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Pattern of Interaction of the Pierid Butterfly with *Vernonia cinerea* Plant in Urban Habitat

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ABSTRACT

Abundance of pierid butterflies were estimated from June to September and their foraging pattern on *Vernonia cinerea* was recorded. Among the five butterfly species *Appias albina* was observed to be most frequent visitor of *Vernonia cinerea* comparatively than *Leptosia nina* (Psyche), *Eurema hecabe* (Common grass yellow), *Catopsilia pomona* (Common emigrant) and *Catopsilia pyranthe* (Mottled emigrant). The foraging activity pattern of these butterflies showed a definite pattern of foraging schedule by showing a resource partitioning. One sample t-test and month wise ANOVA indicated significant difference ($p<0.05$) for each butterfly species in different timeslots and how is co-related with blooming period of *Vernonia cinerea*. Our study indicates the importance of weeds like *Vernonia cinerea* in butterfly conservation project. The present study provides preliminary information on the interaction between native plants and butterflies.

Keywords *Vernonia cinerea*, Butterfly, Foraging, Time slots.

INTRODUCTION

Vernonia cinerea, an erect branched annual herb of family Asteraceae (Compositae) is widely distributed in India, Bangladesh and Sri Lanka (Nwaogaranya and Mbaekwe 2015). Usually, the plants belonging to family Rubiaceae and Asteraceae are rich sources for production of nectar quantity with concentrated sugar (sucrose) content (Nacua *et al.* 2014) and is distributed in the tropical and subtropical regions of Asia, Africa and America (Rao *et al.* 2017). *V. cinerea* commonly grows in the vicinity of human habitation in any garden, roadside areas and cultivated land with moist soils and is very common in disturbed sites and degraded areas (Hassan *et al.* 2019). The plant being perennial appears during the onset of the rainy season and disappears with the onset of the winter season, with flowering peak in August-November. The disc florets of *Vernonia cinerea* open early in the morning 08:00–13:00 h on clear sunny days and partially on rainy days. The herb is a principal source of vernolic acid in addition to sesquiterpene lactones and flavonoid compounds (Haque *et al.* 2012) which

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Fig. 1. Google image of study sites showing different transects (T_1–T_{15}).

are proposed for the reduction of inflammation and tumorigenesis at potentially achievable levels in humans (Gupta *et al.* 2003, Saraphanchotiwitthayaa and Sripalakit 2015). There is an intimate as well as intricate association of butterfly species with *Vernonia cinerea* and availability of food plants act as a limiting factor for the abundance and diversity of butterfly fauna (Kitahara *et al*. 2000). The profitability of butterfly foraging depends on several factors like depth of corolla and clustering of flowers, the tongue length, body mass and wing loading of butterflies (Corbett 2003). Flower color sometimes may act as stimulation which may be expressed by their preference behavior for foraging just like purple- colored flowers is preferred by several papilionids and pierids, whereas the petals coloring yellow is preferred by other pierids and nymphalids (Tang *et al.* 2012). Jothimani *et al.* (2014) documented *V. cinerea* as the larval food plants of common pierrot. Chakraborty Thakur and Chaudhuri (2017) documented that *Vernonia* sp. was placed in the second most preferred nectar plants for the butterfly representatives belonging to family Pieridae and Hesperiidae, whereas *Vernonia* sp. was found to be most selected by the family Lycaenidae.

As the urban landscapes are facing various types of challenges, the recognition, conservation and management of urban habitats is of prime issue for urban ecology (Angold *et al.* 2006). The correspondence of the *Vernonia cinerea* and butterfly abundances is crucial to understand the health and quality of the ecosystem as well as planning conservation strategies. Seasonal fluctuations of plant species are often influenced by environmental factors including temperature, photoperiod, rainfall, humidity, soil nutrients (Ncube *et al.* 2012).

The main objective of our study is to analyze the composition, abundance, foraging behavior of butterfly species with respect to *Vernonia cinerea* and to make a search on the possible factors regulating the attraction of butterflies towards *Vernonia cinerea*.

MATERIALS AND METHODS

Selection of study area : The study was conducted at Dighir Math, Rahara, (Lat: 22°43′44″ N and Long: 88°22′52″ E) under district North 24 Parganas, West Bengal, India approximately 200 meters away from Ramakrishna Mission Vivekananda Centenary College Campus (Fig. 1). The study site is characterized as a wasteland with a fresh water pond and naturally grown herbs and shrubs and surrounded by wall boundaries and human habitation. The total area of the study site (L 150 × W 125 m) is one of the most densely populated areas in and around Kolkata city and is going through a rapid phase of urbanization.

Data collection : Field sampling was carried out from June to September (monsoon) (2021) during the time

Fig. 2. A=*Appias albina*, B=*Catopsilia pyranthe,* C=*Eurema hecabe*, D=*Catopsilia pomana*, E, F=*Leptosia nina*, G=*Vernonia cinerea* Plant, H=*Vernonia cinerea* flower; I=One of the transact of the study area.

of peak flowering season of *Vernonia cinerea* (Rao *et al.* 2017). No live butterflies were captured, digital photography was done (Camera: Canon EOS 1500D, Model No: DS126741; Lens: EFS 18–55 mm, Serial No: 6776059279) for the taxonomic identification using standard references (Kunte 2000, Smetacek 2016, Kehimkar 2008). Abundance of butterflies were estimated using 'Pollard walk' method (Pollard and Yates 1993) using 15 random transects (each of 22 m × 22 m covering 6 minutes) in a stratified manner which means the total study site once within 2 hrs. The study site was divided into 6 different time slots of a day for data collection two hours each from morning to evening session with intermittent time gap of 2 minutes for smooth inter-transect movement like, 06:00 hrs - 08:00 hrs, 8:00 hrs - 10:00 hrs, 10:00 hrs - 12:00 hrs, 12:00 hrs - 14:00 hrs, 14:00 hrs - 16:00 hrs, 16:00 hrs - 18:00 hrs and coded as T_1, T_2, T_3, T_4, T_5 and T_6, respectively. Along with the abundance of *Vernonia cinerea* (Avg 9-10 individual plants per transect) other herbs and shrubs including *Parthenium hysterophorus, Alternanthera sessilis, Cassia sophera, Lantana camara, Ricinus communis, Sida acuta* were also available in the study area.

Statistical data were analyzed using SPSS 17.00 software and Microsoft Office Excel, 2019. Being count data, full data set was square root transformed before analysis. One sample t test was carried out to see the differences within any of the selected time slot in respect of mean abundances of 5 observed pieridae butterfly species. To understand the differences of abundance for a particular time slot in respect of 4 months, one way ANOVA was performed. Post Hoc analysis (Duncan test) was also carried out to identify the differences of mean abundance among months. Month wise rank abundance curves were designed with relative abundance (taking log transformed data)

Table 1. Position of each pierid species throughout the study period (rank abundance model).

Month	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
June	*Appias albina* (Boisduval 1836)	*Eurema hecabe* (Linnaeus 1758)	*Leptosia nina* (Fabricius 1793)	*Catopsilia pyranthe* (Linnaeus 1758)	*Catopsilia pomana* (Fabricius 1775)
July	*Appias albino* (Boisduval 1836)	*Eurema hecabe* (Linnaeus 1758)	*Catopsilia pyranthe* (Linnaeus 1758)	*Leptosia nina* (Fabricius 1793)	*Catopsilia pomana* (Fabricius 1775)
August	*Leptosia nina* (Fabricius 1793)	*Eurema hecabe* (Linnaeus 1758)	*Catopsilia pyranthe* (Linnaeus 1758)	*Appias albina* (Boisduval 1836)	*Catopsilia pomana* (Fabricius 1775)
September	*Eurema hecabe* (Linnaeus 1758)	*Leptosia nina* (Fabricius 1793)	*Appias albina* (Boisduval 1836)	*Catopsilia pomana* (Fabricius 1775)	*Catopsilia pyranthe* (Linnaeus 1758)

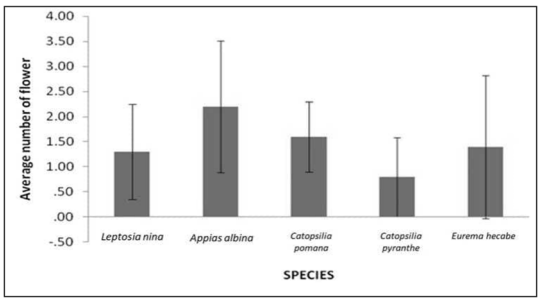

Fig. 3. Relative study of floral visit of *Vernonia cinerea* per minute by each butterfly species.

of each pieridae butterfly species to understand the most and least abundant species for each respective month.

RESULTS AND DISCUSSION

It was previously reported that the flowers of *Vernonia cinerea* were foraged by mainly 5 butterfly species of pieridae family i.e, *Appias albino* (Common albatross), *Leptosia nina* (Psyche), *Eurema hecabe* (Common grass yellow), *Catopsilia pomona* (Common emigrant) and *Catopsilia pyranthe* (Mottled emigrant) (Fig. 2). Month wise relative abundance of the five species of butterfly was calculated and placed according to rank respective of every month (Table 1). *Appias albina* secured rank 1 for the month of June and July each, whereas 1st position was ranked by *Leptosia nina* and *Eurema hecabe* in August and September respectively (Table 1). It is to be mentioned that two butterfly species, *Catopsilia pomona* and *Catopsilia pyranthe* always maintained their rank from rank 3 to rank 5 in those four months. One sample t-test indicates (Table 2) abundance of butterflies was statistically significant ($p < 0.05$) only in two time slots, i.e., in T_3 and T_5 and not varied significantly ($p > 0.05$) in the time slots. ANOVA depicts the mean abundance of 5 pieridae butterfly species varied significantly ($p < 0.05$) for time slots T_2, T_3 and T_4 in 4 months (Table 3). In the post hoc analysis (Duncan test), for the time slots T_2 and T_3 in the month of July showed the highest mean value whereas, for the time slot T_4 in the month of August showed highest mean value (Table 3). The foraging activity pattern of these butterflies showed a definite foraging schedule by landing initially on the flat-topped capitulum and then probed individual florets for nectaring. *Appias albina* was the most frequent visitors of *Vernonia cinerea* flower heads during the study period (Fig. 3). From rank-abundance curve it was found that *Appias albina* constantly dominated over the other four butterfly species during the months of June and July. On the same chart *Catopsilia pomona* always came last over three months from June to August (Fig. 4).

All the five butterflies constantly change position on rank-abundance curve according to their emergence time like the peak position in the rank-abundance curve coincided with *Catopsilia pomona* is September and October in West Bengal. *Appias albina* being medium sized butterfly is seen to visit the field quite early in the morning and constant drop in the population as sun goes up and for visiting flowers *Appias albina* got replaced by with smaller butterflies like *Eurema hecabe* and *Leptosia nina*. Unlike *Appias albina* or *Catopsilia pyranthe*, small sized butterflies can move fast and can cover a large area as a foraging matrix to fulfill their energy demand. As medium sized butterflies having diverse types of proboscises are easily fitted to a variety of flower for nectaring, they choose early morning for foraging from night blooming flowers that are not

Table 2. One sample t-test for abundance of butterfly species among different time slots.

Time slots	F value	P value
T_1 (6 AM-8AM)	1.93	p> 0.05
T_2 (8 AM-10 AM)	3.85	P< 0.05
T_3 (10 AM-12 PM)	3.85	P< 0.05
T_4 (12 PM-2 PM)	4.09	P< 0.05
T_5 (2 PM-4PM)	0.88	p> 0.05
T_6 (4 PM-6PM)	0.69	p> 0.05

Table 3. Month wise ANOVA and Post-hoc analysis of five species among six different time slots.

Time slots	F value	P value	Duncan test
T_1	1.93	p> 0.05	NA
T_2	3.85	P< 0.05	July>Oct=Sept=Aug
T_3	3.85	P< 0.05	July>Aug=Oct=Sept
T_4	4.09	P< 0.05	Aug>Sept=Oct=Aug
T_5	0.88	p> 0.05	NA
T_6	0.69	p> 0.05	NA

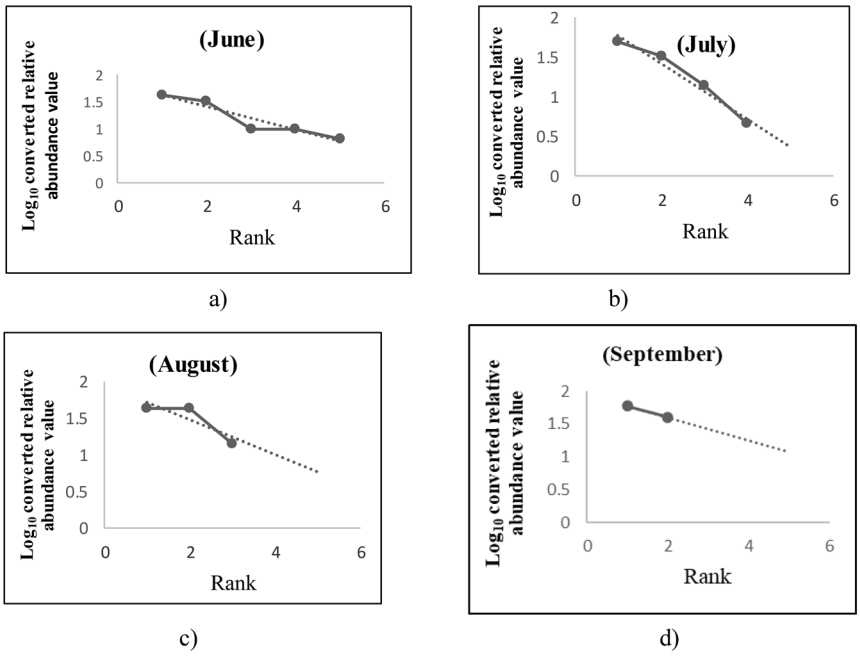

Fig. 4. Rank abundance curve of butterflies in four different months (a=June, b=July, c=August, d=September).

dried up. This pattern of foraging depicts that they have more options as a food source unlike the small butterflies who relies exclusively on some limited options. Humidity gradients in the night blooming flowers can act as a cue of foraging to maximize the energetic profit for the butterfly species (von Arx *et al.* 2012). Size of flowers triggering the perception of vision and smell, *Catopsilia pomona* preferred to visit large and middle-sized flowers for foraging (Tang *et al.* 2012), which might be a cause for low frequency of then to select *Vernonia cinerea* for nectaring. Smaller butterflies mostly being unable to collect nectar from large sized flowers, due to the short length of proboscis depend on *Vernonia* type plants having small flowers and wait till their full blooming which ranges from 08:00 to 13:00 hrs for *Vernonia*. Medium sized butterflies like to visit the field after nearly 14:00 onwards reaching setting time of sun when the abundance count of the medium sized butterflies is regained. Thus, by the synchronization of blooming period of *Vernonia* and the peak emergence period of pierid butterflies, *Vernonia cinerea* is ready to serve food to both smaller and medium sized butterflies over a long period of time. Poor value of relative abundance of *Catopsilia pomana*, *Catopsilia pyranthe* and *Eurema hecabe* might be coincided with their wide range of plant preferences (Mukherjee *et al.* 2016).

In a small ecozone like Dighir Math in Rahara, which is currently going through a rapid phase of urbanization from the last decade, is predominantly dominated by *Vernonia cinerea* plants and pierid butterflies are involved in co-evolution to ensure their dual existence in the habitat matrix. Our study indicates that conservation of *Vernonia* sp can benefit butterfly population in urban environment by providing them a very good food source and hiding place for smaller butterflies.

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