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Butterfly Communities Along Altitudinal Gradients in a Protected Forest in the Western Himalayas, India

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ABSTRACT.– Butterfly communities were studied along altitudinal gradients in the Pindari area of the Nanda Devi Biosphere Reserve in the Bageshwar district of Uttaranchal, India, during April 2005 to March 2006. The altitude of the study area ranged between 2000 m to 3050 m with temperate and sub-alpine types of vegetation. A transect method was used to collect the data. Four transects, two in each site, of a length of 1000 m each, were laid. From 96 sets of data, a total of 5038 individuals from the Papilionodea super family (butterflies) of Lepidoptera, representing 54 species and 9 families were recorded. The family Nymphalidae was the most abundant both in terms of the number of species and individuals, while the two most common species were *Vanessa cashmirensis* Fru and *Pieris canidia indica* Sparr recorded from all the four transects and contributed 8.3% and 6.4% of all individuals collected from all the four transects, respectively. The families Danaidae and Hesparidae were confined to the lower altitude site with broad-leaved forest. *Rahinda hardonia* Stoll, *Caprona ransonnetti* Felder, *Atella phalanta phalanta* Drury, *Chilaria kina* Hewiston, *Parnara guttatus* Bremer, *Colias erate* (Esper.), *Vanessa indica indica* Herbst and *Dodona durga* Kollar were recorded only on a few occasions from all the four transects and need to be monitored regularly. A significant difference was recorded in the species composition, abundance and diversity of the two habitats studied. Higher values of richness, abundance and diversity were recorded for the habitats at lower altitude. The habitats with the same altitude but with more heterogeneity were associated with higher values of all the studied parameters.

KEY WORDS: Butterfly, community, altitudinal gradient, species richness.

INTRODUCTION

Among insects, the order Lepidoptera is ecologically very important. The adults generally feed on nectar and serve as important pollinators of flowering plants. The larvae, which feed on foliage, are frequently the primary herbivores in ecosystems and are important in the transfer of radiant energy fixed by plants, making it available to the other organisms in the ecosystem. The diversity and abundance of butterflies (Lepidoptera: Papilionoidea) varies greatly among different forest habitats

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and along elevation gradients (Lien and Yuan, 2003). The butterflies show distinct patterns of habitat association with the vegetation type, humidity, sunshine, availability of water, etc. which determine the survival of given species in a particular habitat. Tropical butterfly assemblages are highly diverse, with many species endemic to tropics only and dependent to some extent on closed canopy forest (Collins and Morris, 1985; Sutton and Collins, 1991). Compared with other groups of invertebrates, including the rest of the order Lepidoptera, the high visibility of butterflies, together with their relatively well known taxonomy, has resulted in this group receiving a reasonable amount of attention throughout the tropics. Furthermore, the species richness of Lepidoptera (ca 180,000 recorded species), second only to Coleoptera, is represented within the more visible butterfly super family (ca 17,500 recorded species) and has been correlated with the richness of vertebrates and vegetation types (Erhardt, 1985; Thomas and Mallorie, 1985).

Hannyngton (1910 and 1911) listed endemic butterflies from the entire Uttaranchal region almost a century ago. In the recent past, the species composition of butterflies in the high altitude forests of the Western Himalaya was studied by Singh (1963), Joshi (1989), Arora (1995), Uniyal and Mathur (1998) and Joshi *et al.,* (2004). However, no attempts have so far been made to study the butterfly communities along the altitudinal gradients in Western Himalaya, despite the high ecological importance of this region. This study examines the butterfly composition, abundance and diversity associated with elevation gradients in the buffer zone of Nanda Devi Biosphere Reserve in the Pindari area of the Western Himalayas.

MATERIALS AND METHODS

Study Area: The study area is located at 30º 5' to 30º 10'N and 79º 48' to 79º 52'E in the northern part of the Bageshwar district of Uttaranchal State of India. This area lies in the buffer zone of the Nanda Devi Biosphere Reserve in the Western Himalayas. The area is connected to a road head by a footpath with the boundary of the buffer zone starting 20 km from the road head. The main river in the region is the Pindar, which originates from the Pindari glacier and is joined by its tributaries the Sunderdhunga and Kaphni rivers within the buffer zone. Climatically the area has three seasons viz. winter (November to March), summer (April to June) and rainy (July to October).

In this study two sites located at different altitudes were selected and within each site two 1000 m long transects were laid, separated from each other by 400 m. The lower elevation site ranged between 2000 and 2450 m and contained transects 1 and 2. The higher elevation site ranged between 2500 and 3050 m and contained transects 3 and 4. During the study period the temperature and relative humidity at the lower elevation site varied between 9 to 26 ºC, and 30% to 75%, respectively, whilst that at the higher elevation site it ranged between 6 ºC to 22 ºC and 35% to 80%, respectively.

The vegetation of transects 1 and 2 (lower altitude) was that of a temperate forest type with broad leaved deciduous and evergreen species and a forest cover of about 40-47% with natural small gaps in between, although the relative proportion of natural gaps was higher in transect 1 compared to transect 2. The plant diversity was rich with a total of 81 species, which included 15 species of trees, 26 species of

shrubs and 40 species of herbs and grasses. The common tree species in the tree layer are *Aesculus indica* (Cobler. Ex Don) Hk., *Junglens regia* Lin., *Quercus floribunda* Reheder, *Alnus napalensis* Don, *Acer villiousum* Wall., *Ilex dipyrena* Wall, *Caprinus viminea* Lindl. and *Cedrus deodara* (Roxb.) Loud. The common shrubs and floor vegetation species included *Arundinaria facata* Nees, *Hypericum obbngifolium* Choisy, *Hypericum lesnauthiana, Rubus peniculatus* Sm., *Sarcococca saliga* and *Cotoneaster mycrophylla* Wall, *Anaphalis contorta* D. Don., *Elsholtzia strobilifera* Benth., *Juneus bufonius* L., *Polygonum chinense* L., *P. plebejum* R., *Taxaxacum officinalis* Webber and *Arisaema torluosum* Wall.

Transects 3 and 4 (higher altitude site) were comprised of a sub-alpine zone with 39-41% forest cover. Seventy two species of plants including 11 species of trees, 24 species of shrubs and 37 species of grasses and herbs were recorded from these two transects. The common tree species included *Acer cappadocium* Gled, *Rhododendron barbatum* Wall., *R. arboreum* Sm., *Taxus baccata* L *Betula utalis* D. Don and *Ulmus wallichiana* Plank. Shrubs and other floor vegetation included *Thamnocalumus spathiflora* Munro, *Contoneaster acuminatus* Lindl., *Desmodium elengans* DC., *Rosa macrophyll* Lindl, *Barberis kumaonensis* Schn, *Juniperus indica*, *Anaphales triplinervis* Sims., *Carex infuscate* Nees *C. obscura* Nees, *Cerastium ceratiodes* Britton and *Polygonum amplexicaule* D. Don.

Sampling of butterflies: Monthly sampling of butterflies was carried out for a period of 12 months between April 2005 and March 2006 with 4 days in each month. The Pollard and Yates (1993) line transect method was used for survey of butterflies. The surveyor walked with a uniform pace and recorded all butterflies within 5 m on either side or ahead of the observer (an imaginary box of 5 m x 5 m x 5 m). The time required for checking each transect was approximately 70 to 90 minutes, which depended on the terrain, number of butterflies recorded and number of individuals caught for identification. Each transect was checked twice daily between 9.00-11.30 a.m. and 2.30-4.30 p.m. local time. Butterflies, which could not be identified on the wing, were captured for later identification. As far as possible surveys were conducted on sunny days with less than 30% cloud cover as butterfly activity is suppressed on windy or cloudy days (Weiss *et al.*, 1988).

Data analysis: The different species compositions between sites were measured using the following formula of Magurran, (1988):

$$\text{Similarity index } (C) = 2c/a+b$$

Where **a** is the number of species in area A; **b** the number of species in area B; and **c** is the number of shared species between the two areas.

Species diversity was measured by the Shannon-Wiener index H':

$$H' = - \sum_{i}^{s} P_i \ln P_i$$

Where **s** is the number of species and **P** is the proportion of the total number of individuals consisting of the **i**th species.

The t-test was used to (i) examine the differences of diversity (H') of two sites by comparing two diversity indices with the following formula:

$$t = H'_1 - H'_2 / [var(H'_1) + var(H'_2)]^2$$

and (ii) to examine the differences in butterflies abundances between the two sites.

RESULTS

Between both sites, a total of 5038 individual sightings of 54 species in 96 sets of data were recorded. The taxonomic composition of species along with their abundance in each transect of two sites is summarized in Table 1.

Species composition: Fifty two and 32 species were recorded from the lower and higher elevation sites, respectively, with thirty species common to all four transects. *Vanessa cashmirensis* Fru was the most common species in transect 1, 2 and 3 with 164, 123 and 94 recordings, respectively, whilst *Pieris canidia indica* Sparr. was the most abundant species in transect 4 with 55 recordings. The other commoner species recorded during this study included *Neptis yerburyi yerburyi* (But.), *Heliphorous sena* (Kollar), *Aporia agathon caphisa* Moore, *Pieris brassicae* Linn., *Aulocera swaha swaha* (Kollar), *Coloas electo fieldi* Menestries and *Hedoes pavana (*Kollar). These species were recorded in the decreasing order of their abundance from broad leaved forest type at lower altitude and coniferous forest at higher altitude.

Twenty two species of butterflies were recorded only in the lower site (transects 1 and 2) with the most characteristic species among them being *Rahinda hardonia* Stoll, *Caprona ransonnettii* Felder, *Danius plexippus* Linn., *Atella phalanta phalanta* Drury, *Chilaria kina* (Hewiston) and *Parnara guttatus* Bremer, which were recorded only occasionally with less than 20 recordings for each species. All the four species of family Danaidae and two species of Hesperidae were collected from the lower altitude site with broad leaved vegetation. However, in general, transect two had a lower abundance of butterfly species in comparison to transect 1.

Two species of butterflies *Argynmis lathonia issea* Doubleday and *Colias erate* (Esper) were only recorded from the higher altitude site (transects 3 and 4). However, four species *Aporia agathon caphisa* Moore, *Colias electo fieldi* Menestries, *Pararge schakra* Koll and *Acraea issoria anomal* Kollar were recorded in much higher abundance from the higher than lower altitude site.

The butterfly species compositions of sites at lower and higher elevation were rather similar (similarity index of 0.722) and this was true across all families with similarity indices of Nymphalidae, 0.722; Pieridae, 0.818; Lycaenidae, 1.0; Satyridae, 0.99 and Papilionidae, 0.666.

Butterfly richness and abundance: The data on richness, abundance and diversity of butterfly species among different transects are summarized in Table 2. The species richness was similar in transects 1 and 2 (lower elevation) with 52 species each, whilst for the higher elevation site 32 and 31 species were present in transect 3 and 4, respectively. Highest number of individuals were recorded from transect 1 which was followed by transects 2, 3 and 4, respectively. Transect 1 contributed 37.9% towards the total individuals recorded from all the 4 transects, while both transects at the lower elevation contributed 67.2% towards all individuals recorded. There existed a difference in the number of

TABLE 1. Butterfly species and their abundance at the four transects in the Pindari area of Nanda Devi Biosphere Reserve, India.

Sl. No.	Taxonomic Composition	Low site 2000-2450 mamsl			High site 2500-3000 mamsl		
		Tr. 1	Tr. 2	Total	Tr. 3	Tr. 4	Total
	Nymphalidae						
1	*Vanessa cashmirensis* Fru.	164	123	287	94	40	134
2	*Vanessa indica indica* Herbst	10	6	16	3	3	6
3	*Precis iphita siccata* (Stichel)	58	41	99	35	29	64
4	*Pyramies cardui cardui* Linn.	12	8	20	4	3	7
5	*Pseudoergolis wedah* Kollar	24	22	46	10	-	10
6	*Neptis yerburyi yerburyi* (But.)	74	70	144	45	45	90
7	*Neptis ananta* Moore	34	29	63	19	18	37
8	*Argynnis lathonia issea* Doubleday	-			14	41	55
9	*Atella phalanta phalanta* Drury	10	9	19	-	-	-
10	*Sephisa dichroa* (Kollar)	55	42	97	-	-	-
11	*Rahinda hardonia* Stoll.	12	3	15	-	-	-
12	*Eulepis athamas* Druary	24	20	44	-	-	-
13	*Cupha erymanthis* Drury	22	19	41	-	-	-
14	*Eragolis merione* Cram	18	11	29	3	1	4
	Pieridae						
15	*Pieris canidia indica* Sparr.	95	91	186	82	55	137
16	*Pieris brassicae* Linn.	60	63	123	60	27	87
17	*Gonepteryx rhamni neplensis* Doubleday	65	51	116	46	25	71
18	*Delias bellodonna bellodonna* Fabr.	20	19	39	22	11	33
19	*Delias eucharis* Drury	18	11	29	4	2	6
20	*Aporia agathon caphisa* Moore	75	69	144	44	33	151
21	*Anapheis aurota aurota* (Fabr.)	13	14	27	-	-	-
22	*Catopsilia crocale* Cramer	28	25	53	-	-	-
23	*Catopsilia pyranthe* Linn.	18	22	40	-	-	-
24	*Colias electo fieldi* Menestries	67	54	121	49	35	151
25	*Colias erate* (Esper.)	-	-	-	19	25	46
26	*Huphina herissa phryne* Fabr.	29	18	47	-	-	-
27	*Eurema hecabe* Linn.	35	32	67	10	8	18
	Lycaenidae						
28	*Heliphorous sena* (Kollar)	74	69	143	72	33	105
29	*Hedoes pavana* (Kollar)	58	44	102	53	47	100
30	*Celastrina huegelli* Moore	42	39	81	10	6	16
31	*Chilaria kina* (Hewiston)	11	8	19	-	-	-
32	*Lampides bocticus* (Linn.)	33	30	63	13	2	15
33	*Virachola issocrates* F.	20	16	36	18	5	23
34	*Talicada hyseus gyerin* Meneville	26	19	45	-	-	-
	Satyridae						
35	*Aulocera swaha swaha* (Kollar)	65	60	125	48	35	83
36	*Pararge schakra* Koll.	50	41	91	33	28	61
37	*Callerebia scanda scanda* (Kollar)	38	31	69	30	21	51
38	*Lethe sidonis sidonis* Hew	22	24	46	28	16	44
39	*Lethe goalpara* Moore	27	15	42	-	-	
40	*Ypthima* sp.	49	39	89	2	2	4
41	*Ypthima nareda* Kollar	22	19	41	-	-	-
42	*Mycalesis mineus* Linn.	16	12	28	-	-	-

TABLE 1. Cont.

Sl. No.	Taxonomic Composition	Low site 2000-2450 mamsl			High site 2500-3000 mamsl		
		Tr. 1	Tr. 2	Total	Tr. 3	Tr. 4	Total
	Papilionidae						
43	*Paridis aidoneus* Doubday	38	31	69	11	8	19
44	*Papilio polytes romulus* Cramer.	20	18	38	-	-	-
45	*Papilio demoleus* Linn.	24	21	45	-	-	-
46	*Byasa varuna astorian* Wd.	30	22	52	14	6	20
	Danaidae						
47	*Euploea core* (Cramer)	33	25	58	-	-	-
48	*Danius aglea* Stoll.	21	19	40	-	-	-
49	*Danius plexippus* Linn.	11	5	16	-	-	-
50	*Danius chrysippus* Linn.	23	20	43	-	-	-
	Hesperidae						
51	*Parnara guttatus* Bremer	12	8	20	-	-	-
52	*Caprona ransonnettii* Felder	8	7	15	-	-	-
	Erycinidae						
53	*Dodona durga* (Kollar)	12	11	23	3	3	6
	Acraeidae						
54	*Acraea issoria anomal*a Kollar	22	11	33	16	36	52

individuals recorded from each transect at low and high altitudes with 9.7% more individuals in transect 1 than transect 2 (low altitude site), and 16.0 % more individuals in transect 3 than transect 4 (high altitude site). A significant difference was recorded in the number of individuals between the lower and higher altitude sites. The commonest species *V. cashmirensis* was recorded 427 times accounting for 8.3% of all individuals at all transects, closely followed by *P. canidia indica* accounting for 6.4% of all individuals. *C. ransonnettii* was least abundant at transect 1 and *R. hardonia* at transect 2.

Similarly, *Yapthima* sp. was least abundant at transect 3 and *Eragolis merione* Cram at transect 4. Nine species of butterflies accounted for less than 0.5% of the total individuals from all the four transects. Three species of butterflies were recorded less than 10 times from transect 1 while this number was 7, 9 and 12 at transect 2, 3 and 4, respectively.

Species diversity: The diversity indices for each transect showed differences with the highest value recorded for transect 1, followed by transects 2, 3 and 4, respectively (Table 2). The Shannon-Weinner diversity indices were 1.607 and 1.491 for lower and higher altitude sites, respectively. Across the seasons, the maximum diversity was recorded for rainy season followed by summer and winter. The difference in diversity indices were significant between transect 1 and 3 and transect 1 and 4.

DISCUSSION

The results of this study suggest that the butterfly community structure in two habitats with different elevations and vegetational composition differs greatly. The number of species found at the lower elevation is much higher compared to at higher elevation. The species diversity of butterfly communities within the same

TABLE 2. Species richness, abundance and Shannon-Wiener diversity index (H') of butterflies in different transects.

Transect	Total number of species	Mean number of Individuals	Total number of individuals	Diversity index (H')
1	52	35.9	1867	1.611
2	52	29.5	1536	1.592
3	32	28.6	914	1.355
4	31	20.3	649	1.350
Lower altitude	52	62.7	3384	1.607
Higher altitude	32	30.6	1654	1.491

habitats but with slightly more natural gaps, as in case of transect 1 at lower altitude and transect 3 at higher altitude, was higher as compared to transect 2 and 4, respectively. This is in contrast to the studies on other groups of insects, in which it was indicated that communities in closed forests are as a rule richest in species (Morse *et al.*, 1988; Barlow and Woiwod, 1989). However, Leps and Spitzer (1990) reported that the diversity and species richness of butterfly communities were higher in rural communities near a village and in large clearings on the forest edge than in the closed forest. The reasons attributed to these differences in the present study are heterogeneity of habitats caused by the availability of natural gaps in between, and the availability of higher sunshine at transects 1 and 3. Similarly, climatic conditions like low temperature, higher incidence of cloudy sky and presence of a lesser number of plant species at higher altitude (transects 3 and 4) may be the reasons for lower values of richness, abundance and diversity. Butterfly distribution is expected to covary with the distribution of their host plants even on a small local scale within forest stands and changes in stratification and type of forest vegetation may reflect differences in the composition of butterfly communities at the generic and family level (Beccaloni, 1997). Spitzer *et al.*, (1997) have recorded significant differences in butterfly communities in different successions of montane forests. Similarly, Sparrow *et al.* (1994) and Lien and Yuan (2003) have recorded significant differences in the butterfly diversity between low and high altitude sites in other tropical forest ecosystems. In fact the different climatic factors like temperature, humidity, rainfall and sunshine vary between the sites at different altitudes, which bring the changes in vegetational composition, and ultimately the faunal diversity is affected.

Hannygton (1910) recorded 371 species of butterflies from the than Kumaon region which includes the present day 8 districts of Garhwal and 5 districts of Kumon region. Wynter-Blyth (1957) recorded as many as 835 species from the Eastern Himalaya, and only 415 species from the Western Himalaya. Western Himalaya, including the areas surveyed in the present study, receives less rainfall during the monsoon season, compared to that in North-Eastern Himalaya. As a result the climate and temperature are quite different in the eastern and western Himalayas.

The family Nymphalidae, the largest family of butterflies, was represented by the highest number of species, and was well

distributed at all the elevations surveyed. Being fond of sunshine and basking, the lower altitude transects had their greater abundance as compared to transects at the higher altitudes. Similarly, the family Pieridae was represented by 13 species in the present study and together, these two families comprised 50% of the species recorded in the present survey.

Only two species of the family Acraedie are known to occur in India and only one, *Acraea issoria anomal*a Kollar has been recorded from western Himalaya (Arora, 1995) and was recorded in the present survey with greater numbers at the higher altitudes. Similarly, only one species of the family Ercinidae, *Dodona durga* (Kollar), was recorded in the present survey, although it was present at all four transects, a higher abundance was recorded at the lower altitude site.

CONCLUSION

The presence of 54 species of butterflies (13% of the total recorded species for the Western Himalayas) in just two small surveyed sites suggests the Nanda Devi biosphere reserve is likely to be a very important habitat. A clear gradation in the species composition and diversity of butterflies along the altitudes was quite evident. The chances of disturbances in natural habitats of the Pindari are high, because it is becoming a very popular center of tourism, especially during the last decade, and a lot of anthropogenic activities have been noticed close to the buffer zone of the Nanda Devi Biosphere Reserve. Any change and interference in the forest may cause the migration or disappearance of species from these, so far undisturbed areas because the forest restricted species are typically both found only in forests and are very sensitive to even microhabitat damage. Further studies are also required to examine the effects of on going anthropogenic activities on species diversity of butterflies, specially in the buffer zone of the Nanda Devi biosphere reserve.

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