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An investigation of the diversity and abundance of the butterfly (Insecta: Lepidoptera) species in Birati town of North 24 Parganas district, West Bengal

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Abstract
The present study highlights the diversity and abundance of butterfly fauna in Birati town, located in the North 24 Parganas district of West Bengal. During this one-year study [from January 2022 to December 2022], a total of 54 butterfly species, distributed across 15 subfamilies and 5 families, were documented in the town. Notably, the Nymphalidae family dominated among the five butterfly families, comprising 20 species, followed by Lycaenidae, Pieridae, and others. This study is the first recorded documentation of the available species of butterflies and their abundance in Birati town. The findings of this investigation suggest that despite being a densely populated urban area, the town hosts a diverse butterfly fauna, underscoring the importance of sincere monitoring and conservation efforts.

Keywords: Diversity, abundance, butterfly, Birati, West Bengal

Introduction

Butterflies, terrestrial lepidopteran insects, are the most colorful of all insects. These familiar and taxonomically well-studied insects have sucking mouthparts, long, slender, and knobbed antennae, and two pairs of membranous wings covered with minute, overlapping scales, which may be colored or iridescent [1-3].

Though often admired for their stunning colors and graceful flight, the significance of butterflies extends far beyond their aesthetic appeal, as they play multifaceted roles in ecosystems [3-4]. Butterflies have an indispensable role as pollinators, contribute to nutrient cycling, serve as key elements of food webs, and are considered indicator species to gauge the overall health and stability of natural ecosystems [3-6].

As they seek nectar, butterflies inadvertently transfer pollen from flower to flower, facilitating fertilization in plants and the production of seeds and fruits. This process is crucial for the sexual reproduction and genetic diversity of numerous plant species, ensuring the continued existence of flora within ecosystems [3-6].

Caterpillars, the larvae of butterflies, demonstrate a voracious appetite for leaves. Despite the apparent damage caused by their feeding habits, caterpillars play an important role in nutrient cycling within ecosystems. By consuming leaves, they regulate plant growth, prevent overcrowding, and contribute to nutrient redistribution within plants and soil. These processes support the health and sustainability of plant communities and are critical in maintaining healthy and balanced ecosystems [3-6].

The presence of butterflies and their larvae as a primary or supplemental food source sustains various insectivorous animals like birds and reptiles. Butterflies are an important link in food webs as they are an integral part of the diet for many animals, aiding in the energy transfer through different trophic levels and thus supporting biodiversity. Furthermore, their presence influences the population dynamics and behaviors of other species within their ecological community [2-6].

Butterflies are holometabolous insects; their life cycle, undergoing metamorphosis from egg to larva to pupa and finally to an adult butterfly, offers a captivating tale of adaptation and resilience within the intricate web of life. This cycle contributes to the biological diversity within ecosystems and highlights the ability of these lepidopteran insects to adapt to various environmental conditions [2-6].

Many butterfly species exhibit strict seasonality and are highly sensitive to disturbances, changes in vegetation structure, and microclimate variations [7-10]. Renowned as excellent ecological indicators, butterflies showcase sensitivity to environmental and climatic changes, responding to alterations in host plant availability for egg laying and larval development. Their presence, absence, or population shifts can indicate alterations in habitat health, climate, or pollution levels [7-10].

Scientists use butterflies as ecological indicators of urbanization owing to their responsiveness to urbanization-related changes in microclimate, temperature, and solar radiation. Additionally, the fact that butterfly populations can be easily surveyed makes them valuable bioindicators for assessing the general health of terrestrial ecosystems [7-11]. Butterflies use nectar and pollen as food, while caterpillars feed on the leaves of specific host plants. On the other hand, butterflies are efficient pollinators [1-4]. Because of the interdependence between butterflies and plants, the diversity, abundance, and population size of butterflies may be an indicator of overall plant diversity in a given area [12-15]. Changes in land use patterns can manifest in alterations to landscapes, influencing butterfly diversity, abundance, and distribution [9, 10, 15]. Ecologists widely use butterflies as model organisms and monitor their population to assess the impacts of habitat loss, fragmentation, climate change, and plant-animal interactions [4, 7, 8, 10, 11, 15].

Butterflies captivate people with their beauty and diverse colors, sparking interest in nature. They are often used in educational programs, encouraging conservation efforts and fostering appreciation for biodiversity. Butterflies can be used as umbrella species for conservation planning and management because their protection is expected to benefit a wide array of co-occurring species [13, 16].

Scientists have used butterflies as model organisms to study

different areas of biological sciences, including such diverse fields as navigation, pest control, embryology, mimicry, evolution, genetics, ecology and environment, population dynamics, and biodiversity conservation [3, 4, 15, 17].

India, a vast tropical country, ranks among the 17 megadiverse countries globally. Four global biodiversity hotspots are located within its boundaries [18]. Numerous previous reports on butterfly diversity in various regions of India have highlighted the country's rich lepidopteran diversity, with more than 1300 recorded butterfly species [3-6, 19]. While various checklists document butterfly diversity in different parts of the country, no study has been conducted yet in Birati, a highly populated town in the North 24 Parganas district of West Bengal [20-22]. As conservation efforts for butterflies are vital to sustain a variety of important ecosystem services, the present study was undertaken to evaluate the diversity and abundance of various species of this important group of winged insects in Birati.

Materials and Methods

Study Area

Birati [22^{0}66′N, 88°42′E] is a densely populated town in the Barrackpore subdivision in the North 24 Parganas district of West Bengal. The town is situated along Jessore Road, and municipal services are provided by North Dumdum Municipality. The Kolkata Metropolitan Development Authority (KMDA) is the statutory planning and development authority for this town. Covering an area of about 11 km², Birati is bordered by Jessore Road to the East, Belgharia to the West, New Barrackpore to the North, and Durganagar to the South [Figure 1].

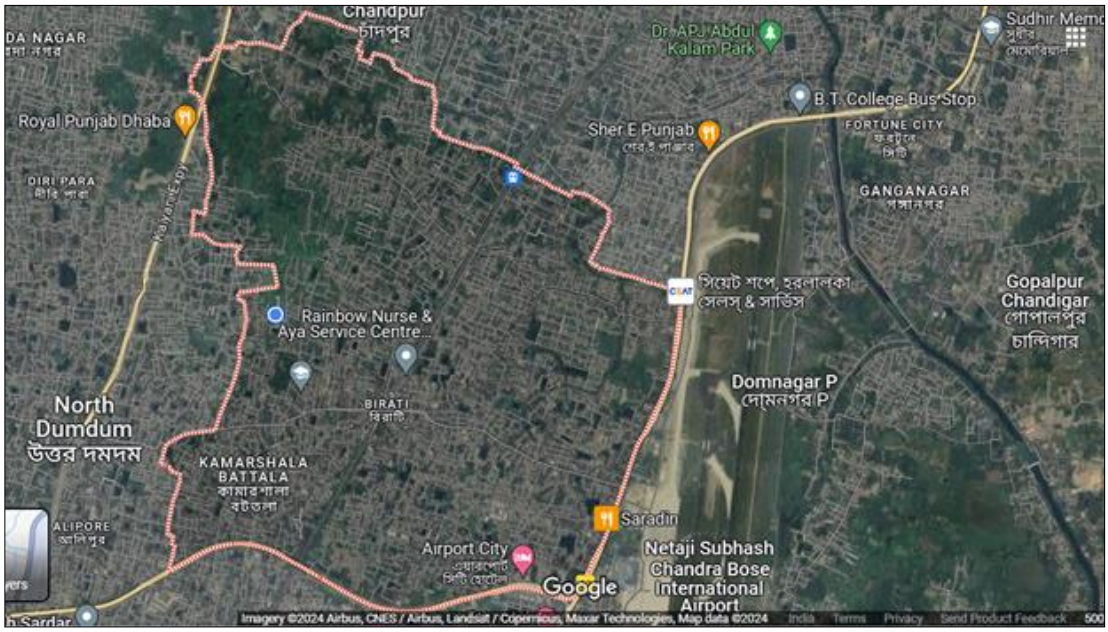

Fig 1: A Satellite image (source: Google Maps) of Birati town, located in the 24 pargans (North) district of West Bengal

During the summer months in Birati, temperatures can reach highs ranging from 30°C to 41°C (March to May), creating a hot and humid environment. In contrast, winter temperatures are milder, ranging from 10°C to 20°C [October to February]. The town experiences a significant amount of rainfall, especially during the monsoon season. Annual rainfall in Birati typically ranges from 1500 to 2500 millimeters, with the primary contributors being the monsoon months of June to September. The Mean Sea Level (MSL) elevation of this town is 6 meters. In the present study, Mrinalini Dutta Mahavidyapith [22^{0}66′47″ N, 88°42′21″ E], Birati Railway Station [22^{0}66′38″ N, 88°42′71″ E], Birati Bus Stop [22^{0}65′95″ N, 88°44′14″ E] on the Jessore Road, and Pratapgarh auto stand [22^{0}67′15″ N, 88°41′82″ E] were used as the central points of the study sites.

Sampling Period and Techniques for Evaluating Butterfly Diversity

The present survey spanned from January 2022 to December 2022, involving weekly site visits conducted between 8 AM and 4:30 PM under normal climatic conditions, devoid of strong winds and heavy rains. The "Pollard Walk" method was employed for observing and recording butterflies directly in the field [17, 23].

Each site featured two transect paths, each measuring 1000 meters, with a 200-meter gap between them. Butterflies were counted on both sides of the path at a distance of 2.5 meters. Consequently, 8 kilometers (1000 meters × 2 × 4) transect tracts was covered for each site per month. Occasionally, specimens were captured using a hand net, identified with the assistance of standard field guides, and released back into their original habitat with minimal damage to the scales on their wings [17, 23-25].

Books authored by Kehimkar (2016) and Smetacek (2016) were followed during the study of butterfly species. Comprehensive data, including the date, location, and associated plant information, were meticulously recorded [24, 25]. Additionally, in-field photography of butterflies was done using Nikon P420 and Nikon Coolpix L22 cameras.

To categorize butterfly species based on their frequency of sightings, a classification system was implemented, comprising four categories: a) abundant [A], b) common [C], c) uncommon [U], and d) rare [R]. Butterfly species with sighting counts of 60 times or more were designated as abundant, those with counts within the range of 40-59 times were classified as common, and species observed between

15-39 times fell into the uncommon category. A species was recorded as rare if it had a sighting count of 1-14 times [22]. This classification system provided a structured framework for analyzing and presenting the diversity and abundance of butterfly species in the study.

Results and conclusion

The conservation of biodiversity in urban ecosystems is a critical and pressing need in the face of rapid urbanization and the expanding footprint of human development. Urbanization, characterized by dense populations, extensive infrastructure development, and significant land-use changes, often exerts considerable pressure on local ecosystems. Ecosystems with high biodiversity provide numerous ecological services; thus, recognizing the importance of biodiversity conservation within urban environments is essential for maintaining ecological balance, human well-being, and the sustainability of urban ecosystems [26, 27].

To actively monitor and develop effective strategies for preserving biodiversity in urban areas, it is essential to first comprehend the current biodiversity status—specifically, the richness and abundance of species—in the concerned locality. Studying butterfly diversity in an area is crucial for gauging the overall health of ecosystems, providing insights into environmental changes, and identifying potential threats to biodiversity [8-11, 15]. Butterflies, considered sensitive ecological indicators, offer valuable information about habitat quality and the impacts of factors like climate change and urbanization [8-11]. Additionally, their versatile roles in the ecosystem, such as being essential pollinators and contributors to nutrient cycling and energy transfer through trophic levels, underscore the importance of preserving butterfly diversity for maintaining the balance of ecosystems and sustaining plant communities [11, 17]. Therefore, in the present study, the authors took the Initiative to assess the diversity and abundance of butterfly species in Birati, a densely populated town in the North 24 Parganas district of West Bengal. This initiative was prompted by the absence of any previously published report on the diversity of butterflies in the aforementioned town, and the current study is the outcome of research conducted on the diversity and abundance of lepidopteran fauna in the town, spanning one year (January 2022 to December 2022).

Birati, a suburban town characterized by high population density, predominantly features residential areas and encompasses large water bodies. The vegetation of the town consists mainly of human-planted large woody trees, flowering shrubs, and bushy herbs; in the northern and north-western parts of the town, there are marshes dominated by ferns, herbaceous plants, and *Phragmites*. Abhay Ashram (a social welfare organization established in 1924) located adjacent to Mrinalini Dutta Mahavidyapith (one of the central points of the study sites) stands out owing to its green campus spanning more than 6 acres with flower gardens, many large trees, and one water body.

In Birati, the present study recorded a total of 54 butterfly species from 41 genera, spanning 15 subfamilies and 5 families [Table 1]. Nymphalidae emerged as the dominant family with 20 species, followed by Lycaenidae with 14 species, Pieridae with 9 species, Papilionidae with 7 species, and Hesperiidae with 4 species. Papilionidae and Hesperiidae were each represented by one subfamily, whereas Lycaenidae, Nymphalidae, and Pieridae were represented by four, seven, and two subfamilies, respectively [Table 1 and Figure 2]. Based on the sighting data of butterflies in the town, 13 butterfly species were categorized as abundant, 23 butterfly species were found to be common, 13 butterfly species were classified as uncommon, and 5 species were identified as rare [Table 1, Figure 3, and Figure 4].

Table 1: Diversity and abundance of butterfly species recorded in Birati town during the present study

Sl. No.	Scientific Name	Common Name	Status
Family: Hesperiidae Subfamily: Hesperiinae			
1.	*Ampittia dioscorides* [Fabricius, 1793]	Bush Hopper	R
2.	*Borbo cinnara* [Wallace, 1866]	Rice Swift	U
3.	*Parnara guttatus* [Bremer & Gray, 1853]	Straight Swift	R
4.	*Matapa aria* [Moore, 1866]	Common Redeye	A
Family: Lycaenidae Subfamily: Aphnaeinae			
5.	*Spindasis vulcanus* [Fabricius, 1775]	Common Silverline	C
6.	*Rapala manea* [Hewitson, 1863]	Slate Flash	U
Family: Lycaenidae Subfamily: Lycaeninae			
7.	*Loxura atymnus* [Cramer, 1780]	Yamfly	C
8.	*Castalius rosimon* [Fabricius, 1775]	Common Pierrot	C
Family: Lycaenidae Subfamily: Polyommatinae			
9.	*Zizula hylax* [Fabricius, 1775]	Tiny Grass Blue	A
10.	*Leptotes plinius* [Fabricius, 1793]	Zebra Blue	A
11.	*Zizeeria karsandra* [Moore, 1865]	Dark Grass Blue	U
12.	*Neopithecops zalmora* [Butler, 1870]	Quaker	C
13.	*Anthene emolus* [Godart, 1824]	Common Ciliate Blue	C
14.	*Anthene lycaenina* [Felder, 1868]	Pointed Ciliate Blue	U
15.	*Pseudozizeeria maha* [Kollar, 1844]	Pale Grass Blue	U
16.	*Jamides celeno* [Cramer, 1775]	Common Cerulean	C
Family: Lycaenidae Subfamily: Theclinae			
17.	*Mahathala ameria* [Hewitson, 1862]	Falcate Oakblue	C
18.	*Rathinda amor* [Fabricius, 1775]	Monkey Puzzle	C
Family: Nymphalidae: Acraeinae			
19.	*Acraea violae* [Fabricius, 1775]	Tawny Coster	U
Family: Nymphalidae Subfamily: Biblidinae			

20.	*Ariadne merione* [Cramer, 1779]	Common Castor	C
21.	*Ariadne ariadne* [Linnaeus, 1763]	Angled Castor	C
Family: Nymphalidae Subfamily: Danainae			
22.	*Tirumala limniace* [Cramer, 1775]	Blue Tiger	U
23.	*Danaus genutia* [Cramer, 1779]	Common Tiger	A
24.	*Danaus chrysippus* [Linnaeus, 1758]	Plain Tiger	A
25.	*Euploea core* [Cramer, 1780]	Common Crow	C
Family: Nymphalidae Subfamily: Heliconiinae			
26.	*Phalanta phalantha* [Drury, 1773]	Common Leopard	U
Family: Nymphalidae Subfamily: Limenitidinae			
27.	*Neptis hylas* [Linnaeus, 1758]	Common Sailer	U
28.	*Moduza procris* [Cramer, 1777]	Commander	C
29.	*Euthalia aconthea* [Cramer, 1779]	Common Baron	R
Family: Nymphalidae Subfamily: Nymphalinae			
30.	*Junonia lemonias* [Linnaeus, 1758]	Lemon Pansy	U
31.	*Junonia atlites* [Linnaeus, 1763]	Grey Pansy	C
32.	*Junonia almana* [Linnaeus, 1758]	Peacock Pansy	C
Family: Nymphalidae Subfamily: Satyrinae			
33.	*Mycalesis perseus* [Fabricius, 1775]	Common Bushbrown	C
34.	*Melanitis leda* [Linnaeus, 1758]	Common Evening Brown	A
35.	*Ypthima baldus* [Fabricius, 1775]	Common Five Ring	C
36.	*Ypthima huebneri* [Kirby, 1871]	Common Four Ring	R
37.	*Ypthima asterope* [Klug, 1832]	Common Three Ring	C
38.	*Elymnias hypermnestra* [Linnaeus, 1763]	Common Palmfly	C
Family: Papilionidae Subfamily: Papilioninae			
39.	*Papilio demoleus* [Linnaeus, 1758]	Lime Butterfly	A
40.	*Graphium agamemnon* [Linnaeus, 1758]	Tailed Jay	U
41.	*Papilio polytes* [Linnaeus, 1758]	Common Mormon	A
42.	*Graphium doson* [Felder & Felder, 1864]	Common Jay	A
43.	*Papilio clytia* [Linnaeus, 1758]	Common Mime	C
44.	*Papilio polymnestor* [Cramer, 1775]	Blue Mormon	A
45.	*Pachliopta aristolochiae* [Fabricius, 1775]	Common Rose	U
Family: Pieridae Subfamily: Coliadinae			
46.	*Eurema hecabe* [Linnaeus, 1758]	Common Grass Yellow	A
47.	*Catopsilia pyranthe* [Linnaeus, 1758]	Mottled Emigrant	U
48.	*Catopsilia pomona* [Fabricius, 1775]	Common Emigrant	C
49.	*Eurema laeta* [Boisduval, 1836]	Spotless Grass Yellow	A
Family: Pieridae Subfamily: Pierinae			
50.	*Delias eucharis* [Drury, 1773]	Common Jezebel	C
51.	*Leptosia nina* [Fabricius, 1793]	Common Gull	A
52.	*Cepora nerissa* [Fabricius, 1775]	Psyche	C
53.	*Appias libythea* [Fabricius, 1775]	Striped Albatross	C
54.	*Pareronia valeria* [Cramer, 1776]	Common Wanderer	R
A = Abundant; C = Common; U = Uncommon; R = Rare			

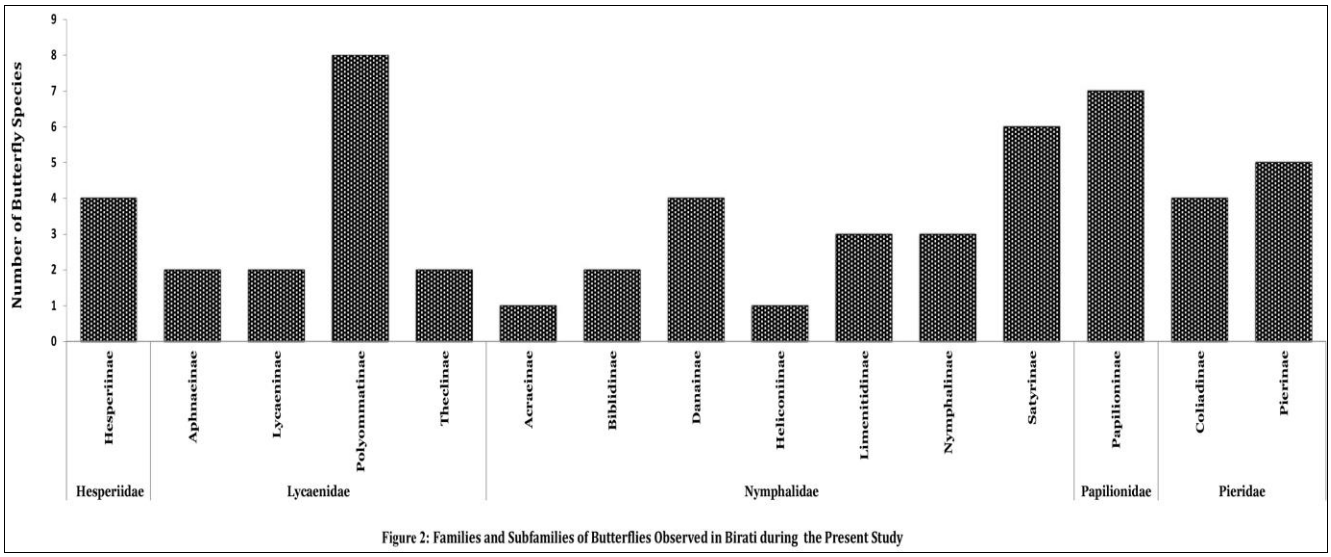

Fig 2: Families and subfamilies of Butterflies Observed in Birati during the Present Study

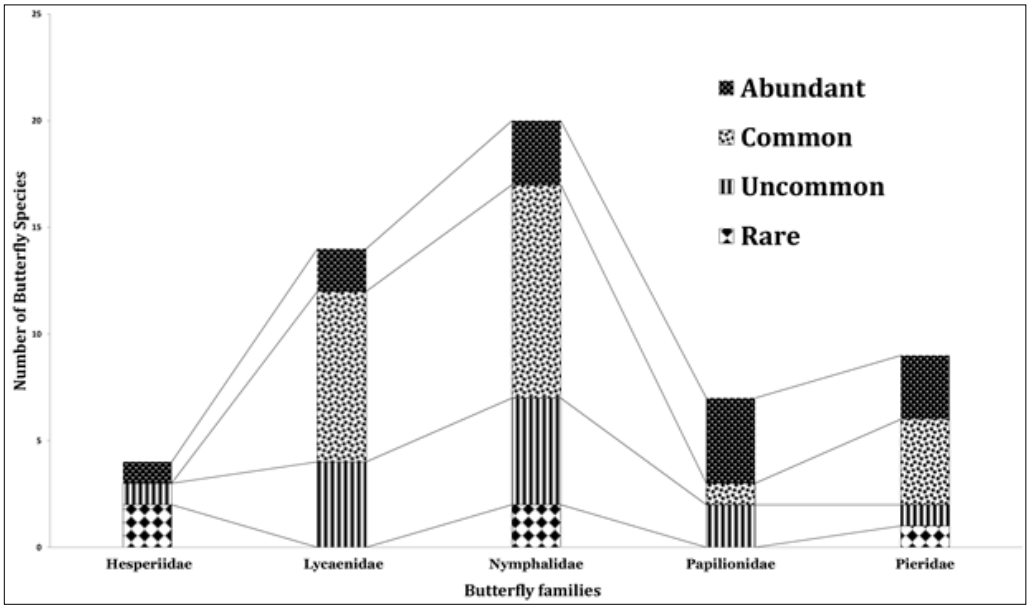

Fig 3: Categorization of species (based on their frequency of sighting) in each butterfly family as recorded in Birati town During the present study

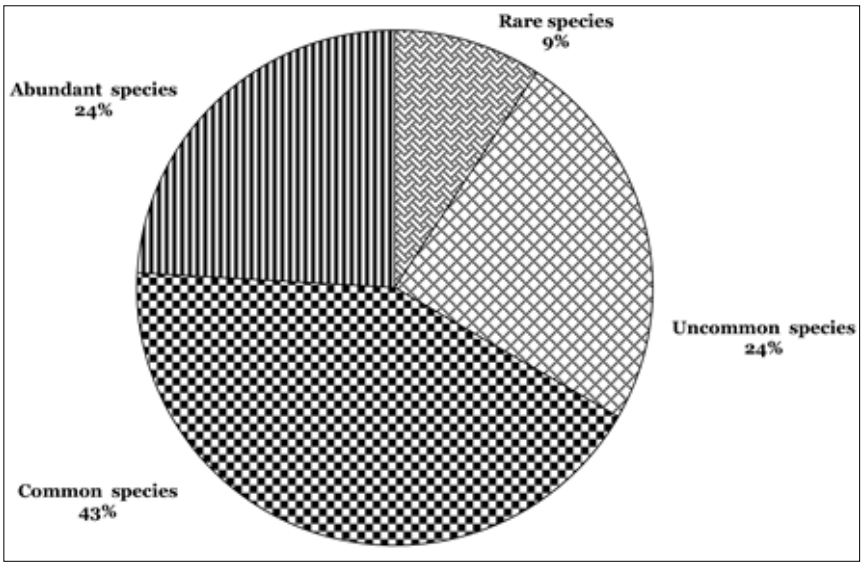

Fig 4: Categorization of butterfly (based on their frequency of sightings) observed Birati town during The present study

In Birati, a significant proportion of the genera (32 out of 54) of butterflies identified in the current investigation were represented by a single species. Furthermore, six other genera of butterflies identified in the town were represented by two species each. Two genera (the genus *Ypthima* and the genus *Junonia* within the Nymphalidae family) of butterflies identified in the town during the present study were represented by three species each, and one genus was found (the genus *Papilio* within the Papilionidae family) to be represented by four species [Table 1]. The findings of the present study indicate a notably low species-to-genus ratio (S/G = 1.31) in the butterfly community of Birati town.

Examinations of data regarding seasonal fluctuations in butterfly populations revealed high abundance during summer and autumn, experiencing a notable decline in the winter and monsoon seasons. These variations may be attributed to the changes in temperature and humidity in the study areas.

Based on the results obtained from the present study, it can be inferred that the Nymphalidae family exhibits the highest abundance among the five families of butterflies observed in Birati town. Additionally, the diversity and prevalence of butterflies belonging to the Lycaenidae family are also notably higher in the study areas compared to those of Pieridae, Papilionidae, and Hesperiidae families [Figure 3]. Based on the observed data, Nymphalidae seems to be the most adept butterfly family among the five families recorded in the town, showcasing the superior acclimatization skills of its members to diverse environmental conditions and microhabitats across the suburban landscape.

Among the study sites, Abhay Ashram has emerged as a hotspot for butterfly sightings, with a notable number of butterfly species documented here compared to other study sites. The higher number of butterfly sightings at Abhay Ashram may be attributed to the presence of a variety of host and nectar plants that serve as a thriving environment for different species of butterflies. This observation also emphasizes the importance of green spaces in supporting and sustaining biodiversity in urban environments. Despite

being situated at the heart of a densely populated suburban town, Abhay Ashram harbors a noteworthy collection of flora and fauna and underscores the potential of such urban green spaces with high species richness in delivering multiple ecosystem services [26, 27].

The present study offers the first comprehensive insights into the variety and abundance of butterfly fauna in Birati town, where, until now, no published study has been available. The findings suggest that despite being situated in a densely populated urban region, the town boasts a flourishing butterfly diversity, thanks in part to small green pockets like Abhay Ashram which serve as a haven for a diverse assemblage of flora and fauna, thriving amidst the bustling town.

This study not only uncovers the existing diversity and abundance of butterfly species in Birati Town in the North 24 Parganas district of West Bengal but also lays the foundation for further exploration into the biodiversity of the town. The town's diverse vegetation and habitats hold the potential to support and sustain biodiversity, demanding sincere attention from authorities to ensure effective monitoring and conservation efforts. These endeavors are crucial to protect the flora and fauna of the town, recognizing their significance for ecosystem services and overall environmental health.

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