International Journal of Web of Multidisciplinary Studies
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
website: http://ijwos.com
Volume.03 Issue.01.
OPEN ACCESS
E-ISSN : 3049-2424
DOI: https://doi.org/10.71366/ijwos
IJWOS International Journal of Web of Multidisciplinary Studies

A Review: Butterfly Assortment and Their Ecosystem Services for Society

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Article Info

Article History:

Published:06 Jan 2026

Publication Issue:
Volume 3, Issue 01
January-2026

Page Number:
102-114

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Abstract:

Butterflies (Order Lepidoptera) are among the most conspicuous and ecologically important groups of insects. They exhibit high species diversity, complex life cycles, and acute sensitivity to environmental changes. This review synthesizes the current literature on butterfly diversity, including taxonomic, geographical, and ecological patterns, and examines their ecosystem services for both ecosystems and human society. Particular emphasis is placed on their roles as pollinators, bioindicators, components of food webs, and agents of environmental education, ecotourism, and conservation awareness. Understanding butterfly diversity and ecological functions is crucial for promoting biodiversity conservation and sustainable development.

Keywords: Lepidoptera, Geographical, Ecosystem, Bioindicator, Food web.

1. Introduction

Butterflies are an important part of global biodiversity, with over 17,500 species found worldwide (Heppner, 1998). Butterflies (Order Lepidoptera, Superfamily Papilionoidea) are considered a vital component of global biodiversity due to their high species richness, wide geographical distribution, and ecological roles in terrestrial ecosystems. Among the diverse array of life forms on Earth, butterflies are one of the most studied and visually appealing groups of insects. Taxonomic estimates suggest that there are numerous species of butterflies worldwide, making them a significant part of terrestrial animal diversity. These species are found on most continents, inhabiting a wide range of habitats, from tropical rainforests to temperate grasslands. Thus, butterflies contribute significantly to the diversity of life forms on the planet and serve as important components of ecological communities. Their complete metamorphosis and close association with host plants make them valuable model organisms in ecological, evolutionary, and environmental studies (Boggs et al., 2003). Butterflies are highly specific to their host plants, particularly during the larval stage, when caterpillars often feed on only a few specific plant species. This close relationship makes butterflies particularly valuable for studying plant-insect interactions, co-evolution, and ecological specialization (Ehrlich and Raven, 1964). Changes in plant availability or quality can directly impact butterfly populations, making them useful indicators for investigating the effects of habitat loss, climate change, and environmental disturbances. Consequently, butterflies are frequently used in environmental monitoring and conservation biology, where their population trends help reflect the health of the broader ecosystem

(Bonebrake et al., 2010). Beyond their aesthetic appeal, butterflies play crucial roles in ecosystem functioning and serve as indicators of environmental quality. This review explores the patterns of butterfly diversity, ecological roles, and their ecosystem services for human society and sustainable practices.

2. Butterfly Diversity: Patterns and Drivers

2.1 Taxonomic Diversity

Butterflies belong to the order Lepidoptera, which also includes moths. The main families of butterflies include Papilionidae, Pieridae, Nymphalidae, Lycaenidae, and Hesperiidae (Kristensen et al., 2007). Butterflies are classified in the order Lepidoptera, one of the largest and most diverse orders of insects, which also includes moths. The name Lepidoptera is derived from the Greek words lepidos (scale) and ptera (wings), referring to the microscopic scales that cover the wings and bodies of these insects. While butterflies and moths share many structural and developmental characteristics, such as complete metamorphosis and scaled wings, butterflies are typically distinguished by features such as club-shaped antennae, diurnal activity, and an upright resting wing posture (Scoble, 1995). Within Lepidoptera, butterflies are further divided into several large families based on morphological, behavioral, and genetic characteristics. Papilionidae (swallowtails) are typically large, colorful butterflies, often with tail-like extensions on their hindwings. Pieridae (whites and sulphurs) are generally light-colored and commonly associated with open habitats. Nymphalidae, the largest family of butterflies, includes diverse species such as monarchs and admirals and is characterized by reduced forelegs in many species. Lycaenidae (blues, coppers, and hairstreaks) are typically small butterflies, many of which have complex relationships with ants. Hesperiidae (skippers) are distinguished by their robust bodies, rapid flight, and hooked antennae (Ackery et al., 1999). These families differ in wing morphology, larval host plant specificity, behavior, and habitat preferences, reflecting a wide range of ecological adaptations, (Table 1).

Table 1: Life stages of butterflies across different families.

Family	Egg Stage	**Larva** (Caterpillar)	**Pupa** (Chrysalis)	Adult Butterfly
Papilionidae (Swallowtails)	Eggs laid singly on host plants	Large, smooth caterpillars; some have a smelly defense organ (osmeterium)	Green or brown chrysalis, often attached upright	Large, colorful butterflies with tail-like extensions
Pieridae (Whites & Sulphurs)	Small, yellow or white eggs	Slender green caterpillars that blend with plants	Green chrysalis attached to stems	Mostly white or yellow butterflies
Nymphalidae (Brush-footed)	Eggs laid singly or in clusters	Spiny or hairy caterpillars	Angular or spiky chrysalis	Strong fliers; front legs reduced
Lycaenidae (Blues, Coppers, Hairstreaks)	Tiny, flattened eggs	Small, slug-like caterpillars; often cared for by ants	Short, rounded chrysalis near ground	Small, brightly colored butterflies
Hesperiidae (Skippers)	Eggs laid on grasses	Caterpillars live in rolled leaves	Cocoon-like chrysalis in leaves	Small, fast-flying butterflies with thick bodies

The average number of days spent in each developmental stage (egg, larva, and pupa) and the total time taken to reach the adult stage for five butterfly families are presented. Papilionidae (swallowtails) take approximately 49 days to complete development, with relatively long larval (24.5 days) and pupal (17.5 days) stages, reflecting their larger body size. Pieridae (whites and sulphurs) have the shortest life cycle, averaging 33 days, due to rapid egg hatching (5 days) and shorter larval (17.5 days) and pupal (10.5 days) stages, allowing for multiple generations per year. Nymphalidae (brush-footed butterflies) exhibit one of the longest developmental periods at 52.5 days, primarily due to a prolonged larval stage (28 days) that supports greater development and stronger flight capabilities. Lycaenidae (blues, coppers, and hairstreaks) complete their life cycle in a moderate 36 days, characterized by the shortest egg stage (4.5 days) and a short pupal period (10.5 days), typical of smaller butterflies and contributing to rapid population turnover. Hesperiidae (skippers) show the longest overall development time at 53 days, with extended larval (28 days) and pupal (17.5 days) stages, likely due to their robust body structure and slow-developing, grass-feeding caterpillars, (Figure 1).

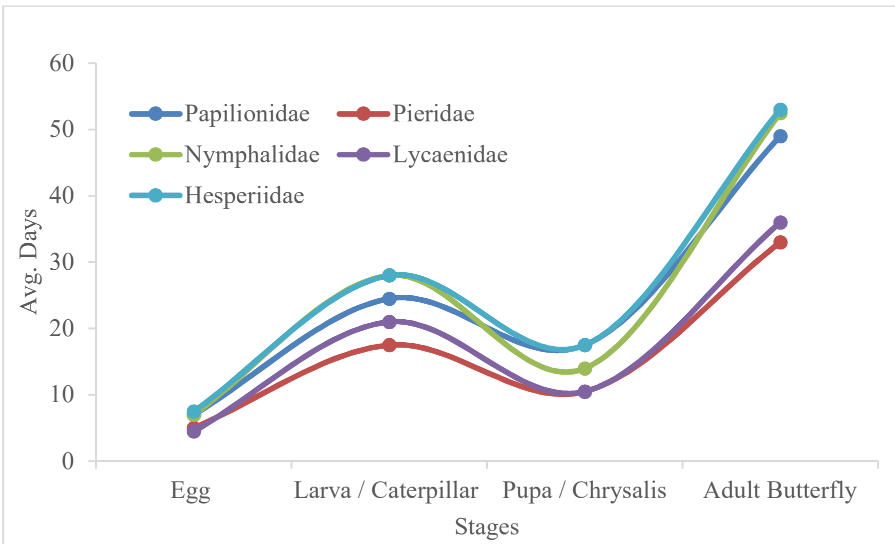

Figure 1: Average estimated number of days in the life cycle of different butterfly families.

2.2 Geographic Distribution and Hotspots

Due to favorable climatic conditions and greater plant diversity, the greatest diversity of butterflies is found in tropical and subtropical regions (Ghazoul, 2002). Biodiversity hotspots such as the Amazon Basin, Central African rainforests, South and Southeast Asia, and Madagascar support high species richness and endemism (Myers et al., 2000). Endemism, the presence of species found nowhere else on Earth, is exceptionally high in these regions due to geographical isolation and long periods of evolutionary stability. For example, Madagascar's separation from mainland Africa has led to the evolution of unique flora and fauna, many of which are endemic (Mittermeier et al., 2004). Similarly, the Amazon Basin and the rainforests of Southeast Asia support a tremendous diversity of plant life, which in turn sustains highly specialized animal species, including insects, birds, and mammals. This combination of high species richness and endemism makes these hotspots critically important for global biodiversity conservation, as habitat loss in these areas can lead to the irreversible extinction of species. Conversely, temperate regions have fewer species but often exhibit strong seasonal population dynamics. Compared to tropical and subtropical regions, temperate regions generally have fewer species, but these species often exhibit large seasonal fluctuations in population size. Seasonal changes in temperature, daylight, and resource availability in temperate climates strongly influence the life cycles of butterflies. Many species are active only during specific times of the year, with populations increasing rapidly during favorable periods such as spring and summer and declining during the colder months (Pollard and Yates, 1993). This seasonality limits the number of species that can survive year-round, resulting in lower overall species diversity compared to tropical regions. Despite lower diversity, temperate butterfly populations exhibit well-defined and predictable fluctuations, making them particularly useful for ecological and population studies. Adaptations such as diapause, migration, and synchronized emergence help butterflies survive unfavorable conditions and take advantage of short periods of resource abundance (Dennis, 1993). These strong seasonal patterns make temperate species highly sensitive to environmental changes, including climate change, habitat alteration, and shifts in phenology.

2.3 Drivers of Diversity

Butterfly diversity is shaped by several interacting factors. Climate influences species distribution, phenology, and survival (Parmesan et al., 1999). Butterfly diversity is shaped by a multitude of interconnected environmental and biological factors, with climate playing a central role. Climatic factors such as temperature, rainfall, and seasonality significantly influence the geographical distribution of butterfly species by determining where suitable environmental conditions exist. Because butterflies are ectothermic organisms, their physiological processes, including development, reproduction, and flight activity, are highly dependent on ambient temperatures (Parmesan, 2006). Consequently, climate acts as a major limiting factor for species ranges at both local and global scales. Climate also influences phenology, which refers to the timing of biological events such as emergence, reproduction, and migration. Changes in temperature and seasonal patterns can alter the timing of butterfly life-cycle stages, potentially leading to mismatches between butterflies and their host plants or nectar resources (Roy & Sparks, 2000). Furthermore, extreme climatic events such as droughts, heat waves, or unusually cold periods can directly impact survival rates, particularly during sensitive life stages such as eggs and larvae. Collectively, these climate-driven effects, along with habitat availability and species-specific characteristics, shape the patterns of butterfly diversity and population dynamics across different regions, (Table 2). The availability of larval host plants strongly determines species presence and abundance (Ehrlich and Raven, 1964). Landscape heterogeneity promotes niche specialization, while human-induced land-use changes can either reduce diversity through habitat loss or increase local richness in managed green spaces such as gardens and parks (Thomas, 2005). Landscape heterogeneity, defined as the diversity and spatial arrangement of habitat types within a landscape, plays a crucial role in promoting niche specialization and supporting higher butterfly diversity. Heterogeneous landscapes provide a mosaic of microhabitats, host plants, and nectar resources that allow different butterfly species to exploit specific ecological niches (Tscharntke et al., 2005). Such environmental complexity reduces competition and enables the coexistence of species with different ecological requirements, particularly those with specialized larval host plants or habitat preferences. Conversely, human-induced land-use changes, such as urbanization, intensive agriculture, and deforestation, often lead to habitat loss and fragmentation, resulting in a decline in butterfly diversity at the regional level. The removal of native vegetation and the simplification of landscapes reduce available resources and disrupt dispersal pathways, negatively impacting specialist species (New, 1997). However, land-use change does not always lead to biodiversity loss. Managed green spaces, including gardens, parks, and urban reserves, can enhance local species richness by providing floral resources, host plants, and refuge habitats, especially for generalist and adaptable butterfly species (Goddard, Dougill, & Benton, 2010). Thus, the impact of human activities on butterfly diversity depends on the scale, intensity, and management of land-use practices.

Table 2: Comparative duration of the stages of the butterfly's life cycle according to the family.

Family	Egg (days)	Larva / Caterpillar (days)	Pupa / Chrysalis (days)	Adult Butterfly: Total Life Cycle (days)
Papilionidae	4-10	21-28	14-21	39-59
Pieridae	3-7	14-21	7-14	24-42
Nymphalidae	4-10	21-35	7-21	39-66
Lycaenidae	3-6	14-28	7-14	24-48
Hesperiidae	5-10	21-35	14-21	40-66

3. Ecological Roles of Butterflies

3.1 Pollination and Plant Interactions

Butterflies act as pollinators for many flowering plants, especially those with brightly colored flowers and easily accessible nectar (Ollerton et al., 2011). Butterflies play a crucial role as pollinators in many terrestrial ecosystems, particularly for flowering plants with brightly colored petals and easily accessible nectar. Unlike some specialized pollinators, butterflies are primarily attracted by visual cues such as bright colors, especially red, orange, pink, and purple, and the structure of the flowers, which allows them to access the nectar with their long proboscis (Proctor, Yeo, and Lack, 1996). As butterflies move from flower to flower in search of nectar, pollen grains adhere to their bodies and are subsequently transferred between plants, facilitating cross-pollination. Although butterflies are generally considered less efficient pollinators than bees, their mobility and frequent visits to a wide variety of flowering plants make them significant contributors to pollination networks. This is especially important in open areas such as meadows, gardens, and forest edges, where butterfly-pollinated plants are common (Willmer, 2011). Butterflies can promote genetic diversity within plant populations by transferring pollen over relatively long distances. Their role as pollinators highlights their ecological importance and further emphasizes the need to conserve butterfly populations as part of the functioning of larger ecosystems. Although generally less efficient than bees, butterflies contribute to long-distance pollen dispersal, increasing genetic diversity in plant populations.

3.2 Contribution to Food Chains

Butterflies and their larvae are essential parts of the terrestrial food chain. Caterpillars are preyed upon by birds, reptiles, and parasitic insects, while adult butterflies are eaten by birds and spiders (Price et al., 2011). Caterpillars and their pupae are integral components of terrestrial food chains, contributing to the cycling of energy, nutrients, and glucose within the ecosystem. During the larval stage, caterpillars act as primary consumers, feeding on plants and incorporating plant biomass into their tissues. These caterpillars, in turn, are a recognizable food source for a variety of predators, including birds, reptiles, and parasitic insects such as wasps and flies, (Table 3). Parasitic or more accurately, parasitoid wasps play a significant role in controlling caterpillar populations by laying eggs on or inside the larvae, thereby impacting caterpillar survival and population dynamics (Price et al., 1997; Hawkins, 1994). Adult moths also contribute to the food web as prey at higher trophic levels. Birds and spiders are among the most common predators of adult moths, catching them while in flight or at rest on vegetation. Although moths possess several defense strategies, such as camouflage, mimicry, and chemical defenses, predation remains a major factor shaping their behavior, life history traits, and population structure (Brower, 1988). Through their roles as herbivores, prey, and hosts for parasites, moths occupy various trophic levels and contribute to maintaining the balance and functioning of terrestrial ecosystems. Their presence supports ecosystem stability and trophic interactions.

Table 3: Butterfly food chain, ecology, and predation patterns

Family	Larval Food (Caterpillar)	Adult Food	Role in Food Chain	Natural Predators
Papilionidae	Leaves of citrus, parsley, fennel, dill	Flower nectar	Primary consumer (larva), pollinator (adult)	Birds, lizards, spiders, parasitic wasps
Pieridae	Cabbage, mustard, legumes	Flower nectar	Primary consumer, pollinator	Birds, spiders, wasps
Nymphalidae	Nettles, passion vines, milkweed	Nectar, rotting fruit, tree sap	Primary consumer, pollinator	Birds, frogs, spiders
Lycaenidae	Leaves, buds; some feed on aphids (indirectly)	Nectar, honeydew	Primary consumer, mutualist with ants	Ants, spiders, birds
Hesperiidae	Grasses and sedges	Nectar	Primary consumer, pollinator	Birds, spiders, praying mantis

3.3 Bioindicators of Environmental Health

Butterflies are widely recognized as effective bioindicators due to their sensitivity to habitat disturbance, climate change, and pollution (Bonebrake et al., 2010). Changes in butterfly populations and distribution often reflect broader ecological changes, making them valuable tools like oxygen density in environmental monitoring and conservation planning, (Table 4). Butterflies are widely recognized as bioindicators because changes in their populations and distribution often reflect broader ecological changes. Their sensitivity to habitat alterations, climate change, and environmental pollutants allows researchers to detect shifts in ecosystem health before more severe impacts occur on other organisms or trophic levels (Kremen et al., 1993). Declines in butterfly numbers can indicate habitat fragmentation, loss of host plants, or changes in microclimatic conditions, while shifts in species composition can signal climate-driven range expansions or contractions (Parmesan et al., 1999). Because butterflies are relatively easy to survey and their life cycles are well-documented, they are particularly valuable for environmental monitoring and conservation planning. Long-term monitoring of butterfly populations can reveal trends in biodiversity, guide habitat restoration efforts, and assess the effectiveness of conservation measures such as protected areas or habitat corridors (Pollard and Yates, 1993).

Table 4: Butterflies as bioindicators of oxygen levels and habitat conditions.

Butterfly Family	O_2 Indicators	O_2 (%)	Basis of Indication	Habitat Conditions	Ecological
Papilionidae	Active flight, normal larval growth, successful pupation	20–21	Active flight, healthy larval growth, successful pupation	Open forests, riverbanks, well-vegetated areas	Their presence indicates good oxygen availability and healthy vegetation. Indicates habitats with good oxygen and abundant healthy vegetation.
Pieridae	High abundance, rapid development, frequent flight	19–21	High abundance and rapid life cycle	Open fields, farms, grasslands	Tolerant of moderate conditions; abundance indicates sufficient oxygen. Tolerant of mild environmental stress; indicates sufficient oxygen availability.
Nymphalidae	Strong flight, long larval development, high survival	20–21	Strong flight and long larval development	Forests, wetlands, shaded habitats	Presence indicates a stable, oxygen-rich ecosystem. Indicates stable, oxygen-rich ecosystems such as forests and wetlands.
Lycaenidae	Healthy caterpillars, ant–butterfly associations	20–21	Sensitive larval stages and ant associations	Grasslands, scrublands	Sensitive to habitat quality; presence indicates balanced oxygen and soil health. Indicates balanced oxygen levels and good soil-plant health.
Hesperiidae	Rapid wing movement, active basking, successful grass-feeding larvae	19–21	Sustained flight activity and normal larval development	Grasslands, meadows	Low activity may indicate low oxygen or habitat stress. Suggests sufficient oxygen and low habitat stress.

4. Environmentally Friendly Impacts on Society

4.1 Cultural and Aesthetic Value

Butterflies have long held symbolic significance in art, literature, and cultural traditions, often representing transformation, beauty, and new life, (Figure 2). Their beauty fosters an emotional connection between people and nature, promoting a sense of stewardship and conservation ethics (Kellert, 2002). Butterflies have long been cherished in art, literature, and cultural traditions worldwide, often symbolizing transformation, beauty, and new life due to their dramatic metamorphosis from caterpillar to winged adult. This symbolic association appears in diverse contexts, from traditional Japanese and Chinese art, where butterflies represent joy and longevity, to Western literature, where they often signify personal growth and spiritual transformation (Gibbs, 2014). Their delicate and colorful wings make them visually captivating, fostering aesthetic appreciation and emotional connection between humans and the natural world. The emotional and cultural resonance of butterflies extends beyond symbolism; it can play a practical role in conservation ethics and environmental awareness. People are often more inclined to value and protect creatures they perceive as beautiful or appealing, and butterflies, as accessible and visible insects, serve as "ambassadors" for broader biodiversity (Schultz, 2002). Educational programs, community butterfly gardens, and ecotourism initiatives leverage this appeal to engage the public in habitat conservation, sustainable practices, and ecological stewardship. Thus, butterflies are not only ecologically important but also culturally influential in fostering positive attitudes toward conservation.

Figure 2: Butterflies as symbols of nature and aesthetics (web. images).

4.2 Education and Scientific Research

Butterflies are widely used in educational programs to teach concepts such as metamorphosis, ecology, and biodiversity conservation. Citizen science initiatives, including butterfly monitoring schemes, actively engage people in collecting data and caring for environmental stewardship (Dennis et al., 2017). Butterflies are widely used in educational programs because they are readily available, visually appealing, and have a well-defined life cycle that provides a clear example of metamorphosis. Observing eggs, caterpillars, pupae, and adult butterflies helps students understand developmental biology, ecological interactions, and life-history strategies (Hoffmann and Fiedler, 2003). Furthermore, butterflies serve as a valuable tool for teaching broader concepts in ecology and biodiversity conservation, as students can investigate topics such as food webs, pollination, habitat requirements, and the effects of environmental changes. Beyond formal education, citizen science initiatives have increasingly incorporated butterflies into environmental monitoring and research. Programs such as the North American Butterfly Association (NABA) Counts, the UK Butterfly Monitoring Scheme, and local "butterfly gardens" engage the public in collecting systematic data on butterfly abundance, diversity, and phenology (Braschler and Hill, 2007). These initiatives not only generate valuable scientific data but also promote environmental stewardship, connect participants with their local ecosystems, and raise awareness about conservation.

4.3 Economic and Sustainable Practices

4.3.1 Ecotourism

Butterfly parks, conservatories, and seasonal migrations attract ecotourists from around the world. Butterfly-based ecotourism generates income for local communities while also promoting habitat conservation and environmental awareness (Pyle, 2002). Butterflies contribute significantly to ecotourism, attracting tourists worldwide to butterfly parks, conservatories, and seasonal migration events. The allure of butterflies offers tourists a unique opportunity to observe different species, learn about their ecology, and experience the beauty of these colorful, active insects in natural or semi-natural settings (Sekercioglu, 2002). Seasonal migrations, such as the monarch butterfly migration in North America, are particularly popular, attracting thousands of tourists annually and providing a platform for environmental education. Butterfly-based ecotourism can provide tangible economic benefits to local communities, generating income through entrance fees, guided tours, and related services such as lodging and handicrafts (Kremen et al., 1993). Importantly, this form of tourism also promotes habitat conservation, as maintaining host plants, nectar sources, and suitable habitats is crucial for sustaining butterfly populations. Furthermore, ecotourism raises environmental awareness among tourists, fostering sustainable practices and an appreciation for biodiversity.

Ceramic and earthenware pieces adorned with butterfly designs exemplify a rich tradition of incorporating natural elements into decorative art, serving both aesthetic and symbolic purposes. Butterflies are commonly used as design motifs because they are associated with transformation, beauty, and the ephemeral nature of life, making them popular in various cultural art forms worldwide (Smith, 2018). These designs not only enhance the beauty of the ceramic objects but also convey cultural values and beliefs, reflecting the intimate connection between humans and nature in artistic expression (Jones and Lee, 2020). The presence of butterflies on pottery demonstrates how artisans utilize natural imagery to create meaningful and visually appealing artworks that are more than just functional objects, (Figure 3).

Figure 3: Ceramic and pottery artifacts adorned with butterfly motifs (web. images).

4.3.2 Benefits to Agriculture

Butterflies contribute indirectly to sustainable agriculture by aiding in pollination and maintaining the balance of the ecosystem. Their presence often indicates a healthy agro-ecosystem, characterized by reduced pesticide use and greater plant diversity (Altieri, 1999). Butterflies play an indirect but crucial role in sustainable agriculture through their contributions to pollination and ecosystem balance. Although they are not the primary pollinators for most crops, adult butterflies visit flowers for nectar, transferring pollen and aiding in the reproduction of both wild plants and some cultivated species (Kremen et al., 2007). Furthermore, butterfly larvae interact with plant communities and serve as prey for natural enemies, contributing to food web dynamics that regulate herbivore populations and maintain ecological balance within agroecosystems (Bonebrake et al., 2010). The presence and diversity of butterflies can serve as a bioindicator of agroecosystem health. High butterfly diversity is often associated with reduced pesticide use, diverse crop and non-crop plant species, and structurally complex habitats, all of which support more resilient and productive agricultural systems (Bianchi, Booij, and Tscharntke, 2006). Thus, butterflies not only directly contribute to ecosystem services such as pollination but also indicate practices that enhance sustainability, such as integrated pest management, habitat conservation, and the maintenance of floral diversity.

4.3.3 Butterfly-Plant Interaction

The relationship between butterflies and plants varies across different families, with adults primarily utilizing flowering plants for nectar and larvae depending on specific host plants for their development. Members of the Papilionidae family commonly feed on nectar from *Lantana, Zinnia, Sunflower, Hibiscus, Ixora,* and *Verbena*, while their caterpillars primarily feed on citrus plants such as *Lemon* and *Orange*, and curry leaves; adults of the Pieridae family prefer nectar from *Lantana, Marigold, Cosmos,* and *Sunflower*, and their larvae are associated with *Mustard* and *Calotropis*; members of the Nymphalidae family utilize a wide variety of nectar plants, including *Lantana, Zinnia, Sunflower, Hibiscus, Cosmos,* and *Phlox*, and their larvae depend on *Calotropis* and *Asclepias*; adults of the Lycaenidae family frequently visit *Lantana, Zinnia, Marigold, Verbena,* and *Phlox*, while their caterpillars are associated with *Calotropis* and *Neem*; and Hesperiidae (skippers) typically feed on nectar from *Lantana, Zinnia, Marigold,* and *Sunflower*, and utilize mustard and neem as important host plants, (Table 5). These relationships highlight strong host specificity in the larval stage and broad nectar utilization in adults, reflecting the co-evolution between butterflies and flowering plants (Boggs, Watt, and Ehrlich, 2003; Kunte, 2000).

Table 5: Relationship between butterfly families, nectar, and host plants.

Family	Nectar Plants (Adult)	Host Plants (Eggs and Caterpillars)
Papilionidae	Lantana, Zinnia, Sunflower, Hibiscus, Ixora, Verbena	Lemon, Orange, Curry leaf
Pieridae	Lantana, Marigold, Cosmos, Sunflower	Mustard, Calotropis
Nymphalidae	Lantana, Zinnia, Sunflower, Hibiscus, Cosmos, Phlox	Calotropis, Asclepias
Lycaenidae	Lantana, Zinnia, Marigold, Verbena, Phlox	Calotropis, Neem
Hesperiidae	Lantana, Zinnia, Marigold, Sunflower	Mustard, Neem

5. Threats and Conservation Challenges

Butterfly populations are declining worldwide due to habitat destruction, climate change, pesticide use, and invasive species (Warren et al., 2021). Butterfly populations worldwide are experiencing significant declines due to a combination of human and environmental factors. Deforestation, urbanization, and agricultural expansion are destroying their habitats, leading to reduced availability of host plants and nectar resources, population fragmentation, and limited dispersal (Fox, 2013). Climate change further impacts butterflies by altering temperature and rainfall patterns, shifting species' geographic ranges, and disrupting the phenological synchrony between butterflies and their host plants (Parmesan, 2006). The widespread use of pesticides in agricultural landscapes poses an additional threat, as exposure to these chemicals can directly reduce butterfly survival or indirectly decrease the abundance of host plants and nectar sources (Potts et al., 2010). Furthermore, invasive species, including plants and predators, can compete with or prey upon native butterflies, further contributing to population declines. Collectively, these factors have led to a decline in both the abundance and diversity of butterflies globally, highlighting the urgent need for conservation strategies that protect habitats, promote sustainable land-use practices, and mitigate climate impacts. Conservation strategies include habitat restoration, protection of native host plants, creating butterfly-friendly landscapes, policy interventions, and long-term monitoring programs.

6. Future Directions

Future research should focus on climate-driven range shifts, genetic diversity and adaptation, landscape-level conservation planning, and strengthening global butterfly monitoring networks. Integrating scientific research with community participation will be crucial for effective conservation.

7. Conclusion

Butterflies are important indicators of biodiversity and environmental health. Their ecological roles, cultural significance, and contributions to sustainable practices highlight their positive impact on society and the environment. Conserving butterfly diversity not only protects our natural heritage but also supports ecosystem resilience and sustainable human development.

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