Available online at www.worldscientificnews.com

World Scientific News

WSN 50 (2016) 197-238 EISSN 2392-2192

Seasonal diversity of butterflies with reference to habitat heterogeneity, larval host plants and nectar plants at Taki, North 24 Parganas, West Bengal, India

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ABSTRACT

Understanding the significance of butterflies in an ecosystem as an environmental healthy indicator and pollination of flowering plants is crucial to achieve sustainability and conservation of floral diversity. The aim of the study is to investigate the butterfly species diversity and abundance and compare the relationship between physical factors and butterfly species at Taki, North 24 Parganas. Survey of six habitats, each containing specific ecological and socio economic profile was conducted. Diversity varies among habitats. Seasonal parameters also play vital roles as the distribution factors for local butterflies. A checklist is made comprising a total of 51 butterfly species belonging to 5 families. Sixty eight species of plants belonging to 28 families served as the larval host plants and 36 species of plants belonging to 20 families served as the nectar plants for butterflies. Maximum number of individuals found at SC (Surrounding College, College Ground, College Hostel Ground) site. The highest species richness and abundance are reported during the post monsoon. The abundance pattern is correlated to the foliage and nutritional support provided by the host plants, both at developmental and at adult stages. Nymphalidae is the most dominant family with 37% of the total number of species.

***Keywords*:** Butterfly diversity; habitat heterogeneity; larval host plants; nectar plants; Taki; West Bengal; India

1. INTRODUCTION

Monitoring species diversity of semi urban ecosystems can be used as a tool to reduce pollution resulting from rural management processes, urbanisation and industrialisation (Wilson, 1997). Habitat compromisations are with direct effect towards the local faunal composition and their dynamics (Gascon *et al.,* 1999; Rickets *et al*., 2001). Performing a complex resource utilisation pattern, butterflies, are with greater sensitivity towards the decline of any ecosystem health than many other taxonomic groups (Thomas *et al.,* 2004; Thomas, 2005). They also act as suitable equipment for biodiversity study as the shortfalls are few (Hortal *et al*., 2015). Further butterflies, can act as the role model group from the conservational point of view (Watt and Boggs, 2003; Ehrlisch and Hanski, 2004).

Nearly 90 percent of all plants rely on pollen vectors and other pollinating agents to carry on pollination for their reproductive success (Kearns and Inouye, 1997). The lepidopterans, made up of approximately 1,50,000 species, are regarded as one of the important components of biodiversity (New, 1991). The number of Indian butterflies amount to one fifth of the world fauna (Kunte, 2000)). Butterfly diversity reflects overall plant diversity of any particular habitat (Padhye *et al.,* 2006). Further, they act as a primary consumer of the terrestrial food chain. A very specific and narrow niche occupancy is exhibited by the developmental stages resulting for most of the butterfly species forming metapopulations depending on a network of suitable habitats. (Thomas *et al.,* 2001; Anthes *et al.,* 2003). So, loss of butterflies from any community would start the “butterfly effect” continuing to affect the entire ecosystem, working its way up to the trophic levels. (Altermatte and Pearse, 2011). They are extremely responsive to changes in microclimate, temperature, humidity, solar radiation and rainfall pattern (Sparrow *et al.,* 1994; Thomas *et al.,* 1998; Fordyce and Nice, 2003). Additionally, they are with different requirements for different habitat types for performing their basic life processes like mating, breeding, foraging, etc. and thus are in synchronization with the diversity and quality of their habitats. As they possess high host plant specificity, so any alteration in native vegetation composition, either natural or through anthropogenic intervention are readily detectable, sometimes also on seasonal basis (Blair and Launer, 1997; Kunte, 1997, 2000; Kocher and Williams, 2000; Summerville and Crist, 2001; Koh 2007,). Minor changes in habitat may lead to migration or local extinction of native butterfly populations (Kunte, 1997; Blair, 1999; Menecheze *et al.,* 2003). Quite significantly, the changes in the land use pattern leading to changes in landscape profile, as a part of ecological succession, reflected very vividly by the changes in butterfly diversity and distribution. Thus, they are considered to be Umbrella species for conservation planning and management (Betrus *et al*., 2005).

The butterflies inhabiting natural areas, forests and protected areas, institutional campuses are mostly studied in India (Bhuyan *et al*., 2002; Ramesh *et al*., 2010; Thakur and Mattu, 2010; Prasad *et al*., 2012; Sengupta *et al*., 2014). In West Bengal, several studies on butterflies are done at Kolkata or its eastern part and North Bengal (DeNiceville, 1885; Ghosh and Sharif, 2005; Chowdhury and Chowdhury, 2006; Chowdhury and Soren, 2011; Roy *et al.,* 2012; Raychaudhuri and Saha, 2014; Mukherjee *et al*., 2015; Ghosh and Mukherjee, 2016). Some works are also done in the Indian Botanic Garden, Howrah (Chowdhury and Das, 2007) and on agroecosystem (Dwari and Mondal, 2015). Also there are some in Sundarban mangroves both in Bangladesh and India (Chowdhury, 2014; Hossain, 2014).

Significant diversity and conservation based documentations are from Bangladesh (Khandokar *et al.,* 2013; Shihan 2014; Shihan and Mohammed, 2014; Shihan and Kabir, 2015). But till date, no significant information on diversities of butterflies as per biomonitoring purpose in the modified wetland ecosystem with multiple secondary habitat establishments and also with the risk of accelerating urbanization and developmental processes along with seasonal exposure to tourism related hazards, like Taki, West Bengal is available. Herein, lies the importance of documentation of native butterflies of Taki, both on the basis of habitat isolation and climatic variations.

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. It is the gateway of Sundarbans (Bay of Bengal) and is a heritage town and well known tourist place. It comprises of multiple land use pattern (Tables: 1a-c and Fig.1). Basically it is a part of Ganga-Ichhamati mature delta, bearing clay and sandy loam soil, with little saline trends. A patch of mangrove plantation is also present there. Being a weekend tourist destination, it has to bear some additional anthropogenic load to its indigenous wetland based ecosystem properties. Presently, Taki is experiencing significant habitat fragmentation with great rapidity. Loss of habitat, reduction of patch size and accelerated patch isolation not only lead to deterioration of habitat quality (Fahrig, 2003, 2007) but also act as major threats to local biodiversity (Dafni, 1992; Rosin *et al*., 2012), particularly affecting the native floral distribution.

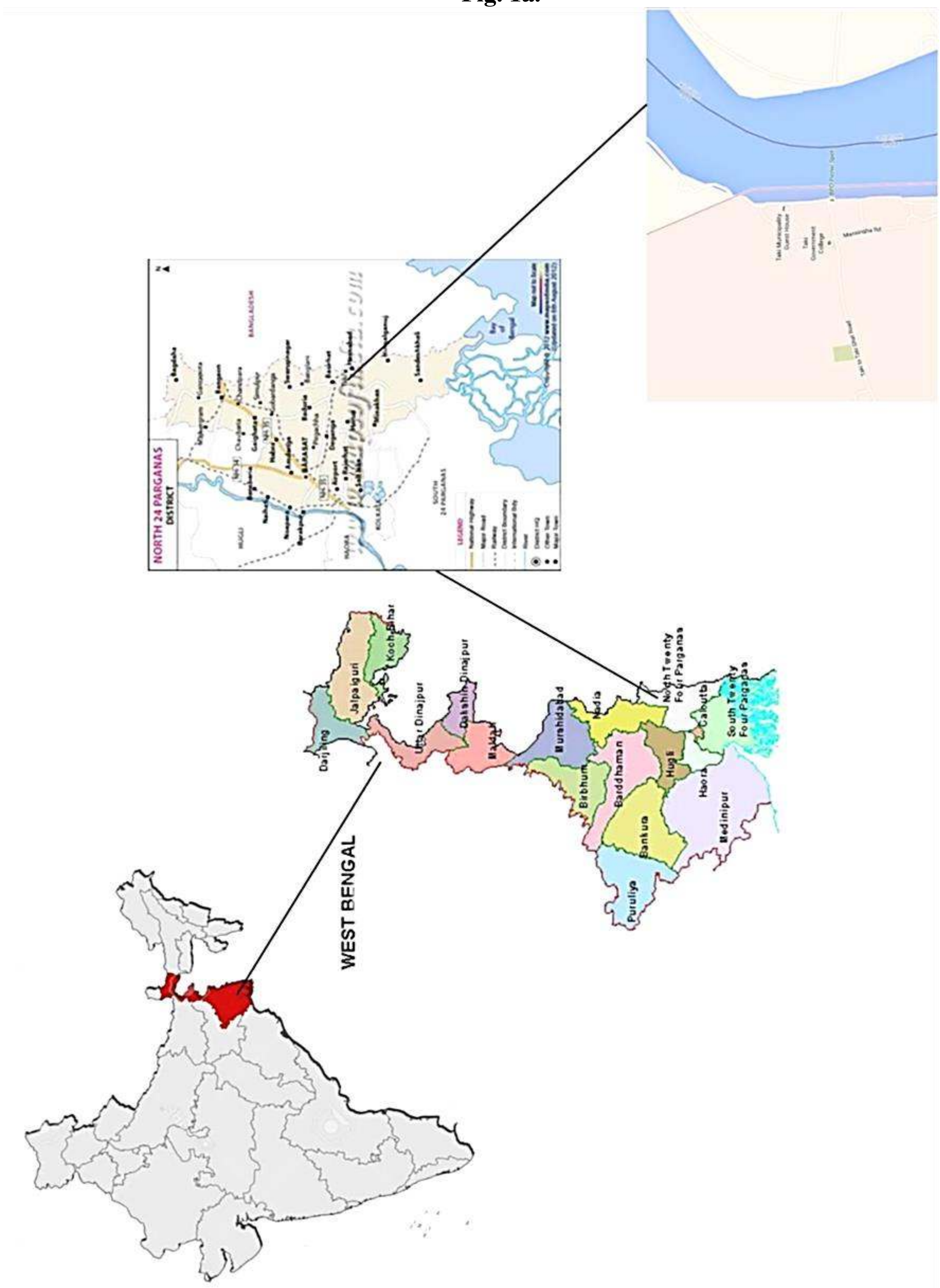
The present discourse is on the estimation of diversity of local butterflies in terms of species richness (Landau *et al*., 1999) and relative abundance of individuals (Hammond *et al.,*1998), found within the study area, compartmentalized into different habitat zones based on the land usage pattern and overall vegetation coverage and floral composition, considering the following objectives to chalk out a primary outline for their conservation on a long term basis :

- Preparation of a preliminary checklist of butterflies
- Finding out the annual abundance and seasonal distribution pattern of commonly available butterfly species
- Documentation about the commonly found larval host plants and nectar plants
- Evaluating their role as efficient bioindicator and at the same time as an ideal ecological model species.

2. MATERIALS AND METHODS

Sampling Site: Taki (22°59′ N and 88°92′E) (Figs :1a & b), is located at an average elevation of 5 meters. Global Positioning System (GPS; GPSMAP 76Cx, Garmin, Olathe, Kansas, USA) was used to record the geographic coordinates. The climate is of subtropical type, with hot summer, from late March to early June (avg. temp.: 25-40 °C). Monsoon dates from mid-June to late August, receiving an average rainfall of 1640-2000 mm.A cool and dry winter ranges from late November to early February (avg. temp: 12-25 °C). To facilitate the sampling process, the entire area is divided into six different study sites: **RS** (Railway Station), **SC** (Surrounding College), **R** (River), **MCLA** (Multiple Cultivated Land Area), **V** (Village) and **GMC** (Golpata Mangrove Coverage). Overall land use pattern and vegetation types in these sites are depicted in Table 1.

Fig. 1a.


WEST BENGAL
NORTH 24 PARGANAS
DISTRICT
Darjiling
Jalpaiguri
Koch Bihar
Uttar Dinajpur
Dakshin Dinajpur
Maldah
Murshidabad
Nadia
North Twenty Four Parganas
Calcutta
South Twenty Four Parganas
Birbhum
Barddhaman
Hugli
Haora
Bankura
Medinipur
Puruliya

Duration of Study: April 2014 to March 2015

Sampling Period: Each study site was visited once in a month and transects were observed for thrice in a day: 9 am to 11 am, 12 noon to 2 pm, 3 pm to 5 pm, during suitable climatic conditions (no heavy rain and strong wind). The division of seasons (summer, monsoon, post monsoon and winter) was based on the variation of rate of precipitation and temperature.

Sampling Techniques: Seasonal availability was determined by presence-absence scoring method and by percentage calculation to determine the status.
The butterflies were observed and recorded directly in the field following "Pollard Walk" method (Pollard, 1977; Pollard and Yates, 1993) with necessary modifications. For each site, there were three transect paths (1000m each) in 500m gap. Individuals were counted on either side of the path (at a distance of 2.5m).Thus there were a total of 3 kms (1000 x 3) transect tracts for each site each month. Collection of specimen was avoided to the extent possible. Mostly photographic documentation was done. They when required, were captured by hand net following Tiple (2012), identified using suitable keys (Evans, 1932; Wynter-Blyth, 1957; Haribal, 1992; Kunte, 2000; Kehimkar, 2008; Varshney and Smetacek, 2015) and released in the same habitat with least disturbance. Appropriate precautions were taken to guarantee the minimum damage to the scales present on the wings. Species were observed *in situ* while perching or foraging or nectaring or puddling or during mate selection. Approximately a uniform pace was maintained at each study site.

Butterflies were broadly sampled in a random manner along the edges and trails available within the mangrove plantation area.
Species were noted along with the date, location of capture and any plant association. At each location the same route of inspection was followed each time to reduce the numbers of variables present (Pyle, 1984). The specific host plants were identified and recorded (Mukherjee,1981; Kehimkar, 2000) in each transect and also from the adjoining areas.

Data Analysis:

Season and habitat wise variation in the number of species sampled during the study period is represented graphically.

The diversity indices of the butterfly abundance of each study site were analysed separately.

(A) Shannon-Weiner Index (H'): Species diversity was calculated using the Shannon-Weiner Index (Shannon-Weiner, 1948; Magurran 1988, 2004) across seasons and habitats.

$$H' = -\Sigma pi \ln pi$$

where, pi is the proportion of the ith species in the total sample. The number of species (species richness) in the community and their evenness in abundance (or equitability) are the two parameters that define H'.

(B) Pielou's Evenness Index (J'): The species evenness is the proportion of individuals among the species. Evenness of species indicates their relative abundance on site (Pielou 1969; Magurran1988, 2004):

$$J' = H'/ \ln S$$

where, S is the number of species present in the site.

(C) Simpson's Dominance Index (D): Species dominance across habitats was estimated by Simpson's dominance index (Simpson, 1949). This index was used to determine the proportion of more common species in a community or an area by the following formula

$$D = {}_{s=1}\Sigma^{n}[n_i(n_i-1)] / [N (N-1)]$$

where, n_i is the population density of the ith species, and N is the total population density of all component species in the study site.

(D) Margalef's Species Richness (R): used to compare the species richness across seasons and habitats.

R = (S-1)/ln N, where S is the number of species and N is the number of individuals (Magurran 1988, 2004).

(E) Calculation of ß diversity by SØrensen's Similarity Index (Sørensen's 1948): Shared species statistics and similarity coefficients calculated between pairs of the six study sites and between the pairs of four prominent seasons

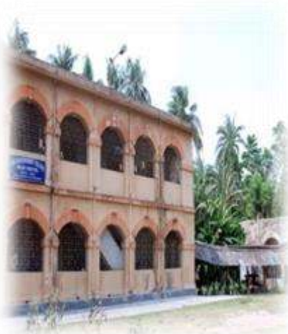
$$ß = 2C/S_1+S_2$$

S_1 = the total number of species recorded in the first community
S_2 = the total number of species recorded in the second community
C = number of species common in both communities

Fig. 1b. Study Sites

RS R R R

SC **V** **V** **V**



MCLA **MCLA** **MCLA**

GMC

3. RESULTS

Table 1a. Land use pattern at different study sites (RS: Railway Station; SC: Surrounding College, College Ground, College Hostel Ground; R: Riverside area; MCLA: Multiple Cultivated Land Area; V: Village Area; GMC: Golpata Mangrove Coverage

STUDY SITES	**LAND USE PATTERN**		**GARDEN/ORCHARD**	**NATIVE VEGETATION**	**GRAZING**	**ESTABLISHMENT**	**TOURISM**	**INTERTIDAL INFLUENCES**	**FLOODING**	**MARSHLAND**
	AGRICULTURE/ or PART TIME CULTIVATION (rice, mustard, wheat, Saccharum, gaanda etc.)	PLANTATION								
RS	I	I	I	II	II	III	IIII	NIL	NIL	II
SC	I	I	II	II	I	III	II	NIL	I	II
R	NIL	II	II	II	I	IIII	IIII	IIII	IIII	I
MCLA	IIII	I	I	I	I	I	NIL	I	II	NIL
V	III	II	III	I	III	III	I	NIL	II	II
GMC	II	IIII	NIL	I	III	I	IIII	IIII	IIII	III

STATUS	**% OF ENGAGEMENT**
I	<20
II	20-50
III	50-80
IIII	>80

Table 1b.

STUDY SITES		INDUSTRIAL SETUP		
	INTEGRATED FISH FARMING	POULTRY	APIARY	BRICKKLIN
RS	NIL	I	I	NIL
SC	NIL	I	I	NIL
R	NIL	NIL	NIL	I
MCLA	II	III	II	NIL
V	I	III	II	I
GMC	IIII	NIL	NIL	NIL

Table 1c. Overall vegetation type and canopy coverage (qualitative assumption) at different study sites

STUDY SITES	VEGETATION TYPE		
	NATURAL VS AGRICULTURAL/PLANTATION	SHRUB vs TREES	CANOPY COVERAGE
RS	mostly natural	shrubs beside the railway track, various grasses and weeds, trees also present	less to moderate
SC	mostly natural, few orchards or garden plants, less crop species	shrubs moderate, Trees also prevalent	less to moderate
R	mostly natural, few agricultural	Shrubs prevalent; trees moderate	moderate to high
MCLA	mostly agricultural, few natural	Cultivated plants. Weeds and to some extent natural flora eliminated as the effect of pesticide use.	less
V	Plantation more. Ornamental plants, gardens, orchards	Due to settlements, wild flora eliminated to some extent. Trees present.	Less
GMC	Mangrove plantation	Single mangrove shrub *Acanthus* sp.	High

STATUS	Approximate % OF ENGAGEMENT
I	<20
II	20-50
III	50-80
IIII	>80

Fig. 1. Land usage and coverage pattern throughout different study sites (approximate).

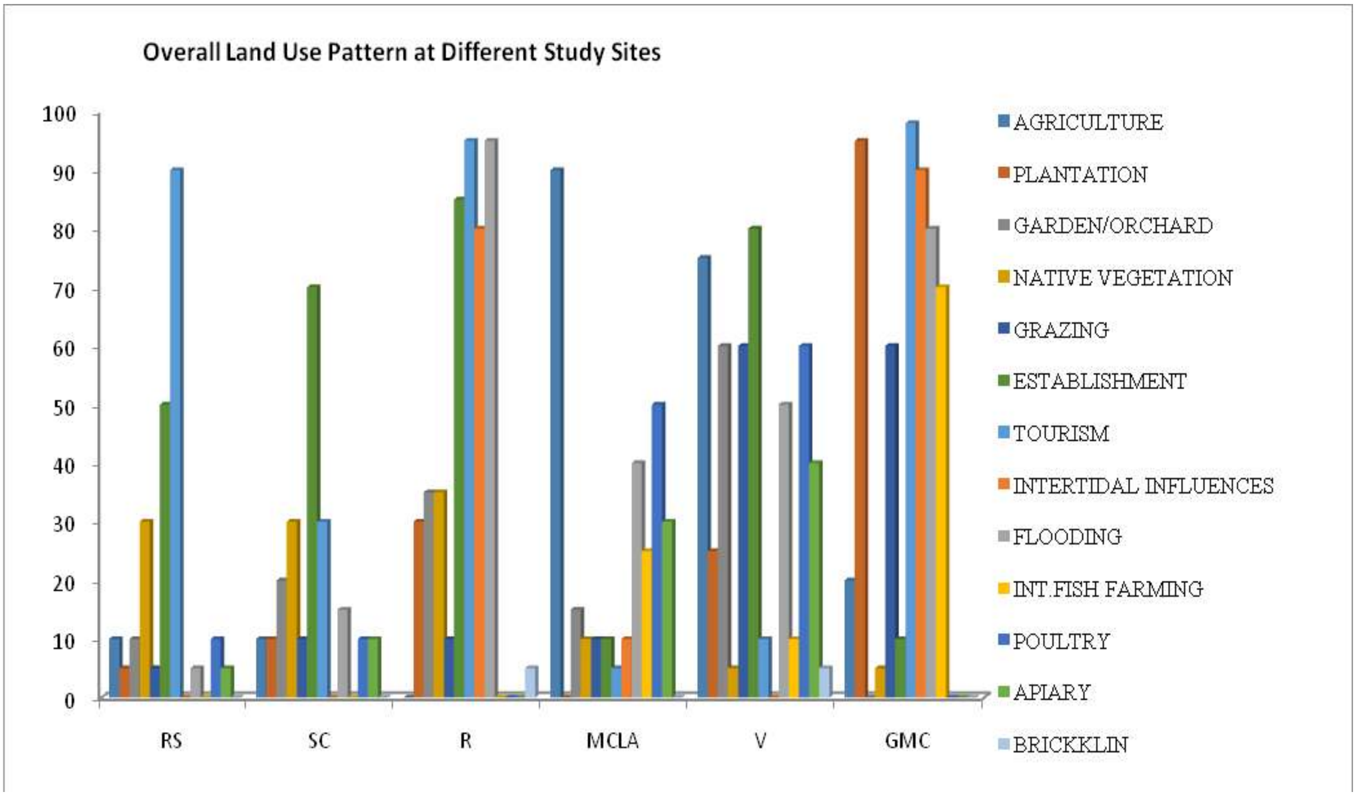


Table 2a. Family wise composition of butterflies showing number of genera, species and individuals.

Sl No.	Family	Genus	Species	Total no. of individuals
1	Hesperiidae	5(~13%)	5(~10%)	117(~4%)
2	Papilionidae	4(~10%)	8(~16%)	450(~15%)
3	Pieridae	7(~18%)	10(~20%)	681(~22%)
4	Lycaenidae	9(~23%)	9(~18%)	370(~12%)
5	Nymphalidae	14(~36%)	19(~37%)	1431(~47%)
Total	5	39	51	3049

Table 2b. Species list of the butterfly fauna, their annual abundance status and their seasonal availability.

Sl no	Common name	Scientific name	Abundance status	Seasonal visibility
Family : Hesperiidae (Skippers)				
1	Rice Swift	*Borbo cinnara* (Wallace)	C	S,M,PM
2	Grass Demon	*Udaspes folus* (Cramer)	M	M,PM
3	Indian skipper	*Spialia galba* (Fabricius)	C	W,S,M,PM
4	Bevan's Swift	*Borbo bevani* (Moore)	R	S,M,PM
5	Small Branded Swift	*Pelopidas thrax* (Huebner)	R	S,M,PM
Family : Papilionidae (Swallowtails)				
6	Common Mormon	*Papilio polytes* (Linnaeus)	VC	S,M,PM,W
7	Common mime	*Papilio clytia* (Linnaeus)	R	S,M,PM,W
8	Tailed Jay	*Graphium agamemnon* (Linnaeus)	C	S,W
9	Red Helen	*Papilio helenus* (Linnaeus)	M	S,M,PM,
10	Lesser Mime	*Papilio epycides* (Hewitson)	R	S,PM
11	Common Rose	*Pachliopta aristolochiae* (Fabricius)	R	S,W
12	Blue Mormon	*Papilio polymnestor* (Cramer)	R	S,PM,W
13	Lime	*Papilio demoleus* (Linnaeus)	VC	S,M,PM,W
Family : Pieridae (Whites and Yellows)				
14	Psyche	*Leptosia nina* (Fabricius)	VC	S,M,PM,W
15	Pioneer	*Belenois aurota* (Fabricius)	M	S,M,PM
16	Red Spot Jezabel	*Delias descombesi* (Boisduval)	R	S,W
17	Yellow Orange Tip	*Ixias pyrene* (Linnaeus)	R	PM,W
18	Common jezabel	*Delias eucharis* (Drury)	R	S,W
19	Common Emigrant	*Catopsilia pomona* (Fabricius)	VC	S,PM
20	Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus)	VC	S,PM

21	Common Grass Yellow	*Eurema hecabe* (Linnaeus)	VC	S,M,PM
22	One Spot Grass Yellow	*Eurema andersoni* (Moore)	VR	PM,W
23	Common Wanderer	*Pareronia valeria* (Cramer)	M	S,PM,W
Family : Lycaenidae (Blues)				
24	Large Oak blue	*Arhopala amantes* (Hewitson)	M	S,M,PM
25	Common Silver line	*Spindasis vulcanus* (Fabricius)	M	S,M,PM
26	Quaker	*Neopithecops zalmora* (Butler)	VC	S,M,PM
27	Common Guava Blue	*Viracholais ocrates* (Fabricius)	C	S
28	Common Ciliate Blue	*Anthene emolus* (Godart)	R	M,PM
29	Slate Flash	*Rapala manea* (Hewitson)	M	M,PM
30	Lime blue	*Chilades lajus* (Stoll)	M	S,M,PM,W
31	Pale Grass Blue	*Pseudozizeeria maha* (Kollar)	R	S,M,PM,W
32	Common Pierrot	*Castalius rosimon* (Fabricius)	M	M,PM
Family: Nymphalidae (Brush-footed)				
33	Tawny Coster	*Acraea violae* (Fabricius)	M	W
34	Common Baron	*Euthalia aconthea* (Cramer)	VC	S,M,PM,W
35	Plain Tiger	*Danaus chrysippus* (Linnaeus)	VC	S,M,PM,W
36	Blue Tiger	*Tirumala limniace* (Cramer)	C	S,M,PM,W
37	Dark Brand Bush Brown	*Mycalesis mineus* (Linnaeus)	VC	S,PM,W
38	Baronet	*Euthalia nais* (Forster)	M	S,M,PM
39	Common Earl	*Tanaecia julii* (Lesson)	R	S,M,PM
40	Common Leopard	*Phalanta phalanta* (Drury)	VC	S,M,PM
41	Peacock Pansy	*Junonia almana* (Linnaeus)	VC	M,PM
42	Chestnut Sreaked Sailer	*Neptis jumbah* (Moore)	C	S,M,PM
43	Common Evening Brown	*Melanitis leda* (Linnaeus)	VC	PM
44	Common Palmfly	*Elymnias hypermenstra* (Linnaeus)	VC	S,M,PM,W
45	Common Four Ring	*Ypthima huebneri* (Kirby)	C	S,M,PM

46	Danaid Eggfly	*Hypolimnas misippus* (Linnaeus)	C	S,M,PM,W
47	Common Five Ring	*Ypthima baldus* (Fabricius)	C	S,M,PM,W
48	Grey Pansy	*Junonia atlitis* (Linnaeus)	C	PM
49	Lemon Pansy	*Junonia lemonias* (Linnaeus)	R	S,PM
50	Common Crow	*Euploea core* (Cramer)	VC	S,PM
51	Brown king Crow	*Euploea klugii* (Moore)	C	S,PM

Legends : VR-1-2; R-2-20;M-20-40; C-40-100; VC->100
S (Summer) - March, April, May; M(Monsoon) - June, July, August; PM(Postmonsoon) - September, October, November; W(Winter) - December, January, February

Table 2c. List of Butterflies with status of endemism.

Sl. No.	Common name	Scientific Name	WPA 1972 Schedules
1	Danaid Eggfly	*Hypolimnas misippus* (Linnaeus)	I and II
2	Common Crow	*Euploea core* (Cramer)	IV
3	Common Pierrrot	*Castalius rosimon* (Fabricius)	I
4	Common mime	*Papilio clytia* (Linnaeus)	I

Fig. 2. Family wise Annual Abundance Status of Butterflies

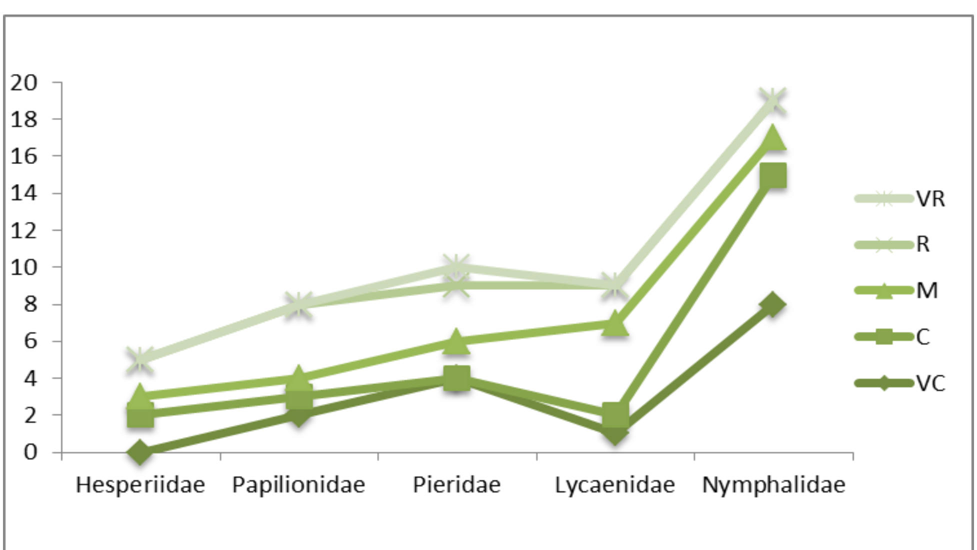


Fig. 3a

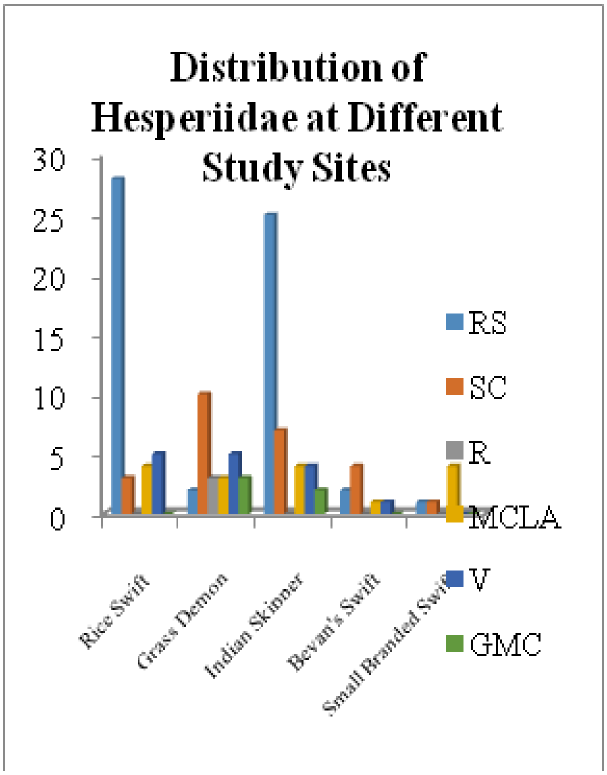


Fig. 3b

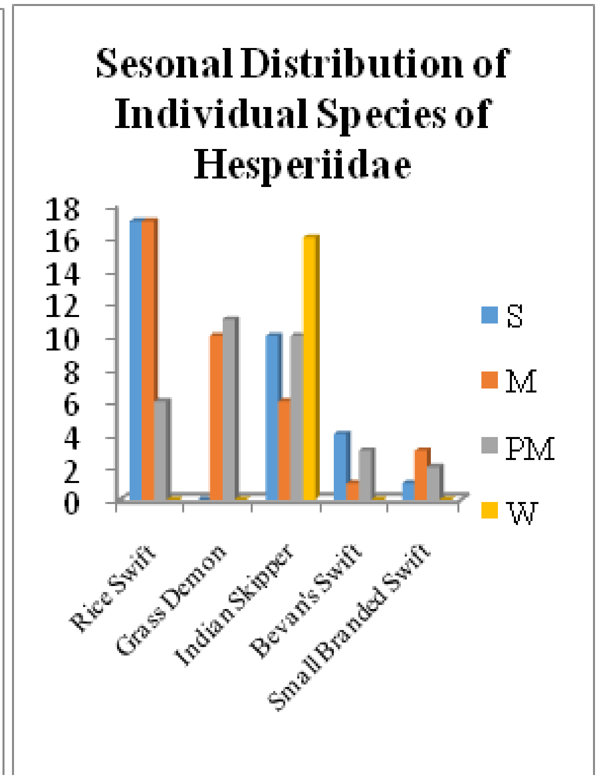


Fig. 3c

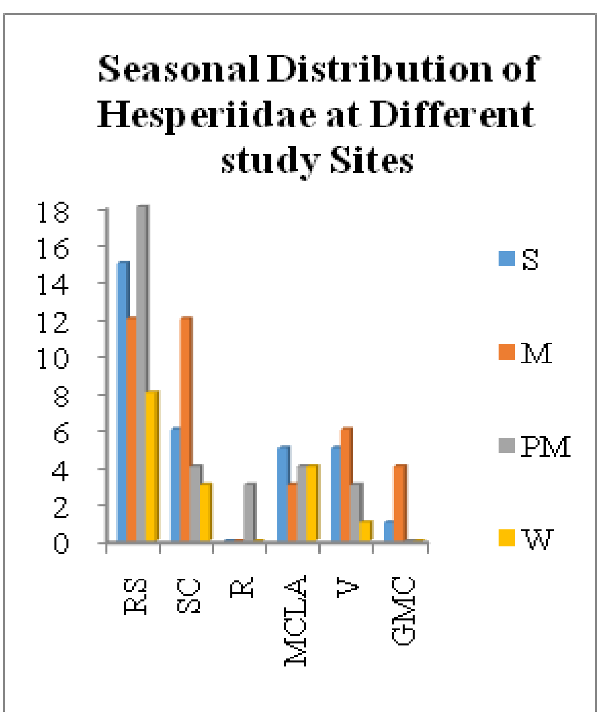


Fig. 4a

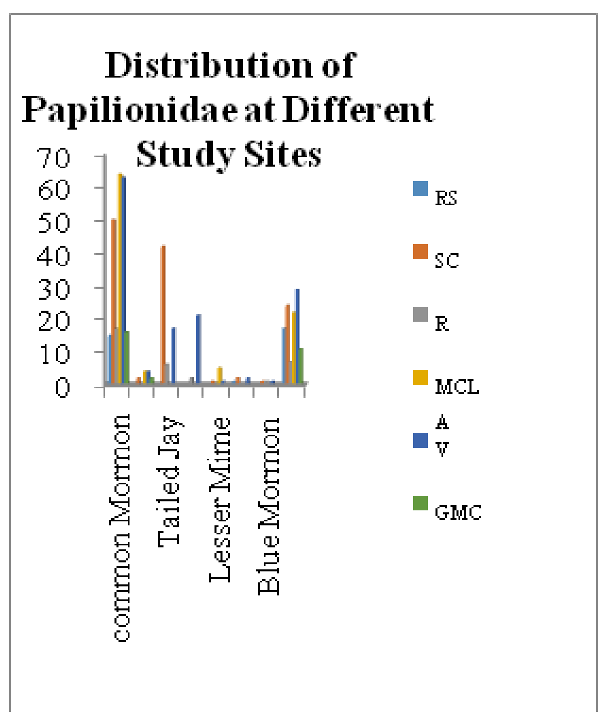


Fig. 4b

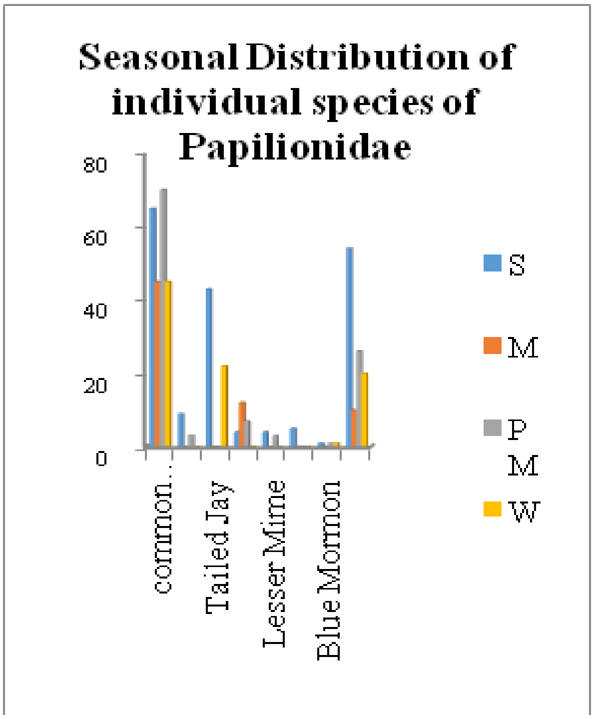


Fig. 4c

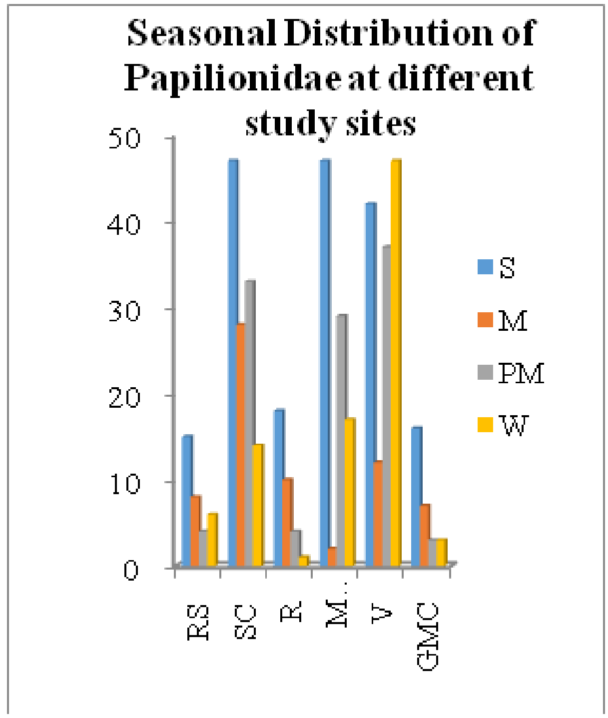


Fig. 5a

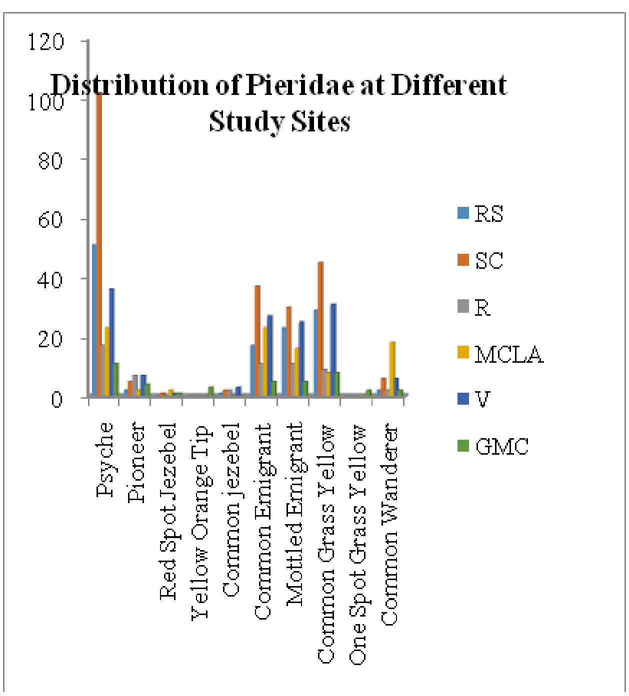


Fig. 5b

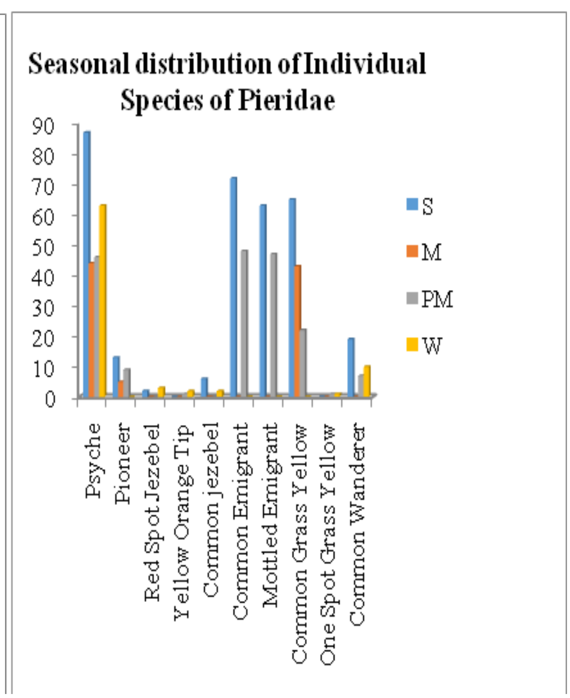


Fig. 5c

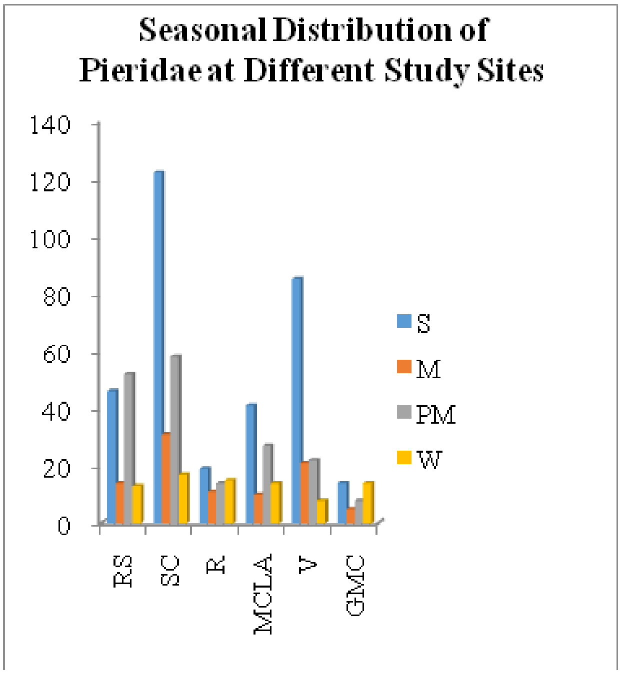


Fig. 6a

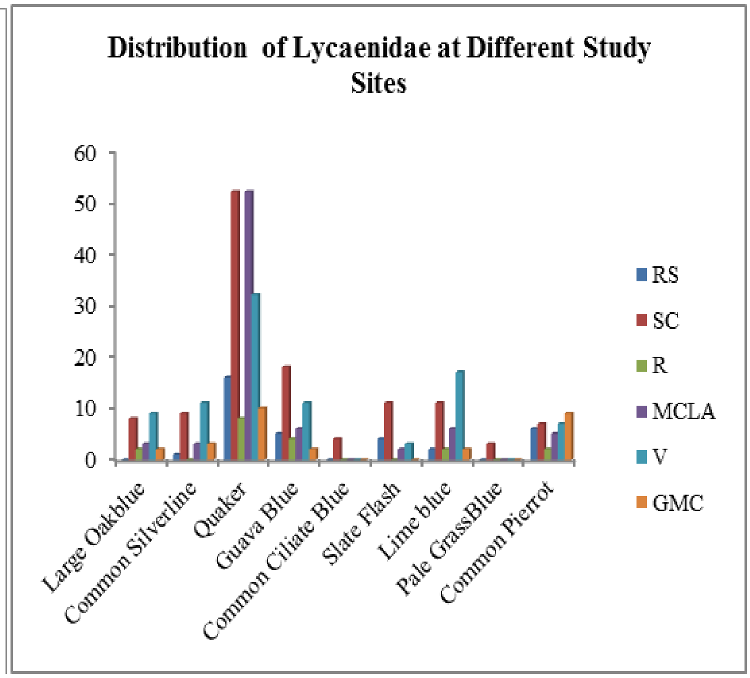


Fig. 6b

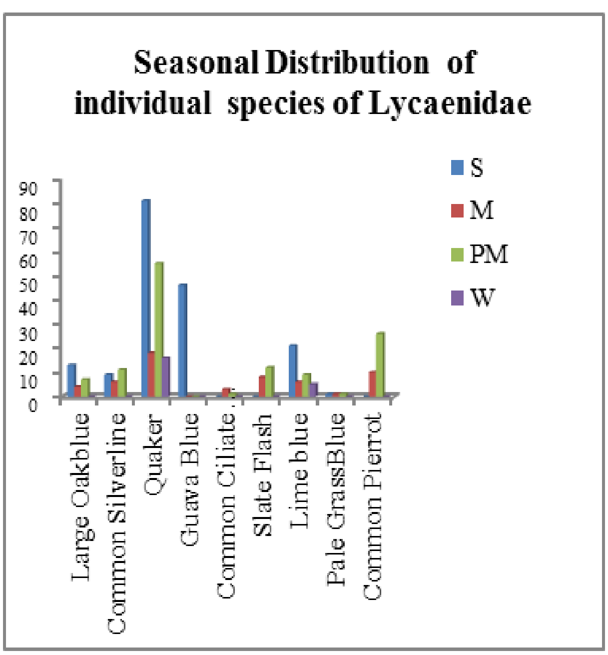


Fig. 6c

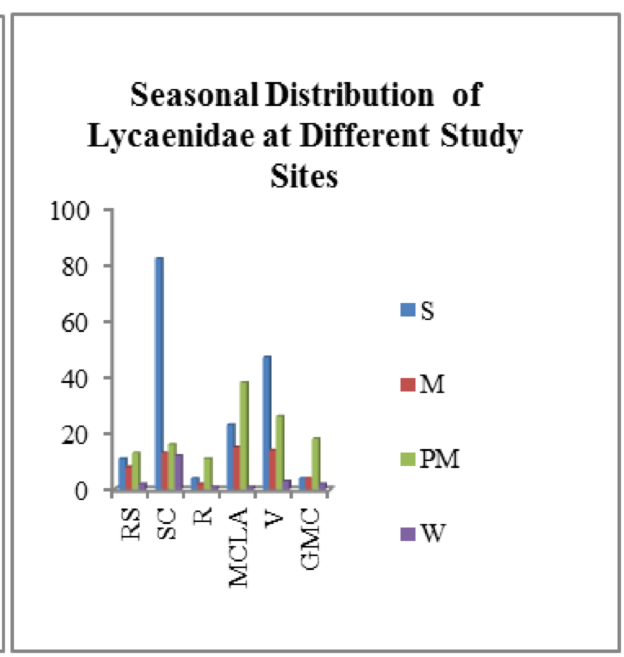


Fig. 7a

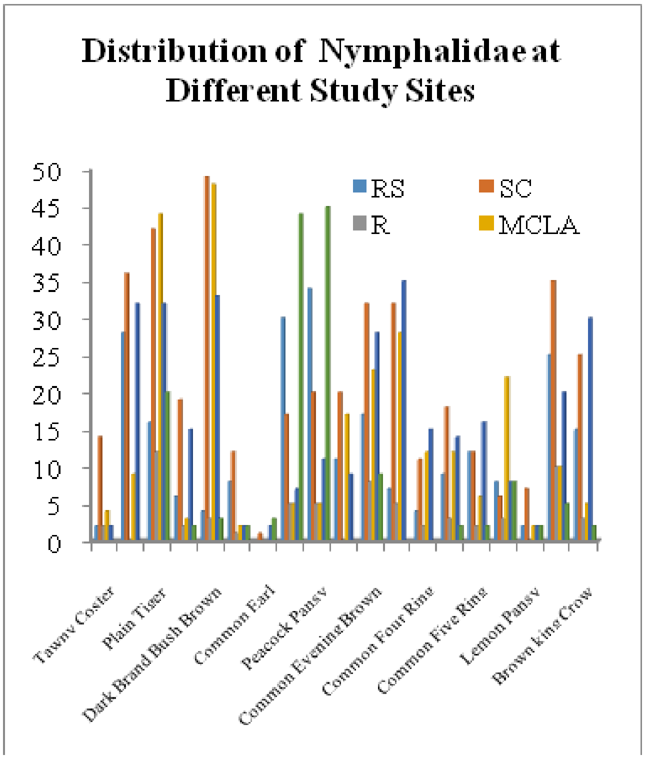


Fig. 7b

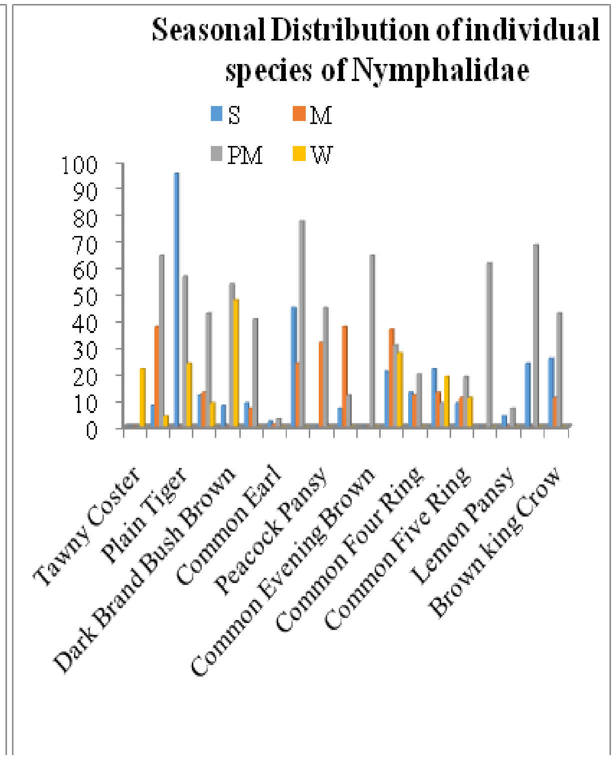


Fig. 7c

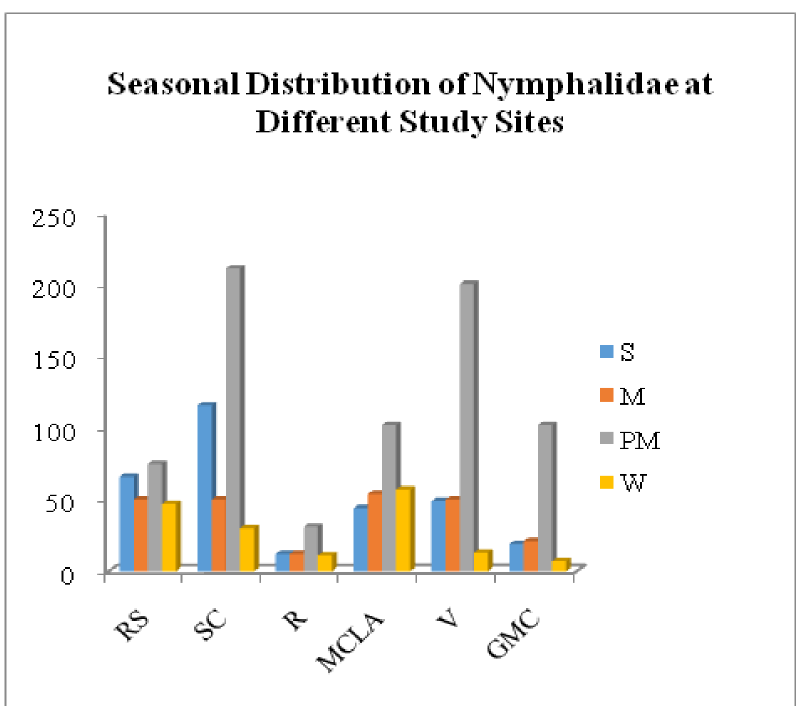


Fig. 8a

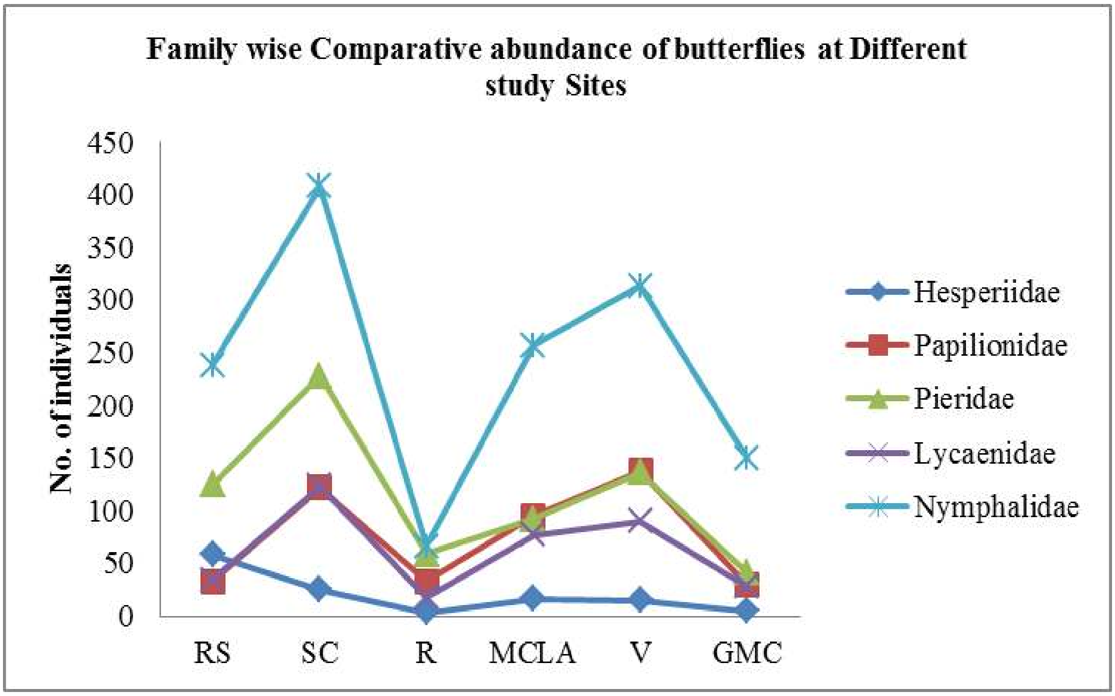

Family wise Comparative abundance of butterflies at Different study Sites
No. of individuals
450
400
350
300
250
200
150
100
50
0
RS
SC
R
MCLA
V
GMC
Hesperiidae
Papilionidae
Pieridae
Lycaenidae
Nymphalidae

Fig. 8b

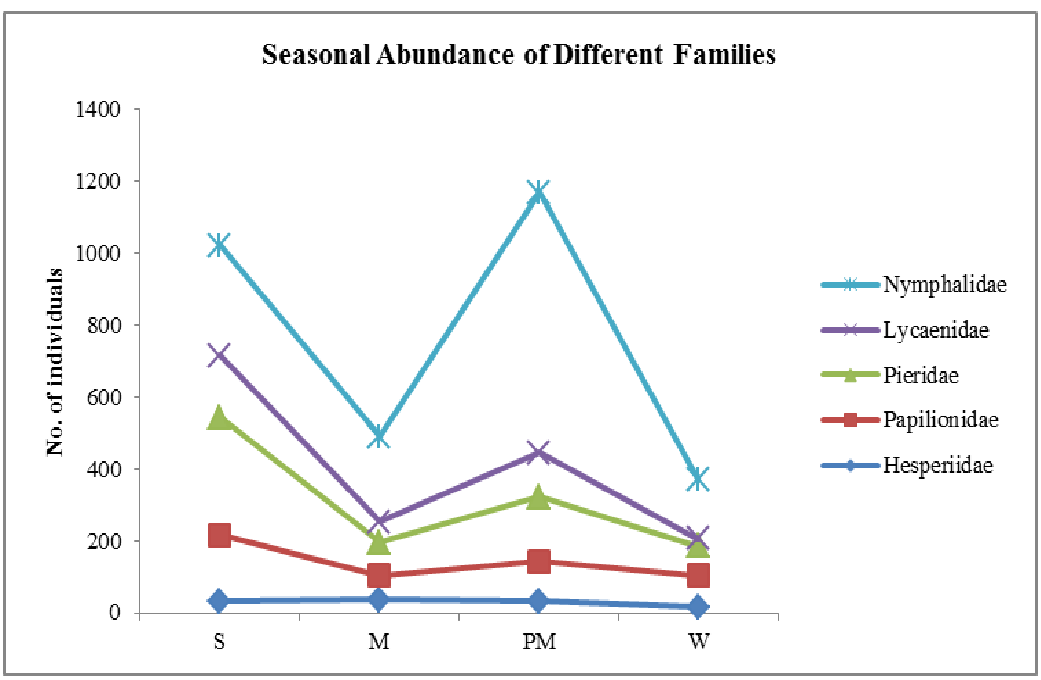

Seasonal Abundance of Different Families
No. of individuals
1400
1200
1000
800
600
400
200
0
S
M
PM
W
Nymphalidae
Lycaenidae
Pieridae
Papilionidae
Hesperiidae

Table 3a. Diversity indices at different study sites.

Ecological Indices	RS	SC	R	MCLA	V	GMC
Total Abundance (N)	488	906	179	537	692	252
Species Richness (s)	39	48	33	41	46	34
Shannon –Weiner Index H′= Σpi (ln pi)	3.25	3.44	3.22	3.21	3.43	2.93
Pielou's Evenness Index J = H′/ln S	0.89	0.89	0.92	0.87	0.9	0.83
Margalef's Species Richhness R = (s-1)/lnN	6.14	6.9	6.17	6.36	6.88	5.97
Simpsons Dominance Index (D)	0.046	0.042	0.044	0.054	0.038	0.081

Table 3b. Beta diversity values at different study sites

Habitat Pairs	No. of Shared Species	Sorensen's Index
RS-SC	39	0.90
RS-R	32	0.89
RS-MCLA	37	0.93
RS-V	38	0.89
RS-GMC	28	0.77
SC-R	32	0.79
SC-MCLA	41	0.92
SC-V	45	0.96
SC-GMC	32	0.78
R-MCLA	29	0.78
R-V	33	0.84
R-GMC	26	0.78
MCLA-V	40	0.92
MCLA-GMC	32	0.85
V-GMC	32	0.8

Table 3c. Diversity indices throughout different Seasons.

Ecological Indices	S	M	PM	W
Total Abundance (N)	1021	489	1168	371
Species Richness (s)	41	31	45	21
Shannon-Weiner Index $H' = \Sigma pi (\ln pi)$	3.2	3.07	3.37	2.64
Pielou's Evenness Index $J = H'/\ln S$	0.86	0.9	0.9	0.87
Margalef's Species Richness $R = (s-1)/\ln N$	5.77	4.85	6.23	3.38
Simpson's Diversity Index $D = \Sigma n(n-1)/N(N-1)$	0.051	0.055	0.04	0.87

Table 3d. Beta diversity values at different seasons.

Pairs of seasons	No. of Shared Sp	Sorensen's Index
S-M	26	0.72
S-PM	36	0.84
S-W	18	0.58
M-PM	31	0.82
M-W	11	0.42
PM-W	17	0.52

Table 4a. Commonly found larval host plants and their distribution.

Sl No.	Family	Larval host plants	Sites of Occurrences	Butterfly Families	Visiting Butterflies
1	Poaceae	*Eragrostis* sp.	RS,SC,R,V,	Hesperiidae, Nymphalidae	Dark Band Bush Brown, Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift,Small Branded Swift
2		*Ischaenum* sp.	RS,SC,R,V,GMP	Hesperiidae	Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift,Small Branded Swift
3		*Imperata* sp.	RS,SC,MCLA,V	Hesperiidae	Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift,Small Branded Swift
4		*Saccharum* sp.	RS,MCLA,V,GMP	Hesperiidae	Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift,Small Branded Swift
5		*Oryza* sp.	RS,MCLA,GMP	Hesperiidae, Nymphalidae	Dark Band Bush Brown, Common Evening Brown, Rice Swift, Grass Demon, Indian Skippers, Bevan's

					Swift,Small Branded Swift
6		*Zea* sp.	V,MCLA	Nymphalidae,	Common Evening Brown,
7		*Cynodon* sp.	RS,SC,R,V,MCLA	Nymphalidae,	Dark Band Bush Brown, Common Four Ring, Common Five Ring
8		*Eleusine* sp.	SC,MCLA,V	Nymphalidae,	Dark Band Bush Brown, Common Evening Brown,
9		*Panicum* sp.	RS,SC,MClA,V	Nymphalidae,	Common Evening Brown,
10		*Sorghum* sp.	RS,SC,R,GMC	Nymphalidae,	Common Evening Brown,
11	Arecaceae	*Areca* sp.	RS,SC,R,V,MCLA	Nymphalidae,	Common Palmfly,
12		*Cocos* sp.	SC,V,R,MCLA	Nymphalidae,	Common Palmfly,
13		*Calamus* sp.	R,V	Nymphalidae,	Common Palmfly,
14		*Phoenix* sp.	V,MCLA	Nymphalidae,	Common Palmfly,
15	Zingiberaceae	*Hedychium* sp.	V	Hesperiidae	Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift,Small Branded Swift
16		*Zingiber* sp.	MCLA,V	Hesperiidae	Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift,Small Branded Swift
17		*Curcuma sp.*	MCLA,V	Hesperiidae	Plain Tiger, Danaid Eggfly,Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift,Small Branded Swift
18	Lorantheceae	*Dendropthoe* sp.	R	Pieridae	Common Jezebel
19	Portulacaceae	*Portulaca* sp.	SC,MCLA,V,GMP	Nymphalidae,	Plain Tiger, Danaid Eggfly
20	Anonaceae	*Annona* sp.	SC,V	Papilionidae	Lime, Tailed Jay, Blue Mormon
21		*Polyalthia* sp.	SC,V	Papilionidae	Tailed Jay
22	Capparidaceae	*Cleome* sp.	RS,SC,R,GMP	Pieridae	Psyche, Pioneer,
23	Papilionaceae	*Psoralea* sp.	SC,V	Papilionidae	Lime
24		*Tephrosia* sp.	SC	Lycaenidae	Pale Grass Blue
25		*Pongamia* sp.	RS,SC,MCLA,V	Nymphalidae,	Chestnut SreakedSailer
26	Caesalpiniaceae	*Cassia* sp.	RS,SC,V	Pieridae	Common Emigrant, Mottled Emigrant, Common Grass Yellow
27		*Cesalpinia* sp.	RS,SC,R	Pieridae	Common Grass Yellow
28		*Tamarindus* sp.	RS,SC,V,MCLA,R	Lycaenidae	Guava Blue
29	Mimosae	*Albizzia* sp.	SC,V	Pieridae	Common Grass Yellow
30		*Acacia* sp.	SC,R	Pieridae, Lycaenidae	Common Grass Yellow, Slate Flash
31		*Bauhinia* sp.	RS,SC,V	Pieridae	Common Emigrant, Mottled Emigrant
32	Oxalidaceae	*Oxalis* sp.	SC,V	Lycaenidae	Pale Grass Blue,LimeBlue
33	Rutaceae	*Atalantea* sp.	SC,V	Papilionidae, Lycaenidae	Common Mormon, Lime Blue
34		*Citrus* sp.	RS,SC,V,R,MCLA	Papilionidae, Lycaenidae	Lime, Blue Mormon, Lime Blue

35		*Glycosmis* sp.	RS,SC	Papilionidae, Lycaenidae	Lime, Blue Mormon, Quaker
36		*Murraya* sp.	SC,MCLA,V	Papilionidae	Lime
37		*Aegle* sp.	RS,SC,R,V,MCLA	Papilionidae, Nymphalidae	common Baron, Lime
38	Anacardiaceae	*Mangifera* sp.	RS,SC,R,MCLA,V,GMP	Nymphalidae,	Common Baron, Chestnut Streaked Sailer,
39	Rhamnaceae	*Zizyphus* sp.	RS,SC,R,V,MCLA,GMP	Papilionidae, Lycaenidae, Nymphalidae	Lime, Common Silverline,Slate Flash, Common Pierrot,Chestnut Streaked Sailer
40	Tiliaceae	*Corchorus* sp.	RS,R,MCLA	Nymphalidae,	Plain Tiger, Danaid Eggfly, Chestnut Streaked Sailer, Grey Pansy, Lemon Pansy
41	Malvaceae	*Hibiscus* sp.	RS,SC,R,V	Hesperiidae, Nymphalidae	Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift,Small Branded Swift, Plain Tiger, Chestnut Streaked Sailer
42		*Sida* sp.	RS,SC,V,MCLA,GMP	Hesperiidae, Nymphalidae	Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift,Small Branded Swift, Grey Pansy, Lemon Pansy
43		*Malvastrum* sp.	SC,V	Nymphalidae,	Plain Tiger, Danaid Eggfly,
44		*Abelmoschus* sp.	V,MCLA	Nymphalidae,	Chestnut Streaked Sailer,
45		*Thespesia* sp.	SC,V	Nymphalidae,	Chestnut Streaked Sailer,
46		*Grewia* sp.	RS,SC,V	Nymphalidae,	Chestnut Streaked Sailer,
47	Sterculiaceae	*Waltheria* sp.	RS,SC	Hesperiidae, Nymphalidae	Tawny Coster,Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift,Small Branded Swift
48	Passifloraceae	*Passiflora* sp	SC	Nymphalidae,	Tawny Coster
49	Combretaceae	*Terminalia* sp.	V	Lycaenidae	Large Oak Blue, Common Ciliate Blue
50		*Combretum* sp.	SC	Lycaenidae	Common Ciliate Blue
51	Mystaceae	*Psidium* sp.	RS,SC,V	Lycaenidae	Guava Blue
52	Apocynaceae	*Nerium* sp.	RS,SC,V	Nymphalidae,	Common Crow, Brown King Crow
53		*Holarrhena sp.*	RS,SC	Nymphalidae,	Common Crow, Brown King Crow
54	Moraceae	*Ficus* sp.	RS,SC,R,V,MCLA,GMP	Nymphalidae,	Common CommonCrow,Brown King Crow
55		*Streblus* sp.	RS,V	Nymphalidae,	Common Baron
56	Asclepiadaceae	*Marsdenia* sp.	SC,V	Nymphalidae,	Blue Tiger,
57		*Asclepius* sp.	SC,MCLA,V	Nymphalidae,	Plain Tiger,DanaidEggfly,Blue Tiger,
58		*Calotropis* sp.	RS,SC,R,MCLA,V,GMP	Nymphalidae,	Plain Tiger,DanaidEggfly,Blue Tiger,
59		*Tylophora* sp.	SC,V	Nymphalidae,	Plain Tiger,BlueTiger,CommonCrow,Brown King Crow
60		*Hemidesmus* sp.	SC,V	Nymphalidae,	Common Crow,Brown King Crow
61	Verbenaceae	*Clerodendron* sp.	RS,SC	Pieridae	Red Spot Jezebel,CommonJezebel,Common Silver line
62	Acantheceae	*Asystacia* sp.	RS,SC	Nymphalidae,	Plain Tiger,DanaidEggfly,

63		*Barleria* sp.	RS,SC,V	Nymphalidae,	Plain Tiger,DanaidEggfly, Peacock Pansy
64		*Hygrophyla* sp.	RS,V	Nymphalidae,	Peacock Pansy, Grey Pansy, Lemon Pansy
65		*Acanthus* sp.	R,GMP	Nymphalidae,	Peacock Pansy
66	Rubiaceae	*Gardenia* sp.	SC,V	Lycaenidae	Guava Blue
67	Aristolochiacea e	*Aristolochia* sp.	SC	Papilionidae	Common Rose
68	Asteraceae	*Mikania* sp.	SC,V,MCLA	Papilionidae	Lime

Table 4b. Commonly found nectar plants and their distribution.

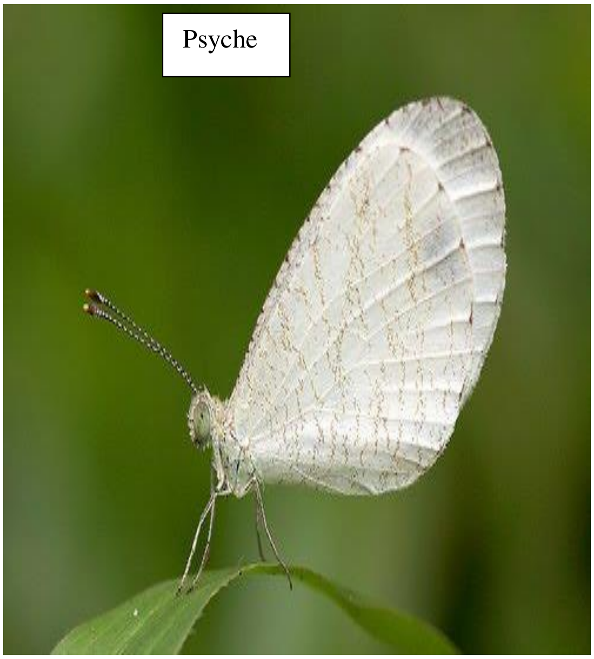
Sl No.	Family	Nectar Plaqnts	Site of Occurrence	Butterfly Families	Visiting Butterflies
1	Rutaceae	*Citrus* sp.	RS,SC,V,R,MCLA	Hesperiidae, Papilionidae	Rice Swifts, Common Mormon
2		*Murraya* sp.	SC,MCLA,V	Papilionidae	Common Mormon
3		*Glycosmis* sp.	RS,SC	Papilionidae, Lycaenidae	Common Mormon, Slate Flash
4	Verbenaceae	*Lantana* sp.	RS,SC,R,V.MCLA,GMP	Lycaenidae, Pieridae, Papilionidae, Hesperiidae, Nymphalidae	Common Silverline, Mottled Emigrant, Common Emigrant, Pioneer, Common Mormon, Lime, Common Rose, Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift,Small Branded Swift, Plain Tiger, Blue Tiger, Common Leopard, Peacock Pansy, Danaid Eggfly, Grey Pansy, Lemon Pansy, Common Crow, Brown King Crow
5		*Phyla nodiflora*	RS,SC,R,V,	Hesperiidae	Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift,Small Branded Swift
6		*Clerodendrum* sp.	RS,SC	Pieridae, Nymphalidae	Pioneer, Common Leopard, Common Four Ring, Common Five Ring
7		*Gmelina* sp.	RS,SC,V,GMP	Nymphalidae	Common Leopard, Common Crow, Brown King Crow
8	Asteraceae	*Tridax* sp.	RS,SC,RV,GMP	Lycaenidae, Pieridae, Nymphalidae	Common Pierrot,Common Grass Yellow, Psyche, Tawny Coster, Peacock Pansy, Common Four Ring, Common Five Ring, Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift, Small Branded Swift
9		*Cosmos* sp.	RS,SC,V	Nymphalidae, Papilionidae	Plain Tiger, Blue Tiger, Grey Pansy, Lemon Pansy, Common Rose
10		*Zinnia* sp.	SC,V	Papilionidae	Common Rose
11		*Tagetes* sp.	RS,SC,R,MCLA,V,GMP	Papilionidae, Nymphalidae, Pieridae	Lesser Mime, Plain Tiger, Blue Tiger, Common Emigrant, Mottled Emigrant
12		*Ageratum* sp.	RS,SC,V	Nymphalidae, Pieridae	Common Crow, Brown King Crow, Common Grass Yellow
13		*Mikania* sp.	RS,SC,GMP	Nymphalidae	Common Leopard
14		*Senecio* sp.	RS,SC,V	Nymphalidae	Common Crow, Brown King Crow

15		*Helianthus* sp.	RS,SC,V	Nymphalidae, Pieridae	Common Jezebel, Common Crow, Brown King Crow
16	Apocyanaceae	*Vinca* sp.	RS,SC,R,V	Hesperiidae	Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift, Small Branded Swift
17	Rubiaceae	*Ixora* sp.	RS,SC,R,V	Pieridae, Nymphalidae, Papilionidae	Pioneer, Lemon Pansy, Common Mormon, Common Wanderer
18		*Mussaenda* sp.	RS,SC,R,V	Papilionidae	Common Mormon, Tailed Jay
19		*Pavetta* sp.	RS,SC,MCLA	Pieridae	Common Wanderer
20	Brassicaceae	*Brassica* sp.	RS,MCLA	Papilionidae	Lesser Mime
21	Amaranthaceae	*Alternantherea* sp.	RS,SC,MCLA	Nymphalidae, Pieridae, Lycaenidae	Common Leopard, Psyche, Common Pierrot
22	Polygoneaceae	*Dendropthoe* sp.	RS,SC,V	Pieridae, Nymphalidae	Common Jezebel, Common Crow, Brown King Crow
23	Bombacaceae	*Sida* sp.	RS,SC,V	Pieridae, Lycaenidae	Common Emigrant, Mottled Emigrant, Common Pierrot,
24	Balsaminaceae	*Impatiens* sp.	MCLA	Pieridae	Common Wanderer
25	Sapindaceae	*Schleichera* sp.	RS,SC,R,V	Nymphalidae	Common Crow, Brown King Crow
26	Myrtaceae	*Syzygium* sp.	RS,SC,R,V	Nymphalidae	Common Crow, Brown King Crow
27	Combretaceae	Terminaliasp.	RS,SC,R,V	Nymphalidae	Common Crow, Brown King Crow
28	Acantheceae	*Justicea* sp.	RS,SC,GMP	Lycaenidae	Common Pierrot
29		Dicliptera sp.	RS,SC	Hesperiidae	Rice Swift, Grass Demon, Indian Skippers, Bevan's Swift, Small Branded Swift
30		*Asytasia* sp.	SC,V	Papilionidae	Blue Mormon
31	Boraginaceae	*Heliotropium* sp.	SC,V	Nymphalidae	Blue Tiger,
32	Euphorbiaceae	*Cipadessa* sp.	RS,SC,MCLA,V	Nymphalidae	Common Four Ring, Common Five Ring
33	Papilionaceae	*Crotalaria* sp.	SC,V	Nymphalidae	Blue Tiger,
34	Oleaceae	*Jasminum* sp.	SC,V	Papilionidae	Blue Mormon
35	Passifloraceae	*Passiflora* sp.	SC	Nymphalidae	Tawny Coster
36	Moraceae	*Streblus* sp.	RS,V	Nymphalidae	Common Baron

Fig. 9a. Representative butterflies belonging to different families

Family: Hesperiidae

Family: Papilionidae



Family: Pieridae

Family: Lycinidae

Family: Nymphalidae

Fig. 9b. Butterflies protected under WPA (1972)

4. DISCUSSION

The one year long study documents the occurrence of altogether 51 butterfly species from six different study sites (representing individual habitat qualities) throughout four different seasons approximately from 10 km^2 of study area. A total of 3049 individuals found covering around 156 km^2 transect tract. Considering the overall socioeconomic profile, in

Taki, tourism is a significant determining factor regarding the overall built up and health of the local ecosystem (Table 1a). Particularly during winter and monsoon the R, GMC and RS sites are more exposed to seasonal tourism activity. Besides agricultural dependence, fish farming, poultry and apiary are the popular local small scale industries (Table :1b). Moderate to higher level of canopy coverage is available almost at every study site(as listed up in Table 1c), though, recently, the wild vegetation pattern and their natural distribution is being affected and fragmented due to various urbanization processes. In the present study, local determinants of biodiversity like inter and intra specific competition, predation etc. remained undetermined. Grossly the landscape heterogeneity and climatic changes in local and regional scale are considered to correlate with the observed butterfly diversity.

As presented in Table 2a, Nymphalidae is the most dominant butterfly family in terms of species composition (total of 19 species, 37%) and abundance (total number of individuals 1431, 47%), followed by Pieridae, Lycaenidae, Papilionidae and Hesperiidae contains the least number of species (5 species; 10% and 117 individuals, 4%). Regarding genus richness, the nymphalids (14 genera, 36%) outnumber the others while papilionids ranked last (4 genera, 10%) in the list. Regarding the species richness, *Papilio* (Family: Papilionidae) is the genus possessing maximum number of species (5). A similar pattern of predominance of Nymphalidae was also reported in different earlier studies (Tiple and Khurad, 2009; Nimbalkar *et al*., 2011; Chowdhury and Soren 2011; Kumar and Murugesan, 2014; Chowdhury, 2014). High abundance of nymphalids may be due to the availability of their specific larval host plants and food plants (Table : 4a and Table : 4b) in the study area (Saikia, 2011).

Table 2b provides a thorough checklist of 51 butterflies, their annual abundance (Fig. 2a) and seasonal availability. Four species of butterflies are listed as endangered in Wildlife (Protection) Act 1972 (Table : 2c) belonging to Nymphalidae (Schedule I, II and IV), Lycaenidae (Schedule I) and Papilionidae (Schedule I). Of them, only the common mime is rarely seen. Rests show moderate to common availability status. Although not protected in scheduled category, few butterflies like Common Rose, Blue Mormon, Yellow Orange Tip, Common Ciliate Blue, etc. were encountered only in fewer numbers. Regarding their frequency of occurrence in Taki, the One Spot Grass Yellow (Pieridae) is classified as ‘very rare’. Papilionidae bears maximum (4) ‘rare’ species at Taki (Fig. 2a). Besides, this region does not hold any endemic species of butterflies Of the 51 species of butterflies most are ‘common’ and ‘generalists’, as none of them are threatened globally as per the IUCN Red List (2015).

All the families show declined abundance at R and GMC (Fig. 8a). Similarly, during winter and monsoon comparatively lower abundance of butterflies observed, which is true for all families (Fig. 8b).The reasons may be multifactorial, both of natural and anthropogenic origin. Plant phenology, variation of canopy coverage and changes in light intensity at different microhabitats are influencing parameters for this diurnal organism’s distribution and species richness. At GMC, there is prevalence of trees, adapted for intertidal zone. The aerial root and canopy of mangroves provide specific microhabitats for butterflies and their resource (Nagelkerken *et al*., 2008), but generally there is deficiency of common larval food plants and nectar plants. Soil sodium content is the primary puddling cue (Boggs and Nieminen, 2004). Males transfer 32% of their abdominal sodium to the females during their first mating. Thus higher sodium intake level guarantees higher reproductive fitness of the males (Kenneth 1987; Saha, 2007-2008). Soil salinity is another important determinant of butterfly distribution.

At monsoon, coincidence of their developmental stages with the climatic parameters may detain the visitors from spotting the adult individuals. The lower environmental temperature during winter restricts the normal distribution range of these poikilothermic creatures. Though butterflies are found during winter in their unique behavioural mode of dorsal and lateral basking to keep their body temperatures up to the ambient temperature (Kehimkar, 2008). On anthropogenic part, daily increment in human settlements, grazing, pesticidal effluents, increased abundance of decorative plants, particularly at R, the accelerated seasonal tourism activities at both sites are some of the factors designing the community composition of butterflies.

Both maximum number of species (48) and individuals (906) are reported from the SC site, with highest values of Shannon index of diversity (H′= 3.44), and species richness (R = 6.9). Site R shows maximum value for species evenness (J = 0.92). The lowest Shannon index is shown at GMC (H′ = 2.93), along with least values of species evenness (J = 0.83) and species richness (R = 5.97) (Table 3a). At GMC, maximum dominance is indicated by the Simpson's Dominance Index D = 0.081, followed by at MCLA (D = 0.054). The least dominance value is found at V (D = .038). Maximum beta diversity is indicated by the obtained value of 0.96 for SC-V and the lowest value obtained is 0.77 for RS-GMC (Table 3b).

A previous study (Wynter-Blyth 1957) had identified two seasons as peaks, March-April (summer) and October (post monsoon) for butterfly abundance in India. Butterflies are said to form peaks at transition periods between the wet and dry seasons (Emmel and Leck, 1970). Our study, however, follows the same line, as the maximum number of butterfly species (45) and the maximum number of individuals (1168) is recorded during the post monsoon. Shannon-Weiner diversity index (H′ = 3.37) along with the Evenness index of species distribution (J = 0.9) also exhibited highest values during this season. Species richness showed maximum values during post monsoon (R = 6.23), summer (R = 5.77) followed by monsoon (R = 4.85) and winter (R = 3.38) (Table 3c). Simpson's Dominance index is highest for winter (D = 0.87), for the rest seasons, dominance values maintained at quite lower level, and therefore, high evenness is established. The Sorensen's index is also highest for summer-post monsoon (0.84) and lowest between monsoon and winter (0.42) (Table 4b). This pattern is consistent with that of Wynter-Blyth (1957), Kunte (1997) and Padhye *et al*. (2006). Significant evenness values indicate towards the absence of noteworthy disturbing parameters. Maximum species diversity along with highest species evenness as observed during the post monsoon could be correlated with the suitable phenophase providing abundant distribution of luxurious vegetation supporting the growth of the larval stages.

The Simpson (D) and Shannon-Weiner (H′) and Pielou's Evenness (J) indices revealed that in some habitats the individuals among species were not evenly distributed during the survey period. This indicates that some species are 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 biotic and abiotic environmental factors.

Butterfly diversity at local or regional scales is closely related to their host plant density (Gutierrez and Mendez, 1995; Cowley *et al.,* 2001). Butterflies bear a long term co evolutionary relationship with plants (Ehrlich and Raven, 1964; Kunte, 2000; Tiple *et al*., 2006). The life span of adult butterflies, consisting of a complex life cycle, ranges between one week and eight months, and averages two to three weeks in length (Bashar, 2013). There is specific age and sex based host plant correlation profile. They usually implies on more vascular plant species for egg laying by females. Leaves and branches of trees and shrubs, climbers, and grasses serve as substrate for butterfly eggs. The developmental stages rely on specific larval host plant for foliage and shelter, whereas adults are dependent on nectar and pollen as their primary nutritional resource (Nimbalkar *et al*., 2011). Differences of nectar plant use between sexes and generations (as food and mode of feeding vary with life stages) of butterflies are reported (Bakowski *et al*, 2009).

Butterflies behave like opportunistic foragers (Courtney and Shapiro, 1986) during nectar gathering, but their choice of flowers is not random, often they possess species specific flower preferences. Nectar resources for adults are likely important limiting factors (Gilbert and Singer, 1975) and may shape community patterns (Gilbert, 1984).Visits of butterflies are more frequent to flowers of herbs and shrubs, rather than to the flowers of trees. Thus, butterfly diversity of any particular habitat reflects especially the diversity of herbs and shrubs in the given area. Herbs and shrubs begin their life cycle in the beginning of the monsoon and complete it by the end of post monsoon, though some shrubs like *Lantana camara* shows flowering throughout the year. They provide consistent power fuel to these flighting creatures. Butterflies hold the position next to the bees as the efficiency of pollen transfer concerned, still, many plant species, particularly those bearing the wild flowers, would be unable to reproduce without the assistance of these beautiful insects.

Tables 4a & b provide information about the larval host plants and nectar plants commonly visited by the local butterfly species, acting as functional pollinators for those plant species. During the developmental stages, nymphalid butterflies depend on host plants belonging to twelve different families of angiosperms. Papilionids and lycaenids depend on six, pierids on five and hesperiids on four different families of plants for larval development to the adult stage. Most of the species belonging to all the five families are found to be polyphagous. Nymphalids feed on nectar from eleven different plant families, papilionids on six, pierids on five, hesperiids on four and lycaenids on three different families. For all the observed butterflies from our study site, nectar plants belong to twenty different families. Fifteen of them show very specific correlation pattern with butterfly populations as each of them found to support the butterflies belonging to only one family.

Also there are few plant families that provide support to multiple butterfly families, like Verbenaceae cater to four different butterfly families followed by Asteraceae, Acantheceae, catering to three and Rubiaceae and Rutaceae to two different butterfly families. Similarly for the larval development, there are twenty single plant families sheltering single butterfly families and four plant families are documented to act as foliage resource towards multiple butterfly families like Papilionaceae serving three different butterfly families, whereas, Poacea, Caesalpiniaceae, Malvaceae serving two families. In the present study, Nymphalidae (12) shows highest host plant diversity (number of plant families used per butterfly family), followed by Papilionidae (6), Lycaenidae (6), Pieridae (5) and Hesperiidae (4). For nectaring purpose, again Nymphalidae shows the highest diversity (11), followed by Papilionidae (6), Pieridae (5), Hesperiidae (4) and Lycaenidae (3). Butterflies are found to depend more on dicotyledons than on monocotyledons.

The only two families associated with the monocotyledons (Poaceae, Arecaceae, Zingiberaceae) are Hesperiidae and Nymphalidae (Table 4a).

Some typical behavioural attributes of the butterflies, like basking, resting, courtship, etc. are noted to be performed on ground or around some shrubs or herbs or trees like

Triticum sp., *Bambusa* sp., *Magnolia* sp., *Nerium* sp., *Vicia* sp., *Dolichos* sp., *Mimosa* sp., *Avicenia* sp., *Adhatoda* sp., *Andrographis* sp., *Hygrophyla* sp., *Bougainvillea* sp., *Thevetia* sp., *Neolamarckia* sp. in all the study sites. None of the documented butterflies are reported as potential pests till date (on basis of random survey among local farmers).

The host plants and the related butterfly species often are known to share some biochemical features. Certain larvae fed on Brassicaceae are known to detoxify and eliminate rather than sequester the degradation products of glycosinolates (present in Brassicales) (Miller *et al*., 2003). Some distasteful butterflies (the model),do not synthesize poison on their own, rather use poison chemicals from their food plants for their self-protection benefit. Certain plants like *Calotropis, Aristolochia, Passiflora* are poisonous and avoided by herbivore predators. Some caterpillars are able to digest the plant poison and store in their body to become distasteful and to be avoided by higher order predators like birds. Encashing this adaptive property, coexistence is already reported of certain model-mimic sets (both Mullerian and Batesian types) in this locality (Ghosh and Saha, 2016).

In the present study, surveying through all the study areas, it became prominent that, at SC and V, presence of orchards, gardens, kitchen gardens, etc. cater to a multiple array of floral population including those of trees, herbs, shrubs and the wild flora nurturing much greater number of butterflies of all the families (Fig. 8a). At RS, natural vegetation profile is predominated by herbs and shrubs and wild flowers beside the railway tracks providing exclusive niches to an interesting variety of butterflies. At MCLA, prioritized by cultivable lands, vegetation maintain a more or less homogenous level with less richness of plant species that act as hosts for butterflies, particularly the bush plants are totally absent. Use of pesticides also impart adverse effects at this site. Here, the seasonal cultivation of *Tagetes* sp., *Calendula* sp., *Solanum* sp., *Musa* sp., *Cucurbita* sp., *Balsam* sp., *Vigna* sp. offers seasonal surge to related butterfly populations. The agricultural fields are unique ecosystems providing suitable microhabitats to some butterflies to complete their life cycle (Dwari and Mondal, 2015). On return, butterflies serve the ecosystem by recycling nutrients (N, P, and K) essential for crops (Schmidt and Roland, 2006). Their larvae release faeces while feeding on the agrestals and provide required nutrients to the crops (Marchiori and Romanowski, 2006).

In contrast, at GMC and R, the diversity of plants is however restricted. Both the sites are with less abundance and species richness of butterflies as the relative abundance of butterflies varies with the number of the host plant species in unit area as observed in different geographical locations (Yamamoto *et al.,* 2007; Bhardwaj *et al*., 2012; Patel and Pandya, 2014).

At GMC, there is prevalence of mangrove plantation including goran (*Ceriops* sp.), baen (*Avicennia* sp.), keora (*Sonneratia* sp.), and gewa (*Excoecaria* sp.), golpata (*Nipa* sp.), kankra (*Bruguiera* sp.), etc., many herbs (dhani ghaas, *Porteresia* sp.), shrubs and climbers such as baoli lata (*Sarcolobus* sp.), asam lata (*Mikania* sp.), swarpogandha (*Aristolochia* sp.), dodhi lata (*Tylophora* sp.), akonda (*Calotropris* sp.), hargoza (*Acanthus* sp.) and Ipomoea (*Ipomoea* sp.) which act as good attractants for various butterflies, for nectar collection and egg laying. However, most of the butterflies found in this mangrove forest are in general periodic visitors coming from nearby places (Larsen, 2004). Butterflies play a vital role in maintaining the mangrove ecosystem by pollination. The general constraint factors at GMC are deficient food sources, nonnutricious mangrove leaves, strong sunlight, high temperature and desiccation (Kathiresan and Bingham, 2001), intrusion of saline water during tidal influx, grazing and other short term agricultural practices and integrated fish culture.

These have modified the intrinsic floral spectrums, leading to the lowered species richness. The fairly high beta diversity between RS-GMC (0.77), SC-GMC (0.78), R-GMC (0.78), V-GMC (0.80), MCLA-GMC (0.85), reflects the local immigration of diverse butterflies from different nearby habitats to the mangrove covered GMC sites.

Short term paddy cultivation is common, but the common rice plant visiting hesperiids like Rice Swift, Small Branded Swifts are not prominently found here. The background reason may be explained on the basis of the multiple or alternate host plant dependence hypothesis. Such type of dependence and preferable switching to an array of different host plants, at most of the times turns to be evolutionarily beneficial, as, native butterflies opt for alternate (may be the invasive ones) host plants, increased chances of multivoltinism and decreased predatory risk (as often the larval prey detection by the predators and parasitoids mediated by the chemical cues released from the respective plants) lead to higher reproductive fitness (Gravesa *et al.*, 2003). On the plant's side it becomes useful by ensuring cross pollination and promoting the hybrid vigour and better resilience against diseases. The mutual dependence act as driving force for the perpetuation of both of the butterfly and plant species at the sites of common occurrence. So, in any habitat, if there is absence of few host plants in the series, the butterflies may not feel the site much suitable to meet their life proceses. In GMC, the absence of other host plants for the paddy field visiting butterflies other than rice, may be the cause of their absence.

The R site faces heavy grazing pressure and exposed to pesticidal effluents. Intertidal influences also present there. Lycaenids feeds on grasses, their distribution gets affected. Effect of tourism load is also maximum at R and GMC sites. They lack the garden or orchard plants which can act as major nectar source. Interestingly at both the sites *Acanthus* (Hargoja), the gregarious, mangrove associated tall shrubs are of common occurrence. The flowering season of this plant spans between May to November, resonating the frequency of visiting populations of the nymphalid Peacock Pansy (Figs: 7a & b).

Early summer, particularly the month of March is the flowering season for most of the angiosperms. A huge number of butterflies are found during this season. Rainy season is the preparatory "caterpillar period". Again there is sudden hike in butterfly visits during post monsoon particularly in/at the month of October. Being poikilothermic creatures (butterflies require body temperatures of 30-35 °C for optimal growth and development) to compensate the metabolic challenges they keep dormant and are comparatively less prominent during December and January (Van Swaay *et al.*, 2010) (Fig. 8b).Thus, the seasonal parameters direct the vegetation profile of any particular habitat, ultimately the major determining factors of abundance, richness and dominance or evenness of any particular butterfly community (Barlow *et al.*, 2007). Even the nectar composition and concentration shows temporal variation in response to natural and induced factors like weather conditions and exploitations (Shreeve, 1992).

In the study area, grazing pressure, influx of tourists, construction of highways, use of pesticides and change in land use pattern, are mainly responsible for diversity loss of both butterflies and plants. Conservation of butterflies are being emphasised for several reasons, including their potential value as indicator or focal species and functions that collectively add to the ecosystem services (Strien *et al.*, 2009; Bonebrake *et al.*, 2010) and also for ecotourism and research purposes. In systematic conservation planning, monitoring and mapping of biodiversity is the first step (Margules and Pressey, 2000).Urban greening, by maintaining small patches of gardens in housing areas, at the sides of the streets, besides railway tracks are valuable sites to reduce the alteration and reduction in the natural communities due to the different development programmes of urban areas (Gaston *et al*., 2005; Mathew and Anto, 2007, Haq, 2011). Sustainable conservation for host plants in the concerned landscape (Smallidge and Leopold, 1997) and nectar plants is urgent as nectar shortage may reduce adult longevity and fecundity (Jervis *et al.,* 2005) and increased emigration from breeding sites (Fred and Brommer, 2009). Some practical and useful measures must be taken for Butterfly Habitat Management like Wildflower (assorted herbs, shrubs and grasses) plantings, garden designing, puddle creating, encouraging native legumes dock, milkweed, nettle, and native grasses; reducing pesticide and herbicide use in agricultural areas, using mechanical means of pest control to minimize loss of nectar-producing trees, shrubs and flowers; maintaining natural and planted grassland by conducting prescribed rotational burning; restoring hydrology and vegetation in forested wetlands; preserving existing trees, shrubs, vines, hedgerows, and wildflowers (NRCS and WHC, 2000), promotion of low impact cutting of ecological compensation areas (the only semi-natural habitats left in many rural areas including green lanes and weed margins) mainly during the flowering of the weeds (Fabbri and Scaravelli, 2002).

The present documentation leaves further scope of detailed study of local butterflies regarding the ethological attributes, the inter and intra specific interactions at functional, behavioural, ecological and evolutionary aspects, specific resource utilization pattern, character displacement at the population level (if any), formation of ecological guild and metapopulational distributions utilizing the varied microhabitat arrays by continuing minute, thorough observations, which ultimately would be helpful for preparing suitable conservation scheme. Long term diversity study may throw light on ecological succession process along the gradient of habitat parameters.

ACKNOWLEDGEMENTS

The authors remain obliged to Prof. Dinendra Raychaudhuri for his crtiical comments. Authors further wish to thank Dr. Santanu Saha, Associate Professor, Dept. of Botany, Taki 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.

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(Received 10 June 2016; accepted 27 June 2016)