Study of Insect Pollinators and their Ecological Role in a Botanical Garden in Changu Kana Thakur Arts, Commerce, and Science College, New Panvel, Raigad district, Maharashtra

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Abstract— **Pollinators are central to the reproduction of flowering plants, biodiversity conservation, and food production. This research was carried out in the botanical garden of Changu Kana Thakur Arts, Commerce, and Science College, New Panvel, Raigad district, Maharashtra, to evaluate the diversity, abundance, and ecological significance of insect pollinators. Field surveys using transect walks, quadrat sampling, timed observations, and floral visitor counts documented butterfly pollinators and their behaviors. Seven butterfly species were identified, including Aphrissa statira, Papilio helenus, Catopsilia florella, Papilio polytes, Pachliopta hector, Tirumala limniace, and Eurema brigitta. These species exhibited varied foraging strategies, host plant associations, mimicry, and migratory behaviors, all contributing to ecosystem stability. The findings demonstrate how important botanical gardens are as urban pollinator refuges particularly in areas facing habitat loss and fragmentation. Conservation strategies focusing on habitat enhancement, reduction of pesticide use, and public awareness are essential for ensuring pollinator resilience.**

Index Terms— **Pollinators, butterflies, biodiversity, botanical gardens, foraging behavior, conservation, ecosystem health.**

I. INTRODUCTION

Insect pollinators play an indispensable role in sustaining terrestrial ecosystems. Approximately 75% of flowering plants and one-third of food crops rely on pollinators for reproduction. Pollinators enhance genetic variability in plants through cross-pollination, which contributes to ecosystem resilience and adaptability to changing environmental conditions. Economically, pollinators contribute between $235 and $577 billion annually to global agriculture. Beyond yield, they also improve the nutritional quality of crops such as fruits, vegetables, and nuts. From an ecological perspective, they stabilize soil, regulate water cycles, and maintain habitats for other species. Despite their importance, pollinators are in global decline. Habitat loss due to urbanization, intensive agriculture, pesticide use, climate change, and invasive species all contribute to reduced abundance and diversity. Botanical gardens, however, offer controlled environments that can serve as refuges for pollinator species, especially in rapidly urbanizing regions.

The present study focuses on documenting pollinator species in the Changu Kana Thakur College Botanical Garden, New Panvel, Raigad. Butterflies were chosen as focal pollinators due to their visibility, ecological importance, and sensitivity to habitat changes.

II. MATERIALS AND METHODS

The study was conducted in the botanical garden of Changu Kana Thakur College, New Panvel (Raigad, Maharashtra). The garden contains both native and ornamental flowering plants, interspersed with water features and shaded areas, creating microhabitats favorable to diverse pollinator species.

Four complementary methods were used:
1. Transect Walks – Observers walked along fixed routes and recorded butterfly activity within a defined range.
2. Quadrat Sampling – Pollinators were counted in 1×1 m plots to assess microhabitat-specific abundance.
3. Timed Observations – Selected flowers were monitored for pollinator visits over fixed time intervals.
4. Floral Visitor Counts – The number of insect visits to particular plant species was recorded to determine preferences.

Species identification was conducted using field guides, taxonomic keys, and photography. Environmental factors such as temperature and humidity were noted, and behavioral observations included foraging duration, flower preference, and flight activity.

III. Observations

Twenty-three butterfly species were recorded as significant pollinators in the garden (Table 1)

Common Name	Scientific Name	Key Traits	Host Plants
Common Tiger	*Danaus genutia*	Distinct orange & black, migratory, unpalatable (toxic)	Milkweeds (*Calotropis*, *Asclepias*)
Plain Tiger	*Danaus chrysippus*	Bright orange with white/black, aposematic, migratory	Milkweeds (*Calotropis*, *Asclepias*)
Lemon Pansy	*Junonia lemonias*	Eye spots on wings, sun-loving, territorial	*Ruellia*, *Phyla nodiflora*
Chocolate Pansy	*Junonia iphita*	Brown wings with wavy lines, prefers shade	*Ruellia*, *Barleria*
Grey Pansy	*Junonia atlites*	Grey-brown, distinct eye spots, open habitats	*Ruellia*, *Barleria*
Peacock Pansy	*Junonia almana*	Bright orange, eye spots, seasonal forms	*Ruellia*, *Barleria*
Common Sailor	*Neptis hylas*	Black with white bands, gliding flight	*Adhatoda*, *Dipteracanthus*
Angled Castor	*Ariadne ariadne*	Orange-brown, angled wing margins	*Ricinus communis* (Castor plant)
Tawny Castor	*Acraea terpsicore*	Tawny orange with black spots, unpalatable	*Ricinus communis* (Castor plant)
Common Crow	*Euploea core*	Dark brown with white spots, unpalatable	Milkweeds (*Calotropis*, *Asclepias*)
Blue Tiger	*Tirumala limniace*	Black with blue streaks, migratory	Milkweeds (*Calotropis*, *Asclepias*)
Glassy Tiger	*Parantica aglea*	Transparent wing patches, slow flight	Milkweeds (*Calotropis*, *Asclepias*)
Black Rajah	*Charaxes solon*	Strong flyer, dark brown with white bands	*Dalbergia*, *Cassia*
Common Bushbrown	*Mycalesis perseus*	Brown with eye spots, crepuscular activity	Grasses (*Cynodon*, *Panicum*)
Great Eggfly	*Hypolimnas bolina*	Sexual dimorphism; males with violet spots	*Ipomoea*, *Portulaca*, *Ruellia*
Blue Mormon	*Papilio polymnestor*	Large, black & blue, fast flyer	Citrus (*Rutaceae*)
Common Mormon	*Papilio polytes*	Female polymorphism, mimicry of toxic species	Citrus (*Rutaceae*)
Lime Butterfly	*Papilio demoleus*	Abundant, black & yellow, rapid flyer	Citrus (*Rutaceae*)
Tailed Jay	*Graphium agamemnon*	Green-spotted, swift flyer	*Annona*, *Polyalthia*, *Cinnamomum*
Spot Swordtail	*Graphium nomius*	Long tail, white with black spots	*Annona*, *Polyalthia*, *Cinnamomum*
Angled Pierrot	*Caleta decidia*	Small, white with angled hindwing margin	*Zizyphus*, *Euphorbia*
Common Pierrot	*Castalius rosimon*	Small, white with black bands	*Zizyphus*, *Euphorbia*
Red Pierrot	*Talicada nyseus*	Small, white with red-orange hindwings	*Kalanchoe* (succulent host)

Table 1 presents the diversity of butterfly pollinators recorded in the botanical garden throughout year for all seasons encompassing 24 species across different families and ecological guilds. The table highlights their common names, scientific names, distinguishing traits, and larval host plants, providing insights into their ecological significance.

Among the recorded species, the Danaid group (Danaus genutia – Common Tiger, Danaus chrysippus – Plain Tiger, Euploea core – Common Crow, Tirumala limniace – Blue Tiger, Parantica aglea – Glassy Tiger) is strongly represented. These butterflies are characterized by their aposematic coloration and chemical defenses, derived from feeding on milkweed plants (Calotropis, Asclepias). Their unpalatability provides protection against predators and ensures their survival in urban landscapes.

The pansies (Junonia lemonias, J. iphita, J. atlites, J. almana) show high adaptability, often found in open sunny patches. Their eye spots and seasonal forms help deter predators, while their larvae feed on plants such as Ruellia and Barleria. Similarly, the sailors and castors (Neptis hylas, Ariadne ariadne, Acraea terpsicore) represent species well adapted to disturbed habitats, with host plants like Adhatoda and Ricinus communis.

Notably, several swallowtails (Papilionidae) were observed, including Papilio polymnestor (Blue Mormon), P. polytes (Common Mormon), P. demoleus (Lime Butterfly), Graphium agamemnon (Tailed Jay), and Graphium nomius (Spot Swordtail). These large, strong fliers are primarily associated with Rutaceae (citrus) and Annonaceae as host plants, making them important for both natural ecosystems and agroecosystems. The polymorphic Papilio polytes is particularly significant due to its female mimicry strategy, which enhances survival by resembling toxic species.

Other notable species include Hypolimnas bolina (Great Eggfly), known for sexual dimorphism and rapid flight; Charaxes solon (Black Rajah), a powerful forest flyer linked with Dalbergia and Cassia; and Mycalesis perseus (Common Bushbrown), a shade-loving butterfly whose abundance reflects the presence of grass patches. The small pierrots (Caleta decidia, Castalius rosimon, Talicada nyseus) represent the Lycaenidae family and are tied to Zizyphus, Euphorbia, and Kalanchoe host plants, showing the diversity of larval food resources available in the garden.

Overall, the table illustrates a rich and ecologically varied butterfly assemblage within the garden, ranging from large swallowtails to small lycaenids. Their presence not only ensures pollination of a wide array of plants but also reflects the habitat heterogeneity and floral diversity maintained in the botanical garden. The combination of resident, migratory, and mimic species underscores the garden's role as a pollinator refuge in an urbanized setting.

A total of twenty-four species were observed, each exhibiting distinct morphological traits, behavioral strategies, and host plant associations.

Seasonal Abundance of Butterfly Species:

The study revealed distinct seasonal fluctuations in butterfly abundance, strongly linked to flowering cycles, climatic conditions, and host plant availability.

Pre-Monsoon (March–May):

Butterfly activity was comparatively low during the pre-monsoon period due to limited floral resources and rising temperatures. Species such as *Papilio demoleus* (Lime Butterfly), *Junonia lemonias* (Lemon Pansy), and *Hypolimnas bolina* (Great Eggfly) were more commonly observed, exploiting hardy nectar plants and citrus hosts. Grassland species like *Mycalesis perseus* (Common Bushbrown) were also present, reflecting the persistence of grasses even during drier months.

Papilio demoleus (Lime Butterfly),	03
Junonia lemonias (Lemon Pansy),	06
Hypolimnas bolina (Great Eggfly)	04
Mycalesis perseus (Common Bushbrown)	03

Monsoon (June–September):

The onset of rains led to a gradual increase in butterfly activity. Moist conditions supported species such as *Danaus chrysippus* (Plain Tiger), *Danaus genutia* (Common Tiger), and *Euploea core* (Common Crow), all of which thrive on milkweeds rejuvenated by rainfall. Shade-loving species like *Junonia iphita* (Chocolate Pansy) and *Junonia atlites* (Grey Pansy) were more prominent in the humid understory. Migratory species including *Catopsilia florella* (Lemon Emigrant) and *Tirumala limniace* (Blue Tiger) began to appear in moderate numbers, marking the seasonal transition.

Danaus chrysippus (Plain Tiger)	11
Danaus genutia (Common Tiger)	09
Euploea core (Common Crow)	12
Junonia iphita (Chocolate Pansy)	11
Junonia atlites (Grey Pansy)	12
Catopsilia florella (Lemon Emigrant)	15
Tirumala limniace (Blue Tiger)	05

Post-Monsoon (October–December):

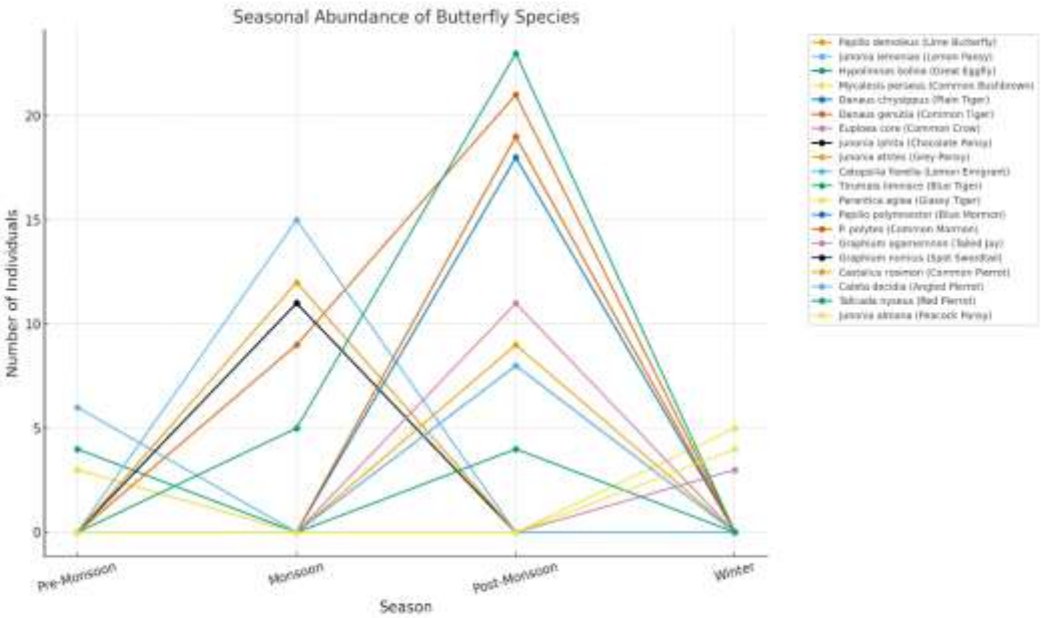
This period represented the peak season for butterfly abundance and diversity. A wide range of species were recorded in high numbers, coinciding with maximum floral availability in the garden. Migratory danaids such as *Tirumala limniace* (Blue Tiger), *Parantica aglea* (Glassy Tiger), and *Danaus genutia* (Common Tiger) formed large aggregations, dominating pollination networks. Swallowtails like *Papilio polymnestor* (Blue Mormon), *P. polytes* (Common Mormon), *Graphium agamemnon* (Tailed Jay), and *Graphium nomius* (Spot Swordtail) were frequent, reflecting the abundance of citrus and annonaceous host plants during this season. Smaller lycaenids such as *Castalius rosimon* (Common Pierrot), *Caleta decidia* (Angled Pierrot), and *Talicada nyseus* (Red Pierrot) also showed high abundance, exploiting a variety of nectar sources. This post-monsoon peak highlights the synchrony between butterfly populations and plant flowering phenology.

Tirumala limniace (Blue Tiger)	23
Parantica aglea (Glassy Tiger),	19
Danaus genutia (Common Tiger)	21
Papilio polymnestor (Blue Mormon),	18
P. polytes (Common Mormon),	19
Graphium agamemnon (Tailed Jay),	11
Graphium nomius (Spot Swordtail)	08
Castalius rosimon (Common Pierrot),	09
Caleta decidia (Angled Pierrot),	08
Talicada nyseus (Red Pierrot)	04

Winter (January–February):

Butterfly activity declined sharply in winter, with fewer species recorded. Resident species such as *Junonia almana* (Peacock Pansy), *Mycalesis perseus* (Common Bushbrown), and *Euploea core* (Common Crow) persisted in smaller numbers, sustained by hardy nectar plants and evergreen host species. Migratory butterflies, particularly danaids and emigrants, were largely absent, reflecting their seasonal dispersal patterns.

Junonia almana (Peacock Pansy),	04
Mycalesis perseus (Common Bushbrown)	05
Euploea core (Common Crow)	03



The graph 1 shows the seasonal abundance of butterfly species, and focusing on post-monsoon, we can describe the Species Richness Distribution in detail:

Peak Abundance in Post-Monsoon: The Post-Monsoon season shows the highest abundance of most butterfly species, indicating favorable environmental conditions such as abundant flowering plants, moderate temperatures, and high humidity.

Dominant Species: Hypolimnas bolina (Great Eggfly): Exhibits the highest abundance (~23 individuals), making it the most dominant species in this season. Danaus chrysippus (Plain Tiger) and Danaus genutia (Common Tiger): Both show high numbers (~20 and ~18 individuals respectively), suggesting strong post-monsoon proliferation. Mycalesis perseus (Common Bushbrown): Moderate abundance (~4 individuals), indicating some species are less numerous.
Moderate Abundance: Species like Junonia lemonias (Lemon Pansy, Junonia iphita (Chocolate Pansy individuals. Papilio demoleus (Lime Butterfly):
Low Abundance Species: Several species appear in smaller numbers (~1–3 individuals), including Eurema hecabe (Common Emigrant), Graphium agamemnon (Tailed Jay), Graphium nomius (Spot Swordtail), Junonia almana (Peacock Pansy)

This indicates these species are either less common or have specific ecological niches.

Species Richness Distribution Pattern: The study revealed marked seasonal variation in species richness and abundance of butterflies, reflecting their close association with floral resource dynamics and climatic conditions.

Pre-Monsoon (March–May):

Species richness was comparatively low (4 species recorded), with limited abundance values. The dominant species included Papilio demoleus, Junonia lemonias, and Hypolimnas bolina, all exploiting hardy nectar plants and citrus hosts. This restricted diversity indicates that butterfly activity during this season is largely constrained by drought stress and reduced floral resources, highlighting their sensitivity as bioindicators of resource scarcity.

Monsoon (June–September):

Species richness increased substantially (7 species), supported by rainfall-driven rejuvenation of host plants like milkweeds and shade vegetation. Notable pollinator species included danaids (Danaus chrysippus, Danaus genutia, Euploea core) and migratory forms such as Catopsilia florella and Tirumala limniace. Their presence in moderate abundance signals ecosystem recovery and resource renewal, making them useful indicators of wet-season floral productivity.

Post-Monsoon (October–December):

This period represented the peak of species richness and abundance (10 species, maximum individuals). Migratory danaids (Tirumala limniace, Parantica aglea, Danaus genutia) dominated, along with swallowtails (Papilio polymnestor, P. polytes) and smaller lycaenids (Castalius rosimon, Talicada nyseus). Such high richness synchronizes with peak flowering and fruiting, reflecting optimal pollinator activity. Butterflies here act as strong ecological indicators of ecosystem health, signaling high floral availability and robust pollination networks.

Winter (January–February):

Species richness again declined (3 species), with only resident species (Junonia almana, Mycalesis perseus, Euploea core) persisting in low abundance. The absence of migratory species demonstrates seasonal dispersal and reduced pollinator services during this dry period. Their restricted presence serves as an indicator of resource limitation and seasonal dormancy in pollination dynamics

Ecological Implications: The post-monsoon season marked the peak of butterfly diversity and abundance, with 10 species recorded in significant numbers. This period coincided with the profuse flowering of wetland-associated plants, garden flora, and forest edges, creating a rich nectar landscape. The diversity included large migratory danaids, strong-flying swallowtails, and small but specialized lycaenids, reflecting a balanced ecological community.

Migratory Danaids such as Tirumala limniace (Blue Tiger, 23 individuals), Parantica aglea (Glassy Tiger, 19), and Danaus genutia (Common Tiger, 21) were dominant. Their large aggregations not only enhanced pollination networks but also indicated landscape connectivity, as these butterflies move across habitats in search of nectar and host plants.

Swallowtails like Papilio polymnestor (Blue Mormon, 18), Papilio polytes (Common Mormon, 19), and Graphium species (G. agamemnon, 11; G. nomius, 8) were frequent, showing the abundance of citrus and annonaceous hosts. As robust pollinators of large flowers, their diversity signals ecosystem resilience and the presence of mixed vegetation.

Lycaenids, represented by Castalius rosimon (9), Caleta decidia (8), and Talicada nyseus (4), exploited smaller floral resources. Despite their smaller size, they play a critical role in pollination of shrubs and herbs, adding functional depth to the pollinator guild.

Species Richness Distribution in Post-Monsoon (October–December):

The post-monsoon period represented the peak season for butterfly diversity and abundance, with 10 species recorded, showing the highest species richness across all seasons. This richness reflects the synchrony between butterfly populations and the maximum availability of floral resources following the monsoon.

Migratory Danaids: Species such as *Tirumala limniace* (Blue Tiger, 23 individuals), *Parantica aglea* (Glassy Tiger, 19), and *Danaus genutia* (Common Tiger, 21) were recorded in large aggregations. Their dominance highlights their crucial role as long-distance pollinators, linking different habitats and ensuring cross-pollination in diverse plant communities. Their presence in such abundance signals healthy wetland-edge ecosystems and milkweed host plant availability.

Swallowtails (Family Papilionidae): Species like *Papilio polymnestor* (Blue Mormon, 18), *Papilio polytes* (Common Mormon, 19), *Graphium agamemnon* (Tailed Jay, 11), and *Graphium nomius* (Spot Swordtail, 8) were well represented. Their abundance reflects the flourishing of citrus and annonaceous host plants. Being strong fliers and frequent visitors of large, fragrant flowers, these swallowtails are important pollinators of garden, forest, and orchard species, making them indicators of high host-plant diversity.

Lycaenids (Small Butterflies): Smaller species such as *Castalius rosimon* (Common Pierrot, 9), *Caleta decidia* (Angled Pierrot, 8), and *Talicada nyseus* (Red Pierrot, 4) were also recorded. Despite their smaller numbers, they exploit a wide range of nectar sources, especially from herbs and shrubs, and are vital for pollination of small-flowered plants. Their presence adds to overall community richness and demonstrates the fine-scale availability of nectar resources.

Ecological Implications:

1. **Peak Pollinator Services:** The post-monsoon peak in richness highlights the synchrony between butterfly life cycles and plant phenology. This ensures effective pollination services, crucial for seed set, fruiting, and regeneration of native vegetation around wetlands.
2. **Indicator of Habitat Quality:** The diversity of danaids, swallowtails, and lycaenids shows that a variety of host plants and nectar sources are available. Such richness is an indicator of high habitat quality, ecological stability, and successful post-monsoon resource recovery.
3. **Landscape Connectivity:** Migratory species like Blue Tiger and Glassy Tiger demonstrate the ecological connectivity of wetland habitats with surrounding landscapes. Their seasonal aggregations emphasize the role of wetlands as critical stopover and foraging sites, making them essential for regional biodiversity conservation.
4. **Resilience of Pollination Networks:** The presence of multiple functional groups (migrants, residents, large swallowtails, and small lycaenids) reflects a robust and resilient pollination network. This diversity reduces dependency on a single pollinator group and enhances ecosystem stability under changing climatic conditions.
5. **Bioindicator Role:** The richness distribution during post-monsoon underscores butterflies as sensitive bioindicators of floral abundance, climate stability, and habitat integrity. Monitoring their diversity can provide early warnings of ecological imbalance caused by urbanization, habitat degradation, or pollution in wetland ecosystems

IV. DISCUSSION-

The present study highlights the ecological significance of butterfly pollinators within an urban botanical garden. The diversity of species recorded — including Aphrissa statira, Papilio helenus, Catopsilia florella, Papilio polytes, Pachliopta hector, Tirumala limniace, and Eurema brigitta — reflects the resilience of pollinators even in semi-managed landscapes. Each of these butterflies contributes uniquely to pollination services, and their presence indicates the suitability of the garden as a refuge for insect biodiversity [1,2].

Ecological Adaptations and Pollination Roles: Butterflies employ a range of adaptations that enhance their efficiency as pollinators. For instance, the mimicry exhibited by *Papilio polytes* enables females to avoid predation, ensuring stable populations and continued pollination of citrus species [3]. Similarly, aposematism in *Pachliopta hector* (Crimson Rose) not only protects it from predators but also stabilizes pollinator networks through consistent floral visitation [4]. Migratory butterflies like *Catopsilia florella* and *Tirumala limniace* extend pollination services across wide spatial scales, ensuring genetic connectivity between plant populations. These findings support earlier work by Garibaldi et al. [5], who emphasized the role of wild pollinators in sustaining crop yields. Recent studies reaffirm the essential role of wild pollinators in maintaining plant reproductive success, even when honeybee populations fluctuate [6].

Seasonal Abundance and Floral Synchrony: The seasonal trends observed in this study, with a marked increase in pollinator abundance post-monsoon, demonstrate the importance of floral synchrony in pollination ecology. Post-monsoon flowering peaks coincide with butterfly population increases, ensuring optimal pollination. This relationship highlights the interdependence between pollinator life cycles and plant phenology, which is increasingly threatened by climate change-induced shifts in flowering times [7]. A mismatch in timing could disrupt plant reproduction and reduce food availability for pollinators.

Pollinators as Bioindicators: Butterflies are highly sensitive to microclimatic conditions and habitat quality, making them effective bioindicators of ecosystem health. The presence of sensitive species like *Eurema brigitta* (Small Grass Yellow), abundant after monsoons, reflects seasonal habitat stability, while migratory species indicate ecological connectivity across landscapes. Such findings align with by recent analyses showing pollinator richness as a strong indicator of ecosystem integrity across human-dominated landscapes. [8].

Urban Botanical Gardens as Refuges: The role of botanical gardens in pollinator conservation is becoming increasingly important as natural habitats decline due to urban expansion. Gardens provide continuous floral resources, minimize pesticide use, and maintain microhabitats suitable for nesting and foraging. The Changu Kana Thakur College Botanical Garden serves as a micro-reserve, supporting pollinator populations that might otherwise be excluded from surrounding urbanized landscapes. Similar studies in urban botanical gardens globally have confirmed their potential as pollinator sanctuaries [9,10].

Threats and Conservation Implications: Despite their resilience, pollinators face multiple anthropogenic threats:

1. Habitat fragmentation reduces nesting and foraging opportunities.
2. Pesticide use, particularly neonicotinoids, impairs navigation and reduces survival rates.
3. Climate variability disrupts synchrony between flowering plants and pollinators.
4. Invasive species and pathogens introduce new competitive pressures.

To mitigate these threats, conservation strategies must integrate habitat management within both urban and agricultural landscapes. Promoting native plant species, ensuring year-round floral availability, creating buffer zones, and involving local communities in citizen science monitoring can strengthen pollinator conservation [10,11].

Broader Ecological Significance: The findings of this study extend beyond the botanical garden context. By documenting species diversity and abundance, it contributes to a growing body of evidence showing that pollinator-friendly landscapes enhance ecosystem resilience and food security. Protecting pollinators is not just an ecological necessity but also a socio-economic imperative, given their role in supporting agriculture, livelihoods, and human nutrition [12].

V.CONCLUSION:

This study confirms that the Changu Kana Thakur College Botanical Garden sustains diverse butterfly pollinators, underscoring the ecological value of botanical gardens in urban ecosystems. Immediate actions like reducing pesticide use, promoting native flora, and conserving nesting sites will further strengthen pollinator resilience. Protecting pollinators is essential for ecological, economic, and social wellbeing. Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE and SI do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

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