecological significance to the assemblage. Diversity indices revealed a Shannon Index ($H' = 3.58$), indicating high species diversity, and a Pielou's Evenness Index ($J' = 0.95$), reflecting an even distribution of individuals across species. The balanced representation across families suggests that Kadamgiri's hilly green landscape provides heterogeneous microhabitats capable of sustaining diverse butterfly guilds. These findings highlight the ecological importance of Kadamgiri as a biodiversity-rich natural habitat. The baseline data generated here can serve as a foundation for long-term ecological monitoring, habitat management, and conservation planning in Gujarat. By documenting species diversity and abundance, this study underscores the role of hilly green regions in supporting pollinator communities and maintaining ecosystem resilience amidst environmental change.

Keywords: Butterfly diversity, pollinators, biodiversity assessment, hilly habitats, species richness

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 diverse habitats ranging from forests and grasslands to scrublands, wetlands, and agricultural landscapes. Their complete metamorphosis—from egg to larva, pupa, and adult—represents evolutionary adaptations that enhance survival and ecological specialization (Sharma *et al*., 2020). Ecologically, butterflies play a crucial role as pollinators, prey species, and bioindicators of environmental health. Their sensitivity to habitat degradation, agricultural intensification, and climate fluctuations makes them valuable for monitoring ecosystem quality (Singh *et al*., 2019). By contributing to pollination and plant reproduction, butterflies support 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, coastal plains, scrublands, wetlands, and hilly green regions. Previous studies in areas such as Champaner-Pavagadh, Rajkot, and Girnar 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 semi-arid zones, coastal belts, and hilly terrain. Within this district, the Kadamgiri region of Talaja is characterized by mixed vegetation, agricultural fields, and scrublands. Its hilly green landscape provides heterogeneous microhabitats conducive to butterfly foraging, breeding, and shelter. Despite its ecological richness, Kadamgiri remains underexplored in terms of systematic butterfly diversity assessments.
To address this gap, the present study documents the species diversity, abundance, and distribution of butterflies in Kadamgiri. By establishing baseline data, the research contributes to regional biodiversity records and informs conservation planning. The aims of this study are: (1) to record butterfly species richness and relative abundance in Kadamgiri; (2) to analyze family-level representation and ecological significance; and (3) to highlight the role of hilly green habitats in sustaining pollinator communities. Butterflies are not only aesthetically appealing but also ecologically indispensable. Their study in natural landscapes like Kadamgiri is essential for understanding biodiversity dynamics and promoting conservation strategies in Gujarat.

Materials and Methods
Study Area
Kadamgiri is a hilly green region located in Talaja, Bhavnagar District, Gujarat, India, at approximately 21.35°N latitude and 72.05°E longitude. The area is characterized by a hilly scrubland and agricultural mosaic, interspersed with orchards and patches of native vegetation. This heterogeneous landscape provides diverse microhabitats suitable for butterfly foraging, breeding, and shelter. The climate is tropical monsoon, with hot summers, mild winters, and seasonal rainfall that influences vegetation dynamics and butterfly activity.

Survey Design
Field surveys were conducted over an eight-day period from 19 July 2025 to 26 July 2025, during peak butterfly activity hours: in the morning from 7:00 AM to 10:00 AM and in

the evening from 4:00 PM to 6:00 PM. Systematic visual encounter surveys were employed, supplemented by photographic documentation for accurate identification. Species were identified using standard field guides (Kunte, 2000; Kehimkar, 2016). Each butterfly sighting was categorized into abundance classes: Very Common (VC), Common (C), Rare (R), Very Rare (VR), and Not Recorded (NR). These categories were later converted into abundance scores (VC = 5, C = 4, R = 3, VR = 2, NR = 1) for statistical analysis.

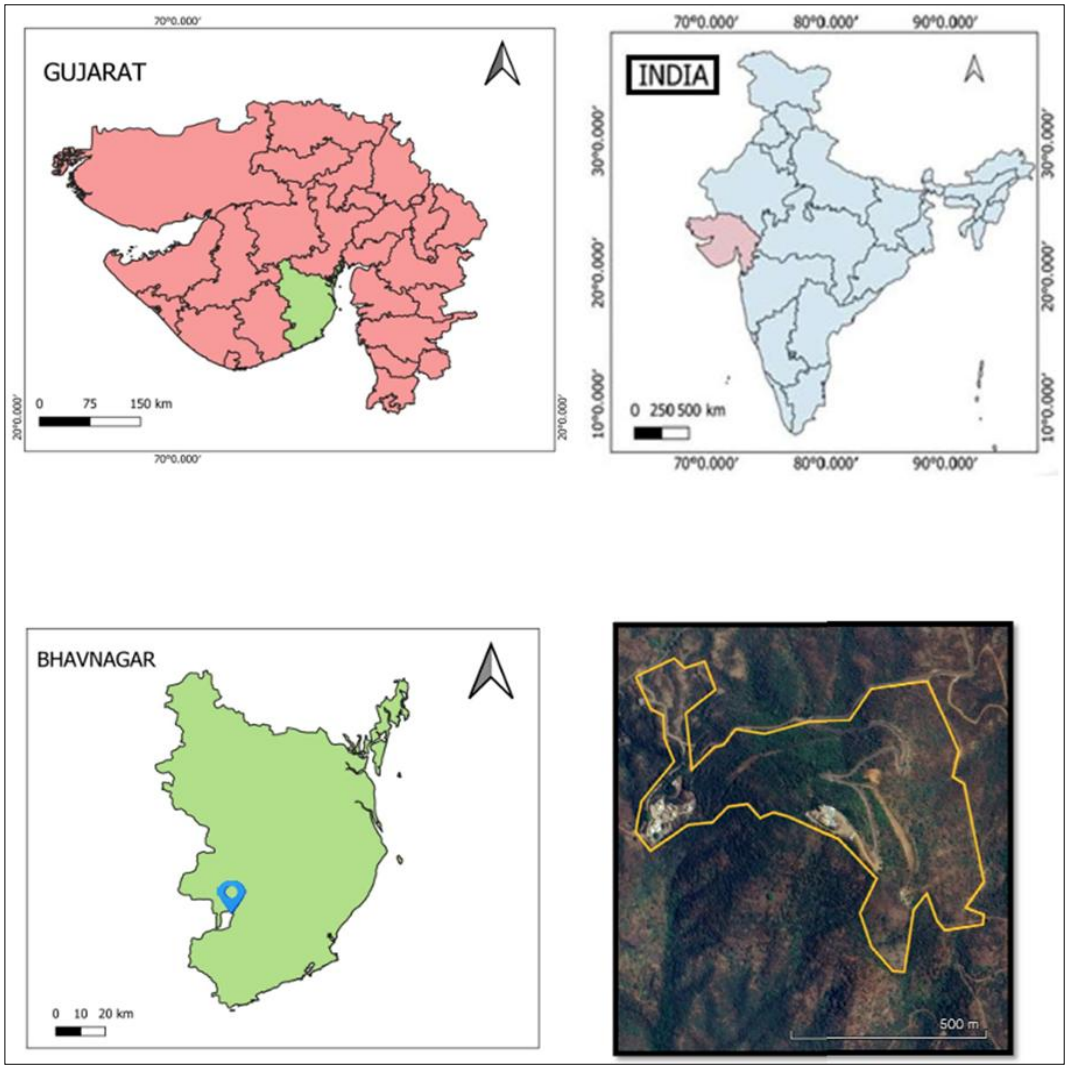

Fig 1: Map of study area

Required Equipment

For the butterfly surveys conducted in the Kadamgiri region, essential equipment included a digital camera fitted with a macro lens to capture detailed images for species documentation, along with binoculars to aid in observing individuals at a distance within scrubland and orchard habitats. Field notebooks were used to record abundance categories, habitat details, and behavioral notes, while a GPS device ensured accurate geotagging of survey locations. Standard butterfly identification guides (Kunte, 2000; Kehimkar, 2016) were consulted for species verification. Mobile phones equipped with time-stamping applications facilitated precise logging of sightings during morning and evening sessions. Given the semi-arid terrain and hilly scrubland mosaic, comfortable walking shoes, protective clothing, and sun protection gear such as caps and sunscreen were indispensable for safe and efficient fieldwork.

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.

Results

Species Recorded

A total of 38 species were documented. Representative families included Nymphalidae (Tiger butterflies, Eggflies, Pansies), Pieridae (Grass Yellows, Orange Tips, Whites), Lycaenidae (Blues, Pierrots, Jewels), Papilionidae (Swallowtails, Roses), and Hesperiidae (Skippers, Swifts).

Results Table

Table 1: 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	Indian Skipper	*Spialia galba*	Hesperiidae	Not Evaluated	R
2	Small Branded Swift	*Pelopidas mathias*	Hesperiidae	Least Concern	VR
3	Small Cupid	*Chilades parrhasius*	Lycaenidae	Least Concern	R
4	Rounded Pierrot	*Tarucus nara*	Lycaenidae	Least Concern	R
5	Indian Sunbeam	*Curetis thetis*	Lycaenidae	Least Concern	R
6	Guava Blue	*Azanus jesous*	Lycaenidae	Least Concern	R
7	Common Pierrot	*Castalius rosimon*	Lycaenidae	Least Concern	C
8	Forget Me Not	*Catochrysops strabo*	Lycaenidae	Least Concern	C
9	Indian Pierrot	*Tarucus indica*	Lycaenidae	Least Concern	R
10	Striped Pierrot	*Tarucus nara*	Lycaenidae	Least Concern	R
11	Grass Jewel	*Freyeria trochylus*	Lycaenidae	Least Concern	R
12	Zebra Blue	*Leptotes plinius*	Lycaenidae	Least Concern	R
13	Common Tiger	*Danaus genutia*	Nymphalidae	Least Concern	VC
14	Spotted Joker	*Byblia ilithyia*	Nymphalidae	Least Concern	R
15	Plain Tiger	*Danaus chrysippus*	Nymphalidae	Least Concern	VC
16	Angled Castor	*Ariadne ariadne*	Nymphalidae	Least Concern	R
17	Great Eggfly	*Hypolimnas bolina*	Nymphalidae	Least Concern	R
18	Blue Tiger	*Tirumala limniace*	Nymphalidae	Least Concern	VR
19	Striped Tiger	*Danaus genutia*	Nymphalidae	Least Concern	R
20	Common Leopard	*Phalanta phalantha*	Nymphalidae	Least Concern	R
21	Common Castor	*Ariadne merione*	Nymphalidae	Least Concern	R
22	Lemon Pansy	*Junonia lemonias*	Nymphalidae	Least Concern	R
23	Blue Pansy	*Junonia orithya*	Nymphalidae	Least Concern	R
24	Danaid Eggfly	*Hypolimnas misippus*	Nymphalidae	Least Concern	R
25	Peacock Pansy	*Junonia almana*	Nymphalidae	Least Concern	R
26	Common Lime	*Papilio demoleus*	Papilionidae	Least Concern	C
27	Common Rose	*Pachliopta aristolochiae*	Papilionidae	Least Concern	R
28	Common Mormon	*Papilio polytes*	Papilionidae	Least Concern	R
29	Crimson Rose	*Pachliopta hector*	Papilionidae	Least Concern	R
30	Common Grass Yellow	*Eurema hecabe*	Pieridae	Least Concern	C
31	Mottled Emigrant	*Catopsilia pyranthe*	Pieridae	Least Concern	C
32	White Orange Tip	*Ixias marianne*	Pieridae	Least Concern	R
33	Pioneer White	*Belenois aurota*	Pieridae	Least Concern	R
34	Spotless Grass Yellow	*Eurema andersonii*	Pieridae	Not Evaluated	R
35	White Arab	*Colotis fausta*	Pieridae	Least Concern	VR
36	Orange Tip	*Ixias pyrene*	Pieridae	Least Concern	R
37	One Spot Grass Yellow	*Eurema blanda*	Pieridae	Least Concern	R
38	Small Grass Yellow	*Eurema laeta*	Pieridae	Least Concern	C

Statistical Analysis

Table 2: Results of different ecological indices

Metric	Value	Interpretation
Total Abundance	114	Overall individuals observed
Species Richness (S)	38	Number of species present
Shannon Index (H′)	3.58	High Shannon Index indicates strong diversity
Pielou's Evenness (J′)	0.95	Evenness close to 1 shows even distribution across species

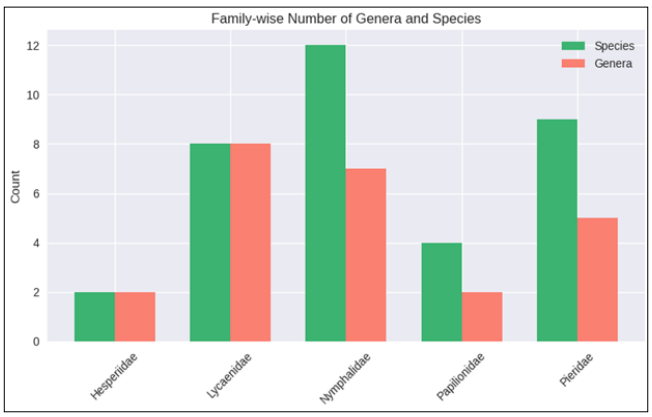

Fig 2: Family-wise number of species and genera

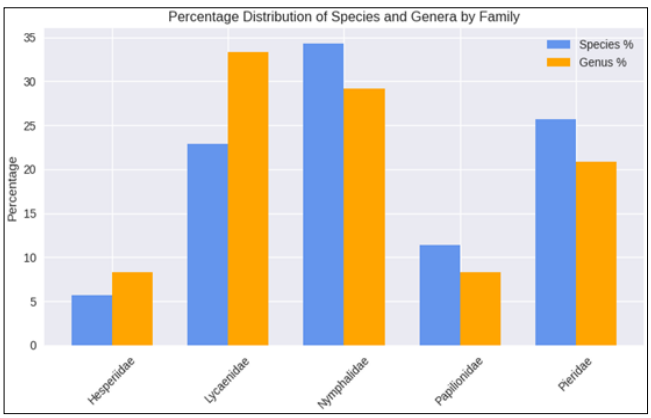

Fig 3: Percentage distribution of species and genera by family

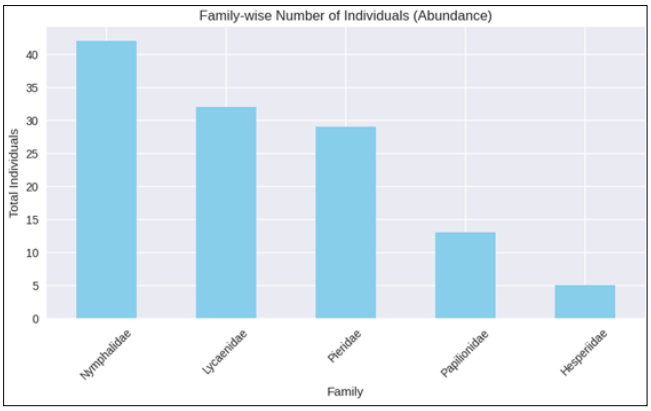

Fig 4: Family-wise number of individuals (Abundance)

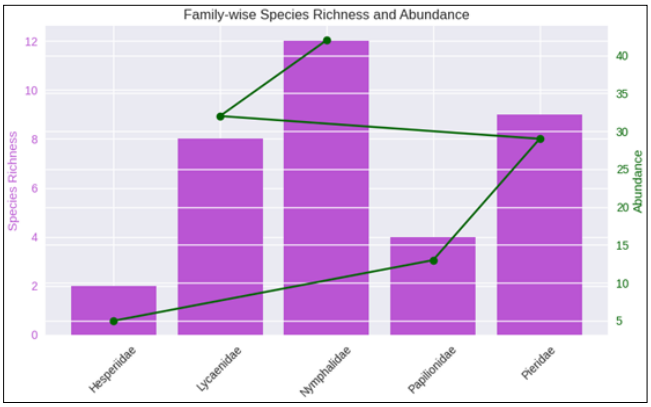

Fig 5: Family-wise species richness and abundance

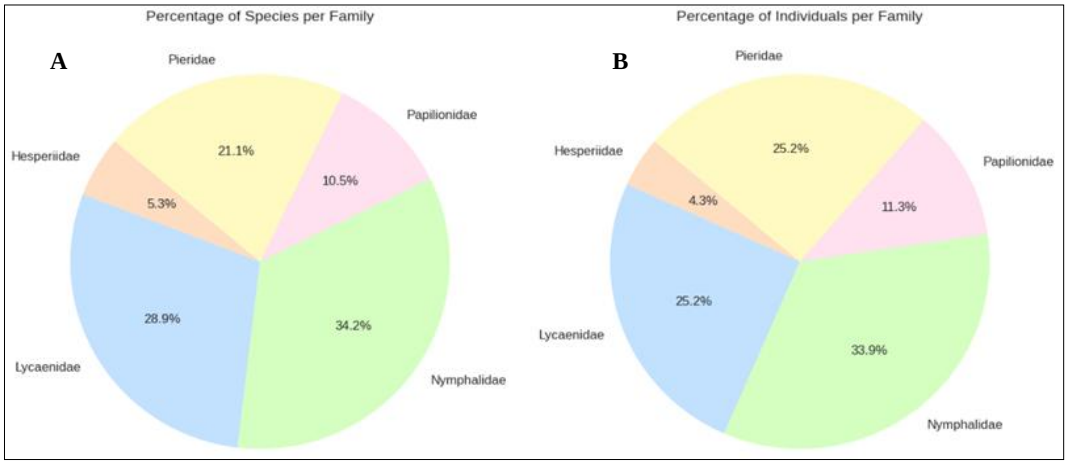

Fig 6: (A) Percentage of species per family, (B) Percentage of individuals per family

Discussion

The present survey documented 38 butterfly species across five families in the Kadamgiri region of Talaja, Gujarat. The calculated Shannon Index (H′ = 3.58) indicates high diversity, while the Pielou's Evenness Index (J′ = 0.95) demonstrates a very even distribution of species. These values suggest that the study site supports a stable and balanced butterfly community. Comparable surveys in Gujarat have reported similar richness but slightly lower evenness values. For example, a study at Rajkot campus recorded 52 species with a Shannon Index of 3.2 (Boricha *et al*., 2021), while another survey at Navsari campus documented 45 species with diversity values around 3.0 (Chauhan *et al*., 2023). Compared to these, Kadamgiri shows moderate richness but higher evenness, indicating that hilly scrubland and agricultural mosaics can sustain butterfly diversity at levels comparable to semi-urban or institutional habitats.

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 mor., 2019). The values observed in the current study may be attributed to the heterogeneous vegetation structure, availability of larval host plants, and the mosaic of scrubland, orchards, and agricultural fields that provide diverse microhabitats.

Nymphalidae dominated both richness and abundance, consistent with findings from Rajkot and Navsari surveys (Boricha *et al*., 2021; Chauhan *et al*., 2023), where this family was also most represented. Their adaptability to varied host plants and habitats explains their dominance. Pieridae contributed significantly to abundance, reflecting their preference for open scrublands and agricultural landscapes (Kunte *et al*., 2000). Lycaenidae showed strong representation in richness, highlighting host plant diversity and microhabitat heterogeneity (Kehimkar *et al*., 2016). Papilionidae, represented by species such as *Papilio demoleus* and *Pachliopta aristolochiae*, serve as indicators of healthy larval host plant availability, while Hesperiidae species such as the Indian Skipper and Small Branded Swift reflect the presence of grassland microhabitats (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 hilly scrubland habitats. The high evenness value suggests that Kadamgiri provides heterogeneous habitats—including scrubland patches, orchards, and agricultural fields—that support diverse butterfly guilds. This diversity is consistent with findings from other natural ecosystems in India, where landscape heterogeneity acts as a refuge for pollinators amidst environmental pressures.

The high diversity and evenness indices suggest that the Kadamgiri region 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*, *Eurema hecabe*, and *Hypolimnas bolina* further underscores the ecological health of the habitat.

These findings highlight the importance of conserving hilly green landscapes like Kadamgiri, which serve as biodiversity reservoirs and play a crucial role in sustaining pollinator communities in Gujarat.

Conclusion

This baseline survey in the Kadamgiri region of Talaja documented 38 butterfly species across five families, with diversity and evenness values (Shannon Index H′ = 3.58; Pielou's Evenness J′ = 0.95) indicating a stable and balanced community structure. The findings demonstrate that hilly scrubland and agricultural mosaics can act as biodiversity reservoirs, supporting butterfly diversity comparable to or exceeding that of semi-urban and institutional habitats. The dominance of Nymphalidae, alongside significant representation of Pieridae, Lycaenidae, Papilionidae, and Hesperiidae, reflects the ecological heterogeneity of Kadamgiri and underscores the importance of host plant diversity and microhabitat availability in sustaining pollinator guilds.

The results highlight the ecological importance of conserving natural hilly landscapes amidst increasing anthropogenic pressures. Long-term monitoring, seasonal surveys, and detailed host plant mapping are recommended to capture temporal dynamics and strengthen conservation strategies. Incorporating landscape-level analyses, such as vegetation structure, land-use change, and climate variability, will further clarify the ecological drivers of butterfly diversity in this region.

Integrating these findings with regional and national surveys will contribute to a broader understanding of butterfly ecology in Gujarat and India. Such baseline data are critical for informing habitat management, guiding restoration efforts, and promoting biodiversity conservation policies. By documenting species richness and ecological balance, this study emphasizes that hilly green habitats like Kadamgiri are indispensable for maintaining ecosystem resilience and ensuring the persistence of pollinator communities in the face of environmental change.

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