BUTTERFLIES DIVERSITY IN SHAMBHUNATH AREA OF SAPTARI DISTRICT, NEPAL

Submitted by

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A Thesis submitted

In partial fulfillment of the requirements for the award of degree of the master's of Science in zoology with special paper Entomology

Submitted To

Central Department of Zoology

Institute of Science and Technology

Tribhuvan University Kirtipur, Kathmandu

September, 2019

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.

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RECOMMENDATION

This is to recommend that the thesis entitled **"Butterflies Diversity in Shambhunath Area of Saptari District, Nepal"** has been carried out by Mr. Sanjay Kumar Sah for the partial fulfillment of Master's Degree of Science in Zoology with special paper Entomology. 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.

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LETTER OF APPROVAL

On the recommendation of supervisor "**Dr. Daya Ram Bhusal, Associate Professor, Central Department of Zoology, Tribhuvan University**" this thesis submitted by **Mr. Sanjay Kumar Sah** entitled **"BUTTERFLIES DIVERSITY IN SHAMBHUNATH ARAE OF SAPTARI DISTRICT, NEPAL"** is approved for the examination and submitted to the Tribhuvan University in partial fulfillment of the requirements for Master's Degree of Science in Zoology with special paper Entomology.

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CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Mr. Sanjay Kumar Sah. Entitled **"Butterflies Diversity in Shambhunath area of Saptari District, Nepal"** has been accepted as a partial fulfillment for the requirements of Master's Degree of Science in Zoology with special paper Entomology.

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LIST OF ABBREVIATION

Abbreviation form	Details of the abbreviation
et al	et alia
m	meter
NHM	Natural History Museum
S.N.	Serial Number
Sn.	Species richnes
T.U.	Tribhuvan University
VDC	Village Development Committee
viz.	Namely

ABSTRACT

The present study was conducted to explore the Butterflies Diversity in Shambhunath Area, Saptari, Nepal. The field work was carried from November 2018 to February 2019 in two different habitats viz. Non-cultivated and cultivated land. A total of 23 species belonging 19 genera under 8 families were identified. Nymphalidae and Pieridae were the most predominant families contributing 39.13% and 21.74% species respectively where as Satyridae, Nemeobidae, Amathusidae and Papilionidae were least families contributing 4.35% of each. Butterfly diversity was recorded higher in Non-cultivated land (H = 2.58) than the cultivated land (H = 2.06). Similarly, higher evenness was found in Non-cultivated land (J = 0.83) than cultivated land (J = 0.74). Highest butterfly diversity was recorded in February (H = 2.27) where as the least diversity was recorded in December (H = 1.96). Similarly, highest Evenness was recorded in November (J =0.87) where least Evenness was recorded in January (J = 0.73). Butterflies have higher diversity in Non-cultivated land probably due to higher heterogeneity than the cultivated land, probably due to monoculture cultivation, use of pesticides and other human activities. Further study is required to fully explore the butterfly fauna and their ecology in Shambhunath area.

1. INTRODUCTION

1.1 Background

Butterflies belong to the order Lepidoptera which are the most taxonomically studied group of insects (Mayur *et al.,* 2013; Sandufu and Dumbuya, 2008). They have always fascinated mankind from the time immemorial. The earliest known butterfly fossils are from mid Eocene epoch, in between 40-50 million years ago (Kocher, 2000). They are suitable for biodiversity studied and occupy the vital position in ecosystem (Kunte, 2000, Bourn, 2002). Insect comprises approximately half of the Earth's diversity (Fjellstad, 1998) and Lepidoptera is the most wide spread order of Insect in the world (Praveen, 2012). Butterfly evolution and diversification through geological time scale which are reflects overall plant diversity (Padhye *et al.,* 2006).

1.1.1 Diversity of butterfly

The estimated species of the butterflies has been reported to be 28000 throughout the world (Robbins and Opler, 1997). Butterfly species are reported to be 242 in Srilanka, and in India total no of species reported to be 1500 species (Gay *et al.,* 1992). In Himachal Pradesh various studies has been done on the butterflies diversities in various areas of the state by various workers as in Kullu and Kinnaur areas Gay (1992) recorded 75 species of butterflies, in Sirmour District by Arun (2008) recorded 118 species of butterflies, In Lower Shivalik Hills by Thakur and Bhardwa., (2012) recorded 40 species., In District Mandi (Balh valley) by Kumar (2014) recorded 40 species and in District Chamba by Singh and Banyal (2013) reported 49 species of butterflies. Total 660 species of butterflies under 263 genera are reported from Nepal (Smith, 2010). About 50%, 80% and 13% butterflies are found in Terai, Midland, and Highland ecological zone of Nepal respectively (Smith, 2011). And 643 species of butterflies reported in Nepal (Islam *et al.,* 2011).

Butterflies as pollinators

Butterflies are graceful insects provide economic and ecological benefits to the human society. (Simonson *et al.,* 2001; Hamer *et al.,* 2005; Chinaru and Joseph, 2011 and Arya *et al.,* 2014). They are good pollinator insects since they are active during day and visit a variety of flowers that helps in the pollination because they are nectar/pollen feeders of

both wild and cultivated plant species (Simonson *et al.,* 2001). 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 (Geiger *et al*., 2003).

Butterflies as an ecological indicator

Butterflies have been recognized as a useful biodiversity indicator group of insects (Lien *et al.,* 2003). They are highly sensitive to change in temperature, humidity, and light (Owen, 1971; Griffis *et al*., 2001; Sawchik *et al*., 2005). Since they can be used to detect, diagnose and summarize information about environmental problems (Kremen 1992). They exhibit interesting phenomena of mimicry and migration and seasonality (Kunte, 2000). Some of the researches have carried out study to examine the geographic range and landscape effects on the population dynamic and its habitat community structure (Collinge *et al.,* 2003). They are always used to monitor indication of climate change and environment degradation.

1.1.3 Threat of butterflies

The global decline of butterflies has been indicated by many researchers in different parts of the world due to habitat degradation, climate change, use of pesticide and deforestation (Murphy, D.D, 1990). Climate influences butterflies both directly and through impacts on their food plants and habitat (Weiss *et al.,* 1988). 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 introduce predators has also acerbated the relocation or the extinction of the butterfly species (Hill *et al.,* 2001, 2002; Parmesan, 2003). Some butterflies species 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 study the butterfly fauna in Shambhunath area of Saptari.

1.2.2 Specific objectives

a. To explore the butterfly diversity in Shambhunath Municipality.

b. To compare the butterfly diversity in Non-cultivated and cultivated land of study area.

c. To determine the monthly variation of butterfly in study area.

1.3 Rationale of the study

Being sensitive towards urbanization, pollution and habitat fragmentation, butterflies are facing the problem of extinction or relocation (Owen, 1971). So it is important to explore their diversity and status and factors influencing their distribution. It is also important to highlight the relationship of butterflies in different habitats. The Shambunath area has provided an environmental quality and habitat stability that contribute abundance of butterflies often an indication that an ecosystem is thriving. This study is an attempt to study the diversity and status of butterflies in order to help in their conservation and support future conservation strategy. The present analysis is revealing the habitat patterns in butterfly populations status, preference habitat effect and monthly variation.

1.3.1 Limitation of study

1. Only four months data was obtained.
2. Difficult to identify the fast flying species of butterfly through field observation.

2. LITERATURE REVIEW

Species diversity of butterflies

Many biologists have done great contribution in the field of butterflies' diversity to conserve threatened butterfly in 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). 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 threat by deforestation and habitat loss by the lack of implementation of conservation education and awareness programme. Suba (2005) recorded a total of 41 species of butterflies belonging to 31 genera and seven families from Gujurmukhi Village Development Committee, Illam, Nepal. Sharma (1962) studied lemon butterflies in Nepal.

Acharya and Vijayan (2015) studied butterflies of Sikkim along the elevation gradient and recorded decreasing species richness along the increase in elevation. Ghori and Senguptas (2014) studied altitudinal distribution of the Papilionidae butterfly in landscape of west Bengal, India and listed 26 Papilionidae species from 11 altitudinal belts. Castro and Espinosa, 2015 recorded the association of butterfly with ripe fruits and foliage. Kunte (2001) studied the diversity of butterfly around the Pune city and recorded 104 species of butterflies. Hamern *et al.* (2005) studied temporal variation in abundance and diversity of butterflies in Bornean rain forest. They found that the family Satyarinae has less restricted flying periods then did by the Nymphalidae. Khanal *et al.* (2012) ended an appreciated research on butterfly with respect to altitudinal rise at various pockets of Langtang National park, Central Nepal. They listed 126 species of butterfly and noted rich diversity at 1500m to 2900m elevation and decreasing diversity along with increasing altitudes. Two species of butterfly *Parnassiusharwickei* and *parnassiusepaphusepaphus* were found to be declining.

Khanal *et al.* (2013) made an intensive research on threatened butterflies of Central Nepal (Kathmandu, Lalitpur, and Bhaktpur district) in 2004, 2009 and 2011. They found that

four species of butterflies – *Teinopalpu simperialis, Papilo krishna, Meandrusalachinus* and *Euripus consimilis* are at high risk due to extreme harvesting of host plants, habitat degradation and fragmentation. Smith (1977b) completed a valuable survey of butterflies from eastern Nepal. He recorded 26 new species of butterflies from Nepal. Smith (1977c) studied butterflies from western Nepal and recorded 28 species. Ghimire (2001) surveyed on diversity of butterfly fauna at Chandradevi in Kirtipur Municipality, Kathmandu district and made a list of 43 species of butterfly belonging to nine families, among them family Nymphalidae was dominant. Khanal (2006) studied the late season butterflies of KoshiTapu wildlife reserve, Eastern Nepal and listed 54 species of butterflies belonging to seven families

Rodriguez and Baz (1995) studied effect of elevation on butterfly communities. They observe butterfly specimens on stations established in each 100m elevation gap from 1100-2000masl. They observe 2,123 individuals of 101 different butterfly species. They found that the abundance and species richness of butterfly was highest in low elevation and it decrease with increasing elevation. Mali *et al.*(2014) recorded 43 butterfly species belonging to five families during the study of biotic interrelationship of plants and butterflies in surrounding of Gandhinagar, Gujrat. The systematic study on butterflies had been carried out since 18th century (Heppner 1998). Smith (1981) published a book "Field duide to Nepals Butterflies" Where he listed 480 species of butterflies belonging to 200 genera under 11 families. Nepali and Khanal (1988) reported 26 species of butterflies under six families from Dolpa and Manang district of Nepal.

Khanal (1999) listed 71 species of butterflies spread over 50 genera and 8 families from Kanchanpur and Kailali district of Far western Nepal. He recorded Nymphalidae and lycanidae had the highest number of species diversity where Nemeobidae had the least number with single species. He also observed hundreds of *Catopsilapomama* (Family: pieridae) migrating to north-east side of Kanchanpur district. Khanal (2001) reported 114 species of butterflies under 9 families from Jhapa district, East Nepal. Among these butterflies he found, 27 species were rare, 11 were uncommon and remaining 76 species were common. He also focused on conservation of butterflies species.

Thapa (2008) recorded 43 species of butterflies from Kathmandu valley. Smith (2010) documented 660 species of butterfly including 263 genera in Nepal. Smith (2011a, 2011b, 2011c) published three guide books namely; Butterfly of Nepal, Butterfly of ACA and

Illustrated checklist of Nepal's butterflies. In these books he listed 278,347 and 600 species respectively.

Monthly variation of butterflies

The systematic study on butterfly has been carried out since 18th century (Happner, 1998). Bhusal and Khanal (2008) studied on the butterfly diversity at churiya range of eastern Nepal in (December-Junuary) and (March-April) months and recorded 40 species of butterflies under 28 genera and 8 families. Prajapati *et al*. (2000) studied seasonal and monthly variation of butterfly species in Daman area of Makawanpur district, Central Nepal. They recorded 65 species of butterflies belonging to 48 genera and 8 families with Nymphalidae and Lycaenidae as most common Acraeidae as least common. They concluded that the species richness was higher in autumn (September – October) than in spring (March - April) Khanal (2008) made a research on diversity and status of butterflies in lowland district of West Nepal. He was recorded 85 species of butterflies belonging to 65 genera and 10 families. Chapagai (2001) recorded 34 Species of butterflies belonging to 23 genera and seven families from KoshiTapuWildlife reserve during taxonomic survey in winter and spring.

Arya *et al.* (2014) studied species richness and diversity of butterflies in and around Kumaun University, Nainaital,Uttrakhand, India. He was recorded 897 individuals belonging to 27 species and 8 families. The pieridae family was dominant followed by Nymphalidae family. They noticed the higher diversity during rainy season followed by summer and winter. Ghosh and saha (2016) recorded higher butterfly diversity during post monsoon. Kumar (2012) studied on butterflies of Jhansi (U.P.) India and listed 27 species of butterflies belonging 5 families with Nymphalidae as dominant.Khanal (2006) listed late season butterflies of KoshiTappu, Wildlife Reserve where he found 54 species of butterflies under seven families.

Sengupta *et al.* 2014) made a valuable research on monthly variation of butterflies and their larval food plants in West Bengal, The maximum species richness and butterfly abundance in monsoon. Khan *et al. (2011*) studied diversity and distribution of butterflies from Kashmir Himalayan and listed 68 species of butterflies belonging to seven families and 38 genera with 36 new species to the region. Khanal (2006) listed late season butterflies of KoshiTappu Wildlife Reserve he found 54 species of butterfly under seven

families. Bhusal and Khanal (2008) study 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 8 families. Shrestha and Smith (1977) studied on different type of variation shown by Nepal's butterflies. They studied sexual dimorphism, regional variation and seasonal variation of butterflies in Nepal. 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 Lycanidas, two species Labytheids, 107 species hesperridas, 82 species Sartyrids and 15 species of Danaides.

Smith (1978) did research in the field of butterflies of Nepal. He listed 565 species of butterflies and publiished scientific list of Nepal's butterflies. Bhusal and Khanal (2008) studied seasonal and altitudinal diversity of butterfly in Eastern Siwalik Hills of Nepal and listed 40 species of butterfly belonging to eight families among them family Nymphalidae was most abundant and the family Hesperidae and Nemeobidae were least abundance. They also noticed increasing species richness of butterfly with upcoming warmer spring days. Gowada *et al.* (2011) studied seasonal diversity and status of butterfly in Lakkavalli range of Bhadra Wildlife sanctuary, Karnataka, India. They recorded 54 species of butterflies belonging to eight families. They found higher butterfly diversity in autumn season. 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.

Effect of habitat and climate on diversity of butterflies

The butterfly diversity in different habitat and stream sides has the greatest individual number, while 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 butterfly abundance. Tiple and Khurad (2009) studied on habitat diversity and reported 145 species of butterfly in the Nagpur city, India. Nymphalidae consist 51 species followed by pieridae 17 species and Lycaenidae 46 species. Ramesh *et al*. (2010) studies 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. Khanal *et al.* (2011) conducted distribution pattern of butterfly and documented 68 species of butterfly belonging 38 genera under seven families in South India.

Bhardwaj *et al*. (2012) studied butterfly communities along an elevation gradient in the Tons valley, Western India and recorded 79 butterfly species. They also found that the diversity was highest in heterogeneous habitats and decreased towards homogeneous habitats. Butterfly species richness and abundance were highly correlated with habitat, 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 109 genera under five families of which Nymphalidae and Lycaenidae were dominanat. Munyuli (2012) studied butterfly diversity from farmlands of Central Uganda and recorded 331 species belonging 95 genera under six families. He found higher butterfly diversity in forest. Roy *et al.* (2012) studied the butterfly diversity in three habitats that in cluded 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 Arunchal Pradesh, India. He documented the butterfly diversity was highest on forest followed by roadside plantation. Collinge *et al.* (2003) carried out on his research the butterfly diversity is significant due to the availability of host plant and well environmental condition. Simonson *et al.* (2001) made a research on rapid assessment of butterfly in a mountain landscape in Rocky mountain National park, Colorado (U.S.A.). They conclude that microclimate variation habitat complexity and open area enhance the butterfly diversity. Hawkins and Devries (1996) conducted a research on effect of altitude on body size of butterflies. While in my study area the butterfly diversity is not so significant due to unavailability of host plant and well environment condition. Thapa and Bhusal (2009) recorded 43 species of butterfly from Thankot and Syuchatar VDCs, Kathmandu. Also recorded most of butterfly species in bushes and forest habitat.

Chinaru and Joseph (2011) made a research on butterfly diversity in protected and Non-proteted habitats of OkwuOgbaku forest reserve in Mbaitoli L.G.A., Imo state, Nigeria. They recorded 28 species of butterflies and belonging to five families. Kumar *et al*. (2016) reported 29 species of butterflies belonging 22 genera and four families from sub alpine area of chanshal valley of Shimla where butterfly diversity was higher in autumn than summer due to host plant availability with suitable temperature and humidity. Fileccia *et al*. (2015) carried out a research work on seasonal patterns in butterfly

diversity in five characteristic habitats and noticed higher butterfly diversity in June and July. They recorded Nymphalids as abundant family.

Khanal *et al.* (2012) ended an appreciated research on butterfly with respect to altitudinal rise at various pockets of Langtang National park, Central Nepal. They listed 126 species of butterfly and noted rich diversity at 1500m to 2900m elevation and decreasing diversity along with increasing altitudes. Two species of butterfly Parnassiu sharwickei and parnassiu sepaphusepaphus were found to be declining. Similarly Khanal *et al.* (2013) made an intensive research on threatened butterflies of central Nepal (Kathmandu, Lalitpur, and Bhaktpur district) during 2004, 2009 and 2010-2011. They found that four species of butterflies – *Teinopalpusim perialis, papilo Krishna, Meandrusa lachinus and Euripus consimilis* are at high risk due to extreme harvesting of host plants, habitat degradation and fragmentation.

Smith (1994) published a book –Butterflies of Nepal (Central Himalaya) including 463 species with description of body size and their habitat status. Smith (1977a) recorded 8 new species of butterflies from Godavari, Lalitpur, Nepal and in 1978 listed 567 species of butterflyof Nepal. Pandey *et al*., (2017) made an extensive research in elevation distribution of butterflies in Himalayas, Lantang region and recorded 28 species of butterflies belonging five families. Thapa (2008) recorded 43 species of butterfies with Nymphalidae families as pre-dominant and Acreidae as least abundant family in Kathmandu valley. Shrestha (2016) carried out a detailed study of butterflies in 15 different sites of Manang district.

3. MATERIALS AND METHODS

3.1 Study Area

The present study was carried out from November 2018 to February 2019 in Shambhunath area of Saptari district. It lies from 61m to 610m asl. It is situated in tropical zone with temperature ranges between 24^0c to 26^0c and lies south to Mahindra high way. The study area consists of land with different features such as forest land, grassland, bush land and cultivated land which shows wide range of biodiversity. Floras of Shambhunath area are highly diversified where Fauna are least diversified. The study was conducted in two different habitat viz. Cultivated and Non-cultivated land. Non-cultivated land has heterogeneous flowering herbs where as cultivated land has monoculture crop like *Brassica campestris* during study period. The dominant plant species of the Non-cultivated land include *Solanum nigrum, Clerodendron* spp*, Lantana camera, Chromolaenao dorata, Parthenium physterophorus,Cynodon, Dioscorea* spp*, Xanthium strumarium* and cultivated land include *Brasica campestris, Solanum tuberosum, Pisum sativum, Zea mays, Coriandrum sativum, Solanum lycopersicum and Brasisica leracea.* Some of the fauna are Fox, wild cat, squirel, varities of snakes, frog, hylas, salamander, and other many more are present. Shambhunath area comprises tropical climate having great vegetation variation.

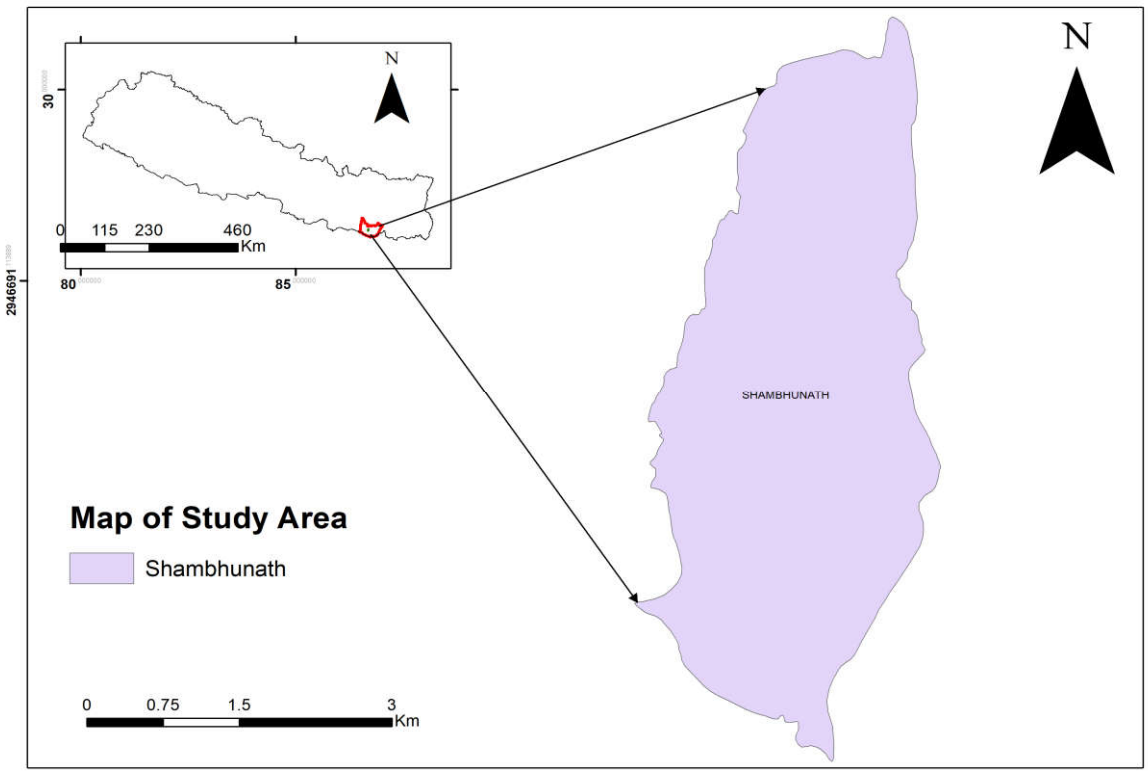

Figure 1. Map of the study area

3.2 Materials

(i) Field materials

a. Sweeping net

b. Field guide book and copy

c.. Triangular paper envelops

d. Air tight box with naphthalene balls

(ii) Lab materials

a. Entomological pin

b. Insect box

c. Hand lens

d. Checklist book of Nepal's butterflies

3.3 Methods

3.3.1 Collection, preservation and identification of butterflies

i. Collection of butterflies

Butterflies species were collected with sweeping net method (the net having telescope stick of one meter at the end of which is joined a metallic circle) from10 am. to 16 pm. under sunny days. The captured butterflies were collected in triangular paper and photographs were taken from different angles to provide a permanent record of identification and occurrence.

ii. Preservation of butterflies

The collected species were killed by thorax pinching. Temporary storage for butterflies species was done using triangle paper and was kept in a plastic box. After that species were kept in the air tight box with naphthalene balls for preserved in Central Department of Zoology, Tribhuvan University as Voucher specimens.

iii. Identification of butterflies

The collected specimens were identified using identification Keys (Smith, C. 1994) and also using literature (Smith, C. 1993), Confused specimens were reconfirmed by tallying the voucher specimens from Natural History Museum (NHM) Swayambhu, Kathmandu Nepal.

3.3.2 Sampling methods

The study was conducted in two different habitat viz. Cultivated and Non-cultivated land. Each habitat had been recorded from 10hr. to 16hr. Butterflies were sampled for four consecutive months from November to February. Each captured butterfly species were photographed from different angles as often as possible to obtain sufficient photographs to enable correct identification of species and were released. The unidentified butterfly species were kept in paper envelops and were kept in the box with naphthalene balls for preservation.

3.3.3 Data analysis

The data was analyzed by using MS - Excel and different statistical test such as Shannon-Wiener diversity index; Sorenson's Coefficient and pielous 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) = -∑pi * ln (Pi) Where,
Pi = the proportion (ni/N), ni is the individuals number of one particular species and
N is the total number of individuals N = ∑ni.
ln = the natural log
∑ = the sum of calculations
Pielou's evenness index (J): It is used to analyze the closeness of number of each species in an environment (Pielou, 1996).
J = H/Hmax where,
H = -∑ pi *ln (pi)
Hmax = ln (n), n is the total number of species richness.

Sorenson's coefficient: It is the statistical technique for comparing the similarity of species composition between two adjacent habitats (Sorenson's, 1948).

Sorensen's Coefficient (cc) =2C / (S1 + S2) Where,
C = number of common species in two habitats.
S1 = total number of species found in cultivated land
S2 = total number of species found in Non-cultivated land

4. RESULTS

4.1 Species diversity and status in the study area

A total of 649 individuals belonging to 23 species of butterflies under 19 genera and 8 families were recorded during the entire study period in which 9 species were found as very common, 9 species found as common and 5 species found as rare. *Danaus chrysippus* was the predominant species recorded throughout the sampling period in study area with 156 individual (Table 1).

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

Families	S.N	Scientific Name	Common Name	Frequency	Habitat	Local Status
Nymphalidae	1	*Aglais cashmirensis* (Kollar, 1844)	Indian Tortoiseshell	14	Nc C	**
	2	*Ariadne ariadne pallidor (*Linnaeus, 1763)	Angled caster	48	Nc C	***
	3	*Limenitis procris* (Crammer, 1777)	Commander	3	Nc	*
	4	*Neptis hylas (*Linnaeus, 1758)	Common sailer	2	C	*
	5	*Neptis soma (*Linnaeus, 1758)	Creamy sailer	1	Nc	*
	6	*Precis almanac (*Hubner 1819)	Peacock pansy	14	Nc C	**
	7	*Precis atlites atlites* (Fruhstorfer, 1912)	Grey pancy	108	Nc C	***
	8	*Precis lemonias* (Linnaeus, 1758)	Lemon pancy	6	Nc	**
	9	*Vanessa cardui* (Linnaeus, 1758)	Painted lady	5	Nc	**
Pieridae `	10	*Catopsilia pyranthe* (Linnaeus, 1758)	Motteled Emigrant	12	Nc	**
	11	*Ceporanerissa phryne* (Moore 1878)	Common Gull	4	Nc	*
	12	*Delias descombei* (Biosduval, 1836)	Red spot Jezebel	8	Nc C	**
	13	*Pieris canidia (*Sparrman ,1768)	Indian Cabbage white	45	Nc C	***
	14	*Terias hecabe* (Linnaeus, 1758)	Common grass yellow	85	Nc C	***
Danaidae	15	Danaus chrysippus (Linnaeus ,1758)	Plain Tiger	156	Nc C	***
	16	*Danaus plexippus* (Cramer, 1979)	Commin Tiger	25	Nc C	***

	17	*Euploea core core* (Crammer 1777)	Common Indian crow	4	Nc C	*
Lycaenidae	18	*Lampides boeticus* (Linnaeus, 1767)	Peablue	15	Nc C	***
	19	*Zizeeria maha maha* (Kollar, 1844)	Pale grass blue	14	Nc C	**
Satyridae	20	*Melanitis leda* (Linnaeus, 1758)	Common evening Brown	43	Nc C	***
Nemeobiidae	21	*Zemeros Flegyas* (Crammer, 1780)	Punchinello	6	Nc	**
Amathusiidae	22	*Discophora sondaicazeal* (Biosduval 1836)	Common Duffer	23	Nc	***
Papilionidae	23	*Papilio demoleus demoleus* (Linnaeus, 1758)	Lime Swallowtail	8	Nc C	**

Note, Nc: Non-cultivated land and

C: Cultivated land

*** = Very Common (<15) ** = Common (5-14) * = Rare (5<

4.1.2 Family composition of butterfly species

A total of 23 species of butterfly were recorded in study area. Nymphalidae was the most abundant family which contributes maximum number of species with (9) followed by Pieridae (5), Danaisae (3), Lycanidae (2), Satyridae, Nemeobidae, Amathusiae and Papilionidae each (1) species with least diversity (Table 2).

S.N.	families Of Butterfly	Species Number
1	Nymphalidae	9
2	Pieridae	5
3	Danaidae	3
4	Lycanidae	2
5	Satyridae	1
6	Nemeobidae	1
7	Amathusidae	1
8	Papilionidae	1

Table 2. Family composition of butterfly species recorded in study area.

4.2 Diversity of butterfly

A total of 649 individuals of 23 species of butterfly belonging to 19 genera under 8 families were recorded during study period. The recorded species were 3.48% of total known 660 species of butterfly in Nepal. Nymphalidae was the most abundant family with 39.13% followed by Pieridae (21.74%), Danaidae (13.04%), Lycaenidae (8.69%), Satyridae (4.35%), Nemeobiidae (4.35%), Amathusiidae (4.35%) and Papilionidae (4.35%). Hence, family Nymphalidae has high diversity where families Satyridae, Nemeobidae, Amathusiade and Papilionidae contribute least diversity in the study area (Figure 3) (Appendix V).

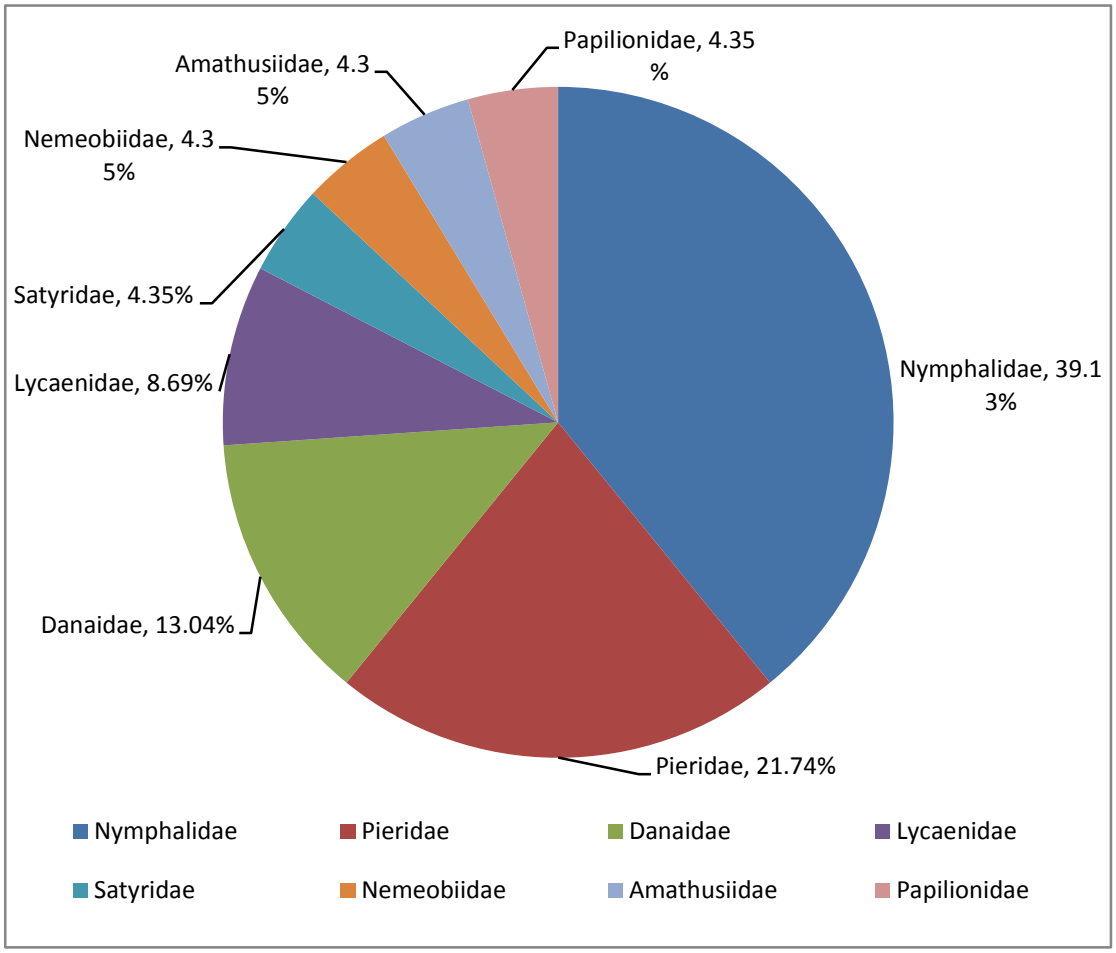

Figure 2.Family wise diversity of butterfly species recorded in the study area.

4.3 Butterfly diversity in different habitat

Among two different habitats Non-cultivated and Cultivated land, the diversity of butterfly was maximum in Non-cultivated land (2.58) followed by cultivated land (2.06) (Appendix III) (Table 3).

Habitats	Non-cultivated land	Cultivated land
Species richnes	22	15
Shannons Diversity index (H)	2.58	2.06
Evenness (J)	0.83	0.74

Table 3. Species richness, Shannon diversity index and Evenness study in different habitats

The highest evenness was found in Non-cultivated land (0.83) than Cultivated land (0.74) (AppendixIII). In Non-cultivated land *Danaus chrysippus* was recorded maximum number (84) and *Neptis soma* was recorded minimum number (1). Where as in cultivated land *Danaus chrysippus* was recorded maximum number (72) and *Neptis hylas* with minimum number (2) (Appendix I).

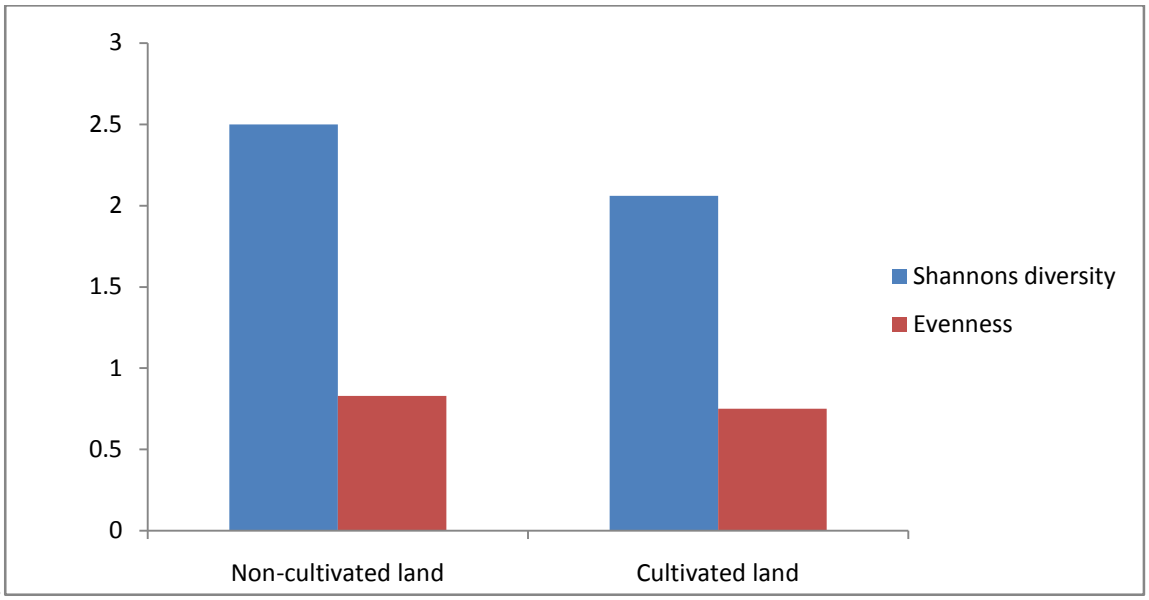

Figure 3.Shannons diversity index and Evenness in different habitat.

4.4 Monthly variation of butterfly species

The diversity of butterfly was maximum in February (2.27) followed by November (2.09), January (1.99) and December (1.96). Similarly, the highest Evenness was found in November (0.87) followed by February (0.84), December (0.79) and January (0.73) (Appendix V) (Table 4).

Months	November	December	January	February
Species richness	11	12	15	15
Shannon's diversity index	2.09	1.96	1.99	2.27
Evenness	0.87	0.79	0.73	0.84

Table 4. Species richness, Shannon's diversity index and Evenness in different months.

Among eight families of Butterfly species, families Nymphalidae, Pieridae and Danaidae were recorded in all the four months. Family Satyridae recorded in three months where family Lycanidae, Nemeobidae, Amathusidae and Papilionidae were recorded in only two months. *Danaus chrysippus* were found maximum number in all months (Appendix IV) out of 23 species (Figure 4).

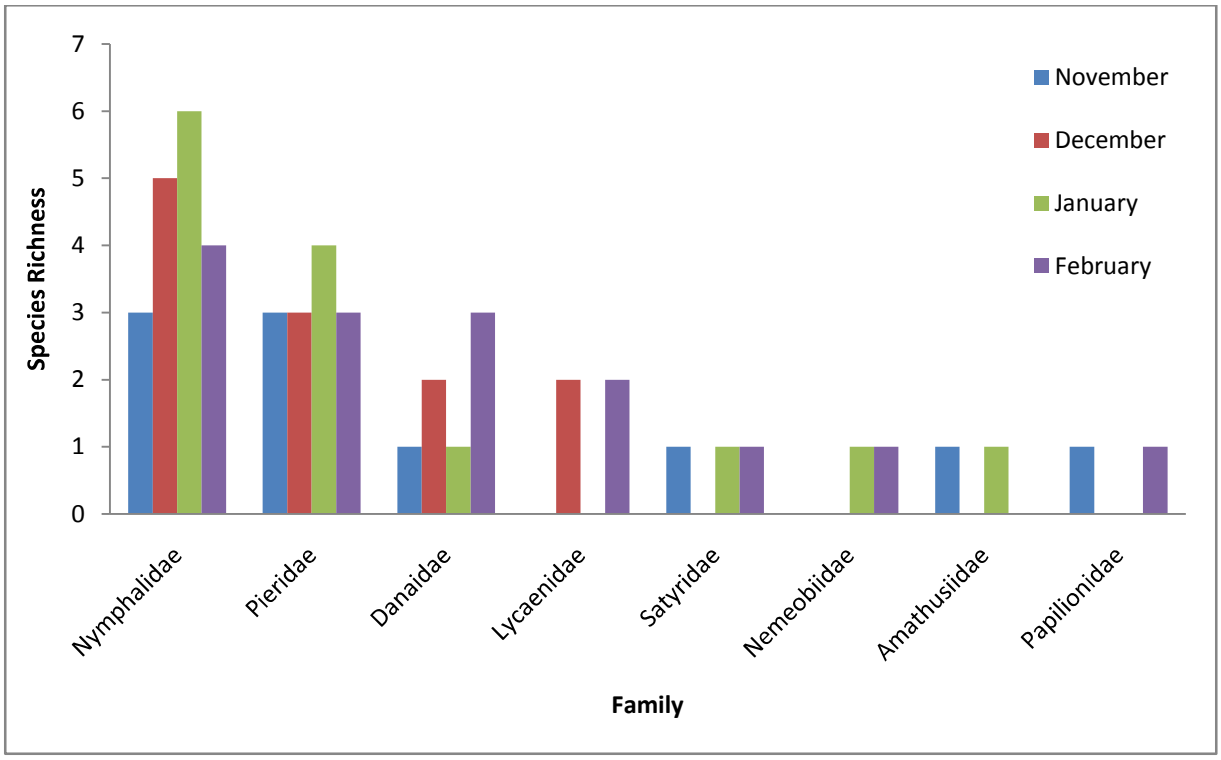

Figure 4. Monthly wise variation of butterfly species and family.

4.5 Species diversity and evenness study

The Shannon-Winner diversity index (*H*) was 2.4656 with Pielou's species evenness (*J*) 0.7864 (Appendix II).

The diversity of butterfly in relation to habitat was found highest in bush land i.e. *H*=2.58 than cultivated land i.e. *H*=2.06. Similarly, species evenness was higher in bush land (*J*=0.83) than cultivated land (*J*=0.74). The Sorenson's species similarity index *(CC)* for forest and cultivated land was 0.7568 (Appendix III). The diversity of butterfly in relation to months was found highest in February (2.27) followed by November (2.09), January (1.99) and December (1.96). Similarly, the highest Evenness was found in November (0.87) followed by February (0.84), December (0.79) and least diversity in January (0.73) (Appendix V).

5. DISCUSSION

5.1 Butterfly diversity and status

A total 23 species of butterflies were recorded. Nymphalidae family contributed the highest species number (39.13%) where as families Satyridae, Nemeobidae, Amathusidae and Papilionidae had the least species number (4.35% of each). Thapa and Bhusal (2009) had also reported the similar result that Nymphalidae and Satyridae contribute the highest and least species number respectively at Kathmandu valley. Bhusal and Khanal (2008) reported Nymphalidae family contributed the highest species number where as Hesperidae and Satyridae contribute least species number in the Eastern of Nepal which support the present study. It might be due to the similar temperature and habitat type. Chalise (2010) had also obtained similar result that Nemeobidae and Amathusidae family contributed the least species number. It might be due to the ecological adaptation.

Similarly, Kumar *et al.* (2016), Gajbe, (2016), Trivedi *et al*. (2013), Kunte (1997), Kunte *et al*. (1999), Soubadra and Priya (2001), Padhey *et al*. (2008) documented Nymphalidae as the most dominant family which might be due to the availability of their specific host plants (Saikia, 2014), their ecological adaptation and high dispersal ability (Alder *et al.,* 2014). Sundarraj *et al*., (2016) recorded Nymphalidae family contributed the highest diversity where as Hespiridae and Papilionidae contributed lowest diversity on Gudalur forest, India. This result also supports the present study might be due to the ecological adaptation and high dispersal ability (Alder *et al.,* 1996).

Shrestha (2016) also recorded Nymphalidae and Hespiridae contributed the highest butterfly species whereas Acraeidae and Satyridae contributed least in Morang district which supports the present study. It might be due to the same ecological adaptation. Khanal (1982, 1984) recorded 54 species of butterfly with Nymphalidae and Satyridae were the dominant family in the same region. Datta and Kalwani (2014) documented the highest butterfly diversity of Nymphalidae and Hespiridae families where Mukherjee *et al*. (2015) also documented highest butterfly diversity of family Nymphalidae followed by pieridae and least diversity was contributed by family Papilionidae which contradict with this present study.

5.2 Butterfly Diversity in different habitats

In the present study, the highest butterfly diversity was recorded in Non-cultivated land (2.58) and least in cultivated land (2.06). Lien and Yuan (2003) and Kitahara *et al*. (2008) had also recorded similar result that least butterfly diversity in cultivated land (agricultural habitat) than Non-cultivated land and forest habitat which support the present study. Fitzherbert *et al.,* (2006) recorded high butterfly diversity in Non-cultivated followed by bush land which contradict with present study. This study revealed that maximum butterfly species prefer Non-cultivated and bush land. Butterfly diversity in cultivated land is less than Non-cultivated land. It might be due to monoculture habitat (Bhardwaj *et al.,* 2012). Ramesh *et al*. (2010) documented cultivated land contributed least butterfly diversity than Non-cultivated land which supports the present study (Benton *et al*., 2003; Tscharntke *et al*., 2005; Ekroos *et al*. (2013) which contradict with present study. It might be due to the present of Heterogeneous plant species (bush plant) supports greater butterfly diversity.

Nectar feeding butterflies are highly vulnerable to cultivated land intensification (Rumdlof *et al*., 2007; Holzschuh *et al*., 2008; Batary *et al*., 2011) because their foraging success and survival are directly affected by pesticide and other chemicals (Henry *et at*., 2012). Low butterfly diversity in cultivated land than grassland might due to the use of cultivated chemicals (Geiger *et al.*, 2010). Munyuli (2012) and Lien (2009) documented high butterfly diversity and stream side forest respectively whereas Roy *et al*.(2012) recorded high butterfly diversity in Non-cultivated land which contribute the present study might be due to the availability of heterogeneous host plant species (Price, 1975).

Butterfly evenness was recorded maximum in Non-cultivated land (0.83) and least in cultivated land (0.74) Abundance of butterfly species is found in Non-cultivated land but *Danaus chrysippus* was found maximum abundance in both habitat. It might be presence of abundant host plant of Asteraceae and Brassicae family in Non-cultivated and cultivated land respectively (John *et al.*, 2008). High diversity of butterfly in Non-cultivated (bush) land might due to the presence of flowering herbs and high exposure of sunlight where as low butterfly diversity in cultivated land could be due to monoculture crop and non-availability of host plant species (Benton *et al.,* 2003).

5.3 Monthly variation of butterfly species

In the present studuy, *Precies atlites atlites,Terias hecabe, Danuaus chrysippus* and *Zizeeria maha maha* were reorded across the months and high diversity of butterfly was recorded during February and lowest in November. Ghosh and Saha (2016) reported similar results that November contribute the least species number which support the present study might be due to the similar temperature. Sengupta *et al*. (2014) documented least butterfly diversity in February that contradicts with present study. Bhusal and Khanal (2008) had also recorded high butterfly diversity in March than February which support the present study. It might be due to the nectar rich plant species (Saikia, 2014). Saikia (2014) also obtained the lowest species diversity during the February and March. Similarly, Singh (2012) has also recorded lowest diversity during the January and February in Sunkoshi River where as Singh (2010) had reported highest diversity during the December and January which is contradicted the present study.

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6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

From the present study following conclusions were derived:

- The butterfly of the families Nymphalidae and Pieridae were most dominant species reported and families Satyridae, Nemeobidae, Amathusidae and Papilionidae were contribute least number of species during study period which may be attributed to the climatic condition.

- Butterflies have higher diversity in Non-cultivated land probably due to higher heterogeneity plant habitat. Similarly in the cultivated land low diversity probably due to monoculture cultivation, use of pesticides and other type of human activities.

6.2 Recommendations

- Further research should be conducted to cover more season and habitats to find detailed butterfly status in study area.

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APPENDICES

Appendix I: Frequency of butterfly species recorded in study area.

Scientific name	Common name	Frequency in Different Habitat	
		Non-cultivated land	Cultivated land
Aglais cashmirensis	Indian Tortoiseshell	8	6
Ariadne ariadne pallidor	Angled caster	45	3
Limenitis procris	Commander	3	
Neptis hylas	Common sailer		2
Neptis soma	Creamy sailer	1	
Precis almanac	Peacock pansy	8	6
Precis atlites atlites	Grey pancy	43	65
Precis lemonias	Lemon pancy	6	
Vanessa cardui	Painted lady	5	
Catopsilia pyranthe	Motteled Emigrant	12	
Cepora nerissa phryne	Common Gull	4	
Delias descombesi	Red spot Jezebel	5	3
Pieris canidia	Indian Cabbage white	20	25
Terias hecabe	Common grass yellow	33	52
Danaus chrysippus	Plain Tiger	84	72
Danaus plexippus	Common Tiger	17	8
Euploea core core	Common Indian crow	1	3
Lampides boeticus	Pea blue	9	6
Zuzeeria maha maha	Pale grass blue	6	8
Melanitis leda	Common evening Brown	28	15
Zemeros flegyas	Punchinello	6	
Discophora sondaicazal	Common Duffer	23	
Papiliodemoleus demoleus	Line Swallow tail	5	3
Total		372	277

Appendix II: Calculation of shannon- winner diversity index (H) and pielou's species evenness(J) in study area.

S.N.	Scientific Name	Common Name	Abundance	Pi	Ln(Pi)	Pi × Ln(Pi)
1.	*Aglais cashmirensis*	Indian Tortoiseshell	14	0.021572	-3.83638	-0.08276
2.	*Ariadne ariadne pallidor*	Angled Castor	48	0.07396	-2.60423	-0.19261
3.	*Limenitis procris*	Commander	3	0.004622	-5.37682	-0.02485
4.	*Neptis hylas*	CommonSailer	2	0.003082	-5.78229	-0.01782
5.	*Neptis soma*	Creamy Sailer	1	0.001541	-6.47543	-0.00998
6.	*Precis almanac*	PecockPancy	14	0.021572	-3.83638	-0.08276
7.	*Precis atlites atlites*	Grey Pancy	108	0.16641	-1.7933	-0.29842
8.	*Precis lemonias*	Lemon Pancy	6	0.009245	-4.68367	-0.0433
9.	*Vanessa cardui*	Painted Lady	5	0.007704	-4.86599	-0.03749
10.	*Catopsilia pyranthe*	Mottled Emigrant	12	0.01849	-3.99053	-0.07378
11.	*Cepora nerissa phryne*	Common Gull	4	0.006163	-5.08914	-0.03137
12.	*Delias descombesi*	Red-spot Jezebel	8	0.012327	-4.39599	-0.05419
13.	*Pieris canidia*	Indian Cabbage White	45	0.069337	-2.66877	-0.18505
14.	*Terias hecabe*	Common Grass Yellow	85	0.130971	-2.03278	-0.26623
15.	*Danaus chrysippus*	Plain Tiger	156	0.24037	-1.42558	-0.34267
16.	*Danaus plexippus*	Common Tiger	25	0.038521	-3.25656	-0.12545
17.	*Euploea core core*	Common Indian Crow	4	0.006163	-5.08914	-0.03137
18.	*Lampides boeticus*	Pea blue	15	0.023112	-3.76738	-0.08707
19.	*Zuzeeria maha maha*	Pale Grass Blue	14	0.021572	-3.83638	-0.08276
20.	*Melanitis leda*	Common Evening Brown	43	0.066256	-2.71423	-0.17983
21.	*Zemeros flegyas*	Punchinello	6	0.009245	-4.68367	-0.0433
22.	*Discophora sondaicazal*	Common Duffer	23	0.035439	-3.33994	-0.11836
23.	*Papiliodemoleus demoleus*	Lime Swallowtail	8	0.012327	-4.39599	-0.05419
	Total		649			-2.4656
H = -Σ Pi × ln(Pi) = 2.4656 And J = H/Hmax = 0.78635						
Shannon wienner diversity index (H) = 2.4656 **Pielou's species evenness (J) = 0.786351**						

Appendix III: Calculation of Shannon Winner diversity Index, Pielou's species evenness and similarity index in different habitats

Scientific Name	Non-cultivated land			
	Abundance	**Pi**	**ln(Pi)**	**Pi × ln(Pi)**
Aglais cashmirensis	8	0.021505376	-3.839452313	-0.082568867
Ariadne ariadne pallidor	45	0.120967742	-2.112231365	-0.255511859
Limenitis procris	3	0.008064516	-4.820281566	-0.038873238
Neptis hylas				
Neptis soma	1	0.002688172	-5.918893854	-0.015911005
Precis almanac	8	0.021505376	-3.839452313	-0.082568867
Precis atlites atlites	43	0.115591398	-2.157693739	-0.249410835
Precis lemonias	6	0.016129032	-4.127134385	-0.066566684
Vanessa cardui	5	0.01344086	-4.309455942	-0.057922795
Catopsilia pyranthe	12	0.032258065	-3.433987204	-0.110773781
Cepora nerissa phryne	4	0.010752688	-4.532599493	-0.048737629
Delias descombesi	5	0.01344086	-4.309455942	-0.057922795
Pieris canidia	20	0.053763441	-2.923161581	-0.157159225
Terias hecabe	33	0.088709677	-2.422386293	-0.214889107
Danaus chrysippus	84	0.225806452	-1.488077055	-0.3360174
Danaus plexippus	17	0.045698925	-3.08568051	-0.141012281
Euploea core core	1	0.002688172	-5.918893854	-0.015911005
Lampides boeticus	9	0.024193548	-3.721669277	-0.090040386
Zuzeeria maha maha	6	0.016129032	-4.127134385	-0.066566684
Melanitis leda	28	0.075268817	-2.586689344	-0.194697047
Zemeros flegyas	6	0.016129032	-4.127134385	-0.066566684
Discophora sondaicazal	23	0.061827957	-2.783399638	-0.172091913
Papiliodemoleus demoleus	5	0.01344086	-4.309455942	-0.057922795
Total	372			-2.57964288
	H= ∑Pi* (ln(Pi)			**H= 2.5794**
	J = H/Hmax			**J=,0.8345**
)	**CC = 2C/ (S_1+S_2**			

Scientific Name	Cultivated land			
	Abundance	**Pi**	**ln(Pi)**	**Pi* (ln(Pi)**
Aglais cashmirensis	6	0.021661	-3.83226	-0.08301
Ariadne ariadne pallidor	3	0.01083	-4.52541	-0.04901
Limenitis procris				
Neptis hylas	2	0.00722	-4.93087	-0.0356
Neptis soma				
Precis almanac	6	0.021661	-3.83226	-0.08301
Precis atlites atlites	65	0.234657	-1.44963	-0.34017
Precis lemonias				
Vanessa cardui				
Catopsilia pyranthe				
Cepora nerissa phryne				
Delias descombesi	3	0.01083	-4.52541	-0.04901
Pieris canidia	25	0.090253	-2.40514	-0.21707
Terias hecabe	52	0.187726	-1.67277	-0.31402
Danaus chrysippus	72	0.259928	-1.34735	-0.35021
Danaus plexippus	8	0.028881	-3.54458	-0.10237
Euploea core core	3	0.01083	-4.52541	-0.04901
Lampides boeticus	6	0.021661	-3.83226	-0.08301
Zuzeeria maha maha	8	0.028881	-3.54458	-0.10237
Melanitis leda	15	0.054152	-2.91597	-0.1579
Zemeros flegyas				
Discophora sondaicazal				
Papiliodemoleus demoleus	3	0.01083	-4.52541	-0.04901
Total	277			-2.06479428
	Diversity index (H) = ∑Pi *(ln(Pi) = -2.06479428 **H = 2.06** **Evenness (J) = H/max = -0.76255 = 0.76**			
Sorenson's coefficient (CC) = 2c/(S1+S2) = 0.76				

Appendix IV: Monthly variation of butterfly species

S.N.	Scientific Name	Species recorded in months			
		November	December	January	February
1	*Aglais cashmirensis*	5	6	-	3
2	*Ariadne ariadne pallidor*	-	17	13	18
3	*Limenitis procris*	-	-	3	-
4	*Neptis hylas*	-	-	2	-
5	*Neptis soma*	-	-	1	-
6	*Precis almanac*	8	6	-	-
7	*Precis atlites atlites*	25	18	30	35
8	*Precis lemonias*	-	4		2
9	*Vanessa cardui*	-	-	5	-
10	*Catopsilia pyranthe*	2	4	3	3
11	*Cepora nerissa phryne*	-	4	-	-
12	*Delias descombesi*	-	-	8	-
13	*Pieris canidia*	15	-	19	11
14	*Terias hecabe*	21	20	22	22
15	*Danaus chrysippus*	40	29	38	49
16	*Danaus plexippus*	-	15	-	10
17	*Euploea core core*	-	-	-	4
18	*Lampides boeticus*	-	9	-	6
19	*Zuzeeria maha maha*	2	1	5	6
20	*Melanitis leda*	15	-	12	16
21	*Zemeros flegyas*	-	-	2	4
22	*Discophora sondaicazal*	14	-	9	
23	*Papiliodemoleus demoleus*	5	-	-	3
	Total	152	133	172	192

Appendix V: Family wise diversity of butterfly species

S.N.	Families Of Butterfly	Species Number	Diversity (%)
1	Nymphalidae	9	9/23×100 = 39.13
2	Pieridae	5	5/23×100 = 21.73
3	Danaidae	3	3/23×100 = 13.04
4	Lycanidae	2	2/23×100 = 8.69
5	Satyridae	1	1/23×100 = 4.34
6	Nemeobidae	1	1/23×100 = 4.34
7	Amathusidae	1	1/23×100 = 4.34
8	Papilionidae	1	1/23×100 = 4.34

Appendix VI: Shannon's diversity index and Pielous Evenness calculation.

November Month

S.N.	Name of the species	Abundance	Pi	lnPi	Pi× (ln(Pi))
1	*Aglais cashmirensis*	5	0.0328947368	-3.4144426097	-0.112317191
2	*Precis almonac*	8	0.0526315789	-2.9444389801	-0.1549704725
3	*Precis atlites atlites*	25	0.1644736842	-1.805004696	-0.2968757724
4	*Catopsilia pyranthe*	2	0.0131578947	-4.3307333431	-0.0569833333
5	*Pieris canida*	15	0.0986842105	-2.31583032	-0.2285358868
6	*Terias hecabe*	21	0.1381578947	-1.9793580834	-0.2734639457
7	*Danaus chrysippus*	40	0.2631578947	-- 1.3350010669	-0.3513160702
8	*Zizeera maha maha*	2	0.0131578947	-4.3307333431	-0.0569833333
9	*Melanitis leda*	15	0.0986842105	-2.31583032	-0.2285358868
10	*Discophora sondaicazeal*	14	0.0921052632	-2.3848231906	-0.2196547677
11	*Papilo demoleus demoleus*	5	0.0328947368	-3.4144426097	-0.112317191
	Total	**152**			**∑Pi * (ln(Pi) = -2.0919538507** **H= 2.09**
					Evenness (J) = 0.87

December Month

S.N.	Name of the Species	Abundance	Pi	lnPi	Pi * (ln(Pi)
1	*Aglais cashmirensis*	6	0.045112782	-3.098589658	-0.1397859997
2	*Ariadne ariadne pallidor*	17	0.1278195489	-2.0571357839	-0.2629421679
3	*Precis almonac*	6	0.045112782	-3.098589658	-0.1397859997
4	*Precis atlites atlites*	18	0.1353383459	-1.9999773701	-0.270673629
5	*Precis lemonias*	4	0.030075188	-3.5040547661	-0.1053851059
6	*Catopsilia pyranthe*	4	0.030075188	-3.5040547661	-0.1053851059
7	*Cepora nerisa phryne*	4	0.030075188	-3.5040547661	-0.1053851059
8	*Terias hecab*	20	0.1503759398	-1.894616855	-0.2849047901
9	*Danaus chrysippus*	29	0.2180451128	-1.5230532982	-0.3320943282
10	*Danaus plexippus*	15	0.1127819549	-2.182298927	-0.2461239392
11	*Lampides boeticus*	9	0.067661729	-2.6931245514	-0.1822214636
12	*Zizeera maha maha*	1	0.007518797	-4.8903491272	-0.0367695423
	Total	**133**			**∑Pi * (ln(Pi) = 1.9653332382** **H = 1.96**
					Evenness (J) = 0.79

January Month

S.N.	Name of the species	Abundance	Pi	lnPi	Pi * (ln(Pi)
1	*Ariadne ariadne pallidor*	13	0.0755813953	-2.58254512	-0.1951923636
2	*Limenitis procris*	3	0.0174418605	-4.0488821861	-0.0706200383
3	*Neptis hylas*	2	0.011627907	-4.4543472943	-0.051794736
4	*Neptis soma*	1	0.0058139535	-5.1474944748	-0.0299272935
5	*Precris atlites atlites*	30	0.1744186047	-1,7462970949	-0.3045867027
6	*Vanessa cardui*	5	0.0290697674	-3.5380565658	-0.1028504814
7	*Catopsilia pyranthe*	3	0.0174418605	-4.0488821861	-0.0706200383
8	*Delias descombesi*	8	0.0465116279	-3.0680529353	-0.1427001365
9	*Pieris canida*	19	0.1104651163	-2.2030554975	-0.2433607817
10	*Terias hecabe*	22	0.1279069767	-2.0564520238	-0.2630345611
11	*Danaus chrysippus*	38	0.2209302326	-1.5099083169	-0.3335843957
12	*Zizeera maha maha*	5	0.0290697674	-3.5380565658	-0.1028504814
13	*Melanitis leda*	12	0.0697674419	-2.6625878265	-0.1857619415
14	*Zemeros flegyas*	2	0.011627907	-4.4543472943	-0.051794736
15	*Discophora sondaicazeal*	9	0.0523255814	-2.9502698994	-0.1543745878
	Total	**172**			**∑Pi * (ln(Pi) = 1.9943040999** **H= 1.99**
					Evenness (J)= 0.737037037 **J = 0.73**

February Month

S.N.	Name of the species	Abundance	Pi	lnPi	Pi *(ln(Pi)
1	*Aglais cashmirensis*	3	0.015625	-4.1588830834	-0.0649825482
2	*Ariadne ariadne pallidor*	18	0.09375	-2.3671236141	-0.2219178388
3	*Precis atlites atlites*	35	0.1822916667	-1.7021473104	-0.3102872702
4	*Precis lemonias*	2	0.0104166667	-4.5643481883	-0.0475452938
5	*Catop silia pyranthe*	3	0.015625	-4.1588830834	-0.0649825482
6	*Pieris canida*	11	0.0572916667	-2.8596000986	-0.1638312557
7	*Terias hecabe*	22	0.1145833333	-2.166452919	-0.2482393969
8	*Danaus chrysippus*	49	0.2552083333	-1.365675074	0.3485316595
9	*Danaus plexippus*	10	0.0520833333	-2.9549102797	0.153901577
10	*Euploea core core*	4	0.0208333333	-3.8712010125	0.080650021
11	*Lampedes boeticus*	6	0.03125	-3.4657359028	-0.108304247
12	*Zizeera maha maha*	6	0.03125	-3.4657359028	-0.108304247
13	*Melaniyis leda*	16	0.0833333333	-2.4849066502	-0.2070755541
14	*Zemeros flegyas*	4	0.0208333333	-3.8712010125	0.080650021
15	*papilo demoleus demoleus*	3	0.015625	-4.1588830834	-0.0649825482
	Total	**192**			**∑Pi *(ln(Pi) = 2.2741860266** **H = 2.27**
					Evenness (J) = 0.8397872483 **J = 0.84**

Appendix VII: Butterfly species with their host plant species

Scientific name	Family	Host plant	
		Non-cultivated land	Cultivated land
Aglais cashmirensis	Nymphalidae	*Clerodendron sp.*	*Solaum tuberosum*
Ariadne ariadne pallidor	Nymphalidae	*Chromolaenao dorata*	*Brasica campestris*
Limeniti sprocris	Nymphalidae	*lantana camera*	
Neptis hylas	Nymphalidae		*Cucurbita spp.*
Neptis soma	Nymphalidae	*Dioscorea sp.*	
Precis almanac	Nymphalidae	*Clerodendron sp.*	*Zea mays*
Precis atlites atlites	Nymphalidae	*Clerodendron sp.*	*Brasica campestris*
Precislemonias	Nymphalidae	*Xanthium strumarium*	
Vanessa cardui	Nymphalidae	*Solanumnigrum*	
Catopsilia pyranthe	Pieridae	*Canna edulis*	
Ceporanerissa phryne	Pieridae	*Bidenspilosa*	
Delias descombesi	Pieridae	*Mirabilis jalapa*	*Solanum tuberosum*
Pieris canidia	Pieridae	*Clerodendron sp.*	*Brasica campestris*
Terias hecabe	Pieridae	*Chromolaenao dorata*	*Brasica campestris*
Danaus chrysippus	Danaidae	*Lantana camera*	*Brasica campestris*
Danaus plexippus	Danaidae	*Mirabilis jalapa*	*Pisum sativum*
Euploea core core	Danaidae	*Dioscorea sp.*	*Raphanus sativus*
Lampides boeticus	Lycaenidae	*Clerodendron sp.*	*Pisum sativum*
Zuzeeriamahamaha	Lycaenidae	*un known*	*Brasica campestris*
Melanitis leda	Satyridae	*Clerodendron sp.*	*Brasica campestris*
Zemeros flegyas	Nemeobiidae	*Chromolaenao dorata*	
Discophora sondaicazal	Amathusiidae	*Mirabilis jalapa*	
Papiliodemoleusdemoleus	Papilionidae	*un known*	*Pisum sativum*

Appendix VIII: Host plant species reported in study area
Non-cultivated land

S.N.	Scientific name	Family
1	*Xanthium strumarium*	Asteraceae
2	*Solanumnigrum*	Solanaceae
3	*Dioscorea spp.*	Discoreaceae
4	*Coriarianepalensis*	Coriariaceae
5	*Clerodendron spp.*	Lamiaceae
6	*Mirabilis jalapa*	Nyctaginaceae
7	*Clerodendron spp.*	Lamiaceae
8	*Dendrocalamus hamiltonii*	Poaceae
9	*Cynodon*	grass family
11	*Chromolaenao dorata*	Asteraceae
12		
13	*Ricinus communis*	Euphorbiaceae
14	*Artemesiaindica*	Asteraceae
15	*Parthenium physterophorus*	Asteraceae
16	*Bidenspilosa*	Asteraceae
17	*Lantana camera*	Asteraceae
18	*Tagates spp.*	Asteraceae
19	*Lantana camera*	Asteraceae
20	*Meliaazedarach*	Meliaceae
21	*Artemesia vulgaris*	Asteraceae
22		
23	*Ageratinaa denophora*	Asteraceae
24	*Canna edulis*	Cannaceae

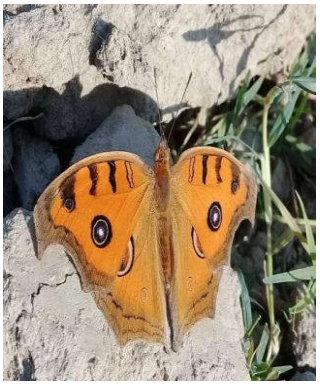
Cultivated land

S.N.	Com. Name	Scientific name	Family
1	Maize	*Zea mays*	Poaceae
2	Potato	*Solanum tuberosum*	Solanaceae
3	Mustard	*Brasica campestris*	Brassicaceae
4	Pea	*Pisum sativum*	Fabaceae
5	Carrot	*Daucus corota*	Apiaceae
6	Pumpkin	*Cucurbita spp.*	Cucurbitaceae
7	Onion	*Allium cepa*	Amaryllidaceae
8	Raddish	*Raphanus sativus*	Brassicaceae
9	Corriender	*Coriandrum sativum*	Apiaceae
10	Tomato	*Solanumly copersicum*	Solanaceae
11	Cabbage	*Brassica oleracea*	Brassicaceae
12	Cauliflower	*Brassica oleraceavar.botrytis*	Brassicaceae

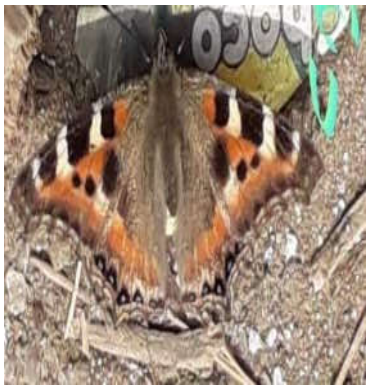
PHOTO PALATES

Photos of butterflies recorded during field period

Terias hecabe



Precies almanac



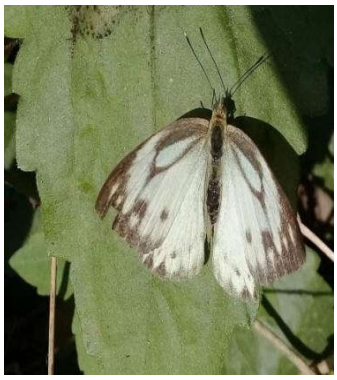
Aglais cashmirensis

Zemeros flegyyas

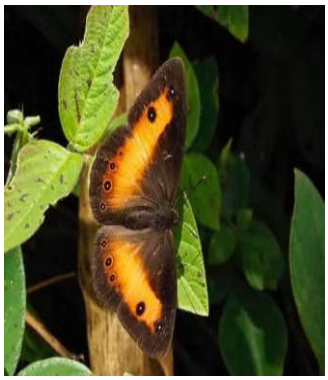
Zizeeria maha maha

Melanitis leda

Catopsilia pyranthe

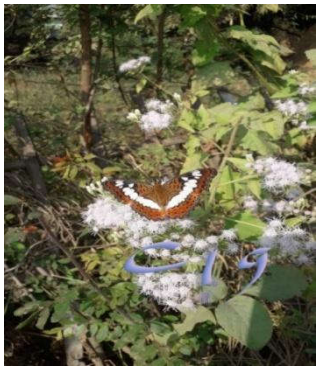


Danus plexippus



Precies lemonias

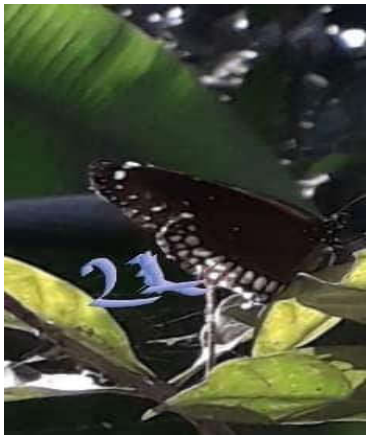
Vanesa cardui



Limenities procris

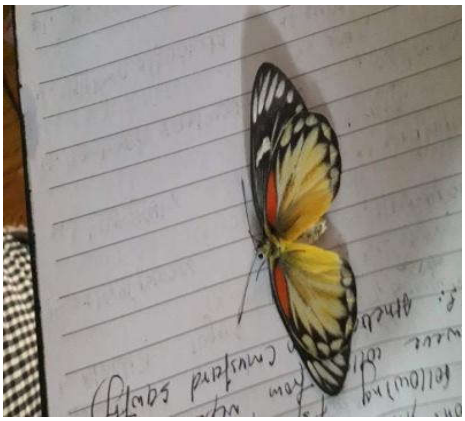
Pieris canida

Précis almanac



Euploea core core

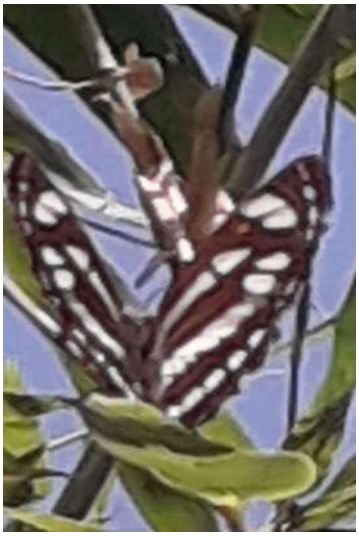
Neptis hylas



Delias descombesi

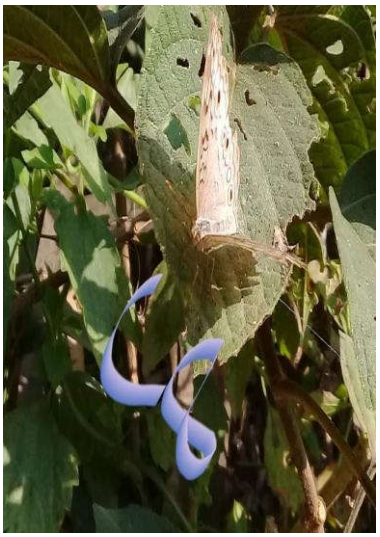
Danus chrysippus

Lampedes boeticus

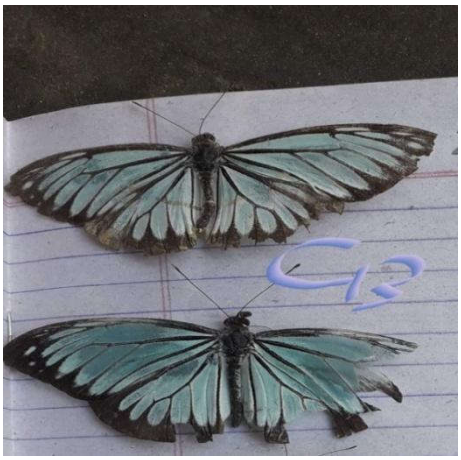


Neptis soma

Discophora sondaicazel



Precies atlites atlites



Ceporanerisa phryne moore

Ariadne ariadne pallidor

Comparing the captured butterfly with the photo palates of field guide book

Conservation threats of butterflies habitats observed during study period