



Lowland forest butterflies of the Sankosh River catchment, Bhutan

Arun P. Singh

Ecology and Biodiversity Conservation Division, Rain Forest Research Institute (ICFRE), P.O. Box no. 136, Deovan, Sotai, Jorhat, Assam 785001, India
Email: ranoteaps@gmail.com, singhap@icfre.org

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Author Details: ARUN P. SINGH works on the conservation of biodiversity of Himalaya with special reference to butterflies and birds since 18 years. His research works include ecology, taxonomy, and environmental impact assessment (EIA) studies. Presently, he heads the Ecology and Biodiversity Conservation Division, Rain Forest Research Institute (ICFRE), Jorhat, Assam.

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Abstract: This paper provides information on butterflies of the lowland forests of Bhutan for the first time. As a part of the biodiversity impact assessment for the proposed Sankosh hydroelectric power project, a survey was carried out along the Sankosh River catchment to study the butterfly diversity. The aim of the study was to identify species of conservation priority, their seasonality and to know the butterfly diversity potential of the area. Surveys were carried out during five different seasons (winter, spring, pre-monsoon, monsoon, post-monsoon) lasting 18 days from January 2009 to March 2010. Pollard walk method was used to assess the diversity on four-line transects within 10–12 km radius of the proposed dam site. Two hundred and thirteen species, including 22 papilionids, were thus sampled. Eleven species amongst these are listed in Schedules I and II of the Indian Wildlife (Protection) Act, 1972, of which 10 taxa (*Pareronia avatar avatar*, *Nacaduba pactolus continentalis*, *Porostas aluta coelestis*, *Elymnias vasudeva vasudeva*, *Mycalesis mestra retus*, *Melanitis zitenius zitenius*, *Charaxes marmax*, *Athyma ranga ranga*, *Neptis manasa manasa* and *Neptis soma soma*) are of conservation priority as they are 'rare' in occurrence across their distribution range in the region. The maximum number of species (128) were recorded during the spring season (March) and lowest (66) during July (monsoon). The seasonal pattern of variation in diversity was very typical of the pattern found in other areas of the lower foothills and adjoining plains of the Himalaya. Relative abundances of butterflies during spring varied significantly ($p < 0.05$) as compared to winter, pre-monsoon and post-monsoon seasons. However, species composition changed with every season as Sorensen's similarity index varied between 0.3076 to 0.5656. All these findings suggest that the lowland forests of Bhutan hold a rich and unique diversity of butterflies during every season of the year thus having a good potential for ecotourism. Establishment of a butterfly conservatory and park as a 'biodiversity offset' for conservation of 'rare' species along with more field surveys in the study area will be a way forward along with the present work to bridge the existing gaps in knowledge on butterflies of the sub-tropical lowland forests of the Himalayas.

Keywords: Indian Wildlife Protection Act 1972, Phibsoo Wildlife Sanctuary, rare species, seasonality, *Shorea robusta*, Simpsons index, Sorensen's index, sub-tropical.

INTRODUCTION

Reducing the impact of large dams on biodiversity calls for knowing where species, ecosystems and ecological functions are located. Lack of that information is one of the serious impediments and is a result of poor support for biological surveys, research and academic work on taxonomy and ecology. IUCN, UNEP and WCD recommendations on dams and biodiversity (McAllister et al. 2001), highlight the need to avoid biodiversity 'hotspots' and 'hot' portions of gradients. The avoidance of areas rich in species and endemic species needs to be given high priority in selection criteria. That includes both, choosing watersheds and sites within watersheds, and taking into account 'hotspots' and gradients in biodiversity. Besides, the recommendations also highlight the need to carry out research on biodiversity as our knowledge on biodiversity is incomplete and geographic distributions are poorly documented



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(McAllister et al. 2001). The environmental impact of large dams on lower groups of organisms, such as insects, is hardly ever studied for loss of wildlife in India (Mishra 2009).

According to Conservation International, Bhutan forms a part of the 'Eastern Himalaya Biodiversity Hotspot' which is one of the 34 biodiversity hotspots of the world today (www.biodiversityhotspots.org/). A home for over 50 species of rhododendrons, large numbers of orchids (<http://www.bhutan2008.bt/en/node/276>), Bhutan is also one of the 221 global endemic bird areas with over 770 avian species (Inskipp et al. 1999). Bhutan along with northeastern India are the meeting place of the central Asian and Chinese subdivisions of the Palaearctic region with the peninsular Indian and Malayan subdivisions of the oriental region and are therefore considered very rich areas in terms of butterflies. With incredible variations, from subtropical to alpine along the altitudinal gradient (100–4,200 m), Bhutan presents a large variety of habitats for butterflies. The adjoining state of Sikkim which lies west of Bhutan in India has over 689 species (Haribal 1992). Besides, 962 taxa of butterflies have been identified from northeastern India from Sikkim, Assam, Manipur; Meghalaya, Nagaland Mizoram and northern Myanmar (Evans 1932). On the other hand Wynter-Byth (1957) gives a figure of 835 species of butterflies from northeastern India including Sikkim, Bhutan and Assam up to Chittagong. However, information on butterflies of Bhutan as such is scanty. A booklet published by van der Poel & Wangchuk (2007) on butterflies of the Bhutan mountains, hills and valleys between 800–3,000 m lists only 136 species from the country. van der Poel & Wangchuk (2007) does not include butterflies from subtropical low land forests of Bhutan lying below 300m, which are contiguous with forests in India and are considered rich in terms of biodiversity. One estimate for Bhutan puts the figure between 800–900 species with the largest number being found in the 'subtropical' zone (van der Poel & Wangchuk 2007).

The present work on butterflies is part of the environment impact assessment studies undertaken on biodiversity of the influence (downstream) and impact zone (upstream) for a proposed dam to be built by India, near Kerabari (26°44'93N & 89°55'55E), in Bhutan, under the Sankosh Hydro-electric Power Project (Images 1 & 2).

MATERIAL AND METHODS

Study Area

The study area falls in the subtropical forests in the southwesternmost part of Bhutan in the south-central Dzongkhag (Sarpang District). These forests are broadly classified as semievergreen but vary from almost totally deciduous on exposed dry slopes to almost totally evergreen in the forest valleys. Adjacent to and east of the study area lies the Phibsoo Wildlife Sanctuary. The sanctuary covers an area of 265km² of unique dry shorea forest ecosystem and conserves tropical fauna such as the Tiger *Panthera tigris*, Elephant *Elephas maximus*, Gaur *Bos gaurus*, Golden Langur *Trachypithecus geei*, Indian Wild Dog or Dhole *Cuon alpinus*, Grey Peacock Pheasant *Polyplectron bicalcaratum*, Rufous-necked Hornbill *Aceros nipalensis*, Wreathed Hornbill *A. undulatus*, Great Hornbill *Buceros bicornis* and is the only protected area in Bhutan having Chital Deer *Axis axis* and natural sal forests. Phibsoo Wildlife Sanctuary touches its border with India and is linked on its southwestern end to the Buxa Tiger Reserve in West Bengal, India ca. 100km to the south-east of the study site, in India, lies the Ripu-Chirang Wildlife Sanctuary (RCWF; 89°55'–90°30'E & 27°15'–26°35'N) in western Assam which is a transitional zone between Manas Tiger Reserve in the east and Buxa Tiger Reserve in the west. About 300 species of butterflies have been recorded from RCWF including the rare Yellow-crested Spangle *Papilio elephenor* Doubleday, 1886 and Moore's Cupid *Shijimia moorei* Leech, 1889 (Choudhury 2010), although the list has not been given.

Sampling

Five sampling surveys were carried out during 7–9 January 2009 (winter), 13–14; 17–19 May 2009 (pre-monsoon), 11–13 July 2009 (monsoon), 26–28 November 2009 (post-monsoon) and 19–22 March 2010 (spring) in the study area (Images 3–8). In January the day temperature and relative humidity (11:30–15:30 hr) varied between 23.6–27.8 °C and 57.4–58.4 %, respectively, with days being short. During March relative humidity varied between 57.1–60.1 % and day temperature between 33.4–34.2 °C. In May the weather was hot and dry while during July (monsoon) the whole area remained under cloud cover

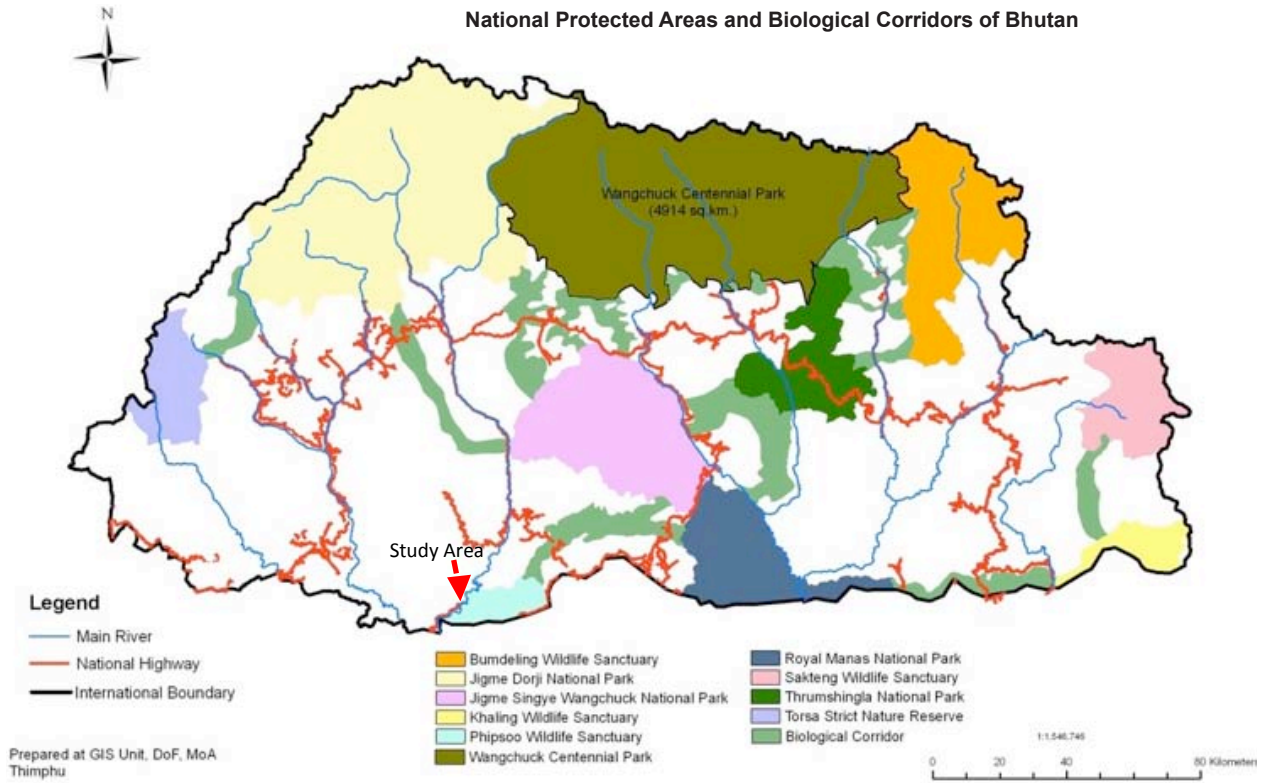


Image 1. Map of Bhutan depicting the location of protected areas and the study area bordering India

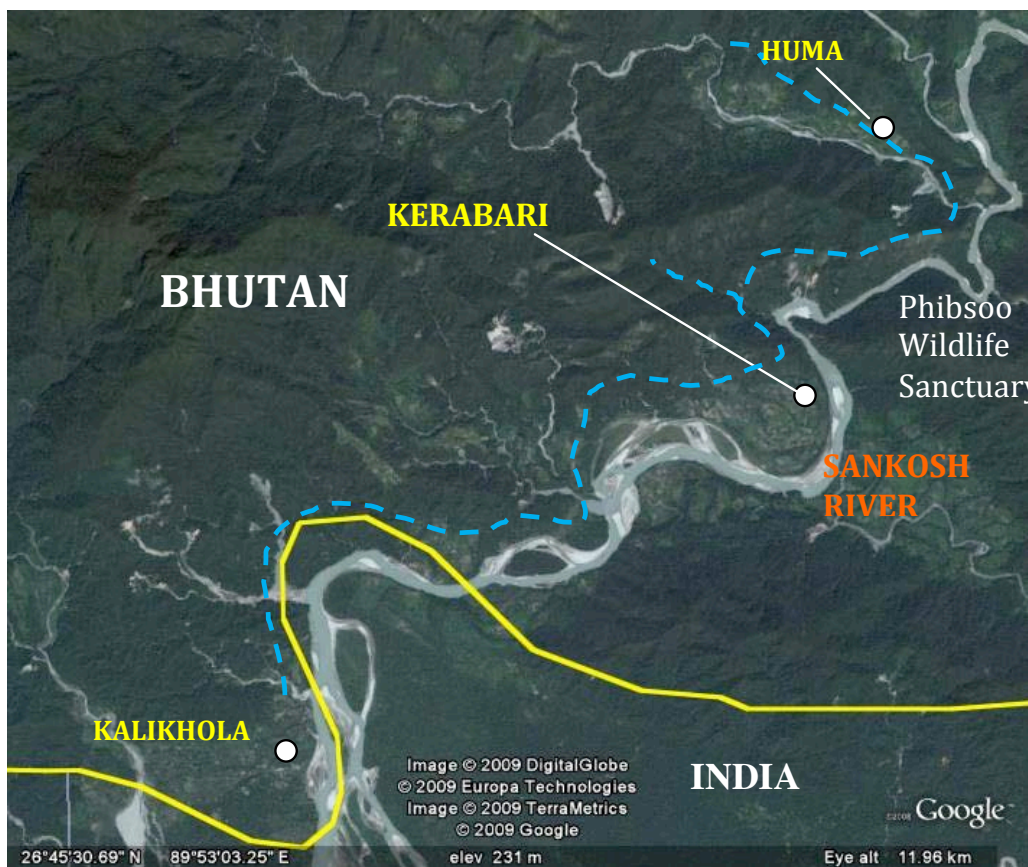


Image 2. Location of study sites, the road from Kalikhola to Kerabari and the foot trail beyond up to Huma Village, marked in blue, along which the sampling surveys were undertaken along the right bank of Sankosh River.



Image 3. Low forest habitat during the monsoon season (July) near Kalikhola



Image 4. Sankosh River flowing through Kalikhola-Huma Khola transect near dam site during winter (January)



Image 5. Sankosh River flowing further up from the dam site close to Huma



Image 6. Low forest habitat during pre-monsoon season (May)



Image 7. Huma Village



Image 8. Hama Khola (riverlet) during winter (January)

with high relative humidity (83–90 %) and temperature (30.3–32.1 °C). At this time rain drizzled intermittently throughout the day while all the road network between Kalikhola (26°44'20N & 89°51'25E) and Kerabari was washed out at places by running seasonal streams. During November the weather was cool and dry (relative humidity 61–62 %; temperature 26–27 °C) the weather at this time being more comfortable to work in and the road network is also restored.

Transect walks were undertaken along the road that links Kalikhola Village located on the Indian border to Kerabari Village (15km) and then further on a foot trail linking Kerabari-Huma Semal Village (6km) along the Sankosh River and finally 5km further north upstream from Huma Khola on a foot trail. All the sampling sites lay on the right bank of the river Sankosh between 118–220 m and 26°44'21"–26°47'69"N & 89°51'25–89°56'05"E. 'Pollard Walk' method used for sampling butterflies was carried out throughout the day from morning (10:00 hr) until sunset (17:00–18:00 hr), but the total number of sampling hours varied from 4–8 hr per day being less during the monsoon season (July=3.5–4h/day) and maximum in the pre-monsoon (May=7–8h/day). Thus, a total of ca.110 hr of sampling was carried out during the entire study period. Butterflies were recorded up to 20m on both sides of the transect and on the river bed of Huma Khola near Huma Village. In addition, a transect (500m) uphill along the forest stream which flows into the river Sankosh at the U-turn near Kerabari was also sampled by trekking for a day (04 March 2011). During each season sampling was carried out for 3–4 successive days at a stretch on these trails. Butterflies were identified mainly by taking photographs, and using field guides for identification (Evans 1932; Wynter-Blyth 1957; D'Abbrera 1982, 1985, 1986; Smith 1989, 2006; Haribal 1992; Kehimkar 2008). Identification of some species of the *Neptis soma* group (Nymphalidae) and the *Telicota colon* group (Hesperiidae) was based on wing pattern as captured in the images, and not based on the genitalia. Hence these might require confirmation.

Data Analysis

Species Accumulation Curve

Data for the number of species recorded in each season was pooled. Species accumulation curve was then plotted seasonally from the first to the last

sampling to see the rate of species accumulation during each of the five successive samplings.

Relative Abundance

The abundance data for each butterfly species for all the five seasons combined was pooled separately to get the overall relative abundance status of each species. This data was then sorted in descending order from highest to lowest value and species were then placed in four different classes based upon their respective quartile divisions from very common to uncommon, respectively i.e. VC - very common or Q1 (7–217 number of individuals sampled); C - common or Q2 (4–6); FC - fairly common or Q3 (2–3); UC - uncommon or Q4 (1), respectively.

Student's t-test

Relative abundance data of 'very common' species (Q4; n=48) of butterflies for individual seasons (n=5) was then subjected to 'paired t-tests' (both two-tailed and one-tailed) to see if the seasonal variations between two different seasons were significant at $p < 0.05$ using SPSS 14 software. [Data was tested for normality prior to analysis and non-parametric tests were followed accordingly to look at the variations].

Simpson's Index

As species richness and evenness increase, diversity increases. 'Simpson's Diversity Index' takes into account both richness and evenness (Evenness is a measure of the relative abundance of the different species making up the richness of an area). 'Simpson's Index of Diversity' was calculated and used here to see the seasonal variation /trend in species diversity of butterflies in the lowland forests of Bhutan. Simpson's Index (D) (Simpson 1949) measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species).

$$D = \sum n(n-1)/N(N-1)$$

n = the total number of organisms of a particular species
N = the total number of organisms of all species

The value of D ranges between 0 and 1. With this index, 0 represents infinite diversity and 1 no diversity. That is, the bigger the value of D, the lower the diversity. As this is neither intuitive nor logical, to get over this problem, D was subtracted from 1 to give Simpson's Index of Diversity = 1–D. The value of

this index also ranges between 0 and 1, the greater the value, the greater the sample diversity. In this case, the index represents the probability that two individuals randomly selected from a sample will belong to different species.

Sørensen's Similarity Index

This index or β was calculated to see the species similarity of butterflies between different seasons in lowland forests.

$$\beta = 2c / (S1 + S2)$$

Here, S1= the total number of species recorded in one season, S2= the total number of species recorded in a different season, and c=the number of species common to both the seasons.

The Sørensen's similarity index (Sørensen 1948) is a very simple measure of beta diversity, ranging from a value of 0 where there is no species overlap between the communities, to a value of 1 when exactly the same species are found in both communities.

RESULTS AND DISCUSSION

A total of 213 species of butterflies were recorded during the five sampling surveys carried out in 18 days in the study area. A complete checklist of butterflies sampled in the study area is given in the Table 1). Amongst these, only 87 species are common with van der Poel & Wangchuk (2007) list for areas between 800–3,000 m in Bhutan.

Species accumulation curve

The increasing trend in the species accumulation curve shows that new species were added during every season up to the last sampling at about the same rate (Fig. 1). This suggests that there is a potential of adding more species to the current list of the area and there is a need to undertake more surveys for a preparing an exhaustive list.

How many species could be there in the study area?

A total of 22 species of the family Papilionidae were recorded in this which suggests that the species richness of the area could be as high as 297 species based on family proportion model (Singh & Pandey 2004) by taking Papilionidae species proportion as

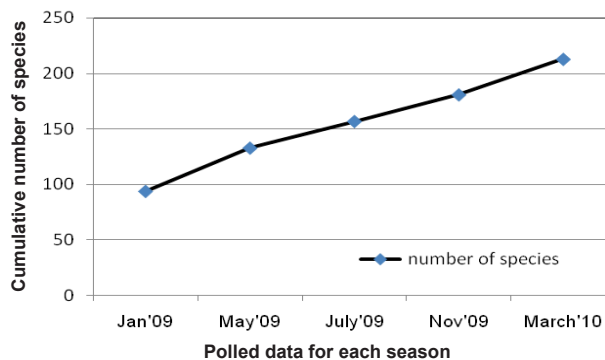


Figure 1. Species accumulation curve in sampling butterflies through different seasons in tropical lowland forests of Bhutan (January 2009–March 2010).

7.4% of the total for northeastern India (Wynter-Blyth 1957). The present findings thus represent only 70.6% of the species found in the study area. The family Pieridae represents only 10.8% of the total; Lycaenidae 24.0%; Nymphalidae 42.4% and Hesperidae 13.3%, respectively, of the total species sampled. As per Singh & Pandey (2004) model, families Lycaenidae and Hesperidae should represent 29.5% and 21.9%, respectively, of the total number of species sampled in northeastern India. These two families are thus under represented in the present sampling and there is a need to look for more species.

Seasonality of butterflies in subtropical lowland forests

Species richness and diversity: The seasonal variation in Simpson's Index of Diversity (Fig. 2) and the number of species sampled during each season (pooled data; Fig. 3), suggests that species diversity and richness both peak during March (spring) and are lowest in January (winter). A second peak was observed during November which was smaller than the first peak. This seasonal pattern of diversity in butterflies is very typical of the lower foothills and valleys of the Himalaya, i.e. Dehradun Valley (400–700 m) (Singh & Bhandari 2003) or even Calcutta (Wynter-Blyth 1957). However, the timing of the two seasonal peaks, as observed in this study, is slightly different in pattern as compared to the butterflies found in the higher reaches of the Himalaya where the first peak is slightly late in April–May while the second peak is slightly earlier in September–October i.e. Bhutan between 1,200–3,000 m (van der Poel & Wangchuk 2007) or Shimla at around 2000m (Wynter-

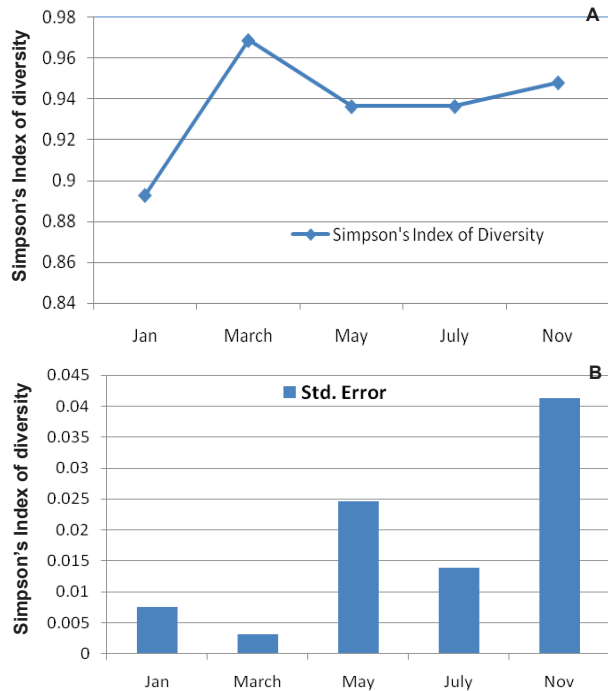


Figure 2. Seasonal variation in (A) species diversity of butterflies, and (B) its standard error in subtropical lowland forests of Bhutan (January 2009–March 2010).

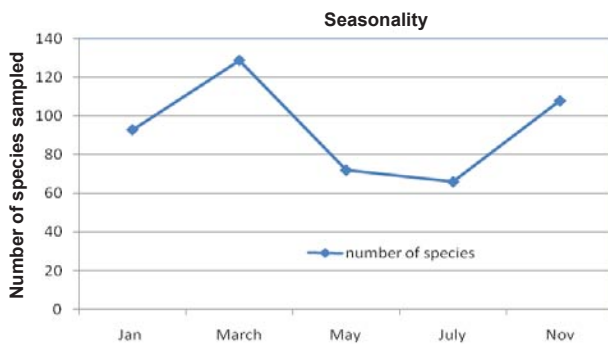


Figure 3. Seasonal variation in number of butterfly species (pooled) in subtropical lowland forests of Bhutan (January 2009–March 2010).

Blyth 1957). This is because spring arrives late in the higher reaches so butterflies emerge later and as winter sets in early in the hills, so butterflies go into hibernation early as compared to the low land forests.

Species similarity between seasons: Sørensen's similarity index between seasons varied between 0.3076 to 0.5656. This suggests that the species composition also changed with the seasons in these forests. Greatest species similarity was observed during January and November followed by March and November, respectively (Fig. 4). However, the least

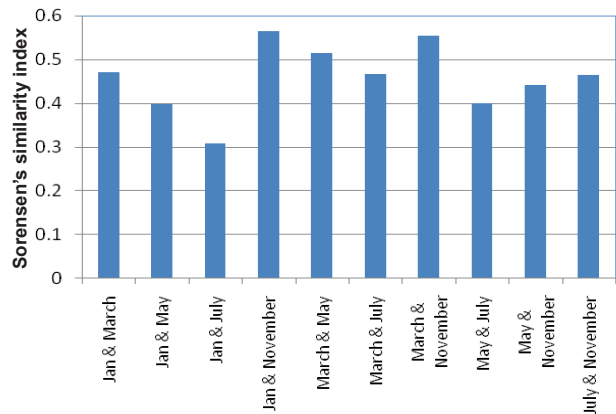


Figure 4. Butterfly species similarity between different seasons in sub-tropical lowland forests of Bhutan (January 2009–March 2010).

species similarity in species composition was observed between January and July followed by January and May, respectively (Fig. 4).

Relative abundance: The five most abundant species in the study area were *Euploea mulciber mulciber*, *Ixais pyrene pirenassa*, *Appias lyncida hippoides*, *Tirumala septentrionis* and *Eurema blanda silhetana*. The seasonal variations in relative abundance of butterflies for 'very common' species (n=48; Q4) were found to be significant ($p < 0.05$; Student's t-test) between only January–March; March–May and March–November. Thus, the abundance of common butterflies during 'spring' varied significantly as compared to 'winter', 'dry summer/pre-monsoon' and 'post-monsoon' seasons.

Species of conservation priority: At least 11 species (*Pareronia avatar avatar*, *Nacaduba pactolus continentalis*, *Porostas aluta coelestis*, *Lampides boeticus*, *Melanitis zitenius zitenius*, *Elymnias vasudeva vasudeva*, *Mycalesis mestra retus*, *Charaxes marmax*, *Athyma ranga ranga*, *Neptis manasa manasa* and *Neptis soma*) recorded in the study area have been listed in Schedules I and II of the Indian Wildlife (Protection) Act, 1972 (IWPA), but none in the 'Forest Nature and Conservation Act of Bhutan 1995' or IUCN Red list of Threatened species (IUCN 2010). Amongst these 11 species, except for *Lampides boeticus*, all other taxa are 'rare' throughout their distribution range (Evans 1932; Wynter-Blyth 1957) and are thus species of conservation priority over rest of the other taxa in the study area. Besides, one more species, *Burala amara* Moore, which has been omitted from the IWPA, is also

Table 1. Checklist of butterflies recorded in subtropical lowland forests of Bhutan along the Sankosh River (118–220 m; January 2009–March 2010).

	Family/Scientific name	Common Name	Jan	Mar	May	Jul	Nov	Relative Abundance
A.	Papilionidae							
1	<i>Graphium sarpedon sarpedon</i> Linnaeus	Common Blue Bottle (Image 9)		*	*	*	*	14
2	<i>Graphium doson axion</i> Felder	Common Jay (Image 10)	*					3
3	<i>Graphium chironides</i> Honrath	Veined Jay			*			9
4	<i>Graphium agamemnon agamemnon</i> Linnaeus	Tailed Jay		*		*	*	3
5	<i>Graphium nomius</i> Swinhoe	Spot Swordtail (Image 11)		*				14
6	<i>Graphium agetes agetes</i> Westwood	Four-bar Swordtail (Image 12)		*	*			3
7	<i>Graphium macareus indicus</i> Rothschild	Lesser Zebra (Image 13)		*		*	*	5
8	<i>Graphium xenocles phrontis</i> DeNiceville	Great Zebra		*				3
9	<i>Graphium antiphates pompilius</i> Fabricius	Fivebar Swordtail (Image 14)		*			*	7
10	<i>Papilio clytia clytia</i> Linnaeus	Common Mime		*	*			3
11	<i>Papilio polytes stichioides</i> Evans	Common Mormon	*	*	*	*	*	46
12	<i>Papilio castor castor</i> Westwood	Common Raven		*				2
13	<i>Papilio helenus helenus</i> Linnaeus	Red Helen (Image 15)		*	*	*	*	18
14	<i>Papilio nephelus chaon</i> Westwood	Yellow Helen (Image 16)		*	*	*	*	17
15	<i>Papilio memnon agenor</i> Linnaeus	Great Mormon (Image 17)		*		*		3
16	<i>Papilio protenor euprotenor</i> Fruhstorfer	Spangle				*	*	2
17	<i>Papilio alcmeno</i> Felder	Redbreast		*		*	*	4
18	<i>Papilio demoleus demoleus</i> Linnaeus	Lime Butterfly			*			1
19	<i>Papilio bianor polyctor</i> Boisduval	Common Peacock		*	*	*		3
20	<i>Atrophaneura varuna astorion</i> Westwood	Common Batwing		*		*	*	3
21	<i>Pachliopta aristolochiae aristolochiae</i> Fabricius	Common Rose		*				1
22	<i>Troides aeacus</i> Felder	Golden Birdwing	*	*		*		4
B.	Pieridae							
23	<i>Eurema blanda silhetana</i> Wallace	Three Spot Grass Yellow	*	*	*	*	*	53
24	<i>Eurema hecabe hecabe</i> Linnaeus	Common Grass Yellow		*	*	*	*	17
25	<i>Gandaca harina assamica</i> Moore	Tree Yellow	*	*	*		*	23
26	<i>Catopsilia pomona</i> Linnaeus.	Common Emigrant	*	*		*		23
27	<i>Catopsilia pyranthe minna</i> Herbst	Mottled Emigrant		*		*	*	32
28	<i>Ixias Marianne</i> Cramer	White Orange Tip					*	2
29	<i>Ixais pyrene pirenassa</i> Wallace	Yellow Orange Tip (Image 18)	*	*	*		*	123
30	<i>Hebomoia glaucippe glaucippe</i> Linnaeus	Great Orange Tip (Image 19)	*	*	*	*	*	32
31	<i>Pareronia valeria hippa</i> Fabricius	Common Wanderer	*					1
32	<i>Pareronia avatar avatar</i> Moore [IWPA Sch. II]	Pale Wanderer			*			1
33	<i>Appias lyncida hippoides</i> Moore	Chocolate Albatross (Image 20)	*	*	*		*	99
34	<i>Appias albino darada</i> Felder	Common Albatross	*				*	11
35	<i>Appias lalage lalage</i> Doubleday	Spot Puffin	*	*				7
36	<i>Pieris canidia indica</i> Evans	Indian Cabbage White	*					1
37	<i>Cepora nerissa phryne</i> Fabricius	Common Gull		*	*	*	*	39
38	<i>Cepora nadina nadina</i> Lucas	Lesser Gull		*	*	*	*	23
39	<i>Prioneris thestylis</i> Doubleday	Spotted Sawtooth (Image 21)	*	*			*	6
40	<i>Delias pasithoe</i> Linnaeus	Red Base Jezebel (Image 22)	*	*			*	4
41	<i>Delias descombesi leucacantha</i> Fruhstorfer	Red Spot Jezebel (Image 23)	*			*	*	7
42	<i>Delias thysbe pyramus</i> Wallace	Red-breasted Jezebel (Image 24)	*	*				5

	Family/Scientific name	Common Name	Jan	Mar	May	Jul	Nov	Relative Abundance
43	<i>Delias agostina</i> Hewitson	Yellow Jezebel	*					1
44	<i>Delias hyparete hierte</i> Drury	Painted Jezebel (Image 25)			*			1
45	<i>Leptosia nina nina</i> Fabricius	Psyche	*	*				2
C.	Lycaenidae							
46	<i>Poritia hewitsoni hewitsoni</i> Moore	Common Gem					*	2
47	<i>Spalgis epius epius</i> Westwood	Apefly (Image 26)	*					1
48	<i>Curetis bulis</i> Doubleday & Hewitson	Bright Sunbeam		*	*			4
49	<i>Curetis dentata dentata</i> Moore	Angled Sunbeam (Image 27)		*				2
50	<i>Chrysozephyrus assamica</i> Tytler*	Silver Hairstreak			*			1
51	<i>Arhopala pseudocentaurus</i> Doubleday	Western Centaur Oakblue	*	*			*	3
52	<i>Arhopala abseus</i> Hewitson	Aberrant Oak Blue		*	*		*	3
53	<i>Arhopala atrax</i> Hewitson	Indian Oak Blue			*			1
54	<i>Surendra quercetorum quercetorum</i> Moore	Common Acacia Blue		*	*			2
55	<i>Loxura atymnus continentalis</i> Fruhstorfer	Yamfly			*	*		4
56	<i>Cheritra freja freja</i> Fabricius	Common Imperial (Image 28)	*	*	*		*	9
57	<i>Remelana jangala ravata</i> Moore	Chocolate Royal (Image 29)	*					3
58	<i>Tajuria cippus cippus</i> Fabricius	Peacock Royal	*					1
59	<i>Pratapa deva lila</i> Moore	Tufted White Royal					*	1
60	<i>Hypolycaena erylus himarantus</i> Moore	Common Tit	*				*	12
61	<i>Zeltus amasa</i> Hewitson	Fluffy Tit (Image 30)			*			1
62	<i>Deudorix epijarbas</i> Moore	Cornelian		*				1
63	<i>Rapala varuna orseis</i> Hewitson	Indigo Flash					*	1
64	<i>Rapala pheretima petosiris</i> Hewitson	Copper Flash	*				*	28
65	<i>Rapala jarbus</i> Fabricius	Indian Red Flash		*			*	2
66	<i>Catapaecilma elegans major</i> Fruhstorfer	Common Tensil		*				2
67	<i>Spindasis vulcanus vulcanus</i> Fabricius	Common Silverline		*				1
68	<i>Spindasis lohita himalayanus</i> Moore	Long-banded Silverline		*			*	8
69	<i>Heliophorus epicles indicus</i> Fruhstorfer	Purple Sapphire	*	*	*		*	5
70	<i>Anthene emolus emolus</i> Godart	Common Ciliate Blue	*	*	*			3
71	<i>Anthene lycaenina lycambes</i> Hewitson	Pointed Ciliate Blue		*		*		2
72	<i>Castalius rosimon rosimon</i> Fabricius	Common Pierrot	*		*			2
73	<i>Leptotes plinius</i> Fabricius	Zebra Blue			*			1
74	<i>Nacaduba pactolus continentalis</i> Fruhstorfer [IWPA Sch. II]	Large 4-Lineblue	*					1
75	<i>Nacaduba kurava euplea</i>	Transparent 6- Lineblue			*			2
76	<i>Nacaduba beroe</i> Felder	Opaque 6 - Lineblue			*			3
77	<i>Porostas aluta coelestis</i> de Niceville [IWPA Sch. II]	Banded Lineblue	*				*	2
78	<i>Prosotas dubiosa indica</i> Evans	Tailless Line Blue				*		1
79	<i>Jamides bochus</i> Cramer	Dark Cerulean	*	*	*			6
80	<i>Jamides celeno celeno</i> Cramer	Common Cerulean	*	*	*		*	49
81	<i>Jamides alecto euryasces</i> Fruhstorfer	Metallic Cerulean		*				1
82	<i>Catochrysops panormus</i> Felder	Silver Forget-me-not		*	*			2
83	<i>Catochrysops Strabo</i> Fabricius	Forget- me- not		*				1
84	<i>Pseudozizeeria maha maha</i> Kollar	Pale Grass Blue		*		*		2
85	<i>Lampides boeticus</i> Linnaeus [IWPA Sch. II]	Pea Blue		*				1

	Family/Scientific name	Common Name	Jan	Mar	May	Jul	Nov	Relative Abundance
86	<i>Zizeeria karsandra</i> Moore	Dark Grass Blue			*	*		2
87	<i>Everes lacturnus assamica</i> Tytler	Indian Cupid					*	1
88	<i>Neopithecops zalmora</i> Butler	Quaker	*	*	*			4
89	<i>Megisba malaya sikkima</i> Moore	Malayan		*		*		3
90	<i>Acytolepis puspa gisca</i> Fruhstorfer	Common Hedge Blue		*				1
91	<i>Celastrina lavendularis placida</i> de Niceville	Plain Hedge Blue				*		1
92	<i>Chilades lajus lajus</i> Evans	Lime Blue		*	*	*		6
93	<i>Abisara fylla</i> Doubleday	Dark Judy	*	*			*	3
94	<i>Abisara echerius suffuse</i> Moore	Plum Judy				*		1
95	<i>Abisara neophron neophron</i> Hewitson	Tailed Judy		*				2
96	<i>Zemeros flegyas indicus</i> Fruhstorfer	Punchinello	*	*	*	*	*	10
D.	Nymphalidae							
97	<i>Libythea lepita lepita</i> Moore	Common Beak		*				1
98	<i>Tirumala limniace mertina</i> Fruhstorfer	Blue Tiger	*	*	*	*	*	15
99	<i>Tirumala septentrionis</i> Butler	Dark Blue Tiger	*		*	*		66
100	<i>Danaus genutia</i> Cramer	Striped Tiger	*	*	*	*	*	11
101	<i>Danaus chrysippus</i> Linnaeus	Plain Tiger	*	*		*	*	12
102	<i>Parantica aglea melanoidea</i> Moore	Glassy Tiger	*	*		*	*	12
103	<i>Parantica sita tylia</i> Gray	Chestnut Tiger	*				*	2
104	<i>Parantica melaneus plantenston</i> Fruhstorfer	Chocolate Tiger (Image 31)	*			*		5
105	<i>Euploea mulciber mulciber</i> Cramer [IWPA Sch. IV]	Striped-blue Crow	*	*	*	*	*	217
106	<i>Euploea radamanthus</i> Fabricius	Maggie Crow (Image 32)				*	*	4
107	<i>Euploea midamus splendens</i> Butler	Blue Spotted Crow	*					13
108	<i>Euploea algae deione</i> Westwood	Long-branded Crow (Image 33)	*			*		16
109	<i>Euploea core core</i> Cramer	Common Crow	*	*	*	*	*	13
110	<i>Polyura athamas athamas</i> Drury	Common Nawab	*	*	*	*	*	9
111	<i>Polyura eudamippus</i> Doubleday	Great Nawab (Image 34)		*				2
112	<i>Polyura arja</i> Felder	Pallid Nawab (Image 35)					*	2
113	<i>Charaxes bernardus</i> Fabricius	Tawny Rajah		*	*	*	*	9
114	<i>Charaxes marmax</i> Westwood [IWPA Sch. II]	Yellow Rajah		*		*	*	3
115	<i>Charaxes solon fabius</i> Fabricius	Black Rajah				*	*	2
116	<i>Faunis canens</i> Hubner	Common Faun				*		1
117	<i>Discophora sondaica zal</i> Westwood	Common Duffer					*	2
118	<i>Melanitis leda ismene</i> Cramer	Common Evening Brown	*	*	*		*	5
119	<i>Melanitis phedima bela</i> Moore	Dark Evening Brown	*	*			*	3
120	<i>Melanitis zitenius zitenius</i> Herbst [IWPA Sch. II]	Great Evening Brown	*	*			*	5
121	<i>Lethe europa niladana</i> Fruhstorfer	Bamboo Treebrown				*		1
122	<i>Lethe rohria rohira</i> Fabricius	Common Treebrown	*			*		3
123	<i>Lethe confuse confuse</i> Aurivillius	Banded Treebrown		*			*	3
124	<i>Lethe mekara mekara</i> Moore	Common Red Forester (Image 36)	*	*				2
125	<i>Lethe verma sintica</i> Fruhstorfer	Straight-banded Treebrown			*			2
126	<i>Elymnias hypermnestra undularis</i> Drury	Common Palmfly	*	*	*	*	*	11
127	<i>Elymnias vasudeva vasudeva</i> Moore [IWPA Sch. II]	Jezebel Palmfly (Image 37)					*	1
128	<i>Mycalesis anaxias aemate</i> Fruhstorfer	White Bar Bushbrown		*				1

	Family/Scientific name	Common Name	Jan	Mar	May	Jul	Nov	Relative Abundance
129	<i>Mycalesis mestra retus</i> Fruhstorfer [IWPA Sch. II]	White-edged Bushbrown	*					1
130	<i>Mycalesis perseus blasieus</i> Fabricius	Common Bushbrown	*	*	*	*	*	33
131	<i>Mycalesis malsara</i> Moore	White line Bushbrown		*				3
132	<i>Mycalesis lepcha lepcha</i> Moore	Lepcha Bushbrown					*	1
133	<i>Orsotrioena medus meudus</i> Fabricius	Medus Brown/Jungle Brown		*	*			8
134	<i>Ypthima baldus baldus</i> Fabricius	Common Five Ring	*	*	*	*	*	47
135	<i>Cethosia biblis tisamena</i> Fruhstorfer	Red Lacewing				*	*	4
136	<i>Vindula erota erota</i> Fabricius	Cruiser (Image 38)				*	*	4
137	<i>Cirrochroa aoris aoris</i> Doubleday	Large Yeoman	*	*	*	*	*	15
138	<i>Cirrochroa tyche mithila</i> Moore	Common Yeoman	*	*	*	*	*	11
139	<i>Vagrans egista sinha</i> Kollar	Vagrant	*				*	2
140	<i>Phalanta phalantha</i> Drury	Common Leopard		*	*		*	23
141	<i>Moduza procris procris</i> Cramer	Commander (Image 39)	*	*				3
142	<i>Athyma perius</i> Linnaeus	Common Sergeant	*					1
143	<i>Athyma asura asura</i> Moore	Studded Sergeant		*				1
144	<i>Athyma ranga ranga</i> Moore [IWPA Sch. II]	Black Vein Sergeant (Image 40)	*	*	*		*	7
145	<i>Athyma selenophora selenophora</i> Kollar	Staff Sergeant	*				*	2
146	<i>Athyma cama</i> Moore	Orange Staff Sergeant		*				1
147	<i>Athyma nefte inara</i> Doubleday	Colour Sergeant (Image 41)	*			*		2
148	<i>Pantoporia hordonia hordonia</i> Stoll	Common Lascar	*	*	*		*	9
149	<i>Neptis miah miah</i> Moore	Small Yellow Sailer	*					1
150	<i>Neptis hylas varmona</i> Moore	Common Sailer	*	*	*		*	26
151	<i>Neptis soma soma</i> Moore [IWPA Sch. II]	Sullied Sailer		*	*	*		5
152	<i>Neptis pseudovikasi</i> Moore	Dingy Sailor (Image 42)					*	1
153	<i>Neptis ananta ochracea</i> Evans	Yellow Sailer (Image 43)		*		*	*	4
154	<i>Neptis manasa</i> Moore [IWPA Sch. I]	Pale Hockey Stick Sailer (Image 44)					*	1
155	<i>Neptis cartica cartica</i> Moore	Plain Sailer		*				1
156	<i>Phaedyma columella ophiana</i> Moore	Short-banded Sailer		*				1
157	<i>Lebadea martha martha</i> Fabricius	Knight (Image 45)	*	*			*	6
158	<i>Euthalia monina kesava</i> Moore	Powdered Baron					*	2
159	<i>Euthalia phemius</i> Doubleday	White-edged Blue Baron	*				*	4
160	<i>Euthalia aconthea suddhodana</i> Fruhstorfer	Common Baron		*			*	5
161	<i>Euthalia lubentina indica</i> Fruhstorfer [IWPA Sch. IV]	Gaudy Baron				*	*	2
162	<i>Tanaecia lepidea lepidea</i> Butler	Grey Count (Image 46)	*	*			*	3
163	<i>Tanaecia julii appiades</i> Menetries	Common Earl		*			*	4
164	<i>Lexias dirtea khasiana</i> Swinhoe	Dark Archduke (Images 47a,b)		*	*		*	4
165	<i>Cyrestis thyodamas thyodamas</i> Boisduval	Common Map	*	*	*		*	5
166	<i>Chersonesia risa</i> Doubleday	Common Maplet (Image 48)					*	2
167	<i>Stibochiona nicea nicea</i> Gray	Popinjay		*			*	2
168	<i>Ariadne ariadne pallidor</i> Fruhstorfer	Angled Castor	*					1
169	<i>Ariadne merione assama</i> Evans	Common Castor		*				1
170	<i>Apatura ambica ambica</i> Kollar	Indian Purple Emperor		*				1
171	<i>Rohana parisatis parosatis</i> Westwood	Black Prince (Image 49)		*	*		*	11
172	<i>Hestina nama</i> Doubleday	Circe	*				*	2

	Family/Scientific name	Common Name	Jan	Mar	May	Jul	Nov	Relative Abundance
173	<i>Symbrenthia lilaea khasiana</i> Moore	Common Jester	*	*			*	8
174	<i>Symbrenthia hypselis cotanda</i> Moore	Himalayan Jester	*				*	2
175	<i>Vanessa indica indica</i> Herbst	Indian Red Admiral	*				*	2
176	<i>Kaniska canace canace</i> Linnaeus	Blue Admiral					*	1
177	<i>Vanessa cardui</i> Linnaeus	Painted Lady	*					1
178	<i>Junonia orithya ocyale</i> Hubner	Blue Pansy	*				*	2
179	<i>Junonia hierta magna</i> Evans	Yellow Pansy	*					1
180	<i>Junonia iphita iphita</i> Cramer	Chocolate Pansy	*	*				2
181	<i>Junonia atlites</i> Linnaeus	Grey Pansy	*			*	*	3
182	<i>Junonia almana almana</i> Linnaeus	Peacock Pansy	*				*	2
183	<i>Junonia lemonias lemonias</i> Linnaeus	Lemon Pansy	*	*	*	*	*	21
184	<i>Hypolimnas bolina</i> Linnaeus	Great Eggfly	*	*	*	*	*	5
185	<i>Kallima inachus inachus</i> Boisduval	Orange Oakleaf	*	*		*		3
186	<i>Doleschallia bisaltide indica</i> Moore	Autumn Leaf		*	*			2
E.	Hesperiidae							
187	<i>Burala oedipodea aegina</i> Plotz	Branded Orange Awlet	*				*	2
188	<i>Burala amara</i> Moore	Small Green Awlet (Image 50)		*				1
189	<i>Burala jaina jaina</i> Moore	Orange Awlet (Image 51)		*	*			2
190	<i>Hasora badra badra</i> Moore	Common Awl			*			2
191	<i>Hasora vitta indica</i> Evans [IWPA Sch. IV]	Plain Banded Awl			*			2
192	<i>Sarangesa dasahara dasahara</i> Moore	Common Small Flat	*	*				2
193	<i>Tagiades japetus khasiana</i> Moore	Common Snow Flat	*	*		*		3
194	<i>Pseudocoladenia dan faith</i> Kollar	Fulvous Pied Flat	*		*		*	3
195	<i>Gerosis bhagava bhagava</i> Moore	Common Yellow-breasted Flat		*			*	2
196	<i>Seseria dohertyi dohertyi</i> Watson	Himalayan White Flat (Image 52)		*				1
197	<i>Tagiades gana athos</i> Plotz	Suffused Snow Flat					*	5
198	<i>Tagiades parra gala</i> Evans	Large Snow Flat (Image 53)					*	1
199	<i>Odotoptilum angulata</i> Felder	Chestnut Angle		*				1
200	<i>Oriens goloides gola</i> Moore	Common Dartlet	*	*		*		4
201	<i>Telicota colon</i> Fabricius	Pale Palm Dart		*		*	*	3
202	<i>Parnara guttatus guttatus</i> Berm	Straight Swift		*		*	*	3
203	<i>Pelopidas assamensis</i> Wood Mason & de Niceville [IWPA Sch. IV]	Great Swift	*					1
204	<i>Pithauria stramineipennis</i> Wood Mason	Light Straw Ace (Image 54)		*				2
205	<i>Arnetta atkinsoni</i> Moore	Atkinson's Bob (Image 55)		*	*			4
206	<i>Iambrix salsala salsala</i> Moore	Chestnut Bob		*			*	3
207	<i>Koruthaialos butleri butleri</i> Wood Mason	Dark Velvet Bob		*				1
208	<i>Matapa aria</i> Moore	Common Redeye	*					1
209	<i>Matapa sasiama</i> Moore	Black-veined Redeye (Image 56)					*	1
210	<i>Udaspes folus</i> Cramer	Grass Demon		*				1
211	<i>Notocrypta curvifascia</i> Felder	Restricted Demon (Image 57)	*	*			*	3
212	<i>Ancistroides nigrita</i> Latreille	Chocolate Demon (Image 58)		*				1
213	<i>Ochus subvittatus</i> Moore	Tiger Hopper			*			2

Relative Abundance: VC - very common (7–217); C - common (4–6); FC - fairly common (2–3); UC - Uncommon (1); * Identity of taxa doubtful.



Images 9 & 10. Common Blue Bottle, *Graphium sarpedon* and Common Jay, *Graphium doson*



Image 11. Spot Swordtail *Graphium nomius*



Image 12. Fourbar Swordtail *Graphium agetes agetes*



Image 13. Lesser Zebra *Graphium macareu*



Image 14. Five bar Swordtail *Graphium antiphates pompilius*



Image 15. Red Helen *Papilio helenus*



Image 16. Yellow Helen *Papilio nephelus*



Image 17. Great Mormon *Papilio memnon*



Image 18–20. Great Orange Tip, *Hebomoia glaucippe*, Yellow Orange Tip, *Ixais pyrene* and Chocolate Albatross, *Appias lycida*



Image 21. Spotted Sawtooth *Prioneris thestylis*



Image 22. Red-Base Jezebel *Delias pasithoe*



Image 23. Red Spot Jezebel
Delias descombesi



Image 24. Red-breast Jezebel
Delias thysbe



Image 25. Painted Jezebel
Delias hyparete



Image 26. Apefly *Spalgis epius*



Image 27. Angled Sumbeam
Caretis acuta



Image 28. Common Imperial
Cheritra freja



Image 29. Chocolate Royal
Eliotia jangala



Image 30. Fluffy Tit *Zeltus amasa*



Image 31. Chocolate Tiger
Parantica melaneus



Image 32. Magpie Crow
Euploea radamanthus



Image 33. Long-branded Crow
Euploea algae deione



Image 34. Great Nawab
Polyura eudamippus



Image 35. Pallid Nawab *Polyura arja*



Image 38. Cruiser *Vindula erota*

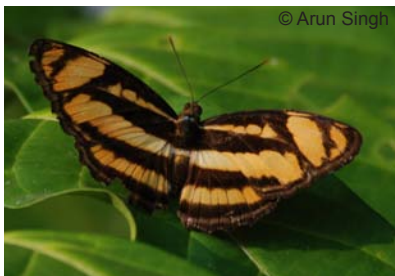


Image 41. Colour Sergeant *Athyma nefte* (male)



Image 44. Pale Hockey Stick Sailer *Neptis manasa*



Image 36. Common Red Forester *Lethe mekara*

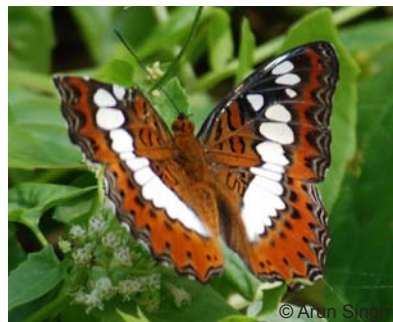


Image 39. Commander *Moduza procris*



Image 42. Dingy Sailer *Neptis pseudovikasi*



Image 45. Knight *Lebadea martha*



Image 37. Jezebel Palmfly *Elymnias vasudeva vasudeva*



Image 40. Black Vein Sergeant *Athyma ranga* (male)



Image 43. Yellow Sailer *Neptis ananta*



Image 46. Grey Count *Tanaecia lepidea* male



Image 47a. Dark Archduke
Lexias dirtea khasiana (female)



Image 47b. Dark Archduke
Lexias dirtea khasiana (male)



Image 48. Common Maplet
Chersonesia risa



Image 49. Black Prince
Rohana parisatis (male)



Image 50. Small Green Awlet
Burala amara



Image 51. Orange Awlet *Burala jaina*



Image 52. Himalayan White Flat
Seseria dohertyi



Image 53. Large Snow Flat
Taigiades parra gala



Image 54. Light Straw Ace
Pithauria stramineipennis



Image 55. Atkinson's Bob
Arnetta atkinsoni



Image 56. Black-veined Redeye
Matapa sasiarna



Image 57. Restricted Demon
Notocrypta curvifascia



Image 58. Chocolate Demon
Ancistroides nigrita

a 'rare' species in India (Evans 1932).

CONCLUSION

High value of 'Simpson's index' (0.8929–0.9687) points to the area having high variation. A stretch of ca. 12km monitored during the 18-day sampling revealed as many as 213 species and had the potential of adding many more species. The list provided here is in no way complete but represents ca. 2/3 species found in these tracts in the study area and ca. 1/4 of the species estimated from Bhutan. Besides, 12 taxa that are 'rare' in occurrence throughout their distribution range and worthy of conservation were also recorded in this subtropical lowland forest tract. Also, a good number of butterfly species were present during all the five seasons (93±12 species per season; range = 66–129 species) which is a good indicator of the potential of this area for butterfly ecotourism, that needs to be explored. 'Biodiversity offsets' such as butterfly conservatories or even a butterfly park can be established here for conserving the 'rare' species and promoting ecotourism. Thus, the present study is a way forward to bridge the remaining gaps today in documenting the complete butterfly fauna of the area, identifying sites and species of conservation concerns in the subtropical lowland forests of Eastern Himalaya.

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