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Floral Preference of Butterflies in Agricultural and Horticultural Ecosystems of Coastal Tamil Nadu

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Abstract: Butterflies, belonging to the order Lepidoptera, represent the second-largest group of insects and play a crucial role in ecosystems, including agricultural and horticultural systems. In Tamil Nadu, however, their roles within the crop ecosystem remain insufficiently studied. Information on feeding preferences, host selection, and pollination contributions is limited and inconsistent. To address this gap, the present investigation explores the butterfly diversity of crop ecosystems and ecology of selected coastal areas of Tamil Nadu. The survey was carried out in six coastal areas during the seasons, *Rabi* 2022-23 and *Summer* 2023 by sweep net and visual observations, in order to the study the relationship between the proboscis length and the flower morphology. A total of 25 nectar yielding plant species were recorded in the study area. Butterfly species recorded exhibited a preference for readily available larval host plants from five families such as Annonaceae, Rhamnaceae, Malvaceae, Fabaceae and Poaceae within the survey area. Statistical analysis employing a multiple linear regression model revealed no significant correlation between proboscis length and floral characteristics, including corolla length, flower color, and corolla type. The findings hold the potential to not only inform conservation strategies and promote sustainable agricultural practices, but also unveil the hidden value of these fluttering ambassadors, paving the way for a more harmonious relationship between butterflies and the agricultural landscapes they grace.

Keywords: Agricultural ecosystem, Butterfly, Floral preference, Horticultural ecosystem, Morphology

The order Lepidoptera is one of the most well-known and well-liked insect orders that include both butterflies and moths. Lepidoptera, which means "scaly-winged" insects, was coined by Linnaeus. Members of this order are distinguished by the presence of dense, wide scales that contain pigments. The scales that give butterflies and moths their stunning and distinctive colour patterns are simply flattened, modified hairs. Lepidoptera are classified into 4 suborders, 139 families, 15,578 genera, and 1,57,424 species that have been described so far (Sidhu 2023). According to Kristenson et al. (2007), suborders of Lepidoptera includes Zeugloptera, Glossata, Aglossata and Heterobathmiina. Recently, the order was divided into two suborders *viz*., Rhopalocera (Butterflies) and Heterocera (Moths), of which 17,000-20,000 taxa are butterflies (Nieukerken Van et al., 2011).

All the butterfly species are grouped under six families, *viz*. Papilionidae, Nymphalidae, Pieridae, Lycaenidae, Riodinidae and Hesperiidae (Bhattacharjee 2020). They serve as bio-indicators of environmental variety and quality that reflect a specific set of ecological conditions or suggest larger consequences of environmental changes, and they are an important component of biodiversity and ecologically vital due to their involvement in the food chain (Singh 2011).

Ganvir et al. (2017) probed that butterflies contribute to the ecology in particular by recycling the N, P, and K needed by crops. The insect community claims that butterflies are important pollinators and herbivores with a long history of coevolving with plants. Owing to their crucial role in pollinating both crop and wild plants worldwide, butterflies have proven useful to those, commonly known as Psychophily. Agricultural fields have multiple agricultural areas with key crops that attract butterflies for a variety of reasons. Butterflies are dependent on nectar and pollen as their food while the caterpillars are dependent on specific host plants for foliage. The presence of weed-eating butterfly species in agroecosystems has made a significant contribution to natural weed suppression (Kathirvelu et al., 2022). Butterflies are thought to be reliable indicators of the condition of any particular terrestrial environment. Bergerot et al. (2010), observed that pollinators employ a variety of characteristics as cues, including flower colour, aroma produced by pollen and nectar composition, flower size, plant size, and flower design. The nectar that the flowers provide, which controls the physiological processes of butterflies, and the compatibility of the flowers with their feeding structures determine how butterflies and flowers interact. The diversity, abundance, and species richness of butterflies are decreasing as more highways, buildings, and green spaces are developed. This is because habitat degradation has decreased the variety of plant species, lowered the water quality, and increased air pollution (Kanagaraj and Kathirvelu 2018). In Tamil Nadu, there is little evidence on butterfly feeding preference, host selection, and pollination in crop ecosystems. Therefore, the present study was conducted in the agricultural and horticultural fields of Coastal areas of Tamil Nadu to examine the floral preferences of butterflies.

MATERIAL AND METHODS

"The study on floral preference of butterflies in agricultural and horticultural ecosystems of Coastal, Tamil Nadu" was conducted at the Department of Entomology, Annamalai University, from November 2022 – 2023 (*Rabi*) to June 2023 (*Summer*).

Study Area: Butterflies and their floral preference were observed in the following villages located in the coastal areas of the Cuddalore district from the crop ecosystems (agricultural and horticultural ecosystems) including agricultural land, fruit orchards, vegetable gardens, flower fields and associated lands. Survey of butterfly and their floral preference were made in two seasons from November 2022 - 2023 (*Rabi*) to June 2023 (*Summer*) in selected localities of Cuddalore district (Fig. 1). The study areas include Annamalainagar, Bhuvanagiri, Parangipettai, Sivapuri, Kavarapattu and Kodiyampalayam. They were systematically surveyed every week over the course of two distinct seasons. Each week, two specific areas were selected for observation. During the visits, the different butterflies visiting flowers were collected using sweep net and preserved for morphometry study.

Proboscis morphometry: The proboscises of butterflies, which were coiled, were carefully uncoiled by separating the heads from preserved butterfly specimens. Subsequently, each butterfly head was inverted and positioned on a slide coated with resin or double-sided adhesive tape. A gradual and precise process involved using sharp needles or forceps to uncoil the proboscis, securing it onto the adhesive surface of the slide. Following the complete uncoiling of the proboscis, a transparent cellophane tape was employed to encase the proboscis on the slide, thus preventing any inadvertent recoiling. Subsequently, the slide was appropriately labelled with the butterfly's name for identification purpose. To determine the proboscis length, the "Image J" software was employed. A photograph of the slide containing the proboscis was captured, and the software was utilized to set the measurement units to millimeters (mm). Subsequently, the software was used to analyze the photograph, and the measurements obtained were recorded for further analysis.

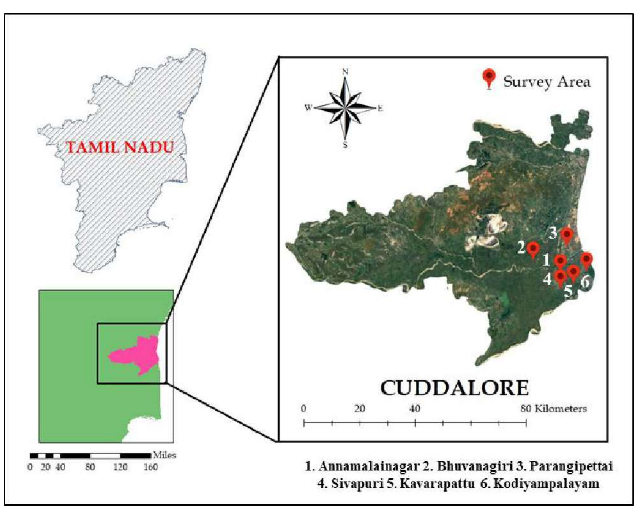


Fig. 1. Study area map

Floral morphometry: A sample of flowers from the chosen plant species is meticulously gathered. These specimens were in pristine condition, free from any physical impairments. To ensure precision and consistency, appropriate measuring instruments, such as rulers or callipers with millimeter (mm) gradations, were employed. The selected flower was placed on a stable, level surface, mimicking its natural positioning when approached by a nectar-seeking butterfly. The specific point on the flower, where a butterfly's proboscis would naturally reach the corolla's base (typically where nectar is located), was determined. Accurate measurements were carried out using the ruler or calliper, documenting the distance from the chosen point to the corolla base in millimetres (mm). Additionally, corolla type (Tubular or non-tubular) and flower colour for each plant species were documented (Subedi et al., 2020).

Data Analysis: STATISTICA version 13.0 was used to explore the connection between proboscis length and the floral characteristics of nectar.

RESULTS AND DISCUSSION

Butterflies in the agricultural and horticultural ecosystems: Butterflies present in the agricultural and horticultural ecosystems during the seasons, *Rabi* 2022-23 and *Summer* 2023 were recorded (Table 1). Butterflies showed clear crop-specific associations. In agricultural fields, rice ecosystems supported the highest richness, with nine species, including *Ampittia dioscorides* Fab., *Borbo cinnara* Wall., and *Junonia orithya* Linn. Sesame fields showed relatively higher diversity with seven species, such as *Chilades pandava* Hors., *Eurema brigittia* Stoll, and *Hupolimnas bolina* Linn. Pulses, maize and castor fields each recorded three species, while sugarcane was represented by a single species (*Catochrysops strabo* Fab.). In horticultural landscapes, *Graphium agamemnon* Linn., and *Delias eucharis* Drury were recorded from trees. The vegetable yard exhibited the greatest diversity with thirteen species, including *Catopsilia pyranthe* Linn., *Pachliopta* *hector* Linn., and *Papilio polytes* Linn.. The fruit orchard supported five species, while the flower yard had three species (*Leptosia nina* Fab., *Pareronia hippie* Fab., *Zizeeria karsandra* Moore). Overall, butterfly communities showed clear habitat preferences, with the greatest diversity observed in vegetable yards and rice fields. In a study conducted by Kanimozhi et al. (2020) in the Namakkal district of Tamil Nadu, they found that out of 60 butterfly species observed in agroecosystems, 49 were found in pulse fields, 60 in rice fields, 59 in vegetable yards, 52 in groundnut fields, and 53 in sugarcane fields. These results align with the findings of the present study.

Floristic inventory associated with butterflies: Butterfly species showed clear host plant associations across crop, weed, and tree ecosystems. Papilionidae members were primarily associated with Rutaceae, Annonaceae, and Aristolochiaceae. Most Lycaenidae were closely linked with Fabaceae hosts, with some extending to Rhamnaceae, Amaranthaceae, and Verbenaceae. Notably, *Spalgis epius* differed by acting as a predator of mealybugs. In the Nymphalidae family, butterflies generally prefer weed hosts over crops and Malvaceae being the most frequently utilized plant family. In Pieridae, most species feed on weeds, except *Pieris brassicae* and *P. canidia*, which prefer Brassicaceae. Other species utilizes Fabaceae as the primary host family, followed by Salvadoraceae and Cleomaceae (Table 2, Plate 1).

Dwari and Mondal (2015) listed the larval host plants of different butterfly families in the Howrah district, West Bengal. Larval food plants of Nymphalidae, Pieridae and Hesperiidae are found in agricultural fields but same in case of Papilionidae and Lycaenidae are different, larval food plants of these groups are absent in agricultural fields of the Howrah district. Papilionidae exhibited a preference for Asteraceae, Pedaliaceae, and Brassicaceae hosts as larval feed. Lycaenidae, on the other hand, favored plants of Poaceae, Malvaceae, Asteraceae, Fabaceae, Pedaliaceae and Cleomaceae. Nymphalidae preferred Asteraceae, Poaceae, Brassicaceae, Lamiaceae, and Euphorbiaceae plants, as their larval hosts and Family Hesperiidae preferred plants of Poaceae, Lamiaceae and Asteraceae as their preferred hosts. The above findings affirm the results accurately.

Proboscis length (mm) of the butterflies surveyed: The maximum proboscis length was recorded in *Papilio polymnester* from Papilionidae at 36.9 mm, followed by 27.4 mm in *Pareronia hippia* from Pieridae and 25.6 mm in *P. conidia*. The shortest proboscis length observed was 4.5 mm in *Pseudozizeeria maha* from Lycaenidae (Table 2). The results are in accordance with the findings of Venkata Ramana (2010) recorded the proboscis lengths of various butterfly species in which *Papilio polymnestor* had the highest proboscis length of 30-32 mm, while *Leptsotia nina* exhibited the smallest proboscis at 5-6 mm in the study sites.

Floral morphometry and Nectar flora preference by butterfly families: A total of 25 nectar plant species were identified, and their flower characteristics, including color, corolla length, and type, were observed and categorized based on distinctive features (Table 3). Flowers were classified into two groups, Tubular (≥ 25 mm) and Non-tubular (< 25 mm), based on corolla length. Twelve species fell into the "Tubular" category, and 13 into "Non-tubular." Both categories were further divided by color (Red, Yellow, Blue, White) (Plate 2). Nectar plant preference differed

Table 1. Butterflies in agricultural and horticultural ecosystems of the survey area

Ecosystem	Species
Rice	*Ampittia dioscorides* Fabricius, *Borbo cinnara* Wallace, *Junonia orithya* Linnaeus, *Melanitis leda* Linnaeus, *Potanthus nesta* Evans, *Prosotas dubiosa* Semper, *Pseudozizeeria maha* Kollar, *Tirumala limniace* Cramer, *Zizula hylax* Fabricius
Pulse	*Graphium doson* Felder, *Euchrysops cnejus* Fabricius, *Lampides boeticus* Linnaeus
Maize	*Junonia iphita* Cramer, *Papilio polymnestor* Cramer, *Zizina otis* Fabricius
Sugarcane	*Catochrysops strabo* Fabricius
Sesame	*Chilades pandava* Horsfield, *Eurema brigittia* Stoll, *Eurema hecabe* Linnaeus, *Hypolimnas bolina* Linnaeus, *Junonia almanac* Linnaeus, *Junonia hierta* Fabricius, *Neptis hylas* Linnaeus
Castor	*Acraea violae* Linnaeus, *Ariadne merione* Cramer, *Junonia lemonias* Linnaeus
Trees	*Graphium agammemnon* Linnaeus, *Delias eucharis* Drury
Vegetable yard	*Castalius rosimon* Fabricius, *Catopsilia pyranthe* Linnaeus, *Cepora nerissa* Fabricius, *Everes lacturnus* Godart, *Freyeria putli* Kollar, *Ixias marianne* Cramer, *Ixias pyrene* Linnaeus, *Mycalesis perseus* Fabricius, *Pachliopta hector* Linnaeus, *Pachliopta aristolochiae* Fabricius, *Papilio polytes* Linnaeus, *Pieris brassicae* Linnaeus, *Pieris canidia* Linnaeus
Fruit orchard	*Colotis amata* Fabricius, *Euploea core* Cramer, *Euthalia aconthea* Cramer, *Hypolimnas misippus* Linnaeus, *Papilio demoleus* Linnaeus
Flower yard	*Leptosia nina* Fabricius, *Pareronia hippie* Fabricius, *Zizeeria karsandra* Moore

Table 2. Floristic inventory associated with butterflies of crop ecosystems and proboscis length

Scientific name	Proboscis length (mm)*	Crop host plant	Weed / Tree host plant	Host family
Graphium agammemnon	14.5±0.31	*Annona squamosa*	-	Annonaceae
		-	*Polyalthia longifolia*	Annonaceae
Graphium doson	10.6±0.31	*Murraya koenigii*	-	Rutaceae
Pachiliopta aristolochiae	16.5±0.21	-	*Aristolochia bracteolata*	Aristolochiaceae
Pachiliopta hector	19.8±0.25	-	*Aristolochia bracteolata*	Aristolochiaceae
Papilio demoleus	24.5±0.30	*Citrus aurantiifolia*	-	Rutaceae
		Murraya koenigii	-	Rutaceae
Papilio polymnestor	36.9±0.30	-	-	-
Papilio polytes	23.1±0.61	*Citrus aurantiifolia*	-	Rutaceae
		Citrus limon	-	Rutaceae
		Murraya koenigii	-	Rutaceae
Spalgis epius	5.5±0.16	Mealybugs*		-
Castalius rosimon	5.8±0.07	-	*Ziziphus* sp.	Rhamnaceae
Castalius strabo	6.4±0.08	*Vigna radiata*	-	Fabaceae
		Vigna unguiculata	-	Fabaceae
Chilades pandava	4.6±0.13	*Vigna* sp.	-	Fabaceae
		-	*Acacia* sp.	Fabaceae
Freyeria putli	5.0±0.07	-	*Pongamia pinnata*	Fabaceae
		-	*Tephrosia purpurea*	Fabaceae
Euchrysops cnejus	6.8±0.08	*Vigna radiata*	-	Fabaceae
Everes lacturnus	8.2±0.10	-	*Trifolium* sp.	Fabaceae
		-	*Desmodium* sp.	Fabaceae
Lampides boeticus	8.9±0.26	*Vigna* sp.	-	Fabaceae
Prosotas dubiosa	4.5±0.10	-	*Mimosa pudica*	Fabaceae
		-	*Acacia* sp.	Fabaceae
Pseudozizeeria maha	4.5±0.01	-	*Tephrosia purpurea*	Fabaceae
Zizeeria karsandra	5.3±0.07	-	*Amaranthus spinosus*	Amaranthaceae
Zizina otis	4.8±0.13	-	*Clitoria* sp.	Fabaceae
		-	*Vicia* sp.	Fabaceae
Zizula hylax	6.8±0.11	-	*Lantana camara*	Verbenaceae
Acraea violae	11.5±0.24	*Nerium oleander*	-	Apocynaceae
Danaus chrysippus	11.6±0.12	-	*Calotropis gigantea*	Apocynaceae
Danaus genutia	12.4±0.15	-	*Calotropis gigantea*	Apocynaceae
Euploea core	11.7±0.35	*Nerium oleander*	-	Apocynaceae
Tirumala limniace	12.7±0.10	-	*Calotropis* sp.	Apocynaceae
Ariadne merione	10.2±0.13	*Ricinus communis*	-	Euphorbiaceae
Euthalia aconthea	13.5±0.29	*Mangifera indica*	-	Anacardiaceae
Neptis hylas	8.6±0.19	-	*Thespesia populnea*	Malvaceae
Hypolimnas bolina	14.4±0.12	-	*Abelmoschus* sp.	Malvaceae
		-	*Abutilon* sp.	
		-	*Hibiscus* sp.	
Hypolimnas misippus	14.5±0.18	-	*Abutilon* sp.	Malvaceae
		-	*Hibiscus* sp.	
Junonia almana	11.4±0.30	-	*Sida rhombifolia*	Malvaceae
Junonia hierta	11.6±0.20	-	*Sida rhombifolia*	Malvaceae
Junonia iphita	10.4±0.21	-	*Sida rhombifolia*	Malvaceae
Junonia lemonias	9.8±0.12	-	*Sida rhombifolia*	Malvaceae

Cont...

Table 2. Floristic inventory associated with butterflies of crop ecosystems and proboscis length

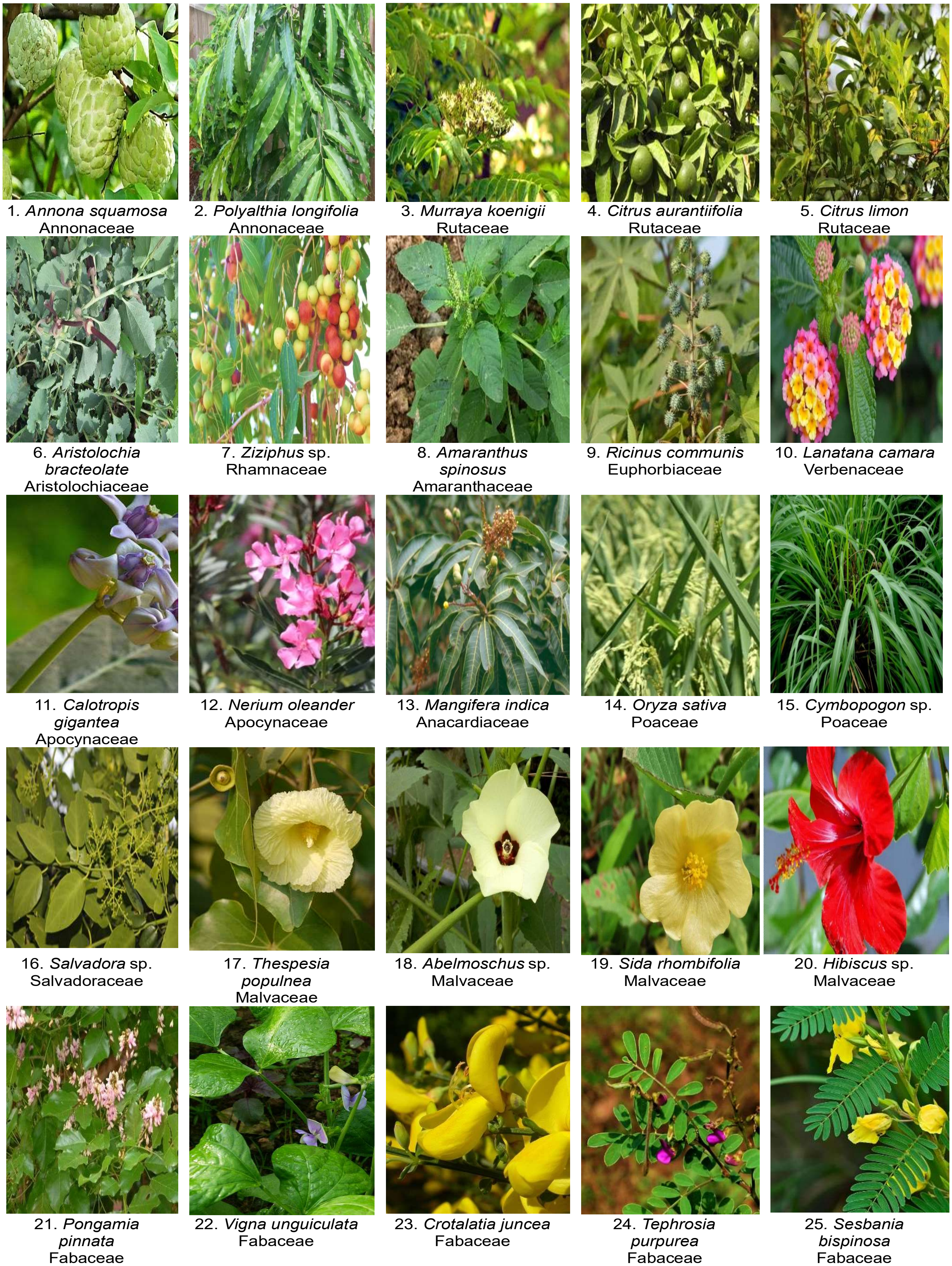
Scientific name	Proboscis length (mm)*	Crop host plant	Weed / Tree host plant	Host family
Junonia orithya	10.4±0.12	-	*Sida rhombifolia*	Malvaceae
Melanitis leda	11.4±0.14	*Oryza sativa*	-	Poaceae
Melanitis perseus	8.2±0.24	*Oryza* sp.	-	Poaceae
Catopsila pomona	16.8±0.21	-	*Cassia fistula*	Fabaceae
		-	*Crotolaria juncea*	Fabaceae
Catopsila pyranthe	16.8±0.21	-	*Cassia fistula*	Fabaceae
		-	*Crotolaria juncea*	Fabaceae
Eurema brigittia	8.5±0.11	-	*Cassia* sp.	Fabaceae
Eurema hecabe	11.2±0.29	-	*Cassia fistula*	Fabaceae
		-	*Crotolaria juncea*	Fabaceae
Cepora nerissa	9.5±0.28	-	-	-
Colotis amata	10.7±0.23	-	*Salvadora* sp.	Salvadoraceae
Delias eucharis	15.2±0.12	-	*Sesbania bispinosa*	Fabaceae
Ixias marianne	21.4±0.36	-	-	-
Ixias pyrene	23.6±0.62	-	-	-
Leptosia nina	9.4±0.20	-	*Cleome viscosa*	Cleomaceae
Pareronia hippia	27.4±0.14	-	-	-
Pieris brassicae	25.4±0.32	Crucifers	-	Brassicaceae
Pieris canidia	25.6±0.75	Crucifers	-	Brassicaceae
Ampittia dioscorides	17.6±0.22	*Oryza sativa*	-	Poaceae
Borbo cinnara	15.8±0.21	*Oryza sativa*	-	Poaceae
Potanthus nesta	13.1±0.82	-	*Cymbopogon* sp.	Poaceae

*Mean values followed by Standard Error (SE)

Table 3. Floral morphology of nectar yielding in the survey area

Family	Nectar plant	Flower colour	Corolla type	Corolla length (mm)
Acanthaceae	*Crossandra infundibuliformis* Linn.	Orange (R)*	Tubular	25.2±0.33
	Ruellia tuberosa Linn.	Purple (B)	Tubular	33.5±0.42
Agavaceae	*Polianthes tuberosa* Linn.	White (W)	Tubular	44.6±1.17
Amarathaceae	*Gomphrena globose* Linn.	Purple (B)	Non-tubular	0.0±0.00
Anacardiaceae	*Mangifera indica* Linn.	Yellow (Y)	Non-tubular	3.5±0.03
Apocynaceae	*Nerium oleander* Linn.	Pink (R)	Non-tubular	21.5±0.27
	Catharanthus roseus Linn.	Pink (R)	Tubular	23.4±0.61
	Allamanda cathartica Linn.	Yellow (Y)	Tubular	72.4±1.23
	Tabernaemontana divaricata Linn.	White (W)	Tubular	20.8±0.59
	Pentalinon luteum Linn.	Yellow (Y)	Tubular	68.4±0.85
Asteraceae	*Tridax procumbens* Linn.	White (W)	Non-tubular	5.6±0.05
	Tagetes erecta Linn.	Orange (Y)	Non-tubular	11.4±0.34
	Cosmos sulphureus Cav.	Yellow (Y)	Non-tubular	17.5±0.21
	Centratherum punctatum Cass.	Purple (B)	Non-tubular	10.4±0.18
Bignoniaceae	*Tecoma stans* Linn.	Yellow (Y)	Tubular	25.6±0.55
	Millingtonia hortensis Linn.	White (W)	Tubular	72.2±1.48
Euphorbiaceae	*Ricinus communis* Linn.	Red (R)	Non-tubular	0.0±0.00
	Arachis hypogea Linn.	Yellow (Y)	Non-tubular	0.0±0.00
Fabaceae	*Cassia fistula* Linn.	Yellow (Y)	Non-tubular	0.0±0.00
	Calliandra sp. Benth.	Red (R)	Tubular	2.6±0.02
	Vigna radiata Linn.	Blue (B)	Non-tubular	0.0±0.00
Laminaceae	*Leucas aspera* Willd.	White (W)	Non-tubular	15.2±0.19
Polygonaceae	*Antigonon leptopus* Hook. &Arn.	Pink (R)	Non-tubular	0.0±0.00
Rubiaceae	*Ixora coccinea* Linn.	Red (R)	Tubular	28.4±0.61
Verbenaceae	*Lantana camara* Linn.	Pink (R)	Tubular	6.7±0.08

* In parentheses, Shade of the flower colour: R - Red , Y–Yellow, B - Blue , W - White



1. *Annona squamosa* Annonaceae
2. *Polyalthia longifolia* Annonaceae
3. *Murraya koenigii* Rutaceae
4. *Citrus aurantiifolia* Rutaceae
5. *Citrus limon* Rutaceae
6. *Aristolochia bracteolate* Aristolochiaceae
7. *Ziziphus* sp. Rhamnaceae
8. *Amaranthus spinosus* Amaranthaceae
9. *Ricinus communis* Euphorbiaceae
10. *Lanatana camara* Verbenaceae
11. *Calotropis gigantea* Apocynaceae
12. *Nerium oleander* Apocynaceae
13. *Mangifera indica* Anacardiaceae
14. *Oryza sativa* Poaceae
15. *Cymbopogon* sp. Poaceae
16. *Salvadora* sp. Salvadoraceae
17. *Thespesia populnea* Malvaceae
18. *Abelmoschus* sp. Malvaceae
19. *Sida rhombifolia* Malvaceae
20. *Hibiscus* sp. Malvaceae
21. *Pongamia pinnata* Fabaceae
22. *Vigna unguiculata* Fabaceae
23. *Crotalatia juncea* Fabaceae
24. *Tephrosia purpurea* Fabaceae
25. *Sesbania bispinosa* Fabaceae

Plate 1. Floral inventories of agricultural and horticultural ecosystem

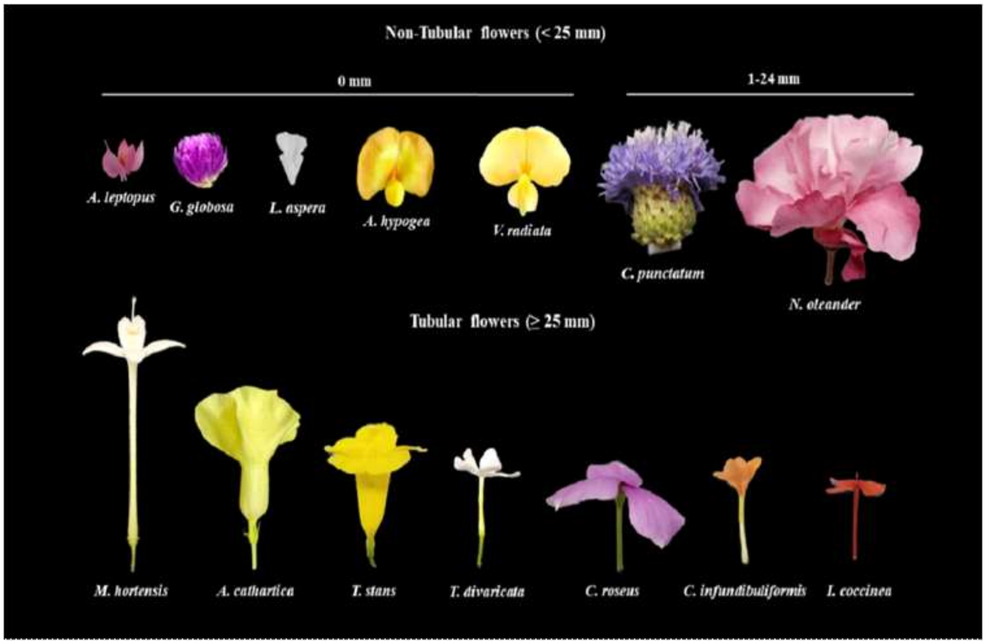


Plate 2. Nectar inventories (Tubular and Non-tubular flowers) recorded in the survey area

across the five butterfly families (Papilionidae, Lycaenidae, Nymphalidae, Pieridae, and Hesperiidae), as detailed in Table 4.

Tiple et al. (2009) demonstrated that Papilionidae had unique plant associations, particularly with Nyctaginaceae and Rubiaceae. There were also highly significant associations observed with flower shape, corolla depth, plant life form, flower abundance (mass), and flower color. Hesperiidae and Nymphalidae exhibited a preference for tubular flowers, while Lycaenidae favored non-tubular flowers. Lycaenidae showed a preference for flowers lacking corolla depth, Nymphalidae and Hesperiidae were biased towards plants with moderately deep corollas (≤10 mm), Pieridae favored flowers with deeper corollas (10–15 mm), and Papilionidae had a preference for flowers with deep or very deep corollas (10–15 mm, >15 mm). Hesperiidae and Nymphalidae also demonstrated a bias for feeding on plants with a dense massing (abundance) of flowers, whereas, in Lycaenidae, the bias was towards plants with moderate flower masses, Pieridae favoured plants with moderate and sparse flowers, and Papilionidae preferred plants with sparse flowers.

Multiple linear regression model analysis for proboscis length of butterflies with the floral characters: The multiple linear regression analysis aimed to investigate the relationship between the dependent variable and three independent variables: flower colour, corolla type, and corolla length (Table 5). The intercept, representing the estimated mean value of the dependent variable when all

Table 4. Nectar flora preference by butterfly families

Butterfly families	Flora
Papilionidae	*Polyanthes tuberosa*
	Mangifera indica
	Catharanthus roseus
	Allamanda cathartica
	Tabermontana divaricata
	Pentalinon luteum
Lycaenidae	*Gomphrena globosa*
	Tridax procumbens
	Cosmos sulphureus
	Centrathemum punctatum
	Arachis hypogea
	Vigna radiata
	Antigonon leptopus
Nymphalidae	*Crossandra infundibuliformis*
	Ruellia tuberosa
	Tagetes erecta
	Tecoma stans
	Millingtonia hortensis
	Ricinus communis
	Ixora coccinea
Pieridae	*Nerium oleander*
	Cassia fistula
	Calliandra sp.
	Leucas aspera
Hesperiidae	*Lantana camara*
	Tridax procumbens

Table 5. Multiple linear regression model analysis for proboscis length of butterflies with the floral characters

Variable	Coefficient	Standard Error	*t*	*P* value	R^2
Intercept	41.39 ^{NS}	35.51	1.17	0.45	0.692
Flower colour, X_1	3.17 ^{NS}	10.04	0.32	0.81	
Corolla type, X_2	-20.78 ^{NS}	18.65	-1.11	0.47	
Corolla length, X_3	-0.19 ^{NS}	0.37	-0.52	0.70	

independent variables are zero, is 41.39. However, the p-value associated with the intercept is 0.45, indicating that it is not statistically significant. The coefficient for flower colour (X_1) is 3.17. The associated t-statistic is 0.32, and the p-value is 0.81. Similarly, the coefficient for corolla type (X_2) is -20.78, a t-statistic of -1.11, and a p-value of 0.47. The coefficient for corolla length (X_3) is -0.19, a t-statistic of -0.52, and a p-value of 0.70. None of the coefficients are statistically significant (Fig. 2). The regression equation for the given dependent variable (Y) and for the each of the independent variables (X) can be given as

$$Y = 41.39 + 3.17X_1 - 20.78X_2 - 0.19X_3$$

where, Y – Dependent variable (proboscis variable)

X – Independent variable

X_1 - Flower colour

X_2 - Corolla type

X_3 - Corolla length

Tiple et al. (2009) demonstrated that the exploitation of flowers by butterflies was constrained by flower corolla depth in relation to proboscis length. Butterflies with high wing load indices exhibited a bias towards nectar feeding on plants with massed flowers. Furthermore, unique associations were observed between butterflies and plants, encompassing various attributes. On the plant side, these attributes included flower shape, corolla depth, life form, flower abundance, and flower color. On the butterfly side, the associations involved proboscis length and wing load index. While the wing load index plays a significant role in explaining proboscis length, only 62% of the variability in proboscis length can be attributed to other morphological measures and indices. Additionally, this relationship is apparent in two butterfly families (Nymphalidae and Pieridae) but not in the other two families (Lycaenidae and Hesperiidae), even though there are consistent variances and comparable ranges in proboscis lengths and wing loading indices.

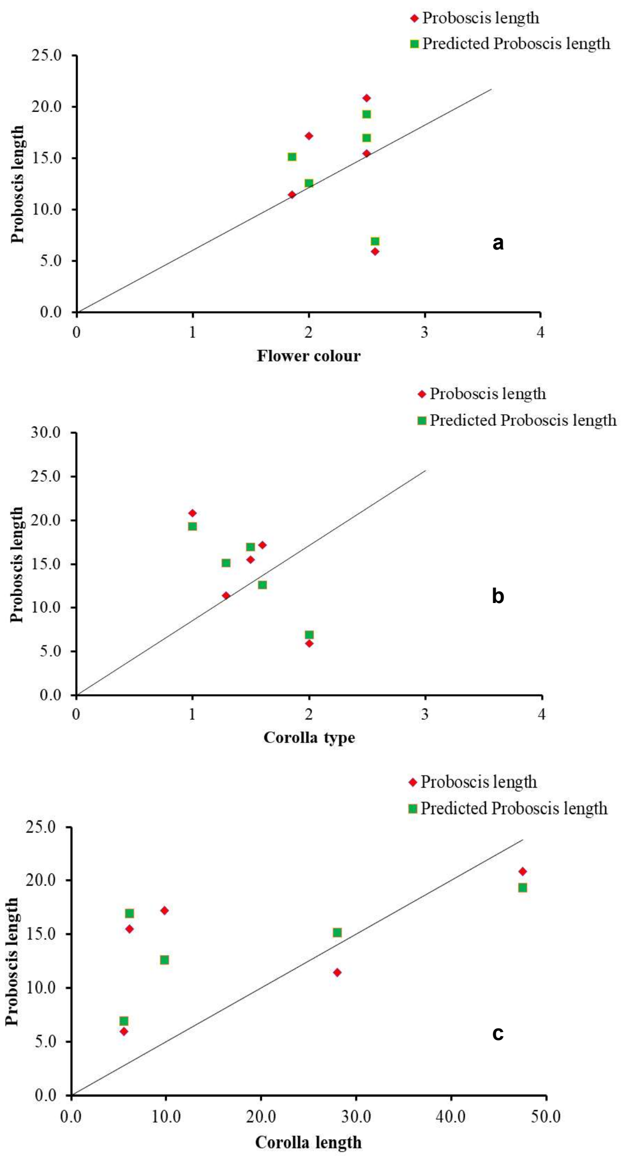


Fig. 2. Multiple linear regression model analysis for proboscis length of butterflies with the floral characters

CONCLUSION

The butterflies exhibit distinct preferences for specific flower species, which can be attributed to various factors such as flower colour, nectar quality and morphology. The preference for specific larval host plants underlines the interconnectedness of butterflies with their habitat. Conservation efforts should thus include the preservation and restoration of these plant families to sustain butterfly populations. Despite the detailed nectar inventory, the lack of statistically significant relationships in the Multiple Linear Regression model for proboscis length suggests a complex interplay of factors influencing this crucial aspect of butterfly biology. This highlights the need for further research to understand better and address the potential threats to butterfly populations.

AUTHOR's CONTRIBUTION

Abinaya, P: Formal analysis, Writing – review & editing; Sujith Daniel Raj, S: Writing – original draft, review & editing; Sakthivel, S: Conceptualization, Writing – review & editing; Kirubakaran, T: Writing – review & editing; Kathirvelu, C: Writing – original draft, Visualization, Formal analysis, Supervision, Resources, Conceptualization.

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