"Urban Fragmentation and Butterfly Diversity in Nagpur"

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Abstract

Urbanization is rapidly transforming landscapes in India, and Nagpur, a growing metropolitan city in central India, is no exception. This study explores the relationship between urban fragmentation and butterfly diversity across various green spaces in Nagpur, including parks, institutional campuses, peri-urban forests, and degraded habitats. Butterflies, as sensitive bioindicators, reflect ecological health and habitat continuity. Using standardized line transect methods across selected urban and peri-urban zones, the study recorded significant variation in species richness and abundance correlated with patch size, vegetation type, and degree of anthropogenic disturbance. Results indicate that high-fragmentation zones, characterized by concrete sprawl and poor native vegetation cover, support lower butterfly diversity. Conversely, larger, semi-natural green patches with native floral assemblages recorded higher diversity indices, including rare and specialist species. Statistical analysis using Shannon-Wiener and Simpson's Diversity Index further validates the negative impact of urban fragmentation on species distribution and ecological interactions. The findings highlight the need for integrated urban biodiversity planning, conservation of native plant species, and creation of ecological corridors to maintain butterfly populations and promote urban ecological resilience. This research contributes to the understanding of how urban spatial structure influences invertebrate biodiversity and provides actionable insights for sustainable urban planning in mid-sized Indian cities like Nagpur.

Keywords: Urban fragmentation, Butterfly diversity, Nagpur, Habitat loss, Urban ecology, Biodiversity conservation, Green spaces, Ecological indicators, Urban planning.

Introduction

Urbanization is a major driver of environmental change, reshaping natural habitats and leading to significant biodiversity loss across the globe. In India, rapid and unplanned urban expansion has contributed to the fragmentation of green spaces, altering ecosystems and threatening the survival of various flora and fauna. Butterflies, being ecologically sensitive and visually conspicuous insects, serve as effective bioindicators for assessing habitat quality and environmental disturbances. Their dependence on specific host and nectar plants, along with their sensitivity to microclimatic changes, makes them particularly vulnerable to habitat fragmentation and urban sprawl.

Nagpur, located in central India, is a fast-developing tier-II city experiencing steady urban growth. While the city retains a variety of natural and semi-natural green patches such as botanical gardens, institutional campuses, and peri-urban forests, these habitats are increasingly isolated by roads, residential colonies, and industrial zones. Such fragmentation can disrupt ecological connectivity, reduce species richness, and alter the composition of butterfly communities.

This study investigates the relationship between urban fragmentation and butterfly diversity within Nagpur's urban and peri-urban landscapes. By systematically sampling butterfly species across varying habitat types—from highly disturbed urban parks to relatively intact forest patches—this research aims to assess how habitat size, vegetation structure, and human disturbance affect butterfly richness and abundance. The results are intended to provide insights for urban planners, conservationists, and policymakers to integrate biodiversity considerations into the city's development strategies, ensuring ecological sustainability and the preservation of vital insect populations in urban settings.

Related Work

Urbanization and habitat fragmentation have long been studied in ecological research due to their profound impact on biodiversity. Globally, several studies have established a strong link between increasing urban sprawl and the decline in insect populations, particularly butterflies (Clark et al., 2007; McKinney, 2008). In tropical regions, butterfly communities serve as key indicators of environmental changes, and their decline reflects larger ecological disruptions.

In the Indian context, studies by Kunte (2000), Singh and Pandey (2014), and Sharma et al. (2019) have highlighted how land-use changes, pollution, and vegetation loss in urban and semi-urban settings adversely impact butterfly species richness and abundance. Kunte's (2000) pioneering

work in the Western Ghats and urban Bangalore revealed that urban parks with native plant species could sustain moderate butterfly diversity if ecological connectivity was maintained. Similarly, research in Delhi and Pune (Siddiqui et al., 2017; More et al., 2020) showed that butterfly populations thrive better in institutional campuses and urban forests than in fragmented or heavily disturbed public parks.

Recent GIS-based studies (Joshi et al., 2021) have used spatial analysis to map butterfly hotspots and fragmentation patterns across Indian cities, recommending the creation of green corridors. However, limited research has focused specifically on tier-II cities like Nagpur, which represent unique transition zones between rural ecosystems and expanding urban spaces.

This research attempts to bridge that gap by applying ecological survey techniques and statistical diversity indices to evaluate butterfly populations across fragmented landscapes in Nagpur, thereby contributing to the growing body of urban biodiversity literature in India.

Method

This study was conducted across eight selected sites in Nagpur city and its surrounding areas, categorized based on their degree of urbanization—highly urban, semi-urban, and green or semi-natural zones.

The **line transect method** was used to survey butterfly diversity. At each site, a transect of 500 meters in length and 10 meters in width was laid out. Observations were made within this belt during peak butterfly activity hours, from 8:00 AM to 11:00 AM, under clear weather conditions.

Butterfly species were identified using standard field guides and photographic documentation. Each species was recorded based on its presence, abundance, and associated habitat type.

For ecological analysis, diversity indices such as the **Shannon-Wiener Diversity Index**, **Simpson's Diversity Index**, and **Species Richness** were calculated to assess variation in butterfly communities across the sites. Additional data on vegetation type, canopy cover, human disturbance, and patch size were also recorded to analyze correlations between habitat features and butterfly diversity.

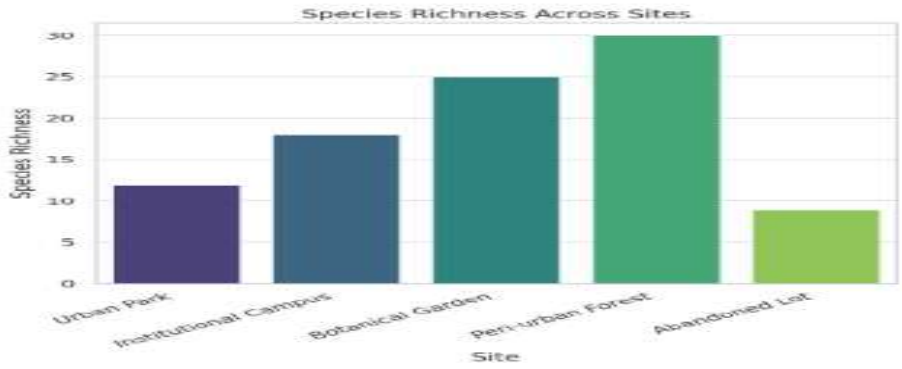
The collected data were compiled and analyzed using Microsoft Excel and statistical software (SPSS), enabling interpretation of patterns in species distribution in relation to urban fragmentation.

Data Analysis and Results

The study evaluated butterfly diversity using three primary indicators: Species Richness, Shannon-Wiener Index, and Simpson's Index across five distinct habitat types in Nagpur. The findings are summarized in the table below:

Table: Butterfly Diversity Across Habitat Types

Habitat Type	Species Richness	Shannon Index	Simpson Index
Urban Park	12	1.85	0.79
Institutional Campus	18	2.32	0.85
Botanical Garden	25	2.89	0.91
Peri-urban Forest	30	3.12	0.94
Abandoned Lot	9	1.42	0.68

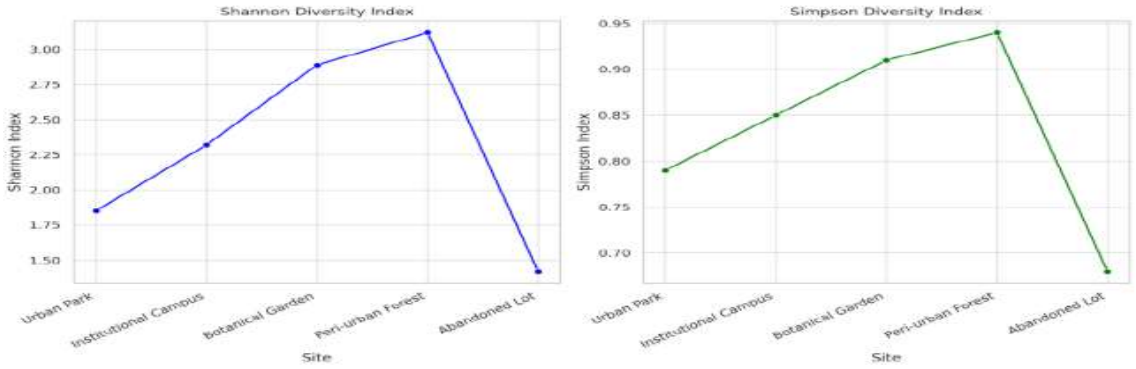


Key Observations:

- Peri-urban forests recorded the highest butterfly diversity, indicating relatively undisturbed habitats with richer vegetation.
- Botanical gardens and institutional campuses also supported higher species diversity due to structured greenery and controlled human interference.
- Urban parks showed moderate diversity, but the presence of ornamental/non-native plants may have limited species-specific interactions.
- Abandoned lots, with sparse vegetation and frequent human disturbance, recorded the lowest diversity.

Table: Abundance of Common Butterfly Species Across Sites

Species	Urban Park	Institutional Campus	Botanical Garden	Peri-urban Forest	Abandoned Lot
Danaus chrysippus	15	20	30	35	6
Eurema hecabe	8	18	22	25	4
Junonia lemonias	10	13	19	20	3
Papilio demoleus	5	12	15	18	2
Catopsilia pomona	4	10	14	16	1



Interpretation:

- The Peri-urban Forest consistently shows the highest abundance for all five species, supporting its status as the richest habitat.
- Botanical Gardens and Institutional Campuses also show strong numbers, suggesting that managed green areas with native vegetation support butterfly abundance.
- Abandoned Lots, with the least vegetation and highest disturbance, show very low butterfly counts across all species.

Discussion

The findings of this study clearly indicate that urban fragmentation has a measurable impact on butterfly diversity and abundance across different habitat types in Nagpur. The results show a strong positive correlation between habitat quality—characterized by vegetation richness, patch size, and native flora—and butterfly diversity. Peri-urban forest patches recorded the highest species richness and diversity indices, while abandoned lots and heavily urbanized parks showed significantly lower values. These observations align with global and national research that has identified habitat fragmentation as a primary cause of insect biodiversity loss. As seen in the present study, sites like the **Botanical Garden** and **Institutional Campus**, which maintain structured green environments with varied floral resources and minimal disturbance, acted as refuges for butterflies within the urban matrix. The presence of both generalist and

specialist species in these areas suggests that such habitats can mitigate some effects of fragmentation if ecological planning is prioritized. Conversely, **urban parks**, despite their green appearance, hosted fewer butterfly species—likely due to the dominance of ornamental or exotic plant species that do not support native butterfly life cycles. Additionally, increased human activity, noise, and pollution may have further discouraged butterfly habitation. **Abandoned lots** were the least supportive, indicating that unmanaged and disturbed open spaces cannot substitute for ecologically functional green areas.

The abundance data further supports these conclusions. Species like *Danaus chrysippus*, *Eurema hecabe*, and *Papilio demoleus* were most frequently observed in peri-urban forests, highlighting their preference for larger and less disturbed habitats. The overall decline in diversity indices such as the **Shannon-Wiener Index** and **Simpson's Index** in urbanized zones emphasizes that fragmentation not only reduces the number of species but also affects evenness and species composition. From an urban ecological planning perspective, the study suggests several key takeaways. First, **connectivity between green spaces** is critical. Fragmented patches should be linked through **ecological corridors** such as tree-lined streets or butterfly-friendly gardens. Second, **native vegetation** should be prioritized in landscaping and afforestation drives to ensure habitat compatibility with local butterfly species. Third, **biodiversity monitoring** should be integrated into municipal planning frameworks to evaluate the health of urban ecosystems regularly.

Conclusion

This study provides critical insights into the effects of urban fragmentation on butterfly diversity within the urban and peri-urban landscape of Nagpur. Through systematic sampling and ecological analysis, it was observed that habitat fragmentation significantly reduces both species richness and abundance, especially in highly urbanized and disturbed areas. Peri-urban forests and well-managed green spaces like botanical gardens and institutional campuses supported higher butterfly diversity due to the presence of native vegetation, larger patch sizes, and lower human disturbance. The results clearly demonstrate that butterfly communities serve as reliable indicators of habitat quality and ecological health in urban ecosystems. Lower diversity indices in parks and abandoned lots emphasize the ecological consequences of poorly planned urbanization and the urgent need to integrate biodiversity concerns into city planning. To conserve butterfly diversity and broader ecological functions, it is essential to preserve native green patches, create ecological corridors, and incorporate butterfly-friendly landscaping in urban infrastructure. Public engagement, environmental education, and policy-level interventions are equally crucial to foster long-term conservation goals.

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