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Study of Butterfly Diversity in Chilkigarh, West Bengal (India)

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ABSTRACT

An attempt has been made to understand the butterfly community of Chilkigarh, a village with a heritage site and one of the famous tourist destinations in the Jhargram subdivision, West Bengal, India. These winged jewels were studied by adopting conventional sampling techniques followed by measurement of different diversity indices. A total of 59 species belonging to 6 families and 14 subfamilies have been documented between December 2021 and November 2022, with a good number of species to genus ratio (1.31:1). Among 59, 11 are protected under different schedules of the Indian Wildlife Protection Act, 1972. Nymphalids with the highest percentage (42.3%) secured the dominant status among the families. Relative abundance study reveals 10 species with subdominant status but no one with dominant status. Analysis of different diversity indices indicates that Chilkigarh carries rich butterfly fauna. Information from this preliminary study may provide a direction for future investigations, such as the identification of new species, host plants, nectar plants, and seasonal fluctuations over time.

Keywords: Butterfly diversity, Lepidoptera, Pollinator, Diversity indices, Chilkigarh, Jhargram.

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INTRODUCTION

Faunal components of forest ecosystems play a crucial role in the maintenance and sustainability of that ecosystem, and ecological indicator species are used worldwide for assessing biodiversity. The effect of forest management on the structure and function of a forest ecosystem can be illustrated by studying bioindicators [1, 2]. Butterflies, among the insect groups, due to their short life history traits, host plant preferences, easily identifiable features (unique wing color patterns), high diversity, sensitivity to microclimate as well as environmental changes, themselves achieve such a status to be accepted as bioindicator [3]. Butterflies are primary consumers in the forest ecosystem and play an important role as herbivores in the stability of food webs [4, 5]. To maintain and improve community structure, they serve as pollinators [5-7], surrogate species for floral and faunal diversity [8], host of parasitoids [5, 9], and prey of predators [4, 5, 10]. Chilkigarh, a rural and tribal area situated on the bank of the Dulung River, is mostly surrounded by Sal Forest and has become a famous tourist destination for the presence of Chilkigarh Raj Palace and Kanak Durga Sacred Grove. In 2018, it received the status of Chilkigarh Kanak Durga Biodiversity Heritage Site from the Environment Department, Govt. of West Bengal, India. Altogether, 388 plant species, including 105 with medicinal values and 26 species of megafauna (vertebrates), have been reported [11]. Recently, 37 species of birds have been documented from different sites in Chilkigarh [12]. To elucidate the butterfly community of this area, a study has been done to gather knowledge about their diversity, dominant family group, species-to-genus ratio, legally protected species, etc., that will surely provide a route for future investigations regarding their nectar plants, host plants, seasonal fluctuations and ultimately planning for conservation.

MATERIALS AND METHODS

Study area

Chilkigarh **(Figure 1)** is a tribal area (latitudes 22°27′20″ N and 22°56′50″ N and longitudes

86°52′20′′ E and 86°53′10′′ E), having an average elevation of 60-85 m above the sea level [13], situated in Jamboni CD block, under Jhargram Subdivision of District Jhargram, West Bengal. The western boundary falls under the lower ranges of the Chhotanagpur Plateau, the northwest area is uninhabitable, and most of the areas are non-productive due to the nature of the lateritic soil. Dulung, a monsoon-nourished river, passes down across the village. Chilkigarh forest is situated on the eastern side of the bank of this river, comprising heterogeneous vegetation of semideciduous, deciduous, and evergreen trees [11]. This area can be classified under the category of "Tropical Moist Deciduous Forest" as huge Sal plants predominate. Different types of shrubs, herbs, climbers, and grasses provide resources to small to large creatures. Dulung river bank, Chilkigarh Kanak Durga Sacred Grove, Open grasslands, Chilkigarh Raj Palace, Sonajhuri garden, Sal forests, and Agricultural lands were selected for study.

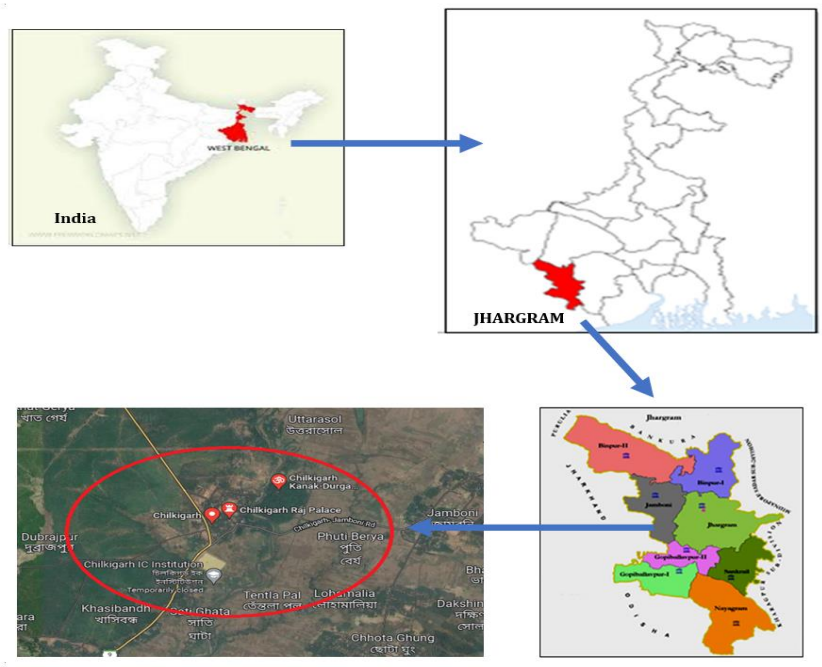

Figure 1. Location map of Chilkigarh in West Bengal, India [12].

Data collection

The study was carried out from 7:00 am to 10:00 am and 3:00 pm to 6:00 pm for 12 months (December 2021 to November 2022), adopting sampling techniques such as the Pollard walk method [14], Direct searching method [15], and Time Constrained method [16].

Identification & documentation of butterfly species

Photographic documentation was done by visiting different sites once or twice per month to capture photos from the best possible angles using a Canon IXUS 190 Digital camera and mobile phone camera – Redmi 6 Pro & Redmi Note 8. Species were identified using the following references [17-19] and further consulting the website of Butterflies of India [20].

Community analysis

To understand the structure of butterfly community α-diversity, i.e., the diversity of species within the community has been measured using the following diversity indices. All data were calculated using MS Excel 2019 software, and results were further verified using statistical software PAST version 4.03 [21].

Species richness

The Shannon-Wiener index, commonly known as the Shannon index of diversity [22], sometimes erroneously called the Shannon-Weaver index, was derived independently by Shannon and Wiener, which apply information theory to measure species diversity. Rare species with very few individuals can contribute some value to this index [23]. It is calculated considering Eq. (1) as follows:

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

Where H' is the value of the Shannon index and pi is the proportion of individuals of ith species in the

community. The value usually ranges between 1.5 to 3.5 and rarely exceeds 4.5. The value of *H'* is related to species richness but is also influenced by underlying species abundance distribution.

Margalef's index [24] is used to calculate species richness considering Eq. (2) as follows:

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

Where S is the total number of species and N is the total number of individuals in S species.

Species abundance

Simpson's index [25] is the measure of the probability that two organisms picked at random from a community will belong to the same species. This index relates the contribution made by each species to the total number of individuals present. It can be calculated considering Eq. (3) as follows:

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

The value of D ranges between 0 to 1 and is inversely proportional to the wealth of species. As the value of Simpson's index increases, the species diversity decreases. Therefore, the more the index value is inclined to 0, the more abundance will be in the community.

Simpson's index of diversity = 1- the probability of picking two organisms that are the same species and calculated considering the following Eq. (4) as follows:

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

Where D is the value of Simpson's index of diversity and pi is the proportion of individuals of the species in the community. Simpson's index of diversity gives relatively little weightage to rare species and more weightage to common species. It ranges from 0 (low diversity) to a maximum of $(1\text{-}1/S)$, where S is the total number of species.

Table 1. Family-wise checklist with common and scientific names along with relative abundance, dominant status, and WPA status of each butterfly species encountered at Chilkigarh.

Sl. No.	Common Name	Scientific name	Abundance	Relative abundance (%)	Dominant status *	WPA Schedule status
		Family: Nymphalidae (Brush-footed Butterflies)				
		Subfamily: Biblidinae (Castors & Jokers)				
1	Angled Castor	*Ariadne ariadne* (Linnaeus, 1763)	79	4.990	SD	
2	Common Castor	*Ariadne merione* (Cramer, 1777)	16	1.010	SR	
		Subfamily: Danainae (Milkweed Butterflies)				
3	Blue Tiger	*Tirumala limniace* (Cramer, 1775)	28	1.768	R	
4	Common Crow	*Euploea core* (Cramer, 1780)	93	5.874	SD	IV
5	Plain Tiger	*Danaus chrysippus* (Linnaeus, 1758)	23	1.452	R	
6	Striped Tiger	*Danaus genutia* (Cramer, 1779)	14	0.884	SR	I
		Subfamily: Heliconiinae (Costers, Lacewings, Fritillaries & Relatives)				
7	Common Leopard	*Phalanta phalantha* (Drury, 1773)	20	1.263	R	
8	Tawny Coster	*Acraea violae* (Fabricius, 1775)	58	3.663	SD	
		Subfamily: Limenitinae (Barons, Sailers, Sergeants & Relatives)				
9	Baronet	*Euthalia nais* (Forster, 1771)	21	1.326	R	
10	Commander	*Moduza procris* (Cramer, 1777)	15	0.947	SR	
11	Common Baron	*Euthalia aconthea* (Cramer, 1777)	18	1.137	R	II
12	Grey Count	*Tanaecia lepidea* (Butler, 1868)	2	0.126	SR	II
13	Chestnut-streaked Sailer	*Neptis jumbah* (Moore, 1857)	34	2.147	R	
		Subfamily: Nymphalinae (Pansies, Eggflies & Relatives)				
14	Great Eggfly	*Hypolimnas bolina* (Linnaeus, 1758)	44	2.779	R	
15	Blue Pansy	*Junonia orithya* (Linnaeus, 1758)	37	2.337	R	
16	Chocolate Pansy	*Junonia iphita* (Cramer, 1779)	46	2.905	R	
17	Grey Pansy	*Junonia atlites* (Linnaeus, 1763)	49	3.095	R	
18	Lemon Pansy	*Junonia lemonias* (Linnaeus, 1758)	25	1.579	R	
19	Peacock Pansy	*Junonia almana* (Linnaeus, 1758)	42	2.653	R	
20	Yellow Pansy	*Junonia hierta* (Fabricius, 1798)	17	1.073	SR	

		Subfamily: Satyrinae (Browns)				
21	Bamboo Treebrown	*Lethe europa* (Fabricius, 1775)	4	0.252	SR	
22	Common Evening Brown	*Melanitis leda* (Linnaeus, 1758)	56	3.537	SD	
23	Common Four-ring	*Ypthima huebneri* (Kirby, 1871)	18	1.137	R	
24	Common Palmfly	*Elymnias hypermnestra* (Linnaeus, 1763)	23	1.452	R	
25	Common Bushbrown	*Mycalesis perseus* (Fabricius, 1775)	19	1.200	R	
		Family: Lycaenidae (Blues & Hairstreaks)				
		Subfamily: Polymmatinae (Weak Blues)				
26	Common Pierrot	*Castalius rosimon* (Fabricius, 1775)	52	3.284	SD	I
27	Dark Grass Blue	*Zizeeria karsandra* (Moore, 1865)	10	0.631	SR	
28	Forget-me-not	*Catochrysops strabo* (Fabricius, 1793)	12	0.758	SR	
29	Lesser Grass Blue	*Zizina otis* (Fabricius, 1787)	21	1.326	R	
30	Lime Blue	*Chilades lajus* (Stoll, 1780)	8	0.505	SR	I
31	Pointed Ciliate Blue	*Anthene lycaenina* (C & R. Felder, 1868)	22	1.389	R	II
32	Quaker	*Neopithecops zalmora* (Butler, 1870)	4	0.252	SR	
		Subfamily: Theclinae (Strong Blues, Hairstreaks)				
33	Common Guava Blue	*Deudorix isocrates* (Fabricius, 1793)	7	0.442	SR	II
34	Common Silverline	*Spindasis vulcanus* (Fabricius, 1775)	5	0.315	SR	
35	Peacock Royal	*Tajuria cippus* (Fabricius, 1798)	4	0.252	SR	II
36	Bengal Slate Flash	*Rapala manea* (Hewitson, 1863)	4	0.252	SR	
37	Indian Oakblue	*Arhopala atrax* (Hewitson, 1862)	2	0.126	SR	
		Family: Papilionidae (Swallowtails)				
		Subfamily: Papilioninae				
38	Lime Swallowtail	*Papilio demoleus* (Linnaeus, 1758)	52	3.284	SD	
39	Common Mormon	*Papilio polytes* (Linnaeus, 1758)	79	4.990	SD	
40	Common Banded Peacock	*Papilio crino* (Fabricius, 1793)	3	0.189	SR	
41	Blue Mormon	*Papilio polymnestor* (Cramer, 1775)	6	0.379	SR	
42	Common Mime	*Chilasa clytia* (Linnaeus, 1758)	15	0.947	SR	I
43	Common Jay	*Graphium doson* (C&R Felder, 1864)	13	0.821	SR	
44	Tailed Jay	*Graphium agamemnon* (Linnaeus, 1758)	49	3.095	R	
45	Spot Swordtail	*Graphium nomius* (Esper, 1799)	1	0.063	SR	
46	Common Rose	*Atrophaneura aristolochiae* (Fabricius, 1775)	45	2.842	R	
		Family: Pieridae (Whites & Yellows)				
		Subfamily: Pierinae (Whites)				
47	Common Gull	*Cepora nerissa* (Fabricius, 1775)	15	0.947	SR	II
48	Common Jezebel	*Delias eucharis* (Drury, 1773)	19	1.200	R	
49	Indian Common Wanderer	*Pareronia hippia* (Fabricius, 1787)	62	3.916	SD	
50	Eastern Striped Albatross	*Appias olferna* (Swinhoe, 1890)	2	0.126	SR	
51	Psyche	*Leptosia nina* (Fabricius, 1793)	83	5.243	SD	
		Subfamily: Coliadinae (Yellows)				
52	Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus, 1758)	54	3.411	SD	
53	Oriental Lemon Emigrant	*Catopsilia pomona* (Fabricius, 1775)	6	0.379	SR	
54	Three-spot Grass Yellow	*Eurema blanda* (Boisduval, 1836)	23	1.452	R	
		Family: Hesperiidae (Skippers)				
		Subfamily: Pyrginae (Flats & Angles)				
55	Common Snow Flat	*Tagiades japetus* (Stoll, 1781)	5	0.315	SR	
		Subfamily: Hesperiinae (Bobs, Hoppers, Redeyes, Swifts & Relatives)				
56	Dark Palm Dart	*Telicota ancilla* (Herrich-Schaffer, 1869)	39	2.463	R	
57	Rice Swift	*Borbo cinnara* (Wallace, 1866)	35	2.210	R	
58	Common Red Eye	*Matapa aria* (Moore, 1865)	18	1.137	R	
		Family: Riodinidae (Metalmarks)				
		Subfamily: Riodininae				

59	Double-banded *RA < 1 = Subrecedent (SR); 1.1-3.1 = Recedent (R); 3.2-10 = Subdominant (SD); 10.1-31.6 = Dominant (D) and > 31.7% = Eudominant Judy	*Abisara bifasciata* (Moore, 1877)	7	0.442	SR

*RA < 1 = Subrecedent (SR); 1.1-3.1 = Recedent (R); 3.2-10 = Subdominant (SD); 10.1-31.6 = Dominant (D) and > 31.7% = Eudominant

Species evenness

Pielou's index [26] was used to measure species evenness. It was calculated considering Eq. (5) as follows:

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

Where H' is the Shannon index and S is the total number of species. The value of e ranges from 0 to 1. The more the index value inclined towards 1, the more will be the evenness in the community.

The dominance status of each species was enumerated based on relative abundance following Engelmann's scale [27]. Rank-abundance curve (Whittaker plot) is prepared, taking abundance rank on the X axis against relative abundance on the Y axis to graphically represent the relative species abundance [28].

RESULTS AND DISCUSSION

In our study, overall, 59 species of butterflies were recorded with a total count of 1583 individuals belonging to 45 genera under 6 families from Chilkigarh **(Table 1; Figures 2 and 3).** The family Nymphalidae appeared to be the most dominant (42.3% with 25 species), followed by Lycaenidae (20.3% with 12 species), Papilionidae (15.2% with 9 species), Pieridae (13.5% with 8 species), Hesperiidae (6.7% with 4 species) and Riodinidae (1.6% with 1 species) **(Figure 4)**. Previous reports also support our findings that Nymphalidae is the dominant family in the neighboring districts: Purulia [29], Haldia [30], Midnapore [23, 30], and Howrah [31].

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.

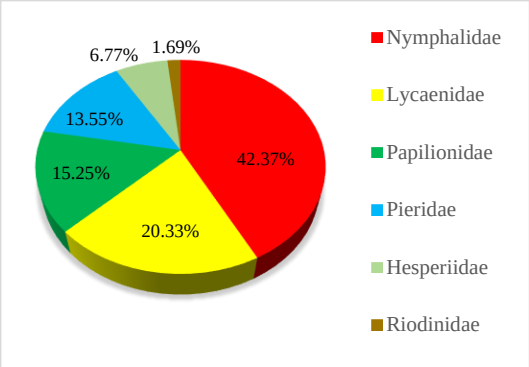

Figure 4. Percentage composition of Butterfly families.

The ratio of species to genus is 1.31: 1. The proportion of butterflies under six families from genera to species is represented in **Figure 5**.

11 species were found legally protected under different Schedules of the Wildlife (Protection) Act, 1972 [32], but none were found globally threatened as per the IUCN Red List (Ver 3.1) [33]. Of these legally protected species Striped Tiger (*D. genutia*), Common Pierrot (*C. rosimon*), Lime Blue (*C. lajus*), Common Mime (*C. Aclytia*) are protected under Schedule I. 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 protected under Schedule II and Common Crow (*E. core*) is protected under Schedule IV. In the family, Nymphalidae *Euploea core* was found to be the most abundant species, while *Tanaecia lepidea* was the least one. Under the family Lycaenidae, *Castalius rosimon* was more common, while *Arhopala atrax* was the least common. Similarly, in Papilionidae, *Papilio polytes* was well encountered compared to only a single species of *Graphium nomius*. In Pieridae, *Leptosia nina was*

counted more than Appias olferna. Abisara bifasciata is the only species recorded under the family Riodinidae. An analysis of relative abundance following Engelmann's scale [26] reveals the absence of dominant species in Chilkigarh but 10 species viz. *Ariadne ariadne, Euploea core, Acraea terpiscore, Melanitis leda, Castalius rosimon, Papilio demoleus, Papilio polytes, Pareronia hippia, Leptosia nina,* and *Catopsilia pyranthe* were subdominant in nature **(Table 1)**.

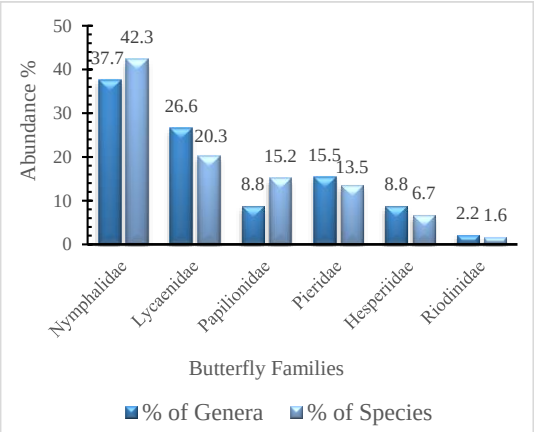

Figure 5. The genus-to-species proportion of butterflies under six families.

The calculated values of Shannon index (1) and Margalef's index (2) are 3.73 and 7.87, respectively, indicating that the butterfly community of Chilkigarh has high species richness which is consistent with the other findings j23, 30, 34]. The calculated value of Simpson's index (3) is 0.029. As the value is more inclined towards 0, it suggests a high proportion of species abundance. The value of Simpson's index of diversity (4) is 0.9708, suggesting the studied butterfly community is a diversified one. The species evenness (5) for the studied community is E = 0.9148, which indicates high evenness, as it is more inclined to 1.

Given that the abundances of the high-ranking and low-ranking species are very different, the rank abundance curve for the community exhibits strong evenness with a comparatively low steep inclination in the Whittaker plot. High evenness between the various species is conditioned by a modest gradient **(Figure 6)**.

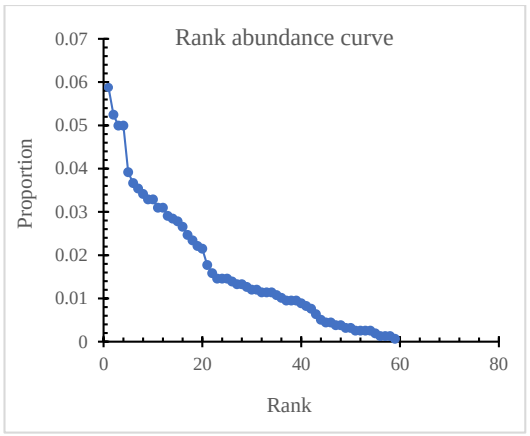

Figure 6. Whittaker plot of rank-abundance of butterfly community of Chilkigarh.

CONCLUSION

This preliminary investigation suggests that the Chilkigarh area has rich butterfly diversity. Identification of different host plants, and nectar plants, studying seasonal variation, searching for new species, measuring different environmental parameters that affect their life cycle, and correlating all these together in the future will surely help us to predict the complete picture of butterfly community in this area. Surveys at regular intervals will make us aware of any anthropogenic impact due to tourism. If any, accordingly, conservation strategies can be planned to restore these beautiful creatures.

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CONFLICT OF INTEREST: None

FINANCIAL SUPPORT: None

ETHICS STATEMENT: In this study, none of the butterfly species were captured or harmed by any means. Images in the figure are the result of live photography in their natural habitat.

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