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Diversity in family Sphingidae: Lepidoptera from Sikkim Himalaya

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Abstract
The Hawk moths are the most abundant group of the insects belonging to Order Lepidoptera. An attempt was made to record the diversity, species richness, and evenness of Hawk moths inhabiting the Temperate and Sub Alpine Zones of Sikkim Himalaya. The species are known to damage economically important agricultural, Horticultural and forestry plantations. The collection of these insects was achieved through the light-trapping technique and the study resulted total of 22 species of Hawk Moths belonging to family Sphingidae under 12 genera. For the exploration of sphingid moth diversity, there are 25 extreme localities falling in 04 districts of Sikkim were thoroughly explored for the purpose during the month of May and September. The Sikkim Himalaya having very rich diversity of flora and fauna which makes rich diversity of insect fauna to this region.

Keywords: Diversity- Sphingidae-Sikkim Himalaya

1. Introduction
The region is often known as hot spot of biodiversity of economically important insects. An attempt was made to record the diversity, species richness, and evenness of Hawk moths inhabiting the Temperate and sub alpine zones of Sikkim Himalaya. Sphingidae (Lepidoptera) species are commonly called “Hawk moths” or sphinx. The hawk moths are medium to large sized, heavy- bodied moths with characteristics of bullet shaped bodies and long blade like wings, long narrow forewings and relatively small hind wings. Wingspans range from about 40 mm to 140 mm. In the fore wing vein M2 arises a little closer M3 than M1. Veins Sc and Rs in the hind wing are to end of discal cell and beyond; near the middle point of the discal cell, connected by an oblique cross vein. Proboscis usually long than the body in Sphinginae and short or vestigial in Smerithinae. They are strong flier with rapidly beating wings, can fly up to 40-50 Km/hr (Carter) [3]. Hawk moths are a very diverse group represented by 203 genera and 1348 species described all over the world (Pogue, 2009). Hawk moth fauna of India is quite rich about 200 species are known and the oriental region contributes 250 species (Chandra *et al*.) [9, 10]. Keeping in view, the economic importance of the family Sphingidae in the region, the present study have been undertaken to know the diversity, richness and evenness of these insects with population abundance of each species.

2. Materials and methods
2.1. Study area
Study was carried out in Sikkim Himalaya, a small beautiful state of India in the Eastern Himalayas with steep mountains and deep valleys. It lies between latitudes 27° 5' N to 20° 9' N and longitudes 87° 59' E to 88° 56' E. The jungles are lush with creepers and crawlers beneath extensive canopies of tree ferns, plantain, bamboo, and several species of tall trees such as kapok and sal. The temperate forests have an interesting variety of trees and include oak, chestnuts, maple, birch, magnolia and rhododendron. In the soft humid soil amidst moss and shrubs are several terrestrial species, and includes several varieties of Paphiopedilum, the exotic ‘ladies slipper’. Elevation plays a prime role in fashioning the eco-regions of the state. This is evident from the presence of Sal forests in the Rangeet Valley in the south to the temperate fir forests in the north, beyond which lie the trans-Himalayas and cold desert of the Tibetan plateau. Broadly speaking there are four zones of vegetation according to altitude variations, but in some stray areas, altitude alone may not define a zone as exposure to other physical properties of the terrain can result otherwise.

2.2. Collection methods
The collection was made during the Year 2009, both in the pre and the post monsoon seasons (May and September) of Sikkim Himalaya, more than 25 extreme localities falling in North, South, East and West Sikkim were thoroughly explored twice for the collection of sphingid moths. The moths were collected by using simple light trap consisting of white cloth 2 meter and 200 watt tungsten bulbs were used as light sources. The trap was set up at different locations and operated from dusk to dawn continuously for 27 nights in pre monsoon (May) and 30 nights in the post monsoon (September). When the moth came to light and sit on white cloth, quickly trapped by a wide mouth bottle containing killing agent (Benzene) soaked cotton placed on bottom of bottle beneath a piece of filter paper to avoid the contact of killing agent with moth. Finally trapped moths were transferred to butter paper envelops and dried at room temperature to avoid fungal infections.

2.3. Identification
The specimens collected from different areas were brought to laboratory for processing and preservation after that they have been identified with the help of all available traditional taxonomic characters for the group & available literature (Bell & Scott) [2]. Holloway [8]; Hampson [4-7], and other electronic and non-electronic sources. The identified material has been deposited at Taxonomy and Biodiversity Laboratory, Division of Entomology SKUAST-K Shalimar Srinagar for ready reference. The current nomenclature used for species identification is based on LEPINDEX Beccaloni *et al*.) [1]. The characters of male genitalia were also studied for distinguishing the allied species.

2.4. Diversity analysis
On the basis of Periodical and locality wise number of collected moths and number of individual species data were maintained and finally species diversity was calculated by using Shanon-Wieners [13] Diversity Index, $H = - \sum Pi (lnPi)$ and Evenness (j) was calculated to estimate the equitability component of diversity using the formula (Pielou) [12] $j= H/Log_{10}S$, species richness (ma) was computed by using formula (Pielou) [11] $Ma= S-1/ Log_{10}N$.

3. Results and discussion
The study resulted total of 22 species of hawk moths under 12 genera of the order Lepidoptera. The individual abundance was found highest in post monsoon season i.e. 61.5% of the overall catch, while in pre monsoon the abundance was recorded 38.44%.(Table 2) The species diversity, richness and evenness of sphingid moths in Sikkim is mainly due to the rich vegetation in this area as vegetation plays an important role in the existence of insect fauna in a community as it provides the main source of food etc. Species diversity was found highest in North Sikkim both in the pre and post monsoon season 0.93 and 1.18 respectively. In South Sikkim the species diversity was found 0.82 in pre monsoon and 0.88 in post monsoon. In East Sikkim the diversity was found lowest 0.55 in pre monsoon and in post monsoon it was 1.02. As far as the west Sikkim is concerned the species diversity was found lowest in post monsoon 0.83 and in pre moon soon it was 0.74. The evenness (j) was computed in all the four districts both in the pre and the post monsoon season and the data reveals that south Sikkim represented highest species evenness 0.97 and it was lowest in North Sikkim 0.11 in pre monsoon. While in post monsoon East Sikkim the highest species evenness 0.99 while it was found lowest in North Sikkim 0.96. The south and west Sikkim represented the same species evenness 0.98 was for both locations during the post monsoon but in pre monsoon the evenness was found 0.93 in East Sikkim and 0.96 in west Sikkim. Species richness was found highest in North Sikkim both in the pre and the post monsoon season 8.45 and 16.53, respectively and it was lowest in East Sikkim in pre monsoon and in post monsoon it was lowest in west Sikkim 3.59. South Sikkim represented (ma) 6.45 in pre monsoon and 3.95 in the post monsoon while the East Sikkim (ma) represented the lowest species richness (ma) in the pre monsoon 1.92 and in post monsoon it was 5.10. (Table1.) North Sikkim contributes 9 and 17 species in pre and post monsoon respectively while East Sikkim represented 4 species in pre and 11 species in the post monsoon as far as the West Sikkim concerned the data reveals that the species catch was lowest only 7 species were reported from the immediate area. Similarly, low species diversity (12 species) of hawk moths belonging to 10 genera and 3 subfamilies were recorded from Veerangana Durgavati Wildlife Sanctuary, Damoh, Madhya Pradesh and same results were also reported from Arunachal Pradesh, India where sphingid diversity was about 2.0 per cent only (Chandra) [9, 10]. The present study is the first study of this type in the area; it is suggested and recommended that the area should be continuously monitored to observe any change in the diversity of moths particularly sphingid moths because the changes in the diversity can only be observed through continuous monitoring and comparing the data of every year. Overall species diversity in the study area was found to be very low this is due to the natural climate which is generally cold, temperate and arid. This is rather unsupportive of great sphingid diversity. Thus, the less species diversity is not entirely due to the climate but is more directly a result of low diversity of flora upon which to support greater sphingid diversity. Similar statement are also made by Smetacek [14] about sphingid moths of Kumaon, of N. India.

Table 1: Diversity, Evenness and Species Richness of Sphingid group from Sikkim Himalayas

District	Total number of individuals		Species Diversity (H)		Evenness (J)		Richness (ma)	
	May	Sept.	May	Sept.	May	Sept.	May	Sept.
North	68	144	0.93	1.18	0.11	0.96	8.45	16.53
South	64	39	0.82	0.88	0.97	0.98	6.45	3.95
East	36	91	0.55	1.02	0.93	0.99	1.92	5.10
West	45	47	0.74	0.83	0.96	0.98	3.02	3.59

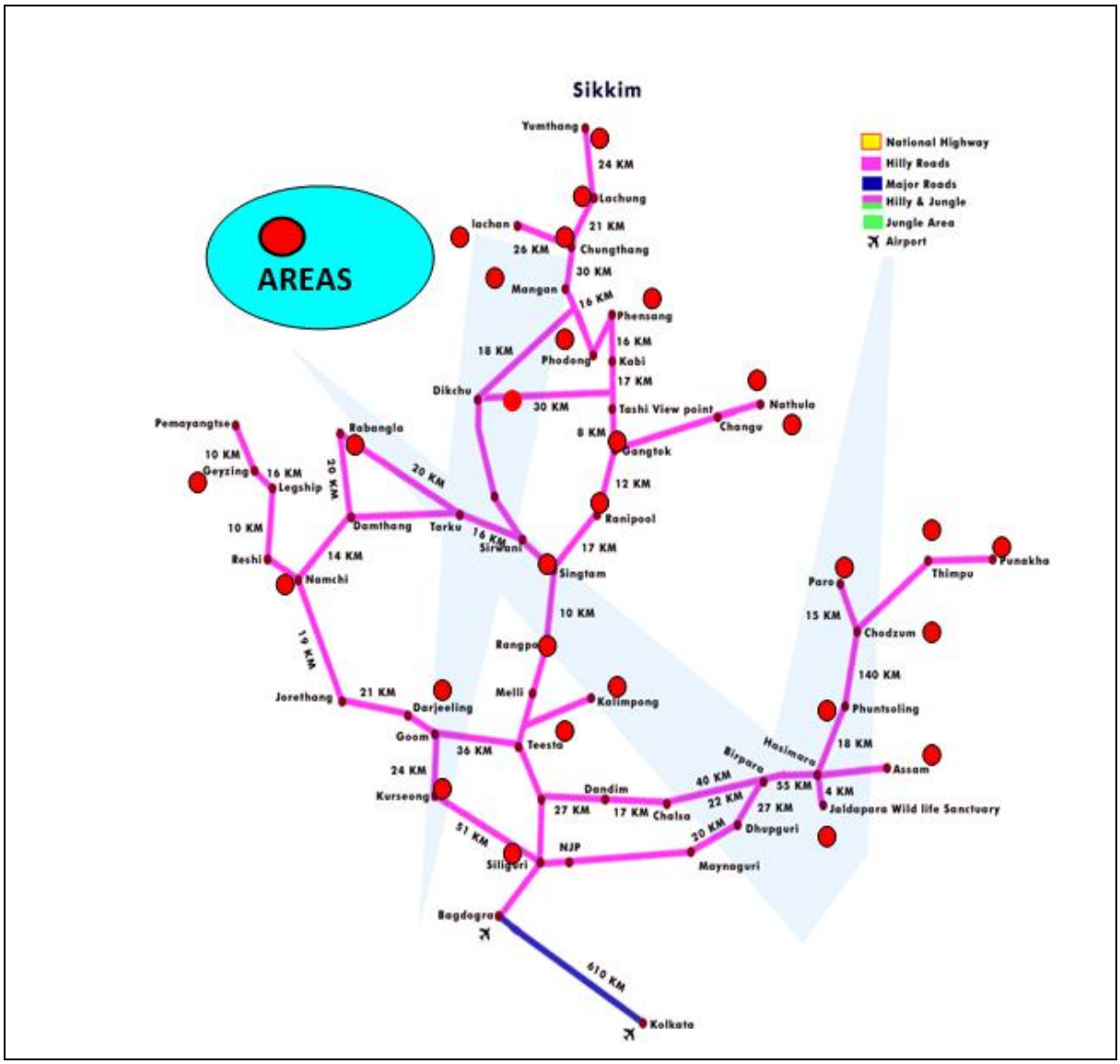

Fig 1: Map showing the localities explored for the collection cum survey of Sphingid moths.

Table 2: Total number of species with their numerical composition of different species of family Sphingidae collected through light trapping technique from Sikkim Himalayas during pre and post monsoon season (May and September, 2009)

S. No.	Insect species	North		South		East		West		Total Catch
		May	Sept.	May	Sept.	May	Sept.	May	Sept.	
1.	*Acosmeryx castanea* Rothschild & Jordan, 1903.	-	06	-	-	09	07	-	08	30
2.	*Acosmeryx naga* (Moore, 1858).	05	10	-	-	13	07	-	06	41
3.	*Acosmeryx* sp.	08	02	-	-	03	07	-	-	20
4.	*Ambulyx ochracea* (Butler, 1885).	-	18	-	05	11	10	-	-	44
5.	*Ambulyx cericeipennis okurai* (Okana, 1959).	-	11	-	05	-	05	-	-	21
6.	*Ambulyx sericeipennis tobii* Inove, 1970.	-	09	-	06	-	09	-	-	24
7.	*Ambulyx* sp.	-	04	-	-	-	07	05	-	16
8.	*Cechenena lineosa* (Walker, 1856).	-	-	-	-	-	13	11	-	24
9.	*Cechenena* sp.	-	-	-	-	-	07	05	-	12
10.	*Hyles gallii* Rottemburg, 1775	09	-	-	06	-	11	12	-	38
11.	*Hyles hippophaes bienerti* (Standinger, 1874).	06	-	-	-	-	08	06	-	20
12.	*Langia zenzeroides formosana* Clark, 1936.	04	-	-	-	-	-	06	04	14
13.	*Macroglossinae nephele hespera* (Fabricius, 1775).	09	13	11	-	-	-	-	-	33
14.	*Marumba cristata* (Butler, 1875).	13	12	15	-	-	-	-	8	48
15.	*Marumba jurencus* Rothschild & Jordan, 1912.	-	08	07	-	-	-	-	-	15
16.	*Meganoton* sp	-	09	06	-	-	-	-	06	21
17.	*Rhyncholoba acteas* Cram.	-	04	09	-	-	-	-	06	19
18.	*Smerinthus kindermannii* Lederer, 1853.	-	09	08	-	-	-	-	09	26
19.	*Theretra nessus* (Drury, 1773).	-	04	08	12	-	-	-	-	24
20.	*Theretra oldenlandiae* Fabricius, 1775**.**	07	10	-	07	-	-	-	-	24
21	*Theretra* sp.	07	06	-	09	-	-	-	-	22
22.	*Xylophanes libya* (Druce, 1878).	-	09	-	09	-	-	-	-	18
		68	144	64	59	36	91	45	47	554

Table 3: Seasonal occurrence of different species of family Sphingidae from Sikkim Himalayas during pre and post monsoon season. (May and September, 2009)

S. No.	Insect species	North		South		East		West	
		May	Sept.	May	Sept.	May	Sept.	May	Sept.
1.	*Acosmeryx castanea* Rothschild & Jordan, 19+.	-	+	-	-	+	+	-	+
2.	*Acosmeryx naga* (Moore, 1858).	+	+	-	-	+	+	-	+
3.	*Acosmeryx* sp.	+	+	-	-	+	+	-	-
4.	*Ambulyx ochracea* (Butler, 1885).	-	+	-	+	+	+	-	-
5.	*Ambulyx cericeipennis okurai* (Okana, 1959).	-	+	-	+	-	+	-	-
6.	*Ambulyx sericeipennis tobii* Inove, 1970.	-	+	-	+	-	+	-	-
7.	*Ambulyx* sp.	-	+	-	-	-	+	+	-
8.	*Cechenena lineosa* (Walker, 1856).	-	-	-	-	-	+	+	-
9.	*Cechenena* sp.	-	-	-	-	-	+	+	-
10.	*Hyles gallii* Rottemburg, 1775	+	-	-	+	-	+	+	-
11.	*Hyles hippophaes bienerti* (Standinger, 1874).	+	-	-	-	-	+	+	-
12.	*Langia zenzeroides formosana* Clark, 1936.	+	-	-	-	-	-	+	+
13.	*Macroglossinae nephele hespera* (Fabricius, 1775).	+	+	+	-	-	-	-	-
14.	*Marumba cristata* (Butler, 1875).	+	+	+	-	-	-	-	+
15.	*Marumba jurencus* Rothschild & Jordan, 1912.	-	+	+	-	-	-	-	-
16.	*Meganoton* sp	-	+	+	-	-	-	-	+
17.	*Rhyncholoba acteas* Cram.	-	+	+	-	-	-	-	+
18.	*Smerinthus kindermannii* Lederer, 1853.	-	+	+	-	-	-	-	+
19.	*Theretra nessus* (Drury, 1773).	-	+	+	+	-	-	-	-
20.	*Theretra oldenlandiae* Fabricius, 1775**.**	+	+	-	+	-	-	-	-
21	*Theretra* sp.	+	+	-	+	-	-	-	-
22.	*Xylophanes libya* (Druce, 1878).	-	+	-	+	-	-	-	-
		09	17	07	08	04	11	06	07

(+)= Present and (-)=Absent

4. Conclusion

A total of 22 species of sphingid moths were collected during the study period, both in the pre and post moon soon season after getting the permission from the Wild life department Govt. of Sikkim. Species Diversity (H) was found highest in North Sikkim both in the pre and post monsoon season 0.93 and 1.18, respectively and lowest in East Sikkim during pre-monsoon 0.55 and in the post monsoon. While as it was found lowest in West Sikkim 0.83. Evenness was found highest in North Sikkim during pre-monsoon 0.11 and it was lowest in South Sikkim 0.97 but in the post monsoon evenness was highest in East Sikkim 0.99 while it was lowest in North Sikkim 0.96. As far as the richness is concerned North Sikkim contributes highest species richness both in the pre and post monsoon season 8.45 and 16.53, respectively. East Sikkim represented lowest species richness 1.92 during the pre-monsoon while in the post monsoon in West Sikkim it was 3.59. Abundant catch was also detected during the post monsoon season with 61.5 % of the overall catch. The overall species diversity, evenness and richness of the entire region were found 1.31, 0.98 and 21.6, respectively. Their existence was a definite relation between catches in the trap and meteorological phenomenon like temperature and relative humidity.

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