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Species richness and diversity of Butterflies in and around Kumaun University, Nainital, Uttarakhand, India

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ABSTRACT

Species richness and diversity of butterflies were investigated in and around Kumaun University, Nainital and Uttarakhand, India. The study area was represented by sub temperate forest ecosystem and surrounded by a series of hills. A total of 897 individuals of butterflies belonging to 27 species and 8 families of the order Lepidoptera were recorded during the study period. Family Pieridae was the dominant family with 373 individuals representing 8 species and constituted 41.91% of the total individuals of butterflies recorded during the study period. Nymphalidae was the second most dominant family with 6 species, followed by Danaidae (4 species), Papilionidae (3 species), Satyridae, Lycaenidae (2 species each), Acraeidae and Erycinidae (1 species each). *Pieris brassicae nepalensis* Doubleday (Family: Pieridae) was the most dominant species and constituted 22.96% of the total individuals of butterflies recorded, followed by *Aglais cashmirensis* Kollar constituting 14.6% and *Vanessa indica* Herbst which constituted 10.03% of the total individuals of butterflies collected. Maximum number of individuals and species of butterflies were recorded during the rainy season followed by summer and winter. Across the study maximum value of Shannon-Wiener diversity index was 2.375 and across the season maximum diversity was 0.987 recorded in the rainy season.

Keywords: Abundance, butterflies, composition, diversity, Nainital, species.

1. Introduction

Butterflies are commonly referred to as “insects of the sun” with their eye catching colour and delicate charisma. They have been admired for centuries for their physical beauty and behavioral display [23]. Approximately, 17,200 species of butterflies throughout the world [16] and 1,504 species from the Indian subcontinent [30] are known. Among the insects, butterflies occupy a vital position in the ecosystem and their occurrence and diversity are considered as good indicators of the health of any given terrestrial biotope [2, 16, 29]. Butterflies are also good indicators of environmental changes as they are sensitive to habitat degradation and climate change [16]. Some workers have subsequently worked on the species composition, richness, diversity and distribution of butterflies in different parts of the world [1, 7, 9, 10, 15, 22, 24, 26, 28, 31, 35, 37]. The distribution of butterflies depends upon the availability of their host plants. In the recent years, some researchers have documented butterflies from different areas of Uttarakhand [4, 11, 12, 36]. Some workers have documented the butterflies of Indian University campus in the India [13, 14, 33]. Butterflies of Nainital city have not so far been explored, although some workers have documented the butterflies from few areas of district Nainital [34]. The present study was carried out in order to assess the species richness and diversity of butterflies in and around the Kumaun University, Nainital.

2. Materials and Methods

Nainital, known as Lake city, is a popular hill station of Uttarakhand state and headquarters of Nainital district in the Kumaun foothills of outer Himalaya. It is situated at an altitude of 1938m above mean sea level and lies between 29°24'N Latitude and 79°28'E Longitude. Nainital is set in a valley containing a pear shaped lake, approximately two miles in circumference and surrounded by mountains containing oak dominant forests. The slopes of the nearby mountains are mostly populated with an elevation ranging from 1940m to 2100m. The highest point nearby is Naina Peak or China Peak, with an elevation of 2619m. On the basis of temperature, humidity and rainfall the climate of Nainital represents three seasons in a year namely, rainy (July- October), winter (November- February) and summer (March- June).

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From the conservation point of view, the present study area is moderately to highly disturbed and very rich in floral and faunal diversity as well as butterfly diversity. To accomplish the present study following two study sites were selected in and around Kumaun University, Nainital.

Site-1 (D.S.B. Campus, Nainital): This site is located at an elevation of 2075m. It extends over an area of 4 km² from D. S. B. Campus, Nainital to Sherwood Public school, Nainital. The vegetation includes oak dominated forest with other kind of shrubs and herbs. This site faces sun directly thus temperature remains optimum for the growth and development of the flora and fauna all along the day. This site receives a high level of disturbance due to the presence of various public schools and other kind of residential colonies.

Site-2 (Administrative Block, Kumaun University, Nainital): This site covers an area of 5 km² from the High Court of Uttarakhand to the Administrative Training Institute, Nainital, Uttarakhand and located at an elevation of 2,000m. It is surrounded by two famous peaks of the city viz., China peak and Tiffin top and covered by mixed oak forest. Other plant species includes *Cedrus deodara*, *Cornus macrophylla*, *Cupressus torulosa*, *Aesculus indica*, *Berberis asiatica* and *Urtica dioica*. Being located in the populous area this site receives moderate level of disturbance.

Sampling of butterflies: Sampling of butterflies was conducted from October 2012 to November 2013. The butterflies were collected by "Sweep Sampling Method", as per Gadagkar *et al.*, 1990^[8]. The net sweeps were carried to collect the butterflies. The collection of butterflies was carried out in the early hours of the day because butterflies are usually active at early sunrise, therefore, it was easy to observe and collect them. Butterflies were primarily identified directly in the field and in difficult cases specimen were identified with the help of scientists of different institutions.

Calculation of species and seasonal diversity of butterflies: The diversity was calculated by using "Shannon Wiener Index", which is defined as,

$$H' (S) = -\sum p_i \ln p_i$$

And the seasonal diversity is written as,

$$H' (P) = -\sum q_j \ln q_j$$

Where, $P_i = n_i/N$ and $q_j = n_j/N$

n_i = Number of individual of a species at a time i , n_j = Number of individual present in a season j , N = Size of whole community, \sum = Number of species/ Number of seasons, S = Total number of species, P = Number of seasons

Evenness of butterflies: Evenness of species was calculated by using the Pielou's Evenness Index,

$$J' = H' / \ln S$$

Where, S is the number of species present in the site and H' is the diversity index. The value of J' ranges from 0 to 1. Lesser the variation in the communities between the species, the higher the value of J' .

3. Results and Discussion

Species composition of butterflies: A total 897 individuals of butterflies belonging to 27 species and 8 families were recorded during the study period (Table 1). On the basis of number of collected species family Pieridae was the most dominant family with 8 species, followed by Nymphalidae (6), Danaidae (4), Papilionidae (3), Satyridae, Papilionidae, Lycaenidae (2 each),

Erycinidae and Acraeidae (1 each). Percent contribution of the relative number of individuals and species of different families of butterflies collected from study area are presented in Table 2. Family Pieridae was the most dominant family which constituted 41.91% of the total collected butterflies. *Pieris brassicae nepalensis* Doubleday was the most dominant species of this family which constituted 54.79% of total individuals of this family followed by *Pieris canidia canidia* Evans (18.63%), *Eurema hecabe fimbriata* Wallace (9.30%) and *Gonepteryx rhamni nepalensis* Doubleday (8.51%). Family Nymphalidae was the second most dominant family which constituted 34.88% of the total collected butterflies. *Aglais cashmirensis* Kollar was the most dominant species of this family which constituted 41.85% of total individuals of this family, followed by *Vanessa indica* Herbst (28.75%), *Junonia iphita* Cramer (12.77%) and *Cynthia cardui* Linnaeus (9.58%). Family Danaidae was third most abundant family which constituted 7.57% of the total recorded individuals of butterflies and represented by 4 species. *Danaus chrysippus chrysippus* Linnaeus was the dominant species of this family which constituted 50% of total individuals of this family followed by *Euploea core core* Cramer (26.47%), *Danaus genutia genutia* Cramer (13.24%) and *Parantica aglea melanoides* Moore (10.29%). Family Papilionidae was represented by 3 species and constituted 5.01% of total collected butterflies. *Pachliopta aristolochiae* Fabricius was the dominant species of this family which constituted 53.34% of total individuals of this family followed by *Papilio polytes romulus* Cramer (37.78%) and *Papilio protenor protenor* Cramer (8.88%). Family Lycaenidae was represented by 2 species and constituted 6.46% of total collected butterflies. *Heliophorus sena* Kollar was the dominant species of this family which constituted 51.73% of total individuals of this family followed by *Lycaena pavana* (Kollar) (48.27%). Family Satyridae was represented by 2 species and constituted 1.55% of total collected butterflies. *Lasiommata schara schara* Kollar was the dominant species of this family which constituted 57.14% of total individuals of this family and followed by *Lethe insana insana* Kollar (42.86%). Family Erycinidae and Acraeidae (each 1 species) constituted 2.29% and 0.33% of the total collected butterflies.

Almost a century ago some worker has given a list of 371 species of butterflies from the Western Himalayan region which includes the present Garhwal region with eight districts and Kumaun region with five districts^[9]. Similarly other workers have recorded as many as 835 species of butterflies from Eastern Himalaya and 415 species from Western Himalaya^[37]. Few workers have reported 100 species of butterflies belonging to 9 families from Silent Valley National Park, Kerala and family Nymphalidae and Papilionidae were the dominant families^[19].

Similarly few other workers have reported 80 species of butterflies belonging to 9 families from Nanda Devi Biosphere Reserve, India. Nymphalidae was the most dominant family with 21 species followed by Satyridae (21), Lycaenidae (13), Pieridae (11), Papilionidae (8), Acraeidae, Erycinidae, and Danaidae (2 each)^[3]. Many workers have reported 40 species of butterflies belonging to 5 families from Great Himalayan National Park, Kullu, Himachal Pradesh. Nymphalidae was the most dominant family with 18 species followed by Pieridae (9), Papilionidae and Lycaenidae (6 each) and Hesperidae (1)^[35]. Similarly many other workers have reported 320 species of butterflies from Kerala, India.

Table 1: Species composition and number of individuals of butterflies collected from different study sites in and around Kumaun University, Nainital during the study period.

S. No.	Species composition	Common Name	Site-1	Site-2	Total
Family: Pieridae					
1.	<i>Anaphaeis aurota aurota</i> (Fabricius)	The Pioneer	5	-	5
2.	<i>Catopsilia pyranthe</i> (Linnaeus)	The African Emigrant	7	-	7
3.	<i>Colias erate erate</i> (Esper)	The Pale Coloured Yellow	-	12	12
4.	<i>Delias belladonna horsfieldi</i> (Gray)	The Hill Jezebel	-	9	9
5.	<i>Eurema hecabe fimbriata</i> (Wallace)	The Common Grass Yellow	20	15	35
6.	<i>Gonepteryx rhamni nepalensis</i> (Doubleday)	The Common Brimstone	19	13	32
7.	<i>Pieris brassicae nepalensis</i> Doubleday	The Large Cabbage White	110	96	206
8.	<i>Pieris canidia canidia</i> Evans	The Large Cabbage White	40	30	70
Family: Nymphalidae					
9.	<i>Aglaais cashmirensis</i> (Kollar)	The Indian Tortoise Shell	70	61	131
10.	<i>Cynthia cardui</i> (Linnaeus)	The Painted Lady	22	8	30
11.	<i>Junonia iphita</i> (Cramer)	The Chocolate Pansy	25	15	40
12.	<i>Neptis yerburyi yerburyi</i> (Butler)	The Yerbury's Sailer	12	-	12
13.	<i>Sephis dichroa</i> Kollar	The Western Courtier	10	-	10
14.	<i>Vanessa indica</i> (Herbest)	The Indian Red Admiral	50	40	90
Family: Danaidae					
15.	<i>Danaus chrysippus chrysippus</i> (Linnaeus)	The Plain Tiger	21	13	34
16.	<i>Danaus genutia genutia</i> (Cramer)	The Common Tiger	9	-	9
17.	<i>Euploea core core</i> (Cramer)	The Common Indian Crow	10	8	18
18.	<i>Parantica aglea melanoides</i> Moore	The Glassy Tiger	7	-	7
Family: Papilionidae					
19.	<i>Pachliopta aristolochiae</i> (Fabricius)	The Common Rose	15	9	24
20.	<i>Papilio polytes romulus</i> Cramer	The Common Mormon	11	6	17
21.	<i>Papilio protenor protenor</i> (Cramer)	The Spanlge	-	4	4
Family: Satyridae					
22.	<i>Lasiommata schara schara</i> (Kollar)	The Common Wall	8	-	8
23.	<i>Lathe insana insana</i> (Kollar)	The Common Forester	6	-	6
Family: Acraeidae					
24.	<i>Acraea issoria anomala</i> Kollar	The Yellow Coster	-	3	3
Family: Erycinidae					
25.	<i>Dodona durga</i> (Kollar)	The Common Punch	12	8	20
Family: Lycaenidae					
26.	<i>Lycaena pavana</i> (Kollar)	The White Bordered Copper	16	12	28
27.	<i>Heliophorus sena</i> (Kollar)	The Sorrel Sapphire	19	11	30
	Total		524	373	897

Table 2: Percent contribution of relative number of individuals and species of different families of butterflies recorded from the study area.

S.No.	Family	Total no. of species	% of species	Total no. of individuals	% of individuals
1.	Pieridae	8	29.6	376	41.91
2.	Nymphalidae	6	22.2	313	34.88
3.	Danaidae	4	14.9	68	7.57
4.	Papilionidae	3	11.1	45	5.01
5.	Lycaenidae	2	7.4	58	6.46
6.	Satyridae	2	7.4	14	1.55
7.	Erycinidae	1	3.7	20	2.29
8.	Acraeidae	1	3.7	03	0.33
	Total	27	100	897	100

Nymphalidae was the most dominant family with 48 species, followed by Pieridae (35), Lycaenidae (35), Satyridae (30), Papilionidae (18), Danaidae (14) and Amathusidae (2) [19]. Few workers have reported 35 species of butterflies belonging to 25

genera and 4 families from Nanda Devi Biosphere Reserve, India. Nymphalidae was the most dominant family with 16 species followed by Pieridae (10), Lycaenidae (6) and Papilionidae (3) [35]. Some workers have reported 40 species of butterflies belonging to 7 families, from Rajaji National Park in Uttarakhand, India. Nymphalidae was the most dominant family with 14 species followed by Pieridae (9), Danaidae (5), Papilionidae (4), Lycaenidae and Satyridae (3 each) and Hesperidae (2) [11]. Similarly many other workers have reported 54 species of butterflies belonging to 9 families from Pindari area of the Nanda Devi Biosphere Reserve, Uttarakhand, India. Nymphalidae was the most dominant family with 14 species followed by Pieridae (13), Satyridae (8), Lycaenidae (7), Papilionidae and Danaidae (4 each), Hesperidae (2), Erycinidae and Acraeidae (1 each) [12]. Some workers have documented 145 species of butterflies belonging to 5 families within and around Nagpur city, Central India. Nymphalidae was the most dominant family with 51 species followed by Lycaenidae (46), Hesperidae (22), Pieridae (17) and Papilionidae (9) [32]. Few other workers have recorded 29 species of butterflies belonging to 5 families from an urban and rural lactation of North- East India. Pieridae and Nymphalidae were represented by 10 species each followed by Papilionidae (6), Lycaenidae (2) and Hesperidae (1) [1]. Some workers have documented 71 species of butterflies belonging to 5 families from tropical moist deciduous sal forests of Ankua Reserve Forest, Koina Range, Saranda Division, West Singhbhum District, Jharkhand, India. Nymphalidae had the maximum number of species (33), followed by Lycaenidae (17), Pieridae (9), Hesperidae (7) and Papilionidae (5) [27]. Some workers have reported 41 species of butterflies belonging to 5 families from Dholbaha Dam in Punjab Shivaliks, India. Nymphalidae was the most dominant family with 19 species followed by Pieridae (10), Lycaenidae (8), Papilionidae (3) and Hesperidae (1) [26]. Some workers have documented 34 species of butterflies belonging to 29 genera and 5 families from Gangotri National Park in Uttarakashi District of state Uttarakhand. Nymphalidae was the most dominant family with 15 species followed by Pieridae (7), Lycaenidae (7), Papilionidae (3) and Hesperidae (2) [4]. Some workers have reported 76 species of butterflies belonging to 15 families from district Nainital, Uttarakhand, India. Pieridae was the most dominant family with 22 species followed by Nymphalidae (18), Noctuidae (7), Papilionidae (6), Danaidae and Lycaenidae (5 each), Satyridae (4), Eupterotidae (2), Hesperidae, Geometridae, Pyralidae, Crambidae, Lymantriidae, Acraeidae and Syntomidae (1 each) [34]. In a more recent study 213 species of butterflies belonging to 5 families have been listed from the Sankosh River catchment of district Sarpang in Bhutan. Nymphalidae was the most dominant family with 90 species followed by Lycaenidae (51 species), Hesperidae (27 species), Pieridae (23 species) and Papilionidae (22 species) [28]. Studies have been carried out on butterfly diversity on the Indian University campus. Few workers have documented 51 species of butterflies belonging to 5 families from Guru Ghasidas University campus and Bilaspur urban areas. Nymphalidae was the dominant family with 24 species followed by Lycaenidae (11), Pieridae (7),

Papilionidae (6) and Hesperidae (3) [13]. During a comparative study in wild and human-impacted areas in the campus of SGB, Amravati University, Amravati, Maharashtra, India a total of 52 species of butterflies belonging to Hesperidae, Papilionidae, Pieridae, Lycaenidae and Nymphalidae have been reported [33]. In a more recent study some other workers have studied the community composition of the butterfly fauna within Gurukula Kangri Vishwavidyalaya Campus, Haridwar, Uttarakhand and reported 179 individuals belonging to 25 species and 4 families. Nymphalidae was the most dominant family in terms of number of species (10) followed by Pieridae (9), Danaidae (4) and Papilionidae (2). In terms of the number of individuals family Pieridae (72) was dominant followed by Nymphalidae (70), Danaidae (30) and Papilionidae (9) [14].

Abundance of butterflies

A total of 897 individuals of butterflies were recorded during the study period. While 524 individuals belonging to 23 species were recorded from site-1 and 373 individuals representing 19 species were recorded from site-2. *Pieris brassicae nepalensis* Doubleday (Family: Pieridae) was recorded as the most abundant species and constituted 22.96% of the total recorded individuals of the butterflies. *Aglais cashmirensis* Kollar (Family: Nymphalidae) was recorded as the second most abundant species constituting 14.6% of the total butterflies collected. *Vanessa indica* Herbst (Family: Nymphalidae) was the third most dominant species and constituted 10.03% of the total butterflies collected. On the other hand, *Acraea issoria anomala* Kollar (Family: Acraeidae) was recorded as less abundant species during the study period followed by *Papilio protenor protenor* Cramer (Papilionidae), *Papilio polytes romulus* Cramer (Family: Papilionidae), *Delias belladonna horsefieldi* Gray (Family: Pieridae) and *Danaus genutia genutia* Cramer (Family: Danaidae).

In the present study site-1 supported the maximum number of species of butterflies (23 species) whereas, 19 species of butterflies were recorded from site-2. It was observed that 15 species were common in both sites. Eight species of butterflies (*Anahaes aurota aurota* Fabricius (Family: Pieridae), *Catopsilia pyranthe* Linnaeus (Pieridae), *Neptis yerburyi yerburyi* Butler (Family: Nymphalidae), *Sephisa dichrora* Kollar (Family: Nymphalidae), *Danaus genutia genutia* Cramer (Family: Danaidae), *Parantica aglea melanoidea* Moore (Family: Danaidae), *Lasiommata schara schara* Kollar (Family: Satyridae) and *Lethe insana insana* (Family: Satyridae) were recorded from site-1. On the other hand, four species of butterflies (*Colias erate erate* Esper (Family: Pieridae), *Delias belladonna horsefieldi* Gray (Family: Pieridae), *Papilio protenor protenor* Cramer (Family: Papilionidae) and *Acraea issoria anomala* Kollar (Family: Acraeidae) were recorded from site-2 during the entire study period. Maximum numbers of butterflies were recorded during the rainy season when the humidity and temperature were favorable for the growth and development of butterflies (Fig 1 & 2).

Fig 1: Variation in the number of individuals of butterflies in relation to temperature ($^{\circ}\text{C}$) during the study period.

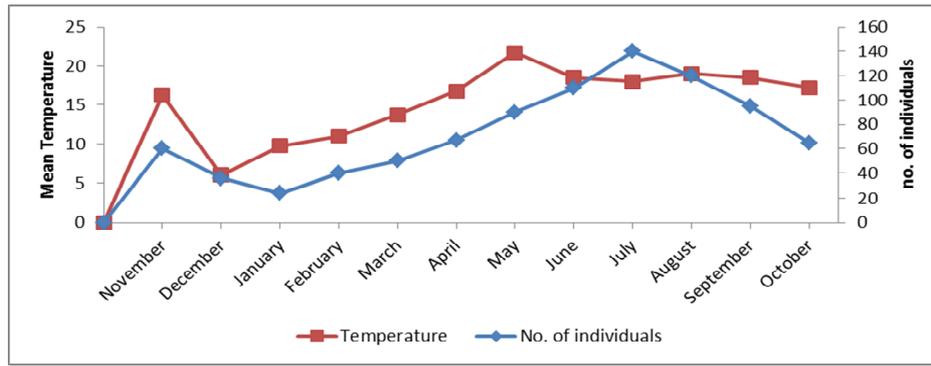
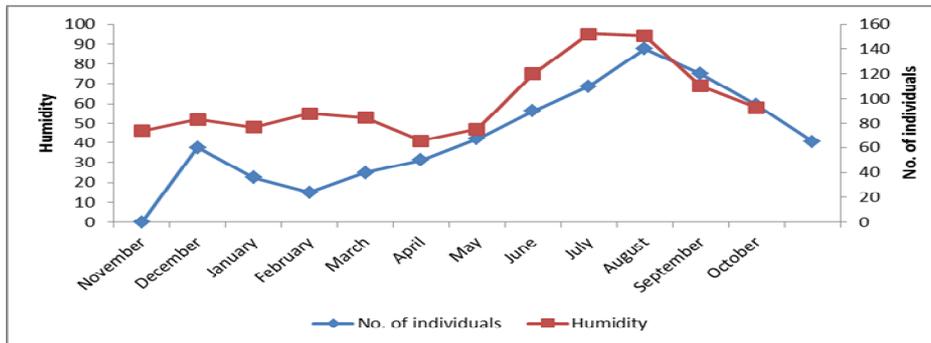


Fig 2: Variation in the number of individuals of butterflies in relation to humidity (%) during the study period.



Species diversity, richness and evenness of butterflies: Table 3 shows the species richness, diversity and evenness calculated during the study period. Across the study period Shannon-Wiener diversity Index (H') was recorded as 2.375 for the butterfly communities. Moreover, maximum species diversity was recorded

in the rainy season (0.987) and the minimum in the winter season (0.545). Similarly the maximum species richness (19) was observed in rainy season followed by summer (15) and winter (09), respectively.

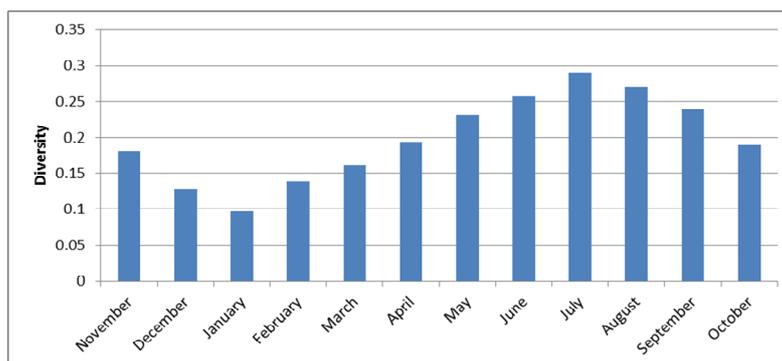
Table 3: Species diversity, richness, abundance and evenness of butterflies recorded from the study area.

Seasons	Abundance	Species richness	Diversity (H')	Evenness
Winter	160	09	0.545	0.248
Summer	317	15	0.843	0.311
Rainy	420	19	0.987	0.335
Across the study	897	27	2.375	
Site-1	524	23	2.747	0.876
Site-2	373	19	2.485	0.844

Figure 3 shows the monthly variation in species diversity of butterflies recorded from the study area during the study period.

Pielou's Evenness index (J') reveals that the species were evenly distributed in study sites.

Fig 3: Monthly variation in species diversity of butterflies recorded from the study area during the study period.



Similarly some workers have also observed the species diversity 0.40 to 3.42 of Lepidopteran insects in Silent Valley National Park, India [20]. Few workers have studied the butterfly communities along altitudinal gradients in a protected forest in the Western Himalayas, India and reported that the higher values of richness, abundance and diversity were recorded for the habitats at lower altitude and Shannon-Wiener diversity indices were 1.607 and 1.491 for lower and higher altitude sites, respectively [12]. Some other workers have observed that the species diversity of butterflies was 3.023 and 2.734 in rural site and urban site in north east India [1]. Some other workers have studied the butterfly diversity of district Nainital, Uttarakhand, India and recorded the mean Shannon diversity (H') as 1.318 and 1.319 in the first year and second year of study, respectively [34]. Some workers have reported the species diversity of butterfly fauna as 3.342 and 2.565 across the two years of study within Gurukula Kangri Vishwavidyalaya Campus at Haridwar, Uttarakhand, India [14]. Likewise other workers have also recorded the Shannon Wiener diversity (H') as 3.62 and Pielou's Evenness Index (J') as 0.89 for butterfly communities in the Trishna Wildlife Sanctuary, in South Asia [18]. In a more recent study few workers have recorded the maximum value of Shannon Wiener Index (H') as 3.247 for butterflies in the Seshachalam Biosphere reserve, Eastern Ghats, Andhra Pradesh, India [5].

4. Conclusion

The present study reveals that the study area provides favorable ecological conditions and habitat for butterflies. The highest number of species was recorded from highly disturbed site (site-1) favoring the observation of Padhey *et al.*, 2006 [24], Kunte, 2001 [17] and Tiple *et al.*, 2007 [33]. Maximum butterflies were recorded during the rainy season. It might be due to the presence of sufficient host plants and favorable climatic conditions for the development and growth of butterflies. The least number of butterflies were collected during the winter season when the adequacy of host plants and unfavorable climatic conditions were observed. Although, study area supports a good number of butterfly species but much has still to be explored. In addition, it is necessary to identify the rare butterfly species and conserve them by establishing conservatories or butterfly parks.

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