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Research Article

Diversity and abundance of butterflies (Lepidoptera) in Byas municipality of the Tanahun district, Nepal

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Abstract: Butterflies are flagship taxa and bio-indicator of terrestrial ecosystems. Studies of butterflies are performed in different regions of Nepal, but no detailed research has been carried out in Tanahun. Hence, this study was conducted to determine the species diversity and abundance of butterflies in Byas municipality-6 of the Tanahun, Nepal, from March to November 2020. The Pollard walk method was used for the data collection. A total of six transects of 500 m, two in each habitat type (forests, settlements, and agricultural lands), were laid out randomly. The study was performed in three seasons (9 months); Pre-Monsoon (March to May), Monsoon (June to September), and Post-Monsoon (October to November). Each transect was surveyed nine times (once a month) to record species in each month. Data were pooled and analyzed with SPSS. A total of 1,753 individuals of 149 butterfly species from 92 genera and six families were recorded during the study. The overall Shannon-Wiener and Margalef diversity indices were H = 4.17 and R = 19.95. Pielou's Evenness was E = 0.83. Nymphalidae was the most diverse, richest species, and most abundant family (H = 3.33, R = 8.30, N = 851). Species evenness was maximum in the family Papilionidae (E = 0.88). The forests comprised the maximum number of species (115 species, 898 individuals). The maximum number of species was recorded in March (106 species), while the highest species abundance was in June (268 individuals). The result of this study could be the baseline for further researches on butterflies in the Tanahun district.

Keywords: Butterfly, Community structure, Conservation, Nymphalidae, Papilionidae

Introduction

Butterflies are fascinating and colorful insects (Arthropods) of the order Lepidoptera and suborder Rhopalocera (Durairaj and Sinha, 2015). They belong to flagship taxa and are among the most studied insects worldwide (Larsen 1987; Robbins and Opler 1997; Tiple and Khurad, 2009). They act as bio-indicators of terrestrial ecosystems (Pywell *et al.,* 2011, Alarape *et al.,* 2015) and play a vital role in the pollination process and the food chain (Tiple *et al.,* 2007). Butterflies can be used as an indicator for vegetative structure, habitat quality (Sawchik *et al.,* 2005; Castro and Espinosa, 2015), climate change (Parmesan *et al.,* 1999), and impact of different threats (Kunte, 2008). Butterflies feed on nectar and sometimes on pollen with the help

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of their sectorial proboscis, during which they contribute to pollination (Blüthgen and Klein, 2011; Bauder *et al.,* 2013). Angiosperm and insect pollinators such as butterflies are closely associated during the evolution process, as they influence the reproductive success of angiosperms (Sargent and Ackerly, 2008; Wright and Schiest, 2009).

About 20,000 species of butterflies are recorded in the world, among which Nepal hosts about 660 species of butterfly (Smith, 2011). However, an updated checklist of the butterfly is necessary to be prepared for Nepal. Thus, the number may increase (Sajan and Pariyar, 2019; Poel, 2020; Sajan, 2020; Sapkota *et al.,* 2020; Subedi *et al.,* 2021b; Subedi *et al.,* 2021a; Sajan, 2021). About 29 species and subspecies of butterflies considered endemic to Nepal are disappearing slowly (Bhuju *et al.,* 2007; Subedi *et al.,* 2021b). Among the butterflies of Nepal, a total of 142 species are placed under IUCN red list category (Endangered-12, Vulnerable-43, and Susceptible-87) (Paudel *et al.,* 2012), and three species are kept under CITES Appendix-S2 (Khanal *et al.,* 2013).

Although insects have vital ecological roles, their diversity is in great threat worldwide. Lepidoptera is rapidly declining, which may lead to the decline of 40% of species on the earth over the next few decades (Sánchez-Bayo and Wyckhuys, 2019). Butterflies need specific plants for food and reproduction (Bernays and Graham 1988). They are sensitive to environmental changes such as habitat degradation, climate change, forest fire, insecticides, nitrogen pollution, fragmentation, etc. (Stefanescu *et al.,* 2011). Small changes in their original habitats may result in their local extinction or migration to another suitable habitat (Kunte, 1997). Habitat loss and host plant loss caused by humans are the major threats to butterflies (New *et al.,* 1995; Hoyle and James, 2005).

Studies related to butterfly diversity, habitats, threats, and host plant availability are necessary to pause extinction and further decline. Their conservation leads to the conservation of many other species in the area (Subedi *et al.,* 2021b). Studies focusing on butterfly diversity have been performed in different parts of Nepal (Acharya and Vijayan, 2015; Bhusal and Khanal, 2008; Khanal, 2006, 2008; Shrestha *et al.,* 2018; Smith, 1994, 2006, 2011; Khanal *et al.,* 2013, 2014; Rai, 2017; Suwal *et al.,* 2019; Tamang *et al.,* 2019; Subedi *et al.,* 2021b), etc. However, no previous study has been carried out on the butterfly in the Tanahun district. This study aimed to determine species diversity, abundance, and community structure of butterflies in Byas Municipality, ward-6, Tanahun district Nepal. The result from the survey will be helpful to make a butterfly conservation plan in the study area.

Materials and Methods

Study area

The study was conducted in Byas municipality (27°58 35N and 84°16 05 E), a community-managed forest that is rapidly converting to agricultural land and open lands threatening species habitats but diverse in flora, altitude, and climate the Tanahun district, Nepal (Fig. 1) from March to November 2020. It is extended over an altitudinal range of 280 to 1,220m a.s.l. The study area occupies an area of 35.39 km^2. Forests, agricultural lands, and settlements were selected for the survey. The forests are dominated by tree species, i.e., *Shorea robusta* (Sal), *Castonopsis indica* (Katus) and *Schima wallichii* (Chilaune), etc. Shrub species, i.e., *Chlerodendrum infortunatum* (Bhat), *Artemisia vulgaris* (Titepati), *Choromolaena odorata* (Banmara), etc. and herb species, i.e., *Ageratum conyzoides* (Gandhe Jhar), *Bidens pilosa* (Kalo kuro), etc. that are dominantly found in open spaces in the forests. The settlement area contains buildings, roads, and open grounds associated with agricultural lands. The agricultural lands produce major crops, i.e., paddy, maize, and soybean. These lands also include shrubs, i.e., *Chromolaena odorata* (Bhat), *Artemesia vulgaris* (Titepati), etc., and herbs like; *Bidens pilosa* (Kalo kuro), *Ageratum conyzoides* (Gandhe), *Imperata cylindrica* (Siru), etc. The area is home to 26 species of Odonata (Miya *et al.* 2021).

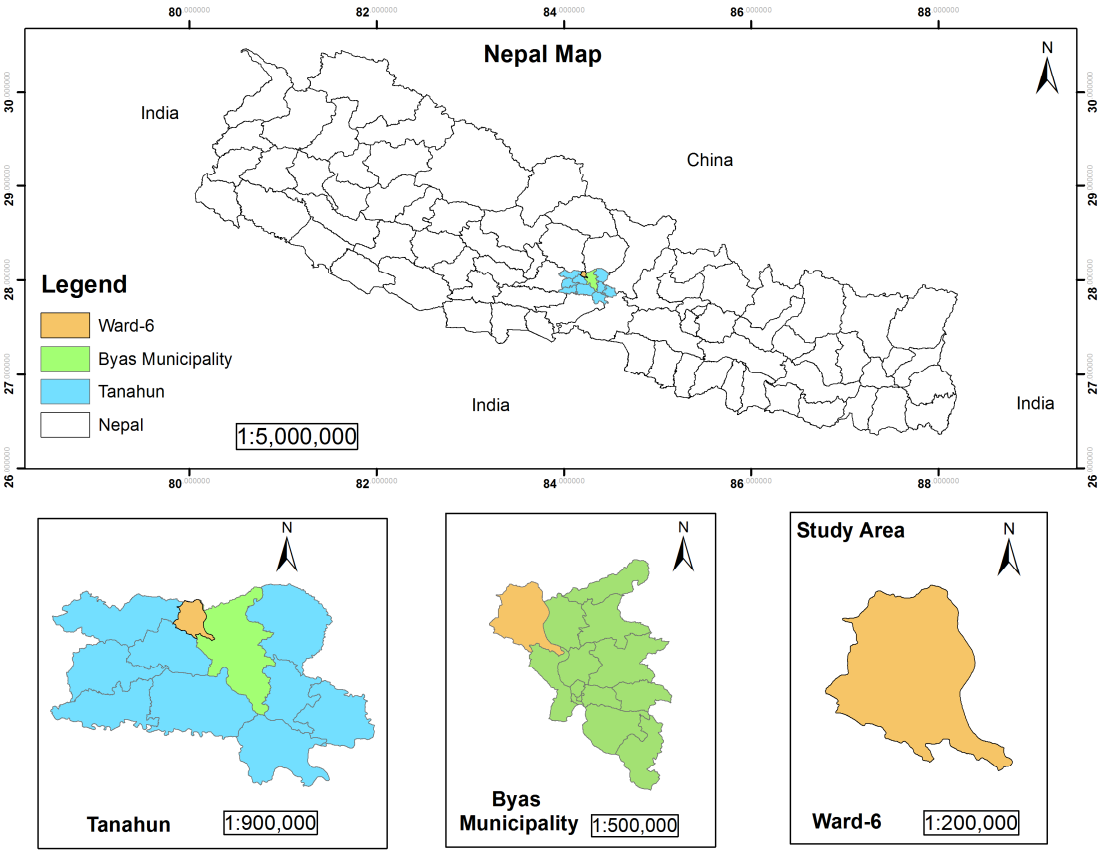

Figure 1 Map of Nepal showing study location.

Data collection

The Pollard Walk method was used to collect data (Pollard, 1977). A total of six transects of 500 m, two in each habitat type (forests, settlements, and agricultural lands), were sampled. Butterflies were surveyed within 5 m width; 2.5 m to each side of the transect. The study was performed in three seasons (9 months); Pre-Monsoon (March to May), Monsoon (June to September), and Post-Monsoon (October to November). The winter season was omitted because it had fewer butterflies due to cold weather. Each transect was surveyed nine times (once a month) to record species in each month. The study was conducted from 9:00 am to 3:00 pm during sunny days to ensure maximum detection of butterflies. Species were identified in the field with the help of field guides 'Butterflies of Nepal in Natural Environment' (Smith, 2011) and 'Butterflies of Begnas and Rupa Watershed Area' (Smith *et al.,* 2016). Butterflies were photographed with a smartphone "Samsung Galaxy Grand Prime +". Those species not identified in the field were later identified with consultation with experts and internet references (https://www.ifoundbutterflies.org/), (https://www.projectnoah.org/).

Data analysis

All the data were pooled and analyzed with SPSS software (Version.26). Butterflies were classified based on (Kehimkar, 2016). The local status of the butterfly was determined based on the number of individual species sighted during the survey, i.e., Very rare (less than 2), Rare (2 to 15),

Fairly Common (15 to 50), Common (50 to 100) and Very Common (more than 100) (Tiple *et al*., 2005). Shannon-Wiener and Margalef Diversity Indices were calculated for butterfly diversity. Species evenness was calculated by Pielou's Evenness; the species abundance was estimated based on the total count/number of individuals of each species. Also, Relative abundance was calculated to compare the species abundance. The obtained values were then compared between butterfly families.

Shannon-Wiener diversity index: $H = -\sum_{i=1}^{n} Pi \times ln\ Pi$

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

Margalefs' richness index $R = \frac{S-1}{n(N)}$

Where, Pi = proportion of individuals belonging to the i^{th} species, S = number of species and N = total count/number of individuals.

$$\text{Relative abundance (RA)} = \frac{\text{Total number of individual of particular species}}{\text{Total individuals of butterflies sampled}} \times 100$$

Results

A total of 1,753 individuals of butterflies of 149 species and 92 genera from six families were recorded during the study. A list of butterflies recorded during the study is given in (Table 1-6). The overall Shannon-Wiener diversity index was H = 4.17, Pielou's Evenness was E = 0.83, and Margalef diversity index was R = 19.95 (Table 7).

Family-wise composition of butterflies

Nymphalidae was the most diverse and species richest family (H = 3.33, R = 8.30), while family Riodinidae was the least diverse and least species-rich (H = 0.31, R = 0.54). Species evenness was maximum in Papilionidae (E = 0.88) and minimum in Riodinidae (E = 0.28). The highest number of species and highest abundance was represented by the family Nymphalidae (57 species from 32 genera, N = 851) followed by Lycaenidae (35 species from 28 genera, N = 277). Riodinidae family represented the lowest species richness and the lowest abundance (3 species from 2 genera, N = 41) (Table 7).

Table 1 Checklist of the Papilionidae in Byas municipality-6, Tanahun.

S. N.	Scientific name	Common name	Count in habitats (N)			RA	LS
			A	**S**	**F**		
1	*Graphium agamemnon* Linnaeus, 1758	Tailed Jay	2	3	3	0.46	R
2	*Graphium cloanthus* (Westwood, 1841)	Glassy Bluebottle			2	0.11	R
3	*Graphium doson* Felder & Felder, 1864	Common Jay	3	3	4	0.57	R
4	*Graphium sarpedon* (Linnaeus, 1758)	Common Bluebottle	4	2		0.34	R
5	*Papilio arcturus* (Westwood, 1842)	Blue Peacock			3	0.17	R
6	*Papilio clytia dissimilis* Linnaeus, 1758	Common Mime			1	0.06	VR
7	*Papilio demoleus* (Linnaeus, 1758)	Lime Swallowtail	9	2	3	0.79	FC
8	*Papilio memnon* Linnaeus, 1758	Great Mormon	8	2	5	0.85	FC
9	*Papilio nephelus* Boisduval, 1836	Yellow Helen	1	1	15	0.97	FC
10	*Papilio paris* Linnaeus, 1758	Paris Peacock	1		5	0.34	R
11	*Papilio polytes* Linnaeus, 1758	Common Mormon	11	8	8	1.54	FC
12	*Papilio protenor* Cramer, 1775	Spangle	5	7	13	1.45	FC
13	*Triodes aeacus* (Felder & Felder, 1860)	Common Birdwing			2	0.11	R

Abbreviations: N = Number of individuals, RA = Relative abundance, A = Agricultural lands, S = Settlements, F = Forest, LS = Local Status, VR = Very Rare, R = Rare. FC = Fairly Common.

Table 2 Checklist of the Pieridae in Byas municipality-6, Tanahun.

S. N.	Scientific name	Common name	Count in habitats (N)			RA	LS
			A	**S**	**F**		
1	*Appias lyncida* (Cramer, 1779)	Chocolate Albatross	9	10	14	1.88	FC
2	*Catopsilia pomona crocale* Fabricius, 1775	Common Emigrant	25	14	25	3.65	C
3	*Catopsilia pomona pomona* (Fabricius, 1775)	Lemon Emigrant		1	1	0.11	R
4	*Catopsilia pyranthe* Linnaeus, 1758	Mottled Emigrant	2			0.11	R
5	*Cepora nadina* (Lucas, 1852)	Lesser Gull			2	0.11	R
6	*Cepora nerissa* Fabricius, 1775	Common Gull			2	0.11	R
7	*Colias fieldii* (Menetries, 1855)	Dark Clouded Yellow	1			0.06	VR
8	*Delias descombesi* (Boisduval, 1836)	Red-spot Jezebel	1			0.06	VR
9	*Delias eucharis* (Drury, 1773)	Common Jezebel	1	1		0.11	R
10	*Delias hyparete* (Linnaeus, 1758)	Painted Jezebel	1	4		0.29	R
11	*Delias posithoe* (Linnaeus, 1767)	Red-base Jezebel	1			0.06	VR
12	*Eurema blanda* (Boisduval, 1836)	Three-spot Grass Yellow	7	4	15	1.48	FC
13	*Eurema brigitta* (Stoll, 1780)	Small Grass Yellow	7	10	10	1.54	FC
14	*Eurema hecabe* (Linnaeus, 1758)	Common Grass Yellow	40	21	47	6.16	VC
15	*Eurema laeta* (Boisduval, 1836)	Spotless Grass Yellow	1			0.06	VR
16	*Gandaca harina* (Horsfield, 1829)	Tree Yellow			5	0.28	R
17	*Hebomoia glaucippe* (Linnaeus, 1758)	Great Orange Tip	1		6	0.39	R
18	*Ixias pyrene* (Linnaeus, 1764)	Yellow Orange Tip	1		2	0.17	R
19	*Pareronia valeria* (Cramer, [1776])	Common Wanderer	1			0.06	VR
20	*Pieris brassicae* (Linnaeus, 1758)	Large Cabbage White	10	7	11	1.59	FC
21	*Pieris canidia* (Linnaeus,1768)	Indian Cabbage White	18	8	9	1.99	FC
22	*Pontia daplidice* (Linnaeus, 1758)	Bath White	1			0.06	VR

Abbreviations: N = Number of individuals, RA = Relative abundance, A = Agricultural lands, S = Settlements, F = Forest, LS = Local Status, VR = Very Rare, R = Rare. FC = Fairly Common, C = Common, VC = Very Common.

Butterfly community, composition in different habitats

The maximum number of species was observed in the forest (115 species, 898 individuals), followed by agricultural lands (92 species, 588 individuals) and minimum from settlements (51 species, 267 individuals) (Fig. 2).

Butterfly species composition in different months

The maximum number of butterfly species was recorded in March (106 species), followed by October (99 species) and the minimum in November (57 species). The maximum number of species in forest and agriculture lands was encountered during March (49 species and 41 species respectively) and the minimum in November (23 species and 22 species respectively). The maximum number of species in settlements was experienced during October (22 species) and the minimum in May (10 species). Species abundance was highest in June (268 individuals), followed by October (259 individuals), and lowest in November (104 individuals) (Table 8).

Table 3 Checklist of the Lycaenidae in Byas municipality-6, Tanahun.

S. N.	Scientific name	Common name	Count in habitats (N)			RA	LS
			A	**S**	**F**		
1	*Acytolepis puspa* (Horsfield, 1828)	Common Hedge Blue			1	0.06	VR
2	*Anthene emolus* Godart, 1823	Ciliate Blue			6	0.34	R
3	*Arhopala atrax* (Hewitson, 1862)	Indian oakblue			1	0.06	VR
4	*Arhopala centaurus* (Fabricius, 1775)	Centaur Oakblue	3		9	0.68	R
5	*Arhopala paramuta* (D. Niceville, 1884)	Hooked Oakblue			3	0.17	R
6	*Caleta elna* (Hewitson, 1876)	Elbowed Pierrot			1	0.06	VR
7	*Castalius rosimon* Fabricius, 1775	Common Pierrot	6		2	0.46	R
8	*Catapaecilma major* (Druce, 1895)	Common Tinsel			2	0.11	R
9	*Catochrysops strabo* (Fabricius, 1793)	Forget-me-not Blue			1	0.06	VR
10	*Chilades lajus* (Stoll, [1780])	Lime blue	1			0.06	VR
11	*Chilades parrhasius* (Fabricius, 1793)	Indian cupid	1		4	0.28	R
12	*Chliaria othona* (Hewitson, 1865)	Orchid Tit			1	0.06	VR
13	*Curetis acuta* Moore, 1877	Angled Sunbeam			1	0.06	VR
14	*Curetis bulis* (Westwood, 1851)	Bright Sunbeam	1		6	0.39	R
15	*Euchrysops cnejus* (Fabricius, 1798)	Gram Blue	5	1	5	0.63	R
16	*Heliophorus brahma* (Moore, 1857)	Golden Sapphire			2	0.11	R
17	*Heliophorus epicles* (Godart, 1824)	Purple Sapphire			18	1.07	FC
18	*Hypolycaena erylus* Godart, 1823	common tit			4	0.23	R
19	*Jamides bochus* (Stoll, 1782)	Dark Cerulean	1			0.06	VR
20	*Jamides celeno* (Cramer, 1775)	Common Cerulean	9	3	7	1.08	FC
21	*Lampides boeticus* (Linnaeus, 1767)	Pea Blue	3	1	3	0.39	R
22	*Lestranicus transpectus* (Moore, 1879)	White-banded Hedge Blue		1		0.06	VR
23	*Loxura atymnus* Stoll, 1780	Yamfly	1	1		0.11	R
24	*Megisba malaya* (Horsfield, 1828)	Malayan			1	0.06	VR
25	*Nacaduba kurava* (Moore [1858])	Transparent Six-line Blue			2	0.11	R
26	*Prosotas nora* (Felder, 1860)	Common Line blue	5		27	1.84	FC
27	*Prosotas pia* Toxopius, 1929	Margined Liine blue			4	0.23	R
28	*Pseudozizeeria maha* (Kollar, 1844)	Pale Grass Blue	30	34	37	5.76	VC
29	*Rapala rectivitta* (Moore, 1879)	Shot Flash	1			0.06	VR
30	*Sinthusa chandrana* (Moore, 1882)	Broad spark			1	0.06	VR
31	*Spindasis syama* Horsfield, 1829	Club Silverlines			1	0.06	VR
32	*Udara dilectus* (Moore, 1879)	Pale Hedge Blue	3		3	0.34	R
33	*Zeltus amasa* (Hewitson, 1865)	Fluffy Tit			6	0.34	R
34	*Zizeeria karsandra* (Moore, 1865)	Dark Grass Blue	1			0.06	VR
35	*Zizina otis* (Fab5ricius, 1787)	Lesser Grass Blue	1		5	0.34	R

Abbreviations: N = Number of individuals, RA = Relative abundance, A = Agricultural lands, S = Settlements, F = Forest, LS = Local Status, VR = Very Rare, R = Rare. FC = Fairly Common, C = Common, VC = Very Common.

Table 4 Checklist of the Riodinidae in Byas municipality-6, Tanahun.

S. N.	Scientific name	Common name	Count in habitats (N)			RA	LS
			A	**S**	**F**		
1	*Abisara fylla* (Westwood, 1851)	Dark Judy			2	0.11	R
2	*Abisara neophron* (Hewitson, 1861)	Tailed Judy			1	0.06	VR
3	*Zemeros flegyas* Cramer, 1780	Punchinello	2		36	2.17	FC

Abbreviations: N = Number of individuals, RA = Relative abundance, A = Agricultural lands, S = Settlements, F = Forest, VR = Very Rare, R = Rare. FC = Fairly Common.

Table 5 Checklist of the Nymphalidae in Byas municipality-6, Tanahun.

S. N.	Scientific name	Common name	Count in habitats (N)			RA	LS
			A	**S**	**F**		
1	*Abrota ganga* Moore, 1858	Sergeant Major			1	0.06	VR
2	*Aglais cashmirensis* (Kollar, 1844)	Indian Tortoiseshell	2		2	0.23	R
3	*Ariadne merione*	Common Castor		1		0.06	VR
4	*Athyma nefte* Cramer, 1780	Color Sergeant			4	0.23	R
5	*Athyma perius* Linnaeus, 1758	Common Sergeant	1		1	0.11	R
6	*Athyma ranga* Moore, 1858	Blackvein Sergeant			1	0.06	VR
7	*Athyma selenophora* (Kollar, 1844)	Staff Sergeant	2		23	1.43	FC
8	*Cethosia biblis* (Drury, 1773)	Red Lacewing			2	0.11	R
9	*Cethosia cyane* (Drury, 1773)	Leopard Lacewing		1	5	0.34	R
10	*Chersonesia risa* (Doubleday, 1848)	Common Maplet			6	0.34	R
11	*Cyrestis thyodamas* Boisduval, 1836	Common Map			1	0.06	VR
12	*Danaus chrysippus* Linnaeus, 1758	Plain Tiger	4	1	8	0.74	R
13	*Danaus genutia* (Cramer, 1779)	Common Tiger	6	1	13	1.14	FC
14	*Elymnias malelas* (Hewitson, 1863)	Spotted Palmfly	7	4	2	0.74	R
15	*Euploea core* (Cramer, 1780)	Common Indian Crow	13	7	22	2.39	FC
16	*Euploea mulciber* (Cramer, 1777)	Striped Blue Crow		2	8	0.57	R
17	*Euthalia aconthea* (Cramer, 1777)	Common Baron	1	1	22	1.37	FC
18	*Hestinalis nama* (Doubleday, 1844)	Circe		1		0.06	VR
19	*Hypolimnas bolina* Linnaeus, 1758	Great Eggfly	4	3	2	0.51	FC
20	*Junonia almana* Linnaeus, 1758	Peacock Pansy	22	8	4	1.94	FC
21	*Junonia altites* (Linnaeus, 1763)	Grey Pansy	21	8	17	2.62	FC
22	*Junonia iphita* (Cramer, 1779)	Chocolate Pansy	13		20	1.88	FC
23	*Junonia lemonias* Linnaeus, 1758	Lemon Pansy	23	16	29	3.88	C
24	*Junonia orithya* (Linnaeus, 1758)	Blue Pansy	2			0.11	R
25	*Kallima inachus* (Doyere, 1840)	Orange Oakleaf			12	0.68	R
26	*Kaniska canace* (Linnaeus, 1763)	Blue Admiral	1			0.06	VR
27	*Lethe confusa* Aurivillius, 1897	Banded Treebrown	4		3	0.39	R
28	*Lethe europa* Fabricius, 1787	Bamboo Treebrown	1			0.06	VR
29	*Melanitis leda* (Linnaeus, 1758)	Common Evening Brown	6	2		0.46	R
30	*Melanitis phedima* (Cramer, 1780)	Dark Evening Brown	1			0.06	R
31	*Mycalesis francisca* Stoll, 1780	Lilacine Bushbrown			5	0.28	R
32	*Mycalesis malsara* (Moore, 1858)	White-line Bushbrown	3		10	0.74	R
33	*Mycalesis mineus* (Linnaeus, 1758)	Dark brand Bushbrown	1		2	0.17	R
34	*Mycalesis perseus* Fabricius, 1775	Common Bushbrown	9		12	1.19	FC
35	*Mycalesis visala* Moore, 1858	Long-brand Bushbrown	3		1	0.23	R
36	*Nemetis chandica* Moore, 1858	Angled Red Forester			3	0.17	R
37	*Neptis cartica* Moore, 1872	Plain Sailer			3	0.17	R
38	*Neptis columella* (Cramer, 1780)	Short-banded Sailer			1	0.06	VR
39	*Neptis hylas* Linnaeus, 1758	Common Sailer	18	6	40	3.65	C
40	*Orsotriaena medus* (Fabricius, 1775)	Jungle Brown	18	5	32	3.14	FC
41	*Pantoporia hordonia* (Stoll, 1790)	Common Lascar	10	1	11	1.25	FC
42	*Pantoporia sadaka* (Butler, 1892)	Extra Lascar	1			0.06	VR
43	*Parantica aglea* (Stoll, 1782)	Glassy Tiger	6	9	12	1.54	FC
44	*Parantica melaneus* (Cramer, 1775)	Chocolate Tiger	1			0.06	VR
45	*Phalanta phalanta* Drury, 1773	Common Leopard	2		2	0.23	R
46	*Polyura athamas* Drury, 1773	Common Nawab		1	1	0.11	VR
47	*Stibochiona nicea* (Gray, 1846)	Popinjay			1	0.06	VR
48	*Symbrenthia lilaea* (Hewitson, 1864)	Common Jester	3		3	0.34	R
49	*Tanaecia julii* Lesson, 1837	Common Earl	6		13	1.08	FC
50	*Tanaecia lepidea* (Butler, 1868)	Grey Count	9	4	11	1.37	FC
51	*Tirumala limniace* (Cramer, 1775)	Blue Glassy Tiger			3	0.17	R
52	*Tirumala septentrionis* (Butler, 1874)	Dark Blue Tiger	1		2	0.17	R
53	*Vanessa cardui* (Linnaeus, 1758)	Painted Lady	1			0.06	VR
54	*Vanessa indica* (Herbst, 1794)	Indian Red Admiral	6	5	3	0.79	R
55	*Ypthima baldus* Fabricius, 1775	Common Five-ring	34	12	64	6.27	VC
56	*Ypthima huebneri* Kirby, 1871	Common Four-ring	18	8	15	2.34	FC
57	*Ypthima newara* Moore, 1875	Newari Three-ring			2	0.11	VR

Abbreviations: N = Number of individuals, RA = Relative abundance, A = Agricultural lands, S = Settlements, F = Forest, LS = Local Status, VR = Very Rare, R = Rare. FC = Fairly Common, C = Common, VC = Very Common.

Table 6 Checklist of the Hesperiidae in Byas municipality-6, Tanahun.

S. N.	Scientific name	Common name	Count in habitats (N)			RA	LS
			A	**S**	**F**		
1	*Aeromachus jhora* de Niceville, 1885	Grey Scrub Hopper			1	0.06	VR
2	*Borbo bevani* (Moore, 1878)	Bevan's Swift	2	1		0.17	R
3	*Borbo cinnara* (Wallace, 1866)	Rice Swift	13	4	3	1.14	FC
4	*Caltoris tulsi* D. Niceville, 1884	Purple Swift	1			0.06	VR
5	*Erionota torus* Evans, 1941	Sikkim Palm Red-eye	2			0.11	VR
6	*Iambrix salsala* (Moore, 1866)	Chestnut Bob	2		3	0.28	R
7	*Matapa aria* (Moore, 1865)	Common Red-eye	2			0.11	VR
8	*Notocrypta curvifascia* (C. & R. Felder, 1862)	Restricted Demon			2	0.11	VR
9	*Parnara apostata* (Snellen, [1880])	Sumatran Swift			1	0.06	VR
10	*Parnara guttata* (Bremer & Grey, 1852)	Straight Swift	4	1	2	0.39	R
11	*Pelopidas sinensis* (Mabille, 1877)	Large Branded Swift	5			0.28	R
12	*Pseudocoladenia dan* (Fabricius, 1787)	Fulvous Pied Flat			1	0.06	VR
13	*Sarangesa dasahara* (Moore, 1866)	Common Small Flat	16	5	1	1.25	FC
14	*Spialia galba* (Fabricius, 1793)	Indian Skipper	5		1	0.34	R
15	*Tagiades litigiosa* Moschler, 1878	Water Snow Flat			3	0.17	R
16	*Tagiades menaka* (Moore, 1866)	Spotted Snow Flat	1		1	0.11	VR
17	*Tegiades gana* (Moore, 1865)	Suffused Snow Flat	1			0.06	VR
18	*Telicota bambusae* Moore, 1878	Dark Palm Dart	1		1	0.11	VR
19	*Udaspes folus* (Cramer, 1775)	Grass Demon	3		2	0.28	R

Abbreviations: N = Number of individuals, RA = Relative abundance, A = Agricultural lands, S = Settlements, F = Forest, LS = Local Status, VR = Very Rare, R = Rare. FC = Fairly Common, C = Common, VC = Very Common.

Table 7 Family wise composition and diversity indices of Butterflies in Byas Municipality of the Tanahun district.

S. N.	Family	Species	Genera	N	H	E	R
1	Papilionidae	13	3	136	2.25	0.88	2.44
2	Pieridae	22	12	357	2.18	0.71	3.57
3	Lycaenidae	35	28	277	2.53	0.71	6.05
4	Riodinidae	3	2	41	0.31	0.28	0.54
5	Nymphalidae	57	32	851	3.33	0.83	8.30
6	Hesperiidae	19	15	91	2.42	0.82	3.99
	Total	149	92	1753	13.02	4.23	24.89

Abbreviations: N = Number of individuals, H = Shannon-Wiener diversity index, E = Pielou's Evenness and R = Margalef diversity index.

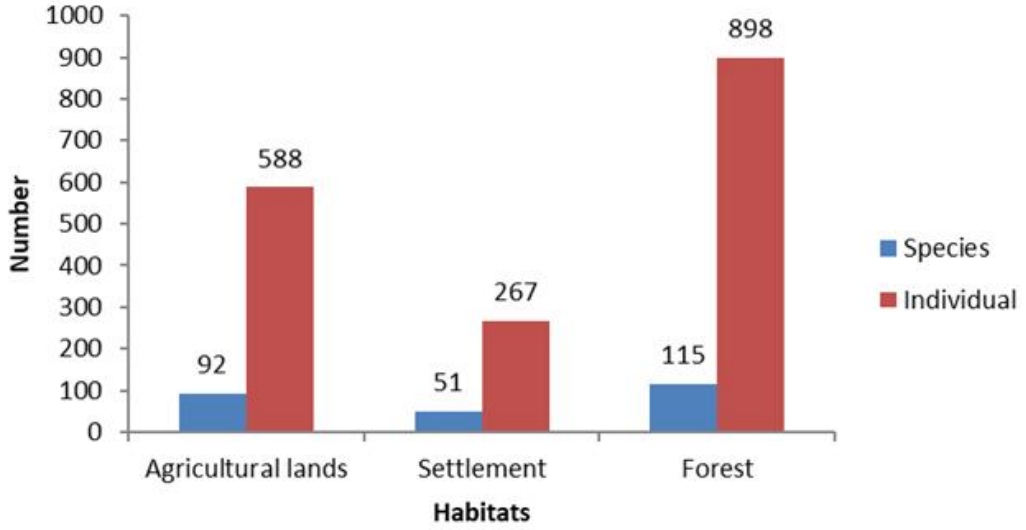

Figure 2 Species number and individual number of butterflies in different habitats in Byas municipality of the Tanahun district.

Table 8 Butterfly species composition in different months in Byas municipality of the Tanahun district.

Months	Forests		Settlements		Agricultural lands			
	Species	N	Species	N	Species	N	Total species	Total N
March	49	104	16	33	41	64	106	201
April	48	68	13	28	36	56	97	152
May	37	63	10	14	28	48	75	125
June	48	146	19	48	31	74	98	268
July	39	119	17	21	34	59	90	199
August	33	77	13	26	33	113	79	216
September	42	133	17	31	30	61	89	225
October	46	139	22	46	31	74	99	259
November	23	48	12	20	22	36	57	104

Local status of butterflies

Among the total recorded species, 46% are rare (66 species), followed by very rare (31%, 46 species), fairly common (21%, 31 species), common (2%, 3 species), and widespread (2%, 3 species) (Fig. 3). *Ypthima baldus* (RA = 6.27, 110 individuals) was the most dominant species, and *Eurema hecabe* (RA = 6.16, 108 individuals) was the second most dominant.

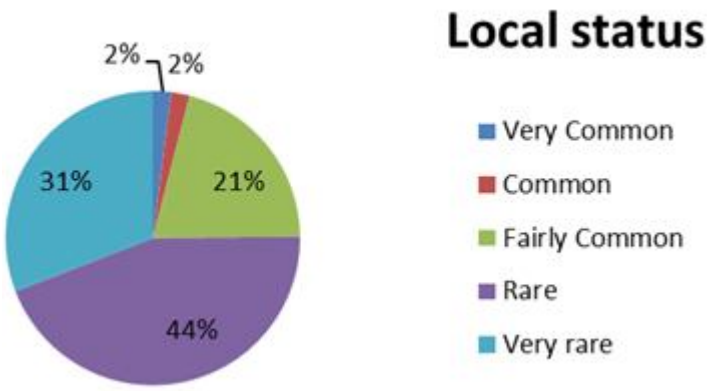

Figure 3 Local status of recorded butterflies in Byas municipality of the Tanahun district.

Discussion

Family-wise composition of butterflies

Nymphalidae represented the highest number of species in the present study, while the Riodinidae family represented the lowest species. The study by Tamang *et al*. (2019) in the eastern lowlands of Nepal has also observed Nymphalidae as the most species-rich family and Riodinidae as the least species-rich family. Similarly, a high number of species from Nymphalidae were observed by (Khanal, 1982; Prajapati *et al.,* 2000; Bhusal and Khanal, 2008; Thapa, 2008; Deb *et al.,* 2015; Dahal, 2017; Rai, 2017) in their study. The highest species richness and abundance might be due to the presence of host plants suitable for Nymphalidae (Malabika, 2011), high dispersal ability (Dudley and Adler, 1996), ecological adaptation (Jiggins *et al.,* 1996), and strong or active flight enabling them to search resources in large geographical areas (Eswaran and Pramod, 2002; Krishnakumar *et al.,* 2008; Raut and Pendharkar, 2009).

Butterfly community, composition in different habitats

The highest number of species with the highest abundance in the forest may be due to the high diversity of host plants and undisturbed habitats compared to agricultural lands and settlements.

Availability of host plants determines butterfly abundance (Guiterrez and Memendez, 1995; Thomas, 1995). Butterflies solely depend on plants, and their diversity highly depends on plant species diversity (Blair and Launer, 1997; Benton *et al.,* 2003; Tscharntke *et al.,* 2005; Padhye *et al.,* 2006; Ekroos *et al.,* 2013). Agricultural lands and settlements have low plant diversity. Lower butterfly diversity in agricultural lands might be due to agricultural intensification and chemical fertilizers (Rundlöf *et al.,* 2008; Holzschuh *et al.,* 2008; Geiger *et al.,* 2010; Batary *et al.,* 2011; Henry *et al.,* 2012). High butterfly diversity was also observed in forests (Van Lien and Yuan, 2003; Munyuli, 2012; Rai, 2017; Tamang *et al.,* 2019).

Butterfly species composition in different months

The minimum number of species encountered during November might be due to the beginning of the winter season. This month is late to find out the existing butterfly diversity (Khanal, 2006). The highest species richness in March (Pre-Monsoon) and lowest in November (Post-Monsoon) is similar to the result of (Acharya and Vijayan, 2015; Islam *et al.,* 2015; Tamang *et al.,* 2019). The highest species richness in the monsoon might be due to the high plant diversity resulting from higher rainfall and humidity (Bhusal and Khanal, 2008). *Gandaca harina, Sinthusa chandrana, Heliophorus brahma, Abisara neophtron* and *Athyma ranga* recorded in the study area are rare for Nepal (Smith, 2011).

Conclusion

The study area is rich in butterflies. A total of 149 species of butterflies from six families were recorded. Nymphalidae was the most diverse, species-rich, and most abundant family (H = 3.33, R = 8.30, N = 851). Species evenness was maximum in the family Papilionidae (E = 0.88). The forests comprised the maximum number of species (115 species and 898 individuals). The maximum number of species was recorded in March (106 species). Also, the maximum number of species in forests was encountered during March (49 species). Species abundance was highest in June (268 individuals) and lowest in November (104 individuals). Among the total recorded species, 46% were locally rare species. This study did not list the winter season butterflies because it comprises fewer species numbers. This checklist should be updated as many species might be missed during the study. The result from the study could be the baseline for further researches on butterflies in the Tanahun district.

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تنوع و فراوانی پروانه‌ها (Lepidoptera) در شهر بیاس واقع در ناحیه تاناهون، نپال

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چکیده: پروانه‌ها گونه‌های شاخص و نشانگرهای زیستی اکوسیستم‌های خشکی هستند. اگرچه مطالعاتی در مورد پروانه‌ها در مناطق مختلف نپال انجام شده است، اما هیچ تحقیق دقیقی در منطقه تاناهون صورت نگرفته است. از این‌رو، این مطالعه به‌منظور تعیین تنوع گونه‌ای و فراوانی پروانه‌ها در شهرداری ۶ بیاس واقع در منطقه تاناهون، کشور نپال، از ماه مارس تا نوامبر ۲۰۲۰ انجام شد. برای جمع‌آوری داده‌ها از روش قدم زدن پولارد استفاده شد. در مجموع ۶ قطعه (ترانسکت) ۵۰۰ متری، دو قطعه در هر نوع رویشگاه (جنگل، آبادی و اراضی کشاورزی) به‌صورت تصادفی انتخاب شد. این مطالعه در سه فصل (۹ ماه) شامل سه ماه پیش از باران‌های موسمی (مارس تا می)، هم‌زمان با باران‌های موسمی (ژوئن تا سپتامبر) و پس از باران‌های موسمی (اکتبر تا نوامبر) انجام شد. هر قطعه ۹ بار و یک بار در هر ماه مورد بررسی شد. داده‌ها گردآوری و با نرم‌افزار SPSS مورد تجزیه‌وتحلیل قرار گرفت. درمجموع ۱۷۵۳ فرد از ۱۴۹ گونه پروانه از ۹۲ جنس و شش خانواده در طول مطالعه ثبت شدند. شاخص‌های کلی تنوع شانون-وینر و مارگالف به‌ترتیب H = ۴/۱۷ و R = ۱۹/۹۵ محاسبه شد. شاخص یکنواختی پیلو E = ۰/۸۳ تعیین شد. خانواده Nymphalidae متنوع‌ترین، با بیش‌ترین تعداد گونه و فراوان‌ترین خانواده بود (H = ۳/۳۳، R = ۸/۳۰، N = ۸۵۱). بیش‌ترین یکنواختی گونه مربوط به خانواده Papilionidae بود (E = ۰/۸۸). بیش‌ترین تعداد گونه (۱۱۵ گونه، ۸۹۸ فرد) در مناطق جنگلی مشاهده شد. بیش‌ترین تعداد گونه در ماه مارس (۱۰۶ گونه) و بیش‌ترین فراوانی گونه در ژوئن (۲۶۸ گونه) ثبت شد. نتیجه این مطالعه می‌تواند مبنایی برای تحقیقات بیش‌تر در مورد پروانه‌ها در منطقه تاناهون باشد.

واژگان کلیدی: پروانه، ساختار جامعه، حفاظت، Nymphalidae، Papilionidae