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Structure and composition of Butterfly (Lepidoptera: Rhopalocera) fauna in Surajpur wetland, National Capital Region, India

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ABSTRACT

Surajpur wetland is a small urban wetland in National Capital Region, India, known for its rich biodiversity of flora and fauna. The land is protected as reserve forest under Uttar Pradesh Forest Department, Government of India. The present communication highlights the significant record of butterfly fauna of Surajpur wetland and forms the first record of its kind hitherto unreported. The study was conducted over the period of three years from March 2010 to February 2013 by applying standard methods. Butterfly species abundance was assessed qualitatively and quantitatively across the different habitats. Being different and mosaics of habitat, serves as a good host for various species of butterflies. During the study period, a total of 2916 individuals belong to 53 butterfly species and 5 families were recorded with Nymphalidae as the dominant family with 23 species and 1800 individuals. Out of 53 butterfly species, 16.98% (n=9) were recorded abundantly, followed by 15.09% (n=8) frequent, 18.87% (n=10) common, 26.42% (n=14) occasional and 22.64% (n=12) rare species. Habitat-wise composition of butterfly species recorded maximum in woodland (39 species) followed by grassland (24 species) and wetland habitat (14 species), however woodland and grassland habitat showed highest number of shared species (n=16). Species wise overall Plain Tiger butterfly *Danaus chrysippus* recorded maximum sighting frequency (42 individuals) during the study period. Out of 20 selected butterfly species, 16 species recorded in morning hours and 14 species recorded in evening hours. Month-wise, out of total 444 sightings of butterfly individuals, November recorded maximum number of individuals 17.34% (n=77) and May recorded least number of individuals 4.05% (n=18), while on seasonal basis, monsoon recorded maximum number of species (37%) followed by summer (32%) and winter (31%). According to the IUCN Red List, 5 species listed as Least Concern (LC) while the rest 47 species as Not Evaluated (NE) and 5 species listed as Schedule species in Indian Wildlife Protection Act 1972. Conservation implications are discussed in the light of the results.

Key words: Faunal survey, Frequency, Abundance, Diversity, Gautam Budh Nagar, Greater Noida

INTRODUCTION

India having only 2.3 percent (3,287,263 Km2) of the total land mass of the world so far recorded around 89,500 animal species, comprises 7.28 percent of the total world animal species (Alfred *et al.,* 1998). Approximately, 17,200 species of butterfly found throughout the world, of which 1,501 species of butterfly are known from India (Kunte, 2000). Although India has a rich butterfly fauna, but due to various reasons such as habitat destruction, fire, use of pesticides and weedicides and illegal collection for trade, many species have become very rare and some are on the verge of extinction (Sharma and Joshi, 2009).

Butterflies are the most beautiful and attractive than most other insects and have fascinated human imagination and creativity (Sharma and Joshi 2009). No group of insects is more charismatic than the butterflies (Reuben 2008). They are valuable pollinators when they move from plant to plant, gathering nectar and are the one of the important food chain components of the birds, reptiles, spiders and predatory insects (Sharma and Joshi, 2009). Many of butterfly species are strictly seasonal and prefer only a particular set of habitats (Kunte, 1997) and they are good indicators in terms of anthropogenic disturbance and habitat quality (Kocher and Williams, 2000). Among insects, butterflies are certainly most popular and eminent group. Butterflies occupy a vital position in ecosystems and their occurrence and diversity are considered as good indicators of the health of any given terrestrial biotope (Aluri and Rao, 2002; Kunte, 2000). Butterflies and moths (order Lepidoptera) offer good opportunities for studies on population and community ecology (Pollard 1991).

Surajpur wetland is an excellent example of urban wetland in Yamuna river basin (Bura *et al.,* 2013). Through the ages, urban wetlands have been the lifeline of most cities in India. They were preserved and looked after by the people as their main source of water supply for drinking and irrigation. These wetlands are found all over the country and are either natural or built by people. Over the years, they have gradually depleted, leading to a number of problems in urban areas such as flooding, water scarcity and water logging (Anon, 2011). Butterflies are taxonomically well studies group, which have received a reasonable amount of attention throughout the world (Winter-Blyth, 1957; Laithwaite *et al.,* 1975; Smart, 1975; Larsen, 1987; Ghazoul, 2002; Uniyal, *et al.,* 2007) but lists of butterfly species at site

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specific are very few (Palot and Sonia, 2000; Sharma and Joshi 2009; Ramesh *et al.,* 2010; Raut and Pendharkar, 2010). However, butterflies of Delhi were earlier studied by Donahue (1967); Ashton (1973); Larsen (2002). Nevertheless this communication is the first ever scientific documentation of the status of butterfly in Surajpur wetland hitherto unreported. The present study was started with a view to examine and understand the diversity and dynamics of butterfly population across seasons and various habitats characteristics in Surajpur wetland.

MATERIALS AND METHODS

Study Site

Surajpur wetland (28°31.425'N; 77°29.714'E) is situated in Dadri Tehsil of District Gautam Budh Nagar in the state of Uttar Pradesh, India (Fig. 1). The wetland falls in the Upper Gangetic Plain Biogeographic Zone (Rodgers *et al.,* 2002) at an elevation of 184.7m above MSL. The area is a reserve forest and spreads over 308 hectare (3.08 km^2) that includes 60 hectare (0.60 km^2) of natural wetland (Bura *et al.,* 2013). The vegetation of the area is tropical dry deciduous type (Champion and Seth, 1968) and supporting mosaic of habitat.

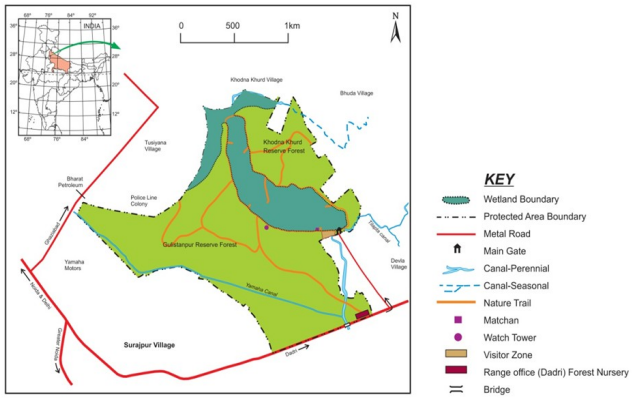


Figure 1. Map of the study area

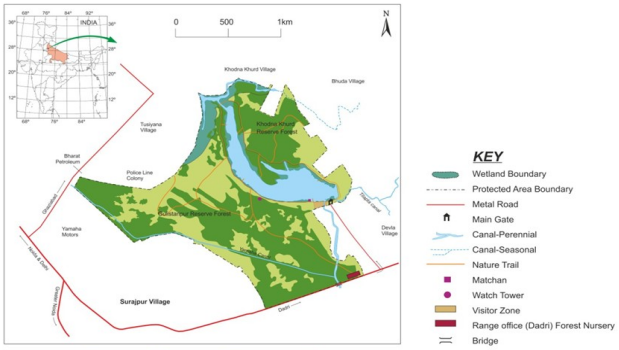
The soil is fine grained called lacustrine soil and the terrain of the area is almost plain, although the area divides into flat terrestrial form and deep wetland area. Surajpur wetland is mainly rain-fed. Other sources for water recharge are catchment area of Hawaliya drain which is attached to Hindon River and the irrigation canal of Tilapta Minor, which originates from Kulesra Bund Hindon River. The general climate is tropical monsoon type and South-west monsoon are the main source of rainfall. Maximum rainfall occurs from July to October ranging from 400-500mm. During monsoon the catchment area is full of water and the inundated area extends up to 108 hectares. However, during summer the major portion of the wetland remains dry and the inundated area recedes to 30-40 hectare.

Data collection

An extensive butterfly survey was conducted during March 2010 to February 2013 to assess the diversity of butterflies. To study the seasonal patterns/diversity in butterfly abundance in relation to nectar food plants, the entire year was divided into three seasons (Nimbalkar, 2011). The three seasons are summer from March to June, monsoon from July to October and winter from November to February. Pollard Walk Method (Pollard, 1977; Pollard and Yates, 1993) was followed for recording the butterflies while walking along fixed paths in the wetland areas (Chowdhury and Soren, 2011). Butterfly species were recorded around a radius of five meter from the observer covering his either sides, above and front (Raut and Pendharkar, 2010; Ramesh *et al.,* 2010). This is a suitable method for surveying butterflies in a wide range of habitats including tropical forest (Walpole and Sheldon, 1999; Caldas and Robbins, 2003; Koh and Sodhi, 2004). The survey was conducted bimonthly between 10:00-16:00 hrs on days when weather was suitable to permit butterfly activity (typically 18-37° C, partial to full sun, low wind) (Whitaker and Long, 2014). Butterflies were identified in flight (Whitaker and Long, 2014) and when sitting on host plant species or mud, by seeking help of taxonomists and referring standard butterfly taxonomic identification manuals such as, Evans (1932); Wynter-Blyth (1957); Gey *et al.* (1992); Kunte (2000); Kehimkar (2008). All scientific names follow Varshney (1983) and common English names follow Wynter-Blyth (1957). Classification of butterflies is after Gaonkar (1996). Benthum and Hooker (1862-1983) system of classification is followed for plants.

Habitat characterisation

Butterfly species abundance was assessed quantitatively across different habitats. The entire study area was divided into three major habitats on the basis of vegetation and soil type, woodland, grassland and wetland habitats (Fig. 2). These major habitat further divided into micro-habitats; woodland includes *Phoenix sylvestris, Terminalia arjuna, Syzigium cumini* and *Prosopis juliflora;* grassland are dominant with *Sachharum* sp., *Vetiveria zizanioides* and *Desmostachya bipinnata* species; whereas wetland includes clear water with submerged aquatic vegetation of *Certaophyllum demersum, Hydrilla verticillata, Vallisneria spiralis*; emergent aquatic vegetation of *Eichhornea crassipes, Alternanthera philoxeroides, Ipomoea* sp., *Typha angustata;* and marshland with *Phoenix sylvestris, Terminalia arjuna, Syzygium cumini* vegetation (Fig. 3). These mosaics of habitat serve as a good host for various species of butterflies in the area.



Habitat	Wetland	Woodland	Grassland	Marshland
Area (Ha)	32	152	96	28
Percentage (%)	10.39	49.35	31.16	9.09

Figure 2. Map showing major habitats of the study area.

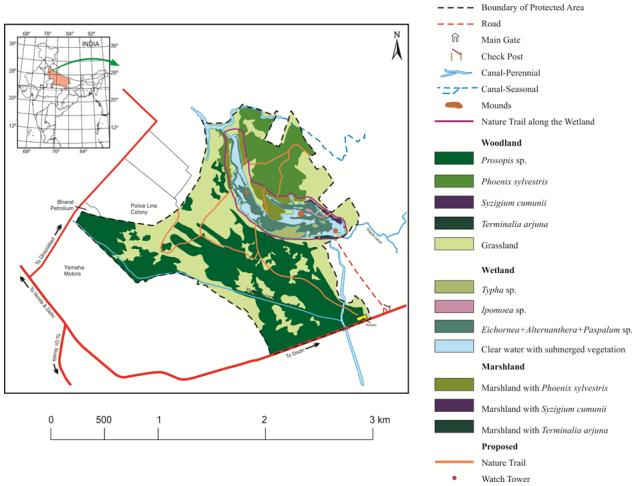


Figure 3. Map showing micro habitats of the study area.

Data analysis

PAleontological Statistics (PAST) version 3.08 was used to calculate diversity indices (Hammer *et al*., 2001). PAST has grown into a comprehensive statistical package that is used not only by paleontologists, but in many fields of life science, earth science, and even engineering and economics (Hossain *et al*., 2012). Abundance categories of butterflies were assigned into five categories on the basis of species abundance recorded during sampling (Uniyal and Bhargav, 2007), abundant (A= >40), frequent (F= 30-40), common (C= 20-30), occasional (O= 10-20) and rare (R= <10). Conservation status of each species was assigned according to the IUCN Red List (2012) and Indian Wildlife (Protection) Act (1972). The Shannon diversity index was used for comparing diversity between various habitats (Clarke and Warwick, 2001). Evenness or Equitability index was calculated, which measures the evenness of species abundance, is complimentary to the diversity index concept and it indicates how the individuals of various species are distributed in the community (Shamsudeen and Mathew 2010). Equitability and Margalef's index was calculated following Ramesh *et al*. (2010). Fisher alpha diversity (Fisher *et al*., 1943) was calculated which is often considered the best diversity index for many communities of species, including Lepidoptera (Robinson and Tuck, 1993; Wolda *et al*., 1994, Chey *et al*., 1997). Patterns of relative abundance of species that determine the dominance of each bird family in the study area was determined by calculating the dominance index (Shamsudeen and Mathew, 2010). The relative dominance of selected bird species in different habitats was expressed by dominance index (Karthikeyan, 2007). Indices of similarity between different habitats were calculated by using Jaccard Index and Sorenson Index (Magurran, 1988; Sorensen, 1948; Misra, 1989). We calculated some classical similarity indices between the different habitats based on shared species *viz*., Sorenson classic and Jaccard classic indices to measure beta diversity based on habitat raw data (Ramesh *et al*., 2010).

RESULTS

A total of 53 butterfly species belonging to 5 families were recorded. Nymphalidae represented by 23 species, was the most dominant family followed by Pieridae-12 species, Lycaenidae- 8 species, Hesperiidae- 7 species and Papilionidae- 3 species respectively (Table 1). The dominance index for various groups of butterflies in the study area is presented in Table 1. Out of 53 butterfly species, 16.98% (n=9) were recorded abundantly (A), followed by 15.09% (n=8) frequent (F), 18.87% (n=10) common (C), 26.42% (n=14) occasional (O) and 22.64% (n=12) rare (R) butterflies (Table 2). Habitat-wise composition of butterfly species recorded maximum in woodland (39 species) followed by grassland (24 species), wetland habitat (14 species) and 4 species recorded overlapping in all the habitats; 12 species recorded in both woodland and grassland habitat; 4 species recorded in both woodland and wetland habitat and only one species in both grassland and wetland habitat, respectively (Table 2). Jaccard and Sorenson similarity index showed the shared species statistics between pairs of the three habitats (Table 4). The woodland and grassland habitat showed highest number of shared species (16 species). The Fisher alpha diversity indicated the following habitats in a decreasing order of diversity; grassland (5.97), woodland (3.31), wetland (3.11). The Shannon's diversity index showed the same pattern with minor variations from 1.55 to 2.05. The equitability or evenness index and Margalef's richness index recorded maximum in grassland habitat (Table 3).

Species wise abundance of butterfly species recorded by frequency of sightings across the study period. Plain Tiger butterfly *Danaus chrysippus* (42 sightings) recorded maximum sighting frequency followed by Peacock Pansy *Junonia almana* (34 sightings) and Common Grass Yellow *Eurema hecabe* (32 sightings), whereas least frequency of sightings recorded by 5 species Forget-Me-Not *Catochrysops strabo*, Grass Demon *Udaspes folus*, Great Swift *Pelopidas assamensis*, Pale Grass Blue *Pseudozizeeria maha* and Tawny Coster *Acraea violae* (only one sighting) (Fig. 4). Daily (morning-evening) sighting frequencies of selected butterfly species were also recorded. Out of 20 selected butterfly species, 16 species recorded in morning hours and 14 species recorded in evening hours, whereas 9 species recorded in both morning and evening hours (Table 5). Monthly sighting frequencies of butterfly individuals vary across the months during the study period. Out of total 444 sightings of butterfly individuals, November recorded maximum number of individuals 17.34% (n=77) and May recorded least number of individuals 4.05% (n=18) (Fig. 5). Seasonal variation of butterfly species recorded over the study period, monsoon recorded maximum number of species (37%) followed by summer (32%) and winter (31%); whereas 16 species recorded in all the seasons, 5 species recorded in both monsoon and winter, 4 species recorded in both summer and monsoon; 6 species recorded in both summer and winter respectively (Table 2).

Host preferences of the 12 selected butterfly species belong to 3 families were also recorded during the study period. Eleven different larval food plants are fed by Nymphalids butterflies, where as Lycanids feed on five food plant species and Pierids feed on six food

Table 1. Family wise species composition and their relative dominance observed during the study period in Surajpur wetland.

S. No.	Family	Number of species	Relative Dominance	Number of individuals	Relative Dominance
	Hesperiidae	7	13.21	252	8.64
	Papilionidae	3	5.66	108	3.70
	Lycaeniidae	8	15.09	324	11.11
	Pieridae	12	22.64	432	14.81
	Nymphalidae	23	43.40	1800	61.73
	Total	**53**	**100.00**	**2916**	**100.00**

Table 2. Systematic list of butterfly species with their abundance status, habitat characterisation, seasonal sightings and conservation status in Surajpur wetland.

Sl. No.	Common English name	Scientific name	Abundance status	Habitat status	Seasonal status	IUCN Status
Papilionidae						
1.	Common Mormon	*Papilio polytes* Linnaeus	O	WD	M	NE
2.	Common Rose	*Pachliopta aristolochiae* Fabricius	C	WD	M	NE
3.	Lime Butterfly	*Papilio demoleus* Linnaeus	O	WD	M	NE
Pieridae						
4.	Common Emigrant	*Catopsilia pomona* Fabricius	A	WT	M	NE
5.	Common Grass Yellow	*Eurema hecabe* Linnaeus	A	WD-GR	W	NE
6.	Common Gull*	*Cepora nerissa* Fabricius	R	WT	SMW	NE
7.	Indian Cabbage White	*Pieris canidia* Sparrman	C	WD	SW	NE
8.	Large Cabbage White	*Pieris brassicae* Linnaeus	O	WD-WT	SW	NE
9.	Mottled Emigrant	*Catopsilia pyranthe* Linnaeus	F	WT	SMW	NE
10.	One Spot Grass Yellow*	*Eurema andersoni* Moore	A	WD-GR	MW	LC
11.	Poineer	*Belenois aurota* Fabricicus	F	WD-GR-WT	SMW	NE
12.	Small Grass Yellow	*Eurema brigitta* Cramer	A	GR	SMW	LC
13.	Spotless Grass Yellow	*Eurema laeta* Boisduval	A	WD-GR	SMW	NE
14.	White Orange Tip	*Ixias marianne* Cramer	R	WD	SM	NE
15.	Yellow Orange Tip	*Ixias pyrene* Linnaeus	R	WD-GR	SM	NE
Nymphalidae						
16.	Blue Pansy	*Junonia orithiya* Linnaeus	A	GR	SMW	NE
17.	Chocolate Pansy	*Junonia iphita* Cramer	R	WD	SM	NE

18.	Common Bushbrown	*Mycalesis perseus* Fabricius	R	WD	M	NE
19.	Common Castor	*Ariadne merione* Cramer	F	WD	M	NE
20.	Common Evening Brown	*Melanitis leda* Linnaeus	A	WD	SMW	NE
21.	Common Fourring	*Ypthima huebneri* Kirby	O	WD-GR-WT	SMW	NE
22.	Common Indian Crow	*Euploea core* Cramer	F	WD	M	LC
23.	Common Leopard	*Phalanta phalantha* Drury	F	WT	MW	NE
24.	Danied Eggfly*	*Hypolimnas misippus* Linnaeus	C	WD	MW	NE
25.	Dark brand Bushbrown	*Mycalesis mineus* Linnaeus	R	WD	M	NE
26.	Glassy Tiger	*Parantica aglea* Stoll	O	WT	M	NE
27.	Great Eggfly	*Hypolimnas bolina* Linnaeus	O	WD-WT	MW	NE
28.	Grey Pansy	*Junonia atlites* Linnaeus	C	WD	SMW	NE
29.	Large Threering	*Ypthima nareda* Kollar	C	WD-GR-WT	SMW	NE
30.	Lemon Pansy	*Junonia lemonias* Linnaeus	C	WD	SMW	NE
31.	Painted Lady	*Vanessa cardui* Linnaeus	O	WD	SMW	NE
32.	Pallid Argus	*Callerebia scanda* Kollar	R	WD	W	NE
33.	Peacock Pansy	*Junonia almana* Linnaeus	A	WD-WT	SMW	LC
34.	Plain Tiger	*Danaus chrysippus* Linnaeus	A	WD-GR	SMW	NE
35.	Ringed Argus	*Callerebia ananda* Kollar	R	GR	SW	NE
36.	Striped Tiger	*Danaus genutia* Cramer	C	WT	SMW	NE
37.	Tawny Coster	*Acraea violae* Fabricius	O	WD	S	NE
38.	Yellow Pansy	*Junonia hierta* Fabricius	O	WD	MW	LC
Lycanidae						
39.	Common Cerulean	*Jamides celeno* Cramer	F	GR	SMW	NE
40.	Common Pierrot	*Castalius rosimon* Fabricius	F	WD	S	NE
41.	Dark Grass Blue	*Pseudozizeeria maha* Kollar	F	GR	M	NE
42.	Forget-Me-Not	*Catochrysops strabo* Fabricius	C	GR-WT	S	NE
43.	Pale Grass Blue	*Pseudozizeeria maha* Kollar	C	WD-GR	S	NE
44.	Pea Blue	*Lampides boeticus* Linnaeus	O	WD	SW	NE
45.	Rounded Pierrot	*Tarucus nara* Kollar	C	WD-GR	SW	NE
46.	Tiny Grass Blue	*Zizula hylax* Fabricius	O	WD-GR-WT	M	NE
Hesperiidae						

47.	Common Banded Awl	*Hasora chromus* Cramer	R	WD-GR	S	NE
48.	Grass Demon	*Udaspes folus* Cramer	R	WD-GR	W	NE
49.	Great Swift*	*Pelopidas assamensis* de Nicéville	R	WD-GR	S	NE
50.	Indian Ace*	*Halpe homolea* Hewitson	O	GR	SM	NE
51.	Indian Skipper	*Spialia galba* Fabricius	O	WD-GR	M	NE
52.	Spotted Angle	*Caprona agama* Moore	R	GR	W	NE
53.	Yellow Spot Swift	*Polytremis eltola* Hewitson	O	WD-GR	SW	NE

Footnote:
***** = Scheduled species by Indian Wildlife (Protection) Act 1972
Abundance status: A (>40); F (30-40); C (20-30); O (10-20); R (<10).
Habitat status: WD= Woodland; GR= Grassland; WT= Wetland
Seasonal status: S= Summer; M= Monsoon; W= Winter
IUCN status: LC= Least Concern; NE= Not Evaluated

Table 3. Diversity indices of butterfly communities along the different habitats in Surajpur wetland.

	Woodland	Grassland	Wetland	Mean
Fisher_alpha	3.31	5.97	3.11	4.13
Shannon_H	1.55	2.05	1.79	1.79
Equitability_J	0.70	0.93	0.81	0.82
Margalef's	2.08	2.63	2.02	2.24

Table 4. Shared species statistics and similarity coefficients between pairs of the three habitats.

First Sample	Second Sample	Shared Species	Jaccard Classic	Sorenson Classic
Woodland	Grassland	16	0.341	0.508
Woodland	Wetland	7	0.152	0.264
Grassland	Wetland	5	0.151	0.263

Table 5. Sighting (morning-evening) hours of selected butterfly species in the study area.

S. No.	Selected Species	Morning hours	Evening hours
1	Blue Pansy	+	+
2	Common Castor	-	+
3	Common Cerulean	+	-
4	Common Crow	-	+
5	Common Emigrant	+	+
6	Common Evening Brown	+	+
7	Common Grass Yellow	+	+
8	Common Leopard	+	-
9	Common Mormon	+	-
10	Glassy tiger	+	-
11	Great Eggfly	-	+
12	Lemon Pansy	-	+
13	Lime Butterfly	+	-
14	Mottled emigrant	+	+
15	Peacock Pansy	+	+
16	Plain tiger	+	+
17	Small Grass Yellow	+	+
18	Spotted Angle	+	+
19	Striped Tiger	+	+
20	Yellow Orange Tip	+	-

plant species (Table 6). Plain Tiger recorded the maximum host species as bare ground and *Evolvulus* sp., *Desmostachya bipinnata*, *Prosopis juliflora*, *Tribulus terrestris*, *Eragrostis* sp., *Achyranthus aspera*, *Sida* sp., *Saccharum* sp. plant species. Common Cerulean preferred in bare ground and *Cynodon dactylon*, *Setaria verticillata*, *Sida* sp., *Desmostachya bipinnata, Saccharum* sp. plant species. Peacock Pansy showed preference in bare ground and *Setaria verticillata*, *Cynodon dactylon, Desmostachya bipinnata* and other grass species. Host preference of other species are as: Blue Pansy- bare ground and *Achyranthes aspera* plant species; Common Emigrant- *Achyranthus aspera;* Common Evening Brown- *Desmostachya bipinnata, Prosopis juliflora;* Common Grass Yellow- *Prosopis juliflora, Sida* sp., *Setaria verticillata, Cynodon dactylon;* Common Leopard- bare ground, *Sida* sp., *Desmostachya bipinnata* and other grasses; Great Eggfly- *Prosopis juliflora;* Lemon pansy- *Achyranthus aspera;* Mottled Emigrant- *Setaria verticillata, Desmostachya bipinnata* and Striped Tiger- mixed grasses, *Phyllanthus reticulates* and *Sida* sp. (Table 6).

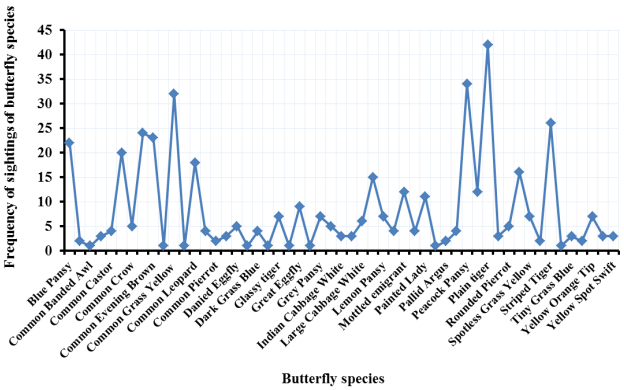


Figure 4. Frequency of sightings of butterfly species across the study period.

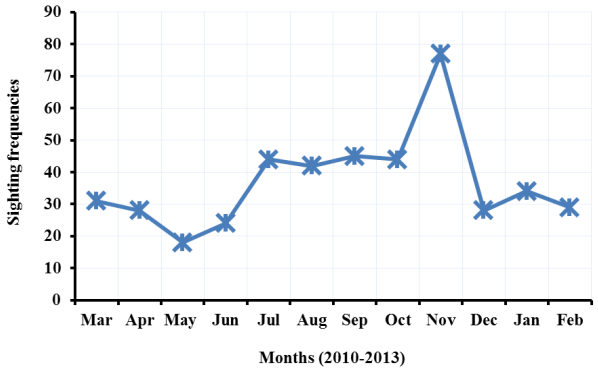


Figure 5. Monthly sighting frequencies of butterfly species across the study period.

According to the IUCN Red List, 5 species listed as Least Concern (LC) while the rest 47 species as Not Evaluated (NE). With respect to the Indian Wildlife (Protection) Act (1972), one species each was listed in Schedule I (Danied Eggfly *Hypolimnas misippus*) and IV (Great Swift *Pelopidas assamensis*) 3 species were listed in Schedule II (Indian Ace *Halpe homolea*, Common Gull *Cepora nerissa* and One Spot Grass Yellow *Eurema andersoni)* while the rest 47 species was not listed in any schedule.

DISCUSSION

The Indian subcontinent hosts about 1,504 species of butterflies (Tiple, 2011) which constitute 65% of total Indian fauna. Various ecosystems of our country support different species of butterfly. The Western Ghats alone support 330 species, out of which 48 are endemic to Nilgiri Biosphere reserve. About 50% of butterfly species of India is found in the state of Assam. Kumar (2011 and 2012) reported 23 species from the different sites of in and around Jhansi. Singh (2009) reported 147 species of butterflies in Kedranath musk deer reserve, Garhwal Himalaya; Uniyal and Bhargav (2007) reported 24 species of butterflies from Bir Shikargarh Wildlife Sanctuary, Haryana. The exact status of butterflies particularly of northern and central region of India is still not clearly known due to lack of proper study (Kumar 2014). As there are no previous studies on butterfly diversity in such an extensive wetland near Greater Noida, the present work therefore demands importance for a better understanding of the health and integrity of the wetland ecosystem.

The diversity and abundance of butterfly species is highly correlated with the availability of food plants and varied assemblage of floral species in the surroundings (Kunte, 2000). Occurrence of maximum number of species in the family Nymphalidae could be the result of high availability of food plants in the study area. Habitat association of butterflies can be directly related to the availability of food plants (Thomas, 1995). Woodland showed maximum butterfly species richness due to rich floral assemblage in the study area. A similar seasonal variation in species abundance was observed by Prajapati *et al*. (2000) in Daman of Makawanpur District of central Nepal. Plants have importance in increasing the butterfly diversity and their abundance in the area.

The woodland and grassland showed highest number of shared species, because these areas had comparatively similar plant composition and provide perennial nectars sources for adult butterflies and this is reflected in both Jaccard and Sorenson values. Sorenson index is recognised as the best indices of shared species measure (Ramesh *et al*., 2010). Similarly the high value for woodland and wetland habitat was due to their similarity in species assemblage. Generally, simple comparison of absolute species number between samples is used most of the time as diversity measure. We also calculated Fisher's alpha diversity and Shannon diversity indices as a measure of diversity within a habitat since these indices incorporate both species richness and abundance into a single value. The equitability or evenness index (J) revealed that in the individuals among species were not evenly distributed during the survey period indicating that some species were more abundant than the others. This reflects on the difference in the efficiency of different butterfly species to efficiently use the habitat. The abundance of individuals of a species at any given point on a temporal scale is again dependent on various

Table 6. Host plant species preferred by selected butterfly species in the study area.

Butterfly Family	Butterfly Species	Host Plant Species
Nymphalidae	Blue Pansy, Common Evening Brown, Common Leopard, Great Eggfly, Lemon pansy, Peacock Pansy, Plain Tiger and Striped Tiger butterfly	*Achyranthes aspera, Desmostachya bipinnata, Prosopis juliflora, Sida* sp., *Setaria verticillata, Cynodon dactylon, Evolvulus* sp., *Tribulus terrestris, Eragrostis* sp., *Saccharum* sp., *Phyllanthus reticulatus* and bare ground
Lycanidae	Common Cerulean	*Cynodon dactylon, Setaria verticillata, Sida* sp., *Desmostachya bipinnata, Saccharum* sp., and bare ground.
Pieridae	Common Emigrant, Common Grass Yellow and Mottled Emigrant butterfly	*Achyranthus aspera, Prosopis juliflora, Sida* sp., *Cynodon dactylon, Setaria verticillata* and *Desmostachya bipinnata*

`biotic and abiotic environmental factors (Ramesh *et al*., 2010).

The species abundance rose from the beginning of the monsoon, from the months June to July and reached a peak in the months from September to November. A decline in species abundance was observed from the months December to January and continued up to the end of May. A previous study (Wynter-Blyth, 1957) had identified two seasons as peaks, March-April and October for butterfly abundance in India. However, our finding observed peak period in the months from September to November, in line with the findings of Kunte (2000). Bhusal and Khanal (2008) reported that there is a significant correlation between species diversity and spring season, indicating the abundances of diverse species was positively affected by approaching warmer days, high relative humidity and more rainfall. These factors help to flourish diverse vegetations, which are vital food sources for many butterfly species. Gutierrez and Mendez (1995) suggested that the abundance of butterflies is not affected by altitudes but it is more related to the availability of food plants.

Butterflies indicate change in environmental variation and also are affected by plant diversity since they are directly dependent on them (Elrich *et al*., 1972). The association between butterflies and plants is highly specific. A large proportion of species of Papilionidae and Pieridae were found to be engaged in mud-puddling behavior in many locations (Uniyal and Bhargav, 2007). Unlike bees, butterflies feed entirely on nectar, which they obtain through their long proboscis from flower. Thus pollination, a crucial link in the survival of ecosystem, is one such factor that needs to be well understood to develop appropriate strategies for conservation of the biodiversity (Sharma and Joshi, 2009).

The structural complexity of habitat and diversity of vegetation forms have been shown to be correlated with animal and insect species diversity (Gardner *et al*., 1995). Southwood (1975) suggest that the herbivores are more influenced by the food quality. Host plants are utilized only when sufficient adult resources (nectar) are also available (Grossmueller and Lederhouse, 1987). Successful butterfly habitat must therefore include sufficient larval and adult food resources. In the present study, the maximum number of species and individuals were observed in woodland and grassland, where availability of diverse plants and access to host plants viz., *Achyranthes aspera, Desmostachya bipinnata, Prosopis juliflora, Sida* sp., *Setaria verticillata, Cynodon dactylon, Evolvulus* sp., *Tribulus terrestris, Eragrostis* sp., *Saccharum* sp., *Phyllanthus reticulatus* and ornamental flowering plants promoted the butterfly richness and density. Most of these plants provide rich nectar sources to adult butterflies. Comparatively the other habitat especially, wetland area have lesser density of vegetation. Restoration of wetlands for butterflies should concentrate on planting of host plants and propagation of conspicuous patches of the preferred nectar plant (Chowdhury and Soren, 2011).

Surajpur wetland provides an opportunity to protect biodiversity and set an example of how wildlife can be protected and preserved close to urban areas, without hindering the development of the same. It will not only provide urban people an opportunity to experience the uniqueness of the wetland area and the species it attracts, but also make them more environmentally conscious (Ansari, 2009). The study area represents the mosaic of habitats which help in supporting high diversity of plant life and avifauna. The study can be used by National Capital Region (NCR) Planning Board. Surajpur wetland has been established as a prominent site for wintering birds, this study helps stress the importance of the area in providing the water birds a larger place to congregate. The study area also serves to promote Surajpur Reserve as a good place for eco-tourism, since it is located on the outskirts of Delhi. Potential threats anthropogenic activities including intense encroachment stress from urban expansion, alterations of wetland habitats to agricultural lands, and discharge of untreated waste water effluent from several industries to the canal, are presently acting as potential threats in Surajpur wetland.

Being potential pollinating agents of their nectar plants as well as indicators of the health and quality of their host plants and the ecosystem as a whole, exploration of butterfly fauna thus becomes important in identifying and preserving critical wetland habitats under threat (Chowdhury and Soren, 2011). More detailed studies regarding the role of butterflies in the wetland ecosystem and their mode of assessment of the habitat quality should be carried out for better management and conservation of Surajpur wetland resources. This information highlights the significant importance of the butterfly

diversity of Surajpur Wetland hitherto unreported. The study area also represents the mosaic of habitats which help in supporting high diversity of flora and fauna. Detailed ecological studies would further help in establishing the conservation importance of the area.

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REFERENCES

Alfred, J.R.B., Das, A.K. and Sanyal, A.K. 1998. Faunal Diversity in India. ENVIS Centre, Zoological Survey of India, Kolkata, pp. 497.

Aluri, J.S.R. and Rao, S.P. 2002. Psychophily and evolution consideration of cadaba fructicosa (capparaceae). Journal of the Bombay Natural History Society 99(1): 59-63.

Anon. 2011. Water Contents: Every drop Counts. Electronic database accessible at http://www.corbettfoundation.org/Water_contents.pdf (Accessed on 28 December 2011).

Ansari, N.A. 2009. Baseline Information on Vegetation Composition and Avian Diversity in Surajpur Wetland, Greater Noida, Uttar Pradesh, India, Unpublished M.Sc. Dissertation, Aligarh Muslim University, Aligarh, India, p. 69.

Ashton, R. 1973. Butterflies of New Delhi (Papilionoidea). Journal of Bombay Natural History Society 69: 502-509.

Benthum, G. and Hooker, J.D. 1862–1883. Genera Plantarum Vol. I, II, III. London, pp. 1040, 1279, 1258.

Bhusal, D.R. and Khanal, B. 2008. Seasonal and Altitudinal Diversity of Butterflies in Eastern Siwalik of Nepal. Journal of the Natural History Museum 23: 82–87.

Bhuyan, M., Bhattachrya, P.R. and Kanjilat, P.B. 2005. Butterflies of the regional research laboratory campus, Jorhat. Assam. Zoos'Print Journal 20(6): 1910-1911.

Bura, P., Ansari, N.A. and Nawab, A. 2013. Ecological Assessment, Conservation and Management of Surajpur Wetland, Greater Noida, Uttar Pradesh. In: International Day for Biological Diversity, Water and Biodiversity, 22nd May 2013, Uttar Pradesh State Biodiversity Board, Lucknow, Uttar Pradesh, pp. 95-103.

Caldas, A. and Robbins, R.K. 2003. Modified Pollard transects for assessing tropical butterfly abundance and diversity. Biological Conservation 110: 211-219.

Champion, H.G. and Seth, S.K. 1968. The revised survey of the Forest Types of India. Manager of Publications, Govt. of India, New Delhi, pp. 404.

Chey, V.K., Holloway, J.D. and Speight, M.R. 1997. Diversity of moths in forest plantations and natural forests in Sabah. Bulletin Entomological Research 87: 371- 385.

Chowdhury, S. and Soren, R. 2011. Butterfly (Lepidoptera: Rhopalocera) Fauna of East Calcutta Wetlands, West Bengal, India. Checklist. 7 (6): 700-703.

Clarke, K.R. and Warwick, R.M. 2001. Changes in marine communities: an approach to statistical analysis and interpretation, 2nd edition, PRIMER -E: Plymouth.

Danahue, J.P. 1967. An annotated list of the butterflies of the Delhi, India, Journal of Bombay Natural History Society 63: 235-269, 64:22-48.

Elrich, P.R., Breedlove, D.E., Brussard, P.F. and Sharp, M.A.D. 1972. Weather and regulation of sub alpine populations, Ecology 53: 243-247.

Evans, W.H. 1932. The identification of Indian Butterflies. (2nd Edition). The Bombay Natural History Society, Mumbai, India, pp. 454.

Fisher, R.A., Corbet, A.S. and Williams, C.B. 1943. The relation between the number of species and the number of individuals in a random sample of an animal population. Journal of Animal Ecology 12: 42-58.

Gaonkar, H. 1996. Butterflies of the Western Ghats, India, including Sri Lanka: A biodiversity assessment of a threatened mountain system, pp. 51.

Gardner, S.M., Cabido, M.R., Valladares, G.R. and Diaz, S. 1995. The influence of habitat structure on arthropod diversity in Argentine semiarid Chaco forest. Journal of Vegetation Science 6: 349–356.

Gay, T., Kehimkar, I. and Punetha, J.C. 1992. Common Butterflies of India. WWF India-Oxford University Press, Bombay.

Ghazoul, J. 2002. Impact of logging on the richness and diversity of forest butterflies in a tropical dry forest in Thailand. Biodiversity and Conservation 11: 521–541.

Grossmueller, D.W. and Lederhouse, R.C. 1987. The role of nectar source distribution in habitat use and oviposition by the tiger swallowtail butterfly. Journal of Research on Lepidoptera 41(3): 159–165.

Gutierrez, D. and Mendez R. 1995. Phenology of butterflies in a mountain area in northen Iberian Peninsual. Ecography 18: 209–2196.

Hammer, Ø., Harper, D.A.T. and Ryan, P.D. 2001. PAST: Paleontological Statistics software package for education and data analysis. Paleantologia Electronica 4(1): 1-9.

Hossain, M.S., Nani, G.D., Sarkar, S. and Rahaman, M.Z. 2012. Fish diversity and habitat relationship with environmental variables at Meghna river estuary, Bangladesh. Egyptian Journal of Aquatic Research 38: 213–226.

IUCN Red List. 2012. IUCN Red List of Threatened Species. (Version 2012.2.) Electronic database accessible at http://www.iucnredlist.org. (*Accessed on 15 April 2013*).

Karthikeyan, M. 2007. Avifauna and their habitat utilization in three different habitats of Parambikulam Wildlife Sanctuary. Unpublished Ph.D Thesis, Mahatma Gandhi University, Kottayam, Kerala.

Kehimkar, I. 2008. The book of Indian Butterflies, Bombay Natural History Society. Oxford University Press Bombay, pp. xvi+497.

Kocher, S.D. and Williams, E.H. 2000. The diversity and abundance of North American butterflies, vary with habitat disturbance and geography. Journal of Biogeography 27: 785-794.

Koh, L.P., Sodhi, N.S. 2004. Importance of reserves, fragments and parks for butterfly conservation in a tropical urban landscape. Ecological Applications 14: 1695–1708.

Kumr, A. (2012). A report on the butterflies in Jhansi (U.P.) India. Journal of Applied and Natural Science 4(1): 51-55.

Kumar, A. 2011. A study of butterfly abundance and diversity in Jhansi, Uttar Pradesh, India. The Biosphere 3(1): 45-48.

Kumar, A. 2014. Butterfly Abundance and Species Diversity in some Urban Habitats. International Journal of Advanced Research 2(6): 367-374.

Kunte, K. 1997. Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in the northern Western Ghats. Journal of Biosciences 22: 593-603.

Kunte, K. 2000. Butterflies of Peninsular India. Indian Academy of Sciences, Universities Press, India, pp. 254.

Laithwaite, E., A. Watson, and Whalley, E.S.P. 1975. The dictionary of butterflies and moths in colour. Michael Joseph, London.

Larsen, T.B. 1987. The butterflies of the Nilgiri Mountains of Southern India (Lepidoptera: Rhopalocera). Journal of Bombay Natural History Society 84: 291-316.

Larsen, T.B. 2002. The butterflies of Delhi, India – An Annotated Checklist. Esperiana 9:459-479pp.

Magurran, A.E. 1988. Ecological Diversity and its Measurement. Chapman and Hall, London.

Misra, R. 1989. Manual of plant ecology (3rd edition). Oxford & IBH Publishing Company, New Delhi.

Nimbalkar, R.K., Chandekar, S.K. and Khunte, S.P. 2011. Butterfly diversity in relation to nectar food plants from Bhor Tahsil, Pune District, Maharashtra, India. Journal of Threatened Taxa 3(3): 1601-1609.

Ninad, R.B. and Pendharkar, A. 2010. Butterfly (Rhopalocera) fauna of Maharashtra Nature Park, Mumbai, Maharashtra, India. Checklist 6(1): 22-25.

Palot, M.J. and Soniya, V.P. 2000. Priliminary report on the butterflies of Keoladeo National Park, Bharatpur, Rajasthan, India. Zoos' Print Journal 15(6): 287-288pp.

Pollard, E. 1977. A method for assessing changes in the abundance of butterflies. Biological Conservation 12: 115–153.

Pollard, E. 1991. Monitoring Butterfly Numbers; in Monitoring for Conservation and Ecology (ed.). Goldsmith F.B. Chapman and Hall, London, pp. 87.

Pollard, E. and Yates, T.J. 1993. Monitoring Butterflies for Ecology and Conservation. Chapman and Hall, London, pp. 274.

Prajapati, B., Shrestha, U. and Tamrakar, A.S. 2000. Diversity of butterfly in Daman area of Makawanpur District, Central Nepal. Nepal Journal of Science and Technology 2: 71–76.

Rachel, R. 2008. Forward. The book of Indian Butterflies, Bombay Natural History Society. Oxford University Press, Bombay, pp. viii-ix.

Ramesh, T., Hussain, K.J., Selvanayagam, M., Satpathy, K.K. and Prasad, M.V.R. 2010. Patterns of diversity, abundance and habitat associations of butterfly communities in heterogeneous landscapes of the department of atomic energy (DAE) campus at Kalpakkam, South India. International Journal of Biodiversity and Conservation 2(4): 75-85.

Robinson, G.S. and Tuck, K.R. 1993. Diversity and faunistics of small moths (microlepidoptera) in Bornean rainforest. Ecological Entomology 18: 385-393.

Rodgers, W.A., Panwar, H.S. and Mathur, V.B. 2002. Wildlife Protected Area Network in India: A Review (Executive Summary). Wildlife Institute of India, Dehradun, pp. 44.

Shamsudeen, R.S.M. and Mathew, G. 2010. Diversity of Butterflies in Shendurny Wildlife Sanctuary, Kerala (India). World Journal of Zoology 5(4): 324-329.

Sharma, G. and Joshi, P.C. 2009. Diversity of Butterflies (Lepidoptera: Insecta) from Dholbaha dam (Distt. Hoshiarpur) in Punjab Shivalik, India. Biological Forum- An International Journal 1(2): 11-14.

Singh, A.P. 2009. Butterflies of Kedarnath Musk deer Reserve, Garhwal Himalaya, India. Journal of Threatened Taxa 1(1): 37-48.

Smart, P.F. 1975. The illustrated encyclopedia of the butterfly world. Salamader Book, London

Sorensen, T. 1948. A method of establishing groups of equal amplitude in plant society based on the similarity of species content. K. Danske, Vidensk 5: 1-34.

Southwood, T.R.E. 1975. The dynamics of insect populations: In Insects Science and Society. Academic Press, New York, pp. 151-199.

Thomas, J.A. 1995. The ecology and conservation of Maculinea arion and other European species of large blue butterfly. In: Pullin A.S. (ed.) Ecology and Conservation of Butterflies. Chapman and Hall, London, pp. 180-210.

Tiple, A.D. 2011. Butterflies of Vidarbha region Maharashtra, India; a review with and implication for conservation. Journal of Threatened Taxa 3(1): 1469–1477.

Uniyal, V.P. and Bhargav, V.K. 2007. Assessment of butterflies in Bir Shikargarh Wildlife Sanctuary, Haryana. Tigerpaper 34(3): 13-15.

Uniyal, V.P., Sivakumar, K., Padmawathe, R., Kittur, S., Bhargav, V.K., Bhardwaj, M. and Dobhal, R. 2007. Ecological Study of Tiger Beetles (Cicindelidae) as Indicator for Biodiversity Monitoring in the Shivalik Landscape. Wildlife Institute of India, Dehradun.

Varshney, R.K. 1983. Index Rhopalocera Indica Part II. Common names of butterflies from India and neighbouring countries. Records of Zoological Survey of India, Occassional Paper 47: 1–49.

Walpole, M.J. and Sheldon, I.R. 1999. Sampling butterflies in tropical rainforest: an evaluation of a transect walk method. Biological Conservation 87: 85–91.

Whitaker, M.R.L. and Long, E.C. 2014. Survey of the butterflies of the Sutter Buttes, California. The Journal of Research on the Lepidoptera 47: 1-10.

Wolda, H., Marek, J., Spitzer, K., Novak, I. 1994. Diversity and variability of Lepidoptera populations in urban Brno, Czech Republic. European Journal of Entomology 91: 213-226.

Wynter-Blyth, M.A. 1957. Butterflies of the Indian region. Bombay Natural History Society, Bombay, pp. 523.