Journal of Threatened Taxa | www.threatenedtaxa.org | 26 January 2014 | 6(1): 5327–5342

ISSN
Online 0974–7907
Print 0974–7893

OPEN ACCESS

Seasonal diversity of butterflies and their larval food plants in the surroundings of upper Neora Valley National Park, a sub-tropical broad leaved hill forest in the eastern Himalayan landscape, West Bengal, India

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Abstract: Seasonal butterfly diversity in the adjacent areas of the upper Neora Valley National Park, a part of the Himalayan landscape, was studied. The available larval host plant resources present within, as well as in the adjoining areas of transect were identified. A total of 4163 butterflies representing 161 species belonging to five families were recorded during this study. One-hundred-and-forty-three species of plants belonging to 44 families served as the larval food plants of butterflies. The maximum number of butterfly species and maximum number of individuals were sampled during the monsoons. The monsoons with least skewed rank abundance curve of species distribution, was also marked by maximum species diversity and maximum species evenness. This was probably due to the abundant distribution of luxurious vegetation that served as food plants for the larval stages of butterflies. Nymphalidae was the most dominant family with 43.48% of the total number of species. Autumn followed by the monsoon was associated with high species richness probably due to the abundance of vegetation that provides foliage to its larval stages.

Keywords: Autumn, Butterfly diversity, Himalayan landscape, larval food plant, monsoon, Neora Valley National Park, Nymphalidae, rank abundance curve, species evenness, species richness.

DOI: http://dx.doi.org/10.11609/JoTT.o3446.5327-42 | **ZooBank:** urn:lsid:zoobank.org:pub:748950A3-E4AA-4865-ABC7-DAF294C33BEE

Editor: B.A. Daniel, Zoo Outreach Organization, Coimbatore, India. **Date of publication:** 26 January 2014 (online & print)

Manuscript details: Ms # o3446 | Received 19 December 2012 | Final received 09 October 2013 | Finally accepted 03 December 2013

Citation: Sengupta, P., K.K. Banerjee & N. Ghorai (2014). Seasonal diversity of butterflies and their larval food plants in the surroundings of upper Neora Valley National Park, a sub-tropical broad leaved hill forest in the eastern Himalayan landscape, West Bengal, India. *Journal of Threatened Taxa* 6(1): 5327–5342; http://dx.doi.org/10.11609/JoTT.o3446.5327-42

Funding: Self funded.

Competing Interest: The authors declare no competing interests.

Authors Contribution: PS was involved in the sampling, identification of studied species; statistical analysis of recorded data, manuscript preparation and site management. KKB was involved in data interpretation, literature survey and framing up of research questions. NG was engaged in the sampling, identification of studied species; statistical analysis of recorded data, data interpretation, framing up of questions and hypothesis along with manuscript preparation.

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Acknowledgements: The authors are thankful to the Head, Department of Zoology, West Bengal State University, West Bengal, India for his constant encouragement and support during the entire study period. Authors would like to extend their gratitude to Professor Gour Maiti, Department of Botany, Kalyani University, West Bengal, India for his assistance in the identification of all the plant based resources. The guidance and efforts of Ram Kumar Chettri, forest guide, Gorumara National Park is also acknowledged by the authors. The authors would like to extend their sincere thanks to Siraj-ul-Haq, Dhruba Manta, Somnath Mandal and all the forest personnel of NVNP for their cooperation and help.

INTRODUCTION

Studies in India (Kunte 1997; Padhye et al. 2006; Bhusal & Khanal 2008) have established a relationship between butterfly species richness, density and diversity with respect to seasonality. For instance, tropical butterflies have been shown to be sensitive to seasonal changes in rainfall (Barby 1995; Hill et al. 2003). Wynter-Blyth (1957) documented 835 species from the eastern Himalaya in sharp contrast to only 415 species from the western Himalaya. The lowland forests of Bhutan harbour a rich and unique diversity of butterflies with maximum number of species recorded during spring and minimum number during the monsoons (Singh 2012). Saikia et al. (2010), during their study on 109 species from Rani-Garbhanga Reserve Forests recorded seasonality of butterflies with differences in the butterfly abundances as well defined dry and wet season forms due to distinct plant phenological state in different seasons of the year. Although a list of butterflies from the Darjeeling District of West Bengal (Maude 1949) is available, studies on the butterflies inhabiting the rich and diverse Himalayan landscape of Neora Valley National Park (NVNP) are lacking. NVNP is located at the trijunction of West Bengal, Sikkim (India) and Bhutan on the north and northeast. *Rechila danda,* the highest point of this National Park is situated at 3,170m (Mallick 2010). Therefore, work was carried out to document diversity of butterflies in different seasons from the fringe regions of the upper range of NVNP. The diversity and seasonality of butterflies probably reflect the phenophases of their host plants (Kunte 1997). Therefore an attempt was also made to record the larval food plants of butterfly species.

MATERIALS AND METHODS

The present study was conducted in the adjacent areas of the upper range of the NVNP (26^{0}52'–27^{0}7'N & 88^{0}45'–88^{0}55'E) located in the Kalimpong sub-division of the Darjeeling District, West Bengal, India (Fig. 1). It was notified as a protected area in April 1986 and was gazetted in December 1992. The park authorities divided Neora Valley into two ranges, namely the upper range with its headquarters at Lava, serving as its western entry point

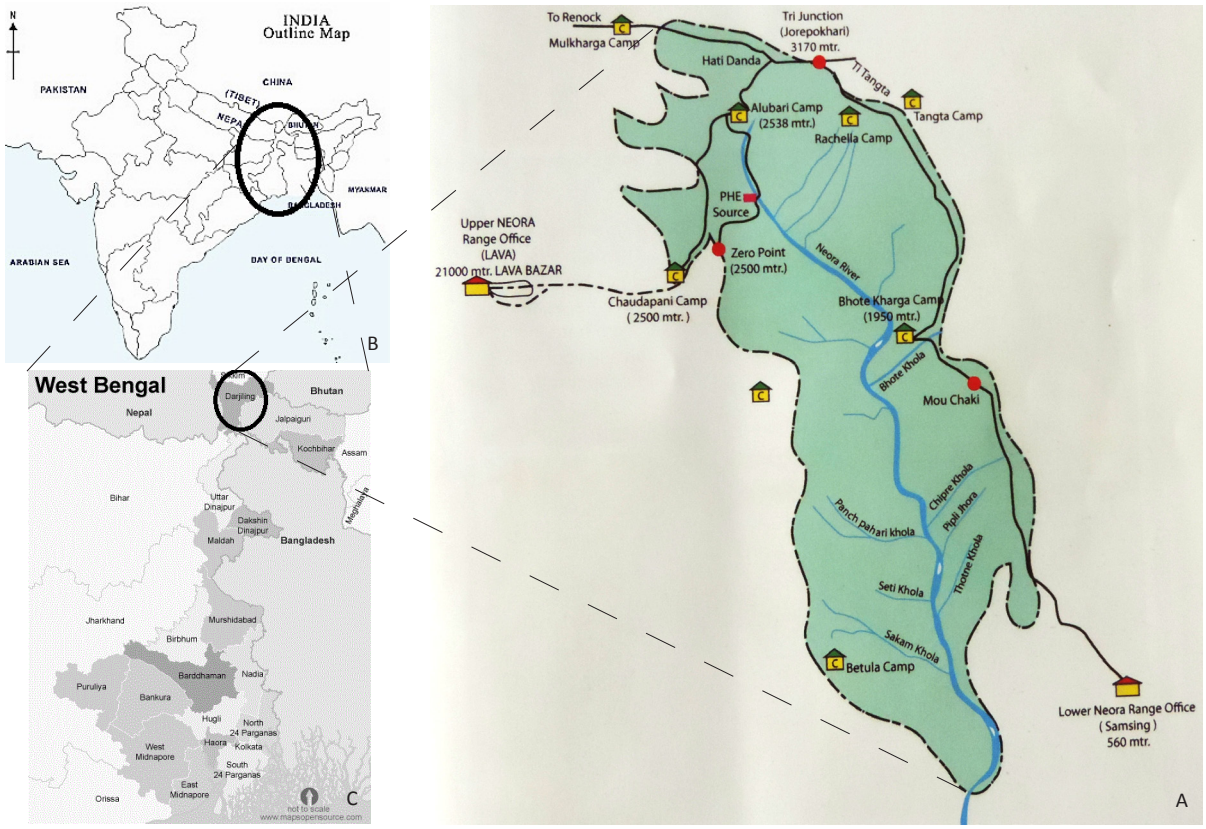

Figure 1. A - Map of Neora Valley National Park; B - Map of India showing the location of West Bengal; C - Map showing Kalimpong sub-division of Darjeeling District of West Bengal.

and the lower range with its headquarters situated at Samsing, the park's eastern entry point (Mallick 2010).

The phytogeography of NVNP includes subtropical broad leaved hill forest, montane wet temperate forest along with subtropical pine forest (Champion & Seth 1968). Rodgers et al. (2002) placed NVNP in the biogeographic zone 2. The park has a wide altitudinal range varying from183m in the plains to 3,200m in the hills (Mallick 2012). The climatic condition varies between tropical/subtropical in its lower range to temperate in its upper range (Mallick 2010). The forest structure at the study site was mostly undisturbed. The surrounding terraces had cultivated fields of forest adjoining dwellers.

Four trail-cum-trekking routes (total length: 16km) (Table 1) were selected as study sites (i.e., NVNP-1, NVNP-2, NVNP-3 and NVNP-4) (Table 1). The survey was conducted between June 2011 and May 2012, following the Pollard-Walk Method (Pollard 1977) at eight randomly selected line transects (approximately 500m length and 8m breadth) located in each of the study sites. Butterflies were observed twice a day, (06:00–13:00 hr in the morning and 14:00–17:00 hr in the afternoon) by walking at a constant pace at each transect. Less time was devoted for sampling in the afternoon due to reduced butterfly activity at that time of the day. Separate days were devoted to sample each transect in each study site weekly for a month with the help of two trained field assistants. The sampling procedure was repeated at an interval of 30 days. As far as possible, surveys were conducted on sunny days with less than 30% cloud cover, as butterfly activity is suppressed on windy or cloudy days (Weiss et al. 1988). The sampling days missed due to inclement weather conditions were recorded.

The butterflies were observed (using Bushnell binoculars) and photographed occasionally (using Nikon COOLPIX-P90) for subsequent identification from literature (Evans 1932; Wynter-Blyth 1957; Haribal 1992; Kunte 2000; Kehimkar 2008) and reference collection at Zoological Survey of India. For better interpretation of collected data the year was divided into five seasons (viz., Spring: March; Summer: April–May; Monsoon: June–September; Autumn: October–November; Winter: December–February). The division of seasons was based on the variation of rate of precipitation and temperature. Larval host plants were recorded in each transect and also identified from the adjoining areas of transect. These plants were identified from published literature (Cowan & Cowan 1979; Polunin & Stainton 2005; Maity & Maiti 2007; Das et al. 2008) along with assistance from plant taxonomists. Meteorological data (i.e., temperature, precipitation) were collected during the study period.

The diversity of butterfly species across seasons was calculated using Shannon index of diversity given by the equation, $H' = \Sigma pi\ (\ln pi)$, where, $pi = ni/N$; ni is the number of individuals of i^{th} species and $N = \Sigma ni$. The Shannon index, which combines the number of species within a site with the relative abundance of each species (Shannon 1948; Magurran 1988) was determined using vegan package of "R". Margalef's species richness was used to compare the species richness across seasons. This index was calculated using equation $R = (S-1)/\ln N$, where S is the number of species and N is the number of individuals (Magurran 1988). Evenness of species reveals how their relative abundance is distributed in a particular site or sample (Pielou 1969; Magurran 1988). This index is given by the equation, $E = H'/\ln S$, where H' is the Shannon index of diversity and S is the number of species. Rank abundance diagram was plotted to represent the distribution pattern of species abundances across each season during the study period (Whittaker 1965). Month-wise variation in the number of species sampled during the study period was represented graphically.

RESULTS

One-hundred-and-sixty-one species of butterflies belonging to five families (i.e., Nymphalidae: 43.48%,

Table 1. Detail parameters of sampling site

Study site	Geographical position	Average altitude	Location	Length of trails surveyed	Forest type
NVNP-1	27°05'N & 88°42'E	2,358m	Lava-Chaudapheri	2km	*Quercus-Lithocarpus-Arundinaria* forest type
NVNP-2	27°07'N & 88°43'E	2,538m	Chaudapheri-Alubari	5km	Lauraceous forest type
NVNP-3	27°04'N & 88°42'E	2,050m	Doley Camp in the mountain ridges of Pankhasari 2 block	7km	*Magnolia-Michelia* as forest type
NVNP-4	27°05'N & 88°43'E	2,958m	Alubari-Jorepokhri	2km	Rocky forest floor covered with thick litter

Lycaenidae: 27.95%, Hesperiidae: 11.18%, Pieridae: 9.32% and Papilionidae: 8.07%) were observed at different sites during the entire study period (Table 2).

During summer (April–May), the temperature varied from 3–6 ^{0}C (min.) to 20–21 ^{0}C (max.) and a precipitation of 95.2–239 mm was recorded, while the monsoon months (June-September) had a temperature of 7–8 ^{0}C (min.) and 22–23 ^{0}C (max.), with a maximum precipitation of 589–620 mm. 1–4 ^{0}C (min.) and 20–22 ^{0}C (max.) temperature was recorded during autumn (October–November), with a precipitation between 16.4–30.0 mm. Winter (December–February) temperatures ranged from minus 3–1 ^{0}C (min.) to 18 ^{0}C (max.), while 4.2–10.9 mm of precipitation was recorded. Spring (March) had a minimum temperature of 2 ^{0}C and maximum temperature of 20 ^{0}C with a precipitation of 20mm (Table 3).

As November to February was marked by a number of foggy days (Table 4), sampling was carried out mostly on sunny days. July had the maximum number of rainy days (Table 4). Thus, a total of 192 days of sampling was carried out during the entire study period, each day devoted to two transects studied in the study site (Table 4).

The number of butterfly species and the total number of individuals recorded is shown in Table 5. The maximum number of butterfly species (158) and the maximum number of individuals (2480) was recorded during the monsoons. Shannon index of diversity (H´=4.968) along with the evenness index of species distribution (E=0.981) also exhibited highest values during this season (Table 5) as compared to summer (H´=4.819; E=0.974), autumn (H´=4.714; E=0.961), spring (H´=4.282; E=0.914) and winter (H´=3.872; E=0.811). The season wise species richness values are recorded in Table 5. Species richness showed maximum values during autumn (21.78), summer (21.58) followed by monsoon (20.09) (Table 5). Additionally, the rank abundance curve plotted to represent the distribution pattern of butterfly species, was least skewed during the monsoons, as supported by highest values of Shannon diversity and Evenness index during this season (Fig. 2). In contrast, winter was associated with a most highly skewed species abundance relationship as evident by lowest values of Shannon diversity and Evenness index (Fig. 2). However, rank abundance curve showed intermediate skewness in case of summer, autumn and spring. The curve representing the month-wise change in the number of species showed an increasing trend from March, through April, and reached its peak in June due to increased number of species with the approaching monsoon. This curve was almost steady throughout this season, and formed a second shorter peak during September–October followed by a decrease in the number during late autumn and winter gradually (Fig. 3).

A total of 143 species of plants belonging to 44 families were recorded as the larval host plants of the butterflies (Table 6). An overwhelming number of butterfly larvae fed on dicotyledons rather than on monocots. The only two groups associated with the monocotyledons were Satyrinae subfamily of Nymphalidae and Hesperiinae subfamily of Hesperiidae butterflies. Nymphalidae utilized 25 plant families and thereby exhibited highest host plant diversity (number of plant families used per butterfly family) in this study site (Table 6). Larvae of Satyrinae mostly preferred plants of Poaceae. Plants of Urticaceae supported a large population of *Acraea* sp.

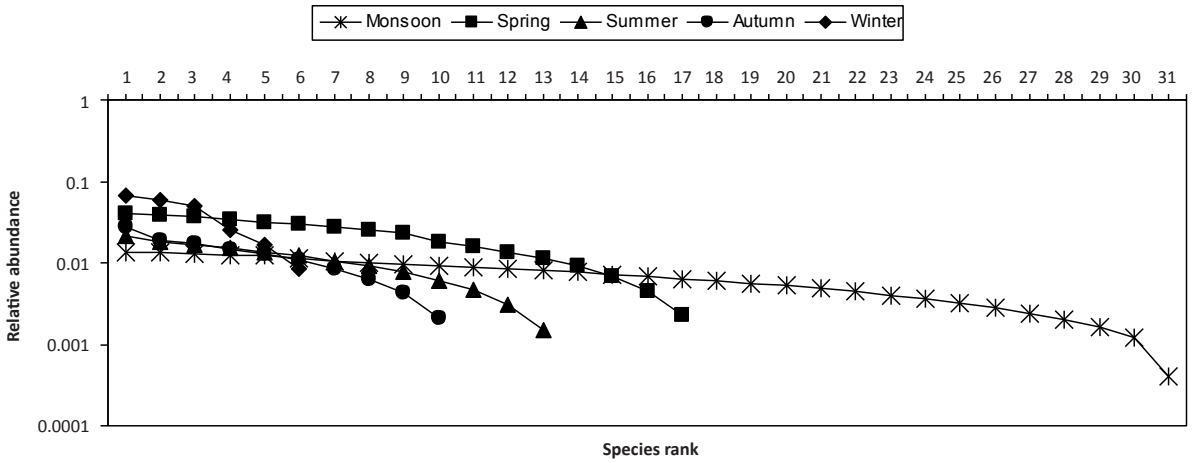

Figure 2. Rank-Abundance of butterflies in relation to seasonal variation. The y-axis shows the relative abundance of species (plotted using log_{10} scale) while the x-axis ranks each species in order from most to least abundant.

Table 2. Seasonal sightings of butterfly species recorded in the surroundings of the upper range of Neora Valley National Park

	Common name	Scientific name	Seasonal sightings					
			I (pi)	II (pi)	III (pi)	IV (pi)	V (pi)	T
	Family: Nymphalidae Subfamily: Satyrinae							
1	Common TreeBrown	*Lethe rohria* (Fabricius)	3 (0.0068)	7 (0.0106)	18 (0.0072)	4 (0.0085)	0 (0.00)	32
2	Banded TreeBrown	*Lethe confusa* Aurivillius	3 (0.0068)	5 (0.0076)	21 (0.0085)	4 (0.0085)	1 (0.0085)	34
3	Common Red Forester	*Lethe mekara* (Moore)	0 (0.00)	0 (0.00)	12 (0.0048)	2 (0.0043)	0 (0.00)	14
4	Common Forester	*Lethe insana* (Kollar)	3 (0.0068)	7 (0.0106)	25 (0.010)	5 (0.0107)	0 (0.00)	40
5	Brown Forester	*Lethe serbonis* (Hewitson)	0 (0.00)	0 (0.00)	22 (0.0089)	2 (0.0043)	0 (0.00)	24
6	Blue Forester	*Lethe scanda* (Moore)	1 (0.0023)	0 (0.00)	12 (0.0048)	0 (0.00)	0 (0.00)	13
7	Bamboo Forester	*Lethe kansa* (Moore)	1 (0.0023)	4 (0.0061)	19 (0.0077)	3 (0.0064)	0 (0.00)	27
8	Pale Forester	*Lethe latiaris* Hewitson	0 (0.00)	3 (0.0046)	15 (0.0060)	1 (0.0021)	0 (0.00)	19
9	Rusty Forester	*Lethe bhairava* (Moore)	0 (0.00)	1 (0.0015)	14 (0.0056)	4 (0.0085)	1 (0.0085)	20
10	Straight banded TreeBrown	*Lethe verma* (Kollar)	0 (0.00)	6 (0.0091)	20 (0.0081)	6 (0.0128)	0 (0.00)	32
11	Yellow Woodbrown	*Lethe nicetas* (Hewitson)	0 (0.00)	7 (0.0106)	8 (0.0032)	0 (0.00)	0 (0.00)	15
12	Large Goldenfork	*Lethe goalpara* (Moore)	0 (0.00)	0 (0.00)	19 (0.0077)	1 (0.0021)	0 (0.00)	20
13	Liliacfork	*Lethe sura* (Doubleday)	0 (0.00)	1 (0.0015)	12 (0.0048)	2 (0.0043)	1 (0.0085)	16
14	Small Silverfork	*Zophoessa jalaurida* De Niceville	3 (0.0068)	3 (0.0046)	14 (0.0056)	3 (0.0064)	2 (0.0169)	25
15	Dusky Labyrinth	*Neope yama* (Moore)	0 (0.00)	6 (0.0091)	17 (0.0068)	0 (0.00)	0 (0.00)	23
16	Veined Labyrinth	*Neope pulaha* (Moore)	0 (0.00)	5 (0.0076)	31 (0.0125)	0 (0.00)	0 (0.00)	36
17	Lilacine Bushbrown	*Mycalesis francisca* (Stoll)	1 (0.0023)	5 (0.0076)	34 (0.0137)	3 (0.0064)	0 (0.00)	43
18	Chinese Bushbrown	*Mycalesis gotama* Moore	1 (0.0023)	2 (0.0030)	8 (0.0032)	1 (0.0021)	0 (0.00)	12
19	Wood Mason's Bushbrown	*Mycalesis suaveolens* Wood-Mason & de Nicéville	0 (0.00)	4 (0.0061)	7 (0.0028)	0 (0.00)	0 (0.00)	11
20	Common Satyr	*Aulocera swaha* (Kollar)	0 (0.00)	5 (0.0076)	20 (0.0081)	1 (0.0021)	0 (0.00)	26
21	Great Satyr	*Aulocera padma* (Kollar)	0 (0.00)	3 (0.0046)	20 (0.0081)	1 (0.0021)	0 (0.00)	24
22	Ringed Argus	*Callerebia ananda* (Moore)	0 (0.00)	2 (0.0030)	14 (0.0056)	1 (0.0021)	0 (0.00)	17
23	Pallid Argus	*Callerebia scanda* (Kollar)	0 (0.00)	0 (0.00)	22 (0.0089)	1 (0.0021)	0 (0.00)	23
24	Large Threering	*Ypthima nareda* (Kollar)	2 (0.0045)	5 (0.0076)	12 (0.0048)	2 (0.0043)	0 (0.00)	21
25	Himalayan Fivering	*Ypthima sakra* Moore	2 (0.0045)	6 (0.0091)	20 (0.0081)	7 (0.0149)	3 (0.0254)	38
	Subfamily: Heliconiinae							
26	Yellow Coster	*Acraea issoria* (Hübner)	3 (0.0068)	5 (0.0076)	22 (0.0089)	5 (0.0107)	1 (0.0085)	36
27	Large Silverstripe	*Childrena childreni* (Gray)	0 (0.00)	5 (0.0076)	21 (0.0085)	5 (0.0107)	0 (0.00)	31
28	Indian Fritillary	*Argyreus hyperbius* (Linnaeus)	2 (0.0045)	4 (0.0061)	19 (0.0077)	5 (0.0107)	2 (0.0169)	32
29	Queen of Spain Fritillary	*Issoria lathonia* (Linnaeus)	2 (0.0045)	5 (0.0076)	19 (0.0077)	6 (0.0128)	1 (0.0085)	33

	Common name	Scientific name	Seasonal sightings					
			I (pi)	II (pi)	III (pi)	IV (pi)	V (pi)	T
	Subfamily: Limenitinae							
30	Green Commodore	*Sumalia daraxa* (Doubleday)	0 (0.00)	4 (0.0061)	18 (0.0072)	2 (0.0043)	0 (0.00)	24
31	White Commodore	*Parasarpa dudu* (Doubleday)	0 (0.00)	7 (0.0106)	20 (0.0081)	4 (0.0085)	0 (0.00)	31
32	Bicolour Commodore	*Parasarpa zayla* (Doubleday)	0 (0.00)	0 (0.00)	19 (0.0077)	2 (0.0043)	0 (0.00)	21
33	Commodore	*Auzakia danava* (Moore)	0 (0.00)	6 (0.0091)	21 (0.0085)	1 (0.0021)	0 (0.00)	28
34	Common Sergeant	*Athyma perius* (Linnaeus)	2 (0.0045)	4 (0.0061)	21 (0.0085)	4 (0.0085)	3 (0.0254)	34
35	Himalayan Sergeant	*Athyma opalina* (Kollar)	2 (0.0045)	6 (0.0091)	20 (0.0081)	3 (0.0064)	0 (0.00)	31
36	Chestnut Streaked Sailer	*Neptis jumbah* Moore	0 (0.00)	0 (0.00)	20 (0.0081)	6 (0.0128)	0 (0.00)	26
37	Studded Sergeant	*Athyma asura* Moore	0 (0.00)	0 (0.00)	7 (0.0028)	0 (0.00)	0 (0.00)	7
38	Orange Staff Sergeant	*Athyma cama* Moore	1 (0.0023)	4 (0.0061)	19 (0.0077)	5 (0.0107)	1 (0.0085)	30
39	Yerbury's Sailer	*Neptis yerburyi* Butler	3 (0.0068)	5 (0.0076)	19 (0.0077)	3 (0.0064)	0 (0.00)	30
40	Common Sailer	*Neptis hylas* (Linnaeus)	0 (0.00)	0 (0.00)	14 (0.0056)	6 (0.0128)	0 (0.00)	20
41	Yellow Sailer	*Neptis ananta* Moore	2 (0.0045)	4 (0.0061)	18 (0.0072)	3 (0.0064)	2 (0.0169)	29
42	Common Baron	*Euthalia aconthea* (Cramer)	1 (0.0023)	3 (0.0046)	12 (0.0048)	3 (0.0064)	2 (0.0169)	21
43	Gaudy Baron	*Euthalia lubentina* (Cramer)	0 (0.00)	4 (0.0061)	16 (0.0064)	2 (0.0043)	0 (0.00)	22
44	Green Duke	*Euthalia sahadeva* (Moore)	0 (0.00)	0 (0.00)	10 (0.0040)	2 (0.0043)	0 (0.00)	12
45	Grey Count	*Tanaecia lepidea* (Butler)	1 (0.0023)	6 (0.0091)	19 (0.0077)	4 (0.0085)	3 (0.0254)	33
	Subfamily: Cyrestinae							
46	Common Map	*Cyrestis thyodamas* Boisduval	2 (0.0045)	5 (0.0076)	19 (0.0077)	5 (0.0107)	2 (0.0169)	33
47	Tabby	*Pseudergolis wedah* (Kollar)	0 (0.00)	5 (0.0076)	17 (0.0068)	5 (0.0107)	2 (0.0169)	29
	Subfamily: Biblidinae							
48	Common Castor	*Ariadne merione* (Cramer)	2 (0.0045)	3 (0.0046)	15 (0.0060)	3 (0.0064)	2 (0.0169)	25
49	Angled Castor	*Ariadne ariadne* (Linnaeus)	3 (0.0068)	2 (0.0030)	16 (0.0064)	2 (0.0043)	1 (0.0085)	24
	Subfamily: Apaturinae							
50	Indian Purple Emperor	*Apatura ambica* Kollar	2 (0.0045)	5 (0.0076)	15 (0.0060)	2 (0.0043)	1 (0.0085)	25
51	Sordid Emperor	*Apatura sordida* Moore	0 (0.00)	5 (0.0076)	19 (0.0077)	5 (0.0107)	0 (0.00)	29
52	Golden Emperor	*Dilipa morgiana* (Westwood)	1 (0.0023)	2 (0.0030)	9 (0.0036)	0 (0.00)	0 (0.00)	12
53	Circe	*Hestina nama* (Doubleday)	4 (0.0091)	6 (0.0091)	28 (0.0113)	8 (0.0170)	2 (0.0169)	48
	Subfamily: Nymphalinae							
54	Mongol	*Araschnia prorsoides* (Blanchard)	0 (0.00)	0 (0.00)	11 (0.0044)	2 (0.0043)	0 (0.00)	13
55	Blue Tailed Jester	*Symbrenthia niphanda* Moore	1 (0.0023)	2 (0.0030)	9 (0.0036)	1 (0.0021)	0 (0.00)	13
56	Himalayan Jester	*Symbrenthia hypselis* (Godart)	1 (0.0023)	5 (0.0076)	13 (0.0052)	2 (0.0043)	1 (0.0085)	22
57	Common Jester	*Symbrenthia hippoclus* (Cramer)	2 (0.0045)	4 (0.0061)	15 (0.0060)	3 (0.0064)	2 (0.0169)	26
58	Indian Red Admiral	*Vanessa indica* (Herbst)	4 (0.0091)	8 (0.0122)	24 (0.0097)	7 (0.0149)	2 (0.0169)	45

	Common name	Scientific name	Seasonal sightings					
			I (pi)	II (pi)	III (pi)	IV (pi)	V (pi)	T
59	Painted Lady	*Vanessa cardui* (Linnaeus)	3 (0.0068)	5 (0.0076)	20 (0.0081)	7 (0.0149)	2 (0.0169)	37
60	Indian Tortoise Shell	*Aglais cashmiriensis* (Kollar)	14 (0.0319)	3 (0.0046)	33 (0.0133)	8 (0.0170)	1 (0.0085)	59
61	Blue Admiral	*Kaniska canace* (Linnaeus)	1 (0.0023)	3 (0.0046)	14 (0.0056)	3 (0.0064)	1 (0.0085)	22
62	Danaid Eggfly	*Hypolimnas misippus* (Linnaeus)	2 (0.0045)	3 (0.0046)	15 (0.0060)	4 (0.0085)	2 (0.0169)	26
63	Orange Oakleaf	*Kallima inachus* (Boisduval)	0 (0.00)	4 (0.0061)	13 (0.0052)	3 (0.0064)	2 (0.0169)	22
64	Scare Blue Oakleaf	*Kallima alompra* Moore	0 (0.00)	0 (0.00)	14 (0.0056)	5 (0.0107)	0 (0.00)	19
	Subfamily: Libytheinae							
65	Common Beak	*Libythea lepita* Moore	3 (0.0068)	4 (0.0061)	16 (0.0064)	0 (0.00)	0 (0.00)	23
66	Club Beak	*Libythea myrrha* Godart	2 (0.0045)	5 (0.0076)	18 (0.0072)	2 (0.0043)	0 (0.00)	27
67	White Spotted Beak	*Libythea narina rohini* Marshall	0 (0.00)	4 (0.0061)	13 (0.0052)	0 (0.00)	0 (0.00)	17
	Subfamily: Danainae							
68	Double-banded Crow	*Euploea sylvester* (Fabricius)	11 (0.0250)	12 (0.0183)	0 (0.00)	0 (0.00)	0 (0.00)	23
69	Striped blue Crow	*Euploea mulciber* (Cramer)	5 (0.0114)	8 (0.0122)	26 (0.0105)	8 (0.0170)	2 (0.0169)	49
70	Common Crow	*Euploea core* (Cramer)	7 (0.0159)	8 (0.0122)	30 (0.0121)	8 (0.0170)	3 (0.0254)	56
	Family: Lycaenidae Subfamily: Curetinae							
71	Bright Sunbeam	*Curetis bulis* (Westwood)	6 (0.0137)	0 (0.00)	22 (0.0089)	4 (0.0085)	0 (0.00)	32
	Subfamily: Theclinae							
72	Powdered Green Hairstreak	*Neozephyrus zoa* (de Nicéville)	0 (0.00)	0 (0.00)	10 (0.0040)	0 (0.00)	0 (0.00)	10
73	Metallic Green Hairstreak	*Neozephyrus duma* (Hewitson)	0 (0.00)	4 (0.0061)	12 (0.0048)	0 (0.00)	0 (0.00)	16
74	Indian Oakblue	*Arhopala atrax* (Hewitson)	4 (0.0091)	5 (0.0076)	20 (0.0081)	0 (0.00)	7 (0.0593)	36
75	Powdered Oakblue	*Arhopala bazalus* (Hewitson)	0 (0.00)	10 (0.0152)	5 (0.0020)	13 (0.0277)	0 (0.00)	28
76	Silverstreak Blue	*Iraota timoleon* (Stoll)	5 (0.0114)	7 (0.0106)	19 (0.0077)	0 (0.00)	0 (0.00)	31
77	Truncate Imperial	*Cheritrella truncipennis* de Nicéville	0 (0.00)	3 (0.0046)	4 (0.0016)	8 (0.0170)	0 (0.00)	15
78	Double Tufted Royal	*Dacalana vidura* (Horsfield)	1 (0.0023)	1 (0.0015)	10 (0.0040)	0 (0.00)	0 (0.00)	12
79	Tufted White Royal	*Pratapa deva* (Moore)	2 (0.0045)	0 (0.00)	5 (0.0020)	2 (0.0043)	0 (0.00)	9
80	Plains Blue Royal	*Tajuria jehana* Moore	1 (0.0023)	1 (0.0015)	7 (0.0028)	1 (0.0021)	0 (0.00)	10
81	Banded Royal	*Rachana jalindra* Horsfield	2 (0.0045)	6 (0.0091)	15 (0.0060)	2 (0.0043)	0 (0.00)	25
82	Bi-Spot Royal	*Ancema ctesia* (Hewitson)	0 (0.00)	2 (0.0030)	18 (0.0072)	1 (0.0021)	0 (0.00)	21
83	Common Guava Blue	*Deudorix isocrates* (Fabricius)	1 (0.0023)	3 (0.0046)	11 (0.0044)	2 (0.0043)	0 (0.00)	17
84	Cornelian	*Deudorix epijarbas* (Moore)	3 (0.0068)	2 (0.0030)	19 (0.0077)	5 (0.0107)	3 (0.0254)	32
85	Slate Flash	*Rapala manea* (Hewitson)	3 (0.0068)	3 (0.0046)	18 (0.0072)	3 (0.0064)	2 (0.0169)	29
86	Long-Banded Silverline	*Spindasis lohita* (Horsfield)	1 (0.0023)	2 (0.0030)	19 (0.0077)	1 (0.0021)	0 (0.00)	23
87	Silver-Grey Silverline	*Spindasis nipalicus* (Moore)	0 (0.00)	3 (0.0046)	17 (0.0068)	1 (0.0021)	0 (0.00)	21

	Common name	Scientific name	Seasonal sightings					
			I (pi)	II (pi)	III (pi)	IV (pi)	V (pi)	T
	Subfamily: Lycaeninae							
88	Common Copper	*Lycaena phlaeas* (Linnaeus)	4 (0.0091)	6 (0.0091)	21 (0.0085)	2 (0.0043)	0 (0.00)	33
89	Golden Sapphire	*Heliophorus brahma* Moore	5 (0.0114)	14 (0.0213)	10 (0.0040)	6 (0.0128)	0 (0.00)	35
90	Purple Sapphire	*Heliophorus epicles* Godart	4 (0.0091)	6 (0.0091)	23 (0.0093)	7 (0.0149)	0 (0.00)	40
91	Powdery Green Sapphire	*Heliophorus tamu* (Kollar)	0 (0.00)	2 (0.0030)	11 (0.0044)	1 (0.0021)	0 (0.00)	14
	Subfamily: Polyommatinae							
92	Zebra Blue	*Leptotes plinius* Fabricius	2 (0.0045)	4 (0.0061)	15 (0.0060)	2 (0.0043)	1 (0.0085)	24
93	Large 4-lineblue	*Nacaduba pactolus* (C. & R. Felder)	0 (0.00)	0 (0.00)	18 (0.0072)	2 (0.0043)	0 (0.00)	20
94	Transparent 6-lineblue	*Nacaduba kurava* (Moore)	0 (0.00)	1 (0.0015)	18 (0.0072)	1 (0.0021)	0 (0.00)	20
95	Common lineblue	*Prosotas nora* (C. Felder)	4 (0.0091)	5 (0.0076)	19 (0.0077)	4 (0.0085)	1 (0.0085)	33
96	Forget me not	*Catochrysops strabo* (Fabricius)	7 (0.0159)	0 (0.00)	15 (0.0060)	2 (0.0043)	0 (0.00)	24
97	Dark Cerulean	*Jamides bochus* (Stoll)	4 (0.0091)	6 (0.0091)	30 (0.0121)	8 (0.0170)	2 (0.0169)	50
98	Pea blue	*Lampides boeticus* (Linnaeus)	14 (0.0319)	6 (0.0091)	3 (0.0012)	2 (0.0043)	3 (0.0254)	28
99	Dark Grass Blue	*Zizeeria karsandra* (Moore)	15 (0.0342)	5 (0.0076)	7 (0.0028)	2 (0.0043)	3 (0.0254)	32
100	Pale Grass Blue	*Pseudozizeeria maha* (Kollar)	18 (0.0410)	10 (0.0152)	14 (0.0056)	8 (0.0170)	6 (0.0508)	56
101	Lesser Grass Blue	*Zizina otis* (Fabricius)	8 (0.0182)	7 (0.0106)	10 (0.0040)	3 (0.0064)	3 (0.0254)	31
102	Grass jewel	*Freyeria trochylus* Freyer	6 (0.0137)	3 (0.0046)	7 (0.0028)	1 (0.0021)	1 (0.0085)	18
103	Tiny Grass Blue	*Zizula hylax* (Fabricius)	7 (0.0159)	1 (0.0015)	14 (0.0056)	1 (0.0021)	0 (0.00)	23
104	African Babul Blue	*Azanus jesous* (Guerin-Méneville)	5 (0.0114)	2 (0.0030)	15 (0.0060)	1 (0.0021)	1 (0.0085)	24
105	Bright Babul Blue	*Azanus ubaldus* (Stoll)	5 (0.0114)	3 (0.0046)	13 (0.0052)	2 (0.0043)	2 (0.0169)	25
106	Indian Cupid	*Everes lacturnus* (Godart)	1 (0.0023)	6 (0.0091)	7 (0.0028)	1 (0.0021)	0 (0.00)	15
107	Gram Blue	*Euchrysops cnejus* (Fabricius)	0 (0.00)	2 (0.0030)	15 (0.0060)	4 (0.0085)	0 (0.00)	21
108	Lime Blue	*Chilades lajus* (Stoll)	2 (0.0045)	4 (0.0061)	15 (0.0060)	5 (0.0107)	1 (0.0085)	27
	Subfamily: Riodininae							
109	Dark Judy	*Abisara fylla* (Westwood)	2 (0.0045)	4 (0.0061)	16 (0.0064)	3 (0.0064)	0 (0.00)	25
110	Orange Punch	*Dodona egeon* (Westwood)	1 (0.0023)	6 (0.0091)	15 (0.0060)	5 (0.0107)	2 (0.0169)	29
111	Striped Punch	*Dodona adonira* Hewitson	0 (0.00)	3 (0.0046)	16 (0.0064)	3 (0.0064)	0 (0.00)	22
112	Lesser Punch	*Dodona dipoea* Hewitson	14 (0.0319)	8 (0.0122)	5 (0.0020)	3 (0.0064)	3 (0.0254)	33
113	Tailed Punch	*Dodona eugenes* Bates	3 (0.0068)	6 (0.0091)	18 (0.0072)	1 (0.0021)	1 (0.0085)	29
114	Mixed Punch	*Dodona ouida* Hewitson	0 (0.00)	6 (0.0091)	17 (0.0068)	5 (0.0107)	1 (0.0085)	29
115	Punchinello	*Zemeros flegyas* (Cramer)	2 (0.0045)	6 (0.0091)	17 (0.0068)	3 (0.0064)	1 (0.0085)	29
	Family: Pieridae Subfamily: Coliadinae							
116	Small Grass Yellow	*Eurema brigitta* (Cramer)	10 (0.0228)	4 (0.0061)	8 (0.0032)	3 (0.0064)	0 (0.00)	25

	Common name	Scientific name	Seasonal sightings					
			I (pi)	II (pi)	III (pi)	IV (pi)	V (pi)	T
117	Common GrassYellow	*Eurema hecabe* (Linnaeus)	16 (0.0364)	7 (0.0106)	20 (0.0081)	6 (0.0128)	0 (0.00)	49
118	Common Brimstone	*Gonepteryx rhamni* (Linnaeus)	2 (0.0045)	6 (0.0091)	18 (0.0072)	2 (0.0043)	0 (0.00)	28
119	Plain Sulphur	*Dercas lycorias* (Doubleday)	0 (0.00)	0 (0.00)	16 (0.0064)	3 (0.0064)	0 (0.00)	19
120	Mottled Emigrant	*Catopsilia pyranthe*(Linnaeus)	3 (0.0068)	2 (0.0030)	13 (0.0052)	2 (0.0043)	0 (0.00)	20
121	Common Emigrant	*Catopsilia pomona* (Fabricius)	12 (0.0273)	6 (0.0091)	32 (0.0129)	4 (0.0085)	2 (0.0169)	56
122	Pale Clouded Yellow	*Colias erate* (Esper)	17 (0.0387)	10 (0.0152)	8 (0.0032)	3 (0.0064)	2 (0.0169)	40
123	Dark Clouded Yellow	*Colias fieldii* Ménétriés	15 (0.0342)	11 (0.0167)	9 (0.0036)	3 (0.0064)	2 (0.0169)	40
	Subfamily: Pierinae							
124	Plain Puffin	*Appias indra* (Moore)	2 (0.0045)	8 (0.0122)	0 (0.00)	0 (0.00)	2 (0.0169)	12
125	Large Cabbage White	*Pieris brassicae* (Linnaeus)	12 (0.0273)	2 (0.0030)	26 (0.0105)	2 (0.0043)	0 (0.00)	42
126	Indian Cabbage White	*Pieris canidia* (Sparrman)	13 (0.0296)	3 (0.0046)	23 (0.0093)	3 (0.0064)	0 (0.00)	42
127	Red-Base Jezebel	*Delias pasithoe* (Linnaeus)	11 (0.0250)	0 (0.00)	12 (0.0048)	0 (0.00)	8 (0.0678)	31
128	Great Blackvein	*Aporia agathon* (Gray)	1 (0.0023)	3 (0.0046)	8 (0.0032)	0 (0.00)	0 (0.00)	12
129	Hill Jezebel	*Delias belladonna* (Fabricius)	0 (0.00)	2 (0.0030)	6 (0.0024)	3 (0.0064)	0 (0.00)	11
130	Pale Jezebel	*Delias sanaca* (Moore)	2 (0.0045)	4 (0.0061)	8 (0.0032)	0 (0.00)	0 (0.00)	14
	Family: Hesperiidae Subfamily: Coeliadinae							
131	Common Banded Awl	*Hasora chromus* (Cramer)	0 (0.00)	6 (0.0091)	18 (0.0072)	5 (0.0107)	0 (0.00)	29
132	Brown Awl	*Badamia exclamationis* (Fabricius)	0 (0.00)	1 (0.0015)	12 (0.0048)	9 (0.0192)	0 (0.00)	22
133	Indian Awkling	*Choaspes benjaminii* (Guerin-Meneville)	1 (0.0023)	4 (0.0061)	13 (0.0052)	2 (0.0043)	0 (0.00)	20
	Subfamily: Pyrginae							
134	Common Spotted Flat	*Celaenorrhinus leucocera* (Kollar)	1 (0.0023)	7 (0.0106)	19 (0.0077)	2 (0.0043)	0 (0.00)	29
135	Common Small Flat	*Sarangesa dasahara* Moore	4 (0.0091)	6 (0.0091)	18 (0.0072)	2 (0.0043)	1 (0.0085)	31
136	Water Snow Flat	*Tagiades litigiosa* Möschler	2 (0.0045)	2 (0.0030)	9 (0.0036)	1 (0.0021)	0 (0.00)	14
137	Chestnut Angle	*Odontoptilum angulata* (C. & R. Felder)	2 (0.0045)	5 (0.0076)	13 (0.0052)	6 (0.0128)	0 (0.00)	26
	Subfamily: Hesperiinae							
138	Straight Swift	*Parnara guttatus* (Bremer & Grey)	1 (0.0023)	9 (0.0137)	18 (0.0072)	1 (0.0021)	0 (0.00)	29
139	Bevan's Swift	*Pseudoborbo bevani* (Moore)	1 (0.0023)	4 (0.0061)	20 (0.0081)	4 (0.0085)	0 (0.00)	29
140	Yellow Spot Swift	*Polytremis eltola* (Hewitson)	1 (0.0023)	4 (0.0061)	18 (0.0072)	2 (0.0043)	0 (0.00)	25
141	Small Branded Swift	*Pelopidas mathias* (Fabricius)	2 (0.0045)	4 (0.0061)	17 (0.0068)	3 (0.0064)	0 (0.00)	26
142	Blank Swift	*Caltoris kumara* (Moore)	1 (0.0023)	3 (0.0046)	20 (0.0081)	5 (0.0107)	1 (0.0085)	30
143	Dark Palm Dart	*Telicota ancilla* (Herrich-Schäffer)	3 (0.0068)	3 (0.0046)	19 (0.0077)	7 (0.0149)	0 (0.00)	32
144	Restricted Demon	*Notocrypta curvifascia* (C. & R. Felder)	3 (0.0068)	3 (0.0046)	17 (0.0068)	4 (0.0085)	0 (0.00)	27
145	Spotted Demon	*Notocrypta feisthameli* (Boisduval)	2 (0.0045)	3 (0.0046)	14 (0.0056)	2 (0.0043)	0 (0.00)	21

	Common name	Scientific name	Seasonal sightings					
			I (pi)	II (pi)	III (pi)	IV (pi)	V (pi)	T
146	Veined Scrub Hopper	*Aeromachus stigmatus* (Moore)	6 (0.0137)	5 (0.0076)	20 (0.0081)	2 (0.0043)	0 (0.00)	33
147	Indian Ace	*Halpe homolea* (Hewitson)	0 (0.00)	10 (0.0152)	6 (0.0024)	6 (0.0128)	0 (0.00)	22
148	Moore's Ace	*Halpe porus* (Mabille)	0 (0.00)	2 (0.0030)	13 (0.0052)	5 (0.0107)	0 (0.00)	20
	Family: Papilionidae Subfamily: Zerynthinae							
149	Bhutan Glory	*Bhutanitis lidderdalei* Atkinson	0 (0.00)	1 (0.0015)	8 (0.0032)	1 (0.0021)	0 (0.00)	10
	Subfamily: Papilioninae							
150	Kaiser-I-Hind	*Teinopalpus imperialis* Hope	0 (0.00)	3 (0.0046)	7 (0.0028)	0 (0.00)	0 (0.00)	10
151	Common Bluebottle	*Graphium sarpedon* (Linnaeus)	3 (0.0068)	6 (0.0091)	16 (0.0064)	4 (0.0085)	0 (0.00)	29
152	Sixbar Swordtail	*Graphium eurous* (Leech)	2 (0.0045)	5 (0.0076)	1 (0.0004)	0 (0.00)	2 (0.0169)	10
153	Yellow Gorgon	*Meandrusa payeni* (Boisduval)	0 (0.00)	0 (0.00)	10 (0.0040)	0 (0.00)	3 (0.0254)	13
154	Tawny Mime	*Chilasa agestor* (Gray)	2 (0.0045)	6 (0.0091)	3 (0.0012)	0 (0.00)	0 (0.00)	11
155	Blue Striped Mime	*Chilasa slateri* (Hewitson)	4 (0.0091)	4 (0.0061)	0 (0.00)	0 (0.00)	0 (0.00)	8
156	Red Helen	*Papilio helenus* Linnaeus	4 (0.0091)	8 (0.0122)	28 (0.0113)	8 (0.0170)	0 (0.00)	48
157	Common Peacock	*Papilio polyctor* Boisduval	2 (0.0045)	6 (0.0091)	19 (0.0077)	2 (0.0043)	0 (0.00)	29
158	Blue Peacock	*Papilio acturus* Westwood	3 (0.0068)	5 (0.0076)	15 (0.0060)	0 (0.00)	0 (0.00)	23
159	Krishna Peacock	*Papilio krishna* Moore	0 (0.00)	5 (0.0076)	4 (0.0016)	0 (0.00)	0 (0.00)	9
160	Common Windmill	*Atrophaneura polyeuctes* (Doubleday)	1 (0.0023)	3 (0.0046)	17 (0.0068)	2 (0.0043)	0 (0.00)	23
161	Great Windmill	*Atrophaneura dasarada* (Moore)	1 (0.0023)	2 (0.0030)	14 (0.0056)	1 (0.0021)	0 (0.00)	18

I - Spring; II - Summer; III - Monsoon; IV - Autumn; V - Winter; T - Total; pi - relative abundance of species

Table 3. Meteorological data of the study site during study period

Months Year	Temperature (in°C)*		Rainfall (in mm) *
	Min.	Max.	
January 2012	1	15	5.1
February 2012	1	18	10.9
March 2012	2	20	20.0
April 2012	3	20	95.2
May 2012	6	21	239.0
June 2011	8	22	620
July 2011	10	20	1070
August 2011	9	22	644.6
September 2011	7	23	589.0
October 2011	4	22	30.0
November 2011	1	20	16.4
December 2011	-3	18	4.2

*Source: Indian Meteorological Department, Govt. of India

(Heliconiinae subfamily), *Araschnia* sp, *Symbrenthia* sp., *Vanessa* sp. and *Aglais* sp. (Nymphalinae subfamily), while *Euploea* larvae predominantly depended on Moraceae plants. Lycaenidae showed the second highest host plant diversity and utilized 20 plant families as their larval resource (Table 6). Fabaceae, Ericaceae, Myricaceae and Loranthaceae were the major food plants of larval lycaenids. A total of six families encompassing 20 species were recorded as the host plants of Pieridae butterflies. While Coliadinae fed predominantly on plants of Fabales, Pierinae butterflies chose Brassicales and mistletoes as their larval resource (Table 6). 28 species of plants belonging to 13 families served as food plants for larvae of Hesperiinae, Pyrignae and Coeliadinae. Although Hesperiinae larvae fed on Poaceae and Pyrignae utilized Acanthaceae, Coeliadinae butterflies used plants of families Combretaceae, Moraceae, Euphorbiaceae, Sabiaceae (Table 6). Four plant families were used by the Papilionidae butterflies

Table 4. Detail schedule of Sampling Design

Month/Year	Number of foggy/Cloudy /rainy days	Number of sampling days (Dates devoted to sampling at each study site per month)	Remarks
January 2012	13 (foggy)	16 (1-3 at NVNP-1, 4 at NVNP-1); (6-9 at NVNP-2); (12-15 at NVNP-3) and (20-23 at NVNP-4)	Two transects were sampled per day at each study site with the help of two trained field assistants and different dates were dedicated to study different study sites
February 2012	7 (foggy)	16 (1-4 at NVNP-1); (5 at NVNP-2, 8-10 at NVNP-2); (12-14 at NVNP-3, 15 at NVNP-3); 20-23 at NVNP-4)	
March 2012	1 (cloudy)	16 (1-4 at NVNP-1); (8-11 at NVNP-2); (15-17 at NVNP-3, 19 at NVNP-3);(20-22 at NVNP-4, 25 at NVNP-4)	
April 2012	1 (cloudy)	16 (1-3 at NVNP-1, 5 at NVNP-1); (6-8 at NVNP-2, 10 at NVNP-2); (12-15 at NVNP-3); (20 at NVNP-4, 25-27 at NVNP-4)	
May 2012	3 (cloudy)	16 (3-6 at NVNP-1); (8 at NVNP-2, 10-12 at NVNP-2); (15-17 at NVNP-3, 20 at NVNP-3); 23-26 at NVNP-4)	
June 2011	4 (rainy)	16 (2-5 at NVNP-1); (8-10 at NVNP-2, 14 at NVNP-2); (16-19 at NVNP-3); (25-28 at NVNP-4)	
July 2011	14 (rainy)	16 (1,2, 4,5 at NVNP-1); (6-8 and 14 at NVNP-2); (18-20 and 22 at NVNP-3); (24-26 and 29 at NVNP-4)	
August 2011	5 (rainy)	16 (3-6 at NVNP-1);(12-14 and 16 at NVNP-2); (20-23 at NVNP-3); (26-28 and 31 at NVNP-4)	
September 2011	3 (cloudy)	16 (2-4 and 7 at NVNP-1); (10-13 at NVNP-2); (15-17 and 20 at NVNP-3); (26-28 and 30 at NVNP-4)	
October 2011	0	16 (3-5 and 8 at NVNP-1); (11-14 at NVNP-2); (18-21 at NVNP-3); (25-28 at NVNP-4)	
November 2011	3 (foggy)	16(1-4 at NVNP-1); (7-9 and 11 at NVNP-2); (15-18 at NVNP-3); (22-25 at NVNP-4)	
December 2011	7 (foggy)	16 (2,3,8,9 at NVNP-1); (14-16 and 18 at NVNP-2); (21-23 and 25 at NVNP-3); (28-31 at NVNP-4)	

Table 5. Seasonal variation in species abundance, diversity index, evenness index and richness index of studied butterfly species

Season	Number of Species	Number of individuals	Shannon Diversity index	Evenness index	Margalef's Species Richness index
Spring	108	439	4.282	0.914	17.59
Summer	141	657	4.819	0.974	21.58
Monsoon	158	2480	4.968	0.981	20.09
Autumn	135	469	4.714	0.961	21.78
Winter	57	118	3.872	0.811	11.74

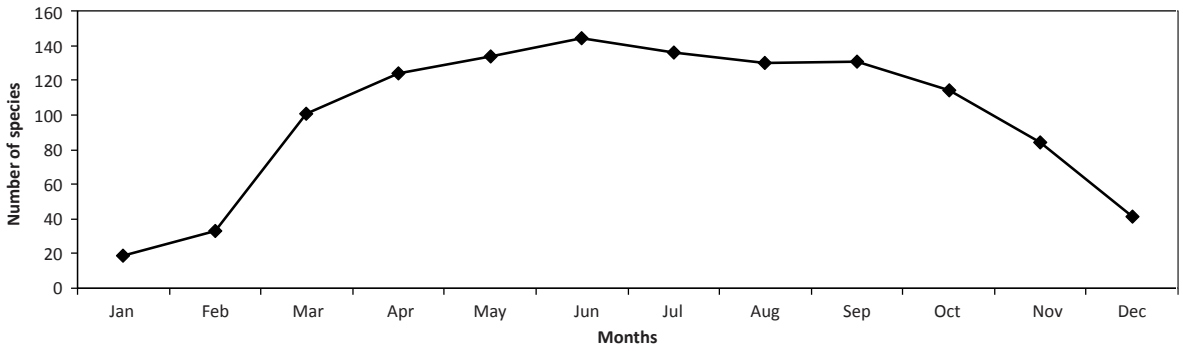

Figure 3. Month-wise seasonal changes in the number of species

as their larval resources. Lauraceae and Rutaceae were their predominant larval food plants (Table 6).

DISCUSSION

Among the butterflies of the Himalayan region, 80% are recorded as forest species of which 60% occur below 3000m elevation (Uniyal & Mathur 1998). The

Table 6. List of larval host plants of butterfly species

Larval host plant of butterfly species	Habit	Butterfly species
Family: Poaceae *Arundinaria aristata* Gamble	Shrub	4,7,9,10,17, 13,12,15,148
Arundinaria maling Gamble	Shrub	8,5,6,4,3,11,19,13,14 ,16,112,113,147,148
Cymbopogon nardus (L.) Rendle	Herb	141,22,24
Imperata cylindrica (L.) Rauschel	Herb	1,143,139,141
Paspalum scrobiculatum (L.)	Herb	139
Isachne albens Trin.	Herb	18
(*ri) *Saccharum arundinaceum* Retz.	Herb	138,143
(***ro)** *Saccharum narenga* Hack.	Herb	138,140,139
(***ri)** *Saccharum spontaneum* L.	Herb	143,139,140
Setaria palmifolia (K.D. Koenig) Stapf	Herb	18
Setaria glauca L.	Herb	18
Poa annua Linn.	Herb	142,146,2,20,21
Eleusine indica (L.) Gaertn.	Herb	22
Cynodon dactylon (L.) Pers.	Herb	23
Digiteria ciliaris (Retz.)Koeler	Herb	23,25
Family: Amaranthaceae **(*ro)** *Amaranthus spinosus* L.	Herb	99
Family: Euphorbiaceae **(*ri)** *Antidesma acidum* Retz.	Tree	85
Drypetes assamica Pax & K. Hoffm.	Tree	124
Ricinus communis L.	Shrub	131,48,49
Glochidion acuminatum Muell.	Tree	34
Glochidion nubigenum Hk. f.	Tree	38
Family: Myrsinaceae **(*ri)** *Ardisia solanacea* Roxb.	Shrub	94
Maesa chisia Don.	Shrub	110,114,109,111,115
(*v) *Maesa indica* Wall.	Shrub	115
Family: Acanthaceae *Asystasia macrocarpa* Ness.	Under shrub	62,134,135
(*ro) *Eranthemum pulchellum* Andrews	Shrub	134,64
Strobilanthes capitatus T. And.	Under shrub	63,64,100,103,134
(*e) *Strobilanthes roseus* Ness	Under Shrub	134,100,103
Strobilanthes thomsoni T. And.	Under shrub	64,103,100
Family: Berberidaceae *Berberis aristata* DC.	Shrub	35
Berberis nepaulensis DC.	Tree	35,128
Mahonia napaulensis DC.	Shrub	35
Family: Bombaceae **(*ri-l)** *Bombax ceiba* L.	Tree	36,137
Family: Fabaceae **(*w-l)** *Abrus precatorius* L.	Climber	71
Bauhinia variegata Linn.	Tree	121
(*ro) *Bauhinia vahlii* Wright & Arn.	Lianas	121
Bauhinia wallichii J.F. Macbride	Lianas	121
(*v) *Butea minor* Buch.- Ham. Ex Baker	Shrub	98,107
(*ro) *Cassia alata* L.	Shrub	116,120,121

Larval host plant of butterfly species	Habit	Butterfly species
(*ro) *Cassia sophera* Linn.	Herb	116,120,121
(*w) *Cassia tora* Linn.	Herb	116,120,121,117
Crotalaria albida Heyne.	Herb	97,98
(*w) *Crotalaria mucronata* Desv.	Herb	98,97
Crotalaria ferrugineum Benth.	Herb	98,97
(*ri) *Dalbergia sissoo* Roxb.	Tree	36,40,119
Dalbergia stipulaceae Roxb.	Lianas	40,119,36
Trifolium repens L.	Herb	122,123,106,96
Indigofera sp L.	Shrub	102,106,92,123
(*w-l) *Desmodium triflorum* (L.) DC.	Herb	106,96
Lathyrus sativus L.	Herb	101
(*ri) *Entada rheedii* Spreng.	Lianas	93
(*e)*Acacia gageana* Craib	Tree	116,107,105,104,85, 117
(*e)*Acacia pennata* (L.) Willd.	Tree	107,116,95,104,105, 117
Family: Lauraceae *Cinnamomum bejolghota* Buchanan-Hamilton	Tree	77,154
Cinnamomum tamala Nees & Eberm.	Tree	77,154
Litsea citrata Blume.	Tree	155
Litsea elongata Wall.	Tree	155
(*v) *Litsea monopetala* (Roxb.) Persoon	Tree	153
(*v) *Litsea polyantha* Juss.	Tree	153
Persea odoratissima (Nees) Kosterm	Tree	152,154,151
Family: Verbenaceae **(*c)** *Clerodendrum indicum* (L.) Kuntze	Shrub	87
Family: Combretaceae **(*ri)** *Combretum decandrum* Roxb.	Lianas	132
(*p)*Terminalia alata* Heyne ex Roth.	Tree	75
(*e)*Terminalia belerica* Roxb.	Tree	132
Family: Dioscoreaceae *Dioscorea sp* L.	Herb	136,61,86
Family: Elaeocarpaceae *Elæocarpus lanceæfolius* Roxb.	Tree	36,40
Family: Sapindaceae *Aesculus sp* L.	Tree	84
(*e) *Sapindus sp* L.	Tree	84
Family: Moraceae *Ficus cunia* Ham.	Tree	132,76,69
Ficus semicordata Buch.-Ham. Ex Smith	Tree	68,69,46
(*ri)*Ficus virens* L.	Tree	76,68,70,132
(*ri)*Ficus drupacea* Thunberg	Climber	46,69,70
(*e) *Streblus asper* Lour.	Tree	42,43
Family: Tiliaceae *Grewia eriocarpa* Drumm.	Tree	65
(*e) *Grewia sapida* Roxb.	Tree	65,40
Family: Apocyanaceae *Holarrhena pubescens* (Buch.- Ham)Wall. Ex DC.	Tree	70
(*e) *Ichnocarpus frutescens* Br.	Climber	68,69,70

Larval host plant of butterfly species	Habit	Butterfly species
Family: Asclepiadaceae *Hoya parasitica* Wall.	Epiphyte	68
Hoya longifolia Wall.	Epiphyte	68
Family:Melastomataceae *Melastoma malabathricum* L.	Shrub	45
Family: Sabiaceae *Sabia campanulata* Wall.	Shrub	133
Family: Oxalidaceae *Oxalis corniculata* L.	Herb	100,102
Family: Arecaceae **(*ri)** *Calamus erectus* Roxb.	Climber	143
Family: Polygonaceae *Polygonum orientale* L.	Herb	90
Polygonum nepalense Meisn.	Herb	88,89,90,91
Rumex nepalensis Sprengel	Shrub	88,89,90,91
Family: Salicaceae *Populus glauca* Haines	Tree	30
Populus gamblei Dode.	Tree	30
(*ri) *Salix tetrasperma* Roxb.	Tree	30
Salix salwinensis Hand.- Mazz.	Tree	30
Family: Portulaceae *Portulaca oleracea* L.	Herb	62
Family: Urticaceae *Pouzolzia hirta* (Blume ex Hassk)	Herb	26
Pouzolzia zeylanica (L.) Benn	Herb	26
Urtica dioica L.	Shrub	58,55,60,54
Urtica parviflora Roxb.	Shrub	60,54
Boehmeria glomerulifera Miq.	Shrub	58
Boehmeria diffusa Wedd.	Herb	58,59
Boehmeria penduliflora Weddell ex D.G. Long	Shrub	58
Debregeasia longifolia (Burm.f.) Wedd.	Shrub	47,56,57
Elatostema hookerianum Weddell	Herb	56
Elatostema sessile J.R.Forst.& G. Forst.	Herb	56
Girardinia heterophylla Decne.	Shrub	55,59
Family: Malvaceae *Urena lobata* Linn.	Herb	137
Family: Asteraceae *Artemisia vulgaris* Linn.	Herb	59
Gnaphalium affine D.Don	Herb	59
Family: Fagaceae *Quercus glauca* Thunb.	Tree	44
Quercus lamellosa Smith	Tree	74
Family: Smilaceae *Smilax ferox* Wallich ex Kunth	Climber	61,136
Smilax zeylanica Linn.	Climber	136,61
Family: Rubiaceae *Catunaregam sp* Wall.	Shrub	83
Randia sikkimensis Hk.f.	Tree	37
Family: Brassicaceae *Rorippa indica* (L.) Hiern	Herb	126
(*c)*Brassica juncea* (L.) Czern.	Herb	125,126
Family: Violaceae *Viola diffusa* Ging.	Herb	27,28,29
Viola serpens Wall.	Herb	27,28
Family: Anacardiaceae *Rhus succedanea* Linn.	Tree	42
Family: Ericaceae *Rhododendron arboreum* Smith	Tree	72,73
Rhododendron decipiens Lacaita	Tree	73,72
Rhododendron falconeri Hook.f.	Tree	73
Rhododendron grande Wright	Tree	72
Rhododendron hodgsoni Hook.f.	Tree	73,72
Family: Caprifoliaceae *Lonicera macrantha* DC.	Climber	31
Lonicera glabrata Wallich.	Climber	32,33
Family: Zingiberaceae **(*e)** *Curcuma aromatica* Salisb.	Herb	144,145
Kaempferia rotunda Linn.	Herb	144
Hedychium acuminatum Roscoe	Herb	145
Costus speciosus (J. Konig) Sm.	Herb	144
Family:Vacciniaceae *Vaccinium retusum* (Griffith) Hook. f. ex C.B. Clarke	Shrub	118
Vaccinium serratum Wright	Epiphyte	118
Family: Loranthaceae *Viscum* sp Linn.	Shrub	82
Scurrula elata (Edgew.) Danser	Shrub	79,43,129,130
Dendrophthoe falcate Mart.	Shrub	78,79,80,81,87,127, 129,130
Family:Ulmaceae *Ulmus* sp L.	Tree	50,52
Celtis sp L.	Tree	39,41,51,53
(*ro)*Celtis cinnamomea* Laidl.	Tree	67,66
Celtis tetrandra Roxb	Tree	67
Family: Dipterocarpaceae **(*p)** *Shorea robusta* Gærtn	Tree	74
Family: Aristolochiaceae *Aristolochia griffithii* Hook. F. & Thoms. Ex Duchartre	Climber	160,161,149
Family: Rutaceae *Zanthoxylum acanthopodium* DC.	Shrub	159,156,158,108
Zanthoxylum armatum DC.	Climber	157,158
Evodia fraxinifolia Hk. f.	Tree	159,156
Family: Magnoliaceae *Magnolia campbellii* Hook. f. & Thoms.	Tree	150
Michelia doltsopa Buch.- Ham. ex DC.	Tree	152

Names of the butterflies are expressed as codes on the basis of their serial numbers as mentioned in Table 2, where:
***ri** - species indentified from the riverine habitat adjoining regions of transect; ***ro** - species indentified from roadsides adjoining transect; ***e** - species identified form the forest edges adjoining transect; ***c** - species cultivated in regions adjoining transect; ***p** - species planted in regions adjoining transect; ***w** - species identified from wasteland adjoining transect; ***v** - species identified from the deep valleys or gorges adjoining transect; ***ri-I** - species indentified from the riverine habitat (status-introduced) adjoining regions of transect; ***w-I** - species identified from wasteland (status-introduced) adjoining transect.

upper range of the NVNP is recognised as the last virgin wilderness in West Bengal (UNESCO World Heritage Centre 2009; Mallick 2010). Such a pristine habitat of tropical to temperate broad leaved forest along with dense undergrowth provides suitable resources for the butterflies. The tropical monsoon climate of this region with little temperature fluctuation between seasons but with huge differences in rainfall, support the abundance of herbs and shrubs as predominant larval host plants of Hesperidae, Pieridae, Nymphalidae and Lycaenidae butterflies as observed in this study. Nymphalidae, the dominant family as in any other tropical region, had well built butterflies with large wingspan that helped them to obtain resource from all habitats (Majumdar et al. 2012).

Wynter-Blyth (1957) identified two periods (March-April and October) as peak season of butterfly abundance in India. Kunte (1997) threw light on the abundance and species diversity of butterflies based on seasonality in four tropical habitats in Northern Western Ghats. Butterfly diversity at local or regional scales is closely related to their host plant density (Gutierrez & Mendez 1995; Cowley et al. 2001). A Rank-Abundance curve with steep gradient indicated low evenness (Magurran 2004) and low species diversity (Kunte 2008), in contrast to a curve with shallow gradient which represented high evenness (Magurran 2004) along with high species diversity (Kunte 2008). A similar trend is evident in the present study (Fig. 2). Maximum species diversity along with highest species evenness as observed during the monsoons could be correlated with the abundant distribution of luxurious vegetation which was said to be in suitable phenophase to support the growth of the larval stages of these butterflies. The monsoons were also associated with a greater abundance of species that had occurred in low frequency during summer (Atluri et al. 2011). Pöyry et al. (2009), stressed the importance of local habitat quality to explain species richness. Higher values of species richness as observed during autumn, summer and monsoon could be indicative of the presence of specific butterfly larval host plants during this season. This pattern is consistent with that of Wynter-Blyth (1957), Kunte (1997) and Padhye et al. (2006). Month wise fluctuation in the sampling size of butterflies could be attributed to the distinct changes from the wet season (May–October) to the dry season (November–April) forms (Emmel & Leck 1970; Saikia et al. 2010) in butterflies. Along with a distinct surge in butterfly distribution as observed during the monsoons (Atluri et al. 2011), butterflies are said to form peaks at transition periods between the wet season and the dry season (Emmel & Leck 1970).

The higher host plant diversity seen amongst the Nymphalid and Lycaenid butterflies in this zone of the National Park are probably due to the greater host plant diversity as previously reported from amongst the South East Asian Nymphalidae and Lycaenidae (Fiedler 1998). The preference for Poaceae hosts observed among Satyrinae larvae in this and other studies (Wynter-Blyth 1957; Haribal 1992; Munguira et al. 1997; Peñal & Wahlberg 2008) are significant. Himalayan distribution of the Heliconiinae subfamily of butterflies (Uniyal 2007; Borang et al. 2008; Singh 2009) also supported their presence in this study site. Occurrence of *Glochidion* sp., a common tree of the middle to upper Himalayan region along with *Lonicera* sp. (Cowan & Cowan 1979), a shrubby climber, probably sustained the larval population of *Athyma* sp. and *Parasarpa* sp respectively. The relationship between *Euthalia lubentina*- Moraceae, *E.aconthea*- Moraceae and Anarcardiaceae and *E. sahadeva* with Fagaceae threw light on the difference in the food plant preference by *Euthalia* butterflies (Wynter-Blyth 1957; Kehimkar 2008). *Ulmus* sp. and *Celtis* sp. (Ulmaceae) which constitute the essential part of the broad leaved forest of higher elevations (Maity & Maiti 2007) supported the larval population of *Apatura* sp and *Hestina* sp of butterflies. Wide scale distribution of *Urtica* sp., *Debreagesia* sp., *Girardiana* sp., *Boehmeria* sp. and *Elatostemma* sp. (Urticaceae) (Cowan & Cowan 1979; Maity & Maiti 2007) sustained the larval population of *Symbrenthia hypselis, S. hippoclus, S. niphanda*, *Vanessa indica*, *V. cardui*, *Araschnia prorsoides* and *Aglais cashmiriensis* (Nymphalinae subfamily) (Wynter-Blyth 1957; Haribal 1992; Kehimkar 2008). The association between *Grewia* sp. *Libythea lepita, Celtis tetrandra*, *L. narina* and *C. cinnamomea* with both *L. myrrha* and *L. narina* also stressed the importance of specific food plants for the butterflies (Haribal 1992; Kehimkar 2008). Daninae butterflies fed on Apocyanaceae, Asclepiadaceae and Moraceae, all plants possessing a milky fluid (Erhlick & Raven 1964).

According to the Singh & Pandey (2004) model, Lycaenidae, should represent 29.5% of the total number of species sampled in northeastern India. Although being the second most (27.95%) abundant family in this study site, Lycaenidae still appears to be slightly under represented in this study, which points towards the need for further investigation. The larvae of *Heliophorus* sp. and *Lycaena phlaeas* fed largely on the *Polygonum* sp. and *Rumex nepalensis,* respectively, throughout its range in the Himalayan region (Uniyal 2007; Borang et al. 2008; Singh 2009). Myrisinae (*Ardisinia solanacea*) served as larval resource of *Nacaduba kurava* (Polyommatinae

subfamily). Besides this, legume feeding was prevalent amongst other Polyommatinae larvae (Wynter-Bylth 1957; Haribal 1992; Kehimkar 2008). Among Riodininae, *Dodona adonira, D. eugenes* and *Zemeros flegyas* were the butterfly species of northeastern India (Borang et al. 2008). Other Himalayan species, *Abisara fylla D.egeon* and *D.ouida* (Uniyal & Mathur 1998) were also associated with *Maesa chisia* plants. *D. dipoea* was reported due to the distribution of its host plant, *Arundinaria maling* which formed an important part of this forest habitat. Overhanging parasitic flora along with *Rhododendron* sp served as the food plants of a majority of Theclinae subfamily of lycaenid larvae (Wynter-Blyth 1957; Kehimkar 2008).

Besides association of *Gonepteryx rhamni* with *Vaccinium* sp., Fabales were decidedly the most important food plant of other Coliadinae butterflies (Ehrlich & Raven 1964). The extensive cultivation of *Brassica juncea* in the adjoining areas of the National Park may be the supportive larval host plant of *Pieris* butterflies. *Pieris* larvae are known to detoxify and eliminate, rather than sequester, the degradation products of glucosinolates (present in Brassicales) (Müller et al. 2003).

The marked reduction in the abundance of Hesperiidae in this study in accordance to that previously stated by the Singh & Pandey (2004) model for northeastern Indian hesperids, probably generates an urgent need for their further study in similar areas.

The association between black-bodied papilionids with Rutaceae and red-bodied papilionids with Aristolochiaceae were similar to observations made on Assam papilionidae (Barua et al. 2004). While Lauraceae - Magnoliaceae served as the food resource for *Graphium eurous* and *Chilasa slateri* larvae, *Meandrusa payeni, Chilasa agestor* and *Graphium sarpedon* depended solely on Lauraceae to sustain their larval population (Wynter-Blyth 1957; Haribal 1992). A report on the occurrence of Kaiser-I-Hind *Teinopalpus imperialis,* from Darjeeling District (Kehimkar 2008) also confirms their record in this study. Species such as *Bhutanitis lidderdalei* and *Teinopalpus imperialis* were strictly seasonal and found on wing between April–November. Such a seasonal trend could be attributed to synchrony with phenology of their food plants (Spitzer 1983).

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