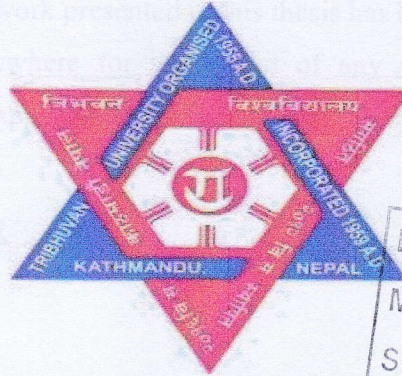


SEASONAL VARIATION OF BUTTERFLY DIVERSITY IN KIRTIPUR,  
KATHMANDU, NEPAL



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Submitted to

Central Department of Zoology  
Institute of Science and Technology  
Tribhuvan University, Kirtipur  
Kathmandu, Nepal

April, 2023

## 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 and institutions.

Date... 12 03 2023



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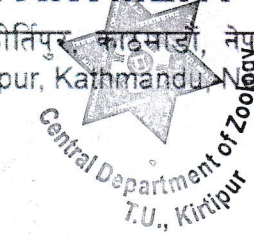
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**RECOMMENDATION**

This is to recommend that the thesis entitled "**Seasonal variation of butterfly diversity in Kirtipur, Kathmandu, Nepal**" has been carried out by Mr. Aashish Prasad Bhatta for partial fulfillment of Master's Degree of science in Zoology with special paper Ecology. This is her original work and has been carried out under my supervision. To the best of my knowledge, this work has not been submitted for any other degree in any institutions.

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**CERTIFICATE OF ACCEPTANCE**

This thesis work submitted by Mr. Aashish Prasad Bhatta entitled “**Seasonal variation of butterfly diversity in Kirtipur, Kathmandu, Nepal**” has been accepted as a partial fulfillment for the requirement of Master’s Degree of Science in Zoology with special paper Ecology.

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Aashish Prasad Bhatta

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## LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
ANOVA	Analysis of variance
m	Meter
T.U	Tribhuvan University
AG	Agricultural land
F	Forest
D <sub>mg</sub>	Margalef's Index

## ABSTRACT

The study was conducted in Tribhuvan University premises to analyze the seasonal variation of butterflies. 100m × 100m plots were made for the collection of butterflies during rainy and autumn season of 2019. A total of 58 species of butterfly belonging to 45 genera under nine families were recorded. The highest species richness was found for family Nymphalidae. The higher butterfly richness was found during rainy season than autumn. Rainy season had high butterfly diversity but the distribution of species was more even in autumn than rainy season. *Zizeeria maha* was the abundant species. Butterfly species was more diverse in forest habitat than agricultural land. Although, species richness of butterfly was higher in rainy season than autumn, one way ANOVA (Fstat= 0.67, P>0.05) showed no significant variation in species richness between rainy and autumn. *Colias erate* visits frequently on invasive *Lantana camara* while *Cupha erymanthis* visits less frequently. The study showed high species richness in the region, therefore research should be conducted in all seasons.

# 1. INTRODUCTION

## 1.1 Background

Butterflies are taxonomically and ecologically well studied groups among all insects (Thomas and Mallorie 2005). Lepidoptera is the most common order of insect in the world (Perveen 2012). According to Poel et al. (2020), there are around 20,000 species of butterflies in the world. Evolution and diversification of butterfly through geological time scale reflects overall plant diversity (Padhye et al. 2006). They are good indicators of environmental changes (Lee et al. 2014) which carry aesthetic and commercial values (Ahsan and Javed 1975). Since 1826 A.D. research on butterfly was started in Nepal (Khanal and Smith 1997). Nepal is home to 672 species under 263 genera (K.C. 2020; Sapkota et al. 2020). Ecologically, butterflies distribution of Nepal comprise 55%, 65% and 10% of known species in Terai, hills and Himalayas respectively (Smith 2011b). There are 11 of the world's 15 families of butterfly (Smith 2011a).

The distribution of butterflies depend on habitat quality and presence of plant resources (Thomas et al. 2001). They are affected by climatic and ecological variations (Camero et al. 2007). They are sensitive to different vegetation kinds based on variations in temperature, humidity, light, and wind. (Montero-Munoz et al. 2013). Butterfly abundance and diversity is also affected by season (Valtonen et al. 2013) as many species depend on plants for food (Bergerot et al. 2010).

The butterflies' short lifespan, high mobility, and specialized habitat requirements make them vulnerable to changes in the environment (Lee et al. 2014). Diversity of butterflies increases with increasing habitat heterogeneity (Price 1975). The largest variety of butterflies can be found near the forest edge (Lien 2009). Butterfly diversity is greater in the forest than in areas of dense woodland. (Spitzer et al. 1997).

Seasonal variations of butterflies depend on environmental factors like temperature, humidity, rainfall, availability of food source, and types of vegetation such as herbs, shrubs and trees (Shanthi et al. 2009). Butterflies have shown high responses to climatic fluctuation as they affect their development, reproduction and survival (Ward and Masters 2007).

In many ecosystems around the globe, butterflies provide crucial ecological benefits for crops and native wild species. To maintain the productivity of natural and agricultural environments, their preservation is required. (Davis et al. 2008). Butterflies are hosts to several parasitoids that control agricultural pests and serve as food for birds and other predators. (Summerville et al. 2001). Studies on the variety of butterflies reveal how changes in species abundance, richness, and evenness are influenced by vegetation. (Ockinger et al. 2009).

Invasive species are foreign species having a capacity to establish and spread rapidly out of its native distribution range (Simberloff et al. 2013). Invasive plants pose serious conservation issues on a global scale because they damage ecosystems in general and specific species in particular. They are becoming more and more prevalent in their non-native ranges (Simberloff 2006). Invasive species pose a threat to the biodiversity of native communities and incur major ecological and economic costs worldwide (Mitchell et al. 2006). The spread and establishment of alien species alters the stability and organization of ecological groups. (Richardson and Pynek 2000). Direct competition for nutrients, light, space, or water, as well as the resulting loss of plant species diversity, are the most prominent impacts of invasive plant species on communities. (Levine et al. 2003).

Many authors found global decline of butterflies in different parts of the world because of habitat degradation, climate change, use of pesticides and deforestation (Murphy et al. 1990). Global warming supposed to play important role to affect population of butterfly (Sengupta et al. 2014). Butterflies will shift or meet extinction due to change in climatic condition (Bourn & Thomas 2002).

Kirtipur is located in Kathmandu valley. It host many species of plants. However, there is absence of systematic study and documentation of flora and fauna including butterflies in Kirtipur. Even all over Nepal few studies have been performed on butterflies. Bhusal and Khanal (2008) conducted study to find the altitudinal diversity of butterflies in Eastern Siwalik of Nepal. Khanal (2008) carried out study to explore diversity and status of Butterflies in lowland districts of West Nepal. Oli (2018) carried out a research work on butterfly fauna in southern hills of Kathmandu Valley. Subedi et al. (2021) conducted a research on butterfly species diversity and their floral preferences in the Rupa wetland. Documentation of flora and fauna provide ingredients

for monitoring species in future. Hence, the area required the documentation of flora and fauna. Therefore, the present study was carried out in butterfly as a representative group. It was not concentrated only on providing data on species richness of butterflies but also its seasonal variation of two seasons.

### **1.2 Rationale of the study**

In many ecosystems around the globe, butterflies provide crucial ecological benefits for crops and native wild species. Since climate and environment are changing due to urbanization, the butterfly diversity of the world is affected and facing the problem of extinction (Lee et al. 2014). Therefore, exploration of their diversity and factor affecting their distribution is crucial. It is also important to find the impact of land use pattern on butterfly diversity. Kirtipur is one of the populated municipality of the country. Due to urbanization forest patches, grasslands and agricultural land which are natural habitat of butterflies are being converted into settlement area in Kirtipur. The present study is aimed to study the diversity and seasonal variation of butterfly in two season.

### **1.3 Objectives**

To find the seasonal variation of butterfly fauna in Tribhuvan University premises, Kirtipur.

#### **Specific objectives**

- i. To estimate the species diversity and abundance of butterflies.
- ii. To determine the seasonal variation of butterflies.
- iii. To find frequency of visits of butterfly to *Lantana camara*.

## 2. LITERATURE REVIEW

### 2.1 Diversity of butterfly

In Nepal, study on butterfly was initiated since 1826 by General Thomson Hardwick. Major General Ramsey, a British resident while being in Kathmandu during the period of 1852-1867, recorded 44 species of butterfly in Nepal (Khanal and Smith 1997). In India there are about 1400 species of butterflies (Kunte et al. 2020). However, there are only 672 species of butterflies in Nepal (K.C. 2020; Sapkota et al. 2020). Butterflies supply economic and ecological benefits to the human being (Chinaru and Joseph 2011); Simonson et al. 2001). After bees, butterflies play an important role of pollinators (Arya et al. 2014; Geiger et al. 2003).

The local variables and habitat factor are important determinants of insect diversity (Nielsen et al. 2014). Many butterfly species prefer only a particular set of habitats (Kunte 1997). Diversity of butterflies increases with increasing of habitat scale and vegetation structure complex (Price 1975). The variation in forest types has wider range of habitats to offer for diverse butterfly species. Habitat preferences of butterfly is related to the population trends with a drastic decline of open habitat species and a moderately rise in forest species (Herrando et al. 2016). Home gardens and agricultural fields harbor less species than the forest (Kunte et al. 1999).

Gavashelishvili and McGrady (2006) recorded that the environmental factors play an important role in generating patterns of species richness in Nepal. Variation in season and availability of nectar plant has direct impact on the distribution and diversity of butterflies. Change in environmental factor not only affect the structure and function of ecosystem but also has distinct impact on butterfly diversity (Tiple 2011). Variation in climatic and ecological factor brings changes in species occurrence and abundance of butterflies (Camero et al. 2007). The butterflies are sensitive to local climate and their distribution depends on weather (Gupta et al. 2019).

Different authors studied butterflies in east, central and west Nepal. Smith (1977b) surveyed butterflies from eastern Nepal. He documented 26 new species of butterflies from Nepal. Smith (1977c) documented 28 species from western Nepal. Khanal (2001) recorded 114 species of butterflies from Jhapa district. Khanal et al. (2012) documented 126 species of butterfly and found rich diversity at 1500 m to 2900 m elevation at

various pockets of Langtang National Park, Central Nepal. Species diversity varies from one author to another ranging from 31 species to 138 species (Thapa 2004; Dahal 2017; Oli 2018; Subedi et al. 2021).

## **2.2 Seasonal variation of butterfly diversity**

The diversity of butterfly species differ with season. The colors of butterflies varied according to the season. Some species exhibit markedly different characteristics depending on the time of year, resulting in two forms of the same species that vary in color, markings, and spots. Species richness of butterfly was found high in dry season than rainy season in a Mamunta Mayosso Wildlife Sanctuary of Sierra Leone (Kyerematen et al. 2018). Higher number of species was found in rainy season followed by summer and autumn in Jammu Shiwaliks, Jammu and Kashmir, India (Sharma and Sharma, 2021). Butterfly diversity was more in dry season than in wet season as found by many researchers ( Raghavendra et al. 2011; Checa et al. 2014; Kyerematen et al. 2018). Barsagade et al. (2019) found highest butterfly diversity from June to December and its number decline from January onward in and around Ramtek Gadmandir forest area, Central India. The decrease in butterfly population may be due to increase of temperature and humidity as well as less availability of host plant population. Gupta et al. (2019) reported maximum diversity in the pre-monsoon period between the months of April and May and lowest diversity was observed during winter and also highest abundance was recorded when the average monthly temperature was highest whereas lowest abundance was recorded when the average temperature was lowest. Virani (2020) carried out study on butterflies in Tipeshwar Wildlife Sanctuary of Maharashtra, India. He discovered that the butterfly population decreased in the summer and pre-monsoon and grew from monsoon to winter, perhaps as a result of the nectar shortage and changes in this protected area's temperature and humidity. Castro and Espinosa (2015) studied seasonal diversity of butterflies and its relationship with woody-plant resources availability in an Ecuadorian tropical dry forest. They found species richness was higher in rainy season coinciding with maximum plant resources availability.

The diversity of butterfly species was higher in spring than winter in Eastern Siwalik of Nepal (Bhusal and Khanal 2008) which might be due to high relative humidity and more rainfall in spring season. Similar case was found in the study of Thapa (2008) in Thankot and Syuchatar VDCs of Kathmandu. This study indicated that spring has

slightly high species richness than winter. Rai (2017) found high species richness of butterfly in autumn followed by spring and winter, probably due to damp-warm and dry-hot weather. Oli (2018) also found high species richness of butterfly in autumn.

### **2.3 Effect of invasive plant species on pollinators**

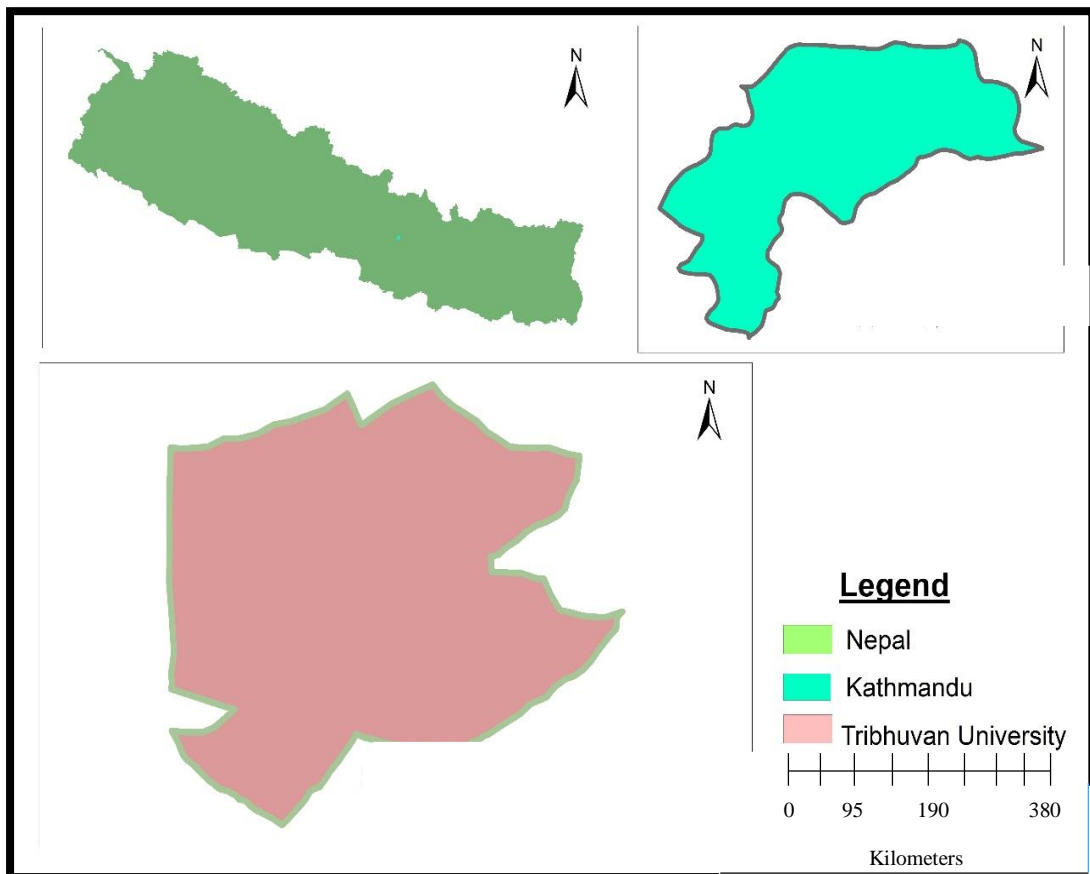
The distribution and abundance of pollinators may be impacted as a result of invasive plants because native flowering plants may be less common (Lopezaraiza-Mikel et al. 2007). For instance, many pollinators such as Hymenoptera (sawflies, bees, wasps, and ants) become less common as the number of invasive species grows (Fork 2010; Hanula and Horn 2011). Since many invasive plants are pollination specialists, changes in vegetation structure can affect the functional connections between pollinators and plants (Aizen et al. 2008). Even if native and invasive plants share pollinators, plant species movement can raise the probability of heterospecific pollen transfer and further hinder native plant reproduction and supremacy (Brown et al. 2002). The colonization of non-native pollinators may also be facilitated by plant invasions (Morales and Aizen 2002). In reaction to non-native plants that are both congeners and noncongeners of native plants, larval Lepidoptera (moths, butterflies, and skippers) experience decreases in abundance and richness. However, declines are most noticeable for noncongeneric plants, particularly for specialist lepidopterans (Burghardt et al. 2010). According to Triplehorn and Johnson (2005), many species in the orders Hemiptera (true bugs) and Lepidoptera, as well as a small number of Thysanoptera (thrips) and Coleoptera (beetles), are host specific at some or all life stages. These species may be significantly impacted by an increase in the abundance of novel plants. Lepidoptera need particular plant for reproduction, In addition to the plants they consume (Thompson and Pellmyr 1991). Preferences for particular plant species may be based on chemical signals for oviposition or traits that promote larval growth and development, such as plant size, proximity to other host plants, and particular microclimate conditions (Thompson and Pellmyr 1991). Only a small number of plant types may offer the necessary conditions for effective reproduction; some invasive plants are even poisonous to larvae (Graves and Shapiro 2003). Plant invasions therefore probably have a negative impact on lepidopterans and related species (Tallamy and Shropshire 2009). Despite the fact that generalist species make up only 10% of insect herbivores (Bernays and Graham 1988), this group may be better able to adapt to a new plant (Tallamy 2004). However, in reality, generalist herbivores may still favor native plants because invading ones

frequently have high lignin and starch content and low tissue nitrogen levels (Haddad et al. 2001). Invasive plant species are very attractive to pollinators, resulting in increased populations of pollinating taxa in regions where they have invaded, but they attract insects away from the flowers of the endangered native plant (Baskett et al. 2011). Butterflies use *Lantana camara* for food (Weiss 1997; Penz and Krenn 2000; Andersson and Dobson 2003), oviposition site, larval development (Jothimani et al. 2014), pollination (Faegri and van der Pijl 1979; Proctor et al. 1996), and mite transfer (Boggs and Gilbert 1987).

### 3. MATERIALS AND METHOD

#### 3.1 Study area

The study was conducted in Tribhuvan University premises, Kirtipur Municipality, Kathmandu, Nepal. It has sub-tropical climate. It comprises land with different features like buildings areas, forest areas and agricultural areas. Although it covers an area of 1.57 km<sup>2</sup>, it has highly diversified plants. Plants include *Lantana camara*, *Populus* sp., *Jacarandra mimisaefolia*, *Cinnamomum camphora*, *Callistemon citrinus*, *Grevillea robusta*, *Cinnamomum tamala*, *Eucalyptus camaldulenis* etc. Agricultural areas consist of seasonal crops occupied by rice and maize. Forest areas include coronation garden and adjoining forest patches.



**Figure 1:** Map of study area

## **3.2 Method**

### **3.2.1 Butterfly survey**

Field survey was conducted from June to November of 2019 in two plots of both habitat viz. agricultural land and forest area during two seasons i.e. rainy (June-September) and autumn (Mid-September-November). The size of the plots was 100m × 100m. Each plots was visited once in a month sampled between 10: 00 am to 1:00 pm on a normal sunny day. Butterflies were captured using sweeping net and their thorax was pinched to kill them. Butterflies were identified using field identification guides (Khanal and Smith 1997). Season wise butterfly population of both habitat were compiled for statistical analysis.

### **3.2.2 Frequency of visits of butterfly to *L. camara***

Butterflies were observed at a specific point over two days per month for three months during autumn season in the morning (08:00-10:00) for 30 min. Butterfly individuals were counted visiting *Lantana camara* flowers. Butterfly individual which spend more than five minutes was consider. The butterfly was observed in the absence of rainfall and harsh winds that would affect the activity of butterflies

## **3.3 Data analysis**

### **3.3.1 Abundance, Species richness, diversity and evenness**

The equation  $P_i = (n_i/N)*100$  was used to calculate relative abundance ( $P_i$ ). where  $n$  is the number of people in the  $i$ th species and  $N$  is the total number of individuals in all species.

A direct measurement of the quantity of species is species richness. Margalef's index ( $D_{mg}$ ) was used to compute it:

$D_{mg}$  is equal to  $(S-1)/\ln N$ , where  $N$  is the total number of sampled individuals and  $S$  is the number of species.

The Shannon diversity measure,  $H' = -\sum P_i \ln P_i$ , was used to determine species diversity.

Pielou's species evenness index,  $J = H'/H_{max}$ , was used to calculate the evenness of butterflies.

$H'$  is equal to the Shannon diversity measure.

$P_i$  = Proportion of  $i$ th species in the entire population

Microsoft Excel was used to compute all the indices.

### **3.3.2. Frequency of visits of butterfly**

Frequency of visits of butterfly was tallied and sum of every counted was done for calculating the frequency of visits of each butterfly to *Lantana camara*.

### **3.3.3 Analysis of Variance**

One-way ANOVA was used to determine whether there is significant variation in species richness of butterflies in two seasons.

The assumed null hypothesis was;

$H_0$ = There is no significant variation in species richness of butterflies between rainy and autumn.

And assumed alternative hypothesis was;

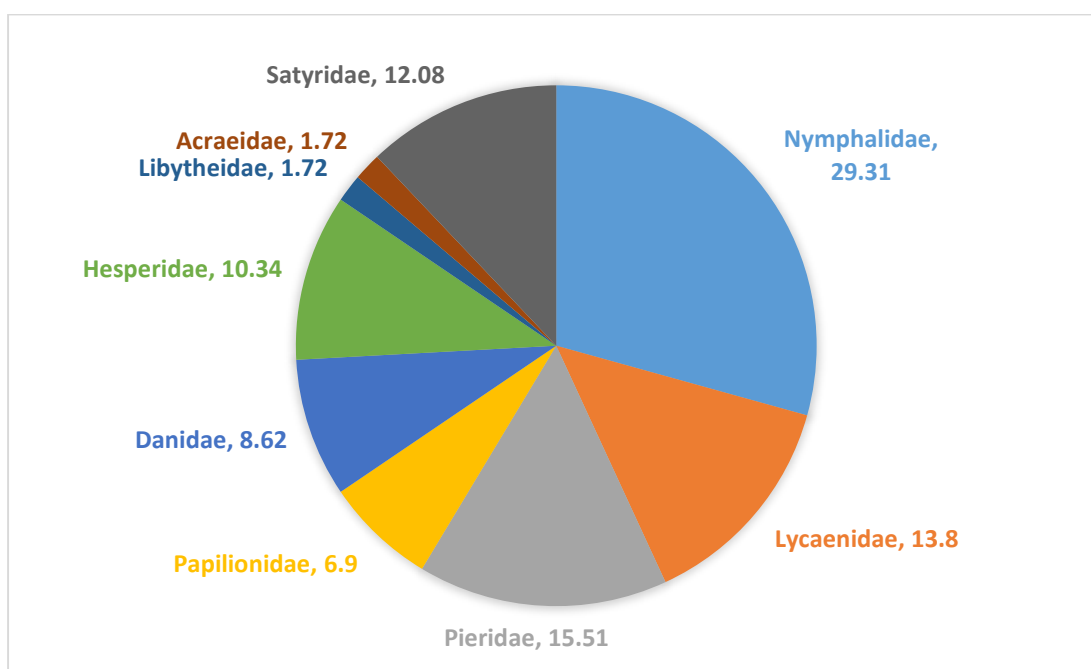
$H_1$ = There is significant variation in species richness of butterflies between rainy and autumn.

PAST version 3.4 was used to calculate One-way ANOVA.

## 4. RESULTS

### 4.1 Butterfly diversity

A total of 2525 butterfly individuals of 58 species belonging to 45 genera under nine families were observed in Tribhuvan University premises, Kirtipur.



**Figure 2:** Family wise composition of species

**Table 1:** Butterfly species reported from the study area

Family/Species name	Common name	Frequency
Nymphalidae		
1. <i>Abisara fylla</i> (Westwood, 1851)	Dark Judy	10
2. <i>Aglais caschmirensis</i> (Kollar, 1844)	Indian Tortoiseshell	56
3. <i>Aridne merione</i> (Cramer, 1777)	Common Castor	75

4. <i>Cethosia biblis</i> (Fruhstorfer, 1912)	Red Lacewing	41
5. <i>Cethosia cyane</i> (Drury, 1773)	Leopard Lace wing	22
6. <i>Childrena children</i> (Gray,1831)	Large Silverstripe	88
7. <i>Cupha erymanthis</i> (Sulzer, 1776)	Rustic	49
8. <i>Junonia atlites</i> (Linnaeus, 1763)	Grey Pansy	40
9. <i>Neptis armandia</i> (Evans, 1912)	Variegated Sailor	53
10. <i>Neptis cartica</i> (Moore, 1872)	Plain Sailer	61
11. <i>Neptis hylas</i> (Moore, 1874)	Common Sailer	43
12. <i>Phalanta phalantha</i> (Drury, 1773)	Common Leopard	36
13. <i>Precis almana</i> (Linnaeus, 1758)	Peacock Pansy	32
14. <i>Precis iphita</i> (Cramer, 1779)	Chocolate Pansy	63
15. <i>Symbrenthia lilaea</i> (Moore, 1874)	Common Jester	21
16. <i>Vanessa cardui</i> (Linnaeus, 1758)	Painted Lady	116
17. <i>Vanessa indica</i> (Herbst, 1784)	Indian Red Admiral	67
Lycaenidae		
18. <i>Euchrysops cnejus</i> (Fabricius, 1798)	Gram Blue	20

19. <i>Heliophorus indicus</i> (Fruhstorfer, 1908)	Indian Purple Sapphire	16
20. <i>Jamides alecto</i> (Swinhoe, 1915)	Metallic Cerullean	7
21. <i>Jamides celeno</i> (Cramer, 1775)	Common Caerulean	23
22. <i>Pratapa icetas</i> (Hewitson, 1865)	Dark Blue Royal	10
23. <i>Prosotas dubiosa</i> (Semper, 1879)	Tailless Blue	17
24. <i>Zizeeria maha</i> (Kollar, 1848)	Pale Grass Blue	183
25. <i>Zizina Otis</i> (Fabricius, 1787)	Lesser Grass Blue	71
Pieridae		
26. <i>Catopsilia Pomona</i> (Fabricius, 1775)	Common Emigrant	31
27. <i>Colias fieldii</i> (Felder, 1865)	Dark Clouded yellow	35
28. <i>Delias eucharis</i> (Drury, 1773)	Common jajebel	54
29. <i>Eurema blanda</i> (Boisduval, 1836)	Three spot Grass yellow	59
30. <i>Eurema hecabe</i> (Linnaeus, 1758)	Common Grass yellow	59
31. <i>Pareronia valeria</i> (Cramer, 1776)	Common Wanderer	28
32. <i>Pieris brassicae</i> (Doubleday, 1846)	Large Cabbage White	109
33. <i>Pieris canidia</i> (Evans, 1926)	Indian Cabbage White	93

34. <i>Vagrans egista</i> (Cramer, 1780)	Vagrant	57
Papilionoidae		
35. <i>Delias acalis</i> (Godart, 1819)	Red Breast Jazebel	17
36. <i>Graphium cloanthus</i> (Cramer, 1875)	Glassy Bluebottle	64
37. <i>Papilio helenus</i> (Linnaeus, 1758)	Red Helen	11
38. <i>Papilio polytes</i> (Linnaeus, 1758)	Common Mormom	37
Danaiidae		
39. <i>Danaus chrysippus</i> (Linnaeus, 1758)	Plain Tiger	75
40. <i>Danaus genutia</i> (Cramer, 1779)	Common Tiger	72
41. <i>Euploea core</i> (Cramer, 1780)	Common Indian Crow	60
42. <i>Euploea mulciber</i> (Cramer, 1777)	Striped Blue Crow	39
43. <i>Parantica aglea</i> (Moore, 1883)	Glassy Tiger	45
Hesperiidae		
44. <i>Borbo bevani</i> (Moore 1778)	Bevans Swift	16
45. <i>Iambrix salsala</i> (Moore, 1866)	Chestnut Bob	23
46. <i>Notocrypta feisthamelii</i> (Boisduval, 1832)	Spotted Demon	24

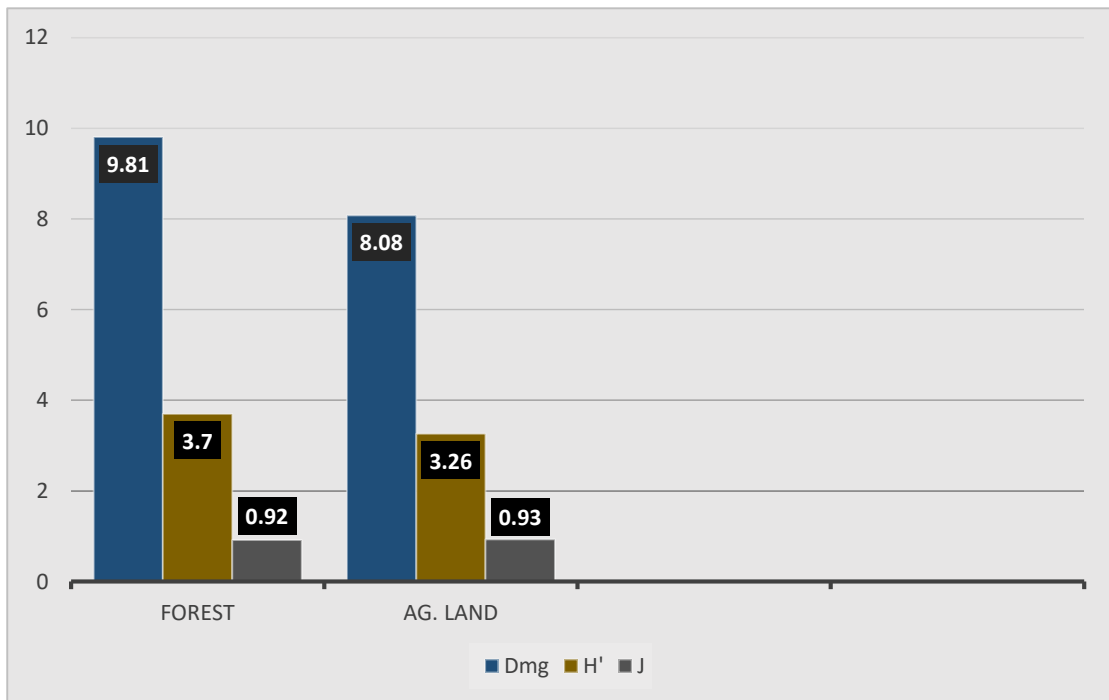
47. <i>Parnara guttata</i> (Moore, 1865)	Straight Swift	13
48. <i>Pelopidas sinensis</i> (Mabille, 1877)	Branded Swift	8
49. <i>Udaspes folus</i> (Cramer, 1775)	Grass Demon	7
Satyridae		
50. <i>Lethe confuse</i> (Aurivillius, 1898)	Banded Tree Brown	36
51. <i>Lethe verma</i> (Fruhstorfer, 1911)	Straight Banded Tree Brown	28
52. <i>Melanitis leda</i> (Linnaeus, 1758)	Common Evening Brown	27
53. <i>Mycalesis heri</i> (Moore, 1857)	Moore's Bush Brown	37
54. <i>Ypthima asterope</i> (Klug, 1832)	Common Three Ring	25
55. <i>Ypthima confuse</i> (Kirby, 1871)	Confusing Three Ring	37
56. <i>Ypthima newara</i> (Moore, 1874)	Newari Three Ring	22
Libytheidae		
57. <i>Libythea myrrha</i> (Godart, 1819)	Club Beak	7
Acraeidae		
58. <i>Acraea issoria</i> (Hubner, 1819)	Yellow Coster	50

*Zizeeria maha* was the most abundant butterfly with 7.21% relative abundance followed by *Venessa cardui* (6.76%), *Pieris brassicae* (5.72%), *Pieris canidia* (5.22%) and *Childrena childreni* (4.56%). *Libythea myrrha*, *Udaspes folus* and *Jamides alecto* were the least abundant butterflies with a relative abundance of 0.08% each.

The overall Margalef's species richness was 7.28, diversity index ( $H'$ ) was 3.83 and the evenness index ( $J$ ) was 0.94. The diversity indices indicate that Tribhuvan University premises is rich in butterfly diversity.

#### 4.2 Butterfly diversity in different habitat

Forest have the highest number of butterfly species (56 species,  $D_{mg}=9.81$ ,  $H'=3.70$ ,  $J=0.92$ ) and agricultural land has less number of butterfly species (34 species,  $D_{mg}=8.08$ ,  $H'=3.26$ ,  $J=0.93$ ). Species richness calculated by Margalef's index ( $D_{mg}$ ) showed the species richness of AG < F displays a difference between forest and agricultural land. Shannon diversity index ( $H'$ ) showed a greater diversity in forest than agricultural land. Evenness measured by Pielou's  $J$  showed the population in agricultural land is more even than the butterfly population in forest.



**Figure 3:** Margalef's species richness, Shannon's diversity index and Evenness in forest and agricultural land.

#### 4.3 Seasonal Variation

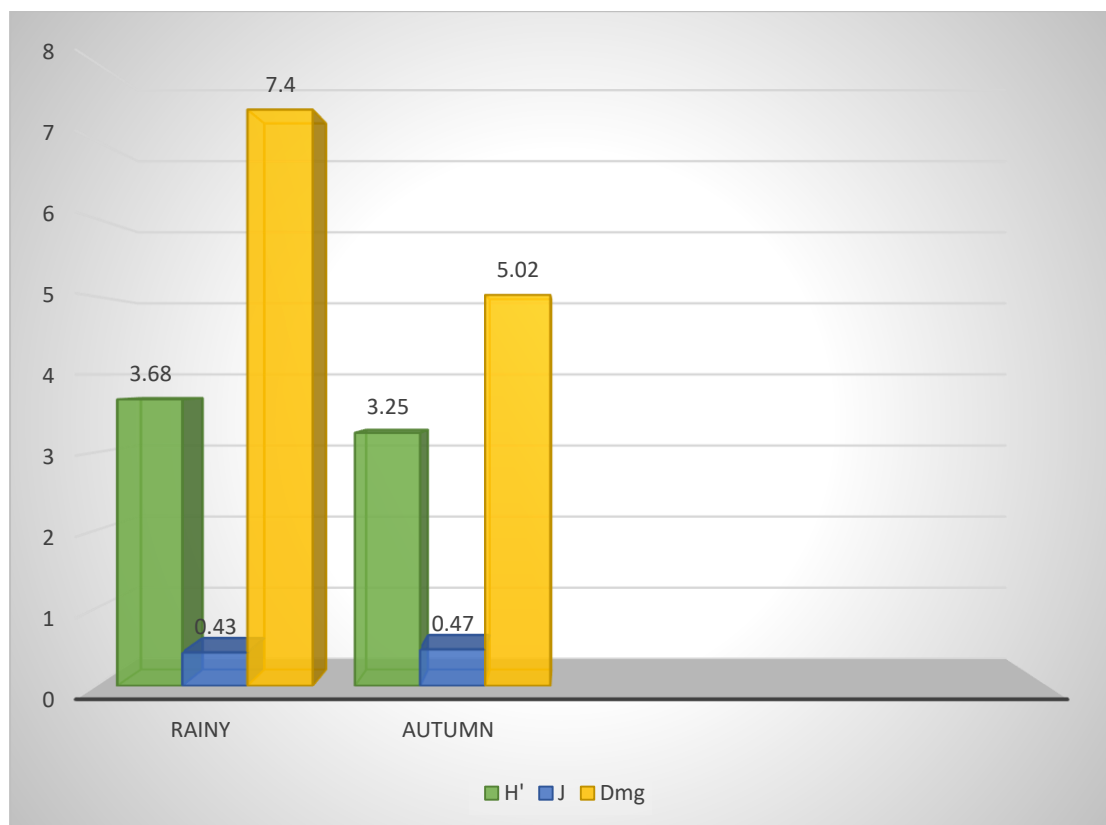
A total of 1462 individuals of 55 species belonging to nine families were recorded in rainy season and 1063 individuals of 36 species belonging to nine families were recorded from autumn season. *Venessa cardui* was found in maximum number (67) whereas *Symbrenthia lilaea* was found in least number (9) during rainy season.

*Childrena childreni* found in maximum number (72) and *Pratapa icetas* found in minimum number (10) during autumn.

Margalef's species richness was found to be higher in rainy season ( $D_{mg}=7.40$ ) than in autumn ( $D_{mg}=5.02$ ). It showed that rainy season was rich in species than autumn.

Shannon Wiener diversity index ( $H'$ ) for rainy season was  $H'=3.68$  whereas the autumn season had the diversity index of  $H'=3.25$  which indicate high butterfly diversity in rainy season than autumn.

The evenness index was found to be higher in autumn season ( $J=0.47$ ) than in rainy season ( $J=0.43$ ). Therefore, evenness index showed that butterflies were slightly more evenly distributed in autumn than in rainy season.



**Figure 4:** Margalef's species richness, Shannon's diversity index and Evenness in rainy and autumn.

**a. ANOVA for species richness**

Since the calculated value of the test statistics  $F=0.67241$  is less than the tabulated value and  $P=0.67124 > 0.05$ , null hypothesis is accepted i.e. there is no any significant variation in species richness of butterflies between two seasons. It was tested at ( $v_1=1$  and  $v_2=169$ ) degree of freedom and 5% level of significance (Table 2).

**Table 2:** ANOVA table between species richness of butterflies in two different seasons.

Source of variation	DF	Sum of squares(SS)	Mean square (MS)	P-value	F statistics	F critical
Between seasons	1	2.954	2.478	0.67124	0.67241	3.84
Within seasons	169	967.214	5.648			
Total	170	970.168				

**b. ANOVA for abundance**

Since the calculated value of the test statistics  $F=2.83078$  is less than the tabulated value and  $P=0.08117 > 0.05$ , null hypothesis is accepted i.e. there is no any significant variation in abundance of butterflies between two seasons. It was tested at ( $v_1=1$  and  $v_2=169$ ) degree of freedom and 5% level of significance (Table 3).

**Table 3:** ANOVA table between abundance of butterflies in two different seasons

Source of variation	DF	Sum of squares (SS)	Mean square (MS)	P-value	F statistics	F critical
Between seasons	1	55.49	55.48	0.08117	2.83078	3.84
Within seasons	169	3367.64	17.76			
Total	170	3423.13				

#### 4.4 Frequency of visits

Altogether 14 species of butterfly visited the *Lantana camara* flower. Frequency of visits was more in *Colias erate* (119) while least in *Cupha erymanthis* (16) (Table 4).

**Table 4:** Frequency of visits of different butterflies to *Lantana camara*

SN.	Species Name	Frequency of visits
1.	<i>Colias erate</i>	119
2.	<i>Terias hecabe</i>	45
3.	<i>Phalanta phalantha</i>	32
4.	<i>Pieris brassicae</i>	78
5.	<i>Libythea myrrha</i>	104
6.	<i>Precis iphita</i>	69
7.	<i>Neptis hylas</i>	26
8.	<i>Papilio polites</i>	83
9.	<i>Cupha erymanthis</i>	16
10.	<i>Catopsilia Pomona</i>	33
11.	<i>Danaus chrysippus</i>	29
12.	<i>Delia eucharis</i>	96
13.	<i>Junonia atlites</i>	62
14.	<i>Junonia almana</i>	112

## 5. DISCUSSION

### 5.1 Butterfly diversity

Out of 672 species recorded from Nepal, the study shows the presence of 58 species i.e. 8.63% of overall available species in Nepal. Oli and Sharma (2019) recorded 43 species of butterfly belonging to nine families in T.U college area. Study area has high butterfly diversity which might be due to the presence of some open area (Oli and Sharma 2019). Shrestha et al. (2018) recorded 77 butterfly species belonging to six families from different sacred forests of Kathmandu Valley. Katuwal et al. (2020) also documented 77 butterfly species belonging to nine families in Chandragiri hills. Oli (2018) listed 113 species of butterfly belonging to nine families from Champadevi and Chandragiri hills. Thapa (2008) recorded 43 species of butterflies belonging to nine families in Thankot and Syuchatar VDCs of Kathmandu. The variation in abundance, richness and evenness of the butterflies is affected by vegetation (Ockinger and Smith 2006; Ockinger et al. 2009). Among all the resources required by butterflies that consist of habitat (Dennis 2010), the host plants are the main resource which is fundamental for reproduction (Tiple et al. 2010).

The study area was dominated by the Nymphalidae family. Thapa (2008) had also obtained the similar result that family Nymphalidae contributed the highest species number and Acraeidae contributed least species number at Thankot and Syuchatar, Kathmandu. Bhusal and Khanal (2008) revealed Nymphalidae family contributed the highest species number in the Eastern Siwalik of Nepal. Shrestha (2016) also found family Nymphalidae contributed the highest butterfly species in Manang district. Oli (2018) revealed family Nymphalidae contributed the highest butterfly species which was in agreement with present study. Subedi et al. (2021) also observed family Nymphalidae had highest number of species in their study. Similarly Kunte (1997), Tiple and Khurad (2009), Trivedi et al. (2013), Hasan et al. (2018), Ojianwuna and Enwemiwe (2021), Samraj and Agnihotri (2021) reported Nymphalidae as the most dominant family which might be due to their ecological adaptation (Jiggins et al. 1996) and strong active fliers (Raut and Pendharkar 2010). Because of active flier which might help them in searching for food in large areas (Raut and Pendharkar 2010). Similar result was acquired from different parts of the world (Prajapati et al. 2000;

Chalise 2010; Khan et al. 2011). The dominance of Nymphalid butterflies is indicative of variety of host plant species present in the forest and agricultural land. The dominance may be because of their broader species ranges, taxonomically well studied and larger family (Sharma and Sharma 2021). Pale Grass Blue was the most dominant species in the study region which was also recorded by Samraj and Agnihotri (2021). The species richness and diversity in rainy season was higher than the autumn in the study area which might be due to the presence of healthier larval host plants because of high rainfall in monsoon (Kunte 1997; Verma and Arya 2018).

This study was only conducted in two seasons, rainy season and autumn, so there is a greater chance of an increase in the species richness of butterflies in this area, which requires a more detailed study in the future covering all seasons.

## **5.2 Butterfly diversity in different habitat**

In insect pollinator community composition, habitat heterogeneity is one of the predictor of spatial variation. Pollinator are affected by the distribution of flower plants as well as amount and composition of soil available for nesting (Aguirre-Gutierrez et al. 2015). Butterflies prefer a particular set of habitat and host plants for their survival (Padhye et al. 2006). Butterflies are sensitive and react immediately to habitat changes (Schmitt et al. 2021; Kunte 1997). Habitat is always changing. Thus, periodic monitoring of habitat is necessary to access the state of biodiversity (Lindenmayer and Likens 2010).

In the present study, the butterfly diversity was highest in forest and less in agricultural land. Samraj and Agnihotri (2021) had also documented similar result that high butterfly diversity in forest than agricultural land. Munyuli (2014) had recorded highest butterfly diversity in forest, which is in support of present study. Sharma et al. (2012) also had similar result that the forest has high butterfly diversity than agricultural land. Benton et al. 2003; Tschardtke et al. 2005 and Ekroos et al. 2013 supports the result of the present study. It might be due to the present of heterogeneous habitat in forest. Low butterfly diversity in agricultural land might be due to the use of chemical pesticides (Geiger et al. 2010). Butterflies are highly vulnerable to agricultural land intensification (Batary et al. 2011) because their foraging behavior are directly affected by pesticides and chemical fertilizer (Henry et al. 2012). Forest is undisturbed habitat and have

different variety of plants from grasses, thick bushes to tall trees is responsible for highest species diversity and abundance in the study area. According to Hart and Horwitz (1991), the habitat heterogeneity hypothesis simply predict that more arthropod species will occur where different forms and species of plants provide greater structural heterogeneity in vegetation. Due to the monoculture habitat, butterfly diversity in agricultural land is less than non-agricultural land (Bhardwaj et al. 2012). The quality of green spaces is critical to butterfly survival (Thomas et al. 2001). The presence of large green patches, a wide varieties of habitats and high cover of natural vegetation support higher butterfly species richness (Beninde et al. 2015).

The studies showed that the land cover, resource availability, level of disturbances and the climatic gradient have a great effect on butterfly species richness and abundance along the spatial gradients (Tzortzakaki et al. 2019). Abundance and habitat preferences of butterflies are directly connected to the availability of host plants (Chettri et al. 2018) and adult nectar sources (Lodh and Agarwal 2016) as well as plant species richness and density (Acharya and Vijayan 2015). Factors such as availability of adults and larval host-plants, behaviour characters and interaction with other species (Pineiro and Ortiz 1992) might explain the high butterfly richness and diversity as well as abundance in forest area of Tribhuvan University college area.

### **5.3 Seasonal Variation in species richness**

Insects survive in the optimum range of temperature and humidity because they are poikilothermic. The climate factors influence the butterfly population directly by affecting the growth of larva and indirectly by affecting the availability of host plants. Flora along the landscape form the diversity and abundance of butterflies (William 1998; Patil 2019). The spatial and temporal distribution of the butterflies is mainly determined by the weather (Kunte 1997). Thus, there might be variations in the number and species of butterflies with season because of changes in several factors like temperature, humidity, vegetation type, availability of water, availability of food resources, etc.

Seasonal changes effect butterfly diversity and richness that are fundamental to the population of the species (Fordyce and DeVries 2016). Butterfly diversity and richness might be related to the availability of food sources since flowering of plants had greater

impact on seasons (Gutierrez and Mendez 1995). Butterflies are very sensitive to varying factors e.g. temperature, humidity and rainfall (Kumar et al. 2016). Higher temperature might effect butterfly life cycle, distribution and abundance (Roy et al. 2012). It has also impact on the fitness, migration, reproduction and final survival of butterflies (Memmott et al. 2007).

In this study there is difference in species richness of butterflies in between season, rainy (55 species) and autumn (36 species), however statistically the result showed no significant variation in species richness between two seasons. Sharma and Sharma (2021) had reported highest butterfly diversity during rainy season which supports the present study. Remadevi et al. (2021) also found maximum species richness and abundance in monsoon season in different urban green spaces of Bengaluru city, Karnataka, India. Lourenco et al. (2019) also recorded greater abundance, richness and species diversity during rainy season. During the study conducted in an Ecuadorian tropical dry forest, the diversity of butterfly was found higher in rainy season as availability of plant resources is higher during rainy season (Castro and Espinosa 2015). Checa et al. (2014) also registered higher species richness and abundance during rainy season. Tiple and Khurad (2009) also found maximum species richness during rainy season. Research finding of Thapa (2008) showed that species richness increased with warmer summer days and decreased with cold and dry winter days which supports the present study. This variation might be due to climatic and biotic factors which differed in different season. The high peaks of temperature and humidity received during rainy season provide butterflies the favorable environmental conditions for their growth and development (Kucherov et al. 2021). Moreover, these conditions also support high diversity and biomass of the vegetation, thus increasing their food, shelter and associated requirements. On the contrary, in autumn there is low temperature and dryness together with decreased biomass and food availability which accounts for the less abundance of butterflies (Jaramillo et al 2019; Sharma and Sharma 2021). Low species richness in autumn might be related to the amount of food available to butterflies which is used to be lower in autumn.

#### **5.4 Frequency of visits**

Invasive alien species may have both direct and indirect impacts on regional pollination services. If the alien species uses the same flower visitors for pollen transfer, it might

directly contend with native co-flowering plants or promote their growth (Lopezaraiza-Mikel et al. 2007). Alien invasion can displace or replace native plants or change their colonization patterns, which may indirectly lead to alternative pollination processes even if there is no overlap in pollinator species or the invasive plant species is pollinated by abiotic vectors (Yurkonis and Meiners 2004). Differences in the biotic and abiotic characteristics of recipient ecosystems may account for a large portion of the observed variation in the success of exotic plants. The success of invader plants on their own can be greatly impacted by abiotic factors in a given habitat (Davis et al. 2000). Interactions with members of the recipient group can have both favorable and unfavorable effects on the growth and spread of exotic plant species (Cushman et al. 2011). Both biotic and abiotic characteristics exhibit significant spatial heterogeneity, which is probably going to impact how herbivores interact with invasive species (Biswas et al. 2014). According to Bartomeus et al. (2008) Lepidoptera visits less frequently in invasive *Carpobrotus affine acinaciformis* and *Opuntia stricta* where both two species studied were visited by 43% and 31% of the total insect taxa in the community, respectively. Six species of order Hymenoptera, six species of Diptera and three species of Lepidoptera visited on invasive *Taraxacum officinale* in the study conducted by Munoz and Cavieres (2008). Jesse et al. (2006) studied insect pollinators of the invasive plant, *Rosa multiflora* (Rosaceae) in Iowa, USA for two years and found that the abundance of Syrphidae was more and of other hymenoptera was less for both two years. Mciver et al. (2009) collected 10 species of order Hymenoptera, one species of Diptera, one species of both Coleoptera and Lepidoptera from invasive *Centaurea solstitialis* in USA. Schemske (1976) collected 24 species belonging to seven families from *Lantana camara* and 18 species belonging to four families from *Lantana trifolia* in the vicinity of the organization for Tropical Studies Field Station on the Osa peninsula.

## 6. CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Conclusions

A total of 2525 individuals of 58 species belonging to 45 genera under nine families were documented. The nine families were Nymphalidae, Pieridae, Lycaenidae, Papilionidae, Danaidae, Hesperidae, Satyridae, Libytheidae and Acraeidae. Among them Nymphalidae was dominant family. *Zizeeria maha* was the dominant species. Overall diversity index showed that Tribhuvan University premises was rich in butterfly diversity. Shannon Weiner diversity Index was found higher in rainy season (3.68) than in autumn (3.25). Rainy season also had high species richness (55) in comparison to autumn (36). Although there was high species richness in rainy season, One-way ANOVA showed that there is no significant difference in species richness between seasons. Butterfly species was more diverse in forest habitat (56) than agricultural land (34). *Colias erate* visits frequently on *Lantana camara* while *Cupha erymanthis* visits less frequently.

### 6.2 Recommendations

1. As the present study was carried out only in two seasons. Therefore, future research should be conducted in all seasons to find the seasonal variation among all seasons.
2. Extensive studies on the effect of invasive plant species on pollinators should be conducted.

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## 8. APPENDICES

### Appendix I: Calculation of Shannon- winner diversity index (H) and Pielou's species evenness (J) in the region.

S.No.	Scientific Name	Frequency	Pi	ln Pi	Pi lnPi
1	<i>Vanessa cardui</i>	116	0.045941	-3.08041	-0.14151569
2	<i>Vanessa indica</i>	67	0.026535	-3.6293	-0.09630232
3	<i>Aglais cashmirensis</i>	56	0.022178	-3.80864	-0.08446895
4	<i>Precis iphita</i>	63	0.02495	-3.69086	-0.09208882
5	<i>Precis almanac</i>	32	0.012673	-4.36826	-0.05536013
6	<i>Neptis hylas</i>	43	0.01703	-4.0728	-0.06935851
7	<i>Junonia atlites</i>	40	0.015842	-4.14512	-0.06566522
8	<i>Symbrenthia lilaea</i>	21	0.008317	-4.78947	-0.03983325
9	<i>Aridne merione</i>	75	0.029703	-3.51651	-0.10445074
10	<i>Neptis cartica</i>	61	0.024158	-3.72312	-0.08994474
11	<i>Phalanta phalantha</i>	36	0.014257	-4.25048	-0.06060087
12	<i>Childrena childreni</i>	88	0.034851	-3.35666	-0.11698457
13	<i>Cethosia cyane</i>	22	0.008713	-4.74295	-0.04132475
14	<i>Neptis armandia</i>	53	0.02099	-3.8637	-0.08109954
15	<i>Cupha erymanthis</i>	49	0.019406	-3.94218	-0.07650163
16	<i>Cethosia biblis</i>	41	0.016238	-4.12042	-0.0669059
17	<i>Abisara fylla</i>	10	0.00396	-5.53141	-0.02190658
18	<i>Zizeeria maha</i>	183	0.072475	-2.62451	-0.19021203

19	<i>Prosotas dubiosa</i>	17	0.006733	-5.00078	-0.03366864
20	<i>Jamides celeno</i>	23	0.009109	-4.6985	-0.04279824
21	<i>Euchrysops cnejus</i>	20	0.007921	-4.83826	-0.03832288
22	<i>Jamides alecto</i>	7	0.002772	-5.88809	-0.01632341
23	<i>Heliophorus indicus</i>	16	0.006337	-5.06141	-0.03207229
24	<i>Zizina Otis</i>	71	0.028119	-3.57132	-0.10042118
25	<i>Pratapa icetas</i>	10	0.00396	-5.53141	-0.02190658
26	<i>Pieris brassicae</i>	109	0.043168	-3.14265	-0.13566284
27	<i>Pieris canidia</i>	93	0.036832	-3.3014	-0.121596
28	<i>Vagrans egista</i>	57	0.022574	-3.79095	-0.08557777
29	<i>Eurema blanda</i>	59	0.023366	-3.75646	-0.08777468
30	<i>Pareronia valeria</i>	28	0.011089	-4.50179	-0.04992086
31	<i>Catopsilia Pomona</i>	31	0.012277	-4.40001	-0.05401991
32	<i>Colias fieldii</i>	35	0.013861	-4.27865	-0.059308
33	<i>Eurema hecabe</i>	59	0.023366	-3.75646	-0.08777468
34	<i>Delias acalis</i>	54	0.021386	-3.84501	-0.08222997
35	<i>Papilio helenus</i>	11	0.004356	-5.4361	-0.02368202
36	<i>Delias acalis</i>	17	0.006733	-5.00078	-0.03366864
37	<i>Graphium cloanthus</i>	64	0.025347	-3.67511	-0.09315139
38	<i>Papilio polytes</i>	37	0.014653	-4.22308	-0.06188273
39	<i>Danaus chrysippus</i>	75	0.029703	-3.51651	-0.10445074
40	<i>Danaus genutia</i>	72	0.028515	-3.55733	-0.10143674
41	<i>Euploea core</i>	60	0.023762	-3.73965	-0.08886301

42	<i>Parantica aglea</i>	45	0.017822	-4.02733	-0.07177427
43	<i>Euploea mulciber</i>	39	0.015446	-4.17043	-0.06441463
44	<i>Parnara guttata</i>	13	0.005149	-5.26905	-0.02712777
45	<i>Iambrix salsala</i>	23	0.009109	-4.6985	-0.04279824
46	<i>Udaspes folus</i>	7	0.002772	-5.88809	-0.01632341
47	<i>Borbo bevani</i>	16	0.006337	-5.06141	-0.03207229
48	<i>Notocrypta feisthamelii</i>	24	0.009505	-4.65594	-0.0442545
49	<i>Pelopidas sinensis</i>	8	0.003168	-5.75455	-0.01823225
50	<i>Ypthima newara</i>	22	0.008713	-4.74295	-0.04132475
51	<i>Melanitis leda</i>	27	0.010693	-4.53816	-0.04852685
52	<i>Lethe confuse</i>	36	0.014257	-4.25048	-0.06060087
53	<i>Ypthima asterope</i>	25	0.009901	-4.61512	-0.04569426
54	<i>Mycalesis heri</i>	37	0.014653	-4.22308	-0.06188273
55	<i>Ypthima confuse</i>	37	0.014653	-4.22308	-0.06188273
56	<i>Lethe verma</i>	28	0.011089	-4.50179	-0.04992086
57	<i>Libythea myrrha</i>	7	0.002772	-5.88809	-0.01632341
58	<i>Acraea issoria</i>	50	0.019802	-3.92197	-0.07766284
				-3.83185409	
				<b>H'=3.83185409</b>	
				<b>J=0.94</b>	

**Appendix II: Calculation of Shannon Winner diversity Index and Pielou's species evenness and similarity index in agricultural land**

S.No.	Scientific Name	Frequency	Pi	ln Pi	Pi lnPi
1	<i>Vanessa cardui</i>	22	0.045455	-3.09104	-0.1405
2	<i>Vanessa indica</i>	25	0.051653	-2.96321	-0.15306
3	<i>Aglais cashmirensis</i>	13	0.02686	-3.61714	-0.09715
4	<i>Precis iphita</i>	8	0.016529	-4.10264	-0.06781
5	<i>Symbrenthia lilaea</i>	8	0.016529	-4.10264	-0.06781
6	<i>Aridne merione</i>	18	0.03719	-3.29171	-0.12242
7	<i>Neptis cartica</i>	9	0.018595	-3.98486	-0.0741
8	<i>Phalanta phalantha</i>	9	0.018595	-3.98486	-0.0741
9	<i>childrena childreni</i>	8	0.016529	-4.10264	-0.06781
10	<i>Neptis armandia</i>	10	0.020661	-3.8795	-0.08015
11	<i>Cupha erymanthis</i>	6	0.012397	-4.39033	-0.05443
12	<i>Cethosia biblis</i>	7	0.014463	-4.23617	-0.06127
13	<i>Abisara fylla</i>	4	0.008264	-4.79579	-0.03963
14	<i>Zizeeria maha</i>	20	0.041322	-3.18635	-0.13167
15	<i>Prosotas dubiosa</i>	6	0.012397	-4.39033	-0.05443
16	<i>Jamides celeno</i>	7	0.014463	-4.23617	-0.06127
17	<i>Euchrysops cnejus</i>	5	0.010331	-4.57265	-0.04724
18	<i>Jamides alecto</i>	1	0.002066	-6.18208	-0.01277
19	<i>Heliophorus indicus</i>	3	0.006198	-5.08347	-0.03151
20	<i>Zizina Otis</i>	20	0.041322	-3.18635	-0.13167

21	<i>Pratapa icetas</i>	3	0.006198	-5.08347	-0.03151
22	<i>Pieris brassicae</i>	53	0.109504	-2.21179	-0.2422
23	<i>Pieris canidia</i>	26	0.053719	-2.92399	-0.15707
24	<i>Eurema blanda</i>	18	0.03719	-3.29171	-0.12242
25	<i>Danaus chrysippus</i>	15	0.030992	-3.47403	-0.10767
26	<i>Danaus genutia</i>	18	0.03719	-3.29171	-0.12242
27	<i>Euploea core</i>	26	0.053719	-2.92399	-0.15707
28	<i>Parantica aglea</i>	16	0.033058	-3.4095	-0.11271
29	<i>Euploea mulciber</i>	20	0.041322	-3.18635	-0.13167
30	<i>Parnara guttata</i>	6	0.012397	-4.39033	-0.05443
31	<i>Iambrix salsala</i>	9	0.018595	-3.98486	-0.0741
32	<i>Udaspes folus</i>	3	0.006198	-5.08347	-0.03151
33	<i>Cethosia cyane</i>	22	0.045455	-3.09104	-0.1405
34	<i>Junonia atlites</i>	40	0.082645	-2.49321	-0.20605
<b>Total</b>	<b>484</b>			<b>-3.26212</b>	
<b>H'=3.26212</b>					
<b>J=0.93</b>					

**Appendix III: Calculation of Shannon Winner diversity Index and Pielou's  
species evenness index in forest**

S.No.	Scientific Name	Frequency	Pi	ln Pi	Pi lnPi
1	<i>Vanessa cardui</i>	94	0.05572	-2.88741	-0.16089
2	<i>Vanessa indica</i>	42	0.024896	-3.69304	-0.09194
3	<i>Aglais cashmirensis</i>	43	0.025489	-3.66951	-0.09353
4	<i>Precis iphita</i>	55	0.032602	-3.42337	-0.11161
5	<i>Symbrenthia lilaea</i>	13	0.007706	-4.86576	-0.0375
6	<i>Aridne merione</i>	57	0.033788	-3.38766	-0.11446
7	<i>Neptis cartica</i>	52	0.030824	-3.47946	-0.10725
8	<i>Phalanta phalantha</i>	27	0.016005	-4.13487	-0.06618
9	<i>childrena childreni</i>	80	0.047421	-3.04868	-0.14457
10	<i>Neptis armandia</i>	43	0.025489	-3.66951	-0.09353
11	<i>Cupha erymanthis</i>	37	0.021932	-3.81979	-0.08378
12	<i>Cethosia biblis</i>	34	0.020154	-3.90435	-0.07869
13	<i>Abisara fylla</i>	6	0.003557	-5.63895	-0.02006
14	<i>Zizeeria maha</i>	163	0.096621	-2.33696	-0.2258
15	<i>Prosotas dubiosa</i>	11	0.00652	-5.03281	-0.03282
16	<i>Jamides celeno</i>	16	0.009484	-4.65812	-0.04418
17	<i>Euchrysops cnejus</i>	15	0.008892	-4.72266	-0.04199
18	<i>Jamides alecto</i>	6	0.003557	-5.63895	-0.02006
19	<i>Heliophorus indicus</i>	13	0.007706	-4.86576	-0.0375
20	<i>Zizina otis</i>	51	0.030231	-3.49888	-0.10578

21	<i>Pratapa icetas</i>	7	0.004149	-5.4848	-0.02276
22	<i>Pieris brassicae</i>	56	0.033195	-3.40536	-0.11304
23	<i>Pieris canidia</i>	67	0.039715	-3.22601	-0.12812
24	<i>Vagrans egista</i>	39	0.023118	-3.76715	-0.08709
25	<i>Eurema blanda</i>	41	0.024303	-3.71714	-0.09034
26	<i>Pareronia valeria</i>	16	0.009484	-4.65812	-0.04418
27	<i>Catopsilia Pomona</i>	20	0.011855	-4.43497	-0.05258
28	<i>Colias fieldii</i>	19	0.011263	-4.48627	-0.05053
29	<i>Eurema hecabe</i>	38	0.022525	-3.79312	-0.08544
30	<i>Delias acalis</i>	11	0.00652	-5.03281	-0.03282
31	<i>Papilio helenus</i>	4	0.002371	-6.04441	-0.01433
32	<i>Delias acalis</i>	10	0.005928	-5.12812	-0.0304
33	<i>Graphium cloanthus</i>	47	0.02786	-3.58056	-0.09975
34	<i>Papilio polytes</i>	29	0.01719	-4.06341	-0.06985
35	<i>Danaus chrysippus</i>	60	0.035566	-3.33636	-0.11866
36	<i>Danaus genutia</i>	54	0.032009	-3.44172	-0.11017
37	<i>Euploea core</i>	34	0.020154	-3.90435	-0.07869
38	<i>Parantica aglea</i>	29	0.01719	-4.06341	-0.06985
39	<i>Euploea mulciber</i>	19	0.011263	-4.48627	-0.05053
40	<i>Parnara guttata</i>	7	0.004149	-5.4848	-0.02276
41	<i>Iambrix salsala</i>	14	0.008299	-4.79165	-0.03976
42	<i>Udaspes folus</i>	4	0.002371	-6.04441	-0.01433
43	<i>Borbo bevani</i>	8	0.004742	-5.35127	-0.02538

44	<i>Notocrypta feisthamelii</i>	12	0.007113	-4.9458	-0.03518
45	<i>Pelopidas sinensis</i>	4	0.002371	-6.04441	-0.01433
46	<i>Ypthima newara</i>	11	0.00652	-5.03281	-0.03282
47	<i>Melanitis leda</i>	13	0.007706	-4.86576	-0.0375
48	<i>Lethe confusa</i>	18	0.01067	-4.54034	-0.04844
49	<i>Ypthima asterope</i>	13	0.007706	-4.86576	-0.0375
50	<i>Mycalesis heri</i>	19	0.011263	-4.48627	-0.05053
51	<i>Ypthima confusa</i>	17	0.010077	-4.59749	-0.04633
52	<i>Lethe verma</i>	15	0.008892	-4.72266	-0.04199
53	<i>Libythea myrrha</i>	4	0.002371	-6.04441	-0.01433
54	<i>Acraea issoria</i>	32	0.018969	-3.96497	-0.07521
55	<i>Neptis hylas</i>	22	0.013041	-4.33966	-0.05659
56	<i>Precis almanac</i>	16	0.009484	-4.65812	-0.04418
<b>Total</b>		1687	<b>-3.69838</b>		
<b>H= 3.69838</b>					
<b>J=0.92</b>					

**Appendix IV: Calculation of Shannon Winner diversity Index and Pielou's species evenness and similarity index in rainy season**

S.No	Name of the species	Frequency	Pi	ln pi	pi lnpi
1.	<i>Euchrysops cnejus</i>	34	0.023255814	-3.761200116	-0.08746977
2.	<i>Phalanta phalantha</i>	23	0.015731874	-4.152066424	-0.065319786
3.	<i>Pieris brassicae</i>	56	0.038303694	-3.26220895	-0.124954652
4.	<i>Piersis canidia</i>	32	0.021887825	-3.821824738	-0.083651431
5.	<i>Precis iphita</i>	59	0.040355677	-3.210023196	-0.12954266
6.	<i>Jamides alecto</i>	64	0.04377565	-3.128677557	-0.136959893
7.	<i>Parantica aglea</i>	13	0.008891929	-4.722611283	-0.041993124
8.	<i>Colias fiedii</i>	54	0.036935705	-3.298576594	-0.12183525
9.	<i>Parnara guttata</i>	9	0.006155951	-5.090336063	-0.031335858
10.	<i>Precis almanac</i>	49	0.033515732	-3.395740342	-0.113810723
11.	<i>Vanessa cardui</i>	38	0.025991792	-3.649974481	-0.094869378
12.	<i>Vanessa indica</i>	28	0.019151847	-3.95535613	-0.075752375
13.	<i>Catopsilia pomona</i>	39	0.026675787	-3.623998994	-0.096673024
14.	<i>Prosotas dubiosa</i>	40	0.027359781	-3.598681186	-0.09845913
15.	<i>Notocrypta feisthamelii</i>	47	0.032147743	-3.437413039	-0.11050507
16.	<i>Vagrans egista</i>	45	0.030779754	-3.480898151	-0.107141188
17.	<i>Symbrenthia lilaea</i>	20	0.013679891	-4.291828367	-0.058711742
18.	<i>Heliophorus indicus</i>	20	0.013679891	-4.291828367	-0.058711742
19.	<i>Jamides celeno</i>	32	0.021887825	-3.821824738	-0.083651431
20.	<i>Zizina Otis</i>	10	0.006839945	-4.984975547	-0.03409696

21.	<i>Ariadne merione</i>	26	0.017783858	-4.029464102	-0.071659416
22.	<i>Udaspes folus</i>	53	0.03625171	-3.317268727	-0.120256664
23.	<i>Ypthima newara</i>	16	0.010943912	-4.514971918	-0.049411457
24.	<i>Zizeeria maha</i>	36	0.024623803	-3.704041702	-0.091207593
25.	<i>Melanitis leda</i>	19	0.012995896	-4.343121661	-0.056442758
26.	<i>Euploea core</i>	13	0.008891929	-4.722611283	-0.041993124
27.	<i>Abisara fylla</i>	56	0.038303694	-3.26220895	-0.124954652
28.	<i>Acraea issoria</i>	43	0.029411765	-3.526360525	-0.103716486
29.	<i>Eurema blanda</i>	21	0.014363885	-4.243038203	-0.060946513
30.	<i>Lethe confusa</i>	26	0.045827633	-3.082868021	-0.141280545
31.	<i>Neptis cartica</i>	43	0.029411765	-3.526360525	-0.103716486
32.	<i>Eurema hecabe</i>	18	0.012311902	-4.397188882	-0.054137756
33.	<i>Libythea myrrha</i>	54	0.036935705	-3.298576594	-0.12183525
34.	<i>Mycalesis heri</i>	25	0.017099863	-4.068684815	-0.069573954
35.	<i>Junonia atlites</i>	30	0.020519836	-3.886363259	-0.079747536
36.	<i>Cethosia biblis</i>	31	0.02120383	-3.853573436	-0.081710517
37.	<i>Cupha erymanthis</i>	24	0.016415869	-4.10950681	-0.067461124
38.	<i>neptis hyla</i>	67	0.045827633	-3.082868021	-0.141280545
39.	<i>ypthima confusa</i>	54	0.036935705	-3.298576594	-0.12183525
40.	<i>neptis armandia</i>	35	0.023939808	-3.732212579	-0.089348454
41.	<i>pareronia valerie</i>	47	0.032147743	-3.437413039	-0.11050507
42.	<i>Mycalesis heri</i>	32	0.021887825	-3.821824738	-0.083651431
43.	<i>Danaus genutia</i>	43	0.029411765	-3.526360525	-0.103716486

44	<i>Danaus chrysippus</i>	53	0.03625171	-3.317268727	-0.120256664	
45	<i>Papilio helenus</i>	56	0.038303694	-3.26220895	-0.124954652	
46	<i>Euploea mulciber</i>	26	0.017783858	-4.029464102	-0.071659416	
47	<i>Lethe verma</i>	49	0.033515732	-3.395740342	-0.113810723	
48	<i>childrena childreni</i>	58	0.039671683	-3.22711763	-0.128025186	
49	<i>pelopidas sinensis</i>	43	0.029411765	-3.526360525	-0.103716486	
50	<i>pratapa icetas</i>	36	0.024623803	-3.704041702	-0.091207593	
51	<i>Delias acalis</i>	54	0.036935705	-3.298576594	-0.12183525	
52	<i>Papilio bootes</i>	11	0.00752394	-4.889665368	-0.036789548	
53	<i>graphium cloanthus</i>	19	0.012995896	-4.343121661	-0.056442758	
54	<i>euploea core</i>	27	0.018467852	-3.991723774	-0.073718565	
55.	<i>Aglais cashmirensis</i>	54	0.036935705	-3.298576594	-0.12183525	
		<b>1462</b>			<b>-3.68</b>	
			<b>H'=3.68</b>			
			<b>J=0.43</b>			

**Appendix V: Calculation of Shannon Winner diversity Index and Pielou's species evenness and similarity index in autumn.**

SN	name of species	Frequency	Pi	ln pi	pi lnpi
1	<i>Libythea myrrha</i>	40	0.032102729	-3.438814245	-0.110395321
2	<i>Borbo bevani</i>	47	0.037720706	-3.277546098	-0.123631354
3	<i>Iambrix salsala</i>	45	0.03611557	-3.32103121	-0.119940935
4	<i>Euchrysops cnejus</i>	20	0.016051364	-4.131961426	-0.066323618
5	<i>Phalanta phalantha</i>	20	0.016051364	-4.131961426	-0.066323618
6	<i>Pieris brassicae</i>	32	0.025682183	-3.661957797	-0.09404707
7	<i>Piersis canidia</i>	10	0.008025682	-4.825108606	-0.038724788
8	<i>Precis iphita</i>	26	0.020866774	-3.869597161	-0.080746008
9	<i>Jamides alecto</i>	53	0.042536116	-3.157401786	-0.134303607
10	<i>Parantica aglea</i>	16	0.012841091	-4.355104977	-0.055924301
11	<i>Colias fiedii</i>	36	0.028892456	-3.544174761	-0.102399913
12	<i>Euchrysops cnejus</i>	19	0.015248796	-4.18325472	-0.063789598
13	<i>Phalanta phalantha</i>	13	0.010433387	-4.562744342	-0.047604877
14	<i>Pieris brassicae</i>	25	0.020064205	-3.908817874	-0.078427325
15	<i>Piersis canidia</i>	30	0.024077047	-3.726496318	-0.089723025
16	<i>Precis iphita</i>	31	0.024879615	-3.693706495	-0.091897995
17	<i>Jamides alecto</i>	24	0.019261637	-3.949639869	-0.07607653
18	<i>Parantica aglea</i>	72	0.053772071	-2.92300108	-0.157175821

19	<i>Colias fiedii</i>	54	0.043338684	-3.138709653	-0.136027545
20	<i>Parnara guttata</i>	35	0.028089888	-3.572345638	-0.100346788
21	<i>Precis almanac</i>	47	0.037720706	-3.277546098	-0.123631354
22	<i>Vanessa cardui</i>	32	0.025682183	-3.661957797	-0.09404707
23	<i>Vanessa indica</i>	43	0.034510433	-3.366493584	-0.116179153
24	<i>Catopsilia pomona</i>	53	0.042536116	-3.157401786	-0.134303607
25	<i>Notocrypta feisthamelii</i>	56	0.04494382	-3.102342009	-0.139431102
26	<i>Vagrans egista</i>	26	0.020866774	-3.869597161	-0.080746008
27	<i>Symbrenthia lilaea</i>	49	0.039325843	-3.235873401	-0.127253448
28	<i>Heliophorus indicus</i>	58	0.046548957	-3.067250689	-0.142777319
29	<i>Jamides celeno</i>	43	0.034510433	-3.366493584	-0.116179153
30	<i>Zizina otis</i>	36	0.028892456	-3.544174761	-0.102399913
31	<i>Ariadne merione</i>	54	0.043338684	-3.138709653	-0.136027545
32	<i>Udaspes folus</i>	32	0.025682183	-3.661957797	-0.09404707
33	<i>Ypthima newara</i>	12	0.009630819	-4.64278705	-0.04471384
34	<i>Zizeeria maha</i>	17	0.01364366	-4.294480355	-0.058592429
35	<i>Melanitis leda</i>	24	0.019261637	-3.949639869	-0.07607653
36	<i>Euploea core</i>	21	0.016853933	-4.083171262	-0.068817493
					<b>-3.25</b>
			<b>H' = 3.25</b>		
		<b>1063</b>	<b>J = 0.47</b>		

## 9. PHOTO PLATES



*Eurema hecabe*



*Catopsilia Pomona*



*Zizina ottis*



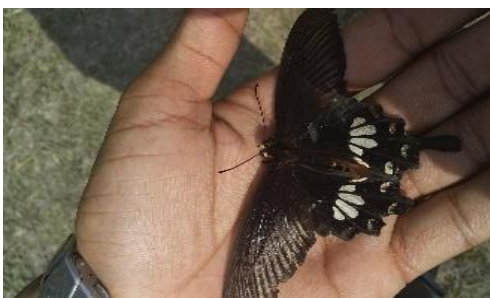
*Precis iphita*



*Junonia atlites*



*Phalanta phalantha*



*Papilio polytes*



*Aglais cashmirensis*



*Mycalesis heri*



*Danaus chrysippus*



*Acraea issoria*



*Zizeeria maha*



*Graphium cloanthus*



*Parnara guttata*



*Ypthima asterope*



*Pieris brassicae*



*Precis almanac*



*Neptis armandia*



*Eurema blanda*



*Neptis cartica*



*Danaus genutia*



*Euchrysops cnejus*



*Colias fieldii*

