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Butterfly diversity in Kolkata metropolis: a synoptic check list

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Abstract: Butterflies are considered charismatic species for conservation planning as well as environmental monitoring and management. In this study, we assessed the richness of butterfly and associated plant species in Kolkata, India to provide baseline information on the extent of species diversity and prospective use in urban planning and conservation. In association with 39 different herbs and shrubs, at least 54 species of butterflies, belonging to five families, were found in urban habitats of Kolkata. Variations in the diversity indices of the butterfly and plant were observed over the months with highest values in the summer and postmonsoon period and low in the winter months. Butterfly association with the host plants reflected the ascendancy of generalist species in the study area. The network of butterfly and the host plant may be explored further to facilitate the conservation of butterfly and sustain the environmental quality of Kolkata, India

Key words: Lepidoptera, species diversity, conservation

INTRODUCTION

The relevance of monitoring biological diversity can be linked with appraisal of changes in the environmental quality at the local and regional scales. Evaluation of species diversity is a pre requisite component for habitat management and prediction of the environmental impacts on the biota (Niemelä 2000; Yoccoz et al. 2001; Nichols and Williams 2006). Assessment of taxa specific diversity enables evaluation of the ecosystem processes and ecosystem services with higher precision (Díaz et al. 2006). Diversity analysis often focuses on the single taxon instead of the species assemblage to predict the ecosystem functions and the services derived from the specific taxa. Selection of limited taxa is often preferred over whole community due to resource limitation (Mihindukulasooriya et al. 2014) and in certain instances the presence/absence data provide useful estimation of population size (Williams et al. 2002; Koleff et al. 2003; MacKenzie 2005). The target taxon varies with the quality of the landscapes and the purpose of the study. Insects are one of the preferred taxa for evaluation of biodiversity for biological conservation, and retrieving information about the environmental conditions (Kim 1993; Samways 1994; Simonson et al. 2001). The taxonomic distinctness and the variations in the habitats exploited by different forms of insects in both terrestrial and aquatic habitats forms a strong basis for using insects as target taxa for monitoring the species diversity. The changes in the environmental quality are easily retrieved through the corresponding changes in the diversity of certain taxa, which are recognized as indicator species, utilized for environmental monitoring (Hogsden and Hutchinson 2004). For terrestrial ecosystems, butterflies are considered as indicator species providing vital information about the environmental conditions. Butterflies are linked with different ecosystem services that are essential for sustenance of the environmental quality and integrity (Kumar 2013). The interaction between diverse species of butterflies and plants are well studied group of mutualist, which is why the representation of the diversity of butterflies is connected with almost equivalent group of plants in any area.

On a global scale more than 19,000 species of butterflies have been described (Heppner 1998), of which around 1,500 species are recorded from India (Haribal 1992). Among the different areas of India, butterfly diversity has been elaborated in many studies including the interactions between different plant species of the concerned area (Kunte et al. 1999). The record of the butterflies associated with the native and the indigenous plants are long being a focus in Kolkata, India (Dronamraju 1958, 1960), which prompted us to carry out field investigation and record the richness and abundance of the butterflies. In order to enhance the environmental monitoring of the concerned geographical area, systematic investigation

on the butterfly richness and the related plant species is essential. The results of the study are presented in this narrative to document a synoptic view of the butterflies recorded from the urban areas of Kolkata, India. An account of the species richness and abundance of butterflies and the related plants species is expected to benefit environmental monitoring and preservation of the species for sustaining ecosystem services.

MATERIALS AND METHODS

This study was carried out in Kolkata, West Bengal, India, between January 2013 and December 2013. We randomly selected three study sites: vicinity of Dumdum metro station (22°37′16.69″ N, 088°23′34.26″ E), Nalban (22°34′08.92″ N, 088°25′10.82″ E), and vicinity of Ballygunge Phari (22°31′41.56″ N, 088°21′57.56″ E). A Global Positioning System receiver (Garmin GPSMAP® 76Cx) was used to record the geographic coordinates of each site. Each site was visited twice in a month. On each occasion, we observed butterflies on either side of a 2.5 m transect using the 'Pollard Walk' method (Pollard 1977; Pollard and Yates 1993) with necessary modifications related to the sampling units considered in the present study. The butterflies were identified in the field using illustrated guides (Wynter-Blyth 1957; Haribal 1992; Kunte 2000; Kehimkar 2008). Occasionally they were captured by hand net for identification, then released. The abundance of each butterfly species was also recorded. We also recorded plant species along each of the transects, following the method employed by Clark et al. (2007), that is, plant species within 2.5 m of each side of each transect were recorded. We recorded those species that are mainly food plants of butterflies and ignored trees except one species (*Carica papaya* L). We collected flowering plant specimens and preserved them for identification by preparing herbarium. Plants were identified to family and species using keys (Kehimkar 2000; Paria 2005, 2010; Mandal and Jana 2012). Using Biodiversity Pro software (McAleece et al. 1997) the diversity indices of the butterfly abundance were calculated. Species diversity was calculated using Shannon diversity index [($H' = \sum P_i \ln p_i$) and Shannon H_{max} ($H_{max} = Log_{10}(S)$)], Shannon evenness was calculated using the formula; $J = H'/H_{max}$, where, H′ = information content of sample (bits/individual) or Shannon diversity index, and P_i = proportion of total sample belonging to i^{th} species, S = total number of species in habitat (species richness) (Magurran 2004).

RESULTS

We recorded 54 butterfly species belonging to five families (Papilionidae, Pieridae, Nymphalidae, Lycaenidae and Hesperiidae; Table 1; Figure 1) and 39 species of nectar plants, along with flowering time and plant type, over the duration of the study period (Table 2).

Table 1. List of butterflies recorded from Kolkata, India during January 2013 to December 2013

Common Name	Scientific name	Short form
Family Papilionidae		
Common jay	*Graphium doson* (Felder & Felder, 1864)	GDO
Tailed Jay	*Graphium agamemnon* (Linnaeus, 1758)	GAG
Common Mormon	*Papilio polytes* (Linnaeus, 1758)	PPO
Lime Butterfly	*Papilio demoleus* (Linnaeus, 1758)	PDE
Common Mime	*Chilasa clytia* (Linnaeus, 1758)	CCL
Common Rose	*Pachliopta aristolochiae* (Fabricius, 1775)	PAR
Family Pieridae		
Three-spot Grass Yellow	*Eurema blanda* (Boisduval, 1836)	EBL
Common Grass Yellow	*Eurema hecabe* (Linnaeus, 1758)	EHE
Common Emigrant	*Catopsilia pomona* (Fabricius, 1775)	CPO
Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus, 1758)	CPY
Common Wanderer	*Pareronia valeria* (Cramer, 1776)	PVA
Striped Albatross	*Appias libythea* (Fabricius, 1775)	ALI
Common Gull	*Cepora nerissa* (Fabricius, 1775)	CNE
Common Jezebel	*Delias eucharis* (Drury, 1773)	DEU
Psyche	*Leptosia nina* (Fabricius, 1793)	LNI
Family Nymphalidae		
Blue Tiger	*Tirumala limniace* (Cramer, 1775)	TLI
Striped Tiger	*Danaus genutia* (Cramer, 1779)	DGE
Plain Tiger	*Danaus chrysippus* (Linnaeus,1758)	DCH
Common Crow	*Euploea core* (Cramer, 1780)	ECO
Common Evening Brown	*Melanitis leda* (Linnaeus, 1758)	MLE
Common Palmfly	*Elymnias hypermnestra* (Linnaeus, 1763)	EHY
Common Bushbrown	*Mycalesis perseus* (Fabricius, 1775)	MPE
Common Five-ring	*Ypthima baldus* (Fabricius, 1775)	YBA
Common Four-ring	*Ypthima huebneri* (Kirby, 1871)	YHU
Tawny Coster	*Acraea violae* (Fabricius, 1775)	AVI
Common Leopard	*Phalanta phalantha* (Drury, 1773)	PPH
Chestnut-streaked Sailor	*Neptis jumbah* (Moore, 1857)	NJU
Angled Castor	*Ariadne ariadne* (Linnaeus, 1763)	AAR
Common Castor	*Ariadne merione* (Cramer, 1779)	AME
Peacock Pansy	*Junonia almana* (Linnaeus, 1758)	JAL
Grey Pansy	*Junonia atlites* (Linnaeus, 1763)	JAT
Lemon Pansy	*Junonia lemonias* (Linnaeus, 1758)	JLE
Great Eggfly	*Hypolimnas bolina* (Linnaeus, 1758)	HBO
Family Lycaenidae		
Indian Sunbeam	*Curetis thetis* (Drury, 1773)	CTH
Slate Flash	*Rapala manea* (Hewitson, 1863)	RMA
Common Silverline	*Spindasis vulcanus* (Fabricius, 1775)	SVU
Common Ciliate Blue	*Anthene emolus* (Godart, 1824)	AEM
Common Pierrot	*Castalius rosimon* (Fabricius, 1775)	CRO
Red Pierrot	*Talicada nyseus* (Guérin-Méneville, 1843)	TNY
Striped Pierrot	*Tarucus nara* (Kollar, 1848)	TNA
Zebra Blue	*Tarucus plinius* (Fabricius, 1793)	TPL
Tiny Grass Blue	*Zizula hylax* (Fabricius, 1775)	ZHY
Pale Grass Blue	*Pseudozizeeria maha* (Kollar, 1844)	PMA
Dark Grass Blue	*Zizeeria karsandra* (Moore, 1865)	ZKA
Quaker	*Neopithecops zalmora* (Butler, 1870)	NZA
Plains Cupid	*Catochrysops vapanda* (Semper, 1890)	CVA
Family Hesperiidae		
Brown Awl	*Badamia exclamationis* (Fabricius, 1775)	BEX
Common Banded Awl	*Hasora chromus* (Cramer, 1780)	HCH
Indian Skipper	*Spialia galba* (Fabricius, 1793)	SGA
Straight Swift	*Parnara guttatus* (Bremer & Gray, 1853)	PGU
Rice Swift	*Borbo cinnara* (Wallace, 1866)	BCI
Small Banded Swift	*Pelopidas mathias* (Fabricius,1798)	PMAT
Large Branded Swift	*Pelopidas subochracea* (Moore, 1878)	PSU
Indian Palm Bob	*Suastus gremius* (Fabricius, 1798)	SGR

Figure 1. Butterfly species recorded in Kolkata, India. 1) *Graphium doson*, 2) *Graphium agamemnon*, 3) *Papilio polytes*, 4) *Papilio demoleus*, 5) *Chilasa clytia*, 6) *Pachliopta aristolochiae*, 7) *Eurema blanda*, 8) *Eurema hecabe*, 9) *Catopsilia pomona*, 10) *Catopsilia pyranthe*, 11) *Pareronia valeria*, 12) *Appias libythea*, 13) *Cepora nerissa*, 14) *Delias eucharis*, 15) *Leptosia nina*, 16) *Tirumala limniace*, 17) *Danaus genutia*, 18) *Danaus chrysippus*. 19) *Euploea core*, 20) *Melanitis leda*, 21) *Elymnias hypermnestra*, 22) *Mycalesis perseus*, 23) *Ypthima baldus*, 24) *Ypthima huebneri*, 25) *Acraea violae*, 26) *Phalanta phalantha*, 27) *Neptis jumbah*, 28) *Ariadne ariadne*, 29) *Ariadne merione*, 30) *Junonia almana*, 31) *Junonia atlites*, 32) *Junonia lemonias*, 33) *Hypolimnas bolina*, 34) *Curetis thetis*, 35) *Rapala manea*, 36) *Spindasis vulcanus*, 37) *Anthene emolus*, 38) *Castalius rosimon*, 39) *Talicada nyseus*, 40) *Tarucus nara*, 41) *Tarucus plinius*, 42) *Zizula hylax*, 43) *Pseudozizeeria maha*, 44) *Zizeeria karsandra*, 45) *Neopithecops zalmora*, 46) *Catochrysops vapanda*, 47) *Badamia exclamationis*, 48) *Hasora chromus*, 49) *Spialia galba*, 50) *Parnara guttatus*, 51) *Borbo cinnara*, 52) *Pelopidas mathias*, 53) *Pelopidas subochracea*, 54) *Suastus gremius*.

Table 2. List of plants observed during January 2013 to December 2013 irrespective of study sites. Type: S = Shrub, H = Herb, T = Tree.

Species code	Scientific name	Type	Flower colour	Flowering time
	Family Acanthaceae			
AA	*Adhatoda vasica* Nees	S	White to red to violet	April to October
	Family Amaranthaceae			
AB	*Alternanthera sessilis* (L.) R.Br. ex DC.	H	White	January to December
AC	*Gomphrena celosioides* Mart.	H	White	December to May
	Family Apocynaceae			
AD	*Catharanthus roseus* (L.) G. Don	S	Pink/white	January to December
	Family Asclepiadaceae			
AE	*Calotropis gigantea* (L.) W. T. Aiton	S	Violet	January to August
	Family Asteraceae			
AF	*Pluchea indica* (L.) Less.	S	Pinkish	February to May
AG	*Ageratum conyzoides* L.	H	Pale blue	January to December
AH	*Eclipta alba* (L.) Hassk.	H	White	January to December
AI	*Mikania cordata* (Burm.f.) B.L.Rob.	H	White	October to March
AJ	*Spilanthes acmella* (L.) Murray	H	Yellow	November April
AK	*Tridax procumbens* L.	H	Yellow	January to December
AL	*Vernonia cinerea* (L.) Less	H	Pink	January to December
AM	*Parthenium hysterophorus* L	H	White	January to December
	Family Boraginaceae			
AN	*Heliotropium indicum* L.	H	Violet	January to December
	Family Capparaceae			
AO	*Capparis zeylanica* L.	S	Violet	January to Junuary
	Family Cleomaceae			
AP	*Cleome rutidosperma* DC.	H	Violet	August to January
AQ	*Cleome viscosa* L.	H	Yellow	April to August
	Family Commelinaceae			
AR	*Commelina benghalensis* L.	H	Blue	August to December
AS	*Commelina salicifolia* Thwaites, nom. illeg.	H	Blue	January to August
	Family Cyperaceae			
AT	*Kyllinga nemoralis* (J.R.Forst. & G.Forst.) Dandy ex Hutch. & Dalziel	H	White	July to January
	Family Euphorbiaceae			
AU	*Jatropha gossypifolia* L.	S	Red	January to July
AV	*Jatropha curcas* L.	S	Yellow	April to October
AW	*Croton bonplandianum* Baill	H	White	May to December
	Family Fabaceae			
AX	*Crotalaria pallida* Aiton	H	Yellow	January to July
	Family Flacourtiaceae			
AY	*Flacourtia indica* (Burm. fil.) Merr.	S	Yellow	January to Jun
	Family Lamiaceae			
AZ	*Leucas aspera* (Willd.) Link	H	White	February toJuly
	Family Linderniaceae			
BA	*Vandellia crustacea* (L.) Benth.	H	white	June toNovember
	Family Malvaceae			
BB	*Abutilon indicum* G.Don	S	Yellow	September to April
BC	*Sida acuta* Burm. fil.	S	Yellow	June to December
BD	*Sida rhombifolia* L.	S	Yellow	January to December
	Family Oxalidaceae			
BE	*Oxalis corniculata* L.	H	Yellow	May to June
	Family Passifloraceae			
BF	*Passiflora foetida* L	H	Violet	May to December
	Family Rhamnaceae			
BG	Ziziphus mauritiana Lam.	S	Yellow	August to December
	Family Rubiaceae			
BH	*Ixora coccinea* L	S	Red, yellow or pink	January to December
	Family Caricaceae			
BI	Carica papaya L	T	White	April to Jun
	Family Rutaceae			
BJ	*Glycosmis pentaphylla* (Retz.) Correa	S	Pinkish	January to December
	Family Solanaceae			
BK	*Cestrum diurnum* L.	S	White	October to June
	Family Verbenaceae			
BL	*Clerodendrum viscosum* vent	S	White	December to March
BM	*Lantana camara* L.	S	Yellow	January to December

Nymphalidae presented the highest richness with 18 species recorded (33.33%), followed by Lycaenidae with 13 species (24.07%), Pieridae with nine species (16.67%), Hesperiidae with eight species (14.81%) and Papilionidae with six species (11.11%). Among plant species, 21 species were herbs, 17 species were shrubs. The species diversity and evenness were expressed by values of Shannon H′, Shannon H_{max}, and Shannon J′ indices (Figure 2), which followed a similar pattern, while the monthly variations were clear. The matrix of butterfly and the linked flowering plants are represented in Table 3, which indicates a wide range of plant preferences by butterflies such as *Catopsilia pomona*, *Eurema hecabe*, *Catopsilia pyranthe*, *Eurema blanda*, *Zizula hylax*, *Pseudozizeeria maha*, *Papilio polytes*, *Papilio demoleus*. The pattern of abundance of different butterflies indicated that the most abundant butterfly species was *Catopsilia pomona* and the least abundant species was *Tarucus plinius* (Figure 3).

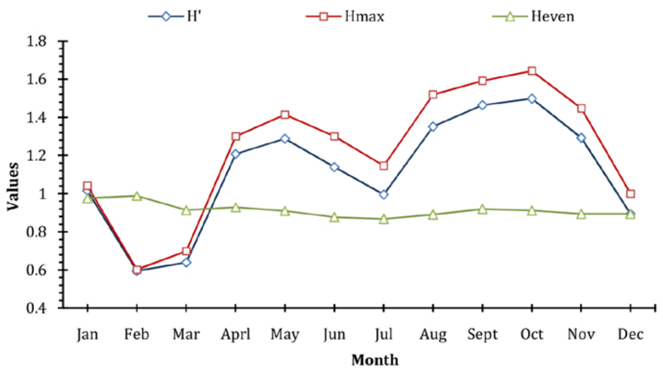

Figure 2. The values of the diversity indices (Shannon-Wiener) of butterflies by month throughout the year (2013) in Kolkata, India.

DISCUSSION

The butterfly species richness observed in our study is comparable to other urban areas of India (Kunte 2000; Agarwala et al. 2010; Sarma et al. 2012; Arya et al. 2014; Kumar 2014), including Kolkata. Although the butterfly species recorded in this study is consistent with earlier studies (Chowdhury and Soren 2011; Nair et al. 2014), variations in the total species richness is evident, possibly because of the differences in the size of the sampling area (Nair et al. 2014) or the habitats conditions within the sampling area. Compared to the earlier studies, the sample size and area was greater in the present study, though the variations in the microhabitat conditions were limited. Earlier studies included the areas in the vicinity of the wetlands (Chowdhury and Soren 2011) as well as suburban conditions where the butterfly richness is generally high, particularly in the adjacent regions of Kolkata, India (Mukherjee et al. 2015). Thus variations in the sampling areas (Chowdhury and Soren 2011) and

Table 3. Matrix of butterfly and plant species associations observed in Kolkata, India. Butterfly species are represented by their 'short form' (see Table 1); nectar plant species are represented by their 'species code' (see Table 2) The '+ sign' indicates butterfly/plant association.

Butterfly	Nectar plant species																																						
species	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM
GDO						+	+		+			+													+								+	+	+			+	+
GAG				+		+	+		+			+													+								+	+	+			+	+
PPO				+		+	+		+			+										+		+	+	+			+	+		+	+	+	+	+	+	+	+
PDE				+		+	+		+			+										+		+	+	+			+	+		+	+	+	+	+	+	+	+
CCL						+	+		+			+												+	+	+			+	+		+	+	+	+	+		+	+
PAR						+	+		+			+												+	+	+			+	+		+	+	+	+	+		+	+
EBL						+	+		+		+		+	+		+	+	+			+	+			+	+	+	+	+	+			+		+	+		+	+
EHE						+	+		+		+	+	+	+		+	+	+			+	+			+	+	+	+	+	+	+		+		+	+		+	+
CPO	+		+	+		+	+		+		+	+	+	+	+		+				+	+			+			+		+	+	+	+			+	+	+	+
CPY	+			+		+	+		+		+	+	+	+	+		+				+	+			+			+		+	+	+	+			+	+	+	+
PVA						+	+		+			+	+	+	+		+				+	+			+			+		+	+		+	+		+		+	+
ALI						+	+		+			+			+		+				+	+			+					+	+		+			+		+	+
CNE						+	+		+			+			+		+				+	+			+					+	+		+			+		+	+
DEU						+	+		+			+			+		+		+		+	+			+					+	+		+			+		+	+
LNI						+	+				+	+	+	+	+	+	+	+			+	+			+					+	+		+			+		+	+

Continued

Table 3. *Continued.*

Butterfly species	Nectar plant species																																				
	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM
TLI						+	+		+			+		+			+				+	+		+	+							+			+		+	+
DGE						+	+		+			+		+			+				+	+		+	+							+				+	+	+
DCH					+	+	+		+		+	+		+							+	+		+	+							+				+	+	+
ECO						+	+		+			+		+										+	+							+						
MLE												+							+																			
EHY												+						+			+																	
MPE																			+		+																	
YBA																	+																+					
YHU																																	+				+	
AVI						+	+		+			+													+				+			+				+	+
PPH						+	+		+			+					+					+			+				+			+				+	+
NJU						+	+		+			+					+					+							+			+				+	+
AAR						+	+		+			+					+					+			+				+			+				+	+
AME				+		+	+		+			+					+					+			+				+			+				+	+
JAL				+		+	+		+			+					+					+			+	+			+			+				+	+
JAT						+	+		+			+					+					+			+	+			+			+				+	+
JLE						+	+		+			+										+			+				+			+				+	+
HBO						+	+		+			+										+			+				+			+				+	+
CTH									+			+										+							+							+	+
RMA						+	+		+													+							+						+		+	+
SVU											+						+							+					+						+			+
AEM			+				+		+							+	+						+	+					+						+			+
CRO			+		+	+		+								+	+						+	+					+						+			+
TNY							+	+	+		+					+	+						+	+		+			+						+			+
TNA		+						+		+	+					+	+	+					+	+		+			+						+			+
TPL		+	+					+		+	+			+		+	+	+	+	+		+	+	+		+			+						+			+
ZHY		+	+		+		+	+	+	+	+			+		+	+	+	+	+		+	+	+		+			+						+			+
PMA		+	+				+	+		+	+			+		+	+	+	+	+		+	+	+	+	+			+						+			+
ZKA		+			+			+		+	+			+		+	+	+	+	+		+	+	+		+			+						+			+
NZA		+					+	+		+	+					+		+	+	+		+	+	+		+			+						+			+
CVA		+	+					+		+	+					+						+		+					+						+			+
BEX	+					+				+															+														+
HCH	+					+				+							+								+							+			+			+
SGA	+	+	+			+	+	+		+	+														+										+			+
PGU	+			+			+	+	+	+	+					+									+							+			+			+
BCI	+		+	+		+		+	+	+															+							+						+
PMAT	+		+	+		+	+	+	+	+	+	+				+									+							+			+			+
PSU	+		+	+		+		+		+															+														+
SGR	+									+																													+

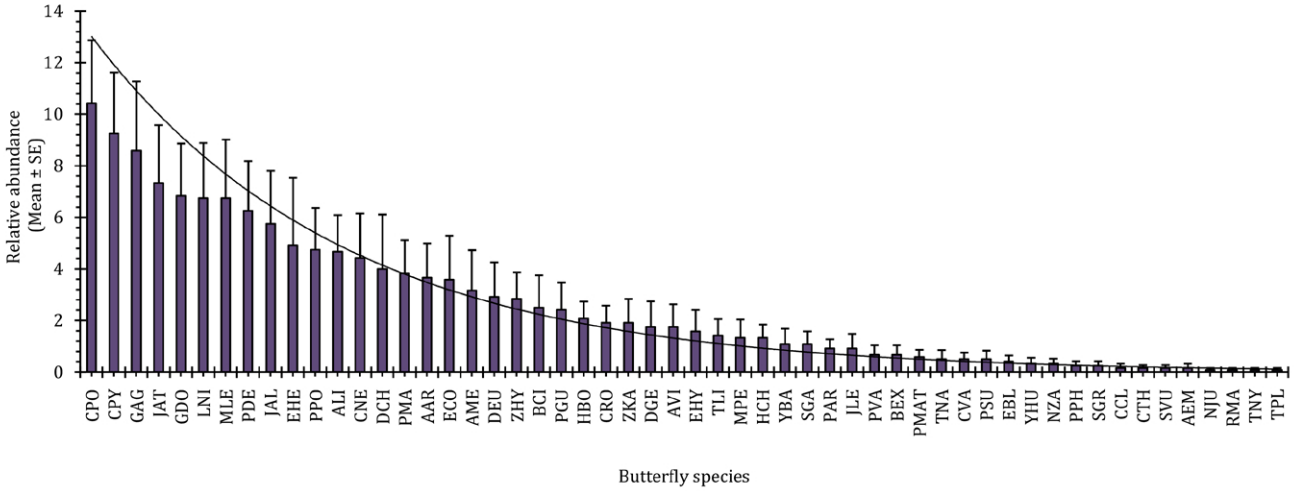

Figure 3. The relative abundance of butterfly species in Kolkata, India, encountered during January 2013 to December 2013. Data of the individual transect of each month were included in construction of the relative abundance of the individual species.

the sample sizes (Nair et al. 2014) may be the reasons for the observed differences in the number of butterfly species encountered in Kolkata, India. However, the species described in the present context is similar and includes the species encountered in the earlier studies (Chowdhury and Soren 2011; Nair et al. 2014).

Among butterflies observed, Nymphalidae exhibited highest richness of butterfly species, which well corroborates with studies elsewhere in India (Tiple and Khurad 2009; Chowdhury and Soren 2011; Kumar and Mattu 2014; Nair et al. 2014). At Simla (Thakur and Bhardwaj 2011), Ankleshwar, Gujarat (Kumar 2013), and Kumaun Himalayas, Uttarakhand Arya et al. (2014), Pieridae was the dominant family. In our study, the two most abundant species (*Catopsilia pomona* and *Catopsilia pyranthe*) were also members of Pieridae. Similar to earlier studies (Wynter-Blyth 1957; Padhey et al. 2006), the maximum appearance of butterflies was in March and April (the summer season), followed by a second peak in October (post-monsoon).

The abundance of butterflies is linked to climatic conditions (Bhusal and Khanal 2008) and availability of host plants (Gutierrez and Mendez, 1995; Öckinger et al. 2009; Nimbalkar et al. 2011). Consistent to this view, in this study, plants known to support butterflies dominated the bush habitats. For instance, the numerical abundance and the association of butterflies were observed to be high for *Lantana camara, Ageratum conyzoides, Pluchea indica, Mikania cordata, Sida rhombifolia, Ziziphus mauritiana, Glycosmis pentaphylla,* and *Clerodendrum viscosum*. Although the phenology of these plants differ considerably, the perennial flowering pattern of *Lantana camara* and *Tridax procumbens* possibly accounted for the maximum load of butterfly species, consistent with earlier observations (Nimbalkar et al. 2011). Herbaceous plants such as *Mikania cordata, Cleome rutidosperma, Cleome viscosa, Ageratum conyzoides* were also found to be positive for the butterfly load at different times of the year. The species specific links of the butterfly and the host plants can be considered as a useful parameter for conservation planning of the butterfly in the urban ecosystem of Kolkata, India. Although at a proximate level, the relative abundance of different species can be considered as a basis to scale the assemblage pattern of butterflies (Figure 3), but for population enhancement, availability of the preferred plant species is equally important. Thus the conservation of the butterfly in the areas should also incorporate strategies to enhance availability of host plants using the network of butterfly and plant links observed in the present study (Table 3).

Butterflies are recognized as charismatic species that perform multiple roles in ecosystems. They can provide useful information on environmental conditions and can be used for environmental monitoring and assessment of habitats. Conservation of butterflies is relevant in the context of urban planning and management where the aesthetic values of the dwindling green spaces may be secured through the availability of the different species of butterflies. The mutualistic relationship of butterfly and plants will also benefit the sustenance of the both the groups and the environmental quality in the long run. In Kolkata, urban forests and gardens are limited, but the diverse butterfly fauna appears to be comparable to similar urban areas of India (Roy et al. 2012; Harsh 2014; Saikia 2014) and other South east Asian countries (Koh and Sodhi 2004; Sodhi et al. 2010). Thus, maintenance of gardens, green spaces and nectar plants should be prioritized for conservation of butterfly diversity while sustaining the valuable ecosystem services.

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