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SHORT COMMUNICATION

A Prefatory Estimation of Diversity and Distribution of Moths in Nanda Devi Biosphere Reserve, Western Himalaya, India

Pritha Dey[1] · V. P. Uniyal[1] · Kailash Chandra[2]

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Abstract A pilot assessment of moth distribution and diversity was conducted in the buffer zone of Nanda Devi Biosphere Reserve, Western Himalaya, Uttarakhand, India. A total of 771 specimens were collected along an elevational gradient between 2000 and 3800 m across different forest types (temperate, sub-alpine, alpine scrublands) in Joshimath and Lata. Specimens were collected using light-trapping method during April–June and September–October 2014. A declining trend in moth diversity along the elevation was found which can be correlated with food resources. Comparative analyses showed different forest types had a more prominent effect on species composition at Joshimath than Lata. The family Geometridae with 475 specimens was found to be the most abundant family across all the sampling plots. Indicator species for forest types and disturbance level can be identified for habitat-quality assessment program and conservation management of the landscape.

Keywords Moths · Western Himalaya · Diversity · Geometridae · Nanda Devi Biosphere Reserve

It is well-established that insect species richness decreases from equator to the poles but there still exists a gap with little comparable data from temperate, tropical and intermediate regions [1]. Insects are a potential group for studying the effects of environmental gradients and habitat attributes on faunal diversity. Lepidoptera being a taxonomically well known insect group is ideal to resolve the questions regarding the patterns of species richness, abundance, and diversity. They have also shown promise as forest condition indicator taxa in many studies [1–3]. Moths have a close functional relationship with vegetation structure that makes them ideal for identifying ecological factors affecting biodiversity, and indicating forest quality. Elevational gradient with associated abiotic and physiognomic contrasts generate patterns of species diversity and composition regionally that can address these questions.

The fragile Western Himalayan landscape faces degradation and loss of biodiversity but also offers habitat heterogeneity that provide refuge to a unique diversity. The typical physical attributes of these landscapes have steep contrasts in environmental factors within a small geographical area and are ideal to study diversity patterns of such a hyperdiverse insect group. Nanda Devi Biosphere Reserve (NDBR) (30°08′–31°02′N, 79°12′–80°19′E) lies in the Uttarakhand state of India. It covers an area of 6407.03 km^2 (core area: 712.12, buffer zone: 5148.57 and transition zone: 546.34 km^2), with an altitudinal range of 1800–7816 m above sea level. It lies in the biogeographic zone 2B. Nanda Devi National Park and Valley of Flowers National Park within NDBR were designated as 'World Heritage Sites' in 1988 and 2004 respectively. The climate is dry with low yearly precipitation. It has heavy rainfall during the monsoon season (June to the beginning of September). The region lies in the transition region from the shivalik and trans-Himalayan region and is an abode to some unique diversity. Invertebrates are poorly documented in this region except for some notable studies [4–6].

The study was conducted at two locations (A) Joshimath (B) Lata (Fig. 1) which are about 25 km apart along the

✉ Pritha Dey
dey.pritha126@gmail.com

1 Wildlife Institute of India, Chandrabani, Dehradun, India

2 Zoological Survey of India, Prani Vigyan Bhawan, New Alipore, Kolkata, India

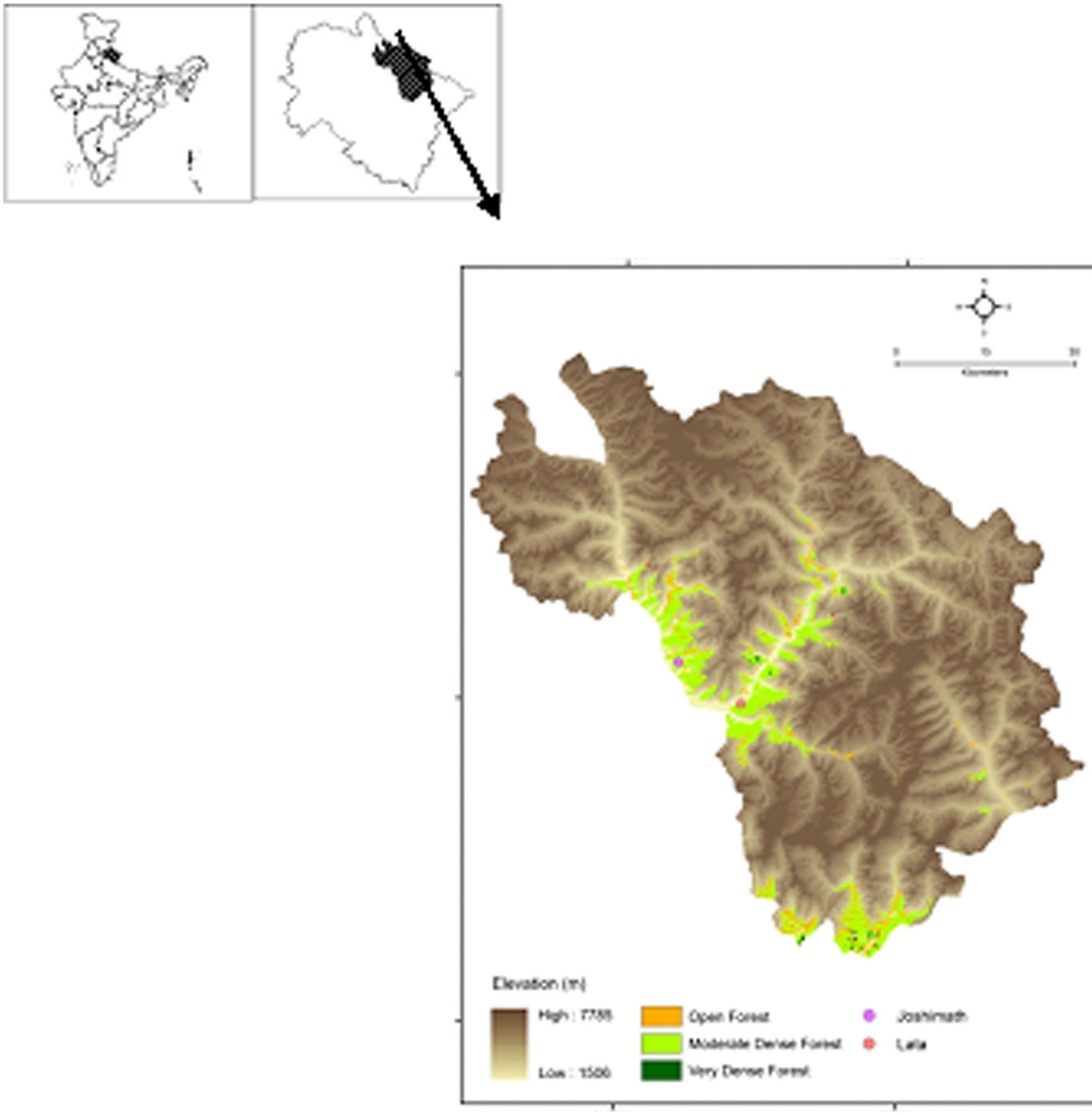

Fig. 1 The plot locations within Nanda Devi biosphere Reserve. Joshimath and Lata werethe two sites where plots were laid along the elevation

motorable road. The locations show a distinctive gradient in vegetation types and associated biotic–abiotic factors along the elevation (Table 1) making them suitable for the study.

Stratified random sampling method was opted at every 200 m along the elevational gradient. Sampling was done within an altitudinal range of 2000–3800 m during April–June 2014. Sites were chosen randomly ensuring homogenous forest cover to avoid cross-habitat attraction to light trap. Thirty-two sites were sampled across all the forest types at the two locations (Joshimath and Lata) with two light traps operating simultaneously separated by a distance of about 50 m. Light traps were operated for 3–4 h from dusk usually from 1900 to 2300 hours and hourly variation in microclimatic variables (temperature, wind speed and humidity) were noted. Species number and abundance were noted for each hour during the sampling. Voucher specimens were preserved in insect storage boxes for further identification. Specimen identification was done by comparing with specimens at the Lepidoptera section,

Table 1 The no. of plots at both the locations with the no. of morphospecies collected at two traps simultaneously

Site	Plot	Elevation	No. of morphospecies	Forest type
Joshimath	1	2106	49	Temperate
	2	2130	78	Temperate
	3	2217	26	Temperate
	4	2237	55	Temperate
	5	2418	31	Temperate
	6	2433	34	Temperate
	7	2609	20	Temperate
	8	2604	13	Sub-alpine
	9	2887	15	Sub-alpine
	10	2893	19	Sub-alpine
	11	3064	13	Sub-alpine
	12	3067	9	Sub-alpine
	13	3227	3	Sub-alpine
	14	3220	11	Sub-alpine
Lata	1	2182	14	Temperate
	2	2126	15	Temperate
	3	2311	10	Temperate
	4	2347	7	Temperate
	5	2544	6	Temperate
	6	2528	13	Temperate
	7	2757	16	Sub-alpine
	8	2763	6	Sub-alpine
	9	2905	11	Sub-alpine
	10	2911	7	Sub-alpine
	11	3105	23	Sub-alpine
	12	3109	15	Sub-alpine
	13	3315	8	Sub-alpine
	14	3354	5	Sub-alpine
	15	3506	4	Sub-alpine
	16	3522	5	Sub-alpine
	17	3786	0	Alpine
	18	3784	3	Alpine

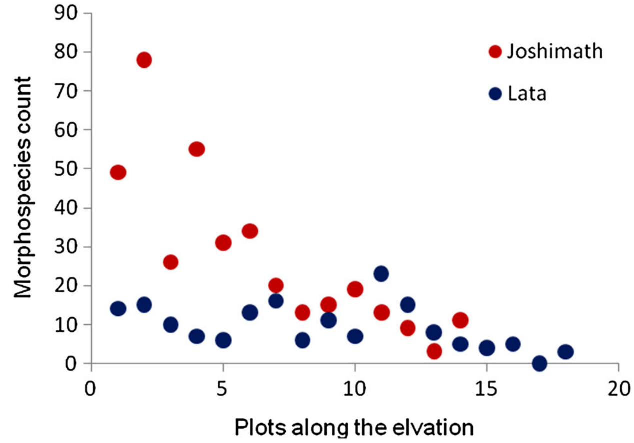

Fig. 2 The morphospecies count in the plots along the increasing elevation gradient. Joshimath showing a steeper decline than at Lata

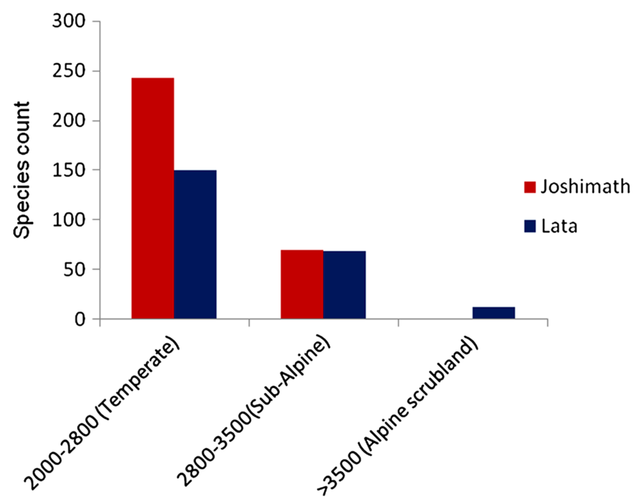

Fig. 3 Temperate forest type was the most sampled (2000–2800 m) and showed the highest diversity of moths. Among the temperate tree species across the elevation gradient, pine, pine-oak, oak dominated forest areas show the highest species number

Zoological Survey of India, Kolkata and available literatures [7–10].

Samples from both the locations (Joshimath and Lata) were analysed separately to compare species diversity and distribution patterns. The moth species belonged mostly to Geometridae, Noctuidae, Erebidae, Brahmeidae, Pyralidae and Drepanidae families. It was found that the Geometridae family was most abundant (475 individuals) across all the sampling plots. There is a differential linear decrease in the number of morphospecies with increasing elevation between Joshimath and Lata (Fig. 2) indicating the interplay of other underlying factors (apart from temperature, elevation and forest types) that regulates species diversity. The observed differential patterns in diversity suggest that the factors governing the community structure in both the sites are acting locally. The samples from all the 32 trap sites from Joshimath and Lata were pooled across similar elevations and forest types and it shows that (Fig. 3) pine and mix coniferous forests (temperate forest type) found in the lower elevations (2000–2800 m) support more number of species.

The study shows that overall resource diversity can predict the distribution of the moth families. A similar study looking into the determinants of moth diversity patterns in the Afrotropical rainforests [11] also showed how vegetation structure can be an important driver of moth abundance and diversity [12]. Studies done on moth assemblages in two other Western Himalayan protected areas, Gangotri National Park and Govind Wildlife

Sanctuary [13] show similar patterns. It shows a linear trend in diversity conforming to the one of the existing trends in altitudinal gradients (i.e. linear or uni-modal) [14, 15]. The pine, pine-oak dominated forests showed the highest species diversity, maybe because of their structural complexity [16] providing more niches and resource availability to harbour more species. High elevation moth and plant communities contain most of the rare and locally restricted species. These rare groups and their habitats should be targeted for conservation management and coupled with the effect of climate change can be a model for long term monitoring of such and many other mountain systems [12].

There is a difference in the prevalent anthropogenic pressures among the two locations. Joshimath is an important tourist location with easy access to the major places of interest in the vicinity, while Lata comprises of a small village with about 100 resident families using the nearby forest patches for livestock grazing. Due to a difference in habitability, Joshimath area has more disturbances related to forest resource extraction.

Community structure requires looking into the interactions of biotic and abiotic factors or else the relevant patterns might be misunderstood [17]. It is well-known that moonlight and weather affect the light trap catch size [18]. The assumption that the number of individuals in the catch is positively related to the number of species in the assemblage is insignificant where undersampling is common in entomology data [19]. As a result, unwanted variation might occur in the data that might override the existing patterns [20].

The study area has places of tourist interest which makes it vulnerable to anthropogenic effects but on the other hand there are areas with little or no tourist related disturbance but different levels of grazing. With such a mosaic of habitats, the region presents a unique platform to study diversity of moths. Keeping these things in mind, further study is needed with thorough exploration. Large parts of this diverse insect group may be at the risk of extinction due to destruction and fragmentation of their habitats. Though the results are prefatory to a broader scenario of moth diversity patterns but can provide the baseline data for management of protected areas in accordance with the convention on biological diversity [21].

The findings might be indicative of the negative impact of the ongoing resource extraction from the forests. It has significant conservation implication as it is a direct evidence of anthropogenic influence on forest ecosystems and also highlights the applicability of moths as a model to monitor climatic or human-caused changes in forest structure. Moth distribution patterns observed in this study have discrete boundaries associated with the presence of their host-plants and are thus potential biological indicators. The ubiquity and sensitivity towards biotic and abiotic factors [12] make the moths a model group to study forest ecosystems.

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