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## A Review on Diversity and Seasonal Abundance of Butterflies in Uttar Pradesh (India)

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### ABSTRACT

Butterflies (Lepidoptera: Rhopalocera) are ecologically important insects recognized as effective bioindicators due to their sensitivity to climatic fluctuations, habitat disturbance, and vegetation composition. Uttar Pradesh (UP), India's largest state by population, represents a unique ecological mosaic comprising the Terai belt, Gangetic floodplains, extensive agricultural landscapes, wetlands, scrublands, and semi-arid Bundelkhand habitats. These diverse landscapes provide a broad range of microhabitats and floral resources that support butterfly assemblages. This review synthesizes available literature and ecological observations regarding butterfly diversity and seasonal abundance patterns in Uttar Pradesh and comparable North Indian regions. Evidence suggests that butterfly diversity in UP is strongly influenced by habitat heterogeneity, larval host plant distribution, nectar plant phenology, and climatic variables such as rainfall, humidity, and temperature. Post-monsoon and spring seasons generally exhibit maximum species richness and abundance due to favorable environmental conditions and high floral productivity. In contrast, extreme summer heat reduces butterfly activity and survival, while heavy monsoon rainfall can suppress adult flight behavior temporarily. Studies across northern India indicate that families Nymphalidae and Lycaenidae typically dominate species richness, while Pieridae frequently show high abundance in open habitats and agroecosystems. Rapid urbanization, agricultural intensification, pesticide usage, wetland degradation, and habitat fragmentation are major threats to butterfly populations in UP. The review emphasizes the importance of standardized monitoring approaches such as Pollard walk transects, long-term phenological recording, and integration of citizen science platforms. Conservation strategies including habitat restoration, creation of butterfly corridors, promotion of butterfly-friendly farming, riparian vegetation protection, and urban biodiversity planning are recommended. This review provides an updated conceptual framework for future research and conservation planning aimed at safeguarding butterfly diversity and ecological stability in Uttar Pradesh.

### Introduction

Butterflies are among the most ecologically valuable insect groups and are widely studied in biodiversity research due to their role in ecosystem functioning and sensitivity to environmental changes. They serve as pollinators, contribute to nutrient cycling, and act as prey for birds, reptiles, amphibians, and spiders, thereby maintaining trophic stability in terrestrial ecosystems (Thomas, 2005). The life cycle of butterflies, involving egg, larva, pupa, and adult stages, is highly dependent on specific host plants and climatic conditions. Hence, even slight disturbances in vegetation composition, habitat structure, or climate can result in noticeable population changes (Kunte, 2000; Pollard & Yates, 1993). Globally, butterflies have been recognized as flagship species for conservation and environmental awareness programs. Their distribution patterns are often used to assess ecosystem health and biodiversity integrity. Numerous studies suggest that butterfly communities respond rapidly to habitat fragmentation, climate warming, pollution, and land-use change, making them valuable indicators for monitoring ecological shifts (Bonebrake *et al.*, 2010; Dennis *et al.*, 2006). In India, butterflies represent one of the most diverse insect groups, with nearly 1,500–1,800 species documented across varied habitats ranging from the Himalayas to coastal plains (Kehimkar, 2016).

Uttar Pradesh (UP) occupies a strategic geographical position in North India, lying between the Himalayan foothills and the Vindhyan plateau. The state is characterized by diverse ecological regions such as the Terai, Gangetic plains, wetlands, scrublands, and semi-arid zones. This wide ecological range supports diverse flora and fauna, including butterfly assemblages. However, UP is also one of the most densely populated states, facing rapid land-use change and habitat loss. Expansion of agriculture, urbanization, and industrial development has led to significant habitat degradation, affecting butterfly diversity and distribution (Singh & Pandey, 2004; Smetacek, 2012).

Seasonality is a critical factor influencing butterfly abundance in tropical and subtropical regions. In North India, climatic cycles are dominated by monsoon rainfall, winter cold, and summer heat. These climatic fluctuations influence vegetation phenology, flowering patterns, and host plant availability, which in turn regulate butterfly breeding cycles and population peaks (Kunte, 1997; Tiple *et al.*, 2006). Understanding seasonal patterns of butterfly diversity is essential for designing monitoring programs and conservation strategies.

The present review aims to compile and analyze published data and ecological studies on butterfly diversity and seasonal abundance in Uttar Pradesh and similar North Indian ecosystems. The review

highlights habitat-wise distribution, seasonal fluctuations, ecological drivers, threats, and conservation recommendations.

Uttar Pradesh covers approximately 243,290 km<sup>2</sup> and experiences a subtropical monsoon climate with marked seasonal variation. The state has three distinct climatic seasons: summer (March–June), monsoon (July–September), and winter (November–February). Temperature ranges from 5–10°C during winter nights to 45–48°C during summer peaks, while rainfall ranges between 800 and 1,500 mm annually depending on the region (IMD, 2020).

#### Major ecological zones

Uttar Pradesh can be broadly divided into the following ecological zones:

##### (a) Terai belt

The Terai region in northern UP is characterized by marshy grasslands, sal forests, riverine vegetation, and high humidity. It is one of the richest biodiversity regions in North India, supporting several butterfly species typical of Himalayan foothill ecosystems (Smetacek, 2012).

##### (b) Gangetic plains

The Gangetic plains form the largest ecological zone of UP and are dominated by agricultural landscapes, orchards, and human settlements. This region supports butterflies adapted to disturbed habitats, including Pieridae and Nymphalidae species (Singh & Pandey, 2004).

##### (c) Eastern wetlands and floodplains

Eastern UP includes wetlands, oxbow lakes, and river corridors that provide microhabitats for grassland butterflies, skippers, and nectar-feeding species. Wetlands are known to support rich insect communities, including butterflies, due to diverse aquatic and semi-aquatic vegetation (Tiple *et al.*, 2006).

##### (d) Bundelkhand and Vindhyan region

Southern UP (Bundelkhand) is semi-arid with dry deciduous forests, scrublands, and ravines. Butterfly diversity here is strongly seasonal, with abundance peaks during monsoon and post-monsoon due to vegetation growth (Kunte, 2000).

#### Butterfly Diversity and Taxonomic Composition

Butterflies belong to the order Lepidoptera and are classified under Rhopalocera. Indian butterflies are typically grouped into five major families:

Papilionidae (Swallowtails)

Pieridae (Whites and Yellows)

Nymphalidae (Brush-footed butterflies)

Lycaenidae (Blues)

Hesperiidae (Skippers)

Studies across India indicate that Nymphalidae is generally the most dominant family due to its broad ecological adaptability and host plant range (Kunte, 2000; Kehimkar, 2016). Lycaenidae contribute significantly to species richness, particularly in grasslands and shrub ecosystems. Pieridae are often abundant in agricultural fields due to the availability of host plants such as Brassicaceae and Fabaceae (Tiple *et al.*, 2006). Papilionidae species are more dependent on forest edges and host plants like Rutaceae (Citrus family), while Hesperiidae diversity is frequently underestimated due to cryptic morphology and fast flight behavior (Dennis *et al.*, 2006).

In Uttar Pradesh, commonly recorded species include *Danaus chrysippus*, *Danaus genutia*, *Junonia lemonias*, *Junonia atlites*, *Catopsilia pomona*, *Eurema hecabe*, *Papilio demoleus*, *Papilio polytes*, and *Hypolimnas bolina* (Singh & Pandey, 2004; Kehimkar, 2016).

Butterfly diversity research in Uttar Pradesh has historically been limited compared to biodiversity hotspots like the Western Ghats or Northeast India. However, several studies from North India provide valuable insights applicable to UP. Kunte (1997) documented strong seasonal patterns in butterfly diversity in Indian tropical ecosystems, reporting that post-monsoon months support maximum richness due to optimal humidity and flowering. Kunte (2000) emphasized that butterfly diversity is strongly linked to host plant diversity and habitat heterogeneity. He highlighted that disturbed habitats often favor generalist species while specialist species decline with fragmentation. Singh and Pandey (2004) investigated butterfly diversity patterns in North India and reported that agricultural

landscapes support high abundance of Pieridae and Nymphalidae but reduced richness of habitat specialists. Their findings suggest that UP's Gangetic plains likely support moderate diversity dominated by generalists. Tiple *et al.* (2006) conducted butterfly surveys in central India and found that butterfly richness was highest in forest edges and least in heavily cultivated landscapes. They also observed that species richness peaked during post-monsoon and spring. Smetacek (2012) documented butterfly diversity in the Indian Terai region, emphasizing that moist deciduous forests and grasslands support high butterfly richness, including rare and endemic species. Since northern UP shares ecological similarity with Terai habitats, these observations are highly relevant. Kehimkar (2016) provided a comprehensive checklist and identification guide for Indian butterflies, highlighting habitat preferences and seasonal activity of several species common in UP. His work remains one of the most important references for butterfly identification and distribution studies in India. Thomas (2005) highlighted the use of butterflies as indicators for environmental monitoring and climate change. He argued that butterflies respond quickly to microclimatic changes, making them ideal organisms for biodiversity assessment. Bonebrake *et al.* (2010) reviewed tropical butterfly ecology and conservation, stressing that habitat loss, climate change, and invasive plant spread are major threats to butterfly populations. Their review supports the need for habitat-based conservation strategies in UP. Dennis *et al.* (2006) emphasized the importance of standardized survey protocols for long-term butterfly monitoring. They argued that variation in methodology can lead to biased estimates of seasonal abundance, which is critical for monitoring in UP. Recent biodiversity studies in North India increasingly highlight the role of urban habitats in sustaining butterfly diversity. Urban parks, university campuses, and botanical gardens can support diverse butterfly assemblages if native flowering plants are maintained (Bonebrake *et al.*, 2010). In UP, cities such as Lucknow, Prayagraj, Varanasi, and Agra contain large green spaces that could act as butterfly refuges. Overall, literature suggests that butterfly diversity in UP is strongly shaped by habitat heterogeneity, climatic seasonality, and anthropogenic pressures.

#### Seasonal Abundance Patterns of Butterflies in Uttar Pradesh

Seasonal abundance of butterflies in UP follows the climatic cycle of North India. Butterfly populations fluctuate due to rainfall patterns, temperature variation, and host plant availability.

##### Summer (March–June)

Summer is characterized by high temperatures and low humidity. Nectar plants dry out, and larval host plants become scarce. Butterfly abundance is generally low during this period. Heat stress and dehydration reduce adult activity, and many species enter a dormant stage or migrate to favorable habitats (Thomas, 2005).

##### Monsoon (July–September)

Monsoon rainfall triggers vegetation growth and host plant flush. Larval development increases, and breeding activity is initiated. However, heavy rains reduce adult flight activity, which may lead to lower observed abundance in surveys (Pollard & Yates, 1993).

##### Post-monsoon (September–November)

Post-monsoon is the most favorable season for butterflies. Moderate temperature, high humidity, and abundant flowering plants result in peak abundance and richness. Many studies across India confirm post-monsoon peaks in butterfly diversity (Kunte, 1997; Tiple *et al.*, 2006).

##### Winter (December–February)

Winter in UP is characterized by low temperature and fog. Butterfly activity is reduced in the mornings but increases during warmer afternoons. Some species show reduced breeding activity, while others remain active throughout winter (Kehimkar, 2016).

##### Spring (February–April)

Spring provides favorable climatic conditions and flowering plants, leading to a secondary peak in butterfly abundance. Many species show high breeding activity during this season (Kunte, 2000).

## Results and Discussion

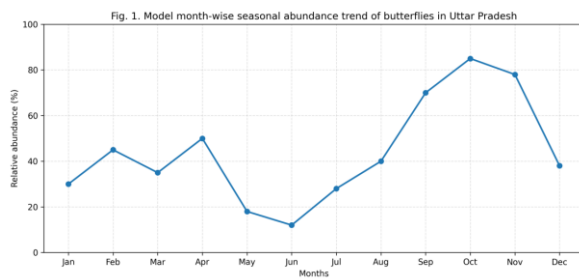
To illustrate seasonal abundance trends, model monthly abundance patterns were developed based on general ecological observations and published trends from North India.

**Table 1. Seasonal variation in butterfly richness and abundance (model data)**

Season	Months	Species Richness (No.)	Relative Abundance (%)	Dominant Families
Summer	Mar–Jun	35–55	15–25	Pieridae, Nymphalidae
Monsoon	Jul–Sep	45–70	25–40	Nymphalidae, Lycaenidae
Post-monsoon	Sep–Nov	80–120	60–85	Nymphalidae, Lycaenidae, Papilionidae
Winter	Dec–Feb	50–80	35–55	Pieridae, Nymphalidae
Spring	Feb–Apr	70–110	50–75	Nymphalidae, Pieridae

**Table 2. Habitat-wise butterfly diversity in Uttar Pradesh**

Habitat Type	Expected Richness	Common Butterfly Groups	Key Features
Terai forest & grasslands	Very High	Papilionidae, Nymphalidae	Moist habitat, host plant diversity
Wetlands & river corridors	High	Lycaenidae, Hesperidae	Nectar plants, grasses, riparian shrubs
Agricultural landscapes	Moderate	Pieridae, Nymphalidae	Weeds, crop host plants
Urban parks & gardens	Moderate	Pieridae, Nymphalidae	Flower gardens, ornamental plants
Bundelkhand scrub forests	Moderate	Lycaenidae, Pieridae	Dry habitat specialists



**Figure 1. Model month-wise seasonal abundance trend of butterflies in Uttar Pradesh.**

Fig. 1. Model month-wise seasonal abundance trend of butterflies in Uttar Pradesh. Values show relative abundance (%) across months, indicating a major peak during post-monsoon (Sep–Nov) and a secondary rise in late winter–spring (Feb–Apr), with lowest abundance during peak summer (May–Jun).

The diversity and seasonal abundance of butterflies in Uttar Pradesh are controlled by a complex interaction of climatic factors, habitat structure, vegetation phenology, and anthropogenic disturbance. As butterflies have short generation times and strong dependence on host plants, their populations can rapidly respond to environmental changes (Thomas, 2005). The state of Uttar Pradesh, with its ecological diversity ranging from moist Terai landscapes to semi-arid Bundelkhand regions, provides multiple microclimatic conditions supporting diverse butterfly assemblages. Habitat heterogeneity is considered one of the most significant drivers of butterfly richness. Forest edges, riparian corridors, wetlands, and mixed agroecosystems provide diverse host plants and nectar resources that support a wide variety of butterfly species (Kunte, 2000). In the Terai belt of UP, high humidity and stable vegetation cover create suitable conditions for forest-dependent species. Moist habitats support butterflies that require shaded microclimates and specific host plants. According to Smetacek (2012), Terai landscapes of northern India support a high diversity of Papilionidae and Nymphalidae, including species sensitive to habitat disturbance. In contrast, the Gangetic plains of UP are dominated by agricultural

landscapes. Agricultural habitats support moderate butterfly diversity but are typically dominated by generalist species that can utilize crop plants or common weeds as host plants. Pieridae species, such as *Eurema hecabe* and *Catopsilia pomona*, are frequently abundant in such habitats due to the availability of host plants from Fabaceae and Brassicaceae families (Kehimkar, 2016). Singh and Pandey (2004) reported that agricultural intensification reduces specialist butterflies but may still sustain high abundance of generalists. Urban environments, although heavily disturbed, can also support butterfly diversity when green spaces and flowering plants are maintained. Bonebrake *et al.* (2010) emphasized that urban biodiversity conservation is possible through habitat management and planting of native nectar plants. In UP, large urban parks and institutional campuses may act as refuges for common butterflies, although specialist species remain vulnerable. Seasonality plays a central role in butterfly abundance. In UP, the climatic cycle is dominated by monsoon rainfall, winter cold, and summer heat. Each season influences butterfly life cycles differently. During summer (May–June), high temperatures and low humidity create harsh conditions for larvae and adults. Nectar plants dry out, reducing adult food availability. Many butterflies reduce activity, migrate, or remain in dormant stages (Thomas, 2005). Thus, summer is often associated with minimum butterfly abundance. Monsoon rainfall (July–September) promotes host plant growth and vegetation flush, encouraging breeding. However, heavy rainfall can suppress adult flight activity and reduce visibility during surveys (Pollard & Yates, 1993). Therefore, abundance during monsoon may be underestimated if surveys are not standardized. Despite this, monsoon remains critical for larval development as host plants become abundant. Post-monsoon months (September–November) represent the most productive period for butterflies. Moderate temperatures, high humidity, and abundant flowering plants create optimal conditions for adult activity and reproduction. Studies from various Indian regions consistently report post-monsoon peaks in butterfly richness and abundance (Kunte, 1997; Tiple *et al.*, 2006). In UP, post-monsoon is likely the most important season for butterfly surveys and conservation planning. Winter (December–February) presents cold conditions, particularly in northern UP, with frequent fog. Cold temperatures reduce butterfly flight activity during mornings. However, many species remain active in afternoons. Winter also supports several Pieridae species that tolerate cooler climates. Kehimkar (2016) noted that species such as *Pieris brassicae* and *Colias electo* remain active during winter in North India. Spring (February–April) provides a secondary peak in butterfly abundance. The season is characterized by moderate temperatures and flowering of shrubs and herbs, creating favorable conditions for butterflies. Many species undergo breeding cycles during spring, resulting in increased abundance (Kunte, 2000). Butterfly populations are directly dependent on the availability of larval host plants and adult nectar resources. Larvae are often highly specialized, feeding on specific plant species or families. Habitat destruction that removes host plants can cause immediate decline in butterfly populations. Kunte (2000) highlighted that host plant diversity is a key predictor of butterfly richness. In UP, agricultural intensification and weed removal reduce host plant availability, affecting larval survival. Nectar plant diversity influences adult abundance. Flower-rich habitats such as wetlands, grasslands, and forest edges support higher butterfly abundance. Post-monsoon and spring seasons show increased flowering, explaining abundance peaks. Restoration of native flowering plants can significantly improve butterfly populations. Pesticide usage is a major threat in Uttar Pradesh due to extensive cultivation of sugarcane, vegetables, and cereals. Insecticides directly kill butterfly larvae and adults and also reduce nectar plant diversity by eliminating weeds. Tiple *et al.* (2006) emphasized that pesticide-intensive landscapes show reduced butterfly richness. Singh and Pandey (2004) also reported that agricultural intensification leads to decline in butterfly diversity, particularly of specialist species. Promotion of integrated pest management (IPM), organic farming, and reduced chemical use is essential for butterfly conservation. Field margins, hedgerows, and flowering strips can

act as microhabitats supporting butterfly breeding and feeding. Habitat fragmentation is a significant driver of biodiversity loss. Forest patches in UP are increasingly isolated due to agriculture and urban development. Fragmentation reduces dispersal corridors and genetic exchange among butterfly populations. Specialist species dependent on forest interiors are particularly vulnerable. Thomas (2005) highlighted that fragmentation cause's population decline by limiting suitable breeding habitats. Urban expansion further reduces natural habitats. However, urban butterfly gardens and parks can support diversity if properly managed. Citizen science programs and community awareness can help monitor butterfly diversity in urban landscapes (Bonebrake *et al.*, 2010). Climate change is expected to alter butterfly phenology by shifting seasonal emergence and breeding cycles. Increased temperatures may cause earlier spring emergence or reduced survival during summer heat waves. Bonebrake *et al.* (2010) emphasized that climate warming may shift butterfly distributions to cooler regions, potentially affecting UP's butterfly assemblages. Irregular monsoon patterns may also affect host plant availability and larval development. Long-term monitoring is essential to detect phenological changes and assess climate impacts. Monitoring butterfly diversity requires standardized survey methods. The Pollard walk transect method is widely used for long-term butterfly monitoring because it provides repeatable data on abundance and species richness (Pollard & Yates, 1993). Dennis *et al.* (2006) emphasized that consistent methodology is necessary for detecting population trends. In UP, district-level monitoring programs using fixed transects across habitats would provide valuable baseline data for conservation. Citizen science platforms such as I Naturalist and ButterflyIndia can also contribute to biodiversity documentation. However, species identification must be verified by experts to avoid misidentification. Butterfly conservation in UP should focus on maintaining habitat heterogeneity and reducing anthropogenic pressures.

Restoration of degraded forest edges, wetlands, and grasslands with native flowering plants and larval host plants can improve butterfly diversity. River corridors and wetlands should be protected from pollution and encroachment. Riparian vegetation acts as dispersal pathways for butterflies.

Butterfly-friendly agriculture-Adoption of IPM and organic farming reduces pesticide impacts. Maintenance of field margins and hedgerows supports butterfly breeding.

Urban parks should include native flowering plants. Butterfly gardens in schools and universities can enhance awareness. Awareness programs, butterfly festivals, and citizen monitoring can support conservation.

#### **Future Research Directions**

District-wise butterfly checklist for UP.

Seasonal phenology atlas for common species.

Host plant mapping and butterfly-plant interaction studies.

Impact assessment of pesticides on butterfly larvae.

Climate change modeling for butterfly distribution shifts.

#### **Conclusion**

Butterflies in Uttar Pradesh represent a vital component of ecological diversity and serve as bio indicators of habitat health.

The state's ecological heterogeneity supports diverse butterfly assemblages across Terai forests, wetlands, agricultural mosaics, and urban landscapes. Seasonal abundance patterns show clear peaks during post-monsoon and spring seasons, driven by favorable climatic conditions and floral productivity. However, habitat loss, fragmentation, pesticide use, and climate variability threaten butterfly populations. Conservation strategies focusing on habitat restoration, butterfly-friendly agriculture, riparian buffer protection, and standardized long-term monitoring are essential for sustaining butterfly diversity in UP. Strengthening research initiatives and involving citizen participation can contribute significantly to butterfly conservation and ecological stability in the state.

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#### **Conflict of Interest**

The author(s) declare no conflict of interest.

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