



Species richness, diversity and relative abundance of lepidoptera in an agricultural ecosystem of Kumaun Himalaya region in district Nainital, Uttarakhand, India

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Abstract

The present preliminary study was conducted to explore the Butterfly fauna (Order: Lepidoptera) in an agricultural ecosystem of Kumaun Himalaya region in Nainital district, Uttarakhand from March 2019 to February 2021. A total of 1225 Lepidopterans were collected, belonging to 35 species of six families. Lycaenidae and Nymphalidae were the most dominant family with (12 species each), followed by Pieridae (7 species), Papilionidae (2 species), Hesperidae and Sphingidae (1 species each) respectively. The highest diversity of Lepidopterans was ($H' = 3.312$), evenness ($E = 0.9514$), Marglef's species richness ($d = 6.244$), and Dominance Index ($D = 0.2778$). The foraging activity of Lepidopterans as flower pollinators was also recorded. The present study was carried out in order to assess the species and richness and diversity of butterflies in and around the Kumaun Himalaya, Nainital, Uttarakhand.

Keywords: Lepidoptera, species diversity, abundance, agricultural ecosystem

Introduction

Insects represent over half of the world's species diversity (May, 1992) [20] and play vital roles in ecosystem functioning, contributing to productivity and stability (Majer 1987; Naeem *et al.*, 1994; Tilman 1996) [17, 22, 31]. The butterflies are found in various environments such as forests, deserts, plains, valleys, and hills (Mani, 1986) [18]. They play a crucial role as pollinators for many wild and cultivated plant species. Butterflies, as one of the most extensively studied groups of insects, have been systematically documented since the 18th century (Heppner, 1998) [11]. Worldwide, there are over 28,000 butterfly species, with approximately 80% located in tropical regions. The Indian subcontinent, known for its diverse terrain, climate, and vegetation, is home to around 1,504 butterfly species (Tiple, 2011) [32].

Uttarakhand is home to a rich variety of flora and fauna. It is located in the central sector of the Himalayas and shares part of both the Central and Western Himalayan region. Butterflies, often known as "insects of the sun" due to their vibrant colors and delicate charm, can be commonly found in this area. There are reports on the species richness, diversity, and distribution of Lepidoptera in different habitats (Bhardwaj *et al.*, 2012; Tewari and Rawat, 2013; Arya *et al.*, 2014; Garia *et al.*, 2016; Arya and Dayakrishna, 2017 and Kumar *et al.*, 2017; Thiruvengadam *et al.*, 2021; Rekha *et al.*, 2023) [3, 29, 2, 9, 1, 13, 30, 26].

Butterflies are important pollinators, along with various other groups of insects such as those belonging to the insect orders Hymenoptera, Diptera, Coleoptera, Lepidoptera, Thysanoptera, and Hemiptera. These insects play a crucial role in pollinating agricultural, horticultural, and medicinal herbal crops (Bhowmik *et al.*, 2014; Subedi and Subedi, 2019) [4, 28]. Butterflies are often considered ecosystem engineers. They are known for their beauty, bearing wings of various colors (Pawar and Deshpande, 2017) [23]. Butterflies are valuable for biodiversity studies because many species' taxonomy, geographic distribution, and status are relatively well-known. Furthermore, butterflies serve as

effective biological indicators of habitat quality and overall environmental health (Larsen, 1988; Kocher and Williams, 2000; Sawchik *et al.*, 2005) [15, 12, 27]. Many butterfly species are strictly seasonal and exhibit preferences for specific habitats (Kunte, 1997) [14]. They can react to habitat disturbances and changes, making them valuable ecological indicators (Mac Nally and Fleishman, 2004) [16]. The main objectives of the current study were to assess the species richness, abundance, and species diversity of lepidopterans serving as pollinators in an agricultural ecosystem located in the Kumaun Himalaya region, Nainital district, Uttarakhand, India.

Materials and Methods

Study area: The findings presented here are based on a monthly random survey carried out from March 2019 to February 2021 in Paharpani village located in tehsil Dhari, (2044 masl, 29° 25'38N, 79° 42'41E) Nainital district of Uttarakhand. The study area covered various types of vegetation, including a wide variety of food plants, nectar plants, and breeding habitats, which provide a strong foundation for butterfly diversity.

Sampling methods: The butterflies were sampled every 30 days using the "Sweep Sampling Method" and by handpicking, following the approach described by Gadagkar *et al.* [8] in 1990. They were then transferred into bottles containing cotton soaked in ethyl acetate. After being brought to the laboratory, the butterflies were stretched, pinned, oven-dried, and placed into labelled wooden boxes for further study. They were identified using keys and available literature.

Data analysis

Data Analysis was done based on their abundance and habit through Shannon-Wiener diversity indices, Evenness indices, Dominance indices as well as Marglef's indices for richness by using PAST4.04 software.

Results and discussion

Species richness and abundance: In the study site, the total number of individuals and their percentage contribution towards the order Lepidoptera is presented in Table 1. The combined data from two years showed that the lepidopteran fauna comprised 35 species belonging to 6 families. The highest number of collected species was recorded from the family Lycaenidae (12 species, 47.18% of total individuals), which was the most dominant followed by Nymphalidae (12 species, 25.71% of total individuals), Pieridae (7 species, 22.29% of total individuals), Papilionidae (2 species, 4.08% of total individuals), Hespriidae (1 species, 0.57% of total individuals) and Sphingidae (1 species, 0.16% of total individuals) were recorded (Table 2). Families Hesperidae and Sphingidae were considered “minor constituents” due to their smaller number of species and abundance of individuals. The observation are similar to the other reported studies (Nadia *et al.*, 2015; Mattu and Bhagat, 2015; Ghani and Maalik, 2019) [21, 19, 10]. It can thus be concluded that species richness and abundance of individuals is affected by average temperature of the study area.

Diversity indices: A maximum number of species and individuals were collected during the summer and rainy seasons, while a minimum number was collected during the winter season. The species diversity (H') ranged from 1.33 to 3.312. The highest species diversity (H' =3.312) was

observed in September, while the lowest (H' =1.33) was observed in January. The evenness (E) values ranged from 0.8706 to 0.9514, indicating a relatively uniform distribution of species across the gradients. Margalef's Richness index returned high values (d =1.674 to 6.244), suggesting a high species richness in the study area. The Dominance Index (D) varied from 0.03911 to 0.2778, and its values were inversely related to the evenness indices.

The diversity of the Lepidoptera order fluctuated with the seasons, as they were abundant for only a few months and were absent or rare during other months of the year. The results obtained for various Diversity Indices in the present study indicate that values for Lepidoptera in different agro-ecosystem (Arya *et al.*, 2014; Usha and John, 2015; Garia *et al.*, 2016; Rabeih, 2018; Farooq and Arya, 2018) [2, 33, 9, 24, 7]. Similarly, in the previous study, Lepidopterans were recorded as less abundant during the winter season due to cold climatic conditions.

Foraging activity of lepidoptera: Lepidopterans were most active in the afternoon. All 35 species of Lepidopterans collected were the most diverse pollinators in the agricultural ecosystem studied. Their body size helps in sticking pollens to their legs and proboscis when they visit flowers for nectar. This ensures effective transfer of pollens when they visit another flower thus making Lepidopterans very effective pollinators of crops (Duara and Kalita 2013, Rader *et al.*, 2016; Das *et al.*, 2018) [6, 25, 5].

Table 1: Diversity and Relative Abundance (%) of Lepidopteran species collected in study site during March, 2019 to February, 2021

S. No.	Taxonomic Composition	No. of individuals	Relative Abundance (%)
Order- Lepidoptera (Family: Pieridae)			
1.	<i>Pieris canidia indica</i> (Evans)	70	5.71
2.	<i>Pieris brassicae</i> (Linnaeus)	51	4.16
3.	<i>Pontia daplidice</i> (Linnaeus)	38	3.10
4.	<i>Goneptyryx rhamni nepalensis</i> (Doubleday)	34	2.78
5.	<i>Aporia agathon</i> (Gray)	25	2.04
6.	<i>Colias felidi</i> (Menetries)	38	3.10
7.	<i>Catopsilia pyranthe</i> (Linnaeus)	17	1.39
Family: Nymphalidae			
8.	<i>Aglais cashmirensis</i> (Kollar)	56	4.57
9.	<i>Vanessa cardui</i> (Herbst)	54	4.41
10.	<i>Danaus chrysippus</i> (Linnaeus)	16	1.31
11.	<i>Callerebia scanda</i> (Kollar)	12	0.98
12.	<i>Callerebia nirmala</i> Moore	18	1.47
13.	<i>Callerebia annada</i> (Moore)	23	1.88
14.	<i>Callerebia hybrid</i> Butler	24	1.96
15.	<i>Ypthima inica</i> Hewiston	22	1.80
16.	<i>Acraea issoria</i> (Hubner)	36	2.93
17.	<i>Cyrestis thyodamas</i> Boisduval	21	1.71
18.	<i>Lasiommata schakra</i> Kollar	27	2.20
19.	<i>Junonia iphita</i> (Cramer)	06	0.49
Family: Lycaenidae			
20.	<i>Lycaena pavana</i> Kollar	65	5.31
21.	<i>Lycaena phleas</i> (Linnaeus)	47	3.84
22.	<i>Zizzeria sp.</i>	68	5.55
23.	<i>Heliophorus androcles</i> (Hewitson)	49	4.00
24.	<i>Heliophorus sena</i> (Kollar)	23	1.88
25.	<i>Euchrysops cnejus</i> Fabricius	45	3.67
26.	<i>Zizina otis</i> Fabricius	53	4.33
27.	<i>Pseudozizeeria maha</i> Kollar	56	4.57
28.	<i>Dodona durga</i> (Kollar)	43	3.51
29.	<i>Aricia agestis</i> (Bergstrasser)	41	3.35
30.	<i>Acytolepis puspa</i> (Horsefield)	53	4.33

31.	<i>Telicada nyseus</i> Guerin-Meneville	35	2.86
Family: Papilionidae			
32.	<i>Papilio polytes</i> Linnaeus	38	3.10
33.	<i>Atrophanura polyeuctus</i> (Doubleday)	12	0.98
Family: Hesperiidae			
34.	<i>Borbo bevani</i> Moore	07	0.57
Family: Sphingidae			
35.	<i>Rhopalopsyche nycteris</i> Kollar	02	0.16
Total		1225	100

Table 2: Percent contribution of species and individuals of different families of Lepidoptera

Family	Species		Individuals	
	Number	Relative Abundance (%)	Number	Relative Abundance (%)
Nymphalidae	12	34.29	315	25.71
Lycanidae	12	34.29	578	47.18
Pieridae	7	20.00	273	22.29
Papilionidae	2	5.71	50	4.08
Hesperiidae	1	2.86	7	0.57
Sphingidae	1	2.86	2	0.16
Total	35	100.00	1225	100.00

Table 3: Diversity indices of Lepidoptera collected in study site during March 2019 to February 2021

Months	Species Richness (S)	Abundance (N)	Relative Abundance (%)	Shannon Index (H')	Evenness (E)	Margalef's Index (d)	Dominance Index (D)
March	11	28	4.57	2.317	0.9221	3.001	0.1046
April	24	86	14.03	3.107	0.9317	5.163	0.04813
May	27	105	17.13	3.244	0.9494	5.587	0.04073
June	29	101	16.48	3.3	0.9347	6.067	0.03911
July	26	66	10.77	3.178	0.9233	5.967	0.04408
August	19	43	7.01	2.862	0.921	4.786	0.06111
September	30	104	16.97	3.312	0.9148	6.244	0.03957
October	18	40	6.53	2.822	0.9337	4.608	0.0625
November	8	19	3.10	1.941	0.8706	2.377	0.1579
December	4	6	0.98	1.33	0.9449	1.674	0.2778
January	5	7	1.14	1.55	0.9421	2.056	0.2245
February	5	8	1.31	1.56	0.9514	1.924	0.2188

Conclusion

It is thus concluded from the present study that Lepidopterans were effective as pollinators due to their high visited frequency. Results showed that highest abundance and species richness of pollinators occurred at 8.00-2.00 and total 35 species were observed. Though it was a preliminary attempt to make a report of Lepidopterans as pollinators in agriecosystem of Kumaun Himalaya region of Nainital district, Uttarakhand. It will undoubtedly help the future workers as a baseline data of pollinators in the area. The geographical location of any area, its climatic conditions and vegetative composition are essential requisites for supporting a rich diversity of Lepidopterans.

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