Article

Butterfly diversity in an urban area illustrates the significance of green spaces in urban biodiversity conservation

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Abstract
Rapid urbanisation and population growth are a threat to butterflies found in urban habitats. In this study, we look at the diversity and abundance of butterflies in a small urban green space, our college campus which is surrounded by urban sprawl in Nagpur City. Species diversity, species richness and Simpson diversity index were used to analyse the composition of the butterfly community. Overall, 2775 individuals, 38 species, and 5 families were recorded. The dominant family at the study site is Nymphalidae, followed by Lycaenidae, Pieridae, Papilionidae and Hesperiidae. Our study reveals that the small urban green space, that is, our study area is supporting about 26 percent of the butterfly species found in Nagpur. It demonstrates that urban green spaces are essential for the conservation of urban butterfly fauna.

Keywords Lepidoptera; Rhopalocera; species composition; urban biodiversity; urbanisation.

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1 Introduction

One of the most important markers of ecosystem health is the presence of insects, which are essential to how ecosystems work (Springett, 1978). Butterflies are among the most common pollinators and biological indicators and are members of the Rhopalocera suborder of order Lepidoptera (Durairaj and Sinha, 2015). The lives of butterflies are intertwined with those of plants due to their coevolution (Johnson and Anderson, 2010). Butterflies can be used to develop conservation plans as they are effective indicators of climatic conditions, and seasonal, and ecological changes. Biodiversity is negatively impacted by urbanisation. Urban areas will continue to grow (United Nations, 2018). The butterfly is one of the organisms threatened by urbanisation (Wepprich et al., 2019).

Butterflies are generally nectar-feeding phytophagous insects. Their primary job of feeding is carried out via their suctorial proboscis, and as a result, they frequently aid in pollination (Bluthgen and Klein, 2011; Bauder et al., 2013). Although different butterfly species use flowering plants differently, they commonly are opportunistic generalists (Courtney, 1986). According to various studies (Pohl et al., 2011; Tiedge and Lohaus, 2017), different factors such as flower colour, flower structure, flower shape and size, nectar quality and quantity affect butterflies' floral preferences. Furthermore, feeding habits are also influenced by the compatibility of floral form, i.e., corolla length and the anatomy of a butterfly’s proboscis (Bergerot et al., 2010).

Although it is well established that insects are essential to the health of ecosystems, the biodiversity of insects is under threat on a global scale. Lepidopteran populations have experienced a sharp fall, which could cause the extinction of 40 percent of species during the next several decades (Sánchez-Bayo and Wyckhuys, 2019).

Urban green spaces such as parks, home and institutional gardens, edible gardens, rooftop gardens, urban forests, peri-urban farms and even roadside vegetation can have a major role in sustaining urban biodiversity including butterflies. Urban green spaces can be a comprehensive tool for the long term protection of environmental sustainability (Shah, 2011). In this context, we have conducted this study to determine the impact of an urban green space on butterfly diversity.

2 Materials and Methods

2.1 Study area

The study was conducted at S. M. Mohota College of Science (SMMCS) campus (Map 1) located in Nagpur City. Nagpur (*C.* 21.1498°N 79.0806°E) is a fast growing city in Central India having a population of 2.5 million. SMMCS campus is spread over approximately 25 acres and is a green space surrounded by urban sprawl. The campus is surrounded by busy roads and a state highway passes just in front of the campus. The climate of Nagpur is tropical wet and dry, with dry conditions dominating most of the year. In June, it receives about 163 mm of rainfall. In July, there is an increase in rainfall to 294 mm. A gradual decrease in rainfall has been observed from July to August (278 mm) and September (160 mm). Summers are extremely hot, lasting from March to June, with May being the hottest month. Winter lasts from November to February, during which temperature drops to 10°C (Nandankaret et al., 2011).

Map 1 Study site, SMMCS campus, Nagpur (Courtesy Google Maps).

2.2 Plant diversity in the study area

The SMMCS campus is lush green with various types of vegetation such as ornamental and flowering plants, local grasses, wild plants and shrubs, and tree canopy, which attract a diversity of butterfly species. Some ornamental plants found at the study site include hibiscus, rose, marigold, lantana, brachyscome, crown of thorns, flame of the forest, *Pentas lanceolata*, *Tagetes erecta*, and *Madagascar periwinkle*.

2.3 Butterfly survey and identification

The present study was conducted from July 2021 to November 2022. Butterflies were sampled once a week during late mornings and all encounters were noted. Most of the butterfly species were photographed directly in the field using a digital camera. Butterfly species were identified with the help of the field guide by Kehimkar (2008). To correctly identify the species, different characteristics were observed, such as size, wing colour, wing span and flight period. Whenever identifying species by sight was challenging, butterflies were caught with a sweep net, then released after identification.

2.4 Data analysis

Butterfly species observed in the study area were analysed using the Simpson index of diversity. The Simpson diversity index value for the study area was calculated using an online resource (Young, 2023).

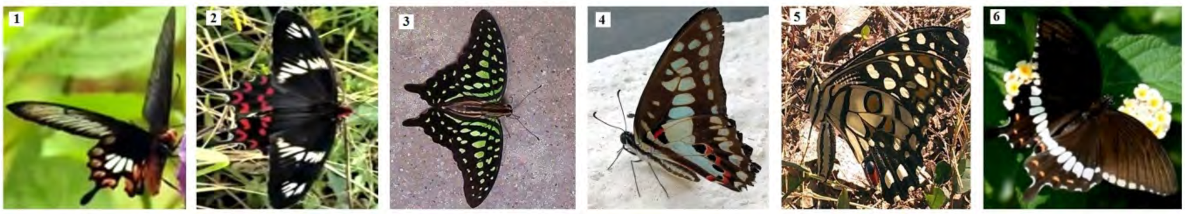
3 Results

The list of butterfly species observed in the study area is provided in Table 1. The study revealed a total of 2775 individuals belonging to 38 species of butterflies in five families (Figs. 1-31). According to the data obtained from the study area, family Nymphalidae had the most butterfly numbers with 1067 (38.45%) individuals recorded, followed by Lycaenidae with 648 (23.35%) individuals, Papilionidae with 470 (16.93%) individuals, Pieridae with 418 (15.06%) individuals, and Hesperiidae with 172 (6.19%) individuals, the lowest number amongst all (Fig. 32). Among the families recorded, Nymphalidae is represented by 16 species, Lycaenidae and Pieridae are represented by seven species each, Papilionidae is represented by six species and Hesperiidae is represented by two species of butterflies. The Simpson index of diversity of butterflies of SMMCS campus calculated as a whole is 0.03042.

Table 1 List of butterflies of SMMCS campus.

S. No.	Common Name	Zoological Name	Number of Specimens Observed
Family Papilionidae (Swallowtails)			
1.	Common Rose	*Pachliopta aristolochiae* (Fabricius, 1775)	52
2.	Crimson Rose	*Pachliopta hector* (Linnaeus, 1758)	25
3.	Tailed Jay	*Graphium agamemnon* (Linnaeus, 1758)	93
4.	Common Jay	*Graphium doson* (C. & R. Felder, 1864)	98
5.	Lime Butterfly	*Papilio demoleus* Linnaeus, 1758	132
6.	Common Mormon	*Papilio polytes* Linnaeus, 1758	70
Family Pieridae (Whites and Yellows)			
7.	Common Emigrant	*Catopsilia pomona* Fabricius, 1775	82
8.	Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus, 1758)	28
9.	Common Gull	*Cepora nerissa* (Fabricius, 1775)	86
10.	Small Grass Yellow	*Eurema brigitta* (Cramer, 1780)	52
11.	Common Grass Yellow	*Eurema hecabe* (Linnaeus, 1758)	56

12.	Spotless Grass Yellow	*Eurema laeta* Boisduval, 1836	61
13.	Common Wanderer	*Pareronia valeria* (Cramer, 1776)	53
Family Nymphalidae (Brush-footed Butterflies)			
14.	Tawny Coster	*Acraea terpsicore* (Linnaeus, 1758)	72
15.	Common Castor	*Ariadne merione* (Cramer, 1777)	77
16.	Plain Tiger	*Danaus chrysippus* (Linnaeus, 1758)	86
17.	Striped Tiger	*Danaus genutia* (Cramer, 1779)	21
18.	Common Crow	*Euploea core* (Cramer, 1780)	83
19.	Common Baron	*Euthalia aconthea* (Hewitson, 1874)	45
20.	Great Eggfly	*Hypolimnas bolina* (Linnaeus, 1758)	82
21.	Danaid Eggfly	*Hypolimnas misippus* (Linnaeus, 1764)	92
22.	Peacock Pansy	*Junonia almana* (Linnaeus, 1758)	32
23.	Yellow Pansy	*Junonia hierta* (Fabricius, 1798)	30
24.	Lemon Pansy	*Junonia lemonias* (Linnaeus, 1758)	110
25.	Blue Pansy	*Junonia orithya* (Linnaeus, 1758)	27
26.	Common Evening Brown	*Melanitis leda* (Linnaeus, 1758)	110
27.	Common Sailor	*Neptis hylas* (Linnaeus, 1758)	22
28.	Common Leopard	*Phalanta phalantha* (Drury, 1773)	89
29.	Blue Tiger	*Tirumala limniace* (Cramer, 1775)	89
Family Lycaenidae (Blues)			
30.	Common Pierrot	*Castalius rosimon* (Fabricius, 1775)	89
31.	Forget-Me-Not	*Catochrysops strabo* Fabricius, 1793	154
32.	Common Cerulean	*Jamides celeno* (Cramer, 1775)	91
34.	Zebra Blue	*Leptotes plinius* (Fabricius, 1793)	71
34.	Red Pierrot	*Talicada nyseus* (Guerin, 1843)	79
35.	Lesser Grass Blue	*Zizina otis* (Fabricius, 1787)	87
36.	Tiny Grass Blue	*Zizula hylax* (Fabricius, 1775)	77
Family Hesperiidae (Skippers)			
37.	Common Banded Awl	*Hasora chromus* (Cramer, 1782)	84
38.	Small Branded Swift	*Pelopidas mathias* (Fabricius, 1798)	88



Figs. 1-6 Family Papilionidae. (1) *Pachliopta aristolochiae* (2) *Pachliopta hector* (3) *Graphium agamemnon* (4) *Graphium doson* (5) *Papilio demoleus* (6) *Papilio polytes*

Figs. 7-11 Family Pieridae. (7) *Catopsilia pomona* (8) *Catopsilia pyranthe* (9) *Cepora nerissa* (10) *Eurema brigitta* (11) *Pareronia valeria*

Figs. 12-26 Family Nymphalidae. (12) *Acraea terpsicore* (13) *Danaus chrysippus* (14) *Danaus genutia* (15) *Euploea core* (16) *Euthalia aconthea* (17) *Hypolimnas bolina* (18) *Hypolimnas misippus* (19) *Junonia almana* (20) *Junonia hierta* (21) *Junonia lemonias* (22) *Junonia orithya* (23) *Melanitis leda* (24) *Neptis hylas* (25) *Phalanta phalantha* (26) *Tirumala limniace*

Figs. 27-31 Families Lycaenidae and Hesperiidae. (27) *Castalius rosimon* (28) *Leptotes plinius* (29) *Talicada nyseus* (30) *Zizina otis* (31) *Pelopidas mathias*

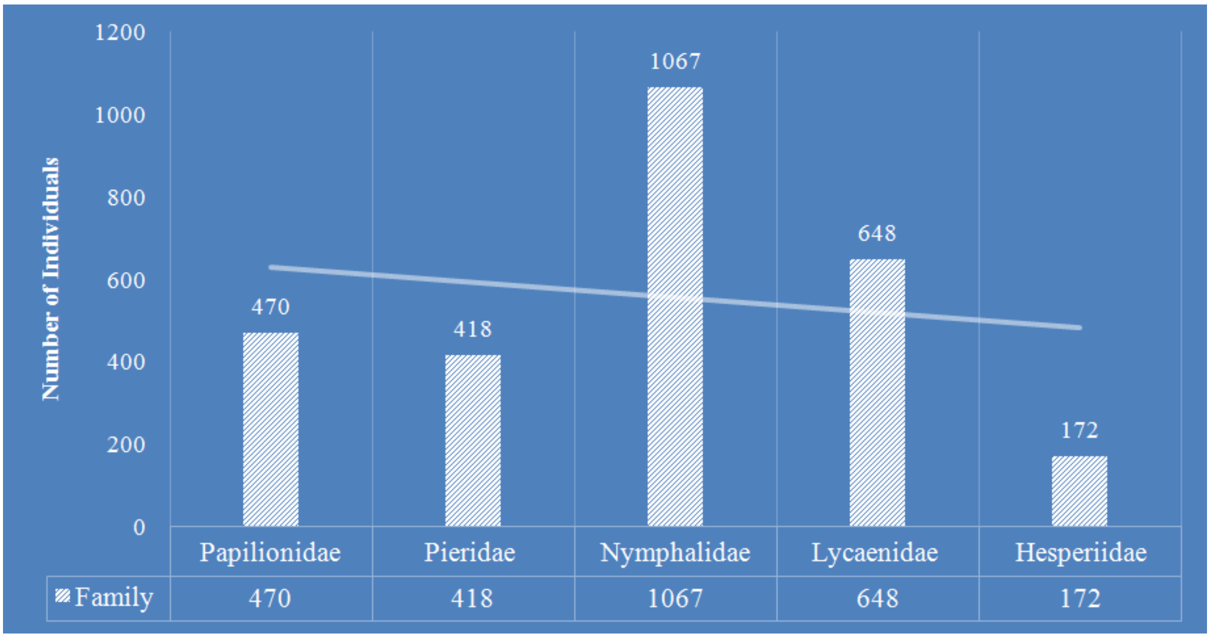


Fig. 32 Number of individuals of each family observed in the study area.

4 Discussion

In our study, family Nymphalidae was found to be having the highest level of diversity, followed by Lycaenidae, Pieridae, Papilionidae and Hesperiidae. The highest species richness was also found among the Nymphalidae. There might be various explanations for this. One explanation is that generalist herbivores have greater resource availability (Bernays and Minkenberg, 1997). The majority of nymphalids are generalist in nature, which facilitates their utilisation of a variety of plant resources. Another explanation would be that a lot of the species in this family have powerful, active wings, which likely aid them in covering large areas when looking for supplies (Eswaran and Pramod, 2005; Padhye et al., 2006).

The Simpson index of diversity of butterflies of SMMCS campus calculated is 0.03042. The value indicates a habitat with limited potential niches and dominance of a modest number of different species. Notwithstanding the small value of the Simpson index of diversity for the study area, the 38 butterfly species recorded in this study, make approximately 26 percent of the butterfly fauna (145 species) recorded from Nagpur by Tiple and Khurad (2009). So, despite having a small area of 25 acres, SMMCS campus is still supporting about 26 percent of the butterfly species found in Nagpur. This clearly demonstrates the importance of this small urban green space in the conservation of butterflies.

Urbanisation has an important impact on biodiversity, mostly driving changes in species assemblages through the replacement of specialist with generalist species, thereby leading to biotic homogenisation, while mobility is also assumed to greatly affect species’ ability to cope in urban environments (Concepción et al., 2015). Urbanisation is threatening to biodiversity as it invariably leads to loss and degradation of native habitats (Braby et al., 2021). Rapid urban expansion has profound impacts on global biodiversity through habitat conversion, degradation, fragmentation and species extinction, and hence, there is an urgent need to develop a sustainable urban development pathway to balance urban expansion and biodiversity conservation (Li et al., 2022).

Lepidoptera play a crucial role in the food chain that connects autotrophs and heterotrophs, making the conservation of butterfly fauna essential. Butterflies are also widely accepted biological markers, responsive to environmental and climate changes, and quick to react to vegetation stratification in terms of temperature, weather, sunlight, and dampness (Dar and Jamal, 2021). The conservation of urban butterflies and their host plants, and the plants that rely on butterflies for pollination would be greatly benefitted by research on the interactions between butterflies and their host plants in urban areas. Such knowledge is essential for creating successful conservation projects. Since plant and insect community compositions are highly correlated (Zhang, 2011; Zhang et al., 2016), protecting and cultivating host plant species can help to improve the diversity of butterflies with their relevant natural ecosystem (Mukherjee et al., 2019). Our study area has a variety of trees, some native wild plant species, and ornamental blooming plants. Our observations lead us to the conclusion that vegetation type had a significant effect on the richness and density trends of butterfly community in a small urban green space like SMMCS campus.

According to a study, urban green spaces in Dhaka, Bangladesh harbour nearly half of that country's butterfly diversity (Chowdhury et al., 2021). As many as 104 butterfly species have been recorded from Ambazari Garden and Lake, Nagpur (Tiple and Khurad, 2010). A total of 92 butterfly species have been reported from Gorewada International Bio-Park, Nagpur (Patil and Shende, 2014). These previous studies on butterfly diversity of urban areas further reiterate that green spaces are essential for sustaining urban butterfly fauna. Hence, it is necessary to properly manage and increase urban green spaces for the conservation of butterfly diversity. It is also obligatory to enhance the diversity of host plants, especially local plant species, as not all butterflies are generalists and some butterfly species require specific host plants. Butterfly gardens can also be created in urban areas for the conservation of butterfly diversity, as well as for research, education and recreation.

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