Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(2): 567-574

Received: 01-01-2017
Accepted: 02-02-2017

Srinjana Ghosh
Post Graduate Department of Zoology, Bethune College, Govt. of West Bengal, 181, Bidhan Sarani, Kolkata, West Bengal, India

Sumana Saha
Post Graduate Department of Zoology, Barasat Government College, Barasat, Kolkata, West Bengal, India

Correspondence
Srinjana Ghosh
Post Graduate Department of Zoology, Bethune College, Govt. of West Bengal, 181, Bidhan Sarani, Kolkata, West Bengal, India

Ecobiological interaction between the Pierides and their floral associates: An estimate of native environmental hygiene

Srinjana Ghosh and Sumana Saha

Abstract
The abundance of lepidopterans over a continuum of successional stages in terrestrial landscapes acts as a potential measure of environmental hygiene and conservational urgency. Butterflies, often threatened with risks of alteration at the landscape matrices may be chosen as bioindicator due to their well-known ecology and the existing standard tools for methodical documentations. Present study area, located in a small township at North 24 Parganas, West Bengal, represents habitats with multiple vegetation profile and anthropogenic interventions. Ecological and ethological associations of two moderate to highly abundant pierids, the Whites and Yellows, to their nectar and non-nectar host plants providing nutritional, reproductive and developmental resources in these habitats are documented. Seasonal variations are considered as underlying factors shaping up the community structure. On basis of minute and detailed field observations, both species are documented to show periodic co-occurrences, habitat co-existence and similarity in host preferences. Whereas specificity reported in case of host dependence, flight profile and basking activities and scavenging pattern. The main objective is to figure out the functional role of the host and nectar plants to maintain the local pierid populations.

Keywords: Butterflies, pierids, floral associates, habitat alterations, landscape ecology, nectar plants, host plants, bioindicator, conservation

Introduction
The diurnal lepidopterans are essential component of any natural terrestrial ecosystem. They are considered as relevant study group due to availability of existing standard tools. Sufficient information regarding their ecobiology is available. They could be considered as model taxon for assessment of environmental health and hygiene [1, 2]. Pierids are on the wing moderately throughout the year, abundant during summer and post monsoon. They frequently cover a wide range of habitat distribution.

Selection of host plants is based on the criteria of host preference (frequency of visits) and host dependence (on time spent basis) [3, 4]. Among the climatic parameters, moisture content, rainfall and photoperiodic gradient act as the promoting factor for reproductive fitness. Being ectothermic, microhabitat determinants are to be stringently maintained for performing delicate life history phases like oviposition, voltinism, diapauses, eclosion etc. Latitudinal gradients affect the realized niche shifts on periodic basis to complete the life cycle [5]. Often particular sets of host plants are optimized for different seasons by these poikilotherms, offering a kaleidoscopic assortment over native habitats [6]. Floral units belonging to different plant families provide nectar pool with a gradient of sugar and other nutrients volume and concentrations [7]. These opportunistic foragers being with weaker olfactory sense, often rely on several visual cues like colour, shape and depth of corollary tubes [8, 9]. Nectar guides also act as significant drive for floral unit selection. Brightly coloured (yellow, orange, red) clustered diurnal flowers with a landing pad reported to offer abundant rewards [10-12]. Nectar is the power fuel for flight. It is the vital force provider for selection of sites for foraging, reproductive partners, oviposition hosts, larval feeding. The nutritional value of consumed nectar promotes adult longevity and reproductive outputs like egg production and egg maturation [13]. Lacking any specific pollen gathering organ, proboscis, head, antenna, wings and legs act as pollen receptor organs. Among the non-floral plant host units, leaves are the major source influencing the probing-sucking assimilation efficiency. Those are characteristic growth-value indicator for the foliage feeding instars and ecological growth efficiency indicator for all concerned stages. Switching of host plants occurs as a result of strong

selection pressure to match its phenology with the temporal distribution [14, 15]. Thermal plasticity of host plant resource quality (e.g. Water and nitrogen content etc.) also act as key factor promoting shifting of host plant preference [16]. Pollinator-host plant correlation co-evolved as highly diversified as well as ecologically sensitive balancing selection measure ensuring their survival. Psychophilic pollinators have established themselves as most effective natural pollinators, just next to hymenopterans (bees) [17]. They are valuable pollinators for wild plants, thus serving key role for natural landscape sustainability [18]. Though the butterflies bear potentiality of playing role as flagship species, recently they are being threatened globally by the risk of habitat isolation, modification, fragmentation or habitat loss mainly due to the natural integrity deteriorating anthropogenic factors like industrialization, urbanisation or overexploiting agrobiological activities [19]. Being extremely sensitive to subtle environmental changes they can act as efficient global bioindicator and the efficient value indicator of biotope quality [20]. Still a huge ratio of Indian species yet to be described with respect to their detailed ecological and behavioural functionality [21].

With this background, the present study is an attempt to unfold the visiting profile of the two commonly found local pierids, Common and Mottled Emigrants to their native host plants. It is worthwhile to mention that various behavioural aspects concerning their resource utilization pattern are reported to be a measure of qualitative description of environmental hygiene [22-24].

Present study site, Taki, North 24 Parganas, is a small semi urban habitat (13 km^2), on the border of Bangladesh, situated at the farthest end of the district standing on the bank of river Ichhamati (for detail see Ghosh & Saha,) [25, 26] They [25] documented the seasonal diversity of butterflies with reference to habitat heterogeneity, larval host plants and nectar plants at Taki. Host plant preferences shown by the butterflies sharing the mimetic relationships, commonly found at Taki has also been reported [26]. Being a weekend tourist destination, Taki, has to bear some additional anthropogenic load to its indigenous wetland based ecosystem properties. Presently, Taki is experiencing significant habitat fragmentation with great rapidity. Thus, scope exists for assessing the role of ecological and anthropogenic parameters influencing habitat exploration abilities of native butterfly communities.

Materials and Methods

The selected study site, Taki, 22.59^{0}N and 88. 92^{0}E, represents a municipality under Hasnabad P.S. of Basirhaat Subdivision in North 24 Pgs., West Bengal. Global Positioning System (GPS; GPSMAP 76Cx, Garmin, Olathe, Kansas, USA) is used to record the geographic coordinates. The average elevation is about 5 meters (16ft) at the bank of Ichhamati river. Subtropical climate prevails with hot summer, from late March to Early June (avg. temp. range 25-40^{0}C), monsoon from mid-June to late August (receiving an average rainfall of 150 mm) and a cool, dry winter from Nov to early Feb (average temperature range 12-25 ^{0}C).The yearlong study duration is from April 2014 to March 2015. Surveys are done monthly once, for thrice in a day from 9 am-11 am, 12 noon to 2 pm, 3 pm to 5 pm. Division of seasons (summer, monsoon, post monsoon and winter) are based on the variation of rate of precipitation and temperature.

Sampling Techniques: Seasonal availability is reported by presence-absence scoring method. Four randomized transect walks performed for 12 minutes during each survey period through the study areas following "Pollard Walk" method with necessary modifications. Fixed transect routes (250m long and 5m wide) followed for a particular habitat patch [27]. Approximately a uniform pace was maintained at each study site. Prominent host plant trails are selected on the basis of >70% of visiting frequencies of the respective butterflies. Nectar and non-nectar host plants randomly selected from the same transect. 5-10 numbers of each host plant species, depending on availability were focussed. Stationary observation time fixed for 15 minutes per survey period at three suitable locations to watch host plant based interactions. Minimum distance for minute observation was constantly maintained to be 1.5 metres between the observer and the host plant. For assuming the visiting profile by butterfly to host plant, 10 frequently encountered and easily observable landing sites, including the floral units and other suitable units were selected for individual host plants. The number of butterflies encountering each host plant and their behavioural specificity were temporarily scanned and reported; duration of specific behaviours noted with the help of a stopwatch. Microhabitat details like canopy layers, foliage surfaces, substratum profiles were also noted. Encountered butterflies were identified using suitable keys [28-30]. Specific host plants were identified and recorded [31, 32].

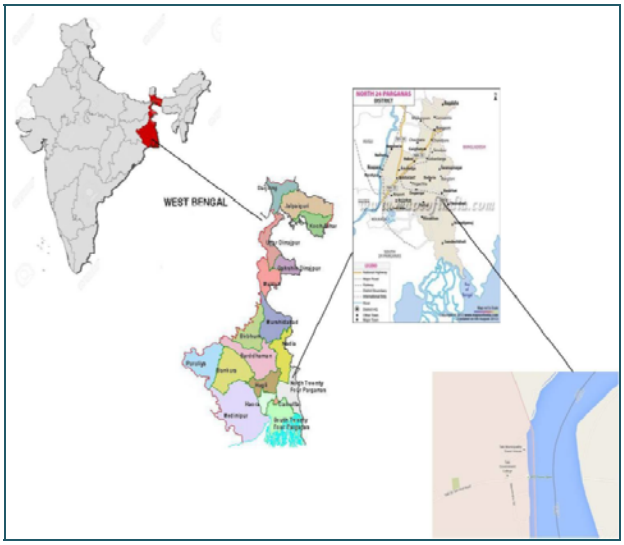


Fig 1A: Study area

Fig 1B. Study sites

Results and Discussion

Table 1: List of Host Plants

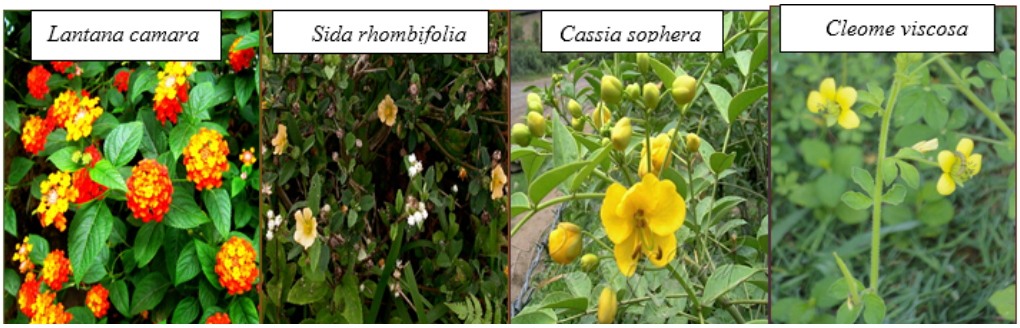
Common Name	Scientific Name	Commonly visited primary host plants	Commonly visited secondary host plants
Common Emigrant	*Catopsilia pomona* (Fabricius)	*Lantana camara*	*Cassia fistula*
Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus)	*Sida rhombifolia*	*Cleome viscosa*

Table 2: Host Plant profile

Sl. No	Plants	Family	Habit	Flowering Seasons	Flower Colour	Local distribution	Avg. height from ground(m)
1	*Lantana camara*	Verbenaceae	widespread evergreen shrub	Jan-Dec (S, M, PM, W)	yellow, orange, red	open land ranges	1-2.25
2	*Sida rhombifolia*	Malvaceae	perennial shrub	Sept-Feb (PM, W)	yellow, orange, red	bushy patches	0.5-1
3	*Cassia sophera*	Caesalpiniaceae	rapidly spreading annual or perennial shrub	Jan-Dec (S, M, PM, W)	yellow, orange, red	roadside, wasteland, near habitations, often in groups	1-3
4	*Cleome viscosa*	Cleomaceae	gregarious annual herb	April -October (S, M, PM)	Yellow	roadside, openland, edges on vegetation patches	1

Common Emigrant

Mottled Emigrant



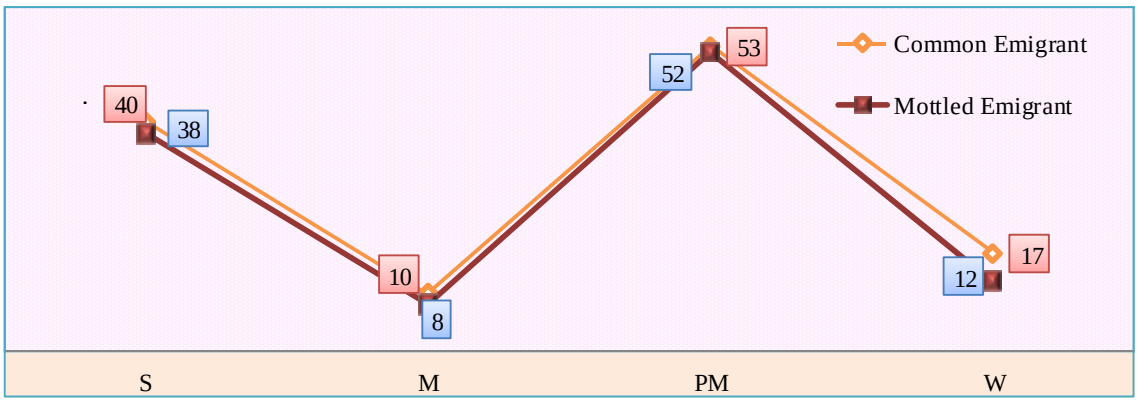


Fig 2: Seasonal Abundance Pattern

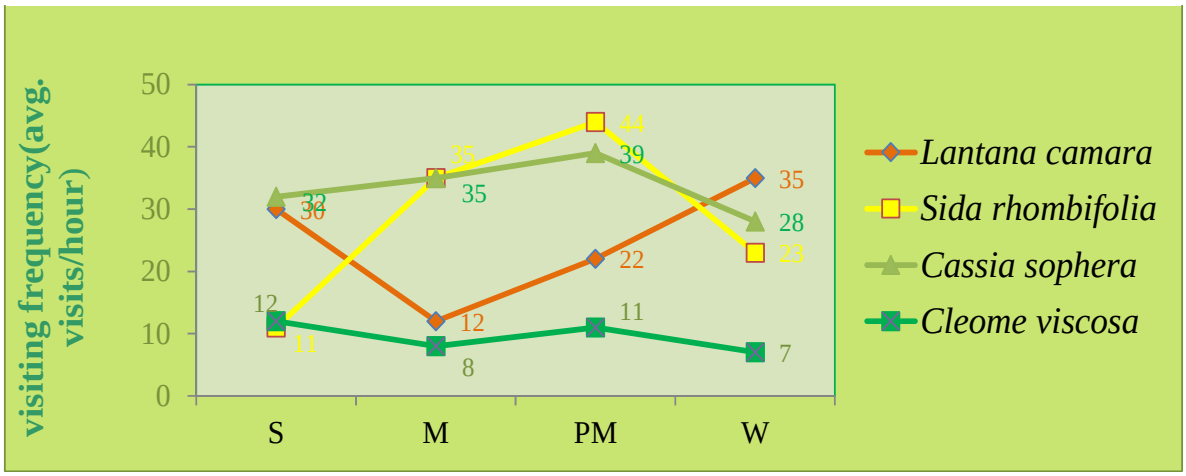


Fig 3: Seasonal visiting frequency of Common Emigrant to host plants

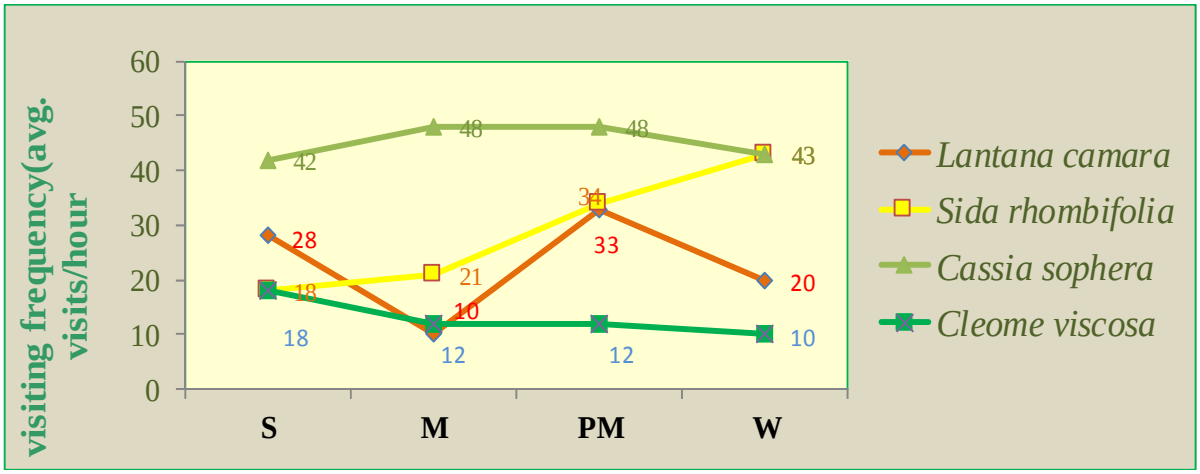


Fig 4: Seasonal visiting frequency of Mottled Emigrant to host plants

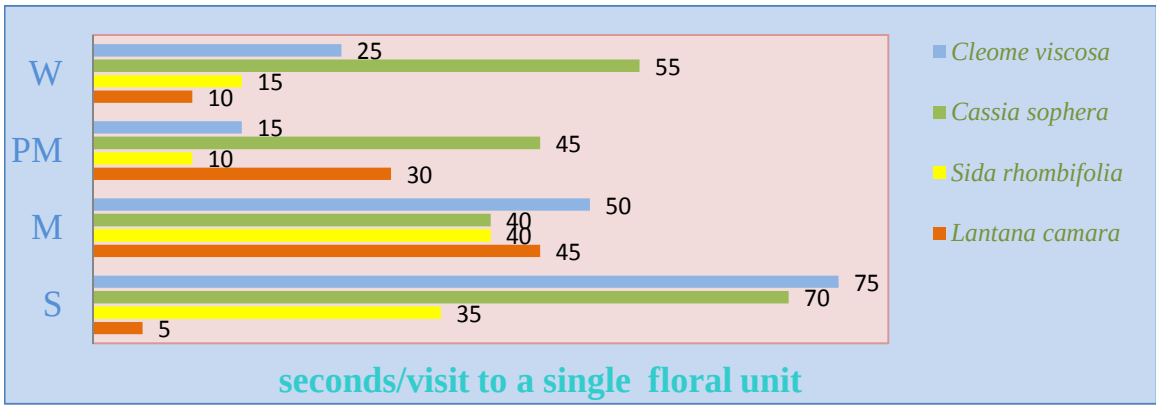


Fig 5: Common Emigrant: average "time spent" on the host plants

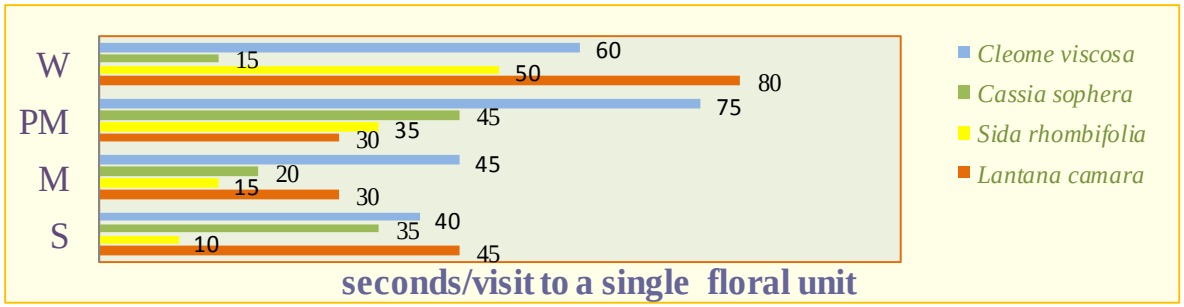


Fig 6: Mottled Emigrant: average "time spent" on the host plants

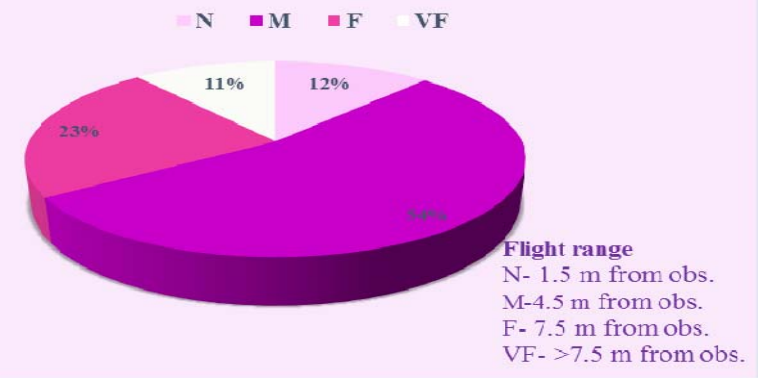
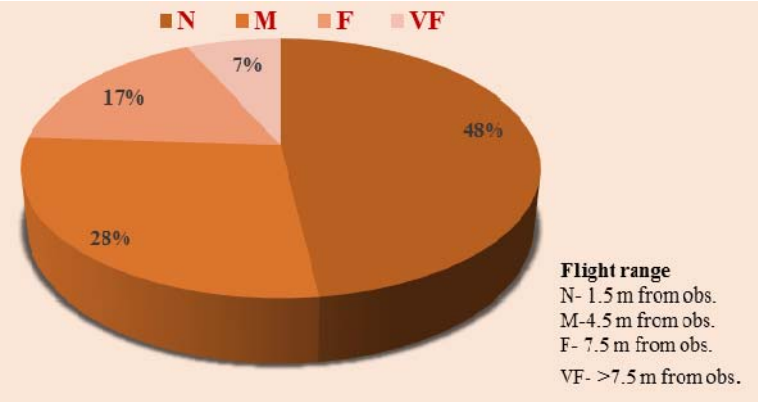


Fig 7a: Comman Emigrant: avg. horizontal flight range (at stretch) (m)



Flight range; N- 1.5 m from observation point; M-4.5 m from observation point; F-7.5 m from observation point- >7.5 m from observation point

Fig 7b: Mottled Emigrant: avg.horizontal flight ramge (at a stretch) (m)

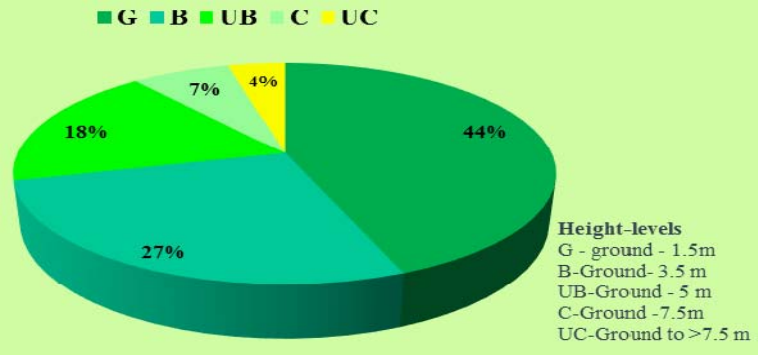
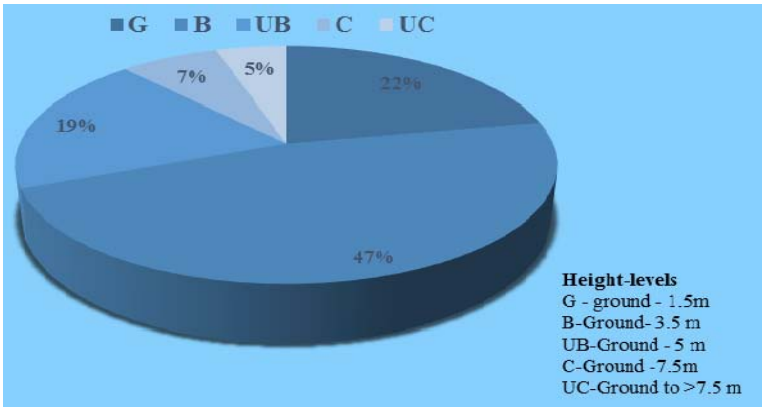


Fig 8a: Common Emigrant: avg. vertical fight height (m)



Flight -height – Ground (Ground – 1.5m); B-Bush level (Ground-3. 5m); UB-Upper Bush level (Ground – 5m); C-Canopy level (Ground to 7.5m); UC-Upper Canopy level (Ground to >7.5 m)

Fig 8b: Mottled Emigrant: avg. vertical flight height (m)

Table 3: Basking activity of butterflies

Name of the butterfly	Frequency based				Duration based				Diurnal phase related			
	S	M	PM	W	S	M	PM	W	S	M	PM	W
Common Emigrant	MF	VLF	MF	F	ST, MD	ST	ST	MD, LT	DAY, AFTN	MOR, DAY	DAY	MOR
Mottled Emigrant	MF	VLF	F	F	MD	MD	ST	LT	DAY, AFTN	DAY	DAY	MOR, DAY

Frequency based
Frequent F-hourly >5 times; Moderately frequent MF-hourly 1-5 times; less frequent LF-hourly once
very less frequent(VLF)-<hourly, once
Duration based
ST-SHORT TERM<1 MIN AT A TIME; MD-MEDIUM- 1-3 MINS AT A TIME; LT-LONG TERM->3 MINS AT A TIME
Diurnal phase
Morning (9-11 am)-MOR; Day (12 noon -2 pm)-DAY; Afternoon (3-5pm)-AFTN

Table 4a: Occasionally Visiting Resources: Temporal Profile: Common Emigrants

Resource Patches	S			M			PM			W		
	Mor	Day	Aftn	Mor	Day	Aftn	Mor	Day	Aftn	Mor	Day	Aftn
Herbivores' faeces	NR	NR	+	NR	NR	+++	NR	+	+++	NR	NR	NR
Rotten vegetation's (fruits, leaves, stem parts)	NR	+++	+++	++	++	++	+	++	++	NR	NR	+
Mud Patches	NR	++	++	NR	NR	+	NR	+	+	NR	+++	+++

Table 4b: Occasionally Visiting Resources: Temporal Profile: Mottled Emigrant

Resource Patches	S			M			PM			W		
	Mor	Day	Aftn	Mor	Day	Aftn	Mor	Day	Aftn	Mor	Day	Aftn)
Herbivores' faeces	NR	NR	+	NR	NR	NR	NR	NR	NR	NR	++	++
Rotten vegetation (fruits, leaves, stem parts)	++	++	+++	+++	+++	+++	+++	+++	+++	+	+	++
Mud Patches	NR	NR	+	NR	NR	NR	NR	NR	NR	NR	++	+

Frequency based:>6 times/hr (+++); 3-6 times/hr (++);1-3 times/hr (+) ; Morning (9-11 am)-MOR; Day (12-2 pm)-DAY; Afternoon(3-5pm)-AFTN; NR: Not reported

Common Emigrants and Mottled Emigrants are co-occurring species. They share almost similar habitats, particularly the similar host plants. During March -April and again during September -October, near the *Lantana* bushes, the favourite host plants, their presence is most obvious. Next abundance value is reported during summer months, followed by that in winter and lowest is reported during monsoon (Fig2). Their abundance pattern is highly correlated to the phenology of their primary and secondary host plants (Table 2). Most of the host plants have their blooming bursts during summer and post monsoon though *Lantana* and *Cassia* flowers bloom almost throughout the year.

Visiting frequency, as depicted in Figs. 3 and 4, reflects a qualitative assessment of host preference by the dependant butterflies. Considering the Common Emigrants, for *Lantana*, highest value is reported during winter, followed by that in summer and the lowest is during monsoon. *Sida* is most frequently visited during post monsoon, then during monsoon and in winter. Yearlong consistent visiting preference is maintained for both *Cassia* and *Cleome*, but the visiting frequency is lower for *Cleome* during all seasons. Mottled emigrants show (Fig.4) highest visiting frequency on *Cassia*, almost consistently throughout the year. Their lowest preference is documented for *Cleome*, throughout all the seasons. *Sida* is highly preferred during winter and post monsoon, whereas *Lantana* is preferred during summer and post monsoon. Thus, it becomes clear that except in the monsoon, *Lantana* plays the role of efficient primary host plant both for the Common Emigrant and Mottled Emigrant. As for the non-nectar, secondary host plant, both the butterfly species show higher preference for *Cassia*, than for the *Cleome*, as reported in all of the four seasons.

The average "time-spent" by individual species on a single host plant during a single visit provides a qualitative measure to estimate the host-dependence [33]. Common Emigrant (Fig.5) shows highest dependence on *Cleome*, during summer, when lowest dependence is recorded on *Lantana*, the primary nectar plant of the same. Mottled Emigrant (Fig.6) shows highest dependence on *Lantana* during winter. It shows minimum level of dependence on *Sida* during summer.

Thus, from the host plant preference and host plant dependence profile, it becomes prominent that the overall pattern is determined by the availability of resources from the host plants in the form of food (nectar, pollen), shelter, nuptial display premises, oviposition site, nurturing ground for the molting instars. Seasonal variation in the efficiency of utilization of the host plant provided resources by the dependant species and the life process specific usage of microhabitats provided by the host plants also shape up a host plant network for the concerned species [34].

Common Emigrants (Fig.7a) mostly (54%) are found to avail the 'moderate' range, when the average horizontal at a stretch flight range is considered. whereas, Mottled emigrants commonly (48%) occupy the 'near' range.'

As considered, the average vertical flight height, for Common Emigrants (Fig.8a), the ground level are found to be most suitable (44%) whereas the Mottled Emigrants (Fig.8b) are most commonly found at bush level (47%).

Basking activities of both the species reported to reflect marked differential features throughout the temporal scale, following the gradients of climatic parameters like solar radiance, environmental temperature, moisture and humidity content, rainfall or precipitation proportions [35]. For Common Emigrants basking activity is highly frequent during winter season. During monsoon, they bask for short term duration whereas moderate basking period is noted both at summer and winter. Throughout the year basking activity is more common during day time, whereas in winter moderate to long term basking is reported also in the morning. For Mottled Emigrants, frequent basking is reported during post monsoon

and winter. Medium duration baskings are reported in summer and monsoon. In winter, they generally go for long term basking. Regarding the diurnal phases, for Mottled Emigrants day time basking is common at all the seasons, morning basking is reported only during winter.

Apart from the vegetational hosts including the nectar and non-nectar host plants and larval host plants these lepidopterans occasionally scavenge for some alternate and to some extent detritus resources like herbivore's faeces, rotten fruit and vegetables as alcoholic sources, and mud patches. Common Emigrants go for faecal visits generally during afternoon throughout the year, except in winter. Mottled Emigrants visit those also during the day time. Rotten vegetation often visited by the Mottled Emigrants without any diurnal specificity. Common Emigrants visit them less frequently during winter. Mud patches are somewhat common destination for Common Emigrants during the later part of day at winter.

There exists a link between the native community composition and local and regional habitat characterisation [36]. Ecological outcomes of host-specificity and habitat associations of the butterflies range from local dispersion to metapopulational expansion [37]. Mechanical type of floral isolation also gets its way by the pollination shifting criteria of the co-evolved pollinating agents like these diurnal lepidopterans [9]. Prevention of interbreeding between sympatric populations and maintenance of allopatric speciation mechanisms could be made possible by host specificity shown at different levels of floral unit dependence, viz. unifloral, polyfloral or multifloral [38].

Based on the detailed field observation over the behavioural attributes, favourable conditions for native butterfly species as potential biotope indicators, should encompass the presence of series of host plant species flowering over all seasons. Retention of wild floral den, composed of annual or perennial rapid growing herbs or shrubs with at least few blooming all times and providing microhabitats for foraging, nesting, basking, resting and hiding purposes [39, 40]. Presence of mud patches play vital role as essential mineral and water resource. Suitable soil salinity level, directly correlates to fecundity and developmental progression. Lastly, restricted anthropogenic activities like grazing, pesticidal over-exposure prevent the ecobiological impairment [41-43].

Conclusion

It can be summarized that, pre-requisite for butterfly conservation programme includes the need of conservation both at the levels of adult and developmental phases. Awareness about adult and larval habitat and mode of optimisation of the natural resources by the individuals over a spatial and temporal scale is urgent [44, 45]. Both at habitat and landscape level conservation and restoration approaches should be adopted. Sustainable microhabitat management and methodical documentation of sufficient information regarding species autecology must be maintained on periodic basis.

Acknowledgements

Authors wish to thank Smt. Bidisha Ray, Department of Zoology,Taki Government College, for her cooperation during field visits.They are thankful to Dr. Santanu Saha, Associate Professor, Dept. of Botany, Bidhannagar Govt College for his valuable suggestions. Necessary logistic support extended by the respective Principals is thankfully acknowledged. First author (SG) expresses sincere thanks to The Officer-in-charge & Head, Department of Zoology, Taki Government College for their constant encouragement**.** Sincere thanks are also due to Prof. Dinendra Raychaudhuri for his valuable suggestions during preparation of the manuscript.

Reference

1. Pollard E. A method for assessing changes in the abundance of butterflies. Biol. Conservation. 1977; 12:115-134.
2. Jothimani K, Ramachandran VS, Rajendran A. Towards a monitoring method and a number of multifaceted and hierarchical biodiversity indicators for urban and suburban parks. Landsc. Urban Plann. 2014, 149-162.
3. Tiple AD, Khurad AM, Dennis RLH. Adult butterfly feeding-nectar flower associations: constraints of taxonomic affiliation, butterfly, and nectar flower morphology. J Nat. Hist. 2009; 43(13):855-888.
4. Mohan Ram HY, Mathur G. Flower-insect interaction in pollination. Proc. Indian Acad. Sci. Anim. Sci. 1984; 93(4):359-363.
5. Öckinger E, Smith HG. Landscape composition and habitat area affect butterfly species richness. Oecologia, 2006; 149:526-534.
6. Patel AP, Pandya NR. Assessment of temporal & spatial variation in species richness and diversity of butterfly host plants. International Journal of Plant, Animal and Environmental Sciences. 2014; 4(3):235-245.
7. Jose A, Navarro C, Bengt K, Diana P, Tenna T, Christer W *et al*. Climate change, phenology, and butterfly host plant utilization. AMBIO. 2015; 44(1):S78-S88.
8. Andersson S, Dobson HEM. Behavioral foraging responses by the butterfly *Heliconius melpomene* to *Lantana camara* floral scent. J Chem. Ecol. 2003; 29(10): 2303-2318.
9. Faegri K, Van Der Pijl L. The principles of pollination ecology 3rd rev. ed. Oxford: Pergamon Press.1979, 244.
10. Dronamraju KR. The visits of insects to different coloured flowers of *Lantana camara* L. Curr. Sci. 1958; 27:452-453.
11. Goulson D, Derwent L. Synergistic interactions between an exotic honeybee and an exotic weed: pollination of *Lantana camara* in Australia. Weed Res. 2004; 44:195-202.
12. Weiss MR. Innate colour preferences and flexible colour learning in the pipevine swallowtail. Anim. Behav. 1997; 53:1043-1052.
13. Proctor M, Yeo P, Lack A. The natural history of pollination. London: Harper Collins. 1996; 2:479.
14. Yeargan, KV, Colvin SM. Butterfly feeding preferences for four Zinnia cultivars. J Environ. Hortic. 2009; 27(1):37-41.
15. Penz CM, Krenn HW. Behavioral adaptations to pollen-feeding in *Heliconius* butterflies (Nymphalidae, Heliconiinae): an experiment using *Lantana* flowers. J Insect Behav. 2000; 13(6):865-880.
16. Peterson MA. Host plant phenology and butterfly dispersal: causes and consequences of uphill movement. Ecology. 1997; 78(1):167-180.
17. Sajjad A, Saeed S, Burhan-u-din S. Yearlong association of butterfly populations with flowering plants in Multan, Pakistan. Pak. Entomol. 2012; 34(2):105-110.
18. van Rossum F, Triest L. Pollen dispersal in an insect–pollinated wet meadow herb along an urban river. Landsc. Urban Plann. 2010; 95:201-208.
19. van Strien AJ, van Duuren L, Foppen RPB, Soldaat LL.

A typology of indicators of biodiversity change as a tool to make better indicators. Ecol. Indic. 2009; 9:1041-1048.
20. Tiple AD. Butterfly species diversity, relative abundance and status in Tropical Forest Research Institute, Jabalpur, Madhya Pradesh, and central India. Journal of Threatened Taxa. 2012; 4(7):2713-2717.
21. Haribal M. Butterflies of Sikkim Himalaya and their natural history. Gangtok: Nature Conservation Foundation. 1992, 217.
22. Atluri JB, Bodapati S, Matala BR, Devara SD, Chilakala SBR. Ecobiology of the common castor butterfly *Ariadne merione merione* (Cramer) (Lepidoptera: Rhopalocera: Nymphalidae).Journal of Research on the Lepidoptera. 2010; 42:13-20.
23. Collinge SK, Prudic KL, Jeffrey C, Oliver JC. Effects of Local Habitat Characteristics and Landscape Context on Grassland Butterfly Diversity. Conservation Biology. 2003; 17(1):178-187.
24. Krauss J, Dewenter IS, Tscharntke T. How does landscape context contribute to effects of habitat fragmentation on diversity and population density of butterflies? Journal of Biogeography. 2003; 30:889-9002.
25. Ghosh S, Saha S. Seasonal diversity of butterflies with reference to habitat heterogeneity, larval host plants and nectar plants at Taki, North 24 Parganas, West Bengal, India. World Scientific News. 2016; 50:197-238
26. Ghosh S, Saha S. Mimetic relationships of butterflies, commonly found at Taki, North 24 Parganas, West Bengal. World Scientific News. 2016; 45(2):292-306.
27. Pollard E, Yates TJ. Monitoring butterflies for ecology and conservation. Publ. Chapman and Hall, London, 1993, 292.
28. Kehimkar I. The book of Indian butterflies. Mumbai: Bombay Natural History Society, 2008, 497.
29. Kunte K. Butterflies of Peninsular India. Hyderabad: University Press. 2000, 254
30. Varshney RK, Smetacek P. (Eds.). A Synoptic Catalogue of the Butterflies of India. Butterfly Research Center, Bhimtal and Indinov Publishing, New Delhi. 2015; ii(8):261.
31. Mukherjee M. Plant Groups. New Central Book Agency (P) Ltd., 1981, 727-1117.
32. Kehimkar I. Common Indian wild flowers. Bombay Natural History Society, Mumbai, 2000, 22-41.
33. Harinat HP, Suryanarayana KK, VenKata MR, VenKata ramana SP. Biology and Food Utilization Efficacy of the Small Grass Yellow *Eurema brigitta* (Cramer) (Lepidoptera: Rhopalocera: Pieridae) in the Eastern Ghats of Southern Andhra Pradesh. 2015; 3(2):63-71
34. Shapiro AM. The Californian urban butterfly fauna is dependent on alien plants. Diversity Distribution. 2002; 8:31-40.
35. Jothimani K, Ramachandran VS, Rajendran A. Role of butterflies as pollinators in Maruthamalai Hills of Southern Western Ghats. Acad. J Entomol. 2014; 7(1):7-16.
36. Clark PJ, Reed JM, Frances S. Effects of urbanization on butterfly species richness, guild structure, and rarity.Chew Urban Ecosyst 2007; 10:321-337.
37. John Dover J, Settele J. The influences of landscape structure on butterfly distribution and movement: a review.J Insect Conserv. 2009; 13:3-27.
38. Dronamraju KR. Selective visits of butterflies to flowers: a possible factor in sympatric speciation. Nature. 1960; 186:178.
39. Mukherjee S, Banerjee S, Basu P, Saha GK, Aditya G. *Lantana camara* and Butterfly Abundance in an Urban Landscape: Benefits for Conservation or Species Invasion. 2015; 34(4):309-328.
40. Harinatha P, Venkata Reddy M, Suryanarayanac K, Venkata Ramanad SP. Ecobiology of the Spot Swordtail *Graphium nomius* (Esper) (Lepidoptera : Rhopalocera : Papilionidae) from the eastern Ghats of Southern Andhra Pradesh. 2015; 5(3):77-87
41. Smallidge PJ, Leopold DJ. Vegetation management for the maintenance and conservation of butterfly habitats in temperate human-dominated landscapes. Landsc. Urban Plann. 1997; 38:259-280.
42. Thomas JA, Bourn NAD, Clarke RT, Stewart KE, Simcox DJ, Pearman GS *et al*. The quality and isolation of habitat patches both determine where butterflies persist in fragmented landscapes. Proc. R. Soc. London B. 2001; 268:1791-1796.
43. Pöyry J, Lindgren S, Salminen J, Kuussaari M. Responses of butterfly and moth species to restored cattle grazing in semi-natural grasslands. Biol. Conserv. 2005; 122:465-478.
44. Venkataramana SP, Atluri JB, Reddy CS. Autecology of the endemic Crimson Rose butterfly *Pachliopta hector* (Lepidoptera : Rhopalocera : Papilionidae). J Indian Inst. Sci. 2004; 84:21-29.
45. Harinath P, Suryanarayana K, Venkata Ramana SP. The efficiency of food utilization by the small orange tip butterfly *Colotis etrida* (Boisduval, 1836) (Lepidoptera: Rhopalocera: Pieridae) in the Eastern Ghats of Southern Andhra Pradesh-India. Journal of Entomology and Zoology Studies. 2016; 4(4):198-204.