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Butterfly Diversity and Distribution in Lowland of Western Nepal: A Case Study of Thakurbaba Municipality, Bardiya, Nepal

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Abstract

Butterflies are insects known for their large, colorful wings and distinctive, fluttering flight. They serve as both pollinators and important environmental indicators. Previous researchers have predominantly centered on assessing the status and creating checklists of various butterfly species across the country. However, there has been a notable lack of comprehensive, habitat-focused investigations into butterflies. In the face of ongoing, rapid anthropogenic development and environmental changes, it is imperative to regularly monitor the status of butterflies in diverse habitats and consider the influence of environmental factors. This study was conducted during the winter season (January 2020) to assess the spatial distribution and diversity of butterflies in Thakurbaba Municipality, Bardiya. The study was conducted in three riverbank, forest, and farmland habitats. Sampling was carried out along a line transect of 10 meters length and butterflies encountered within 5 meters wide along each side were recorded. A total of 12 transects across the different habitats were studied: 5 in farmland, 3 in riverbank, and 4 in forest respectively. Altogether 130 individual butterflies belonging to 27 species, 18 genera, and 4 families were recorded from three different habitats. Nymphalidae was the most abundant family with 18 species. The forest seemed highly diverse and rich in butterflies during the study period followed by the riverbank. Additionally, evenness was higher in the riverbank than in the other two habitats. Intensive and regular monitoring is necessary to determine butterflies' seasonal variability and recognize their ecological significance in the study area.

Keywords: *Disturbance, ecological habitat, lepidoptera, transect, similarity coefficient*

Introduction

Butterflies are the most widely studied insects in the world. They are classified under the order Lepidoptera, together with moths (Marren et al, 2010). Butterflies are regarded as good indicators of anthropogenic disturbance in ecosystems' habitat quality (Khanal et al., 2012; Kocher & Williams, 2000). They hold a significant position within ecosystems, serving as both a pollinator and a source of food, while also serving as an indicator of the ecosystem's health (Stokl et al., 2011, Shi et al., 2009; Webb, 2008). They are the prey for several animals such as birds, reptiles, amphibians, etc. in every stage of their life cycle. Reduction in their abundance can result in the reduction of their predator species. Similarly, their caterpillar stage acts as biological pest control as they feed on harmful insects (Ehrlich, 1984). Butterflies play a crucial role in dispersing pollen throughout the ecosystem over a range of 3,000 miles (Stokl et al., 2011). Their sensitivity to abrupt environmental changes, such as those brought about by climate change (Subedi et al., 2021; Woods et al., 2014), affects pollination patterns and leads to habitat loss, underscoring their responsiveness. The presence of a substantial butterfly population indicates a significant amount of plant diversity and other pollinator groups within an ecosystem indicating a clear signal of its overall well-being (Ghazanfar et al., 2016).

Being a mountainous country located in the junction of Indo-Malayan and Palearctic biogeographic realms (Paudel et al., 2012), Nepal possesses a wide variety of climatic and topographic variability. This variability within a certain range and distance has provided the habitats for unique biodiversity within the country (Paudel et al., 2012). Within the narrow geographic range, 693 species of butterflies with 29 subspecies, and 11 families are documented from Nepal (K.C. & Pariyar, 2019; Sapkota et al., 2020; Oli et al., 2023; Smith, 2011). Out of these about four species and 25 subspecies of butterflies are endemic to Nepal. Similarly, a total of 142 butterflies present in Nepal are categorized in the Red Data Book of Nepal as 12 endangered, 43 vulnerable, and 87 susceptible (BPP, 1995; ICIMOD & MOEST, 2007). Likewise, three species (Swallowtail butterfly *Teinopalpus imperialis*, Golden Birdwing *Troides aeacus*, and, Common Birdwing *Troides helena*) are placed under CITES Appendix II (UNEP-WCMC, 2014, CITES, 2023).

The presence of butterfly species is associated with the components and quality of particular habitats such as vegetation types, the presence of floral plants, canopy cover, wind speed, etc (KC, 2023). Because of their phytophagous nature, they feed on nectar and pollen (Bauder et al., 2011 and 2013). Butterfly diversity is highest in areas where large amounts of host plants are available (Ghorai & Sengupta, 2014) and lowest in shrubs, grassland, and open areas (DeVries, 1988). Food preferences and floral preferences determine their presence, which can be influenced by flower color, nectar concentration, nectar quantity and quality, flower structure, flower shape, and size (Tiedge & Lohaus, 2017; Subedi et al., 2021). Thus, understanding the butterfly composition within the different habitats will help develop species-focused conservation action plans. Based on their habitat preferences we can focus on the microhabitat conservation for their survival. Understanding Organic and inorganic components in focusing on different habitats is fundamental for their sustainable conservation (KC, 2023; Kumar et al., 2017).

Despite their ecological importance for healthy habitats and ecosystems (Molina & Palma, 1996), they are facing a huge population decline (Pullin, 1996) due to increasing anthropogenic disturbances. Nepal is progressing towards rapid development, resulting in habitat degradation, modification, and fragmentation, which has increased threats for sensitive species like butterflies. Excessive use of forest resources and habitat alteration in the country are threatening the current population and status of the butterflies (Khanal, 2008; Joshi, 2023). The use of different agricultural fertilizers (Braak et al., 2018), increasing invasive species and Climate change (Choudhary & Chishty, 2020), monocultural farming practices, and pollution (Gaudel et al., 2020; Shrestha et al., 2018) are slowly damaging the valuable and pristine macro-habitats of rare butterflies. However, none of the species under the Lepidoptera order are considered for regional (Asia region) assessment by the IUCN Red List (IUCN, 2023). Conservation of butterflies is crucial as they offer vital ecological services to native wild plant species, crops, and livestock in many habitats across the world. It is necessary to preserve them to sustain the agricultural and natural ecosystem's productivity (Davies et al., 2018). Protecting butterflies and their habitat can also help to control the agricultural pest. They have an important position in the Trophic structure as they serve as a primary consumer and act as food for birds and other predators (Summerville and Crist, 2001). Regardless of being of huge ecological importance, their study is shadowed over the other charismatic species.

The number of research on butterflies and their associated habitat is limited in Nepal and the case for the western region (Suwal et al., 2019a; Suwal et al., 2019b; Joshi, 2023; Khanal, 2008) including Bardiya is nothing different. Post Smith's (1994) variation of the butterfly diversity and richness over the country with increasing anthropogenic disturbances and habitat type change is unexplored and unidentified. Due to the major focus on charismatic species in the field of ecology; research and identification of insect species are lacking (Prajapati et al., 2000). Bardiya National Park has categorized Butterfly species as one of the least studied species and needs to prioritize research works on these species under the current management plan (BNP, 2022). Also, butterflies are sensitive to anthropogenic disturbances like pollution, they are facing a risk of survival. Thus, understanding the species composition and regular monitoring in different habitats in terms of both area coverage and taxonomic investigation are crucial.

This study aims to document the diversity of the butterflies within the three different habitats of Bardiya in the winter season. This research will act as a foundation for further detailed and systematic research on butterfly species present in the Thakurbaba Municipality of Bardiya District.

Materials and Methods

Study Area

The study was conducted in Thakurbaba Municipality of Bardiya District located in Lumbini Province, Nepal, which covers an area of 104.57-kilometer square (km²) (CBS, 2013) (Fig. 1). Most of its area is fertile Terai plains covered with agricultural land and forest. Bardiya districts have a minimum average annual temperature in the range is 18°C to 20°C and the maximum average temperature has varied from 28°C to 30.5°C. The average annual rainfall for the Bardiya is 1900 millimeters (mm) (AEPC, 2014). The studied farmland habitat was filled with wheat *Triticum aestivum* and mustard *Brassica nigra* plants. Additionally, it also inhabited invasive species like *Ageratum houstonianum.* The municipality is surrounded by the Bardiya National Park from the east, west, and north, and Madhuwan and Barbardiya Municipality from the south. Bardiya National Park (BNP).

BNP covers an area of 968km². It is one of the largest undisturbed wildernesses in Nepal's Terai. Bardiya National Park is rich in biodiversity which inhabits several rare and endangered species of flora and Fauna. Being a sandwich between the tropical and sub-tropical zone it has alluvial grassland and sub-tropical deciduous and riverine forest, which supports a suitable habitat for Large wild lives. For the butterfly study, we selected the riverbank and forest habitats of BNP (Fig. 1). Among the mentioned two habitats river bank was a little bit disturbed compared to the forest habitat and has an open canopy as well. BNP is one of the major habitats for wildlife of high conservation significance (Dhakal et al., 2023; Thapa et al., 2021).

The Park is home to 60 mammalian species, 513 bird species, 52 herpetofauna species, and 121 fish

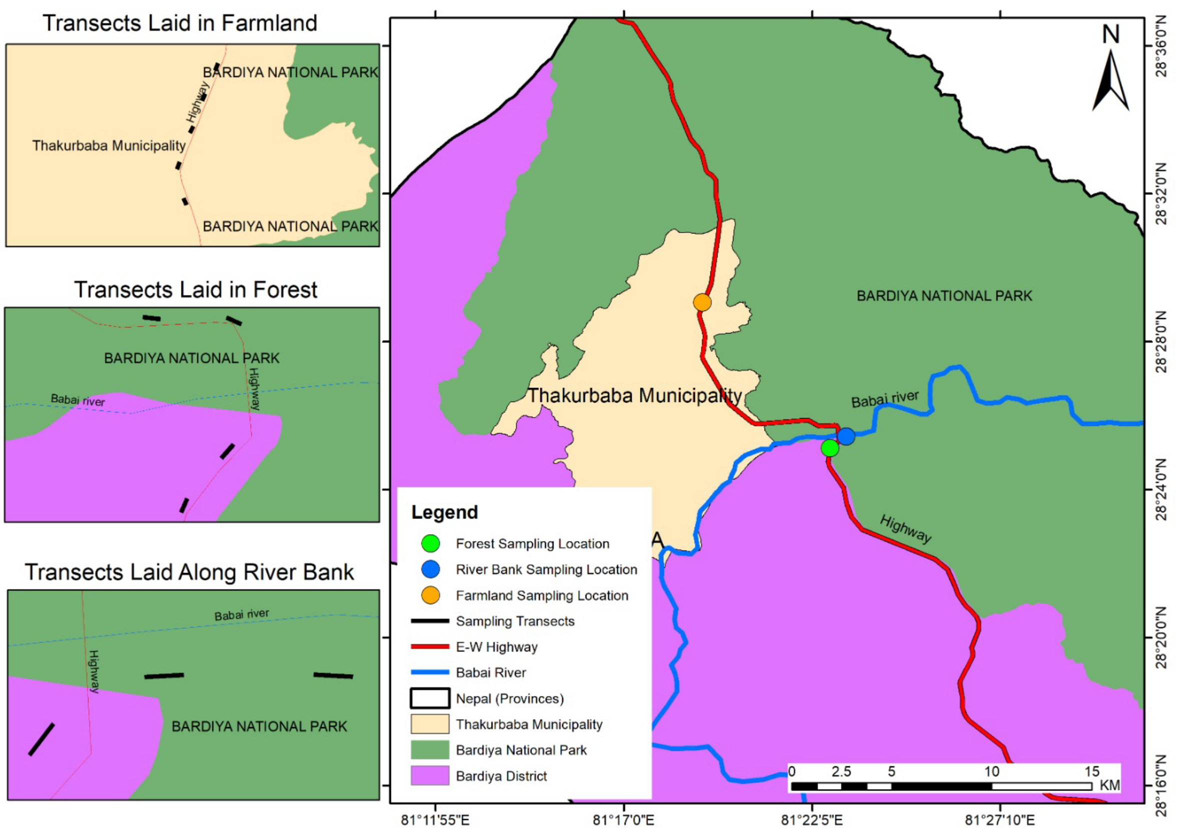

Figure 1: Study area including three different habitats denoted by different dot colors (Yellow dot= farmland, blue dot= Riverbank, and green dot= Forest habitat)

species (BNP, 2022). Some of the charismatic species found in BNP are the Royal Bengal Tiger (*Panthera tigris tigris*), Asian Wild Elephant (*Elephus maximus*), One-Horned Rhinoceros (*Rhinoceros unicornis*), Dolphin (*Platanista gangetica*), among many mammals; Gharial Crocodile (*Gavialis gangeticus*), and Burmese Python (*Python molurus*) among many other reptiles; Bengal Floricans (*Houbaripsis bengalensis*), White-Rumped Vulture (*Gyps bengalensis*) and Giant Hornbill (*Buceros bicornis*) among many of the bird species (BNP, 2022).

Sampling Methodology

The study was conducted during the winter season (January 2020). Each habitat was observed for two consecutive days from 10 a.m. to 4 p.m. The temperature ranged from 13 to 16 ºC on the sampling days, and there was cloud cover and haze. Notably, during the sampling days we experienced light rain. Sampling was avoided during rainy days. The east-west highway was considered as a sampling transect for the forest and farmland. Similarly, the Babai River is considered the transect for the Riverbank sampling. Within each habitat, we set up a 100-meter horizontal line transect referencing the east-west highway and Babai River, and sampled butterflies within a 5-meter on both sides of the transect (Pollard, 1977). For the river bank sampling, only the eastern section of the Babai River was considered for sampling due to inaccessibility considering 10m in the accessible section. We used 12 transects for this study: 5 in farmland, 3 in riverbank, and 4 in forest respectively (table 1). To minimize duplication of species, a 500-meter distance between each transect was maintained. Butterflies were captured using a circular sweeping net with a mesh size of 1.2 millimeters (0.047 inches) and a diameter of 28 cm (11.0236 inches). After capture, we photographed each butterfly from multiple angles to aid in accurate identification before releasing them unharmed back into their natural habitat. The recorded species were identified using the field guidebook “Butterflies of Western Ghats” (Kasambe, 2018) and “Butterflies of Nepal (Central Himalaya)” (Smith, 1994), and released unharmed. For those unidentified species in the field, the photographs taken were used as

Table 1: Number of transects and spatial location of each habitat under study of Bardiya District, Nepal

S.N.	Habitats	Coordinates	Altitude	Transects Used	Sampling Date &Time
1	Farmland	28º 23' 3.72" N 81º 19' 6.58" E	212m	Transect 1	21 January (10:15 am to 11:15 pm), 22 January (3:00 pm to 4:00 pm)
				Transect 2	21 January (11:15 am to 12:15 pm), 22 January (2:00 pm to 3:00 pm)
				Transect 3	21 January (12:15 pm to 1:15 pm), 22 January (12:30 pm to 1:30 pm)
				Transect 4	21 January (2:15 pm to 3:15 pm), 22 January (11:30 am to 12: 30 pm)
				Transect 5	21 January (3:15pm to 4:15 pm), 22 January (10:30 am to 11:30 am)
2	Riverbank	28º 25' 26.24" N 81º 22' 59.80" E	118m	Transect 1	17 January (10:05 am to 12 pm), 18 January (2:30 pm to 4:15 pm)
				Transect 2	17 January (12 pm to 2:30 pm), 18 January (1:30 pm to 2 pm)
				Transect 3	17 January (3 pm to 4 pm), 18 January (11 am to 1:15 pm)
3	Forest	28º 25' 13.18" N 81º 22' 50.44" E	200m	Transect 1	19 January (10 am to 11:30 am), 20 January (10 am to 11:30 am)
				Transect 2	19 January (11:30 am to 1:15 pm), 20 January (11:30 am to 1 pm)
				Transect 3	19 January (1:30 pm to 3 pm), 20 January (1:30 pm to 2:45 pm)
				Transect 4	19 January (3 pm to 4:15 pm), 20 January (2:45 pm to 4 pm)

reference seeking expert judgment for species identification. .

Data Management and Analysis

Quantile classification was initially employed to classify butterflies documented in the study region. The categorization was predicated on the recorded abundance of butterflies across all three habitats. Afterward, butterflies were delineated into three categories, namely frequent, co-dominant, and dominant, owing to their homogeneous distribution and comparable abundance.

Similarly, Various diversity indices such as Margalef's richness index, Pielou evenness index (e), and Simpson's diversity index were calculated to assess species richness, evenness, and diversity. To evaluate habitat similarity, the Jaccard coefficient index was employed (table 2).

Results and Discussion

Butterfly Diversity and Distribution

Altogether 130 individuals of 27 species of butterflies belonging to 18 genera under four families namely: Nymphalidae, Pieridae, Lycaenidae, and Hesperiidae were recorded from three different habitats (Annex I & II) which contributed around 4% of the total butterfly species in the country (Smith, 2011). We found a majority of the species recorded from the study area have oriental elements characteristics of tropical to subtropical climatic types (Khanal, 2006; Khanal et al., 2013). In comparison to previous studies (Khanal, 2008), we recorded a lower diversity of butterflies. Sampling during the winter season might be the reason for the lower detection of these cold-blooded species. Similarly, butterflies go into hibernation as they have a low ability to survive in cold climatic and weather conditions (Khanal et al., 2012). Raining and cloudy weather addition to the winter climate during the study period could be another reason for lesser flighting events of the butterflies.

The quantile classification method has grouped butterflies into three categories: frequent, co-dominant, and dominant. Among the total 27 species recorded, 16 were identified as frequent, while the remaining 11 were categorized as co-dominant (6) and dominant (5) (Annex I). It's important to highlight that the limited detection of certain

Table 2: Methodologies to calculate the status of butterflies in different habitats of Bardiya District, Nepal

S.N.	Method	Formula	Description
1	Margalef's index (DMg)	$DM = (S - 1)/\log N$ Where, S= the number of species recorded, N = the total number of individuals summed over all S species (Odum & Barrett, 2005)	To measure the richness of butterfly species
2	Pielou index (e)	$e = H'/\log S$ H'= Shannon index, S= Number of species recorded (Pielou, 1969)	To calculate the evenness of butterflies
3	Simpson's index:	$D = \sum[ni\,(ni - 1)/N(N - 1)]$ Where, D= Dominance, ni= Importance value for each species, N= Total number of importance value Simpson's diversity = 1-D or 1/D (Magurran, 2004)	To measure the diversity of butterfly species within a community or habitat
4	Jaccard Coefficient index	$S_J = a/(a + b + c) * 100\%$ Where, = Jaccard similarity coefficient, a = number of species common to (shared by) habitats, b = number of species unique to the first habitat, c = number of species unique to the second habitat (Jaccard, 1912)	To estimate the community similarity among butterfly species in different habitats

butterfly species during the winter season is likely a result of seasonal characteristics and the constraints of our sampling efforts, rather than an indication of the rarity of these species.

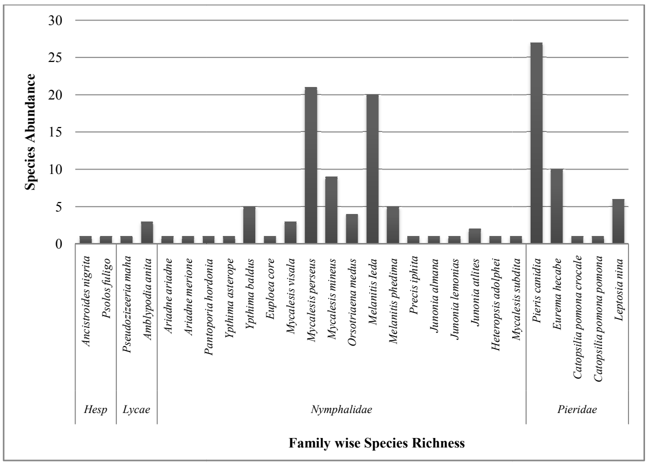

Figure 2: Species richness and abundance of butterflies in Bardiya District, Nepal across three different habitats recorded during January 2020

Family Nymphalidae contributed to 18 species (66.66%); the highest number of individuals from the study area, followed by 5 species (18%) from the family Pieridae, and two species each (7.4%) from Lycaenidae and Hesperiidae family (Fig. 2). In our study, Nymphalidae is the most dominant family in all the habitats. Khanal (2008), and Khanal and Bhusal (2008) also observed a higher abundance of the Nymphalidae family in the Western lowland and Eastern Siwalik of Nepal respectively. A similar observation was also highlighted in Kathmandu Valley by Thapa and Bhusal (2009). Family Nymphalidae represents the largest and most common family signifying nearly one-third of known butterflies in the world (Kasangaki et al., 2012; Al Haidar et al., 2017). Because of their higher ecological adaptation (Jiggins et al., 1996), speciation, high dispersal ability (Dudley & Adler, 1996), distance migration, and powerful flight (Kasambe, 2018; Al Haidar et al., 2017), they can adjust to any type of habitat condition. Several species under the Nymphalidae family are considered model organisms in evolutionary biology due to their adaption capability (Brakefield et al., 2009; Khyade et al., 2018).

Altogether, Indian Cabbage White (*Pieris canidia*) (n=27) was the most dominant among the recorded species which was followed by Common Bush Brown (*Mycalesis perseus*) (n=21) and Common Evening Brown (*Melanitis Ieda*) (n=20).

Similarly, the Indian Cabbage White, Common Evening Brown, and Common Bush Brown were found to be dominant in farmland, forest, and Riverbank respectively (Fig. 2). The common nature and distribution of Common Bush Brown and Common Evening Brown make them resist in any kind of season and habitat (Khyade et al., 2018; Dwari et al., 2017). They are the tropical species that occur in shady parts of the jungle, are dominant in the forest habitat, and are commonly found under leaf litter (Cowan & Cowan, 2019; Kasambe, 2018). Whereas, Indian Cabbage White is found to be the major pest for crucifer plants which are cultivated in the winter season (Evans et al., 1932; Braak et al., 2018). Due to the availability of crucifer plants in farmland during the study period such as mustard, cauliflower, and cabbage attracted the Indian Cabbage White making it dominant on farms (Evans et al., 1932; Wang et al., 2020). According to Khanal et al. (2012) and Kasambe (2018) Indian Cabbage White and Common Grass Yellow (*Eurema hecabe*) from the family Pieridae, are confined to cultivated land of lower and midland regions up to 3000m. Moreover, the presence of butterfly species in any habitat is determined by different abiotic and biotic factors in that particular habitat.

Butterfly Diversity in Different Habitats

Different components of biotic and abiotic factors such as host plants, plant parts, food availability and latitude and altitude, temperature, humidity, rainfall, wind pressure, light, etc. affect the distribution and diversity of butterflies in any habitat (Khan et al., 2004; Khanal et al., 2012; Lien & Yuan, 2003). Among the three habitats, species diversity and species richness of butterflies in the forest habitat were found higher at 0.87, and 9.85 followed by the riverbank at 0.86, and 6.1 and farmland at 0.67, and 4.73 respectively (table 3). Kitahara and Fujii (1994) in central Japan also observed the matching kind of result in their study. However, Lien and Yuan (2003) and Bhusal et al. (2018) recorded higher butterfly diversity in agricultural land than in grassland and forest. In our case, the higher diversity of the forest habitat may be because of the higher preferences of forest area by the dominant Nymphalidae family (Bobo et al., 2006; Miya et al., 2021). Open canopy and homogeneity of plants like *Eulaliopsis binate* might have affected the diversity of butterflies on the riverbank. Saikia et al. (2009), in their research, stated forest gaps, heterogeneous vegetation, close canopy cover and moisture in the ground can affect the density and distribution of butterflies in any habitat. Additionally, changes in the canopy cover and light penetration relating to moisture content can affect the survival of a butterfly's adult and larva. Forest gaps due to the east-west highway in the forest area and the light penetration through it might result in the higher density of the butterflies in the forest area.

Table 3: Measures of diversity indices of butterflies for the three different habitats in Bardiya district, Nepal during January 2020. Bold values with an asterisk sign (*) indicate higher values for each index

S.N.	Indices	Riverbank	Forest	Farmland
1	Margalef richness measures	6.1	**9.85***	4.73
2	Pielou evenness index	**0.89***	0.8	0.67
3	Simpson diversity index	0.86	**0.87***	0.67
4	Species richness	8	**19***	9
5	Species abundance	14	**67***	49

Moreover, different environmental factors within different habitats mentioned above are more responsible for supporting the population of butterflies rather than the habitat itself. Likewise, Rija (2022) stated that butterfly diversity is correlated with the canopy cover and lower ground cover of any habitat. Equally, species richness of butterflies tended to increase at high canopy cover and in sites closer to the water source. Shade availability is known to favor egg ovipositioning and larval development during butterfly breeding (Warren, 1985; Grundel et al., 1998). Because of higher canopy cover, plant diversity, and near water sources, studied habitats forests and river bank holds a higher density and diversity of butterflies compared to farmland.

Different habitats were covered by different plant types and floral plants. For example, the forest was covered by Sal *Shorea robusta*, Saaj *Terminalia tomentosa,* Balki *Anogeissus latifolia,* and Bhellar *Trewia nudiflora, etc.; the* riverbank with khair sissoo forest with domination of Kans Grass *Saccharum spontaneum*, Congongrass *Imperata cylindrical*, Baruwa grass *Saccharum bengalensis*, Khus *Vetiveria zizanoides*, *Nepeta* species, *Elsholtzia* species, and Dhursul *Colebrookea oppositifolia;* and farmland with mustard and wheat, and an invasive *Ageratum houstonianum*. The presence of each butterfly species in different habitats reflects their preferences for specific plant types.

The unfavorable conditions for butterfly survival are evident in the continuous changes in land use, habitat quality, and evolving crop types in farmland. Butterfly populations in the area face increased risks due to habitat conversion and fragmentation resulting from human activities. Research has indicated a decline in insect abundance and diversity over the past several decades, attributed to the use of pesticides (Gilburn et al., 2015; Olaya-Arenas et al., 2020). Effects of pesticides on agricultural-oriented butterflies are majorly observed rather than butterflies associated with other habitats (Olaya-Arenas et al., 2020). In our case too, the presence of pesticides could be the reason behind the lower diversity and abundance of butterflies in farmland. In general, butterfly prefers a habitat with lower disturbance (Tamang et al., 2019). Construction of road and vehicle mobility from the protected areas has massively increased wildlife mortality due to road accidents in Nepal. The presence of the east-west highway along the Bardiya NP is also risking the survivability of butterflies in Bardiya. Gaudel et al. (2020) have reported 364 individual butterflies were recorded from road kill along an east-west highway in Nepal within three months in 2017. Their findings revealed that butterflies made a more substantial contribution to both road-killed and living specimens compared to those found in human settlement landscapes. The majority of the roads and highways of the country go through the forest area affecting the biodiversity and habitat quality of the region. Similarly, increasing pollution along human settlements and highways is also risking the lives of insect species. Habitat disturbances hampers the habitat quality required for butterfly breeding affecting their overall abundance and richness (Hellmann, 2002).

Local habitat characteristics variously influenced species diversity, abundance, and species richness in the study area. The increasing rate of human encroachment has led to habitat loss and fragmentation and a direct impact on the habitats of butterflies (Blair & Launer, 1997) and the situation is similar to the study area. Increasing pollution near the riverbank has disturbed and altered their habitat. The expansion of human settlements and the use of pesticides, and insecticides are the reasons for reducing the abundance of species in farmland (Khanal et al., 2015). Blair and Launer (1997) mentioned that disturbance can result in the increasing diversity of species but decreasing abundance but this research contradicts their prediction. This study found that diversity and richness decreased with human disturbances (Bhusal et al., 2018).

Community Similarity Index and Habitat Preferences by Butterflies

In terms of community similarity, Riverbank, and forest had a higher similarity of 22.72% in comparison to another group of habitats (table 4). Forest and riverbanks show similar kinds of habitat structure, components, and resource availability for plants and species development concerning microclimatic habitats. The interconnectedness between the forest and riverbank habitats in our butterfly research study may be a key factor contributing to the higher level of similarity observed between these two environments. Two species Purple Leaf Blue (*Amblypodia anita*, Hewitson, 1862) and Common Bush Brown (*Mycalesis perseus*, Fabricius, 1775) were common in all three habitats (Fig. 3) which resemblances their wide distributional range and survivability. Similarly, among the recorded species about 51% recorded butterflies individual preferred forest habitat whereas only 11% as riverbank (Fig. 3).

Table 4: Community similarity of different habitats

S.N.	Habitat Communities	Jaccard coefficient
1	Riverbank and forest	22.72%
2	Forest and farmland	16.66%
3	Farmland and riverbank	13.33%

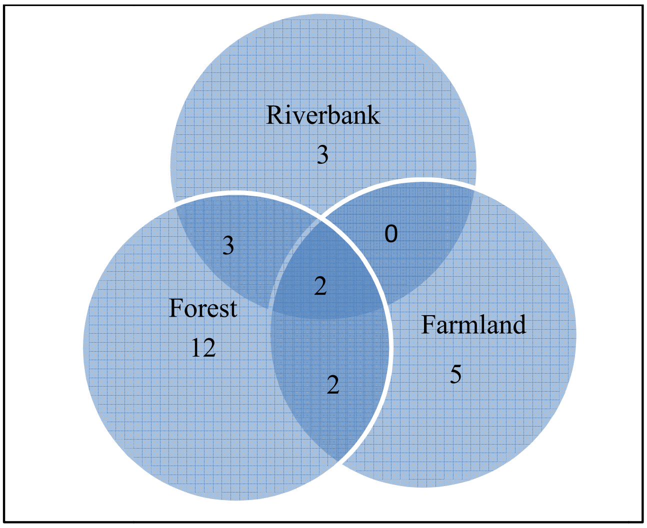

Figure 3: Species richness of butterfly species across different habitats in Bardiya District, Nepal during January 2020

Consistent and systematic monitoring across various habitats and seasons, along with comprehensive environmental assessments, is essential for the successful implementation of butterfly species conservation measures. It is vital to comprehend how population changes are influenced by human-driven alterations and development to ensure the sustainable survival of these important pollinators.

Conclusion

This study provides a checklist of butterfly diversity in Thakurbaba Municipality of Bardiya district across three habitats for the winter season. Family Nymphalidae was the most dominant family and Lycaenidae was the least dominant family in the study area. In comparison to the three habitat groups riverbank and forest were more similar in terms of resource availability and characteristics. Forest habitat is observed to be the most preferred habitat for butterflies.

This baseline study serves as a reference for future butterfly species monitoring, but its short sampling period lacks conclusive evidence regarding the relationship between butterflies and associated environmental factors. The seasonal constraints in this study have hindered the recording and assessment of a more wide-ranging butterfly population in the study area. Therefore, a prolonged and consistent assessment is essential to establish a robust connection between butterflies and their associated environmental factors. Additionally, to ensure the sustainable survival of these indicator species, it is imperative to document and monitor threats associated with both natural and anthropogenic disturbances. There necessary to examine the unknown existing threats in the study ecosystem which will help track changes in the butterfly communities inhabiting a particular habitat. Thus, for long-term species conservation habitat habitat-focused and species-focused, seasonal monitoring of butterflies is crucial.

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Annex I: Overview of butterflies recorded in Bardiya District, Nepal during January 2020

Family	Scientific name	Common name	Quintile Classification	Habitat	Abundance recorded
Hesperiidae	*Ancistroides nigrita* (Latreille, 1824)	Chocolate Demon	Frequent	F	1
	Psolos fuligo (Mabille, 1876)	Coon/Dusky Partwing	Frequent	F	1
Lycaenidae	*Pseudozizeeria maha* (Kollar, 1844)	Pale Grass Blue	Frequent	F	1
	Amblypodia anita (Hewitson, 1862)	Purple Leaf Blue	Co-dominant	F,Fa, RB	3
Nymphalidae	*Ariadne ariadne* (Linnaeus, 1763)	Angled Castor	Frequent	Fa	1
	Ariadne merione (Cramer, 1777)	Common Castor	Frequent	Fa	1
	Pantoporia hordonia (Stoll, 1790)	Common Lascar	Frequent	F	1
	Ypthima asterope (Klug, 1832)	Common Three Ring	Frequent	F	1
	Ypthima baldus (Fabricius, 1775)	Common Five Ring	Co-dominant	F,RB	5
	Euploea core (Cramer, 1780)	Common Crow	Frequent	Fa	1
	Mycalesis visala (Moore, 1858)	Long Brand Bush Brown	Co-dominant	F	3
	Mycalesis perseus (Fabricius, 1775)	Common Bush Brown	Dominant	F,Fa, RB	21
	Mycalesis mineus (Linnaeus, 1758)	Dark-Brand Bush Brown	Dominant	F,RB	9
	Orsotriaenamedusmedus (Fabricius, 1775)	Nigger/Jungle Brown	Co-dominant	F	4
	Melanitis leda (Linnaeus, 1758)	Common Evening Brown	Dominant	F,RB	20
	Melanitis phedima (Cramer, 1780)	Dark Evening Brown	Co-dominant	F	5
	Precis iphita (Cramer, 1782)	Chocolate Pansy	Frequent	F	1
	Junonia almana (Linnaeus, 1758)	Peacock Pansy	Frequent	Fa	1
	Junonia lemonias (Linnaeus, 1758)	Lemon Pansy	Frequent	RB	1
	*Junonia atlites (*Linnaeus, 1763)	Grey Pansy	Frequent	F	2
	Heteropsis adolphei (Guérin-Ménéville, 1843)	Red Eye Bush Brown	Frequent	RB	1
	Mycalesis subdita (Moore, 1890)	Tamil Bush Brown	Frequent	RB	1
Pieridae	*Pieris canidia* (Linnaeus, 1768)	Indian Cabbage White	Dominant	F, Fa	27
	Eurema hecabe (Linnaeus, 1758)	Common Grass Yellow	Dominant	F, Fa	10
	Catopsilia Pomona crocale (Fabricius, 1775)	Common Emigrant	Frequent	F	1
	*Catopsilia pomona pomona (*Fabricius, 1775)	Lemon Emigrant	Frequent	F	1
	Leptosia nina (Fabricius, 1793)	Psyche	Co-dominant	Fa	6
Total butterfly abundace recorded					**130**

Note: F=Forest, Fa=Farmland, RB= Riverbank

Annex II: Photographs of Butterflies recorded in Bardiya District, Nepal during January 2020

Photograph 1: Common Caster *(Ariadne merione)*

Photograph 2: Common Lascar (*Pantoporiahordonia*)

Photograph 3: Common Evening Brown (*Melanitisleda*)

Photograph 4: Lemon Emigrant (*Catopsiliapomonapomona*)

Photograph 5: Lemon Pansy (*Junonialemonias*)

Photograph 6: Long Brand Bush Brown (*Mycalesisvisala*)

Photograph 7: Common Emigrant (*Catopsiliapomona*)

Photograph 8: Peacock Pansy (*Junoniaalmana*)

Photograph 9: Jungle Brown *(Orsotriaenamedusmedus)*

Photograph 10: Common Grass Yellow (*Euremahecabe*)

Photograph 11: Indian Cabbage White (*Pieriscanidia*)

Photograph 12: Pale grass blue (*Amblypodiaanita)*

Photograph 13: Common Bush Brown *(Mycalesis perseus)*

Photograph 14: Dark Brand Bush Brown (*Melanitisphedima*)

Photograph 15: Butterfly Sampling in Riverbank

Photograph 16: Butterfly Sampling in Farmland