Butterfly Species Diversity in Betana Wetland, Belbari, Morang, Nepal

Financially Supported by the Research Management Cell of Sukuna Multiple Campus

Submitted To:

Research Management Cell (RMC-Sukuna)

Sukuna Multiple Campus

Sundarharaincha, Morang, Nepal

Submitted By:

Kishor Dahal

Teaching Assistant

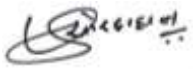
Faculty of Science & Technology

Sukuna Multiple Campus

2025

Declaration

I hereby declare that the work presented in this research report has been done by myself, and has not been submitted elsewhere for the award of any degree. This research report would not be used any other context except in the Research Management Cell (RMC-Sukuna) because of its financial support. All the sources of information have been specifically acknowledged by reference to the authors or institutions.



Date: 01 March 2025 Kishor Dahal

Date: 3 March 2025

To

The RMC Head,

Sukuna Multiple Campus

Sundarharaincha, Morang

Subject: Plagiarism Free Self-Declaration

Dear Sir/Ma'am,

I hereby affirm that there exists no disparity in the substance of the physical print and digital version of the document specified below, which has been submitted to this establishment for the purpose of undergoing a plagiarism examination. If any dissimilarity is discovered between the physical print and digital version, I am prepared to accept any consequences as per the established regulations.

Details

Author Name: Kishor Dahal

Document Title: Butterfly Species Diversity in Betana Wetland, Belbari, Morang, Nepal

Faculty: Science & Technology

Document Type: Mini-Research

Submitted To: Research Management Cell (RMC-Sukuna), Sundarharaincha, Morang, Nepal

Mobile No: 9852034922

Email: kishordahal47@gmail.com

Signature:

Designation: Teaching Assistant

Name of the Campus: Sukuna Multiple Campus

Address of the Campus: Sundarharaincha, Morang, Nepal

Copy Right

Acknowledgements

I would like to express my sincere gratitude to the Resource Management Cell (RMC) of Sukuna Multiple Campus for providing me with this grant for mini-research.

I would like to extend my special thanks to the campus chief, Mr. Arjunraj Adhikari, and the chairperson of RMC, Ganesh Prasad Dahal, for their kind suggestions and encouragement.

I wish to express my sincere appreciation and profound respect to Mr. Shambhu Bhattarai, the current Chairperson, and the entire team of Betana Wetland along with the entire team of Betana Wetland, for generously granting me access to the research field, as well as to Mr. Dambar Basnet, the former Chairperson, for his invaluable support during the initiation of my work.

I am thankful to Mr. Nara Prasad Bhandari for his advice, support, guidance, motivation, and constant support throughout my studies.

I express my sincere gratitude to Professor Dr. Bhaiya Khanal, Nepal's renowned butterfly specialist, for his guidance, and final evaluation of my mini-research. His feedback, encouragement, and insights played were crucial for shaping my work. I am sincerely grateful for his mentorship and for his contribution for the quality enhancement of my mini-research.

I am deeply grateful to Ashma Khatiwada for her fieldwork support, Mr. Bimal Raj Shrestha for his assistance with species identification, and Mr. Dibya Raj Dahal for his encouragement, moral support, and help throughout the writing of this mini-research.

Kishor Dahal

kishordahal47@gmail.com

त्रिभुवन विश्वविद्यालयद्वारा सम्बन्धनप्राप्त
AFFILIATED TO TRIBHUVAN UNIVERSITY
सुकुना बहुमुखी क्याम्पस
SUKUNA MULTIPLE CAMPUS
सुन्दरहरैंचा नगरपालिका, मोरङ, कोशी प्रदेश, नेपाल
SUNDARHARAINCHA MUNICIPALITY, MORANG, KOSHI PROVINCE, NEPAL
स्था: २०४८ (ESTD. 1992)
विश्वविद्यालय अनुदान आयोग नेपालद्वारा गुणस्तर प्रत्यायनकृत (२०८१)
Accredited by University Grants Commission (UGC) Nepal (2024)

प.सं/च.नं. :
(Ref No.):

Date: 4th March 2025

Plagiarism Test Report

The mini-research, entitled **"Butterfly Species Diversity in Betana Wetland, Belbari, Morang, Nepal"** submitted by **Mr. KISHOR DAHAL** for a plagiarism test on 4 March 2025, has been checked by the iThenticate plagiarism checker software. The software found an overall similarity index of **4%** based on the following criteria.

Criteria

Phrases: Excluded
Quotes: Excluded
Bibliography: Excluded
Small Sources: Percentage (< 1 %)
Small Match: Word Count (< 8 words)
Abstract: Included
Methods and Materials: Included

Note:

Kindly be advised that the similarity index produced by software may not comprehensively reflect the caliber and criteria of the document. Consequently, it is highly advisable for the appropriate authority to manually assess the examined file to ascertain its adherence to the essential benchmarks of being articulate, well investigated, and upholding academic integrity.

RMC Head
Ganesh Prasad Dahal

E-mail: sukunamc2048@gmail.com, info@sukuna.edu.np website: www.sukuna.edu.np
फोन: ०२१-५४७६१७, ०२१-५४७७१७, ९८५२०४५६१७

iThenticate

Similarity Report ID: oid:3117:436152440

PAPER NAME

Butterfly Species Diversity in Betana Wet land, Belbari, Morang, Nepal

AUTHOR

Kishor Dahal

WORD COUNT

4957 Words

CHARACTER COUNT

28317 Characters

PAGE COUNT

26 Pages

FILE SIZE

941.0KB

SUBMISSION DATE

Mar 4, 2025 2:51 PM GMT+5:45

REPORT DATE

Mar 4, 2025 2:51 PM GMT+5:45

4% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

- 4% Internet database
- 1% Publications database
- Crossref database
- Crossref Posted Content database
- 0% Submitted Works database

Excluded from Similarity Report

- Bibliographic material
- Quoted material
- Cited material
- Small Matches (Less then 8 words)
- Manually excluded text blocks

RMC Head
Ganesh Prasad Dahal

त्रिभुवन विश्वविद्यालयद्वारा सम्बन्धनप्राप्त
AFFILIATED TO TRIBHUVAN UNIVERSITY
सुकुना बहुमुखी क्याम्पस
SUKUNA MULTIPLE CAMPUS
सुन्दरहरैंचा नगरपालिका, मोरङ, कोशी प्रदेश, नेपाल
SUNDARHARAINCHA MUNICIPALITY, MORANG, KOSHI PROVINCE, NEPAL
स्था: २०४८ (ESTD. 1992)
विश्वविद्यालय अनुदान आयोग नेपालद्वारा गुणस्तर प्रत्यायनकृत (२०८१)
Accredited by University Grants Commission (UGC) Nepal (2024)

च.सं./च.नं. :
(Ref No.):

Recommendation

This is to recommend that the research report entitled **"Butterfly Species Diversity in Betana Wetland, Belbari, Morang, Nepal"** has been carried out by Mr. Kishor Dahal, a Teaching Assistant at Sukuna Multiple Campus, under my supervision.

To the best of my knowledge, this is his original work, which has been rigorously tested for plagiarism by iThenticate software and has passed with a similarity index of just 4%, affirming its originality and adherence to academic integrity.

Mr. Dahal's research report is thorough and well-executed, providing significant insights into the butterfly species richness and abundance in Betana Wetland. The methodology, analysis, and presentation of findings are of high quality, making this report a valuable contribution to the field of wildlife conservation.

I am pleased to recommend this report to the Research Management Cell of Sukuna Multiple Campus for final approval.

Nara Prasad Bhandari
Research Facilitator
Member, RMC-Sukuna
Date: 09 March 2025

E-mail: sukunamc2048@gmail.com, info@sukuna.edu.np website: www.sukuna.edu.np
फोन: ०२१-५४६६१७, ०२१-५४६६१७, ९८५२०४५६१७

त्रिभुवन विश्वविद्यालयद्वारा सम्बन्धनप्राप्त
AFFILIATED TO TRIBHUVAN UNIVERSITY
सुकुना बहुमुखी क्याम्पस
SUKUNA MULTIPLE CAMPUS
सुन्दरहरैंचा नगरपालिका, मोरङ, कोशी प्रदेश, नेपाल
SUNDARHARAINCHA MUNICIPALITY, MORANG, KOSHI PROVINCE, NEPAL
स्था: २०४८ (ESTD. 1992)
विश्वविद्यालय अनुदान आयोग नेपालद्वारा गुणस्तर प्रत्यायनकृत (२०८१)
Accredited by University Grants Commission (UGC) Nepal (2024)

च.नं./च.नं. :
(Ref No.):

Letter of Approval

This research report submitted by Mr. Kishor Dahal entitled **"Butterfly Species Diversity in Betana Wetland, Belbari, Morang, Nepal"** is funded and approved by the Research Management Cell (RMC-Sukuna) of Sukuna Multiple Campus, Sundarharaincha, Morang.

Committee

1. Ganesh Prasad Dahal
   Head of the RMC-Sukuna

2. Nara Prasad Bhandari
   Member, RMC-Sukuna
   (Research Facilitator)

3. Dipak Prasad Neupane, PhD
   Member, RMC-Sukuna
   Date: 10 March 2025

E-mail: sukunamc2048@gmail.com, info@sukuna.edu.np website: www.sukuna.edu.np
फोन: ०२१-५४६६१७, ०२१-५४६६१७, ९८५२०८५६१७

त्रिभुवन विश्वविद्यालयद्वारा सम्बन्धनप्राप्त
AFFILIATED TO TRIBHUVAN UNIVERSITY
सुकुना बहुमुखी क्याम्पस
SUKUNA MULTIPLE CAMPUS
सुन्दरहरैंचा नगरपालिका, मोरङ, कोशी प्रदेश, नेपाल
SUNDARHARAINCHA MUNICIPALITY, MORANG, KOSHI PROVINCE, NEPAL
स्था: २०४८ (ESTD. 1992)
विश्वविद्यालय अनुदान आयोग नेपालद्वारा गुणस्तर प्रत्यायनकृत (२०८१)
Accredited by University Grants Commission (UGC) Nepal (2024)

प.सं/च.नं. :
(Ref No.):

Thanking Letter

I would like to express my heartfelt thanks to Mr. Kishor Dahal for his invaluable contribution to the research report entitled **"Butterfly Species Diversity in Betana Wetland, Belbari, Morang, Nepal."** Mr. Dahal's dedication and hard work have been instrumental in the successful completion of this project, and we are truly appreciative of his efforts.

The mini-research has been financially supported by RMC-Sukuna, and we are confident that the findings of this report will significantly contribute to our academic community. As such, the research report will be considered valuable campus academic property.

Once again, thank you for your hard work, dedication, and commitment to this project. Lastly we are proud to have him as a part of our campus community. We look forward to continuing our collaboration on future projects.

Date: 10 March 2025

Arjun Raj Adhikari
Campus Chief
Sukuna Multiple Campus
Sundarharaincha, Morang, Nepal

Campus Chief

E-mail: sukunamc2048@gmail.com, info@sukuna.edu.np website: www.sukuna.edu.np
फोन: ०२१-५४७६१७, ०२१-५४७७१७, ९८५२०४५६१७

Abstract

Butterflies are attractive insects that have aesthetic value and are biological indicators, as they are highly sensitive to changes in environmental conditions. The study was conducted to document the species diversity and abundance of butterflies in the Betana wetland, Belbari, Morang, Nepal, from March to May 2024, using line transects and the Pollard walk methods. Three transect routes, each 500 meters in length, were designed and observed on sunny days. A total of 1124 butterfly individuals, representing 65 species, 43 genera, 14 subfamilies, and six families, were recorded. The Nymphalidae family showed the highest species richness (28 species), followed by Lycaenidae (12), Pieridae (9), Papilionidae (8), Hesperiidae (7), and least by Riodinidae (1). The family Nymphalidae, with 543 species, had the highest butterfly abundance, while Riodinidae, with 14 species, showed the lowest abundance. The Shannon Diversity Index (H = 3.60), Pielou's Evenness (E = 0.86), and Margalef's Richness Index (D = 9.11) indicated a high level of butterfly diversity, a balanced community, and a stable ecosystem in the study area. The results of the present study could be a foundational reference for future butterfly research in the Betana wetland of Belbari, Morang, Nepal.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

°C	Degree Celsius
et al.	and others
GPS	Global Positioning System
i.e.	that is
SN	Serial Number
spp	Species

Introduction

Background

Butterflies are among the most thoroughly researched insect groups in terms of taxonomy (Sundufu & Dumbuya, 2008), and their colours and patterns make them excellent indicators of environmental changes (Mayur et al., 2013). Additionally, they have significant aesthetic and commercial value (Ahsan & Javaid, 1975), which has attracted global attention (Fjellstad, 1998).

Research on butterflies in Nepal has been ongoing since 1826 A.D. (Khanal & Smith, 1997; Smith, 2011). The order Lepidoptera includes approximately 150,000 species of moths and butterflies (New & Collins, 1991), with about 19,238 butterfly species found worldwide (Weiss et al., 1988), and Nepal alone has 692 species of butterflies across six families (Van der Poel & Smetacek, 2022). Butterfly distribution in Nepal varies across physiographic zones (Bhusal & Khanal, 2008); the Terai, midland, and highland ecological zones host 50%, 81%, and 13% of all butterflies, respectively (Smith, 2011).

Several butterfly species exhibit distinct seasonal behaviour and are restricted to particular habitats, while others are found consistently throughout the year (Kunte, 1997). Butterflies are reliable indicators (Simonson et al., 2001; Hamer et al., 2005) of both anthropogenic disruption and habitat quality (Kocher & Williams, 2000). There is increasing evidence suggesting that the distribution patterns of butterfly species worldwide are changing due to consistent global warming (Walther et al., 2002). Climate change and habitat degradation in Nepal, particularly in the agricultural field, due to soil erosion (Chalise et al., 2019). Globally, climate change affected rainfall patterns and temperature resulting in the shift range, seasonal behaviours, and a high risk of extinction (Dillon, 2010).

Butterflies exhibit a high sensitivity to fluctuations in temperature, humidity, and light conditions (Owen, 1971), and habitat degradation also significantly affects butterfly richness (Murphy et al., 1990). In Nepal, forest degradation, approximately 24.5% between 1990 and 2005 (FAO, 2006), also played a role in the decline in butterfly species.

Studies have shown that butterfly diversity and population sizes tend to be greater at the edges of forests (Lien, 2009) and in regenerating forests disturbed by human activity, characterised by high vegetation diversity and abundant flowering plants (Ghorai & Sengupta, 2014), compared to undisturbed natural forest environments (Lien & Yuan, 2003). Additionally, the presence of butterflies is influenced by factors such as habitat size and the composition of vegetation (Price, 1975).

Butterfly species diversity offers significant ecological benefits for native wild plant species and crops in various environments (Davis et al., 2008). They are primary pollinators of over 50 valuable crops, facilitating seed production and genetic diversity, and also support food chains (Borges et al., 2003). Hence, their conservation is crucial for maintaining the productivity of crops and natural plants.

Environmental factors and flight capabilities significantly influence the species richness and abundance of butterflies in a particular habitat. The present study, focused on butterfly richness and abundance, was conducted within the Betana wetland area in Belbari, Morang, Nepal.

Objectives

1. To study the butterfly species richness and abundance in the study area
2. To develop a detailed butterfly checklist from the Betana wetland, Belbari, Morang, Nepal

Justification of the study

The diversity of butterfly species in Betana Wetland, Belbari, Morang, Nepal, has not been studied, and no scientific papers on this topic have been published. Therefore, this study aims to explore and document the butterfly species richness and abundance in the area, developing a detailed checklist for future conservation efforts. The final documentation will be the property of the publisher and Sukuna Multiple Campus, providing valuable resources for students of science and technology.

Limitations of the study

The study's findings are limited by time constraints, as data collection occurred only during a single season and was limited exclusively to the Betana Wetland. Consequently, the generalizability of the results beyond this specific geographical area is restricted.

Literature Review

Previous research on butterflies has examined their diversity, distribution, and ecological significance. These studies offer valuable insights and form the foundation for understanding butterfly populations in different regions.

Hari (2020) conducted a butterfly survey using random sampling at Amrita Vishwa Vidyapeetham, Tamil Nadu, India, spanning from August 2013 to May 2017. The study documented 138 butterfly species across 104 genera and five families. Nymphalidae emerged as the most dominant family, followed by Lycaenidae, Hesperiidae, and Pieridae, while Papilionidae was found to be the least dominant during the study period.

The study of butterfly diversity and abundance was conducted in Byas municipality, Tanahun, Nepal, from March to November 2020 using the Pollard walk method. A total of 1753 individuals from 149 species were recorded, with Nymphalidae being the most diverse family and Riodinidae the least dominant (Miya et al., 2021).

Rahman & Maryati (2021) conducted a nine-day butterfly survey between October 2017 and March 2018 in Gunung Pulai Forest Reserve, Johor Darul Takzim, documenting 101 individuals across 61 species. The species richness of the families Nymphalidae and Riodinidae was found to be highest and lowest, respectively.

Samal et al. (2021) conducted a butterfly study in Bhubaneswar, Odisha, India, from July 2018 to August 2020. They utilized pollard walks, opportunistic surveys, and random sightings to collect data, identifying a total of 107 butterfly species across five families. The family that had recorded the highest number of species was Nymphalidae, with 34 species, followed by Lycaenidae with 27 species, Hesperiidae with 25 species, Pieridae with 12 species, and Papilionidae with just 9 species.

Sharma & Paudel (2021) carried out a butterfly survey in Kumakh Rural Municipality, in the northern part of Salyan District, using Pollard walk and random survey methods. They found that the family Nymphalidae (69%) was the most prevalent in the study area, followed by the families Lycaenidae (11%), Pieridae (9%), Hesperiidae (7%), and Papilionidae (4%), which was the least represented family.

Bisht et al. (2022), in an article published in the Asian Journal of Conservation Biology, used sweeping net and direct observation methods to record 2339 butterfly individuals across 51 species and five families. The most dominant family was Nymphalidae, followed by Pieridae, Lycaenidae, Papilionidae, and Hesperiidae. Pieridae had the highest species abundance with 921 individuals, while Hesperiidae had the lowest with 64 individuals.

Dar et al. (2022) conducted research on butterfly diversity along an elevational gradient in the Gulmarg region of Jammu and Kashmir. They used sweeping nets and photography techniques for data collection between March 2018 and November 2020. The study documented 2023 butterflies belonging to 40 species and 27 genera from five families. Nymphalidae was the most prevalent family, comprising 23 species, while Papilionidae and Hesperiidae were the least represented each with one species.

Hailay et al. (2022) conducted a butterfly survey in Gozamen Woreda, Amhara, Ethiopia, and sampled 1,023 individuals representing 44 species across five families. The Nymphalidae family exhibited the greatest species richness, comprising 23 species. In contrast, the Hesperiidae and Papilionidae families were the least represented each with only three species. Additionally, the Nymphalidae family had the highest abundance, with 321 individuals, while the Hesperiidae family had the lowest, with just 20 individuals.

Roy et al. (2022) conducted research on butterfly diversity and population in Dinhata subdivision, West Bengal, covering the period from June to November 2020. They identified a total of 40 butterfly species belonging to five different families. The family Nymphalidae was found to be the most prevalent, while Hesperiidae exhibited the lowest dominance.

Andrade et al. (2023) studied the butterfly community in the Brazilian Atlantic Forest from 2018 to 2019 using sweeping nets and bait traps. They observed a total of 1,253 butterfly individuals across 124 species and six families. The Nymphalidae family had the highest species richness, followed by Hesperiidae, Pieridae, Lycaenidae, and Papilionidae. The Riodinidae family was the least represented in terms of species.

Gajbe & Badiye (2023) conducted research on butterfly diversity in Nagpur City from July 2021 to November 2022 using photography. They documented a total of 2775 butterflies belonging to 38 species across five families. In their study, Nymphalidae had the highest number of species, followed by Lycaenidae, Pieridae, and Papilionidae. On the other hand, Hesperiidae showed the lowest species count among these families.

Gogoi et al. (2023) conducted a survey on butterfly diversity in the Soraipung range of Dehing Patkai National Park, Assam, India, and identified a total of 92 butterfly species under five families. The Nymphalidae family exhibited the highest species richness, followed by Papilionidae, Lycaenidae, and Hesperiidae. The Pieridae family was found to be the least dominant.

Joshi (2023) researched butterfly diversity in Bheemdatta municipality, Kanchanpur district, from April to November 2020, documenting 52 butterfly species. The family Nymphalidae dominated with 24 species, while the family Papilionidae had the least presence, with only four species recorded.

Mukherjee et al. (2023) documented a checklist of butterfly fauna in Ajodhya Hills, Purulia, West Bengal, India, identifying 143 species, 95 genera, and 19 subfamilies from six families. The family Nymphalidae was the most dominant, with 45 species, while the family Riodinidae had the least representation, with only one species.

Ningrum (2023) conducted a study on the diversity and ecological roles of butterfly species in PT Permata Sawit Mandiri, West Kalimantan. The research identified a total of 59 butterfly species from five different families. The Nymphalidae family was the most prevalent, comprising 37 species. This was followed by the Pieridae with 8 species, Lycaenidae with 7 species, Hesperiidae with 4 species, and the Papilionidae, which had the least species richness with just 3 species.

In a study conducted by Oli et al. (2023) at Kakrebihar, Surkhet, Nepal, they observed butterflies from January to December 2021 using the ocular point observation method. They documented a total of 431 individuals from 33 species, belonging to 24 different genera. The Nymphalidae family was found to be the most dominant, while the Hesperiidae family was the least represented.

Gupta & Kumar (2024) conducted a year-long survey on butterflies at Kurukshetra University Campus, Haryana. They recorded 710 butterflies spanning 39 species, 32 genera, and five families. Nymphalidae exhibited the highest species diversity, while Hesperiidae had the least species. Pieridae had the highest abundance with 158 individuals, whereas Hesperiidae had the lowest with just 4 individuals.

Sheng-Quan et al. (2024) conducted a survey of butterfly diversity at Chenggong Campus, Yunnan University, and identified 3625 individuals and 50 species across six families using the Pollard walk method.

Nymphalidae was the most species-rich family with 17 species, followed by Pieridae with 16 species, Papilionidae with 8 species, Lycaenidae with 4 species, and Hesperiidae with 3 species. Riodinidae was the least species-rich family, with only 2 species. In terms of abundance, Pieridae was the most abundant, followed by Nymphalidae, Lycaenidae, Papilionidae, and Hesperiidae. The Riodinidae family was the least abundant.

Materials and Methods

Study area

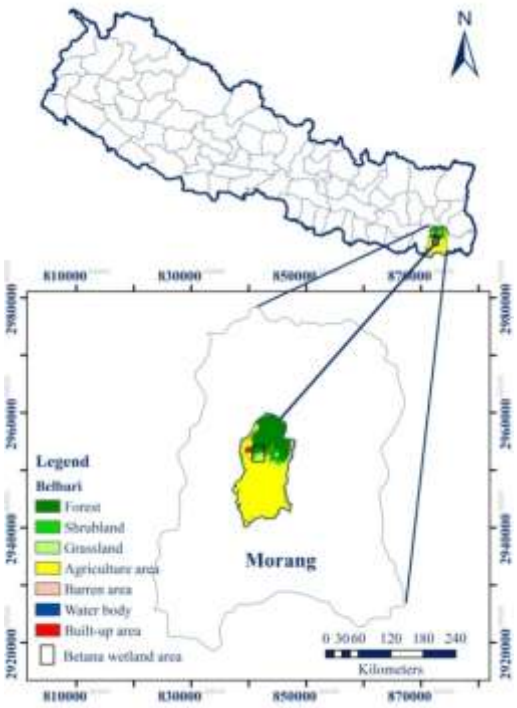
Location

The study was conducted in Betana Wetland, located in Belbari Municipality in the Morang District. It was situated on the north side of the highway, one kilometer east of Belbari Bazar. The wetland provided its natural water supply throughout the year. The study area was at a latitude of 26°39’ N and a longitude of 87°25’ E, covering 5.5 hectares of land and situated at an elevation of 123 meters above sea level (Adhikari et al., 2023).

The depth of the pond varied from 0.5 to 1.5 meters in the dry season and from 1 to 2.5 meters in the monsoon season (Rai, 2011). During the rainy season, as the water level increased, overflow was often drained out through artificial outlets constructed on the southern bank. It is well-known for being a great area for picnicking, boating, refreshing with nature, and other recreational activities. The average annual temperatures vary from a high of 30.6°C to a low of 14.6°C (Mandal et al., 2021).

Figure 1

Map of the study area



Flora

The wetland's forest area is predominantly composed of Sal (*Shorea robusta*) and Khair-Sissoo (*Acacia catechu*) forests. The grasslands feature a diverse range of damp grass species and wetland herbs, including Dubo (*Cynodon dactylon*), Kagat Mothe (*Cyperus papyrus*), Siru (*Imperata cylindrica*), Jhuse Jhar (*Bulbostylis barbata*), Vanso (*Eragrostis tenella*), Citre Vanso (*Digitaria ciliaris*), and *Cyperus rotundus* (Subba & Chhetri, 2005). Additionally, the area supports aquatic plants such as Kamal (*Nelumbo nucifera*) and Seto Kamal (*Nymphaea nouchali*).

Ornamental and decorative plants present include Kalki Flower (*Callistemon citrinus*), Jacaranda (*Jacaranda mimosifolia*), Royal Poinciana (*Delonix regia*), Ashoka (*Monoon longifolium*), Tejpatta (*Cinnamomum tamala*), Nilkada (*Duranta erecta*), Be-Still Tree (*Cascabela thevetia*), Crepe Jasmine (*Tabernaemontana divaricata*), Dwarf Buddha Belly Bamboo (*Bambusa verticosa*), and Golden Shower Tree (*Cassia fistula*).

Other plants include Banana (*Musa spp.*), Guava (*Psidium guajava*), Mango (*Mangifera indica*), Lemon (*Citrus limon*), and Pipal (*Ficus religiosa*). Invasive alien plant species such as Ban Fanda (*Lantana camara*), Lahare Banmara (*Mikania micrantha*), Seto Banmara (*Chromolaena odorata*), and Jal Kumbhi (*Eichhornia crassipes*) are also abundant.

Fauna

The study area hosts a variety of wildlife, such as the Gray-headed Fish Eagle (*Icthyophaga humilis*) and the Lesser Adjutant Stork (*Leptoptilos javanicus*), along with wild mammals like *Axis axis*, *Canis aureus* that inhabit the surrounding forest. Additionally, the area is home to the tortoise *Indotestudo elangata* and three species of turtles: *Nilssonia hurum*, *Lissemys punctata*, and *Pangshura smithii* (Dahal, 2019).

Furthermore, the region boasts a rich avian diversity, comprising 96 different bird species. Notably, it shelters several endangered species, including the Darter (*Anhinga melanogaster*) and the Cinereous Vulture (*Aegypius monachus*), as well as the highly endangered Egyptian Vulture (*Neophron percnopterus*) and critically endangered White-rumped Vulture (*Gyps bengalensis*) (Basnet et al., 2006).

Sampling technique

Butterfly observations were conducted over three months, from March to May 2024. The study utilized line transects and the Pollard walk method (Pollard, 1977). Three transect routes, each 500 metres long, were designated for the research. Observations were conducted on both sides of each transect, extending up to 10 meters, while walking at a slow and steady pace on sunny days. Butterflies were observed using a sweeping net and photographed using a DSLR camera (Nikon D5600) equipped with an AF-P NIKKOR 70-300mm 1:4.5–6.3 G ED lens.

Identification

Most of the captured butterflies were identified on the study area using field guides "Illustrated Checklist of Nepal's Butterflies" and "Butterflies of Nepal" by Smith (2011). Species that couldn't be identified were repeatedly photographed from various angles then identified through internet reference (https://www.ifoundbutterflies.org/) and consulting with experts.

Data analysis

The local status of butterfly species was assessed by counting the number of individuals observed during the study: very rare (single sighting), rare (2-15 sightings), fairly common (16-50 sightings), common (51-100 sightings), and very common (>100 sightings) (Tiple et al., 2005).

The data were analyzed in MS Excel, and statistical tests such as the Shannon-Wiener diversity index, Pielou's evenness, and Margalefs' richness index were calculated.

The Shannon-Wiener Diversity Index (H) quantifies the species diversity in a community (Shannon & Wiener, 1948), and is calculated using the formula:

Shannon-Wiener Diversity Index (H) = $-\sum_{i=1}^{n} \text{Pi} \times \ln Pi$ Where,

Pi represents the proportion of individuals of a specific species n divided by the total number of individuals N in the community,

ln denotes the natural logarithm,

Σ is the sum over all species present in the community.

Pielou's Evenness (E): It evaluates how evenly species are distributed in a community in terms of abundance (Pielou, 1969) and is calculated by:

Pielou's Evenness (E) = $\frac{H}{\ln(S)}$ where,

H denotes Shannon-Wiener Diversity Index,

ln represents the natural logarithm,

S is the number of species present in the community.

Margalefs' Richness Index (D): The Margalef's index measures species richness relative to sample size or biomass (Margalef, 1958) and analyzed by:

Margalef's Richness Index (D) = $\frac{S-1}{\ln(N)}$where,

S is species richness,

N denotes the total number of individuals in the community.

Results

Family and subfamily-wise butterfly species richness

The study documented a total of 1124 individuals of butterflies, representing 65 species, 43 genera, 14 subfamilies, and six families. A checklist with families, subfamilies, scientific names, their authors, common names, abundance, and local status is given (Table 1).

Table 1

Checklist of butterfly species

SN	Subfamily	Scientific name	Author & Year	Common name	Abundance	LS
Family: Hesperiidae						
1	Hesperiinae	*Borbo cinnara*	Wallace, 1866	Rice Swift	4	R
2		*Hyarotis adrastus*	Stoll, 1782	Tree Flitter	7	R
3		*Matapa aria*	Moore, 1866	Common Red-Eye	3	R
4		*Parnara bada*	Moore, 1878	Ceylon Swift	2	R
5		*Pelopidas mathias*	Fabricius, 1798	Small Branded Swift	12	R
6	Pyrginae	*Pseudocoladenia dan*	Fabricius, 1787	Fulvous Pied Flat	5	R
7		*Tagiades japetus*	Stoll, 1781	Common Snow Flat	3	R
Family: Lycaenidae						
8	Polyommatinae	*Castalius rosimon*	Fabricius, 1775	Common Pierrot	2	R
9		*Chilades lajus*	Stoll, 1780	Lime Blue	3	R
10		*Euchrysops cnejus*	Fabricius, 1798	Gram Blue	1	VR
11		*Jamides bochus*	Stoll, 1782	Dark Cerulean	14	R
12		*Jamides celeno*	Cramer, 1775	Common Cerulean	9	R
13		*Lampides boeticus*	Linnaeus, 1767	Pea Blue	2	R
14		*Pseudozizeeria maha*	Kollar, 1844	Pale Grass Blue	24	FC

15		*Zizeeria karsandra*	Moore, 1865	Dark Grass Blue	2	R
16	Theclinae	*Arhopala amantes*	Hewitson, 1862	Large Oakblue	16	FC
17		*Arhopala atrax*	Hewitson, 1862	Indian Oakblue	48	FC
18		*Arhopala centaurus*	Fabricius, 1775	Centaur Oakblue	72	C
19		*Rapala pheretima*	Hewitson, 1863	Copper Flash	4	R
Family: Nymphalidae						
20	Biblidinae	*Ariadne ariadne*	Linnaeus, 1763	Angled Castor	2	R
21	Danainae	*Danaus chrysippus*	Linnaeus, 1758	Plain Tiger	32	FC
22		*Danaus genutia*	Cramer, 1779	Common Tiger	24	FC
23		*Euploea core*	Crammer, 1780	Common Indian Crow	36	FC
24		*Euploea mulciber*	Cramer, 1777	Striped Blue Crow	6	R
25		*Parantica aglea*	Stoll, 1782	Glassy Tiger	3	R
26		*Tirumala limniace*	Cramer, 1775	Blue Tiger	9	R
27	Heliconiinae	*Phalanta phalanta*	Drury, 1773	Common Leopard	4	R
28	Limenitidinae	*Moduza procris*	Cramer, 1777	Commander	1	VR
29		*Neptis clinia*	Moore, 1872	Clinia Sailor	4	R
30		*Neptis hylas*	Linnaeus, 1758	Common Sailor	25	FC
31		*Neptis miah*	Moore, 1857	Small Yellow Sailor	2	R
32		*Pantoporia hordonia*	Stoll, 1790	Common Lascar	7	R
33		*Tanaecia lepidea*	Butler, 1868	Grey Count	3	R
34	Nymphalinae	*Hypolimnas bolina*	Linnaeus, 1758	Great Eggfly	9	R
35		*Hypolimnas misippus*	Linnaeus, 1764	Danaid Eggfly	2	R
36		*Junonia almana*	Linnaeus, 1758	Peacock Pansy	26	FC
37		*Junonia altites*	Linnaeus, 1763	Grey Pansy	21	FC
38		*Junonia hierta*	Fabricius, 1798	Yellow Pansy	29	FC

39		*Junonia iphita*	Cramer, 1779	Chocolate Pansy	22	FC
40		*Junonia lemonias*	Linnaeus, 1758	Lemon Pansy	15	R
41		*Symbrenthia lilaea*	Hewitson, 1864	Common Jester	4	R
42	Satyrinae	*Melanitis leda*	Linnaeus, 1758	Common Evening Brown	13	R
43		*Mycalesis mineus*	Linnaeus, 1758	Dark-Brand Bushbrown	18	FC
44		*Mycalesis visala*	Moore, 1858	Long-Brand Bushbrown	11	R
45		*Orsotriaena medus*	Fabricius, 1775	Jungle Brown	46	FC
46		*Ypthima baldus*	Fabricius, 1775	Common Five-Ring	103	VC
47		*Ypthima huebneri*	Kirby, 1871	Common Four-Ring	66	C
Family: Papilionidae						
48	Papilioninae	*Graphium agamemnon*	Linnaeus, 1758	Tailed Jay	8	R
49		*Graphium doson*	C. and R. Felder, 1864	Common Jay	11	R
50		*Graphium nomius*	Esper, 1799	Spot Swordtail	3	R
51		*Pachliopta aristolochiae*	Fabricius, 1775	Common Rose	9	R
52		*Papilio clytia*	Linnaeus, 1758	Common Mime	5	R
53		*Papilio demoleus*	Linnaeus, 1758	Lime Swallowtail	21	FC
54		*Papilio nephelus*	Boisduval, 1836	Yellow Helen	1	VR
55		*Papilio polytes*	Linnaeus, 1758	Common Mormon	14	R
Family: Pieridae						
56	Coliadinae	*Catopsilia pomona*	Fabricius, 1775	Common Emigrant	105	VC
57		*Catopsilia pyranthe*	Linnaeus, 1758	Mottled Emigrant	32	FC
58		*Eurema andersoni*	Moore, 1886	One-Spot Grass Yellow	17	FC
59		*Eurema hecabe*	Linnaeus, 1758	Common Grass Yellow	23	FC
60	Pierinae	*Appias libythea*	Fabricius, 1775	Striped Albatross	2	R
61		*Appias lyncida*	Cramer, 1779	Chocolate Albatross	3	R
62		*Leptosia*	Fabricius,	Psyche	7	R

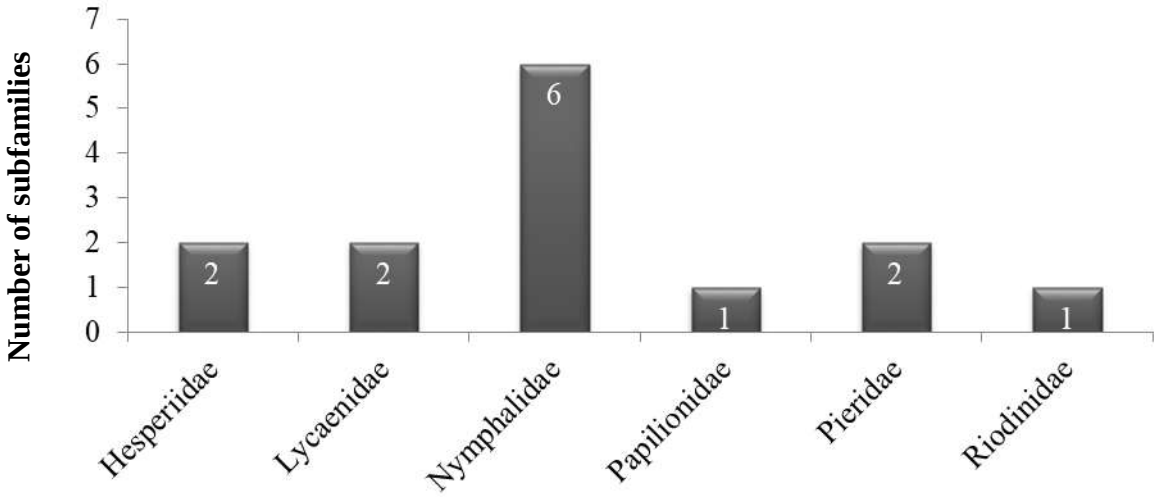
		nina	1793			
63		*Pieris canidia*	Sparrman, 1768	Indian Cabbage White	38	FC
64		*Pontia daplidice*	Linnaeus, 1758	Bath White	35	FC
Family: Riodinidae						
65	Nemeobiinae	*Abisara bifasciata*	Moore, 1877	Plum Judy	14	R

Note. Table 1 listed 65 butterfly species, totaling 1124 individuals, and categorized their local status (LS) as VR (very rare), R (rare), FC (fairly common), and C (common). The abundance data represented the total number of individuals recorded for each species.

Among six families and 14 subfamilies, the family Nymphalidae had the highest number of subfamilies, with a total of six. Following this, the families Hesperiidae, Lycaenidae, and Pieridae each contained two subfamilies. The families Papilionidae and Riodinidae each had one subfamily. (Figure 2)

Figure 2

Family and number of subfamilies of butterfly species



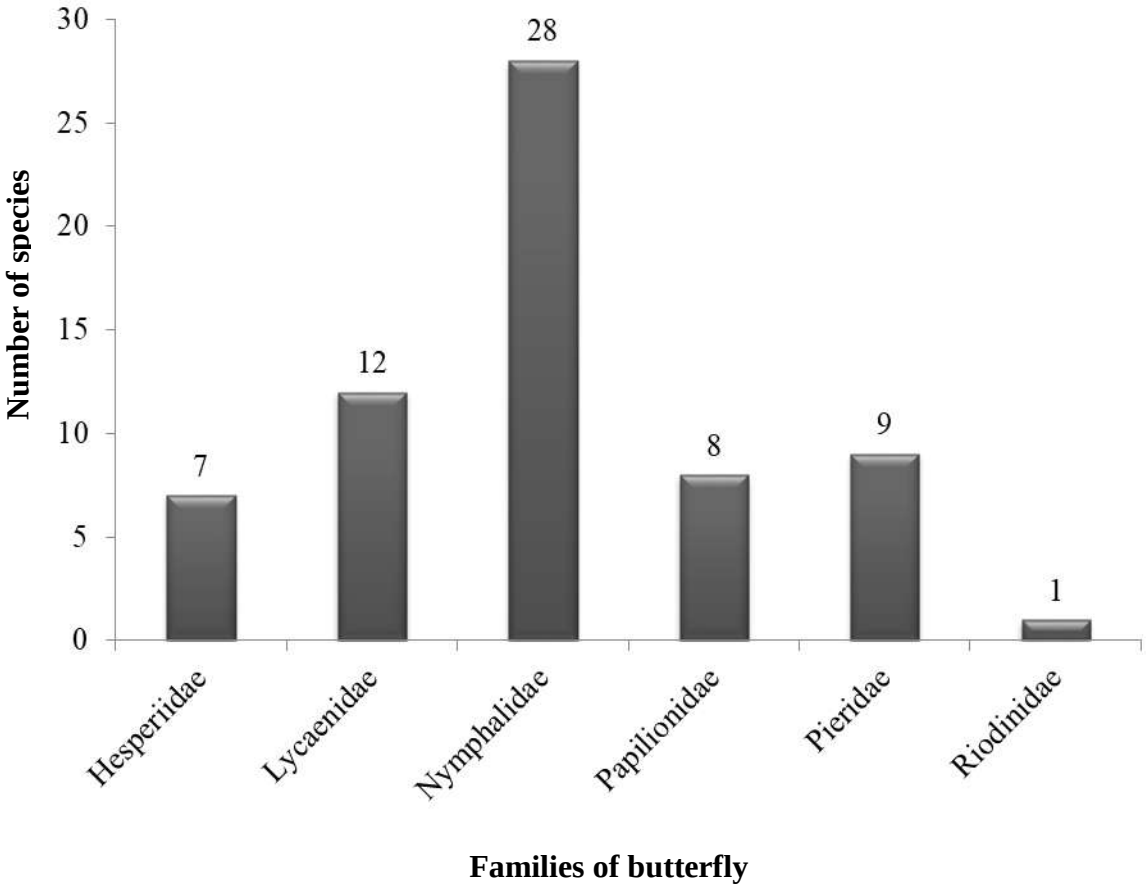
Note. The figure displays the number of subfamilies within each of the six main butterfly families. The families are Hesperiidae, Lycaenidae, Nymphalidae, Papilionidae, Pieridae, and Riodinidae.

Family-wise butterfly species richness

Among 65 butterfly species, the family Nymphalidae, with 28 species (43.08%), was the most dominant family, followed by Lycaenidae with 12 species (18.46%), Pieridae with 9 species (13.85%), Papilionidae with 8 species (12.31%), Hesperiidae with 7 species (10.76%), and Riodinidae with a single species (1.54%), which had the lowest richness during this study (Figure 3).

Figure 3

Family-wise butterfly species richness



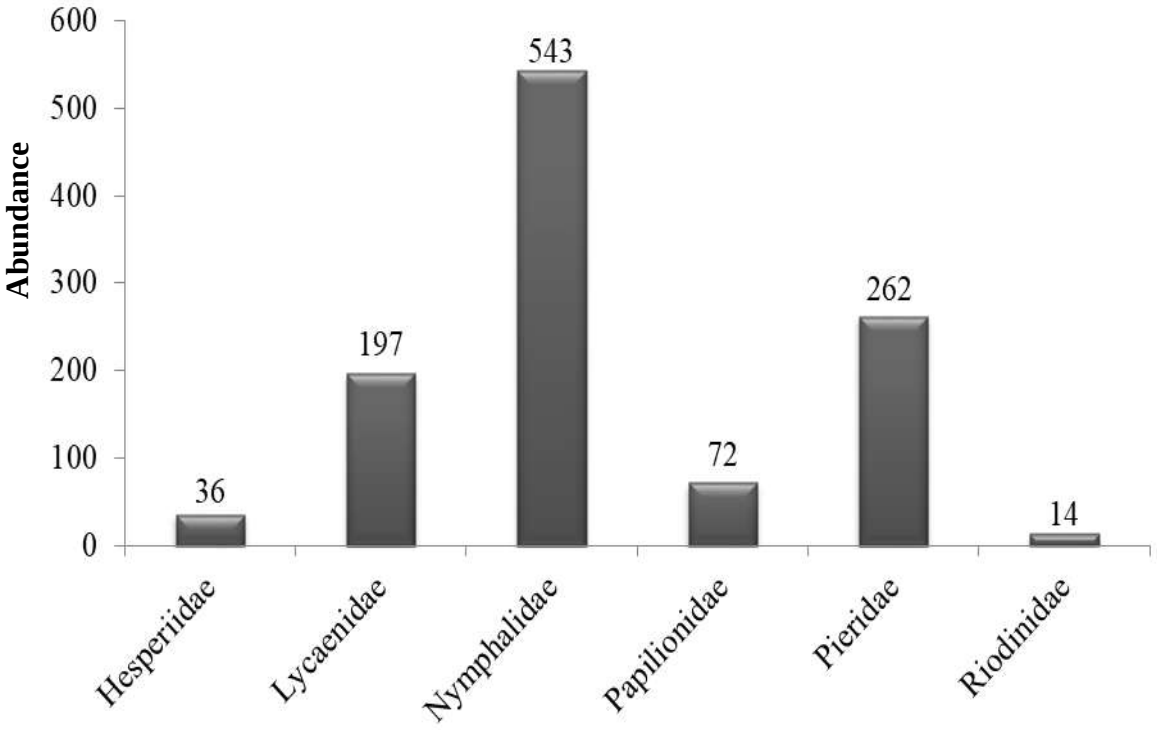
Note. The figure illustrates the distribution of butterfly species among various families, with the Nymphalidae having the highest number of species and the family Riodinidae showing the lowest butterfly species representation.

Family-wise butterfly abundance

Among the 1124 butterfly individuals, the most dominant family was Nymphalidae, comprising 543 individuals (48.31%). This was followed by Pieridae with 262 individuals (23.31%), Lycaenidae with 197 individuals (17.52%), Papilionidae with 72 individuals (6.41%), Hesperiidae with 36 individuals (3.20%), and Riodinidae with 14 individuals (1.25%) (Figure 4).

Figure 4

Family-wise butterfly abundance



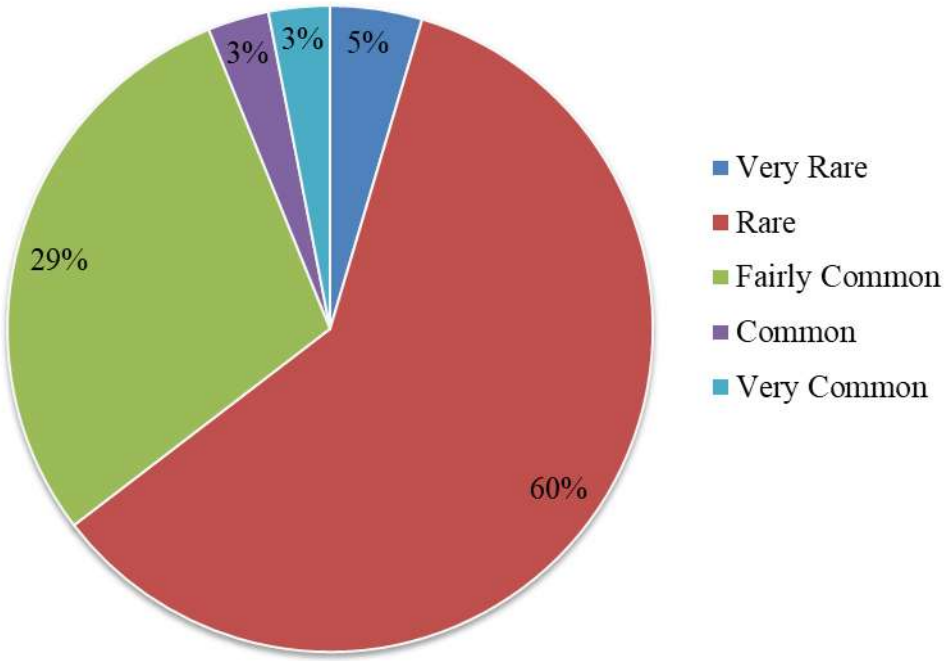
Note. This chart illustrates the abundance of butterfly across families, emphasizing Nymphalidae as the most abundant and Riodinidae as the least abundant.

Local status of the butterfly species

Among the total recorded species, 60% (39 species) are rare, 29% (19 species) are fairly common, 5% (3 species) are very rare, and both the common and very common categories each include 3% (2 species each) (Figure 5). The most prevalent butterfly species were *Catopsilia pomona* and *Ypthima baldus*, while the least abundant were *Euchrysops cnejus*, *Moduza procris,* and *Papilio nephelus*.

Figure 5

Local status of the butterfly species



Note. The pie chart illustrates the distribution of butterfly species by abundance categories: very rare, rare, fairly common, common, and very common.

Ecological indices of butterfly

In the present study, the Shannon Diversity Index (H) is 3.60, Pielou's Evenness (E) is 0.86, and Margalef's Richness Index (D) is 9.11 (Appendix I).

Discussion

Family-wise butterfly species richness

A total of 65 butterfly species were recorded, with Nymphalidae represented as the most dominant family due to its highest species count, whereas the family Riodinidae, with a single species, indicated the least dominance. Similar findings were reported by Miya et al. (2021) in their study in the Byas Municipality of the Tanahun district, where Nymphalidae exhibited the highest species richness and Riodinidae the lowest.

The pattern of high species richness in Nymphalidae has been consistently observed in many studies (Hari, 2020; Rahman & Maryati, 2021; Samal et al., 2021; Sharma & Paudel, 2021; Bisht et al., 2022; Dar et al., 2022; Hailay et al., 2022; Roy et al., 2022; Andrade et al., 2023; Gajbe & Badiye, 2023; Gogoi et al., 2023; Joshi, 2023; Mukherjee et al., 2023; Ningrum, 2023; Oli et al., 2023; Gupta & Kumar, 2024; Sheng-Quan et al., 2024).

The high species richness of the family Nymphalidae may be attributed to several factors, including their high dispersal ability (Dudley & Adler, 1996), strong and active flight (Raut & Pendharkar, 2010), and rapid ecological adaptation (Jiggins et al., 1996).

Additionally, the presence of various types of host plants, such as *Lantana camara* and *Jacaranda mimosifolia* (Chahar et al., 2021), along with other local flora like *Callistemon citrinus, Tabernaemontana divaricata*, *Delonix regia*, *Cascabela thevetia*, and various grasses, plays a crucial role in the life cycle of these butterflies (Malabika, 2011).

In the present study, the Riodinidae family exhibited minimal species richness, with a single species. This finding aligned with other studies where the Riodinidae family had the least number of species recorded (Rahman & Maryati, 2021; Andrade et al., 2023; Mukherjee et al., 2023; Sheng-Quan et al., 2024). The limited species richness was likely due to their specialized habitat preferences, restricted geographic distribution, and adaptation to specific environmental conditions (Siewert et al., 2014).

In contrast to this study, Dar et al. (2022), Oli et al. (2023), and Gupta & Kumar (2024) documented that the family Hesperiidae is the least dominant in species richness due to their older evolutionary lineage, specialized ecological niches, and limited geographical distribution (Warren et al., 2009).

Family-wise butterfly abundance

In the current study, the family Nymphalidae had the highest butterfly abundance, similar to the findings of Hailay et al. (2022), because these butterflies are highly adaptable and thrive in a variety of habitats, including forests, grasslands, and disturbed areas (Ojianwuna & Akpan, 2021; Nair et al., 2014).

In the present study, the family Riodinidae had the lowest abundance (1.25%), consistent with the findings (Sheng-Quan et al., 2024). This might be due to their specialized habitat requirements and sensitivity to environmental changes (Harvey, 1991). Additionally, species richness is often associated with high species abundance as diverse habitats that support a wide variety of butterfly species tend to provide abundant resources, such as food and breeding sites, supporting larger populations (Padhye et al., 2006).

This study revealed that the family Pieridae ranked second in abundance (23.31%), which contradicts prior findings where it was the most dominant family (Bisht et al., 2022; Gupta & Kumar, 2024). This difference could be their faster life cycles and wider habitat adaptability (Scriber & Slansky, 1981; Dennis & Shreeve, 1991).

Prior studies (Bisht et al., 2022; Hailay et al., 2022; Gupta & Kumar, 2024) documented the low species abundance of the Hesperiidae family because of insufficient specific host or nectar plants, limited dispersal ability, and their research conducted during daytime hours. However, these butterflies typically fly during the early morning at dawn and dusk (Kehimkar, 2008).

Local status of butterfly species

During the current study, 42 butterfly species exhibited very rare and rare categories (Tiple et al., 2005). A single sighting was recorded for the species *Euchrysops cnejus*, *Moduza procris*, and *Papilio nephelus*, possibly influenced by factors such as the impact of the under-construction Asian Highway, climate change affecting their life cycles, and the scarcity of food sources for species dependent on specific host plants (Chen et al., 2020; Oliver et al., 2012; Thomas, 2016).

The most common butterfly species, *Catopsilia pomona*, in the study area is due to the presence of a wide range of host plants, such as *Cassia fistula*, *Citrus limon* (Kunte, 2000), as well as moist lands and edges of drains with a high abundance of grasses, herbs, and shrubs (Atluri et al., 2004).

Ecological indices of butterfly

In the study area, the Shannon Diversity Index (H) for butterflies is 3.60, indicating very high butterfly diversity (Fernando et al., 1998). This high diversity suggests favourable environmental conditions in Betana Wetland, with a wide range of available habitats and food sources for different species.

Pielou's evenness (E) measured 0.86, close to 1, and fell within the 0.8–0.9 range, indicating a healthy and balanced ecosystem (Hussain et al., 2012). This finding highlighted a nearly equal distribution of individuals among species, with no single species dominating in abundance.

The Margalef's Richness Index value was 9.11 (>5), which indicated a diverse and ecologically rich environment (Hussain et al., 2012), beneficial for ecological diversity and stability.

Conclusions

The following conclusions were derived from the present study:

1. Betana wetland was rich in butterflies, with 65 species across 43 genera, 14 subfamilies, and six families.
2. The families Nymphalidae and Riodinidae revealed the highest and lowest species richness and abundance.
3. The present study area demonstrates high butterfly diversity, a balanced ecosystem, ecological richness, and stability, as indicated by the ecological indices.

Recommendations

Based on the findings of the study, the following suggestions have been recommended:

1. The pioneering research conducted at Betana wetland focused on butterflies, establishing baseline data on their richness and abundance. Further investigation is necessary to examine the population dynamics of butterflies across consecutive years and seasons, addressing existing research gaps.
2. Regular butterfly monitoring should be implemented in Betana due to the construction of the Asian highway nearby, which may alter butterfly population dynamics. This monitoring should extend post-completion to assess long-term impacts and implement conservation measures to protect Betana Wetland's rich butterfly biodiversity.
3. Awareness programs should be implemented for local residents, students, and relevant stakeholders to highlight the crucial role butterflies and their importance in ecosystems for conservation efforts.

References

Adhikari, R., Basnet, R., & Bista, B. B. (2023). Turtle-Based Ecotourism in the Betana Wetland of Nepal. *Bouddhik Abhiyan, 8*(01), 188–200. https://doi.org/10.3126/bdkan.v8i01.57807

Ahsan, M., & Javaid, I. (1975). A contribution to the butterflies of Lahore Pakistan with the addition of new records. *Biologia, 21*, 143–158.

Andrade, A. G., Pereira, C. C., Sperandei, V. F., & Cornelissen, T. (2023). Small reserve but high diversity: butterfly community across an altitudinal gradient in the Brazilian Atlantic Forest. *Nature Conservation, 53*, 321–340. https://doi.org/10.3897/natureconservation.53.113052

Atluri, J. B., Venkata Ramana, S. P., & Reddi, C. S. (2004). Ecobiology of the tropical pierid butterfly *Catopsilia pyranthe*. *Current Science, 86*(3), 457–461.

Basnet, Y. R., Tamang, B., & Gautam, B. (2006). Bird diversity and habitat status at Raja Rani Community Forest, Bhogteny, Morang, Nepal.

Bhusal, D. R., & Khanal, B. (2008). Seasonal and altitudinal diversity of butterflies in Eastern Siwalik of Nepal. *Journal of Natural History Museum, 23*, 82–87.

Bisht, M., Goswami, D., Uniyal, V. P., & Singh, V. (2022). Diversity of butterfly along different altitudinal gradient of Munsiyari, Western Himalayan, Uttarakhand, India. *Asian Journal of Conservation Biology, 11*(2), 258–265.

Borges, R. M., Gowda, V., & Zacharias, M. (2003). Butterfly pollination and high-contrast visual signals in a low-density distylous plant. *Oecologia, 136*(4), 571–573.

Chahar, S., Dubey, S., & Panchal, N. (2021). Butterfly diversity in Bhandup (west), Mumbai, Maharashtra, India. *Journal of Emerging Technologies and Innovative Research, 8*(9), 346–352.

Chalise, D., Kumar, L., & Kristiansen, P. (2019). Land degradation by soil erosion in Nepal: A review. *Soil Systems, 3*(1), 1–19. https://doi.org/10.3390/soilsystems3010012

Chen, L., Oliver, T. H., & Thomas, C. D. (2020). Impact of habitat fragmentation and climate change on butterfly communities. *Biological Conservation, 248*, 108567. http://doi.org/10.1016/j.biocon.2020.108567

Dahal, D. (2019). Species diversity and conservation practices of turtle and tortoises in Betana Wetland Area. https://www.researchgate.net/publication/349833311

Dar, A. A., Jamal, K., Shah, M. S., Ali, M., Sayed, S., Gaber, A., Kesba, H., & Salah, M. (2022). Species richness, abundance, distributional pattern and trait composition of butterfly assemblage change along an altitudinal gradient in the Gulmarg region of Jammu & Kashmir, India. *Saudi Journal Biological Sciences, 29*(4), 2262-2269. https://doi.org/10.1016/j.sjbs.2021.11.066

Davis, J. D., Hendrix, S. D., Debinski, D. M., & Hemsley, C. J. (2008). Butterfly, bee and forb community composition and cross Taxon incongruence in tall grass prairie fragments. *Journal of Insect Conservation, 12*(1), 69-79.

Dennis, R. L. H., & Shreeve, T. G. (1991). Climatic change and the British butterfly fauna: Opportunities and constraints. *Biological Conservation, 55*(1), 1-16. https://doi.org/10.1016/0006-3207(91)90002-I

Dillon, M. E., Wang, G., & Huey, R. B. (2010). Global metabolic impacts of recent climate warming. *Nature, 467*, 704–706.

Dudley, R., & Adler, G. H. (1996). Biogeography of milkweed butterflies (Nymphalidae: Danainae) and mimetic patterns on tropical Pacific archipelagos. *Biological Journal of the Linnean Society, 57*(4), 317-326. https://doi.org/10.1111/j.1095-8312.1996.tb00313.x

FAO. (2006). Understanding forest degradation in Nepal. *Food and Agriculture Organization of the United Nations.*

Fernando, E. S., Suh, M. H., Lee, J., & Lee, D. K. (1998). Butterfly species diversity and habitat heterogeneity across altitudinal gradients of Mt. Banahaw de Majayjay, Philippines. *Ecosystems and Development Journal.*

Fjellstad, W. (1998). The landscape ecology of butterflies in traditionally managed Norwegian farmland. Ph.D. thesis, Durham University.

Gajbe, P. U., & Badiye, V. H. (2023). Butterfly diversity in an urban area illustrates the significance of green spaces in urban biodiversity conservation. *Arthropods*, *12*(2), 111-119.

Ghorai, N., & Sengupta, P. (2014). Altitudinal Distribution of Papilionidae Butterflies along with Their Larval Food Plants in the East Himalayan Landscape of West Bengal, India. *Journal of Biosciences and Medicines, 2*, 1-8.

Gogoi, R., Chetry, A., & Bhuyan, A. (2023). Diversity and species richness of butterfly in soraipung range of Dehing Patkai National Park, Assam, India. *The Journal of Basic and Applied Zoology, 84*, 6. https://doi.org/10.1186/s41936-023-00327-9

Gupta, V., & Kumar, P. (2024). Diversity and status of butterfly fauna at Kurukshetra University campus, Haryana, India. *Journal of Threatened Taxa, 16*(5), 25209–25219.

Hailay, G., Biru, Y., & Kassie, A. (2022). Butterfly diversity and abundance at two different habitat types of Gozamen woreda, Amhara regional state, Ethiopia. *Arthropods, 11*(3), 153-163.

Hamer, K. C., Hill, J. K., Mustaffa, N., Benedick, S., Sherratt, T. N., Chey, V. K., & Maryati, M. (2005). Temporal variation in abundance and diversity of butterflies in Bornean rain forests: opposite impacts of logging recorded in different seasons. *Journal of Tropical Ecology, 21*, 417-425.

Hari, T. (2020). Butterfly diversity of Amrita Vishwa Vidyapeetham, Coimbatore, Tamil Nadu, India. *Journal of the Bombay Natural History Society, 117*, 66-78.

Harvey, D. J. (1991). Higher classification of the Nymphalidae. In D. J. Harvey (Ed.), *The development and evolution of butterfly wing patterns* (pp. 255-276). Washington: Smithsonian University Press.

Hussain, N. A., Ali, A. H., & Lazem, L. F. (2012). Ecological indices of key biological groups in Southern Iraqi marshland during 2005-2007. *Mesopotamian Journal of Marine Sciences, 27*(2), 112–125. https://doi.org/10.58629/mjms.v27i2.162

Jiggins, C. D., McMillan, W. O., Neukirchen, W., & Mallet, J. (1996). What can hybrid zones tell us about speciation? *Journal of Biological Society, 59,* 221-242.

Joshi, R. (2023). Checklist of butterfly species in Bheemdatt municipality, Kanchanpur district. *Species*, *24*, e26s1026. https://doi.org/10.54905/disssi/v24i73/e26s1026

Kehimkar, I. (2008). *The book of Indian butterflies*. Bombay Natural History Society, Oxford University Press.

Khanal, B., & Smith, C. (1997). Butterflies of Kathmandu valley (5 pp.). TAC Press.

Kocher, S. D., & Williams, E. H. (2000). The diversity and abundance of North American butterflies vary with habitat disturbance and geography. *Biogeography, 27*(5), 785-794.

Kunte, K. (1997). Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in the northern Western Ghats. *Journal of Biosciences, 22*(5), 593-603.

Kunte, K. (2000). *Butterflies of peninsular India*. Hyderabad: Universities Press (India) Ltd.

Lien, V. V. (2009). Diversity and similarity of butterfly communities in five different habitat types at Tam Dao National Park, Vietnam. *Journal of Zoology, 277*(1), 15-22.

Lien, V. V., & Yuan, D. (2003). The differences of butterfly (Lepidoptera, Papilionoidea) communities in habitats with various degrees of disturbance and altitudes in tropical forests of Vietnam. *Biodiversity and Conservation, 12*(6), 1099-1111.

Malabika, S. K. (2011). Impact of tropical forest degradation on nymphalid butterflies: A case study in Chandubi tropical forest, Assam, India. *International Journal of Biodiversity and Conservation, 3*(12), 650-669. https://doi.org/10.5897/IJBC.9000081

Mandal, H. R., Katel, S., Baidhya, S., Kattel, S., & Katuwal, A. (2021). A case study of medicinal plants and their uses by the Sundar Haraicha Nagarpalika community in Morang District, East Nepal. *Matrix Science Pharma, 5*(1), 84–88.

Margalef, R. (1958). Information theory in ecology. *General Systems, 3*, 36-71.

Mayur, A. M., Hattappa, S., Mahadevamurthy, M., & Chakravarthy, A. K. (2013). The impact of newly established Bangalore international airport on local biodiversity. *Global Journal of Biology, Agriculture and Health Sciences, 2*(2), 49-53.

Miya, M. S., Chhetri, A., Gautam, D., & Omifolaji, J. K. (2021). Diversity and abundance of butterflies (Lepidoptera) in Byas municipality of the Tanahun district, Nepal. *Journal of Crop Protection, 10*(4), 685-700.

Mukherjee, A., Kumar, A., Mahato, S., & Samanta, S. (2023). West Bengal, India along with new distribution records. *Journal of Animal Diversity, 5*(1), 65–79.

Murphy, D. D., Freas, K. E., & Weiss, S. B. (1990). An environment-metapopulation approach to population viability analysis for a threatened invertebrate. *Conservation Biology, 4*, 41-51.

Nair, A. V., Mitra, P., & Aditya, S. (2014). Studies on the diversity and abundance of butterfly (Lepidoptera: Rhopalocera) fauna in and around Sarojini Naidu college campus, Kolkata, West Bengal, India. *Journal of Entomology and Zoology Studies, 2*(4), 129-134.

New, T. R., & Collins, N. M. (1991). *Swallowtail butterflies-an action plan for their conservation*. Gland: International Union for Conservation of Nature.

Ningrum, I. K. (2023). Diversity and the role of butterflies' species at PT Permata Sawit Mandiri, West Kalimantan. *IOP Conference Series: Earth and Environmental Science, 1243*(1), 012013. https://doi.org/10.1088/1755-1315/1243/1/012013

Ojianwuna, C. C., & Akpan, E. E. (2021). Temporal variation in abundance and distribution of butterflies in a Southern Nigerian National Park. *Open Environmental Research Journal, 14*, 1-11.

Oli, B. R., Sharma, M., & Shahi, B. (2023). Butterfly Diversity in Kakrebihar Forest Area, Birendranagar, Surkhet, Nepal. *Surkhet Journal, 2*(1), 10–19. https://doi.org/10.3126/surkhetj.v2i1.58743

Oliver, T. H., Marshall, H. H., Morecroft, M. D., Brereton, T., Prudhomme, C., & Huntingford, C. (2012). Interacting effects of climate change and habitat fragmentation on drought-sensitive butterflies. *Nature Climate Change, 2*(4), 1-4. https://doi.org/10.1038/nclimate1370

Owen, D. F. (1971). *Tropical butterflies*. Oxford University Press, London.

Padhye, A. D., Dahanukar, N., Paingankar, M., Deshpande, M., & Deshpande, D. (2006). Season and landscape wise distribution of butterflies in Tamhini, Northern, Western Ghats, India. *Zoo's Print Journal, 21*(3), 2175-2181. https://doi.org/10.11609/JoTT.ZPJ.1142.2175-81

Pielou, E. C. (1969). *An introduction to mathematical ecology*. New York, NY: John Wiley.

Pollard, E. (1977). A method for assessing changes in the abundance of butterflies. *Biological Conservation, 12*, 115–134.

Price, P. W. (1975). *Insect Ecology*. New York, NY: John Wiley & Sons.

Rahman, A. A. A., & Maryati, M. (2021). Checklist of butterflies (Lepidoptera: Papilionoidea and Hesperioidea) in Gunung Pulai Forest Reserve, Johor. *IOP Conference Series: Earth and Environmental Science, 736*(1). https://doi.org/10.1088/1755-1315/736/1/012058

Rai, S. K. (2011). Algal flora of Betana wetland, Morang, Nepal. *Nepalese Journal of Biosciences, 1*, 104-113.

Raut, N. B., & Pendharkar, A. (2010). Butterfly (Rhopalocera) fauna of Maharashtra Nature Park, Mumbai, Maharashtra, India. *Check List, 6*(4), 548-551.

Roy, G. C., Miah, A., Roy, S., Roy, D., Kar, D., Banerjee, S., & Gupta, M. (2022). Diversity and abundance of butterfly as an environmental indicator at Dinhata Subdivision, Cooch Behar, West Bengal, India. *Notulae Scientia Biologicae, 14*(1), 11156. https://doi.org/10.15835/nsb14111156

Samal, S. K., Satapathy, A., & Pattanaik, N. (2021). Diversity of butterflies (Lepidoptera: Rhopalocera) in Bhubaneswar, Odisha, India. *Notulae Scientia Biologicae, 13*(4), 11074. https://doi.org/10.15835/nsb13411074

Scriber, J. M., & Slansky, F. (1981). The nutritional ecology of immature insects. *Annual Review of Entomology, 26*(1), 183-211. https://doi.org/10.1146/annurev.en.26.010181.001143

Shannon, C. E., & Weiner, W. (1948). A mathematical theory of communication. University of Illinois Press.

Sharma, J., & Paudel, L. (2021). Butterfly diversity in Kumakh Rural Municipality, northern part of Salyan District, Karnali Province, Nepal. *Arthropods, 10*(2), 53-59.

Sheng-Quan, F., Yong-Ping, L., Pan, Y., Chong-Yun, W., Ming-Chun, P., & Shao-Ji, H. (2024). Butterfly Diversity in a Rapidly Developing Urban Area: A Case Study on a University Campus. *Diversity, 16*(1), Article 4. https://doi.org/10.3390/d16010004

Siewert, R. R., Iserhard, C. A., Romanowski, H. P., Callaghan, C. J., & Moser, A. (2014). Distribution patterns of riodinid butterflies (Lepidoptera: Riodinidae) from southern Brazil. *Zoological Studies, 53*, Article 15. https://doi.org/10.1186/1810-522X-53-15

Simonson, S. E., Opler, P., & Stohlgren, T. J. (2001). Rapid assessment of butterfly diversity in a montane landscape. *Biodiversity and Conservation, 10*, 1369-1386.

Smith, C. (2011). *An Illustrated Checklist of Nepal's butterfly*. Craftsman Press, Bangkok, Thailand.

Subba, B. R., & Chhetri, D. C. (2005). Study of fauna of Betana village development committee, Morang, Nepal. *APEC, Biratnagar*.

Sundufu, A. J., & Dumbuya, R. (2008). Habitat preferences of butterflies in the Bumbuna forest, Northern Sierra Leone. *Journal of Insect Science, 8*(64), 1–17. https://doi.org/10.1673/031.008.6401

Thomas, J. A. (2016). Butterfly communities under threat. *Science, 353*(6296), 216-218. https://doi.org/10.1126/science.aaf2402

Tiple, A. D., Deshmukh, V. P., & Dennis, D. L. (2005). Factors influencing nectar plant resource visits by butterflies on a university campus: implications for conservation. *Nota Lepidopterologica, 28*(3/4), 213.

Van der Poel, P., & Smetacek, P. (2022). An annotated catalogue of the butterflies of Nepal. *Bionotes.*

Walther, G. E., Post, E., Convey, P., Mentzel, A., Parmesan, P., & Beebe, T. J. (2002). Ecological responses to recent climate change. *Nature, 416*, 389-395.

Warren, A. D., Ogawa, J. R., & Brower, A. V. Z. (2009). Phylogenetic relationships of subfamilies and circumscription of tribes in the family Hesperiidae (Lepidoptera: Hesperioidea). *Cladistics, 25*(1), 17-31. https://doi.org/10.1111/j.1096-0031.2009.00239.x

Weiss, S. B., Murphy, D. D., & White, R. R. (1988). Sun, slope and Butterflies: Topographic determinants of habitat quality for Euphydryas editha. *The Journal of Ecological Society America, 69*(5), 1486-1496.

Appendix I: Butterfly Species Diversity in Betana Wetland, Belbari, Morang, Nepal

Table 2

Calculation of Shannon's Diversity Index, Pielou's Evenness, and Margalef's Richness Index

SN	Name of the species	Abundance	Pi	ln Pi	Pi ln Pi
1	*Borbo cinnara*	4	0.0035587	-5.6383547	-0.0200653
2	*Hyarotis adrastus*	7	0.0062278	-5.0787389	-0.0316292
3	*Matapa aria*	3	0.0026690	-5.9260367	-0.0158168
4	*Parnara bada*	2	0.0017794	-6.3315018	-0.0112660
5	*Pelopidas mathias*	12	0.0106762	-4.5397424	-0.0484670
6	*Pseudocoladenia dan*	5	0.0044484	-5.4152111	-0.0240890
7	*Tagiades japetus*	3	0.0026690	-5.9260367	-0.0158168
8	*Castalius rosimon*	2	0.0017794	-6.3315018	-0.0112660
9	*Chilades lajus*	3	0.0026690	-5.9260367	-0.0158168
10	*Euchrysops cnejus*	1	0.0008897	-7.0246490	-0.0062497
11	*Jamides bochus*	14	0.0124555	-4.3855917	-0.0546248
12	*Jamides celeno*	9	0.0080071	-4.8274245	-0.0386538
13	*Lampides boeticus*	2	0.0017794	-6.3315018	-0.0112660
14	*Pseudozizeeria maha*	24	0.0213523	-3.8465952	-0.0821337
15	*Zizeeria karsandra*	2	0.0017794	-6.3315018	-0.0112660
16	*Arhopala amantes*	16	0.0142349	-4.2520603	-0.0605275
17	*Arhopala atrax*	48	0.0427046	-3.1534480	-0.1346668
18	*Arhopala centaurus*	72	0.0640569	-2.7479829	-0.1760274
19	*Rapala pheretima*	4	0.0035587	-5.6383547	-0.0200653
20	*Ariadne ariadne*	2	0.0017794	-6.3315018	-0.0112660
21	*Danaus chrysippus*	32	0.0284698	-3.5589131	-0.1013214
22	*Danaus genutia*	24	0.0213523	-3.8465952	-0.0821337
23	*Euploea core*	36	0.0320285	-3.4411301	-0.1102141
24	*Euploea mulciber*	6	0.0053381	-5.2328896	-0.0279336
25	*Parantica aglea*	3	0.0026690	-5.9260367	-0.0158168
26	*Tirumala limniace*	9	0.0080071	-4.8274245	-0.0386538
27	*Phalanta phalanta*	4	0.0035587	-5.6383547	-0.0200653
28	*Moduza procris*	1	0.0008897	-7.0246490	-0.0062497
29	*Neptis clinia*	4	0.0035587	-5.6383547	-0.0200653
30	*Neptis hylas*	25	0.0222420	-3.8057732	-0.0846480
31	*Neptis miah*	2	0.0017794	-6.3315018	-0.0112660
32	*Pantoporia hordonia*	7	0.0062278	-5.0787389	-0.0316292
33	*Tanaecia lepidea*	3	0.0026690	-5.9260367	-0.0158168
34	*Hypolimnas bolina*	9	0.0080071	-4.8274245	-0.0386538
35	*Hypolimnas misippus*	2	0.0017794	-6.3315018	-0.0112660
36	*Junonia almana*	26	0.0231317	-3.7665525	-0.0871267
37	*Junonia altites*	21	0.0186833	-3.9801266	-0.0743618

38	*Junonia hierta*	29	0.0258007	-3.6573532	-0.0943623
39	*Junonia iphita*	22	0.0195730	-3.9336066	-0.0769923
40	*Junonia lemonias*	15	0.0133452	-4.3165988	-0.0576059
41	*Symbrenthia lilaea*	4	0.0035587	-5.6383547	-0.0200653
42	*Melanitis leda*	13	0.0115658	-4.4596997	-0.0515802
43	*Mycalesis mineus*	18	0.0160142	-4.1342773	-0.0662073
44	*Mycalesis visala*	11	0.0097865	-4.6267538	-0.0452796
45	*Orsotriaena medus*	46	0.0409253	-3.1960076	-0.1307975
46	*Ypthima baldus*	103	0.0916370	-2.3899200	-0.2190051
47	*Ypthima huebneri*	66	0.0587189	-2.8349943	-0.1664676
48	*Graphium agamemnon*	8	0.0071174	-4.9452075	-0.0351972
49	*Graphium doson*	11	0.0097865	-4.6267538	-0.0452796
50	*Graphium nomius*	3	0.0026690	-5.9260367	-0.0158168
51	*Pachliopta aristolochiae*	9	0.0080071	-4.8274245	-0.0386538
52	*Papilio clytia*	5	0.0044484	-5.4152111	-0.0240890
53	*Papilio demoleus*	21	0.0186833	-3.9801266	-0.0743618
54	*Papilio nephelus*	1	0.0008897	-7.0246490	-0.0062497
55	*Papilio polytes*	14	0.0124555	-4.3855917	-0.0546248
56	*Catopsilia pomona*	105	0.0934164	-2.3706887	-0.2214611
57	*Catopsilia pyranthe*	32	0.0284698	-3.5589131	-0.1013214
58	*Eurema andersoni*	17	0.0151246	-4.1914357	-0.0633936
59	*Eurema hecabe*	23	0.0204626	-3.8891548	-0.0795823
60	*Appias libythea*	2	0.0017794	-6.3315018	-0.0112660
61	*Appias lyncida*	3	0.0026690	-5.9260367	-0.0158168
62	*Leptosia nina*	7	0.0062278	-5.0787389	-0.0316292
63	*Pieris canidia*	38	0.0338078	-3.3870629	-0.1145092
64	*Pontia daplidice*	35	0.0311388	-3.4693010	-0.1080298
65	*Abisara bifasciata*	14	0.0124555	-4.3855917	-0.0546248
Total species abundance		**1124**	**∑Pi ln Pi = -3.60**		
			Shannon Diversity Index (H) = 3.60		
			Pielou's Evenness (J′) = 0.86		
			Margalef's Richness Index (D) = 9.11		

Appendix II: Butterfly Species Diversity in Betana Wetland, Belbari, Morang, Nepal

Family: Hesperiidae

		
Borbo cinnara	*Hyarotis adrastus*	*Matapa aria*
		
Parnara bada	*Pelopidas mathias*	*Pseudocoladenia dan*


Tagiades japetus

Family: Lycaenidae

		
Arhopala amantes	*Arhopala atrax*	*Arhopala centaurus*
		
Castalius rosimon	*Chilades lajus*	*Euchrysops cnejus*

Family: Lycaenidae

		
Jamides bochus	*Jamides celeno*	*Lampides boeticus*
		
Pseudozizeeria maha	*Rapala pheretima*	*Zizeeria karsandra*

Family: Nymphalidae

		
Ariadne ariadne	*Danaus chrysippus*	*Danaus genutia*
		
Euploea core	*Euploea mulciber*	*Hypolimnas bolina*
		
Hypolimnas misippus	*Junonia almana*	*Junonia altites*

Family: Nymphalidae

		
Junonia hierta	*Junonia iphita*	*Junonia lemonias*
		
Melanitis leda	*Moduza procris*	*Mycalesis mineus*
		
Mycalesis visala	*Neptis clinia*	*Neptis hylas*
		
Neptis miah	*Orsotriaena medus*	*Pantoporia hordonia*
		
Parantica aglea	*Phalanta phalanta*	*Symbrenthia lilaea*

Family: Nymphalidae

Tanaecia lepidea

Tirumala limniace

Ypthima baldus

Ypthima huebneri

Family: Papilionidae

Graphium agamemnon

Graphium doson

Graphium nomius

Pachliopta aristolochiae

Papilio clytia

Papilio demoleus

Papilio nephelus

Papilio polytes

Family: Pieridae

Appias libythea

Appias lyncida

Catopsilia Pomona

Catopsilia pyranthe

Eurema andersoni

Eurema hecabe

Leptosia nina

Pieris canidia

Pontia daplidice

Family: Riodinidae

Abisara bifasciata

Appendix III: Butterfly Species Diversity in Betana Wetland, Belbari, Morang, Nepal

Request letter to the Betana wetland user group

त्रिभुवन विश्वविद्यालयद्वारा सम्बन्धनप्राप्त
AFFILIATED TO TRIBHUVAN UNIVERSITY
सुकुना बहुमुखी क्याम्पस
SUKUNA MULTIPLE CAMPUS
सुन्दरहरैंचा नगरपालिका, मोरङ, कोशी प्रदेश, नेपाल
SUNDARHARAINCHA MUNICIPALITY, MORANG, KOSHI PROVINCE, NEPAL
स्था: २०४८ (ESTD. 1992)
विश्वविद्यालय अनुदान आयोग नेपालद्वारा गुणस्तर प्रत्यायनकृत (२०७२)
Accredited by University Grants Commission (UGC) Nepal (2015)

चलानी नम्बर ०७४६
(Ref No.): २०८०/०८१

मितिः २०८०/११/१४ गते।

श्रीमान् अध्यक्ष/प्रमुख/संयोजकज्यू,
बेतना सिमसार सामुदायिक वन उपभोक्ता समूह,
(बेतना सिमसार क्षेत्र)
बेलबारी १, मोरङ।

विषयः अनुसन्धान कार्यका लागि सहयोग, समन्वय र सहजीकरण गरिदिनु हुन।

प्रस्तुत विषयमा यस क्याम्पसको अनुसन्धान व्यवस्थापन एकाइ (RMC-Sukuna) को वार्षिक कार्ययोजना अनुसार क्याम्पसको वित्तिय सहयोगमा शिक्षक तथा कर्मचारीहरूबाट शैक्षिक, आर्थिक, सामाजिक, साँस्कृतिक, प्राविधिक, वैज्ञानिक तथा अन्य समसामयिक विषयबस्तुहरू सँग सम्बन्धित भई खोज/अनुसन्धान कार्य हुँदै आइरहेको छ। यस पटक क्याम्पसको अनुसन्धान व्यवस्थापन एकाइको तर्फबाट यसै क्याम्पसका विज्ञान विषयका शिक्षणसहायक **श्री किशोर दाहाल**ले तहाँको बेतना सिमसार सामुदायिक वन उपभोक्ता समूह अन्तर्गत रहेको वेतना सिमसार क्षेत्रमा "Butterfly Species Diversity in Betana Wetland " शीर्षकमा खोज तथा अनुसन्धानका लागि त्यस क्षेत्रका पुतलिहरूको तथ्याङ्याक सङ्कलन गर्नु हुनेछ। त्यसकारण यस अध्ययन अनुसन्धान कार्यमा निज अनुसन्धानकर्तालाई पुतलिको तथ्याङ्याक सङ्कलन, अवलोकन, भ्रमण र निरीक्षण गर्ने कार्यमा तहाँको समिति, उपसमिति तथा कर्मचारी वर्गबाट निःशुल्क सहयोग, सहजीकरण र आवश्यक समन्वय गरिदिनु हुन अनुरोध छ।

१. अनुसन्धानकर्ताको नामः **श्री किशोर दाहाल**
२. अनुसन्धानकर्ताको पदः **शिक्षणसहायक**
३. अनुसन्धानकर्ताको विषयः **विज्ञान (प्राणिशास्त्र)**
४. अनुसन्धानकर्ता संलग्न निकायः **सुकुना बहुमुखी क्याम्पस, सुन्दरहरैंचा, मोरङ।**
५. अनुसन्धान कार्यका लागि वेतना सिमसार क्षेत्रमा लाग्ने समयः **आजको मितिबाट बढिमा तीन महिना।**
६. अनुसन्धानको शीर्षकः **Butterfly Species Diversity in Betana Wetland**
७. अध्ययन/अनुसन्धान क्षेत्रः **बेतना सिमसार सामुदायिक वन उपभोक्ता समूह अन्तर्गत वेतना सिमसार क्षेत्र, बेलबारी १ र बेलबारी ४, मोरङ।**

अर्जुनराज अधिकारी
क्याम्पस प्रमुख

E-mail: sukunamc2048@gmail.com website: www.sukuna.edu.np
फोन: ०२१-५४७६१७, ०२१-५४७७१७, ९८५२०४५६१७

Appendix IV: Butterfly Species Diversity in Betana Wetland, Belbari, Morang, Nepal

Letter of permission for the researcher from the Betana wetland user group

रुख रोपौं, वन जोगाउौं ।

दर्ता नं. : MOR/DE/58/04

श्री बेतना सिमसार सामुदायिक वन उपभोक्ता समूह

Shree Betana Wetland Community Forestry Users Group

बेलवारी नगरपालिका, मोरङ

Belbari Municipality, Morang

स्थापित २०७२

पत्रसङ्ख्या: ८०/८९ चलान नम्बर: ४५ मिति: २०८०/११/१४

श्री किशोर दाहाल ज्यू
सुन्दरहरैचा-१२ , मोरङ

विषय :- अध्ययन अनुमति सम्बन्धमा ।

उपर्युक्त विषयमा यस श्री बेतना सिमसार सामुदायिक वन उपभोक्ता समूहमा सुकुना बहुमुखी क्याम्पस सुन्दरहरैचा, मोरङको मिति २०८०/११/१४ चलान नं. १०५६/२०८०/०८१ को प्राप्त पत्र अनुसार यस क्षेत्रको वरिपरि "Butterfly Species Diversity in Betana Wetland" शीर्षकमा खोज तथा अनुसन्धानको लागि यस क्षेत्रको पुतलीहरुको तथ्याङ्क संकलन, अवलोकन, भ्रमण र निरिक्षणको लागि मिति २०८० जेठ २० गते सम्मको लागि अनुमति दिइएको छ । साथै अन्त्यमा रिर्पोट तयार भएपछि सो अध्ययन अनुसन्धानको रिर्पोट एक प्रति यस समितिमा उपलब्ध गराउन अनुरोध छ ।

डम्बर [redacted]नेत
(अध्यक्ष)

SUKUNA MULTIPLE CAMPUS
SUNDARHARAICHA MUNICIPALITY, MORANG
ESTD. 1992

Sukuna Multiple Campus
Research Management Cell, Sundarharaicha, Morang