Nepalese Journal of Zoology
ISSN: 2705-4403 (Print); 2705-4411 (Online)
www.cdztu.edu.np/njz
Volume 9 | Issue 2 | December 2025
https://doi.org/10.3126/njz.v9i2.88224

Research article

Diversity and abundance of butterflies in Tokha Municipality, Kathmandu, Nepal

Prakriti Chataut[1]* | **Smriti Rokka[1]**

[1] Institute of Forestry, Hetauda Campus, Tribhuvan University, Hetauda 44107, Nepal
*** Correspondence:** prakritichataut232@gmail.com

Suggested citation: Chataut P. and Rokka S. 2025. Diversity and abundance of butterflies in Tokha Municipality, Kathmandu, Nepal. Nepalese Journal of Zoology, 9(2):48–57.
https://doi.org/10.3126/njz.v9i2.88224

Article history:
Received: 21 August 2024
Revised: 19 July 2025
Accepted: 06 October 2025

Publisher's note: The statements, opinions and data contained in the publication are solely those of the individual author(s) and do not necessarily reflect those of the editorial board and the publisher of the NJZ.

Abstract

This study investigated the diversity and abundance of butterflies in Tokha Municipality, Ward No. 2 and 3, Kathmandu, Nepal from November 2023 to January 2024 using pollard walk method. During the study period, 219 individuals of 47 butterfly species were documented, with an overall Shannon-Wiener diversity index (H) of 3.17 and an evenness (E) of 0.823. The study area encompasses 3 different habitats: forest, agriculture land and settlement area where the forest habitat had the highest species richness (H= 29). Among the 6 families detected, Nymphalidae family was the most dominant with 19 species. When assessing the diversity on a monthly basis, the species richness was the highest in November (N=32) and least in January (N=16). This study provides baseline data for monitoring the butterfly population under the influence of rapid urbanization and environmental changes occurring in this area.

Keywords: Lepidoptera; Butterfly diversity; Shannon-Weiner diversity index; Pollard walk method; Nymphalidae

1 | Introduction

Butterflies are a diverse group of insects belonging to the order Lepidoptera. They are widely distributed and are one of the most extensively studied insects in terms of taxonomy (Bonebrake et al. 2010). In Nepal, a total of 629 butterfly species has been documented (Poel et al. 2022) and 29 species and subspecies are classified as endemic (Subedi et al. 2020).

Butterflies play a vital role in maintaining ecological balance and supporting food security, primarily as specialized pollinators. They pollinate over 50 economically important crops, directly contributing to local ecosystems and agricultural productivity (Borges et al. 2003). In addition, butterflies serve as crucial bio-indicators within terrestrial ecosystems (Tiple & Khurad 2009) because their presence and abundance not only gives information about the vegetation and habitat quality of a site (Sawchik et al. 2005) but on the impacts of climate change in the habitat as well (Parmesan et al. 1999).

Despite their ecological importance, butterflies have been facing alarming decline in their population in recent decades. Anthropogenic activities such as habitat destruction, fragmentation, declining native host plants, and the excessive use of pesticides and insecticides are major contributors to their decline (Kremen et al. 1993; New 1993). Additional pressures, including climate change, urbanization, and light pollution, further threaten their existence by disrupting ecosystems dependent on them. These challenges underscore the urgent need for conservation efforts and emphasize the broader implications for biodiversity and environmental health.

In Nepal, various natural and human-induced factors are driving the decline in butterfly diversity. Rapid urbanization in lowland districts like Banke and Dang (Khanal 2008), infrastructure development projects leading to habitat fragmentation (Khanal 2022), marble mining (Khanal et al. 2015), and environmental pollution (Oli et al. 2023) are some of the significant threats. The introduction of non-native species has further disrupted local ecosystems, adversely affecting native butterfly populations (Oli 2024). Additionally, the impacts of climate change are exacerbating these issues (Khanal 2022). Long-term monitoring and records of butterfly diversity and distribution offer valuable insights into their population dynamics and responses to environmental changes.

Butterfly diversity has been studied extensively across Nepal, including various parts of Kathmandu Valley such as Thankot and Syuchatar areas (Thapa 2008), sacred forests of Kathmandu Valley (Shrestha et al. 2018), Kirtipur (Oli & Sharma 2019), however, Tokha Municipality remains largely underexplored. Shivapuri Nagarjun National Park (SNNP), located adjacent to Tokha Municipality has documented 124 butterfly species (SNNP 2017; SNNP 2024). However, these studies cover the park's extensive area, from Shivapuri, Nagarjun, Kakani, and Sundarijal, and primarily focuses on butterflies thriving in the protected habitats within the park's boundaries. In contrast, our study focuses specifically on Wards 2 and 3 of Tokha Municipality, an area undergoing rapid urbanization (Shrestha & Tiwari 2021), covering not only forested areas but also human-influenced landscapes such as settlements and agricultural fields.

This study aimed to document the diversity and abundance of butterflies across three habitat types (settlement area, agriculture land and forest) in Tokha Municipality. It seeks to establish baseline data for the long-term monitoring of the butterflies in this region because records of butterfly diversity offer valuable insights into their population dynamics and responses to environmental changes.

2 | Materials and methods

2.1 | Study area

Tokha Municipality is located in Kathmandu district of Nepal on the northern side of the valley between coordinates 27°27'N to 27°49'N, 85°10'E to 85°32'E, above 1349 m asl (Fig. 1). It covers a total area of 17.11 km^2 and is bordered by Budhanilkantha Municipality to the east, Tarakeshwor Municipality to the west, Nuwakot District to the north, and Kathmandu Metropolitan City to the south (Tokha Municipality 2025). Tokha Municipality experiences a humid subtropical climate, characterized by dry cool winters and humid warm summers with temperatures ranging from 3 °C to 26 °C throughout the year (Weather Atlas 2024). The highest mean temperature ranges from 17.4 °C in June to 26 °C in August whereas the lowest mean temperature ranges from 3 °C in January to 5.3 °C in February.

The study encompassed three distinct habitats: forest, settlement area, and agricultural land, each with unique ecological characteristics. In order to minimize the sampling bias across these ecologically distinct habitats, an equal sampling effort was ensured by allocating equal number of transects (two per habitat) where each transect was surveyed six times in each habitat type. Additionally, surveys were performed under similar weather conditions to ensure consistency in butterfly activity, across habitats. Although habitat characteristics varied, our sampling design maintained equal temporal and spatial effort across forest, agriculture and settlement areas.

The forest habitat, classified as a lower mixed hardwood forest, is dominated by tree species such as *Schima wallichii, Castanopsis indica, Alnus nsepalensis, Prunus cerasoides*, and *Rhododendron arboreum*. It also includes a variety of shrubs, notably *Urtica dioica*, along with invasive species such as *Lantana camara*. Tokha, historically an agrarian town where agriculture was the primary occupation of the local people, still retains patches of agricultural land, although these have been significantly fragmented due to rapid and unplanned urbanization (Shrestha & Tiwari 2021). The primary crops cultivated in the field are *Oryza sativa* (rice), *Triticum aestivum* (wheat), *Brassica campestris* (mustard), *Zea mays* (maize), and a variety of seasonal vegetables, including plants such as *Brassica oleracea* (cabbage) and *Pisum* species (peas), that serve as host plants for butterflies.

2.2 | Data collection

The data were collected using the Pollard walk method (Pollard 1977). A total of six transects, each 500 meters in length, were randomly established across the study area so that they can adequately represent the habitats intended to study while also ensuring that the route is accessible for regular monitoring. Two transects were allocated to each habitat types: forest, settlement area, and agriculture land. Transects were spaced at least 100 meters apart to minimize the overlap and ensure broader coverage of the study area and butterflies spotted only within a 5-meter width, with 2.5 meters on each side of the transect were recorded. Each transect was surveyed six times during the study period, from November to January 2024, with two visits per month to account for temporal variations in butterfly populations. Surveys were conducted between 10:00 AM and 3:00 PM on sunny days to maximize the likelihood of observing butterfly species.

Butterfly identification has primarily and traditionally relied on the examination of morphological characteristics such as wing shape, color patterns, and venation (Theivaprakasham 2020). However, in

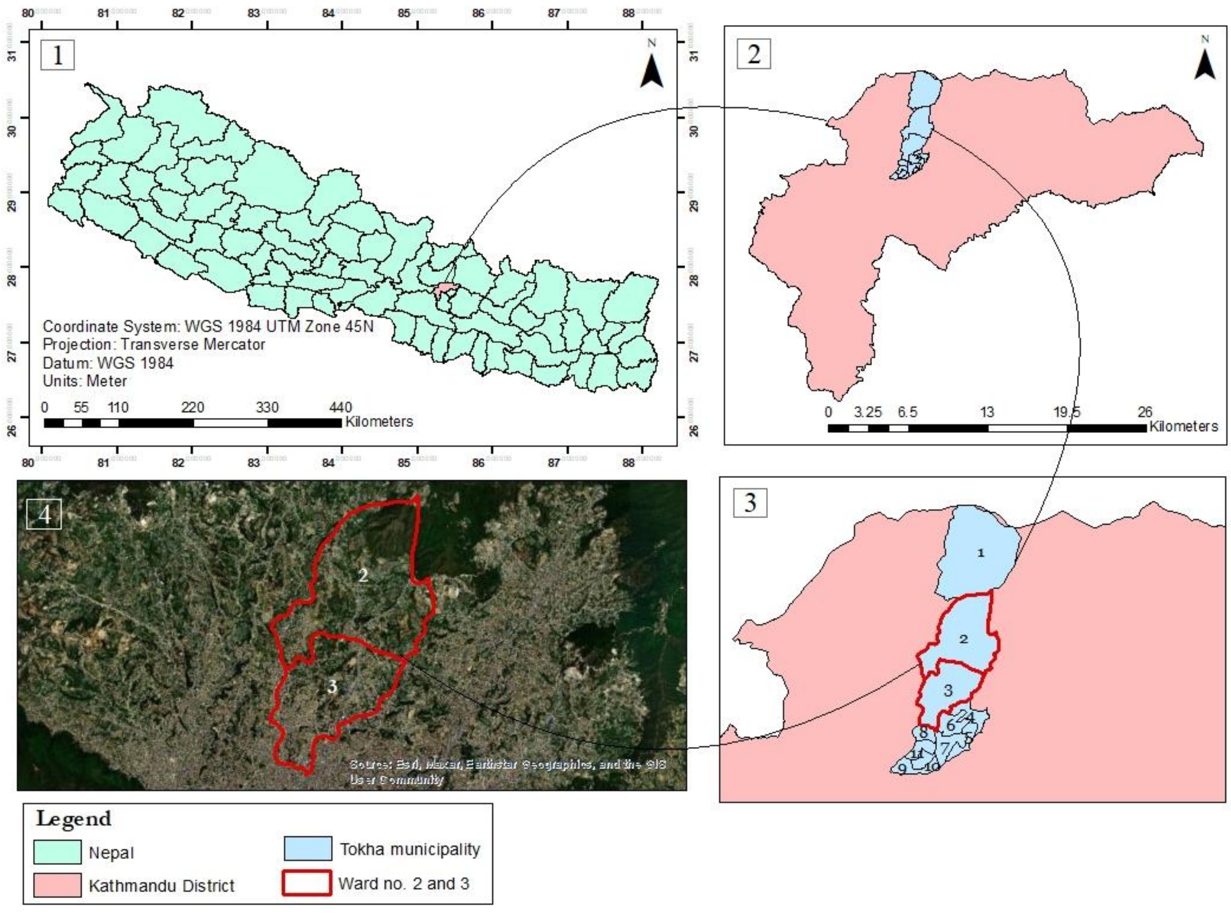


Figure 1. Map showing the location of 1) Kathmandu Valley in map of Nepal, 2) location of Tokha Municipality, 3) location of wards 2 and 3 in Tokha Municipality and 4) boundary of study area wards 2 and 3

recent years, photographic identification has emerged as a reliable, efficient, and non-invasive alternative. This approach allows researchers to document species without capturing or harming them, making it especially suitable for conservation-sensitive areas or observational studies with limited resources.

Advancements in digital photography and the availability of expert-reviewed platforms such as iNaturalist have further strengthened the accuracy of photographic identification. These platforms allow for crowdsourced verification and expert input, increasing confidence in species-level identifications based on high-quality images. Furthermore, a growing body of literature supports the use of this method in butterfly diversity and checklist studies. Several recent studies have successfully employed photographic identification to produce robust and credible data (Ganvir & Khaparde 2018; Miya et al. 2021; Sharma & Paudel 2021).

Thus, in this study the individuals were photographed using a DSLR camera (Canon EOS 1200D) and a smartphone (Xiaomi Redmi Note 11S), but none were captured or collected, to adhere to ethical guidelines and to maintain a cost-effective, non-destructive survey approach (Theivaprakasham 2021). Photographs of both the dorsal and ventral sides were taken whenever possible for accurate identification.

The species were initially identified in the field based on their morphology using standardized field guides such as Butterflies of Nepal by Colin Smith. The recorded species were later confirmed using comprehensive references such as An Annotated Catalogue of the Butterflies of Nepal by Colin Smith, which provided detailed morphological descriptions (Poel et al. 2022). The identification was further cross-checked using expert consultations and community science platforms like Project Noah (https://www.projectnoah.org/) and iNaturalist (https://www.inaturalist.org/) were also utilized to ensure accurate identification.

While this method may have limitations in distinguishing subspecies, sexes, or cryptic species in some cases, such distinctions were beyond the scope of this study. The primary objective was to record butterfly presence and diversity at the species level, for which photographic identification-backed by expert consultation and authoritative field guides-was deemed sufficient and appropriate.

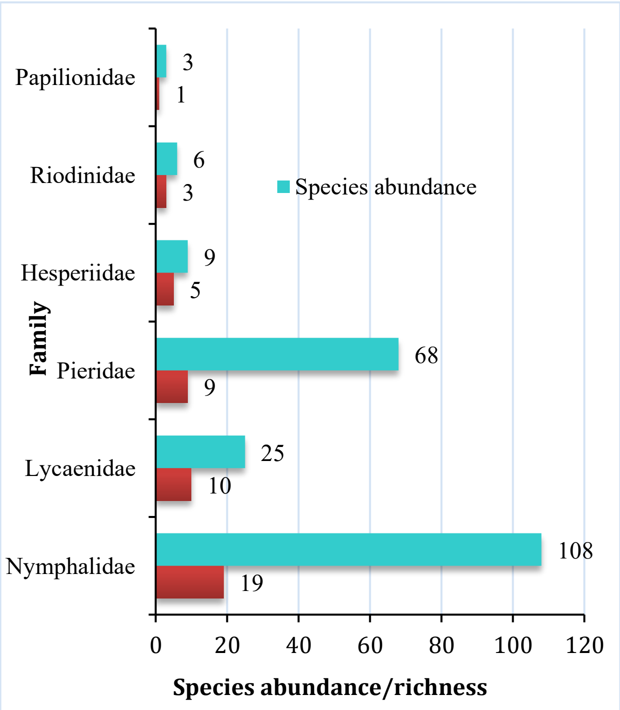


Figure 2. Family-wise composition of butterfly showing the species richness and species abundance within each family

2.3 | Data analysis

Species richness was determined based on the total number of species recorded.

The diversity of butterflies was calculated using the Shannon-Weiner diversity index (H) (Shannon & Weaver 1964; Spellerberg & Fedor 2003).

Shannon-Wiener diversity index (H) = $-\sum^{n}_{i=1}$ pi * ln (Pi)

Where, Pi = the proportion (ni/N),

ni is the number of individuals of one particular species and

N is the total number of individuals, N=∑ni.

Species evenness was calculated using the Pielou's evenness index (Pielou 1966):

Species evenness (E) = H/ln(S)

Where,

H= Shannon's diversity index

S=Species richness

3 | Results

The study recorded a total of 219 individual butterflies representing 47 species across 6 families. The overall Shannon-Wiener diversity index (H') was 3.17, indicating a high level of diversity. Similarly, the Pielou's evenness index (E) was 0.823, reflecting a fairly even distribution of individuals among the species, indicating a balanced community structure.

The description of the butterflies with their common name, scientific name and species abundance (N) is mentioned in Table 1.

3.1 | Family-wise composition of butterflies

Out of the 47 species recorded, 19 belonged to the Nymphalidae family, followed by Lycaenidae (10), Pieridae (9), Hesperiidae (5), Riodinidae (3), and Papilionidae (1). Figure 2 illustrates the richness and abundance of each butterfly family. Among them the most diverse and abundant family was Nymphalidae (H'=2.47, N=108) while the least diverse and abundant family was Papilionidae with only one species (Papilio polytes). The Hesperiidae family exhibited the highest species evenness, with a value of 0.887, as shown in Table 2.

3.2 | Species diversity in accordance with the habitat

Table 3 shows the butterfly species recorded in different habitats, while Table 4 provides details on species richness, diversity, and evenness for each habitat. The forest habitat recorded the most species (29) and the highest number of individuals (134), followed by the settlement area, with 19 species and 49 individuals. Agricultural land had the lowest number of species (14) and individuals (36). The highest diversity index was recorded in forest (2.89) followed by settlement area (2.94) and least in the agriculture land (2.42) as shown in Table 4. The most dominant species was *Pieris canidia* with 41 individuals sighted during the study while only single individuals of red lacewing (*Cethosia biblis*), rustic (*Cupha erymanthis)*, common leopard (*Phalanta phalantha)*, common map (*Cyrestis thyodamas)*, clouded yellow (*Colias croceus)*, forget-me-not (*Catochrysops strabo)*, lime blue (*Chilades lajus)*, dark cerulean (*Jamides bochus)*, purple sapphire (*Heliophorus epicles)*, pale hedge blue (*Udara dilecta)*, red-breast jezebel (*Delias acalis)*,

Table 1. List of butterflies recorded from wards 2 and 3 of Tokha Municipality along with their abundance (#)

S. N.	Common name	Scientific name	#
Family Nymphalidae			
1	Peacock pansy	*Junonia almana*	8
2	Common jester	*Symbrenthia lilaea*	6
3	Common fourring	*Ypthima huebneri*	3
4	Plain tiger	*Danaus chrysippus*	3
5	Indian red admiral	*Vanessa indica*	14
6	Common crow	*Euploea core*	2
7	Red lacewing	*Cethosia biblis*	1
8	Indian tortoiseshell	*Aglais caschmirensis*	11
9	Banded treebrown	*Lethe confusa*	7
10	Chocolate pansy	*Junonia iphita*	30
11	Common sailor	*Neptis hylas*	4
12	Glassy tiger	*Parantica aglea*	2
13	Rustic	*Cupha erymanthis*	1
14	Common castor	*Ariadne merione*	4
15	Common leopard	*Phalanta phalantha*	1
16	Common sergeant	*Athyma perius*	4
17	Lemon pansy	*Junonia lemonias*	2
18	Common map	*Cyrestis thyodamas*	1
19	Staff sergeant	*Athyma selenophora*	4
Family Lycaenidae			
1	Gram blue	*Euchrysops cnejus*	3
2	Metallic cerulean	*Jamides alecto*	6
3	Pale grass blue	*Pseudozizeeria maha*	3
4	Pea blue	*Lampides boeticus*	6
5	Forget-me-not	*Catochrysops strabo*	1
6	Common cerulean	*Jamides celeno*	2
7	Lime blue	*Chilades lajus*	1
8	Dark cerulean	*Jamides bochus*	1
9	Purple sapphire	*Heliophorus epicles*	1
10	Pale hedge blue	*Udara dilecta*	1
Family Pieridae			
1	Indian cabbage white	*Pieris canidia*	41
2	Redbreast jezebel	*Delias acalis*	1
3	Large cabbage white	*Pieris brassicae*	3
4	Chocolate wlbatross	*Appias lyncida*	2
5	Lemon emigrant	*Catopsilia pomona*	1
6	Three-spot grass yellow	*Eurema blanda*	13
7	Red-spot jezebel	*Delias descombesi*	1
8	Common grass yellow	*Eurema hecabe*	5
9	Clouded yellow	*Colias croceus*	1
Family Hesperiidae			
1	Large-branded swift	*Pelopidas subochracea*	4
2	Fulvous pied flat	*Pseudocoladenia dan*	1
3	Short-branded swift	*Pelopidas thrax*	1
4	Straight swift	*Parnara guttata*	2
5	Common spotted flat	*Celaenorrhinus leucocera*	1
Family Riodinidae			
1	Dark judy	*Abisara fylla*	4
2	Orange punch	*Dodona egeon*	1
3	Punchinello	*Zemeros flegyas*	1
Family Papilionidae			
1	Common mormon	*Papilio polytes*	3

lemon emigrant (*Catopsilia pomona)*, red-spot jezebel (*Delias descombesi)*, fulvous pied flat (*Pseudocoladenia dan)*, short-branded swift (*Pelopidas thrax)*, common spotted flat (*Celaenorrhinus leucocera)*, orange punch (*Dodona egeon)* and punchinello (*Zemeros flegyas)* were recorded during the study period.

3.3 | Composition of butterflies based on months

During the three months in which the study was conducted, maximum number of species were recorded in November (32) with 104 individuals whereas in January, a total of 16 butterfly species and 39 individuals were recorded (Fig. 3), making it the month with the lowest diversity and abundance observed during the study. Among the species identified in January, *Neptis hylas* was the most prevalent, with 11 individuals documented. The species chocolate pansy (*Junonia iphita*), common four-ring (*Ypthima huebneri*), common sailor (*Neptis hylas*), Indian cabbage white (*Pieris canidia*), Indian tortoise shell (*Aglais caschmirensis*), pea blue (*Lampides boeticus*) and three-spot grass yellow (*Eurema blanda*) were spotted in all three months.

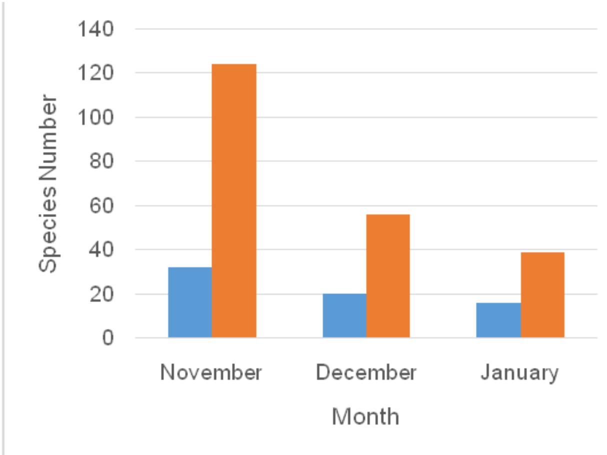


Figure 3. Month-wise composition of butterflies recorded in the study area; Blue- richness, orange- abundance

Table 2. Species richness, diversity indices, evenness, and abundance for each butterfly family

Family	Richness	H	Evenness	Abundance
Nymphalidae	19	2.47	0.838	108
Lycaenidae	10	2.04	0.886	25
Pieridae	9	1.3	0.593	68
Hesperiidae	5	1.43	0.887	9
Papilionidae	1	0		3
Riodinidae	3	0.87	0.79	6
Total	47	3.1694	0.823	219

4 | Discussion

Butterflies are one of the most extensively studied groups of insects (Bonebrake et al. 2010). In recent years, numerous studies have been conducted on butterflies in various parts of the Kathmandu Valley, including Thankot and Syunchatar (Thapa 2008), the forests of Suryabinayak, Dakshinkali, Swyambhunath, and Pashupatinath (Shrestha et al. 2018), Godawari in Lalitpur (Nepali et al. 2018), and the T.U. Campus in Kirtipur (Oli & Sharma 2019). These studies primarily focused on the forests, grasslands, and cultivated areas of the valley. Across all these regions, the Nymphalidae family consistently emerged as the most dominant group, exhibiting the highest diversity and abundance of recorded species.

The dominance of the Nymphalidae family in Tokha, can be attributed to several ecological factors that is similar to the study areas in other parts of the Kathmandu Valley. Given the similar geographical and climatic conditions, characterized by a sub-tropical climate and mixed hardwood forests, our study area provides comparable habitats to those previously studied. This may be the reason why Nymphalidae family demonstrated the highest species richness and abundance in our study as well.

Nymphalidae butterflies thrive in diverse habitats such as forests or regions abundant in host plants and nectar sources (Jiggins et al. 1996). Tokha's landscape, with its mosaic of forested areas, agricultural land and gardens in settlement areas, creates a

Table 2. Occurrence of butterfly species according to the habitat types in Tokha Municipality

Scientific name	Common name	Habitat		
		F	SA	AL
Nymphalidae				
Junonia almana	Peacock pansy	-	+	+
Symbrenthia lilaea	Common jester	+	+	+
Ypthima huebneri	Common four-ring	+	+	+
Danaus chrysippus	Plain tiger	-	+	-
Vanessa indica	Indian red admiral	+	+	+
Euploea core	Common crow	-	+	-
Cethosia biblis	Red lacewing	+	-	-
Aglais caschmirensis	Indian tortoiseshell	+	+	+
Lethe confusa	Banded tree-brown	+	-	-
Junonia iphita	Chocolate pansy	+	-	-
Neptis hylas	Common sailor	+	-	+
Parantica aglea	Glassy tiger	+	-	-
Cupha erymanthis	Rustic	+	-	-
Ariadne merione	Common castor	-	+	-
Phalanta phalantha	Common leopard	+	-	-
Athyma perius	Common sergeant	+	-	-
Junonia lemonias	Lemon pansy	+	-	-
Cyrestis thyodamas	Common map	+	-	-
Athyma selenophora	Staff sergeant	+	-	-
Pieridae				
Pieris canidia	Indian cabbage white	+	+	+
Delias acalis	Redbreast jezebel	-	+	-
Pieris brassicae	Large cabbage white	-	+	+
Appias lyncida	Chocolate albatross	+	-	-
Catopsilia pomona	Lemon emigrant	-	-	+
Eurema blanda	Three-spot grass yellow	+	-	+
Delias descombesi	Red-spot jezebel	+	-	-
Eurema hecabe	Common grass yellow	+	-	-
Colias croceus	Clouded yellow	-	+	-
Lycaenidae				
Euchrysops cnejus	Gram blue	-	+	+
Jamides alecto	Metallic cerulean	+	+	+
Pseudozizeeria maha	Pale grass blue	-	+	+
Lampides boeticus	Pea blue	+	+	-
Catochrysops strabo	Forget-me-not	+	-	-
Jamides celeno	Common cerulean	-	+	-
Chilades lajus	Lime blue	+	-	-
Jamides bochus	Dark cerulean	+	-	-
Heliophorus epicles	Purple sapphire	+	-	-
Udara dilecta	Pale hedge blue	-	-	+
Hesperiidae				
Pelopidas subochracea	Large branded swift	-	+	-
Pseudocoladenia dan	Fulvous pied flat	+	-	-
Pelopidas thrax	Short-branded swift	-	+	+
Parnara guttata	Straight swift	-	+	-
Celaenorrhinus leucocera	Common spotted flat	+	-	-
Papilionidae				
Papilio polytes	Common mormon	+	-	-
Riodinidae				
Abisara fylla	Dark judy	+	-	-
Zemeres flegyas	Punchinello	+	-	-
Dodona egeon	Orange punch	+	-	-

Note: F- Forest, SA- Settlement area, and AL- Agricultural land

Table 1. Species richness, Shannon diversity index, evenness and abundance in different habitats

Habitat	Forest	Settlement area	Agriculture land
Species richness	29	19	14
Shannon diversity index	2.89	2.94	2.42
Species evenness	0.858	0.999	0.917
Abundance	134	49	36

favorable environment for these butterflies. Additionally, the strong dispersal abilities of Nymphalidae species (Dudley & Adler 1996) enable them to navigate Tokha's varied topography, which includes open spaces, forest edges, and natural corridors. These features facilitate them to search for resources over wider areas (Raut & Pendharkar 2010).

The highest number of butterfly species in our study was observed in forest habitats (29), followed by settlement areas (19), while agricultural lands (14) hosted the least diversity. The forest, which were better preserved with minimal human interference among the three habitats, supported the highest butterfly diversity. This finding aligns with numerous studies which suggest that forest sustain greater butterfly diversity due to their complex habitat structures, including canopies, understories, and edge environments, accommodating a wide range of butterfly species (Vogel et al. 2023). Tammaru et al. (2023) further emphasized that forests provide better habitat quality, resulting in a more stable balance between colonization and extinction rates compared to urban or agricultural areas. Sagwe et al. (2015) also highlighted that reduced human activities in forests lead to abundant food resources and stable microclimates, creating favorable conditions for the survival and reproduction of the butterflies. In our study, forest areas hosted a variety of plant species, including host plants such as *Calotropis gigantea, Urtica dioica, Lantana camara, Dendrophthoe falcata,* and *Ruellia tuberosa*, which likely supported more species. Furthermore, the minimal human disturbance in forest habitats, compared to settlements and agricultural lands, likely contributed to the greater butterfly diversity.

In contrast, a study by Spitzer et al. (2013) in the Tam Dao Mountains of Vietnam, a tropical-subtropical montane region recorded fewer butterfly species in forest as compared to disturbed habitats, such as ruderal zones with cultivated and abandoned terrace fields. They reasoned those forests provide highly specialized environments that support habitat-specialist butterflies only, while disturbed habitats offer a broader range of adaptable species.

The timing of our study may have influenced the result. During the survey period, agricultural lands were mostly barren with little vegetation available since the harvest season had ended. This lack of plants likely contributed to the lower species diversity in the agriculture habitat. In contrast, the forest habitat, had ample vegetation, providing abundant resources for butterflies because habitat preferences of the butterflies are often linked to the availability of larval host plants and nectar sources (Thomas 1995).

During the three months of the study, 68.08% of species were recorded in November, 42.55% in December, and 34.04% in January. Seasonal changes have a significant influence on butterfly diversity and their population dynamics across different habitats and seasons, as evidenced by several studies conducted in sub-tropical regions. Research by Sharma and Sharma (2021) and Sengupta et al. (2014) in sub-tropical vegetation areas found that butterfly diversity peaks during the monsoon and pre-monsoon periods, from April to December, primarily due to the increased availability of host plants and favorable climatic conditions. These findings are consistent with those of other studies, which have observed that butterfly diversity is generally lowest during the winter months, with peaks occurring in the wet season when flowering and food availability are higher (Gupta et al. 2019; Bisht et al. 2022). In our study, November, which marks the transition from wet to the dry season, showed relatively higher butterfly population compared to the other two seasons. This may be due to the residual flowering plants from the wet season still providing food resources.

We also observed a gradual decline in butterfly population from November to January, as the transition from autumn to winter occurred. In fact, the population decreased significantly from 68.8% in November to 34.04% in January. This decline highlights the impact of seasonal changes on butterfly populations which may be due to the drop in temperatures and the subsequent reduction in available food sources.

Similarly, January showed a further decline in butterfly diversity, as lower temperatures and reduced floral resources lead to less butterfly activity (Ganvir & Khaparde 2018). This seasonal trend further underscores the significance of climate and food availability in shaping butterfly populations across different seasons. A more comprehensive study, covering all seasons and encompassing all the wards of the municipality, is essential to assess the butterfly diversity of Tokha Municipality throughout the year. This would provide a more holistic understanding of the seasonal variations in diversity, addressing the limitations of the current study.

Urbanization in Tokha is increasing at an unprecedented rate, with rapid change in the land structures and rise in population with a 1.35% annual growth rate (Shrestha & Tiwari 2021). These economic activities of the people are shifting from agriculture to business and services, which renders many agricultural land to go barren and unused or being replaced by housing and buildings. This may have a serious threat to the butterflies in the coming future. This study provides baseline data for the butterflies of Tokha, so that future research on butterflies in Tokha can get information as well as to compare the population trend for the future. In this time of rapid change, it is important to have a proper record on not only the butterflies, but the biodiversity of Tokha, so that we can assess the impact of the unmanaged change.

5 | Conclusions

This study highlights the rich butterfly diversity in Tokha, with 47 species from 6 families. The dominance of Nymphalidae aligns with findings from other regions in the Kathmandu Valley that share the similar geo-climatic conditions. Furthermore, butterfly diversity was found to be highest in forest habitats compared to settlements and agricultural lands. This pattern can be explained by several ecological factors. Forest areas in Tokha were relatively undisturbed and supported a wider range of native vegetation, including important host plants such as *Calotropis gigantea*, *Urtica dioica*, and *Lantana camara*, which are essential for butterfly survival and reproduction. The complex structure of forest habitats, with canopies, understories, and edge environments, provides shelter, stable microclimates, and continuous availability of nectar sources. These ecological conditions create a more suitable environment for a wider variety of butterfly species. In contrast, agricultural lands, which were mostly barren during the survey period, and settlement areas, which face higher levels of human activity, offered fewer floral resources and were less favorable for butterfly habitation. When observing the monthly trends, the butterfly population peaked in November and gradually decreased up to January. Given the increasing urbanization and land-use changes in Tokha, we recommend further research into butterfly diversity, particularly focusing on seasonal variations and habitat preferences. Additionally, we propose the development and implementation of a conservation management plan, with an emphasis on community outreach and awareness to ensure the long-term preservation of butterfly populations in the face of ongoing environmental changes.

Acknowledgements

We are grateful to Mr. Pratit Chataut and Ms. Pabitra Maya Tamang for their assistance during the data collection. We also sincerely thank all the senior researchers and colleagues for their valuable guidance in species identification. We would also like to thank the local communities for their cooperation during the fieldwork.

Authors' contributions

P.C. designed the research and performed fieldwork; both authors analyzed the data and finalized the manuscript.

Conflicts of interest

The authors declare no conflict of interest.

References

Bisht M., Goswami D., Uniyal V.P. and Singh V. 2022. Diversity of butterfly along different altitudinal gradient of Munsiyari, Western Himalayan, Uttarakhand, India. Asian Journal of Conservation Biology, 11:258–265. https://doi.org/10.53562/ajcb.72630

Bonebrake T.C., Ponisio L.C., Boggs C.L., Ehrlich P.R., Gilbert L.E. and Singer M.C. 2010. More than just indicators : A review of tropical butterfly ecology and conservation. Biological Conservation, 143:1831–1841. http://dx.doi.org/10.1016/j.biocon.2010.04.044

Borges R.M., Gowda V. and Zacharias M. 2003. Butterfly pollination and high-contrast visual signals in a low-density distylous plant. Oecologia, 136:571–573. https://doi.org/10.1007/s00442-003-1336-yy

Dudley R. and Adler G.H. 1996. Biogeography of milkweed butterflies (Nymphalidae : Danainae) and mimetic patterns on tropical Pacific archipelagos. Biological Journal Linnean Society, 57:317–326. https://doi:10.1006/bijl.1996.0019

Ganvir D.R. and Khaparde K.P. 2018. Seasonal Diversity and Status of Butterfly Fauna in Sakoli Taluka of Bhandara District, Maharashtra, India. Int. J. Life. Sci. Scienti. Res., 4:1905–1914. https://doi.org/10.21276/ijlssr.2018.4.4.8

Gupta H., Tiwari C. and Diwakar S. 2019. Butterfly diversity and effect of temperature and humidity gradients on butterfly assemblages in a sub-tropical urban landscape. Tropical Ecology, 60:150–158. https://doi.org/10.1007/s42965-019-00019-y

Jiggins C.D., McMillan W.O., Neukirchen W. and Mallet J. 1996. What can hybrid zones tell us about speeiation? The case of Heliconius erato and H. himera (Lepidoptera: Nymphalidae). Biological Journal of the Linnean Society, 59:221–242. h https://doi.org/10.1111/j.1095-8312.1996.tb01464.x

Khanal B. 2008. Diversity and Status of Butterflies in Lowland Districts of West Nepal. Journal of Natural History Museum, 23:92–97. https://doi.org/10.3126/jnhm.v23i0.1846

Khanal B. 2022. Survey of population and threats of a cites listed butterfly Troides aeacus aeacus (Felder and Felder, 1860) in central Nepal. Journal of Natural History Museum, 32:77–86. https://doi.org/10.3126/jnhm.v32i1.49954

Khanal B., Chalise M.K. and Solanki G.S. 2012. Diversity of butterflies with respect to altitudnal rise at various pockets of the Langtang National Park, Central Nepal. International Multidisciplinary Research Journal, 2(2):41–48.

Khanal B., Chalise M.K. and Solanki G.S. 2015. Population Status and Threats of Phaedyma Aspasia kathmandia Fujioka 1970 (Lepidoptera: Nymphalidae), an Endemic Subspecies of Butterfly in Godavari Forest of Central Nepal. Journal of Natural History Museum, 27:87–91. https://doi.org/10.3126/jnhm.v27i0.14157

Kremen C., Colwell R.K., Erwin T. and Noss R. 1993. Terrestrial Arthropod Assemblages : Their Use in Conservation Planning. Conservation Biology, 7(4):796–808. https://doi.org/10.1046/j.1523-1739.1993.740796.x

Miya M.S., Chhetri A., Gautam D. and 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.

Nepali K.B., Lamichhane D. and Shah S. 2018. Diversity of butterfly and its relationship with plants in National Botanical Garden, Godawari, Lalitpur, Nepal. Journal of Plant Resources, 16(1):124–129.

New T.R. 1993. Conservation Biology of Lycaenidae (Butterflies). Information press, Oxford, U.K.

Tokha Municipality. 2025. Tokha Municipality. https://www.tokhamun.gov.np/en/node/4

Oli B.R. and Sharma M. 2019. Butterfly Species Richness in Tu College Area, Kirtipur, Kathmandu, Nepal. PRAYAS, 2(1):35–42.

Oli B.R., Sharma M. and 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

Oli L.B. 2024. Biodiversity in Nepal: Current Status, Threats and Conservation. Gipan, 6(1):244–258. doi:https://doi.org/10.3126/cognition.v6i1.64477.

Parmesan C., Ryrholm N., Stefanescu C., Hill J.K., Thomas C.D., Descimon H. et al. 1999. Poleward shifts in geographical ranges of butterfly species associated with regional warming. Nature, 399:579–583.

Pielou E.C. 1966. The measurement of diversity in different types of biological collections. Journal of Theoretical Biology, 13(C):131–144. https://doi.org/10.1016/0022-5193(66)90013-0

Poel P.V.P and Smetacek P. 2022. An Annotated Catalogue of the Butterflies of Nepal. (1st ed). Bionotes.

Pollard E. 1977. A method for assessing changes in the abundance of butterflies. Biological Conservation, 12(2):115–134. https://doi:10.1016/0006-3207(77)90065-9.

Raut N.B. and Pendharkar A. 2010. Butterfly (Rhopalocera) fauna of Maharashtra Nature Park, Mumbai, Maharashtra, India. Check List, 6(1):22–25. https://doi.org/10.15560/6.1.022

Sagwe R.N., Muya S.M. and Maranga R. 2015. Effects of land use patterns on the diversity and conservation status of butterflies in Kisii highlands, Kenya. Journal of Insect Conservation, 19(6):1119–1127. https://doi.org/10.1007/s10841-015-9826-x

Sawchik J., Dufrêne M. and Lebrun P. 2005. Distribution patterns and indicator species of butterfly assemblages of wet meadows in southern Belgium. Belgian Journal of Zoology, 135(1):43–52.

Sengupta P., Banerjee K.K. and Ghorai N. 2014. Seasonal diversity of butterflies and their larval food plants in the surroundings of upper Neora Valley National Park, a sub-tropical broad leaved hill forest in the eastern Himalayan landscape, West Bengal, India. Journal of Threatened Taxa, 6(1):5327–5342. https://doi.org/10.11609/jott.o3446.5327-42

Shannon C.E. and Weaver W. 1964. The Theory of Mathematical Communication. Bell System Technical Journal, 27:379–429.

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

Sharma N. and Sharma S. 2021. Assemblages and seasonal patterns in butterflies across different ecosystems in a sub-tropical zone of Jammu Shiwaliks, Jammu and Kashmir, India. Tropical Ecology, 62(2):261–278. https://doi.org/10.1007/s42965-020-00139-w

Shrestha B.R., Sharma M., Magar KT., Gaudel P., Gurung M.B. and Oli B. 2018. Diversity and status of butterflies at different sacred forests of Kathmandu valley, Nepal. Journal of Entomology and Zoology Studies, 6(3):1348–1356.

Shrestha S. and Tiwari S.R. 2021. Effect of Contemporary Urbanization on Historic Town Tokha. Proc 10th IOE Graduate Conference, 8914:392–399.

SNNP. 2017. Shivapuri Nagarjun National Park and Buffer Zone Management Plan Fiscal Year 2074/75-087/079 (2017/018-2021/022).

SNNP. 2024. Shivapuri Nagarjun national park and buffer zone management plan 2024-2029.

Spellerberg I.F. and Fedor P.J. 2003. Tribute To Claude Shannon (1916-2001) and a plea for more rigorous use of species richness, species diversity and the 'Shannon–Wiener' Index. Global Ecology Biogeography, 12:177–179.

Spitzer K., Novotny V. and Tonner M. 2013. Habitat preferences , distribution and seasonality of the butterflies (Lepidoptera , Papilionoidea) in a montane tropical rain forest , Vietnam. Journal of Biogeography, 20(1):109–121. https://doi.org/10.2307/2845744

Subedi B., Stewart A.B., Neupane B., Ghimire S. and Adhikari H. 2020. Butterfly species diversity and their floral preferences in the Rupa Wetland of Nepal. Ecology and Evolution, 11(5):2086–2099. https://doi.org/10.1002/ece3.7177

Tammaru T., Valdma D., Tiitsaar A., Kaasik A., Ounap E., Remm J. et al. 2023. Landscape-level determinants of butterfly species richness in northern Europe: A country-wide survey reveals the paramount importance of forest land. Biological Conservation, 286(0006–3207). https://doi.org/10.1016/j.biocon.2023.110294

Thapa G. 2008. Diversity of butterflies in the Thankot and Syuchatar VDCs of Kathmandu District. Tribhuvan University, Kritipur, Kathmandu, Nepal.

Theivaprakasham H. 2020. Identification of Indian butterflies using Deep Convolutional Neural Network. Journal of Asia-Pacific Entomology, 24(1):329–340. https://doi.org/10.1016/j.aspen.2020.11.015

Thomas J.A. 1995. The ecology and conservation of Maculinea arion and other European species of large blue butterfly. In: Pullin,A.S.(eds) Ecology and Conservation of Butterflies. Springer, Dordrecht, p. 181–197. https://doi.org/10.1007/978-94-011-1282-6_13

Tiple A.D. and Khurad A.M. 2009. Butterfly Species Diversity, Habitats and Seasonal Distribution in and Around Nagpur City, Central India. World Journal of Zoology, 4(3):153–162.

Vogel C., Mayer V., Mkandawire M., Küstner G., Kerr R.B., Krauss J. et al. 2023. Local and landscape scale woodland cover and diversification of agroecological practices shape butterfly communities in tropical smallholder landscapes. Journal of Applied Ecology, 60(8):1659–1672. https://doi.org/10.1111/1365-2664.14446

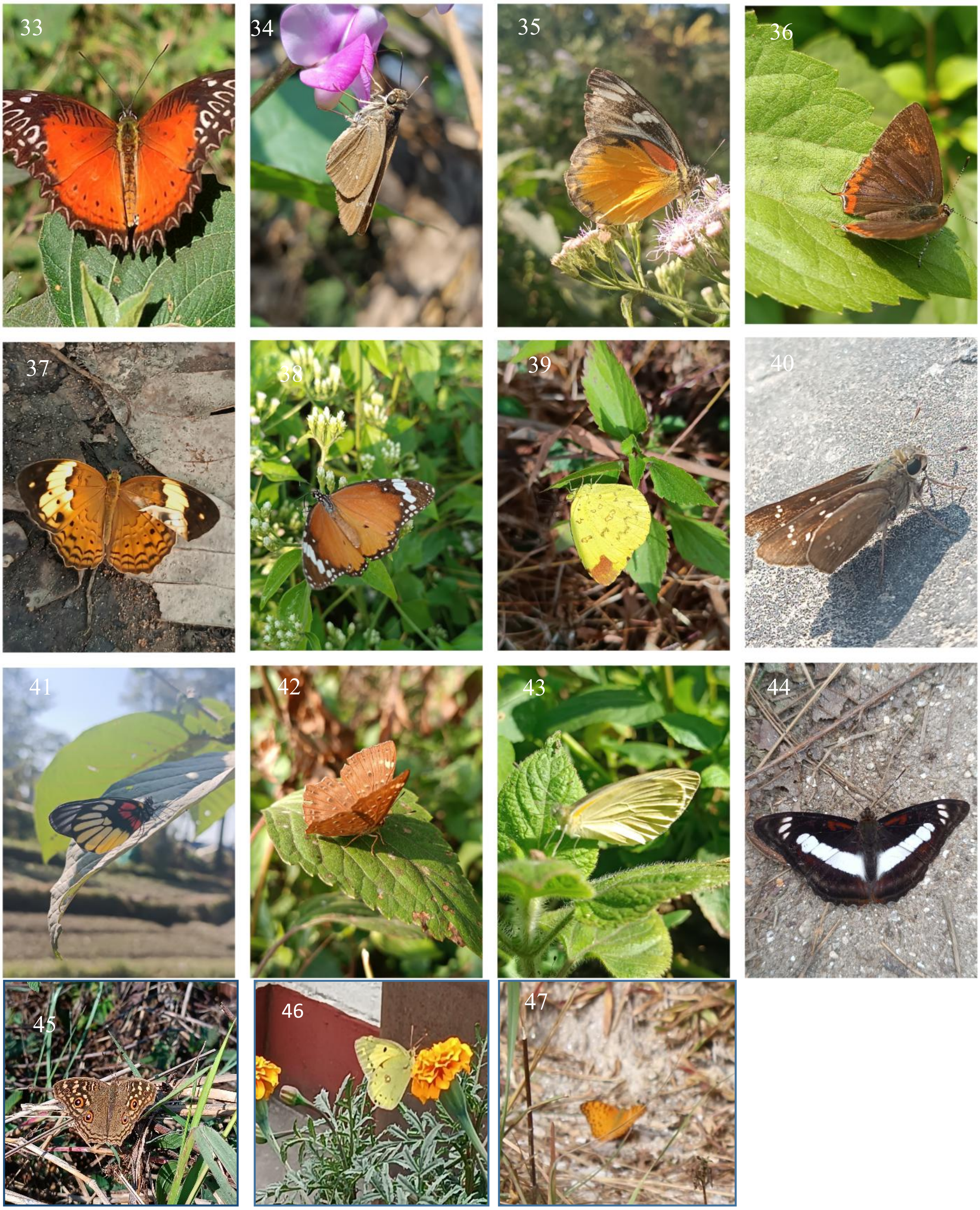
Weather Atlas. 2024. Climate and monthly weather forecast Tokha, Nepal. Weather Forecast Clim. https://www.weather-atlas.com/en/nepal/tokha-climate.

Accessed on 15 October 2024.

Photo plates (© = Prakriti Chataut)

Images 1–16. 1- *Lethe confusa* | 2- *Ypthima huebneri* | 3- *Papilio polytes* | 4- *Jamides bochus* | 5- *Junonia iphita* | 6- *Eurema hecabe* | 7- *Neptis hylas* | 8- *Zizeeria karsandra* | 9- *Ariadne merione* | 10- *Symbrenthia lilaea* | 11- *Athyma perius* | 12- *Abisara fylla* | 13- *Euploea core* | 14- *Cyrestis thyodamas* | 15- *Celaenorrhinus leucocera* | 16- *Catochrysops strabo*

Images 17-32. 17- *Pseudocoladenia dan* | 18- *Vanessa indica* | 19- *Chilades lajus* | 20- *Pseudozizeeria maha* | 21- *Parantica aglea* | 22- *Aglais caschmirensis* | 23- *Jamides alecto* | 24- *Udara dilecta* | 25- *Euchrysops cnejus* | 26- *Pelopidas subochracea* | 27- *Jamides celeno* | 28- *Lampides boeticus* | 29- *Pieris canidia* | 30- *Catopsilia pomona* | 31- *Dodona egeon* | 32- *Junonia almanac*



Images 33-47. 33- *Cethosia biblis* | 34- *Borbo cinnara* | 35- *Delias descombesi* | 36- *Heliophorus epicles* | 37- *Cupha erymanthis* | 38- *Danaus chrysippus* | 39- *Eurema blanda* | 40- *Pelopidas mathias* | 41- *Delias acalis* | 42- *Zemeros flegyas* | 43- *Pieris brassicae* | 44- *Athyma selenophora* | 45- *Junonia lemonias* | 46- *Colias croceus* | 47- *Phalanta phalantha*