

Project Title: High-altitude moth (Lepidoptera: Heterocera) assemblages: Assessing the diversity and potential bio-indicator species in Kedarnath Wildlife Sanctuary, India

Grant holder: Pritha Dey

Summary of the work done:

The baseline data for an important bio-indicator group like moths (Lepidoptera: Heterocera), where there are 10000+ species reported patchily throughout the country, is missing from this region to pile on further extensive research. The study aimed to document the diversity of moths (Lepidoptera: Heterocera) from the western Himalayan Protected Area of Kedarnath Wildlife Sanctuary. The region is hitherto unexplored for moths and provides a unique dynamic scenario where nature and human are at crossroads. I surveyed 8 locations at different elevational zones and recorded 153 species of moths, creating the first diversity inventory for moths from the study area. Many species are still left to be identified. I have provided photographs of 50 of them in this report. The diversity of each location was monitored with replicates in sampling. A photo guidebook for moths was prepared from the campus of the Wildlife Institute of India (Dehradun), which is nested within young Sal (*Shorea robusta*) forest areas, typical of lower Shivalik Himalayas. Public moth-watching sessions, educational workshops and presentations for school children, forest department staffs, researchers and young moth enthusiasts were conducted in collaboration with a local NGO - Titli Trust (headed by Mr. Sanjay Sondhi). This project has helped me move ahead with the independent work, putting my doctoral work into broader perspective, to understand the diversity and ecology of moths in the dynamic landscape of the western Himalaya. The project will eventually lead to the comprehension of sporadic documentation of moths in the most threatened mountain system in the world.

Introduction and study area:

Mountains have always been considered as centres of spectacular biological diversity, so the Himalayas also stand as one of the major mountain systems supporting high biodiversity. But human activities are threatening such an important resource. The Himalayan mountain system has been recognized globally for its ecosystem services for maintaining slope stability, regulating hydrological integrity, sustaining high levels of biodiversity and gaining attention for biodiversity conservation in global agendas (Sharma et al. 2008).

An inventory of biodiversity is of primary importance as a part of biodiversity conservation for sustainable development, particularly in threatened and fragmented landscapes like western Himalaya that harbours a unique assemblage of flora, fauna of considerable conservation importance. Inventory of insects in Western Himalayan landscape is still fragmentary and incomplete which makes monitoring and conservation of insect biodiversity impractical for the protected area managers. Instead of studying the entire insect community the attention should be given to identify and select an easy-to-monitor assemblage that serves as a surrogate for entire insect community and act as an indicator of changes in habitat quality.

Through this project, a baseline inventory of moths has been made, the influence of climatic, topographic and anthropogenic effect on moth has been understood. It is possible to identify groups of indicator species with correspondence to intact or disturbed patches in the given landscape. This will have a conservation implication by depicting the habitat condition of the landscape which is a very important repository for unique Himalayan flora and fauna. In short, this study will promote moth as model terrestrial insect group for concurrent conservation management target.

Study area:

The Kedarnath Wildlife Sanctuary (KWLS) (30°25'–30°41'N, 78° 55'–79°22'E) located in the Chamoli-Rudraprayag district in the state of Uttarakhand is one of the prominent protected areas in the western Himalaya, home to the endangered Himalayan Musk deer (*Moschus chrysogaster*). KWLS lies in the upper catchment area of the rivers Alakananda and Mandakini, which form the major tributaries of the river Ganga, covering an area of 975 sq.km. The altitude of the protected area ranges from 1160-7068 masl. There are about 175 villages in the southern part of the sanctuary, where people depend mainly on the forest resources for fuel wood, medicinal plants, and livestock grazing pastures. Habitats range from mixed oak forests in the south to the lush alpine meadows. The combination of human pressure, pristine forest areas and a large altitudinal range make it an ideal site for exploring trends in moth diversity. The forest types are dominated by different oak species (*Quercus leucotrichophora*, *Quercus floribunda*, *Quercus glauca*, *Quercus semecarpiflora*). The forests provide the resource requirement for the local villagers.

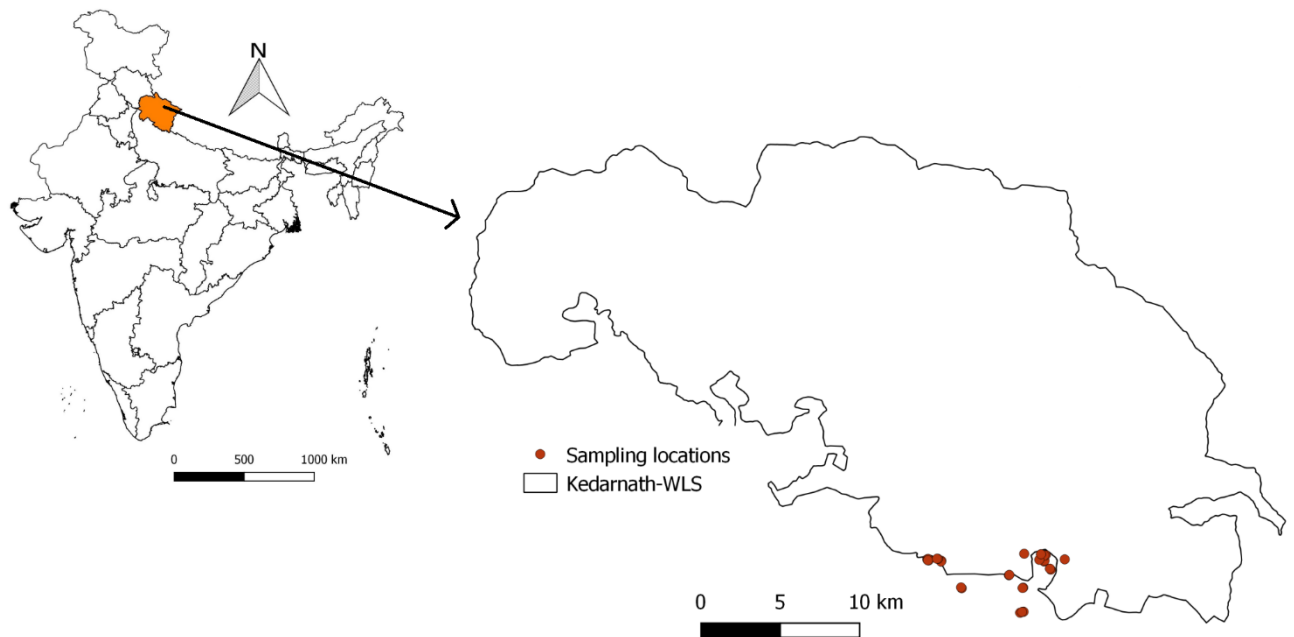


Figure 1: Map showing the sampling locations in and around the buffer zone of Kedarnath Wildlife Sanctuary, which is located in northern side of the mountainous state of Uttarakhand (highlighted on the map of India on the left side)

Methods:

The study area was stratified on the basis of elevation & vegetation types to explore the moth diversity along the gradients. Sampling was done at every 200m along the elevation upto 3500m. The most adopted method for studying moths is light -trapping. Two light traps operated for 3-4 hours after dusk, as logistic constraints do not permit all night sampling. The light source that was used to set up the trap was lepiLED developed by Dr. Gunnar Brehm, Germany. This effective light trap has been used for the first time in India, with this project. The minimum distance between two light-traps was 50 m, with lamps not visible from neighbouring sites, so that cross-habitation sampling does not occur. At each site 2-3-night sampling were done at different times to capture at least 90% of species of that area. The photographed and documented species were identified by referring to the available resources for Indian fauna like the Fauna of British India (Hampson 1892-1896), Moths of Nepal Series (Haruta 1992, 1995, 1998, 2000) and online resources like Moths of Borneo (<http://www.mothsofborneo.com>), Lepindex (<http://www.nhm.ac.uk/our->

science/data/lepindex/search/index.dsml?) and Barcode of Life Database (BOLD) (<http://www.boldsystems.org/index.php/default>) along with expert consultation.



Figure 2: The different habitat types that were sampled during the study from the mixed oak-coniferous, oak-rhododendron, oak-maple to the alpine meadows (clockwise from top left)



Figure 3: Clockwise from top left: Light -trap set up with lepiLED; Prabhat (my full-time field assistant) helping to set up a light-trap; the team of volunteers (Meghavi, Bhargav and Kunjan) sorting samples indoor when rain played a spoilsport; myself and a volunteer (Mohit) sorting and labelling samples at the time of light-trapping

Table 1: Species list documented from all the locations (M=Mandal, G=Gondi, K=Khalla, J=Jatholi, A=Ansuya, Ka=Kanchula, B=Bulkhan, S=Shokharak) (1=presence, gap=absence)

Family	Subfamily	Genus	species	M	G	K	J	A	Ka	B	S
Geometridae	Ennominae	<i>Gasterocome</i>	<i>pannosaria</i>	1	1	1	1	1			
	Ennominae	<i>Krananda</i>	<i>semihyalina</i>			1					
	Ennominae	<i>Xandrames</i>	<i>dholaria</i>	1							
	Ennominae	<i>Pseudomiza</i>	<i>cruentaria</i>	1	1	1	1	1			
	Ennominae	<i>Plagodis</i>	<i>inustaria</i>				1	1			
	Ennominae	<i>Plagodis</i>	<i>reticulata</i>						1		
	Ennominae	<i>Fascellina</i>	<i>plagiata</i>			1	1	1	1	1	1
	Ennominae	<i>Heterostegania</i>	<i>lunulosa</i>				1		1	1	
	Ennominae	<i>Orthobrachia</i>	<i>flavidior</i>					1			
	Ennominae	<i>Orthobrachia</i>	<i>latifasciata</i>					1			
	Ennominae	<i>Abraxas</i>	sp.		1	1	1		1		
	Ennominae	<i>Arichanna</i>	<i>albivertex</i>	1	1	1	1			1	1
	Ennominae	<i>Arichanna</i>	<i>tramesata</i>		1		1	1	1		
	Ennominae	<i>Arichanna</i>	sp.1			1					
	Ennominae	<i>Arichanna</i>	sp.2								
	Ennominae	<i>Loxaspilates</i>	<i>obliquaria</i>						1	1	1
	Ennominae	<i>Medasina</i>	<i>albidaria</i>		1	1		1	1	1	1
	Ennominae	<i>Pseudopanthera</i>	<i>himaleyica</i>	1							
	Ennominae	<i>Micronidia</i>	sp.					1	1		
	Ennominae	<i>Dalima</i>	<i>truncataria</i>				1	1			
	Ennominae	<i>Plutodes</i>	<i>costatus</i>			1					
	Ennominae	<i>Alcis</i>	<i>cf. paraclarata</i>							1	1
	Ennominae	<i>Alcis</i>	<i>cf. semiclarata</i>	1	1		1	1	1	1	
	Ennominae	<i>Alcis</i>	<i>cf. quadrifera</i>							1	1
	Ennominae	<i>Alcis</i>	<i>albifera</i>	1			1				
	Ennominae	<i>Psyra</i>	<i>angulifera</i>	1	1	1			1	1	
	Ennominae	<i>Psyra</i>	<i>spurcataria</i>				1	1	1		1
	Ennominae	<i>Odontopera</i>	sp.	1			1	1		1	1
	Ennominae	<i>Amblychia</i>	<i>pardicelata</i>		1	1	1	1	1		
	Ennominae	<i>Gonodontis</i>	sp.		1						
	Ennominae	<i>Erebomorpha</i>	sp.				1				
	Ennominae	<i>Garaeus</i>	<i>specularis</i>			1	1	1		1	
	Ennominae	<i>Leptomiza</i>	<i>calcearia</i>			1	1				
	Ennominae	<i>Corymica</i>	sp.				1				
	Ennominae	<i>Tanaorhinus</i>	<i>kina</i>	1							
	Ennominae	<i>Hypomecis</i>	sp.				1				
	Ennominae	<i>Phthonandria</i>	<i>atrilineata</i>				1	1			
	Ennominae	<i>Ourapteryx</i>	sp.	1		1	1		1		
	Ennominae	<i>Ophthalmitis</i>	<i>cf. cordularia</i>	1							
	Ennominae	<i>Petelia</i>	sp.				1				
	Ennominae	<i>Peratophyga</i>	<i>hyalinata</i>	1		1					
	Ennominae	<i>Menophra</i>	<i>subplagiata</i>					1			

	Hypeninae	<i>Hypena (Dichromia)</i>	<i>quadralis</i>			1						
	Hadeninae	<i>Athetis</i>	<i>lineosa</i>						1			
	Hadeninae	<i>Polytela</i>	<i>cliens</i>			1						
	Hadeninae	<i>Mythimna</i>	<i>unipuncta</i>						1			
	Hadeninae	<i>Mythimna</i>	sp.						1			
	Hadeninae	<i>Tiracola</i>	<i>plagiata</i>			1						
	Hadeninae	<i>Orthosia</i>	<i>cf. reticulata</i>							1	1	
	Hadeninae	<i>Spodoptera</i>	<i>litura</i>						1			
	Noctuinae	<i>Phlogophora</i>	<i>distorta</i>						1			
	Acronictinae	<i>Nacna</i>	<i>malachitis</i>	1		1						
	Catocalinae	<i>Arcte</i>	sp.					1				
	Xyleninae	<i>Auchmis</i>	<i>inextricata</i>						1			
	Plusiinae	<i>Thysanoplusia</i>	sp.							1		
	Plusiinae	<i>Chrysodeixis</i>	sp.						1			
	Heliiothinae	<i>Helicoverpa</i>	<i>armigera</i>	1					1		1	
Drepanidae	Drepaninae incertae sedis	<i>Agnidra</i>	<i>discipilaria</i>		1		1	1	1	1	1	1
	Drepaninae incertae sedis	<i>Agnidra</i>	<i>vinacea</i>		1			1	1			
	Drepaninae	<i>Macrocilix</i>	<i>mysticata</i>			1	1	1	1	1		1
	Drepaninae	<i>Drepana</i>	<i>pallida</i>	1			1	1				
	Drepaninae	<i>Oreta</i>	sp.					1				
	Drepaninae	<i>Oreta</i>	sp.2							1		
	Drepaninae	<i>Thymistida</i>	sp.						1	1	1	
	Drepaninae	<i>Nordstromia</i>	<i>lilacina</i>				1		1			
	Drepaninae	<i>Nordstromia</i>	sp.		1	1		1				
	Thyatirinae	<i>Thyatira</i>	<i>batis</i>									
	Thyatirinae	<i>Habrosyne</i>	sp.	1							1	
Notodontidae	Dicranurinae	<i>Syntypistis</i>	<i>comatus</i>					1	1			
	Dicranurinae	<i>Formofentonia</i>	<i>orbifer</i>					1				
	Ptilodoninae	<i>Ptilodon</i>	<i>cf. saturata</i>						1		1	
	Pygaerinae	<i>Ginshachia</i>	<i>gemmifera</i>					1	1			
Sphingidae	Macroglossinae	<i>Acosmeryx</i>	<i>naga</i>						1			
	Smerinthinae	<i>Dalbina</i>	<i>inexacta</i>				1					
	Smerinthinae	<i>Ambulyx</i>	sp.							1		
Erebidae	Lymantriinae	<i>Calliteara (Dasychira)</i>	<i>complicata</i>									
	Lymantriinae	<i>Calliteara (Dasychira)</i>	sp.								1	
	Lymantriinae	<i>Calliteara (Dasychira)</i>	sp.2							1		
	Lymantriinae	<i>Ramadra</i>	<i>caligramma</i>	1		1						
	Lymantriinae	<i>Numenes</i>	<i>patrana</i>	1		1	1					
	Lymantriinae	<i>Lymantria</i>	<i>cf. concolor</i>							1		
	Lymantriinae	<i>Arctornis</i>	<i>cf. submarginata</i>	1								
	Arctiinae	<i>Spilosoma (Spilarctia)</i>	<i>comma</i>	1						1		

	Arctiinae	<i>Spilosoma (Spilarctia)</i>	<i>cf. obliqua</i>			1	1		1		
	Arctiinae	<i>Callimorpha (Callindra)</i>	<i>principalis</i>			1			1		
	Arctiinae	<i>Lemyra</i>	<i>obliquivittata</i>							1	
	Arctiinae	<i>Vamuna</i>	<i>remelana</i>			1					
	Arctiinae	<i>Barsine</i>	<i>cf. orientalis</i>	1							
	Arctiinae	<i>Chrysorabdia</i>	<i>viridata</i>			1	1				
	Anobiinae/Arctiinae	<i>Aglaomorpha</i>	<i>plagiata</i>	1	1						
	Erebinae	<i>Hypersypnoides</i>	<i>constellata</i>				1				
	Erebinae	<i>Mocis</i>	<i>discios</i>		1						
	Erebinae	<i>Bastilla</i>	<i>cramerii</i>				1				
Saturniidae	Saturniinae	<i>Anthraea</i>	<i>roylei</i>					1			
	Saturniinae	<i>Actias</i>	<i>selene</i>								
Endromidae		<i>Mustilizans</i>	<i>hepatica</i>	1							
Endromidae		<i>Mustilla</i>	<i>cf. sphingiformes</i>		1			1			
		<i>Mustilia</i>	<i>falcipennis</i>				1				
Nolidae	Risobinae	<i>Risoba</i>	<i>cf. obstructa</i>				1				
	Chloephorinae	<i>Tyana</i>	<i>cf. falcata</i>							1	
	Chloephorinae	<i>Tyana</i>	<i>marina</i>					1			
	Chloephorinae	<i>Tyana</i>	sp.1				1		1		
	Chloephorinae	<i>Tyana</i>	sp.2							1	
Uraniidae	Epipleminae	<i>Epiplema</i>	<i>arcuata</i>		1		1	1			
	Epipleminae	<i>Phazaca</i>	sp.								
	Auzeinae	<i>Decetia</i>	sp.				1				
Lasiocampidae		<i>Gastropacha</i>	sp.							1	
Crambidae		<i>Eoophyla</i>	sp.								



Figure 4: (1-13) Family Geometridae: 1. *Abraxas* sp., 2. *Erebomorpha* sp., 3. *Fascellina plagiata*, 4. *Leptomiza calcearia*, 5. *Lassaba albidaria*, 6. *Ourapteryx* sp., 7. *Pseudomiza cruentaria*, 8. *Orthobrachia flavidior*, 9. *Plagodis reticulata*, 10. *Gasterocome pannosaria*, 11. *Perizoma albofasciata*, 12. *Electrophaes* sp., 13. *Eustroma melancholica*, (14-20) Family Noctuidae; 14. *Athetis lineosa*, 15. *Mythimna unipuncta*, 16. *Tiracola plagiata*, 17. *Spodoptera litura*, 18. *Helicoverpa armigera*, 19. *Auchmis inextricata*, 20. *Dichromia quadralis*, (21-26) Family Drepanidae; 21. *Agnidra discipilaria*, 22. *Macrocilix mysticata*, 23. *Drepana pallida*, 24. *Oreta* sp. 1, 25. *Oreta* sp.2, 26. *Thyatira batis*, (27-29) Family Notodontidae; 27. *Syntypistis commatus*, 28. *Formofentonia orbifer*, 29. *Ginshachia gemmifera*, 30. *Gastropacha* sp. (Lasiocampidae)

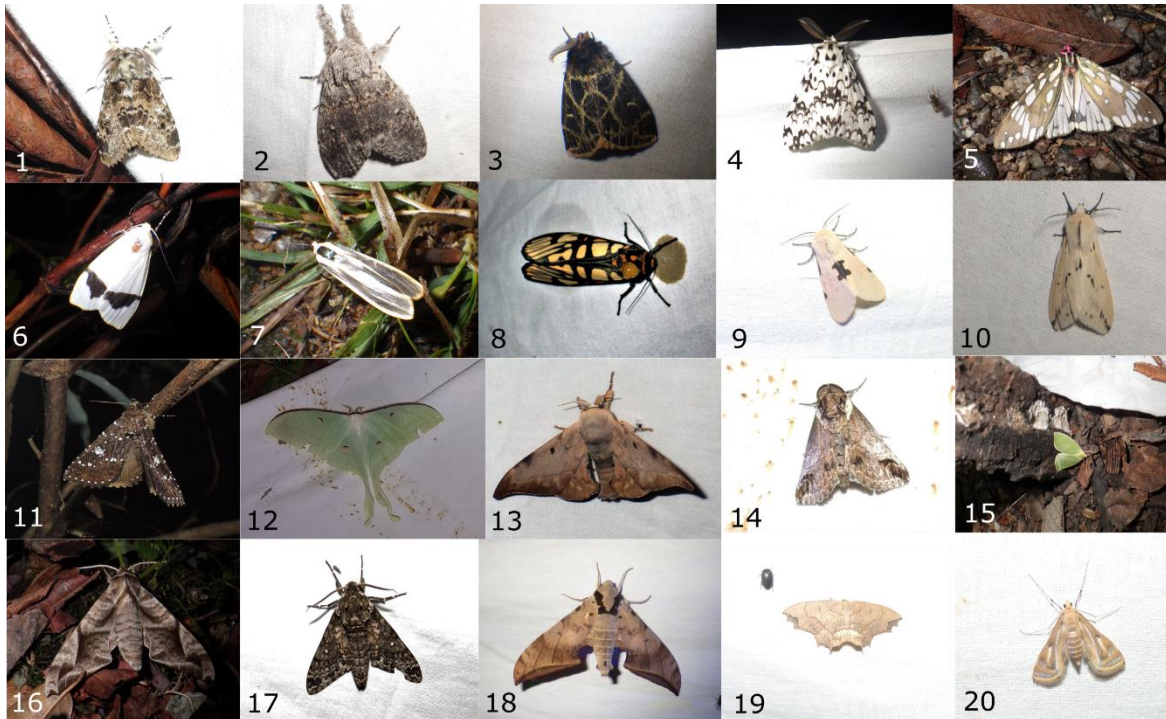


Figure 5: (1-11) Family Erebinidae: 1. *Dasychira complicata*, 2. *Calliteara* sp.1, 3. *Ramadra caligramma*, 4. *Lymantria* cf. *concolor*, 5. *Callindra principalis*, 6. *Vamuna remelana*, 7. *Chrysozabdia bivitta*, 8. *Agalaomorpha plagiata*, 9. *Spilarctia comma*, 10. *Spilarctia* cf. *obliqua*, 11. *Hypersypnoides constellata*, 12. *Actias selene* (Saturniidae), 13. *Mustilizans hepatica* (Endromidae); (14-15) Family Noilidae; 14. *Risoba* cf. *obstructa*, 15. *Tyana* cf. *falcata*, (16-18) Family Sphingidae; 16. *Acosmeryx naga*, 17. *Dolbina inexacta*, 18. *Ambulyx* sp., 19. *Epiplema arcuata* (Epipleminae), 20. *Eoophyla* sp. (Crambidae)

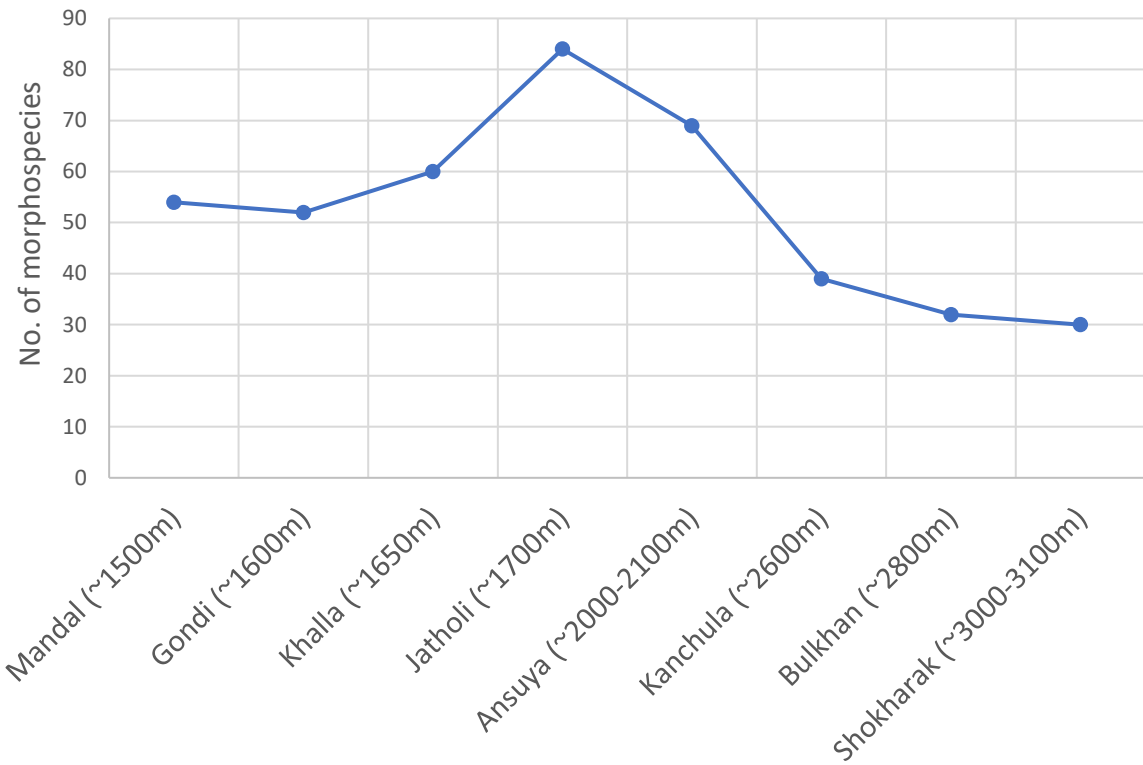


Figure 6: The graph shows the number of morphospecies documented from each of the sampling sites at different elevational bands

Outreach activities:

As mentioned in the summary, the following outreach activities had been conducted during the project tenure;



Educational workshop and presentation with the students of the Purkul Youth Development Society (myself at centre), with Ms. Anchal Sondhi (bottom left; co-founder of Titli Trust)



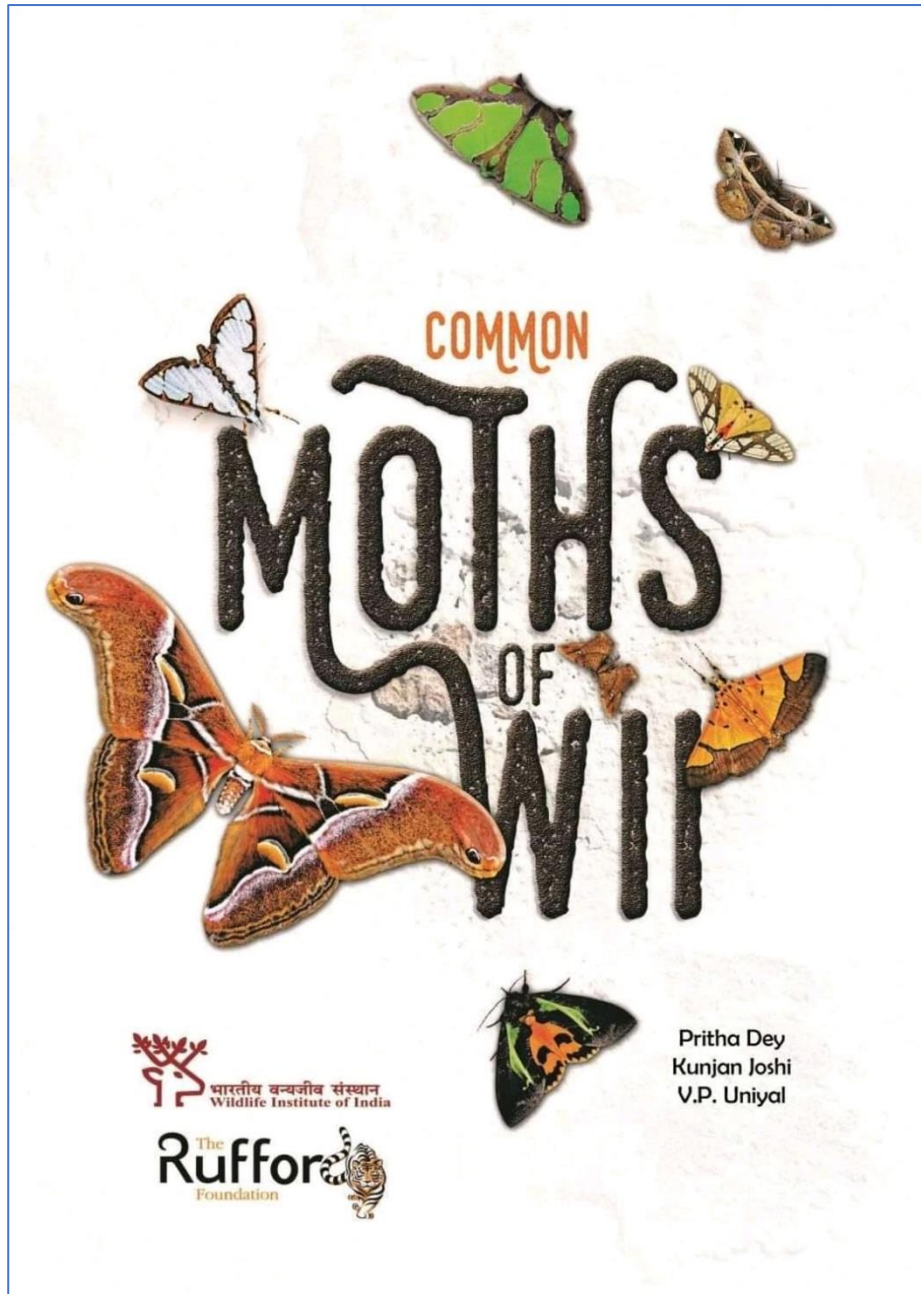
Moth-watching session with the researchers of the Wildlife Institute of India during the National Moth Week, July 2018.



Moth-watching session as a part of the Devalsari Titli Utsav (annual moth-butterfly meet). Moth enthusiasts, local people, researchers gather for this four-day workshop at Devalsari (a tiny village nestled within the deodar (*Cedrus deodara*) forests in the western Himalaya) every year in the month of May



Talks on moth conservation to the Forest Officer Trainees and the Forest Department Staffs at the Forest Research Institute (top) and Dehradun Zoo (bottom right)



A photo-guidebook of the moth diversity of the Wildlife Institute of India campus was published in August 2018. We documented 219 species of moths belonging to 18 families from the campus in the lower Shivalik Himalaya. The book can be freely downloaded from the institute website.

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I would like to thank Prabhat Singh Bisht, a young enthusiastic bird-watcher and trekking guide, for assisting me throughout the fieldwork. He started off working with me, because he thought a female researcher would not be safe in the forest at night! But eventually we made such a good team, where he understood my pulse, my anxieties for the sampling to be successful, my disappointment at rains spoiling sampling sessions and shared my joy equally at getting a new moth species. I gained a lifelong friend in him.

I cannot thank enough Kunjan Joshi, who did his dissertation under my partial guidance and came over to volunteer for this project. Both of us later worked on the guidebook on moths. He patiently dealt with my anxieties, impatience and scolding throughout. I could not have done so much without him.

My other volunteers, young and energetic people, who believed in me and my ability to work towards conserving moths. Mohit Patel, Meghavi Purohit and Bhargav Bhadreshvara were a constant encouragement towards this project.

I need to extend my gratefulness to Sanjay Sondhi and Anchal Sondhi, founders of Titli Trust, who let me do some outreach work with them. Both of them always gave me an opportunity whenever I turned to them.

I could not have done any of this without the relentless support of my parents and family and most of all Rohit, who completes me.