BUTTERFLY DIVERSITY IN GHANDRUK AREA OF MID-MOUNTAIN, NEPAL

Dibya Rai

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T.U Examination Roll No: 16/070

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Submitted to

Central Department of Zoology

Institute of Science and Technology

Tribhuvan University

Kirtipur, Kathmandu

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DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the authors.

Date: ……..... ….....…….

Dibya Rai

TRIBHUVAN UNIVERSITY
01-4331896
CENTRAL DEPARTMENT OF ZOOLOGY
Kirtipur, Kathmandu, Nepal.
Institute of Science and Technology
Ref.No.:

RECOMMENDATION

This is to recommend that the thesis entitled "**Butterfly Diversity in Ghandruk Area of Mid-hill Mountain, Nepal**" has been carried out by Ms. Dibya Rai for partial fulfillment of Master's Degree of science in Zoology with special paper Entomology. This is her original work and has been carried out under my supervision. To the best of my knowledge, this work has not been submitted for any other degree in any institutions.

Date…….

…….

Daya Ram Bhusal, Ph.D.
Associate Professor
Central Department of Zoology,
Tribhuvan University,
Kirtipur, Kathmandu, Nepal

TRIBHUVAN UNIVERSITY
☎ 01-4331896
CENTRAL DEPARTMENT OF ZOOLOGY
Kirtipur, Kathmandu, Nepal.
Institute of Science and Technology
Ref.No.:

LETTER OF APPROVAL

On the recommendation of supervisor Mr. Daya Ram Bhusal; Associate Professor, Central Department of Zoology, Tribhuvan University, the thesis entitle "**Butterfly Diversity in Ghandruk Area of Mid-hill Mountain, Nepal**" is approved for the examination and submitted to the Tribhuvan University in partial fulfillment of the requirement for the Master's Degree of Science in Zoology with special paper Entomology.

.

Date: …….

……

Prof. Dr. Ranjana Gupta
Head of Department
Central Department of Zoology
Tribhuvan University
Kirtipur, Kathmandu, Nepal

TRIBHUVAN UNIVERSITY
☏ 01-4331896
CENTRAL DEPARTMENT OF ZOOLOGY
Kirtipur, Kathmandu, Nepal.
Institute of Science and Technology
Ref.No.:

CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Ms. Dibya Rai entitled "**Butterfly Diversity in Ghandruk Area of Mid-hill Mountain, Nepal**" has been accepted as a partial fulfillment for the requirement of Master's Degree of Science in Zoology with special paper Entomology.

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EVALUATION COMMITTEE

…….
(Supervisor)
Daya Ram Bhusal, Ph.D.
Associate Professor
Central Department of Zoology
Tribhuvan University
Kirtipur, Kathmandu, Nepal

……
(Head of Department)
Prof. Dr. Ranjana Gupta
Central Department of Zoology
Tribhuvan University
Kirtipur, Kathmandu, Nepal

……...
External Examiner

…….....
Internal Examiner

Date of Examination: …….

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Dibya Rai
Examination Roll No.: 16/070
Batch No: 070/071
bantawaani@gmail.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviated Form	Detail of Abbreviations
ACA	Annapurna Conservation Area
ACAP	Annapurna Conservation Area Project
asl	Above sea level
Fig	Figure
GPS	Global Positioning System
NSTR	Nagarjunasagar Srisailam Tiger Reserve
NTNC	National Trust for Nature Conservation
viz	Namely
WWF	World Wildlife Fund
VDC	Village Development Community

ABSTRACT

This study was conducted in Ghandruk area of mid-mountain, Nepal from October 2015 to March 2016 within altitude of 1800 m asl to 2400 m asl. Butterfly diversity was recorded in different habitats; cropland, human settlement area and forest in different seasons; autumn, winter and spring in different altitude. All together, 1664 individuals representing 37 species belonging to 30 genera and seven families were observed during study. Nymphalidae and Pieridae were the dominating families whereas Papilionidae and Nemobiidae were the least. Human settlement area possessed the greatest species richness followed by cropland and forest. High diversity and evenness of species was found in cropland followed by forest and human settlement area. Accounting the seasonal variation more species were recorded during the autumn season followed by spring and less species were recorded during winter season. Species richness was decreased with approaching colder days. Low altitude was found to be more diversed than higher altitude. Further study is required to fully explore the butterfly fauna and their ecology in Ghandruk area of mid mountain.

1. INTRODUCTION

1.1 Background

According to Heppner (1998), 19,238 species of butterfly has been described worldwide which represent 12% of the total world's species of Lepidoptera (Kristensen *et al*., 2007). In Nepal, distribution patterns of butterflies are varied with respect to physiographic zones (Bhusal and Khanal, 2008). Their distribution ranges from sub-tropical to the Himalayan regions up to an altitude of 18000 feet (Khanal and Bhandary, 1982). The area above 3000m is occupied mostly by Palearctic butterflies while the temperate, subtropical and tropical species are sequentially distributed below this altitude (Khanal *et al.*, 2013). Of the world's total species, 660 species of butterflies included in 263 genera are reported from Nepal (Smith, 2010). Nepal is home to 11 of the World's 15 families of butterfly (Smith, 2011a), ecologically possessing 55%, 65% and 10% of total species in Terai, Mid-land and Highland respectively (Smith, 2011b). Annapurna Conservation Area (ACA) represents 332 species (Pariyar, 2064).

Butterflies are among the most beautiful insect having a large coloured wings and conspicuous, fluttering flight. They are always been the point of attraction. Butterflies are generally regarded as among the best-studied group of insects (Ghazoul, 2002; Bonebrake *et al*., 2010) as they are relatively easy to capture and identify (Ulrich and Buszko, 2003). For assessing and monitoring the terrestrial arthropod pattern, they are possibly the best group (Kreman, 1993). They exhibits a interesting phenomena of mimicry and migration and seasonality (Kunte, 2000).

Due to conspicuous, diurnal, widely distributed, short- lived, dependent on plants, and quick respond to habitat disturbance and fragmentation butterflies are considered as a good indicator (Griffis *et al*., 2001; Sawchik *et al*., 2005). Their short life cycles require them to track environmental conditions more closely than longer-lived organisms (Ehrlich and Murphy, 1987; Nelson and Andersen, 1994; DeVries *et al*., 1997; MacNally *et al*., 2003) and are often anticipated as surrogate taxa for various biodiversity groups (Bonebrake and Sorto, 2009; Hayes *et al*., 2009). Another reason to consider them as very useful indicators is their larval form feeding upon the plant foliage and many of them are monophagous (Hammond, 1995), their complex lifecycle, importance in the food chain, and sensitivity towards environmental changes (Savannah, 2014).

Beside, being a good indicator they have enormous ecological importance as important components of food chain, pollinators and bioindicators. After bees, butterflies are the insects which are very specific to their food plant so they play an important role of pollinator in the local environment and pollinate more than 50 economically important crops (Borges *et al*., 2003).

Abiotic and biotic factors such as: vegetation including host plants, food availability, temperature, wind exposure and elevation gradient influences the patterns of butterfly diversity (Lien and Yuan, 2003; Khan *et al*., 2004). Due to difference in feeding behaviour of adult and larva, habitat selection in butterflies is directly related to the availability of preferred host plants (Grossmueller and Lederhouse, 1987; Thomas, 1995). Different types of vegetation show different butterfly species composition (Sawchik *et*

al., 2005) which shows positive relationships between butterfly diversity and plant diversity (Thomas and Malorie, 1985; Leps and Spitzer, 1990).

Climate influences butterflies both directly and through impacts on their food plants and habitat (Woods *et al*., 2008). Global warming is expected to play a vital role to affect butterfly population (Parmesan *et al*., 1999; Parmesan, 2003). With change in climatic condition, butterflies and other species will relocate or face extinction in which relocation is not the option for small butterfly (Crone and Schultz, 2003). In addition to climate change, reduction and fragmentation of suitable habitat, use of pesticide, loss of native plants and/ or introduce predators has also acerbated the relocation or the extinction of the butterfly species (Hill *et al*., 2001, 2002; Parmesan, 2003).

Some population of butterflies have experienced major declines over the past few decades as a result of habitat loss and fragmentation, loss of native host and nectar plants, and use of insecticides (Cushman and Murphy, 1993; Iftner *et al*., 1992; Kremen *et al*., 1993) and being sensitive towards the climate change and urbanization, the conservation of butterflies is of major concern and to study about the status of butterflies from the local level is important to assist their conservation.

1.2 Objectives

1.2.1 General objective

To explore the butterfly fauna in Ghandruk area of mid-mountain, Nepal.

1.2.2 Specific objectives

i. Find the butterfly diversity in different habitats.
ii. Assess seasonal and altitudinal diversity of the butterfly.
iii. Identify the habitat preference in butterfly fauna.

1.3 Rational of study

1.3.1 Justification of study

Being sensitive towards urbanization, pollution and habitat fragmentation, butterflies are facing the problem of extinction or relocation. So it is important to explore and recoed their state and factors influencing their distribution. An extensive research work on butterfly diversity of this area has not been performed. This study is an attempt to study the diversity and state of butterflies in order to help in their conservation and support future conservation strategy.

1.3.2 Limitation of the study

i. Difficult to identify some species of butterfly through direct observation.

2. LITERATURE REVIEW

2.1 In context of Nepal

In Nepal, butterfly study was started since 1826 by General Thomson Hardwick, the first known butterfly collector in Nepal. Then after Maj, Gen. Ramsey , a British resident while being deputed in Kathmandu recorded 44 species during the period of 1852-67 (Khanal and Smith, 1997).

Bailey (1951) made a remarkable study of butterflies in Nepal. His finding included a total of 196 species. This comprises of 75 species from Nymphalidae, 44 from Satyridae, 35 from Pieridae, 31 from Papilionidae, 11 from Danaidae, 1 from Amathusidae and Acreidae each.

Igarashi (1963), a Japanese national was able to observe and draw the pictures of immature stages of 16 species of butterflies of Nepal which is reported in the Special Bulletin of Lepidopterological Society of Japan (No. 1, 2).

Smith (1977a) further recorded 8 new species of butterflies from Godavari. Later, Smith, (1977b) reported 26 more butterflies from Eastern Nepal. And, again Smith, (1977c) in the following year recorded 28 spring butterflies from west Nepal of Mahakali and Seti zone.

Smith (1978) did remarkable work in the research field of butterflies of Nepal. He published scientific list of Nepal's butterflies where he listed 565 species of butterflies.

Smith (1980) recorded 47 species of butterflies from westernmost districts Mahakali, Seti, and Karnali. This research was the continuation of the research done in 1977 by Smith in west Nepal.

Smith (1981) published a book 'Field Guide to Nepal's Butterflies' where he listed the 480 species of butterflies under 200 genera and 11 families and also described their characteristics and mentioned the status of the listed butterflies in Nepal.

Khanal (1982) reported 97 species of butterflies belonging nine families under 61 genera from different altitudinal levels of Lamjung and Manang districts. In the same year Khanal and Bhandari (1982) studied the food plants of some butterfly larvae. Again Khanal (1984) reported 21 new species of butterflies from Lamjung and Manang districts of Nepal.

Khanal (1985a, 1985b) studied butteflies of Gorkha and Trishuli and listed a total of 52 species of butterflies under eight families and 42 genera and in the same year 39 species of butterflies were recorded from Piper, Kaski. In 1987 he reported 50 species of butterflies from Pokhara- Mukthinath trekking route. Nepali and Khanal (1988) reported 26 species of butterflies under six families from Dolpa and Manang districts.

Smith (1989) published a book "Butterflies of Nepal'' mentioning 614 species of butterflies existing in Nepal of which 43 species were Papilionids, 49 were Pierids, 173 were Lycaenids, two were Labytheids, 107 were Hesperiids, 82 Satyrids and 15 Danaids.

Thapa (1998) mentioned 656 butterfly species of 286 genera in his book "An Inventory List of Nepal's insects Lepidoptera vol. 2" and found *Orinoma gray* (1846) and one of its sub species as endemic to Nepal.

Khanal (1999) brought out list of 71 species of butterflies spread over 50 genera and eight families from Kanchanpur and Kailali districts of Far western Nepal where he recorded Nymphalidae and Lycaenidae had the highest number of species diversity where Nemeobiidae had the least number with a single species.

Prajapati *et al.* (2000) recorded a total of 65 different species of butterfly belonging to 48 genera and 8 families from Daman area of Makawanpur district, Central Nepal. The most common families were Nymphalidae and Lycaenidae where as the butterflies of family Acraeidae was less abundant. They found *Chrysozephyrus esakii* and *Tijuria illurgis* as the rare species and *C. esakii* as a new species for Nepal.

Bhuju and Yonzon (2001) enumerated total of 35 species belonging to 28 genera and 8 families from the Churiya of eastern Nepal which is 5.3**%**of the total species of butterflies known to Nepal. Nymphalidae family comprised 34.3%, Lycaenidae 20%, Pieridae 14.3% and Satyridae 11.4%. They found the species richness being increased from winter to spring whereas the habitat loss adversely affecting the butterfly diversity.

Thapa (2004) found 31 species of butterflies belonging to 7 families (Nymphalidae, Lycaenidae, Danaidae, Pieridae, Satyridae, Papilionidae and Hesperiidae) from Mahendranagar municipality area within the altitudinal range from 250m to 350m above sea level.

Subba (2005) recorded a total of 41 species of butterflies spread over 31 genera and 7 families from Gujurmukhi Village Development Committee (VDC), Illam, Eastern Nepal. He reported Nymphalidae as the dominant family and Danaidae as scarce one.

Khanal (2006) brought a list of 54 species of late season butterflies of Koshi Tappu Wldlife Reserve, Eastern Nepal categorized under seven families out of 14 families occurring in Nepal.

Bhusal and Khanal (2008) recorded 40 species of butterflies belonging to 28 genera and 8 families in the Eastern Siwalik of Nepal in which both of seasonal and altitudinal effects on the abundance of butterflies were noticed in the area.

Khanal (2008) studied the diversity of butterfly in four districts ((Dangdeukhuri, Banke, Bardia and Surkhet) of western Terai and recorded 85 species under 64 genera and 10 families according to their altitudinal distribution. And also observed the loss of butterfly richness due to degradation of habitat with aid of urbanisation in Dangdeukhuri and Banke.

Thapa (2008) recorded 43 species of butterflies from Thankot and Syuchatar VDCs, Kathmandu. Also she recorded most of butterfly species in bushes and forest habitat.

Thapa and Bhusal (2009) from Thankot and SyunchataraVDC of Kathmandu Valley, Nepal reported 43 species of butterfly regarding species diversity and seasonal variations.

Chalise (2010) reported 75 species of butterflies belonging to 51 genus and 9 families in two different seasons; pre- monsoon and monsoon.

Smith (2011a, 2011b, 2011c) published 3 manual books namely; Butterflies of Nepal, Butterflies of ACA and Illustrated checklists of Nepal's butterflies. In his books he listed 278, 347 and 600 species of butterflies respectively.

Khanal *et al.* (2012) researched about butterfly in Langtang National Park within the altitudinal ranges of 1500 m to 4300 m and recorded 126 species of butterflies. They found maximum number of species inside the altitude varying from 1500 - 2900 m and also located the population declination of *Parnassius epaphus epaphus* and *Parnassius hardwickei* because of habitat loss and human interferences.

Khanal *et al.* (2013a) designed study specifically to assess the population status and prevailing threats of *Phaedyma aspasia kathmandia* an endangered and endemic subspecies of butterfly in Godavari forest of Lalitpur district of central Nepal. They revealed the occurrence of only 11 individuals of this species. They found habitat shrinkage due to the establishment of the marbel quarry around its habitat as the underlying threat to this butterfly.

Khanal *et al.* (2013b) conducted study on the threatened butterflies of central Nepal. They recorded 18 species of butterflies under 5 families. Out of them, they found four species of butterflies namely *Teinopalpus imperialis, Papilio krishna, Meandrusa lachinus and Euripus consimilis* were at high risk, 12 species of butterflies were found endemic to central Nepal and *Diagora nicevillei*, an endangered species was also recorded.

Khanal *et al.* (2014) performed an extensive study of *Teinopalpus imperialis*, an endangered swallowtail butterfly with respect to its population status, associated habitats and prevailing threats in Phulchoki Mountain (Lalitpur District), Nagarjun –Shivapuri National Park (Kathmandu District) and Nagarkot Mountain (Bhaktapur District). This revealed out the occurrence of 21 individual populations of this butterfly in the Phulchowki Mountain and eight individuals in the Nagarjun forest but Nagarkot of Bhaktapur didn't represented any.

Khanal, *et al.* (2015) recorded 34 species of Nymphalid Butterflies at different altitudinal Ranges in Godavari- Phulchowki Moutain Forest, Central Nepal. In addition they recorded *Phaedyma aspasia kathmandia*, an endangered and endemic Nymphalid species of Nepal. And in the same year Khanal recorded 26 Lycaenidae butterfly species within the altitude ranges of 1400-2700 m at Shivapuri mountain forest.

Shrestha (2016) recorded a total of 57 species belonging to 8 families and 39 genera among them Nymphalidae and Satyridae were the predominant families in Manang. He also found that butterfly species preferring the herbs, shrubs and few were found in cultivated vegetation and garden.

2.2 In context of World

The study of butterflies has been done systematically since the early 18^{th} century (Heppner, 1998). The series of paper had been published by Wordmason and de Niceville in various issues of the Journal of Asiatic Society of Bengel for the year 1880-82 and listed 133 species of butterflies of the Andamans and Nocobar. Furthermore, Ferrar (1948) also recorded 268 species of Butterflies from the same area.

Parsons and Cantlie (1948) listed 273 species of butterflies from Khasi and Jaintia Hills, Assam. They also described the habitat, distribution and status of the listed species. And, again in the year 1952, they added 210 more species of butterflies from the same area.

Ehrlich and Raven (1964) studied on the relationship between different families of butterfly species and their food plants and found that butterfly are the phytophagous groups of organism affecting the plant evolution.

Donahue (1967) explored the butterfly fauna of Delhi, India and reported 77 species and among them 32 species were recorded new for Delhi.

Smithers (1971) listed 24 species from Lord Howe Island during February.

Hoffmann (1973) studied the photo periodic adaptation of*Colias eurytheme*. He found that the seasonal variation in wing pigmentation and size is controlled by the photoperiod that the larvae experience during development.

Kitching *et al.* (1978) listed out the 79 butterflies from the Australian Capital Territory regarding the months of capture or sighting, habitats and altitude.

Ruszczyk (1986) studied the distribution of 29 species in the urban area of Porto Alegre. He found that the increase in the urbanization and pollution was accompanied by a decrease in the number of species and individuals registered as well as by a homogenization in butterfly distribution.

Shields (1989) brought out the list of world butterflies which had about 17,280 species representing described taxa that have not been synonymized, and are currently grouped into 1855 genera, 35 subfamilies, and 7 families.

Cary and Holland (1992) recorded 300 butterfly species. They also point out New Mexico having the most diverse butterfly faunas.

Spitzer *et al.* (1993) performed study of butterfly distribution and its relation with habitat, distribution and season in a montane tropical rain forest of Vietnam.

Sanchez- Roudriguez and Baz (1995) recorded 101 different butterfly species with total abundance of 2123 from the Sierra de Javalambre of central Spain. They found abundance and species richness highest at low elevations and declined with increasing altitude, while the converse held for habitat breadth.

Spitzer *et al.* (1997) studied the differences between the composition of butterfly communities in gaps created by illegal logging and closed canopy habitat in montane forest in the Tam Dao Mountains, northern Vietnam. They found the creation of gaps by local people changes thee natural disturbance regime and causes a threat to biota confined to the closed canopy forest.

Braby (1997) studied the occurene of *Eurema alitha* in Australia and its distinctiveness from *E. Hecabe* in male geniitalia.

Fleshman *et al.* (1999) recorded significantly greater butterfly abundance in agricultural sites than in non-agricultural sites, but species richness of non-agricultural sites was reported significantly greater than species richness of agricultural sites. They also found that habitat type did not have a significant effect on species richness.

Bonvanno *et al.* (2000) recorded 147 species of butterfly belonging 77 genera under 9 families at Ton Nga-Chang Wildlife Sanctuary, Songkhla Province, Southern Thailand. They found Nymphalidae and Lycaenidae were the most dominant families.

Kunte (2001) studied the butterfly diversity in and around the Pune city where he recorded 104 species of butterfly. In the same year Sreekumar and Balakrishna recorded 71 species of butterfly in the Aralam Wildlife Sanctuary, Kerala, India.

Beaumont and Hughes (2002) accessed potential changes in the distributions of Australian butterfly species in response to global warming. Their result suggested that even species with currently wide climatic ranges may still be vulnerable climate change.

Konvicka *et al.* (2003) studied whether altitude changes in the distribution of butterflies with climate warming in Czech Republica. They found the increasing species do not show any consistent pattern in habitat affiliations, conservation status and mountain vs. Non-mountain distribution, which renders climatic explanation as the most likely cause of the distributional shifts. In the same year research of Kitahara and Watanabe showed that butterfly species richness and species diversities were significantly higher in forest-edge sites than in forest-interior and/or open-land sites, and variation in the total number of species among these three landscape types was well accounted for by ecologically specialist species, such as landscape specifics, oligovoltines, narrow diet feeders and low density species.

Kitahara *et al.* (2003) examined the relationships between the diversities of vegetation, adult nectar plants, and butterflies in and around the Aokigahara primary woodland on the northwestern foot slopes of Mount Fuji, central Japan where they detected the strongest correlation between butterfly species richness and nectars plant species richness. Also they found nectars feeding butterfly species were significantly biased to herbaceous and perennials plants.

Stefanescu *et al.* (2004) recorded 131 species from Catalonia (north-east Iberian Peninsula). They also found the species richness was negatively correlated with temperature and positively correlated with rainfall, except for extreme cold and wet conditions.

Kaynas and Gurkan (2007) listed out 18 species and 114 individuals from the *Pinus brutia* forest of Turkey after forest. The species richness and species diversity of butterflies were higher in middle successional stages, abundance decreased with successional age.

Uniyal (2007) documented 75 species of butterflies belonging to 48 genera and five families from different forest types and watershed in the Great Himalayan conservation Landscape area of Himachal Pradesh.

Sandufu and Dumbuya (2008) studied the habitat preferences of the butterfly fauna in the Bunbuna Forest Reserve in Northern Sierra Leone. 290 species were collected of which 147 was forest species. 111 (75.5%) showed preferences for the forest habitat where as 70(47.6%) and 34(23.1%) preferred disturbed and savannah habitats respectively.

Tiple and Khurad (2009) recorded 145 species of butterfly in and around the Nagpur city, India. They recorded 62 new species of butterfly for the Nagpur city. The highest number of butterflies was from the family Nymphalidae (51 species) with 17 new records, followed by Lycaenidae (46 species) with 29 new records, Hesperiidae (22 species) with 14 new records, Pieridae (17 species) with 4 new records and Papilionidae (9 species).

Bhardwaj and Uniyal (2011) recorded a total of 1639 butterfly individuals representing 34 species, 29 genera and five families from Gangotri National Park, Uttarakhand, India during April-November ranging from 2800 m amsl to 5200 m amsl.

Gowda, *et al.* (2011) recorded 54 species of butterfly in Lakkavalli Range of Bhadra Wildlife Sanctury, Karnatak, India.

Roy *et al.* (2012) studied Butterfly diversity in and around Neora Valley National Park (NVNP), West Bengal, India in which they recorded a total of 30 butterfly species belonging to the families of Hespeririidae (3.33%), Papilionidae (16.65%), Pieriidae (13.32%), Nymphalidae (53.28%) and Lycaenidae (13.32%).

Kumar (2012) studied the foraging activity and abundance of butterflies in Jhasi, India and recorded 27 species belonging 5 families.

Tewari and Rawat (2013) recorded 134 species belonging to 81 genera and 8 families from Jhilmil Jheel Conservation Reserve located between Haridwar- Najimabad highway and river Ganges in Uttarakhand, India.

Majumder *et al.* (2013) recorded 59 butterfly species that included 21 unique species and 9 species listed in the threatened category from Trishna Wildlife Sanctuary of south Asia.

Chandekar *et al.* (2014) carried out the study at Maval Tahsil of Pune District, Maharashtra, India, during August 2007 to August 2009 in which a total of 85 species of butterflies were recorded among them Nymphalidae is dominating, followed by Lycaenidae, Hesperiidae, Pieridae, and Papilionidae.

Bora and Merti (2014) found a total of 96 species of butterflies belonging to 68 genera and 5 families were recorded. Among them 13 species were rare species. Nymphaidae with 23 genera was fond to be the most dominant followed by Lycacnidae 19 genera, Hesperiodae 13 genera,, Pieridae nine genera and Papilionidae four genera.

Krishna and Swamy (2014) performed the butterfly diversity study in Nagarjunasagar Srisailam Tiger Reserve [NSTR] located in Nallamalai hill ranges of Eastern Ghats, India during which they recorded 85 species belonging to 59 genera under five families. They also recorded three endemic butterfly species *(Pachliopta hector, Delias eucharis* and *Spindasis vulcanus vulcanus*).

Nidup *et al.* (2014) researched the butterfly diversity in Royal Manas National Park and recorded 91 species belonging to five major families of which one species was new record for Bhutan.

Patel and Pandya (2014) studied the relationship of local butterflies with host plant species they preferred around the Maharaja Sayajirao University of Baroda, Sayajigaunj, Gujarat, India. They recorded 21 host plant species distributed in 13 families and maximum number of butterflies preferred plants of Asteraceae family.

Smith and Cherry (2014) documented 11200 and four butterfly individuals of 42 different species during the course of the study over the 3 summers (2007–2009) in the Southern Appalachian Mountains of western Virginia and North Carolina. They noticed a varying response by different groups of species as well as individual species, indicating multiple management techniques are necessary for conserving a wide range of species. Specific techniques can be used in conservation to target specialist groups of butterflies and rare species.

Vu *et al.* (2015) studied the butterfly diversity and its relation with habitat variation in a disturbed forest in northern Vietnam in which they recorded a total of 147 species and 4,685 individual butterflies. They revealed that road construction within the forests of

Tam Dao likely affected the butterfly community such that road-impacted areas now have communities that resemble communities found in secondary forest.

Chhetri (2015) recorded 189 species among them Nymphalidae family was dominant (44%) followed by Lycanidae (19%) and the least number of species was recorded from Riodinidae (1%) from Khangchendzonga Biosphere Reserve, West Sikkim, India.

Kingsolver (2015) studied the evolutionary respose of *Colias* butterfly to climate variability. They found that variation in climate within and among years may strongly limit evolutionary responses of ectotherms to mean climate warming.

Alarape (2015) published a checklist of a total of 57 butterfly species that were surveyed belonging to 9 families of Ibadan botanical garden, Nigeria. They showed a relationship between temperature and butterfly species diversity and abundance but no correlation between physical factors (relative humidity and temperature) and the total number of species and families.

Pawar and Deshpande (2016) studied the diversity of family Nymphalidae in Satara Tehsil, District Satara Maharashtra. They recorded a total of 52 individuals belonging to 9 sub families 28 genera. Among which Limenitidiae was found to be the most dominant subfamily followed by Satyrinae.

Alleppa and Shrivastava (2016) recorded a total of 45 species, belonging to five families. In their study the predominance of family Nymphalidae was noted, which comprised of 37.77% of the butterflies surveyed, followed by Pieridae (22.22%), Papilionidae (20%), Lycaenidae (11.11%), and Hesperidae (8.88%).

Hernandez-Baz (2016) studied he butterflies at Natura Park in Veracruz, Mexico, their annual peak in abundance and collected 775 specimens of 120 species in 81 genera, 15 subfamilies, and five families (573 specimens of 68 species of Nymphalidae, 135/25 of Pieridae, 31/11 of Lycaenidae, 27/nine of Papilionidae, and nine/seven of Riodinidae).

3. MATERIALS AND METHODS

3.1 Study area

Ghandruk lies at 83.84° E and 28.22.49° N in mid-mountain of Nepal. Mid-mountain of Nepal lies 1000 m to 3000 m asl (NBSAP, 2014). This village is situated at an altitude of 1975 m asl on the west slopes of the Modi watershed. The topography is moderately steep with aspects mainly facing south. It covers an area of 18464 sq. km, which is 2.42% of the total area of the ACA. It is a pioneer area of the ACA where National Trust for Nature Conservation (NTNC) established its first field office in December 1986 to run Annapurna Conservation Area Project's (ACAP) pilot phase. It is the largest Gurung settlement in Nepal (Fig 1).

Due to combined effect of climatic and topographic variation, this area comprises wide range of bio-climatic zones hosting a rich biological diversity. This region exhibits vegetation from sub-tropical forest to alpine grassland. Different types of vegetations were found in three different habitats. In forest, vegetation like *Alnus nepalensis, Arundinaria aristata, Bauhinia variegate, Berberis aristata, Brassiopsis polycantha, Castanopsis indica, Ficus nerifolia, Ficus roxburghii, Michelia champaca, Quercus semicarpifolia, Rhododendron arboretum, Rubus ellipticus, Taxus bacatta, Urtica dioca, Gentiana carinata, G. viola,* etc. are found. Human settlement comprised different types of vegetations like *Tagetes* sp., *Fagopyrum dibotrys, Oxalis corniculata, Cyanodon dactylon, Cyperus* sp., *Geranium* sp., *Braaaica juncea, B. oleracea, Cirsium verutum,* etc. *Oryzae sativa, Triticum aestivum, Brassica nigra, Rubus ellipticus, Bidens pilosa, Oxalis corniculata, Fagopyrum dibotrys,* etc. are the flora found in cropland.

In general Ghandruk comprises temperate, mild alpine and alpine type of climate. The average annual temperature in Ghandruk is 14.2 °C. In a year, the average rainfall is 2747 mm. The least amount of rainfall occurs in November and most precipitation falls in July. The temperatures are highest on average in June and lowest in January. The average annual maximum temperature of Ghandruk ranges between 23.9°C to 27.4°C whereas the winter is cold and severe with the average annual minimum temperature ranges between 3.3^{o}C to 7^{o}C.

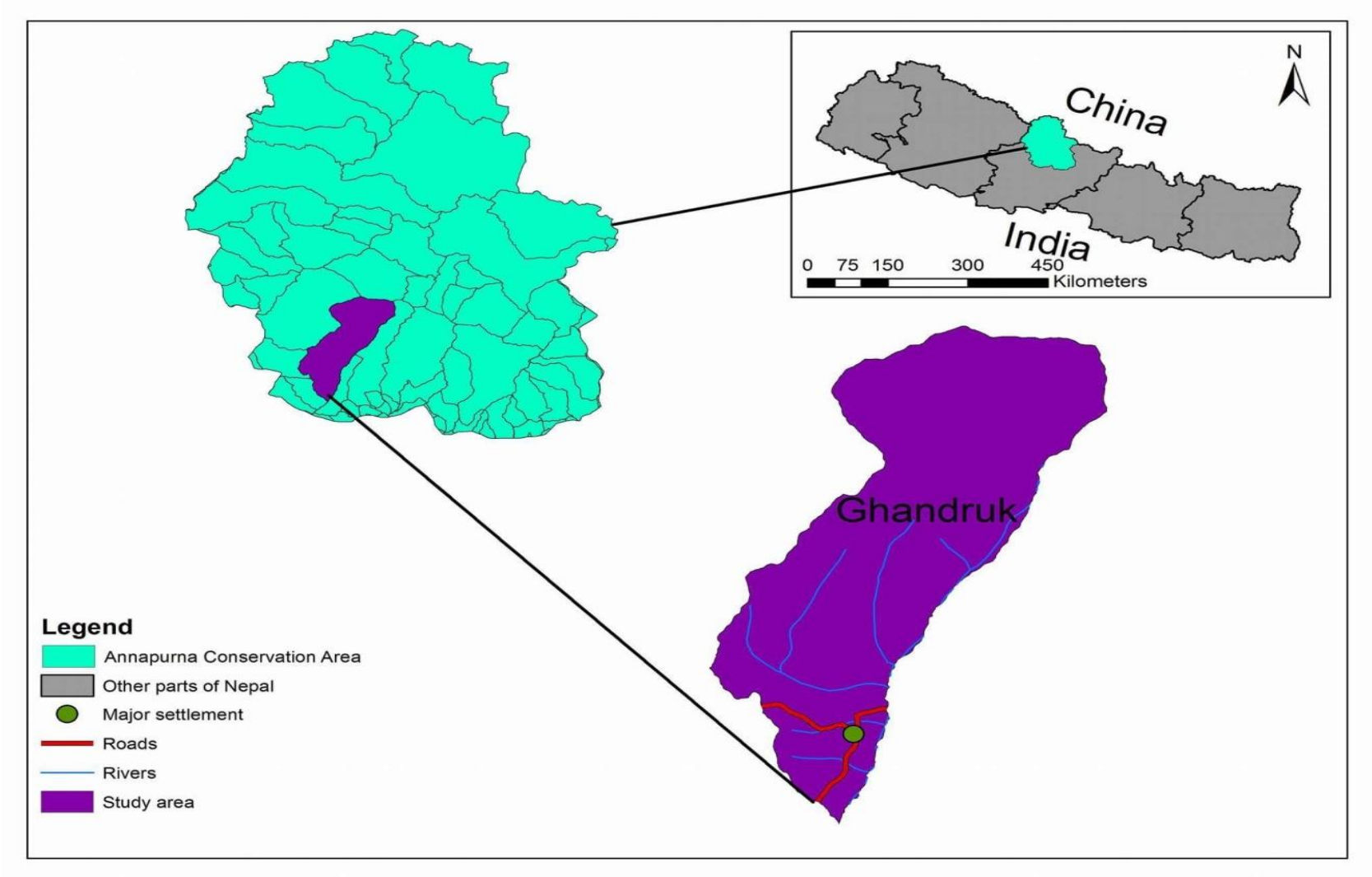

Figure 1. Map of the study area

3.2 Sampling

The study was done during October 2015 to March 2016. The study was conducted at three different habitats; cropland, human settlement area and forest in three different seasons; autumn winter and spring from 1800 m asl to 2400 m asl of Ghandruk village. The altitude from 1800-2000 m asl was classified as low altitude and altitude from 2000 – 2400 m asl as high altitude. Cropland lied within range of 1800- 2000m asl, human settlement lied between 1900-2100m asl and forest lied between 2100- 2400m asl. Line transect method had been used to collect the data of butterfly. The line transects were set as appropriate in each sites. The butterflies within a 5 metre range on both sides, front and above of transect was observed while walking at a slow and steady pace.The transects were visited between 10:00 am to 3:00 pm. Identification was done by capturing with nets, photographs was taken and the butterfly was released unharmed. While observing butterfly, the types of habitat and altitude in different season was recorded.

3.3 Identification

The captured species were identified using the field guideline book 'Illustrated checklist of Nepal's Butterfly (Smith, 2011c) and 'Butterflies of the Annapurna Conservation Area (Smith, 2011b) and released unharmed. Photographs of both identified and unidentified captured species were taken in the field. Unidentified species were later identified by tallying its photograph with the preserved species of Natural History Museum, Swyambhu, Kathmandu and identified species were also confirmed. Photographs were taken using camera Fujifilm FinePix F800EXR. Also coordinates (latitudes and longitudes) and elevation was recorded with the help of Garmin Global Positioning System (GPS) device.

3.4. Data processing and statistical analyses

The complete count of the number of species present in each habitat and season were done for species composition and species structure indices. The results were used to indicate the butterfly species diversity in habitats, seasons and altitude. Shannon-Wiener index was used to calculate the species diversity indices, Pielou's evenness index used to know the closeness of species of butterfly in different type of habitat, season and altitude. The Sorensen's similarity index was used to analyze the similarity between the habitats. Data analysis was proceed using MS- Excel.

Shannon – Weiner diversity index

$$H=\sum (pi)* (lnPi)$$

Where, H= Shannon-Weiner diversity index.

n= Important value for each species is the number of individual in each; the abundance of each species.

N= Total important value, total number of individual observed.

Pi= n/N = Relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individual in the community.

Pielou's Evenness Index (E):

$$J = H / \ln(S)$$

Where, S= Total number of species (Species richness)

H= Shannon-Weiner diversity index

The value of J ranges from 0 to 1. Lesser the variation in the communities between the species, the higher will be the value of J.

To measure the similarity between two habitat samples, coefficient of Sorensen's similarity index was used as the following equation.

$$ß = 2c / (S1 + S2)$$

Where, S1= the total number of species recorded in one habitat

S2= the total number of species recorded in a different habitat

c= the number of species common to both the habitat.

The Sorensen's similarity index 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.

4. RESULTS

4.1 Species composition

A total of 1664 individuals of 37 species of butterflies belonging to 30 genera and seven families were observed at different sites during the entire study period in Ghandruk village (Table 1). Of these, family Nymphalidae and Pieridae were largest represented by 10 of each species (27% of each) followed by Satyridae with six species (16%), Lycaenidae with five species (13%), Hesperiidae with four species (11%) and Papilionidae and Nemobiidae were the lowest with one species each (3% each) (Figure 2). Nymphalidae represented the greater number of genera (9) and then Pieridae (7), Lycanidae (5), Hesperidae (4), Satyridae (3), Nemobidae and Papilionidae one, one respectively (Figure 3). The most common species was of family Nymphalidae and Pieridae recorded distributed throughout all the habitat, season and altitude whereas the families Papilionidae was recorded only in winter and Hesperiidae only in autumn season. Nymphalidae showed the greater abundance (789) with nine genera and 10 species where as the lowest abundance was shown by Papilionidae (3) with one genera.

Vanessa indica showed highest abundance i.e. 256 followed by *Aglais cashmirensis* i.e. 221 where as the *Delias hyparete* showed the lowest abundance i.e. 1 (Figure 4). The most commonly occuring species was *Aglais cashmirensis* and *Vanesa indica* which were recorded during every season, in every habitat and altitude. The most common species was of family Nymphalidae and Pieridae recorded distributed throughout all the habitat, season and altitude whereas the families Papilionidae was recorded only in winter and Hesperiidae only in autumn season.

Table 1. Butterflies species reported from the study area

S.No.	Family	Species	Common Name
1	Nymphalidae	*Aglais cashmirensis* Kollar, 1844	Indian Tortoiseshell
2		*Doleschallia bisaltide* Cramer, 1779	Autumn Leaf
3		*Neptis hylas kamarupa* Moore, 1874	Common Sailer
4		*Vanessa inidca* Herbst, 1784	Indian Red Admiral
5		*Pseudergolis wedah* Kollar 1884	Tabby
6		*Precis iphita* Cramer, 1779	Chocolate Pansy
7		*Neptis ananta ochracea* Evans, 1924	Yellow Sailer
8		*Precise almana* Linnaeus, 1758	Peacock Pansy
9		*Vanessa cardui* Linnaeus, 1758	Painted Lady
10		*Issoria issaea* Doubleday, 1846	Queen of Spain Fritillary
11	Hesperiida	*Pelopidas sinensis* Mabille,1877	Large Branded Swift
12		*Parnara guttata mangala* Moore, 1865	Straight Swift
13		*Caltoris cahira austeni* Moore, 1883	Colon Swift

14		*Polytremis eltola* Hewitson, 1869	Yellow- Spot Swift
15	Nemeobiidae	*Dodona adonira* Hewitson, 1865	Striped Punch
16	Papilionidae	*Papilio arcturus* Westwood, 1842	Blue Peacock
17	Pieridae	*Delias pasithoe* Linnaeus, 1767	Red- base Jezebel
18		*Delias hyparete* Linnaeus, 1758	Painted Jezebel
19		*Delias sanaca oreas* Talbot, 1928	Pale Jezebel
20		*Metaporia agathon agathon* Gray, 1831	Great Blackvein
21		*Catopsilia pyranthe* Linnaeus, 1758	Mottled Emigrant
22		*Colias fieldii* Menetries, 1855	Dark Clouded Yellow
23		*Pieris brassicae nepalenis* Doubleday, 1846	Nepal Cabbage White
24		*Pontia daplidice* Linnaeus, 1758	Bath White
25		*Terias brigitta* Cramer, 1780	Small Grass Yellow
26		*Terias laeta sikkima* Moore, 1906	Spotless Grass Yellow
27	Satyridae	*Lethe serbonis teesta* Talbot, 1947	Brown Forester
28		*Ypthima avanta* Moore, 1874	Jewel Four- ring
29		*Lethe baladeva* Moore, 1865	Treble Silverstripe
30		*Ypthima newara* Moore, 1874	Newar Three- ring
31		*Zophoessa sidonis* Hewitson, 1863	Common Woodbrown
32		*Ypthima kasmira* Moore, 1884	Kashmir Fourring
33	Lycaenidae	*Udara dilecta* Moore, 1879	Pale Hedge Blue
34		*Heliophorus androcles coruscans* Moore, 1882	Green Sapphire
35		*Zizeeria maha* Kollar, 1848	Pale Grass Blue
36		*Celastina huegeli* Gistel,1857	Large Hedge Blue
37		*Lampides boeticus* Linnaeus, 1767	Pea Blue

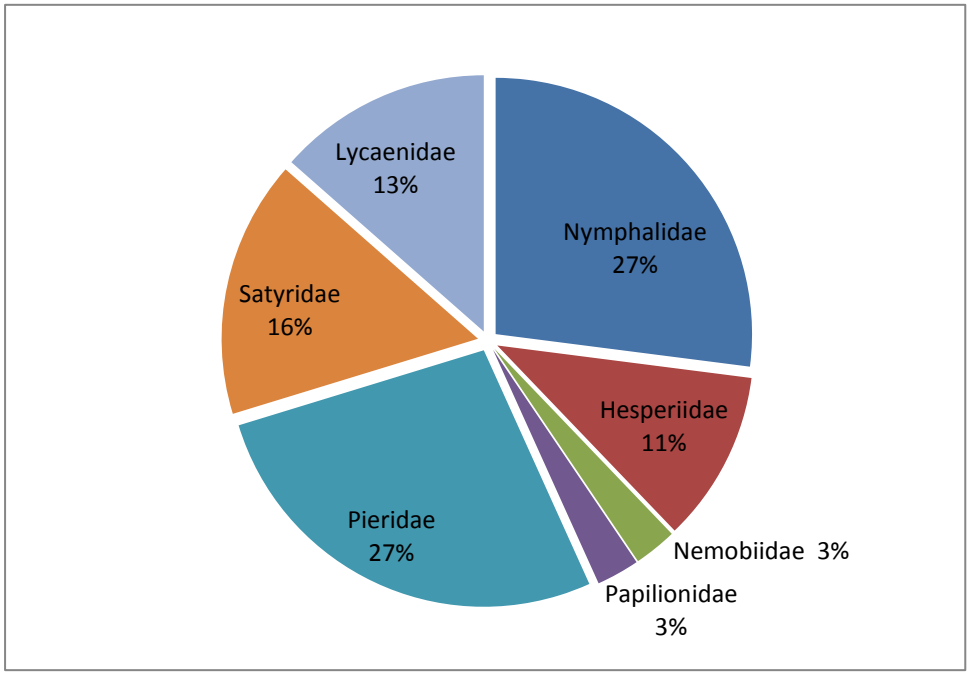

Figure 2. Family wise composition of species

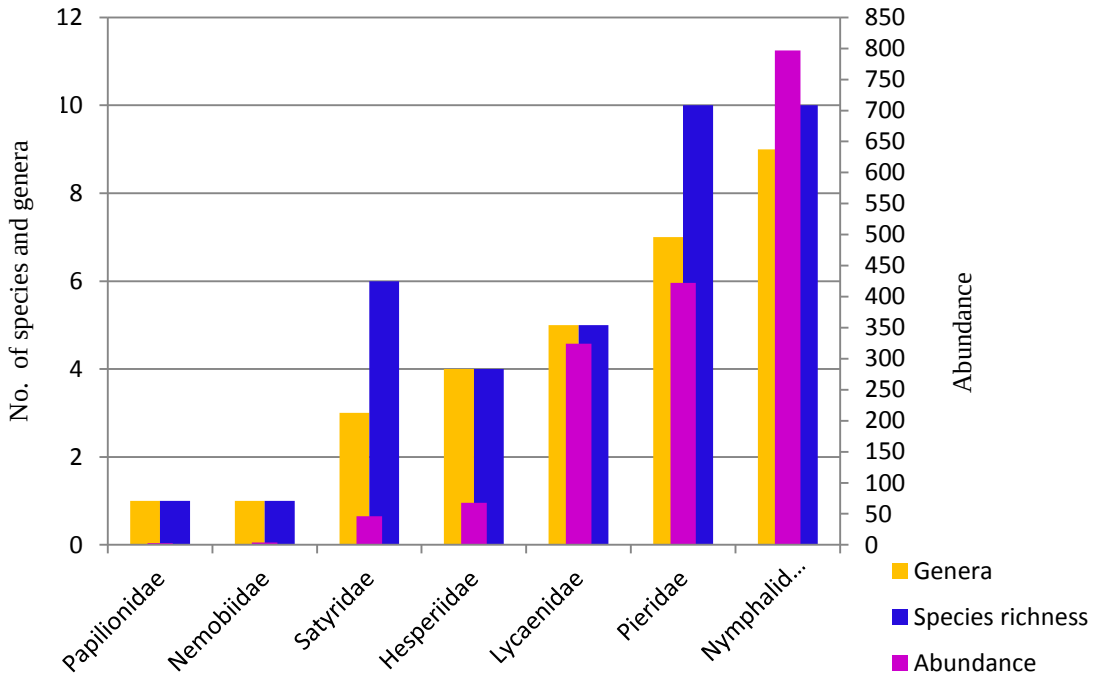

Figure 3. Family wise number of species, genera and abundance

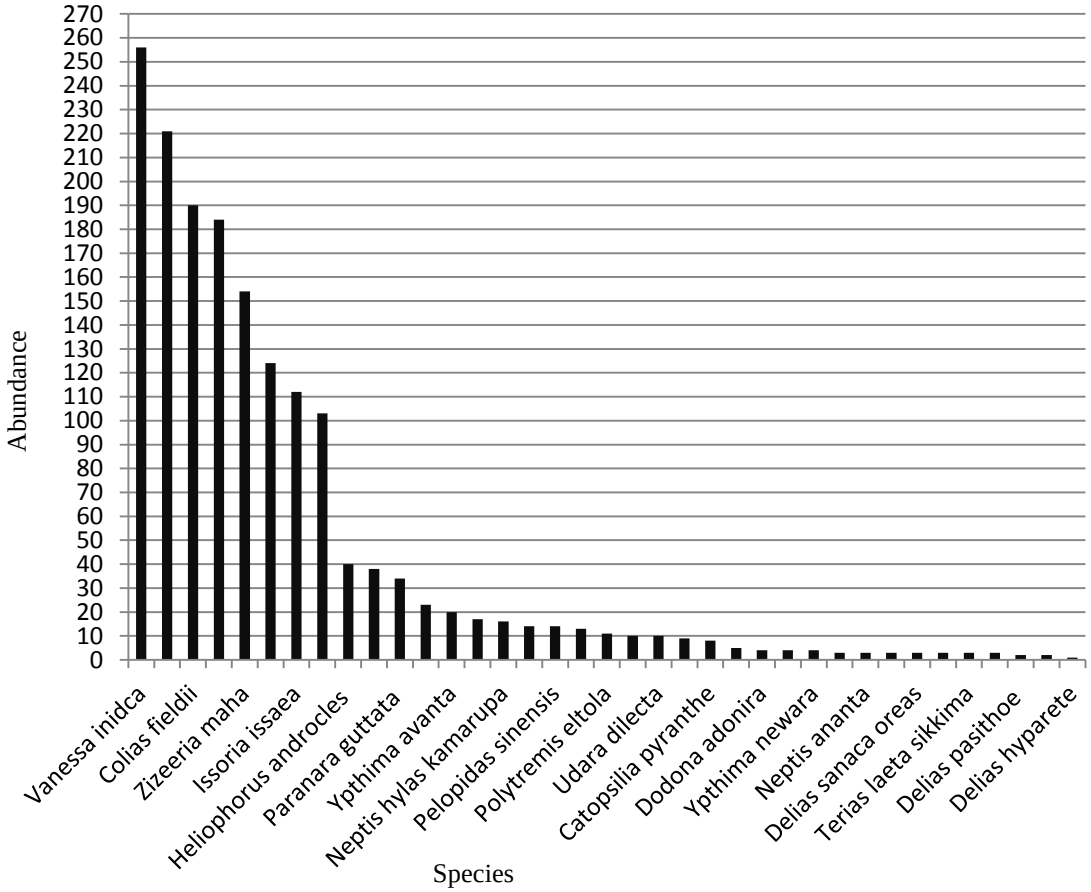

Figure 4. Rank abundance of species

4.2 Butterfly diversity and abundance in different habitats

The specis present in each habitat is shown in Table 2. Species richness, diversity index and evenness for three different habitat is presented in Table 3.The habitat with the highest abundance is forest with 613 numbers of individuals which is 37% of the total observation. Human settlement and cropland have similar observation results to each other with 33% and 30 % of the total observation, respectively. Species richness was high in the human settlement representing 24 species followed by cropland and forest representing 21 and 16 species respectively (Figure 5). The diversity index was high in cropland i.e. 2.640. Similarly evenness was also high (0.881). Cropland is followed by the forest with a diversity index of 2.326 with evenness of 0.839. The least diversity index was of human settlement area (1.557) along with least evenness (0.489946). The commonness between the different pairs of habitat was estimated through Sorensen's Similarity index among all the three habitat types and presented in Table 4 and Figure 7. The value of this index was found below 0.6 in all the possible pairs. 39% of butterflies were seen to preffer human settlement area whereas 35% and 26% butterflies were seen to prefer cropland and forest respectively (Figure 6).

Table 2. Showing presence and absence of species in different habitats

S.No.	Family	Species	Habitat		
			Forest	Human	Cropland
1	Nymphalidae	*Aglais cashmirensis*	+	+	+
2		*Doleschallia bisaltide*	+	-	-
3		*Neptis hylas kamarupa*	-	+	+
4		*Vanessa inidca*	+	+	+
5		*Pseudergolis wedah*	-	+	+
6		*Precis iphita*	-	+	+
7		*Neptis ananta ochracea*	-	+	-
8		*Precise almana*	-	-	+
9		*Vanessa cardui*	+	+	+
10		*Issoria issaea*	+	-	+
11	Hesperiidae	*Pelopidas sinensis*	+	+	-
12		*Parnara guttata mangala*	+	+	+
13		*Caltoris cahira austeni*	-	+	-
14		*Polytremis eltola*	-	+	-
15	Nemeobiidae	*Dodona adonira*	-	-	+
16	Papilionidae	*Papilio arcturus*	-	+	-
17	Pieridae	*Delias pasithoe*	+	-	-
18		*Delias hyparete*	-	+	-
19		*Delias sanaca oreas*	-	+	-
20		*Metaporia agathon agathon*	-	+	-
21		*Catopsilia pyranthe*	+	+	-
22		*Colias fieldii*	+	+	+
23		*Pieris brassicae nepalenis*	+	+	+
24		*Pontia daplidice*	-	-	+
25		*Terias brigitta*	-	-	+
26		*Terias laeta sikkima*	-	-	+
27	Satyridae	*Lethe serbonis teesta*	+	-	-
28		*Ypthima avanta*	+	-	-
29		*Lethe baladeva*	-	+	-
30		*Ypthima newara*	-	-	+
31		*Zophoessa sidonis*	+	-	-
32		*Ypthima kasmira*	-	+	+
33	Lycaenidae	*Udara dilecta*	-	+	-
34		*Heliophorus androcles coruscans*	-	+	+
35		*Zizeeria maha*	+	+	+
36		*Celastina huegeli*	-	-	+
37		*Lampides boeticus*	+	-	+

- = Absence + = Presence

Table 3. The species richness, Shannon diversity index and evenness in different habitats

Habitats	Forest	Human settlement	Cropland
Species richness	16	24	21
Shannon diversity index	2.326	1.557	2.640
Evenness	0.839	0.489	0.881

Table 4. Showing Sorensen's similarity index between different habitats

	Sorensen's similarity index	Percentage
Human settlement and Cropland	0.533	53.333
Forest and Human settlement	0.5	50
Forest and Cropland	0.486	48.648

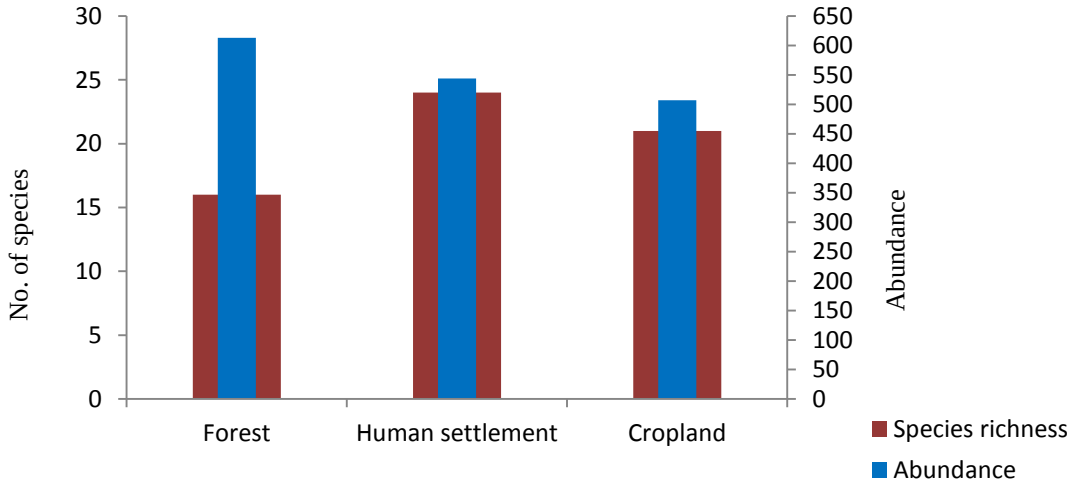

Figure 5. Species richness and abundance in different habitats

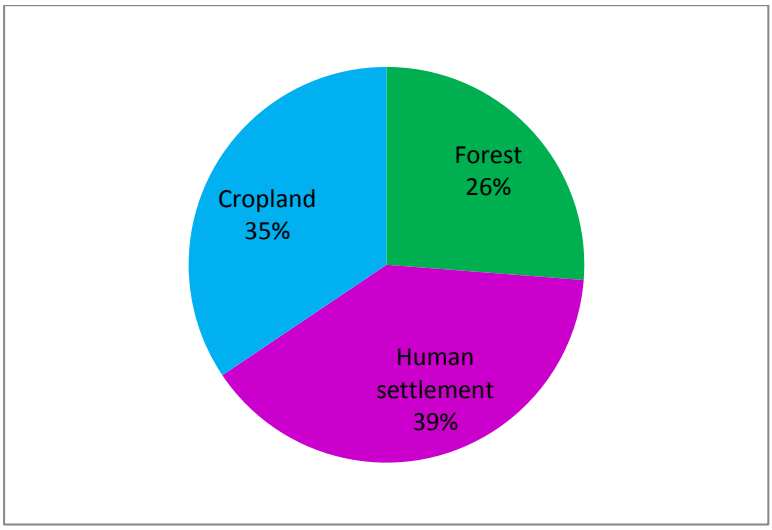

Figure 6. Habitat preference in butterflies

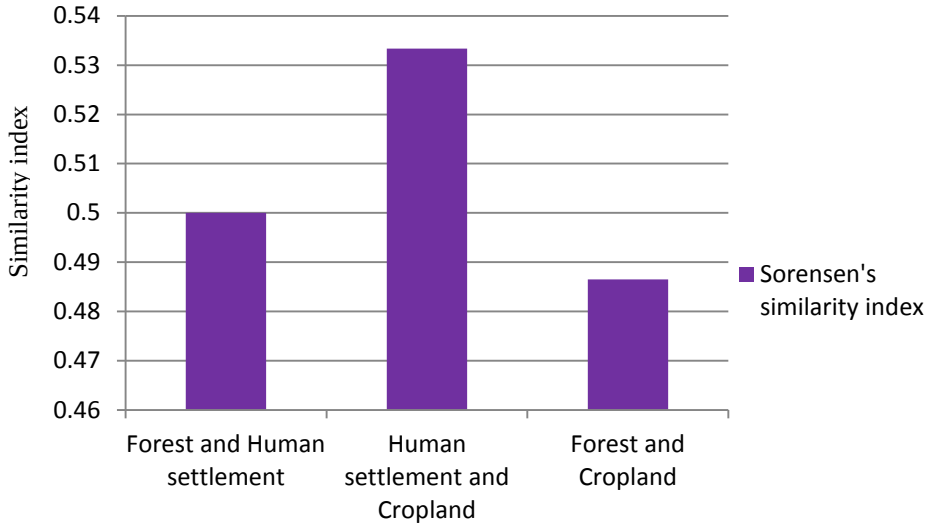

Figure 7. Diagrammatic representation of Sorensen's similarity index between different habitats

4.3 Seasonal variation in the diversity of butterfly

Species present during different seasons are given in Table 5. The season wise species richness, diversity index and evenness values are recorded in Table 6. The maximum number of butterfly species (26) was recorded during autumn and the maximum number of individuals (1148) was recorded during the spring (Figure 8). The second large number of species was recorded during spring season (14) followed by the winter season (13). 315 individuals were recorded during autumn while 201 during winter. Shannon index of diversity (H=2.802) exhibited highest with the evenness index of species distribution (E=0.860) during autumn season as compared to spring (H=2.249; E=0.877) and winter (H=2.017; E=0.786).

Table 5. Showing presence and absence of species in different seasons

S.No.	Family	Species	Season		
			Autumn	Winter	Spring
1	Nymphalidae	*Aglais cashmirensis*	+	+	+
2		*Doleschallia bisaltide*	+	-	-
3		*Neptis hylas kamarupa*	+	+	+
4		*Vanessa inidca*	+	+	+
5		*Pseudergolis wedah*	+	+	-
6		*Precis iphita*	+	+	-
7		*Neptis ananta ochracea*	+	-	-
8		*Precise almana*	+	+	-
9		*Vanessa cardui*	-	-	+
10		*Issoria issaea*	-	-	+
11	Hesperiidae	*Pelopidas sinensis*	+	-	-
12		*Parnara guttata mangala*	+	-	-

13		*Caltoris cahira austeni*	+	-	-
14		*Polytremis eltola*	+	-	-
15	Nemeobiidae	*Dodona adonira*	+	-	-
16	Papilionidae	*Papilio arcturus*	-	+	-
17	Pieridae	*Delias pasithoe*	+	-	-
18		*Delias hyparete*	+	-	-
19		*Delias sanaca oreas*	+	-	-
20		*Metaporia agathon agathon*	+	-	-
21		*Catopsilia pyranthe*	+	-	+
22		*Colias fieldii*	+	+	+
23		*Pieris brassicae nepalenis*	-	-	+
24		*Pontia daplidice*	-	-	+
25		*Terias brigitta*	-	-	+
26		*Terias laeta sikkima*	+	-	-
27	Satyridae	*Lethe serbonis teesta*	+	-	-
28		*Ypthima avanta*	+	-	-
29		*Lethe baladeva*	-	+	-
30		*Ypthima newara*	-	+	-
31		*Zophoessa sidonis*	-	+	-
32		*Ypthima kasmira*	-	-	+
33	Lycaenidae	*Udara dilecta*	+	-	-
34		*Heliophorus androcles coruscans*	+	+	+
35		*Zizeeria maha*	+	+	+
36		*Celastina huegeli*	+	-	-
37		*Lampides boeticus*	-	-	+

- = Absence

+ = Presence

Table 6. The species richness, Shannon diversity index and evenness in different seasons

Season	Autumn	Winter	Spring
Species richness	26	13	14
Shannon diversity index	2.802	2.017	2.245
Evenness	0.860	0.786	0.876

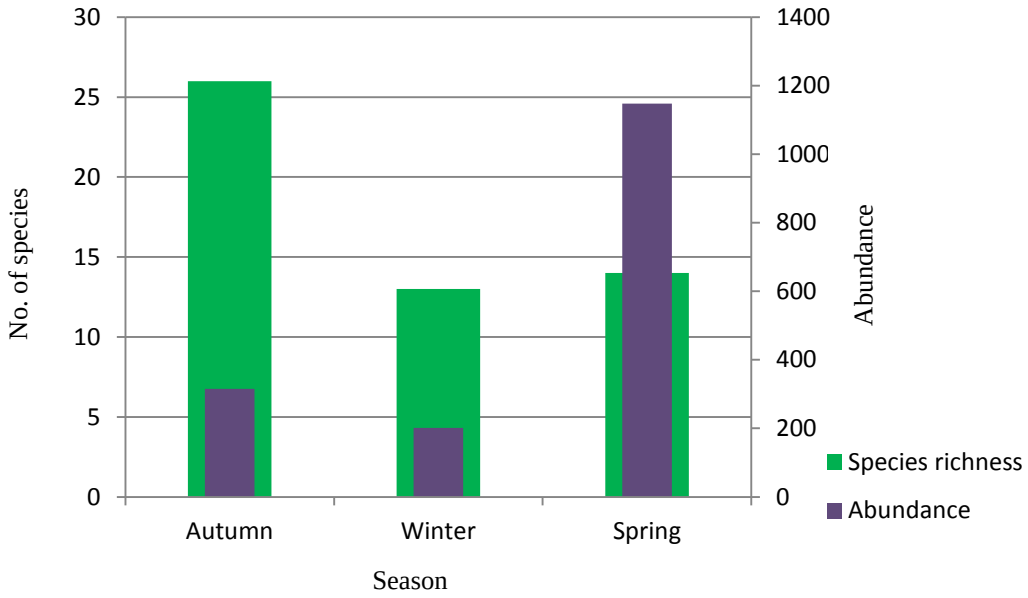

Figure 8. Species richness and abundance in various seasons

4.4 Altitudinal Variation

Species found at different altitude are given in Table 7. Species richness, diversity index and evenness for different altitude are presented in Table 8. The maximum number of butterfly species (31) and maximum number of individuals (852) was recorded at low altitude (Figure 9). At high altitude the 17 species and 812 individuals were recorded. Shannon index of diversity (H=2.8) with the evenness index of species distribution (E=0.8154) exhibited highest at low altitude as compared to high altitude (H=2.309; E=0.8152).

Table 7. Showing presence and absence of species in different seasons

S.No.	Family	Species	Altitude	
			High	Low
1	Nymphalidae	*Aglais cashmirensis*	+	+
2		*Doleschallia bisaltide*	+	-
3		*Neptis hylas kamarupa*	+	+
4		*Vanessa inidca*	+	+
5		*Pseudergolis wedah*	-	+
6		*Precis iphita*	-	+
7		*Neptis ananta ochracea*	-	+
8		*Precise almanac*	-	+
9		*Vanessa cardui*	+	+
10		*Issoria issaea*	+	+
11	Hesperiidae	*Pelopidas sinensis*	+	-
12		*Parnara guttata mangala*	+	+
13		*Caltoris cahira austeni*	-	+
14		*Polytremis eltola*	-	+

15	Nemeobiidae	*Dodona adonira*	-	+
16	Papilionidae	*Papilio arcturus*	-	+
17	Pieridae	*Delias pasithoe*	+	-
18		*Delias hyparete*	-	+
19		*Delias sanaca oreas*	-	+
20		*Metaporia agathon agathon*	-	+
21		*Catopsilia pyranthe*	+	+
22		*Colias fieldii*	+	+
23		*Pieris brassicae nepalenis*	+	+
24		*Pontia daplidice*	-	+
25		*Terias brigitta*	-	+
26		*Terias laeta sikkima*	-	+
27	Satyridae	*Lethe serbonis teesta*	+	-
28		*Ypthima avanta*	+	-
29		*Lethe baladeva*	-	+
30		*Ypthima newara*	-	+
31		*Zophoessa sidonis*	+	-
32		*Ypthima kasmira*	-	+
33	Lycaenidae	*Udara dilecta*	-	+
34		*Heliophorus androcles coruscans*	-	+
35		*Zizeeria maha*	+	+
36		*Celastina huegeli*	-	+
37		*Lampides boeticus*	+	+

- = Absence + = Presence

Table 8. The species richness, Shannon diversity index and evenness in different altitude

Season	High	Low
Species richness	17	31
Shannon diversity index	2.31	2.8
Evenness	0.8152	0.8154

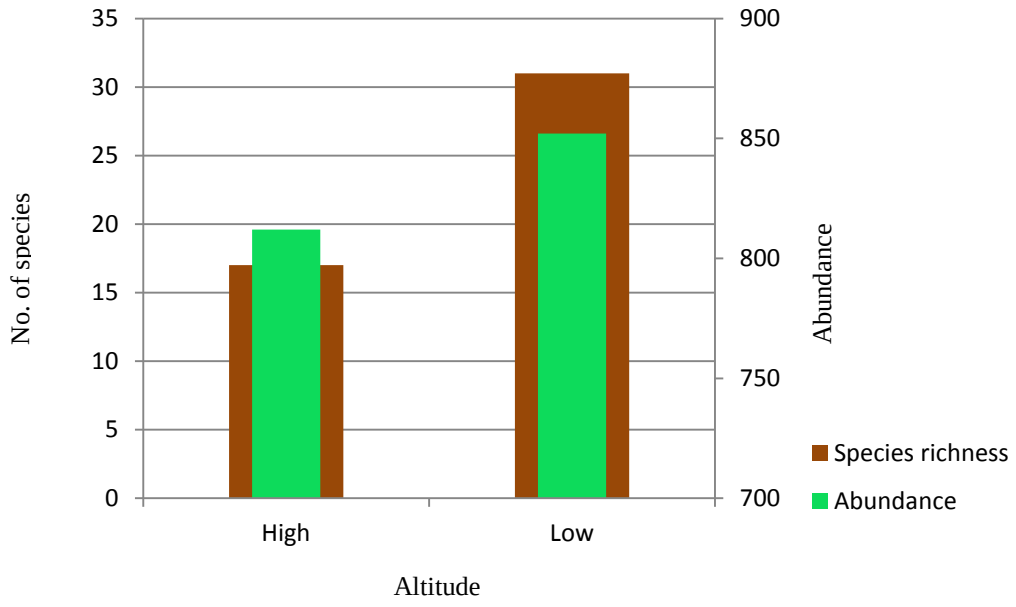

Figure 9. Species richness and abundance with respect to altitude

5. DISCUSSION

In this study, species of Nymphalidae and Pieridae contributed the highest species number followed by Satyridae, Lycaenidae, Hesperiidae whereas Papilionidae and Nemobiidae had the least species number. The maximum species of Nymphalidae may be because of their ecological adaptation (Jiggins *et al*., 1996), speciation and high dispersal ability (Adler *et al*., 1996). Additionally, many species of this family are strong, active fliers that might help them in searching for resources in large areas (Eswaran and Pramod, 2002; Krishnakumar *et al*., 2008; Raut and Pendharkar, 2010). Family Nymphalidae is the largest family representing nearly one-third of the known butterflies of the world. Singh (2010) recorded Nymphalidae and Pieridae as the dominant family in Dalma Wildlife Sanctuary in Jharkhand, India and Gabriel and Ignacimuthu (2005) from Chennai which is similar to this research finding. Bhusal and Khanal (2008) observed Nymphalidae as highest family and Nemobiidae as least in the Eastern Siwalik of Nepal. Thapa (2008) had also obtained the similar result that Nymphalidae and Acreidae contributed the highest and least species number respectively at Thankot and Syuchatar, Kathmandu. Khanal (1982 and 1984), Prajapati *et al*. (2000) and Bhuju and Yonzon (2001) recorded Nymphalidae as the dominant families. Kumar (2013), Arya *et al*. (2014), Avuletey and Niba (2014) and Alarape *et al*, (2015) recorded Pieridae as the dominant family from different sites.

So far as distribution pattern of butterfly from the present location is concerned the *Vanessa indica, Aglais cashmerensis* and *Colias fieldii* was recorded in every study sites in every season. On other hand, *Pieris brassicae nepalensis, Lampides boeticus, Vanessa cardui, Pontia daplidice moorei, Issoria issaea* were season specific, found only in spring season. On the same way all the species of Hesperidae family including *Delias pasithoe thyra, D. hyparete, D. sanaca oreas, Metaporian agathon agathon, Neptis ananta ochracea,Terias laeta sikkima, Ypthima avanta, Lethe serbonis teesta, Doleschallia bisaltide* and *Celastina huegeli* were found only in autumn season whereas *Papilio arcturus, Zophoessa sidonic, Ypthima newara* and *Lethe baladeva* were recorded only during winter season. *Vanessa inidca, Aglais cashmirensis, Colias fieldii, Pieris brassicae nepalenis, Zizeeria maha, Vanessa cardui, Issoria issaea* and *Lampides boeticus* were the dominated butterfly species seen in most of the study sites and found at maximum number. Other species like *Caltoris cahira austeni, Neptis hylas kamarupa, Catopsilia pyranthe, Terias brigitta, Dodona adonira, Lethe serbonis teesta, Ypthima newara, Doleschallia bisaltide, Neptis ananta ochracea, Papilio arcturus, Delias sanaca oreas, Metaporia agathon, Terias laeta sikkima, Lethe baladeva, Papilio arcturus, Doleschallia bisaltide, D. pasithoe, D. hyparete* and *Zophoessa sidonic* were observed very rarely and found in minimum number.

Highest numbers of species were recorded in human settlement area followed by cropland whereas the lowest species were recorded in forest. Habitat association of butterflies can be directly related to the availability of larval host plants, vegetation cover of herbs, shrubs and trees for nectaring of butterflies (Thomas, 1995). Lepidopterans are found to

visit flowering plants mostly for nectar and oviposition (Herrara, 1989; Liu *et al.*, 2010; Sivinski, 2014). Therefore the preffered butterfly habitat must include sufficient larval and adult food resources. In the present study, the higher percentage of species was observed in human settlement area which signifies the human settlement area was more preffered by the butterfly species where the access to host plants and ornamental flowering plants promoted the butterfly richness. Tiple and Khurad (2009) revealed that species richness increases in disturbed habitats and human impacted sites but the uniqueness decreases. Kunte (2000-2001) has recorded 68 species in forest and 69 in agriculture habitat which is similar to this research finding, forest representing the less species richness than that of cropland. Alarape *et al.* (2015) observed 48 species of butterfly in garden habitat while forest and cultivated habitats reached 28 species each respectively. Similarly, in Bumbuna Forest Reserve in northern Sierra Leone, the largest proportion of Savanna species were found in disturbed habitats (69%), a comparable proportion was recorded in the Savanna habitat (62%), which was not surprising and less than one fourth were recorded in forest habitats (Sundufu and Dumbuya, 2008).

Analyzing the Sorenson's similarity index, the human settlement area and cropland showed highest similarity in species composition (53.33%) than those between forest and human settlement (50%) and cropland and forest (48.64%). Results showed that more than 45% of the butterfly species recorded in all the sampling sites was the same despite differences in habitat characteristics which reveals that there is no more difference in the habitat which may be due to the presence of some common host plant.

The Shannon-Wiener Index of diversity between forest and human settlement has shown some sort of contradictory results, higher in forest than in human settlement which is against the hypothesis that, disturbed habitat or forest gaps have higher butterfly diversity than that in closed canopy or dense forests (Spitzer *et al*., 1993; Hill *et al*., 1995 and Hamer *et al*., 1997), but agrees the prediction that there is lesser butterfly diversity in regions with high human disturbances (Kitahara and Fujii, 1994). Sarma *et al.* (2012) has also obtained result which is similar to this research finding in which he found higher diversity in forest patch than in open grassland, roadside plantation and home garden. Roy *et al.* (2012) reported greater number of species from forest edges (54.83% of individuals represented by 16 different species) whereas lowest from the human habitats (14.52 % of individuals represented by 8 different species) which is just opposite with present finding. This may be due to the difference in the type of vegetation and the landscape type of the study areas.

Butterflies show seasonality. They are common in some months, rare for other and may be absent for rest of the year (Kunte, 2000). The species of Hesperidae appeared only during the autumn season. The species like *Pieris brassicae nepalensis, Vanessa cardui, Pontia daplidice moorie, Issoria issaea, Lampides boeticus* occured only during the spring season while they were absent during other seasons. The species *Aglais cashmirensis* and *Vanessa indica* occurred throughout the three seasons but comparing the number of individuals of these species, maximum individuals were recorded during the spring season. High abundance was recorded during the spring season which is 70% of the total individuals. Low abundance was recorded during the winter season where as moderate number of individuals were found during autumn season. This shows the

decreasing of abundance with approaching colder days (winter season) and raising with approaching warmer days (spring season). Species richness and months shows a significant correlation indicating that the abundance of butterfly is positively affected by the approaching warmer days and availability of more food that is nectar (Bhuju and Yonzon, 2001). Bhusal and Khanal (2008) also reported a significant relation between species diversity and spring season, indicating the abundances of diverse species was positively affected by approaching warmer days, high relative humidity and more rainfall. These factors help to flourish diverse vegetations, which are vital food sources for many butterfly species. Chandekar *et al*. (2014) has also reported a decline in species abundance from the months of December to January which is parallel to present finding.

The study of seasonal variation revealed that 26 species present in autumn which decreased to 13 species in winter and further increased to 14 species in spring which shows the maximum number of species was recorded during the autumn season followed by spring season and winter. The finding shows that the species richness was higher during autumn than spring and winter. We can assume that butterflies favours damp-warm weather than dry- hot weather. During the research in Daman Area of Makwanpur district of Central Nepal, Prajapati *et al*. (2000) recorded 38.46% of total species during spring and 84.6 1% during autumn which is parallel to this research. Similar finding was obtained by Thapa (2008) from Thankot and Syuchatara VDCs of Nepal and Bhusal and Khanal (2008) from Eastern Siwalik of Nepal recording the lowest number of species during winter season. Likewise, Manwar and Wankhade (2014) found less number of butterfly species during winter comparing to other season. But Gowda *et al*. (2011) has recorded the increasing number of species from monsoon to winter and then decreasing toward summer.

The seasonal variation in Shannon's Index of Diversity and the number of species sampled during each season suggests that species diversity peaked during autumn and was lowest in winter. More evenness was obtained during spring than in the autumn. During winter season the declination of species diversity and abundance are associated with habitat dryness and differences in microhabitat conditions with other seasons (Saikia, 2014). Saikia (2014) also obtained the lowest species diversity during the winter season. Similarly, Singh (2012) has also obtained lowest diversity during the winter season in Sankosh river catchment, Bhutan whereas Singh (2010) had obtained highest diversity during the winter and spring which is conflicting to findings of this study.

Analyzing the altitudinal variation low altitude had showed higher number of species and abundance in comparison to high altitude. Species richness and abundance both decreased with the increasing altitude. In total 31 species were recorded in low altitude whereas only 17 were recorded in high altitude. 11 species were found to be common in both altitudes. Species like *Doleschallia bisaltide, Pelopidas sinensis, Delias pasithoe, Lethe serbonis teesta, Ypthima avanta* and *Zophoessa sidonic* were found only in the higher altitude whereas *Pseudergolis wedah, Precis iphita, Neptis ananta ochracea, Precise almana, Caltoris cahira austeni, Polytremis eltola, Dodona adonira, Papilio arcturus, Delias hyparete, Delias sanaca oreas, Metaporia agathon agathon, Pontia daplidice, Pontia daplidice, Terias laeta sikkima, Ypthima kasmira, Udara dilecta, Heliophorus androcles coruscans* were recorded only in low altitude. *Aglais cashmirensis, Neptis hylas kamarupa, Vanessa inidca, Vanessa cardui, Issoria issaea, Parnara guttata mangala, Catopsilia pyranthe, Colias fieldii, Pieris brassicae nepalenis, Zizeeria maha* and *Lampides boeticus* were recorded in both altitudes.

Present data signify that both richness and abundance of butterflies decrease with altitude. This may be interpreted as a result of the interaction of two different variables-habitat and

disturbance. Lowest values of species richness observed at higher altitude are indicative of a negative correlation between species richness and their altitudinal distribution. Artusi (2014) observed the lower altitude was the most diversed based on its species richness, abundance and biodiversity index. Decreasing numbers of butterflies species richness with increasing elevation was also reported from Spain (Sanchez-Rodriguez and Baz, 1995). Sreekumar and Balakrishna (2001) and Bhardwaj and Uniyal (2011) made similar observation in a study in Kerela and Uttarakhand of India respectively. Acharya and Vijayan (2011) also found the decreasing species richness and abundance from lower altitude to higher. The continuous decrease in the number of species with increasing elevation may be caused by the harshness of environmental and climatic conditions, area reduction, scarce vegetation and few preferable habitats but also as a consequence of a reduction in resource diversity (Lawton *et al*., 1987; Khanal *et al*., 2012).

Maximum number of species was observed at low altitude and higher diversity level was also recorded. Number of species (species richness) and equitability (evenness in abundance) are the two components defining H'. Diversity increases as species are added, as well as when species abundances are evenly distributed (Sanchez- Rodriguez and Baz, 1995). The lowest diversity level in higher altitude may be due to the habitat disturbance and fragmentation.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Altogether 30 genera and 37 species of butterfly were recorded which were categorized under seven families (Nymphalidae, Hesperiidae, Nemobiidae, Papilionidae, Pieridae, Satyridae and Lycaenidae). This study concludes that Nymphalidae and Pieridae were the dominant among other recorded family whereas Papilionidae and Nemobiidae were among the rare families. *Issoria, issaea*, *Metaporia agathon agathon*, *Ypthima newara* and *Udara dilecta* are the endemic species recorded from the study area. This study also shows that the most preferred habitat was human settlement area comprising the larger number of species which is 39% of whole species. 24, 21 and 16 species were recorded from human settlement area, cropland and forest respectively. Cropland and human settlement area were found to be more similar than forest and human settlement and forest and cropland. Looking to the seasonal variation, spring season was more diversed than other two seasons representing 26 of the total species where as 13 and 14 species were recorded during winter and spring seasons respectively. In lower altitude a total of 31 species were found whereas 17 from higher altitude.

6.2 Recommendations

1. Further study should be done to cover all seasons to explore more butterflies of that study area.
2. Human settlement area has high species richness in this study so the food plant ot that area should be further maintained.
3. In forest low species is probably due to habitat distruction so this area should be conserved to maintain butterfly diversity.

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APPENDICES

Appendix I: GPS reading of each species

S. No	Species	GPS Reading		
		Latitude (N)	Longitude (E)	Altitude (m)
1	*Aglais cashmirensis*	28° 22' 46.27"	83° 48' 41.44"	1880
2	*Aglais cashmirensis*	28° 22' 27.26"	83° 47' 55.1"	2304
3	*Doleschallia bisaltide*	28° 22' 41.59"	83° 48' 1.44"	2095
4	*Neptis hylas kamarupa*	28° 22' 50.41"	83° 48' 19.4"	2000
5	*Vanessa indica*	28° 22' 41.2"	83° 48' 44.06"	1909
6	*Vanessa indica*	28° 22' 8.03"	83° 47' 16.48"	2280
7	*Pseudergolis wedah*	28° 22' 32.7"	83° 48' 37.44"	1966
8	*Precis iphita*	28° 22' 32.74"	83° 48' 37.4"	1966
9	*Neptisi ananta ochracea*	28° 22' 32.74"	83° 48' 37.4"	1966
10	*Precis almanac*	28° 22' 37.6"	83° 48' 40.86"	1944
11	*Vanessa cardui*	28° 22' 10.33"	83° 48' 11.23"	1948
12	*Vanessa cardui*	28° 22' 8.03"	83° 47' 16.48"	2280
13	*Issoria issaea*	28° 22 '8.65"	83° 48' 3.45"	2254
14	*Pelopidas sinensis*	28° 22' 42.17"	83° 47' 59.75"	2141
15	*Parnara guttata mangala*	28° 22' 42.53"	83° 47' 3.23"	2155
16	*Caltoris cahira austeni*	28° 22' 32.77"	83° 48' 37.37"	1970
17	*Polytremis eltola*	28° 22' 32.74"	83° 48' 37.4"	1966
18	*Dodona adonira*	28° 22' 46.27"	83° 48' 41.44"	1880
19	*Papilio arcturus*	28° 22' 32.34"	83° 48' 39.53"	1963
20	Delias pasithoe thyra	28° 22' 43.14"	83° 47' 57.01"	2165
21	*Delias hyparete*	28° 22' 32.74"	83° 48' 37.4"	1966
22	*Delias samaca oreas*	28° 22' 32.74"	83° 48' 37.4"	1966
23	*Metaporia agathon agathon*	28° 22' 32.7"	83° 48' 37.44"	1966
24	*Catopsilia pyranthe*	28° 22' 32.7"	83° 48' 37.44"	1966
25	*Catopsilia pyranthe*	28° 22'10.16"	83° 47' 14.88"	2216
26	*Colias fieldii*	28° 22' 38.35"	83° 48' 40.86"	1944
27	*Colias fieldii*	28° 22' 8.65"	83° 48' 0.45"	2254
28	*Pieris brassicae nepalensis*	28° 22' 10.16"	83° 47' 14.88"	2216
29	*Pontia daplidice moorei*	28° 22' 10.6"	83° 48' 11.43"	1934
30	*Terias laeta sikkima*	28° 22' 37.6"	83° 48' 40.86"	1944
31	*Terias brigitta*	28° 22' 35.72"	83° 48' 38.77"	1948
32	*Lethe serbonis teesta*	28° 22' 42.71"	83° 48' 2.48"	2107
33	*Ypthima avanta*	28° 22' 35.76"	83° 48' 5.11"	2205

34	*Lethe baladeva*	28° 22' 32.7"	83° 48' 37.44"	1966
35	*Ypthima newara*	28° 22' 38.35"	83° 48' 41.26"	1944
36	*Zophoessa sidonic*	28° 22' 29.89"	83^{o} 48' 15.34"	2146
37	*Yapthima kasmira*	28^{o} 22' 6.05"	83^{o} 48' 11.43"	1934
38	*Udara dilecta*	28^{o} 22' 10.18"	83^{o} 48' 9.91"	1964
39	*Heliophorus androcles coruscans*	28° 22' 35.72"	83° 48' 38.77"	1948
40	*Zizeeria maha*	28° 22' 35.72"	83° 48' 38.77"	1948
41	*Zizeeria maha*	28° 22' 42.1"	83° 47' 60"	2143
42	*Celastina huegeli*	28^{o} 22' 10.6"	83^{o} 48' 11.43"	1934
43	*Lampides boeticus*	28^{o} 22' 10.16"	83^{o} 47' 14.88"	2216

Appendix II: Shannon- Weinner species diversity and Evenness index of different habitats

S.No	Species	Forest			Human settlement			Cropland		
		No. of species	pi	pi*(ln(pi))	No. of species	pi	pi*(ln(pi))	No. of species	pi	pi*(ln(pi))
1	*Aglais cashmirensis*	85	0.138662	-0.27396	92	0.084715	-0.20912	44	0.086785	-0.21213
2	*Doleschallia bisaltide*	3	0.004894	-0.02603						
3	*Neptis hylas kamarupa*				13	0.011971	-0.05297	2	0.003945	-0.02184
4	*Vanessa inidca*	75	0.122349	-0.25704	104	0.095764	-0.22465	77	0.151874	-0.28624
5	*Pseudergolis wedah*				7	0.006446	-0.03251	3	0.005917	-0.03035
6	*Precis iphita*				8	0.007366	-0.03618	6	0.011834	-0.05251
7	*Neptis ananta ochracea*				3	0.002762	-0.01628			
8	*Precise almana*							38	0.074951	-0.19419
9	*Vanessa cardui*	58	0.094617	-0.2231	44	0.040516	-0.1299	22	0.043393	-0.13614
10	*Issoria issaea*	64	0.104405	-0.2359				48	0.094675	-0.22318
11	*Pelopidas sinensis*	7	0.011419	-0.05107	7	0.006446	-0.03251			
12	*Parnara guttata mangala*	14	0.022838	-0.08631	13	0.011971	-0.05297	7	0.013807	-0.05913
13	*Caltoris cahira austeni*				9	0.008287	-0.03972			
14	*Polytremis eltola*				11	0.010129	-0.04652			
15	*Dodona adonira*							4	0.00789	-0.0382

16	*Papilio arcturus*				3	0.002762	-0.01628			
17	*Delias pasithoe*	2	0.003263	-0.01868						
18	*Delias hyparete*				1	0.000921	-0.00644			
19	*Delias sanaca oreas*				3	0.002762	-0.01628			
20	*Metaporia agathon agathon*				3	0.002762	-0.01628			
21	*Catopsilia pyranthe*	6	0.009788	-0.04528	2	0.001842	-0.0116			
22	*Colias fieldii*	68	0.11093	-0.24392	108	0.099448	-0.22954	14	0.027613	-0.09912
23	*Pieris brassicae nepalenis*	99	0.161501	-0.29446	38	0.034991	-0.11731	47	0.092702	-0.22048
24	*Pontia daplidice*							23	0.045365	-0.14031
25	*Terias brigitta*							5	0.009862	-0.04555
26	Terias laeta sikkima							3	0.005917	-0.03035
27	*Lethe serbonis teesta*	4	0.006525	-0.03284						
28	*Ypthima avanta*	13	0.021207	-0.08172	7	0.006446	-0.03251			
29	*Lethe baladeva*				3	0.002762	-0.01628			
30	*Ypthima newara*							4	0.00789	-0.0382
31	*Zophoessa sidonic*	2	0.003263	-0.01868						
32	*Ypthima kasmira*				6	0.005525	-0.02872	7	0.013807	-0.05913
33	*Udara dilecta*				10	0.009208	-0.04316			

34	*Heliophorus androcles coruscans*				3	0.002762	-0.01628	37	0.072978	-0.19103
35	*Zizeeria maha*	48	0.078303	-0.19945	45	0.041436	-0.13192	61	0.120316	-0.25478
38	*Celastina huegeli*							17	0.033531	-0.11385
37	*Lampides boeticus*	65	0.106036	-0.23794				38	0.074951	-0.19419
	Total	613		2.326384	543		1.5559	507		2.640907
	Evenness			0.839066			0.48957			0.881556

Appendix III: Shannon-Weinner diversity index and Evenness index of different seasons

S. No.	Species	Autumn			Winter			Spring		
		No. of species	pi	pi*(ln(pi))	No. of species	pi	pi*(ln(pi))	No. of species	pi	pi*(ln(pi))
1	*Aglais cashmirensis*	46	0.146032	-0.28096	59	0.293532	-0.3598	116	0.101045	-0.23161
2	*Doleschallia bisaltide*	3	0.009524	-0.04432						
3	*Neptis hylas kamarupa*	4	0.012698	-0.05544	6	0.029851	-0.10482	6	0.005226	-0.02746
4	*Vanessa inidca*	24	0.07619	-0.19615	54	0.268657	-0.3531	178	0.155052	-0.28902
5	*Pseudergolis wedah*	3	0.009524	-0.04432	7	0.034826	-0.11692			
6	*Precis iphita*	11	0.034921	-0.11715	3	0.014925	-0.06276			
7	*Neptis ananta ochracea*	3	0.009524	-0.04432						
8	*Precise almanac*	25	0.079365	-0.20109	13	0.064677	-0.17711			
9	*Vanessa cardui*							124	0.108014	-0.24038
10	*Issoria issaea*							112	0.097561	-0.22705
11	*Pelopidas sinensis*	14	0.044444	-0.13838						
12	*Parnara guttata mangala*	34	0.107937	-0.24029						
13	*Caltoris cahira austeni*	9	0.028571	-0.10158						
14	*Polytremis eltola*	11	0.034921	-0.11715						
15	*Dodona adonira*	4	0.012698	-0.05544						

16	*Papilio arcturus*				3	0.014925	-0.06276			
17	*Delias pasithoe*	2	0.006349	-0.03212						
18	*Delias hyparete*	1	0.003175	-0.01826						
19	*Delias sanaca oreas*	3	0.009524	-0.04432						
20	*Metaporia agathon agathon*	3	0.009524	-0.04432						
21	*Catopsilia pyranthe*	2	0.006349	-0.03212				6	0.005226	-0.02746
22	*Colias fieldii*	7	0.022222	-0.08459	17	0.084577	-0.20891	166	0.144599	-0.27962
23	*Pieris brassicae nepalenis*							184	0.160279	-0.29344
24	*Pontia daplidice*							23	0.020035	-0.07834
25	*Terias brigitta*							5	0.004355	-0.02368
26	Terias laeta sikkima	3	0.009524	-0.04432						
27	*Lethe serbonis teesta*	4	0.012698	-0.05544						
28	*Ypthima avanta*	20	0.063492	-0.17504						
29	*Lethe baladeva*				3	0.014925	-0.06276			
30	*Ypthima newara*				4	0.0199	-0.07795			
31	*Zophoessa sidonic*				2	0.00995	-0.04587			
32	*Ypthima kasmira*							13	0.011324	-0.05074
33	*Udara dilecta*	10	0.031746	-0.10952						

34	*Heliophorus androcles coruscans*	8	0.025397	-0.09329	18	0.089552	-0.21608	14	0.012195	-0.05374
35	*Zizeeria maha*	44	0.139683	-0.27495	12	0.059701	-0.16826	98	0.085366	-0.21007
36	*Celastina huegeli*	17	0.053968	-0.15755						
37	*Lampides boeticus*							103	0.089721	-0.21632
	Total	315		2.802465	201		2.017109	1148		2.248949
	Evenness			0.860154			0.786413			0.8768

Appendix IV: Shannon-Weinner diversity index and Evenness index of different altitude

S.No.	species	High Altitude			Low Altitude		
		No. of species	pi	pi*(ln(pi))	No. of species	pi	pi*(ln(pi))
1	*Aglais cashmirensis*	89	0.109606	-0.24232	132	0.15493	-0.28891
2	*Doleschallia bisaltide*	3	0.003695	-0.02069			
3	*Neptis hylas kamarupa*	4	0.004926	-0.02617	12	0.014085	-0.06004
4	*Vanessa inidca*	152	0.187192	-0.31366	104	0.122066	-0.25673
5	*Pseudergolis wedah*				10	0.011737	-0.05217
6	*Precis iphita*				14	0.016432	-0.06751
7	*Neptis ananta ochracea*				3	0.003521	-0.01989
8	*Precise almana*				38	0.044601	-0.13871
9	*Vanessa cardui*	102	0.125616	-0.26059	22	0.025822	-0.09442
10	*Issoria issaea*	64	0.078818	-0.20025	48	0.056338	-0.16205
11	*Pelopidas sinensis*	14	0.017241	-0.07001			
12	*Parnara guttata mangala*	14	0.017241	-0.07001	20	0.023474	-0.08807
13	*Caltoris cahira austeni*				9	0.010563	-0.04807
14	*Polytremis eltola*				11	0.012911	-0.05616
15	*Dodona adonira*				4	0.004695	-0.02517
16	*Papilio arcturus*				3	0.003521	-0.01989

17	*Delias pasithoe*	2	0.002463	-0.01479			
18	*Delias hyparete*				1	0.001174	-0.00792
19	*Delias sanaca oreas*				3	0.003521	-0.01989
20	*Metaporia agathon agathon*				3	0.003521	-0.01989
21	*Catopsilia pyranthe*	6	0.007389	-0.03626	2	0.002347	-0.01421
22	*Colias fieldii*	114	0.140394	-0.27564	76	0.089202	-0.21559
23	*Pieris brassicae nepalenis*	99	0.121921	-0.25657	85	0.099765	-0.22995
24	*Pontia daplidice*				23	0.026995	-0.09751
25	*Terias brigitta*				5	0.005869	-0.03015
26	Terias laeta sikkima				3	0.003521	-0.01989
27	*Lethe serbonis teesta*	4	0.004926	-0.02617			
28	*Ypthima avanta*	20	0.024631	-0.09123			
29	*Lethe baladeva*				3	0.003521	-0.01989
30	*Ypthima newara*				4	0.004695	-0.02517
31	*Zophoessa sidonic*	2	0.002463	-0.01479			
32	*Ypthima kasmira*				13	0.015258	-0.06382
33	*Udara dilecta*				10	0.011737	-0.05217
34	*Heliophorus androcles coruscans*				40	0.046948	-0.1436

35	*Zizeeria maha*	58	0.071429	-0.1885	96	0.112676	-0.246
36	*Celastina huegeli*				17	0.019953	-0.0781
37	*Lampides boeticus*	65	0.080049	-0.20213	38	0.044601	-0.13871
	Total	812		.309801	852		2.800256
	Evenness			0.815258			0.815453

Appendix V: Photo plates

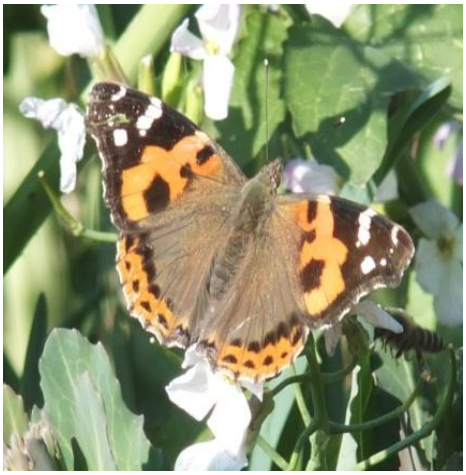
Lampides boeticus

Zizeeria maha

Colias fieldii

Pieris brassicae nepalensis

Vanessa cardui



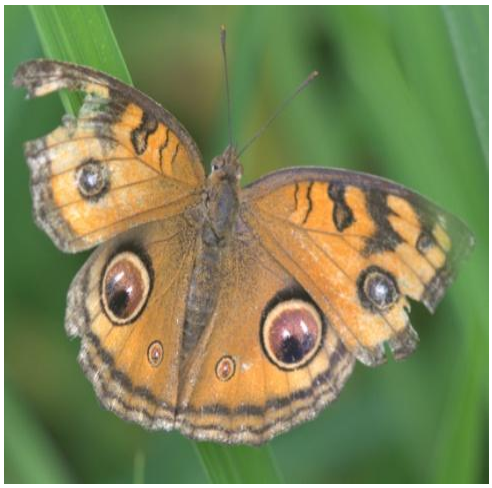
Vanessa indica

Issoria issaea

Aglais cashmirensis

Neptis hylas kamarupa

Pontia daplidice



Precis almanac

Precis iphita

Parnara guttata mangala

Pelopidas sinensis

Heliophorus androcles coruscans

Delias sanaca oreas

Catopsilia pyranthe

Ypthima kasmira