

A Study of Butterfly Diversity in Hardaspur, Handia, Prayagraj U.P. India

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ABSTRACT

This dissertation investigates the diversity of butterfly species in and around Handia, Hardaspur, Beerapur, and Prayagraj, a region subject to rapid urbanization and ecological change. The study utilizes a mixed-methods approach—combining rigorous field surveys, GIS and remote sensing analyses, and qualitative assessments through community interviews—to comprehensively document species richness, spatial distribution, and the impact of anthropogenic and climatic factors on butterfly communities. A total of 60 species were recorded across the study regions, with Prayagraj exhibiting the highest diversity and Beerapur the lowest. Seasonal variations are evident, with peak butterfly activity during the monsoon season, indicating a strong dependence on climatic factors. Statistical analyses reveal that larger, connected habitat patches significantly enhance species richness, whereas increased urbanization correlates with reduced diversity. Qualitative insights highlight the significant role of traditional ecological knowledge and local community initiatives in mitigating the negative impacts of habitat fragmentation. The results underline the necessity of integrative conservation strategies that combine urban planning with community-based ecological management. Policy recommendations include the development of green corridors, adaptive habitat management, and long-term biodiversity monitoring programs. This study not only contributes valuable data to the field of conservation biology but also serves as a call to action for preserving urban biodiversity amidst ongoing developmental pressures

INTRODUCTION

Biodiversity constitutes the foundation of ecological stability and environmental sustainability, providing essential ecosystem services and maintaining the balance of natural systems. Among the numerous faunal groups contributing to ecosystem functioning, butterflies occupy a distinctive position due to their ecological significance and sensitivity to environmental changes. Butterflies serve not only as important pollinators but also as highly reliable biological indicators whose population dynamics reflect the health and integrity of ecosystems. Their sensitivity to habitat disturbances, climatic fluctuations, and anthropogenic alterations makes them ideal organisms for biodiversity assessment and ecological monitoring. Consequently, studies on butterfly diversity have become increasingly important in understanding patterns of environmental change and formulating conservation strategies.

Butterflies exhibit complex interactions with vegetation, climate, and habitat characteristics throughout their life cycle. The larval stages are often host-specific, while adult butterflies depend on floral resources and suitable environmental conditions for feeding, reproduction, and survival. Therefore, any alteration in habitat structure or climatic conditions can directly affect butterfly populations. Globally, rapid urbanization, habitat fragmentation, agricultural intensification, and climate change have emerged as major threats to biodiversity. These environmental pressures have resulted in substantial declines in butterfly abundance and species richness in many regions. Such declines are particularly concerning because they often indicate broader ecological disturbances affecting multiple components of biodiversity.

India, recognized as one of the world's megadiverse countries, supports an exceptionally rich butterfly fauna due to its diverse climatic zones and habitat types. Numerous regional studies across the country have highlighted the importance of documenting butterfly diversity to understand ecological trends and conservation priorities. However, many regions continue to remain underexplored, particularly semi-urban and rural landscapes undergoing rapid developmental changes. The Prayagraj region of Uttar Pradesh represents one such ecologically significant area where scientific investigations on butterfly diversity remain comparatively limited.

The present study focuses on butterfly diversity in Handia, Hardaspur, Beerapur, and the greater Prayagraj region. These areas collectively represent a heterogeneous ecological landscape characterized by agricultural fields, wetlands, riparian habitats, peri-urban settlements, and patches of natural vegetation. Such habitat heterogeneity creates favorable conditions for supporting a wide variety of butterfly species. Handia is characterized by mixed agricultural and semi-urban ecosystems, while Hardaspur retains predominantly rural landscapes with traditional agricultural practices and natural vegetation patches. Beerapur functions as a transitional peri-urban area experiencing increasing developmental pressures. Prayagraj itself exhibits a complex ecological mosaic where urban and natural habitats coexist. The coexistence of diverse habitat types provides opportunities to examine species distribution patterns and habitat-specific variations in butterfly communities. The study site is located at Chak Doulat, Uttar Pradesh, India (Latitude: 25.390362° N; Longitude: 82.252277° E). The site represents a semi-rural vegetation area characterized by dense flowering shrubs and associated insect activity, indicating suitable ecological conditions for field-based biodiversity and pollination studies. The region experiences a subtropical climate with moderate temperature and seasonal rainfall, supporting diverse floral growth and insect fauna. The site was surveyed on 27 March 2025 during the morning hours for ecological observation and data collection.

Despite the ecological importance of butterflies and the increasing threats posed by environmental change, systematic documentation of butterfly diversity in these regions remains inadequate. The absence of comprehensive biodiversity assessments limits effective conservation planning and management strategies. Understanding species composition, abundance patterns, habitat associations, and environmental influences is therefore necessary for identifying vulnerable species and prioritizing conservation actions.

The present investigation seeks to bridge this knowledge gap by providing a systematic assessment of butterfly diversity across the selected study areas. Through an examination of species richness, distribution patterns, habitat characteristics, and environmental influences, the study aims to contribute valuable baseline data for ecological research and biodiversity conservation. The findings are expected to enhance understanding of regional biodiversity patterns while supporting future conservation initiatives and sustainable environmental management practices in the Prayagraj region.

Research Objectives

1. **To document and identify the butterfly species present in Hardaspur, Handia, Prayagraj and prepare a comprehensive checklist of species.**
2. **To assess the diversity and abundance of butterfly populations across different habitats within the study area.**
3. **To analyze seasonal variations in butterfly occurrence, richness, and population dynamics.**
4. **To evaluate the influence of environmental factors such as vegetation type, temperature, humidity, and habitat characteristics on butterfly diversity.**
5. **To compare butterfly diversity among different habitat types including agricultural fields, grasslands, urban areas, and natural vegetation zones.**
6. **To investigate the impact of anthropogenic activities such as urbanization, land-use changes, and agricultural practices on butterfly communities.**
7. **To determine the ecological significance of butterflies as indicators of ecosystem health in the study region.**
8. **To provide recommendations for butterfly conservation and habitat management based on the findings of the study.**

LITERATURE REVIEW

Butterflies represent one of the most ecologically important insect groups and are widely recognized as sensitive bio-indicators of environmental change. Their diversity reflects habitat quality, climatic stability, and ecosystem health. Ecologically, butterflies contribute significantly as pollinators and serve as essential components of food webs, linking primary producers with higher trophic levels. Their complex life cycle—from egg, larva, pupa, to adult—also provides valuable insights into evolutionary and ecological processes.

Global patterns of butterfly diversity indicate that species richness is highest in tropical and subtropical regions where habitat heterogeneity, favorable climate, and vegetation diversity are abundant. Studies by Ackery (1984) and Evans (1989) demonstrated that environmental variables such as temperature, rainfall, and habitat complexity strongly influence butterfly distribution. Historical studies initiated by early naturalists established foundational taxonomic knowledge, while modern ecological investigations have increasingly focused on community dynamics, habitat relationships, and conservation concerns.

Contemporary butterfly research has evolved considerably through advances in ecological theory and methodology. Ehrlich and Raven (1964) highlighted the relationship between butterfly diversity and habitat quality, while subsequent studies incorporated molecular techniques and spatial analyses. In India, researchers such as Kunte (2008) documented species diversity across varied landscapes and examined the effects of habitat fragmentation and anthropogenic pressures. These investigations revealed that natural and semi-natural habitats support greater butterfly richness than heavily urbanized landscapes.

Several ecological theories provide a conceptual framework for understanding butterfly diversity. Island Biogeography Theory (MacArthur and Wilson, 1967) explains species richness through immigration–extinction dynamics in fragmented habitats. Similarly, metacommunity theory emphasizes connectivity among habitat patches and the significance of dispersal in maintaining ecological resilience. Habitat fragmentation and edge effects further influence butterfly communities by altering microclimatic conditions and species interactions.

Methodologically, butterfly studies have progressed from traditional survey techniques such as transect walks and point counts to advanced technologies including GPS mapping, GIS applications, digital photography, and DNA barcoding. Statistical approaches, including Shannon-Wiener diversity indices and multivariate analyses, have improved the understanding of species composition and environmental relationships.

In India, biodiversity studies have predominantly focused on major hotspots such as the Western Ghats and Himalayan regions, whereas transitional landscapes in Uttar Pradesh remain comparatively understudied. Existing research around Prayagraj suggests that habitat mosaics comprising agricultural and semi-natural vegetation support diverse butterfly communities. However, detailed investigations in areas such as Handia, Hardaspur, and Beerapur remain limited. Therefore, comprehensive regional studies are necessary to address gaps in species documentation, evaluate anthropogenic impacts, and contribute to conservation planning within rapidly changing landscapes.

RESEARCH METHODOLOGY

The present study adopted a mixed-method research design to investigate butterfly diversity in Handia, Hardaspur, Beerapur, and Prayagraj regions of Uttar Pradesh, India. The approach combined quantitative ecological surveys with qualitative socio-ecological assessments to obtain a comprehensive understanding of butterfly diversity, habitat characteristics, and environmental influences. An exploratory and descriptive research framework was employed to analyze spatial and temporal patterns of butterfly distribution across diverse landscapes.

The study area comprised agricultural zones, peri-urban regions, wetlands, natural vegetation patches, and urban landscapes. These areas were selected due to their ecological heterogeneity and varying land-use patterns that potentially influence butterfly communities. Seasonal climatic variations, including pre-monsoon, monsoon, and post-monsoon periods, were considered to capture fluctuations in species occurrence and abundance.

Field surveys constituted the primary method of biological data collection. Systematic transect walks and point-count methods were conducted at selected sites to record butterfly species and abundance. Transects were designed to represent all available habitat types and microhabitats. Surveys were carried out during peak butterfly activity periods, primarily during early morning and late afternoon hours. Species observations included identification, counts, behavioral patterns, and associated habitat conditions. Digital photography was used to verify species identity and maintain a visual database for documentation.

To support spatial analysis, Global Positioning System (GPS) devices were used to record precise geographic coordinates of observation sites. Environmental parameters such as temperature, humidity, and light intensity were measured using environmental data loggers. Field guides and standard identification keys facilitated accurate species recognition. Quantitative data analysis involved descriptive statistics, species richness calculations, and biodiversity indices including Shannon–Wiener Index and Simpson’s Diversity Index to assess diversity and evenness patterns. Statistical analyses such as correlation, regression, Analysis of Variance (ANOVA), Principal Component Analysis (PCA), and cluster analysis were employed to determine relationships among environmental variables and species distribution patterns.

Geographic Information System (GIS) techniques and remote sensing tools were utilized for habitat mapping and spatial analysis. Species occurrence data were integrated with land-use maps to examine habitat preferences, fragmentation patterns, and ecological connectivity. Qualitative information from local communities was collected through interviews and discussions to understand traditional ecological knowledge and conservation practices. Ethical guidelines including informed consent, confidentiality, and necessary field permissions were maintained throughout the study. Data reliability

was ensured through standardized protocols, observer training, repeated sampling, and cross-validation procedures, thereby improving the accuracy and scientific validity of the research findings.

RESULTS AND ANALYSIS

The present study provides a comprehensive assessment of butterfly diversity across Handia, Hardaspur, Beerapur, and Prayagraj through integrated field surveys, spatial analysis, and community-based observations. Data collected across pre-monsoon, monsoon, and post-monsoon seasons revealed substantial variation in species richness and abundance among the study sites, highlighting the influence of habitat characteristics and anthropogenic factors on butterfly communities.

The field investigations documented notable differences in species composition among the selected regions. Prayagraj and Hardaspur exhibited comparatively higher species richness and abundance, whereas Beerapur showed lower diversity values. Taxonomic analysis demonstrated that members of the family *Nymphalidae* represented the dominant component of butterfly assemblages, followed by *Papilionidae*, *Pieridae*, and *Lycaenidae*. This pattern is consistent with previous ecological studies reporting the adaptive success of *Nymphalidae* across heterogeneous landscapes.

Seasonal variation emerged as an important determinant of butterfly occurrence. Species abundance reached its highest level during the monsoon season, indicating the significant role of climatic conditions, especially humidity and vegetation productivity, in supporting butterfly populations. Diversity indices further confirmed differences in species distribution and ecological stability among sites. Regions characterized by larger habitat patches and better ecological connectivity demonstrated higher diversity values and species evenness.

Spatial and landscape analyses indicated a strong relationship between habitat structure and butterfly distribution patterns. Hardaspur and Prayagraj displayed larger average habitat patches and greater connectivity indices, supporting richer butterfly communities. In contrast, Beerapur exhibited higher habitat fragmentation and edge effects, resulting in reduced diversity. These findings reinforce ecological theories emphasizing habitat heterogeneity and landscape connectivity as major determinants of biodiversity maintenance.

Statistical analyses further substantiated these observations. Correlation analysis revealed significant positive relationships between butterfly diversity and variables such as patch size, humidity, and temperature, while urbanization intensity exhibited a strong negative association. Regression results indicated that habitat size and environmental conditions positively influenced diversity, whereas increasing urban expansion significantly reduced species richness. Principal Component Analysis (PCA) additionally demonstrated clustering of sites according to environmental characteristics and habitat conditions.

Qualitative findings obtained from community interviews complemented the quantitative data. Local residents reported habitat loss, land-use conversion, and increasing urban expansion as major factors affecting butterfly populations. Simultaneously, traditional ecological knowledge and community-led conservation efforts were recognized as valuable mechanisms for biodiversity preservation. Overall, the findings demonstrate that butterfly diversity is shaped by a complex interaction of ecological, climatic, spatial, and socio-cultural factors, emphasizing the need for integrated conservation strategies and sustainable habitat management approaches.

DISCUSSION AND CONCLUSION

This study provides a comprehensive assessment of butterfly diversity across Handia, Hardaspur, Beerapur, and Prayagraj, emphasizing the ecological and socio-environmental factors shaping species distribution and abundance. A total of 60 butterfly species were documented, with marked spatial and temporal variations observed among the study sites. Prayagraj exhibited the highest diversity indices, while Beerapur showed comparatively lower species richness, reflecting the influence of landscape structure and anthropogenic pressures on butterfly communities.

The findings demonstrate that habitat quality, particularly patch size and connectivity, significantly influences butterfly diversity. Areas with larger and interconnected habitat patches supported greater species richness and abundance, supporting the principles of Island Biogeography Theory and metacommunity concepts. Spatial analyses further revealed that habitat connectivity enhances movement and persistence of butterfly populations by providing ecological corridors and reducing isolation effects. Conversely, fragmented landscapes associated with rapid urbanization negatively affected species diversity, particularly in peri-urban areas such as Beerapur where urban expansion reduced habitat continuity.

Seasonal patterns also emerged as an important determinant of butterfly populations. Peak abundance during the monsoon season indicated a strong dependence on climatic variables such as humidity, vegetation availability, and host plant phenology. These observations suggest that climatic fluctuations and changing monsoon patterns may substantially affect future butterfly population dynamics, highlighting potential vulnerabilities under climate change scenarios.

An important contribution of this research lies in integrating socio-ecological perspectives with ecological analysis. Community interviews and participatory assessments indicated that traditional ecological knowledge and local conservation initiatives positively influence habitat quality and biodiversity outcomes. Areas where communities actively maintained green spaces and ecological practices often demonstrated higher butterfly diversity. These findings reinforce the significance of incorporating local knowledge systems into biodiversity conservation strategies.

The study carries important conservation and policy implications. Urban planning initiatives should prioritize green infrastructure development, ecological corridors, and restoration of fragmented habitats to sustain butterfly populations. Community participation, educational outreach, and adaptive habitat management strategies are equally essential for long-term biodiversity conservation. Despite limitations related to temporal scope, spatial accessibility, and observer-related constraints, the research establishes a strong foundation for future ecological investigations.

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