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A report on Butterfly (Order: Lepidoptera) diversity and Plant – interaction dynamics across urban – Semiurban Landscapes of Chittaranjan and Hindustan Cables, Paschim Bardhaman, West Bengal, India

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Abstract
Urban and semiurban green spaces represent vital refuges for pollinators within human-dominated landscapes. The present study documented butterfly diversity and their plant associations across Chittaranjan (CRJ) and Hindustan Cables (HCL), Paschim Bardhaman district, West Bengal, India, over an 8-month survey (February–September 2025). A total of 86 butterfly species belonging to 65 genera and 6 families were recorded. Nymphalidae emerged as the most dominant family (38.4%), followed by Lycaenidae (19.7%) and Pieridae (16.3%). While the highest abundance was observed in *Eurema hecabe* (4.7%). Diversity indices indicated high heterogeneity: Shannon-Weiner diversity Index (1.568), Simpson's Index of Diversity (0.88) and Pielou's Evenness Index (0.76). Floral associations highlighted strong nectaring preferences for *Tridax procumbens*, *Gomphrena globosa* and *Ixora coccinea*, while puddling behavior was frequent in *Graphium sarpedon*, *Jamides celeno* and *Doleschallia bisaltide*. The study documented 13 species legally protected under the Indian Wildlife (Protection) Act, 1972, including 5 species on Schedule I. The study demonstrated that urban – semiurban green spaces can serve as critical biodiversity refuges and conservation hotspots, underscoring the urgent need for their protection within industrial landscapes.

Keywords: Butterfly diversity, Chittaranjan, Hindustan Cables, nectaring plants, puddling, urban ecology, Lepidoptera

Introduction
Paschim Bardhaman is a predominantly urban mining – industrial district in West Bengal, covering 1603 km^2 of the area. Its headquarters lie in Asansol with two subdivisions: Asansol Sadar and Durgapur. Chittaranjan and Hindustan Cables town drops under Asansol Sadar subdivision which is well connected with its surrounding state Jharkhand and districts by two State Highways (SH 5 and SH 9) and two National Highways (NH 14 and NH 19). The adjoining rivers flowing, North-West to the South-East are Ajay and Damodar rivers, in courses roughly parallel to one another.
Although Chittaranjan is a locomotive area, it is renowned for its high-standing green urban center, gathering a huge collection of insect species across the area, especially lepidopteran butterflies. Slightly heading southwardly; Hindustan Cables town, Kalyangram, Ghiadoba and Malbahal areas also show elite green city and village statuses, providing a resilient habitat for existing population. These areas togetherly provide diverse microhabitats including fragmented forests, wetlands, gardens and parks. In forested and human dominated landscapes, both larvae and adult butterflies serve as a major component of biological food chain (Payra *et al*.,2017) [16]. As such, the beauty and ecological significance of butterflies are a well-studied group throughout the world (Ghazoul,2002; Kumari *et al*.,2024) [7, 9]. About 16,000 butterfly species are reported globally out of the 1.4 million species on Earth (Bibi *et al*.,2022; Rout *et al*.,2023) [2, 21]. Butterflies being frequent visitors of wide variety of flowers, constitute an effective and potential pollinator group along with other insect pollinators of the world (Nayak,2020) [15]. They serve in formulating conservation strategies. Hence, butterflies play a vital role in the ecosystem and the co-evolutionary relationship between plants as well as their life span are interlinked (Ghazanfar *et al*.,2016) [6]. They also provide economically important services within terrestrial ecosystems such as nutrient recycling, soil formation and food resources. (Kumari *et al*.,2024) [9].
Most butterfly species are found in the tropical region of the Earth. Species diversity and abundance depend on their habitat. The species diversity of butterfly count is directly relative to the vegetation of the given area (Rani and Kashyap, 2024) [20]. India harbored a total of 1504 butterfly species which accounted for 8.74% of the world's butterflies, and 285 species were found in Southern India. The Peninsular India and Western Ghats have 351 and 334 species respectively (Kunte *et al*.,2012) [11]. The Zoological Survey of India has reported only, 1318 species of butterflies in India, of which 35 species are critically endangered as per the IUCN Red List (Cotton et al.,2015) [4]. Compared to other parts of West Bengal, there were no previous studies on butterfly diversity in the Asansol Sadar subdivision of Chittaranjan and Hindustan Cables town, drawing relatively little attention to urban – industrial townships. Hereby, the present study was conducted to document butterfly species richness and abundance across the selected habitats which reflected diversity comparison among forests, wetlands, gardens, residential colonies and parks. It also aimed to highlight conservation significance of urban green spaces for sustaining lepidopteran fauna.

Materials and Methods
Study area
Surveys were conducted in Chittaranjan (CRJ) and Hindustan Cables (HCL) township, located in the Asansol Sadar subdivision, Salanpur Block, Paschim Bardhaman district (23.86^{0}N, 86.87^{0}E). Chittaranjan is positioned at (23.87^{0}N, 86.87^{0}E) occupying 18.3 km^2 of the area whereas Hindustan Cables town, located in Rupnarayanpur, is situated at (23.82^{0}N, 86.90^{0}E) corner with 3.9 km^2 of the area (Fig 1). Key habitats included forests of Ghiadoba village (HCL) dominated by *Alstonia scholaris* tree, fragmented forests of Malbahal village (HCL) and Fatehpur (CRJ) with *Lantana camara*, *Tridax procumbens*, *Cynodon*

dactylon and *Zizipus oenopolia* as major wild plants, Open grasslands and roadside vegetations around CRJ and HCL, dominated by *Samanea saman, Guazuma ulmifolia, Adenanthera pavonia* and *Boerhavia diffusa*. Semi – Urban parks of Karnel Singh and Deshbandhu Loco Park in CRJ mostly included *Axonopus compressus, Cassia fistula* and *Gomphrena globosa* as dominant flora whereas, Residential gardens of Kalyangram 1 (HCL), railway and RPF colonies in CRJ showed majorly dominated trees like *Ficus benghalensis, Cocos nucifera, Mangifera indica* and *Eucalyptus globulus, Calotropis gigantea, Ixora coccinea, Cosmos sulphureus* flora. Lastly Wetlands on the bank of Ajay River, Hospital dam, Hill colony dam in CRJ and swampy ponds of Malbahal, Ghiadoba showed *Turnera subulata* and *Sphagneticola trilobata* as the most prevalent wild floral habitat (Fig 2).

Sampling Method and Identification of the species

The selected field areas were surveyed once in every two weeks for a period of 8 months from February, 2025 to September, 2025, displaying variation of three seasons: Spring- February and March (pleasant transitioning season), Summer- April to June (hot dry and dusty winds), and Rainy season- July to September (1200-1400mm average annual rainfall) respectively. The region experiences a tropical savanna climate. Butterfly counts were done from (8:00 am to 11:00 am) and (16:00 pm to 17:00 pm) using Pollard Walk method (Pollard,1977) [18]. Imaginary transect routes ranging from 50m-100m were followed for the entire survey areas. Butterflies were recorded using opportunistic visual encounter surveys (VES). Photographs were taken for species identification. The identification was done by using standard literature (Evans,1932; Kunte,2000; Kehimkar,2016; Bhakare and Ogale,2018) [5, 10, 8, 1]. Nectar sucking, roosting and puddling activities were also observed.

Statistical Data Analysis

The number of species present in each of the 6 families is considered as the species richness. To quantify butterfly diversity of the areas, different diversity indices and their relative abundance were calculated by the following formulas:

Relative Abundance (R.A) % = $(n_i/N) \times 100 = p_i \times 100$, where n_i = Total number of i^{th} species in an area, N= Total sum of population of all species in that area.

Shannon-Weiner Diversity Index (Shannon and Weaver,1949) [22]: $H = -\Sigma^{s}_{i=1}\ p_i \ln(p_i)$, where p_i = Proportion of total sample belonging to i^{th} species, *ln* = natural logarithm and *s* = species richness.

Evenness Index (Pielou,1966) [17]: $J = H/H_{max}$, where H = Observed index of species diversity, H_{max} = Maximum possible index of diversity.

Simpson's Index of Diversity (Simpson,1949) [24]: $D = 1-\Sigma^{s}_{i=1}\ (pi)^2$, where p_i = Proportion of total sample belonging to i^{th} species.

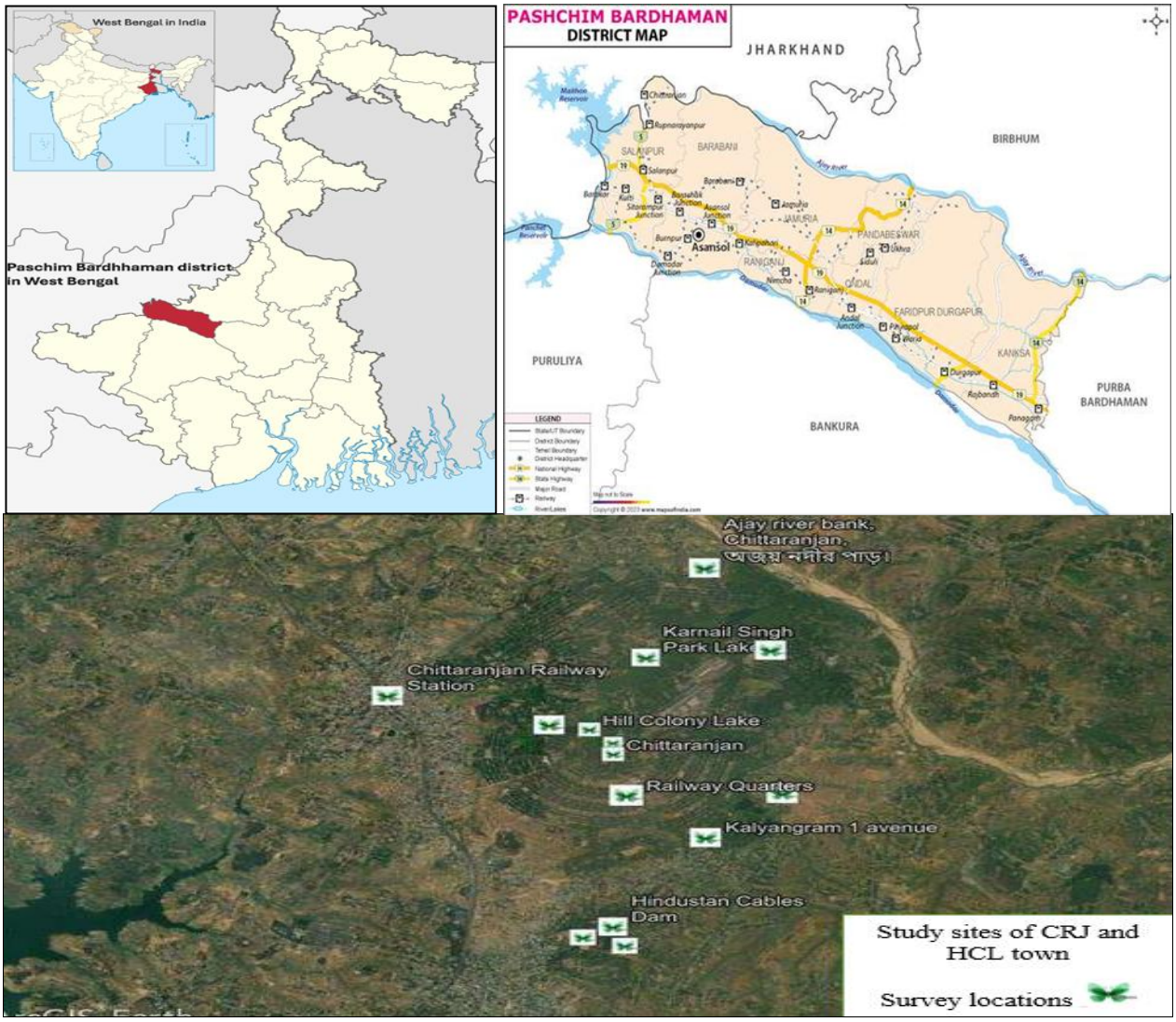

Fig 1: Geographical representation of the study areas

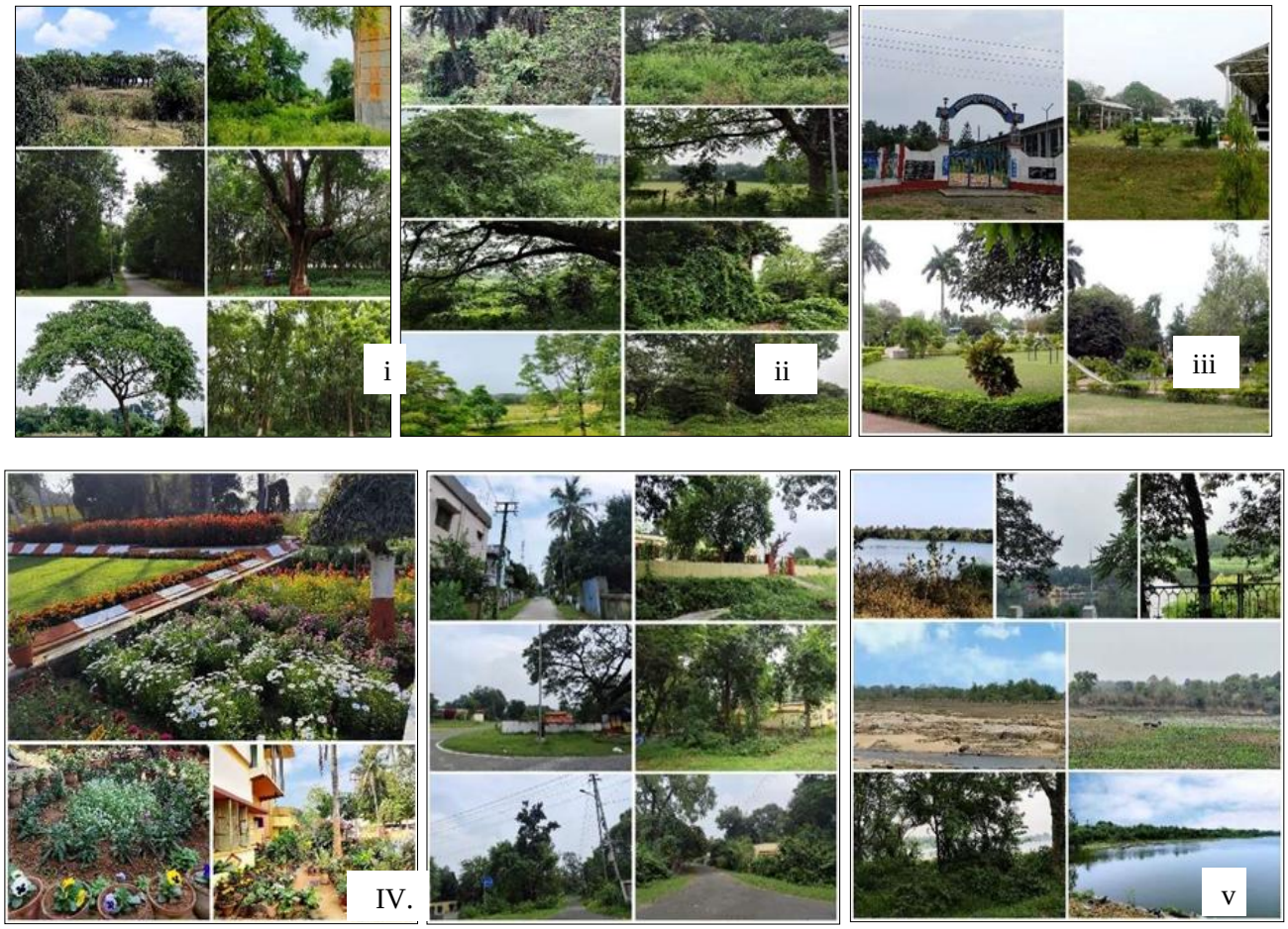

Fig 2: Photographic illustrations of studied habitats. i. Forests and fragmented patches, ii. Open grassland & roadside vegetation, iii. Semi – urban Parks, iv. Gardens & Residential colonies, v. Wetlands

Results

Species Richness

During the entire course of study, a total of 86 butterfly species belonging to 6 families and 65 genera were documented across the landscapes of Chittaranjan (CRJ) and Hindustan Cables (HCL) township. Fig 9 depicted Nymphalidae family as the most dominant, contributing 33 species (38.4%), followed by Lycaenidae (17 species; 19.7%) > Pieridae (14 species; 16.3%) > Hesperiidae (12 species; 13.9%) > Papilionidae (8 species; 9.3%) and Riodinidae (2 species; 2.3%). In terms of abundance, Table 1, the highest population was represented by *Eurema hecabe* (Common Grass Yellow) with 145 individuals;4.7% followed by *Catopsilia pyranthe* (123;3.99%) > *Leptosia nonia lemonias* (72;2.33%) > *Danaus chrysippus* (71;2.30%) and *Kallima inachus* (71;2.3%). Rare species included *Zemeros flegyas* (1 individual;0.03%) < *Abisara echerius* (3 individuals;0.1%) < *Loxura atymnus* (5 individuals;0.16%), all confined to shaded forest patches.

Diversity Patterns

Diversity indices reflected considerable heterogeneity across sites. The pooled Shannon–Weiner diversity index (H) was 1.568, indicating high species diversity, while the Simpson's index of diversity (D) was 0.88, highlighting low dominance of any single taxon. Pielou's evenness index (J) was calculated as 0.76, suggesting relatively even distribution of species across habitats. Diversity analysis also revealed marked variations among butterfly families (Fig 10). Family Nymphalidae recorded the highest Shannon–Weiner Diversity Index (H = 3.348), Simpson's Index of Diversity (D = 0.961), and Pielou's Evenness Index (J = 0.957), highlighting its dominance and balanced species distribution within the study area. Lycaenidae (H = 2.71, D = 0.93, J = 0.96) and Pieridae (H = 2.45, D = 0.896, J = 0.928) also exhibited high diversity, reflecting their stable representation. Moderate values were observed in Papilionidae (H = 2.02, D = 0.86, J = 0.972) and Hesperiidae (H = 2.393, D = 0.903, J = 0.963), suggesting consistent but less dominant presence. In contrast, Riodinidae showed the lowest diversity (H = 0.563, D = 0.375) and comparatively lower evenness (J = 0.812). Overall, Nymphalidae contributed substantially to community stability and heterogeneity, while Riodinidae displayed restricted diversity.

Habitat Influence

Habitat-wise comparison (Table 2) revealed that the semi-evergreen and mixed deciduous forests of Ghiadoba (Salanpur block), fragmented forest patches at Malbahal (HCL) and Fatehpur (CRJ), form crucial habitats. These sites harbor native vegetation, leaf-litter microhabitats and canopy layers that provide shelter, roosting, and breeding opportunities for several butterfly species, that represented Nymphalidae (Plate 1, Fig 8) and Lycaenidae (Plate 1, Fig 6) as dominant families. Wetland habitats along the Ajay River bank and dams in CRJ, as well as marshy ponds of Malbahal, Ghiadoba, sustain rich butterfly activity, especially Papilionidae (Plate 1, Fig 4) and Pieridae (Plate 1, Fig 5) species. Residential gardens of Kalyangram 1 under

Jitpur – Uttarampur Gram Panchayat and green spaces within railway and RPF colonies of CRJ host a mix of ornamental and wild plants such as *Ixora coccinea*, *Catharanthus roseus*, *Lantana camara*, providing abundant nectar sources and larval host plants, mostly for Papilionidae and Hesperiidae (Plate 1, Fig 3) families. Semi-urban parks such as Karnel Singh Park and Deshbandhu Loco Park in CRJ represent managed green landscapes served as refuges within urban – industrial surroundings, supporting butterfly (especially Nymphalidae, Pieridae) species adapted to disturbed yet resource-rich habitats. Grass-dominated patches, railway embankments, and roadside vegetation create transitional habitats that support grass-feeding butterfly species like *Ypthima* spp., *Anthene* spp. etc. (Nymphalidae, Lycaenidae). Riodinidae (Plate 1, Fig 7) was only found in shady forests and grasslands. These habitats provide basking sites and early successional plants crucial for several resident species.

Butterfly – Plant Association

Butterflies exhibited diverse nectaring, roosting, and puddling behaviors, highlighting intricate plant–pollinator interactions.

Conservation-Important Species

Several species of high conservation value were recorded (Table 1), including *Papilio clytia*, *Pachliopta hector*, *Neptis jumbah*, *Discophora sondaica*, and *Doleschallia bisaltide*, listed under Schedule I; *Appias albina*, *Cepora Nerissa*, *Eurema andersonii*, *Anthene lycaenina*, *Charaxes solon* and *Mycalesis mineus*, listed under Schedule II; *Baoris farri* and *Euthalia lubentina*, listed under Schedule IV of the Indian Wildlife (Protection) Act, 1972. Altogether, 13 species were found to be legally protected under various Schedules of the Act, emphasizing the conservation importance of these urban–semiurban habitats.

Table 1: Checklist of butterfly species and activities observed in CRJ and HCL township

Sl No.	Families	Scientific Name	English Name	Nectaring/ Roosting/ Puddling	Total count	Abundance	IWPA,1972
1.	Hesperiidae	*Gomalia elma* (Trimen,1862)	African Marbled Skipper	*Abutilon indicum*	18	0.583	
2.		*Suastus gremius* (Fabricius,1798)	Oriental Palm Bob	*Chromolaena odorata*	22	0.713	
3.		*Telicota bambusae* (Moore,1878)	Dark Palm-Dart	*Lantana camara*	13	0.421	
4.		*Potoanthus omaha* (H. Edwards,1863)	Lesser Dart	*Axonopus compressus*	11	0.356	
5.		*Oriens gola* (Moore,1877)	Common Dartlet	*Nyctanthes arbor-tristis*	8	0.259	
6.		*Matapia aria* (Moore,1866)	Common Branded Redeye	*Bambusa striata*	9	0.292	
7.		*Lambrix salsala* (Moore,1866)	Chestnut Bob	*Melissa officinalis*	25	0.810	
8.		*Pelopidas agna* (Moore,1866)	Obscure Branded Swift	*Urochloa setigera*	16	0.518	
9.		*Pelopidas mathias* (Fabricius,1798)	Small Branded Swift	*Zea mays*	12	0.389	
10.		*Baoris farri* (Moore,1878)	Complete Paint-brush Swift	*Oryza sativa*	19	0.616	Schedule IV
11.		*Udaspes folus* (Cramer,1775)	Grass Demon	*Solanum melongena*	35	1.134	
12.		*Badamia exclamationis* (Fabricius,1775)	Brown Awl	*Murraya paniculata*	21	0.680	
13.	Papilionidae	*Papilio demoleus* (Linnaeus,1758)	Lime Swallowtail	*Catharanthus roseus*	51	1.652	
14.		*Papilio clytia* (Linnaeus,1758)	Common Mime	*Lantana camara*	28	0.907	Schedule I
15.		*Papilio polytes* (Linnaeus,1758)	Common Mormon	*Ixora coccinea*	42	1.361	
16.		*Pachliopta aristolochiae* (Fabricius,1775)	Common Rose	*Ixora coccinea*	31	1.004	
17.		*Pachliopta hector* (Linnaeus,1758)	Crimson Rose	*Xanthostemon chrysanthus*	19	0.616	Schedule I
18.		*Graphium Sarpedon* (Linnaeus,1758)	Common Bluebottle	Puddling	29	0.940	
19.		*Graphium doson* (C. & R. Felder,1864)	Common Jay	*Tridax procumbens*	55	1.782	
20.		*Graphium agamemnon* (Linnaeus,1758)	Tailed Jay	*Polyalthia longifolia*	53	1.717	
21.		*Appias albina* (Boisduval,1836)	Common Albatross	*Gmelina arborea*	49	1.588	Schedule II
22.		*Appias olferna* (Swinhoe,1890)	Eastern Striped Albatross	*Bougainvillea spectabilis*	41	1.329	
23.		*Cepora nerissa* (Fabricius,1775)	Common Gull	*Tridax procumbens*	46	1.491	Schedule II

24.	Pieridae	*Pieris canidia* (Linnaeus,1768)	Asian Cabbage White	*Sinapis arvensis*	58	1.879	
25.		*Eurema hecabe* (Linnaeus,1758)	Common Grass yellow	*Portulaca grandiflora*	145	4.699	
26.		*Eurema blanda* (Boisduval,1836)	Three-spot Grass Yellow	*Tridax procumbens*	51	1.652	
27.		*Eurema andersonii* (Moore,1886)	One-Spot Grass Yellow	*Tridax procumbens*	32	1.037	Schedule II
28.		*Prioneris philonome* (Boisduval,1836)	Redspot Sawtooth	*Cleome viscosa*	18	0.583	
29.		*Delias eucharis* (Drury,1773)	Indian Jezebel	*Oenothera biennis*	24	0.777	
30.		*Catopsilia pyranthe* (Linnaeus,1758)	Mottled Emigrant	*Gomphrena globosa*	123	3.986	
31.		*Catopsilia pomona* (Fabricius,1775)	Lemon Emigrant	*Clerodendrum paniculatum*	52	1.685	
32.		*Colotis danae* (Fabricius,1775)	Crimson Tip	*Capparis divaricata*	21	0.680	
33.		*Pareronia hippia* (Fabricius,1787)	Indian Wanderer	*Turnera subulata*	27	0.875	
34.		*Leptosia nina* (Fabricius,1793)	Psyche	*Tridax procumbens*	58	1.879	
35.	Lycaenidae	*Rapala manea* (Hewitson,1863)	Slate Flash	*Tabernaemontana divaricata*	33	1.069	
36.		*Talicada nyseus* (Guerin-Meneville,1843)	Red Pierrot	*Sphagneticola trilobata*	16	0.518	
37.		*Tarucus balkanica* (Freyer,1844)	Little Tiger Pierrot	*Calotropis gigantea*	19	0.616	
38.		*Pseudozizeeria maha* (Kollar,1844)	Pale Grass Blue	*Digitaria ischaemum*	59	1.912	
39.		*Zizula hylax* (Fabricius,1775)	Tiny Grass Blue	*Ruellia tuberosa*	42	1.361	
40.		*Zizeeria karsandra* (Moore,1865)	Dark Grass Blue	*Boerhavia diffusa*	38	1.231	
41.		*Arhopala atrax* (Hewitson,1862)	Indian Oakblue	*Murraya paniculata*	42	1.361	
42.		*Catochrysops strabo* (Fabricius,1793)	Forget-me-not	*Barleria cristata*	29	0.940	
43.		*Cigaritis vulcanus* (Fabricius,1775)	Common Silverline	*Cuphea hyssopifolia*	22	0.713	
44.		*Euchrysops cnejus* (Fabricius,1798)	Gram Blue	*Tagetes erecta*	39	1.264	
45.		*Jamides celeno* (Cramer,1775)	Common Cerulean	Puddling	25	0.810	
46.		*Neopithecops zalmora* (Butler,1870)	Common Quaker	*Glycosmis pentaphylla*	21	0.680	
47.		*Loxura atymnus* (Stoll,1780)	Yamfly	*Dioscorea deltoidea*	5	0.162	
48.		*Chilades lajus* (Stoll,1780)	Lime Blue	*Gerbera jamesonii*	52	1.685	
49.		*Anthene emolus* (Godart,1824)	Common Ciliate Blue	*Cassia fistula*	13	0.421	
50.		*Anthene lycaenina* (R. Felder,1868)	Pointed Ciliate Blue	Puddling	24	0.777	Schedule II
51.		*Luthrodes pandava* (Evans,1925)	Cycad Blue	*Axonopus compressus*	60	1.944	
52.	Riodinidae	*Abisara echerius* (Stoll,1790)	Plum Judy	*Maesa argentea*	3	0.097	
53.		*Zemeros flegyas* (Cramer,1780)	Punchinello	*Mikania micrantha*	1	0.032	
54.		*Kallima inachus* (Doyere,1840)	Orange Oakleaf	Leaf litters	71	2.301	
55.		*Ypthima huebneri* (Kirby,1871)	Common Four-ring	*Eleusine indica*	65	2.106	
56.		*Ypthima baldus* (Fabricius,1775)	Common Five-ring	*Tridax procumbens*	58	1.879	
57.		*Melanitis leda* (Linnaeus,1758)	Common Evening Brown	*Lantana camara*	40	1.296	
58.		*Elymnias hypermnestra* (Linnaeus,1763)	Common Palmfly	*Dypsis lutescens*	61	1.977	
59.		*Euthalia aconthea*	Common Baron	*Mangifera indica*	28	0.907	

		(Cramer,1777)					
60.		*Euthalia lubentina* (Cramer,1777)	Gaudy Baron	*Eclipta prostrata*	10	0.324	Schedule IV
61.		*Neptis hylas* (Linnaeus,1758)	Common Sailer	*Turnera subulata*	35	1.134	
62.		*Neptis jumbah* (Moore,1858)	Chestnut-Streaked Sailer	*Garcinia xanthochymus*	26	0.843	Schedule I
63.		*Charaxes solon*	Black Rajah	*Euphorbia heterophylla*	20	0.648	Schedule II
64.		*Hestinalis nama* (Doubleday,1844)	Circe	Basking	6	0.194	
65.		*Phalanta phalantha* (Drury,1773)	Common Leopard	*Gomphrena globosa*	52	1.685	
66.		*Euploea core* (Cramer,1780)	Common Crow	*Zizipus oenopolia*	68	2.203	
67.		*Euploea klugii* (Moore,1858)	Brown King Crow	*Adenium obesum*	31	1.005	
68.		*Discophora sondaica* (Boisduval,1836)	Common Duffer	*Alstonia scholaris*	24	0.777	Schedule I
69.		*Hypolimnas bolina* (Linnaeus,1758)	Great Eggfly	*Tridax procumbens*	40	1.296	
70.	Nymphalidae	*Aglais caschmirensis* (Kollar,1844)	Indian Tortoiseshell	Puddling	17	0.551	
71.		*Acraea issoria* (Hubner,1819)	Yellow Coster	*Hymenachne acutigluma*	20	0.648	
72.		*Acraea terpsicore* (Linnaeus,1758)	Tawny Coster	*Sphagneticola trilobata*	36	1.167	
73.		*Ariadne merione* (Cramer,1777)	Common Castor	*Ricinus communis*	27	0.875	
74.		*Ariadne ariadne* (Linnaeus,1763)	Angled Castor	*Cynanchum laeve*	21	0.680	
75.		*Danaus chryssipus* (Linnaeus,1758)	Plain Tiger	*Gomphrena globosa*	71	2.301	
76.		*Danaus genutia* (Cramer,1779)	Striped Tiger	*Cosmos sulphureus*	52	1.685	
77.		*Tirumala limniace* (Cramer,1775)	Blue Tiger	*Mangifera indica*	43	1.393	
78.		*Pantoporia hordonia* (Stoll,1790)	Common Lascar	*Mimosa pudica*	31	1.005	
79.		*Doleschallia bisaltide* (Cramer,1777)	Autumn Leaf	Puddling	34	1.102	Schedule I
80.		*Junonia lemonias* (Linnaeus,1758)	Lemon Pansy	*Gomphrena globosa*	72	2.333	
81.		*Junonia almana* (Linnaeus,1758)	Peacock Pansy	*Gomphrena globosa*	60	1.944	
82.		*Junonia atlites* (Linnaeus,1763)	Grey Pansy	*Cosmos sulphureus*	68	2.203	
83.		*Junonia iphita* (Cramer,1779)	Chocolate Pansy	*Aloe barbadensis*	57	1.847	
84.		*Vanessa cardui* (Linnaeus,1758)	Painted Lady	*Plumbago zeylanica*	15	0.486	
85.		*Mycalesis mineus* (Linnaeus,1758)	Dark-branded Bushbrown	*Cynodon dactylon*	12	0.388	Schedule II
86.		*Parantica sita* (Kollar,1844)	Chestnut Tiger	*Lantana camara*	10	0.324	

Table 2: Habitat-wise summary of butterfly diversity in Chittaranjan (CRJ) and Hindustan Cables (HCL) study area.

Habitat Type	Key Sites	Dominant Families	Representative Species
Forests & Fragmented Patches	Ghiadoba, Malbahal (HCL), Fatehpur (CRJ)	Nymphalidae, Lycaenidae	*Kallima inachus, Melanitis leda, Arhopala atrax*
Open Grasslands & Roadside Vegetation	Grass patches, Railway embankments, Roadside strips (CRJ & HCL)	Nymphalidae, Lycaenidae	*Ypthima huebneri, Mycalesis mineus, Pseudozizeeria maha*
Semi – Urban Parks	Karnel Singh Park, Deshbandhu Loco Park (CRJ)	Nymphalidae, Pieridae	*Junonia almana, Danaus chrysippus, Pieris canidia*
Gardens & Residential Colonies	Kalyangram 1, Railway & RPF colonies (CRJ)	Papilionidae, Hesperiidae	*Papilio demoleus, Papilio polytes, Suastus gremius*
Wetlands	Ajay River, Hospital Dam, Hill Colony Dam (CRJ), Marshy ponds of Malbahal & Ghiadoba	Pieridae, Papilionidae	*Eurema hecabe, Catopsilia pyranthe, Graphium sarpedon*

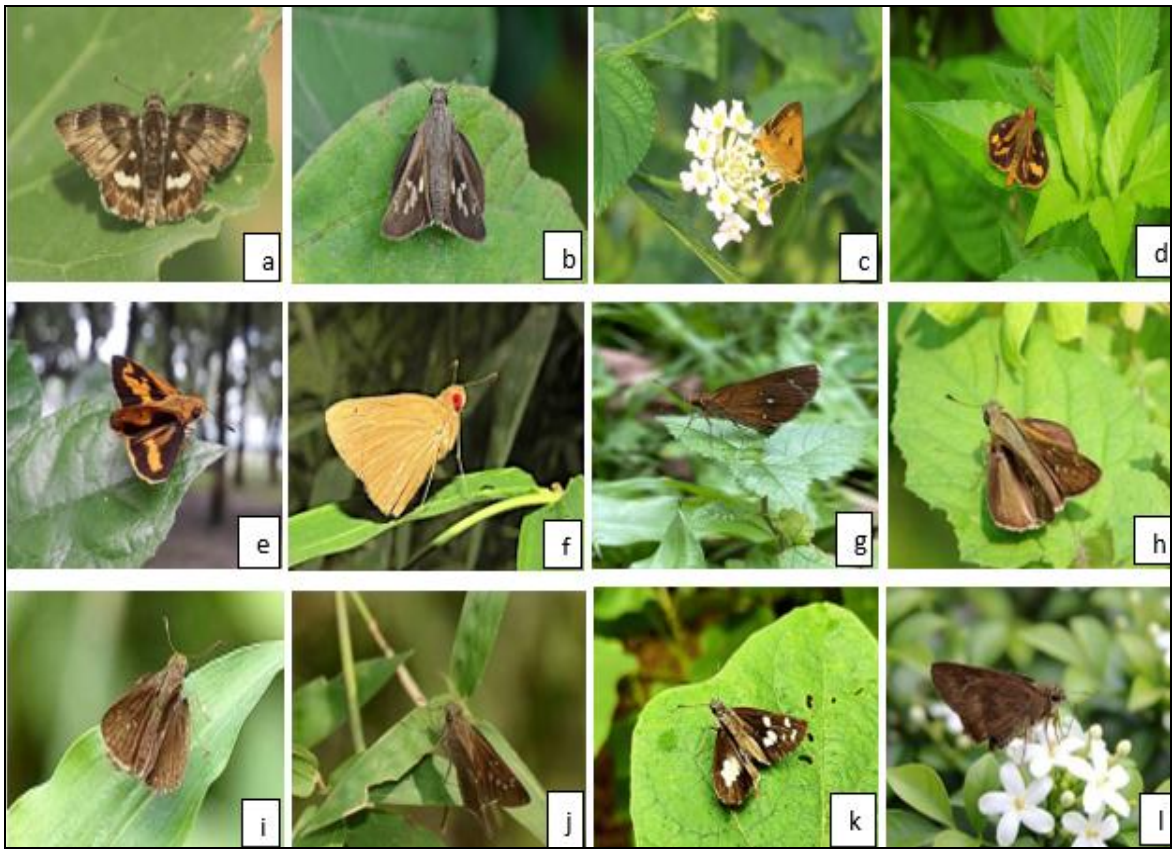

Fig 3: Family Hesperiidae, a. *Gomalia elma* b. *Suastus gremius* c. *Telicota bambusae* d. *Potoanthus omaha* e. *Oriens gola* f. *Matapia aria* g. *Lambrix salsala* h. *Pelopidas agna* i. *Pelopidas mathias* j. *Baoris farri* k. *Udaspes folus* l. *Badamia exclamationis*

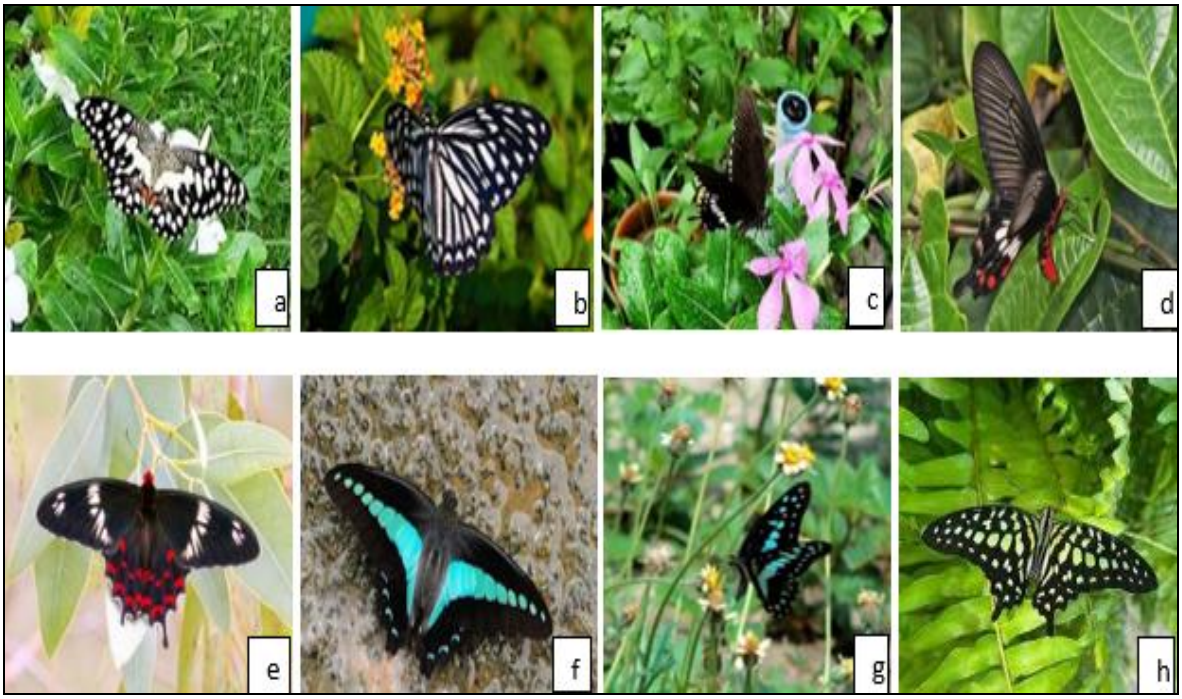

Fig 4: Familly Papilionidae, a. *Papilio demoleus* b. *Papilio clytia* c. *Papilio polytes* d. *Pachliopta aristolochiae* e. *Pachliopta hector* f. *Graphium sarpedon* g. *Graphium doson* h. *Graphium Agamemnon*

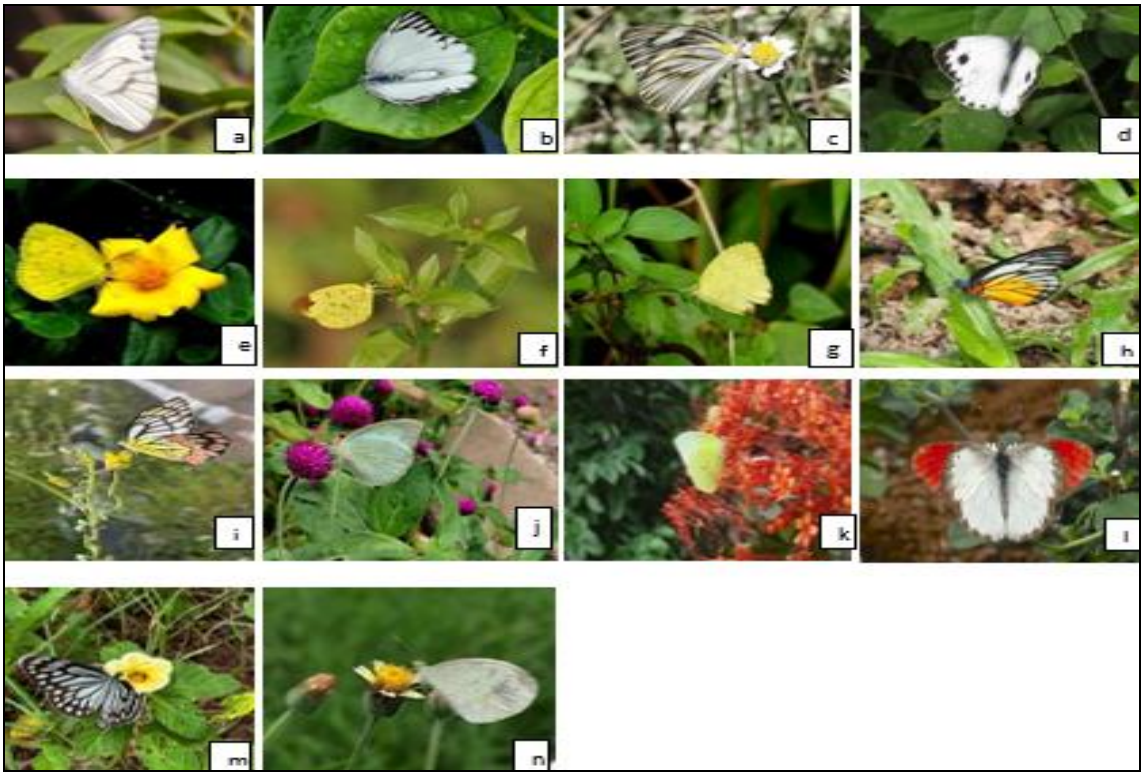

Fig 5: Family Pieridae, a. *Appias albina* b. *Appias olferna* c. *Cepora nerissa* d. *Pieris canidia* e. *Eurema hecabe* f. *Eurema blanda* g. *Eurema andersonii* h. *Prioneris philonome* i. *Delias eucharis* j. *Catopsilia pyranthe* k. *Catopsilia pomona* l. *Colotis danae* m. *Pareronia hippia* n. *Leptosia nina*

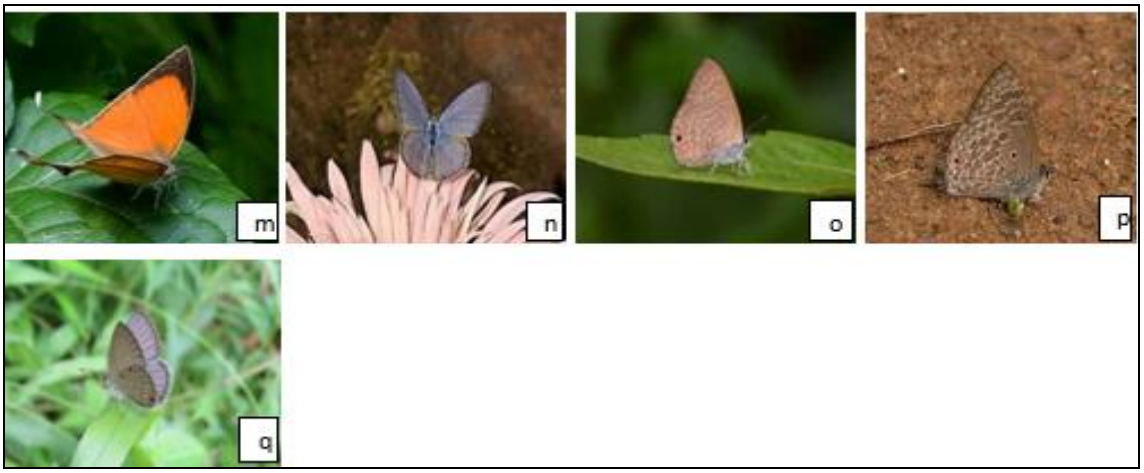

Fig 6: Family Lycaenidae, a.*Rapala manea* b.*Talicada nyseus* c.*Tarucus balkanica* d.*Pseudozizeeria maha* e.*Zizula hylax* f.*Zizeeria karsandra* g.*Arhopala atrax* h.*Catochrysops strabo* i.*Cigaritis vulcanus* j.*Euchrysops cnejus* k.*Jamides celeno* l.*Neopithecops zalmora* m.*Loxura atymnus* n.*Chilades lajus* o.*Anthene emolus* p.*Anthene lycaenina* q.*Luthrodes pandava*

Fig 7: Family Riodinidae, a. *Abisara echerius* b. *Zemeros flegyas*

Fig 8: Family Nymphalidae, a.*Kallima inachus* b.*Ypthima huebneri* c.*Ypthima baldus* d.*Melanitis leda* e.*Elymnias hypermnestra* f.*Euthalia aconthea* g.*Euthalia lubentina* h.*Neptis hylas* i.*Neptis jumbah* j.*Charaxes solon* k.*Hestinalis nama* l.*Phalanta phalantha* m.*Euploea core* n.*Euploea klugii* o.*Discophora sondica* p.*Hypolimnas bolina* q.*Aglais caschmirensis* r.*Acraea issoria* s.*Acraea terpsicore* t.*Ariadne merione* u.*Ariadne ariadne* v.*Danaus chryssipus* w.*Danaus genutia* x.*Tirumala limniace* y. *Pantoporia hordonia* z.*Doleschallia bisaltide* a1. *Junonia lemonias* a2. *Junonia almana* a3. *Junonia atlites* a4. *Junonia iphita* a5. *Vanessa cardui* a6. *Mycalesis mineus* a7. *Parantica sita*

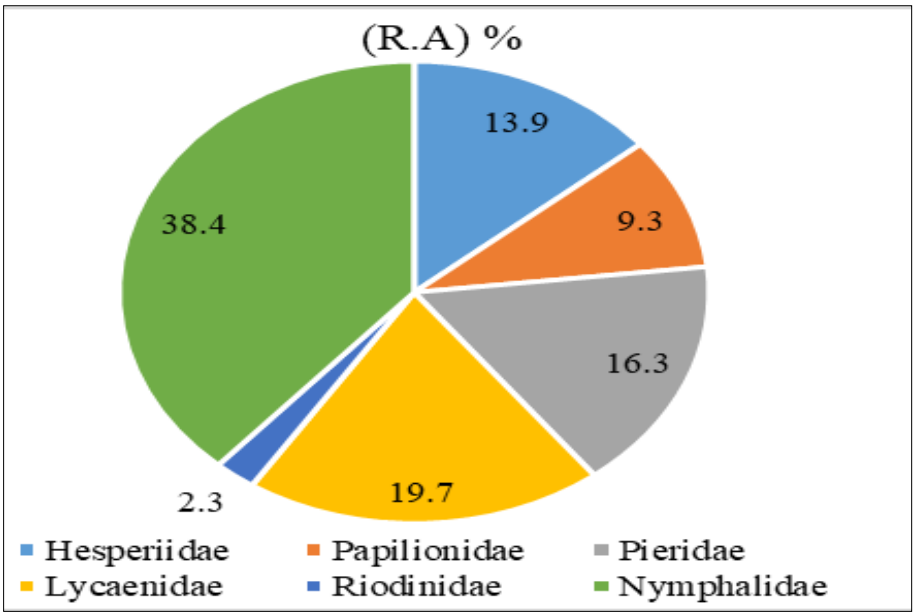

Fig 9: Pie chart representing abundance of each family of butterflies

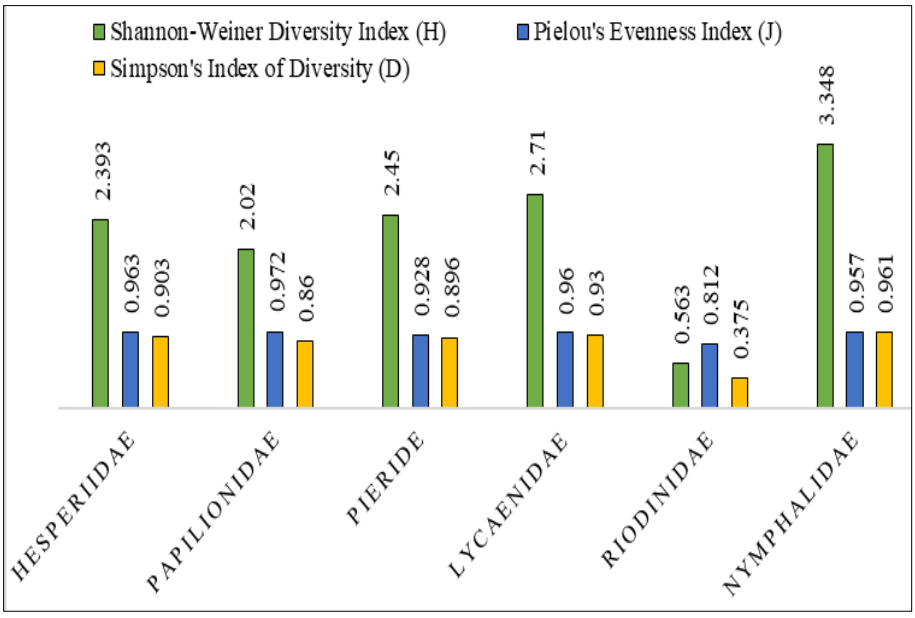

Fig 10: Graphical representaion of Family – wise diversity indices of surveyed butterflies

Discussion

This study recorded 86 butterfly species across six families in Chittaranjan (CRJ) and Hindustan Cables (HCL), demonstrating that urban–industrial mosaics can sustain rich lepidopteran communities. Contrary to the traditional view that urbanization reduces biodiversity (McKinney, 2008) [13], the findings support evidence that heterogeneous green spaces provide critical refuges for butterflies (Ramírez-Restrepo and MacGregor-Fors, 2017) [19].

Nymphalidae and Lycaenidae dominated the assemblages, consistent with reports from Jharkhand and Ranchi (Rout et al., 2023; Kumari et al., 2024) [21, 9]. Generalist species such as *Eurema hecabe* and *Catopsilia pyranthe* were most abundant, reflecting their tolerance of anthropogenic habitats, as noted in Bankura and Purba Medinipur (Nayak, 2020; Payra et al., 2017) [15, 16]. Rare species like *Zemeros flegyas* were confined to shaded forests, underscoring the role of microhabitats, a pattern also documented in the Western Ghats (Kunte et al., 2012) [11]. These habitats are important for puddling behavior, where butterflies congregate on moist soil and mudflats to extract minerals, amino acid and salts (Molleman *et al.*, 2005; Boggs and Jackson, 2008; Mallik *et al.*, 2022) [14, 3, 12].

Diversity indices reflected high heterogeneity, comparable to values from other semiurban ecosystems (Mallik et al., 2022; Sharma & Joshi, 2021) [12, 23]. The presence of 13 protected species, including *Papilio clytia* and *Pachliopta hector*, emphasizes the conservation value of these habitats. Similar studies across India and globally suggest that urban green spaces, if managed with ecological sensitivity, can function as biodiversity hotspots (Thomas, 2016) [25].

Overall, the results highlighted that even industrial townships can harbor resilient butterfly communities when habitat heterogeneity and floral diversity are maintained.

Conclusion

The present study provided the first comprehensive assessment of butterfly diversity in the urban-industrial landscapes of Chittaranjan and Hindustan Cables, revealing a remarkably rich and resilient lepidopteran fauna. The

documentation of 86 species, characterized by a high diversity index and even species distribution, challenged the conventional view of urban areas as biodiversity deserts. Each habitat type played a distinct and essential role in sustaining the butterfly community, highlighting that the preservation of ecological heterogeneity is paramount for urban conservation. The most profound implication of this research lied in the discovery of 13 species with legal protection under the Indian Wildlife (Protection) Act, 1972. The presence of Schedule I species such as *Papilio clytia* and *Pachliopta hector* within this urban context was extraordinary and provided a powerful, legally-grounded mandate for conservation. These areas were not merely recreational parks but were de facto conservation hotspots for endangered and vulnerable fauna. The findings therefore transform the perception of this industrial township, positioning it as a critical site for biodiversity preservation within a rapidly developing region.

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