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Assessment of Butterfly Diversity in Chilkiarh, West Bengal, with Emphasis on Species Richness and Habitat Effects

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ABSTRACT

This study examines the butterfly diversity of Chilkiarh, a heritage village and a well-known tourist attraction in the Jhargram subdivision of West Bengal, India. Using standard sampling methods, various diversity indices were assessed to analyze the butterfly community composition. During a year (December 2021 to November 2022), a total of 59 species from 6 families and 14 subfamilies were recorded, with a significant species-to-genus ratio of 1.31:1. Among them, 11 species are listed under various schedules of the Indian Wildlife Protection Act, 1972. The Nymphalidae family emerged as the most dominant, comprising 42.3% of the total species documented. Relative abundance analysis identified 10 species as subdominant, while no species showed dominant status. The diversity indices suggest that Chilkiarh supports a rich butterfly population. This preliminary study serves as a foundation for further research on species identification, host and nectar plants, as well as seasonal variations in butterfly populations.

Keywords: Pollinator, Lepidoptera, Diversity indices, Butterfly diversity, Chilkiarh, Jhargram

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Introduction

The faunal diversity within forest ecosystems plays an essential role in ensuring their stability and long-term sustainability. To evaluate biodiversity effectively, ecological indicator species are widely utilized across the globe. The impact of forest management on both the structural and functional aspects of these ecosystems can be assessed through the study of bioindicators [1, 2]. Among various insect groups, butterflies have been recognized as significant bioindicators due to their short life cycle, specific host plant associations, distinct wing coloration patterns, high species diversity, and heightened sensitivity to microclimatic and environmental variations [3].

As primary consumers, butterflies contribute significantly to forest ecosystems, playing a crucial role as herbivores in maintaining the equilibrium of food webs [4, 5]. Beyond this, they serve multiple ecological functions—acting as pollinators [5-7], indicators of floral and faunal diversity [8], hosts for parasitoids [5, 9], and as an integral part of predator-prey interactions [4, 5, 10].

Chilkiarh, a rural and tribal region located along the Dulung River, is predominantly bordered by Sal Forest. It has gained popularity as a tourist attraction, primarily due to the presence of Chilkiarh Raj Palace and the Kanak Durga Sacred Grove. Recognizing its ecological significance, the Government of West Bengal, through its Environment Department, designated it as the Chilkiarh Kanak Durga Biodiversity Heritage Site in 2018. The region is home to 388 recorded plant species, 105 of which possess medicinal properties, along with 26 vertebrate species categorized as megafauna [11]. Additionally, recent surveys have documented the presence of 37 bird species across various sites within Chilkiarh [12].

To better understand the butterfly assemblage of this ecologically rich area, a study was conducted to examine their diversity, dominant family groups, species-to-genus ratio, and legally protected species. The findings from this research will contribute to future studies focused on identifying their nectar and host plants, seasonal variations, and developing conservation strategies.

Materials and Methods

Study area

Chilkigarh (**Figure 1**) is a tribal region located within the Jamboni CD block of the Jhargram Subdivision, under the jurisdiction of Jhargram District, West Bengal. Geographically, it is positioned between latitudes 22°27'20" N to 22°56'50" N and longitudes 86°52'20" E to 86°53'10" E, with an elevation ranging from 60 to 85 meters above sea level [13]. The area is characterized by diverse landscapes—its western boundary is part of the lower ranges of the Chhotanagpur Plateau, while the northwest section remains largely uninhabited, with vast stretches of non-arable land due to the predominance of lateritic soil.

The Dulung River, a monsoon-fed water body, meanders through the village, nourishing the surrounding ecosystem. The Chilkigarh Forest, situated on the eastern bank of this river, features a mix of vegetation types, including semi-deciduous, deciduous, and evergreen tree species [11]. Given the abundance of Sal trees, this region falls under the classification of a Tropical Moist Deciduous Forest. The presence of a variety of herbs, shrubs, climbers, and grasses further supports a wide range of faunal species, from small invertebrates to larger wildlife.

For this study, several distinct habitats were selected for butterfly sampling, including the Dulung Riverbank, Chilkigarh Kanak Durga Sacred Grove, Sal forests, Chilkigarh Raj Palace, open grasslands, Sonajhuri Garden, and nearby agricultural lands. These diverse sites provided an ideal setting for assessing butterfly diversity and their ecological associations.

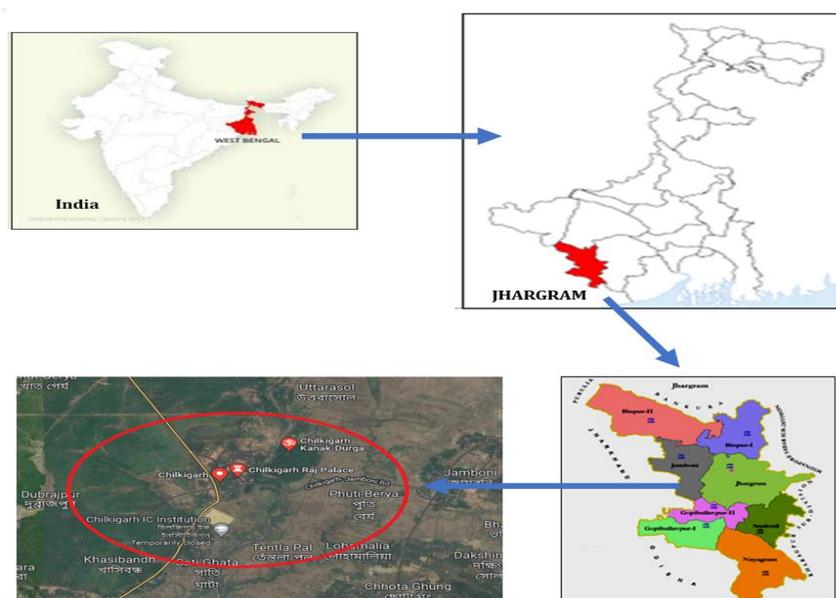


Figure 1. Map of Chilkigarh, India [12].

Data collection

The research was conducted over 12 months, from December 2021 to November 2022, during two observation windows: 7:00 AM to 10:00 AM and 3:00 PM to 6:00 PM. Sampling was performed using multiple well-established techniques, including the Pollard Walk Method [14], the Direct Searching Method [15], and the Time-Constrained Method [16]. These approaches ensured a comprehensive survey of butterfly species across various habitats.

Documentation and identification of butterfly species

Field visits were carried out once or twice a month to document butterfly species through photography. To capture high-quality images from multiple angles, a Canon IXUS 190 Digital Camera and mobile phone cameras (Redmi

6 Pro and Redmi Note 8) were used. Identification of species was based on standard references [17-19] and was further verified using the Butterflies of India online database [20].

Community analysis

To assess the composition of the butterfly community, α -diversity, which measures species diversity within a given community, was analyzed using multiple diversity indices. All collected data were processed in MS Excel 2019, and statistical validation of results was conducted using PAST software (version 4.03) [21].

Species richness

The Shannon-Wiener Index—commonly referred to as the Shannon Diversity Index [22]—was employed to quantify species richness. While occasionally misattributed as the Shannon-Weaver Index, it was independently formulated by Wiener and Shannon and applies information theory principles to evaluate biodiversity. Even rare species with low individual counts contribute to this index [23-25]. The calculation follows Eq. 1:

$$H' = - \sum p_i \ln p_i \quad (1)$$

Where H' represents the Shannon diversity index, and p_i denotes the proportion of individuals belonging to the i -th species within the population. Typically, values range between 1.5 and 3.5, with rare cases exceeding 4.5. Although this index primarily reflects species richness, it is also influenced by variations in species abundance.

$$I_{Mg} = S - 1 / \ln N \quad (2)$$

Additionally, Margalef's Index was applied to quantify species richness, as it provides a comparative measure based on the total number of species and individuals in the community. The equation for this index is as follows: Where S corresponds to the total number of species, and N represents the total number of individuals recorded across all species.

Species abundance

Species abundance was determined using Simpson's Index (D), which measures the likelihood that two randomly selected individuals from the community belong to the same species. The equation for this index is:

$$D = \sum_{i=1}^S (p_i)^2 \quad (3)$$

The value of D ranges from 0 to 1 and is inversely related to species diversity—higher values indicate lower diversity. A D value closer to 0 suggests a more balanced and diverse community structure.

Furthermore, Simpson's Index of Diversity was employed to highlight the proportion of species contributing to overall diversity. This index is expressed as:

$$D = 1 - \sum_{i=1}^S (p_i)^2 \quad (4)$$

Where D represents Simpson's diversity value, and p_i is the proportion of individuals belonging to each species in the community. This index assigns greater importance to dominant species while giving less weight to rare ones. It ranges from 0 (indicating low diversity) to a theoretical maximum of $(1 - 1/S)$, where S represents the total number of species observed.

Table 1 provides a categorized list of butterfly species recorded in Chilkigarh, arranged by family and subfamily. It includes their common and scientific names, abundance count, percentage of relative abundance, dominant status, and their classification under the Wildlife Protection Act (WPA) schedule.

Table 1. Family-wise checklist of butterfly species in Chilkiagarh

Sl. No.	Common name	Scientific name	Abundance	Relative abundance (%)	Dominant status	WPA schedule
Family: Nymphalidae (Brush-footed Butterflies)						
Subfamily: Biblidinae (Castors & Jokers)						
1	Angled Castor	<i>Ariadne ariadne</i> (Linnaeus, 1763)	79	4.990	SD	-
2	Common Castor	<i>Ariadne merione</i> (Cramer, 1777)	16	1.010	SR	-
Subfamily: Danainae (Milkweed Butterflies)						
3	Blue Tiger	<i>Tirumala limniace</i> (Cramer, 1775)	28	1.768	R	-
4	Common Crow	<i>Euploea core</i> (Cramer, 1780)	93	5.874	SD	IV
5	Plain Tiger	<i>Danaus chrysippus</i> (Linnaeus, 1758)	23	1.452	R	-
6	Striped Tiger	<i>Danaus genutia</i> (Cramer, 1779)	14	0.884	SR	I
Subfamily: Heliconiinae (Costers, Lacewings, Fritillaries & Relatives)						
7	Common Leopard	<i>Phalanta phalantha</i> (Drury, 1773)	20	1.263	R	-
8	Tawny Coster	<i>Acraea violae</i> (Fabricius, 1775)	58	3.663	SD	-
Subfamily: Limenitinae (Barons, Sailers, Sergeants & Relatives)						
9	Baronet	<i>Euthalia nais</i> (Forster, 1771)	21	1.326	R	-
10	Commander	<i>Moduza procris</i> (Cramer, 1777)	15	0.947	SR	-
11	Common Baron	<i>Euthalia aconthea</i> (Cramer, 1777)	18	1.137	R	II
12	Grey Count	<i>Tanaecia lepidea</i> (Butler, 1868)	2	0.126	SR	II
Subfamily: Nymphalinae (Pansies, Eggflies & Relatives)						
13	Great Eggfly	<i>Hypolimnys bolina</i> (Linnaeus, 1758)	44	2.779	R	-
14	Blue Pansy	<i>Junonia orithya</i> (Linnaeus, 1758)	37	2.337	R	-
15	Chocolate Pansy	<i>Junonia iphita</i> (Cramer, 1779)	46	2.905	R	-
Family: Papilionidae (Swallowtails)						
Subfamily: Papilioninae						
16	Lime Swallowtail	<i>Papilio demoleus</i> (Linnaeus, 1758)	52	3.284	SD	-
17	Common Mormon	<i>Papilio polytes</i> (Linnaeus, 1758)	79	4.990	SD	-
18	Blue Mormon	<i>Papilio polymnestor</i> (Cramer, 1775)	6	0.379	SR	-
Family: Pieridae (Whites & Yellows)						
Subfamily: Pierinae (Whites)						
19	Common Jezebel	<i>Delias eucharis</i> (Drury, 1773)	19	1.200	R	-
20	Psyche	<i>Leptosia nina</i> (Fabricius, 1793)	83	5.243	SD	-
Family: Hesperidae (Skippers)						
Subfamily: Pyrginae (Flats & Angles)						
21	Common Snow Flat	<i>Tagiades japetus</i> (Stoll, 1781)	5	0.315	SR	-
Family: Riodinidae (Metalmarks)						
Subfamily: Riodininae						
22	Double-banded Judy	<i>Abisara bifasciata</i> (Moore, 1877)	7	0.442	SR	-

Classification of dominant status: SR (subrecedent) = relative abundance less than 1%; R (recedent) = relative abundance between 1.1% and 3.1%; SD (subdominant) = relative abundance between 3.2% and 10%; D (dominant) = relative abundance from 10.1% to 31.6%; and ED (eudominant) = relative abundance above 31.7%

Species evenness

To evaluate species evenness, Pielou's index [26] was applied. The calculation was performed using the following equation:

$$E = H' / \ln S \quad (5)$$

S denotes the number of species. The index value varies between 0 and 1, with higher values indicating greater evenness in species distribution within the community.

The dominance level of each one was determined based on relative abundance, adhering to Engelmann's scale [27]. Additionally, a rank-abundance curve (Whittaker plot) was generated by plotting abundance rank on the X-axis against relative abundance on the Y-axis, offering a visual representation of species distribution within the ecosystem [28].

Results and Discussion

A total of 59 butterfly species, comprising 1583 individuals from 45 genera across six families, were documented in Chilkigarh. Among the recorded families, Nymphalidae was the most prevalent, contributing 42.3% with 25 species. It was followed by Lycaenidae (20.3% with 12 species), Papilionidae (15.2% with 9 species), Pieridae (13.5% with 8 species), Hesperidae (6.7% with 4 species), and Riodinidae (1.6% with 1 species) (**Figures 2-4**). Similar trends have been reported in neighboring districts such as Purulia [29], Haldia [30], Midnapore [23, 30], and Howrah [31], where Nymphalidae has also been identified as the dominant butterfly family.



Figure 2. 1. Angled Castor, 2. Common Castor, 3. Common Crow, 4. Blue Tiger, 5. Plain Tiger, 6. Striped Tiger, 7. Common Leopard, 8. Tawny Coster, 9. Baronet, 10. Commander, 11. Common Baron, 12. Grey Count, 13. Chestnut-streaked Sailer, 14. Great Eggfly (male), 15. Great Eggfly (female), 16. Gray Pansy, 17. Yellow Pansy (male), 18. Blue Pansy (male), 19. Lemon Pansy, 20. Peacock Pansy, 21. Chocolate Pansy, 22. Bamboo Tree Brown, 23. Common Evening Brown, 24. Common Four-ring, 25. Common Palmfly (male), 26. Common Bush Brown, 27. Dark Grass Blue, 28. Lesser Grass Blue, 29. Lime Blue, 30 and 31. Common Pierrot, 32. Forget-me-not, 33. Pointed Ciliate Blue, 34. Quaker, and 35. Common Guava Blue.



Figure 3. 36. Common Silverline, 37. Peacock Royal, 38. Indian Oak Blue, 39. Bengal Slate Flash, 40. Common Jay, 41. Tailed Jay, 42. Spot Swordtail, 43. Blue Mormon, 44. Common Mormon (male), 45. Common Mormon (female), 46. Common Rose, 47 and 48. Lime Butterfly, 49. Common Mime (male), 50. Common Mime (female), 51. Common Banded Peacock, 52. Indian Common Wanderer, 53. Common Gull, 54. Eastern Striped Albatross, 55. Common Jezebel, 56. Psyche, 57. Three Spot Grass Yellow, 58. Mottled Emigrant, 59. Oriental Lemon Emigrant, 60. Double Banded Judy (male), 61. Double Banded Judy (female), 62. Common Red Eye, 63. Dark Palm Dart, 64. Rice Swift, and 65. Common Snow Flat.

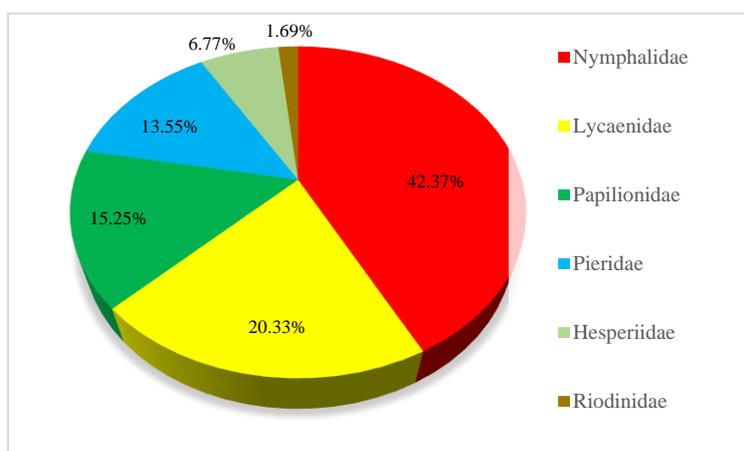


Figure 4. Percentage composition of butterfly families.

The species-to-genus ratio was determined to be 1.31:1. The distribution of butterfly species across 6 families, along with their corresponding genera, is illustrated in **Figure 5**.

A total of 11 species were identified as legally protected under various Schedules of the Wildlife (Protection) Act, 1972 [32]. However, none of these species were classified as globally threatened according to the IUCN Red List (Ver 3.1) [33]. Among the species, Striped Tiger (*D. genutia*), Common Pierrot (*C. rosimon*), Lime Blue (*C. lajus*), and Common Mime (*C. aclytia*) fall under Schedule I. Species such as Common Baron (*E. aconthea*), Grey Count (*T. lepidea*), Pointed Ciliate Blue (*A. lycaenina*), Common Guava Blue (*V. isocrates*), Peacock Royal (*T. cippus*), and Common Gull (*C. nerissa*) are listed under Schedule II, whereas Common Crow (*E. core*) is categorized under Schedule IV.

Within the Nymphalidae family, *Euploea core* emerged as the abundant species, while *Tanaecia lepidea* had the lowest count. In the Lycaenidae family, *Castalius rosimon* was the most frequently observed species, whereas *Arhopala atrax* was the least common. Also, within Papilionidae, *Papilio polytes* had a significantly higher presence than *Graphium nomius*, which was represented by a single individual. In the Pieridae family, *Leptosia nina* was recorded in greater numbers compared to *Appias olferna*. The only species documented from the Riodinidae family was *Abisara bifasciata*.

The Calculations of relative abundance based on Engelmann's scale [26] indicated that Chilkigarh lacked any dominant species. However, 10 species, namely *Ariadne ariadne*, *Euploea core*, *Acraea terpiscore*, *Melanitis leda*, *Castalius rosimon*, *Papilio demoleus*, *Papilio polytes*, *Pareronia hippia*, *Leptosia nina*, and *Catopsilia pyranthe*, were classified as subdominant (**Table 1**).

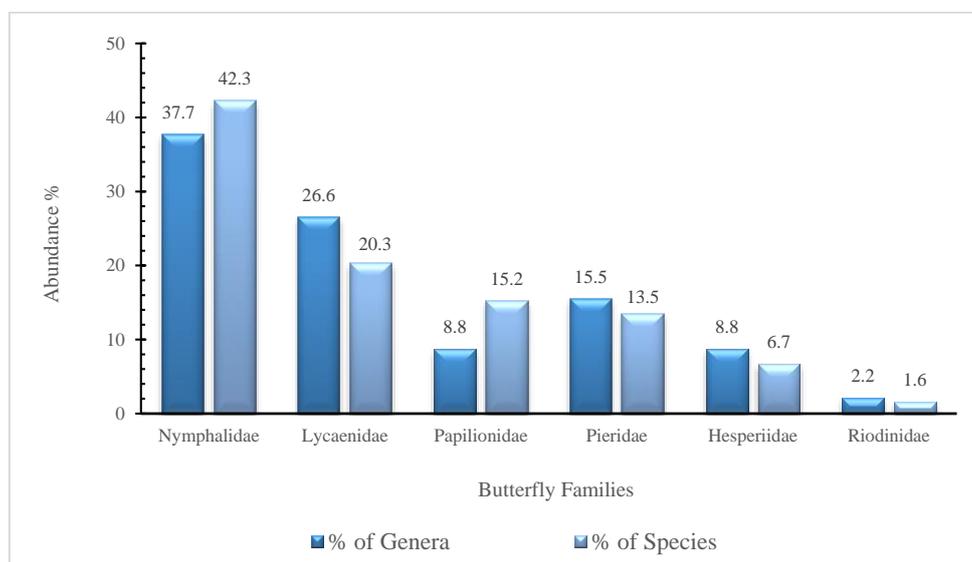


Figure 5. The genus-to-species proportion of butterflies under six families.

The computed values for the Shannon index (1) and Margalef's index (2) are 3.73 and 7.87, respectively, signifying a high level of species richness in the butterfly community of Chilkigarh. These results align with previous studies [23, 30, 34]. The measured Simpson's index (3) stands at 0.029, indicating a high species abundance as the value is closer to 0. Additionally, the Simpson's diversity index (4) is 0.9708, reinforcing that the butterfly community in the study area is highly diverse.

The species' evenness (5) is determined as $E = 0.9148$, demonstrating a high level of evenness since it approaches 1. Due to the significant variation between the most and least abundant species, the rank-abundance curve in the Whittaker plot exhibits strong evenness with a relatively shallow gradient. The high degree of evenness among species is reflected in this moderate slope (**Figure 6**).

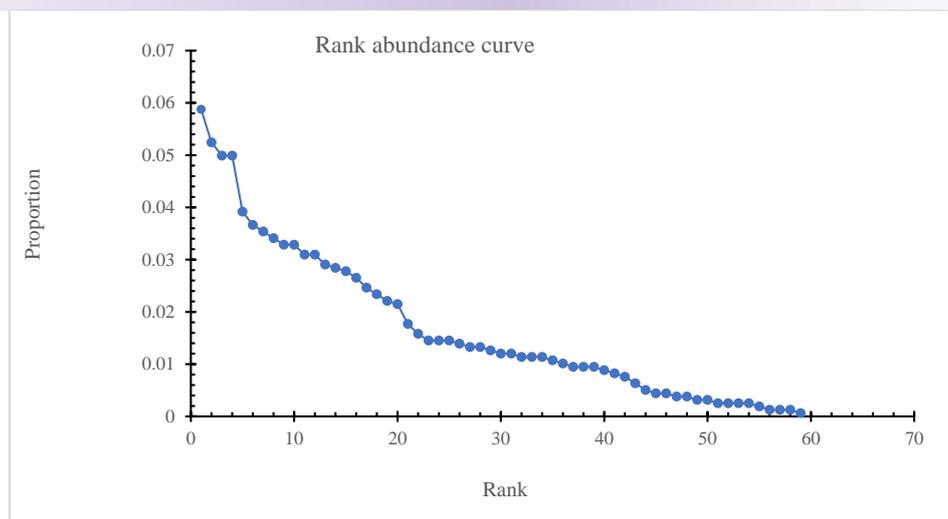


Figure 6. Whittaker plot of rank-abundance of butterfly community of Chilkigarh.

Conclusion

This initial study highlights the rich butterfly diversity present in the Chilkigarh region. Future research involving the identification of host and nectar plants, assessment of seasonal variations, exploration of new species, and analysis of environmental factors influencing their life cycle will contribute to a more comprehensive understanding of the butterfly community in this area. Conducting periodic surveys will also help monitor any anthropogenic effects caused by tourism. If such impacts are detected, appropriate conservation measures can be implemented to safeguard these remarkable species.

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