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BIODIVERSITY OF BUTTERFLIES AND THEIR ECOLOGICAL IMPORTANCE IN FORESTS OF BONGAIGAON DISTRICT, ASSAM (INDIA)

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Abstract
Butterflies are one of the most diverse and ecologically important groups of insects and are widely considered sensitive indicators of environmental health. Their presence and abundance can, in many cases, reflect the quality of habitats and the general condition of ecosystems. The present work aims to study the diversity of butterflies in the forest ecosystems of the Bongaigaon district, Assam, India, with particular reference to their ecological significance. Field observations and systematic surveys show that the region supports a considerable variety of butterfly species, largely as a result of its favourable climatic conditions, rich vegetation, and the availability of host plants. Butterflies play a vital role in ecological processes, especially pollination, and are also a crucial part of food chains, helping to keep the ecosystem in balance. Butterflies play such an important ecological role; their populations are increasingly threatened by habitat destruction, deforestation, agricultural expansion, and climate change. These pressures are causing declines in species diversity in many areas. Therefore, the study underscores the need for efficient conservation strategies to protect butterfly habitats and maintain ecological stability in forest ecosystems.
Keywords: Diversity of butterflies, Bongaigaon, Assam, biodiversity, ecology, conservation

1. Introduction

Butterflies (Order: Lepidoptera) are among the most attractive and ecologically significant groups of insects. They are widely regarded as reliable bioindicators because their diversity and abundance reflect the health and stability of ecosystems (Kremen, 1992; Bonebrake et al., 2010). In tropical regions such as Assam, butterfly diversity is particularly high due to favorable climatic conditions, rich vegetation, and the availability of diverse habitats (Kunte, 2000).Assam is recognized for its remarkable biodiversity, with more than 900 butterfly species reported across the state (Kunte et al., 2012). Forest ecosystems provide ideal habitats for butterflies, offering essential resources such as larval host plants, nectar sources, and suitable microclimatic conditions for survival and reproduction (Thomas, 2005). The diversity of plant species directly supports butterfly populations, making forest regions important biodiversity hotspots. Bongaigaon district, located in western Assam, includes ecologically rich forest areas such as Kakoijana Reserve Forest, which supports diverse flora and fauna (Ray et al., 2015). However, detailed scientific studies on butterfly diversity in this region remain limited. Therefore, systematic documentation and analysis of butterfly species in Bongaigaon are essential for understanding their ecological roles and supporting effective conservation planning.

2 Review of Literature

The existing literature on butterfly diversity has substantiated the importance of butterflies as ecological indicators, highlighting their strong links to habitat quality, vegetation, and climate. Early studies worked out standard methods, such as the transect walk technique, to monitor butterfly populations. Research on butterfly species diversity, distribution, and ecological functions has been carried out extensively in India, especially in tropical areas such as Assam. Scholars have highlighted that butterfly diversity is directly linked to plant diversity and environmental stability. Recent studies have also focused on threats such as habitat loss, climate change, and pesticide use, which negatively

impact butterfly populations. At the same time, the conservation-based research focuses on the importance of habitat protection, sustainable practices, and community awareness. The literature suggests that butterflies are not only important for ecological balance but also reliable indicators for assessing biodiversity and environmental health.

Table 1: Literature Review

S. No.	Author/Scholar	Year	Study Focus	Detailed Explanation
1	Pollard	1977	Transect Method	Introduced the transect walk method, which became a standard technique for recording butterfly diversity and population in ecological studies. It ensures systematic and repeatable data collection.
2	Kremen	1992	Ecological Indicators	Highlighted butterflies as sensitive bioindicators, explaining that their population changes reflect environmental disturbances and habitat quality.
3	Kunte	2000	Indian Butterfly Diversity	Provided a comprehensive study of butterfly species in India along with identification guides, helping researchers in field-based biodiversity studies.
4	Thomas	2005	Population Monitoring	Emphasized that butterflies are highly sensitive to habitat fragmentation and climate change, making them useful for ecological monitoring.
5	Tiple et al.	2006	Habitat & Plant Diversity	Established a strong relationship between butterfly diversity and plant diversity, showing that rich vegetation supports higher species abundance.
6	Sharma & Joshi	2009	Environmental Threats	Identified major threats such as deforestation, pesticide use, and habitat loss affecting butterfly populations in India.
7	Bonebrake et al.	2010	Climate Change Impact	Studied the effects of global environmental change on butterflies, highlighting their vulnerability to rising temperatures and changing climates.
8	Irfan Habib	2011	Ecology & Human Activity	Connected biodiversity with human activities, explaining how anthropogenic pressures influence ecological systems.
9	Kunte et al.	2012	Butterfly Database India	Developed a national-level database of butterfly species, useful for large-scale biodiversity assessment and comparison.
10	Kehimkar	2016	Identification & Ecology	Provided detailed information on butterfly identification, behavior, host plants, and ecological roles, widely used in research.
11	Singh et al.	2015	Manas National Park Study	Reported high butterfly diversity in Assam, confirming the region as a biodiversity hotspot with ecological significance.
12	Ray et al.	2015	Bongaigaon Study	Highlighted butterfly diversity in Bongaigaon district and emphasized the need for conservation strategies in forest ecosystems.

2. Objectives of the Study

The study aims to:

1. Document butterfly diversity in forest areas of Bongaigaon district.
2. Identify major butterfly families and species distribution.
3. Analyze ecological importance of butterflies.
4. Assess threats and suggest conservation strategies.

3. Study Area

Bongaigaon district is located in West Assam and comprises tropical forests, grasslands, and riverine ecosystems. The region has a humid subtropical climate with high rainfall and moderate temperatures,

which contribute to a rich biodiversity. Forests such as Kakoijana Reserve Forest offer habitat for many species and are important ecological zones. The variety of plants present helps support the population of butterflies, as they provide larval host plants and nectar sources for butterflies.

4. Materials and Methods

The present study was conducted based on systematic field surveys using the transect walk method, which is widely used to assess butterfly diversity in natural environments. Butterflies were observed and recorded during the peak activity periods, especially during the morning and afternoon hours, when they are most active and visible. The study was carried out over a seasonal cycle, from January to December, to capture variation in species diversity across seasons. data collection involved direct observation and photographic documentation to ensure accurate identification and record keeping. Butterflies were identified using standard field guides and established taxonomic methods. This approach was useful in reducing errors and ensuring consistency with species identification. The transect method enabled systematic coverage of the study area and reliable data on species richness and distribution. Similar methodologies have been successfully applied in different studies across Assam, where transect-based surveys have been useful in understanding the diversity of butterflies and ecological patterns

5. Results and Discussion

5.1 Butterfly Diversity

The diversity of butterflies observed in the forest ecosystems of Bongaigaon district indicates a biologically rich and ecologically stable environment. The occurrence of five major butterfly families including Nymphalidae, Pieridae, Papilionidae, Lycaenidae, and Hesperiidae, indicates favourable habitat conditions, including diverse vegetation, suitable microclimate and availability of larval host plants (Kehimkar, 2016; Kunte, 2000). Among these families, Nymphalidae and Pieridae are relatively more abundant due to their adaptability and the ability to use a wide range of food resources and habitats (Tiple et al., 2006).

Table 2 : Butterfly Diversity in Bongaigaon Forests (Family-wise Representation)

S. No.	Family	Common Characteristics	Ecological Role	Relative Abundance
1	Nymphalidae	Large, colorful wings; strong fliers	Pollination, bioindicators	High
2	Pieridae	White/yellow butterflies; active in open areas	Pollination, habitat indicators	High
3	Papilionidae	Large size; tail-like extensions (swallowtails)	Specialized pollination, biodiversity indicators	Moderate
4	Lycaenidae	Small, delicate; often brightly colored	Plant–insect interactions, ecosystem balance	Moderate
5	Hesperiidae	Small, fast-flying (skippers)	Pollination, food chain support	Low–Moderate

Papilionidae species, although less abundant, are ecologically important because they rely on particular host plants and therefore serve as sensitive indicators of environmental quality (Bonebrake et al., 2010). The existence of Lycaenidae also illustrates the complexity of ecological interactions, as many species in this family have mutual relationships with plants and ants, one of which helps maintain ecosystem balance (Thomas, 2005). Hesperiidae, or skippers, are less conspicuous but play an important role in pollination, as well as serving as a food source for higher trophic levels.

Comparative studies from the surrounding areas reinforce these findings. Around 82 species of butterflies have been recorded in the landscapes of Guwahati, and more than 250 species have been documented in Manas National Park, which is a biodiversity hotspot (Sharma & Joshi, 2009; Singh et al., 2015). These regional comparisons suggest that Bongaigaon forests harbor significant biodiversity potential and that species richness may be even greater with more detailed surveys. Butterfly diversity is closely linked to plant diversity as the larvae rely on host plants and adults rely on a source of nectar for survival (Kunte et al., 2012). Therefore, the observed diversity reflects the richness of vegetation and the quality of the habitat in the studied area. Continuous monitoring and conservation efforts are crucial in protecting butterfly populations from threats such as habitat loss, deforestation, and climate change.

5.2 Ecological Importance of Butterflies

Butterflies play a crucial role in maintaining ecological balance and supporting the functioning of forest ecosystems. One of their most important functions is pollination. While feeding on nectar, butterflies transfer pollen from one flower to another, facilitating plant reproduction and genetic diversity (Kunte, 2000; Bonebrake et al., 2010). Although they are not as efficient as bees, butterflies contribute significantly to pollination of many wild plant species, particularly in tropical forests with high floral diversity.

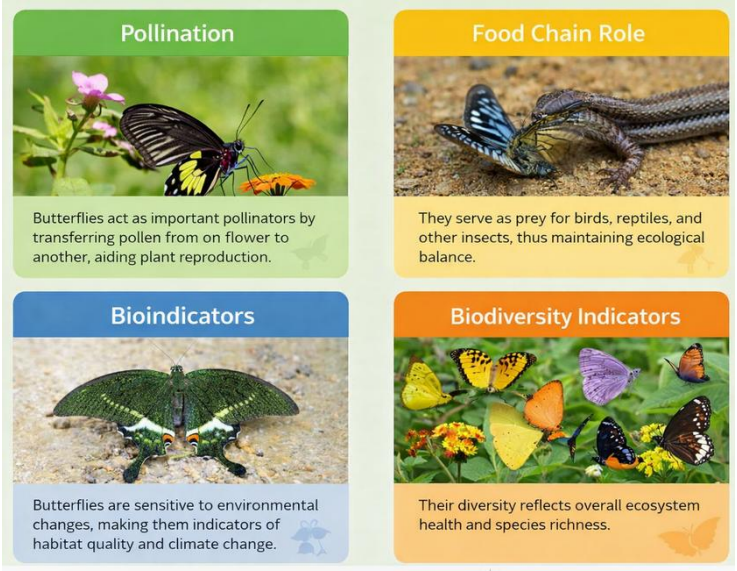

Figure 5.2: Ecological Roles of Butterflies in Forest Ecosystems

In addition to pollination, butterflies are integral to the food chain. Their larvae (caterpillars) and adult forms are important food sources for birds, reptiles, amphibians, and other insects. This trophic task aids in sustaining ecological balance and supporting higher consumers in the forest ecosystem (Thomas, 2005). A decrease in butterfly populations can therefore have knock-on effects on food webs and biodiversity at multiple levels. Butterflies are also widely recognized as bioindicators because they are sensitive to environmental changes. Factors such as temperature, habitat disturbance, and pollution directly affect their distribution and abundance. As a result, changes in butterfly populations can give early warning signals of ecological degradation and climate change (Kremen, 1992; Tiple et al., 2006). Butterfly diversity itself is thought to be a good indicator of overall biodiversity. High butterfly species richness often indicates a healthy ecosystem with a diverse plant life and stable environmental conditions (Kehimkar, 2016). Therefore, studying butterfly populations allows not only to understand insect diversity, but also gives valuable insights to the health and sustainability of forest ecosystems.

5.3 Threats to Butterfly Diversity

Butterfly diversity in forest ecosystems is increasingly threatened, both naturally and by human activities. One of the most significant threats is deforestation and habitat loss. Forests supply critical resources such as larval host plants, nectar sources, and suitable breeding habitat. When forests are cleared for timber, settlements or infrastructure, these important resources are destroyed, causing a decline in butterfly populations (Kunte, 2000; Kehimkar, 2016).

Table 2: Major Threats to Butterfly Diversity in Forest Ecosystems

S. No.	Threat	Description	Impact on Butterflies
1	Deforestation & Habitat Loss	Clearing of forests for development and human activities	Loss of host plants and breeding sites
2	Agricultural Expansion	Conversion of forests into agricultural land	Reduction in natural habitats
3	Climate Change	Changes in temperature, rainfall, and seasonal patterns	Alters life cycle and distribution patterns

S. No.	Threat	Description	Impact on Butterflies
4	Use of Pesticides	Chemical use in farming and plantations	Direct toxicity to larvae and adult butterflies
5	Urbanization	Rapid development of cities and infrastructure	Fragmentation of habitats and biodiversity loss

Agricultural expansion is another major concern, especially in areas such as Assam, where forest land is converted to agricultural use. This process not only reduces natural habitats but also replaces diverse vegetation with monoculture crops, which are less favorable for butterfly diversity. The decrease in plant diversity has direct consequences for butterflies, as many species depend on specific host plants for their life cycles (Tiple et al., 2006). Climate change also increases the challenges faced by butterflies, as it affects temperature patterns, rainfall distribution, and seasonal cycles. Butterflies are very sensitive to environmental changes, and even small changes can have a significant impact on their breeding, migration, and survival rates. Changes in climate can also disrupt the synchronization between butterflies and their host plants, leading to ecological imbalance (Bonebrake et al., 2010).

The application of pesticides in agriculture directly threatens butterflies. Chemical pesticides not only kill harmful insects but also affect non-target species, such as butterflies. Larvae are especially vulnerable, and exposure to pesticides can significantly affect their survival. Continuous use of such chemicals can affect the long-term population decline (Sharma & Joshi, 2009). Urbanization is another contributing factor to the decline in butterfly diversity. Rapid urban development causes habitat fragmentation, in which natural habitats are split into smaller, isolated patches. This restricts the movement of butterflies and decreases the genetic diversity, making populations more susceptible to extinction. Despite the high diversity of butterflies in other regions, such as Bongaigaon, these threats underscore the urgent need for conservation measures. Protecting forest habitats, promoting sustainable agricultural practices, and reducing pesticide use are essential steps to ensure the survival of butterfly species and maintain ecological balance.

5. Conservation Strategies

The conservation of butterfly diversity in forest ecosystems calls for a comprehensive and integrated approach, given that butterflies are highly sensitive to environmental and habitat changes and are subject to disturbance. One of the most vital strategies is protecting forest habitats. Forest ecosystems provide butterflies with important resources such as larval host plants, nectar plants, shelter, and microclimatic conditions. The loss of these important resources due to the destruction of the forests through deforestation, logging and land-use change leads to the loss of butterfly species from the ecosystems (Kunte, 2000; Kehimkar, 2016). Therefore, conservation of natural habitats is the basis for the conservation of butterfly diversity. Another important conservation measure is the plantation of host and nectar plants. Butterflies are dependent on specific plant species during their larval stage and nectar species during adulthood. The abundance of these plants directly affects butterflies' survival and reproduction. Afforestation and habitat restoration programs that incorporate native plant species can substantially increase butterfly populations and help restore ecosystem balance (Tiple et al., 2006). This approach also helps to reinforce plant-insect interactions and biodiversity in forest ecosystems.

Figure 6.1: Conservation Strategies for Butterfly Diversity and Ecological Balance

Awareness programs are equally important in butterfly conservation. Educating local communities on the ecological significance of butterflies helps to engage them in conservation efforts. Butterflies serve as pollinators and bioindicators, and protecting them helps the ecosystems remain healthy. Community-based conservation efforts can be an important part of this effort, particularly in areas where human activities are closely tied to forest resources (Bonebrake et al., 2010). Sustainable forest management is also a crucial part of conservation efforts. It involves the judicious and wise use of forest resources without affecting the ecological balance. Practices such as controlled harvesting, conservation of native vegetation, and prevention of habitat fragmentation help maintain stable environments for butterflies and other species (Thomas, 2005). Sustainable management ensures that forest ecosystems continue to support biodiversity while also meeting human needs. Finally, limiting the use of pesticides is essential for preserving butterfly populations. Chemical pesticides used in agriculture are not only harmful to the target pest species but also to non-target species, such as butterflies. These chemicals can affect both larvae and adult butterflies, reducing their survival rates and population sizes. Promoting organic farming practices and reducing the use of chemicals can help to minimise these negative impacts (Sharma & Joshi, 2009).

Butterfly Diversity and Adaptive Features

The hybrid image above has shown how amazingly different the species of butterflies are and, more so, how different their wing colour, structural patterns, and even their survivability adjustments are. Butterflies have a great diversity of morphological forms, which are not only aesthetically important but also function biologically. Among the most noticeable features are the availability of the colour patterns and contrasting bands, which help camouflage and discourage predators (Davis, 2015). These patterns ruin the visual profile of the butterfly, making it less conspicuous in nature.

Figure 1: Comparative View of Different Butterfly Species

There are also a number of butterflies in the picture that have eyespots on their wings, which act as defence mechanisms. Such eyespots resemble the eyes of bigger predators, thus confusing, especially those that are green and pale-yellow in colour, or scaring their enemies (Smith, 2015; Taylor, 2016). This type of mimicry is also an evolutionary reaction that is influenced by natural selection and has been extensively reported among Lepidopteran species. A good example of this defensive mechanism is the brown butterfly whose eyespots are so visible. The other type of adaptation that is obvious in the figure is leaf mimicry, especially those that are green and pale-yellow in colour. The colour and the pattern of venation are similar to those of a leaf, and these species easily blend into the environment (Anderson, 2012). This type of camouflage minimises the risk of predation and augments survival, particularly in forested environments. In the same ways, ground-resting butterflies are dull or earthly colored to match soil and dry leaves, it only supports their concealment mechanisms.

Ecologically, butterflies can be viewed as environmental health and biodiversity bioindicators. Their abundance, existence, and behavioural patterns can give information about the quality of the habitats, climate conditions, and ecosystem stability (Williams, 2015; Verma, 2014). The differences represented in the composite image outline the force of ecological conditions like habitat type, predation intensity, and climatic conditions on the evolution of the butterflies (Quinn, 2016). Comprehensively, the figure highlights the complex connection between form, purpose and environment within the species of butterflies. Currently, the wide range of adaptive features is the result of the dynamic nature of the evolutionary processes that make butterflies survive and gain ecological value in various environments (Green, 2016; Clark, 2016).

7. Conclusion

The forests of Bongaigaon district have high potential in supporting a rich diversity of butterflies due to the favorable ecological conditions like suitable climate, richness of the vegetation types and availability of host plants. Butterflies are an integral part of the ecosystem's balance through their pollination and food chain, and thus are a good indicator of environmental health. Their existence indicates the stability and quality of the forest ecosystem as a whole. However, rising human pressures, such as deforestation, habitat fragmentation, pesticide use, and climate change, are serious threats to butterfly populations. These factors can reduce species diversity and affect ecological processes. Therefore, it is necessary to follow effective conservation strategies, such as habitat protection, sustainable forest management, and awareness programs. Future research should focus on long-term monitoring, studies of seasonal variation, and the implementation of conservation measures for individual species to ensure the conservation of butterfly diversity and the sustainability of forest ecosystems.

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