INTRODUCTION

1.1 Background

Butterflies (Phylum, Arthropoda; Class, Insecta and order, Lepidoptera: Rhopalocera) are generally regarded as one of the best taxonomically studied group of insects and have been studied since the early 18th century (Sundufu and Dumbuya, 2008). Butterflies are strong pollinators and regarded as a good indicator of climate change (Simonson *et al*., 2001; Hamer *et al*., 2005; Chinaru and Joseph, 2011 and Arya *et al*., 2014). Butterfliee reflect changes in climatic conditions and are key taxa for biodiversity monitoring (Beaumont and Hughes, 2002). Also butterflies response quickly to the habitat change (Bourn and Thomas, 2002). As more butterflies are important component of ecosystem (Ghazanfar *et al*., 2016) and have aesthetic value (Chinaru and Joseph, 2011).

The altitudinal pattern of body size of insect fauna has no longer history. However changes in body sizes of animals along environmental gradient have attracted the attention of ecologist (Bergmann, 1847). Flying capacity of butterflies depend on structural features of the wings and the body (Davis and Holden, 2015). There is no general altitudinal relationship with respect to body size among butterflies, although positive, negative or null relationships may occur in any particular bio-geographical region (Hawkins and Devries, 1996).

In Nepal, study on butterfly was started from 1826 (Khanal and Smith, 1997). Out of 19,238 species of butterflies in the world (Weiss *et al*., 1988), 660 species are reported in Nepal, which are categorized under 11 families and 263 genera (Smith, 2010). Species composition of butterfly varies with abiotic factors and environmental gradients (Khanal, 1982). About 50%, 81% and 13% butterflies are found in Tarai, Midland and Highland ecological zones of Nepal respectively (Smith, 2011). The distribution pattern of butterflies varies with respect to physiographic zones (Bhusal and Khanal, 2008). At mid altitudes, the species richness becomes more which may due to overlapping of ranges and habitat, called mid domain effect (Colwell *et al*., 2004). Species richness and diversity is low at higher altitudes (Ghorai and Sengupta, 2014). The decrease in species richness of butterflies in higher altitudes is due to at least four causes: reduced habitat area, reduced resources diversity, increasing unfavorable environments and reduced primary productivity (Rodriguez and Baz, 1995). The flying capacity and special ecological needs of the species plays vital role in the distribution of that species (Khan *et al*., 2011).

Only few researches have carried out study to examine how the landscape affects on the population dynamics. Hence, researchers have emphasizes on role of local habitat on community structure and dynamics and also the effects of landscape cannot be neglected (Collinge *et al*., 2003). Thermal conditions influence on behavioral pattern and growth and development of butterfly community. Seasonal butterflies are under high pressure to

complete their lifecycle. The warmer microclimatic conditions due to sunlight are suitable for development of butterfly of any stage. The survival rate of butterflies larva and the adults in warmer region is more due to availability of larval host plants and nectar (Weiss *et al.*, 1988).

Many butterfly species are seasonal but some are present year around (Kunte, 1997). Butterflies prefer only particular types of habitat (Patel and Pandya, 2014). Floral components and their density play key role in butterfly diversity and distribution (Chinaru and Joseph, 2011; Arya *et al*., 2012 and Khanal *et al*., 2012). Butterfly diversity is highest in areas where large amount of host plants are available (Ghorai and Sengupta, 2014) and is lowest in shrub, grass and open areas (DeVries, 1988). Butterfly diversity reflects overall herbs and shrubs plant's diversity in the given area (Patel and Pandya, 2014). Adult butterflies are sensitive to their choice of flowers for feeding (Mali *et al*., 2014).

The global declination of butterflies has been indicated by many researchers in different parts of the world due to habitat degradation, climate change, use of pesticides and deforestation (Smith, 1994). The major aim of this research was to assess the diversity and distribution pattern of the butterfly. As more the research also analyzed the relation of butterfly species richness with different environmental parameters.

1.2 Objectives

1.2.1 General objective

To assess the butterfly diversity and status in Chandragiri and Champadevi hills of Kathmandu valley, Nepal.

1.2.2 Specific objectives

a. To assess the butterfly diversity in Chandragiri and Champadevi hills.
b. To find the relation of butterfly with elevation, aspect and season.
c. To determine the altitudinal variation of wing size in butterflies.

1.3 Rationale

1.3.1 Justification of study

Chandragiri and Champadevi hills are the unprotected region of southern part of Kathmandu valley. Hence, the study of fauna was given less priority as compare to the protected areas of northern hills of the valley. The study prepared a list of butterfly from this site. These two hills are affected by habitat degradation due to human encroachment, forest fire and deforestation. As butterflies are indicator of environmental quality and habitat suitability. Information provided by this study can be utilized for further study conservation action implementation.

2. LITERATURE REVIEW

2.1 In national context

Butterfly collection and study in Nepal was initiated by General Thomson Hardwick in 1826. During 1852–1867, Maj. Gen. Ramsey, a British resident while being deputed in Kathmandu, recorded 44 species of butterfly of Nepal (Khanal and Smith, 1997).

Pandey *et al.* (2017) made an extensive research in elevational distribution of butterflies in Himalayas, Langtang region and recorded 28 butterfly species belonging to the five families and revealed the declination of species along the higher elevational gradients. Recently, Shrestha (2016) carried out a detailed survey of butterflies in 15 different sites of Manang district. He recorded 57 species of butterfly belonging to eight families and 39 genera. Similarly, Chalise (2010) recorded 75 species of butterfly belonging to 51 genera and nine families from Badikhel VDC, Lalitpur during pre-monsoon and monsoon in which Nymphalids were most dominant and Acraeids were the least recorded species. Furthermore, Thapa (2008) recorded 43 butterfly species with Nymphalidae family as pre-dominant and Acreidae as least abundant family in Thankot and Syuchatar VDCs. Ghimire (2001) surveyed on diversity of butterfly fauna at Champadevi in Kirtipur Municipality, Kathmandu district and made a list of 43 species of butterfly belonging to nine families, among them family Nymphalidae was dominant. Khanal (2006) studied the late season butterflies of Koshi Tappu wildlife reserve, Eastern Nepal and listed 54 species of butterflies belonging to seven families. Moreover, Chapagai (2001) recorded 34 species of butterfly belonging to 23 genera and seven families from Koshi Tappu Wildlife reserve during taxonomic survey in winter and spring.

Khanal *et al.* (2012) made a valuable research on diversity of butterfly with respect to altitudinal rise at various pockets of Langtang National park, Central Nepal. They listed 126 species of butterfly and noted rich diversity at 1500 m to 2900 m elevation and decreasing diversity along with increasing altitudes. Two species of butterfly *Parnassius harwickei* and *Parnassius epaphus epaphus* were found to be declining. Similarly, Bhusal and Khanal (2008) studied seasonal and altitudinal diversity of butterfly in Eastern Siwalik Hills of Nepal and listed 40 Species of butterfly belonging to eight families among them family Nymphalidae was most abundant and the family Hesperidae and Nemeobidae had least number. They also noticed the increasing species richness of butterfly with upcoming warmer spring days. In addition, Prajapati *et al.* (2000) studied seasonal and altitudinal variations of butterfly species in Daman area of Makawanpur district, Central Nepal. They recorded 65 species of butterfly belonging to 48 genera and 8 families with Nymphalidae and Lycaenidae as most common families and Acraeidae as least common. They conclude that the species richness was higher in autumn than in spring. Khanal (2008) made a research on

diversity and status of butterflies in lowland districts of West Nepal. He recorded 85 species of butterflies categorized into 64 genera and 10 families. He noticed that butterfly diversity differing with the change in land structure and vegetation type.

Khanal *et al.* (2013) made an intensive research on threatened butterflies of central Nepal (Kathmandu, Lalitpur and Bhaktapur districts) during 2004–2009 and 2010–2011. They found that four species of butterfly - *Teinopalpus imperialis, Papilio krishna, Meandrusa lachinus and Euripus consimilis* are at high risk due to extreme harvesting of host plants, habitat degradation and fragmentation. Smith (1994) published a book – Butterflies of Nepal (central Himalaya) including 463 species with description of body size, their habitat, status and altitudinal range of them. Smith (1978) listed 567 species of butterfly of Nepal. This was the first updated list as no integrated publication on Nepal's butterflies was made in the last 20 years. Smith (1977a) reported 8 new species of butterfly from Godavari, Lalitpur, Nepal and among them 4 were new species for Nepal. Smith (1977b) made a valuable survey of butterflies from eastern Nepal. He recorded 26 new species of butterflies for Nepal. Smith (1977c) studied butterflies from western Nepal and recorded 28 species. It displayed fewer butterflies, less variety, but also recorded some species not found elsewhere.

2.2 In global context

The systematic study on butterflies had been carried out since 18th century (Happner 1998). Kumar *et al.* (2016) reported 29 species of butterflies belonging to 22 genera and four families from subalpine area of Chanshal Valley of Shimla where butterfly diversity was higher in autumn than in summer due to host plant availability and suitable environmental conditions like temperature and humidity. Mali *et al.* (2014) recorded 43 butterfly species belonging to five families during the study of biotic interrelationship of plants and butterflies in surrounding of Gandhinagar, Gujrat.

Acharya and Vijayan, 2015 studied butterflies of Sikkim along the elevational gradient and recorded decreasing species richness along the increase in elevation. Ghorai and Sengupta (2014) studied altitudinal distribution of the papilionidae butterfly in landscape of West Bengal, India and listed 26 papilionids species from 11 altitudinal belts. The diversity was uniform up to the altitude 2,300 m above sea level followed by decreasing diversity with increase the altitude. Castro and Espinosa, 2015 recorded the association of butterfly with ripe fruits and foliage and also the association with the sampling date and seasons. Arya *et al*. (2014) studied Species richness and diversity of butterflies in and around Kumaun University, Nainaital, Uttarakhand, India and recorded 897 individuals belonging to 27 species and 8 families. The Pieridae family was dominant family followed by family Nymphalidae. They noticed the higher diversity during rainy season followed by summer and winter. Ghosh and Saha (2016) recorded higher butterfly diversity during post monsoon. Furthermore, Kumar (2012) studied on butterflies of Jhansi (U.P.) India and listed 27 species

of butterflies belonging to 5 families with Nymphalidae as dominant family. He also noticed that diversity and the abundance of the butterfly decreases by the cause of human disturbance, habitat fragmentation, monoculture, forest fire etc.

Fileccia *et al.* (2015) carried out a research work on seasonal patterns in butterfly abundance and species diversity in five characteristic habitats in sites of community Importance in Sicily (Italy) and noticed higher butterfly diversity in June and July. They recorded Nymphalids as abundant family. Sengupta *et al.* (2014) made a valuable research on seasonal diversity of butterflies and their larval food plants in West Bengal, India and found the maximum species richness and butterfly abundance in monsoon. Khan *et al*. (2011) studied diversity and distribution of butterflies from Kashmir Himalayas and listed 68 butterfly species belonging to seven families and 38 genera with 36 species new to the region. Gowada *et al*. (2011) studied seasonal diversity and status of butterfly in Lakkavalli range of Bhadra Wildlife sanctuary, Karnataka, India by using line transect method. They record 54 butterfly species belonging to eight families. They found higher butterfly diversity in autumn season. Chinaru and Joseph (2011) made a research on diversity of butterfly species in protected and unprotected habitats of Okwu Ogbaku forest reserve in Mbaitoli L.G.A., Imo state, Nigeria. They listed 28 genera of butterfly belonging to five families from the study site. They found the Lycanidae was abundant butterfly family from the study site. Hamer *et al*. (2005) studied temporal variation in abundance and diversity of butterflies in Bornean rain forests: opposite impacts of logging recorded in different seasons. They found that the family Satyrinae has less restricted flying periods then did by the Nymphalinae.

Collinge *et al*. (2003) carried out a research on effects of local habitat characteristics and landscape on butterfly community and they found the significant effect of host plant heterogeneity and habitat quality on butterfly diversity where as insignificant effects of landscape type. Simonson *et al*. (2001) made a research on rapid assessment of butterfly diversity in a Montane landscape in Rocky mountain National park, Colorado (U. S. A.). They conclude that microclimate variation and habitat complexity and open areas enhance the butterfly diversity.

Sreekumar and Balakrishnan (2001) studied habitat and altitude preference of butterflies in Aralam Wildlife Sanctuary, Kerala by establishing line transects in different altitudinal gradients (<250 m, 251-750 m and >750m asl). They found that butterflies are highly associated with the host plants. They recorded the higher diversity of butterfly at middle elevation of the study site i.e. 250-700 m asl. Kunte (2001) studied the butterfly diversity in and around the Pune city where he recorded 104 species of butterfly.

Hawkins and Devries (1996) conducted a research on effect of altitude on body size of butterflies in Costa Rica. They studied body size of butterflies in different altitudes (200 to 3000 m asl) and conclude that body size of butterflies are larger in mid altitudes (around

1500 m asl) and decreases in higher altitude. Alder and Dudley (1996) studied Biogeography of Milkweed of Milk butterflies Nymphalidae, Danaidae and mimetic patterns on tropical pacific archipelagos. They found high dispersal capacity and ecological adaptation of Nympahalids. Rodriguez and Baz (1995) studied effects of elevation on butterfly communities of a Mediterranean mountain Sierra De Javalambre, Central Spain. They observe butterfly specimens on stations established in each 100 m elevation gap from 1100-2000 m asl. They observe 2,123 individuals of 101 different butterfly species. They found that the abundance and species richness of butterfly was highest in low elevation and it declines with increasing elevation.

Butterflies are seasonal and have effect of elevation on diversity. They have altitudinal wing size variation in different pattern. Extensive researches have not been conducted in Chandragiri and Champadevi hills till now. So to list out the butterfly fauna from that site, to find diversity and to analyse the pattern of wing size variation among butterfly community in that site, this research was conducted.

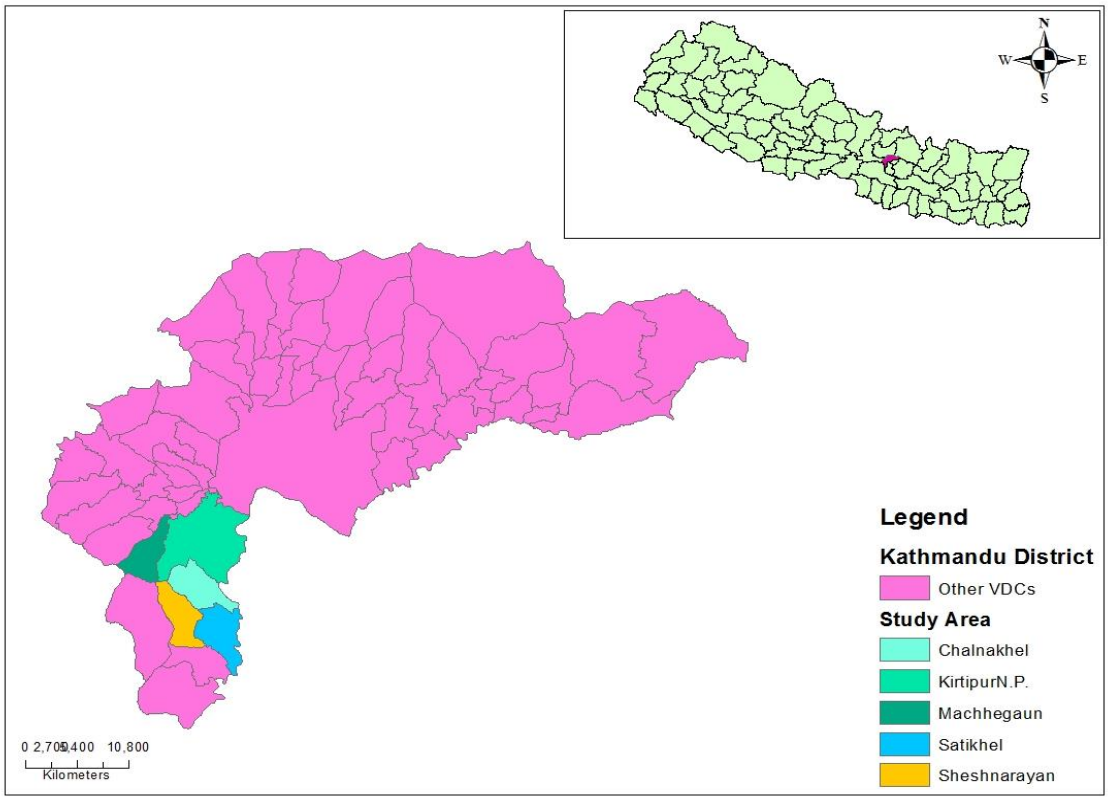
3. MATERIALS AND METHODS

3.1 The study Area

The study area covers the part of Chandragiri and Champadevi hills (85°14′22″ to 85°17′6.47″ E and 27°37′26.45″ to 27°39′48.01″ N) of Kathmandu district. The observation spots in study area for southern aspect lie around the accessible route from Satikhel to Bhasmashur danda whereas for northern aspect around the accessible path from Matchhegaun to the Bhasmashur dada. Wide altitudinal ranges (1550 m to 2,450 m asl) exist within short distance in the study area. The altitudinal gradient from 1550 m asl to 1950 m can be considered as low altitude and from 1950 m asl to 2450 m asl as the high altitudes. In low altitude, there was medium disturbed area with low canopy covering where as in high altitudes; there was low disturbance and high canopy cover.

Nowadays, these two hills are facing with habitat degradation and habitat fragmentation due to human activities. The firewood collection and coal collection are common in this area. The grazing of domestic animals was frequently observed during field visit. Some open areas of the hills are also using as picnic spots and trekking routes for cycle race. Although, some open areas and some parts forest of high altitudes of the study site are in good condition.

The study area was dominated by evergreen broad-leaved mixed forests. *Pinus roxburghii* Sargent, *Schima wallichii* Blume, *Caranopsis indica* Reinwdt, *Alnus nepalensis* Don, *Rhododondron arboretum* Linnaeus, *Myrsine semiserrata* Wall, *Myrsine esculenta* Linnaeus are main flora of the study area.



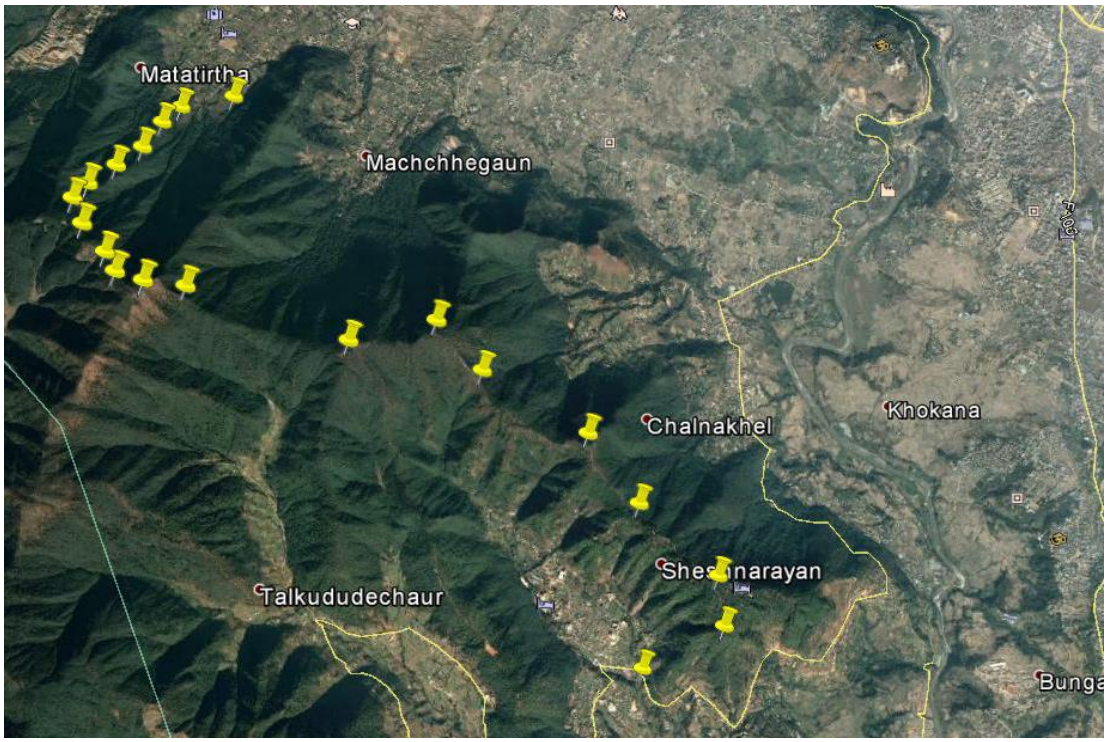


Figure 1: Map of study area (Chandragiri and Champadevi hills), Kathmandu, Nepal. Source: map.google.com

3.2 Materials

Following materials were used during field work:

i. Sweeping net: The net having length of handle 140 cm and diameter of the rim 50 cm made up of steel was used. Bag of the net was made up from muslin cloth of fine mesh which was 90 cm long so that the bag can be folded over the frame of the net to avoid the escape of the catch.
ii. GPS (Garmin extra 10)
iii. Field guide book: An Illustrated Checklist of Butterflies of Nepal, By Colin Smith, 2011.
iv. Scale (30 cm long)
v. Triangular paper envelops
vi. Air tight box with naphthalene balls

3.3 Methods

3.3.1 Field design

Chandragiri and Champadevi hills were sampled based on following the altitudinal gradient. Butterfly collection was started from 1550 m to 2450 m. Within this range, sampling spots in every 100 m elevational gradient was established. For extensive study, the study site was divided into two altitudinal zones i.e. low (1550–1950 m) and high (1950–2450 m).

3.3.2 Observation, collection and preservation of specimens

Butterflies were observed in summer (June to August) and autumn (September to November) in 2016. In each month, data was taken from four consecutive days. Butterflies were observed between 9:00 AM to 1:00 PM under sunny days. Unidentified species were killed by thorax pinching and kept in triangular paper envelops with proper labeling and put in the air tight box with naphthalene balls for preservation. Wingspan of captured individuals was measured. The wings size of butterflies was measured by the holding the butterfly in the right hand with the thorax and wings within the thumb and forefinger and right and left wing facing upward and scale was used for their measurement (Hook *et al*., 2012). The abundance of each species also noted at each altitudinal gradient.

The local status of butterfly was measured as per the number of individual counted during the field period. For the status, the recorded butterflies were categorized as rare, common and very common. We considered, the specific species counted less than five as rare; 5–14 as common and more than 14 as very common. To find threats of butterfly, direct observation and local peoples' perception were followed.

3.3.3 Identification

Butterflies were captured by using sweeping net and released after close identification by using suitable field guide book (Smith, 2011). Unidentified collected specimens were identified with the help of standard butterflies identification keys {(list of identification keys of butterflies (Lovalerkar and Kunte, 2017) and Butterflies of Nepal (Central Himalaya), Smith, 1994)} and reconfirmed by comparing collected specimens and photos with the preserved specimens of butterfly in Natural History Museum (NHM), Swyambhu, Kathmandu Nepal.

3.3.4 Statistical analysis

The collected data was initially arranged in Excel file. Later, the abundance data of butterflies was analysed descriptive statistics such as correlation analysis. Multivariate type of analysis such as Discriminant Analysis (DA) was carried out by using statistical data analysis tool "R", version 3.3.1.

The diversity of butterfly species was calculated using Shannon-Winner diversity index (H), given by the equation, $H = - \sum pi \times \ln(pi)$.
Where, $pi = ni / N$, ni is the number of individuals of ith species and $N = \Sigma ni$.
ln = the natural log
$\sum$ = the sum of the calculations

To find the evenness of species Pielou's species evenness index (J), given by, $J = H/Hmax$ was calculated.
Where $H = - \sum pi \times In(pi)$
$Hmax = \ln (n)$, n is the total species richness.

To compare the similarity of species composition between two adjacent habitats, Sorensen's similarity index (CC) given by $CC = 2C / (S_1 + S_2)$ was calculated.
Where, C = number of common species in two habitats.
S_1 = total number of species found in first habitat
S_2 = total number of species found in second habitat

4. RESULTS

4.1 Butterfly diversity and status

4.1.1 Family composition of butterfly species

A total of 2293 individuals of 113 species of butterfly belong to 71 genera and nine families were recorded during study period. The recorded species were 17.12% of total known 660 species of butterflies in Nepal. Nymphalidae was the most abundant family which contributes maximum number of species (29) followed by Satyridae (20), Lycaenidae (17), Pieridae (14), Papilionidae (14), Hesperiidae (8), Danaidae (5), Nemeobidae (5) and Acraeidae (1) (Figure 2).

The following bar diagram shows species richness of different families of butterflies recorded during study period.

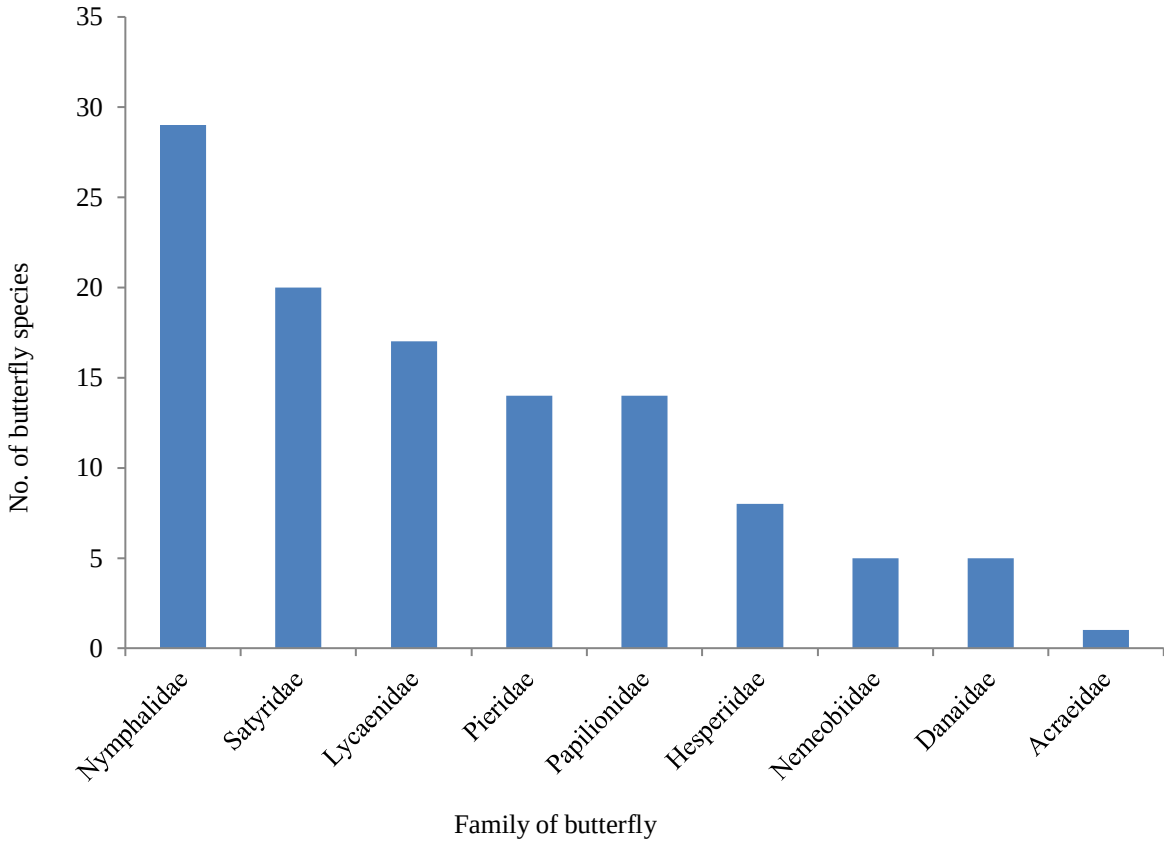


Figure 2: Family wise composition of butterfly species recorded in the study site.

4.1.2 Butterfly listing and species status

During study period, 46 species were found as very common whereas 27 species were common and 40 species were rare. *Aglais cashmirensis aesis* was the predominant species recorded throughout the sampling period in the study area with 176 individual. In contrast, *Solvia grahami, Appias lyncida eleonora, Pseudergolis wedah, Dallacha hygriva hygriva* and *Lethe baladeva baladeva* were the rare butterfly species recorded with single individual.

Table 1: Butterflies recorded during study period, their frequency and local status

Family	S.N.	Scientific Name	Common Name	Frequency	Local Status
Papilionidae	1	*Byasa latreillei latrellei* Donovan, 1826	Rose Windmill	5	**
	2	*Byasa polyeuctes letincius* Doubleday, 1842	Common Windmill	34	***
	3	*Graphium agamemnon agamemnon* Linnaeus, 1758	Tailed Jay	5	**
	4	*Graphium cloanthus cloanthus* Cramer, 1875	Glassy Bluebottle	3	*
	5	*Graphium sarpedon luctatius* Linnaeus, 1758	Common Bluebottle	34	***
	6	*Pachliopta aristolochiae aristolochiae* Fabricius, 1775	Common Rose	3	*
	7	*Papilio demoleus demoleus* Linnaeus, 1758	Lime Swallowtail	3	*
	8	*Papilio helenus helenus* Linnaeus, 1758	Red Helen	23	***
	9	*Papilio memon agenor* Linnaeus, 1758	Great Mormon	8	**
	10	*Papilio polyctor genesa* Boisduval, 1836	Common Peacock	20	***
	11	*Papilio polytes romolus* Linnaeus, 1758	Common Mormon	3	*
	12	*Papilio protenor euprotenor* Cramer, 1775	Spangle	23	***
	13	*Papilo arcturus arcturus* Westwood, 1842	Blue Peacock	2	*
	14	*Troides helena cerberus* Linnaeus, 1758	Common Birdwing	3	*
	15	*Aeromachus stigmaticus*	Veined Scrub	2	*

		stigmaticus Moore, 1878	Hopper		
Hespiridae	16	*Celaenorrhinus dhanada dhanada* Moore, 1865	Common Small Flat	3	*
	17	*Clatoris sirius siriusEvans*, 1926	Sirius swift	8	**
	18	*Coladenia dasahara dasahara* Moore, 1865	Himalayan Yellow Banded Flat	4	*
	19	*Parnara guttata mangala* Moore, 1865	Straight Swift	57	***
	20	*Polytremis eltola eltola* Hewitson, 1869	Yellow Spot Swift	3	*
	21	*Solvia grahami* Evans, 1926	Graham's Ace	1	*
	22	*Udaspes folus* Cramer, 1775	Grass Demon	2	*
Pieridae	23	*Appias lyncida eleonora* Cramer, 1777	Chocolate Albatross	1	*
	24	*Catopsila pomona pomona* Fabricius, 1775	Common Emegrant	10	**
	25	*Catopsila pyranthe pyranthe* Linnaeus, 1758	Mottled Emigrant	3	*
	26	*Cepora nerissa phryne* Fabricius, 1775	Common Gull	2	*
	27	*Colias erate lativilla* Moore, 1882	Pale Clouded Yellow	5	**
	28	*Colias fieldii fieldii* Felder, 1865	Dark Clouded Yellow	5	**
	29	*Delias eucharis* Drury, 1773	Common Jezebel	2	*
	30	*Gonopteryx aspasia* Minetries, 1858	Lesser Brimstone	8	**
	31	*Gonepteryx rhamni nepalensis* Linnaeus, 1858	Common Brimstone	83	***
	32	*Pieris brassicae nepalensis* Doubleday, 1846	Large Cabbage White	17	***
	33	*Pieris canidia indica* Evans, 1926	Indian Cabbage White	59	***
	34	*Terias blanda silhetana* Wallace, 1867	Three Spot Grass Yellow	3	*
	35	*Terias hecabe contubernalis* Moore, 1886	Common Grass Yellow	46	***

	36	*Terias laeta sikkima* Moore, 1906	Spotless Grass Yellow	3	*
Lycaenidae	37	*Acytolepsis puspa gisca* Fruhstorfer, 1910	Common Hedge Blue	45	***
	38	*Aestranicus transpecta* Moore, 1879	White Banded Hedge Blue	2	*
	39	*Arhopala rama rama* Kollar, 1848	Dark Himalayan Oakblue	10	**
	40	*Celastrina argiolus kollari* Linnaeus, 1758	Hill Hedge Blue	4	*
	41	*Celastrina gigas* Hemming, 1928	Silvery Hedge Blue	5	**
	42	*Celastrina lavendularis limbata* Moore, 1879	Plain Hedge Blue	4	*
	43	*Celatoxia marginata marginata* DeNiceville, 1884	Margined Hedge Blue	18	***
	44	*Chrysozephyrus syla* Kollar, 1848	Silver Hairstreak	4	*
	45	*Everes hugelii hugelii* Gistel, 1935	Tailed Cupid	7	**
	46	*Jamides alecto alocina* Swinhoe, 1915	Metalic Cerulian	58	***
	47	*Jamides celenoaelianus* Fabricius, 1793	Common Cerulian	7	**
	48	*Lampides boeticus* Linnaeus, 1767	Peablue	18	***
	49	*Oreolyce vardhana* Moore, 1874	Dusky Hedge Blue	69	***
	50	*Pratypa deva lila* Moore, 1883	White Tufted Royal	4	*
	51	*Zizeeria karsandra* Moore, 1865	Dark Grass Blue	6	**
	52	*Zizeeria maha maha* Kollar, 1848	Pale grass Blue	52	***
	53	*Zizeeria otis otis* Fabricius, 1787	Lesser Grass Blue	6	**
Nemeobiidae	54	*Abisara fylla fylla* Doubleday, 1847	Dark Judy	3	*
	55	*Dodona dipoea* Hewitson, 1865	Lesser Punch	26	***
	56	*Dodona eugenes eugenes* Bates, 1867	Tailed Punch	8	**
	57	*Dodona ouida* Hewitson, 1865	Mixed Punch	59	***

	58	*Zeneris fegyas indicus* Fruhstorfer, 1898	Punchinello	34	***
Acraeidae	59	*Acraea issoria* Hubner, 1818	Yellow Coster	3	*
Nymphalidae	60	*Argyreus hyperbius hyperbius* Linnaeus, 1765	Indian Fritillary	50	***
	61	*Aglais cashmirensis aesis* Fruhstorfer, 1912	Indian Tortoise Shell	176	***
	62	*Ariadne merione* Cramer, 1777	Common Castor	16	***
	63	*Athyma jina jina* Moore, 1857	Bhutan Sergeant	10	**
	64	*Athyma opalina orientalis* Elwes, 1888	Himalayan Sergeant	25	***
	65	*Athyma perius* Linnaeus, 1758	Common Sergeant	2	*
	66	*Cethosia biblis tisemina* Fruhstorfer, 1912	Red Lacewing	26	***
	67	*Childrena childreni childreni* Gray, 1831	Large Silverstripe	3	*
	68	*Cupha erymanthis lotis* Sulzer, 1776	Rustic	19	***
	69	*Cyrestis thyodamas thyodamas* Doisduval, 1836	Common Map	2	*
	70	*Dichora chandra chandra* Moore, 1857	Eastern Courtier	4	*
	71	*Dilipa morgiana* Westwood, 1851	Golden Emperor	6	**
	72	*Euthalia patala patala* Kollar, 1844	Grand Duches	2	*
	73	*Euthalia sahadeva sahadeva* Moore ,1859	Green Duke	10	**
	74	*Hestina nama nama* Doubleday, 1845	Circe	32	***
	75	*Hypolimnas bolina jacintha* Drury, 1775	Great Eggfly	4	*
	76	*Kaniska canace canace* Linnaeus, 1763	Blue Admiral	19	***
	77	*Neptis hylas kamarupa* Moore, 1874	Common Sailer	45	***
	78	*Neptis zaida bhutanica* Eliot, 1969	Pale Green Sailer	2	*
	79	*Polyura athamas* Drury, 1770	Common Nawab	3	*

	80	*Precis almana almana* Linnaeus, 1758	Peacock Pancy	5	**
	81	*Precis hierta hierta* Fabricius, 1798	Yellow Pancy	22	***
	82	*Precis iphita* Cramer, 1779	Chocolate Pancy	139	***
	83	*Precis lemonias* Fruhstorfer, 1912	Lemon Pancy	4	*
	84	*Pseudergolis wedah* Kollar, 1844	Tabby	1	*
	85	*Symbrenthia lilaea khasiana* Moore, 1874	Common Jester	19	***
	86	*Vagrans egista* Cramer, 1780	Vagrant	16	***
	87	*Vanessa cardui* Linnaeus, 1758	Painted Lady	32	***
	88	*Vanessa indica* Herbst, 1784	Indian Red Admiral	109	***
Satyridae	89	*Aulocera saraswatti* Kollar, 1844	Striated Satyr	5	**
	90	*Callerebia scanda opimam* Watkins, 1927	Pallid Argus	39	***
	91	*Dallacha hygriva hygriva* Moore, 1857	Brown Argus	1	*
	92	*Lethe baladeva baladeva* Moore, 1865	Treble Silverstripe	1	*
	93	*Lethe confusa confusa* Aurivillius, 1898	Banded Treebrown	53	***
	94	*Lethe rohria rohria* Fabricius, 1778	Common Treebrown	7	**
	95	*Lethe serbonis teesta* Talbot, 1947	Brown Forester	17	***
	96	*Lethe verma sintica* Fruhstorfer, 1911	Straight Banded Treebrown	34	***
	97	*Melanitis leda ismene* Linnaeus, 1758	Common Evening Brown	12	**
	98	*Melanitis phedima bela* Moore, 1857	Dark Evening Brown	10	**
	99	*Mycalesis mineus mineus* Linnaeus, 1767	Dark Brand Bushbrown	4	*
	100	*Nemetis chandica* Moore, 1857	Angled Red Forester	2	*
	101	*Rhaphicera moorei* Butler, 1867	Small Tawny Wall	5	**

	102	*Ypthima baldus* Fabricius, 1775	Common Five Ring	56	***
	103	*Ypthima indica* Hewitson, 1865	Lesser Three Ring	10	**
	104	*Ypthima newara* Moore, 1874	Newar Three Ring	42	***
	105	*Ypthima parasakra* Eliot, 1987	Himalayan Four Ring	20	***
	106	*Ypthima sakra* Moore, 1857	Himalayan Five Ring	105	***
	107	*Zophoessa nicetas* Hewitson, 1863	Yellow woodbrown	15	***
	108	*Zophoessa sidonis sidonis* Hewitson, 1863	Common Woodbrown	2	*
Danaidae	109	*Danus genutia* Cramer, 1779	Common Tiger	11	**
	110	*Euploea core core* Cramer, 1780	Common Indian Crow	15	***
	111	*Euploea mulciber mulciber* Cramer, 1777	Stripped Blue Crow	18	***
	112	*Parantica aglea melanoides* Moore, 1883	Glassy Tiger	44	***
	113	*Tirmala septentrionis* Butler, 1874	Dark Blue Tiger	14	**
Total				2293	

*** =Very common ** = Common * = Rare

4.1.3 Butterfly diversity and evenness study

The Shannon-Winner diversity index (*H*) was 4.0544 with Pielou's species evenness (*J*) 0.857 (Appendix: IV).

The butterfly abundance was highest at elevation of 2050 m with 320 individuals belonging to 61 species and lowest at 2450 m with 144 individuals of 29 species. The diversity index was highest (H = 3.71) at 1950 m and 2050 m and lowest at 2450 m (H = 2.7499). The species evenness was highest (J = 0.91) in elevation of 1850 m and 2050 m and lowest at 2450 m (J = 0.816) (Table 2).

The diversity index of butterfly in relation to aspect was found highest in southern aspect i.e. H = 3.99 than northern i.e. H = 3.77. In contrast, species evenness was somewhat higher in northern aspect (J = 0.873) than southern aspect (J = 0.863). The Sorenson's species similarity index (*CC*) for northern and southern aspect was 0.7231 (Appendix: V).

The diversity index (H) for the butterflies of summer was 3.83 whereas for autumn is 3.85. But the Pielou's species evenness index was somewhat higher in summer (J = 0.882) than

southern aspect (J = 0.8592). The Sorenson's species similarity index (CC) for northern and southern aspect was found to be 0.638 (Appendix: VI).

Table 2: Species richness, abundance of butterflies and diversity indices from different elevations of study site.

Elevations (m asl)	Species richness	Abundance	Shannon-Winner diversity index (H)	Species evenness index (J)
1550	54	307	3.6283	0.90958
1650	49	207	3.4891	0.896521
1750	43	191	3.3342	0.886472
1850	56	233	3.7002	0.919224
1950	61	302	3.7128	0.903166
2050	61	320	3.7101	0.902509
2150	52	241	3.4919	0.883747
2250	39	202	3.2521	0.887688
2350	39	146	3.21833	0.87847
2450	29	144	2.7499	0.816649

4.2 Relation of butterfly with elevation, aspect and season

4.2.1 Altitudinal diversity of butterfly

Butterflies were observed in different altitudinal ranges. The species richness significantly (p = 0.04315) decreases with increase in elevation (Figure 3).

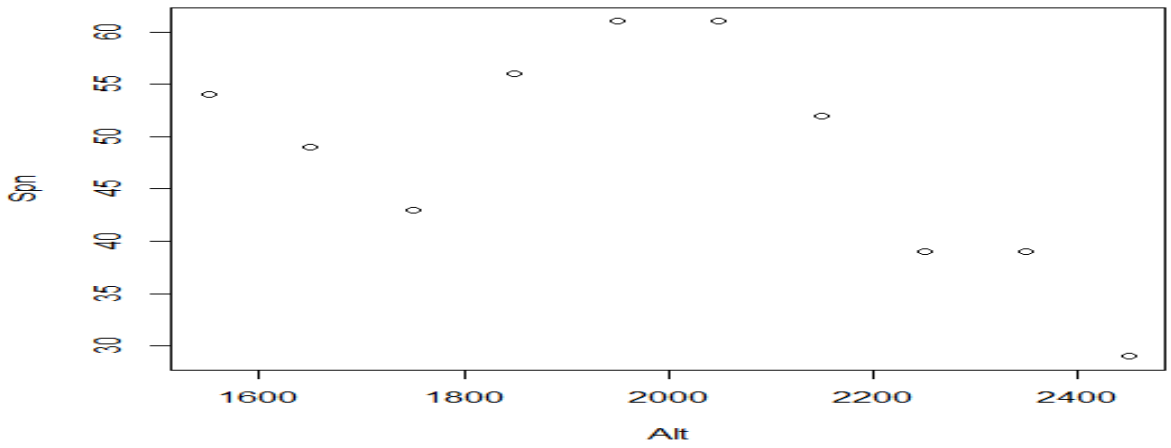


Figure 3: Species richness of butterfly from different elevations of study site. (Spn = species number, Alt = Altitude)

The species richness of butterfly also significantly decreases (P = 0.0427) with increase in elevation in northern aspect. Similar relation (P = 0.045) was found between elevation and species richness in southern aspect.

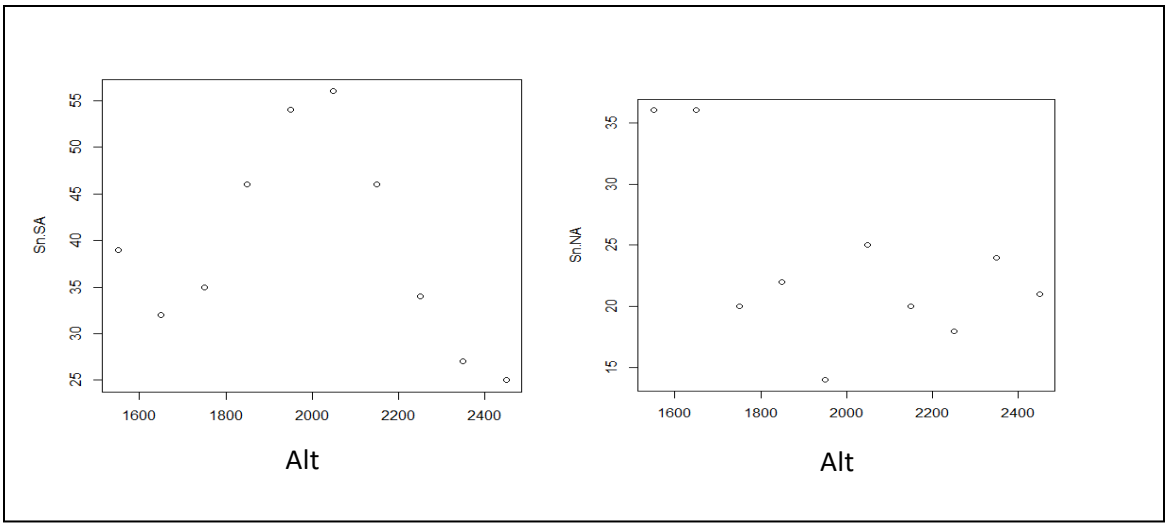


Figure 4: Species richness of butterfly from different elevations of southern and northern aspect of study site. (Sn SA = Species number in southern aspect, Sn NA = Species number in northern aspect and Alt = Altitude)

4.2.2 Butterfly diversity and distribution in Northern and Southern aspects

A total of 780 individuals of 75 species of butterfly were recorded in northern aspect whereas 1513 individuals of 102 species were recorded in southern aspect. Eleven species of butterfly were recorded only in northern aspect which accounts for 9.73% of total recorded species. Similarly 34 species of butterfly were recorded only in southern aspect which comprises 33.62% of total recorded species. Sixtyfour species of butterflies were recorded in both northern and southern aspects which come 56.64% of total (Figure 4). The detail lists of butterflies of both aspects are given in Appendix I.

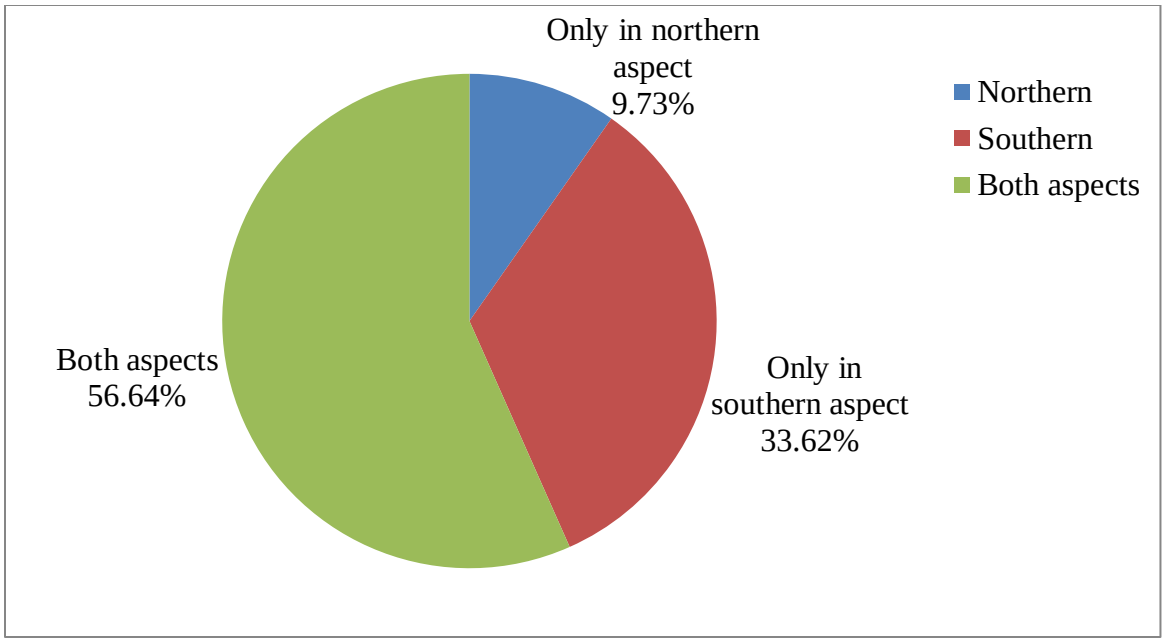


Figure 5: Species composition of butterfly in northern and southern aspect.

Comparing to aspect and elevations, the species abundance was more in higher elevation of northern aspect and low at the high elevation of southern aspect. Species are well separated in different clusters according to the elevations and aspects.

Figure 6: Discriminate analysis (DA) showing the combine effect of elevation and aspects in species abundance. (NL = Northern Low elevation, NH = Northern High elevation, SL = Southern low elevation and SH = Southern High elevation)

Table 3: Effects of elevation and aspects on species abundance of butterfly

Variables	DS1	DS2
NH	2.02	2.30670
NL	-1.51	0.10057
SH	-4.33	-0.8519
SL	1.20	-0.2098

4.2.3 Indicator species (Aspect and elevation)

Indicator species were determined by analysis of the relationship between the species abundance with altitude and aspects (Dufrene and Legender, 1997). A total of 21 species were identified as indicator species as they show significant relationship with the aspect and elevation. There was highly significant association of *Vagrans egistaa* and *Zeneris fegyas indicus* with the low elevation of southern aspect and low elevation of the northern aspect respectively. *Cethosia biblis tisemina, Symbrenthia lilaea khasiana* and *Zeneris fegyas indicus* are representative species in low elevation of the northern aspect whereas there was no any indicator species for the high elevation of the northern aspect. *Acytolepsis puspa gisca, Aglais cashmirensis aesis, Vanessa.cardui* and *Vanessa indica* are representative species for high elevation of the southern aspect. A total of 14 species were associated with low elevation of southern aspect.

Table 4: Species indicator value of different species with elevation and aspects.

Scientific name of the species	NH	NL	SH	SL	p value
Acytolepsis puspa gisca	0.00	0.01	**0.52**	0.22	0.006
Aglais cashmirensis aesis	0.16	0.05	**0.49**	0.23	0.056
Argyreus hyperbius hyperbius	0.01	0.08	0.09	**0.66**	0.005
Ariadne merione	0.02	0.00	0.00	**0.58**	0.016
Cethosia biblis tisemina	0.02	**0.51**	0.01	0.01	0.058
Coladenia dasahara dasahara	0.00	0.00	0.00	**0.50**	0.037
Cupha erymanthis lotis	0.00	0.01	0.01	**0.60**	0.01
Euploea mulciber mulciber	0.00	0.08	0.00	**0.50**	0.033
Graphium sarpedon luctatius	0.01	0.00	0.03	**0.51**	0.022
Hestina nama nama	0.02	0.05	0.08	**0.59**	0.005
Lethe confuse confusa	0.01	0.08	0.06	**0.62**	0.005
Papilio helenus helenus	0.00	0.14	0.00	**0.47**	0.05
Parantica aglea melanoides	0.00	0.21	0.09	**0.48**	0.023
Parnara guttata mangala	0.01	0.04	0.11	**0.53**	0.016
Pieris canidia indica	0.03	0.08	0.20	**0.58**	0.006
Precis hierta hierta	0.00	0.00	0.06	**0.68**	0.005
Symbrenthia lilaea khasiana	0.01	**0.64**	0.00	0.06	0.006
Vagrans egista	0.00	0.01	0.00	**0.78**	0.001

Vanessa.cardui	0.02	0.00	**0.52**	0.14	0.035
Vanessa indica	0.05	0.05	**0.59**	0.15	0.005
Zeneris fegyas indicus	0.01	**0.88**	0.02	0.00	0.001

NH = High elevation of Northern aspect, NL = Low elevation of Northern aspect, SH = High elevation of southern aspect and SL= Low elevation of southern aspect

4.2.4 Seasonal diversity of butterfly

A total of 937 individuals of 77 species of butterfly were recorded in summer whereas 1356 individuals of 89 species were recorded in autumn (Appendix: I). Butterflies recorded only in summer were 24 which falls 21.24% of the total recorded species. Similarly butterflies recorded only in autumn are 36 species which accounts for 31.85% of total. 53 species of butterfly were recorded in both seasons which come 46.90% of total (Appendix: I).

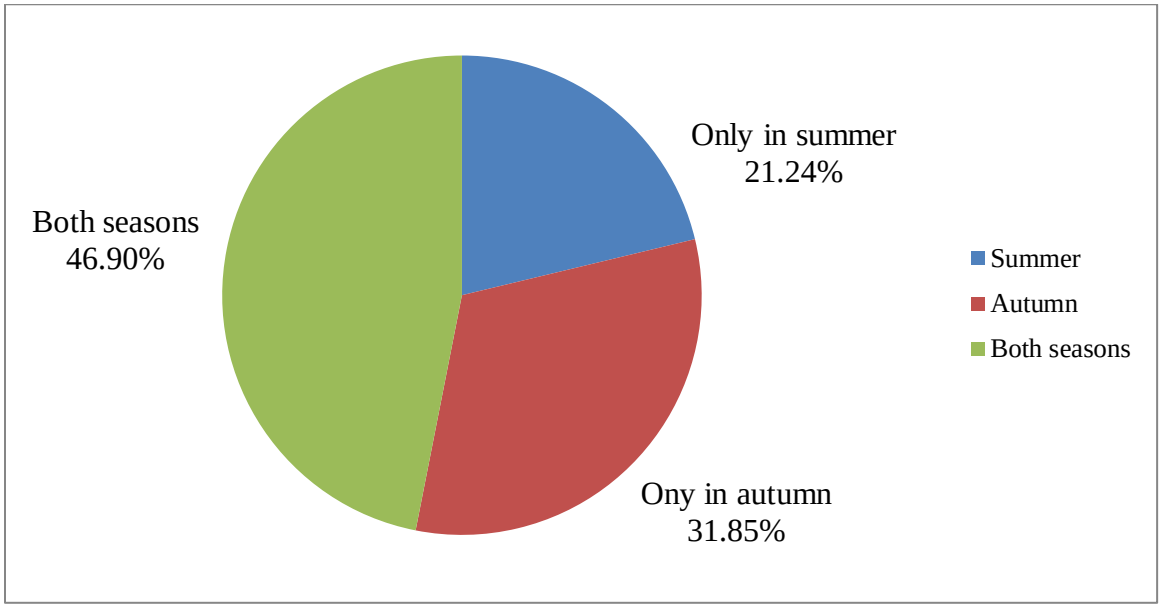


Figure 7: Seasonal compositions of recorded butterfly species.

4.3 Altitudinal wings size variations of butterflies

Wings size of butterflies was measured by using standard wing size measurement technique (Hook *et al.*, 2012). Significant negative correlation between elevation and average wingspan

of butterflies were observed (Appendix: II).

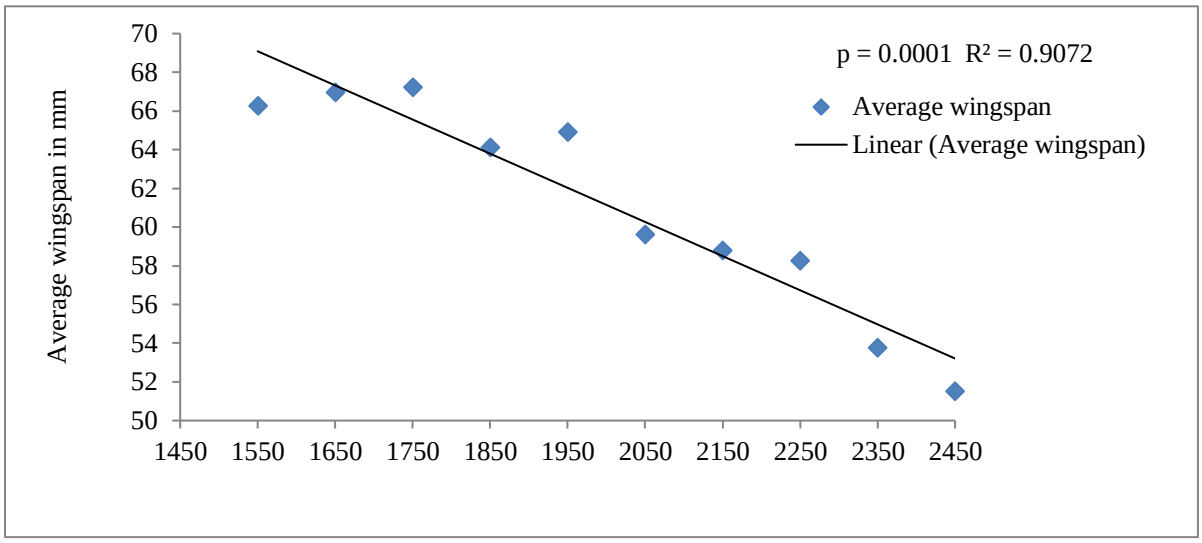


Figure 8: Altitudinal wings size variations of butterflies.

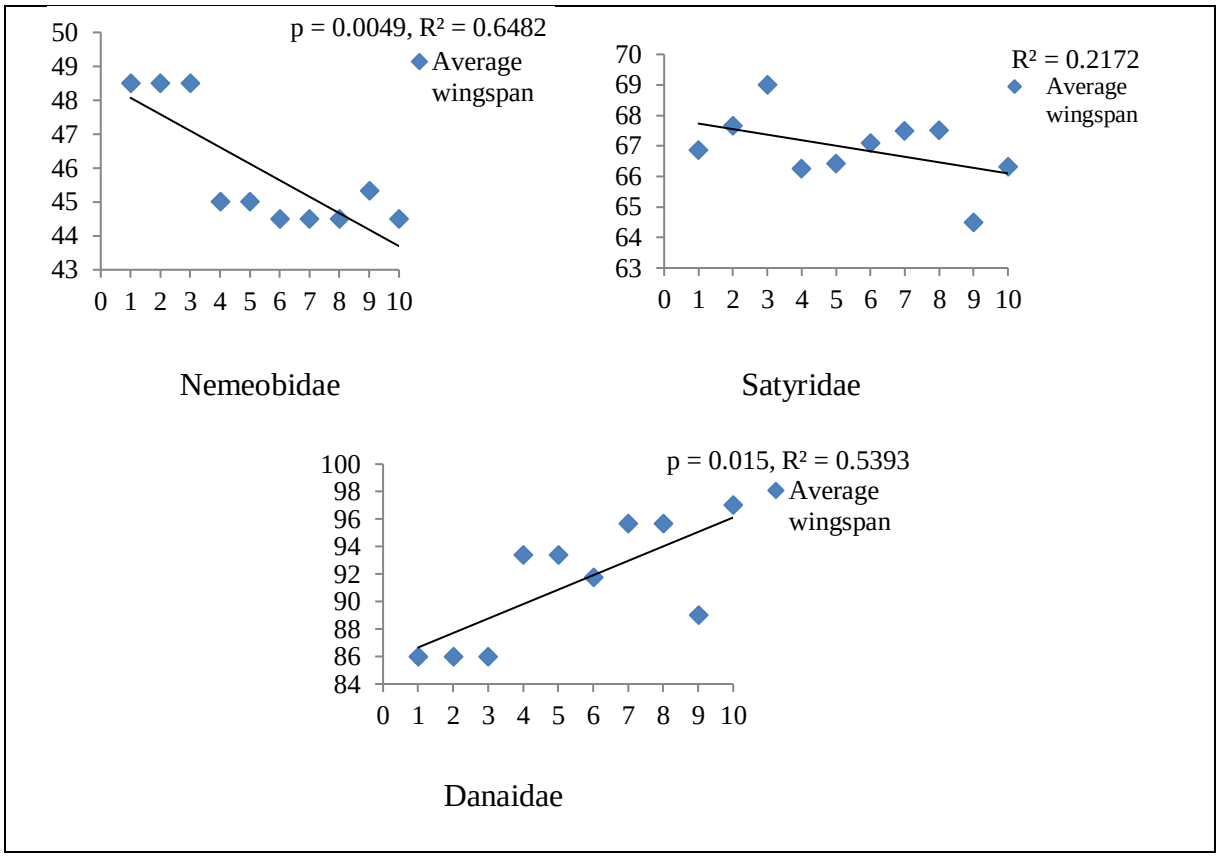


Figure 9: Altitudinal wing size variations of different families of butterfly. (In x- axis, 1,2,3 … refers to altitude of 1550 m, 1650m and so on and in y-axis, wingspan is given in mm)

The correlation between elevation and average wingspan of different families was analyzed separately. An insignificant negative correlation between elevation and body size was observed in four families of butterflies viz. Papiolionidae, Hespiridae, Pieridae, and Nymphalidae.

Significant negative association of wing size of Nemeobiids and insignificant negative association of wing size of Satyrides with the elevation was observed whereas Danaids has significantly larger wing size in higher elevations. The body size of Lycaeinids was also found to be insignificantly larger in higher elevations. There are no effects of elevation in the body size of butterflies belonging to family Acraeidae.

5. DISCUSSION

5.1 Butterfly diversity and status

Butterfly diversity was high in the study area which may be due to presence of some open area (Patel and Pandya, 2014). Nymphalidae was most abundant family (Fileccia *et al.,* 2015) recorded followed by Satyridae, Lycaenidae, Pieridae, Papilionidae, Hesperiidae, Danaidae, Nemeobidae and Acraeidae. The maximum species of Nymphalidae may be because of their ecological adaptation, speciation and high dispersal ability (Alder *et al*., 1996). Similar result was obtained by (Ghimire, 2001 and Thapa, 2008) in and around the Kathmandu valley as Nymphalidae was the dominant whereas Acraeidae was least family recorded. Similar result was drawn by different researchers from different part of the world (Prajapati *et al.,* 2000; Hamer *et al*., 2005; Bhusal and Khanal, 2008; Chalise, 2010 and Khan *et al.*, 2011).

One of the species of family Nymphalidae - *Aglais cashmirensis aesis* was the species having highest abundance and was recorded through out the study period from both aspects and all types of habitat along the altitudinal gradients of the study site. Among recorded species, 40 were rare as their abundance was less than five. The butterfly diversity and distribution decreases with increase in human disturbance, habitat fragmentation and forest fire (Kumar, 2012 and Khanal e*t al.,* 2013). The population declination of butterfly species in this area may due to the similar cause. As the butterflies are ecological indicators, the decreasement of population may the indication of habitat degradation (Bourn and Thomas, 2002 and Chinaru and Joseph, 2011). Similar serious conservation threats such as, over use of Non-timber Forest Product (NTFPs) by local people, forest fire, fire wood collection, coal collection and over grazing of herders were found leading the declination of butterfly species in the study sites.

5.2 Relation of butterfly with elevation, aspect and season

Butterfly species richness significantly decreased with increase in altitude (Ghorai and Sengupta, 2014). But in general, the species richness of butterfly was highest at mid altitudes and lowest at highest altitude of the study site (Sreekumar and Balakrishnan, 2001). This finding is also accordance to the finding for butterfly species (Khanal *et al.*, 2012) in the high altitudes of Nepal. The higher species richness at the mid altitude of the study site may be due to less human disturbance (DeVries, 1988) and overlaping of ranges at the centre creating mid domain peak of species richness (Colwell *et al*., 2004).

Butterfly diversity was more in southern aspect as it supports more plant species (Ramos, 2000 and Barlow *et al*. 2007). This may be due to that the Southern aspect receives more sunlight, wide habitat range and availability of host plant which have positive effects on development of butterfly of any stages (Ghorai and Sengupta, 2014). Butterflies are

associated with the ripe fruits and foliage (Castro and Espinosa, 2015). Weiss *et al*. (1988) found the earliest larval development in warmer aspects then the progressively cooler aspects. The larval mortality is also associated with the low temperature. Similarly the pupation period is also short in warmer aspects then cooler aspects. The higher butterfly diversity in southern aspect of the study site may be due to the similar cause.

Butterflies have been using as indicator species in ecology to find the similarity and dissimilarity of habitat (Timothy *et al*., 2010). Recorded butterfly species were well separated in different altitudinal gradient of the northern and southern aspect. The identification of indicator species has been carried out to characterize the habitat (Dufrene and Legender, 1997). A total of 21 species were identified as indicator species as they show significant relationship with the aspect and altitude. *Cethosia biblis tisemina*, *Symbrenthia lilaea khasiana* and *Zeneris fegyas indicus* are representative species in low altitude of the northern aspect whereas there was no any indicator species for the high altitude of the northern aspect. *Acytolepsis puspa gisca, Aglais cashmirensis aesis, Vanessa.cardui* and *Vanessa indica* were representative species for high altitudes of the southern aspect. A total of 14 species viz. *Argyreus hyperbius hyperbius, Ariadne merione, Coladenia dasahara dasahara, Cupha erymanthis lotis, Euploea mulciber mulciber, Graphium sarpedon luctatius, Hestina nama nama, Lethe confuse confuse, Papilio helenus helenus, Parantica aglea melanoides, Parnara guttata mangala, Pieris canidia indica, Precis hierta hierta, Vagrans egista*, were associated with low altitude of southern aspect.

Butterfly diversity was higher in autumn then in summer (Prajapati e*t al.*, 2000). High butterfly diversity in autumn was due to availability of larval food plants and nectar rich flower sources for adult butterflies (Kumar *et al*., 2016). High butterfly diversity in autumn was found by many researchers in different part of the world (Gowada *et al*., 2011; Arya *et al*., 2014 and Ghosh and Saha, 2016). However, some researcher revealed the dominant of butterfly population during summer (Kunte, 1997 and Sengupta *et.al*, 2014).

5.3 Wing size variation of butterfly

Flying capacity of butterflies depend on structural features of the wings (Davis and Holden, 2015). Hawkins and Devries (1996) also recorded that the wings size of butterflies is higher in altitudes of 1500 m asl and decreases with increasing altitudes and there was no general trend for the wings size variation of other family of butterfly along the altitudinal gradient in Costa Rica. In this study, Average wings size of butterfly recorded to be decreased with increase in altitude. Wingspan of Nemeobiids and Satyrids butterflies also found to be decreased with increase in altitude. But, significant positive effects of elevation on wings size of Danaids butterflies were recorded.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Southern hills of Kathmandu valley have high butterfly diversity. Family Nymphalidae was the most abundant family which contributes maximum number of species whereas family Acraeidae was least abundant. *Aglais cashmirensis aesis* was the highly abundant species. A total of 40 species of butterfly i.e. 35.39% of total recorded species are locally rare. Elevation has significant negative effect on species richness of butterfly. Species richness was high at mid altitudes and lowest in highest altitude of the study area. Butterfly diversity was higher in autumn then in summer. Similarly, butterfly diversity was higher in southern aspect then the northern aspect. Butterfly species are well clustered in different altitudes of different aspects and 21 of them are significantly associated with altitudes of both northern and southern aspects so they are listed as indicator species. Average wings size of butterfly community decreases with increase in altitude. Butterfly fauna in the study area were facing conservation threats due to human encroachment and forest fire.

6.2 Recommendations

- Further study should be conducted covering all seasons.
- Human enchroachment should be minimized by public awareness.

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APPENDICES

Appendix I: Abundance of butterflies in different aspects and seasons from the study site.

Family	S.N.	Scientific Name	Common name	Average wing span (mm)	Altitudinal range	Frequency in different aspects		Frequency in different seasons	
						Norhtern	Southern	Summer	Autumn
Papilionidae	1	*Byasa latreillei latrellei*	Rose Windmill	107	1750 -2450	0	5	5	0
	2	*Byasa polyeuctes letincius*	Common Windmill	123	1550 - 1950	24	10	21	13
	3	*Graphium agamemnon agamemnon*	Tailed Jay	96	1550 - 2350	1	4	0	5
	4	*Graphium cloanthus cloanthus*	Glassy Bluebottle	75	1950 - 2150	0	3	0	3
	5	*Graphium sarpedon luctatius*	Common Bluebottle	85	1550 - 2350	2	32	28	6
	6	*Pachliopta aristolochiae aristolochiae*	Common Rose	73	1550 - 2250	1	2	1	2
	7	*Papilio demoleus demoleus*	Lime Swallowtail	84	1950	0	3	2	1
	8	*Papilio helenus helenus*	Red Helen	125	1650 - 1950	10	13	9	14
	9	*Papilio memon agenor*	Great Mormon	128	1550 - 1950	2	6	8	0
	10	*Papilio polyctor genesa*	Common Peacock	128	1650 -1950	5	15	12	8
	11	*Papilio polytes*	Common	110	1550	3	0	0	3

		romolus	Mormon						
	12	*Papilio protenor euprotenor*	Spangle	114	1550 - 1950	12	11	10	13
	13	*Papilo arcturus arcturus*	Blue Peacock	103	1650	2	0	0	2
	14	*Troides helena cerberus*	Common Birdwing	125	1650 - 2050	3	0	2	1
Hespiridae	15	*Aeromachus stigmaticus stigmaticus*	Veined Scrub Hopper	24	1850	2	0	2	0
	16	*Celaenorrhinus dhanada dhanada*	Common Small Flat	36	1550	3	0	0	3
	17	*Clatoris sirius Sirius*	Sirius swift	43	1650 - 2150	3	5	0	8
	18	*Coladenia dasahara dasahara*	Himalayan Yellow Banded Flat	38	1550 - 1650	0	4	1	3
	19	*Parnara guttata mangala*	Straight Swift	34	1550 - 2450	9	48	4	53
	20	*Polytremis eltola eltola*	Yellow Spot Swift	38	2050-2150	0	3	3	0
	21	*Solvia grahami*	Graham's Ace	29	2450	0	1	1	0
	22	*Udaspes folus*	Grass Demon	44	2350	0	2	2	0
Pieridae	23	*Appias lyncida eleonora*	Chocolate Albatross	74	1650	1	0	0	1
	24	*Catopsila pomona pomona*	Common Emegrant	70	2050 - 2150	0	10	10	0
	25	*Catopsila pyranthe pyranthe*	Mottled Emigrant	69	1950 - 2050	0	3	0	3
	26	*Cepora nerissa*	Common	58	1550 - 2350	1	1	0	2

		phryne	Gull						
	27	*Colias erate lativilla*	Pale Clouded Yellow	59	2350 - 2450	3	2	4	1
	28	*Colias fieldii fieldii*	Dark Clouded Yellow	54	2350 - 2450	2	3	0	5
	29	*Delias eucharis*	Common Jezebel	71	1850 - 1950	0	2	0	2
	30	*Gonopteryx aspasia*	Lesser Brimstone	52	1950 - 2050	0	8	8	0
	31	*Gonepteryx rhamni nepalensis*	Common Brimstone	66	1550 - 2450	32	51	29	54
	32	*Pieris brassicae nepalensis*	Large Cabbage White	68	1550 - 2450	8	9	8	9
	33	*Pieris canidia indica*	Indian Cabbage White	55	1550 - 2450	13	46	21	38
	34	*Terias blanda silhetana*	Three Spot Grass Yellow	61	1550 - 1850	0	3	0	3
	35	*Terias hecabe contubernalis*	Common Grass Yellow	44	1550 - 2450	17	29	15	31
	36	*Terias laeta sikkima*	Spotless Grass Yellow	45	1650 - 1950	0	3	0	3
Lycaenidae	37	*Acytolepsis puspa gisca*	Common Hedge Blue	33	1550 - 2450	2	43	31	14
	38	*Aestranicus transpecta*	White Banded Hedge Blue	33	2050	0	2	2	0
	39	*Arhopala rama rama*	Dark Himalayan Oakblue	41	1950 - 2250	0	10	7	3

	40	*Celastrina argiolus kollari*	Hill Hedge Blue	29	2350	4	0	4	0
	41	*Celastrina gigas*	Silvery Hedge Blue	33	1950 - 2450	0	5	0	5
	42	*Celastrina lavendularis limbata*	Plain Hedge Blue	33	1850	0	4	4	0
	43	*Celatoxia marginata marginata*	Margined Hedge Blue	28	2250 - 2450	3	15	18	0
	44	*Chrysozephyrus syla*	Silver Hairstareak	37	1850	4	0	4	0
	45	*Everes hugelii hugelii*	Tailed Cupid	24	1850 - 2150	0	7	3	4
	46	*Jamides alecto alocina*	Metalic Cerulian	40	1550 - 2450	10	48	29	29
	47	*Jamides celenoaelianus*	Common Cerulian	33	1750 - 1950	0	7	0	7
	48	*Lampides boeticus*	Peablue	336	1650 - 2250	5	13	15	3
	49	*Oreolyce vardhana*	Dusky Hedge Blue	32	1850 - 2450	37	32	10	59
	50	*Pratypa deva lila*	White Tufted Royal	35	1950 - 2450	3	1	0	4
	51	*Zizeeria karsandra*	Dark Grass Blue	25	1650 - 2450	2	4	6	0
	52	*Zizeeria maha maha*	Pale grass Blue	29	1550 - 2350	5	47	38	14
	53	*Zizeeria otis otis*	Lesser Grass Blue	22	1550 - 2350	4	2	6	0
Nemeobiidae	54	*Abisara fylla fylla*	Dark Judy	55	1550 - 1750	2	1	0	3
	55	*Dodona dipoea*	Lesser Punch	41	2050 - 2450	12	14	5	21

	56	*Dodona eugenes eugenes*	Tailed Punch	47	2050 - 2350	8	0	0	8
	57	*Dodona ouida*	Mixed Punch	48	1850 - 2450	37	22	8	51
	58	*Zeneris fegyas indicus*	Punchinello	42	1550 - 2250	31	3	12	22
Acraeidae	59	*Acraea issoria*	Yellow Coster	67	1550 - 1650	2	1	1	2
Nymphalidae	60	*Argyreus hyperbius hyperbius*	Indian Fritillary	78	1550 - 2250	10	40	16	34
	61	*Aglais cashmirensis aesis*	Indian Tortoise Shell	60	1550 - 2450	49	127	32	144
	62	*Ariadne merione*	Common Castor	58	1750 - 2350	2	14	5	11
	63	*Athyma jina jina*	Bhutan Sergeant	71	1550 - 1750	4	6	0	10
	64	*Athyma opalina orientalis*	Himalayan Sergeant	66	1550 - 2150	5	20	8	17
	65	*Athyma perius*	Common Sergeant	69	1650 - 1750	0	2	0	2
	66	*Cethosia biblis tisemina*	Red Lacewing	88	1550 - 2450	23	3	2	24
	67	*Childrena childreni childreni*	Large Silverstripe	85	1950 - 2150	0	3	0	3
	68	*Cupha erymanthis lotis*	Rustic	67	1550 - 2150	1	18	10	9
	69	*Cyrestis thyodamas thyodamas*	Common Map	53	2050 - 2150	0	2	2	0
	70	*Dichora chandra*	Eastern	85	2050 - 2250	0	4	0	4

		chandra	Courtier						
	71	*Dilipa morgiana*	Golden Emperor	59	1950 - 2050	0	6	6	0
	72	*Euthalia patala patala*	Grand Duches	100	1750	2	0	2	0
	73	*Euthalia sahadeva sahadeva*	Green Duke	74	2050 - 2250	2	8	10	0
	74	*Hestina nama nama*	Circe	92	1550 - 2150	8	24	15	17
	75	*Hypolimnas bolina jacintha*	Great Eggfly	70	1950	0	4	4	0
	76	*Kaniska canace canace*	Blue Admiral	71	1550 - 2250	0	19	1	18
	77	*Neptis hylas kamarupa*	Common Sailer	53	1550 - 2450	15	30	9	36
	78	*Neptis zaida bhutanica*	Pale Green Sailer	67	2050	0	2	2	0
	79	*Polyura athamas*	Common Nawab	59	2050 - 2150	0	3	0	3
	80	*Precis almana almana*	Peacock Pancy	60	1550 - 2350	5	0	0	5
	81	*Precis hierta hierta*	Yellow Pancy	50	1550 - 2150	0	22	4	18
	82	*Precis iphita*	Chocolate Pancy	68	1550 - 2350	65	74	97	42
	83	*Precis lemonias*	Lemon Pancy	56	1550	0	4	0	4
	84	*Pseudergolis wedah*	Tabby	54	1950	0	1	0	1
	85	*Symbrenthia lilaea khasiana*	Common Jester	54	1550 - 2250	16	3	4	15
	86	*Vagrans egista*	Vagrant	68	1550	1	15	12	4

	87	*Vanessa cardui*	Painted Lady	61	1850 - 2450	3	29	8	24
	88	*Vanessa indica*	Indian Red Admiral	68	1550 - 2450	21	88	24	85
Satyridae	89	*Aulocera saraswatti*	Striated Satyr	77	1750 - 2250	0	5	0	5
	90	*Callerebia scanda opimam*	Pallid Argus	67	1550 - 2450	17	22	18	21
	91	*Dallacha hygriva hygriva*	Brown Argus	53	1550	0	1	0	1
	92	*Lethe baladeva baladeva*	Treble Silverstripe	58	2150	0	1	1	0
	93	*Lethe confusa confusa*	Common Treebrown	61	1550 - 2250	11	42	8	45
	94	*Lethe rohria rohria*	Banded Treebrown	62	1650 - 2050	6	1	0	7
	95	*Lethe serbonis teesta*	Brown Forester	54	1750 - 2350	8	9	0	17
	96	*Lethe verma sintica*	Straight Banded Treebrown	54	1650 - 2350	22	12	12	22
	97	*Melanitis leda ismene*	Common Evening Brown	80	1550 - 2350	4	8	0	12
	98	*Melanitis phedima bela*	Dark Evening Brown	83	1550 - 1750	0	10	0	10
	99	*Mycalesis mineus mineus*	Dark Brand Bushbrown	55	2050 - 2250	0	4	0	4
	100	*Nemetis chandica*	Angled Red Forester	71	1550	1	1	0	2
	101	*Rhaphicera moorei*	Small Tawny Wall	58	2150 - 2450	3	2	3	2
	102	*Ypthima baldus*	Common	38	1550 - 2150	37	19	52	4

			Five Ring						
	103	*Ypthima indica*	Lesser Three Ring	35	1850 - 2050	6	4	10	0
	104	*Ypthima newara*	Newar Three Ring	44	1650 - 2350	16	26	38	4
	105	*Ypthima parasakra*	Himalayan Four Ring	45	1650 - 2450	10	10	16	4
	106	*Ypthima sakra*	Himalayan Five Ring	55	1550 - 2450	44	61	50	55
	107	*Zophoessa nicetas*	Yellow woodbrown	57	1750 - 2450	3	12	0	15
	108	*Zophoessa sidonis sidonis*	Common Woodbrown	56	2250	0	2	2	0
Danaidae	109	*Danus genutia*	Common Tiger	80	1550 - 2050	3	8	7	4
	110	*Euploea core core*	Common Indian Crow	87	1550 - 2450	8	7	1	14
	111	*Euploea mulciber mulciber*	Stripped Blue Crow	100	1850 - 1950	6	12	17	1
	112	*Parantica aglea melanoides*	Glassy Tiger	91	1550 - 2350	13	31	20	24
	113	*Tirmala septentrionis*	Dark Blue Tiger	109	1850 - 2250	0	14	0	14
Total						780	1513	937	1356

Appendix II: Average wingspan of different families of butterfly from different elevations of study area.

Elevation (m asl) → / Families ↓	Average wingspan (in mm) in different elevations										R^2
	1550	1650	1750	1850	1950	2050	2150	2250	2350	2450	
Papilionidae	104	110	110.04	110	105	93.5	87.2	90.25	96	107	0.273
Hespiridae	36	38.33	38.5	33.7	38.5	38.3	38.3	34	34	31.5	0.306
Pieridae	58.6	58.8	56.7	58.5	58.7	60.3	60.2	58.2	57.7	57.66	0.001
Lycaenidae	31	30.88	31.14	31.3	31.3	31.9	31.8	32.18	30.6	30.77	0.014
Nemeobiidae	48.5	48.5	48.5	45	45	44.5	44.5	44.5	45.3	44.5	0.648
Nymphalidae	66.8	67.66	69	66.3	66.4	67.1	67.5	67.53	64.5	66.33	0.217
Satyridae	63.5	58.45	59.67	56.1	56.1	56	57.4	58.69	51.4	56.4	0.452
Danaidae	86	86	86	93.4	93.4	91.8	95.7	95.6	89	97	0.539
Acraeidae	67	67									-
Papilionidae	104	110	110.04	110	105	93.5	87.2	90.2	96	107	0.273
Hespiridae	36	38.33	38.5	33.7	38.5	38.3	38.3	34	34	31.5	0.306

Appendix III: Species richness, abundance of butterflies and diversity indices from different elevations of Northern (N) and Southern (S) aspects of the study site

Elevations (m asl)	Species richness		Abundance		Shannon-Winner diversity index (H)		Species evenness index (J)	
	S Aspect	N Aspect	S Aspect	N Aspect	S Aspect	N Aspect	S Aspect	N Aspect
1550	39	36	168	139	3.208	3.273	0.875	0.913
1650	32	36	98	109	3.086	3.301	0.890	0.921
1750	35	20	120	71	3.197	2.781	0.894	0.907
1850	46	22	163	70	3.556	2.762	0.928	0.893
1950	54	14	240	62	3.635	2.285	0.911	0.865
2050	56	25	241	79	3.704	2.797	0.920	0.869
2150	46	20	177	64	3.410	2.671	0.890	0.891
2250	34	18	151	51	3.168	2.617	0.906	0.905
2350	27	24	84	62	2.938	2.961	0.891	0.931
2450	25	21	71	73	2.805	2.439	0.871	0.801

Appendix IV: Calculation of Shannon-Winner diversity index (H) and Pielou's species evenness (J)

S.N.	Scientific Name	Common Name	Abundance	Pi	ln(pi)	Pi × ln(Pi)
1	*Byasa latreillei latrellei*	Rose Windmill	5	0.002181	-6.1281	-0.01336
2	*Byasa polyeuctes letincius*	Common Windmill	34	0.014828	-4.2112	-0.06244
3	*Graphium agamemnon*	Tailed Jay	5	0.002181	-6.1281	-0.01336
4	*Graphium cloanthus*	Glassy Bluebottle	3	0.001308	-6.639	-0.00869
5	*Graphium sarpedon luctatius*	Common Bluebottle	34	0.014828	-4.2112	-0.06244
6	*Pachliopta aristolochiae*	Common Rose	3	0.001308	-6.639	-0.00869
7	*Papilio demoleus demoleus*	Lime Swallowtail	3	0.001308	-6.639	-0.00869
8	*Papilio helenus helenus*	Red Helen	23	0.010031	-4.6021	-0.04616
9	*Papilio memon agenor*	Great Mormon	8	0.003489	-5.6581	-0.01974
10	*Papilio polyctor genesa*	Common Peacock	20	0.008722	-4.7418	-0.04136
11	*Papilio polytes romolos*	Common Mormon	3	0.001308	-6.639	-0.00869
12	*Papilio protenor euprotenor*	Spangle	23	0.010031	-4.6021	-0.04616
13	*Papilo arcturus arcturus*	Blue Peacock	2	0.000872	-7.0444	-0.00614
14	*Troides Helena Cerberus*	Common Birdwing	3	0.001308	-6.639	-0.00869
15	*Aeromachus stigmaticus*	Veined Scrub Hopper	2	0.000872	-7.0444	-0.00614
16	*Celaenorrhinus dhanada*	Common Small Flat	3	0.001308	-6.639	-0.00869
17	*Clatoris sirius Sirius*	Sirius swift	8	0.003489	-5.6581	-0.01974
18	*Coladenia dasahara dasahara*	Himalayan Yellow Banded Flat	4	0.001744	-6.3513	-0.01108
19	*Parnara guttata mangala*	Straight Swift	57	0.024858	-3.6945	-0.09184
20	*Polytremis eltola eltola*	Yellow Spot Swift	3	0.001308	-6.639	-0.00869
21	*Solvia graham*	Graham's Ace	1	0.000436	-7.7376	-0.00337
22	*Udaspes folus*	Grass Demon	2	0.000872	-7.0444	-0.00614
23	*Appias lyncida eleonora*	Chocolate Albatross	1	0.000436	-7.7376	-0.00337
24	*Catopsila pomona pomona*	Common Emegrant	10	0.004361	-5.4350	-0.0237
25	*Catopsila pyranthe pyranthe*	Mottled Emigrant	3	0.001308	-6.639	-0.00869
26	*Cepora nerissa phryne*	Common Gull	2	0.000872	-7.0444	-0.00614
27	*Colias erate lativilla*	Pale Clouded Yellow	5	0.002181	-6.1281	-0.01336
28	*Colias fieldii fieldii*	Dark Clouded Yellow	5	0.002181	-6.1281	-0.01336

29	*Delias eucharis*	Common Jezebel	2	0.000872	-7.0444	-0.00614
30	*Gonopteryx Aspasia*	Lesser Brimstone	8	0.003489	-5.6581	-0.01974
31	*Gonepteryx rhamni*	Common Brimstone	83	0.036197	-3.3187	-0.12013
32	*Pieris brassicae nepalensis*	Large Cabbage White	17	0.007414	-4.9044	-0.03636
33	*Pieris canidia indica*	Indian Cabbage White	59	0.02573	-3.6600	-0.09418
34	*Terias blanda silhetana*	Three Spot Grass Yellow	3	0.001308	-6.639	-0.00869
35	*Terias hecabe contubernalis*	Common Grass Yellow	46	0.020061	-3.9089	-0.07842
36	*Terias laeta sikkima*	Spotless Grass Yellow	3	0.001308	-6.639	-0.00869
37	*Acytolepsis puspa gisca*	Common Hedge Blue	45	0.019625	-3.9309	-0.07714
38	*Aestranicus transpecta*	White Banded Hedge Blue	2	0.000872	-7.0444	-0.00614
39	*Arhopala rama rama*	Dark Himalayan Oakblue	10	0.004361	-5.4350	-0.0237
40	*Celastrina argiolus kollari*	Hill Hedge Blue	4	0.001744	-6.3513	-0.01108
41	*Celastrina gigas*	Silvery Hedge Blue	5	0.002181	-6.1281	-0.01336
42	*Celastrina lavendularis*	Plain Hedge Blue	4	0.001744	-6.3513	-0.01108
43	*Celatoxia marginata*	Margined Hedge Blue	18	0.00785	-4.8472	-0.03805
44	*Chrysozephyrus syla*	Silver Hairstareak	4	0.001744	-6.3513	-0.01108
45	*Everes hugelii hugelii*	Tailed Cupid	7	0.003053	-5.7917	-0.01768
46	*Jamides alecto alocina*	Metalic Cerulian	58	0.025294	-3.6771	-0.09301
47	*Jamides celenoaelianus*	Common Cerulian	7	0.003053	-5.7917	-0.01768
48	*Lampides boeticus*	Peablue	18	0.00785	-4.8472	-0.03805
49	*Oreolyce vardhana*	Dusky Hedge Blue	69	0.030092	-3.5035	-0.10543
50	*Pratypa deva lila*	White Tufted Royal	4	0.001744	-6.3513	-0.01108
51	*Zizeeria karsandra*	Dark Grass Blue	6	0.002617	-5.9458	-0.01556
52	*Zizeeria maha maha*	Pale grass Blue	52	0.022678	-3.7863	-0.08587
53	*Zizeeria otis otis*	Lesser Grass Blue	6	0.002617	-5.9458	-0.01556
54	*Abisara fylla fylla*	Dark Judy	3	0.001308	-6.639	-0.00869
55	*Dodona dipoea*	Lesser Punch	26	0.011339	4.47952	-0.05079
56	*Dodona eugenes eugenes*	Tailed Punch	8	0.003489	-5.6581	-0.01974
57	*Dodona ouida*	Mixed Punch	59	0.02573	-3.6600	-0.09418

58	*Zeneris fegyas indicus*	Punchinello	34	0.014828	-4.2112	-0.06244
59	*Acraea issoria*	Yellow Coster	3	0.001308	-6.639	-0.00869
60	*Argyreus hyperbius hyperbius*	Indian Fritillary	50	0.021805	-3.8255	-0.08342
61	*Aglais cashmirensis aesis*	Indian Tortoise Shell	176	0.076755	-2.5671	-0.19704
62	*Ariadne merione*	Common Castor	16	0.006978	-4.9650	-0.03464
63	*Athyma jina jina*	Bhutan Sergeant	10	0.004361	-5.4350	-0.0237
64	*Athyma opalina orientalis*	Himalayan Sergeant	25	0.010903	-4.5187	-0.04927
65	*Athyma perius*	Common Sergeant	2	0.000872	-7.0444	-0.00614
66	*Cethosia biblis tisemina*	Red Lacewing	26	0.011339	-4.4795	-0.05079
67	*Childrena childreni children*	Large Silverstripe	3	0.001308	-6.639	-0.00869
68	*Cupha erymanthis lotis*	Rustic	19	0.008286	-4.7931	-0.03972
69	*Cyrestis thyodamas*	Common Map	2	0.000872	-7.0444	-0.00614
70	*Dichora chandra chandra*	Eastern Courtier	4	0.001744	-6.3513	-0.01108
71	*Dilipa morgiana*	Golden Emperor	6	0.002617	-5.9458	-0.01556
72	*Euthalia patala patala*	Grand Duches	2	0.000872	-7.0444	-0.00614
73	*Euthalia sahadeva sahadeva*	Green Duke	10	0.004361	-5.4350	-0.0237
74	*Hestina nama nama*	Circe	32	0.013956	-4.2718	-0.05962
75	*Hypolimnas bolina jacintha*	Great Eggfly	4	0.001744	-6.3513	-0.01108
76	*Kaniska canace canace*	Blue Admiral	19	0.008286	-4.7931	-0.03972
77	*Neptis hylas kamarupa*	Common Sailer	45	0.019625	-3.9309	-0.07714
78	*Neptis zaida bhutanica*	Pale Green Sailer	2	0.000872	-7.0444	-0.00614
79	*Polyura athamas*	Common Nawab	3	0.001308	-6.639	-0.00869
80	*Precis almana almanac*	Peacock Pancy	5	0.002181	-6.1281	-0.01336
81	*Precis hierta hierta*	Yellow Pancy	22	0.009594	-4.6465	-0.04458
82	*Precis iphita*	Chocolate Pancy	139	0.060619	-2.8031	-0.16992
83	*Precis lemonias*	Lemon Pancy	4	0.001744	-6.3513	-0.01108
84	*Pseudergolis wedah*	Tabby	1	0.000436	-7.7376	-0.00337
85	*Symbrenthia lilaea khasiana*	Common Jester	19	0.008286	-4.7931	-0.03972
86	*Vagrans egista*	Vagrant	16	0.006978	-4.9650	-0.03464
87	*Vanessa cardui*	Painted Lady	32	0.013956	-4.2718	-0.05962
88	*Vanessa indica*	Indian Red Admiral	109	0.047536	-3.0462	-0.14481
89	*Aulocera saraswatti*	Striated Satyr	5	0.002181	-6.1281	-0.01336

90	*Callerebia scanda opimam*	Pallid Argus	39	0.017008	-4.0740	-0.06929
91	*Dallacha hygriva hygriva*	Brown Argus	1	0.000436	-7.7376	-0.00337
92	*Lethe baladeva baladeva*	Treble Silverstripe	1	0.000436	-7.7376	-0.00337
93	*Lethe confuse confusa*	Common Treebrown	53	0.023114	-3.7673	-0.08708
94	*Lethe rohria rohria*	Banded Treebrown	7	0.003053	-5.7917	-0.01768
95	*Lethe serbonis teesta*	Brown Forester	17	0.007414	-4.9044	-0.03636
96	*Lethe verma sintica*	Straight Banded Treebrown	34	0.014828	-4.2112	-0.06244
97	*Melanitis leda ismene*	Common Evening Brown	12	0.005233	-5.2527	-0.02749
98	*Melanitis phedima bela*	Dark Evening Brown	10	0.004361	-5.4350	-0.0237
99	*Mycalesis mineus mineus*	Dark Brand Bushbrown	4	0.001744	-6.3513	-0.01108
100	*Nemetis chandica*	Angled Red Forester	2	0.000872	-7.0444	-0.00614
101	*Rhaphicera moorei*	Small Tawny Wall	5	0.002181	-6.1281	-0.01336
102	*Ypthima baldus*	Common Five Ring	56	0.024422	-3.7122	-0.09066
103	*Ypthima indica*	Lesser Three Ring	10	0.004361	-5.4350	-0.0237
104	*Ypthima newara*	Newar Three Ring	42	0.018317	-3.9999	-0.07327
105	*Ypthima parasakra*	Himalayan Four Ring	20	0.008722	-4.7418	-0.04136
106	*Ypthima 46acra*	Himalayan Five Ring	105	0.045792	-3.0836	-0.14121
107	*Zophoessa nicetas*	Yellow woodbrown	15	0.006542	-5.0295	-0.0329
108	*Zophoessa sidonis sidonis*	Common Woodbrown	2	0.000872	-7.0444	-0.00614
109	*Danus genutia*	Common Tiger	11	0.004797	-5.3397	-0.02562
110	*Euploea core core*	Common Indian Crow	15	0.006542	-5.0295	-0.0329
111	*Euploea mulciber mulciber*	Stripped Blue Crow	18	0.00785	-4.8472	-0.03805
112	*Parantica aglea melanoides*	Glassy Tiger	44	0.019189	-3.9534	-0.07586
113	*Tirmala septentrionis*	Dark Blue Tiger	14	0.006106	-5.0985	-0.03113
Total			2293			- 4.05444

$$H = - \sum Pi \times \ln(Pi) = 4.0544$$

And $J = H/Hmax = 0.857$

Appendix V: Calculation of Shannon-Winner diversity index, Species evenness and Similarity index in different aspects.

S.N.	Name of the species	Aspects							
		Northern				Southern			
		Abundance	Pi	ln(Pi)	Pi × ln(pi)	Abundance	Pi	ln(Pi)	Pi × ln(pi)
1	*Atrophaneura latreillei latrellei*					5	0.003305	-5.71241	-0.01888
2	*Atrophaneura polyeuctes letincius*	24	0.03077	-3.4812	-0.1071	10	0.006609	-5.01926	-0.03317
3	*Graphium agamemnon Agamemnon*	1	0.00128	-6.6593	-0.0085	4	0.002644	-5.93556	-0.01569
4	*Graphium cloanthus cloanthus*					3	0.001983	-6.22324	-0.01234
5	*Graphium sarpedon luctatius*	2	0.00256	-5.9661	-0.0153	32	0.02115	-3.85611	-0.08156
6	*Pachliopta aristolochiae*	1	0.00128	-6.6593	-0.0085	2	0.001322	-6.6287	-0.00876
7	*Papilio demoleus demoleus*					3	0.001983	-6.22324	-0.01234
8	*Papilio helenus helenus*	10	0.01282	-4.3567	-0.0559	13	0.008592	-4.7569	-0.04087
9	*Papilio memon agenor*	2	0.00256	-5.9661	-0.0153	6	0.003966	-5.53009	-0.02193
10	*Papilio polyctor genesa*	5	0.00641	-5.0499	-0.0324	15	0.009914	-4.6138	-0.04574
11	*Papilio polytes ormolus*	3	0.00385	-5.5607	-0.0214				
12	*Papilio protenor euprotenor*	12	0.01538	-4.1744	-0.0642	11	0.00727	-4.92395	-0.0358
13	*Papilio arcturus arcturus*	2	0.00256	-5.9661	-0.0153				
14	*Troides helena Cerberus*	3	0.00385	-5.5607	-0.0214				
15	*Aeromachus stigmaticus stigmaticus*	2	0.00256	-5.9661	-0.0153				
16	*Celaenorrhinus dhanada*	3	0.00385	-5.5607	-0.0214				
17	*Clatoris sirius Sirius*	3	0.00385	-5.5607	-0.0214	5	0.003305	-5.71241	-0.01888
18	*Coladenia dasahara dasahara*					4	0.002644	-5.93556	-0.01569
19	*Parnara guttata mangala*	9	0.01154	-4.4621	-0.0515	48	0.031725	-3.45065	-0.10947
20	*Polytremis eltola eltola*					3	0.001983	-6.22324	-0.01234
21	*Solvia graham*					1	0.000661	-7.32185	-0.00484

22	*Udaspes folus*					2	0.001322	-6.6287	-0.00876
23	*Appias lyncida eleonora*	1	0.00128	-6.6593	-0.0085				
24	*Catopsila pomona pomona*					10	0.006609	-5.01926	-0.03317
25	*Catopsila pyranthe pyranthe*					3	0.001983	-6.22324	-0.01234
26	*Cepora nerissa phryne*	3	0.00385	-5.5607	-0.0214	2	0.001322	-6.6287	-0.00876
27	*Colias erate lativilla*	2	0.00256	-5.9661	-0.0153	3	0.001983	-6.22324	-0.01234
28	*Colias fieldii fieldii*					2	0.001322	-6.6287	-0.00876
29	*Delias eucharis*					8	0.005288	-5.24241	-0.02772
30	*Gonepteryx Aspasia*	1	0.00128	-6.6593	-0.0085	1	0.000661	-7.32185	-0.00484
31	*Gonepteryx rhamni*	32	0.04103	-3.1936	-0.131	51	0.033708	-3.39002	-0.11427
32	*Pieris brassicae nepalensis*	8	0.01026	-4.5799	-0.047	9	0.005948	-5.12463	-0.03048
33	*Pieris canidia indica*	13	0.01667	-4.0943	-0.0682	46	0.030403	-3.49321	-0.1062
34	*Terias blanda silhetana*					3	0.001983	-6.22324	-0.01234
35	*Terias hecabe contubernalis*	17	0.02179	-3.8261	-0.0834	29	0.019167	-3.95455	-0.0758
36	*Terias laeta sikkima*					3	0.001983	-6.22324	-0.01234
37	*Acytolepsis puspa gisca*	2	0.00256	-5.9661	-0.0153	43	0.02842	-3.56065	-0.10119
38	*Aestranicus transpecta*					2	0.001322	-6.6287	-0.00876
39	*Arhopala rama rama*					10	0.006609	-5.01926	-0.03317
40	*Celastrina argiolus kollari*	4	0.00513	-5.273	-0.0324				
41	*Celastrina gigas*					5	0.003305	-5.71241	-0.01888
42	*Celastrina lavendularis*					4	0.002644	-5.93556	-0.01569
43	*Celatoxia marginata*	3	0.00385	-5.5607	-0.0214	15	0.009914	-4.6138	-0.04574
44	*Chrysozephyrus syla*	4	0.00513	-5.273	-0.027				
45	*Everes hugelii hugelii*					7	0.004627	-5.37594	-0.02487
46	*Jamides alecto alocina*	10	0.01282	-4.3567	-0.0559	48	0.031725	-3.45065	-0.10947
47	*Jamides celenoaelianus*					7	0.004627	-5.37594	-0.02487
48	*Lampides boeticus*	5	0.00641	-5.0499	-0.0324	13	0.008592	-4.7569	-0.04087
49	*Oreolyce vardhana*	37	0.04744	-3.0484	-0.1446	32	0.02115	-3.85611	-0.08156
50	*Pratypa deva lila*	3	0.00385	-5.5607	-0.0214	1	0.000661	-7.32185	-0.00484
51	*Zizeeria karsandra*	2	0.00256	-5.9661	-0.0153	4	0.002644	-5.93556	-0.01569
52	*Zizeeria maha maha*	5	0.00641	-5.0499	-0.0324	47	0.031064	-3.4717	-0.10785
53	*Zizeeria otis otis*	4	0.00513	-5.273	-0.027	2	0.001322	-6.6287	-0.00876

54	*Abisara fylla fylla*	2	0.00256	-5.9661	-0.0153	1	0.000661	-7.32185	-0.00484
55	*Dodona dipoea*	12	0.01538	-4.1744	-0.0642	14	0.009253	-4.68279	-0.04333
56	*Dodona eugenes eugenes*	8	0.01026	-4.5799	-0.047				
57	*Dodona ouida*	37	0.04744	-3.0484	-0.1446	22	0.014541	-4.23081	-0.06152
58	*Zeneris fegyas indicus*	31	0.03974	-3.2253	-0.1282	3	0.001983	-6.22324	-0.01234
59	*Acraea issoria*	2	0.00256	-5.9661	-0.0153	1	0.000661	-7.32185	-0.00484
60	*Argyreus hyperbius hyperbius*	10	0.01282	-4.3567	-0.0559	40	0.026438	-3.63297	-0.09605
61	*Aglais cashmirensis aesis*	49	0.06282	-2.7675	-0.1739	127	0.083939	-2.47766	-0.20797
62	*Ariadne merione*	2	0.00256	-5.9661	-0.0153	14	0.009253	-4.68279	-0.04333
63	*Athyma jina jina*	4	0.00513	-5.273	-0.027	6	0.003966	-5.53009	-0.02193
64	*Athyma opalina orientalis*	5	0.00641	-5.0499	-0.0324	20	0.013219	-4.32612	-0.05719
65	*Athyma perius*					2	0.001322	-6.6287	-0.00876
66	*Cethosia biblis tisemina*	23	0.02949	-3.5238	-0.1039	3	0.001983	-6.22324	-0.01234
67	*Childrena childreni childreni*					3	0.001983	-6.22324	-0.01234
68	*Cupha erymanthis lotis*	1	0.00128	-6.6593	-0.0085	18	0.011897	-4.43148	-0.05272
69	*Cyrestis thyodamas*					2	0.001322	-6.6287	-0.00876
70	*Dichora chandra Chandra*					4	0.002644	-5.93556	-0.01569
71	*Dilipa morgiana*					6	0.003966	-5.53009	-0.02193
72	*Euthalia patala patala*	2	0.00256	-5.9661	-0.0153				
73	*Euthalia sahadeva sahadeva*	2	0.00256	-5.9661	-0.0153	8	0.005288	-5.24241	-0.02772
74	*Hestina nama nama*	8	0.01026	-4.5799	-0.047	24	0.015863	-4.1438	-0.06573
75	*Hypolimnas bolina jacintha*					4	0.002644	-5.93556	-0.01569
76	*Kaniska canace canace*					19	0.012558	-4.37741	-0.05497
77	*Neptis hylas kamarupa*	15	0.01923	-3.9512	-0.076	30	0.019828	-3.92065	-0.07774
78	*Neptis zaida bhutanica*					2	0.001322	-6.6287	-0.00876
79	*Polyura athamas*					3	0.001983	-6.22324	-0.01234
80	*Precis almana almanac*	5	0.00641	-5.0499	-0.0324				
81	*Precis hierta hierta*	0	0	0	0	22	0.014541	-4.23081	-0.06152
82	*Precis iphita*	65	0.08333	-2.4849	-0.2071	74	0.048909	-3.01778	-0.1476
83	*Precis lemonias*					4	0.002644	-5.93556	-0.01569
84	*Pseudergolis wedah*					1	0.000661	-7.32185	-0.00484
85	*Symbrenthia lilaea khasiana*	16	0.02051	-3.8867	-0.0797	3	0.001983	-6.22324	-0.01234

86	*Vagrans egista*	1	0.00128	-6.6593	-0.0085	15	0.009914	-4.6138	-0.04574
87	*Vanessa cardui*	3	0.00385	-5.5607	-0.0214	29	0.019167	-3.95455	-0.0758
88	*Vanessa indica*	21	0.02692	-3.6148	-0.0973	88	0.058163	-2.84451	-0.16544
89	*Aulocera saraswatti*					5	0.003305	-5.71241	-0.01888
90	*Callerebia scanda opimam*	17	0.02179	-3.8261	-0.0834	22	0.014541	-4.23081	-0.06152
91	*Dallacha hygriva hygriva*					1	0.000661	-7.32185	-0.00484
92	*Lethe baladeva baladeva*					1	0.000661	-7.32185	-0.00484
93	*Lethe confusa confuse*	11	0.0141	-4.2614	-0.0601	42	0.027759	-3.58418	-0.09949
94	*Lethe rohria rohria*	6	0.00769	-4.8675	-0.0374	1	0.000661	-7.32185	-0.00484
95	*Lethe serbonis teesta*	8	0.01026	-4.5799	-0.047	9	0.005948	-5.12463	-0.03048
96	*Lethe verma sintica*	22	0.02821	-3.5683	-0.1006	12	0.007931	-4.83694	-0.03836
97	*Melanitis leda ismene*	4	0.00513	-5.273	-0.027	8	0.005288	-5.24241	-0.02772
98	*Melanitis phedima bela*					10	0.006609	-5.01926	-0.03317
99	*Mycalesis mineus mineus*					4	0.002644	-5.93556	-0.01569
100	*Nemetis chandica*	1	0.00128	-6.6593	-0.0085	1	0.000661	-7.32185	-0.00484
101	*Rhaphicera moorei*	3	0.00385	-5.5607	-0.0214	2	0.001322	-6.6287	-0.00876
102	*Ypthima baldus*	37	0.04744	-3.0484	-0.1446	19	0.012558	-4.37741	-0.05497
103	*Ypthima indica*	6	0.00769	-4.8675	-0.0374	4	0.002644	-5.93556	-0.01569
104	*Ypthima newara*	16	0.02051	-3.8867	-0.0797	26	0.017184	-4.06375	-0.06983
105	*Ypthima parasakra*	10	0.01282	-4.3567	-0.0559	10	0.006609	-5.01926	-0.03317
106	*Ypthima sacra*	44	0.05641	-2.8751	-0.1622	61	0.040317	-3.21098	-0.12946
107	*Zophoessa nicetas*	3	0.00385	-5.5607	-0.0214	12	0.007931	-4.83694	-0.03836
108	*Zophoessa sidonis sidonis*					2	0.001322	-6.6287	-0.00876
109	*Danus genutia*	3	0.00385	-5.5607	-0.0214	8	0.005288	-5.24241	-0.02772
110	*Euploea core core*	8	0.01026	-4.5799	-0.047	7	0.004627	-5.37594	-0.02487
111	*Euploea mulciber mulciber*	6	0.00769	-4.8675	-0.0374	12	0.007931	-4.83694	-0.03836
112	*Parantica aglea melanoides*	13	0.01667	-4.0943	-0.0682	31	0.020489	-3.88786	-0.07966
113	*Tirmala septentrionis*					14	0.009253	-4.68279	-0.04333
Total		780			-3.7701	1513			-3.9941
Shannon-Winner diversity index (H)		3.77				3.99			
Species evenness (J)		0.873				0.863			
Similarity index (CC)		0.7231							

Appendix VI: Calculation of Shannon-Winner diversity index, Species evenness and Similarity index in different seasons.

S.N.	Name of the species	Seasons							
		Summer				Autumn			
		Abundance	Pi	ln(Pi)	Pi ×ln(Pi)	Abundance	Pi	ln(Pi)	Pi × ln(Pi)
1	*Atrophaneura latreillei latrellei*	5	0.00533	-5.23324	-0.027925				
2	*Atrophaneura polyeuctes letincius*	21	0.02241	-3.79816	-0.085124	13	0.009587	-4.64735	-0.04455
3	*Graphium agamemnon Agamemnon*					5	0.003687	-5.60286	-0.02066
4	*Graphium cloanthus*					3	0.002212	-6.11368	-0.01353
5	*Graphium sarpedon luctatius*	28	0.02988	-3.51047	-0.10490	6	0.004425	-5.42053	-0.02398
6	*Pachliopta aristolochiae*	1	0.00106	-6.8426	-0.00730	2	0.001475	-6.51915	-0.00962
7	*Papilio arcturus arcturus*					2	0.001475	-6.51915	-0.00962
8	*Papilio demoleus demoleus*	2	0.00213	-6.14953	-0.01312	1	0.000737	-7.21229	-0.00532
9	*Papilio helenus helenus*	9	0.00960	-4.64545	-0.04462	14	0.010324	-4.57324	-0.04722
10	*Papilio memon agenor*	8	0.00853	-4.76324	-0.04066				
11	*Papilio polyctor genesa*	12	0.01280	-4.35777	-0.05580	8	0.0059	-5.13285	-0.03028
12	*Papilio polytes ormolus*					3	0.002212	-6.11368	-0.01353
13	*Papilio protenor euprotenor*	10	0.01067	-4.5400	-0.04845	13	0.009587	-4.64735	-0.04455
14	*Troides helena Cerberus*	2	0.00213	-6.14953	-0.01312	1	0.000737	-7.21229	-0.00532
15	*Aeromachus stigmaticus*	2	0.00213	-6.14953	0.013126				
16	*Celaenorrhinus dhanada*					3	0.002212	-6.11368	-0.01353
17	*Clatoris sirius Sirius*					8	0.0059	-5.13285	-0.03028
18	*Coladenia dasahara dasahara*	1	0.00106	-6.84268	-0.00730	3	0.002212	-6.11368	-0.01353
19	*Parnara guttata mangala*	4	0.00426	-5.45638	-0.02329	53	0.039086	-3.242	-0.12672
20	*Polytremis eltola eltola*	3	0.00320	-5.74407	-0.01839				
21	*Solvia graham*	1	0.00106	-6.84268	0.007302				

22	*Udaspes folus*	2	0.00213	-6.14953	-0.01312				
23	*Appias lyncida eleonora*					1	0.000737	-7.21229	-0.00532
24	*Catopsila pomona pomona*	10	0.01067	-4.54009	-0.04845				
25	*Catopsila pyranthe pyranthe*					3	0.002212	-6.11368	-0.01353
26	*Cepora nerissa phryne*	8	0.00853	-4.76324	-0.04066				
27	*Colias erate lativilla*					2	0.001475	-6.51915	-0.00962
28	*Colias fieldii fieldii*	4	0.00426	-5.45638	-0.02329	1	0.000737	-7.21229	-0.00532
29	*Delias eucharis*					5	0.003687	-5.60286	-0.02066
30	*Gonopteryx Aspasia*					2	0.001475	-6.51915	-0.00962
31	*Gonepteryx rhamni*	29	0.03094	-3.47538	-0.10756	54	0.039823	-3.22331	-0.12836
32	*Pieris brassicae nepalensis*	8	0.00853	-4.76324	-0.04066	9	0.006637	-5.01507	-0.03329
33	*Pieris canidia indica*	21	0.02241	-3.79816	-0.08512	38	0.028024	-3.57471	-0.10018
34	*Terias blanda silhetana*					3	0.002212	-6.11368	-0.01353
35	*Terias hecabe contubernalis*	15	0.01600	-4.13463	-0.06618	31	0.022861	-3.77831	-0.08638
36	*Terias laeta sikkima*					3	0.002212	-6.11368	-0.01353
37	*Acytolepsis puspa gisca*	31	0.03308	-3.40869	-0.11277	14	0.010324	-4.57324	-0.04722
38	*Aestranicus transpecta*	2	0.00213	-6.14953	-0.01312				
39	*Arhopala rama rama*	7	0.00747	-4.89677	-0.03658	3	0.002212	-6.11368	-0.01353
40	*Celastrina argiolus kollari*	4	0.00426	-5.45638	-0.02329				
41	*Celastrina gigas*					5	0.003687	-5.60286	-0.02066
42	*Celastrina lavendularis*	4	0.00426	-5.45638	-0.02329				
43	*Celatoxia marginata*	18	0.01921	-3.95231	-0.07592				
44	*Chrysozephyrus syla*	4	0.00426	-5.45638	-0.02329				
45	*Everes hugelii hugelii*	3	0.00320	-5.74407	-0.01839	4	0.00295	-5.826	-0.01719
46	*Jamides alecto alocina*	29	0.03094	-3.47538	-0.10756	29	0.021386	-3.845	-0.08223
47	*Jamides celenoaelianus*					7	0.005162	-5.26638	-0.02719
48	*Lampides boeticus*	15	0.01600	-4.13463	-0.06618	3	0.002212	-6.11368	-0.01353
49	*Oreolyce vardhana*	10	0.01067	-4.54009	-0.04845	59	0.04351	-3.13476	-0.13639
50	*Pratypa deva lila*					4	0.00295	-5.826	-0.01719
51	*Zizeeria karsandra*	6	0.00640	-5.05092	-0.03234				
52	*Zizeeria maha maha*	38	0.04055	-3.20509	-0.12998	14	0.010324	-4.57324	-0.04722
53	*Zizeeria otis otis*	6	0.00640	-5.05092	-0.03234	0			

54	*Abisara fylla fylla*					3	0.002212	-6.11368	-0.01353
55	*Dodona ouida*	8	0.00853	-4.76324	-0.04066	51	0.037611	-3.28047	-0.12338
56	*Dodona eugenes eugenes*					8	0.0059	-5.13285	-0.03028
57	*Dodona dipoea*	5	0.00533	-5.2332	-0.02792	21	0.015487	-4.16777	-0.06455
58	*Zeneris fegyas indicus*	12	0.01280	-4.35777	-0.05580	22	0.016224	-4.12125	-0.06686
59	*Acraea issoria*	1	0.00106	-6.84268	-0.00730	2	0.001475	-6.51915	-0.00962
60	*Argyreus hyperbius hyperbius*	16	0.01707	-4.07009	-0.06950	34	0.025074	-3.68593	-0.09242
61	*Athyma perius*					2	0.001475	-6.51915	-0.00962
62	*Athyma opalina orientalis*	8	0.00853	-4.76324	-0.04066	17	0.012537	-4.37908	-0.0549
63	*Athyma jina jina*					10	0.007375	-4.90971	-0.03621
64	*Aglais cashmirensis aesis*	32	0.03415	-3.37694	-0.11532	144	0.106195	-2.24248	-0.23814
65	*Ariadne merione*	5	0.00533	-5.2332	-0.02792	11	0.008112	-4.8144	-0.3905
66	*Cethosia biblis tisemina*	2	0.00213	-6.1495	-0.01312	24	0.017699	-4.03424	-0.0714
67	*Childrena childreni childreni*					3	0.002212	-6.11368	-0.01353
68	*Cupha erymanthis lotis*	10	0.01067	-4.54009	-0.04845	9	0.006637	-5.01507	-0.03329
69	*Cyrestis thyodamas*	2	0.00213	-6.14953	-0.01312				
70	*Dilipa morgiana*	6	0.00640	-5.05092	-0.03234				
71	*Dichora chandra Chandra*					4	0.00295	-5.826	-0.01719
72	*Euthalia patala patala*	2	0.00213	-6.14953	-0.01312				
73	*Euthalia sahadeva sahadeva*	10	0.01067	-4.5400	-0.04845				
74	*Hestina nama nama*	15	0.01600	-4.13463	-0.06618	17	0.012537	-4.37908	-0.0549
75	*Hypolimnas bolina jacintha*	4	0.00426	-5.45638	-0.02329				
76	*Kaniska canace canace*	1	0.00106	-6.8426	-0.00730	18	0.013274	-4.32192	-0.05737
77	*Neptis zaida bhutanica*	2	0.00213	-6.14953	-0.01312				
78	*Neptis hylas kamarupa*	9	0.00960	-4.64545	-0.04462	36	0.026549	-3.62878	-0.09634
79	*Precis almana almanac*					5	0.003687	-5.60286	-0.02066
80	*Precis iphita*	97	0.10352	-2.26797	-0.23478	42	0.030973	-3.47462	-0.10762
81	*Precis hierta hierta*	4	0.00426	-5.45638	-0.02329	18	0.013274	-4.32192	-0.05737
82	*Precis lemonias*					4	0.00295	-5.826	-0.01719
83	*Polyura athamas*					3	0.002212	-6.11368	-0.01353
84	*Pseudergolis wedah*					1	0.000737	-7.21229	-0.00532
85	*Symbrenthia lilaea khasiana*	4	0.00426	-5.45638	-0.02329	15	0.011062	-4.50424	-0.04983

86	*Vanessa cardui*	8	0.00853	-4.76324	-0.04066	24	0.017699	-4.03424	-0.0714
87	*Vanessa indica*	24	0.02561	-3.66462	-0.09386	85	0.062684	-2.76964	-0.17361
88	*Vagrans egista*	12	0.01280	-4.35777	-0.05580	4	0.00295	-5.826	-0.01719
89	*Aulocera saraswatti*					5	0.003687	-5.60286	-0.02066
90	*Callerebia scanda opimam*	18	0.01921	-3.95231	-0.07592	21	0.015487	-4.16777	-0.06455
91	*Dallacha hygriva hygriva*					1	0.000737	-7.21229	-0.00532
92	*Lethe verma sintica*	12	0.01280	-4.35777	-0.05580	22	0.016224	-4.12125	-0.06686
93	*Lethe baladeva baladeva*	1	0.00106	-6.84268	-0.00730				
94	*Lethe rohria rohria*					7	0.005162	-5.26638	-0.02719
95	*Lethe serbonis teesta*					17	0.012537	-4.37908	-0.0549
96	*Lethe confusa confuse*	8	0.00853	-4.76324	-0.04066	45	0.033186	-3.40563	-0.11302
97	*Mycalesis mineus mineus*					4	0.00295	-5.826	-0.01719
98	*Melanitis phedima bela*					10	0.007375	-4.90971	-0.03621
99	*Melanitis leda ismene*					12	0.00885	-4.72739	-0.04184
100	*Nemetis chandica*					2	0.001475	-6.51915	-0.00962
101	*Rhaphicera moorei*	3	0.00320	-5.74407	-0.01839	2	0.001475	-6.51915	-0.00962
102	*Ypthima sacra*	50	0.05336	-2.93066	-0.15638	55	0.04056	-3.20496	-0.12999
103	*Ypthima baldus*	52	0.05549	-2.89143	-0.16046	4	0.00295	-5.826	-0.01719
104	*Ypthima parasakra*	16	0.01707	-4.07009	-0.06950	4	0.00295	-5.826	-0.01719
105	*Ypthima indica*	10	0.01067	-4.54009	-0.04845				
106	*Ypthima newara*	38	0.04055	-3.20509	-0.12998	4	0.00295	-5.826	-0.01719
107	*Zophoessa nicetas*					15	0.011062	-4.50424	-0.04983
108	*Zophoessa sidonis sidonis*	2	0.00213	-6.14953	-0.01312				
109	*Danus genutia*	7	0.00747	-4.89677	-0.03658	4	0.00295	-5.826	-0.01719
110	*Euploea core core*	1	0.00106	-6.84268	-0.00730	14	0.010324	-4.57324	-0.04722
111	*Euploea mulciber mulciber*	17	0.01814	-4.00946	-0.07274	1	0.000737	-7.21229	-0.00532
112	*Parantica aglea melanoides*	20	0.02134	-3.84695	-0.08211	24	0.017699	-4.03424	-0.0714
113	*Tirmala septentrionis*					14	0.010324	-4.57324	-0.04722
Total		937			-3.83385	1356			-3.85679
Shannon-Winner diversity index (H)		3.833				3.856			
Species Evenness (J)		0.8826				0.8592			
Similarity index (CC)		0.638							