

Colour selection in *Lantana camara* L. blooms: A study on butterfly attraction

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Abstract

Flower colour is a crucial factor influencing pollinator-plant interactions. *Lantana camara* L., a popular ornamental plant, attracts various butterfly species. The present study was conducted in Serampore, Hooghly, West Bengal, India, spanning a period of one year from June 2022 to May 2023. This study investigates the preferences of some butterfly species for flowers of a certain colour and the choice of *Lantana camara* flowers as nectar sources. *L. camara* is known for its vibrant and diverse colour variations, making it an ideal candidate for attracting various pollinators. Through field observations and controlled experiments, we aimed to identify if certain butterfly species exhibit distinct colour preferences when foraging on *Lantana* blooms. Our preliminary findings suggest that different butterfly species display varying degrees of colour selectivity, with some showing a preference for warm colour within the *L. camara* spectrum. These initial insights provide a foundation for further research into the intricate relationship between butterfly species and floral coloration. Understanding the nuanced preferences of butterflies for *L. camara* flowers can contribute to the development of targeted conservation and gardening practices aimed at supporting specific butterfly populations. This study offers a valuable starting point for future investigations into the broader implications of floral colour preferences in pollinator ecology.

Keywords: butterfly species; colour preference; foraging behaviour; *L. camara*; pollinators

Introduction

Butterflies are herbivorous insects that exhibit complex foraging behaviours in their search for food and nectar (Bernays, 1998; Wäckers *et al.*, 2007). Their interactions with flowers play a crucial role in shaping their ecology and influencing their populations (Strauss and Irwin 2004; Stefanescu and Traveset, 2009; Burkle and Alarcón, 2011). Nectar resources, particularly the distribution and availability of nectar-rich flowers, significantly impact butterfly populations (Wiklund and Åhrberg, 1978; Pywell *et al.*, 2011; Szigeti *et al.*, 2018). Understanding flower use and preference is essential for effective habitat management and conservation. Butterflies demonstrate individual differences in flower preference, influenced by factors such as morphology, nectar characteristics, and nutritional needs (May, 1992; Krenn *et al.*, 2001; Wackers *et al.*, 2005; Tiple *et al.*, 2009). They use visual cues like flower colour and olfactory signals like floral scents to guide their foraging behaviour (Raguso, 2008; Schiestl and Johnson, 2013; Balamurali *et al.*, 2015; Briggs *et al.*, 2018).

The combination of floral scent and colour creates a multifaceted signal that helps butterflies identify suitable nectar sources (Chen *et al.*, 2014; Woodcock *et al.*, 2014; Yoshida *et al.*, 2015; Reverté *et al.*, 2016; Kantsa *et al.*, 2017). During the flowering season, butterfly species often exhibit flower specificity, selectively choosing to feed from a limited number of plant species (Boggs, 1987; Junker and Parachnowitsch, 2015; Paul *et al.*, 2022; Zariman *et al.*, 2022). Butterflies have innate preferences for specific flower features, such as colour, which reflect their evolved responses to visual stimuli (Weiss, 1991; Weiss, 1997; Ômura and Honda., 2005; Shivanna, 2014). Co-evolutionary processes have shaped these interactions over time (Benson *et al.*, 1975; Althoff *et al.*, 2014; Krishna and Kesar, 2018).

Lantana camara L. (family Verbenaceae), with its diverse array of vibrant colours, is an intriguing subject for studying pollinator preferences (Kevan and Baker, 1983; Oberrath *et al.*, 1999; Balamurali *et al.*, 2015; Narbona *et al.*, 2021). This study focuses on the relationship between selective butterfly species and *Lantana* flowers, seeking to understand whether certain species demonstrate distinct colour preferences when choosing *Lantana* as a foraging resource. This relationship, we aim to contribute to the understanding of nuanced interactions between butterflies and floral pigmentation, and offer insights into the ecological dynamics of *Lantana* as a crucial nectar source for specific butterfly populations.

Materials and Methods

Study Area

The present study was conducted in Serampore, Jolkel ($22^{\circ}74'88''$ N and $88^{\circ}55'46''$ E), West Bengal, India (Figure 1). The study area is characterized by diverse vegetation, including trees, shrubs, herbs, and grasses. A reservoir pond adds to the ecological richness of the landscape. The location's heritage status further emphasizes its historical and cultural significance, providing a unique backdrop for exploring the interactions between butterfly species and the varied flora within this dynamic ecosystem. The combination of natural elements and cultural heritage in this study area offers a compelling context for investigating the intricate relationships between butterflies and their floral resources (Mallick, 2023).

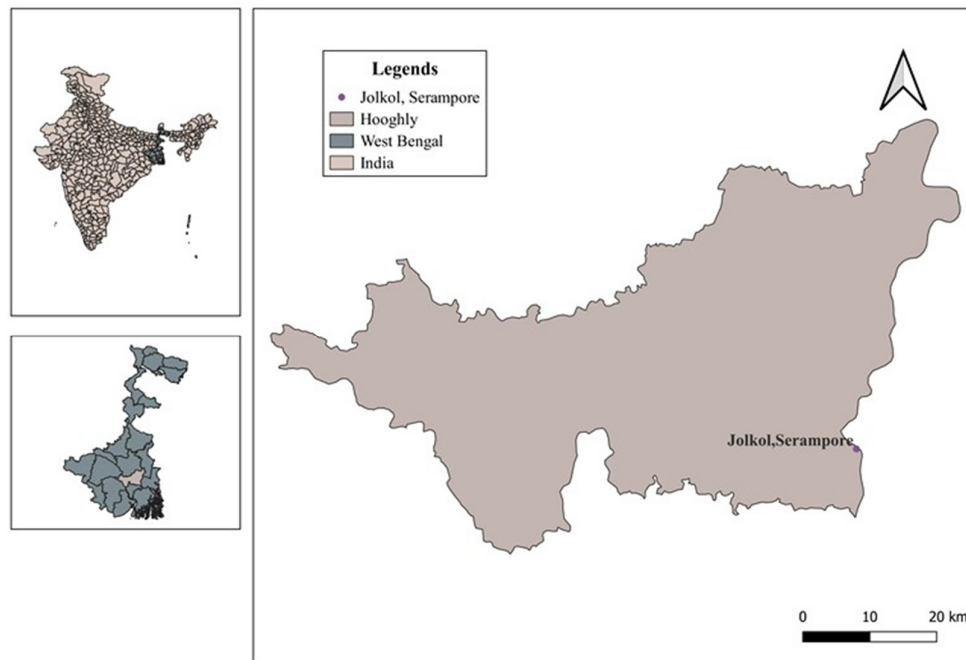


Figure 1. Study area map

Methods

The study spanned one year, from June 2022 to May 2023, with systematic observations recorded using ad-libitum and continuous scan sampling techniques (Altmann, 1974). Within the study plot at Serampore, Jolkol, West Bengal, India, 18 patches of *Lantana camara* were identified, each associated with various vegetation types (Mallick, 2023).

Diurnal observations of butterfly encounters were conducted from 9 AM to 4 PM, with a detailed 7-hour scan sampling period occurring biweekly. Each 1-hour scan was subdivided into seven 15-minute intervals, resulting in 7 hours of intense observation daily.

Butterflies were identified using field guide books, specifically referring to works by Kunte (2000), Smetacek (2017), and the NCBS database. This comprehensive methodology aimed to capture the diverse interactions between butterfly species and *L. camara* in the unique ecological and cultural setting of the study area over the course of a year.

The study site was mapped using GPS, employing Google Earth Pro software. Study area was mapped using ArcMap 10.6 for characterizing study area, Hooghly River and urban area of Serampore. Subsequent data analysis was conducted using R studio (2023.09.0 build 463) & MS- Excel (2016) software. MS-Excel 2016 was utilized for data loading, management and the preparation of graphs.

Results

A total of twelve different species within the families Hesperidae, Papilionidae, Nymphalidae, and Pieridae have been identified throughout the subject of study area within the order Lepidoptera. During the data acquisition process, five species of Nymphalidae, four species of Papilionidae, one species of Hesperidae, and one species of Pieridae seemed encountered (Table 1).

Table 1. List of selective butterfly species in study area

Common name	Scientific name	Family
Rice Swift	<i>Borbo cinnara</i>	Hesperiidae
Common Jay	<i>Graphium doson</i>	Papilionidae
Tailed jay	<i>Graphium agamemnon</i>	Papilionidae
Great Eggfly	<i>Hypolimnas bolina</i>	Nymphalidae
Lime Butterfly	<i>Papilio demoleus</i>	Papilionidae
Indian Jezebel	<i>Delias eucharis</i>	Pieridae
Blue Tiger	<i>Tirumala limniace</i>	Nymphalidae
Common Crow	<i>Euploea core</i>	Nymphalidae
Common Mormon	<i>Papilio polytes</i>	Papilionidae
Common Emigrant	<i>Catopsilia pomona</i>	Pieridae
Tawny Castor	<i>Acraea terpsicore</i>	Nymphalidae
Peacock Pansy	<i>Junonia almana</i>	Nymphalidae

The overwhelming majority of Lepidoptera species, according to analysis, prefer 10 AM to 2 PM for daily activities including feeding, bathing, and peddling (Figure 2). However, data generated suggests that some species, including *Delias eucharis*, *Euploea core*, *Graphium doson*, *Tirumala limniace*, and *Borbo cinnara*, are quite busy in the afternoon. For the purpose of identifying the preferred flower colour for each of the 12 species' everyday activities, observations were made of them all. This investigation focused on five different *L. camara* flower colour varieties. These are Pink, Red Yellow, Pink Yellow, and Red Yellow (Figure 3).

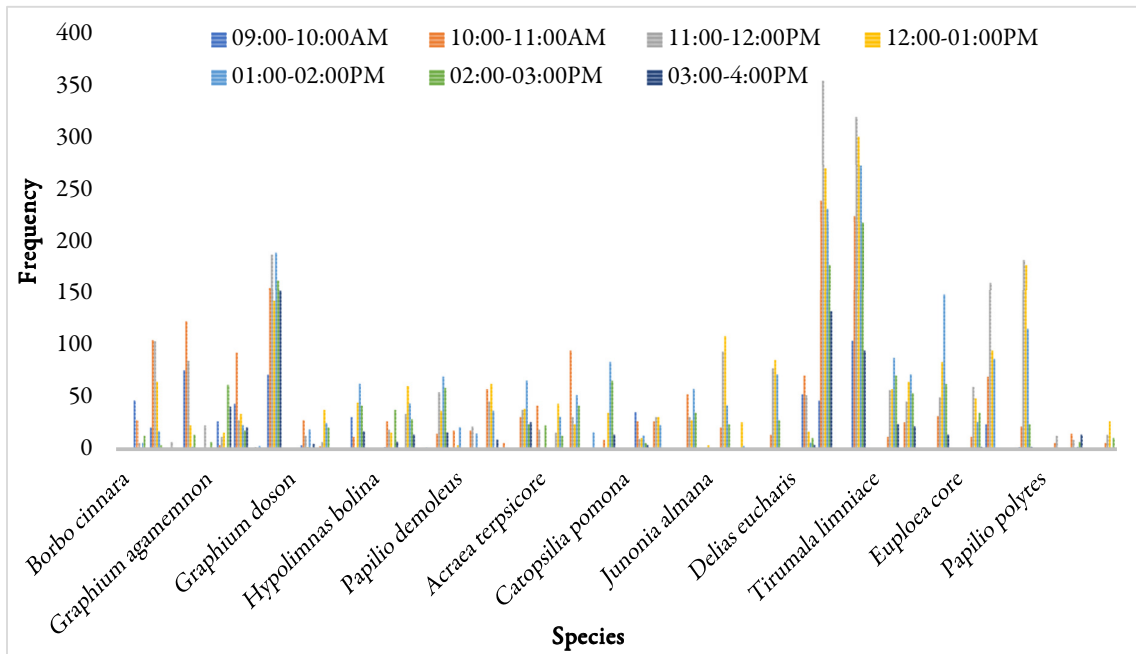


Figure 2. The occurrence and timing of different species of butterflies upon flowers of *L. camara*

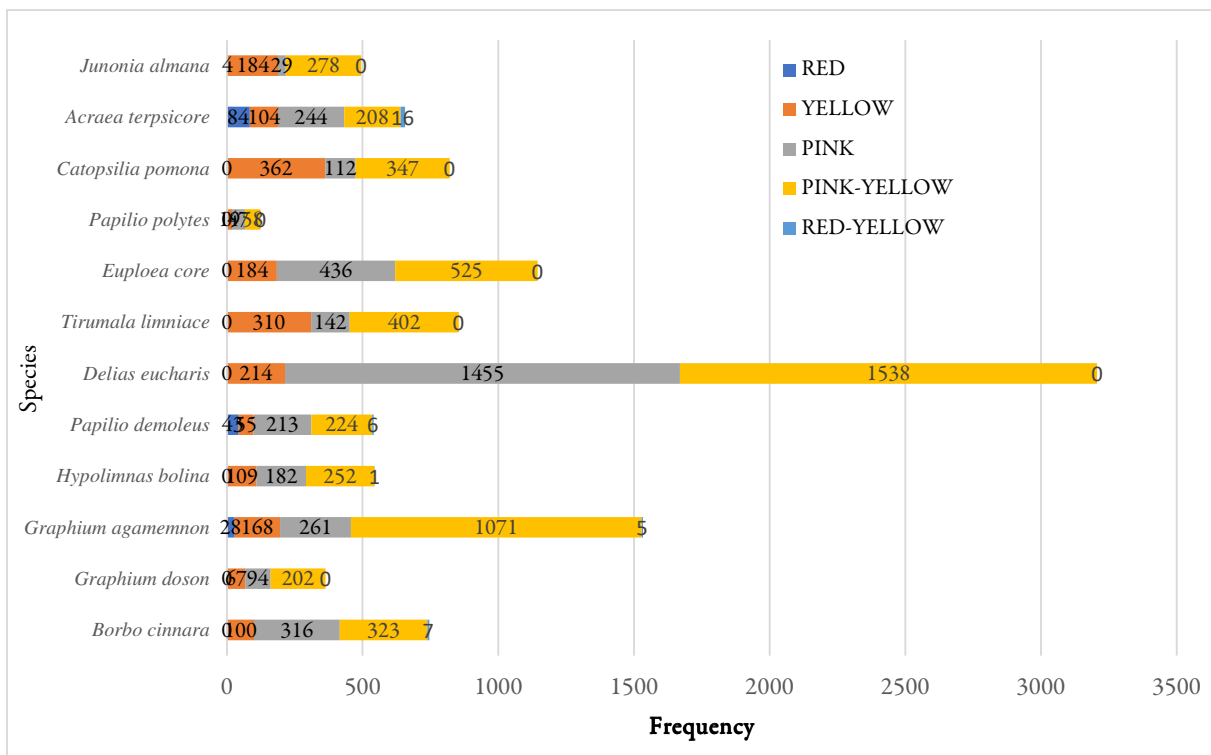


Figure 3. The frequency of butterflies upon five different flower colour of *L. camara*

It is hypothesized that each of the *L. camara*'s five flower colours engages with every species in exactly the same way during pollination. Using R Studio, a generalized linear model was employed to investigate this hypothesis (Table 2). Based on model output, it has been established that not every Lepidoptera species used every colour of *Lantana* flower. With a smaller P value ($P=0.0651$) for every colour of flower, the statistical model rejects the null hypothesis. With an insignificant t value of 0.926, the pink flower exhibits a fairly insignificant P value of 0.3901. The standard error is 0.005239 and the estimates are 0.004852, respectively. Likely to Pink flower, Pink yellow has a minimal negative t value ($t = -1.416$) and a p value ($P=0.2066$). As opposed to other flower colours, the red flower has an insignificant t value ($t=1.428$) and p value ($P=0.2032$). This model possesses an AIC of ($AIC=68.904$), null deviance on 11 degrees of freedom, and residual deviance on 6 degrees of freedom, which correspond to 143.0 and 68.194. The model has been computed using the Gaussian family dispersion parameter, which is 11.3656.

Table 2. The output, resulted out between five flower colours in Generalized Linear Model

Coefficients	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	5.109849	2.267602	2.253	0.0651
Red	0.019268	0.011423	1.813	0.1198
Yellow	0.019268	0.011423	1.687	0.1426
Pink	0.004852	0.005239	0.926	0.3901
Pink Yellow	-0.007016	0.004956	-1.416	0.2066
Red Yellow	-0.704204	0.493106	-1.428	0.2032

Leveraging box plot representations, a second generalized linear model has been validated between Pink and Pink yellow to determine whether they offer significant mean. An intercept of p value ($P=0.00203$) demonstrates a significant mean interaction between Pink and Pink Yellow. With estimates ($ES=0.001023$), standard error ($SE=0.005748$), and t value ($t=0.178$), the mean's interaction with Pink Yellow is not statistically significant, as indicated by Pink's P value ($P=0.86264$). Conversely, pink yellow yields insignificant p values ($P=0.64589$) and T values ($t= -0.475$) (Table 3). This illustrates the way various species use different flowers uniquely in terms of pollination processes. The model makes use of an 11-degree-of-freedom null value of 148 in conjunction with the AIC value of 71.265. 136.88 is the residual value on the ninth degree of freedom. 15.2088 is the dispersion parameter for the Gaussian family that the model uses.

Table 3. The output, resulted out between two flower colours in Generalized Linear Model

Coefficients	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	7.311302	1.705418	4.287	0.00203 **
Pink	0.001023	0.005748	0.178	0.86264
Pink Yellow	-0.002459	0.005174	-0.475	0.64589

Twelve species that were found at the study site were noted for their five distinct *L. camara* flower colours in order to maximize pollination interaction and other activities. Based on data, it was found that when it comes to butterflies encountering flowers, pink and pink-colored flowers exhibit the greatest number of interactions with butterfly species, but red-colored flowers of *L. camara* exhibit the least number of interactions. This illustration demonstrates how not all butterflies use the five distinct *L. camara* flowers in the same way. Box plot shows that there are two outliers in Pink-Yellow and in Pink, which are very far away from the standardized values (Figure 4).

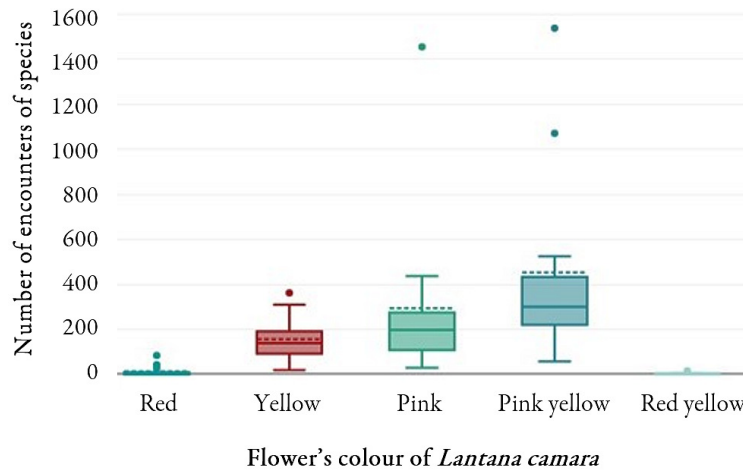


Figure 4. Flower colour-wise butterfly species frequency in *L. camara*

Discussion

The study's findings suggest that butterflies exhibit a strong innate preference for pink and pink-yellow flowers, with minimal variation even when pink flowers offer rewards. This behaviour indicates an early and likely unchanging preference, supported by observations of repeated checking of yellow flowers before exploring others. While butterflies occasionally visit red and red-yellow flowers, especially when containing nectar, the overall pattern indicates a primary inclination towards pink and pink-yellow blooms. The consistent presence of at least 12 different butterfly species at *L. camara* plants across various observation sites highlights the significance of Lepidopteran pollinators. Their broad range of light perception adds complexity to their interaction with plant signals, underscoring the intricate relationship between pollinators and colours in their environment.

Colour plays a crucial role in nature, facilitating behaviours like foraging, mate recognition, and species identification. The diversity in physical appearances across species testifies to the intricate signalling systems developed in the natural world. Investigating plant-pollinator signals offers unique insights and allows direct testing of signal theory concepts. The evolution of signals, receptors, and signalling behaviours is fundamentally driven by the universal needs of organisms to acquire essential resources, such as food and mates, thereby ensuring their survival and reproductive success (Greenfield, 2002; Symonds and Elgar, 2008). The elucidation of chromatic preferences in specific butterfly species towards *Lantana* flowers yields significant insights into the mechanisms governing pollination dynamics and the complex interplay of ecological interactions between anthophilous insects and florally diverse plant species (Kessler and Chautá, 2020). The findings suggest that butterflies exhibit specific preferences for certain flower colours, possibly influenced by their evolved visual systems and resource availability.

Conclusions

This study underscores the significance of understanding colour preferences in pollinators, shedding light on co-evolutionary relationships between butterflies and *Lantana* flowers. The observed preferences may have implications for plant reproductive success and population dynamics, emphasizing the importance of considering these factors in ecological studies. Further research could investigate the underlying mechanisms driving these preferences and their implications for ecosystem biodiversity.

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Statement of conflict of interest

The authors declare no conflict of interest.

Authors' Contributions

Md Abu Imran Mallick: Writing – review & editing, writing – original draft, Visualization, Supervision, Field Work, Methodology, Map Making, Investigation, Formal analysis, Conceptualization. Uttam Gupta: Field Work, review & editing. Both authors read and approved the final manuscript.

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