Lepidoptera (Insecta) as a Potential Indicator-Taxa for Tracking Climate Change in Indian Himalayan Landscape

Himalayan Research Fellowship (HSF2015-16_I003)

ANNUAL REPORT

(Reporting Period: 1st April, 2018 to 31st March, 2019)

Principal Investigator
Dr. Kailash Chandra, Director

Co-Principal Investigator
Dr. Vikas Kumar, Scientist-D

Zoological Survey of India

National Mission on Himalayan Studies (NMHS)

HIMALAYAN RESEARCH FELLOWSHIP

(PRO FORMA FOR THE ANNUAL PROGRESS REPORT)

[Reporting Period: *from* 1st April, 2018 to 31st March, 2019]

Kindly fill the NMHS Fellowship Annual Progress Report segregated into the following 7 segments, as applicable to the NMHS Fellowship nature and outcomes.

1. Fellowship Grant Information and Other Details
2. Fellowship Description at Himalayan Research Associates (H-RAs) Level
3. Fellowship Description at Himalayan Junior Research Associates (H-JRFs) Level
4. Fellowship Description at Institutional/ University Level
5. Fellowship Concluding Remarks/ Annual Summary
6. Specific Research Question(s) Addressed with Succinct Answer(s)
7. Any other information

Please let us know in case of any query at: nmhspmu2016@gmail.com

PRO FORMA

NMHS-Fellowship Annual Progress Report (APR)

1. Fellowship Grant Information and Other Details

NMHS Fellowship Grant ID:	HSF2015-16_I003
Name of the Institution/ University:	Zoological Survey of India, Kolkata
No. of Himalayan Research/Project Associates:	03
No. of Himalayan Junior Research/Project Fellows:	09

2. Fellowship Description at H-RA Level

Himalayan Research Associates (H-RAs)

H-RAs Profile Description:

S. No.	Name of RA	Date of Joining	Research Title	Name of the PI and Designation	Qualification
1.	Dr. Abesh Kumar Sanyal	03.06.2016	Lepidoptera (Insecta) as Potential Indicator-Taxa for Tracking Climate Change in the Indian Himalayan Landscape	Dr. Kailash Chandra, Director	Ph.D.
2.	Dr. Angshuman Raha	03.06.2016	Lepidoptera (Insecta) as Potential Indicator-Taxa for Tracking Climate Change in the Indian Himalayan Landscape	Dr. Kailash Chandra, Director	Ph.D.
3.	Dr. John Caleb T.D.	01.03.2017	Lepidoptera (Insecta) as Potential Indicator-Taxa for Tracking Climate Change in the Indian Himalayan Landscape	Dr. Kailash Chandra, Director	Ph.D.

Progress Brief (*to be filled for each H-RA in separate row*):

RA No.	Research Objective(s)	Addressed Deliverables	Achievements	Research/ Experimental Work*
1.	• Number of Long-Term Ecological/Environmental Monitoring (LTEM) sites establishment • Status & Distribution of Threatened Apollo and other Parnassini butterflies	• Identification of sites for LTEM. • Habitat-suitability mapping of threatened Himalayan butterflies • Conservation frameworks development for Himalayan Lepidoptera	• Altogether Four Field Tours have been undertaken during Current Reporting Period: i. SNP, WB (May, 2018) ii. AWLS, UT (June-July, 2018) iii. Permanent Light Trap Station establishment in Darjeeling (October, 2018) iv. DDBR, AP (November-December, 2018) • Taxonomic identification of collected Lepidoptera samples from all the Himalayan Landscapes: 376 species were further identified, totaling the current number of Identified moth species to 1142, with 58 species newly added to Indian fauna. • The dataset compiling Historical Altitudinal Envelope, range-distribution and phenology/voltinism of these identified species is currently under preparation • An approach of numerical investigation into the biogeography of Identified Lepidopteran assemblage was undertaken, where genera were classified into Faunal Centers in terms of similarity of geographical distribution. • Two Abstracts Accepted: 5th Asian	Details provided in separate descriptive file

			Lepidoptera Conservation Symposium, Hong Kong. • Seminar Presentation: 1st Himalayan Researchers consortium, 2018", Dehradun.	
2	• Monitoring surveys in historical collection localities • Climate-Envelope modelling & Distribution mapping for responses to changing climate	• Predictive species distribution modelling for future climatic scenario • Landscape level conservation approach of Himalayan Lepidoptera through Indicator taxa and awareness generation	• Permanent Light Trap Stations (PLTS) were set up and sampled continuously for one month in Dharamshala, an identified Historical Collection Locality, in October-November and 1600 Lepidopteran individuals were sampled through 10 LTEMs • Criteria was established for assessing climate-sensitivity of Himalayan Lepidoptera, for which Climate Envelop Modelling will be performed. Initial assessment revealed 49 species undergoing significant Altitudinal Range Extension and 8 species highly restricted in range-distribution. • Taxo-Ecological assessment of Notodontidae fauna, an important forest-pest group of Lepidoptera, was undertaken. Altitudinal stratification, richness pattern across major environmental gradient (like precipitation) and Himalayan-endemicity were assessed. Assessment revealed 2 species New to Science,4 New to India and 2 New to Himalaya with unusual altitudinal occurrence (>3000m) detected for 4 species. • Two Abstracts Accepted: 5th Asian Lepidoptera Conservation Symposium, Hong Kong. • Seminar Presentation: 1st Himalayan Researchers consortium, 2018", Dehradun.	Details provided in separate descriptive file
3.	• Molecular Phylogenetic work through DNA Barcoding to resolve species complexes	• DNA Barcode database generation for future molecular and phylogenetic research on Himalayan Lepidoptera	• DNA isolation was performed for 881 specimens and PCR reactions were carried out for 630 specimens. 320 full length and good quality sequences were obtained. • The developed sequences were submitted to BOLD database under the project 'Lepidoptera of Indian Himalayas' for acquiring unique BOLD-IDs. • Species of the genus *Abraxas* were examined and found that no significant taxonomic characters were found in their general morphology. The DNA information with high genetic distinctiveness and monophyletic clustering in NJ and BA tree indicated cryptic diversity. The manuscript on the cryptic diversity and species complex of the genus *Abraxas* is under preparation.	Details provided in separate descriptive file

*<u>*Experimental work*</u> giving full details (in separate sheet, within 300 words) of experimental set up, methods adopted, data collected supported by necessary table, charts, diagrams & photographs. *Note*: Data, table and figures may be attached as separate source file (.docx, .xls, jpg, .jpeg, .png, .shp, etc.).

3. Fellowship Description at H-JRF Level

Himalayan Junior Research Project Fellows (H-JRFs)

H-JRFs Profile Description:

S. No.	Name of JRF	Date of Joining	Name of the PI	Qualification
1.	Mohd. Ali	29.09.2016	Dr. Kailash Chandra, Director	M.Sc.
2.	Kaushik Mallick	06.06.2016	Dr. Kailash Chandra, Director	M.Sc.
3.	Uttaran Bandyopadhyay	14.06.2016	Dr. Kailash Chandra, Director	M.Sc.
4.	Rushati Dey	08.12.2017	Dr. Kailash Chandra, Director	M.Sc.
5.	Kamalika Bhattacharyya	14.06.2017	Dr. Kailash Chandra, Director	M.Sc.
6.	Subrata Gayen	14.06.2017	Dr. Kailash Chandra, Director	M.Sc.
7.	Gaurab Nandi Das	14.06.2016	Dr. Kailash Chandra, Director	M.Sc.
8.	Moumita Das	08.12.2017	Dr. Kailash Chandra, Director	M.Sc.
9.	Rahul Ranjan	24.02.2017	Dr. Kailash Chandra, Director	M.Sc.
10.				

Progress Brief (*to be filled for each JRF in separate row*):

JRF No.	Research Objectives	Deliverable	Achievements	Research/ Experimental Work*
1.	• To investigate the differential processes influencing the distribution pattern of Lepidoptera assemblages (moths and butterflies) of Hemis National Park (HNP), Jammu & Kashmir. • Generation of robust data sets generated through ecological monitoring at habitat level	• Generation of scientific evidences in the form of reports on Lepidopteran diversity of HNP • Robust data sets. • Thesis on the subject area	• During current Reporting Period, Two field surveys were undertaken: i. HNP, J&K: June-August, 2018 ii. SNP, WB: October-November, 2018 • 71 butterfly transects and 68 Light Traps were performed in altitudinal range 2900m-5300m, resulting in 3666 individuals of butterflies and 3304 individuals of moth. • Altogether with 2017 field data, 57 species of butterflies and 54 species of Moths have been identified from Trans-Himalayan sites of Ladakh, with plenty of newly recorded species from India, which were previously known exclusively from Central & West Asia and Europe. • Socio-Economic backdrop of Butterfly Conservation in the form of Awareness and sensitivity of local people towards butterflies and their ecological services in Trans-Himalaya was looked upon through Questionnaire Survey. • Participated and presented in 5th Asian Lepidoptera Conservation Symposium, held in University of Hong Kong, December, 2018. • Participated and presented work in “1st Himalayan Researchers consortium, 2018”, Dehradun.	Details provided in separate descriptive file

2.	• To investigate the differential processes influencing the Lepidoptera diversity of Great Himalayan National Park (GHNP) • Generation of robust datasets generated through ecological monitoring at habitat level Generation of scientific evidences	• Generation of scientific evidences in the form of reports on Lepidopteran diversity of GHNP. • Robust data sets. • Thesis on the subject area.	• During current Reporting Period, Two field surveys were undertaken in Great Himalayan National Park (GHNP) and Dharamshala in the month of July and October-November and sampled about 3900 Lepidopteran individuals. • Taxonomic Identification of Geometrid Moths collected from GHNP and different Himalayan study sites. • Currently 206 species of moths are identified (103 species added during current reporting period) from GHNP under 160 genera belonging to 44 sub-families of 16 families belonging to 8 super-families. • Among GHNP assemblage, 3 species were reported for the first time from India, viz. *Zeuzera nepalense*, *Sirinopteryx nepalensis* and *Epiplema adamantina* • Robust dataset of all the identified species of moths (currently 1142) from Himalaya were prepared alongwith their updated distribution • Abstract submitted and accepted for "5th Asian Lepidoptera Conservation Symposium" held in Hong-Kong University, December 2018, Hong Kong • Participated and presented work in "1st Himalayan Researchers consortium, 2018", Dehradun.	Details provided in separate descriptive file
3.	• To investigate how diverse are the Lepidopteran assemblages in Askot Wildlife Sanctuary (AWLS), Uttarakhand. • Generation of robust datasets generated through ecological monitoring at habitat level	• Generation of scientific evidences in the form of reports on Lepidopteran diversity of AWLS. • Robust data sets • Thesis on the subject area	• Field survey at AWLS in May-June, 2018 & at Dharamshala (Himachal Pradesh) in October-November, 2018 was under taken. • Processing and curation of total 1500 Lepidoptera specimens from Dharamshala and 4522 Lepidoptera specimens from AWLS was done. • The collected specimens represented 400 morpho-species (about 55% of total collection), among which 302 species consisting 235 genera of 21 families have been identified up to species level through morpho-taxonomy. • The identified species list includes 4 species newly recorded to India, viz. *Achaea catella*, *Apamea purpurina*, *Siriniopteryx nepalensis* & *Nothomiza costinotata*. Furthermore, rare and beautiful species like *Preparctia hannyngtoni* was rediscovered after >100 years. • Taxonomic revision of high-altitude specialist Noctuidae genus *Phlogophora* Treitschke, 1825 undertaken earlier, revealed 13 species from Indian Himalaya including two new species records from India. Specimen record for *P. calamistrata* was added to the list in this season. • A new species of Genus *Donda*, *D. unispinosa* sp. nov. (Family Noctuidae: Subfamiliy Pantheinae) was described	Details provided in separate descriptive file

			(Accepted in Entomological News). • Abstract selected and published in the 5th Asian Lepidoptera Conservation Symposium 2018 held at the University of Hong Kong, Hong Kong in December, 2018.	
4.	• To investigate the differential processes influencing the Lepidoptera diversity of Kangchendzongha Biosphere Reserve (KBR), Sikkim • Generation of robust data sets generated through ecological monitoring at habitat level.	• Generation of scientific evidences in the form of reports on Lepidopteran diversity of AWLS. • Robust data sets • Thesis on the subject area	*(No sampling/collection permission has been received from Sikkim Forest Department, so field sampling couldn't be initiated in KBR. Fellow was engaged in molecular work)* • DNA isolation using organic phase extraction method/silica column kit method protocol. • Amplification of isolated DNA samples. • DNA isolation has been carried out for 400 samples out of which 380 samples were amplified successfully for targeted COI barcode region. • Curation and alignment of generated sequences obtained from morphologically identified specimens • Similarity search of the representative barcode sequences with data available from global database.	Details provided in separate descriptive file
5.	• To investigate the differential processes influencing the Lepidoptera diversity of Singalila National Park (SNP)/Neora Valley National Park (NVNP), West Bengal • Generation of robust datasets generated through ecological monitoring at habitat level	• Generation of scientific evidences in the form of reports on Lepidoptera diversity of KBR. • Robust data sets. • Thesis on the subject area.	• Field surveys at SNP during May-June and October-November 2018: 1500 specimen collected and identified to 115 morphospecies of moths and butterflies. • Field survey in July 2018 at NVNP: 830 specimens collected and identified to 80 species morphospecies of moths. • Currently 356 species of moths are identified from these two landscapes of Central Himalaya, West Bengal • 1 new species of *Cyana* (Arctiinae) was described along with two new records from families Yponomeutidae and Attevidae. • Presented at "5th Asian Lepidoptera Conservation Symposium (ALCS 5) At University of Hong Kong" and "1st Himalayan Researchers consortium, 2018". • 1 manuscript on new record to India and 1 manuscript on new species of moths are accepted.	Details provided in separate descriptive file
6.	• To investigate the differential processes influencing the distribution pattern of Lepidoptera assemblages (moths and butterflies) from Dihang-Dibang Biosphere reserve (DDBR), Arunachal Pradesh. • Generation of robust datasets generated through long-term ecological monitoring at habitat level.	• Generation of scientific evidences in the form of reports on Lepidoptera diversity of DDBR. • Robust data sets. • Thesis on the subject area.	• During Current Reporting Period, Three field Surveys were undertaken: i. DDBR, AP (June-July, 2018) ii. SNP-NVNP, WB (October, 2018) i. DDBR, AP (November-December, 2018 • Sampled 1173, 3800 and 375 Lepidopteran individuals respectively during these three field sessions, which were subsequently processed, pinned and stretched. • Currently 285 species of moths are identified from DDBR (134 species have been added during current reporting period) including 15 species first-time reported from Indian mainland. • Morpho-Taxonomic study of Family Sphingidae was undertaken from the collection of allover Himalayas, among which 43 species were identified.	Details provided in separate descriptive file

			Morphometric data of Wing, head, thorax, abdomen, compound eye, Proboscis of collected Sphingidae samples were measured and under process of analysis. • Proportional changes in light and dark colours on wing surface were investigated along altitudinal gradient for Geometridae genus from photographs of Stretched Specimens in TinEye Colour Extraction Software Package. • Co-Occurrence Model through Non-Random Pairwise Species Association was run in Package COOCUR in R platform with 283 identified species from DDBR, which indicated Positive Co-occurrence between 2 Saturniidae species, while most species were associated randomly. • Abstract submitted and accepted for "5th Asian Lepidoptera Conservation Symposium" held in Hong-Kong University, December 2018, Hong Kong • Participated and presented work in "1st Himalayan Researchers consortium, 2018", Dehradun	
7.	• To investigate the differential processes influencing the distribution pattern of Lepidoptera assemblages (moths and butterflies) from Dihang-Dibang Biosphere reserve (DDBR), Arunachal Pradesh. • Generation of robust datasets generated through long-term ecological monitoring at habitat level.	• Generation of scientific evidences in the form of reports on Lepidoptera diversity of DDBR. • Robust data sets. • Thesis on the subject area.	• Five Butterfly Sampling Sessions were undertaken during Current Reporting Period: i. DDBR, AP (April, 2018) ii. SNP, WB (May, 2018) iii. AWLS, UT (June-July, 2018) iv. SNP, WB (October, 2018) v. DDBR, AP (November-December, 2018) • Currently, 471 species/subspecies of butterflies have been identified belonging to 213 genera under 6 families from all over Himalaya • In-Depth Morphological Taxonomy through genitalia dissection was undertaken for cryptic butterfly genera like *Ypthima*, *Neope*, *Mycolesis* (Nymphalidae), *Udara* (Lycaenidae) and *Polyptremis* (Hesperidae) from HNP, AWLS and DDBR • Analysis were undertaken to identify Butterfly assemblages which are restricted to High altitude Alpine Meadow habitats (>3500m), and are thus most vulnerable to Climate-Change associated range-constriction, and 55 species were identified belonging to 32 genera, most prominently *Aulocera*, *Polyommatus*, *Pontia* and *Parnassius*. • First record of *Drupadia scaeva cyara* from DDBR, published in *Journal of Threatened Taxa* • Rediscovery and first time genitalic description of *Polyommatus dux* Riley, 1926, manuscript accepted in *Caucasian Entomological Bulletin* • Abstract submitted and accepted for "5th Asian Lepidoptera Conservation	Details provided in separate descriptive file

			Symposium" held in Hong-Kong University, December 2018, Hong Kong • Participated and presented work in "1st Himalayan Researchers consortium, 2018", Dehradun	
8.	• Study of Molecular Taxonomy of Himalayan Lepidoptera	• Generation of DNA barcode data of Lepidoptera from Indian Himalayas	• Legs extraction and tagging were done for the samples collected from NVNP and SNP. • DNA isolation has been carried out for 881 samples out of which 630 samples were amplified successfully for targeted COI barcode region. • 120 full length sequences have been generated and being processed for further analysis. • Pairwise genetic divergence was studied among widely distributed species of Erebidae, which revealed high intra-specific divergence across biogeographic provinces, while less or no divergence was detected among different altitudinal sites within same landscape.	Details provided in separate descriptive file
9.	• Morphology based taxonomy	• Report on status of Morpho taxonomy	• Two Field surveys have been conducted during current reporting period: i. DDBR, AP (April-May, 2018) ii. SNP, WB (October, 2018) • All the collected specimens have been stretched and sorted out. • 335 specimens have been identified within 86 species under the family Lasiocampidae, Cossidae, Geometridae, Pyralidae, Endromidae and Erebidae. • 35 dissections have been performed for the identification of species from family Endromidae. • Genitalia photography undertaken of all the dissected species under genus *Abraxas* Leach. • One new species from the Dihang Dibang Biosphere Reserve (DDBR) under the family Endromidae submitted for consideration in Zootaxa.	Details provided in separate descriptive file

*<u>*Experimental work*</u> giving full details (in separate sheet, within 300 words) of experimental set up, methods adopted, data collected supported by necessary table, charts, diagrams & photographs. *Note*: Data, table and figures may be attached as separate source file (.docx, .xls, jpg, .jpeg, .png, .shp, etc.).

4. Fellowship Description at Institutional/ University Level

Annual Deliverables/ Outputs (during the reporting year)

S. No.	*Deliverables/ Parameters*	*No.*	*Description*
1.	No. of Research Publications (monograph/ articles/ peer-reviewed articles):	15	Details provided in separate descriptive file
2.	No. of Data Sets generated:	03	Details provided in separate descriptive file
3.	No. of Conferences/ Workshops attended:	03	Details provided in separate descriptive file
4.	No. of Sites/ Study Area Covered:	06	Details provided in separate descriptive file
5.	No. of Best Practices suitable for IHR:	NA	NA
6.	New Observations/ Innovations	05	Details provided in separate descriptive file

5. Fellowship Concluding Remarks/ Annual Summary

Conclusions summarizing the achievements and indication of remaining work (within 300 words):

***Achievements*:**

- Permanent Light Trap Stations (PLTS) were established and continuously sampled for one month during October-November 2018 in Darjeeling (West Bengal) and Dharamshala (Himachal Pradesh), the two identified Prominent Historical Collection Localities.
- Additional 160 and 376 species of butterflies and moths, respectively, were identified from the Lepidoptera samples collected from the Himalayan study areas during the present reporting period. Thus, a total of 471 and 1142 species of butterflies and moths, respectively, were identified from the Indian Himalayan Landscape till date. Moreover, one species of butterfly and 58 species of moths were recorded for the first time from India.
- Description of 2 new species, each of genera *Cyana* (Erebidae) and *Donda* (Noctuidae) were accepted for publication and 7 probable new species viz. 4 species of family Geometridae, 2 species of family Notodontidae and one species of family Endromidae were encountered.
- Morpho-Taxonomic study of 43 identified species of the Family Sphingidae was undertaken from the present collection of the entire Himalayan Landscape. Morphometric analyses are being carried out on wing, head, thorax, abdomen, compound eye and proboscis of the Sphingidae specimens.
- Co-occurrence model with 283 identified species from DDBR revealed Positive Co-occurrence between 2 Saturniidae species, while most of the species showed random association.
- An approach of numerical investigation into the biogeography of Identified Lepidopteran assemblage was undertaken, where genera were classified into Faunal Centers in terms of similarity of geographical distribution.
- Climate sensitive species have been identified based on unusual altitudinal ascends, rarity and distribution limitations. Initial assessment revealed 49 species undergoing significant Altitudinal Range Extension and 8 species highly restricted in range-distribution.
- Field samplings in Ladakh (J&K), GHNP (HP) and AWLS (UT) detected 3 apollo species viz. *Parnassius hardwickii hardwickii*; *Parnassius charltonius* and *Parnassius epaphus*. Among these, *P. epaphus* was most widely distributed spanning all the three areas mentioned. Maximum Entropy (MaxEnt) Modeling of *P. epaphus* indicated 3 BIOCLIM variables viz. Mean Temperature of Warmest Quarter, Maximum Temperature of Warmest Week, Highest Weekly Radiation and Precipitation of Coldest Quarter contributing significantly to the distribution pattern of *P. epaphus.*
- DNA isolation was performed for 881 specimens and PCR reactions were carried out for 630 specimens. 320 full length and good quality sequences, thus obtained, were submitted to BOLD database under the

project 'Lepidoptera of Indian Himalayas' for acquiring unique BOLD-IDs.

- The DNA information of the genus *Abraxas* (Geometridae) revealed high genetic distinctiveness and monophyletic clustering in NJ and BA tree indicating cryptic diversity.

Remaining works:

- LTEM plot and PLTS establishment in Sikkim and extensive resampling of LTEM plots established >3000 m for collecting occurrence and habitat data of selected Apollo species.
- Repeat sampling in the established PLTS in Darjeeling and Dharamshala.
- Identification of the backlog collections from previous field surveys and taxonomic revisions of cryptic genera and sub-families based on genitalia and molecular studies.
- Indicator Species Analysis (ISA) with all the identified species of moth & Butterflies to identify critical habitat specialist species.
- Climate Envelop Modeling of the identified Climate Sensitive species.
- Distribution modeling of other two, *Parnassius hardwickii hardwickii* and *Parnassius charltonius*, widely distributed Apollo species.
- Identification of critical habitats and threat assessment for Himalayan Lepidoptera.
- Generation of more DNA barcode data and their analyses to estimate the genetic divergence, phylogeny, and MOTU estimation through species-delimitation methods and bioinformatics tools.
- After completion of field-work and species identification, photographic Guide-Book will be prepared covering diagnoses, distribution, bionomy and photographic illustrations of every species documented during entire study tenure.
- Manuscripts on probable new species and new country records will be communicated for publication consideration.

6. Specific Research Question(s) Addressed with Succinct Answer(s)

S. No.	***Research Questions Addressed***	***Succinct Answers (within 150-200 words)***
1.	Differential processes influencing the diversity and distribution pattern of Lepidoptera assemblages (moths and butterflies)	Across Himalayan Biogeographic Provinces, Altitude is the main governing factor determining Lepidopteran diversity and distribution. Other co-varying factors like Temperature and Precipitation explains much of the pattern, especially Mean Temperature and Mean Precipitation of Warmest Quarter explained differential Lepidopteran abundance. Among Habitat-level parameters, Lepidopteran assemblages were highly influenced by Tree and Herb Abundance. Average GBH of tree and canopy cover moderately influenced assemblage structure but had a strong influence on assemblage composition. Particular set of biotic-abiotic factors had selective influence on diversity and abundance of specific families, e.g., while Canopy cover explained Erebidae diversity and richness, turnover in Noctuid species composition was governed mostly by changes in shrub and understory composition. Furthermore, these habitat-level parameters had differential influences in different biogeographic provinces of Himalaya, e.g. whereas <500mm Annual Mean Precipitation define major species richness in Jammu & Kashmir, 1500-2000mm rainfall in Western Himalaya and 2500-3000mm rainfall in Central and Eastern Himalaya explained maximum diversity pattern.
2.	Any changes in species distribution range compared to Historical data	As most of the described Indian Lepidoptera species were reported from single locality report without any specific locality details, comparing the altitudinal range in Historical and present time poses serious challenges. So far, we've compiled distribution records of most of the species from screening huge secondary literature, and

		comparing altitudinal envelop with species recorded in the current project is ongoing. Preliminary analysis indicated few species for which huge altitudinal differences are evident: *Trachea auriplena* (2800m diff.), *Actias windbrechlini* (2684m diff.), *Diphtherocome fasciata* (2280m diff.). Furthermore, >1000m differences in past and present altitudinal range in 42 moth species have been detected. 500-1500m changes in altitudinal envelop of 3 Saturniidae genus, *Caligula*, *Actias* and *Salassa* were visible. Among major butterfly species, *Arhopala Ganesa* (1177m diff.), *Cyrestis thyodamas* (877m diff.), *Euthalia telchinia* (600m diff.) were noted undergoing major altitudinal ranges. While all these examples signified upward range extension, few species from Ladakh, *Baltia butleri, Pieris deota, Colias ladakensis*, *Euchloe dephalis* showed altitudinal range contraction.
3.	Assess optimum habitat conditioning for status and distribution of threatened Apollo and other Parnassini butterflies	Primary field-work in Ladakh (J&K), GHNP (HP) and AWLS (UT) was able to detect occurrence of three species of Apollo: *Parnassius hardwickii hardwickii*; *Parnassius charltonius* and *Parnassius epaphus*. Among these *P. epaphus* was most widely distributed spanning all the three areas mentioned. Collection of detailed habitat level parameters at local scale like vegetation composition and structure, Soil chemical properties are currently undergoing. Among BIOCLIM variables generating Maximum Entropy (MaxEnt) Model for *P. epaphus*, Mean Temperature of Warmest Quarter, Maximum Temperature of Warmest Week, Highest Weekly Radiation and Precipitation of Coldest Quarter contributed most significantly. We detected change in altitudinal envelop for two species: *P. epaphus* had mean abundance more than 500m higher than its historical mean abundance, whereas in case of *P. hardwickii* current altitudinal mean abundance was quite Low as compared to its past record.
4.	Genetic distinctness of Lepidopteran species commonly occurring in Western, Central and Eastern Himalaya through DNA Barcoding	Pairwise genetic divergence was studied for two species of Erebidae which are designated as serious agricultural pest: *Creatonotos transiens* and *Asota caricae,* as the number of repeated sampling for these two species are more as compared to others. Divergence was seen for different location of collection as well as for different altitude. Maximum intra specific genetic divergence for *C. transiens* and *A. caricae* was observed to be 1.7% and 4% respectively. However, no divergence was observed when compared in different altitude gradient of same locality. It can be said that geographical barriers might play a key role for genetic divergence in Lepidoptera, though this is a preliminary study and has to be confirmed with more data-sets.

Dr. Kailash Chandra, PI
Director, Zoological Survey of India

डॉ. कैलाश चंद
Dr. Kailash Chandra
निदेशक / Director
भारतीय प्राणि सर्वेक्षण
Zoological Survey of India
M... & CC, Govt. of India
कोलकाता / Kolkata

Descriptive files

for

Table No. 2 (Fellowship Description at H-RA Level)

Table No. 3 (Fellowship Description at H-JPF/H-SPF Level)

and

Table No. 4 (Fellowship Description at Institution Level)

Table 2: Fellowship Description at H-RA Level
Descriptive File for *Dr. Abesh Kumar Sanyal*

Goal & Objectives: (I) Identification and establishment of Long-Term Ecological/Environmental Monitoring (LTEM) sites. (II) Status & Distribution of Threatened Apollo and other Parnassini butterflies (III) Conservation frameworks development for Himalayan Lepidoptera

Experimental Set-up & Methodology Adapted:
Long-Term Ecological/Environmental Monitoring (LTEM) sites were established across 5 Himalayan States. In the current reporting period additional sites were identified and established in Singalila NP (WB), Askot WLS (UT) and Dihang-Dibang BR, totaling to 130 LTEM sites. Lepidoptera was sampled through transects and light trap methods in these sites, alongwith collection of habitat-level parameters like: topographic (Altitude, Slope, Aspect), microclimatic (Ambient Temperature, Relative Humidity, Wind Speed, Air pressure), vegetation structural & composition (Canopy Cover, Tree species richness and density, Herb species richness, density and average height, Shrub species richness and cover, etc.) and disturbance variables (Logging, lopping and grazing signs, fire, distance to human settlement, etc.). Identification of collected Lepidopteran samples were undertaken following standard taxonomic procedure and consulting all available literature. Database is being prepared from all these identified species incorporating their current known distribution (global distribution, Indian distribution and past altitudinal records), host-plant record and phenology and specimen photographs. Furthermore, initial analyses were performed to see the significant habitat-covariates influencing Lepidopteran diversity and species richness across all Himalayan Biogeographic Provinces.

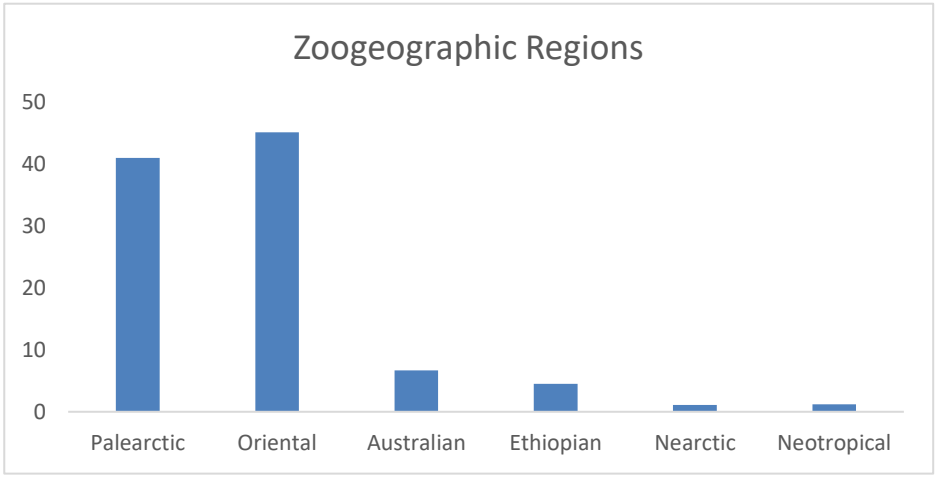
Significant Findings:

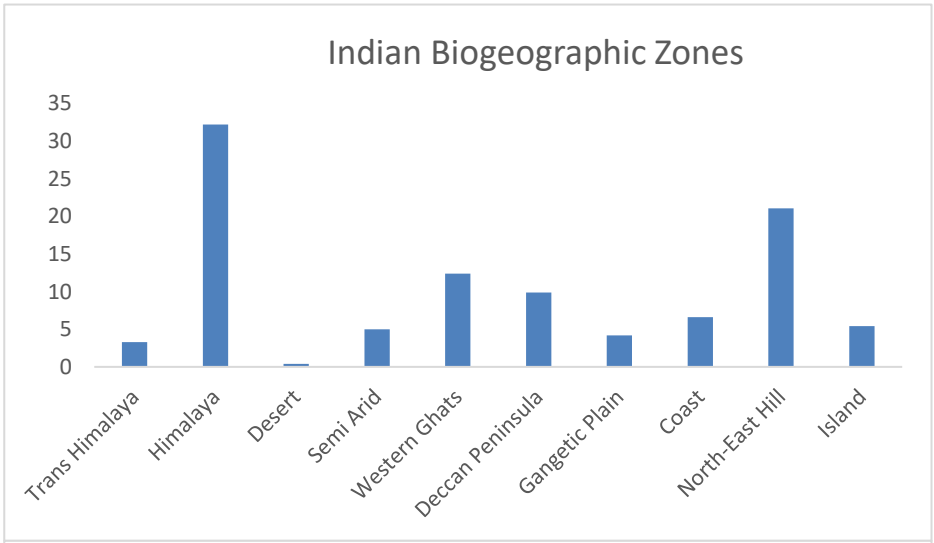
- **Moth Diversity Across Himalaya:** Altogether 1131 species of moths have been identified from all the Himalayan Landscape. Maximum number of species were identified from Central Himalayan landscape. Geometridae and Erebidae were most dominant families.

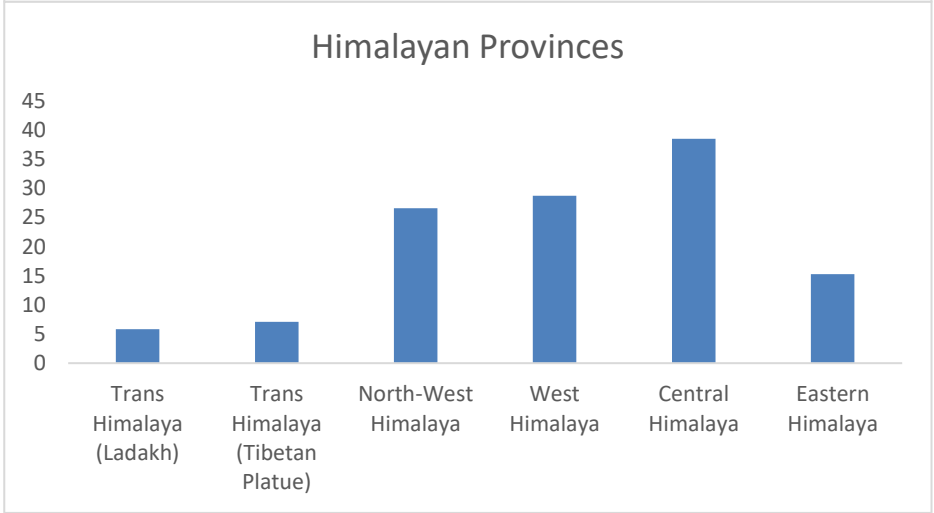
Table 1: Family wise number of identified species for each PA

			Western Himalaya		Central Himalaya	Eastern Himalaya	
Family	**No. of Genera**	**No. of Species**	**GHNP**	**AWLS**	**NVNP**	**NNP**	**DDBR**
Limacodidae	13	19		4	7	6	4
Zygaenidae	10	10		2	4	5	1
Pyralidae	11	15		3	7	4	3
Crambidae	70	102	14	18	38	43	22
Drepanidae	23	35	9	13	11	1	21
Lasiocampidae	13	18	1	4	11	6	4
Saturniidae	12	18	1	2	4		8
Sphingidae	29	52	7	16	16	17	6
Geometridae	155	301	84	69	68	53	96
Notodontidae	39	53	11	11	10	14	15
Erebidae	150	296	38	95	123	71	47
Nolidae	18	28	2	5	13	3	6
Noctuidae	81	135	40	43	21	10	24
Total	**661**	**1131**	**214**	**300**	**349**	**248**	**271**

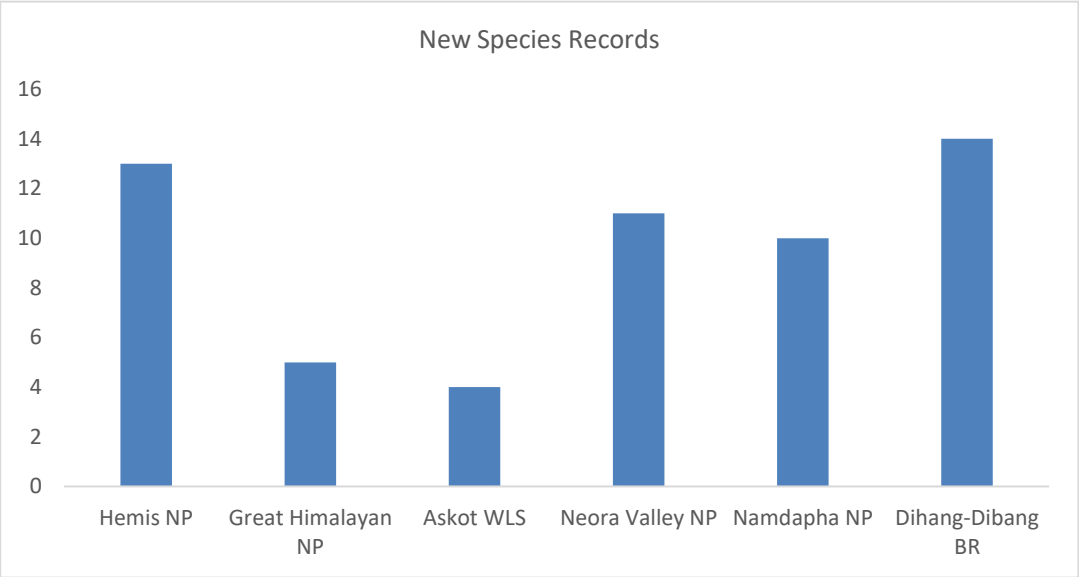
- **Biogeographic Pattern of Assemblage Composition:** The assemblage was dominated by Oriental fauna, closely followed by Palearctic elements. Within Indian Biogeographic zones, assemblage was most similar in composition to north-eastern elements, closely followed by Western Ghats and Deccan Peninsular elements. Dominance of Himalayan elements was prominent. Among Himalayan elements, Central Himalayan species were most dominant, closely followed by North-Western and Western Himalayan Species.







- **Species Recorded newly to Indian mainland:** Altogether during current project tenure, 42 species were recorded newly to Indian territory. Among them, the two extreme landscapes of Hemis National Park and Dihang-Dibang Biosphere reserve harbored maximum number of new species.



- **Determinants of Lepidopteran Diversity:** Species distributions is likely to be affected by a combination of environmental drivers not just one or two. PCA of Bioclim variables with species abundance showed significant correlation among species distribution and mean temperature and precipitation of warmest quarters. The data also showed that Lepidoptera were most abundant in 15-20^{C} of mean temperature and in 500-1000 mm mean precipitation of the warmest quarter. Additionally, elevation and species abundance were positively correlated.

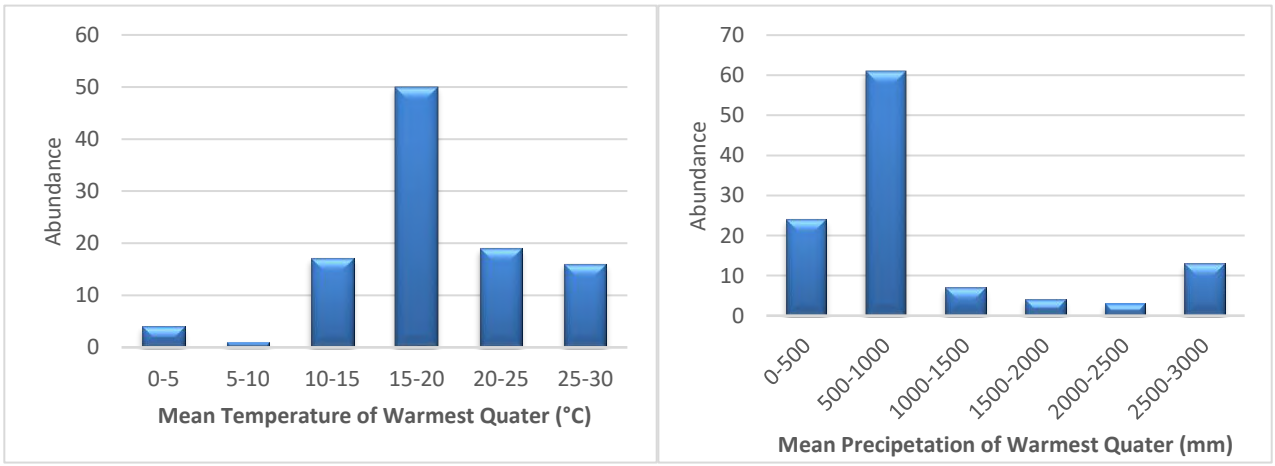


Figure 1: Determinants of Lepidopteran abundance

Descriptive File for *Dr. Angshuman Raha*

Goal & Objectives: (I) Monitoring surveys in historical collection localities. (II) Climate-Envelope modelling & Distribution mapping for responses to changing climate (III) Landscape level conservation approach of Himalayan Lepidoptera through Indicator taxa and awareness generation

Experimental Set-up & Methodology Adapted:
From Secondary Data Set generated through Intensive Literature Survey and geo-tagging of extracted species occurrence record, two Historically Prominent localities were selected, one in Western Himalaya (Dharamshala, HP), and one in Central Himalaya (Darjeeling, WB), which have >300 species records. Our approach was to resample these historical sites, in continuous manner, to compare the species composition as well as their altitudinal envelop between historical time and current condition. To fulfill this objective, Permanent Light Trap stations were established in Dharamshala and continuously monitored for one month during October-November, 2018. Altogether 1500 individual moths were sampled through 10 monitoring plots, which are currently under the process of Identification and altitudinal comparison.
Furthermore Taxo-Ecological assessment of Notodontidae fauna, an important forest-pest group of Lepidoptera of Indian Himalaya, was undertaken. Altitudinal stratification, richness pattern across major environmental gradient (like precipitation) and Himalayan-endemicity were assessed.

Significant Findings:

- **Notodontidae Fauna of Indian Himalaya:** Indian Notodontidae is represented by 242 species/10 subspecies under 116 genera of 10 subfamilies. Indian Himalaya holds more than 35% of the species reported from India. Several species of Notodontidae are serious defoliators of commercial plantations, while some others are established indicators of vegetation alteration or even climate change. Notodontidae assemblage along Himalayan altitudinal gradient showed species' elevation range from 400m to 3600m with mean distribution around 2400m, while maximum abundance was recorded between 1500m and 2800m (Fig. 2)

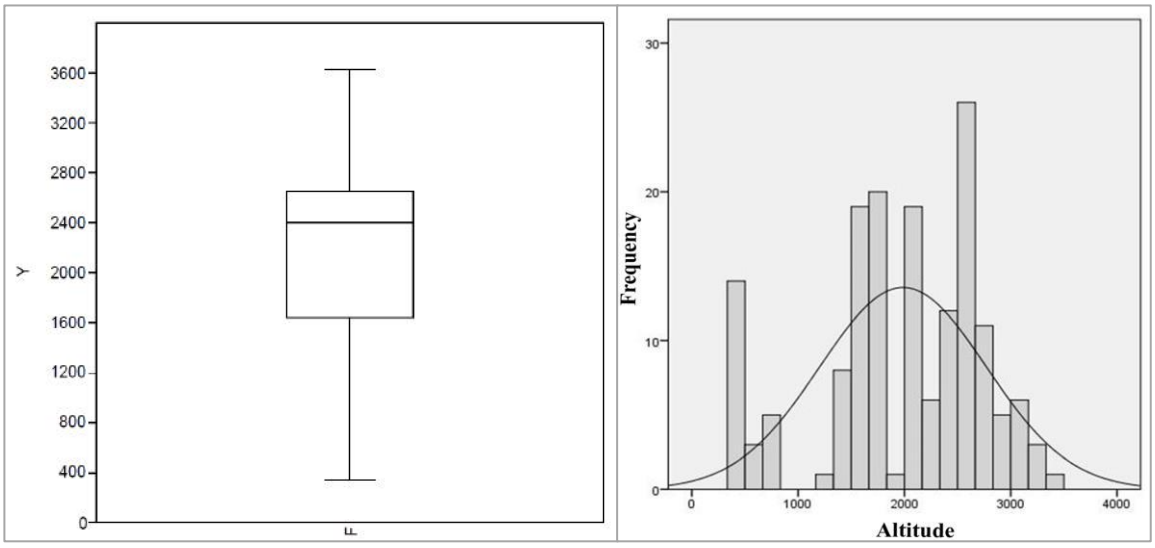


Figure 2: Species' elevation range and abundance pattern in different altitude strata in Indian Himalaya

- 19 Notodontidae species have been recorded distributed exclusively in the Himalayan Biogeographic zone. Two species viz. *Pseudallata laticostalis* & *Antiphalera bilineata*, having past distribution from Meghalaya, are being recorded for the first time from IHR. Four species viz. *Clostera anachoreta anachoreta*, *Rachia plumosa*, *Gazalina apsara* & *G. chrysolopha* were recorded from altitudes >3000m. *Clostera anachoreta anachoreta* & *Rachia plumosa* showed occurrences >3500m. Such ascends in distribution are unusual and should be intensively monitored to assess any probable effect of climatic stochasticity.
- Maximum species richness of Notodontidae was found to be in 2000m-3000m altitudinal band, whereas 800mm-3500mm Annual Precipitation Range harbored maximum species (Fig. 3)

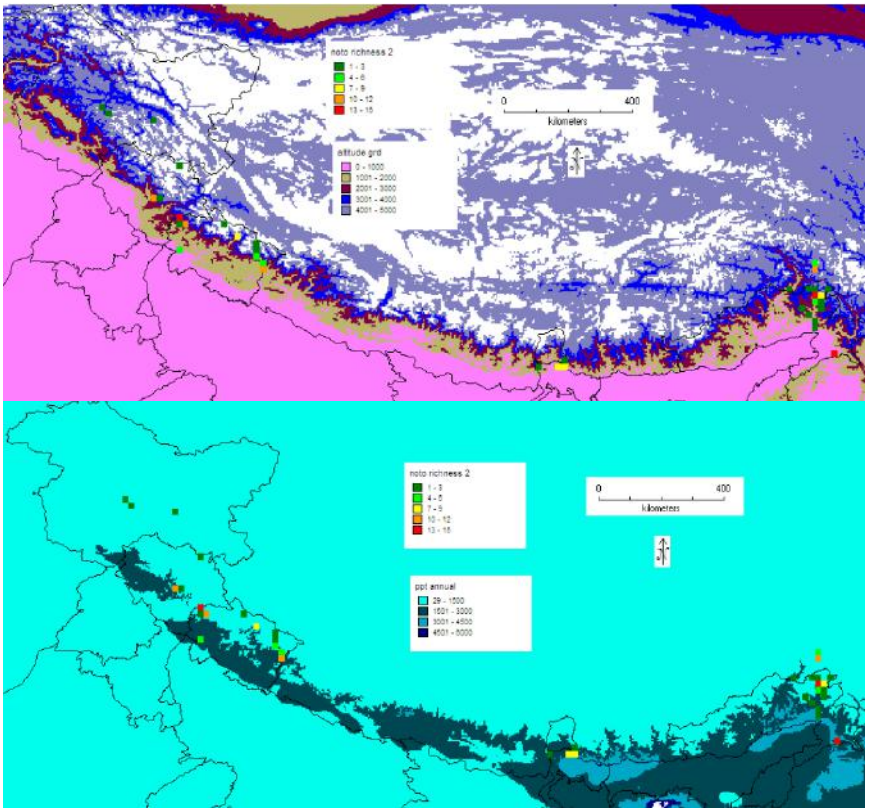


Figure 3: Altitude-wise and Precipitation-wise species richness-grid map for Notodontidae of Indian Himalaya

Figure 4: New Species of Notodontidae reported from Indian Himalaya: (i) *Fentonia*, (ii) *Syntypistis*, (iii) *Phalera*, (iv) *Pheosia*

- **<u>Notodontidae New Records to India:</u>** One species each of following genera have been reported for the first time from India: *Fentonia*, *Honveda*, *Periergos*, *Phalera*, *Pheosia, Syntypistis*. Probable new species of *Nerice* from Dihang-Dibang Biosphere Reserve is under the process of description

Descriptive File for *Dr. John Caleb T.D.*

Goal & Objectives:

DNA barcode database generation for future molecular and phylogenetic research on Himalayan Lepidoptera

Experimental Set-up & Methodology Adapted:

The samples collected from different localities of the Indian Himalayan Region (IHR); West Bengal and Arunachal Pradesh were processed for molecular analysis and preserved in 70% ethanol at 4 °C in the Centre for DNA Taxonomy (CDT), ZSI, Kolkata. The genomic DNA was extracted by using DNeasy Blood & Tissue Kit (Qiagen, Valencia, CA). The DNA barcode region (~648 bp) of mitochondrial Cytochrome c-Oxidase subunit I (mtCOI) gene was amplified through polymerase chain reaction (PCR) by using the universal barcode primer LCO-HCO. The total volume (25µl) of PCR consisted of 10-20 ng of genomic DNA, 10 pmol each of forward and reverse primers, 10X PCR buffer, 0.1-0.2U Taq polymerase (Takara, Japan), 2.5mM dNTP, 2mM MgCl2, and adjusted by the desired amount of nuclease free water. The PCR was performed in Veriti™ 96-Well Thermal Cycler (Applied Biosystem). The thermal profile of PCR reaction process was as follows: 5 min at 94 °C; followed by 40 cycles of 30 s at 94 °C, 40 s at 49 °C, 1 min at 72 °C and final extension for 5 min at 72 °C. The PCR products were purified using the QIAquick Gel Extraction Kit (Qiagen, Valencia, CA). Approximately, 1-2µl of the purified PCR product was used for Sanger sequencing. The cycle sequencing was performed with BigDye®Terminator ver. 3.1 Cycle Sequencing Kit (Applied Biosystems, Inc.) using 3.2 pmol of both forward and reverse primers on Veriti™ 96-Well Thermal Cycler with following parameters: 96 °C for 1 min, then followed by 25 cycles of 96 °C for 10 s, 50 °C for 5 s and a final extension at 60 °C for 1 min 15 s. The cycle sequencing products were cleaned using BigDye X-terminator kit (Applied Biosystems Inc.) and sequenced on 48 capillary ABI 3730 Genetic analyzer, housed at the Zoological Survey of India, Kolkata. The generated DNA barcode sequences were submitted in the BOLD database under the project named 'Lepidoptera of India'. To estimate the Molecular Operational Taxonomic Units (MOTUs), three species delimitation methods: Automatic Barcode Gap Discovery (ABGD), the General Mixed Yule-coalescent (GMYC), and Poisson-Tree-Processes (PTP) were applied.

Significant Findings:

A total of 881 samples were processed for DNA isolation. Among them 630 PCR products were amplified and 320 DNA barcodes were generated. The rest of the samples are being processed.

In order to resolve the species complexes in the genus *Abraxas*, the generated DNA barcodes were analyzed. A Bayesian inference gene tree was constructed depicting the monophyletic clustering of the studied *Abraxas* species from different geographical regions (Fig. 5). After finalizing the dataset, 44 sequences along with other sequences available from the global database was obtained to prepare the gene tree. Out of the 44 specimens, 38 specimens were identified up to species level and the remaining specimens were identified up to genus level. Six distinct species namely: *Abraxas paucinotata*, *Abraxas neomartaria*, *Abraxas martaria*, *Abraxas illuminata*, *Abraxas leopardina*, and *Abraxas sublepida* were identified morphologically. From the gene tree it was evident that the species morphologically identified as *A. martaria* did not form monophyletic cluster. Three different species delimitation methods were adopted to infer the species boundaries. The pruned Bayesian phylogeny shows cohesive clustering of *A. martaria*, collected from two different geographical regions. The Molecular Operational Taxonomic Units (MOTUs) identified by different delimitation methods (ABGD, PTP, and GMYC) are shown in Figure 6. Of the three methods, two (ABGD, PTP) indicated that all the specimens belonged to the same species, while the other method (GMYC) indicated the presence of three distinct species.

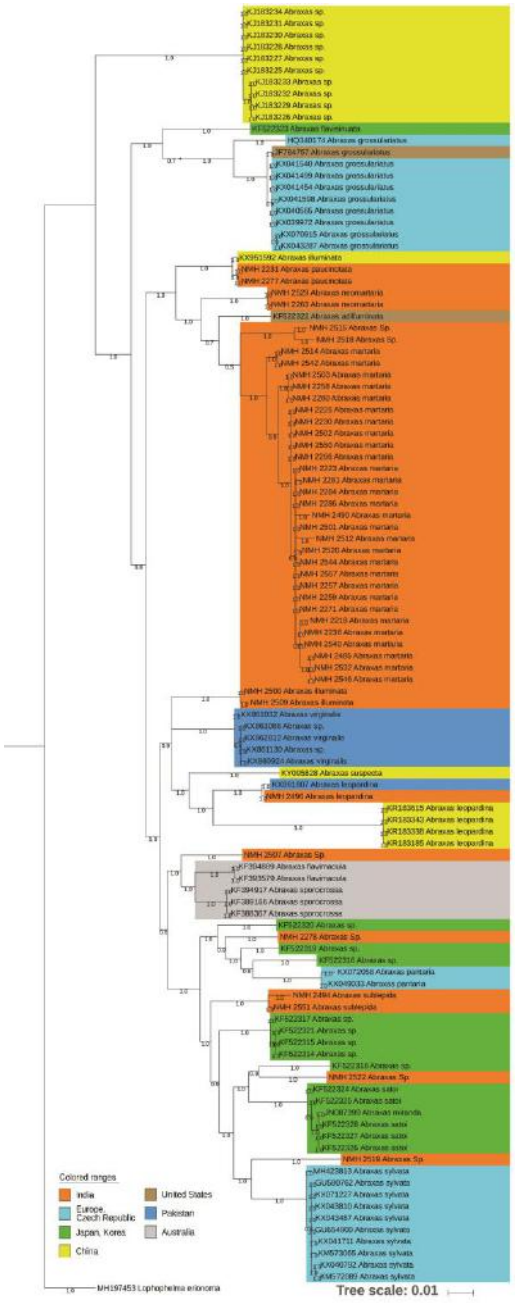


Figure 5. Bayesian inference gene tree depicting the monophyletic clustering of the studied *Abraxas* species from different geographical regions.

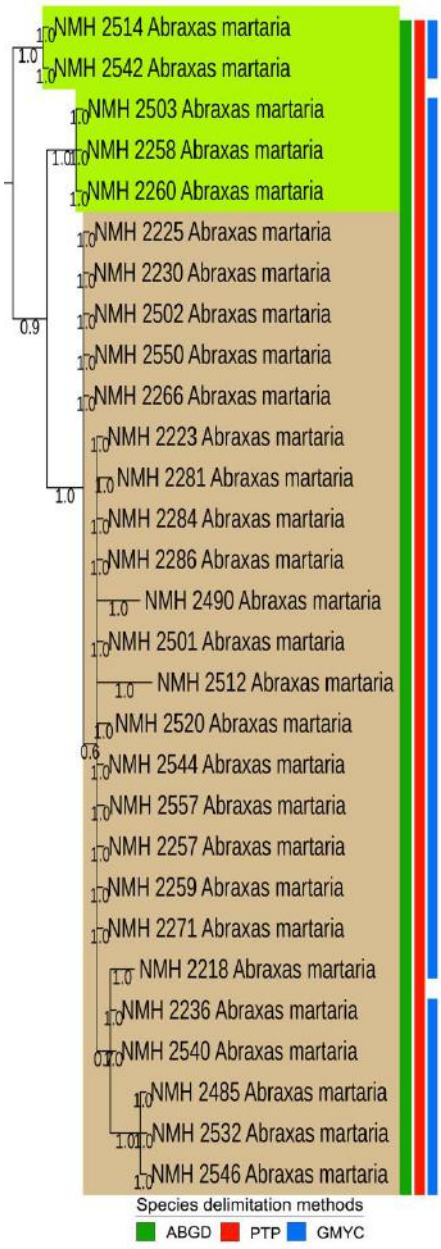


Figure 6. Pruned Bayesian phylogeny showing the cohesive clustering of *A. martaria*, collected from two different geographical regions. Color bars indicate delineated MOTUs by different methods (ABGD, PTP, and GMYC).

Table 3: Fellowship Description at H-SPF/H-JPF Level
Descriptive File for *Mohd. Ali*

Goal & Objectives: (I) To investigate the differential processes influencing the distribution pattern of Lepidoptera assemblages (moths and butterflies) of Hemis National Park (HNP), Jammu & Kashmir. (II) Generation of robust datasets generated through ecological monitoring at habitat level. (III) Thesis on the subject area.

Experimental Set-up & Methodology Adapted:
From initial reconnaissance survey in Trans-Himalayan habitats of Hemis NP and associated areas, 2 major Habitat Types were identified: Moist Alpine Scrub & Dry Alpine Scrub. These four major habitat types were further subdivided into: (i) Birch-Rhododendron Scrub forest (3500-3800m), (ii) Dwarf Juniper-Rhododendron Scrub, (iii) *Hippophae-Myriacaria* Scrub, and (iv) Alpine-Pasture. These Habitat Types were further categorized according to Land-Use classes: Agriculture, Transition Zone, Steppe Slope, Alpine Meadow and Dry Rocky Desert. Butterfly transects and Moth light trap stations were established in all these habitat subdivisions with more-or-less equal sampling effort. Altogether 71 butterfly transects and 68 Light Traps were performed in altitudinal range 2900m-5300m, resulting in 3666 individuals of butterflies and 3304 individuals of moth.

Significant Findings:

- **Butterfly Diversity in different Habitats:** Butterfly species diversity varied in different habitat types sampled. Transitional habitat, which is actually an ecotonal habitat between agriculture and natural vegetation had maximum diversity in terms of number of species, individuals as well as Estimated Species Richness (Chao 1) compared to other habitats. In terms of local diversity, Alpha diversity was highest in Dry Rocky Desert (5.906), and as a consequence dominance was minimum among sites representing this habitat. Diversity was lowest in Alpine meadow (4.295). Alpine meadows and steppe slope habitats were most similar in terms of butterfly composition. Non-Metric-Multidimensional Scaling of different habitat types (Fig. 7) showed that faunal composition was most unique for Steppe Slopes. Composition for agricultural habitats was nested within Transition zone, with whom Alpine Meadow formed a separate cluster. Rocky Desert habitat was also unique in terms of species composition.

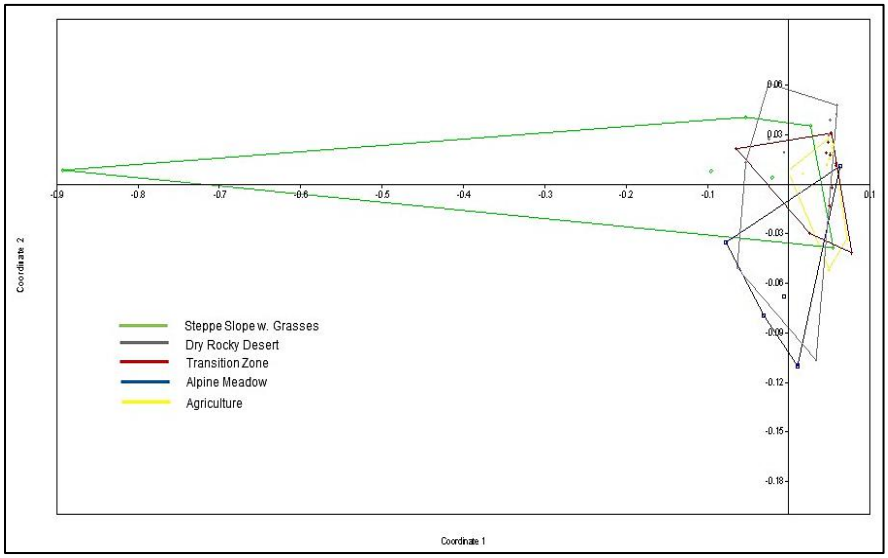


Figure 7: Non-Metric MDS ordination plots of sampling sites in Indian Tran Himalaya, generated by species composition sorted according to habitat types

- **Important species of Butterflies:** During study period, only three species of *Parnassius* (Parnassiinae) had been recorded, viz. *Parnassius hardwickii hardwickii*; *Parnassius charltonius*; *Parnassius epaphus*. Some significant records from this study: *Baltia butleri* was recorded at 2900m elevation where it was restricted to high mountain ranging from 3800-5400m. Similarly *Pieris deota* was recorded at elevation from 2909-4500m, while Tshikolovets (2005) stated that its distribution in Ladakh needs clarification (ranges from 3500-5300m). *Colias ladakensis* is previously ranging from 3700-5300m, where it was recorded from 3018m elevation. Other rare sighting such as, *Euchloe dephalis* (Moore, 1865) was recorded from Khalsi, Leh (3290m), which was previously recorded between 3100-3400m from Drass Valley and some places of Himachal Pradesh and Uttarakhand.
- **Moths of Trans-Himalaya:** In the current reporting period 55 species of moths were identified pertaining to 599 specimens. Family Noctuidae dominated the assemblage with 23 species followed by Geometridae (16 species), Erebidae (6 species), Sphingidae (4), Saturniidae (4). *Callindra principalis* (94 specimens), *Spilosoma melanostigma* (54), *Drasteria caucasica* (47), *D. cailino* (48), *Dichagyris himalayensis* (41) are some of the superabundant species. Maximum diversity and abundance were reported in the altitudinal belt of 2900m-3400m. Being contiguous with Central and West-Asiatic Palearctic habitat, bulk of the species are being reported for the first time within Indian territory. Further investigation should be carried out on whether these species are recent colonizer due to suitable habitat tracking owing to Climate Change, or they are some relict form previously unreported.

Figure 8: Few Noctuidae identified from Ladakh Trans-Himalaya: (i) *Mythimna vitellina*, (ii) *Heliothis maritima*, (iii) *Cucullia aksuana*, (iv) *Drasteria cailino*

- People's perception about Butterfly Conservation: As conservation of any endangered group of species can't be possible without the help of local people, we wanted to assess the socio-economic backdrop in the form of awareness and sensitivity of local people towards butterflies and their ecological services. We conducted Questionnaire survey to 25-30% houses in a village including questions like what species were observed in past and present showing them butterfly photographs. Species observed around agriculture fields, their activity period, flower visiting routines were also asked. According to local people, Butterfly activity reaches at its peak during the month of June to August, in Indian Trans-Himalaya. The pasture lands around villages are well watered throughout the year and thus different species of flowering plants grow here which makes it a suitable habitat for butterflies, even in extreme winter months. People expressed their concern on receding ice caps from the top of the mountains and resultant decline in water availability which is probably one of the main causes of declining butterfly numbers in recent years.

Descriptive File for *Kaushik Mallick*

Goal & Objectives: (I) Generation of scientific evidences on Lepidopteran diversity of Great Himalayan NP (GHNP), Himachal Pradesh. (II) Generation of robust datasets generated through ecological monitoring at habitat level. (III) Thesis on the subject area.

Experimental Set-up & Methodology Adapted:
Initially four major gradients were selected ranging 1500m-4000m and 23 LTEM sites were established for the generation of the scientific evidences on Lepidopteran diversity of GHNP through random stratified sampling. Along the altitude gradient, random sites were selected at every 300m vertical distance according to vegetation type. 2-3 sampling plots were established for Light trapping until at least 90% of all species had been assembled at every altitude and the data was pooled for analysis.

Significant Findings:

- **Sampling Effort:** During current reporting period, successful light trapping was performed for total 37 nights in GHNP, alongwith collecting weather data and other significant habitat variables. Sampling was done in following vegetation types: Chir Pine Forest, Temperate Broadleaved Forest, Temperate Conifer forest, Temperate Broadleaved-Conifer Mixed Forest, Sub-Alpine Forest, Temperate Grasslands, Alpine Forest.
- **Total Inventory & Family Composition:** Currently, 206 species of moth belonging to 106 genera, 44 sub-families, 16 families and 8 Superfamilies are identified. Species richness of the Family Geometridae was highest, having 80 species under 59 genera followed by Noctuidae, having 40 species under 31 genera and Erebidae, having 35 species under 27 genera (Fig. 9). Other prominent families were Crambidae (14 species under 14 genera), Notodontidae (11species under 7genera), Drepanidae (9 species under 8 genera) and Sphingidae (7species under 6 genera).

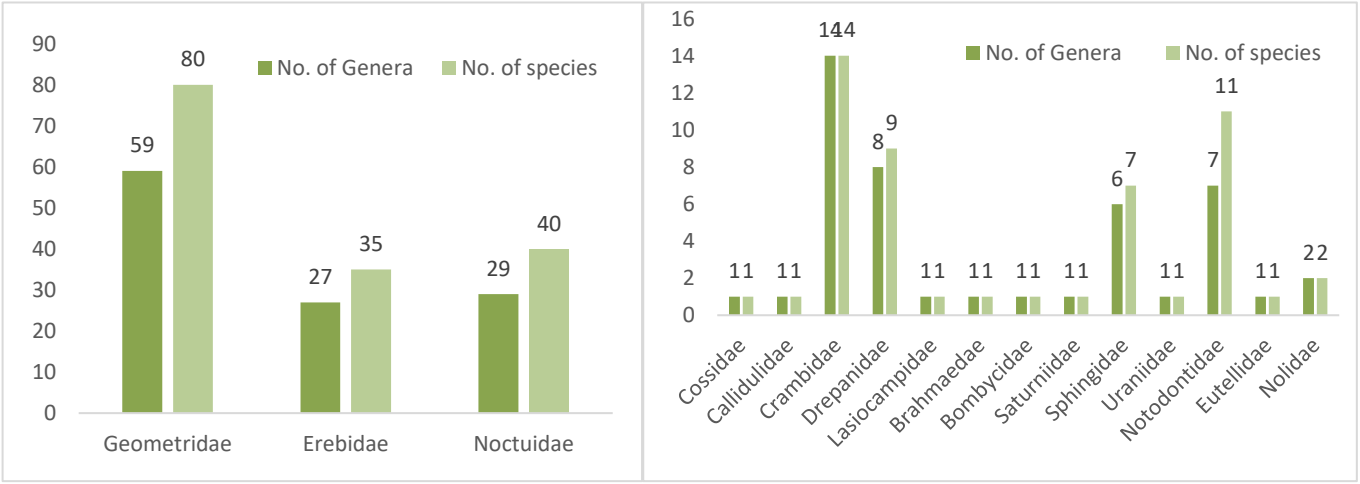


Figure 9*:* Number of Genera & Species recorded under (a) three major families, (b) all other families from GHNP, Himachal Pradesh

- **Subfamily Composition:** The most abundant subfamily among GHNP moths is Ennominae with 53 species under 36 genera. The moths of this subfamily have a wide ecological range occurring in diversity at all except very high altitudes, thus specificity to lower altitude forest types, and include several species that appear to fly predominantly in the forest understory. They are thus considered as highly suitable as an environmental indicator group. Among Ennominae of GHNP,

Arichanna flavinigra Hampson,1907; *Menophra subplagiata* (Walker,1860); *Ourapteryx ebuleata* Guenée,1859 and *Odontopera kametaria* Felder,1873 were most abundant species. Three species, viz. *Arichanna flavinigra* Hampson,1907; *Arichanna tenebraria* Moore,1867; *Opisthograptis tridentifera* (Moore,1888), were recorded only from altitude above 3500m, may be those species are highly specific to High-altitude Alpine habitats, whereas *Menophra subplagiata* (Walker,1860) and *Odontopera kametaria* Felder,1873 were recorded only from altitude below 2100m, suggesting that the distribution of those species may be specific to low altitudinal habitats, i.e., Chir Pine Forest or Temperate Broadleaved Forest. *Ourapteryx ebuleata* Guenée,1859, recorded all through the gradient sampled, had highest abundance in lowest altitudinal site, suggesting that this species may be a generalist in its food choice.

- Another Geometridae subfamily Larentiinae, which tends to predominate over other groups of Geometridae with increasing altitude and are highly successful in reaching remote habitats, was represented by 24 species under 20 genera. In GHNP, *Photoscotosia amplicata* Walker,1862, although present all through the gradient sampled, but was highly abundant at highest altitudinal point, whereas, *Photoscotosia miniosata* Walker,1862, recorded from two altitudinal sites (2200m & 3567m), had highest abundance in 3567m. The pattern of Larentiinae moth clearly indicated that they highly prefer the alpine habitat condition.
- Among Superfamily Noctuoidea, mostly represented by family Erebidae and Noctuidae, subfamily Arctiinae (16 species under 10 genera) having the highest number of species, followed by Erebinae and Lymantriinae, having 7 species under 7 genera and 4 species under 4 genera respectively. In case of Family Noctuidae, the species richness of subfamily Noctuinae was highest, having 23 species under 15 genera, followed by Xyleninae and Plusiinae having 5 and 4 species respectively. Among subfamily Arctiinae, *Cyana adita* Moore,1859; *Barsine orientalis* (Daniel,1951) and *Ghoria postfusca* (Hampson,1894) were the most abundant species in our study. *Cyana adita* Moore,1859 and *Barsine orientalis* (Daniel,1951) were recorded from the altitude upto 2500m but abundance of those species was higher around the altitude of 1500-2000m, this species may be specific to lower altitudinal habitats i.e., Chir Pine Forest, Temperate Broadleaved Forest. *Ghoria postfusca* (Hampson,1894) recorded all through the gradient but had higher abundance in 2800-3000m, suggesting that this species may be specific to Temperate Broadleaf Conifer (mixed) Forest or Temperate Conifer Forest.
  In our study, *Lygephila dorsigera* (Walker,1865); Catocala patala Felder,1874 and *Supersypnoides kirbyi* (Butler,1881) were the most abundant species under the subfamily Erebinae. *Lygephila dorsigera* (Walker,1865) and *Supersypnoides kirbyi* (Butler,1881) were recorded from the altitude upto 2400m, but *Catocala patala* Felder,1874 were found only from altitude above 3500m, indicating that this species is highly specific to high altitudinal Alpine meadow habitat.

- **Taxonomical review, Altitudinal and Biogeographic distribution of Indo-Chinese genus Psyra (Geometridae: Ennominae):** Taxonomic review of Highly cryptic Indo-Chinese Genus Psyra was undertaken with description of 4 probable new species, and 4 species newly recorded to India. 5 species viz. *P. similaria* Moore, 1868; *P. angulifera* (Walker, 1866); *P. szetschwana* Wehrli, 1953; *P. spurcataria* (Walker, 1863) and *P. debilis* Warren, 1888 with multiple locality records (>5) were selected for Habitat-Suitability study using DIVA GIS incorporating BIOCLIM variables like Annual mean Temperature, Annual mean Precipitation.
  - *P. similaria* was recorded only from Western Himalaya and distributed between the altitude range of 1397-3128m with a mean altitude of 2665.6 ± 319.6 m. High altitude areas of Uttarakhand and few areas in HP showed excellent habitat for this species.
  - *P. angulifera* was recorded throughout the IHR between the altitude range of 1405-2600 m with a mean altitude of 2153.6 ±362.2 m. Species distribution modelling showed high altitude

habitats of Uttarakhand and few areas of South-eastern Arunachal Pradesh (AP) to be most preferred habitats for this species.

- *P. szetschwana* was recorded throughout the IHR between the altitude range of 2273-3800 m with a mean altitude of 2731 ±565.7 high altitude areas of Uttarakhand and Eastern AP having most preferred habitat for this species.
- *P. spurcataria* was recorded throughout the IHR between the altitude range of 1554-2971 m with a mean altitude of 2321.8 ±531.3 m. Among these distribution modelling, *P. spurcataria* showed throughout distribution of the species along IHR with few areas of Uttarakhand, Sikkim and Eastern AP having most preferred habitats.
- *P. debilis* was recorded only from Western Himalaya and distributed between the altitude range of 2137-3408m with a mean altitude of 2696.9 ± 377.9 m. Trans-Himalayan region of North Western Jammu and Kashmir and few areas of Himachal Pradesh (HP) showed most preferred habitats for this species.

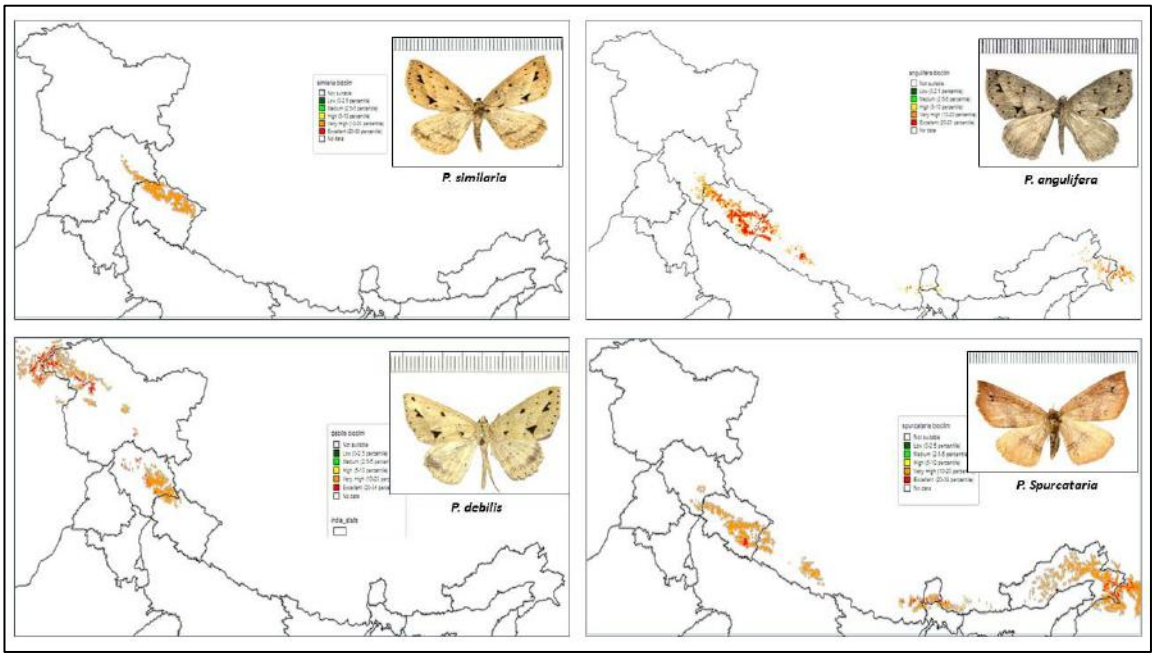


Figure 10*:* Distribution Modelling of major species of Psyra in Indian Himalayan region

- Predictive distributional model of three species viz. *P. angulifera*, *P. szetschwana* and *P. spurcataria* may be done in future as they are recorded from all-over the IHR in this preliminary study. The species with the mean altitude >2500m viz. *P. similaria*, *P. szetschwana* and *P. debilis* can be used as indicator species for tracking or monitoring climate change studies in future.

Descriptive File for *Uttaran Bandyopadhyay*

Goal & Objectives: (I) Generation of scientific evidences in the form of reports on Lepidopteran diversity of Askot Wildlife Sanctuary (AWLS), Uttarakhand (II) Generation of robust data sets generated through ecological monitoring at habitat level, (III) Thesis on the subject area.

Experimental Set-up & Methodology Adapted:
To generate the scientific database of the Lepidopteran diversity in the study area, LTEM (Long Term Ecological Monitoring) sites has been established. To do so, several reconnaissance surveys has been carried out in different region of the PA and a total of 27 sites has been identified. The sites were chosen carefully in different habitat type and altitude level. Widely used Light Trapping method has been followed throughout to sample Lepidopteran specimens and to assess the diversity and primary distribution of Lepidopteran assemblage in the area. A database having valid species and their detailed locality record (with habitat type and altitude) has been prepared.

Significant Findings:

- A total number of 302 species of moths under 235 genera of 21 families have been recorded from the study area. Family Erebidae showed the maximum species richness (93 species, 176 specimens) followed by Geometridae (66 species, 188 specimens), Noctuidae (44 species, 96 specimens), Sphingidae (18 species, 36 specimens) and Crambidae (18 species, 27 specimens) (Fig. 11 a & b).

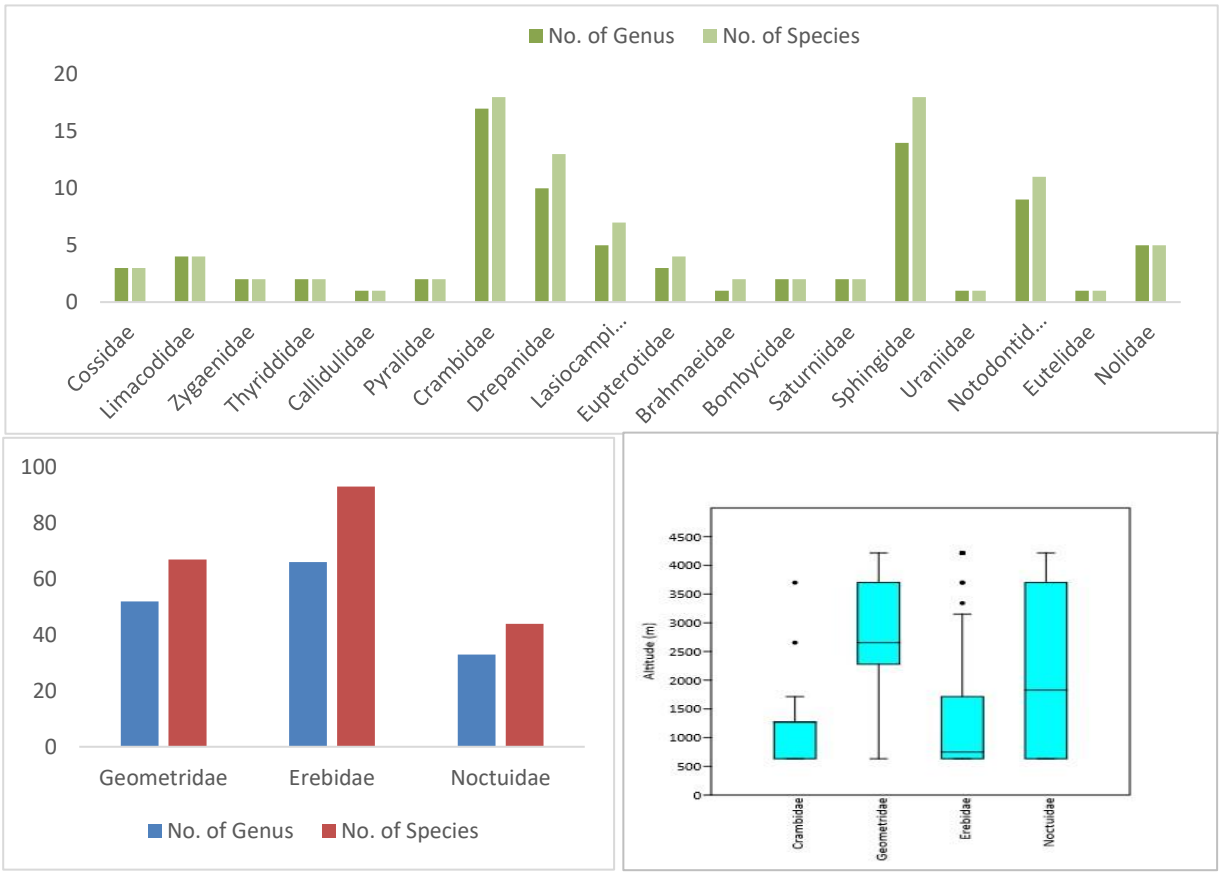


Figure 11: Family wise Genus & Species recorded for (a) All the minor families, (b) 3 major families, (c) Altitudinal distribution pattern of major families in Askot WLS.

- Species of family Erebidae showed a mean distribution at 600 m altitude and majorly distributed between 600-1800 m altitudinal range. A few representative of the group were also recorded from much higher altitudes, from 3700-4200 m. For family Geometridae, the species were mainly distributed between 2200-3700 m altitude with a mean distribution near 2600 m. Noctuids were majorly generalist in case of their distribution pattern. They were recorded throughout the gradient and showed a mean distribution at around 2500 m altitude. Crambids and Sphingids were mainly recorded from lower altitudes with mean distribution at 1200 m and 600 m respectively (Fig. 11 c).
- *Loxaspilates hastigera* (Butler, 1889) (Ennominae) was the most abundant species and only recorded from sites having an altitude of more than 3200 m so, the species may be very specific to alpine habitats. The second most abundant species was *Gazalina apsara* (Moore, 1859) followed by *Gazalina chrysolopha* (Kollar, 1844) (Thaumetopoeinae). *G. apsara* was mainly recorded from Kharsu Oak and Banj Oak forests which suggests the species may be specific to Oak forest habitats. The later has a huge range distribution from 1400 m to 3150 m and mostly evenly distributed.
- *Sirinopteryx harutai* Yazaki, 1998, *Amnesicoma bicolor* (Moore, 1888) and *Cucullia pullata* Moore, 1881 (Cuculliinae) were exclusively recorded from sites having altitude greater than 3700 m which are typical alpine pasture lands (Fig. 12). *Spatalia (Celeia) sikkima* (Moore, 1879) (Notodontidae) showed a strikingly wide range of altitudinal distribution from 630 m to 4200 m, which was earlier known from up to 2000 m. *Preparctia hannyngtoni* Hampson, 1910 (Arctiinae), which was also a typical high altitude species (recorded only from two sites above 3700 m), was rediscovered after 109 years after its first description.

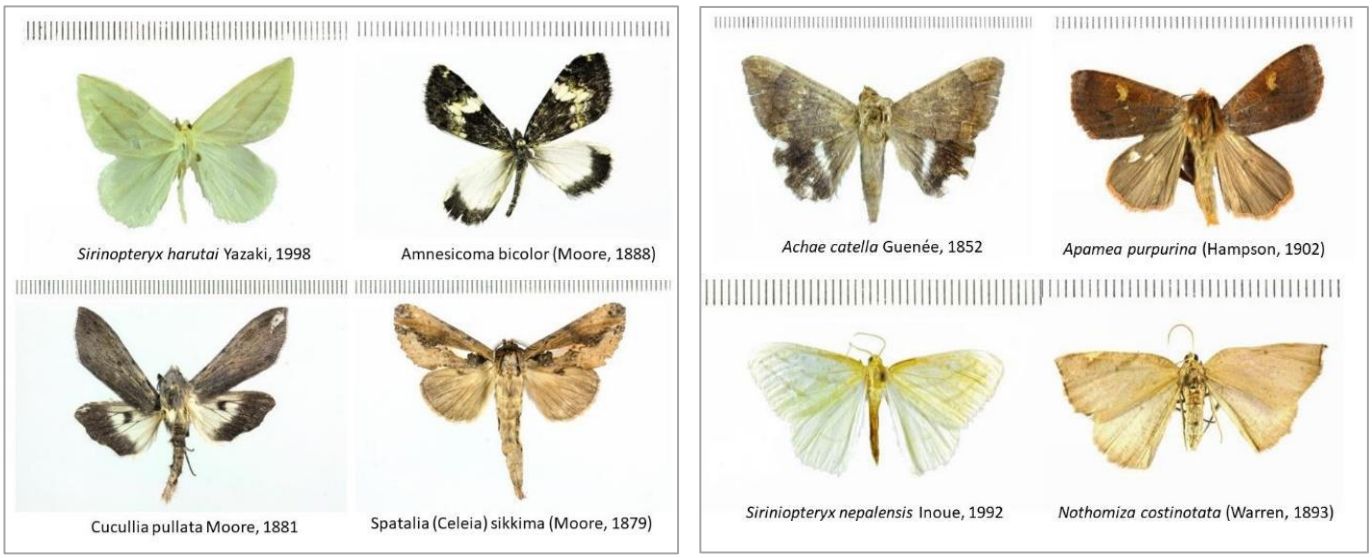
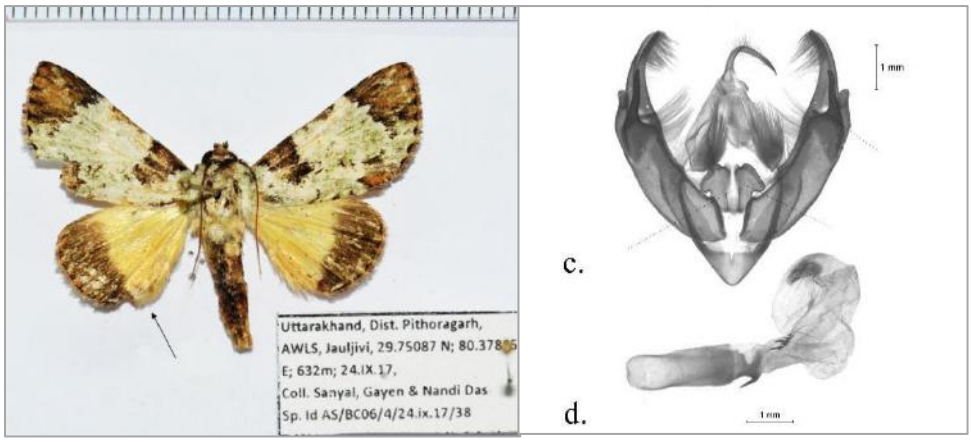


Figure 12: Range-restricted & range-extended species group and new species recorded to India from AWLS

- The identified species list includes 4 species newly recorded to India, viz. *Achae catella* Guenée, 1852, *Apamea purpurina* (Hampson, 1902), *Siriniopteryx nepalensis* Inoue, 1992 & *Nothomiza costinotata* (Warren, 1893) (Fig. 12).
- A new species of Genus Donda (Family Noctuidae: Subfamiliy Pantheinae), Donda unispinosa Bandyopadhyay, Raha & Chandra, 2019 has been described from the area (Accepted in Entomological News).



- Taxonomic revision of high-altitude specialist Noctuidae genus Phlogophora Treitschke, 1825 undertaken earlier, revealed 13 species from Indian Himalaya including 2 new species records from India. Specimen record for P. calamistrata was added to the list in this season (Fig. 13).

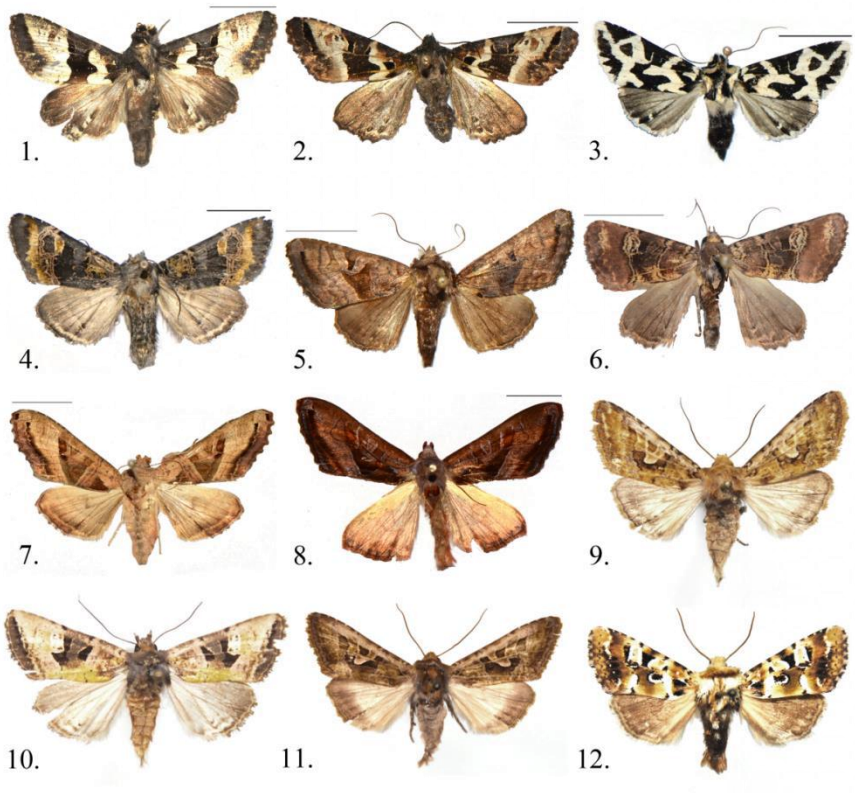


Figure 13**:** Habitus images of Indian *Phlogophora* species
1. *P. albovittata* (Moore, 1867) 2. *P. pectinata* (Warren, 1888) **3.** *P. distorta* (Moore, 1881) **4.** *P. plumbeola* (Hampson, 1894)
5. *P. conservuloides* (Hampson, 1898) **6.** *P. striatovirens* (Moore, 1867) **7.** *P. meticulodina* (Draudt, 1950)
8. *P. subpurpurea* Leech, 1900 **9.** *P. costalis* (Moore, 1882) **10.** *P. diseisignata* (Moore, 1867)
11. *P. humilis* Hreblay & Ronkay, 1998 **12.** *P. calamistrata* (Moore, 1882)

Descriptive File for *Ms. Rushati Dey*

Goal & Objectives: (I) Generation of scientific evidences in the form of reports on Lepidopteran diversity of Kangchendzongha Biosphere Reserve, Sikkim (KBR); (ii) Generation of robust data sets generated through ecological monitoring at habitat level (iii) Thesis on the subject area

(As no research permission in Kangchendzongha Biosphere Reserve, Sikkim was obtained from the concerned Forest Department, field sampling couldn't be initiated here. The fellow was engaged in processing, identification and molecular study of Lepidopteran samples collected from different study sites.)

Experimental Set-up & Methodology Adapted:

For DNA based molecular taxonomic studies, leg samples of collected Lepidopteran specimens were coded and isolated with unique NMH ID. DNA Isolation was carried out using organic phase extraction method/ silica column kit method. The isolated samples were amplified for nearly 648 base pairs (bp) from the 5' end of the mtCO1 gene using primer pair LCO-HCO and LepF1-LepR1. The amplified PCR products were purified and used for sequencing. The SeqScape software version 2.7 (Applied Biosystems Inc.) was used to analyze the forward and reverse chromatograms to obtain the consensus sequences after checking insertion, deletionand stop codons. The similarity search of the generated sequences were performed through BLASTn in GenBank and identification engine in the BOLD Database. MEGA 6.0 was used to analyze pairwise genetic divergence.

Significant Findings:

- Pairwise genetic divergence was studied for *Creatonotos transiens* and *Asota caricae* belonging to Erebidae family as the number of repeated sampling for these two species are more as compared to others. Divergence was seen for different location of collection as well as for different altitude. Maximum intra specific genetic divergence for *A.caricae* and *C.transiens* was observed to be 1.7% and 4% respectively (Table 2 and 3).

Table 2. Intra specific pairwise genetic divergence of *Asota caricae*

ZSILH380-17|Asota_caricae|NMH_1617Himachal; 1515m									
ZSILH612-18|Asota_caricae|NMH_2607|Uttarakhand; 632m	0.033								
ZSILH750-18|Asota_caricae|NMH_2652|Uttarakhand; 632m	0.033	0.000							
ZSILH661-18|Asota_caricae|NMH_2661|Uttarakhand; 632m	0.033	0.000	0.000						
ZSILH663-18|Asota_caricae|NMH_2665|Uttarakhand; 632m	0.033	0.000	0.000	0.000					
KX587505.1_Asota_caricae_voucher_India:_Kerala_Malappuram_Parappanangadi Ullanam	0.040	0.014	0.014	0.014	0.014				
KU201286.1_Asota_caricae_voucher_India:_Kerala_Malappuram_Parappanangadi	0.040	0.014	0.014	0.014	0.014	0.000			
Asota_caricae_India_Himalaya__Nainital_Bhim_Tal_Kumaon_1500m/ Uttarakhand	0.014	0.022	0.022	0.022	0.022	0.029	0.029		
Asota caricae; Kerala_Malappuram_Parappanangadi_11.03N_76.05E	0.040	0.014	0.014	0.014	0.014	0.000	0.000	0.029	
Asota caricae; Kerala_Malappuram_Parappanangadi_Ullanam_11.03N_76.05E	0.040	0.014	0.014	0.014	0.014	0.000	0.000	0.029	0.000

- However, no divergence was observed when compared in different altitude gradient of same locality. It can be said that geographical barriers might play a key role for genetic divergence in Lepidoptera, though this is a preliminary study and has to be confirmed with more data-sets. To form a combined data-set, additional 9 published sequences from India were obtained from BOLD and GenBank

Table 3. Intra specific pairwise genetic divergence of *Creatonotus transiens*

ZSILH330-17|Creatonotos_transiens|NMH_1082|Himachal; 1515m														
ZSILH588-18|Creatonotos_transiens|NMH_2571|Uttarakhand; 1272m	0.002													
ZSILH650-18|Creatonotos_transiens|NMH_3083|West Bengal; 751m	0.007	0.005												
ZSILH618-18|Creatonotos_transiens|NMH_2620|Uttarakhand; 632m	0.002	0.000	0.005											
ZSILH660-18|Creatonotos_transiens|NMH_2647|Uttarakhand; 632m	0.007	0.005	0.005	0.005										
ZSILH748-18|Creatonotos_transiens|NMH_2650|Uttarakhand; 632m	0.002	0.000	0.005	0.000	0.005									
ZSILH664-18|Creatonotos_transiens|NMH_2666|Uttarakhand; 632m	0.007	0.005	0.000	0.005	0.005	0.005								
ZSILH647-18|Creatonotos_transiens|NMH_3075|West Bengal; 751m	0.007	0.005	0.000	0.005	0.005	0.005	0.000							
ZSILH648-18|Creatonotos_transiens|NMH_3078|West Bengal; 751m	0.017	0.014	0.009	0.014	0.014	0.014	0.009	0.009						
ZSILH649-18|Creatonotos_transiens|NMH_3080|West Bengal; 751m	0.014	0.012	0.007	0.012	0.012	0.012	0.007	0.007	0.002					
ZSILH754-18|Creatonotos_transiens|NMH_3082|Uttarakhand; 2800m	0.007	0.005	0.000	0.005	0.005	0.005	0.000	0.000	0.009	0.007				
AGIRI024-17|Creatonotos_transiens|COI-5P/ Himachal; 2319m	0.005	0.002	0.007	0.002	0.007	0.002	0.007	0.007	0.017	0.014	0.007			
AGIRI047-17|Creatonotos_transiens|COI-5P/ Bnagalore; 678m	0.012	0.010	0.005	0.010	0.010	0.010	0.005	0.005	0.014	0.012	0.005	0.012		
GBGL18524-15|Creatonotos_transiens|Chambal, Himachal;	0.005	0.002	0.007	0.002	0.007	0.002	0.007	0.007	0.017	0.014	0.007	0.000	0.012	
KP233790.1_Creatonotos_transiens_Chambal Himachal_Pradesh	0.005	0.002	0.007	0.002	0.007	0.002	0.007	0.007	0.017	0.014	0.007	0.000	0.012	0.000

- Till date, approximately 700 full length sequences and 100 mini barcodes have been generated from different PA of Indian Himalaya with over 300 more under processing. The maximum number of barcodes have been generated from Neora Valley National Park. Family Geometridae consisting of the highest numbers of generated barcodes followed by Erebidae and Noctuidae. Fig 14 represents the family wise barcode generation data from the PAs till date.

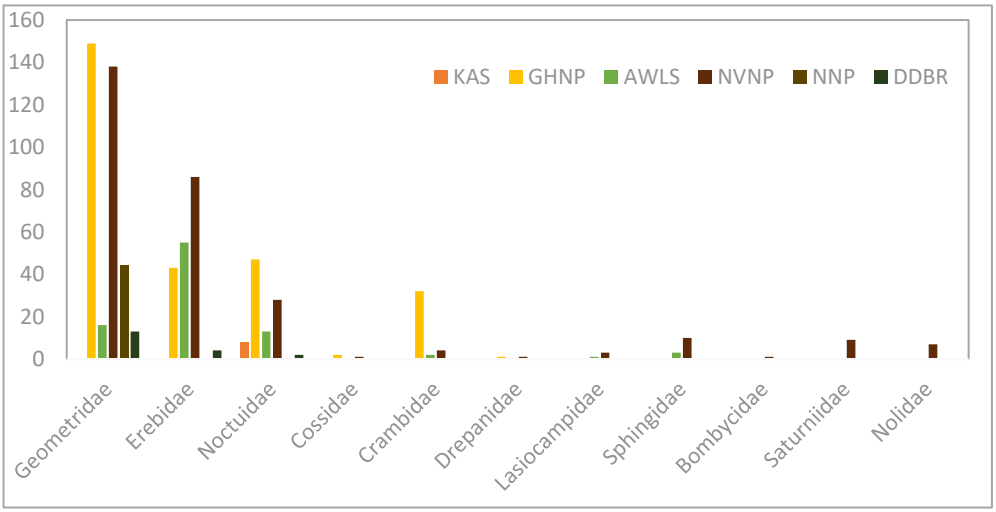


Figure 14: Family wise barcode generation data from different PA of Indian Himalaya

Descriptive File for *Ms. Kamalika Bhattacharyya*

Goal & Objectives: (I) Generation of scientific evidences in the form of reports on Lepidopteran diversity of Neora Valley National Park (NVNP), West Bengal, (II) Generation of robust datasets generated through ecological monitoring at habitat level, (III) Thesis on the subject area.

Experimental Set-up & Methodology Adapted:
Stratified random sampling was conducted at along altitudinal range of 750m-3600m from SNP and NVNP during May- July and October - November 2018. Samples were collected using benzene vapour killing bottle and curated following standard practices. Identification of specimens were conducted through wing venation and male genital studies. Comstock–Needham system were followed for wing venation and external genitalia were studied following Robinson, 1976.

Significant Findings:

- **Total Inventory & Family Composition:** A total of 63 species of moths from NVNP and 15 species from SNP identified from study area during the report period contributing 345 species of identified moths from 258 genera belonging to 58 sub-families under 20 different families from SNP & NVNP. The most specious families form the recorded assemblage were Erebidae and Geometridae followed by Crambidae, Noctuidae, Sphingidae, Nolidae, Drepanidae and Lasiocampidae (Fig 15). The most specious sub-families recorded were Arctiinae, Erebinae, Calpine, and Lymantriinae of Erebidae, followed by Ennominae and Geometriinae of Geometridae and Spilomelinae of Crambidae

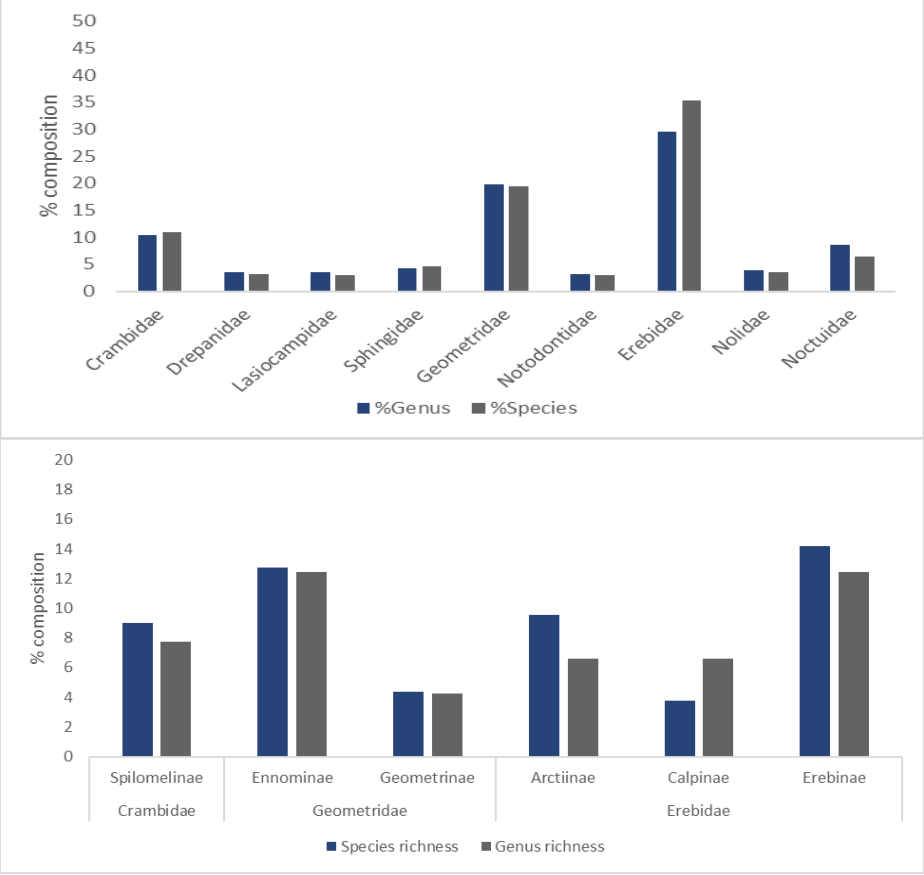
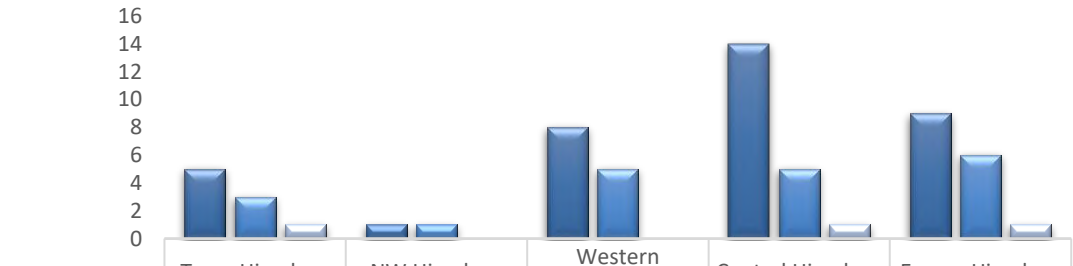


Figure 15: Percentage composition of Genus & Species of major Families and, (b) Relative Abundance of Genus & Species of Dominant subfamilies recorded from NVNP

- Some of the most specious genera were *Bastilla* (6)*, Cyana* (5), *Asota* (5)*, Eudocima* (5), *Barsine* (4)*, Lymantria* (4), *Nyctemera* (3), *Oraesia* (3)*, Thyas* (3) and *Ischyja* (3) of Erebidae; *Glyphodes* (5) and *Cydalima* (3) of Crambidae; *Achrosis* (3), *Biston* (3), *Chorodna* (3) and *Comostola* (3) of Geometridae.
- Moderate diversity of pest and open habitat species of families Crambidae and Noctuidae were recorded from mid-altitudinal region in the southern fringes of the National Park, which are affected by vicinity to agricultural land and urban development.

- **Taxonomic & Bio-Ecological Studies of Family Saturniidae:** 28 species from 11 genera of family Saturniidae were recorded from different Himalayan landscapes, v*iz*., HNP, GHNP, AWLS, SNP, NVNP & DDBR including 4 new range records. Comparison of Saturnid assemblage composition of the 5 biogeographic provinces of Indian Himalaya showed that Eastern & Central Himalaya had higher similarity in composition and that of Trans-Himalayan region was significantly unique (Fig 15)



	Trans Himalaya	NW Himalaya	Western Himalaya	Central Himalaya	Easern Himalaya
Species	5	1	8	14	9
Genus	3	1	5	5	6
New Records	1	0	0	1	1

Figure 16: Distribution of Saturniids recorded from Indian Himalaya from current study

- The mean altitudinal distribution of all the species from the region was around 2000m including both past and present records. One species each of *Neoris* was found to restricted to high altitudes of Trans Himalaya and one species of *Actias* was found to be restricted to eastern Himalaya. (Fig. 17).

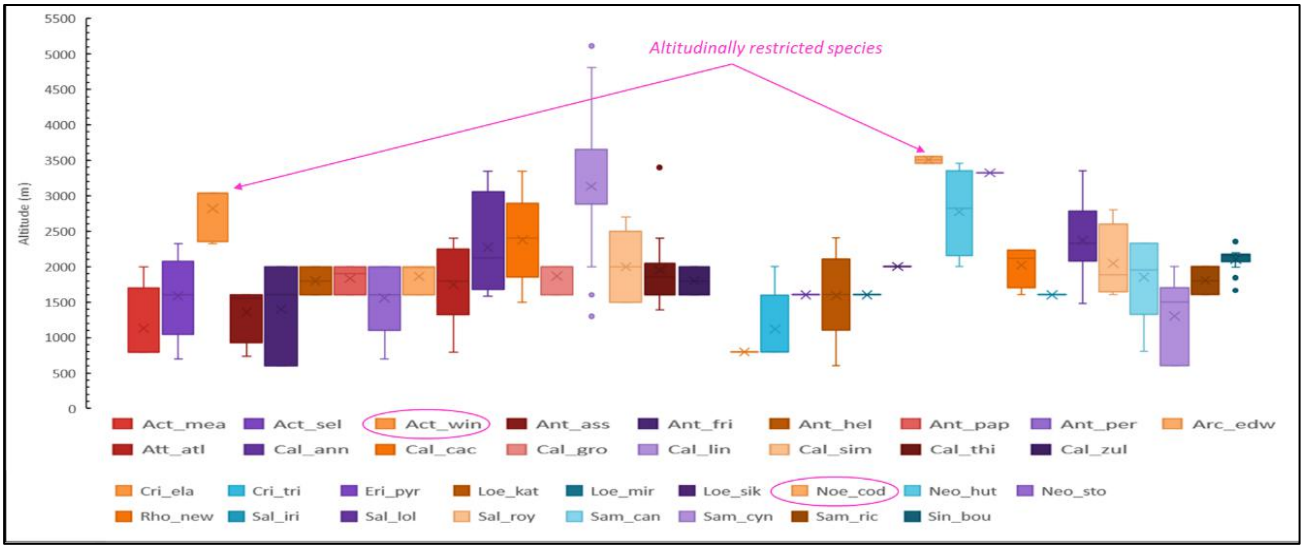


Figure 17: Altitudinal distribution of Saturniidae of Indian Himalaya

Descriptive File for *Mr. Subrata Gayen*

Goals & objectives: (i) Taxonomic inventory of moth assemblages among different elevations and vegetation types at DDBR. (ii) Determinants of assemblage pattern of moth families along Biogeographic provinces of Indian Himalaya. (iii) Morphometric analysis of wing size and other body parts among selected groups of moths across Himalayan bio-geographic provinces and attitudinal gradient.

Experimental Set-up & Methodology Adapted:

To consolidate our experimental study, we opted random stratified sampling along with the attitudinal ecoregions based on different parameters i.e. gradient, vegetation type, canopy cover and distance to water. Three different sampling period, viz. Pre-Monsoon, Monsoon and Post-Monsoon was identified to monitoring the species richness and its distributions. Till now, we have conducted light trapping in 47 major sampling sites which were categorized based on altitude and major vegetation type: Tropical Evergreen (500m-1000m), Tropical semi-evergreen (1001m-1500m), Subtropical Broadleaved forest (1501m- 2000m), Temperate Broadleaved forest (2001m-2500m) and Temperate Conifer forest (2501m-3000m). In our sampling strategy, we have tried to execute three light trap stations into a single attitudinal band to intensify the spatial replicates (Fig: 18). So far, across the Dihang Dibang Biosphere Reserve (DDBR) 3 different attitudinal gradient were identified viz. South-western having one gradient and North eastern gradient having one gradient, and north western having one gradient, altogether 82 different trap location were established across DDBR.

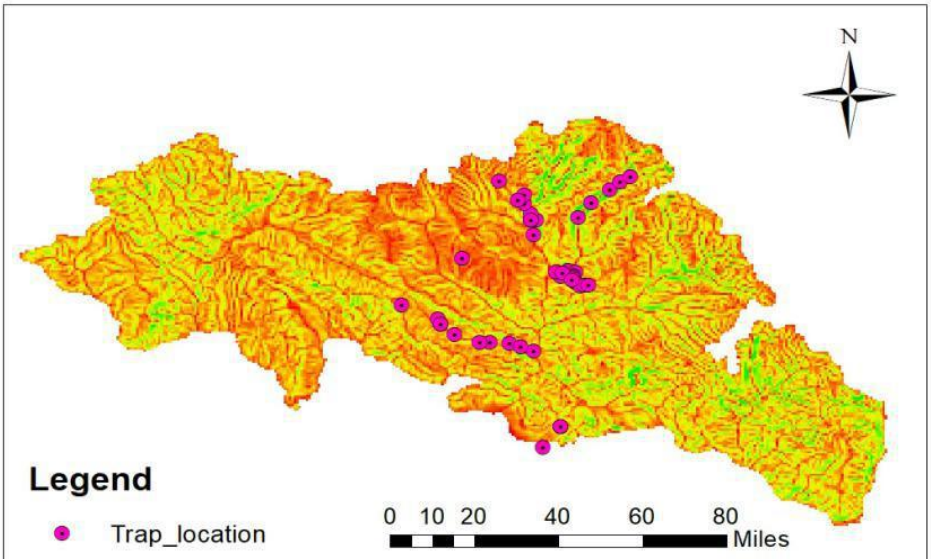


Figure 18: Light trap locations in different gradients in DDBR

Significant Findings:

- **Total Inventory & Family Composition:** From up-to-date surveys in DDBR representing 376 hours of light trapping efforts resulted 285 species of identified moths. Family Geometridae was the most dominant among the identified moths followed by family Erebidae, with respective altitude. Among Geometridae, major subfamilies are Ennominae, Geometrinae, Larentiinae followed by Orthostixinae and Sterrhinae. Subfamilies Aganainae, Calpinae, Hypeninae, Hypocalinae,

Rivulinae had minor representation. In family Erebidae, subfamily Erebinae represents dominant hierarchy classes, followed by Arctiinae, Lymantriinae, Calpinae, Lithosinae, Rivulinae. 7 species of Geometridae, and 1 species each of Erebidae, Limacodidae, Bombycidae and Epicopeiidae were recorded first time from Indian territory which were previously known from China and South-East Asia.

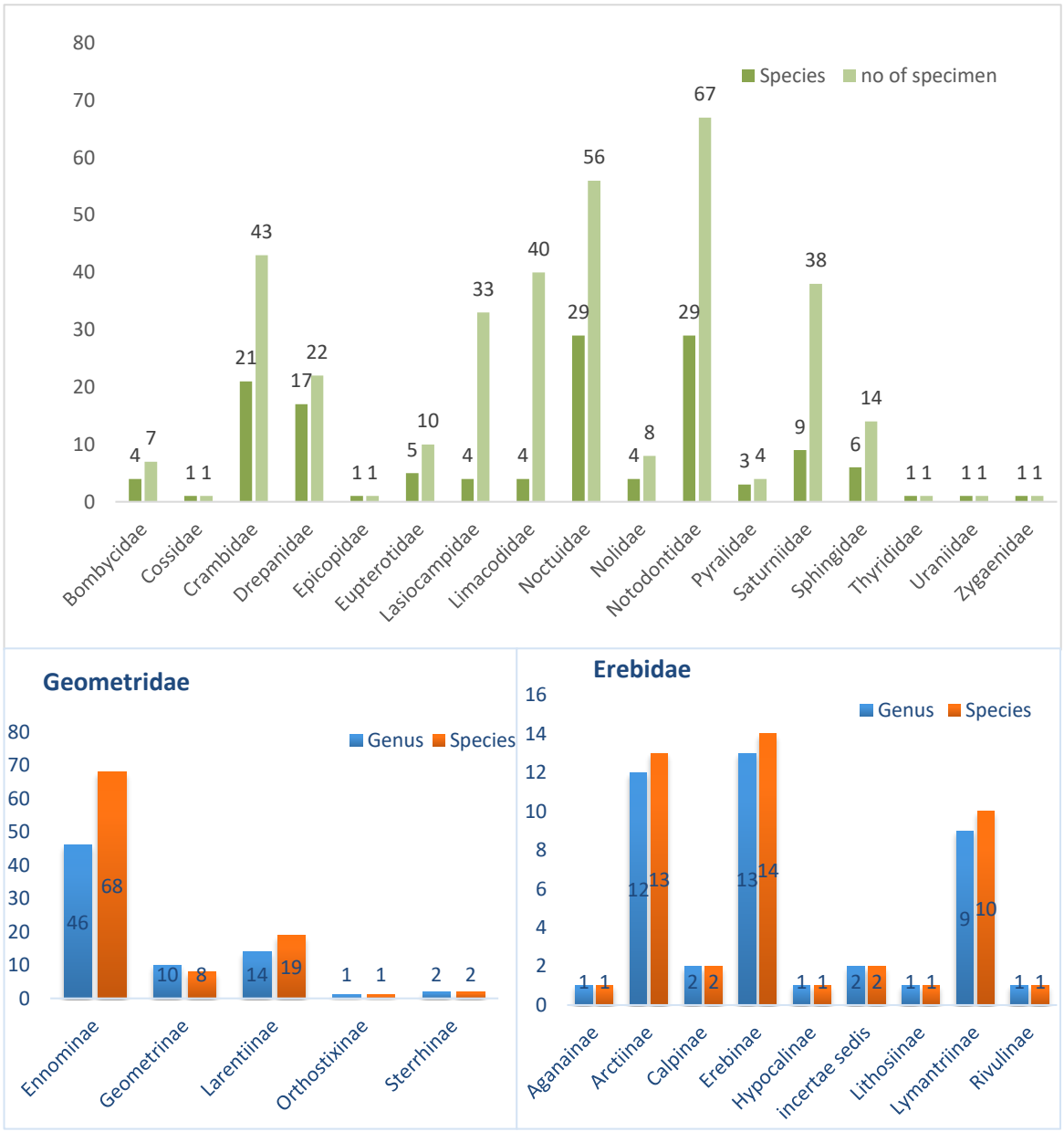


Fig. 19: (a) Assemblage Pattern and composition of different families, & Subfamily composition of (b) Family Geometridae & (c) Family Erebidae sampled from DDBR

- **Colour Morphometry of Genus Abraxas:** Insect wing colouration is an adaptive trait dependent on associated altitude and temperature. Along altitudinal gradient colours may vary from light to dark as species try to cope up with heat retention in cooler environments. I investigated proportional changes in light and dark colours on wing surface along altitudinal gradient for Geometridae genus *Abraxas*, as this genus is particularly abundant all through the gradient. Differential colour patterns were analyzed from photographs of Stretched Specimens in

TinEye Colour Extraction Software Package. Specimens from 700m, 2000m, 3000m and 3500m were selected for analysis. Preliminary result indicates that proportion of Dark colour, in this case, Brown, increased with increasing altitude whereas the light colour, Grey decreased. Our preliminary hypothesis is thus set as Dark Colouration helping in Heat Absorption, is thus Physiologically adaptive in cooler temperature of high-altitude environments.

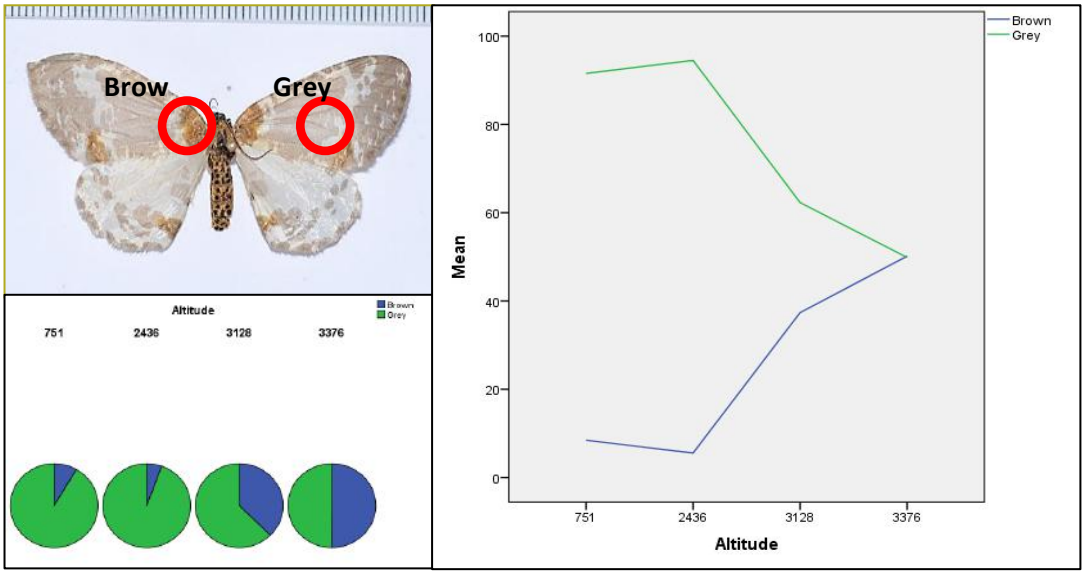


Figure 20: Proportion of dark and light colours in wing surface of genus *Abraxas* along increasing altitude

- **Species Co-Occurrence Modelling:** In community ecology existence of a species and assemblage patterns are variable according to the resources. Historical dichotomy of species existence always considers individualistic importance for survivorship, explicitly undergoing positive and negative interactions with the co-occurring species, in term of overlapping response and adaptability. Co-Occurrence Model through Non-Random Pairwise Species Association was run in Package COOCUR in R platform with 283 identified species from 47 sites in DDBR (2 species were omitted due to insufficient occurrence records). Results indicated 39,990 pairwise species association showing 8% species composition as random, whereas 11.1% species showed non-random association. Two species of family Saturniidae, *Salassa lola* and *Caligula anna* showed Positive Association which might be resulted due to similar kind of host-plant association.

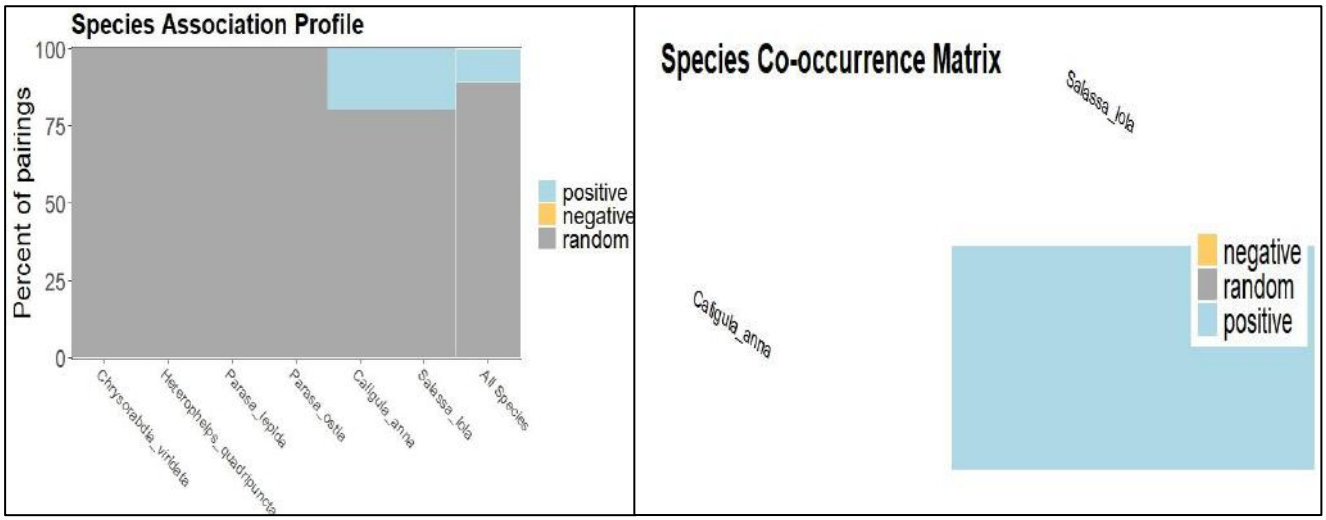


Figure 21: (a) Species association profile & (b) sympatric species composition among identified moths from DDBR

Descriptive File for *Mr. Gaurab Nandi Das*

Goal & Objectives: (I) To investigate the differential processes influencing the distribution pattern of butterfly assemblages in Indian Himalaya; (II) Generation of robust datasets generated through ecological monitoring at habitat level.

Experimental Design & Methodology Adapted

After an initial reconnaissance survey in every landscape, one GRADSECT was selected ranging from lowest altitudinal site to highest site. This GRADSECT was divided into 200m Altitude-Bins and transects were laid in each representative bin. For the purpose of sampling butterflies, we followed different trails through different habitats following modified Pollard Walk on appropriate weather condition.

Significant Findings

- In the present reporting period, a total of 450 species with 471 subspecies of butterflies belonging to 213 genera under 6 families have been recorded from entire Himalayan stretch, where Nymphalidae is the most dominant family, having 198 species followed by Lycaenidae 97 species, Hesperiidae 73 species, Pieridae 50 species, Papilionidae 42 species and Riodinidae 11 species. Of which, *Papilio* and *Lethe* were most dominant genera with 15 species of each, followed by *Mycalesis* (12 species), *Graphium* (11 species), *Athyma* (11 species), *Neptis* (10species), *Euthalia* (8 species), *Ypthima* (8 species) and all. There were stark contrast in diversity between North-Western Himalaya and Eastern Himalaya, although sampling was not uniform in the PAs covered in-between landscapes, like Central Himalaya.

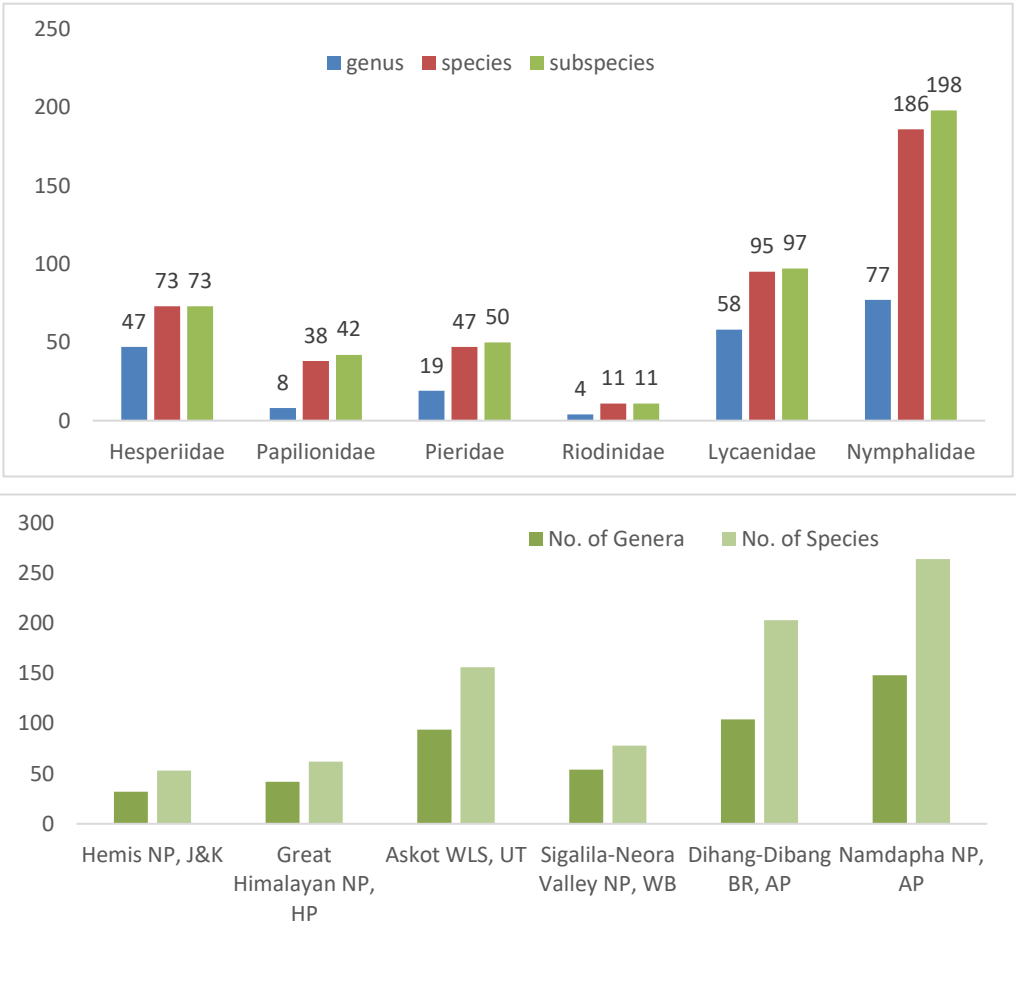


Figure 22: (a) Family composition, & (b) Number of Genera & Species of Butterflies identified in all the PAs sampled in Indian Himalayan region during 2018-2019

- Systematic sampling in Askot WLS during June-July, 2018 through 21 transects along altitudinal gradient 825m-4244m resulted in 1069 individuals representing 86 species. The diversity was maximum in 800-1600m altitude zone. In this gradient we recorded eight individuals of Common Blue Apollo (Parnassius hardwickii) from 3700m to 4200m. Systematic sampling in Dihang-Dibang BR during March-April, 2018 through 26 transects along altitudinal gradient 800-2400m resulted in 267 individuals representing 47 species. The diversity was maximum in 800m-1600m altitude zone.

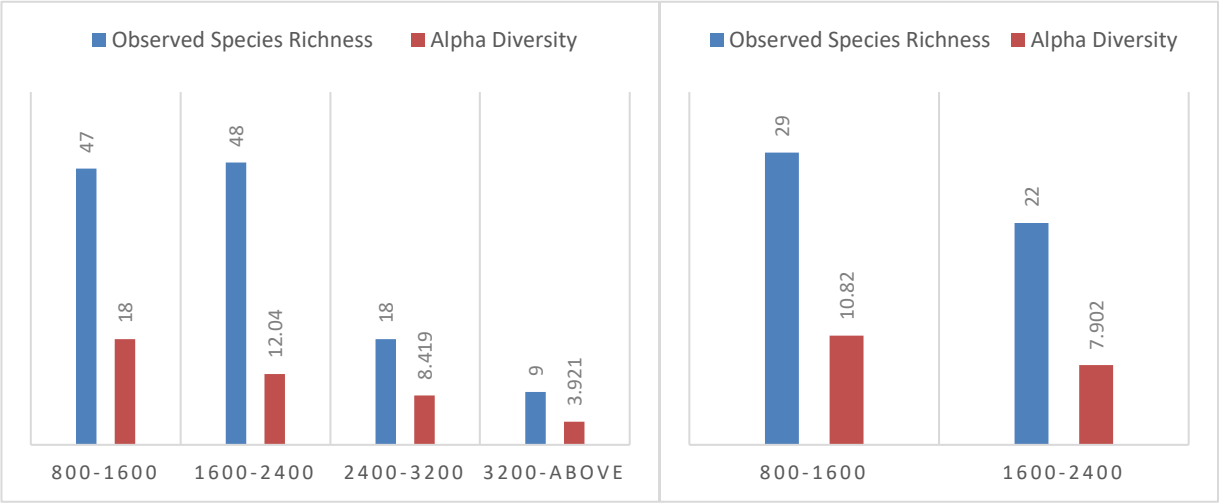


Figure 23: Diversity & Species Richness of Butterflies in different altitudinal zones of (a) Askot WLS & (b) Dihang-Dibang BR recorded during 2018-2019

- Butterfly assemblage restricted to Alpine Meadows above 3000m were identified from different Himalayan Biogeographic Provinces. Among these assemblages, Nymphalidae had highest number of genera (12) and species (16) with dominating genera like *Aulocera*, *Boloria*, *Hyponephele* and *Vanessa*. Lycaenidae was represented by 8 genera and 13 species with *Polyommatus*, *Agriades, Pamiria* with major species records. Pieridae had 16 species under 7 genera, among which most abundant were *Colias*, *Pieris* and *Pontia*. Papilionidae had 4 species belonging to 2 genera viz. *Papilio* and *Parnassius*. While Hesperiidae was represented by only 3 genera with 3 species namely *Pyrgus cashmirensis*, *Polytremis eltola* and *Carterocephalus avanti*.

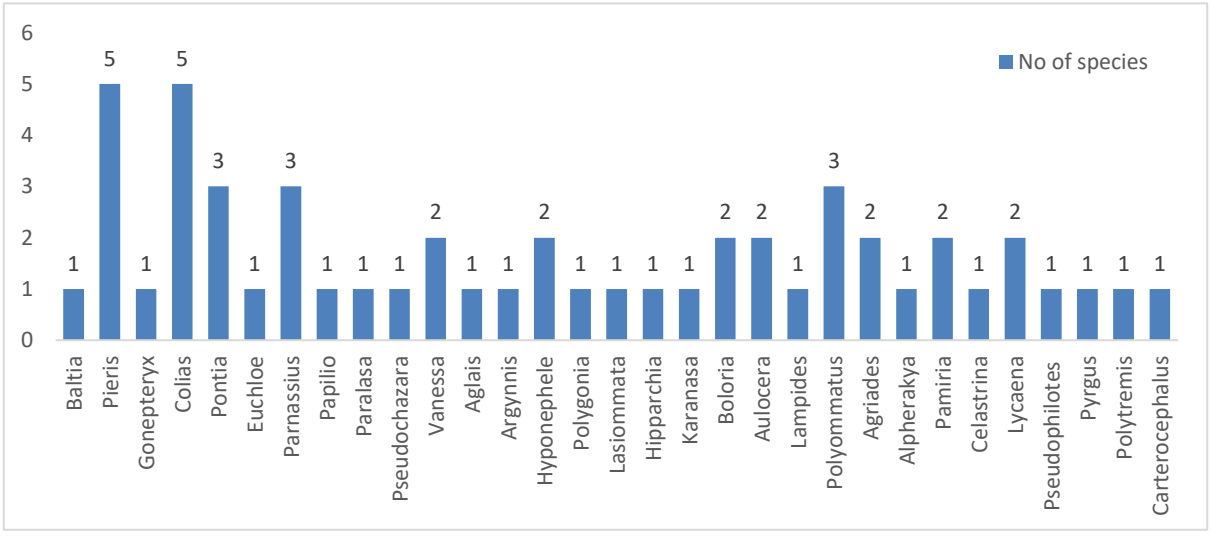


Figure 24: Butterfly Genera and their respective species number recorded from High-Altitudes (>3000m) from Himalaya

- **Significant Species Records:**
  - *Lethe dura* was recorded from Kanar village, Uttarakhand; it was first time records from Uttarakhand, previously its known distribution from Sikkim to E. Himalaya. This should be probable rang extension of the species towards western Himalaya.
  - *Polyommatus dux* Riley, 1926 was reported from Kumaon Himalaya (type locality), as only second record since its discovery. On the basis of new material, the external habitus of the male diagnosed and genitalia structures were described. The species is vulnerable to climate change driven range restriction and extinction threats, and thus considered as a candidate for flagship species for ecological studies in nature conservation investigations in the high-altitude region of the Kumaon Himalaya, India.
  - The genus *Euaspa* (Moore, 1884) (Lycaenidae: Theclinae: Theclini) of *Zephyrus* Hairstreak butterflies is represented by 13 species worldwide. Among which presently, four species had been recorded from Indian mainland. *E. motokii* Koiwaya, 2002, which was previously known only from Kachin State of Myanmar, is reported for the first time from India from the state of Arunachal Pradesh. Alongside we also report *E. mikamii* Koiwaya 2002 for the second time from India since collection of Holotype material in 1991 from Eastern Himalaya.

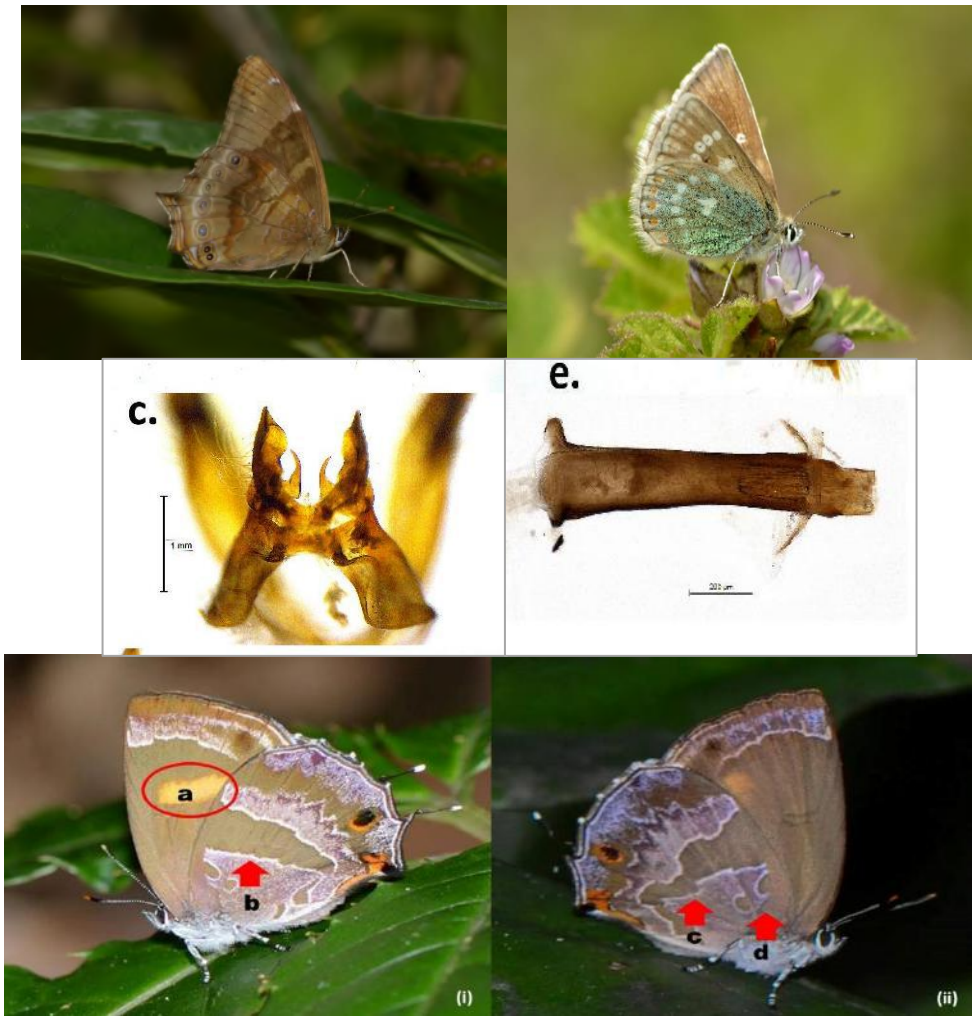


Figure 25: Significant Species records: (a) *Lethe dura*; (b) *Polyommatus dux*; (c) Male Genitalic Image of *Polyommatus dux*; (d) *Euaspa mikamii* & *E. motokii*

Descriptive File for *Ms. Moumita Das*

Goal & Objectives: (I) Study of Molecular Taxonomy of Himalayan Lepidoptera; (II) Generation of DNA barcode data of Lepidoptera from Indian Himalayas.

Experimental Design & Methodology Adapted

DNA isolation has been carried out using organic phase extraction method and silica based column kit method. Qubit Fluorometric Assay was done for quantification of the isolated DNA. Isolated samples were successfully amplified for about 648 base pairs (bp) from the 5' end of the mtCOI gene using 10 Picomoles of primer pair LEPF1-LEPR1 and LCO-HCO. Amplification for about 180 base pairs (bp) from the 5' end of the mtCOI gene was done using 10 Picomoles of primer pair MINIF-MINIR generating mini barcodes. The amplified PCR products were checked in 1% agarose gel. The PCR amplified products were purified using QIAquick Gel Extraction Kit (Qiagen, Valencia, CA) and Nucleospin Gel and PCR Cleanup Kit following the manufacturer's protocols. Approximately, 15 ng of the purified PCR product for each of the sample was used for sequencing. The cycle sequencing was performed with BigDye®Terminator ver. 3.1 Cycle Sequencing Kit (Applied Biosystems, Inc.) using 3.2 Picomoles of both forward and reverse PCR primers on a ABI thermal cycler. The cycle sequencing products were cleaned by using BigDye X-terminator kit (Applied Biosystems Inc.) and loaded on 48 capillary ABI 3730 Genetic analyser. The SeqScape software version 2.7 (Applied Biosystems Inc.) and MEGA 6.0 was used to analyze the forward and reverse chromatograms to obtain the consensus sequences. The generated forward and reverse sequences were aligned with the representative barcode sequences from global database for similarity search. The developed sequences were submitted to BOLD database under the project 'Lepidoptera of Indian Himalayas' for acquiring the BOLD-IDs.

Legs extraction and tagging were done for the samples collected from NVNP and SNP. DNA isolation has been carried out for 881 samples out of which 630 samples were amplified successfully for targeted COI barcode region.

Significant Findings

In the current reporting period 120 full length sequences has been generated and being processed for further analysis (Table.)

Table 4: List of identified samples processed for DNA Barcode from Singalila NP

DNA Code	Family	Subfamily	Genus	Species
NMH_5153	Erebidae	Calpinae	*Eudocima*	*hypermnestra*
NMH_5157	Erebidae	Erebinae	*Ischyja*	*manlia*
NMH_5158	Erebidae	Erebinae	*Ischyja*	*marapok*
NMH_5159	Erebidae	Erebinae	*Artena*	*dotata*
NMH_5160	Erebidae	Erebinae	*Ischyja*	*manlia*
NMH_5161	Erebidae	Calpinae	*Oraesia*	*rectistria*
NMH_5162	Erebidae	Calpinae	*Oraesia*	*rectistria*
NMH_5164	Erebidae	Erebinae	*Anomis*	*nigritarsis*
NMH_5165	Erebidae	Erebinae	*Mocis*	*frugalis*
NMH_5168	Erebidae	Erebinae	*Ercheia*	*cyllaria*
NMH_5171	Erebidae	Calpinae	*Daddala*	*brevicauda*
NMH_5174	Erebidae	Arctiinae	*Nyctemera*	*arctata*
NMH_5177	Erebidae	Arctiinae	*Nyctemera*	*arctata*
NMH_5178	Erebidae	Erebinae	*Ischyja*	*manlia*
NMH_5181	Erebidae	Erebinae	*Hypopyra*	*vespertilio*
NMH_5182	Erebidae	Erebinae	*Pindara*	*illibata*
NMH_5183	Erebidae	Erebinae	*Pindara*	*illibata*

NMH_5184	Erebidae	Erebinae	*Ercheia*	*cyllaria*
NMH_5190	Erebidae	Erebinae	*Lygniodes*	*hypoleuca*
NMH_5191	Erebidae	Calpinae	*Daddala*	*brevicauda*
NMH_5192	Erebidae	Calpinae	*Sphingomorpha*	*chlorea*
NMH_5193	Erebidae	Erebinae	*Arcte*	*taprobana*
NMH_5195	Erebidae	Calpinae	*Hulodes*	*caranea*
NMH_5202	Erebidae	Arctiinae	*Vamuna*	*remelana*
NMH_5204	Erebidae	Calpinae	*Erygia*	*spissa*
NMH_5205	Erebidae	Calpinae	*Ericeia*	*eriophora*
NMH_5206	Erebidae	Erebinae	*Phyllodes*	*eyndhovii*
NMH_5207	Erebidae	Calpinae	*Eudocima*	*phalonia*
NMH_5209	Erebidae	Erebinae	*Thyas*	*honesta*
NMH_5210	Erebidae	Calpinae	*Eudocima*	*materna*
NMH_5212	Erebidae	Calpinae	*Eudocima*	*sulaminia*
NMH_5213	Erebidae	Erebinae	*Thyas*	*coronata*
NMH_5262	Erebidae	Calpinae	*Supersypnoides*	*malaisei*
NMH_5268	Erebidae	Arctiinae	*Nyctemera*	*arctata*
NMH_5280	Erebidae	Hypeninae	*Hypena*	*qudralis*
NMH_5296	Erebidae	Arctiinae	*Nyctemera*	*arctata*
NMH_5298	Erebidae	Arctiinae	*Vamuna*	*remelana*
NMH_5306	Erebidae	Lymantriinae	*Numenes*	*patrana*
NMH_5313	Erebidae	Arctiinae	*Vamuna*	*remelana*
NMH_5330	Erebidae	Erebinae	*Arcte*	*coerula*
NMH_5368	Erebidae	Calpinae	*Eudocima*	*phalonia*
NMH_5490	Erebidae	Calpinae	*Sypna*	*omicronigera*
NMH_5502	Erebidae	Erebinae	*Ischyja*	*manlia*
NMH_5503	Erebidae	Erebinae	*Arcte*	*coerula*

Descriptive File for *Mr. Rahul Ranjan*

Goal & Objectives: (I) Report on status of Morphology based Taxonomy of Himalayan Lepidoptera, (II) Generation of identification keys for Himalayan Lepidoptera.

Experimental Set-up & Methodology Adapted:
The adult moths were collected with the help of light traps fitted with solar lamp and petromax lamp. Collected moths were killed with the help of ethyl acetate vapours and specimens pinned and stretched on stretching boards. Before identification, tentative sorting of the collections has been completed. External male and female genitalia were studied by dissecting them out from the adult moths. The procedure includes detachment of abdomen and dipping in 10% KOH overnight to soften the chitin and for dissolving away the muscles and other unwanted parts.

Identification was done on the basis of different taxonomic characters like general colouration, labial palpi, type of antennae, wing venation and maculation, different characters of legs and external male and female genitalia. Relevant literature has been followed for the same. The photography of adult moths had been done with the help of digital camera and the external male and female genitalia has been photographed with the help of Leica image processing unit.

Significant Findings:

- 335 examples have been identified under the family Crambidae, Pyralidae, Erebidae Lasiocampidae and Endromidae.

- One new species under the family Endromidae submitted for publication entitled **"The genus *Mustilizans* Yang, 1995 (Lepidoptera, Endromidae) from India with the description of a new species".** This species was collected from the Dihang Dibang Biosphere Reserve (DDBR), Arunachal Pradesh.

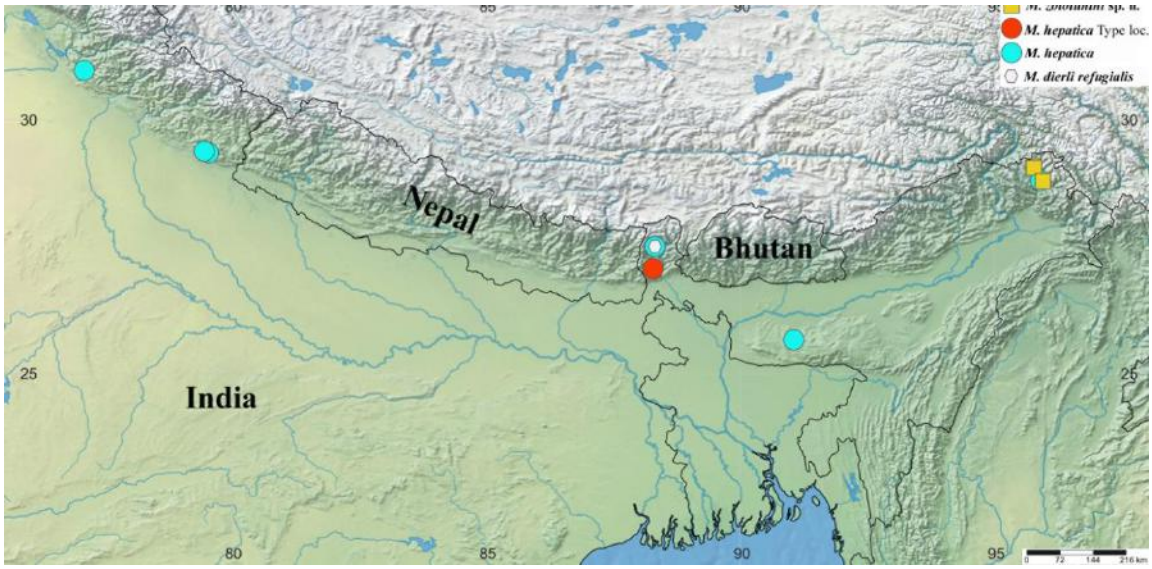


Figure 26: Map showing the distribution of *Mustilizans* sp. along with the new species from India

- The genus *Abraxas* (Geometridae: Ennominae) is a highly cryptic group consisting of several similar looking species. Moreover, they are habitat-specific and present all through the Himalayan altitudinal gradient. During current course of study 86 specimens of *Abraxas* comprising different species were collected, among which 80 specimens have been investigated during this year, some specimens and their respective male and female genitalia are provided below.

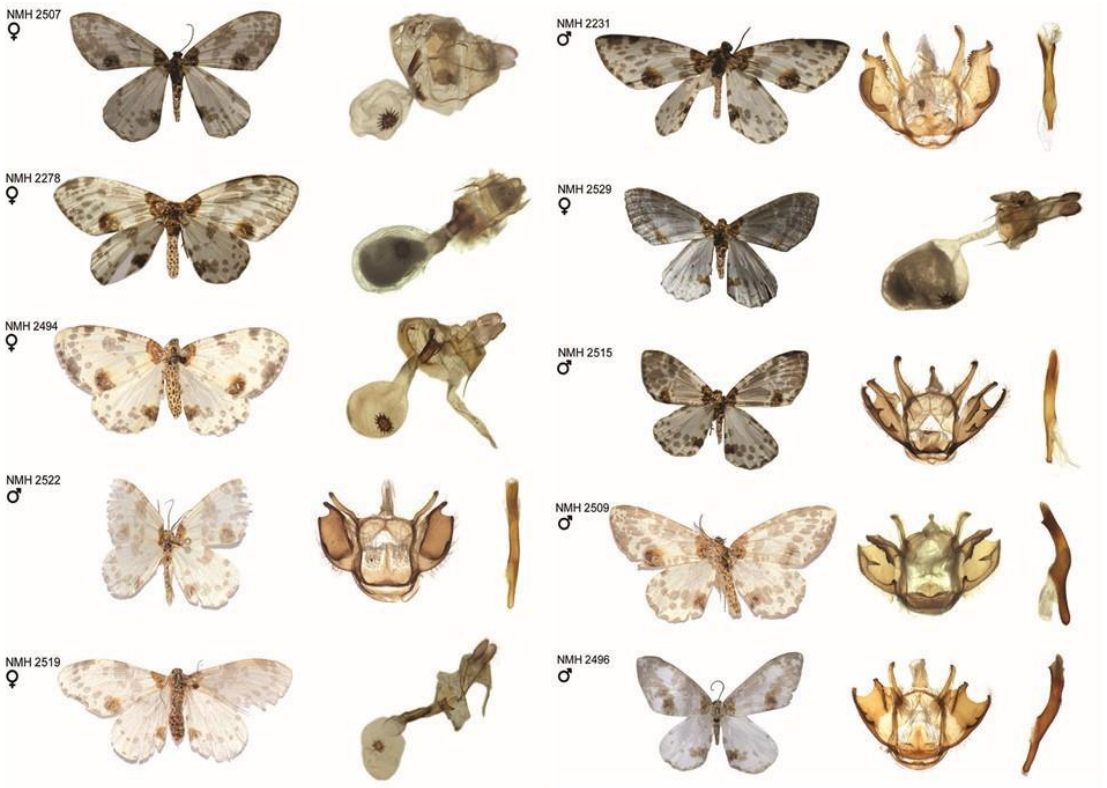


Figure 27: Morpho-taxonomic investigation of genus *Abraxas* consisting of imagos and male & female genitalias under the following species: *Abraxas sublepida*, *Abraxas martaria*, *Abraxas neomartaria*, *Abraxas leopardiana*, *Abraxas paucinotata* and *Abraxas illuminata*

1. No. of Research Publications:

Published: **02**

a) Chandra, K., Mazumder, A., Sanyal, A. K., Ash, A., Bandyopadhyay, U., Mallick, K. and Raha, A., 2018. Catalogue of Indian Notodontidae Stephens, 1829 (Lepidoptera: Noctuoidea). Zootaxa, 4505(1): 1-84. DOI: https://doi.org/10.11646/zootaxa.4505.1.1

b) Kumar, V., Kundu, S., Chakraborty, R., Sanyal, A., Raha, A., Sanyal, O., Ranjan, R., Pakrashi, A., Tyagi, K. and Chandra, K., 2019. DNA barcoding of Geometridae moths (Insecta: Lepidoptera): a preliminary effort from Namdapha National Park, Eastern Himalaya. Mitochondrial DNA Part B: Resources, 4(1): 309-315. DOI: https://doi.org/10.1080/23802359.2018.1544037.

Conferences Proceeding: **10**

a) Altitudinal and Biogeographic distribution of Indo-Chinese genus Psyra (Geometridae: Ennominae) from Indian Himalaya. Kaushik Mallick, Vikas Kumar and Kailash Chandra. (5th Asian Lepidoptera Conservation Symposium, 13-14th December, 2018, Hong Kong)

b) Pyraloidea (Pyralidae & Crambidae) assemblage along bio geographic provinces of Indian Himalaya. Rahul Ranjan, Vikas Kumar and Kailash Chandra.
(5th Asian Lepidoptera Conservation Symposium, 13-14th December, 2018, Hong Kong)

c) Notodontidae of Indian Himalayan Region: A spatial approach. Arna Mazumder, Angshuman Raha and Kailash Chandra.
(5th Asian Lepidoptera Conservation Symposium, 13-14th December, 2018, Hong Kong)

d) Smaller Wing Size & darker colour: High altitude adaptation of genus Abraxas across various provinces of Indian Himalaya. Subrata Gayen, Vikas Kumar and Kailash Chandra.
(5th Asian Lepidoptera Conservation Symposium, 13-14th December, 2018, Hong Kong)

e) Up above or go below? Altitudinal changes in species of Noctuidae restricted to Alpine Areas of Indian Himalaya. Uttaran Bandyopadhyay, Vikas Kumar and Kailash Chandra.
(5th Asian Lepidoptera Conservation Symposium, 13-14th December, 2018, Hong Kong)

f) Lepidoptera as Potential Indicator Taxa for Tracking Climate Change: An Initiative undertaken in Indian Himalayan Landscape. Kailash Chandra, Vikas Kumar, Abesh Kr. Sanyal, Angshuman Raha & John Caleb
(5th Asian Lepidoptera Conservation Symposium, 13-14th December, 2018, Hong Kong)

g) Wild Silk Moths (Lepidoptera: Saturniidae) and their suitability in Climatic Monitoring in Indian Himalaya. Kamalika Bhattacharyya, Vikas Kumar and Kailash Chandra.
(5th Asian Lepidoptera Conservation Symposium, 13-14th December, 2018, Hong Kong)

h) Exploring the suitability of Apollo species (Papilionidae: Parnassini) as Indicator of Climate-Changes in Indian Himalaya. Mohd. Ali, Vikas Kumar and Kailash Chandra.
(5th Asian Lepidoptera Conservation Symposium, 13-14th December, 2018, Hong Kong)

i) Butterfly assemblage of Himalayan High Altitudes: A Model System to investigate effect of climate change on restricted-range species. Gaurab Nandi Das, Vikas Kumar and Kailash Chandra.
(5th Asian Lepidoptera Conservation Symposium, 13-14th December, 2018, Hong Kong)

j) What Defines the Structure & Diversity of Moth Assemblages in an Altitudinal Gradient: An Experiment in Western Himalaya, India. Abesh Kumar Sanyal, Kailash Chandra and V. P. Uniyal.
(5th Asian Lepidoptera Conservation Symposium, 13-14th December, 2018, Hong Kong)

Accepted Articles: **03**

a) Bhattacharyya, K. and Chandra, K. 2019. First record of *Yponomeuta antistatica* (Meyrik, 1931) (Lepidoptera: Yponomeutidae) from India. Accepted in Entomological News on 04.01.2019.

b) Bandyopadhyay, U., Raha, A., Sanyal, A. K., Gayen, S. and Chandra, K. Description of a new species of *Donda* Moore, 1882 (Lepidoptera: Noctuidae: Pantheinae) from the Western Himalayas, India. Accepted in Entomological News on 11.01.2019.
c) Singh, N., Bhattacharyya, K., Volynkin, A. and Chandra, K. A new species of *Cyana* (Elwes, 1890) from India. Accepted in Zootaxa on 26.03.2019.

Under Review: **02**

a) Das, G. N., Gayen, S., Saito, M., Chandra, K. Notes on Genus *Euaspa* (Moore, 1884) (Lepidoptera: Lycaenidae) and its new distribution records to Eastern Himalaya, India. C*aucasian Entomological Bulletin.*
b) Das, G. N., Gayen, S., Sanyal, A. K., Bálint, Z., Chandra, K. A lesser-known butterfly from Uttarakhand, Western Himalaya: *Polyommatus dux* Riley, 1926 (Kumaon Meadow Blue) (Lycaenidae: Polyommatinae: Polyommatini). *JoTT.*

2. No. of Data Sets generated: 03

- Identified Himalayan species list (Moth & Butterflies) comprising of 1131 moths and 471 butterflies.
- *Abraxas* morphological/DNA sequences DNA data sets
- Project Console-Lepidoptera of Indian Himalayas [ZSILH]: Sequence data belonging to 21 families of Lepidoptera (18 families of Rhopalocera and 3 families of Heterocera).

3. No. of Conferences/ Workshops attended: 03

a) "Workshop on Species Distribution Modelling with MaxEnt and R" held at Indian Statistical Institute, Kolkata from 3rd to 9th December, 2018 was attended by Ms. Rushati Dey.
b) "5th Asian Lepidoptera Conservation Symposium", held at University of Hong Kong, Hong Kong from 13th to 14th December, 2018, was attended by Ms. Kamalika Bhattacharyya and Mr. Mohd. Ali. Best Presentation Award has been achieved by Ms. Kamalika Bhattacharyya during the symposium.
c) "National Seminar-cum-Monitoring & Evaluation (M&E) Workshop-2019", held at GBPNIHESD HQs, Kosi-Katarmal, Almora, Uttarakhand from 4th to 7th February, 2019 was attended by Dr. Abesh Kumar Sanyal.

4. No. of Sites/ Study Area Covered: 06

i. Hemis National Park, Jammu & Kashmir (1 gradient explored)
ii. Great Himalayan National Park, Himachal Pradesh (2 gradients explored)
iii. Askot Wildlife Sanctuary, Uttarakhand (1 gradient explored)
iv. Dihang-Dibang Biosphere Reserve, Arunachal Pradesh (2 gradients explored)
v. Singalila National Park, West Bengal (1 gradient explored)
vi. Manedara, West Bengal (1 Historical monitoring plot established and sampled)
vii. Dharamshala, Himachal Pradesh (1 Historical monitoring plot established and sampled)

5. No. of Best Practices suitable for IHR: NA

6. New Observations/ Innovations:

Family Notodontidae: Two species from genera *Phalera* Hübner, 1819 (Phalerinae) and *Nerice* Walker, 1855 (Notodontinae) has been identified as new to science.

Four species from genera *Fentonia, Syntypistis*, *Phalera* and *Pheosia* have been recorded as new to India.

Family Noctuidae: One new species of genus *Donda* has been described and eight species from genera *Mythimna, Dichagyris, Heliothis, Acronicta, Cucullia, Euxoa, Isochlora and Anarata* has been recorded as new to India.

Family Geometridae: Four species of genera *Psyra* Walker, 1860 (Ennominae) has been identified as probable new to science/Paper under preparation for *Zootaxa.*

Ten species of genera *Chorodna, Dilophodes, Platycerota, Pseudomiza, Trimandromorpha, Docirava, Naxa, Sirinopteryx, Xenortholitha* and *Perizoma* has been recorded as new to India.

Family Erebidae: One new species of genus *Cyana* has been described and six species from genus *Drasteria, Scoliopteryx, Eurogramma, eudocima* and *Supersypnoides* has been recorded as new to India.

Other Families: Five species from families Limacodidae, Bombycidae, Epicopidae, Uraniidae and Cossidae are also identified as new country records.