BUTTERFLY DIVERSITY IN MADI RAMBENI AREA, EASTERN MID-HILL REGION, SANKHUWASABHA, NEPAL

Kishor Dahal
T.U. Registration No: 5-1-3-65-2006
T.U. Examination Roll No: 23/070
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A thesis submitted
In partial fulfillment of the requirement for the award of the degree of Master of Science in Zoology with special paper Entomology

Submitted to
Central Department of Zoology
Institute of Science and Technology
Tribhuvan University
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Nepal
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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 the sources of information have been specifically acknowledged by reference to the authors or institutions.

Date……... …….

Kishor Dahal

TRIBHUVAN UNIVERSITY
01-4331896
CENTRAL DEPARTMENT OF ZOOLOGY
Kirtipur, Kathmandu, Nepal.

Ref.No.:

RECOMMENDATION

This is to recommend that the thesis entitled **"Butterfly Diversity in Madi Rambeni Area, Eastern Mid-Hill Region, Sankhuwasabha, Nepal"** has been carried out by **Mr. Kishor Dahal** for partial fulfillment of the requirement for Master's Degree in Zoology with the special on Entomology under my supervision. This is his original work and has been carried out under my supervision. To the best of my knowledge, this thesis 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.

Ref.No.:

LETTER OF APPROVAL

On the recommendation of supervisor "Dr. Daya Ram Bhusal" this thesis submitted by Mr. Kishor Dahal entitled **"Butterfly Diversity in Madi Rambeni Area, Eastern Mid-Hill Region, Sankhuwasabha, Nepal"** is approved for the examination and submitted to the Tribhuvan University in partial fulfillment of the requirement for 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.
Ref.No.:

CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Mr. Kishor Dahal entitled **"Butterfly Diversity in Madi Rambeni Area, Eastern Mid-Hill Region, Sankhuwasabha, Nepal"** has been accepted as a partial fulfillment for the requirement of Master's Degree of Science in Zoology with special paper Entomology.

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

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Kishor Dahal
Examination Roll No: 23/070
kishordahal47@gmail.com

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LIST OF ABBREVIATIONS

Abbreviated Form	Detailed of Abbreviations
DHM	Department of Hydrology and Meteorology
et al.	and others
GPS	Global Positioning System
Mm	Millimeters
SN	Serial Number
VDC	Village Development Committee
viz.	namely

ABSTRACT

The present work was result of a survey on butterfly fauna of Madi Rambeni area, Eastern Mid-Hill Region, Sankhuwasabha. The objective of the study was to explore butterfly diversity. A detailed survey of butterflies was conducted during September-October, 2015 and March-April, 2016 in three habitats viz. agricultural land, grassland and forest. Four random plots of area 50 m X 50 m were made in each habitat and abundance and richness of butterflies were recorded. A total of 31 species belonging to 27 genera under nine families were documented. Nymphalidae and Satyridae were the most predominant families contributing 25.81% and 19.35% species respectively where the families Acraeidae and Hesperiidae were least observed contributing 3.23% each. Butterfly diversity was recorded highest in grassland followed by agricultural land and forest. High butterfly diversity was recorded in post-monsoon season than pre-monsoon and low seasonal overlapping was seen.

1. INTRODUCTION

1.1 Background

Butterflies are the most taxonomically studied groups of insects and are also good indicators of environmental changes with color and pattern (Mayur *et al*., 2013) possess great aesthetic and commercial values (Ahsan and Javaid, 1975) which have attention throughout the world (Fjellstad, 1998). It is estimated that there are 18, 000 species of butterflies in the world and Nepal alone has recorded 660 species under 263 genera (Smith, 2010). Distribution patterns of Nepalese butterflies are varied with respect to physiographic zones which include 51% in Terai and Siwalik zone, 88% in middle zone and 13% in the highland zone of the country. About 18% species of the Mid-Hill zones are considered threatened (BPN, 1996).

Many of butterfly species are strictly seasonal and prefer only a particular set of habitats (Kunte, 1997) and they are good indicators in terms of anthropogenic disturbance and habitat quality (Kocher and Williams, 2000). Species richness is influenced by climatic factors, which determine reproduction and survival conditions. Many butterfly species can typically be sampled and identified in a short time and provide an indication of habitat or conservation value as well (Brown, 1997). Consistent global warming (Walther *et al*., 2002) increasing evidence of distribution pattern of butterfly species throughout the Earth. Butterflies are highly sensitive to changes in temperature, humidity and light (Owen, 1971) are easily influenced by habitat deterioration (Murphy *et al*., 1990). Relationships between habitat and butterfly diversity are well on record from different parts of the Indian subcontinent (Tiple and Khurad, 2009; Ramesh *et al*., 2010). The numbers of butterfly species and individuals are high in disturbed and regenerating forests and low in natural forests (Lien and Yuan, 2003). The variation in forest types has wider range of habitats to offer for diverse butterfly species (Smith, 1994). Insect diversity is highest in habitats with the most plant diversity and is lowest in shrub, grass and open areas (Barlow and Woiwod, 1989; DeVries, 1988).

Diversity of butterflies increases with increasing of habitat scale and vegetation structure complex (Price, 1975). The forest edge has the greatest diversity of butterflies (Lien, 2009). Forest habitat with more forest canopy layers and high vegetation diversity supports more insect species than a forest habitat with less forest canopy layers and less vegetation diversity. The gaps in the forest have higher diversity of butterflies than the closed forest areas (Spitzer *et al*., 1997). Studies have found that increasing productivity increases the diversity of organisms (Gaston, 2000; Ding *et al*., 2005; Whittaker, 2010; Craig and Klaver, 2013). Butterflies provide important ecological services for crops and native wild plant species in many ecosystems of the world and their conservation is essential to sustain the productivity of natural and agricultural landscapes (Davis *et al*., 2008). Butterflies are food to birds and other predators and are hosts to several parasitoids that suppress crop pests (Summerville *et al*., 2001). Feeding is a significant activity and food may often be the most decisive factor affecting distribution, abundance and movements of animals. In butterflies, this has a special relevance because food and mode of feeding are different in the larval and adult stages (Kunte, 2000). Butterflies and their caterpillar are dependent on specific host plants for foliage and nectar as their food.

Thus butterfly diversity reflects overall plant diversity, especially that of herbs and shrubs in the given area. There are studies related to diversity and species richness in Nepal (Shrestha and Smith, 1977; Smith, 1977a, 1977b, 1977c; Thapa, 1998; Giri, 1991; Prajapati *et al*., 2000; Bhuju, 2001; Bhusal and Khanal, 2008; Khanal, 2008; Smith, 2010; Khanal *et al*., 2013a, 2013b). However, habitat preference and seasonal variation of butterfly is lacking in Nepal. Thus present study focusing on habitat preference and seasonal variation of butterfly was carried out in Madi Rambeni area of Eastern Mid-Hill region, Nepal.

1.2 Objectives

1.2.1 General objective

- To explore the butterfly diversity in Madi Rambeni area, Sankhuwasabha.

1.2.2 Specific objectives

- To compare the butterfly diversity in different habitats.
- To document the seasonal diversity of butterfly.

1.3 Rationale of the study

1.3.1 Justification of study

The research studies on butterfly in Mid-Hill region and mountain region of Nepal are scanty (Smith, 2011a). Seasonal and habitat preference butterfly diversity in Sankhuwasabha was not carried out and this research signifies for the documentation of butterfly diversity and habitat status of this fauna from proposed study area. So this study is needed to find the current status of butterfly for future conservation.

1.3.2 Limitation of study

- It was difficult to identify some species of butterfly through direct observation.

2. LITERATURE REVIEW

2.1 In National context

Many biologists have done great contribution in the field of butterflies' diversity to conserve threatened species in Nepal. The first butterfly collector in Nepal was General Thompson Hardiwickii in 1826. Sharma (1962) studied lemon butterflies in Nepal. Japanese scientist (Fujioka, 1963) documented 263 butterflies in Nepal. Smith (1975) found 100 genera of common butterflies of Nepal. Smith (1977a, 1977b, 1977c) recorded eight new species of butterflies from Godawari, Lalitpur. Shrestha and Smith (1977) studied variation among Nepal's butterflies. In 1989 they published a book mentioning 614 species of butterflies existing in Nepal of which 43 species were papilionids, 49 species pierids, 173 species lycaenids, two species labytheids, 107 species hesperiids, 82 species Satyrids and 15 species of Danaides. Smith (1978) did research in the field of butterflies of Nepal. He listed 565 species of butterflies and published scientific list of Nepal's butterflies.

Smith (1981) published a book "Field Guide to Nepal's Butterflies" where he listed 480 species of butterflies belonging to 200 genera under 11 families. Khanal (1982) recorded 97 butterfly species belonging to 61 genera under nine families from different altitudinal levels of Lamjung and Manang. Nepali and Khanal (1988) reported 26 species of butterflies under six families from Dolpa and Manang districts of Nepal. Khanal (1985a, 1985b) reported a total of 52 species of butterflies belonging 42 genera under eight families from Gorkha and Trisuli regions and in the same year he recorded 39 species of butterflies from Piper, Kaski. Smith (1989) documented 614 species of butterflies belonging to seven families of which 173 species were Lycaenids, 107 Hesperiids, 82 Satyrids, 49 Pierids, 43 papilionids, 15 Danaides and two species were Labytheids and published a book "Butterflies of Nepal".

Giri (1991) studied butterflies of Sankhuwasabha district of Nepal and found 117 different species representing 68 genera and eight families including an endemic species for the district *Papilio castor* and a rare species *Neope pulahoides*. Earlier reported butterflies from Sankhuwasabha and Giri's collection made checklists for Sankhuwasabha where 304 species were reported. Thapa (1998) made a list of 656 Nepalese butterfly species under 286 genera. Khanal (1999) recorded 71 species of butterflies under 50 genera belonging to eight families from Kanchanpur and Kailali districts of Far Western Nepal where he found Nymphalidae and Lycaenidae contributed the highest number of species diversity and Nemeobiidae had the least number.

Prajapati *et al.* (2000) studied diversity of butterfly in Daman area of Makawanpur district, Central Nepal and found one new species *Chrysozephyrus esakii*. They recorded 65 species belonging 48 genera under eight families. They also documented families Nymphalidae and Lycaenidae were more dominant whereas the family Acraeidae was less abundant. Bhuju and Yonzon (2001) found that species richness being increased from winter to spring whereas the habitat loss adversely affecting the butterfly diversity of Churiya Eastern Nepal. Ghimire (2001) listed 43 species of butterflies belonging 29 genera from Champadevi, Kathmandu.

Khanal (2001) documented 114 species of butterflies under nine families from Jhapa district, Eastern part of Nepal. Among these butterflies 27 species were rare, 11 were uncommon and 76 species were common. He focused on conservation of butterflies and other flora and fauna which was in threat by deforestation and habitat loss by the lack of implementation of conservation education and awareness programme. Subba (2005) recorded a total of 41 species of butterflies belonging to 31 genera and seven families from Gujurmukhi Village Development Committee, Illam, Eastern Nepal. Khanal (2006) listed late season butterflies of Koshi Tappu, Wildlife Reserve where he found 54 species of butterflies under seven families. Bhusal and Khanal (2008) studied on the butterfly diversity at Churiya range of Eastern Nepal in winter and spring season and documented 40 species of butterflies belonging 28 genera and eight families.

Khanal (2008) studied the diversity of butterfly in four districts (Dang, Banke, Bardia and Surkhet) of western Terai and recorded 85 species under 64 genera and 10 families according to their altitudinal distribution. He also observed the loss of butterfly richness due to degradation of habitat by increase urbanization in Dang and Banke. Thapa (2008) recorded 43 species of butterflies from Thankot and Syuchatar, Kathmandu. Smith (2010) documented 660 species of butterfly including 263 genera in Nepal. Smith (2011a, 2011b, 2011c) published three guide books namely; Butterflies of Nepal, Butterflies of ACA and Illustrated checklists of Nepal's Butterflies. In these books he listed 278, 347 and 600 species respectively.

Khanal *et al*. (2012) did research on butterfly in Langtang National Park and documented 126 species. Khanal *et al*. (2013a, 2013b) documented 11 species from Godavari forest of Lalitpur, Central Nepal. They also revealed the reasons of butterfly declination and main reasons were due to rapid growth of human settlement, lack of host plants, loss of habitat and establishment of marble quarry nearby from that area. Inside Himalayas (2015) documented 60 species of butterflies in Annapurna Sanctuary. Among them *Abisara chela* was new species for Nepal. Khanal (2015) recorded 34 species of Nymphalid butterflies at different altitudinal ranges in Godavari – Phulchowki Mountain Forest, Central Nepal. In the same year he documented 26 butterfly species of family Lycaenidae from Shivapuri mountain forest.

2.2 In Global context

The study of butterfly has been done since 18th century (Happner, 1998). Pullin (1996) studied about the status of butterflies of Britain and found that distribution and abundance of butterflies were declined rapidly due to unsuitability of habitat. Ali and Basistha (2000) studied butterfly diversity of Assam State zoo-cum-botanical garden and recorded 79 species of butterflies. Among them 29 belong to the family Hesperiidae, 16 to Pieridae and nine to Papilionidae. Boonvanno *et al*. (2000) recorded 147 species of butterfly belonging 77 genera under nine families at Ton Nga-Chang Wildlife Sanctuary, Songkhla Province, Southern Thailand where Nymphalidae and Lycaenidae were the most dominant families. Kunte (2001) studied the butterfly diversity in Pune where he recorded 104 species of butterfly. Abbas *et al.* (2002) studied taxonomy and distribution of butterflies of the Skardu Region, Pakistan and recorded 16 species belonging 14 genera under five families. Sandufu and Dumbuya (2008) studied the habitat preferences butterfly fauna in the Bunbuna Forest Reserve in Northern Sierra Leone and documented 290 species. Among them 75.5% showed preferences for the forest habitat where as 47.6% and 23.1% preferred disturbed and savannah habitats respectively.

Lien (2009) worked on butterfly diversity in different habitats and found the stream sides have the greatest individual number, while the disturbed forest contains the greatest species number. The bamboo forest had the least species and individual numbers. The stream side environment in the forest plays an important role in conserving butterfly abundance while the bamboo shows the poorest butterfly diversity. Tiple and Khurad (2009) found total 145 species in the Nagpur out of which 62 species were new for the Nagpur city. Nymphalidae consist 51 species followed by Pieridae 17 species and Lycaenidae 46 species. Ramesh *et al*. (2010) studied on diversity pattern, abundance and habitat of butterfly at Department of Atomic Energy Campus, Kalpakkam, India and recorded 55 species of butterflies under five families where Nymphalidae was the most dominant family.

Khan *et al*. (2011) conducted altitudinal distribution pattern of butterfly and documented 68 butterfly species belonging to 38 genera under seven families at Kashmir Himalayas. Bhardwaj *et al*. (2012) studied butterfly communities along an elevational gradient in the Tons valley, Western Himalayas and recorded 79 butterfly species. They also found diversity was highest in heterogeneous habitats and decreased towards homogeneous habitats. Butterfly species richness and abundance were highly correlated with altitude, temperature and relative humidity. From different habitat of Goumara National Park of West Bengal, India, (Das *et al*., 2012) recorded 170 species of butterflies belonging to 109 genera, 21 sub-families and five families of which Nymphalidae and Lycaenidae were dominant. Munyuli (2012) studied butterfly diversity from farmlands of Central Uganda and recorded 331 species belonging to 95 genera under six families. He found higher butterfly diversity in forest. Perveen (2012) recorded 21 species of butterflies from Kohat, Khyber Pakhtunkhwa, Pakistan. He documented only three families of butterfly that were Nymphalidae, Papilionidae and Pieridae. Roy *et al*. (2012) studied the butterfly diversity in three habitats that included vegetation assemblages with closed canopy cover, edges of forest and areas of human intervention and documented 30 species of butterflies where he recorded highest diversity and abundance from the edges of the forest.

Sharma *et al*. (2012) did research on diversity and habitat association of butterfly species in foothills of Itanagar, Arunachal Pradesh, India and recorded 63 species of butterflies where Nymphalidae 44% were the most dominant followed by Lycaenidae 17%, Pieridae 16%, Papilionidae 14% and Hesperiidae 8%. They also documented that butterfly diversity was highest on forest followed by roadside plantation. Shobana *et al*. (2012) studied diversity and abundance of butterflies in Villupuram Tamil Nadu, South India. They recorded 56 species of butterfly. Singh (2012) studied on lowland forest butterflies of the Sankosh River of Bhutan and documented 213 species of butterflies. Among them 128 species were recorded during the spring season and 66 during monsoon season.

Trivedi *et al*. (2013) did research on diversity pattern of butterfly communities at Mangrol Region of Kathiawar Peninsula, India and recorded 27 species belonging to 21 genera and four families. Among them Nymphalidae 55.56% were the most dominant family followed by Pieridae 22.22%, Papilionidae 14.81% and Lycaenidae 7.41%. Bora and Merti (2014) found a total of 96 species of butterflies belonging to 68 genera under five families. Among them 13 species were rare species. Nymphaidae with 23 genera was found to be the most dominant followed by Lycacnidae 19 genera, Hesperiidae 13 genera, Pieridae nine genera and Papilionidae four genera. Ghorai and Sengupta (2014) studied altitudinal distribution of Papilionidae butterflies along with their larval food plants in the Eastern Himalayan Landscape of West Bengal, India. They found 26 species of butterflies across 11 altitudinal belts and 35 species of plants belonging to six families serve as the larval food plants of these butterflies.

Manwar and Wankhade (2014) studied seasonal variation in diversity and abundance of butterfly at Sawanga Vithoba lake area, Amravati district, Maharashtra, India and recorded 28 species of butterflies. Narasimmarajan *et al*. (2014) did research on Butterflies diversity in Gugamal National Park, Melghat Tiger Reserve, Maharashtra-Central India and recorded 66 species of butterflies belonging five families. The highest number of species was documented in Nymphalidae 31 followed by Pieridae 16, Papilionidae eight, Lycaenidae seven and Hesperidae four. Saikia (2014) studied the diversity of butterfly in Gauhati University College, Jaulapuri, Assam, India from 2003 to 2010 and recorded 140 species of butterfly under five families. He found that monsoon season had maximum diversity than the pre-monsoon, winter and post-monsoon. Acharya and Vijayan (2015) studied butterfly diversity along the elevation gradient of Eastern Himalaya, India and found that 161 species under six families. They also documented species richness of butterflies followed declining trend along the elevation gradient and various environmental factors were correlated strongly with the species richness and abundance of butterflies. Castro and Espinosa (2015) studied about seasonal diversity of butterflies and its relationship with woody-plants resources availability in an Ecuadorian tropical dry forest and documented 20 species of butterflies.

Mukherjee *et al*. (2015) studied on butterfly diversity in Kolkata, India and recorded 96 butterfly species, dominated by Lycaenidae 31.25% over Nymphalidae 28.13%, Hesperiidae 18.75%, Pieridae 12.50%, and Papilionidae 9.38%. Alleppa and Shrivastava (2016) did research on butterfly diversity in Bhilai Mahila Mahavidyalaya College and recorded 45 species belonging to five families.

Among them Nymphalidae 37.77% was the most dominant family, followed by Pieridae 22.22%, Papilionidae 20%, Lycaenidae 11.11% and Hesperidae 8.88%. Gajbe (2016) did research on diversity of butterflies in Karhandla Region of Umred-Karhandla Wildlife Sanctuary, Maharashtra, India and recorded 53 species belonging to 34 genera of five families. Among them Nymphalidae 23 Contributed highest number of butterfly species followed by Pieridae 10, Lycaenidae 10, Papilionidae seven and Hesperiidae three. Ghosh and Saha (2016) did research on seasonal diversity of butterflies with reference to habitat heterogeneity, larval host plants and nectar plants at Taki, North 24 Parganas, West Bengal, India and found 51 species of butterflies belonging to five genera. They also documented higher species richness and abundance of butterflies during post-monsoon.
Kumar *et al*. (2016) studied diversity and abundance of butterfly fauna of subalpine area of Chanshal Valley of Shimla and recorded 29 species belonging to 22 genera under four families. They also revealed Nymphalidae 34.48% was the most dominant family, followed by Pieridae 31.03%, Lycaenidae 27.59% and Papilionidae 6.90%. Pang *et al.* (2016) studied diversity of butterflies on Gunung Serambu, Sarawak, Malaysia and recorded 97 species. Among them Nymphalidae was the most dominant species. Sundarraj *et al.* (2016) studied diversity of butterflies in Gudalur forest area, Nilgiri hills, Southern Western Ghats, India and recorded 64 species of butterflies belonging to five families where Nymphalidae 18 was the most dominant family followed by Pieridae 15, Papilionidae 12, Lycaenidae 11 and Hesperidae eight. They also documented that higher butterfly diversity during monsoon season.

3. MATERIALS AND METHODS

3.1 The Study Area

Study area is Madi Rambeni area of Eastern Mid-Hill zone of Sankhuwasabha district. Mid-Hill zone of Nepal lies 1000 m to 2000 m from sea level ICIMOD (2016). Madi Rambeni lies in 27° 15′ 33″ to 27° 16′ 10″ in east and 87° 21′ 17″ to 87° 22′ 22″ in north. It is situated south to Siddhakali VDC, north to Madi Mulkharka VDC, west to Mawadin VDC and east to Mamling VDC. Madi Rambeni area is a land with different features such as forest, hills, grassland and farmland terraces. Due to variation in landscape and the natural sources it shows wide range of biodiversity.

Floras of Madi Rambeni area are highly diversified ranging from subtropical and temperate zones. Grassland has heterogeneous flowering herbs whereas cropland has monoculture crop *Tritucum aestivum* (pre-monsoon), *Oryza sativa* (post-monsoon) and temperature ranges between 18.6°C to 29.2°C during study period. The dominant plant species of Madi Rambeni include *Alnus nepalensis, Schima wallichi, Bambusa nutans, Citrus reticulata, Pyrus communis, Ficus neriifolia, Rubus ellipticus, Amomum subulatum, Thysanolaena maxima* and *Leucosceptrum canum.* Crop plants include *Oryza sativa, Tritucum aestivum, Brassica juncea, Brassica oleracea* and *Brassica campestris.* Flowering plants of study *a*rea includes *Malvaviscus arboreus, Tagetes erecta, Hibiscus rosa, Durunta repens, Rosa rosa* and medicinal plants are *Rubia manjith, Swertia chirayeta, Zingiber officinale, Justicia adhatoda* and *Phyllanthus emblica*.

Madi Rambeni area comprises sub-tropical and temperate type of climate. It lies in Mid-Hill region having great variation in altitude, landscape and climate. The maximum temperature of study area ranges between 17.1°C to 29.8°C and minimum temperature ranges between 3°C to 16.5°C from past 10 years. An annual rainfall varies from minimum 5.40 mm in the winter to maximum 302.6 mm in summer (DHM, 2015). The altitude of study area varies from 1120 m to 1950 m.

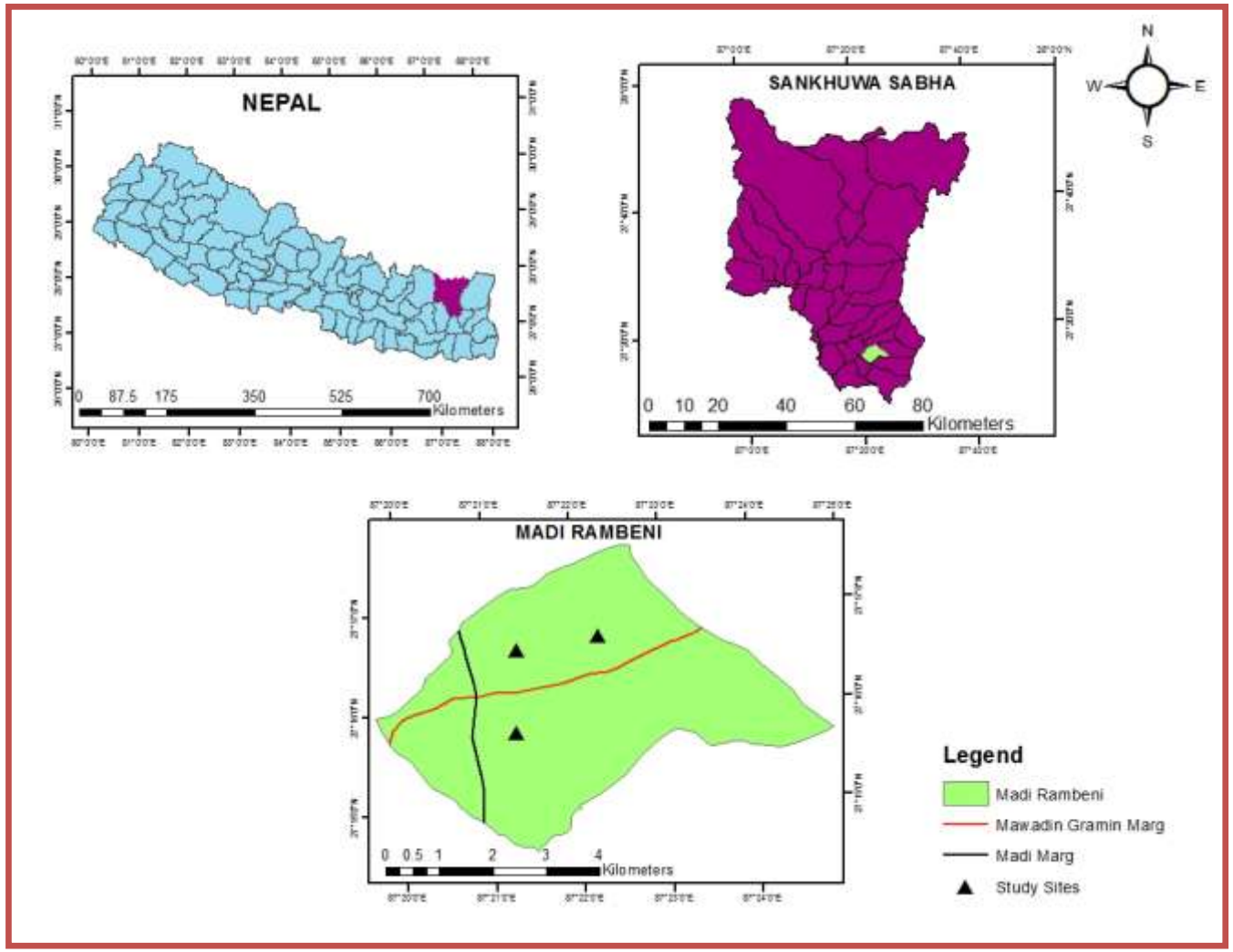

Figure 1. Map of study area

3.2 Sampling methods

The study was conducted at four plots of each three habitats viz. agricultural land, grassland and forest during two seasons i.e. pre-monsoon and post-monsoon. Random four plots had been made in each habitat of size 50 m X 50 m. Each habitat had been observed daily 10 am to 3 pm on sunny day. Butterfly observation was carried out for 15 days in each data collecting season i.e. pre-monsoon (March and April), 2016 and post-monsoon (September and October), 2015. The data of butterfly were collected by sweeping net. Each captured butterfly species was photographed from different angles as often as possible to obtain sufficient photographs to enable correct identification of species and were released. The confused butterfly species were kept in paper envelops and put in the box with naphthalene balls for preservation. Altitude of study area was recorded with the help of GPS device.

3.3 Butterfly identification

Butterfly photos were sorted and the species were identified using literature (Smith, 2011a; Evans, 1932; Wynter-Blyth, 1957; Haribal, 1992; Kehimkar, 2008; Kunte *et al.*, 2016). Confused butterfly species were confirmed by tallying the voucher specimens from Natural History Museum Swayambhu, Kathmandu.

3.4 Data processing and statistical analysis

The data were analyzed by using MS - Excel and different statistical tests such as Shannon-Wiener diversity index, Sorenson's Coefficient and Pielou's Evenness were done.

Shannon-Wiener Diversity Index (H): It is the index that is commonly used to characterize species diversity in a community (Shannon and Wiener, 1948).

Shannon-Wiener Diversity Index (H) = $- \Sigma$ pi ln pi Where,

P = the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N)

ln = the natural log

Σ = the sum of the calculations.

Sorenson's Coefficient: It is the statistical technique for comparing the similarity of two samples or habitats (Sorenson, 1948).

Sorenson's Coefficient (CC) = $2C / (S_1 + S_2)$ Where,

C = the number of species the two communities have in common

S_1 = the total number of species found in community 1

S_2 = the total number of species found in community 2

Pielou's Evenness (J′): It refers to how closeness of numbers of each species in an environment (Pielou, 1969).

J′ = H / ln(S) Where,

H = Shannon diversity index

ln = the natural log

S = total number of species

4. RESULTS

4.1 Diversity and distribution

A total of 31 species belonging to 27 genera under nine families were recorded during the entire study period (Table 1).

Table 1. Name of butterfly species recorded in study area

S.N.	Family	Scientific Name	Common Name
1.	Nymphalidae	*Aglais cashmirensis* Kollar 1844	Indian Tortoiseshell
2.		*Argyreus hyperbius* Linnaeus 1763	Indian Fritillary
3.		*Precis iphita* Crammer 1779	Chocolate Pansy
4.		*Cethosia biblis* Drury 1770	Red Lacewing
5.		*Athyma cama* Moore 1857	Orange Staff Sergent
6.		*Issoria issaea* Doubleday 1846	Queen of Spain Fritillary
7.		*Neptis hylas* Linnaeus 1758	Common Sailer
8.		*Vanessa cardui* Linnaeus 1758	Painted Lady
9.	Satyridae	*Lethe confusa* Aurivillius 1898	Banded Tree-Brown
10.		*Ypthima baldus* Fabricius 1775	Common Five-Ring
11.		*Melanitis leda* Linnaeus 1758	Common Evening Brown
12.		*Mycalesis perseus* Fabricius 1775	Common Bush-Brown
13.		*Mycalesis fransisca* Stoll 1780	Lilacine Bush-Brown
14.		*Ypthima huebneri* Hubner 1818	Common Four-Ring
15.	Danaidae	*Danaus genutia* Crammer 1979	Common Tiger
16.		*Danaus chrysippus* Linnaeus 1758	Plain Tiger
17.		*Parantica aglea* Stoll 1781	Glassy Tiger
18.		*Euploea mulciber* Crammer 1777	Striped Blue Crow
19.	Pieridae	*Catopsilia pyranthe* Linnaeus 1758	Mottled Emigrant
20.		*Terias hecabe* Linnaeus 1758	Common Grass Yellow
21.		*Colias fieldii* Menetries 1855	Dark Clouded Yellow
22.		*Pontia daplidice* Linnaeus 1758	Bath White
23.	Nemeobiidae	*Zemeros flegyas* Crammer 1780	Punchinello
24.		*Abisara fylla* Doubleday 1847	Dark Judy
25.		*Dodona adonira* Hewitson 1865	Striped Punch
26.	Lycaenidae	*Heliophorus indicus* Frushtorfer 1908	Eastern Blue Sapphire
27.		*Lampides boetics* Linnaeus 1767	Pea Blue
28.	Papilionidae	*Papilio paris* Linnaeus 1758	Paris peacock
29.		*Papilio protenor* Crammer 1775	Spangle
30.	Acraeidae	*Acraea issoria* Hubner 1818	Yellow Coaster
31.	Hesperiidae	*Parnara guttata* Stoll 1781	Straight Swift

Among 31 species family Nymphalidae contributed eight species (25.81%) followed by Satyridae six species (19.35%), Danaidae and Pieridae each with four species (12.90%), Nemeobiidae three species (9.68%), Lycaenidae and Papilionidae each two species (6.45%), Acraeidae and Hesperiidae each with one species (3.23%).

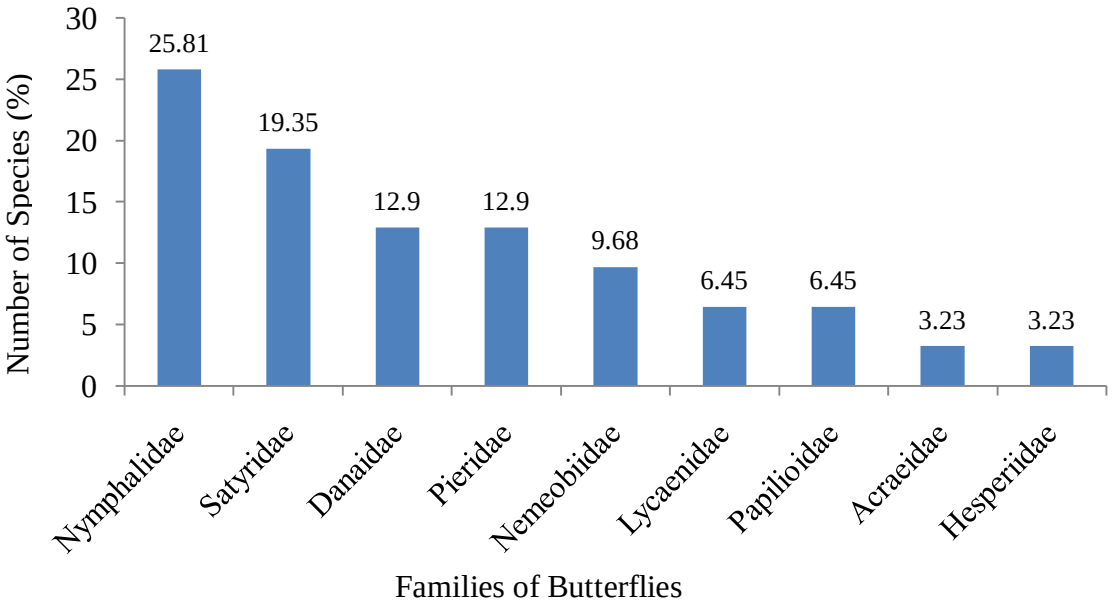

Figure 2. Family wise distribution of butterfly species recorded in the study sites

Pontia daplidice was the most dominant species recorded with 198 individuals whereas *Papilio paris* was the least individuals recorded with 2 individuals. Likewise, with family distribution concern family Pieridae contributed highest with 234 individuals of species whereas the family Hesperiidae of with 11 individuals of species recorded throughout the study period.

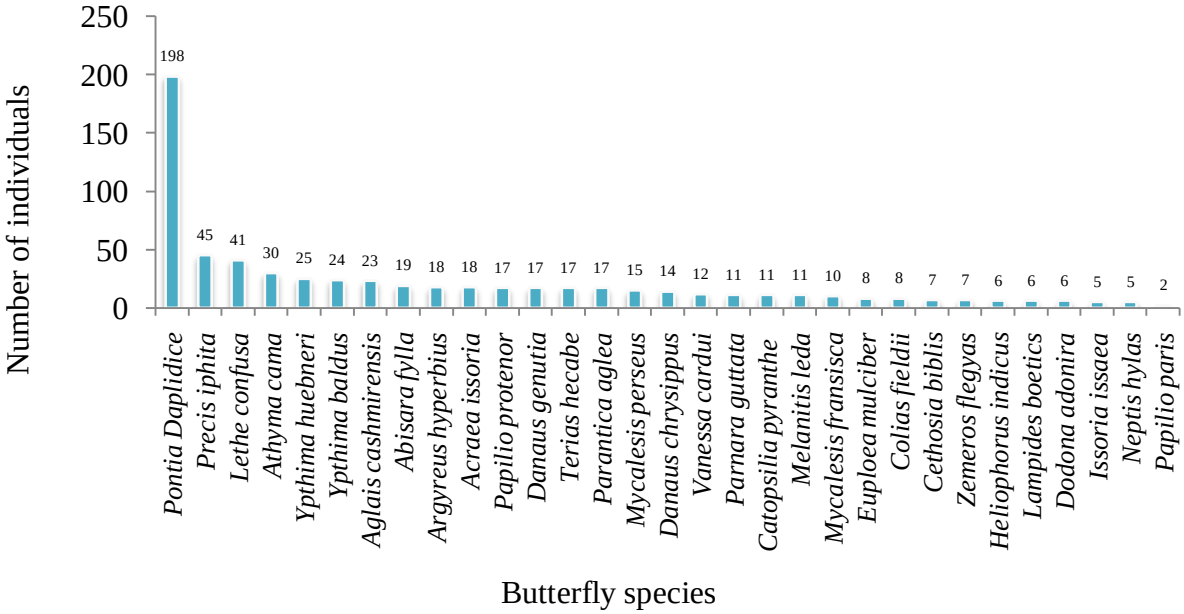

Figure 3. Species wise distribution of butterfly species recorded in the study area

4.2 Butterfly diversity in different habitats

Among three different habitats grassland, agricultural land and forest, the diversity of butterfly was maximum in grassland (2.15) followed by agricultural land (1.77) and forest (1.72) (Table 2).

Table 2. Species richness, Shannon's Diversity Index and Evenness among different habitats

Habitats	Grassland	Agricultural land	Forest
Species richness	10	14	7
Shannon's Diversity Index (H)	2.15	1.77	1.72
Evenness	0.92	0.67	0.89

The highest evenness was found in Grassland (0.92) followed by forest (0.89) and agricultural land (0.67) (Appendix III). In agricultural land *Pontia daplidice* was recorded in maximum number (198) and *Papilio paris* was with minimum number (2). Abundance of *Athyma cama* was recorded maximum (30) and *Dodona adonira* with minimum number (6) in Grassland. Forest habitat had maximum abundance of *Precis iphita* (45) and minimum of *Neptis hylas* (5) (Appendix I).

4.3 Seasonal butterfly diversity

Butterfly species of families Nymphalidae, Satyridae, Danaidae, Pieridae, Nemeobiidae, Lycaenidae and Papilionidae were recorded in both seasons. Family Acraeidae documented in pre-monsoon whereas Hesperiidae in post-monsoon season.

Table 3. Seasonal species richness, Shannon's Diversity Index and Evenness

Seasons	Pre-monsoon	Post-monsoon
Species richness	16	20
Shannon's Diversity Index (H)	1.92	2.84
Evenness	0.69	0.95

The butterfly diversity of pre-monsoon was found 1.92 and post-monsoon 2.84. Sixteen butterfly species were recorded in pre-monsoon (spring) where *Pontia daplidice* found in maximum number (198), *Neptis hylas* and *Issoria issaea* found in minimum number (5 each). Twenty butterfly species were recorded in post-monsoon (autumn) where *Lethe confusa* found in maximum number (41) and *Papilio paris* found in minimum number (2). Five species were recorded in both seasons.

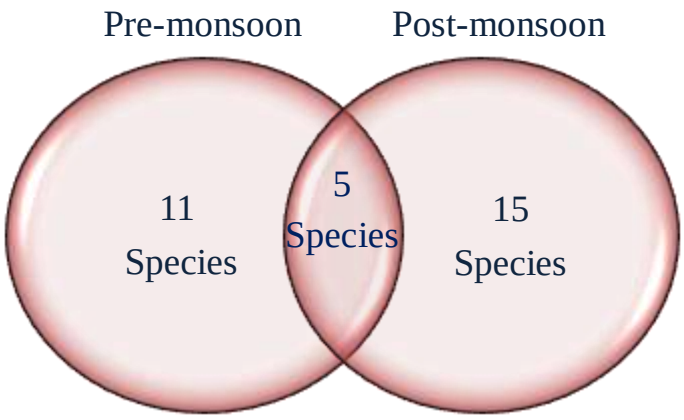

Figure 4. Butterfly species in pre-monsoon and post-monsoon

Butterfly Evenness was found highest in post-monsoon season (0.95) than pre-monsoon season (0.69) but number of individuals was recorded higher in pre-monsoon (375) than post-monsoon (278).

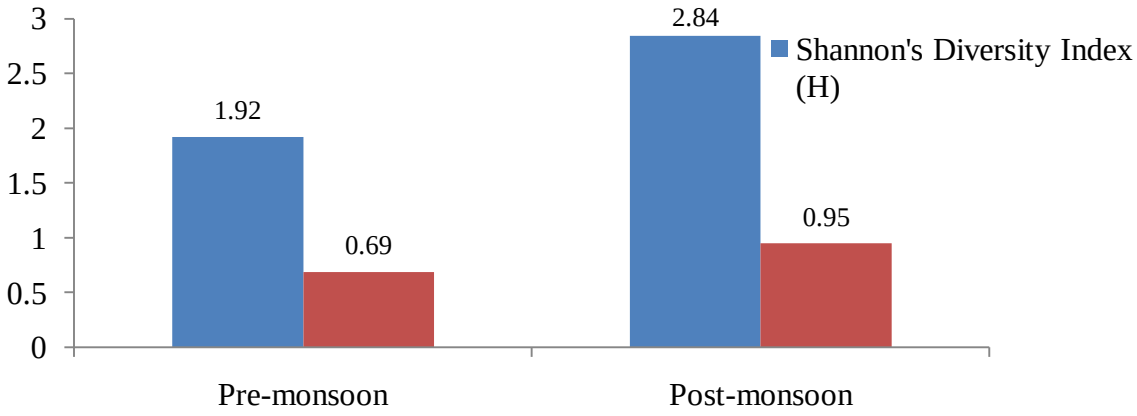

Figure 5. Shannon's diversity index and Evenness in pre-monsoon and post-monsoon

Post-monsoon season contributed 55.56% butterflies species whereas pre-monsoon 44.44%. Sorenson's Coefficient of two seasons is 0.28.

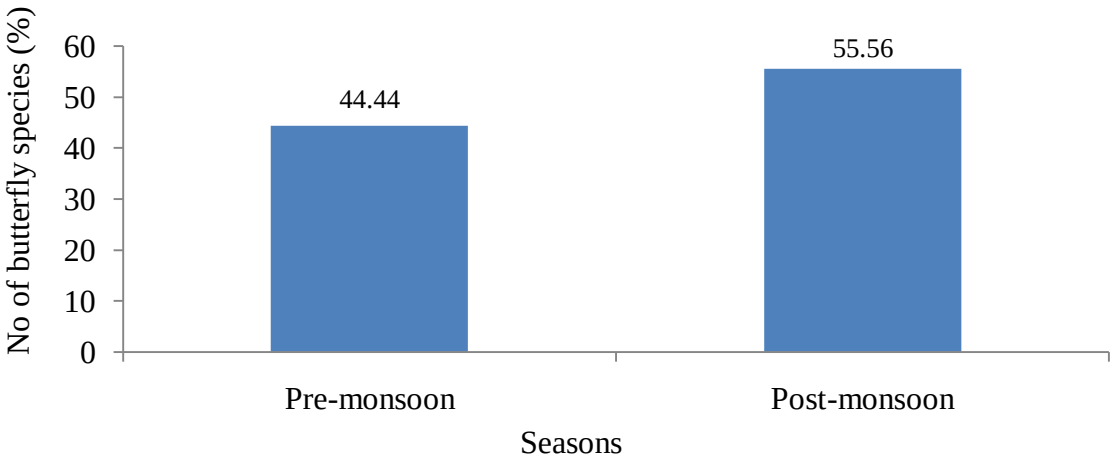

Figure 6. Percentage of butterfly species in pre-monsoon and post-monsoon

5. DISCUSSION

Total 31 butterfly species were recorded. Nymphalidae family contributed the highest species number (25.81%) whereas families Acraeidae and Hesperiidae had the least species number (3.23% each). Thapa (2008) had also obtained the similar result that Nymphalidae and Acraeidae contributed the highest and least species number respectively at Thankot and Syuchatar, Kathmandu. Khanal (1982, 1984) recorded 54 species of butterfly with Nymphalidae and Satyridae were the dominant families in the same region where Bhusal and Khanal (2008) observed Nymphalidae family contributed the highest species number whereas Hesperidae contributed least in the Eastern Siwalik of Nepal. Shrestha (2016) recorded families Nymphalidae and Satyridae contributed the highest butterfly species whereas Acraeidae and Hespiridae contributed least in Manang district which supports the present study. It might be due to quite similar elevation and temperature.

Similarly, Kumar *et al*. (2016), Gajbe, (2016), Narasimmarajan *et al.*, (2014), Trivedi *et al*. (2013), Tiple and Khurad (2009), Kunte (1997), Kunte *et al.* (1999), Eswaran and Pramod (2005), Soubadra and Priya (2001), Padhye *et al.* (2008) and Pang *et al. (*2016) documented Nymphalidae as the most dominant family which might be due to the availability of their specific larval host plants (Saikia, 2014), their ecological adaptation (Jiggins *et al*., 1996) and high dispersal ability (Adler *et al*., 1994). Sundarraj *et al.* (2016) recorded Nymphalidae family contributed the highest diversity whereas Hespiridae contributed lowest diversity on Gudalur forest area, Nilgiri hills, India. This result supports present study might be due to similar elevation.

Datta and Kalwani (2014) documented the highest butterfly diversity contributed by families Nymphalidae and Hespiridae but family Pieridae had the highest abundance which is parallel to this study. However, Mukherjee *et al.* (2015) documented highest butterfly diversity of family Lycaenidae followed by Nymphalidae and least contributed by Papilionidae which contradict with this study.

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5.1 Butterfly diversity in different habitats

In the present study, the highest butterfly diversity was recorded in grassland (2.15) and least in forest (1.72). Fitzherbert *et al*. (2006) recorded high butterfly diversity in grassland followed by agricultural land which supports present study. This study revealed that maximum Nymphalid butterfly species prefer agricultural land and they do not fly to high elevation. Lien and Yuan (2003) and Kitahara *et al.* (2008) recorded higher butterfly diversity in agricultural habitat than grassland and forest which contradict with present study. Butterflies diversity in agricultural land is less than grassland due to monoculture habitat (Bhardwaj *et al*., 2012). Ramesh *et al.* (2010) documented monoculture crop habitat contributed least butterfly diversity which supports the present study. This research was also conducted in monoculture agricultural land of *Triticum aestivum* during pre-monsoon and *Oryza sativa* during post-monsoon. Heterogeneous plant species supports greater butterfly diversity (Benton *et al*., 2003; Tscharntke *et al*., 2005; Ekroos *et al*., 2013).

Low butterfly diversity in agricultural land might be use of agricultural chemicals (Geiger *et al*., 2010). Nectar feeding butterflies are highly vulnerable to agricultural intensification (Rundlof *et al*., 2007; Holzschuh *et al*., 2008; Batary *et al*., 2011) because their foraging success and survival are directly affected by pesticides and other chemicals (Henry *et al*., 2012). Munyuli (2012) and Lien (2009) documented high butterfly diversity in forest and stream side forest respectively whereas Roy *et al*. (2012) recorded high diversity in edge of forest. However, present study documented the lowest butterfly diversity in forest might be due to selection of four quadrates in forest habitat whereas Roy *et al*. conducted their research by making seven transects of 500 m which increases the butterfly diversity with increasing habitat scale (Price, 1975).

Butterfly evenness was recorded maximum in grassland (0.92) and least in agricultural land (0.67). Abundance of butterfly species in grassland and forest were evenly distributed in comparison of agricultural land where *Pontia daplidice* was found with maximum abundance. It might be presence of abundant host plant of Brassicae family (John *et al*., 2008). Ignacimuthu *et al.* (2012) recorded less butterfly evenness in agricultural land than River bank which is similar to the present research. High diversity of butterfly in grassland might be due to flowering herbs and high exposure of sunlight whereas low butterfly diversity in the forest habitat could be due to non availability of host plant and low exposure of sunlight due to canopy cover.

5.2 Seasonal butterfly diversity

In the present study, butterfly species *Aglais cashmirensis, Argyreus hyperbius, Precis iphita, Ypthima huebneri* and *Athyma cama* were recorded during both seasons and high butterfly diversity was recorded during post-monsoon-season. Ghosh and Saha (2016) reported similar results which supports present study which might be due to quite similar temperature. Prajapati *et al.* (2000) recorded high butterfly diversity post-monsoon than pre-monsoon season which is parallel to the present study might be due to hot and wet environmental conditions favorable for butterfly diversity (Ashish *et al.*, 2009). Gandhi and Kumar (2016) documented high butterfly diversity during post-monsoon due to abundant larval food plants, nectar rich flower source for adult butterflies. Nair *et al.* (2014) documented high butterfly diversity during post-monsoon which is similar to the present study might be due to quite similar temperature during study period. Sengupta *et al.* (2014) documented higher butterfly diversity and evenness during post-monsoon than pre-monsoon season in India which supports the present study could be due to similar temperature.

Kunte (2001) and Wynter-Blyth (1956) documented high butterfly diversity during post-monsoon in India. *Ypthima huebneri* recorded in both seasons. Its caterpillar can feed on old or drying, less nutritious grass and can adjust in different seasons (Kunte, 1997). Ignacimuthu *et al.* (2012) recorded high butterfly diversity during post-monsoon which supports present result. It might be due to similar temperature and elevation. However, Bhusal and Khanal (2008) recorded high butterfly diversity during spring (pre-monsoon) season. It might be due to comparison of different seasons. They compared seasonal butterfly diversity of winter and spring (pre-monsoon) seasons whereas present study compared pre-monsoon and post-monsoon seasons.

The Sorenson's Coefficient of two seasons is 0.28 which is not close to one so that these seasons do not have much overlap and similarity. Bhusal and Khanal (2008) also reported low seasonal overlapping of butterfly species which is similar to the present study. Islam *et al.* (2015) documented high butterfly diversity during pre-monsoon than post-monsoon which contradict the findings of present research which might be due to the climatic factors of the study area.

Butterfly evenness was recorded highest in post-monsoon season (0.95) followed by pre-monsoon season (0.69). In this research maximum species diversity along with highest species evenness as observed during the post-monsoon could be related with abundant distribution of vegetation supporting the growth of the larval stages, flowering plants, wet and availability of water and high sun exposure. Significant evenness values indicate towards the absence of disturbing parameters. The low butterfly diversity during pre-monsoon might be due to non-availability of nectar, dry vegetation, dry land cover and scarcity of water.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

From the present study following conclusions were derived:

- The butterfly of the families Nymphalidae and Satyridae were the most dominant species observed during the study and the families Acraeidae and Hesperiidae contributed least number of species.
- Butterfly showed higher diversity in heterogeneous plants habitat than homogenous plants habitat.
- Post-monsoon was the favorable season for higher butterfly diversity than pre-monsoon season.

6.2 Recommendations

Based upon the study, following suggestions have been recommended for further studies:

- Butterfly related research should be designed to cover more seasons and habitats within a year and in between year.
- Butterfly species preferred grassland habitat so that conservation of grassland should be done.

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Appendix I: Butterflies species recorded in Madi Rambeni area

S.N.	Family	Scientific Name	Common Name	Seasons		Habitats			Abundance
				Pre-monsoon	Post-monsoon	Agricultural land	Grassland	Forest	
1.	Nymphalidae	*Aglais cashmirensis* Kollar 1844	Indian Tortoiseshell	+	+	+	-	-	23
2.		*Argyreus hyperbius* Linnaeus 1763	Indian Fritillary	+	+	+	-	-	18
3.		*Precis iphita* Crammer 1779	Chocolate Pansy	+	+	-	-	+	45
4.		*Cethosia biblis* Drury 1770	Red Lacewing	-	+	+	-	-	7
5.		*Athyma cama* Moore 1857	Orange Staff Sergent	+	+	-	+	-	30
6.		*Issoria issaea* Doubleday 1846	Queen of Spain Fritillary	+	-	+	-	-	5
7.		*Neptis hylas* Linnaeus 1758	Common Sailer	+	-	-	-	+	5
8.		*Vanessa cardui* Linnaeus 1758	Painted Lady	+	-	+	-	-	12
9.	Satyridae	*Lethe confusa* Aurivillius 1898	Banded Tree-Brown	-	+	-	-	+	41
10.		*Ypthima baldus* Fabricius 1775	Common Five-Ring	-	+	-	-	+	24
11.		*Melanitis leda* Linnaeus 1758	Common Evening Brown	-	+	-	-	+	11
12.		*Mycalesis perseus* Fabricius 1775	Common Bush-Brown	-	+	-	-	+	15
13.		*Mycalesis fransisca* Stoll 1780	Lilacine Bush-Brown	-	+	-	-	+	10
14.		*Ypthima huebneri* Hubner 1818	Common Four-Ring	+	+	-	+	-	25
15.	Danaidae	*Danaus genutia* Crammer 1979	Common Tiger	+	-	+	-	-	17
16.		*Danaus chrysippus* Linnaeus 1758	Plain Tiger	+	-	+	-	-	14
17.		*Parantica aglea* Stoll 1781	Glassy Tiger	-	+	-	+	-	17

18.		*Euploea mulciber* Crammer 1777	Striped Blue Crow	-	+	+	-	-	8
19.	Pieridae	*Catopsilia pyranthe* Linnaeus 1758	Mottled Emigrant	-	+	-	+	-	11
20.		*Terias hecabe* Linnaeus 1758	Common Grass Yellow	-	+	-	+	-	17
21.		*Colias fieldii* Menetries 1855	Dark Clouded Yellow	+	-	-	+	-	8
22.		*Pontia daplidice* Linnaeus 1758	Bath White	+	-	+	-	-	198
23.	Nemeobiidae	*Zemeros flegyas* Crammer 1780	Punchinello	-	+	+	-	-	7
24.		*Abisara fylla* Doubleday 1847	Dark Judy	-	+	-	+	-	19
25.		*Dodona adonira* Hewitson 1865	Striped Punch	+	-	-	+	-	6
26.	Lycaenidae	*Heliophorus indicus* Frushtorfer 1908	Eastern Blue Sapphire	-	+	-	+	-	6
27.		*Lampides boetics* Linnaeus 1767	Pea Blue	+	-	-	+	-	6
28.	Papilionidae	*Papilio paris* Linnaeus 1758	Paris peacock	-	+	+	-	-	2
29.		*Papilio protenor* Crammer 1775	Spangle	+	-	+	-	-	17
30.	Acraeidae	*Acraea issoria* Hubner 1818	Yellow Coaster	+	-	+	-	-	18
31.	Hesperiidae	*Parnara guttata* Stoll 1781	Straight Swift	-	+	+	-	-	11

(+) Sign indicates presence and (-) sign indicates absence of specimens.

Appendix II: GPS reading of each species

S.N.	Family	Scientific Name	Common Name	Latitude	Longitude
1.	Nymphalidae	*Aglais cashmirensis* Kollar 1844	Indian Tortoiseshell	27°16.088′	87°21.410′
2.		*Argyreus hyperbius* Linnaeus 1763	Indian Fritillary	27°16.098′	87°21.410′
3.		*Precis iphita* Crammer 1779	Chocolate Pansy	27°16.277′	87°21.657′
4.		*Cethosia biblis* Drury 1770	Red Lacewing	27°16.090′	87°21.397′
5.		*Athyma cama* Moore 1857	Orange Staff Sergent	27°16.110′	87°22.732′
6.		*Issoria issaea* Doubleday 1846	Queen of Spain Fritillary	27°16.048′	87°21.299′
7.		*Neptis hylas* Linnaeus 1758	Common Sailer	27°16.326′	87°21.780′
8.		*Vanessa cardui* Linnaeus 1758	Painted Lady	27°15.994′	87°21.350′
9.	Satyridae	*Lethe confusa* Aurivillius 1898	Banded Tree-Brown	27°16.281′	87°21.661′
10.		*Ypthima baldus* Fabricius 1775	Common Five-Ring	27°16.286′	87°21.671′
11.		*Melanitis leda* Linnaeus 1758	Common Evening Brown	27°16.320′	87°21.719′
12.		*Mycalesis perseus* Fabricius 1775	Common Bush-Brown	27°16.327′	87°21.757′
13.		*Mycalesis fransisca* Stoll 1780	Lilacine Bush-Brown	27°16.167′	87°21.717′
14.		*Ypthima huebneri* Hubner 1818	Common Four-Ring	27°16.073′	87°22.827′
15.	Danaidae	*Danaus genutia* Crammer 1979	Common Tiger	27°16.000′	87°21.341′
16.		*Danaus chrysippus* Linnaeus 1758	Plain Tiger	27°16.087′	87°21.325′
17.		*Parantica aglea* Stoll 1781	Glassy Tiger	27°16.102′	87°22.732′
18.		*Euploea mulciber* Crammer 1777	Striped Blue Crow	27°16.084′	87°21.397′
19.	Pieridae	*Catopsilia pyranthe* Linnaeus 1758	Mottled Emigrant	27°16.099′	87°22.732′
20.		*Terias hecabe* Linnaeus 1758	Common Grass Yellow	27°16.063′	87°22.823′
21.		*Colias fieldii* Menetries 1855	Dark Clouded Yellow	27°16.159′	87°22.849′
22.		*Pontia daplidice* Linnaeus 1758	Bath White	27°15.990′	87°21.355′

23.	Nemeobiidae	*Zemeros flegyas* Crammer 1780	Punchinello	27°16.088′	87°21.331′
24.		*Abisara fylla* Doubleday 1847	Dark Judy	27°16.104′	87°22.940′
25.		*Dodona adonira* Hewitson 1865	Striped Punch	27°16.156′	87°22.841′
26.	Lycaenidae	*Heliophorus indicus* Frushtorfer 1908	Eastern Blue Sapphire	27°16.105′	87°22.949′
27.		*Lampides boetics* Linnaeus 1767	Pea Blue	27°16.156′	87°22.852′
28.	Papilionidae	*Papilio paris* Linnaeus 1758	Paris peacock	27°16.086′	87°21.341′
29.		*Papilio protenor* Crammer 1775	Spangle	27°16.032′	87°21.299′
30.	Acraeidae	*Acraea issoria* Hubner 1818	Yellow Coaster	27°16.051′	87°22.901′
31.	Hesperiidae	*Parnara guttata* Stoll 1781	Straight Swift	27°16.080′	87°21.402′

Appendix III: Shannon's Diversity Index and Pielou's Evenness calculation. Agriculture land

S.N.	Name of the Species	Abundance	Pi	Pi*(ln(Pi))
1.	*Pontia Daplidice*	198	0.554621849	-0.326932249
2.	*Aglais cashmirensis*	23	0.06442577	-0.176671025
3.	*Argyreus hyperbius*	18	0.050420168	-0.150623396
4.	*Acraea issoria*	18	0.050420168	-0.150623396
5.	*Papilio protenor*	17	0.047619048	-0.144977259
6.	*Danaus genutia*	17	0.047619048	-0.144977259
7.	*Danaus chrysippus*	14	0.039215686	-0.127006998
8.	*Vanessa cardui*	12	0.033613445	-0.114044677
9.	*Parnara guttata*	11	0.030812325	-0.107221976
10.	*Euploea mulciber*	8	0.022408964	-0.085115837
11.	*Cethosia biblis*	7	0.019607843	-0.07709462
12.	*Zemeros flegyas*	7	0.019607843	-0.07709462
13.	*Issoria issaea*	5	0.014005602	-0.059780082
14.	*Papilio paris*	2	0.005602241	-0.029045314
	Total	**357**		**Σ Pi*(ln(Pi)) = -1.77120871**
				∴H = 1.77
				Evenness (J′) = 0.67

Grassland

S.N.	Name of the Species	Abundance	Pi	Pi*(ln(Pi))
1.	*Athyma cama*	30	0.206896552	-0.32597304
2.	*Ypthima similis*	25	0.172413793	-0.303078951
3.	*Abisara fylla*	19	0.131034483	-0.266300693
4.	*Terias hecabe*	17	0.117241379	-0.251309288
5.	*Parantica aglea*	17	0.117241379	-0.251309288
6.	*Catopsilia pyranthe*	11	0.075862069	-0.195636022
7.	*Colias fieldii*	8	0.055172414	-0.159850604
8.	*Heliophorus indicus*	6	0.04137931	-0.131792039
9.	*Lampides boetics*	6	0.04137931	-0.131792039
10.	*Dodona adonira*	6	0.04137931	-0.131792039
	Total	**145**		**Σ Pi*(ln(Pi)) = -2.148834003**
				H = 2.15
				Evenness (J′) = 0.92

Forest

S.N.	Name of the Species	Abundance	Pi	Pi*(ln(Pi))
1.	*Precis iphita*	45	0.298013245	-0.360780004
2.	*Lethe confusa*	41	0.271523179	-0.353986878
3.	*Melanitis leda*	11	0.072847682	-0.190816094
4.	*Ypthima baldus*	24	0.158940397	-0.292327312
5.	*Mycalesis perseus*	15	0.099337748	-0.229393672
6.	*Mycalesis fransisca*	10	0.066225166	-0.179781109
7.	*Neptis hylas*	5	0.033112583	-0.112842448
	Total	**151**		**Σ Pi*(ln(Pi)) = -1.719927518**
				H = 1.72
				Evenness (J′) = 0.89

Pre-monsoon

S.N.	Name of the Species	Abundance	Pi	Pi*(ln(Pi))
1.	*Aglais cashmirensis*	9	0.024	-0.089512835
2.	*Argyreus hyperbius*	7	0.018666667	-0.074312296
3.	*Precis iphita*	23	0.061333333	-0.171207818
4.	*Danaus chrysippus*	14	0.037333333	-0.122747098
5.	*Danaus genutia*	17	0.045333333	-0.140248308
6.	*Issoria issaea*	5	0.013333333	-0.057566508
7.	*Lampides boetics*	6	0.016	-0.066162665
8.	*Neptis hylas*	5	0.013333333	-0.057566508
9.	*Papilio protenor*	17	0.045333333	-0.140248308
10.	*Colias fieldii*	8	0.021333333	-0.082079669
11.	*Vanessa cardui*	12	0.032	-0.11014462
12.	*Pontia daplidice*	198	0.528	-0.33721195
13.	*Dodona adonira*	6	0.016	-0.066162665
14.	*Ypthima similis*	13	0.034666667	-0.116548525
15.	*Athyma cama*	17	0.045333333	-0.140248308
16.	*Acraea issoria*	18	0.048	-0.145754605
	Total	**375**		**Σ Pi*(ln(Pi)) = -1.917722686**
				H = 1.92
				Evenness (J′) = 0.69

Post-monsoon

S.N.	Name of the Species	Abundance	Pi	Pi*(ln(Pi))
1.	*Aglais cashmirensis*	14	0.050359712	-0.150503212
2.	*Argyreus hyperbius*	11	0.039568345	-0.127794907
3.	*Precis iphita*	22	0.079136691	-0.200736441
4.	*Catopsilia pyranthe*	11	0.039568345	-0.127794907
5.	*Cethosia biblis*	7	0.025179856	-0.092704952
6.	*Parantica aglea*	17	0.061151079	-0.170881051
7.	*Euploea mulciber*	8	0.028776978	-0.102105887
8.	*Heliophorus indicus*	6	0.021582734	-0.082788381
9.	*Lethe confusa*	41	0.147482014	-0.282287809
10.	*Parnara guttata*	11	0.039568345	-0.127794907
11.	*Athyma cama*	13	0.04676259	-0.143218463
12.	*Terias hecabe*	17	0.061151079	-0.170881051
13.	*Ypthima baldus*	24	0.086330935	-0.211473435
14.	*Melanitis leda*	11	0.039568345	-0.127794907
15.	*Mycalesis perseus*	15	0.053956835	-0.157530805
16.	*Papilio paris*	2	0.007194245	-0.035499812
17.	*Mycalesis fransisca*	10	0.035971223	-0.119605612
18.	*Zemeros flegyas*	7	0.025179856	-0.092704952
19.	*Ypthima similis*	12	0.043165468	-0.135656739
20.	*Abisara fylla*	19	0.068345324	-0.183382952
	Total	**278**		**Σ Pi*(ln(Pi)) = -2.84314118**
				H = 2.84
				Evenness (J′) = 0.95

Appendix IV: Some photos of recorded butterfly species.
Pre-monsoon season


Argyreus hyperbius


Colias fieldii


Danaus chrysippus


Papilio protenor


Danaus genutia


Issoria issaea


Vanessa cardui


Neptis hylas


Precis iphita


Pontia daplidice


Lampides boetics


Aglais cashmirensis


Dodona adonira


Athyma cama

Post-monsoon season

Euploea mulciber

Lethe confusa

Melanitis leda

Parantica aglea

Parnara guttata

Terias hecabe

Mycalesis perseus

Ypthima baldus

Abisara fylla

Papilio paris

Mycalesis fransisca

Zemeros flegyas

Catopsilia pyranthe

Heliophorus indicus