

Feeding butterflies with *Tridax procumbens* (L.), a beneficial plant for maintaining butterfly populations

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Abstract

Butterflies play a crucial role in pollination by feeding on nectar from flowers. In the urbanized area, the interaction of butterflies and flowering plants indicates the state of the environment in this area. *Tridax procumbens* Linnaeus is an invasive plant, best known as a widespread weed and pest plant. A study was conducted to analyze the association of butterflies with *T. procumbens* in different time intervals, namely 10 am – 12 pm, 12 – 2 pm, and 2 – 4 pm. A total of 34 species of butterflies belonging to 5 families were reported to visit this plant. Among these three time slots, 12 pm to 2 pm holds significantly the highest number of butterfly visitors ($X^2=13131.3818$, $df=33$, $p=0.00001$). The present study demonstrated that the presence of butterfly species and their frequency on *T. procumbens* shows different visitation patterns for different families in each time interval. The study determined that the butterfly species helps to pollinate this plant, which in turn helps to conserve these butterfly species.

Keywords: butterfly diversity, conservation, flower visitor, flowering plant, interaction

Introduction

Inter-specific interactions, such as competition, predation, mutualism, and parasitism, play a crucial role in shaping the dynamics of ecosystems, species richness, and community structure (Thebault and Fontaine, 2010; Benadi *et al.*, 2013; Lang and Benbow, 2013; Wilby and Orwin, 2013). Understanding these dynamics is crucial for maintaining the balance and health of ecosystems (Brose and Hillebrand, 2016). It allows for developing more effective conservation and management strategies to ensure the long-term persistence and sustainability of species and ecosystems (Moritz, 2002; Branson *et al.*, 2006). Plant-pollinator interactions are a key area of ecological research, and studying them at the community level provides valuable insights into the composition, structure, and ecological benefits of these interactions (Olito and Fox, 2015; Peralta *et al.*, 2020; Schwarz *et al.*, 2020). Bees are indeed a central focus in the study of plant-pollinator interactions, primarily because of their crucial role in pollination and ecosystem functions (Huang and Giray, 2012; Rosas-Guerrero *et al.*, 2014; Ashworth *et al.*, 2015; Silva *et al.*, 2021). They are among the most effective and frequent flower visitors, and their contribution to pollinating a wide range of plants is essential for the reproduction of many

species (Kevan and Baker, 1983; Rosas-Guerrero *et al.*, 2014; Ashworth *et al.*, 2015). Their impact on ecosystems is of significant importance for ecological research.

Butterflies are vital flower visitors in various ecosystems, especially in tropical regions where they are abundant and they contribute to pollination and biodiversity by visiting flowers and transporting pollen (Bawa, 1990; Kevan and Viana, 2003; Dick *et al.*, 2008). The effectiveness of butterflies as pollinators can vary depending on the specific plant species, as not all plants are equally adapted for butterfly pollination (De Araujo *et al.*, 2014; Aroujo *et al.*, 2018). Butterflies can indeed act as secondary pollinators in situations where the primary pollinators, such as bees, are either absent or less abundant (Rosas-Guerrero *et al.*, 2014; Ashworth *et al.*, 2015; Wenzel *et al.*, 2020). While some people might perceive butterflies as simply floral visitors or nectar robbers, there are certain butterfly species that indeed serve as genuine and important pollinators (Epps *et al.*, 2015).

The association between butterflies and flowering plants is a fascinating aspect of nature, contributing to the beauty of urban landscapes and the improvement of air quality (Younis *et al.*, 2009; Mukherjee *et al.*, 2015). However, as urbanization progresses, invasive plant species like *Tridax procumbens* (Asteraceae family) can disrupt this balance. *T. procumbens* has traditionally been used in India for various medicinal purposes (Andriana *et al.*, 2019; Dattaray, 2022), such as wound healing and insect repellent, even though it is considered invasive and problematic in many countries (Simberloff, 2014). Balancing the preservation of native ecosystems and traditional uses with the management of invasive species is a complex challenge (Pfeiffer and Voeks, 2008; Kritasampan *et al.*, 2016).

This present study was conducted in urban area of West Bengal State University (WBSU) campus, from which communication reports total number of 34 species of butterflies belonging to five families from *T. procumbens* L. A study on different time specific visitation has also been conducted to observe the visitation pattern of butterfly on this plant in campus.

Materials and Methods

Study area

The study was conducted in West Bengal State University (WBSU) campus (88°26' E, 22°44'N) and belongs to the urban belt of North 24 Parganas, Barasat, West Bengal, India (Figure 1). The campus is spread over an area of 27.86 acres with green vegetation of naturally growing large trees, shrubs, and grasses that provide shelter to butterfly species (Mallick 2023). The presence of *Tridax procumbens* at study site is noteworthy, given its status as an invasive plant species.

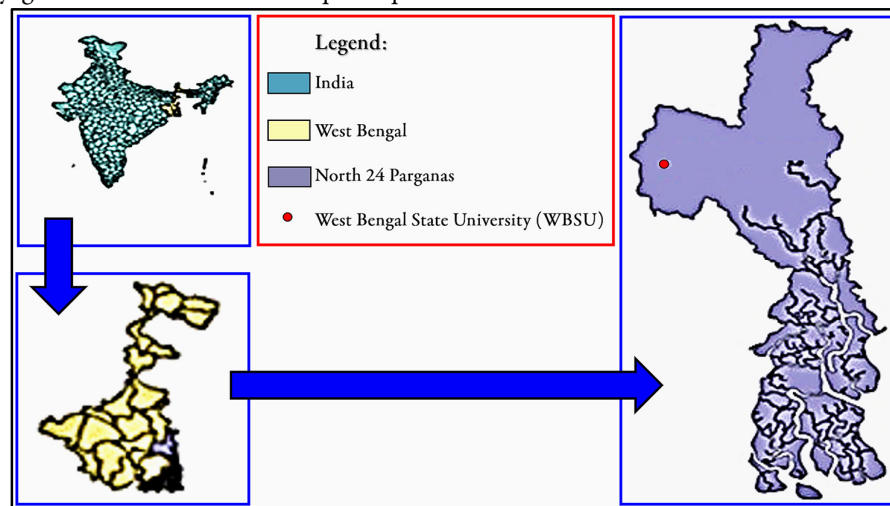


Figure 1. Map of the study area

Sampling methods

To conduct the study, three transect paths of 100 meters were placed in three different grids in WBSU campus. Total numbers of four quadrates with grid of (4×4 m) were placed randomly on the transect path to study butterfly diversity (Phillips *et al.*, 2021). Total twelve quadrates have been placed among all the grids in WBSU campus. The study was conducted in the period of six consecutive months (May to October) of the year 2023. Transects were monitored during different time intervals of day-time. The study was conducted during 10 AM to 3:30 PM with the time frames of 2 hours intervals i.e. 10 AM to 12 PM, 12 PM to 2 PM, and 2 PM to 4 PM. These butterfly species belonging from five families were observed to visit only in *T. procumbens*. The frequencies of visit by butterfly species were recorded in the plant only when butterflies uncoiled their proboscis for collecting food. The butterfly species were identified with the help of the book Butterflies of India by Issac Kehimkar (Kehimkar, 2016) and photographed with Realme 8 camera. To measure its significance, the recorded data was analysed by using Chi-square test, and time-based ANOVA test with the help of Microsoft Excel, Windows 2007.

Result

Among the 34 butterfly species belonging to 5 families recorded as visitors of *Tridax procumbens* L (Table 1, Plate 1). *Cigaritis vulcanus* was found to be the most dominant species in study area (Relative abundance = 8.07) followed by *Tarucus nara* (Relative visiting frequency = 7.80), *Luthrodes pandava* (Relative visiting frequency = 7.75), *Ypthima huebneri* (Relative visiting frequency = 7.48), *Papilio polytes* (Relative visiting frequency = 6.63), and others (Table 2). The basis of relative visiting frequencies also known as “encounter” on *T. procumbens* in the distributed habitat. The ray florets often have colorful petals and serve to attract pollinators, such as bees and butterflies, to the central disc florets. The disc florets were visiting during day-time by butterflies for nectar collection.

The butterflies include 34 species representing Papilionidae, Pieridae, Nymphalidae, Lycaenidae and Hesperidae. The data collected on the foraging visits of butterflies of each family showed that Lycaenidae made (N=814), Hesperidae (N=357), Pieridae (N=285), Nymphalidae (N=283), and Papilionidae (N=130) of total visits (Figure 2). The Lycaenidae was by 10 (29%) species, Nymphalidae by 8 (23%) and Hesperidae by 7 (21%) species, Pieridae by 6 (18%) species and Papilionidae 3 (9%) species (Figure 3). With the respect of the study from different time intervals, the highest numbers of butterfly species were recorded in the time frame of 12 am to 2 pm (34 species), followed by 10 pm to 12 pm (26 species) and least number of species had been found in the time frame of 2 pm to 4 pm (18 species) (Figure 4).

The chi square test indicates a significant peak value on the number of butterfly species in the time frame between 12 pm to 2 pm during the study period (Table 3). With the respect of the pattern of visit of butterflies from different families, the observation is clearly showcasing the number of butterflies from different family with their inclination and declination order in different studied time frames (Figure 5). The foraging activity of these butterflies did not show a definite pattern but the foraging was intense during for noon period for all butterfly species. This foraging trend was observed almost throughout the flowering season for butterflies of all families recorded in this study. They frequently moved between individual plants and between patches situated nearby and far away were considered to be important in pollination.

Table 1. Checklist of butterflies recorded on *Tridax procumbens* during the study

No.	Common Name	Scientific Name	Family	Status
1	Quaker	<i>Neopithecops zalmora</i> (Butler, 1870)	Lycaenidae	C
2	Common Silverline	<i>Cigaritis vulcanus</i> (Fabricius, 1775)	Lycaenidae	VC
3	Gram Blue	<i>Euchrysops cnejus</i> (Fabricius, 1798)	Lycaenidae	C
4	Pale Grass Blue	<i>Pseudozizeeria maha</i> (Kollar, 1844)	Lycaenidae	C
5	Striped Pierrot	<i>Tarucus nara</i> (Kollar, 1848)	Lycaenidae	VC
6	Zebra Blue	<i>Leptotes plinius</i> Fabricius, 1793)	Lycaenidae	C
7	Common Cerulean	<i>Jamides celeno</i> (Cramer, 1775)	Lycaenidae	C
8	Lime Blue	<i>Chilades lajus</i> (Stoll, 1780)	Lycaenidae	C
9	Pea Blue	<i>Lampides boeticus</i> (Linnaeus, 1767)	Lycaenidae	NR
10	Plains Cupid	<i>Luthrodes pandava</i> (Horsfield, 1829)	Lycaenidae	C
11	Lemon Emigrant	<i>Catopsilia pomona</i> (Fabricius, 1775)	Pieridae	C
12	Mottled Emigrant	<i>Catopsilia pyranthe</i> (Linnaeus, 1758)	Pieridae	VC
13	Common Gull	<i>Cepora nerissa</i> Fabricius, 1775)	Pieridae	C
14	Psyche	<i>Leptosia nina</i> (Fabricius, 1793)	Pieridae	VC
15	Striped Albatross	<i>Appias libythea</i> (Fabricius, 1775)	Pieridae	C
16	Common Grass Yellow	<i>Eurema hecabe</i> (Linnaeus, 1758)	Pieridae	C
17	Common Rose	<i>Pachliopta aristolochiae</i> (Fabricius, 1775)	Papilionidae	NR
18	Common Mormon	<i>Papilio polytes</i> (Linnaeus, 1758)	Papilionidae	C
19	Lime Butterfly	<i>Papilio demoleus</i> (Linnaeus, 1758)	Papilionidae	VC
20	Rice Swift	<i>Borbo cinnara</i> (Wallace, 1866)	Hesperiidae	NR
21	Indian Bush Hopper	<i>Ampittia dioscorides</i> (Fabricius, 1793)	Hesperiidae	NR
22	Chesnut Bob	<i>Iambrix salsala</i> (Moore, 1866)	Hesperiidae	C
23	Small Branded Swift	<i>Pelopidas mathias</i> (Fabricius, 1798)	Hesperiidae	C
24	Palm Dart	<i>Telicota ancilla</i> (Herrich-Schaffer, 1869)	Hesperiidae	NR
25	Plain Palm Dart	<i>Cephyres acalle</i> (Hopffer, 1874)	Hesperiidae	C
26	Indian Palm Bob	<i>Suastus gremius</i> (Fabricius, 1798)	Hesperiidae	C
27	Grey Pansy	<i>Junonia atlites</i> (Linnaeus, 1763)	Nymphalidae	VC
28	Lemon Pansy	<i>Junonia lemonias</i> (Linnaeus, 1758)	Nymphalidae	C
29	Striped Tiger	<i>Danaus genutia</i> (Cramer, 1779)	Nymphalidae	C
30	Plain Tiger	<i>Danaus chrysippus</i> (Linnaeus, 1758)	Nymphalidae	C
31	Peacock Pansy	<i>Junonia almana</i> (Linnaeus, 1758)	Nymphalidae	VC
32	Common Four-ring	<i>Ypthima huebneri</i> (Kirby, 1871)	Nymphalidae	VC
33	Common Five-ring	<i>Ypthima baldus</i> (Fabricius, 1775)	Nymphalidae	C
34	Common Crow	<i>Euploea core</i> (Cramer, 1780)	Nymphalidae	C

*Note: VC= Very Common (>100 sighting), C= Common (50-100 sighting), NR= Note Rare (15-20 sighting)

Table 2. Relative visiting frequency of different butterflies in study area

Scientific Name	Relative Visiting Frequency
<i>Neopithecops zalmora</i>	4.010695187
<i>Cigaritis vulcanus</i>	8.07486631
<i>Euchrysops cnejus</i>	2.352941176
<i>Pseudozizeeria maha</i>	2.299465241
<i>Tarucus nara</i>	7.807486631
<i>Leptotes plinius</i>	3.262032086
<i>Jamides celeno</i>	2.352941176
<i>Chilades lajus</i>	5.401069519
<i>Lampides boeticus</i>	0.213903743
<i>Luthrodes pandava</i>	7.754010695
<i>Catopsilia pomona</i>	0.64171123
<i>Catopsilia pyranthe</i>	0.695187166
<i>Cepora nerissa</i>	2.032085561
<i>Leptosia nina</i>	4.919786096
<i>Appias libythea</i>	1.390374332
<i>Eurema hecabe</i>	5.561497326
<i>Pachliopta aristolochiae</i>	0.213903743
<i>Papilio polytes</i>	6.631016043
<i>Papilio demoleus</i>	0.160427807
<i>Borbo cinnara</i>	0.053475936
<i>Ampittia dioscorides</i>	4.117647059
<i>Iambrix salsala</i>	3.422459893
<i>Pelopidas mathias</i>	5.026737968
<i>Telicota ancilla</i>	0.320855615
<i>Cephrenes chrysozona</i>	2.887700535
<i>Suastus gremius</i>	3.262032086
<i>Junonia atlites</i>	0.962566845
<i>Junonia lemonias</i>	0.427807487
<i>Danaus genutia</i>	1.871657754
<i>Danaus chrysippus</i>	0.748663102
<i>Junonia almana</i>	1.497326203
<i>Ypthima huebneri</i>	7.486631016
<i>Ypthima baldus</i>	1.176470588
<i>Euploea core</i>	0.962566845

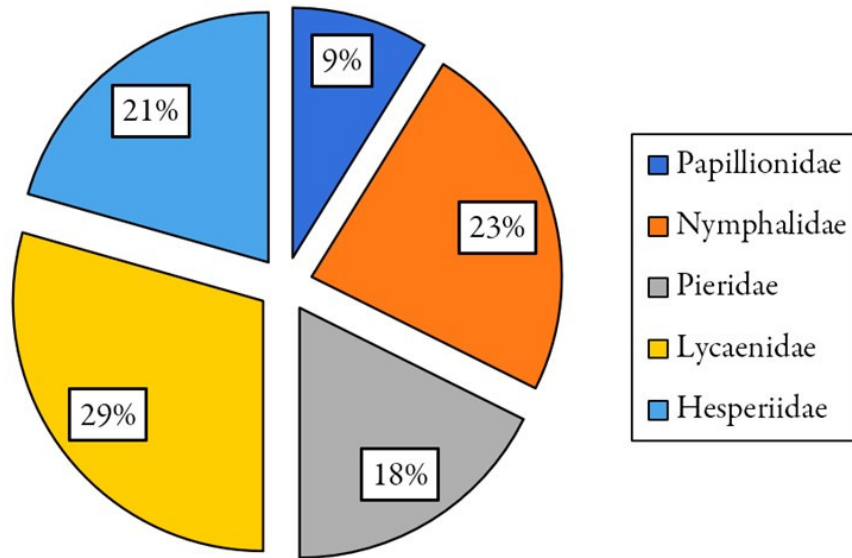


Figure 2. Family-wise foraging visits frequency of butterflies on *Tridax procumbens*

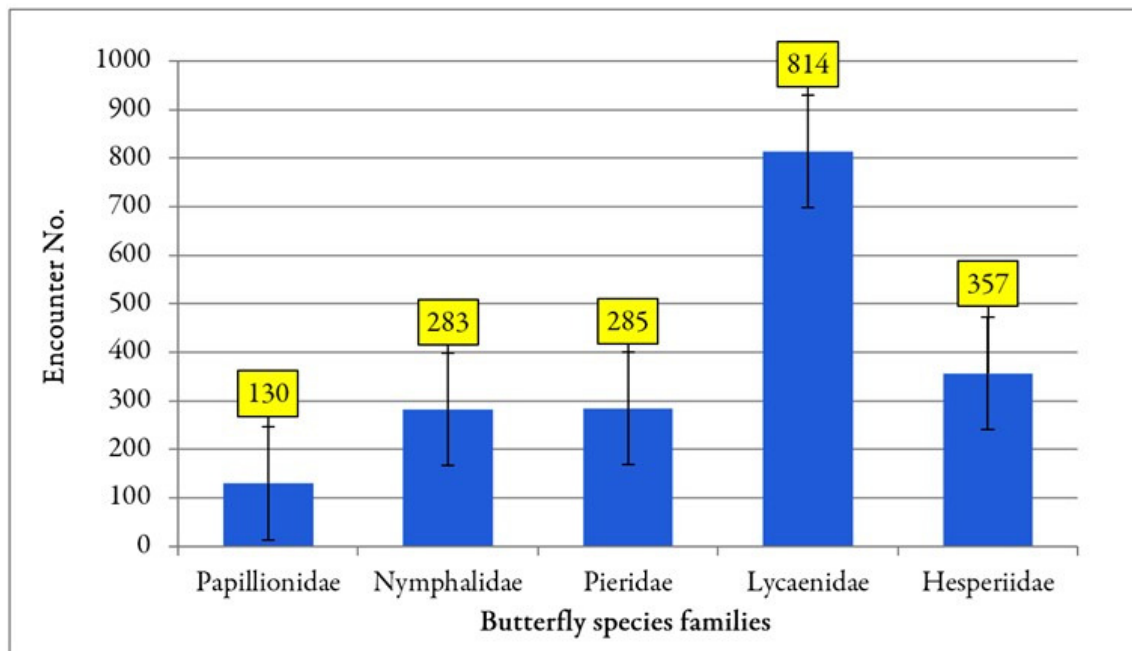


Figure 3. Status of family-wise butterfly species on *Tridax procumbens*

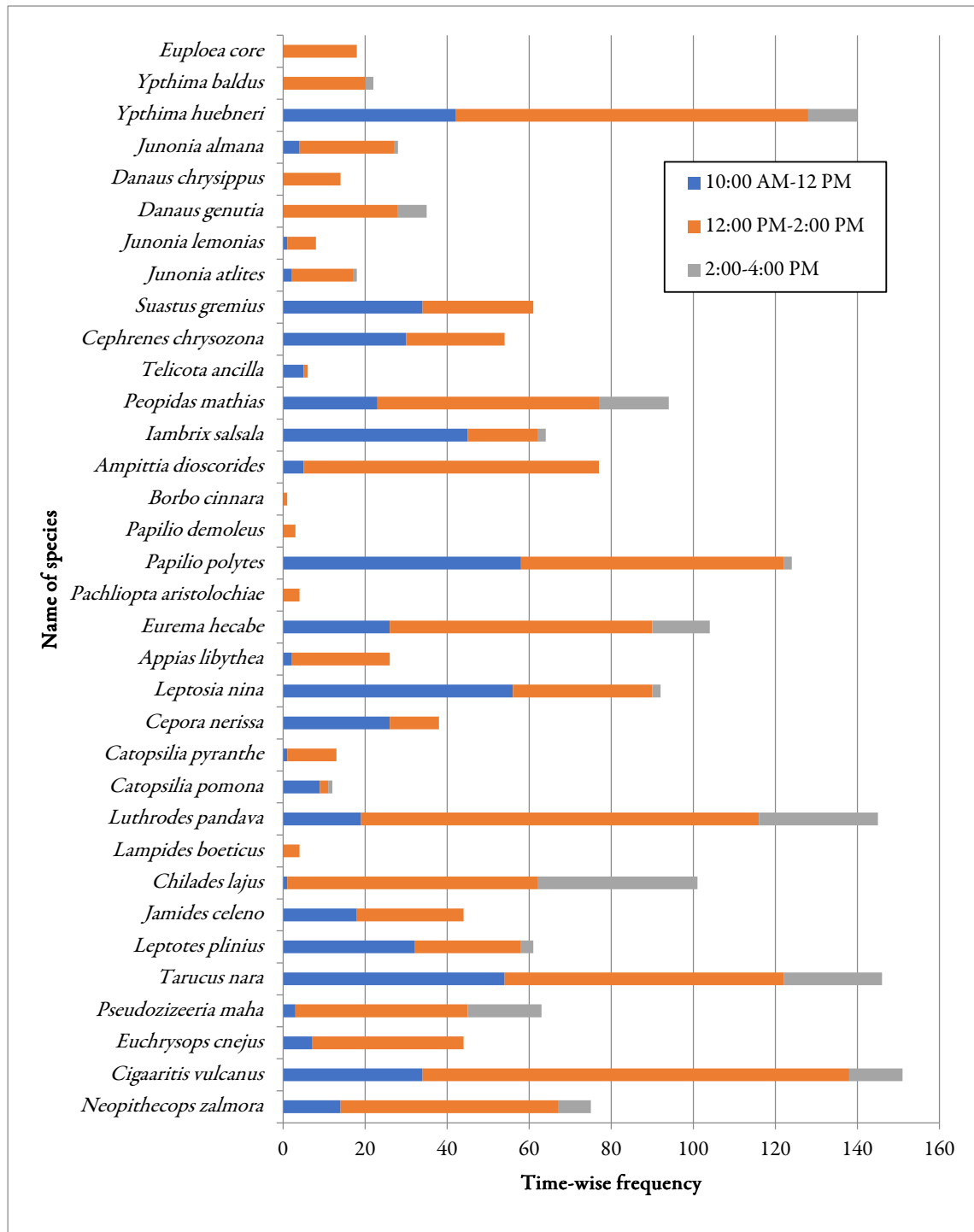


Figure 4. Time-wise foraging visits of butterfly species on *Tridax procumbens*

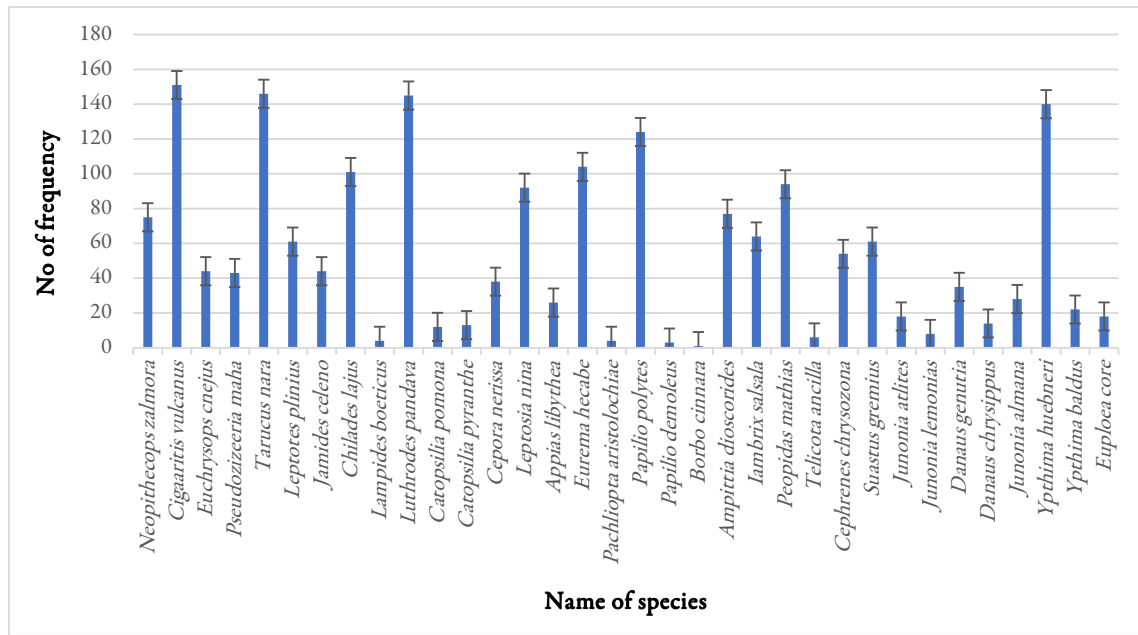


Figure 5. Foraging visits of butterfly species on *Tridax procumbens*

Table 3. Time specific ANOVA test result butterfly species foraging visits on *Tridax procumbens*

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	13519.47059	2	6759.735	16.00992	9.45707E-07	3.08824
Within Groups	41799.94118	99	422.2216			
Total	55319.41176	101				

Discussion

Lepidoptera, which includes butterflies, can indeed serve as bio-indicators for assessing the environmental condition of an ecosystem (Rollin *et al.*, 2016). The study of butterfly species diversity can provide valuable insights into the vegetation status and overall health of an area, as different species often have specific habitat and food plant requirements (Dennis *et al.*, 2006). *Tridax procumbens*, commonly known as coat-buttons, is indeed a weed that produces numerous capitula (flower heads) and each capitulum typically contains several florets, and these florets often offer nectar and pollen rewards (Varalakshmi, Raju and Chandra. 2012). But due to the effective reproductive character and pollination by insects it seems to have an importance for holding a great insect biodiversity. *T. procumbens* L. is associated with butterfly pollination due to its flower structure which has long narrow corolla tube and nectar accumulation with grouped in inflorescences (Carrion-Tacuri *et al.*, 2014). Therefore, enriched butterfly diversity can be observed as visitors of *T. procumbens* L.

In this present study, data reveals that the highest number of butterfly species visited between 12 pm to 2 pm. By the help of statistical analysis (Chi square) data shows a significant peak at $p < 0.05$ level ($X^2 = 1331.3818$, $df = 33$, $p = 0.00001$) in butterfly species number in that particular time interval. Butterflies are cold-blooded organisms, meaning they rely on external sources of heat to regulate their body temperature. To enable flight and other activities, butterflies bask in the sun to absorb heat, as they cannot generate enough metabolic energy internally to sustain their flight (Peiris, P.U.S., 2016).

T. procumbens plays a significant role in providing nectar for various butterfly species. The flowers of *T. procumbens* are rich in nectar, making them an attractive food source for butterflies. This plant's nectar serves as a valuable energy source for butterflies and supports their foraging activities. As butterflies feed on the nectar, they inadvertently assist in the pollination of *T. procumbens*, contributing to the overall biodiversity and ecological balance in their habitat.

The study involved observing butterflies visiting the flowers of *T. procumbens* selected plant species during day-light hours to study their foraging behavior and nectar collection. The frequency of individual butterfly species in relation to other butterfly species visiting each plant, categorizing their interactions as very common, Common, Rare or Very rare. Additionally, the nectar feeding activity of butterflies was examined concerning the flower-opening time and the flower's lifespan, aiming to understand the relationship between flower availability and the schedule of nectar feeding by butterflies. The study describes that *T. procumbens* L. Holds an enrich butterfly diversity throughout the day. So, the association of butterfly with this plant indicates probably a good ecosystem in such urbanized areas. The present study aims to identify flowering plant those are preferred by the all butterfly species families and comments in their potential role in pollination, thereby conservation of the host plant species and in alteration of conservation of butterfly species.

The study highlights the significance of nectar quality and quantity in attracting butterflies to specific plant species. This is crucial for the foraging activity of butterflies, as they require essential nutrients found in nectar. The interaction between butterflies and these plants is mutuality, benefiting both by contributing to pollination and fruit set, which plays a role in sustaining biodiversity. Additionally, the findings of this study provide valuable insights for promoting butterfly diversity in the WBSU campus, serving as a baseline for conservation efforts.

Conclusion

From the present study it was revealed that, there are 34 different types of butterflies dependent on *Tridax procumbens* in the study area, within study records. As the butterflies have been marked as a pollinator and remarkable visitor of this plant, therefore this invasive plant shows a good biodiversity impact on the aspect of insect diversity. Excluding this view, *T. procumbens* L. Also have a number of uses in the anthropogenic aspects such as various medicinal uses. So, the study determined the butterfly species helps in pollination of these herb that in turn helps the conservation of these butterfly species.

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Authors Contribution

Neharika Viridi: Writing – review & editing, Resources. Md Abu Imran Mallick: Writing – review & editing, Writing – original draft, Visualization, Supervision, Field Work, Methodology, Map Making Investigation, Formal analysis, Conceptualization.

Conflict of interest

The authors declares that there are no conflicting issues related to this research article.

References

- Aguilar R, Martén Rodríguez S, Avila Sakar G, Ashworth L, Lopezaraiza Mikel M, Quesada M (2015). A global review of pollination syndromes: a response to Ollerton et al. 2015. *Journal of Pollination Ecology* 17(18):126-128. [https://doi.org/10.26786/1920-7603\(2015\)21](https://doi.org/10.26786/1920-7603(2015)21)
- Andriana Y, Xuan TD, Quy TN, Minh TN, Van TM, Viet TD (2019). Antihyperuricemia, antioxidant, and antibacterial activities of *Tridax procumbens* L. *Foods* 8(1):21. <https://doi.org/10.3390/foods8010021>
- Araujo LS, Medina AM, Gimenes M (2018). Pollination efficiency on *Ipomoea bahiensis* (Convolvulaceae): morphological and behavioural aspects of floral visitors. *Iheringia. Série Zoologia* 108:e2018012. <https://doi.org/10.1590/1678-4766e2018012>
- Bawa KS (1990). Plant-pollinator interactions in tropical rain forests. *Annual Review of Ecology and Systematics* 21(1):399-422. <https://doi.org/10.1146/annurev.es.21.110190.002151>
- Benadi G, Blüthgen N, Hovestadt T, Poethke HJ (2013). When can plant-pollinator interactions promote plant diversity?. *The American Naturalist* 182(2):131-146. <https://doi.org/10.1086/670942>
- Branson DH, Joern A, Sword GA (2006). Sustainable management of insect herbivores in grassland ecosystems: new perspectives in grasshopper control. *Bioscience* 56(9):743-755. [https://doi.org/10.1641/0006-3568\(2006\)56\[743:SMOIHJ\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2006)56[743:SMOIHJ]2.0.CO;2)
- Brose U, Hillebrand H (2016). Biodiversity and ecosystem functioning in dynamic landscapes. *Philosophical Transactions of the Royal Society B: Biological Sciences* 371(1694):20150267. <https://doi.org/10.1098/rstb.2015.0267>
- Carrión-Tacuri J, Berjano R, Guerrero G, Figueroa E, Tye A, Castillo JM (2014). Fruit set and the diurnal pollinators of the invasive *Lantana camara* and the endemic *Lantana peduncularis* in the Galapagos Islands. *Weed Biology and Management* 14(3):209-219. <https://doi.org/10.1111/wbm.12048>
- Dattaray D (2022). Traditional uses and pharmacology of plant *Tridax procumbens*: A review. *Systematic Reviews in Pharmacy* 13:476-482.
- De Araújo LDA, Quirino ZGM, Machado IC (2014). High specialisation in the pollination system of *Mandevilla tenuifolia* (J.C. Mikan) Woodson (Apocynaceae) drives the effectiveness of butterflies as pollinators. *Plant Biology* 16(5):947-955. <https://doi.org/10.1111/plb.12152>
- Dennis RL, Shreeve TG, Van Dyck H (2006). Habitats and resources: the need for a resource-based definition to conserve butterflies. *Biodiversity and Conservation* 15:1943-1966. <https://doi.org/10.1007/s10531-005-4314-3>
- Dick CW, Hardy OJ, Jones FA, Petit RJ (2008). Spatial scales of pollen and seed-mediated gene flow in tropical rain forest trees. *Tropical Plant Biology* 1:20-33. <https://doi.org/10.1007/s12042-007-9006-6>
- Epps MJ, Allison SE, Wolfe LM (2015). Reproduction in flame azalea (*Rhododendron calendulaceum*, Ericaceae): a rare case of insect wing pollination. *The American Naturalist* 186(2):294-301. <https://doi.org/10.1086/682006>
- Huang ZY, Giray T (2012). Factors affecting pollinators and pollination. *Psyche: A Journal of Entomology* 302409. <https://doi.org/10.1155/2012/302409>
- Kehimkar ID (2016). *Butterflies of India: BNHS Field Guides*. Bombay Natural History Society.
- Kevan PG, Baker HG (1983). Insects as flower visitors and pollinators. *Annual Review of Entomology* 28(1):407-453. <https://doi.org/10.1146/annurev.en.28.010183.002203>
- Kevan PG, Viana BF (2003). The global decline of pollination services. *Biodiversity* 4(4):3-8. <https://doi.org/10.1080/14888386.2003.9712703>

- Kritasampan K, Milne JR, Srikosamatara S, Jitklang S, Jeratthitikul E (2016). Flower-visiting arthropods of the invasive weed, *Lantana camara* L. Tropical Natural History 16(1):7-19.
- Lang JM, Benbow ME (2013). Species interactions and competition. Nature Education Knowledge 4(4):8.
- Mallick MAI (2023). Abundance, habitat preference and seasonal patterns of different butterfly species (Order: Lepidoptera): A preliminary study in West Bengal State University (WBSU) campus, West Bengal, India. International Journal of Advanced Research in Biological Sciences 10(3):6-21.
- Moritz C (2002). Strategies to protect biological diversity and the evolutionary processes that sustain it. Systematic Biology 51(2):238-254. <https://doi.org/10.1080/10635150252899752>
- Mukherjee S, Banerjee S, Basu P, Saha G, Aditya G (2015). *Lantana camara* and butterfly abundance in an urban landscape: Benefits for conservation or species invasion?. Ekológia (Bratislava) 34(4):309-328. <https://doi.org/10.1515/eko-2015-0029>
- Olito C, Fox JW (2015). Species traits and abundances predict metrics of plant–pollinator network structure, but not pairwise interactions. Oikos 124(4):428-436. <https://doi.org/10.1111/oik.01439>
- Peiris PUS (2016). Study on butterfly visitation patterns of *Stachytarpheta jamaicensis* as a beneficial plant for Butterfly conservation. International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering 10(2):97-100. <https://doi.org/10.5281/zenodo.1111931>
- Peralta G, Vazquez DP, Chacoff NP, Lomáscolo SB, Perry GL, Tylianakis JM (2020). Trait matching and phenological overlap increase the spatio-temporal stability and functionality of plant–pollinator interactions. Ecology Letters 23(7):1107-1116. <https://doi.org/10.1111/ele.13510>
- Pfeiffer JM, Voeks RA (2008). Biological invasions and biocultural diversity: linking ecological and cultural systems. Environmental Conservation 35(4):281-293. <https://doi.org/10.1017/S0376892908005146>
- Phillips BB, Bullock JM, Gaston KJ, Hudson-Edwards KA, Bamford M, Cruse D, ... Osborne JL (2021). Impacts of multiple pollutants on pollinator activity in road verges. Journal of Applied Ecology 58(5):1017-1029. <https://doi.org/10.1111/1365-2664.13844>
- Rollin O, Benelli G, Benvenuti S, Decourtye A, Wratten SD, Canale A, Desneux N (2016). Weed-insect pollinator networks as bio-indicators of ecological sustainability in agriculture. A review. Agronomy for Sustainable Development 36:1-22. <https://doi.org/10.1007/s13593-015-0342-x>
- Rosas-Guerrero V, Aguilar R, Martín-Rodríguez S, Ashworth L, Lopezaraiza-Mikel M, Bastida JM, Quesada M (2014). A quantitative review of pollination syndromes: do floral traits predict effective pollinators?. Ecology Letters 17(3):388-400. <https://doi.org/10.1111/ele.12224>
- Schwarz B, Vázquez DP, CaraDonna PJ, Knight TM, Benadi G, Dormann CF, ... Fründ J (2020). Temporal scale-dependence of plant–pollinator networks. Oikos 129(9):1289-1302. <https://doi.org/10.1111/oik.07303>
- Silva JLS, de Oliveira MTP, Cruz-Neto O, Tabarelli M, Lopes AV (2021). Plant–pollinator interactions in urban ecosystems worldwide: A comprehensive review including research funding and policy actions. Ambio 50(4):884-900. <https://doi.org/10.1007/s13280-020-01410-z>
- Simberloff D (2014). Biological invasions: What's worth fighting and what can be won?. Ecological Engineering 65:112-121. <https://doi.org/10.1016/j.ecoleng.2013.08.004>
- Thébaud E, Fontaine C (2010). Stability of ecological communities and the architecture of mutualistic and trophic networks. Science 329(5993):853-856. <https://doi.org/10.1126/science.1188321>
- Varalakshmi P, Raju AS, Chandra PH (2012). Pollination ecology of *Tridax procumbens* L. (Asteraceae). Journal of Palynology 49:143-158.
- Wenzel A, Grass I, Belavadi VV, Tschamtker T (2020). How urbanization is driving pollinator diversity and pollination—A systematic review. Biological Conservation 241:108321. <https://doi.org/10.1016/j.biocon.2019.108321>
- Wilby A, Orwin KH (2013). Herbivore species richness, composition and community structure mediate predator richness effects and top-down control of herbivore biomass. Oecologia 172(4):1167-1177. <https://doi.org/10.1007/s00442-012-2573-8>
- Younis A, Riaz A, Saleem S, Hameed M (2010). Potential use of wild flowers in urban landscape. Acta Horticulturae 881:229-233. <https://doi.org/10.17660/ActaHortic.2010.881.29>

Appendix

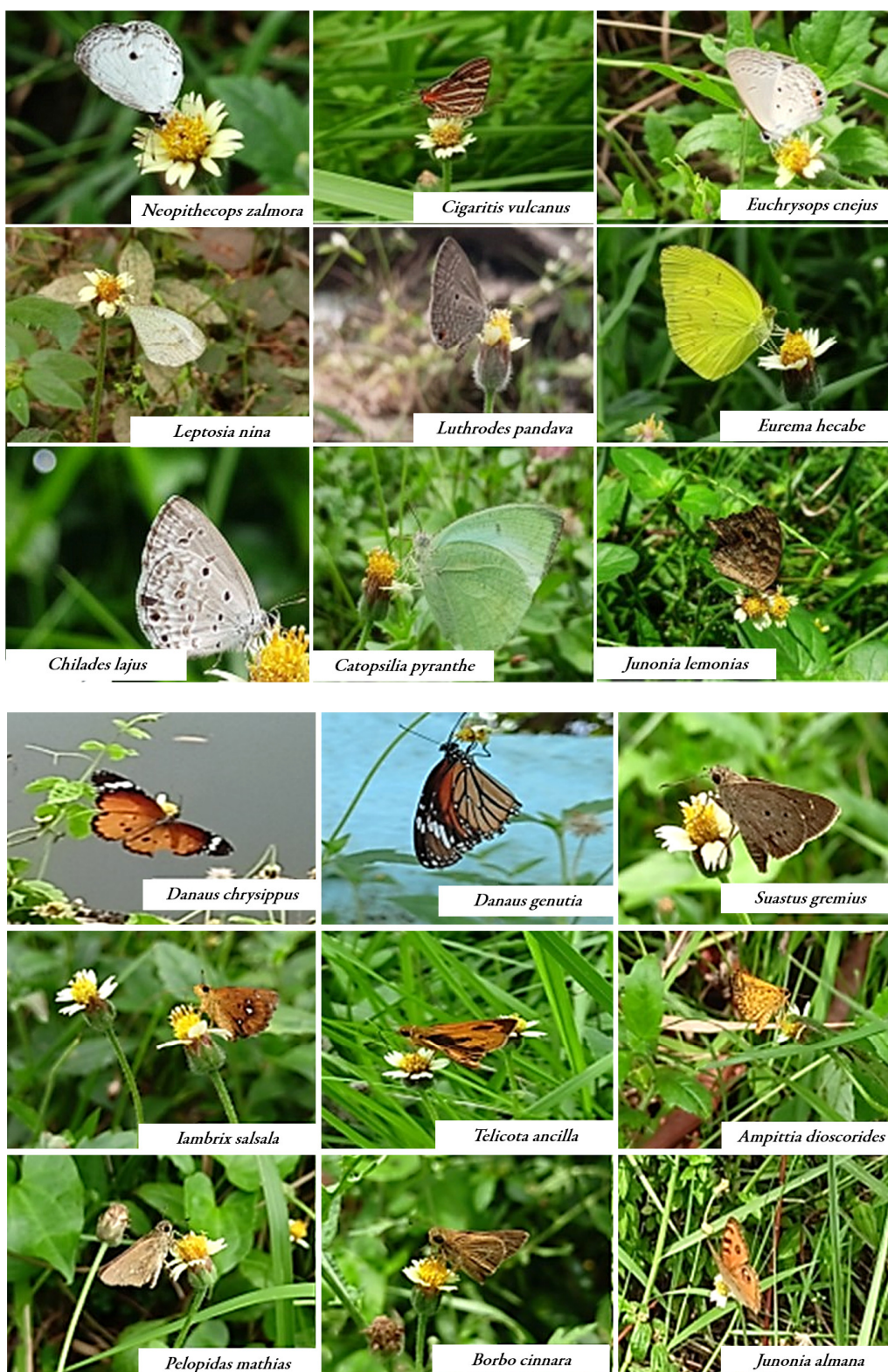




Plate 1. Photographs of butterflies on *Tridax procumbens* in study area



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