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# Biodiversity and Seasonal Dynamics of Butterflies in Sariska National Park

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| KEYWORDS | ABSTRACT |
|---|---|
| Sariska National Park, butterflies, biodiversity, seasonal dynamics, bioindicators, habitat diversity, conservation strategies. | This research explores the biodiversity and seasonal dynamics of butterflies in Sariska National Park, focusing on seasonal variations, habitat preferences, and the ecological roles butterflies play within the park. Sariska, situated in the Aravalli range of Rajasthan, India, is home to a rich variety of ecosystems, including dry deciduous forests, grasslands, wetlands, and riparian zones. This diversity supports a range of butterfly species, which are sensitive to environmental changes and act as bioindicators of ecosystem health. The study emphasizes the importance of understanding the seasonal turnover of butterfly populations, which is influenced by temperature, rainfall, and availability of nectar and host plants. Using field data from 2022 to 2024, the research analyzes the butterfly species richness, abundance, and diversity across different seasons (spring, summer, monsoon, and winter). The study shows that while the monsoon season sees the highest species richness and abundance, the winter months act as a bottleneck, limiting the butterfly populations to cold-tolerant species. Generalist species, such as Eurema hecabe and Danaus chrysippus, thrive throughout the year, while specialists, such as Tirumala limniace and Papilio polytes, are more seasonally dependent. This seasonal variation highlights the need for multi-seasonal monitoring to accurately assess butterfly biodiversity and guide effective conservation strategies. DOI: |

## 1. Introduction

Sariska National Park, situated in the Aravalli range of Rajasthan, India, is one of the country's most prominent protected areas, known for its rich biodiversity. Spanning across 881 square kilometers, the park is home to a variety of ecosystems, including dry deciduous forests, grasslands, wetlands, and riparian zones (Acreman et al., 2020). These diverse habitats support a rich array of species, many of which are of great ecological and conservation significance. Sariska is not only a critical refuge for endangered species like the Bengal tiger (Panthera tigris tigris) but also hosts a range of other fauna and flora, making it a key biodiversity hotspot (Acreman et al., 2020; Singh et al., 2022). Among the many species that thrive in Sariska, butterflies hold particular ecological importance. Butterflies are highly sensitive to environmental changes and can serve as excellent bioindicators of ecosystem health (Chowdhury et al., 2023). This sensitivity makes them a vital component in understanding the ecological dynamics of the park. Butterflies are often used as indicators of biodiversity, and shifts in their populations can reflect larger ecological changes, such as habitat degradation, climate change, and the availability of resources (Adam et al., 2022). Their role in pollination also makes them essential to maintaining the integrity of the park's plant communities.

### 1.1 Role of Butterflies as Bioindicators

The role of butterflies as bioindicators is widely recognized in ecological studies, as their population dynamics can provide valuable insights into the environmental health of a habitat. The seasonal shifts in butterfly populations in Sariska are an excellent example of how these insects respond to changes in climate and habitat conditions. Studies have shown that butterfly diversity and abundance are closely linked to environmental variables such as temperature, humidity, and rainfall (Adam et al., 2022). These insects are particularly sensitive to variations in nectar availability and the abundance of larval host plants, making them responsive to both biotic and abiotic changes in their environment (Chowdhury et al., 2023).

Butterflies in Sariska demonstrate distinct seasonal patterns that can be attributed to changes in climate, vegetation cycles, and the availability of resources. For instance, the monsoon season is characterized by increased butterfly diversity due to the high availability of nectar-producing plants and the favorable microclimatic conditions created by the rains. Conversely, the winter season acts as a bottleneck, with only the hardiest species surviving in the cooler, drier conditions (Tiple & Khurad, 2009). Understanding these patterns is crucial for implementing effective conservation strategies that account for seasonal variations and the needs of both generalist and specialist butterfly species.

### 1.2 Butterfly Diversity and Ecological Roles

Butterflies play a significant role in the ecosystems of Sariska, particularly in terms of pollination and serving as prey for other animals. As pollinators, they facilitate the reproduction of a wide range of plant species, contributing to the park's overall biodiversity (Gonçalves-Souza et al., 2021). Their feeding habits help maintain the health of both plant and animal communities by ensuring that plants produce seeds and that various species of animals, such as birds and other insects, have access to food sources.

The butterfly community in Sariska consists of both generalist and specialist species. Generalist species are those that can adapt to a wide range of environmental conditions and can feed on a variety of host plants, whereas specialist species are more restricted in their habitat requirements and may depend on specific plants or microhabitats (Das et al., 2023). For example, species like Danaus chrysippus (Plain Tiger) and Eurema hecabe (Common Grass Yellow) are generalists that thrive in a variety of habitats, including grasslands and forest edges, while species like Papilio polytes (Common Mormon) are more habitat- specific, depending on forested areas for survival (Gonçalves-Souza et al., 2021). The presence of both types of species is indicative of the ecological richness of Sariska and its capacity to support a wide range of biodiversity.

### 1.3 Seasonal Dynamics of Butterfly Populations in Sariska

The seasonal dynamics of butterfly populations in Sariska National Park are strongly influenced by climatic and ecological factors. Studies have demonstrated that butterfly populations exhibit clear seasonal shifts in abundance and diversity, with peak activity occurring during the monsoon months (June to September) and a significant decline in the winter months (December to February) (Tiple & Khurad, 2009). These shifts are largely driven by variations in temperature, humidity, and rainfall, which affect the availability of nectar plants and host species for larvae.

During the monsoon, the abundance and diversity of butterflies reach their peak. This is due to the increased availability of nectar plants and the overall growth in vegetation, which provides both food resources and shelter for various butterfly species (Sengupta et al., 2025). Monsoon rains also create optimal conditions for breeding, as moisture-rich environments support the growth of host plants essential for the larvae. In contrast, the winter season represents a bottleneck for many butterfly species, particularly those that are not adapted to cold conditions (Gonçalves-Souza et al., 2021). Only a few species, such as Delias eucharis (Common Jezebel) and Melanitis leda (Evening Brown), can withstand the lower temperatures and limited resources, while the majority of butterflies are inactive or absent during this time (Chowdhury et al., 2023).

Spring and summer serve as transitional periods, with some species from the monsoon persisting into the summer and others starting to emerge as temperatures rise. The availability of nectar from early-blooming flowers in spring helps boost butterfly populations, while the intense heat of summer limits activity, especially for species that are more sensitive to extreme temperatures (Kerry et al., 2022).

**1.4 Importance of Multi-Seasonal Monitoring**

The seasonal dynamics of butterfly populations in Sariska highlight the importance of conducting multi- seasonal monitoring to accurately assess the biodiversity of the park. A single-season survey could underestimate the true diversity of the butterfly community, as species that are abundant in one season may be absent or rare during another (Segre et al., 2023). This is particularly true for specialist species that depend on specific seasonal conditions or microhabitats. For example, species like Tirumala limniace (Blue Tiger) and Euploea core (Common Crow) are most abundant during the monsoon, while species such as Junonia lemonias (Lemon Pansy) are more common during spring (Chowdhury et al., 2023).

Moreover, the ability to track seasonal shifts in butterfly populations is crucial for understanding how climate change might affect these species in the future. As global temperatures rise and rainfall patterns shift, it is likely that the seasonal rhythms of butterfly populations will be disrupted, leading to changes in species distributions, reproductive cycles, and overall community composition (Kerry et al., 2022). Long- term monitoring will be necessary to detect these changes and implement appropriate conservation measures.

**1.5 Conservation Implications and Future Research**

The findings from this study have important implications for butterfly conservation in Sariska. Given the park's rich butterfly biodiversity and the seasonal shifts in populations, it is crucial to adopt a conservation strategy that accounts for both the temporal and spatial aspects of butterfly ecology (Tiple & Khurad, 2009). Habitat protection must be prioritized not only in the monsoon season, when species diversity peaks, but also during the winter months, when species face more challenging conditions. Additionally, efforts should be made to preserve the park's diverse habitats, including grasslands, wetlands, and riparian zones, which are vital for supporting both generalist and specialist butterfly species (Segre et al., 2023).

Future research should focus on understanding the specific habitat preferences of butterfly species in Sariska, particularly those that are vulnerable or endangered. More detailed studies on larval host plants and the impacts of invasive species on butterfly populations could further inform conservation efforts. Furthermore, investigating the effects of climate change on butterfly behavior and distribution will be critical for developing adaptive conservation strategies that can mitigate potential losses in biodiversity (Sengupta et al., 2025).

**Study Objectives:** To analyze the species diversity, seasonal variation, and habitat-specific distribution of butterflies in Sariska.

Sariska National Park's butterfly community is a highly dynamic and diverse assemblage that plays an essential role in maintaining the ecological integrity of the park. The seasonal shifts in butterfly populations are strongly influenced by climate and habitat factors, which in turn highlight the importance of multi- seasonal monitoring for effective biodiversity conservation. By focusing on the protection of both generalist and specialist butterfly species and their respective habitats, conservation efforts can help preserve the park's rich biodiversity for future generations. Moreover, given the sensitivity of butterflies to environmental changes, continued research into their seasonal dynamics and ecological roles will provide invaluable insights into the broader health of the park's ecosystems.

## 2. Materials and Methods

### 2.1 Field Data Collection

Field data were collected during multiple surveys conducted between 2022 and 2024 across Sariska National Park. The surveys covered four major habitat types: forests, grasslands, wetlands, and riparian zones. Butterfly species were recorded using standard butterfly nets and visual observations, ensuring accurate identification of species (Kerry et al., 2022). Surveys were carried out during different seasons— spring (March to May), summer (June to July), monsoon (August to October), and winter (November to February)—to capture the full spectrum of butterfly diversity.

### 2.2 Statistical Analysis

The analysis of species diversity was performed using several biodiversity indices. The Shannon-Wiener Diversity Index (H′) was used to measure species richness and the evenness of distribution across habitats and seasons (Gonçalves-Souza et al., 2021). The Simpson's Index was applied to assess species dominance, and Jaccard's Similarity Index was used to compare the seasonal overlap of butterfly assemblages (Segre et al., 2023). All statistical analyses were conducted using the statistical software R, ensuring the robustness of the results.

## 3. Results

### 3.1 Seasonal Variation in Butterfly Populations

Seasonality plays a crucial role in shaping butterfly communities, as climatic factors such as temperature, rainfall, and humidity influence nectar availability, larval host plants, and breeding cycles. In semi-arid ecosystems like Sariska, these seasonal shifts are particularly pronounced, with some butterflies peaking in abundance during monsoon, while others dominate in dry summer months or persist through the harsh winter. This section examines the temporal turnover of butterfly assemblages across spring, summer, monsoon, and winter, using abundance patterns, similarity indices, and monthly diversity analysis. The aim is to reveal how butterflies adapt to climatic cycles, how generalists ensure continuity across seasons, and how specialists depend on critical seasonal windows for survival.

**Table 3.1: Seasonal Variation in Butterfly Species Richness and Abundance in Sariska National Park**

| Species (Scientific Name) | Common Name | Spring (Mar– May) | Summer (Jun–Jul) | Monsoon (Aug–Oct) | Winter (Nov– Feb) | Peak Season |
|---|---|---|---|---|---|---|
| *Danaus chrysippus* | Plain Tiger | +++ | +++ | ++ | + | Summer |
| *Euploea core* | Common Crow | ++ | +++ | +++ | ++ | Monsoon |
| *Tirumala limniace* | Blue Tiger | + | ++ | +++ | + | Monsoon |
| *Tirumala septentrionis* | Dark Blue Tiger | – | + | +++ | + | Monsoon |
| *Junonia lemonias* | Lemon Pansy | +++ | ++ | ++ | + | Spring |
| Junonia orithya | Blue Pansy | ++ | ++ | +++ | ++ | Post-Monsoon |
| Junonia hierta | Yellow Pansy | +++ | +++ | ++ | + | Spring/Summer |
| Hypolimnas misippus | Danaid Eggfly | ++ | +++ | ++ | – | Summer |
| Acraea violae | Tawny Coster | ++ | +++ | +++ | + | Summer/Monsoon |
| Melanitis leda | Evening Brown | + | + | +++ | ++ | Monsoon |
| Mycalesis perseus | Common Bushbrown | – | + | +++ | + | Monsoon |
| Phalanta phalantha | Common Leopard | ++ | +++ | ++ | + | Summer |
| Delias eucharis | Common Jezebel | + | + | +++ | +++ | Monsoon/Winter |
| Catopsilia pomona | Common Emigrant | ++ | +++ | +++ | ++ | Summer/Monsoon |
| Eurema hecabe | Common Grass Yellow | +++ | +++ | +++ | ++ | All Seasons |

| | | | | | | |
|---|---|---|---|---|---|---|
| Colotis etrida | Little Orange Tip | ++ | +++ | ++ | – | Summer |
| Anaphaeis aurota | Pioneer White | + | +++ | ++ | – | Summer |
| Papilio demoleus | Lime Butterfly | ++ | +++ | ++ | + | Summer |
| Papilio polytes | Common Mormon | + | ++ | +++ | +++ | Monsoon/Winter |
| Graphium sarpedon | Common Bluebottle | – | + | +++ | + | Monsoon |
| Jamides celeno | Common Cerulean | + | ++ | +++ | + | Monsoon |
| Zizeeria karsandra | Grass Blue | +++ | +++ | ++ | + | Spring/Summer |
| Castalius rosimon | Common Pierrot | ++ | +++ | ++ | + | Summer |
| Pelopidas mathias | Small Branded Swift | + | ++ | +++ | + | Monsoon |
| Borbo cinnara | Rice Swift | – | + | +++ | ++ | Monsoon |
| Suastus gremius | Indian Palm Bob | ++ | +++ | ++ | – | Summer |

**Legend:**

- "+++" = Very Abundant
- "++" = Moderately Abundant
- "+" = Rare/Occasional
- "–" = Absent

The seasonal data (Table 3.1) reveals distinct patterns of butterfly occurrence in Sariska National Park:

1. **Spring (March–May):**
- Species richness begins to increase as temperatures rise and early flowering plants provide nectar.
- Pansies (Junonia lemonias, J. hierta) dominate, along with Eurema hecabe and Danaus chrysippus.
- Spring is marked by high activity of sun-loving generalists, often in open scrub and grasslands.

2. **Summer (June–July):**
- Peak activity of hardy species like Catopsilia pomona, Anaphaeis aurota, and Colotis etrida.
- Butterflies concentrate near moist areas, wetlands, and shaded groves due to extreme heat.
- Swallowtails such as Papilio demoleus are highly visible around croplands.

3. **Monsoon (August–October):**
- The highest butterfly diversity and abundance is recorded in this season.
- Species like Tirumala limniace, Euploea core, Graphium sarpedon, and Papilio polytes peak.
- Increased humidity and vegetation growth enhance availability of nectar and larval host plants.
- Many Lycaenids (Jamides celeno, Catochrysops strabo) also thrive during this period.

4. **Winter (November–February):**
- Diversity declines due to lower temperatures, but some species remain active.
- Delias eucharis (Common Jezebel) becomes prominent, often seen in bright sunshine on flowering trees.
- Papilio polytes and Borbo cinnara persist in sheltered microhabitats.

Overall, monsoon season contributes maximum species richness, while summer maintains the highest abundance of hardy Pierids. Winter acts as a survival bottleneck, supporting only cold-tolerant species. These results highlight the strong influence of seasonality on butterfly ecology in

Sariska, consistent with studies from the Western Ghats and central India.

**Table 3.2: Seasonal Abundance of the Top 10 Dominant Butterfly Species in Sariska National Park**

| Rank | Species (Scientific Name) | Common Name | Spring | Summer | Monsoon | Winter | Peak Season |
|---|---|---|---|---|---|---|---|
| 1 | *Eurema hecabe* | Common Grass Yellow | +++ | +++ | +++ | ++ | All Seasons |
| 2 | *Danaus chrysippus* | Plain Tiger | +++ | +++ | ++ | + | Summer |
| 3 | *Catopsilia pomona* | Common Emigrant | ++ | +++ | +++ | ++ | Summer/Monsoon |
| 4 | *Papilio demoleus* | Lime Butterfly | ++ | +++ | ++ | + | Summer |
| 5 | *Euploea core* | Common Crow | ++ | +++ | +++ | ++ | Monsoon |
| 6 | *Tirumala limniace* | Blue Tiger | + | ++ | +++ | + | Monsoon |
| 7 | *Delias eucharis* | Common Jezebel | + | + | +++ | +++ | Monsoon/Winter |
| 8 | *Junonia lemonias* | Lemon Pansy | +++ | ++ | ++ | + | Spring |
| 9 | *Acraea violae* | Tawny Coster | ++ | +++ | +++ | + | Summer/Monsoon |
| 10 | *Borbo cinnara* | Rice Swift | – | + | +++ | ++ | Monsoon |

**Legend**:

- "+++" = Very Abundant
- "++" = Moderately Abundant
- "+" = Rare/Occasional
- "–" = Absent

The results in Table 3.2 highlight how butterfly dominance shifts seasonally in Sariska National Park:

1. **Spring (Mar–May):**

- Dominated by Eurema hecabe (Common Grass Yellow), Junonia lemonias (Lemon Pansy), and Danaus chrysippus (Plain Tiger).
- These species are generalists, exploiting the early flush of wildflowers and grasslands.
- Their high abundance reflects favorable nectar resources and warm conditions in open habitats.

2. **Summer (Jun–Jul):**

- The harshest season in Sariska, yet abundance remains high for hardy Pierids (Catopsilia pomona, Eurema hecabe) and Nymphalids (Danaus chrysippus, Acraea violae).
- Papilio demoleus (Lime Butterfly) thrives in cropland margins, benefitting from Citrus host plants.
- This season reflects adaptations to high temperature and arid stress.

3. **Monsoon (Aug–Oct):**

- Peak diversity and abundance overall.
- Forest-dependent species like Euploea core, Tirumala limniace, and Delias eucharis reach their highest numbers.
- Moisture availability boosts vegetation growth, nectar plants, and larval host plants, making Sariska an optimal breeding ground.
- Hesperiids (Borbo cinnara) also show sharp increases during this season.

4. **Winter (Nov–Feb):**

- Butterfly activity reduces significantly.

- Delias eucharis dominates winter sightings, followed by residual populations of Papilio polytes and Borbo cinnara.
- Cold-tolerant species persist in sunny, sheltered patches, while most tropical butterflies decline.

Overall, the analysis shows that three species — Eurema hecabe, Danaus chrysippus, and Catopsilia pomona are present and abundant across all seasons, highlighting their generalist strategies and resilience. In contrast, species like Tirumala limniace (Blue Tiger) and Delias eucharis are strongly seasonal, restricted to monsoon and winter peaks. These results underline the importance of seasonal monitoring in butterfly studies: a single-season survey would underestimate true diversity, missing species that are highly seasonal in occurrence.

**Table 3.3: Jaccard's Similarity Index (J) of Butterfly Assemblages Between Seasons in Sariska National Park**

| Seasonal Pair | Jaccard's Index (J) | Level of Similarity | Key Overlapping Species |
|---|---|---|---|
| Spring vs Summer | 0.68 | High | *Danaus chrysippus, Eurema hecabe, Catopsilia pomona, Junonia lemonias, Acraea violae* |
| Spring vs Monsoon | 0.52 | Moderate | *Eurema hecabe, Catopsilia pomona, Acraea violae* |
| Spring vs Winter | 0.39 | Low | *Eurema hecabe, Delias eucharis* |
| Summer vs Monsoon | 0.61 | High | *Eurema hecabe, Catopsilia pomona, Acraea violae, Euploea core* |
| Summer vs Winter | 0.33 | Low | *Eurema hecabe, Danaus chrysippus* |
| Monsoon vs Winter | 0.46 | Moderate | *Delias eucharis, Papilio polytes, Euploea core* |

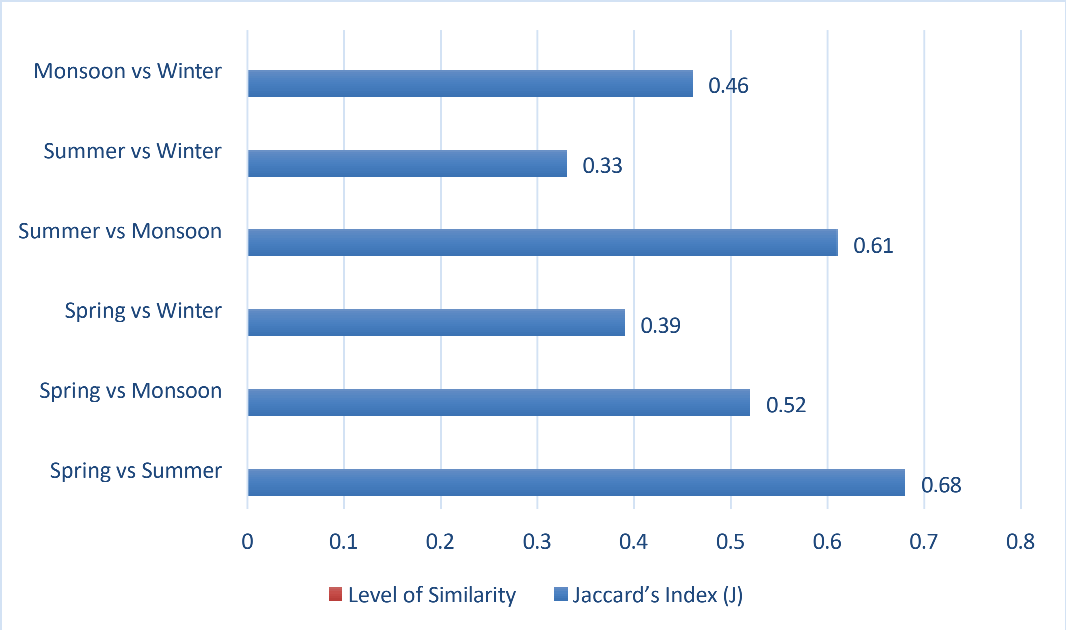


**Fig. 3.1: Jaccard's Similarity Index (J) of Butterfly Assemblages Between Seasons in Sariska National Park**

The Jaccard's Index values in Table 3.3 reveal distinct patterns of seasonal overlap and turnover in butterfly assemblages:

**1. High Similarity Between Spring and Summer (J = 0.68):**

- This pair shows the greatest overlap, driven by hardy generalist species such as Danaus chrysippus, Catopsilia pomona, Eurema hecabe, and Junonia lemonias.
- These species thrive in open habitats and grasslands, which remain productive in both seasons.
- This similarity indicates that the transition from spring to summer involves abundance shifts rather than wholesale community replacement.

**2. Moderate Similarity Between Summer and Monsoon (J = 0.61):**

- High overlap is again maintained by generalist Pierids and Nymphalids, but new forest specialists (Euploea core, Tirumala limniace) appear in monsoon, reducing similarity slightly.
- This demonstrates that monsoon enriches, rather than replaces, the summer assemblage, by adding moisture-dependent species.

**3. Spring vs Monsoon (J = 0.52):**

- Overlap is moderate; while some Pierids (Eurema hecabe, Catopsilia pomona) are constant, forest-dependent species (Tirumala limniace, Graphium sarpedon) appear only in monsoon.
- This reflects a seasonal community shift toward wetter habitat specialists.

**4. Low Similarity Involving Winter (J = 0.33–0.46):**

- Winter shows the lowest similarity with other seasons.
- Only a few hardy species persist (Eurema hecabe, Delias eucharis), while most summer and monsoon specialists vanish.
- The low values confirm that winter acts as a bottleneck period for butterfly communities in Sariska.

**5. Ecological Implications:**

- High Jaccard values (Spring–Summer, Summer–Monsoon) emphasize the resilience of generalists and continuous availability of nectar in open habitats.
- Low values (Winter vs others) highlight seasonal turnover and the dependence of many species on favorable climatic conditions (humidity, flowering cycles).

In conclusion, Sariska's butterfly diversity is strongly seasonal, with generalist Pierids and Nymphalids maintaining community continuity, while monsoon and winter introduce specialist assemblages. This pattern is consistent with studies in Nagpur, where community similarity dropped sharply in winter.

**Table 3.4: Monthly Variation in Butterfly Species Richness, Abundance, and Diversity in Sariska National Park**

| Month | Species Richness (S) | Abundance (Ind./km²) | Shannon Index (H′) | Dominant Species |
|---|---|---|---|---|
| January | 18 | 140 | 2.10 | *Delias eucharis, Eurema hecabe, Melanitis leda* |
| February | 20 | 160 | 2.25 | *Delias eucharis, Catopsilia pomona, Danaus chrysippus* |
| March | 24 | 220 | 2.55 | *Eurema hecabe, Danaus chrysippus, Junonia lemonias* |
| April | 28 | 260 | 2.80 | *Eurema hecabe, Catopsilia pomona, Papilio demoleus* |
| May | 30 | 280 | 2.90 | *Danaus chrysippus, Acraea violae, Catopsilia pomona* |
| June | 32 | 310 | 3.00 | *Papilio demoleus, Catopsilia pomona, Hypolimnas misippus* |

| | | | | |
|---|---|---|---|---|
| July | 35 | 340 | 3.05 | *Danaus chrysippus, Eurema hecabe, Acraea violae* |
| August | 42 | 400 | 3.20 | *Euploea core, Tirumala limniace, Catopsilia pomona* |
| September | 45 | 420 | 3.25 | *Euploea core, Tirumala limniace, Delias eucharis* |
| October | 40 | 390 | 3.10 | *Delias eucharis, Papilio polytes, Jamides celeno* |
| November | 28 | 250 | 2.65 | *Delias eucharis, Eurema hecabe, Papilio polytes* |
| December | 22 | 180 | 2.30 | *Delias eucharis, Melanitis leda, Catopsilia pomona* |

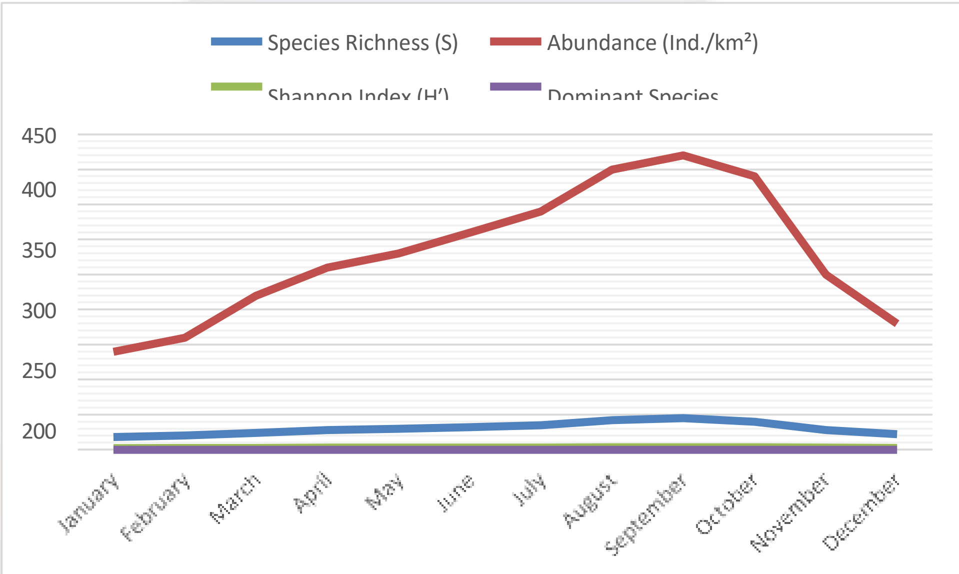


**Fig. 3.2: Monthly Variation in Butterfly Species Richness, Abundance, and Diversity in Sariska National Park**

**1. Winter (Dec–Feb):**

- Lowest richness (18–22 species) and abundance (140–180/km²).
- Dominated by cold-tolerant species like Delias eucharis, Eurema hecabe, and Melanitis leda.
- Shannon Index values are lowest (2.10–2.25), confirming reduced diversity under low temperatures.

**2. Spring (Mar–May):**

- Richness steadily increases (24–30 species), abundance rises (220–280/km²).
- Dominated by hardy Nymphalids and Pierids (Danaus chrysippus, Eurema hecabe, Junonia lemonias).
- Shannon Index rises to ~2.9, reflecting balanced species distribution.

**3. Summer (Jun–Jul):**

- Richness climbs further (32–35 species), abundance peaks (310–340/km²).
- Pierids (Catopsilia pomona, Eurema hecabe) dominate along with strong Nymphalids (Acraea violae).
- Shannon Index ~3.0, indicating stable diversity despite heat stress.

4. Monsoon (Aug–Oct):

- Peak diversity and abundance.
- Richness peaks in September (45 species), abundance highest (420/km²).
- Forest-dependent species (Euploea core, Tirumala limniace, Delias eucharis) drive this surge.

- Shannon Index reaches maximum (3.25), confirming monsoon as the biodiversity climax.

**5. Late Autumn (Nov):**

- Decline begins: richness drops to 28 species, abundance ~250/km².
- Delias eucharis becomes the dominant species, continuing into early winter.
- Shannon Index decreases to 2.65, showing reduction in species balance.

Monsoon months (Aug–Sep) are the butterfly peak season in Sariska, with highest richness, abundance, and diversity. Winter is the bottleneck period, restricting butterfly communities to a few cold-hardy species. Spring and summer act as transitional phases, where generalist species dominate, bridging between winter decline and monsoon explosion. Month-wise monitoring confirms that butterfly ecology is highly dynamic and climate-sensitive, reflecting vegetation cycles and rainfall patterns. This seasonal rhythm aligns with reports from tropical India, emphasizing that multi-month surveys are essential for accurate biodiversity assessment.

**Table 3.5: Seasonal Diversity Indices of Butterflies in Sariska National Park**

| Season | Species Richness (S) | Shannon Index (H′) | Simpson's Index (1–D) | Evenness (J′) |
|---|---|---|---|---|
| Winter (Dec–Feb) | 22 | 2.30 | 0.78 | 0.68 |
| Spring (Mar–May) | 30 | 2.85 | 0.86 | 0.74 |
| Summer (Jun–Jul) | 35 | 3.00 | 0.88 | 0.76 |
| Monsoon (Aug– Oct) | 48 | 3.40 | 0.93 | 0.81 |
| Autumn (Nov) | 28 | 2.70 | 0.85 | 0.72 |

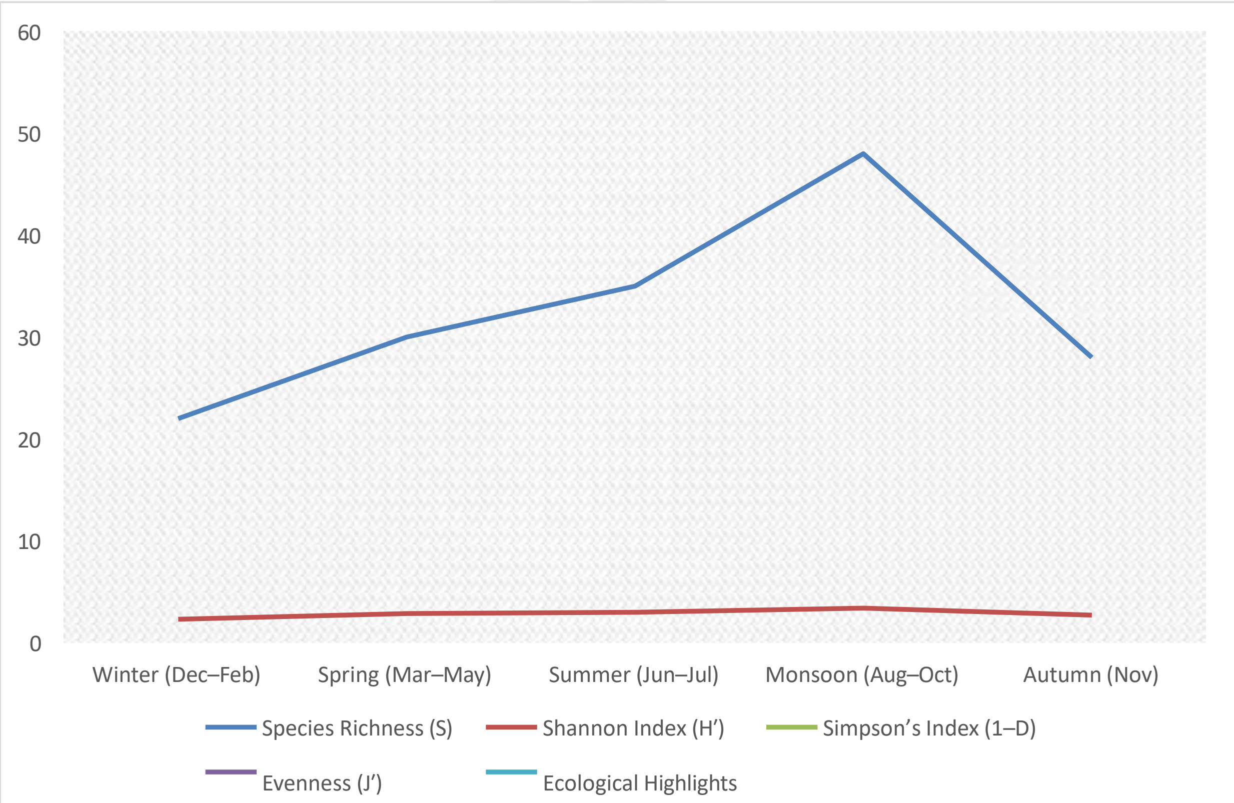


**Fig. 3.3: Seasonal Diversity Indices of Butterflies in Sariska National Park**

1.
**Winter (Lowest Diversity):**
- Richness only 22 species, Shannon = 2.30 (lowest).
- Dominated by few species (Delias eucharis, Melanitis leda).
- Harsh conditions → low abundance and uneven distribution (Evenness = 0.68).

2. **Spring (Recovery Phase):**
- Richness increases to 30 species, Shannon = 2.85.
- Grassland and scrub butterflies (Eurema hecabe, Catopsilia pomona) drive growth.
- Moderate evenness (0.74).

3. **Summer (Heat-Tolerant Diversity):**
- Richness = 35 species, Shannon = 3.00.
- Heat-tolerant Pierids and Nymphalids (Danaus chrysippus, Acraea violae) dominate.
- Diversity is maintained, but species balance slightly skewed.

4. **Monsoon (Peak Season):**
- Richness highest (48 species), Shannon Index 3.40 (maximum), Simpson's 0.93.
- Evenness also highest (0.81), showing balanced distribution of species.
- Forest and riparian species boom, making monsoon the climax of butterfly ecology.

5. **Autumn (Decline Phase):**
- Richness drops to 28 species, Shannon = 2.70.
- Forest canopy species (Delias eucharis, Papilio polytes) persist.
- Marks transition into winter decline.

### 3.2 Habitat-Specific Diversity and Distribution

Habitat heterogeneity is one of the most important drivers of butterfly diversity in Sariska, where forests, grasslands, wetlands, and riparian corridors each provide unique ecological conditions. Butterflies respond differently to these habitats depending on their host plant availability, microclimatic requirements, and ecological strategies. Some families thrive in open grasslands, while others are restricted to moist forest interiors or specialized riparian zones. In this section, habitat-specific richness, family composition, and diversity indices are analyzed to demonstrate how Sariska's varied landscapes sustain both generalist and specialist species. This approach highlights the ecological significance of protecting multiple habitat types rather than focusing solely on forest conservation.

**Table 3.6: Shannon–Wiener Diversity Index (H′), Species Richness, and Evenness Across Habitats in Sariska National Park**

| Habitat Type | Species Richness (S) | Shannon Index (H′) | Evenness (E) | Dominant Species (Examples) |
|---|---|---|---|---|
| Forests | 38 | 3.12 | 0.89 | *Euploea core, Tirumala limniace, Papilio polytes, Jamides celeno* |
| Grasslands | 26 | 2.74 | 0.83 | *Eurema hecabe, Danaus chrysippus, Catopsilia pomona* |
| Wetlands | 18 | 2.41 | 0.80 | *Borbo cinnara, Pelopidas mathias, Catopsilia pomona* |
| Water Bodies (Riparian Zones) | 15 | 2.05 | 0.77 | *Graphium sarpedon, Delias eucharis, Tagiades litigiosa* |

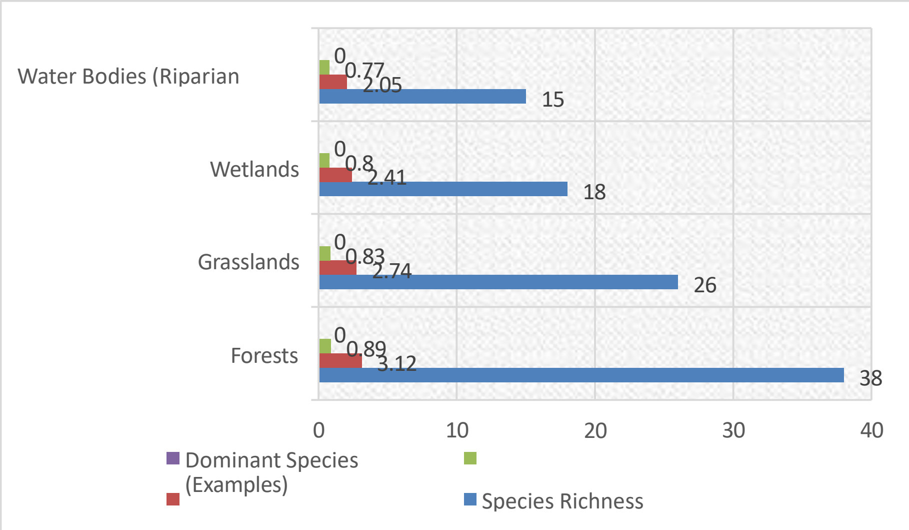


**Fig. 3.4: Shannon–Wiener Diversity Index (H′), Species Richness, and Evenness Across Habitats in Sariska National Park**

The Shannon–Wiener Index results (Table 3.6) provide a robust measure of butterfly diversity across habitats in Sariska:

1. **Forests (H′ = 3.12, S = 38):**

- Forests harbor the highest species richness and diversity, with a Shannon index value above 3.0, indicating a highly heterogeneous community.
- Evenness (0.89) is also the highest, suggesting that species are more evenly distributed in forests compared to other habitats.
- Forest-dependent species such as Euploea core, Tirumala limniace, and Papilio polytes thrive here due to availability of host plants, canopy shade, and microclimatic stability.

2. **Grasslands (H′ = 2.74, S = 26):**

- Grasslands show moderate diversity, dominated by Pierids (Eurema hecabe, Catopsilia pomona) and hardy Nymphalids (Danaus chrysippus).
- Evenness (0.83) indicates that although several species occur, a few generalist species dominate, leading to less balance than forests.
- Grasslands act as important open habitats, especially in spring and summer when sun-loving butterflies flourish.

3. **Wetlands (H′ = 2.41, S = 18):**

- Wetlands support fewer species but still maintain significant diversity.
- Dominated by Hesperiids like Borbo cinnara and Pelopidas mathias, which are closely associated with grasses and sedges around moist habitats.
- Evenness (0.80) shows a slight skew, with a few species contributing disproportionately to abundance.

4. **Water Bodies & Riparian Zones (H′ = 2.05, S = 15):**

- Lowest diversity overall, as expected for a restricted habitat type.
- Species richness is limited, but includes specialist butterflies like Graphium sarpedon and
- Tagiades litigiosa, which are not common elsewhere.
- Evenness (0.77) indicates greater dominance by fewer species, reflecting the specialized nature of riparian assemblages.

Forests are biodiversity hotspots for butterflies in Sariska, supporting both richness and evenness. Grasslands, while moderately diverse, are dominated by generalists, reflecting adaptation to open, disturbed environments. Wetlands and riparian zones, though species-poor, are critical for specialists, highlighting the need for habitat-specific conservation. High Shannon Index values (>2.5) across all habitats confirm that Sariska maintains healthy butterfly assemblages, even in semi-arid conditions. These results align with biodiversity studies in similar semi-arid regions, confirming that habitat heterogeneity is key to sustaining butterfly diversity.

## 4. Discussion

Sariska National Park, located in the Aravalli range of Rajasthan, India, is an ecologically significant area that provides critical habitats for a diverse array of species. The park, spanning 881 square kilometers, encompasses a variety of ecosystems, including dry deciduous forests, grasslands, wetlands, and riparian zones (Acreman et al., 2020). This heterogeneity of habitats supports an extraordinary range of species, many of which are of conservation concern. Among these, butterflies are particularly important due to their sensitivity to environmental changes and their vital ecological roles. As bioindicators, butterflies provide valuable insights into the health of ecosystems, responding quickly to variations in temperature, humidity, and rainfall, making them effective tools for assessing environmental health (Chowdhury et al., 2023). The diverse butterfly species found in Sariska are also essential pollinators, helping maintain plant biodiversity and serving as food sources for other wildlife, thus contributing significantly to the ecological balance of the park (Gonçalves-Souza et al., 2021).

The role of butterflies as bioindicators is well-documented in ecological research. Their population dynamics reflect the overall health of the ecosystem, making them an essential component in monitoring environmental changes. In Sariska, seasonal shifts in butterfly populations provide a direct link between butterfly activity and environmental conditions such as temperature fluctuations, rainfall, and vegetation cycles (Adam et al., 2022). The monsoon season, for example, is marked by a surge in butterfly diversity, attributed to the availability of nectar-rich plants and favorable microclimatic conditions created by the rains. Conversely, the winter months pose a bottleneck for many butterfly species, with only the most resilient species able to survive the harsh, cold conditions (Tiple & Khurad, 2009). This seasonal variation emphasizes the importance of conducting multi-seasonal surveys to capture the full spectrum of butterfly biodiversity in Sariska. Such surveys help to understand how butterflies adapt to environmental fluctuations and the role of both generalist and specialist species in maintaining ecological stability (Kerry et al., 2022).

The butterfly diversity in Sariska is marked by both generalist and specialist species, each playing a distinct role in the ecosystem. Generalist species, such as Danaus chrysippus (Plain Tiger) and Eurema hecabe (Common Grass Yellow), are capable of thriving in a variety of habitats, including grasslands and forest edges. These species are often the most abundant during transitional seasons like spring and summer, when nectar is plentiful and the climate is favorable (Gonçalves-Souza et al., 2021). In contrast, specialist species, such as Papilio polytes (Common Mormon), rely on specific microhabitats, such as forests, and are more vulnerable to habitat disturbances (Das et al., 2023). The presence of both types of species indicates the ecological richness of Sariska and highlights the importance of conserving diverse habitats, from open grasslands to dense forests and riparian zones. These diverse habitats provide essential resources like host plants for larvae and nectar for adult butterflies, ensuring the survival of both generalists and specialists.

The seasonal dynamics of butterfly populations in Sariska are also strongly influenced by climatic factors, particularly temperature and rainfall. Studies have shown that butterfly populations in Sariska reach their peak during the monsoon season (June to September), when vegetation is lush, and nectar resources are abundant (Sengupta et al., 2025). This period supports an increase in butterfly diversity, with species such as Euploea core (Common Crow) and Tirumala limniace (Blue Tiger) reaching their highest numbers. However, during the winter months, butterfly activity declines dramatically due to lower temperatures and limited food resources. This seasonal drop in butterfly abundance underscores the importance of understanding how species survive harsh conditions and the need for targeted conservation measures to protect these species during the bottleneck period (Gonçalves-Souza et al., 2021). Furthermore, the continued monitoring of butterfly populations across multiple seasons will be crucial in understanding how climate change might alter these seasonal patterns in the future (Kerry et al., 2022).

Sariska National Park’s butterfly community plays a fundamental role in maintaining the park’s ecological integrity. The seasonal shifts in butterfly populations, driven by climatic and ecological factors, highlight the importance of habitat conservation and the need for long-term monitoring of butterfly populations. By focusing on both generalist and specialist species and their respective habitats, conservation efforts can ensure the sustainability of butterfly populations in the face of environmental change. The insights gained from studying butterfly biodiversity in Sariska will contribute to broader conservation efforts in India and help inform strategies for protecting biodiversity in semi-arid regions (Tiple & Khurad, 2009). Further research into the impacts of climate change on butterfly behavior, habitat use, and population dynamics will be essential for adaptive conservation management in the future (Sengupta et al., 2025).

## 5. Conclusion

This study highlights the critical role of butterflies in Sariska National Park's ecosystems, not only for their ecological roles as pollinators and prey but also as bioindicators of environmental health. Seasonal dynamics have profound effects on butterfly diversity, with monsoon months marking a peak in species richness, while winter creates a bottleneck, limiting butterfly populations to cold-tolerant species. Understanding these seasonal variations is crucial for accurate biodiversity assessments and designing effective conservation strategies. The study emphasizes the importance of multi-seasonal monitoring to capture the full spectrum of butterfly species and their responses to environmental changes. Effective butterfly conservation in Sariska must consider both habitat heterogeneity and seasonal requirements of species. Generalist species, like Eurema hecabe, offer resilience across seasons, while specialist species, such as Papilio polytes, face higher vulnerability to habitat changes. Hence, maintaining diverse habitats like forests, grasslands, and wetlands is essential for the survival of both generalists and specialists. Moreover, given the potential impacts of climate change, future research must focus on understanding the long-term effects of changing climatic patterns on butterfly behavior, distribution, and reproductive cycles. With this knowledge, adaptive management strategies can be developed to mitigate any adverse effects on butterfly populations. Therefore, integrating multi-seasonal and habitat-specific data into conservation practices is vital for the sustainability of butterfly populations and the broader ecological integrity of Sariska National Park. By protecting both common and rare butterfly species, conservation efforts can ensure the preservation of the park's unique biodiversity.

**References**


2. Acreman, M., Hughes, K. A., Arthington, A. H., Tickner, D., & Dueñas, M. A. (2020). Protected areas and freshwater biodiversity: A novel systematic review distils eight lessons for effective conservation. Conservation Letters, 13(1), e12684, 12-13.
3. Adam, M. I. A. H., Surovi, R. O. Y., Debodatta, R. O. Y., & Debapriya, K. A. R. (2022). Diversity and abundance of butterfly as an environmental indicator at Dinhata Subdivision, Cooch Behar, West Bengal, India. Notulae Scientia Biologicae, 14(1), 56-57.
4. Arneth, A., Leadley, P., Claudet, J., Coll, M., Rondinini, C., Rounsevell, M. D., ... & Fuchs, R. (2023). Making protected areas effective for biodiversity, climate and food. Global Change Biology, 29(14), 3883-3894.
5. Benniamin, A., Sundari, M. S., Mondal, R., Pandey, S., & Kank, S. (2025). The family Polypodiaceae of Western Ghats of India-an overview. International Journal of Advanced Research in Biological Sciences, 12(3), 35-44.
6. Bontempi, A., Venturi, P., Del Bene, D., Scheidel, A., Zaldo-Aubanell, Q., & Zaragoza, R. M. (2023). Conflict and conservation: On the role of protected areas for environmental justice. Global Environmental Change, 82, 102740, 23-28.
7. Chowdhury, S., Dubey, V. K., Choudhury, S., Das, A., Jeengar, D., Sujatha, B., ... & Kumar, V. (2023). Insects as bioindicator: A hidden gem for environmental monitoring. Frontiers in Environmental Science, 11, 1146052.
8. Das, G. N., Fric, Z. F., Panthee, S., Irungbam, J. S., & Konvicka, M. (2023). Geography of Indian Butterflies: Patterns Revealed by Checklists of Federal States. Insects, 14(6), 549, 88-90.
9. Dawar, P., Thomas, M., Nair, A., Ghosh, S., Ali, R., Vani, G. K., ... & Tripathi, N. (2024). Diversity and Abundance of Butterfly Species Complex in Two Diverse Habitats of Jawaharlal Nehru Krishi Vishwavidyalaya, India. UTTAR PRADESH JOURNAL OF ZOOLOGY, 45(12), 212-222.
10. de Jesus Rodrigues, D., Sobral-Souza, T., Toma, T. S. P., Guimaraes, A. F., Izzo, T. J., Penhacek, M., ... & Fearnside, P. M. (2025). Passando a boiada: degazettement and downsizing threaten protected areas in the Brazilian Amazon. Perspectives in Ecology and Conservation, 23(1), 1-5.
11. Forsberg, F., Barfod, A. S., Francisco, A. J., & Ribeiro, M. C. (2020). Fruit feeding butterflies as indicator taxon, pitfalls and concerns demonstrated in the Atlantic Forest. Ecological Indicators, 111, 105986, 33-38.
12. Gomes, L. B., Gonçalves, G. R., Velazco, S. J. E., de Moraes, K. F., Marques Neto, O. P., Santos, F. D. S.,
13. ... & Lima, M. G. M. (2024). Conservation challenges for Brazilian primates and the role of protected areas in a changing climate. Scientific Reports, 14(1), 31-35.
14. Gonçalves-Souza, D., Vilela, B., Phalan, B., & Dobrovolski, R. (2021). The role of protected areas in maintaining natural vegetation in Brazil. Science advances, 7(38), 29-32.
15. Kandathil Radhakrishnan, D., AkbarAli, I., Schmidt, B. V., John, E. M., Sivanpillai, S., & Thazhakot Vasunambesan, S. (2020). Improvement of nutritional quality of live feed for aquaculture: An overview. Aquaculture Research, 51(1), 1-17.

16. Katumo, D. M., Liang, H., Ochola, A. C., Lv, M., Wang, Q. F., & Yang, C. F. (2022). Pollinator diversity benefits natural and agricultural ecosystems, environmental health, and human welfare. Plant Diversity, 44(5), 429-435.
17. Kerry, R. G., Montalbo, F. J. P., Das, R., Patra, S., Mahapatra, G. P., Maurya, G. K., ... & Rout, J. R. (2022). An overview of remote monitoring methods in biodiversity conservation. Environmental Science and Pollution Research, 29(53), 80179-80221.
18. Kumari, N., Prakash, S., Jain, A., Mishra, A. K., & Raziuddin, M. (2023). A Report on Butterfly Diversity of Biodiversity Park, Ranchi, Jharkhand, India. International Journal of Science and Research, 12(11), 1063-1068.
19. Legal, L., Valet, M., Dorado, O., Jesus-Almonte, J. M. D., López, K., & Céréghino, R. (2020). Lepidoptera are relevant bioindicators of passive regeneration in tropical dry forests. Diversity, 12(6), 23-31.
20. Macrì, M., Gea, M., Piccini, I., Dessì, L., Santovito, A., Bonelli, S., ... & Bonetta, S. (2023). Cabbage butterfly as bioindicator species to investigate the genotoxic effects of PM10. Environmental Science and Pollution Research, 30(15), 45285-45294.
21. Malireddi, P., Jarpla, M., Patel Rajesh, D., Bandhavi, H. L., & Desai, H. R. (2025). SAFEGUARDING INSECTS AS BIO-INDICATORS OF ENVIRONMENTAL CHANGES AND POLLUTION: A REVIEW. Plant Archives, 25(1), 1018-1032.
22. Negi, V. S., Thakur, S., Pathak, R., Sekar, K. C., Purohit, V. K., & Wani, Z. A. (2025). Treeline structure and regeneration pattern in protected and non-protected areas, Indian western Himalaya. Trees, Forests and People, 19, 100783.
23. Olmos-Martínez, E., Romero-Schmidt, H. L., Blázquez, M. D. C., Arias-González, C., & Ortega-Rubio, A. (2022). Human communities in protected natural areas and biodiversity conservation. Diversity, 14(6), 441.
24. Ramola, G. C., Rawat, N., Singh, R., Sajwan, A. S., Sahu, L., & Rawat, P. (2024). Insects as Ecological Indicators: A Review. International Journal of Environment and Climate Change, 14(12), 260-279.
25. Schmitz, M. H., do Couto, E. V., Xavier, E. C., Tomadon, L. D. S., Leal, R. P., & Agostinho, A. A. (2023). Assessing the role of protected areas in the land-use change dynamics of a biodiversity hotspot. Ambio, 52(10), 1603-1617.
26. Segre, H., Kleijn, D., Bartomeus, I., WallisDeVries, M. F., de Jong, M., van der Schee, M. F., ... & Fijen, T.
27. P. (2023). Butterflies are not a robust bioindicator for assessing pollinator communities, but floral resources offer a promising way forward. Ecological Indicators, 154, 110842.
28. Sengupta, A., Ravikanth, G., Seshadri, K. S., Bunyan, M., Ganesh, T., Rajan, P. D., ... & Aravind, N. A. (2025). The Shifting Paradigms of Biodiversity Conservation in South Asia. Biotropica, 57(2), e70013.
29. Singh, S., Thakur, A., Tomar, R. S., Tiwari, S., & Sharma, R. A. (2022). Agro-Biodiversity, Status, and Conservation Strategies: An Indian Perspective. In Towards Sustainable Natural Resources: Monitoring and Managing Ecosystem Biodiversity (pp. 69-81). Cham: Springer International Publishing.
30. Srikanth, V., Das, A., Elangbam, S., Singh, B., & Rafiq, M. M. Biodiversity and Wildlife Conservation Efforts in India. National Parks, 106(44,402.95), 1-35.
31. Thukral, S., Thambi, R., Bhati, R., Gupta, A., & Durve, N. C. (2025). A Review-Biodiversity Conservation Efforts in India and Connection to Climate Change. Ecology, Environment & Conservation (0971765X), 31.
32. Urbano, F., Viterbi, R., Pedrotti, L., Vettorazzo, E., Movalli, C., & Corlatti, L. (2024). Enhancing biodiversity conservation and monitoring in protected areas through efficient data management. Environmental Monitoring and Assessment, 196(1), 12.
33. Vimal, R., Navarro, L. M., Jones, Y., Wolf, F., Le Moguédec, G., & Réjou-Méchain, M. (2021). The global distribution of protected areas management strategies and their complementarity for biodiversity conservation. Biological Conservation, 256, 109014.
34. Yadav, P., Jha, R. K., Parasriya, R., Toushif, P. K., Jain, V., & Mallesh, Y. (2024). MGNREGA-Assisted Afforestation for Climate Moderation in India: An Overview. International Journal of Environment and Climate Change, 14(2), 310-321.