



Butterflies biodiversity and conservation efforts in Haryana's ecosystem: A review

Mansi Dhiman¹, Dr. Sajad Ahmad Bhat^{2*}, Dr. Priyanka Chaudhary³, Vishesh Kumar⁴, Tashmil Yatro⁵,

¹ Department of Zoology, School of Agriculture and Natural Sciences, CT University, Punjab, India

² Assistant Professor, Department of Zoology, School of Agriculture and Natural Sciences, CT University, Punjab, India

³ Assistant Professor, Department of Zoology, DAV College, Ambala Kurukshetra University, Haryana, India

⁴ Research Scientist, Department of Zoology Postgraduate Institute of Medical Education and Research, Chandigarh India.

⁵ Research Scholar, Department of Zoology, Central University of Kashmir, Jammu and Kashmir, India

Abstract

Background: India harbours an extraordinary diversity of over 1,379 butterfly species, reflecting the country's vast range of ecosystems, from dense forests to arid landscapes. In contrast, the state of Haryana has documented only 42 butterfly species, primarily due to limited survey efforts. Despite this relatively low number, the recorded diversity suggests significant untapped potential. Given their crucial roles as pollinators, ecological indicators, and contributors to ecosystem stability, butterflies warrant focused study and conservation, particularly in underexplored regions like Haryana.

Rational of the study: This review examines the current status of butterfly biodiversity, distribution, and conservation efforts across different landscapes of Haryana, including forests, urban environments, districts, and protected areas. It discusses the ecological importance of butterflies, emphasizing their dual roles as pollinators and bioindicators for assessing habitat quality and environmental sustainability. Analysis of literature from the past two decades reveals critical findings on species richness, distribution patterns, and emerging threats, such as habitat fragmentation, pesticide use, and urbanization. Comparative insights between national and regional conservation trends highlight Haryana's relative deficiencies and the opportunities to strengthen local biodiversity initiatives. The review further identifies significant research gaps that must be addressed to develop a comprehensive understanding of butterfly ecology in the state

Conclusion: The findings highlight an urgent need for expanded research and the development of targeted conservation strategies tailored to Haryana's unique ecological context. Strengthening butterfly conservation efforts will not only protect these vital species but also enhance broader biodiversity conservation and ecosystem resilience. A systematic and region-specific approach will be essential to align Haryana's initiatives with national conservation goals and ensure the long-term sustainability of its natural habitats

Keywords: Butterfly, nymphalidae, papilionidae, pieridae, biodiversity, conservation

Introduction

Butterflies play a vital role as indicators of biodiversity and ecosystem health, as they provide important insights into the overall condition of our environment. Their presence and diversity reflect the health of various ecosystems, bridging ecological, cultural, and aesthetic values. This review focuses on Haryana, a state in northern India notable for its semi-arid climate and significant agricultural activities. Despite its agricultural dominance, Haryana is home to various ecosystems supporting numerous species, including butterflies. By exploring the butterfly population in this region, we can gain a deeper understanding of the ecological dynamics at play, while also appreciating the cultural and aesthetic contributions these beautiful insects make to the landscape. Through this analysis, we aim to highlight the importance of conserving butterfly habitats and the biodiversity they represent, which is the importance of conserving butterfly habitats and the biodiversity they represent, which is crucial for maintaining the ecological balance in Haryana.

Life on Earth contributes a unique quality to our planet, with its astonishing diversity making it even more distinctive. Estimates suggest that between 10 million and 15 million species of plants, animals, protists, and fungi exist. However, only around 1.2 million of these species have been officially documented, meaning that roughly 86% of

them are still undescribed (Stocker, 1999; Mora *et al.*, 2011). India accounts for only 2.3 percent of the world's total area but is home to about 7.3 percent of all recorded animal species worldwide (Alfred *et al.*, 1998). Among these, insects play a crucial role in biodiversity and are intricately connected to plant life. The variety of insect populations serves as a vital indicator of forest ecosystem health. Butterflies, which belong to the order Lepidoptera, are among the visually appealing and easily identifiable insects. Their taxonomy is well documented, and substantial information exists regarding their life cycles and biological traits (Nelson and Anderson, 1994).

Butterflies have an impressive ability to adapt to different climatic conditions, making some of the most successful organisms on the planet. Additionally, butterflies serve as important symbols in conservation efforts for insects (New *et al.*, 1995). They garner substantial global attention due to their critical role in assessing environmental quality in terrestrial ecosystems (Ghazoul, 2002) [7]. Their beauty captivates human interest and encourages ecological conservation. As important pollinators, butterflies contribute significantly to food web dynamics (Kumar *et al.*, 2007). Unfortunately, many butterfly species face threats from habitat loss, wildfires, pesticide use, and illegal trade, leading to a decline in their populations with some species at risk of extinction (Sharma *et al.*, 2006).

Biodiversity of Butterfly in Haryana

India's rich biodiversity ranks it among the 12 megadiverse countries globally, with approximately 1,800 butterfly species representing both endemic and globally threatened taxa (Harisha & Hosetti, 2021) [27]. Butterflies play a vital

ecological role as pollinators and bioindicators, making their conservation critical for maintaining ecological balance. Despite the global and national focus on butterfly diversity, research in Haryana remains sparse, with most studies concentrated in protected areas such as wildlife sanctuaries.

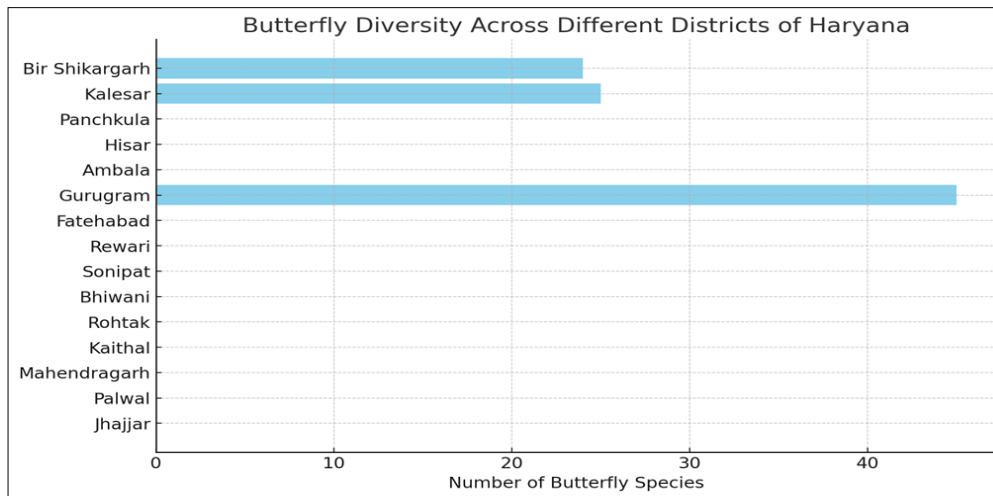


Fig 1: Butterfly Diversity across different districts of Haryana.

Studies in Haryana's Protected Areas

Haryana's butterfly diversity has primarily been documented in its wildlife sanctuaries. Uniyal and Bhargav (2007) [31] identified 24 butterfly species across four families in Bir Shikargarh Wildlife Sanctuary, highlighting the region's potential as a biodiversity hotspot. Similarly, Sethy and Ray (2010) [15, 30] documented 25 species from 24 genera and five families in Kalesar Wildlife Sanctuary, underlining the sanctuary's importance as a repository for Lepidopteran diversity. However, these studies only scratch the surface, as Haryana's urban and rural landscapes remain underexplored for butterfly diversity.

Expanding the Horizon: Insights from Recent Studies

Beyond Haryana, recent studies provide valuable context for understanding butterfly diversity and conservation strategies. For instance, Gupta *et al.* (2019) [25] conducted a comprehensive assessment of butterfly species in Uttarakhand, a neighboring state with similar ecological zones, reporting over 300 species. This underscores the potential for Haryana to harbor a more diverse array of species than currently recorded.

Globally, studies like those by Habel *et al.* (2019) [26] emphasize the alarming decline in butterfly populations due to habitat loss, climate change, and pesticide use. Such findings resonate with research in Indian urban areas, where rapid urbanization has fragmented butterfly habitats. Kumar and Rahman (2021) [29] analyzed butterfly diversity in Delhi, identifying 45 species even in heavily urbanized zones, suggesting the resilience and adaptability of some species, which could be applicable to urban areas in Haryana.

Common Butterfly Families in Haryana

1. Nymphalidae

This family, known as the brush-footed butterflies, is characterized by its unique foot structure, which is adapted for grasping rather than walking. In Haryana, species like the Common Crow (*Euploea core*) and the Four-spot Flash *Appias lycinda* are prevalent.

2. Pieridae

This family known as the whites and yellows, this family is recognized for its bright colors and typically includes butterflies like the Common Yellow Swallowtail (*Papilio machaon*) and the Cabbage White (*Pieris rapae*). These butterflies are important pollinators in agricultural and urban areas.

3. Papilionidae

Commonly known as swallowtails, this family includes some of the largest and most striking butterflies. The Common Mormon (*Papilio polytes*) is a notable example found in Haryana, renowned for its mimetic behavior, often resembling the toxic females of the species to avoid predation.

4. Lycaenidae

This family is commonly referred to as the Gossamer-winged butterflies and is characterized by their small size and iridescent colors. Species such as the Common Pierrot (*Tarucus nara*) are commonly observed. These butterflies often have symbiotic relationships with ants, which can provide them protection.

5. Hesperidae

Known as the skippers, this family is distinct for their rapid flight patterns. In Haryana, species like the Common Skipper (*Pyrgus malvae*) can be found, which are often seen darting around flowers.

Regional Distribution

- **Ambala Division:** Rich in diversity due to subtropical forest cover.
- **Yamuna Floodplains:** Seasonal butterflies thriving in wetland habitats.
- **Aravali Hills:** Habitat for species adapted to dry and rocky terrains.

Seasonal Variations

- **Peak seasons for butterfly sightings:** Post-monsoon (August-October) and spring (March-May).
- Influence of temperature and precipitation on butterfly activity.

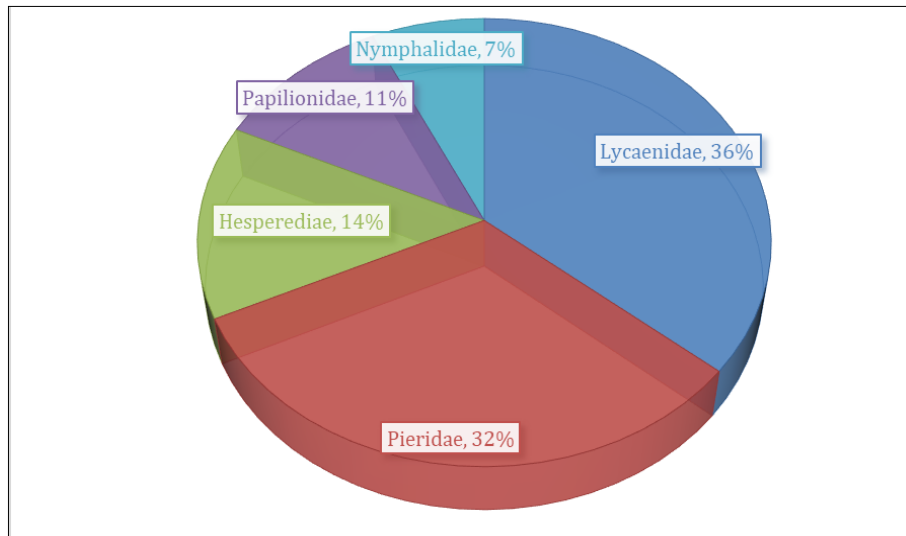


Fig. 2: Observed percent occurrence of butterfly species under different families.

Another study on butterfly diversity was conducted in Haryana, spanning from March 2021 to November 2022, and offers an in-depth analysis of these vital pollinators across different seasons. By applying the pollard walk method, a widely accepted technique for ecological surveying, researchers meticulously observed and photographed butterflies, from various angles using a Nikon camera, ensuring that no harm was inflicted on these living organisms.

The survey highlighted the detrimental effects of human activities such as industrialization, traffic emissions, soil excavation, grazing, and burning. These factors drastically alter habitat quality, thereby impeding the availability of essential host plants and disrupting butterfly populations. Such anthropogenic pressures pose significant threats to the delicate balance of ecosystems, impacting the habitats crucial for butterfly's life cycles (Chaudhary & Christy, 2020). The findings identified peak butterfly populations

during the summer months of July, August, and September periods marked by favorable conditions- specifically increased humidity, rainfall, and an abundance of flowering plants. These environmental factors create a conducive atmosphere for butterfly activity (Sharma & Sharma, 2013; Priya & Krishanaraj, 2017). Interestingly, certain species like *Pieris* spp. were predominantly sighted in the early part of the year from February to April.

While another research in Haryana including Gumber (2022) [8], has explored butterfly diversity in specific regions like Mandi Dabwali in Western Haryana, the current study addresses a significant gap in the literature regarding other areas within the Rewari district. By investigating butterfly diversity in this region and its associated environmental dynamics, this study contributes valuable insights that enhance our understanding of these essential pollinators and the ecological challenges they face.

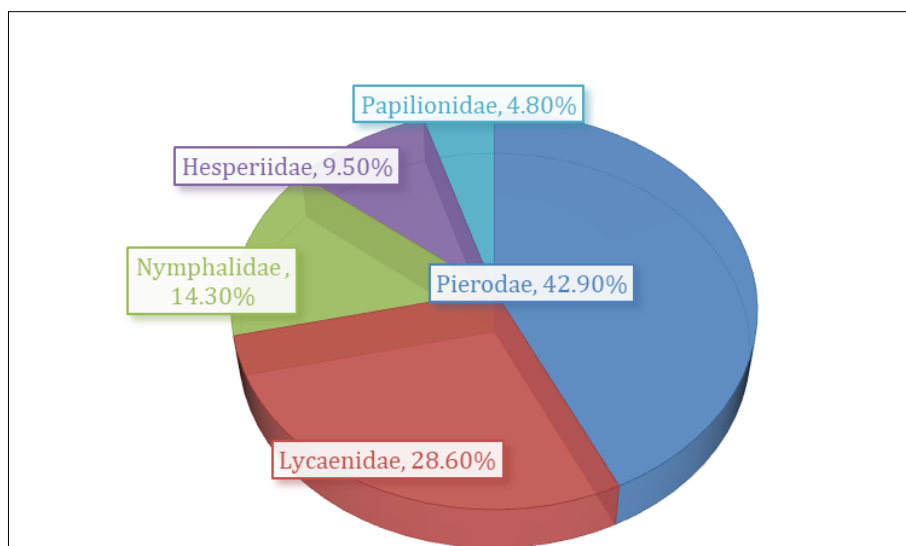


Fig.3: Butterfly Species Distribution Among Families in Rewari, Haryana

Comparative Analysis: India vs Haryana

Parameter	India	Haryana
Species Diversity	~1379 species	42 species (documented in Rewari)
Hotspots	Western Ghats, Himalayas, etc	No official Biodiversity hotspots
Endemism	High	Low
Threats	Habitat loss, climate change	Habitat fragmentation, Urbanization
Conservation Efforts	National Parks, Community projects	Limited to localized surveys

Ecological Significance of Butterflies

- **Pollination:** This is key in pollinating crops and wild plants.
- **Food Chain:** Importance as prey for birds, reptiles, and other animals.
- **Indicators of Climate Change:** Sensitivity to habitat alterations and temperature shifts.

Monitoring Methods

Effective conservation demands accurate monitoring. In Haryana, butterfly monitoring is conducted through field surveys, transect walks, and photographic documentation. These traditional methods are essential for gathering critical data on butterfly populations and their habitats. Citizen science initiatives, such as butterfly counts and school-based awareness programs, play a vital role in data collection. Programs like the Indian Butterfly Monitoring Scheme actively involve volunteers in recording butterfly sightings, thereby enhancing public participation and raising awareness about local biodiversity (Banerji *et al.*, 2018).

Despite progress, significant challenges remain. Limited funding, a shortage of trained personnel, and inconsistent methodologies hinder the collection of comprehensive and reliable data, which is essential for effective conservation strategies (Kumar *et al.*, 2020). Furthermore, the absence of standardized protocols leads to variations in data quality, complicating efforts to draw accurate conclusions about butterfly populations over time.

Emerging technologies, including Geographic Information Systems (GIS) mapping and machine learning algorithms, are poised to revolutionize butterfly monitoring in Haryana. GIS enables researchers to visualize the geographical distribution of butterfly species and analyze the environmental factors impacting their habitats (Mishra *et al.*, 2021). Meanwhile, machine learning algorithms can automate the identification of butterfly species from images, significantly speeding up data analysis and improving accuracy (Raj *et al.*, 2020) ^[24]. These advanced tools empower precise tracking of distribution patterns and facilitate the identification of at-risk species more effectively.

Methods to Monitor Butterfly Populations in Haryana

Monitoring butterfly populations involves various techniques that assess species diversity, abundance, and distribution. Key methods include.

Transect Walks (Pollard Walks)

Transect walks, often referred to as Pollard walks, involve observers walking along fixed routes (transects) to systematically count butterflies within a specific area. This method is beneficial for monitoring butterfly populations over time and can provide valuable insights into habitat preference and seasonal variations (Pollard, E., & Yates, T. J. (1993) ^[19].

Methodology

1. **Selection of Transects:** Fixed routes are chosen based on the habitat types being studied. These routes should be representative of the overall area where butterflies are expected to be present.
2. **Counting Protocol:** Observers typically walk at a steady pace (often between 1-2 km/h), counting all butterflies seen within a certain distance (usually 5 meters) on either side of the route.
3. **Data Recording:** Observers note the species and the number of butterflies observed, along with the time and weather conditions to analyze the impact of environmental factors.

Timed Count Surveys

Timed count surveys involve observing and recording the number of butterflies present in a designated area during a specified time interval. This method can complement transect walks by providing a snapshot of butterfly activity in specific locations (Baker, R., & Clay, T. (2000).

Methodology

1. **Designating Areas:** Specific areas are selected for observation based on habitat heterogeneity and previous butterfly activity records.
2. **Timing:** Observers record butterflies for a fixed duration, often between 10 to 30 minutes, during which they document as many individuals as possible.
3. **Data Collection:** The number of butterflies, species identity, and any notable behaviors are recorded. This data helps in understanding the relative abundance of different species in the area.

Mark-Release-Recapture

The Mark-Release-Recapture (MRR) method is a technique used to estimate population size and track the movement of butterflies. This method provides insights into population dynamics and migration patterns (Seber, G. A. F. (1982).

Methodology

1. **Capture:** Butterflies are captured using nets, and each individual is carefully marked with a non-toxic paint or tag.
2. **Release:** After marking, butterflies are released back into their natural habitat. It's important to allow them time to disperse before recapturing.
3. **Recapture:** Observers return to the same site after a designated period and capture butterflies again. The proportion of marked to unmarked individuals allows for estimates of the total population size based on the Lincoln-Petersen estimator.

Netting

Netting is a common method used in entomological studies, particularly for the collection of butterflies. It involves the use of butterfly nets, which are lightweight nets with a long

handle, designed specifically for gently capturing these delicate insects.

Methodology

- 1. Capturing:** Researchers approach butterflies quietly to avoid startling them. The net is swung in a sweeping motion to enclose the butterfly, ensuring it is caught without harm. Once captured, the specimen is usually placed in a small container for brief identification purposes. The handling is conducted with great care to avoid stress or injury to the butterflies.
- 2. Identification:** After capture, butterflies are identified based on various morphological features such as wing patterns, colors, and body shapes. Field guides and taxonomic keys are typically used to assist with accurate identification (Schaefer & Sanker, 2021)^[35].
- 3. Release:** After identification, butterflies are released unharmed at the same site where they were captured. This minimizes the impact on local populations and contributes to ethical scientific practicing and Identification

Photographic Surveys

Photographic surveys are another important method used for documenting butterfly species and populations. This technique leverages high-resolution photography to capture detailed images of butterflies in their natural habitats.

Methodology

- 1. Equipment:** High-resolution cameras, often equipped with macro lenses, are used to take clear and detailed photographs of butterflies at close range. This allows for more accurate identification and study of species, especially those that are otherwise difficult to capture or handle (Hammond, 2020)^[34].
- 2. Procedure:** Photographers aim to capture images of butterflies in various poses and angles to provide comprehensive documentation of their physical characteristics. Good lighting conditions and backgrounds are also crucial for quality images. This method allows researchers to study behavior, habitat preferences, and population distributions over time without physically capturing the specimens.
- 3. Record-Keeping:** The images taken during photographic surveys are archived in databases, where they can be analyzed and used for future reference. These photographic records augment traditional specimen collections and serve as valuable tools for monitoring biodiversity and ecological changes (Bourn & Thomas, 2002).

Online platforms and citizen science initiatives, such as iNaturalist, allow researchers and enthusiasts to share their photographs, contributing to collaborative conservation efforts.

Conservation Efforts and Initiatives

Government Policies and Protected Areas

- Overview of policies such as the Wildlife Protection Act and their impact on butterfly conservation. (Government of India, Wildlife Protection Act, 1972)
- The role of protected areas in Haryana, including Kalesar National Park and Sultanpur National Park. (Haryana Forest Department, Protected Areas of Haryana)

Community-Based Initiatives

- Success stories of community-led conservation programs. (Nanda, A. & Kumar, R. (2020). Community Conservation and Biodiversity Journal: Case Studies from Haryana. Journal of Environmental Conservation)
- The involvement of local schools and NGOs in creating butterfly gardens and raising awareness through educational programs. (Bansal, S. (2021). Engaging Youth in Conservation is crucial for a sustainable future in Haryana. Schools and NGOs play key roles in fostering environmental awareness among young people.
- Studies show that various grassroots organizations effectively mobilize youth for conservation, instilling a sense of responsibility and leadership (Choudhary & Bhattacharya, 2020)^[5].
- Active participation in conservation initiatives enhances their understanding of sustainability issues (Rao & Rao, 2018).

Role of Local Communities in Butterfly Conservation

Habitat Protection

Haryana: Farmers and villagers in Haryana play an essential role in preserving uncultivated patches and planting native flora. These actions create habitat corridors and buffer zones for butterflies, especially in areas with agricultural landscapes. Agroforestry practices have been promoted to encourage biodiversity-friendly farming (Kumar *et al.*, 2020).

India-wide: In states like Meghalaya and Nagaland, communities protect sacred groves, which are crucial habitats for many butterfly species. These areas often remain undisturbed due to cultural and religious beliefs, providing safe havens for diverse flora and fauna, including butterflies (Sarma & Pandit, 2017).

Eco-tourism

Haryana: While eco-tourism initiatives for butterfly conservation are still in their early stages in Haryana, the state is beginning to explore the potential for nature-based tourism to promote environmental awareness. There are some small-scale efforts to involve communities in guiding eco-tourism and butterfly-watching (Singh & Chawla, 2020).

India-wide: States like Kerala and Himachal Pradesh have well-established eco-tourism models that leverage butterfly tourism as a tool for both education and conservation. These states organize butterfly festivals, trekking, and butterfly-watching tours that generate revenue for local communities while promoting habitat protection (Sreenivasan *et al.*, 2018).

Traditional Knowledge

Haryana: Local communities in Haryana possess valuable traditional knowledge of local plant species, their use as butterfly host plants, and the seasonal behavior of butterflies. Such knowledge is critical for conservation efforts, particularly in identifying species that are integral to local ecosystems (Sharma & Yadav, 2019).

India-wide: In other regions like Sikkim, Meghalaya, and Nagaland, the indigenous knowledge of plant species and

butterfly migratory patterns plays a significant role in the preservation of butterfly populations. Communities use this knowledge to cultivate plants that attract butterflies and protect key migratory routes (Rai & Bhutia, 2016).

Conservation Efforts and Citizen Science

Recent advancements in citizen science have significantly contributed to butterfly conservation. Initiatives like the "Indian Butterfly Monitoring Scheme" encourage amateur naturalists to record observations, bridging the gap between professional researchers and the public (Kunte *et al.*, 2020)^[28]. Such programs could be instrumental in Haryana, where systematic studies on butterflies are limited.

Research Gaps and Future Directions

While existing literature provides foundational knowledge, the biodiversity of butterflies in Haryana's non-protected areas, including agricultural fields, urban gardens, and semi-urban landscapes, remains uncharted. Integrating modern tools such as Geographic Information Systems (GIS) and machine learning models could enhance biodiversity assessments. Additionally, longitudinal studies focusing on seasonal variations and climate impacts are necessary to develop comprehensive conservation strategies.

Conclusion

Butterflies are crucial to the ecological and agricultural landscapes of Haryana. Although they face challenges such as habitat loss and urbanization, significant opportunities exist for enhancing conservation efforts. By engaging the community, leveraging technological innovations, and promoting eco-tourism, we can help safeguard the region's butterfly diversity while fostering sustainable development. This review references established research on butterfly ecology and conservation strategies, underscoring the necessity of integrating conservation practices into broader environmental and developmental policies. Such integration is vital for achieving a balanced coexistence between human activities and natural ecosystems, thereby ensuring the long-term sustainability of both the butterflies and the region as a whole.

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