JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A Comprehensive Review of Sustainable Strategies for Butterfly Conservation at Bannerghatta Butterfly Park, Bengaluru, Karnataka

Bapuram Ashalatha[1,*] Kulkarni K.R[2,] Sushma N.M[3,] Kamatchi S[4]

[1]*Department of Zoology, Vijaya College, IV block Jayanagar, Bangalore City University, Bengaluru 560011, Karnataka, India.*

[2]*Range Forest officer, Butterfly Park, Bannerghatta biological Park, Bengaluru560011, Karnataka, India.*

[3]*Deputy Range Forest Officer, Butterfly Park, Bannerghatta biological Park, Bengaluru560011, Karnataka, India.*

[4]*Department of Zoology, Bishop cotton women's Christian college, Bangalore City University, Bangalore 560027, Karnataka, India.*

Abstract

Butterflies are among the most beautiful organisms in the universe. In addition to their aesthetic appeal, butterflies play a crucial role in the food chain, serving as a vital food source for birds, reptiles, spiders, and predatory insects. They play an important role as pollinators and bio indicators, contributing significantly to ecosystem health and stability. Bannerghatta Biological Park in Bengaluru, Karnataka, is home to a rich diversity of butterfly species, making it a critical area for conservation and management. This research paper explores effective strategies for preserving butterfly populations in the park through habitat restoration, native plant cultivation, and sustainable landscaping practices. It highlights the importance of maintaining nectar and host plants, reducing pesticide use and implementing educational programs to raise awareness about butterfly conservation. The study evaluates the on-going breeding programs at the Butterfly Park and highlights the efforts taken to preserve and maintain butterfly species for long-term sustainability. This research focuses on ecological strategies for butterfly conservation, integrating community involvement to create replicable models for preserving urban biodiversity hotspots like Bannerghatta Biological Park.

Key words: Bioindicators, Bannerghatta Biological Park, Butterfly Conservation, Breeding, Sustainability.

Introduction:

Insects make up more than half of the world's biodiversity, accounting for approximately 70% of the global animal population (Subhashini, R and Antony P, 2019) which is the highest level of species richness (Thomas J.A., 2005). Among them, butterflies are one of the most popular and widely recognized groups. Known for their vibrant colours and striking beauty, they are often called the "flying jewels of nature"(Subhashini, R and Antony P, 2019). Their vibrant and delicate wing colours significantly contribute to the aesthetic appeal of the environment. Butterflies display a wide range of colours and sizes, with approximately 20,000 species identified globally (Mathew, G., 2006). The Indian subcontinent, with its diverse terrain, climate, and vegetation, hosts about 1,504 butterfly species (Kunte, 2000; Kehimkar, 2008)

Butterflies contribute significantly to biodiversity and play a vital role in plant-pollinator interactions, thereby supporting ecosystem health and stability (Remadevi, 2016). Their abundance and diversity are key indicators of a thriving ecological community and reflect a healthy environment (Kunte, 2000). As essential pollinators of both wild and cultivated crops, butterflies promote genetic diversity and facilitate cross-pollination. Additionally, they serve as biological indicators of climatic and seasonal changes, making them valuable for monitoring environmental health and developing effective conservation strategies (Kunte K., 1997).

Butterflies belong to the phylum Arthropoda, class Insecta, and order Lepidoptera. They are classified into two superfamilies'—Hesperioidea, which includes skippers, and Papilionoidea, which comprises true butterflies. The five main butterfly families are Hesperiidae, Papilionidae, Pieridae, Nymphalidae, and Lycaenidae.

Butterflies rely on liquid food sources, mainly nectar from flowers and occasionally overripe fruits for their survival. They play a crucial role in ecosystems as pollinators, food sources, and indicators of environmental health. They are especially important for pollinating flowers that bloom during the daytime, contributing significantly to the maintenance of plant diversity and ecological balance (Ghazanfar, M., 2016).

The ecological importance of butterflies extends across their entire life cycle, which consists of four stages—egg, caterpillar (larval stage), pupa, and adult. Each stage of a butterfly's life cycle plays a unique role in supporting ecological processes. During the larval stage, caterpillars feed on plants, influencing vegetation dynamics, while adult butterflies serve as vital pollinators, aiding in plant reproduction. Following metamorphosis, the pupa transforms to an adult butterfly that emerges with fully developed wings ready to fulfil its role as an active pollinator in maintaining ecological balance. The duration of this cycle varies across species, with some completing two or three cycles per year. Understanding their life cycle is crucial for designing conservation strategies that protect habitats and ensure the availability of host plants and nectar sources needed for their survival (Radchuk, V., et al.,2013).

The primary objective of this research paper is to evaluate the efforts undertaken for effective management strategies aimed at conserving and enhancing butterfly diversity in the Butterfly Park of Bannerghatta Biological Park (BBP), Bengaluru.

Threats to Butterfly Populations

Butterflies, with their diverse habits and ecological roles, rely on specific environmental conditions for survival. Their typical habitats include natural forests, grasslands, tree canopies, and moist areas along riverbanks and streams. However, due to various factors, especially human interventions, these habitats have undergone significant alterations. Consequently, many butterfly species that were once commonly found in homesteads and rural landscapes have now disappeared. The loss of such species profoundly impacts biodiversity, as the extinction of a single species can cascade into the decline or extinction of others intricately linked to it, thereby disrupting ecological balance and reducing Biodiversity (Mathew G., 2006).

In recent decades, urbanization has emerged as a major threat to butterfly populations. It has led to the reduction of natural habitats, increased pollution (soil, water, air, and noise), and the disruption of ecosystems (McKinney, 2002). Habitat loss, modification, and pollution from expanding urban areas pose significant risks to plant and animal communities (Rathcke & Jules, 1997). The pressure from high human population density further intensifies these impacts, leading to the gradual disappearance of natural habitats (Blair, R. B., & Launer, A. E., 1997).

Butterflies are highly sensitive to subtle changes in microclimates, temperature, radiation, and the availability of host plants for reproduction. Urbanization leads to habitat fragmentation, resulting in small, isolated green spaces surrounded by human development. This fragmentation not only reduces biodiversity but also negatively impacts both genetic diversity and ecosystem functioning (Grimm et al., 2008).

Seasonal variations in meteorological parameters, such as temperature, day length, rainfall, and humidity, significantly influence butterfly abundance and diversity. Minute changes in habitat leads to mass migration of butterflies from one place to another place causing local extinction of butterfly (Schtickzelle and Baguette,2003)

Butterflies rely on host plants during their larval stage for development and on flowering plants for nectar as adults. Their co-evolution with host plants is crucial for understanding ecosystem health and guiding conservation efforts (Sparks et al.,1996). However, the widespread use of pesticides in agriculture contributes significantly to their decline. While pesticides help control agricultural pests, they accumulate in soil and food chains, threatening ecosystems and potentially leading to global biodiversity loss (Aktar et al., 2009; Potts et al., 2016).

Pollination, a critical ecological interaction facilitated by butterflies, is essential for plant reproduction and ecosystem sustainability (Arun, 2003). However, chemical sprays during flowering seasons harm pollinator populations (Johansen, 1977). Herbicides further threaten pollinators and insects by damaging larval food sources and disrupting nesting habitats. The intricate relationship between butterflies and their environment underscores their importance in maintaining biodiversity. Protecting their habitats and minimizing harmful agricultural practices are vital for conserving not only butterflies but also global biodiversity (Saikia et al., 2009).

Anthropogenic disturbances in both urban and rural areas, including land cultivation, have significantly contributed to habitat depletion and the reduction of food sources, ultimately leading to the extinction of many species of butterflies (Grimm et al., 2008; Choudhary & Chishty, 2020).

Protecting a butterfly population within a nature reserve alone does not ensure its long-term survival. Various unforeseen events, such as extreme weather conditions, habitat degradation, disease outbreaks, invasive species, and changes in food availability, can severely impact populations. If the reserve is isolated from other butterfly populations, the chances of recolonization and recovery become significantly low. To ensure the survival of rare butterfly species, specific management strategies may be necessary within the reserve to maintain optimal habitat conditions (Yates, 1993).

Establishment of Butterfly parks for conservation and recreation:

Conserving butterflies is crucial for preserving their populations and maintaining the balance of natural ecosystems. India, renowned for its rich biodiversity, is home to an incredible array of butterfly species. To celebrate and protect these fragile yet essential pollinators, butterfly gardens are being established across the country. These gardens not only offer a captivating visual experience but also play a significant role in promoting environmental conservation and supporting ecological balance. The establishment of such gardens can contribute to the conservation and proliferation of butterfly species (Thakur, Chakrabarti, & Chaudhuri, 2017).

Research indicates that nectar availability, along with specific colours and fragrances attracts butterflies. Additionally, studies show that butterflies have specific feeding and egg-laying preferences for certain plant species. This highlights the importance of thoughtful plant selection in habitat restoration efforts to ensure the survival and growth of butterfly populations (Radchuk, V., et al., 2013).

India is home to several notable butterfly parks that conserve and showcase the country's rich butterfly diversity while serving as educational and recreational spaces. The Bannerghatta Butterfly Park in Bengaluru, Karnataka, is India's first butterfly park hosting around 150 species, featuring a climate-controlled conservatory, a museum, and a lush habitat for species like the Blue Tiger and Common Jezebel, common caster, pioneer, blue Mormons etc. The Butterfly Conservatory of Goa in Ponda houses over 100 species in a serene 4000-square-meter space. In Odisha, the Chilika Lake Butterfly Garden supports butterfly conservation near Asia's largest brackish water lagoon. Kerala's Thenmala Butterfly Safari Park, part of the ecotourism zone, offers butterfly trails surrounded by nectar-rich plants. The Sikkim Butterfly Reserve Park spans 29 hectares and focuses on conservation in the Northeast. Maharashtra boasts the Ovalekar Wadi Butterfly Garden in Thane, home to 132 species, while Chandigarh's Butterfly Park and Delhi's Asola Bhatti Wildlife Sanctuary Butterfly Park provide urban conservation spaces. Tamil Nadu's Tropical Butterfly Conservatory in Trichy and new parks in Madhya Pradesh further highlight India's commitment to butterfly. These parks are vital for promoting conservation and spreading awareness about butterfly ecology (https://timesofindia.indiatimes.com).

The Butterfly Park within Bannerghatta Biological Park in Bengaluru, the largest butterfly parks in India, inaugurated on February 23, 2006, is a pioneering initiative and the first of its kind in India. It is spread across 7.5 acres which has a butterfly trail of about 1 km length. The 'butterfly trail' established over a five acre garden. Established by the Zoo Authority of Karnataka (ZAK) in collaboration with the Department of Biotechnology (DoBT), Government of India, this park has become a model for similar conservation and educational projects nationwide. (https://bannerughattabiopark.org/butterfly_park.htm)

Bannerghatta Butterfly Park (BBP) has been established to promote the conservation of butterfly species, both native and exotic. The park also aims to educate the public about the ecological importance of butterflies and their role in maintaining biodiversity. It also provide

a safe and natural habitat for butterflies to breed and thrive, supporting biodiversity. Through research, captive breeding, and habitat restoration, BBP aims to contribute to the conservation of endangered butterfly species. Additionally, the park serves as an educational centre, raising awareness about butterfly life cycles, their role in pollination, and the significance of plant-butterfly interactions by establishing a museum.

Figure 1: Butterfly Park in Bannerghatta Biological Park, Bengaluru

Materials and survey methods:

The survey and identification of butterflies at Bannerghatta Butterfly Park (BBP) were conducted from April 2024 to July 2024. A comprehensive survey of butterfly species and other pollinators was carried out thrice weekly on the BBP campus and surrounding areas, during peak activity hours from 9:30 AM to 11:00 AM and 3:30 PM to 5:00 PM. Separate checklists for butterfly species, nectar plants, host plants and larval food plants and alkaloid plants were prepared. Butterfly species were identified directly in the field, by capturing them using a butterfly net, and through photographs. RFO Kulkarni K.R. and DRFO Sushma N.M. of the Butterfly Park provided invaluable guidance in identifying butterfly species.

In our study at the butterfly park, we meticulously observed and documented the key breeding stages of butterflies: egg, larva (caterpillar), pupa (chrysalis), and imago (adult butterfly). We emphasized the critical role of environmental factors such as temperature, humidity, and the availability of host plants in ensuring successful breeding, as well as the significance of the netting system in protecting butterflies from predators. Additionally, we gained valuable insights about protection of butterflies from predators throughout their life cycle. These observations have enhanced our understanding of the factors that support butterfly reproduction that will contribute significantly to conservation efforts.

The Park at Bannerghatta has the following major components:

1. A Butterfly garden to sustain local butterfly population.
2. A butterfly conservatory enclosed under polycarbonate roof.
3. Research and captive breeding laboratory.
4. A museum. (https://bannerughattabiopark.org)

The Butterfly Garden:

The Bannerghatta Butterfly Park is located within the Bannerghatta Biological Park, about 22 kilometres south of Bengaluru, Karnataka. Its location is ideal for a butterfly park, as it is situated within a rich natural ecosystem that includes forests, grasslands, and a variety of plant species, making it a suitable environment for both native and exotic butterflies.

The park benefits from its proximity to the Bannerghatta National Park, which offers a diverse range of flora and fauna, contributing to the park's ability to attract and sustain a variety of butterfly species. The location also provides a serene and protected environment, essential for butterfly conservation efforts. Additionally, being close to Bengaluru, the park is easily accessible for tourists, researchers, and conservationists, making it an excellent spot for both recreation and education on butterfly conservation.

The Bannerghatta Butterfly Park in Bengaluru employs key breeding strategies to support butterfly conservation and enhance populations. These strategies focus on creating ideal conditions by providing a diverse range of nectar and host plants to support butterflies at every stage of their life cycle. The park maintains a balance of sunlight and shelter to mimic natural conditions, encouraging butterflies to breed and thrive. The park is specifically designed to meet the essential needs of butterflies, including food, sunlight, water, and shelter. It includes various components like host plants, nectar plants, and designated areas for activities such as puddling, perching, patrolling, and basking. Additionally, the park uses garden adornments to attract butterflies while enhancing the garden's aesthetic appeal. While wild butterflies have a survival rate of just 2% due to natural threats such as climate, predators, and parasites, captive breeding in the park can boost survival rates to as high as 90% by protecting them from unfavourable conditions.

Key features of Butterfly Park:

Nectar Plants: At the Butterfly Park, significant efforts have been made to cultivate a diverse range of flowering plants that bloom year-round, ensuring a continuous source of nectar to nourish butterflies. The team has carefully selected nectar plants by considering the specific feeding preferences of the butterfly species present, along with the timing and duration of the plants' flowering cycles. Plants that bloom continuously, such as *Clerodendrum capitatum*, *Cuphea*, *Marigold*, *Lantana camara*, and *Ixora sp*., are chosen for their consistent nectar availability. These plants are easily accessible nectar due to their shallow nectaries, which are ideal for most butterflies, enabling them to feed efficiently without expending excessive energy. Species like *Lycaenids* and *Pierids*, with shorter proboscises, tend to favour smaller

flowers such as those in the Compositae family. On the other hand, larger butterflies like Papilionids prefer flowers with longer pistils, such as *Hibiscus*, *Ixora*, and *Clerodendrum capitatum*, as they can more easily access the nectar (Mathew, G., 2006).

Pentas lanceolata
(pentas)

Hibiscus rosa-sinensis
(china rose)

Chrysanthemum multicaule
(yellow daisy)

Combretum indicum
(Rangoon creeper)

Lantana camara
(Common Lantana - yellow)

Stachytarpheta cayennensis
(Blue spike)

Lantana camara
(Common lantana- Orange)

Cuphea hyssopifolia
(False heather)

Tithonia diversifolia
(Mexican sunflower)

Euphorbia milii
(crown of thorns)

Calliandra haematocephala
(Red powder puff)

Plumeria pudica
Golden Arrow

Figure 2: Nectar plants of Butterfly Park of BBP (Source – Butterfly Park-BBP)

Host Plants: Female butterflies lay their eggs on specific host plants, which serve as the primary food source for the larval stage, or caterpillar. Typically, the caterpillar feeds solely on the leaves of its host plant, though some species may also consume flowers, stems, or young seedpods. Most butterfly caterpillars spend their entire larval life feeding on a single plant species, often the same plant where they hatched (Tekulsky, 1985). For instance, the Monarch butterfly exclusively feeds on plants from the milkweed family. In contrast, other species are feeding generalists, using a variety of host plants for caterpillar development. Host plants are generally native species that naturally occur in the butterfly's region, providing the necessary support for the caterpillar's growth and survival (Rashidha, C. K.,2020).

Turnera ulmifolia
(Yellow Alder)

Annona reticulate
Custard apple

Mangifera indica
Mango tree

Delonix regia
Gulmohar tree




Kalanchoe pinnata **(Bryphillium)** | ***Cassia auriculata*** **(Tanner's Cassia)** | ***Asclepias curassavica*** **(Tropical milkweed)** | ***Ficus racemosa*** **(cluster fig)**




Salix tetrasperma **(Indian willow)** | ***Wattakakka volubilis*** **(Greenmilkweed climber)** | ***Helictrus isora*** **(Indian screw tree)** | ***Chloroxylon swetania*** **(Ceylon satinwood)**

Figure 3: Host plants of Butterfly Park of BBP (Source – Butterfly Park-BBP)

The Bannerghatta Butterfly Park is home to over 150 species of plants, which include a mix of nectar plants, host plants, and other vegetation that supports the butterfly population. These plants are carefully chosen to cater to the specific needs of both native and exotic butterfly species, ensuring a diverse and sustainable environment for their breeding, feeding, and development. The plant diversity in the park plays a crucial role in attracting a wide variety of butterflies throughout the year.

The Bannerghatta Butterfly Park features a five-acre host plant garden adjacent to its butterfly garden, designed to mimic natural habitats that promote butterfly breeding and survival. This garden attracts both migratory and local butterfly species, creating a thriving environment for their sustenance. Larvae, pupae, and adults are collected from the host plant garden for breeding and maintenance. Initially, the garden was dedicated exclusively to host plants, but it has since been expanded to include nectar plants as well, creating a more comprehensive habitat for butterflies. These efforts have contributed to an increase in the diversity of butterfly species within the garden.

Alkaloid plants:

The butterfly park also cultivates alkaloid-producing plants, such as **Rattle pod** (Crotalaria), **Turnsole** (Heliotropium), and **Eupatorium** species that are crucial for the reproduction of certain male butterfly species. These plants provide essential alkaloids, which the males consume to synthesize **sex pheromones** needed to attract females. The alkaloids are vital for enhancing the males' reproductive success. By creating small plots of these plants, the butterfly Park attracts flocks of butterflies, particularly tiger butterflies such as the **Blue Tiger** (*Tirumala limniace*), **Glassy Tiger** (*Parantica aglea*), **Dark Blue Tiger** (*Tirumala septentrionis*), Plain Tiger (*Danaus chrysippus*), Striped Tiger (*Danaus genutia*), Common Indian Crow (*Euploea core*), and Brown King Crow (*Euploea klugii*). These butterflies, also known as brush-footed butterflies, benefit from these plants by fulfilling their unique biological needs, thus supporting their breeding behaviors, population health, and biodiversity (Rashidha, C. K.,2020).



Crotalaria retusa **(Rattle pod)** | **(Heliotropium curassavicum) Turnsole** | ***Eupatorium sordidum*** **(hemp-agrimony)**

Figure 4: Alkaloid plants of Butterfly Park of BBP (Source – Butterfly Park-BBP)

Butterflies are highly sensitive to chemicals, and the application of insecticides or pesticides can harm them along with other beneficial insects. Additionally, such practices can disrupt the natural balance of the environment, undermining the park's efforts to maintain a sustainable and thriving habitat. Hence at Bannerghatta Butterfly Park the use of insecticides and pesticides are avoided to preserve the delicate ecosystem and protect the health of the butterfly populations. Instead, the butterfly park likely adopts eco-friendly pest management

practices, such as biological control using natural predators or parasites to control pests, manual removal of harmful pests, and the promotion of natural biodiversity that helps control pest populations without harming the butterflies or other wildlife. For example Apeflies (*Spalgis epius*) in the park act as a form of biological pest management, keeping mealybug populations in check by feeding on them, thus preventing overpopulation that could harm the plants they infest. These sustainable practices support the park's conservation goals, ensuring that both plant and butterfly species thrive in a safe and natural habitat.

Figure 5: Apefly (*Spalgis epius*), the carnivorous butterfly in Butterfly Park of BBP (Source – https://www.inaturalist.org/)

Butterfly species of Bannerghatta butterfly park:

The Bannerghatta Butterfly Park is home to a diverse range of butterfly species, including both native and exotic varieties. Through our survey and based on the information gathered from the Range forest officers of Banneghatta butterfly park, Kulkarni K.R., Range Forest Officer and Sushma N.M, Deputy Range Forest Officer, 140 butterfly species have been identified in and around the park during various seasons.

The highest diversity of butterfly species at Bannerghatta Biological Park is usually seen during the monsoon season (June to September). This season offers an abundance of nectar-rich plants and favourable weather conditions, supporting the breeding and activity of numerous butterfly species. The increased availability of host plants and lush vegetation during the monsoon creates an ideal environment for a wide range of butterflies.

The common butterflies observed in the Butterfly Park include Common Crow, various types of Tigers, Tawny Coster, Common Castor, Angled Castor, Common Leopard, Common Mormon, Southern Birdwing, Pioneer, White Orange Tip, Yellow Orange Tip, Great Orange Tip, Lemon Emigrant, Red Pierrot, Mottled Yellow, Grass Yellow, Common Rose, Crimson Rose, Baron, Tailed Jay, and Common Jay, among others. Breeding programs for these butterfly species are also conducted within the park.

***Danaus plexippus* (Monarch)**

***Catopsilia pomona* (Lemon Migrant)**

***Catopsilia pyranthe* (Mottled Emigrant)**

***Tirumala limniace* (Blue Tiger)**

***Euploea core* (Common crow)**

***Jamides celeno* (common cerulean)**

***Catopsilia pomona* (Common Emigrant)**

***Papilio demoleus* (lemon butterfly)**

Belenois aurota
(Pioneer White)

Papilio polytes
(Common Mormon)

Papilio polytes
(Common Mormon)

Ariadne merione
(Common Castor)

Ixias marianne
(White Orange Tip)

Acraea terpsicore
(Tawny Coster)

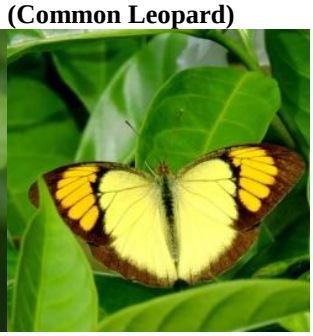
Ariadne ariadne
(Angled Castor)

Phalanta phalantha
(Common Leopard)

Troides minos
(Southern Birdwing)

Papilio polymnestor
(Blue Mormon)

Ixias marianne
(White Orange Tip)



Ixias pyrene
(Yellow Orange Tip)

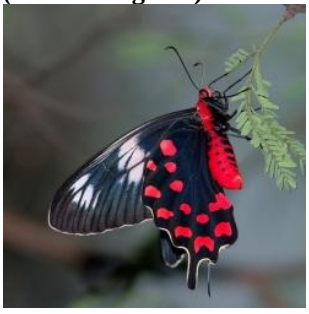
Hebomoia glaucippe
(Great Orange Tip)

Catopsilia pomona
(Lemon Migrant)

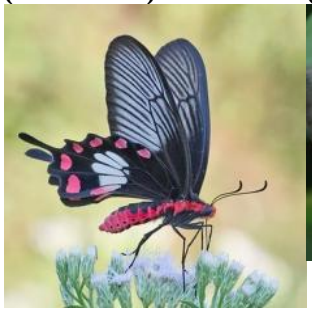
Talicada nyseus
(Red Pierrot)

Catopsilia pyranthe
(Mottled Emigrant)

Terias hecabe
(Common Grass Yellow)



Pachliopta hector
(Crimson Rose)



Pachliopta aristolochiae
(Common Rose)

Euthalia aconthea
(Common Baron)

Graphium doson **(Common Jay)**

Papilio clytia **(Common Mime Swallowtail)**

Graphium agamemnon **(Tailed Jay)**

Danaus chrysippus **(Plain Tiger)**

Figure 6: Some of the Butterfly species of Butterfly Park of BBP (Source – Butterfly Park-BBP)

Co-evolution of Butterflies and Plants refers to the mutual evolutionary influence that butterflies and plants have had on each other over time. As butterflies evolved to specialize in feeding and breeding on certain plants, these plants also developed adaptations to either attract butterflies or deter them, creating a dynamic evolutionary relationship. For example, many butterflies are highly adapted to feed on specific plants, known as host plants, which cater to their larvae's feeding requirements. In return, the butterflies help pollinate the plants, assisting their reproduction. This co-evolutionary relationship has led to specialized features in both plants and butterflies.

Butterflies are primarily attracted to flowers that provide abundant nectar, such as Lantana, pentas, Marigold, Zinnia, Ixora, and Hibiscus. They are especially drawn to brightly coloured blooms in shades of red, orange, yellow, blue, and purple, which signal the presence of nectar. Flowers with open or flat structures, like daisies and sunflowers, make it easier for butterflies to access nectar with their long proboscis. Additionally, the fragrance of flowers like Lavender and Jasmine attracts butterflies, while plants that bloom year-round, such as Lantana and Bougainvillea, provide a continuous food source, ensuring butterflies visit throughout the seasons. By carefully selecting nectar and host plants, the butterfly park has created a thriving ecosystem that supports the entire butterfly lifecycle, while promoting ecological balance within the park. The list of butterflies and their host plants and nectar plants in butterfly park of BBP is provided in the following table (Table:2).

Table 1: List of host plants and nectar plants planted in the butterfly garden and butterflies attracted to them.

Sl. No	Name of the plant	Common Name	Type of the Plant	Name of the butterfly dependent on the food plant
1.	Crotalaria sp	Rattleweed	Alkaloid	Blue Tiger and other butterflies
2.	*Crotalaria retusa*	*Rattleweed*	Alkaloid	Milkweed butterflies like Plain Tiger (For mating)
3.	*Murraya koenigi*	curry leaf tree	Host	Lime Butterfly and Common Mormon
4.	Ixora sp.	Jungle flame	Nectar and host	Host - Monkey Puzzle Nector- larger butterflies.
5.	Lantana Sp,	common lantana	Nectar & host	For flash species butterflies like Slate flash in BBP
6.	*Passiflora foetida* _	Stinking Passion Flower wild water lemon, stoneflower	Nectar and host	Tawny Coster
7.	Catharanthus sp.	Periwincle	Nectar	Most of the Butterflies
8.	*Heliotropium indicum*	Indian Turnsole, Indian Heliotrope	Alkaloid	Milk weed butterflies
9.	*Aristolochia indica*	Indian birthwort	Host	Common Rose Crimson rose Southern Bird wing
10.	*Citrus* limon	Lemon plant	Host	Common lime Lime swallow tail Blue mormon

11.	*Ricinus communis*	castor bean	Host	Common castor butterflies
12.	*Annona squamosal*	Custard plant	Host	Common Jay butterflies
13.	*Delonix regia*	Gulmohar	Host	Navab butterflies
14.	*Diospyrosn melanoxylon*	Coromandel ebony	Host	Baronet Butterfly
15.	*Mangifera indica*	Mango tree	Host	Baron butterfly
16.	*Kalanchoe pinnata*	Bryophillium sps	Host	Red Pierrot butterfly
17.	*Wattakaka volubilis*	Woody climber	Host	Blue tiger
18.	*Caesalpinia pulcherrima*	Peacock Flower	Host	Common Grass Yellow
19.	*Shorea roxburghii*	Lac tree	Host	Oak blue butterfly
20.	*Loranthus sps.*	Showy mistletoe	Host	common Jezebel
21.	*Hibiscus rosa-sinensis*	china rose, shoeblack plant	Nector	Monarch Butterfly
22.	*Hamelia patens*	Fire Bush, Scarlet Bush	Nector	Larger butterflies, Southern birdwing, Crimson rose. Blue Mormon
23.	*Stachytarpheta jamaicensis*	Jamaican spike	Nector	Lemon emigrant, Mottled emigrant
24.	*Salix tetrasperma*	Indian willow (Neeranji_	Host	Common leapord Butterfly
25.	*Clerodendrum sps.*	Vishandhari glorybower, bagflower	Nector	Large butterfly
26.	*Jatropa Sps.*	purging nut, Barbados nut	Nector	Most butterflies
27.	*Quinqualis indica*	Rangoon creeper	Host & Nector	Host -Slate flash, Indigo flash Nector - Large butterflies
28.	*Pentas Sps.*	Egyptian Star Cluster	Nector	Large butterfly
29.	*Capparis Sps.*	hedge caper or wild caper bush		Pioneer butterflies, Common gull butterflies, Tips (White organge tip, yellow orange tip, Great organge tip & crimson tip)
30.	*Turnera ulmifolia*	Yellow alder	Host	tawny coster butterfly
31.	*Cuphea hyssopifolia,*	Cuphea,	Nector	Small butterflies: Blues & copper butterflies
32.	*Nerium indica*	Rose Bay	Host	Common crow
33.	*Bambusa vulgaris*	Bamboo tree	Host	Bamboo tree brown butterfly
34.	*Chrysalidocarpus lutescens*	Ornamental palm	Host	Tailed palm butterflies
35.	*Cocos nucifera*	Cocnut tree	Host	Tailed palm butterflies
36.	*Asclepias curassavica*	blood flower plant	Host	Plain Tiger butterfly

37.	*Tithonia rotundifolia*	Mexican sun flower	Nector	Monarch butterflies
38.	*Cassia tora*	Sickle Senna	Host	Grass yellow butterflies
39.	*Cassia siamea*	Kassod Tree, Siamese Cassia		Common emigrant butterflies
40.	*Cassia occidentalis*	Coffee Senna. Coffeeweed	Host	Host Mottled Emigrant, Common Emigrants,
41.	Tridax sp.		Nectar	Small butterflies
42.	Vernonia sp.	bitterleaf	Nectar	Most of the butterflies

2. A butterfly conservatory enclosed under polycarbonate roof:

A butterfly conservatory enclosed under a polycarbonate roof provides a controlled environment for butterfly conservation and breeding. The polycarbonate roof allows for natural sunlight to penetrate, creating optimal conditions for the butterflies to thrive well. It also provides protection from extreme weather conditions such as heavy rain, high winds, or excessive heat. This setup maintains a stable microclimate, required for the butterflies' life cycle, including egg laying, larval development, pupation and emergence of adults. Additionally, the polycarbonate material offers protection to the plants within the conservatory from harsh environmental factors. It also provides protection from natural predators and harsh weather conditions, allowing butterflies to thrive in a stable habitat. The dome is also provided with artificial flowers that mimic real flowers in shape and colour, attracting butterflies with visual cues. The flowers are soaked or fitted with absorbent materials containing 10%-20% honey or sugar solution to replicate the nutritional content of natural nectar.

Additionally, the dome replicates natural conditions by housing abundant nectar and host plants, fostering the growth and development of caterpillars, chrysalises, and adult butterflies. This controlled environment not only aids in the conservation of both native and exotic species but also provides visitors with the opportunity to observe butterflies in their natural habitat, enhancing education and raising awareness about butterfly ecology and conservation.

Information Board

A butterfly conservatory dome

Inside view of the dome

Acoustics to reduce noise inside the dome

A small puddle inside the dome

Artificially created water fall

Common Mormone mating inside the dome

Garden inside the dome

Pupae of the butterflies are displayed to educate the public.

Artificial flowers with coloured petals provided with cotton soakes with diluted honey

Additional food source

Additional food source

Figure 7: Butterfly Park in Bannerghatta

Research and captive breeding laboratory:

The Research and Captive Breeding Laboratory at Bannerghatta Butterfly Park (BBP) plays a pivotal role in conserving and maintaining the sustained diversity of butterfly species. These breeding rooms are provided with polycarbonate roof to provide optimal conditions for butterfly development. This laboratory ensures high survival rates for eggs, larvae, and pupae, particularly for endangered species or those threatened in the wild. It also facilitates research on butterfly species, their host plant preferences, nectar sources, and ecological significance. By combining scientific research with breeding initiatives, the laboratory contributes to the conservation of native and exotic species while promoting public education and biodiversity. These efforts culminate in the successful rearing of butterflies and their release into the park's conservatory.

The breeding area is provided with several large nets that houses adult butterflies for feeding and breeding. Sprinkling of water is done to maintain humidity if the environment is hot. During winter incandescent lights are put to maintain required temperature. Compatible species are kept together in the nets.

Artificial flowers with honey or sugar solutions can serve as an alternative nectar source for butterflies, especially during periods when natural blooms are scarce. These artificial feeding stations are typically designed to mimic real flowers in shape and colour, attracting butterflies with visual cues. The flowers are soaked or fitted with absorbent materials containing 10%-20% honey or sugar solution to replicate the nutritional content of natural nectar(Calvert, 1990). This method ensures that butterflies have a consistent food source, supporting their survival and activity in controlled environments like butterfly conservatories. Some butterflies show preferences for other substances like fruits, berries, sap, dung and carrion.

Figure 8: butterfly breeding centre in Bannerghatta Butterfly Park

The butterfly lifecycle consists of four stages: egg, larva (caterpillar), pupa (chrysalis), and adult. During these stages, the butterfly undergoes significant transformation, from hatching as a caterpillar to metamorphosing into an adult butterfly. The breeding efforts aim to protect the eggs, larvae, and pupae from predators, diseases, and extreme weather conditions while ensuring an adequate supply of food and moisture.

The breeding program at Bannerghatta Butterfly Park (BBP) focuses on the conservation and propagation of butterfly species in a controlled environment.

The breeding program involves the following steps:

1. **Collection of Eggs and Larvae**:

Adult butterflies are collected from the host plant garden and released into breeding nets within the designated breeding area to protect them from predators such as wasps and rats. Compatible species are housed together to prevent interspecific conflicts. Each breeding net is equipped with specific potted host plants based on the species' requirements. The adults are encouraged to lay eggs on suitable host plants. Once the eggs are laid, typically on the underside of leaves, they are carefully transferred to separate nets for monitoring. The development of the larvae is closely observed, and the nets are periodically cleaned to maintain hygiene.

Figure 9: The potted plants with collected eggs are kept inside the nets

Nurturing Larvae: Once the larvae (caterpillars) hatch, they are placed in separate trays. These trays are disinfected first by washing with detergent, followed by sterilization with 70%-90% alcohol. The larvae undergo five moults, with each successive stage referred to as an instar. Once the larvae are grown then they are introduced into trays covered with blotting paper or Cora cloth to ensure proper aeration and controlled moisture and their growth is monitored regularly. The first to third instar larvae are kept in one tray, while the fourth and fifth instar larvae are placed in another. The larvae are monitored carefully and infected larvae are identified and removed so that the infection does not spread to the other larvae.

Feed Preparation: Fresh and clean leaves are collected every day from the host plants garden or from the forest area and rinsed with clean water before being air-dried and placed in the rearing trays. For certain butterfly species, additional food supplements such as tender shoots or seed pods may be provided based on their dietary needs. Regular monitoring and timely replacement of the leaves ensure a continuous supply of fresh food. During the first to third instar stages, larvae are voracious feeders and require tender leaves. In contrast, from the fourth instar onward, the larvae are provided with more mature leaf stock to support their growth. The larval growth is monitored periodically and infected larvae are isolated to avoid spreading of infections. The breeding rooms are also kept clean to promote proper growth.

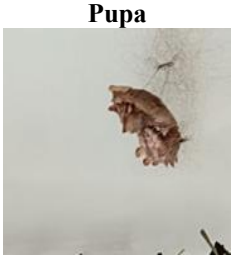
Figure 10: Preparation of fresh Feed for the larvae of Butterflies

2. **Pupation**: Once the larvae reach their full size, they undergo pupation and form chrysalises. These chrysalises are carefully transferred to the pupa chambers, where Cora cloth is provided for attachment. The chambers are maintained with controlled humidity and temperature conditions to facilitate successful metamorphosis.

Figure 11: Pupae o Butterflies are maintained in Breeding rooms

3. **Release of Imago or Adults**: When the imago (adult butterfly) emerges from the pupa (chrysalis), the process is known as eclosion. At this stage, the adult butterfly breaks free from the chrysalis, often using a fluid to soften the outer casing. Upon emerging, the butterfly's wings are soft and crumpled. The butterfly will then hang upside down or rest on a surface for several hours, allowing the wings to expand and harden fully. This process is crucial for the butterfly to achieve the strength and flexibility needed for flight. Once the wings are properly dried and the butterfly's body has fully inflated, it can begin flying and starts searching for food. Once the butterflies emerge as adults, within two hours they are released into the park's butterfly conservatory dome. Otherwise they die of starvation. In the dome the released butterflies continue to mate and contribute to the park's butterfly population. 80% of the adult butterflies are released into the dome and 20% of them are kept for the next breeding cycle.

Figure 12: Adult butterflies are collected in the nets and released in the dome.

Butterfly species	Egg	Larva	Pupa
			
Troides minos **(Southern Birdwing)**			
			
Phalanta phalantha **(Common leopard)**			
			
Terias hecabe **(Common Grass Yellow)**			
			
Papilio polymnestor **(Blue Mormon)**			
			
Euploea core **(Common crow)**			

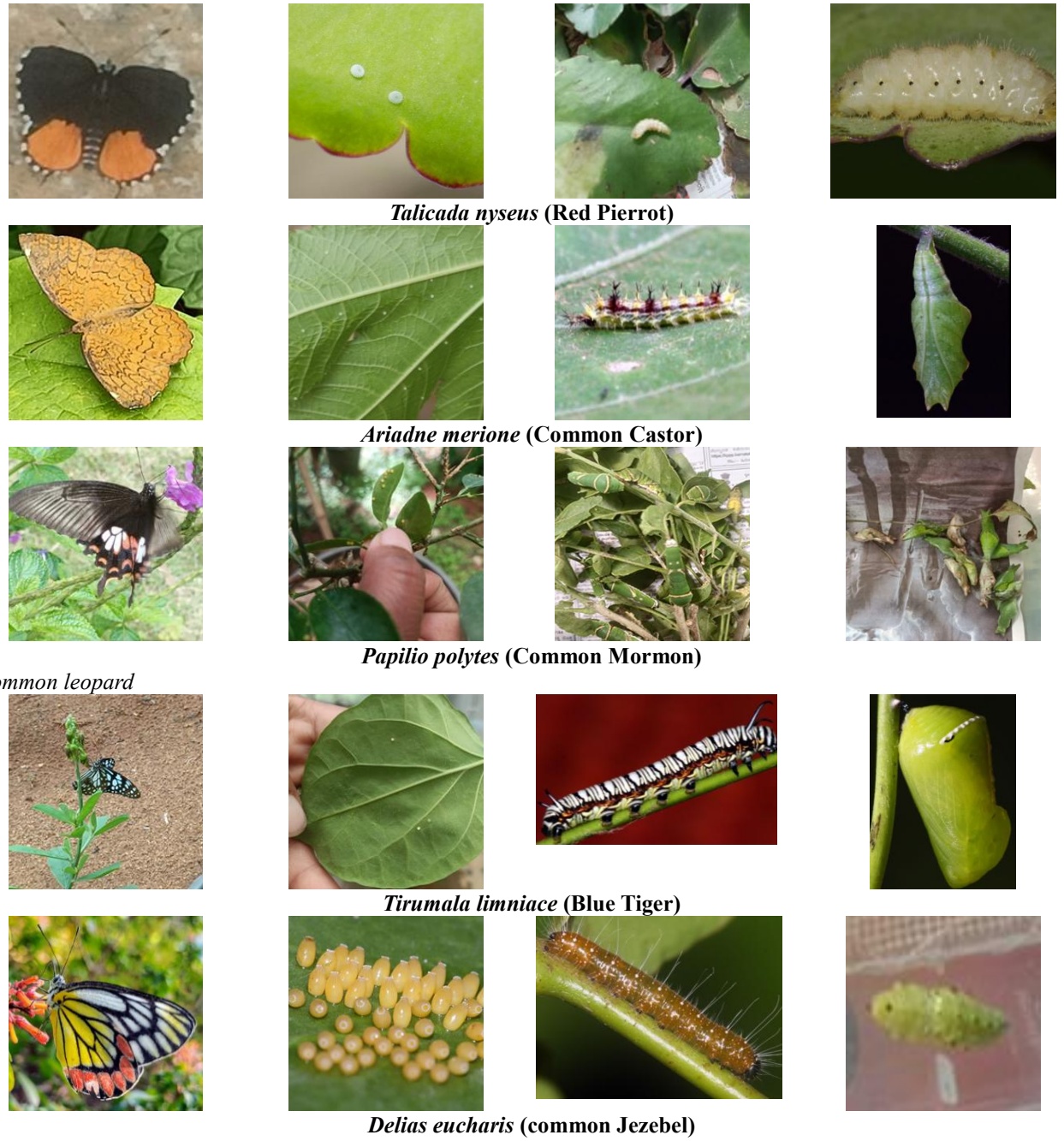


Figure 13: Stages of life cycle of some of the common butterflies in Bannerghatta butterfly Park (Source Bannerghatta butterfly Park and https://www.ifoundbutterflies.org)

Under the guidance of a lepidopterist and a forest official, lab assistants collect larvae, eggs, and feed from the garden, overseeing the breeding process at every stage. The dome's temperature and moisture levels are carefully regulated using exhaust fans, periodic watering, heating bulbs, and fans to maintain the appropriate conditions for each season (Mathew, G. (2006).

A regular inspection for predators, including ants, spiders, rats, birds, and lizards, is conducted to protect the breeding unit and dome from potential threats. In addition to predators, climate change has become a significant challenge for the survival of butterfly species. In recent years, erratic weather patterns and increasing urbanization have made butterfly breeding more difficult, as noted by park officials.

Water: Shallow water sources or damp sand mixed with salt provide a spot where butterflies can gather to drink and extract minerals, a behaviour known as "puddling." Sponges or Cotton Pads soaked with water and sometimes mixed with salts or minerals, these provide hydration in a controlled manner.

Museum: A butterfly museum is a dedicated space that showcases the beauty and ecological significance of butterflies through educational displays, live exhibits, and research initiatives. It features collections of preserved specimens organized by species and geography, live butterfly enclosures that mimic natural habitats, and interactive learning zones explaining their lifecycle and behaviour. Museum also provides information through dioramas with their host plants etc., which leads into audio visual dome where a documentary movie on butterflies is projected. Research and conservation programs focus on breeding and studying butterflies, particularly endangered species, while thematic displays highlight their role in ecosystems and cultural symbolism. Museums like the one at Bannerghatta Butterfly Park (BBP) combine science, education, and recreation to inspire appreciation and action for butterfly preservation.

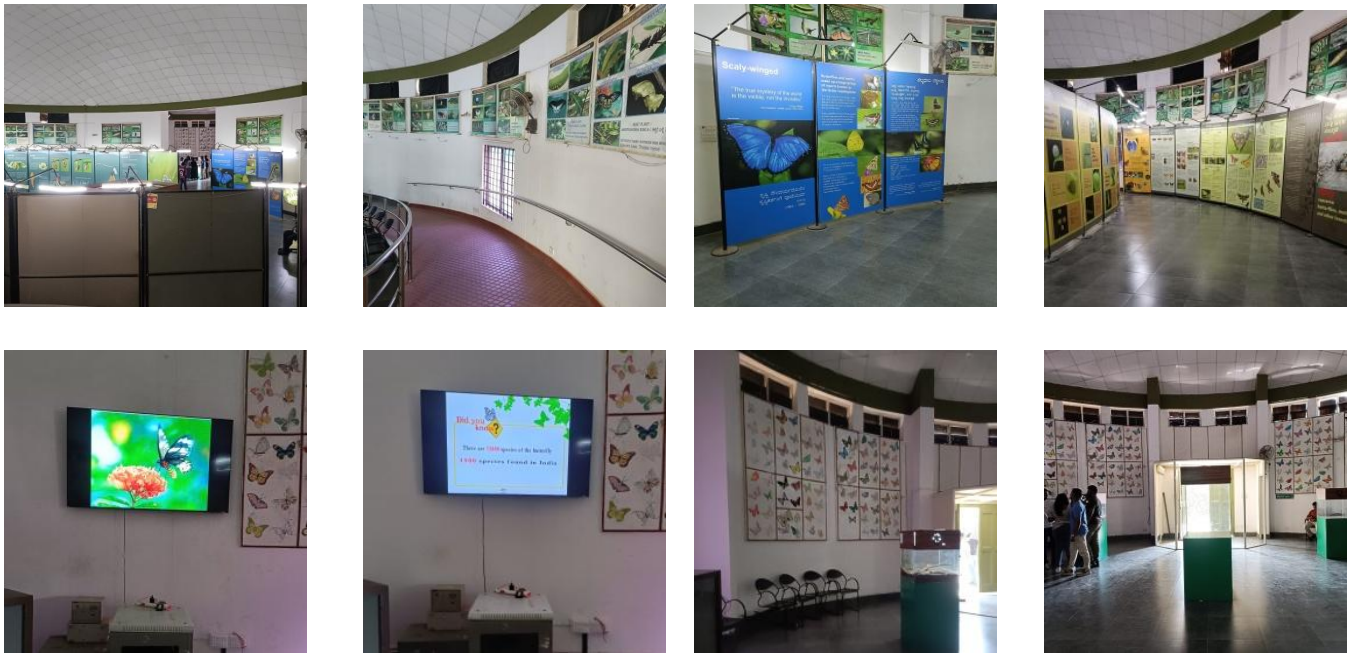


Figure 14: Butterfly Museum at Bannerghatta butterfly Park (Source: Bannerghatta Butterfly Park)

Enhancements Witnessed at BBP: The Butterfly Park at Bannerghatta Biological Park (BBP) has seen significant improvements aimed at both conserving local butterfly species and supporting migratory butterflies. The park has created a more natural and supportive environment, featuring nectar-rich plants and specialized gardens that attract a diverse range of species. Key efforts include the conservation of endangered butterflies through breeding programs, habitat restoration, and the monitoring of butterfly visitors, with a particular focus on the successful breeding of the Southern Birdwing, the state butterfly of Karnataka. The park has seen an increase in migratory butterfly visits, with enhanced habitats that cater to their seasonal needs, such as food sources and safe resting areas. Additionally, the Butterfly Park now features better facilities for research on butterfly behaviour and ecology, making it an important hub for scientific studies on Lepidoptera. Educational initiatives, including informative displays and videos, have been strengthened to raise awareness about the ecological role of butterflies. These research upgrades support studies on butterfly behaviour, migration patterns, and ecological impacts, further reinforcing the Butterfly Park's role as a critical centre for conservation, education, and research.

Conclusion:

The Bannerghatta Butterfly Park in Bengaluru, Karnataka, exemplifies a successful model for butterfly conservation and management, employing innovative strategies to sustain butterfly diversity. Through habitat restoration, captive breeding programs, and community outreach initiatives, the park has established a flourishing sanctuary that highlights the essential role of pollinators in sustaining ecological balance. Its holistic approach integrates scientific research, sustainable practices, and public engagement, demonstrating the significance of conservation centres in protecting biodiversity. Serving as both a refuge for butterflies and an educational resource, Bannerghatta Butterfly Park continues to inspire similar conservation efforts, promoting ecological stewardship and a harmonious relationship between humans and nature. This pioneering model has become a source of inspiration for zoos and parks nationwide. Strengthening efforts in habitat enhancement, implementing continuous monitoring, and fostering collaborations with researchers and conservationists will be essential to ensure the long-term survival of butterfly species.

Acknowledgements

We are deeply thankful to the Deputy Conservator of Forests and Executive Director of Bannerghatta Biological Park (BBP) Sri A V Surya Sen, IFS., Bannerghatta Biological Park (BBP), for granting us permission to conduct our research in the butterfly park and for his continuous encouragement and administrative support throughout the project. We express our heartfelt gratitude to Sri Kulkarni K. R., Range Forest Officer (RFO), and Smt. Sushma N. M., Deputy Range Forest Officer (DRFO), for their invaluable assistance in facilitating our study on butterfly breeding strategies.

Our sincere thanks extend to Dr. Lokanath V., Senior Entomologist, for his insightful contributions and guidance. We also express our deep appreciation to the dedicated workers of Bannerghatta Biological Park, whose tireless efforts and support were crucial to the smooth execution of this study. Their collective contributions have been instrumental in the successful completion of this research, furthering both scientific knowledge and conservation efforts.

Bibliography

1. Aktar, W., Sengupta, D., Chowdhury, A., (2009). Impact of pesticides use in agriculture: their benefits and hazards. Interdisciplinary Toxicology 2, 1-12.
2. Arun P,B, Azeez P,A,(2003). On the butterflies of Puyankutty forest, Kerala, India. Zoo's print Journal 18(12): 1276-1279.
3. Blair, R. B., & Launer, A. E. (1997). Butterfly diversity and human land use: Species assemblages along an urban grandient. *Biological conservation*, *80*(1), 113-125.
4. Choudhary, N. L., & Chishty, N. (2020). Effect of Habitat Loss and Anthropogenic activities on butterflies survival: A review. *International Journal of Entomology*.
5. Ghazanfar, M., Malik, M. F., Hussain, M., Iqbal, R., & Younas, M. (2016). Butterflies and their contribution in ecosystem: A review. *Journal of Entomology and Zoology Studies*, *4*(2), 115-118.

6. Grimm, N. B., Foster, D., Groffman, P., Grove, J. M., Hopkinson, C. S., Nadelhoffer, K. J., Pataki DE, & Peters, D. P. (2008). The changing landscape: ecosystem responses to urbanization and pollution across climatic and societal gradients. Frontiers in Ecology and the Environment, 6(5), 264-272. https://doi.org/10.1890/070147
7. Hoyle, M., & James, M. (2005). Global warming, human population pressure, and viability of the world's smallest butterfly. *Conservation biology*, *19*(4), 1113-1124.
8. http://carbon-based-ghg.blogspot.com/2012/09/butterfliesact-as-wildlife-indicators.html.
9. https://timesofindia.indiatimes.com
10. https://bannerughattabiopark.org
11. https://www.ifoundbutterflies.org
12. Johansen, C. A. (1977). Pesticides and pollinators. *Annual review of entomology*, *22*(1), 177-192.Kevan PG, Greco CF, Belaoussoff S (1997). Lognormality of biodiversity and abundance in diagnosis and measuring of ecosystemic health: pesticide stress on pollinators on blueberry heaths. Journal of Applied Ecology 34:1122–1136.
13. Kehimkar, I., 2008. Book of Indian butterflies. Mumbai , India: Bombay Natural History Society, and Oxford ,United Kingdom: Oxford University Press. 497 p.
14. Kunte K. Butterflies of Peninsular India, Universities Press Limited Hyderabad India, 2000, 254.
15. Kunte K., "Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in northern Western Ghats," Journal of Bioscience, vol. 22, no. 5, pp. 593-603, December 1997.
16. Mathew, G. (2006). Development of butterfly farming enterprises vis-a-vis conservation and sustainable utilisation of biodiversity (No. 286, p. 50). KFRI research report.
17. Mathew, G., George, E., & Anto, M. (2011). Role of Butterfly gardens in promoting biodiversity conservation and ecotourism. *ENVIS Bulletin: Wildlife and Protected Areas-Athropods and their conservation in India (Insects and Spiders) Vol*, *14*, 87-97.
18. McKinney, M. L. (2002). Urbanization, biodiversity, and conservation: the impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems. Bioscience, 52(10), 883-890.
19. Potts, S.G., Imperatriz-Fonseca, V., Ngo, H.T., Aizen, M.A., Biesmeijer, J.C., Breeze, T.D., Dicks, L.V., Garibaldi, L.A., Hill, R., Settele, J., Vanbergen, A.J., 2016. Safeguarding pollinators and their values to human well-being. Nature 540, 220-229.
20. Radchuk, V., Turlure, C., & Schtickzelle, N. (2013). Each life stage matters: the importance of assessing the response to climate change over the complete life cycle in butterflies. *Journal of Animal Ecology*, *82*(1), 275-285.
21. Remadevi, O. K, 2016. Butterflies as indicators of climate change: A Base line study in Bangalore city. Bangalore: Govt. of Karnataka.
22. Rashidha, C. K. (2020). Butterfly gardening: Landscaping for aesthetics and butterfly conservation.
23. Rathcke BJ, Jules ES.(1997). Habitat fragmentation and plant- pollinator interactions. Current Science 65(3):273- 277.
24. Ruchita, N. D., & Paari, K. A. (2022). A comparative study of butterfly diversity in varying habitats of urban green spaces.
25. Saikia, M. K., Kalita, J., & Saikia, P. K. (2009). Ecology and conservation needs of nymphalid butterflies in disturbed tropical forest of Eastern Himalayan biodiversity hotspot, Assam, India. *International Journal of Biodiversity and Conservation*, *1*(7), 231-250.
26. Schtickzelle, N., & Baguette, M. (2003). Behavioural responses to habitat patch boundaries restrict dispersal and generate emigration–patch area relationships in fragmented landscapes. *Journal of Animal Ecology*, *72*(4), 533-545.
27. Shanthi, R., Hussain, K. J., & Sanjayan, K. P. (2009). Influence of weather on the incidence of sucking pest complex on summer-irrigated cotton crops of Tamil Nadu. *Hexapoda*, 89-92.
28. Sparks, T.H., Bellamy, P.E., Eversham, B.C., Greatorex-Davies, J.N., Hinsley, S.A., Jones, S.M., et.al International Journal of Entomology Research www.entomologyjournals.com 97 (1996). The effects of three hedge management treatments on the wildlife of a Cambridgeshire Hedgerow. Annals of Applied Biology, 44,277–284.
29. Subhashini, R and Antony P, 2019. Diversity of butterflies during monsoon season in an urban reserve forest patch of Bangalore city. Bangalore: International Journal of Innovative Science and Research Technology. 22pp.
30. Thakur, D. C., Chakrabarti, P., & Chaudhuri, A. C. (2017). An approach for butterfly conservation through setting up a garden in an urban area, Kolkata, India. World Scientific News, 61(2), 65-81.
31. Thomas J. A., "Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups," PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B: BIOLOGICAL SCIENCES, pp. 339-357, 28 February 2005.
32. Yates T, 1993. Monitoring butterflies for ecology and conservation. London: Chapman & Hall. Open Journal of Ecology, 5(8): 374-401.