Ecological assessment of Geometridae moths (Lepidoptera: Heterocera) along altitudinal gradient in Dhauladhar mountain range in Kangra (North Western) and Lahaul & Spiti (Trans Himalaya) regions of Himachal Pradesh

THESIS

SUBMITTED TO THE

FOREST RESEARCH INSTITUTE DEEMED to be UNIVERSITY

DEHRADUN, UTTARAKHAND

For

the award of the degree of

DOCTOR OF PHILOSOPHY IN FORESTRY

(Wildlife Science)

By

Shabnam Kumari

under the supervision of

Dr V P Uniyal
Former Scientist-G
Wildlife Institute of India

Dr Kailash Chandra
Former Director
Zoological Survey of India

Research Centre

Wildlife Institute of India, Dehradun

Year

2024

To my parents, family members and supervisors ....

And the beautiful winged lives (moths) sacrificed in search of the knowledge ......

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Certificate of Pre-thesis Presentation

This is to certify that Ms. **Shabnam Kumari** (Registration no. **18PHD501**), carried out research work under the supervision of **Dr. V P Uniyal**, Former Scientist-G, Wildlife Institute of India, Dehradun and co-supervision of **Dr. Kailash Chandra**, Former Director, Zoological Survey of India, Kolkata. The topic of the research registered with FRI (Deemed to be) University was "**Ecological assessment of Geometridae moths (Lepidoptera: Heterocera) along altitudinal gradient in Dhauladhar mountain range in Kangra (North Western) and Lahaul & Spiti (Trans Himalaya) regions of Himachal Pradesh**". The scholar presented her work in the pre-thesis submission seminar held on **16th August 2024**, and the RAC found the work to be satisfactory and approved the work to be presented in the form of thesis for evaluation by examiners for "Award of Ph.D. Degree" by FRI (Deemed to be) University.

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This is to declare that the thesis titled "**Ecological assessment of Geometridae moths (Lepidoptera: Heterocera) along altitudinal gradient in Dhauladhar mountain range in Kangra (North Western) and Lahaul & Spiti (Trans Himalaya) regions of Himachal Pradesh**", submitted by me, **Ms. Shabnam Kumari** (Registration no. 18PHD501 dated 01.03.2019) to **Forest Research Institute** (Deemed to be) University (FRI), Dehradun for the award of the degree of Doctor of Philosophy in Forestry (Wildlife Science), is a record of original research work carried out by me during the period from 2019 to 2024 under the guidance of **Dr. V P Uniyal**, Former Scientist-G, Wildlife Institute of India, Dehradun and co-supervision of **Dr. Kailash Chandra**, Former Director, Zoological Survey of India, Kolkata.

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Date: 28.08.2024
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CERTIFICATE

Certified that the thesis of Ms. **Shabnam Kumari**, titled "**Ecological assessment of Geometridae moths (Lepidoptera: Heterocera) along altitudinal gradient in Dhauladhar mountain range in Kangra (North Western) and Lahaul & Spiti (Trans Himalaya) regions of Himachal Pradesh**", is a record of bonafide research work submitted to the Forest Research Institute (Deemed to be) University, Dehradun, for the award of Doctor of Philosophy (PhD) in Forestry (Wildlife Sciences) from Wildlife Institute of India under my supervision. To the best of my knowledge, she has not submitted the same research work to any other institution for any degree/diploma, associateship, fellowship or other similar titles. The thesis submitted is a record of independent and original research work she did during the study period under my supervision. It fulfils all the ordinance requirements governing the award of a PhD degree from FRI (Deemed to be) University, Dehradun. This thesis has been duly verified through DrillBit for plagiarism, as approved by the FRI (Deemed to be) University, and has plagiarism to acceptable limits. I further confirm that Ms. Shabnam Kumari has adequate attendance during her thesis work and she was not engaged in any paid assignment.

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Certificate of Co-supervision

This is to certify that the thesis of Ms. **Shabnam Kumari**, titled "**Ecological assessment of Geometridae moths (Lepidoptera: Heterocera) along altitudinal gradient in Dhauladhar mountain range in Kangra (North Western) and Lahaul & Spiti (Trans Himalaya) regions of Himachal Pradesh**", is a record of bonafide research work submitted to the Forest Research Institute (Deemed to be) University, Dehradun, for the award of Doctor of Philosophy (Ph.D.) in Forestry (Wildlife Sciences) from Wildlife Institute of India under my co-supervision.

To the best of my knowledge, she has not submitted the same research work to any other institution for any degree/diploma, associateship, fellowship or other similar titles. The thesis submitted is a record of independent and original research work she did during the study period under my supervision. It fulfils all the ordinance requirements governing the award of a PhD degree of FRI (Deemed to be) University, Dehradun. I further confirm that this thesis has been duly verified through DrillBit for plagiarism, as approved by the FRI (Deemed to be) University, and has plagiarism to acceptable limits.

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It is certified that the Ph.D. thesis entitled **"Ecological assessment of Geometridae moths (Lepidoptera: Heterocera) along altitudinal gradient in Dhauladhar mountain range in Kangra (North Western) and Lahaul & Spiti (Trans Himalaya) regions of Himachal Pradesh"** submitted by **Ms. Shabnam Kumari** has been examined by Library and Documentation Centre of Wildlife Institute of India for plagiarism check as per UGC (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulations. The following inferences are drawn from this check:

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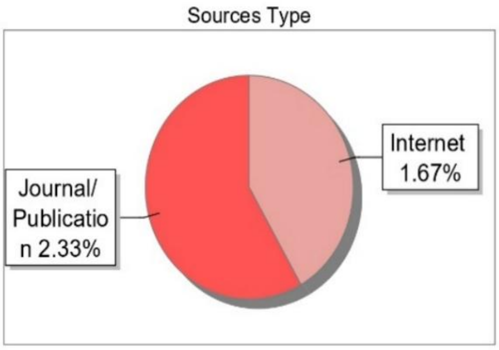

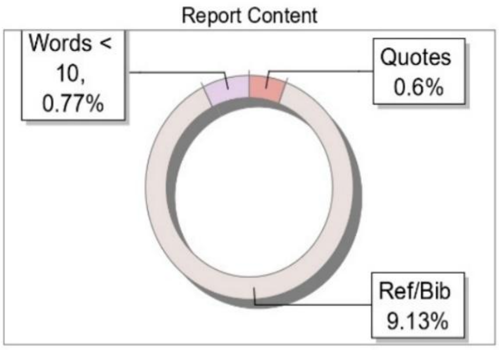

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CONTENT

Acknowledgements

I was hesitant to choose 'entomology' during my MSc because of the intimidating task of memorising numerous insect orders. Also, my knowledge of moths was confined to knowing only the names and life histories of common agricultural pest species from the economic entomology section. But later I ended up pursuing my doctorate in entomology, studying the diversity and ecology of moths in Himachal Pradesh. My journey began through collaboration with a project under the National Mission on Himalayan Studies (NHMS) focused on Himalayan Lepidoptera. Notably, Dharamshala, located on the Western end of Dhauladhar Mountain Range (DMR) and close to my hometown, is a very important type locality for moths. Many moth species have been described mentioning Dharamshala as their type locality, but there had been no systematic documentation of moth diversity done previously in DMR. To address this research gap and to make our research plan more comprehensive, the Lahaul and Spiti areas were included. These regions are not only mostly unexplored for moth diversity but also have a great potential to hold a unique and endemic diversity of moths.

Science was always my favourite subject but there are a few of my teachers and seniors worth mentioning as they ultimately guided me towards research. Their engaging and thought-provoking teaching sparked my love for learning and deepened my pursuit of knowledge. Mr. Arun Singh (my biology lecturer) was instrumental in developing a strong foundation for my future studies. Whenever I look back on my journey, it was his teaching that triggered my interest in natural sciences. As I progressed, my college and university professors helped me to expand my knowledge of animal world. Dr. Shriya Bhatt introduced me to biochemistry and other tech-based subjects. It was she who highlighted the perks of being a university scholar that further paved the way towards my master's journey at Himachal Pradesh University, Shimla (otherwise, I might have followed my father's wish and pursued civil services).

I am deeply grateful to my PhD supervisor, Dr V. P. Uniyal, Former Scientist-G, Wildlife Institute of India (WII), Dehradun and now a Professor Adjunct, Graphic Era (Deemed to be) University, Dehradun, Uttarakhand. I wouldn't have been able to register for the PhD program at the WII without his initial support during the interview. It was his initial idea for my PhD research which we further refined and developed as an acceptable doctoral research synopsis. I am especially thankful to him for acquiring the LepiLED light trap, which significantly eased otherwise a very rigorous fieldwork associated with traditional light-trapping method of moth sampling. His continuous guidance and the resources he provided, have played a crucial role in shaping and advancing my career as a doctoral researcher. I am also sincerely thankful to my co-supervisor, Dr. Kailash Chandra, Former Director, Zoological Survey of India (ZSI). It was only through his initial support and guidance that I was able to equip myself with the basics of Lepidoptera taxonomy. His continuous support has always been instrumental in achieving different targets and completing this humongous task. It has been a privilege to work under the guidance of two of the best mentors who are working tirelessly to advance insect science and conservation in India and providing unwavering support to their students. My heartfelt thanks and deepest gratitude to both of you for inspiring and guiding me at every step of my journey.

I am highly indebted to the Ministry of Human Resource Development for their Council of Scientific and Industrial Research (CSIR) fellowship program that supported my [file no. 09/668(0011)/2019-EMR-1] doctoral research work for five years. My sincere thanks go to Mr. V. R. Tiwari, Director and Dr Ruchi Badola, Dean of the WII, for providing the institutional support. I thank the faculty and staff of the WII for providing a conducive environment for my academic growth and research. Special thanks go to Mr. Rakesh Sundriyal, Lab Officer, Wildlife Biology Lab, and other staff members of the lab for their unconditional support and help during the laboratory work of specimen preparation and identification. My sincere gratitude to the Research Advisory Committee (RAC) members for their time and expertise in reviewing and finalising the synopsis. Thanks are also due to the Principal Chief Conservator of Forest (Wildlife), Forest Department Himachal Pradesh, and all officials of the Himachal Forest Department for providing all necessary permissions (letter no. WLM/Research Study/5000), and logistic support during the fieldwork.

The pandemic posed a significant challenge to my fieldwork. First, it delayed the fieldwork for a year, and also there were times when I was refrained from crossing the villages in midway of the sampling. This situation was one of the many situations of panic during this journey. I am grateful to Deepu Bhaiya, Kartik and Aartik (my cousins), who volunteered to be my field assistants for most of my work. Their help along with the support from other family members, made this rigorous fieldwork both manageable and enjoyable.

This work would not have been successful without the initial training in basic taxonomic techniques provided by Dr. Navneet Singh, Scientist-E, ZSI, Kolkata. I was also fortunate to meet a stalwart on moth taxonomy in India, Dr. Jagbir Singh Kirti during his visit at the WII campus. A short two-day personnel interaction with him along with a detailed lecture on moths helped me gain some invaluable insights and a deeper understanding of moth taxonomy and ecology in the early phase of my career. Thanks are due to all of the PhD students of Dr Jagbir and Dr Navneet, working on moths' taxonomy in India, namely, Dr Harbinder Singh Dutta, Dr Rahul Ranjan, Dr Harsimran Singh and Mr Manpreet Singh. They always helped me to clarify my confusions whenever needed. I would especially like to thank Dr. Harbinder for helping me develop the basic techniques of moth taxonomy at ZSI.

I was lucky enough to be guided by a large team of moth experts who were my seniors. Dr Abesh Kumar Sanyal, a pioneer moth ecologist in India, Dr Angshuman Raha, Dr Kaushik Mallick, and the entire Himalayan Lepidoptera team of ZSI. All of you have helped me to develop a solid foundation in the basics of moth research. I would also extend my sincere gratitude to Dr Pritha Dey, my immediate senior, who completed her PhD on Geometridae moths just before my joining. She always helped me with various things remotely throughout this journey. It was only because of her positive influence that I was fortunate to be guided by the world's leading expert on Geometridae moths, Dr. Axel Hausmann, SNSB-ZSM, Munich.

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WII offers a beautiful and serene campus to work in, where one can find solace in its natural beauty. I will always hold deep gratitude for being an alumnus of this institution that nurtured my growth, kept me motivated throughout my journey, and is home to brilliant researchers. Dr. Aashna Sharma has always inspired me to be consistent in work. Her valuable inputs not only resolved my confusions but also enhanced my understanding of the ecological analysis related to my work. She was always there to guide or support me whenever I needed clarity or direction. I am grateful to Dr. Bhim Singh and Dr. Kumudani Bala Gautam, who made the sequence and phylogenetic analyses easier for me. I thank Mr. Vabesh Tripura and Ms. Kratika Goswami for their help with the manuscript preparation.

There is a very famous quote asking what matters the most, is the journey or the destination, and it says it is companionship which matters the most. I was fortunate enough to share my journey to complete this thesis with my incredibly talented, fun-loving friends and family members. Your presence has made this journey truly memorable; whether it was navigating through challenges or celebrating successes, your unwavering support and companionship have been invaluable. I am grateful to one and each of the lessons learned and the experiences shared with each of you along the way.

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Words would not be able to justify or express my gratitude for the love, sacrifices and support of my family members—Mummy, Papa, Bhaiya, and Bhabhi. Your boundless love, unwavering understanding, and constant encouragement have been the driving force that inspired me to complete this journey. A special mention to my tiny newborn nephew, Ashvik, whose birth gave me a sense of responsibility, kept me grounded and his innocent smile continually compelled me to finalize this thesis with utmost diligence and dedication. I am profoundly grateful to my two beloved long-distance, always-a-call-away friends, Shivani Balyan and Archana Thakur, who always listened, supported and motivated me to persist through every challenge. Every journey is the toughest towards its end, with the steepest climb in the last. When everything felt uncertain and almost unreal, it was an unexpected shower of love and care by Mr. Shakti Prajapati that helped me complete this nearly impossible-to-end journey. I could not have finished it without your unconditional love, care, and constant belief in me.

Finally, I acknowledge God or a higher power for guiding me throughout my journey and for all my life's blessings. I may have also missed many names or events who have been directly or indirectly instrumental to the completion of this thesis. Nevertheless, I am deeply grateful to one and all who have been the part of this journey and I will always remember their support with heartfelt gratitude.

This study owes a profound debt to the delicate and beautiful winged lives of the moths, who were sacrificed in the way of deepen understanding of moth ecology and advance our knowledge of their diversity and conservation in the intricate Himalayan ecosystems.

Place: Dehradun

Date: 30.12.2024 (Shabnam Kumari)

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Summary

This thesis investigates the ecology (diversity and distribution patterns) of Geometridae moths across the altitudinal gradients of the Himalayan and Tran Himalayan regions in Himachal Pradesh. Geometridae moths are the famous insect herbivore surrogate taxa. They have been studied globally across different mountain systems. Through the documentation of species diversity, and the analysis of ecological patterns associated with these moths, this study aimed to contribute towards a better understanding of biodiversity dynamics in the Himalayan region. The research findings hold significant implications as a comprehensive baseline information on the species diversity and community dynamics of Geometridae moths in the region along with insights from the zoogeographic analysis. It also highlights future research needs and conservation concerns in light of the impacts of climate change and human-driven changes in land-use patterns in the region.

Background and Objectives

Altitudinal gradients of biodiversity are a fundamental concept in ecology, representing continuous changes in environmental factors and species distributions along mountain slopes. Along with latitudinal gradients, they comprise the two most important spatial gradients for defining and understanding biodiversity patterns and species composition across space and time. Latitudinal gradients are the earth's primary spatial gradients, representing changes in biodiversity and climate from the equator to the poles. Because these changes occur very gradually over the distance of hundreds to thousands of kilometres, investigating latitudinal gradients to understand biodiversity on Earth poses significant logistical challenges. Compared to this, altitudinal gradients compress similar climatic changes over much shorter (and logistically convenient) vertical distances of few kilometres. Also, due to differences in origin, size, geological history, and zoogeographical location, altitudinal gradients of the world's mountains provide multiple scales for such studies. Therefore, scientists often use altitudinal gradients as 'natural experimental laboratories. These gradients can be used for the study and analyses of species adaptations and diversification in the different environmental conditions, patterns of species richness and their underlying drivers, and the impact of climate change on species and ecosystem dynamics, in controlled and natural settings.

Along altitudinal gradients, high-altitude ecosystems—typically found above the timberline at altitudes above 2500–3000 m up to mountain summits—are characterised by

extremely harsh topoclimatic conditions. These systems are extremely fragile and ecologically very sensitive because of their harshness and spatial and climatic isolation. The flora and fauna here are intricately adapted to the local environmental conditions on a small geographical scale and have developed in situ and pari passu along with the upliftment of this region. Therefore, they are particularly specialised and vulnerable to even small changes in the system. The global warming can disrupt the delicate balance of these high-altitude systems by stimulating and favouring the upward shift of the species ranges from lowland habitats. Moreover, anthropogenic pressure threatens the very nature and survival of land-use patterns in this ecosystem. Despite its ecological importance and vulnerability, this ecosystem has been very poorly researched. Therefore, understanding the dynamics of these systems is important for the effective conservation, predicting future ecological changes and ensuring the preservation of their uniqueness (in terms of species and habitats) in the wake of climate change and human-induced habitat alteration.

Indian Himalayan Region (IHR) plays a crucial role in maintaining the ecological integrity of the Indian subcontinent. It acts as a significant natural barrier that influences and maintains regional climate, hydrology and biodiversity. This region lies at the crossroads of different zoogeographical realms and is critical for ecological and biogeographical research. Along its length (from the Western to the Eastern end), it offers diverse climatic zones along with vast altitudinal ranges and rich biodiversity. This way the region provides an ideal setting for studying altitudinal gradients. Additionally, the unique climatic types and topographic complexity of this mountain system contribute to the high endemism in these areas, making the documentation of its biodiversity a priority.

Insects, the largest animal taxon, are often ignored in biodiversity studies due to their huge diversity and the challenges posed by their taxonomic identification process. However, studying insect surrogate taxa through standardised methods—combining species listing with the investigation and documentation of associated ecological patterns and underlying drivers—is the best way to effectively use resources and extract valuable ecological information through statistical analysis. Moths, particularly those in the family Geometridae, are used as target taxa in the context of herbivorous insect groups to understand important ecological factors and processes. They constitute the second-largest moth family with worldwide distribution and a diverse range of species. The members have moderate dispersal abilities and react sensitively to habitat alterations, and are also the well-established indicators of ecosystem health and biodiversity globally.

Building upon this background, the objectives proposed for this study were i) to study the diversity and species richness patterns of Geometridae moths along the altitudinal gradient of the Dhauladhar Mountain Range (DMR) (within the administrative boundary of the district Kangra), ii) to identify the potential indicator species of Geometridae moths for different habitat types (altitude) and environmental variables affecting their distribution and iii) assessment of the high-altitude Geometrid moth assemblage of Trans Himalaya (Lahaul and Spiti) region of Himachal Pradesh.

Materials and Methods

Study area

The study was undertaken across the altitudes of the DMR and Lahaul and Spiti Valleys (LSVs) representing the Himalayan and Trans Himalayan biogeographic zones of India in Himachal Pradesh respectively. The DMR (a lesser Himalayan Mountain range) lies between 31° 2' to 32° 5' N latitudes and 75° to 77° 45' E longitudes, forms a steep wall and follows a curvilinear path from the North Western to South Eastern administrative boundary of the district Kangra. It holds eight major forest types, viz., Northern Mixed Deciduous Forests (5B/C2), Lower or Siwalik Chir Pine Forests (9/C1a), Upper or Himalayan Chir Pine Forests (9/C1b), Ban Oak Forests (12/C1a), Moist Deodar Forests (12/C1c), Kharsu Oak (12/C2a), West Himalayan Upper Oak-Fir Forests (12/C2b) and Birch-Rhododendron scrub Forests (15/C1). LSVs are part of the Zanskar mountain range in Himachal Pradesh. The entire landscape lies between 31° 44' 57'' and 32° 59' 57'' N latitudes and 76° 46' 29'' and 78° 41' 34'' E longitudes and comprises seven major forest types, viz., Dry Deodar forests (13/C2b) West Himalayan High-level Dry Blue pine forests (13/C4), West Himalayan dry Juniper Forest (13/C5), Birch-Rhododendron scrub Forests (15/C1), Alpine pasture (15/C3), Dry alpine Scrub (16/C1) and Dwarf Juniper Scrub (16/E1)

Sampling and Identification

To study the communities of Geometridae moths across different altitudinal zones and forest types, sampling was performed following a stratified random sampling study design. Altitudinal gradients were divided at every 300 m vertical distance, followed by random sampling within each forest type in that zone. Moths were sampled manually using the traditional vertical white (chequered) sheet method with a LepiLED light trap. Two altitudinal gradients were selected in the DMR—Kareri gradient (from Charri-Kareri Khas-

Kareri Lake) with an elevational range of 800–3200 m and the Rajgundha gradient (comprising Bir-Billing-Rajgundha-Palachak) ranging from 1500 to 3200 m—with 34 sampling sites across eight major forests. Sampling was performed from September 2020 to June 2022 during two sampling seasons—pre- (April–June) and post-monsoon (September–October). Similarly, 21 sampling sites were established across the altitudinal gradient of 2500–5000 m asl and seven major forest types in the LSVs which were sampled during June–August 2021 for a single growing season (with favourable conditions for sampling in this region).

Species identities were confirmed after the original descriptions of the species, major genus reviews, and museum collections (National Museum collection at ZSI Kolkata; Herbulot Collection of the world's geometrid moths in Munich, Germany; type specimens at the Natural History Museum, London, UK). Morphological and genital features (only in the case of cryptic genera) were studied along with DNA barcoding (only for the members of the Sterrhinae subfamily) for species validation. For every documented species in this study, synonymy, diagnostic characteristics, distributional details, and habitus images were provided in the systematic account of the species.

Data analysis

Total (γ) diversity of the Geometridae family in the landscape and site-wise (α) diversity were calculated. For diversity and species richness, the total observed species richness and standard diversity indices, Dominance (D), Simpson's (1-D), Shannon (H) and Evenness (e^H/S) and non-parametric estimators were calculated to estimate the true (observed and undetected) number of species. The iChao-1 measure was used as the standard estimator to evaluate sampling completeness at both local and regional levels. Fisher's alpha of the log-series distribution was used as the alpha diversity measure. Seasonal comparisons of species richness and composition between the pre- and post-monsoon periods were conducted to explore the temporal variations in geometrid moth communities. Species richness and diversity were calculated by pooling data for each season. Species compositions were compared using Analysis of Similarity (ANOSIM) and Similarity/dissimilarity Percentage (SIMPER) analyses, which revealed statistical significance, cumulative dissimilarity, and the species with the highest contribution to the overall dissimilarity between the two seasons. These analyses were performed using PAST4 software. The biogeographic affinity of the total observed species richness from the two landscapes was analysed based on the documented distributions of the species in the secondary literature.

To compare the species richness and composition of different altitudinal zones and forest types, sampling sites were grouped into 500 m altitudinal zones and major forest types (classified based on Champion and Seth 1968) within the study areas. Species relative abundances, richness and diversity measures (observed and estimated) were calculated in the PAST4 software. Species rarefactions and extrapolation curves were drawn in the R (version 4.2.1) using the iNEXT package. The beta diversity pattern along the altitudinal gradient was analysed using the paired Sørensen-Simpson's index (species presence-absence-based) and Bray-Curtis index (species abundance-based) of dissimilarity—as total dissimilarity, species turnover, and species nestedness components—between consecutive pairs of altitudinal zones. These analyses were performed using the betapart package in the R (version 4.2.1). Species composition was compared using ANOSIM and SIMPER analyses, revealing the species with the highest contribution to the overall dissimilarity between consecutive pairs of altitudinal zones and different forest types. To identify the important environmental drivers for the observed diversity patterns, Canonical Correspondence Analysis (CCA) was performed with all four sets of environmental variables (first checked and filtered for autocorrelation).

Species with special preferences for specific altitudinal zones or forest types were identified using Indicator Species Analysis (ISA). This analysis was performed with the 'indicspecies' package in the R (version 4.2.1). Species with IndVal >0.7 and significant p-values (<0.05) for a particular altitudinal zone or forest type were referred to hold specialised environmental requirements and indicators of the ecological conditions or habitat quality specific to those zones or forest types respectively.

Results and Discussion

Species Inventory, Seasonality and Biogeographic Affinity (for DMR): A total of 280 species in the family Geometridae were documented from DMR. This includes 7 species records as new to India and 56 new to Himachal Pradesh. Seasonal differences in the observed species richness and abundance between the pre- and post-monsoon seasons were marked by higher species richness and abundance in the post-monsoon season. However, the species richness estimates were slightly higher for the pre-monsoon season than in the post-monsoon season. Overall, the species composition in the two seasons differed significantly, with a cumulative dissimilarity of 88.25%. This mountain range is a part of the Saharo-Arabian zoogeographic realm. The zoogeographical analysis shows its maximum affinity with the Sino-Japanese realm, shares ~80% of the total documented species. Among the Indian Himalayan zones, a maximum of 64% species were shared with the Central Himalayan (2C) biogeographic province and 76% with the Gangetic Plains biogeographic zone.

Patterns along the altitudinal gradient of the DMR and underlying drivers: Box plots displaying the altitudinal distribution of the family Geometridae and its four major subfamilies—Sterrhinae, Geometrinae, Larentiinae and Ennominae—showed the median distribution of the individuals for the family Geometridae around 2200 m. For species richness and diversity measures of Geometridae moths across the five altitudinal zones of the DMR, a distinct unimodal/humpback-shaped pattern was observed. However, the peak was located at different altitudinal zones for different measures. No consistent pattern was found for beta diversity, species turnover, species nestedness, or overall dissimilarity. For the abundance data-based dissimilarity measures (Bray-Curtis dissimilarity), the highest dissimilarity was reported between Zones 3 and 4 for the family Geometridae as well as its two major subfamilies, Ennominae and Larentiinae. The dissimilarity between these two zones was mainly attributed to species turnover rather than species nestedness. Similar results were observed through ANOSIM-SIMPER analysis of the species composition of different pairs of altitudinal zones. These analyses also showed the highest dissimilarities in species composition between Zones 3 and 4, and Zones 1 and 2. Cluster analysis of the different forest types showed distinct species assemblages for the forest types at the lower, middle and higher altitudinal sites. Among the four different sets of habitat covariates (topographic, environmental, vegetation, and disturbance variables), elevation, slope (comparatively weak), and NDVI (topographic variables); ATNT (Average Trapping Night Temperature), BIO12 (annual precipitation) and BIO4 (temperature seasonality) (environmental variables); all vegetation variables (tree species richness and abundance, tree height, GBH, shrub species richness and % cover, and herb species richness and abundance) and lopping signs and distance to the nearest village (disturbance variables) were reported to be significant in explaining the overall species and environmental relationships for the Geometridae moths in the DMR landscape.

Potential Indicator species: Indicator species analysis (ISA) showed IndVal > 0.7 at a significance level for 108 species across five altitudinal zones. Of these, 43 species were uniquely associated with a particular altitudinal zone, whereas 65 species were associated with more than one altitudinal zone. The highest 17 indicator species (IndVal > 0.7) were reported for Zone 1, with seven species having IndVal > 0.9. Four species had high and statistically significant indicator values for zone 2, six species for zone 3, eight for zone 4, and seven species for zone 5. Out of eight different forest types, 138 species had IndVal >0.7 for seven forest types; no indicator species was observed for Upper Chir Pine (UCP) forests, and 18 species were specifically associated with a single forest type. The highest 5 indicator species (IndVal > 0.7) for the Birch-Rhododendron Scrub (BRS) forest, four species with IndVal = 1. There were four species with high and statistically significant indicator values for Ban oak (BO), three for Kharsu oak (KO), two each for Northern Mixed deciduous (NMD) and lower chair pine (LCP) forests, and one each for Moist Deodar (MD) and Upper-Oak Forest (UOF).

High-altitude assemblage of LSVs: Total 87 species among five macro moth families; Geometridae (48 spp.), Noctuidae (32 spp.), Erebidae (3 spp.), Notodontidae (3 spp.) and Cossidae (1 sp.) were identified from LSVs. Of these, 10 species and subspecies are new to India and 4 species and subspecies are new to Himachal Pradesh. The altitudinal distribution of the family in the boxplot showed a major distribution of individuals between 2500–4000 m altitude and very rare encounters above this range. Overall, species richness showed a declining pattern across the three altitudinal zones, whereas abundance peaked in zone 2. The higher altitudinal zones were more distinct (Zones 2 and 3, 78.39% dissimilarity) than the lower zones (Zones 1 and 2, 65.24% dissimilarity). The highest dissimilarity occurred between zones 1 and 3, with 92.66 a cumulative dissimilarity. Thirteen indicator species were found for different combinations of altitudinal zones (three zones) and forest types (seven forest types). The total assemblage was found to be an admixture of Sino-Japanese (~49%) and Palearctic (48%) realms, whereas only 19% of the species were distributed in the Oriental realm.

Synthesis

Through the documentation of the ecology (diversity and distribution patterns) of Geometridae moths across the altitudinal gradients of the Himalayan and Trans Himalayan regions in Himachal Pradesh, this study conducts the first-ever systematic survey of moth diversity in these biogeographic regions. The use of standardised sampling methods has helped to assess ecological patterns, contribute to a deeper understanding of complex biodiversity patterns of these moths, and demonstrate their potential as indicators for monitoring environmental changes through rigorous statistical analyses. Such methodologically standardised studies are vital for advancing our ability to assess ecosystem health and inform conservation strategies, along with biodiversity documentation. The study has outlined a unimodal/humpback-shaped diversity pattern of Geometridae moths in DMR. This pattern has been found as a characteristic of Geometridae moths in a meta-analysis of different altitudinal gradients worldwide. Among the studied environmental factors, ATNT, BIO4 and BIO12, altitude, vegetation and disturbance variables are found to be important for explaining the observed patterns and variations in the community characteristics. Species with strong preferences for specific altitudinal zones and forest types have the potential to serve as indicator species for long-term monitoring of climate change, habitat quality, and land-use changes in these regions. These findings provide valuable insights into our understanding of the biodiversity patterns and community characteristics of Geometridae moths across altitudinal gradients and different forest types in the regions. However, given the limitation of time and resources many areas of concerns still need considerations in future studies. Specific recommendations from the study includes, the implementation of conservation measures that prioritise the preservation of natural habitat diversity and development of monitoring protocols targeting the identified indicator species.

Chapter 1
Introduction and
Review of Literature

1.1 Overview and Background

Mountains: definition, importance and their role as natural laboratories

Mountains are defined as mighty raised landforms, at least 300 m or 1,000 feet high to surrounding land or ocean surface. They are characterised by steep slopes, sharp or rounded ridges, and a pointed peak or summit (the highest point on the mountain). Compared to hills, mountains are much steeper, taller, and more prominently defined. Globally, mountains are broadly categorized into different "mountain systems" based on their form, structure, alignment, and origin (orogeny). On the scale, however, they often form long linear arcs (with multiple peaks), closely aligned in parallel chains called "mountain ranges" (Mountain: Definition, Formation, Characteristics and Examples, 2016). The world's mountains cover approximately 27% (nearly a quarter) of the earth's surface, with nearly 12% of the world's population residing in mountainous regions. Endowed with both economic and ecological importance, they are the only source of water for most of the world's perennial rivers and are an important source of fresh water for about half of the world's population. Furthermore, they are home to approximately 23% of the world's forests and support approximately 25% of terrestrial biodiversity. Worldwide, they attract nearly 20% of global tourism (Price 2013; FAO 2014; https://www.mountainresearchinitiative.org/who-we-are/why-mountains-matter), hold 32% of protected areas and about half of the world's biodiversity hotspots (Öztürk et al. 2015).

Geographically, mountains are secondary geographical features, formed as a consequence of tectonic plate movements during Earth's geological history. They are found in diverse biogeographic settings worldwide. Moreover, every mountain has developed its unique topography, climate, and life assemblage since its formation (von Humboldt and Bonpland 2009). The formation of these geographic structures has significantly impacted both local and global climate as well as biodiversity patterns. Their formation has offered a very complex, diverse and unique set of habitats for species to colonise and diversify in (Perrigo et al. 2019; Rahbek et al. 2019). Consequently, species from regional species pools have migrated, adapted, and diversified within these systems following their development. Species have also used mountains as cradles, bridges, or corridors depending on their dispersal abilities. Likewise, they are endowed with intricate topo-climatic features coupled with compressed life zones and small-scale habitat diversity (Öztürk et al. 2015). All this sets the stage for complex ecological and evolutionary processes to play in and foster the formation of regional biodiversity in these systems. As a result, a very unique and highly endemic biodiversity has formed, making these ecosystems global biodiversity reservoirs (Spehn and Körner 2005; Perrigo et al. 2019).

An additional defining feature of mountain systems is, the continuous change in elevation from the base to its summit, often associated with variations in environmental variables. This change, known as an "elevational gradient". It offers a rapid transition across a wide range of environmental conditions within a short distance of a few km. Elevational gradients, spanning various mountain systems, serve as ideal experimental setups to understand the diversification and distribution of life on Earth. As each mountain range is unique, the elevational gradients of different mountain ranges act as independent and "unique replicated units" i) to explore the factors and processes underlying the distribution of global biodiversity (Wyckhuys et al. 2022) and ii) to tease apart the individual roles played by these environmental factors, based on the consistency and differences of results among these systems. Moreover, these gradients offer three distinct scales for documenting and understanding biodiversity patterns: i) Horizontal or Biogeographical (at a global scale), ii) Vertical or Regional (elevational transect), and iii) Temporal or Geological (Spehn and Körner 2005).

The life assemblage of these systems, especially the high-altitude assemblages, is primarily shaped by the "climatic variables through environmental filtering' (Wesche et al. 2010; Telwala et al. 2013; Tolonen et al. 2017; Ahlborn et al. 2020; Wang et al. 2017). Therefore, although natural and anthropogenic changes are both linked to the fragility of mountain systems (Öztürk et al. 2015), climatic changes are more likely to affect these systems (Hunter et al. 2014). Henceforth, their monitoring helps to provide the "early warning signals" of species' response to ongoing or future global changes (Parmesan 2006; Wyckhuys et al. 2022), and can help to plan and take conservation-oriented steps early.

Himalaya: biological and ecological significance

Himalaya is the youngest, tallest, largest and most populated mountain system of the world which began to form around 40–50 million years ago due to the collision of Indian and Eurasian landmasses. It has a series of many "parallel and converging ranges" with around 30 highest points, including the world's highest point (Mt. Everest) on Earth (http://gbpihedenvis.nic.in/indian_him_reg.html) and lies at the junction of four zoogeographic realms, namely, the Palearctic, Saharo-Arabian, Sino-Japanese, and Oriental.

Indian Himalayan Region (IHR) forms a long stretch of approximately 2,500 km in length and has an average width of approximately 80 km, with a maximum width of up to 300 km. It covers around 5.3 km^2 area and comprises 16% of the country's total geographical area. This region is very important due to its political and geological location, holds unique species diversity, complex topography, and is highly threatened and vulnerable. Owing to its location, it regulates the general climate of the country and maintains its ecological integrity. It is an important repository of medicinal plants, and its forests rank among the good quality forests in the country, providing various goods and services for the people residing in the harsh climatic and topographic conditions presented by this region.

Trans Himalaya: an overview in India's context

The Trans-Himalaya is a high-altitude cold desert-like mountain system situated to the north of the main Himalayan range. It is a rain-shadowed area with an average altitude of ~4,000 m (Mani 1974). In India, the Trans Himalayan region is represented by the Zanskar, Ladakh and Karakoram ranges (Mani 1962; Mani 1974), covering about 5.62% of the total geographical area (Rodgers et al. 2002), and has been divided biogeographically into three provinces viz., Ladakh Mountains (1A), Tibetan Plateau (1B) and Trans Himalaya-Sikkim (1C) (Rodgers et al. 2002; Kumar et al. 2017). This region is one of the most ecologically fragile biogeographic zones in India (Rodgers and Panwar 1988).

Arthropods in an ecosystem

Insects constitute the most speciose and diverse animal taxon on earth. They provide numerous critical functions within an ecosystem (Kremen and Chaplin-Kramer, 2007). Therefore, understanding the rate of insect extinction or population decline is crucial for comprehending global biodiversity loss and its ecosystem-level impacts (Fox et al. 2011). The absence of such information for nature's most diverse animal groups can lead to the underestimation or overestimation of biodiversity loss and its underlying threats. The conservation status of insects is barely known, just like that of any other invertebrate group. The reasons are the same and include taxonomic complexity, limited taxonomic expertise, huge diversity, and large sample size, even after a small survey, demanding time, resources, and expertise to process. Furthermore, the challenges of insect conservation are further intensified by negative perceptions of insects among people. They are mostly seen as pests and nuisances that need to be eradicated from the earth (Sanyal et al. 2011).

As of 2023, only 12, 568 insect species have been evaluated for their conservation status in the IUCN Red List of threatened species categories. This represents approximately 1.2% of the total estimated number of described species (IUCN Red List version 2023-1: Table 1a). Moreover, worldwide the estimated number of total insect species across the Earth varies widely (Stork 1988). One of the studies estimated 4–6 million (Novotny et al. 2002) insect species to occur globally, for which only 23–35% have been named to date (Hammond, 1992). Insufficient understanding of insect species richness and their spatial and temporal distribution poses a formidable obstacle to insect conservation efforts. This limited knowledge forbids how many species of insects are present on Earth and what species are facing threats to their survival. In addition, recent studies projecting the rate of insect decline have predicted the extinction of nearly 40% of the world's insect species over the next few decades (Sánchez-Bayoa and Wyckhuys 2019). To address these challenges effectively, there is an urgent need for concerted efforts to fill knowledge gaps regarding insect diversity, distribution, and their population dynamics. However, considering the constraints of time, money, and expertise, it is vital to shift focus first to highly sensitive, ecologically diverse, species-rich, and taxonomically well-known surrogate taxa (Lawton et al. 1993; Ricketts et al. 1999). This is especially important in priority areas such as biodiversity hotspots (Prendergast et al. 1993; Reid 1998; Dobson 1997) or any other areas holding unique, contrasting species assemblage and high complementarity (Howard et al. 1998) with high conservation value.

Herbivorous insects: as surrogate taxon

Herbivorous insects owing to their numerical superiority consistently comprise a significant portion of insect fauna (Ødegaard 2000; Basset et al. 2001; Novotny et al. 2002). Additionally, this feeding guild is also central to ecosystem functions and plays both top-down (through plant feeding and nutrient cycling) and bottom-up regulatory roles (by serving as a food source for higher trophic levels) in any ecosystem. Herbivory (consumption of plants by animals) is considered a great nuisance and disturbance by the general audience. However, it also plays a vital role in the modulation and regulation of ecosystem dynamics. It decreases plant density, transfers biomass and nutrients to the soil, and influences the habitat and resource conditions for other organisms (Schowalter 2006). Also, as herbivores have a close functional association with plants, they often serve as valuable indicators of changes in vegetation structure, composition, quality and phenological changes. Henceforth, can be important in the effective monitoring of ecosystem dynamics.

Among the largest herbivorous taxa, are the largest insect orders namely, Coleoptera (Beetles), Homoptera (Aphids) and Lepidoptera (Moths and Butterflies). The orders Coleoptera and Homoptera are effective indicator taxa, but they often pose challenges owing to the associated complex sampling techniques and taxonomy (Holloway 1982). In contrast, members of the order Lepidoptera benefit from their vibrant and colourful scaly vestiture. Lepidopterans have an extensive history of comprehensive studies and, therefore, have comparatively sound and comprehensive taxonomy and distribution data within the class Insecta. Also, they have comparatively easy sampling methods such as light trapping and transect walks. In addition, they are often closely associated with local flora (have strong habitat fidelity) and display a greater range of host specificity and dispersal abilities (Holloway 1982).

There are two major subgroups in the order Lepidoptera: butterflies and moths. Among butterflies and moths, moths are far more diverse constituting 88-90% of the total lepidopteran diversity. Moreover, moths exhibit greater ecological, behavioural, and biological diversity than butterflies. This allows them to represent a broader spectrum of terrestrial insect taxa within their habitat (Conrad et al. 2006). However, as moths are taxonomically more challenging and species-rich, earlier long-term monitoring programs established in many countries have considered butterflies rather than moths to be a suitable indicator taxon (van Swaay et al. 2008; Richter et al. 2018). A single night of moth sampling yields an extensive dataset on species presence/absence and abundance. They are also species-rich and abundant in dense forests and high-elevational habitats and yield a good sample size. In contrast, butterfly abundance and diversity tend to be lower in such habitats. Moreover, sampling with a standardized 3–4 h light-trapping period is sufficient to provide a robust dataset. Studies focusing on moths have produced a robust dataset for comprehensive statistical analyses. This further encourages moths to be used as model insect herbivore taxa for studying biodiversity patterns and ecosystem dynamics (Dorow et al. 2019; Despland et al. 2012; Beck et al. 2017). Therefore, the recent studies focus more on moth studies and using them for all of the three categories of indicators recognised by McGeogh (1998) i) environmental indicators (detect and monitor environmental change)

ii) ecological indicators (track and reveal the long-term effects of stressor-induced changes in the environment) iii) biodiversity indicators (Dey 2015).

Geometridae moths as target taxon

Geometridae (Lepidoptera: Heterocera) is the second-most diverse moth family. Its members have a very characteristic body form with a low body mass, slender build, and medium to large wing spans. Because of these attributes, these moths have a very low wing loading and can fly even below the ambient body temperature. However, such flights are often comparatively weak and have poor manoeuvrability power (Heinrich 1981). Nonetheless, owing to their weak flight, they are known to show high habitat fidelity (Holloway 1984; Intachat 1995; Intachat et al. 1997, 1999a, b). The family boasts distribution in every biogeographical region of the world (Scoble et al. 1995). Moreover, it exhibits high species richness and abundance in temperate high latitudes and high-elevation areas of mountains in different parts of the world (Brehm and Fiedler 2003; Paknia and Sh 2015). Hence, this family can also be a good candidate as an "ideal model taxon for conservation research in the temperate habitats" of the Indian Himalayan region.

Geometridae moths are famously called the "Forest moths." Their members are highly associated with forests and generally have high species richness and a greater proportional contribution to the overall macro lepidopteran assemblage in forest habitats (Kitching 2000; Beck et al. 2002; Brehm and Fiedler 2005). Their proportion and species diversity decrease with increased disturbance in forest habitats owing to forest management, fires, and other anthropogenic activities that affect the ecological and environmental conditions of forests (Holloway et al. 1999; Kitching et al. 2000; Beck et al. 2002). Among subfamilies, Ennominae moths are the most sensitive to changes or disturbances in forest habitats (Kitching 2000; Brehm and Fiedler 2005; Choi and An 2013), and their species composition is often used to characterise different vegetation types and elevational zones (Choi and An 2013). Therefore, numerous studies have been conducted globally on various aspects of this model taxon from different biogeographic regions, focusing on their ecological, taxonomic, and phylogenetic perspectives (discussed in the literature review section).

1.2 Literature review

Geometridae moths: overall diversity

The latest figures for the total number of species described in the family Geometridae were provided by Rajaei et al. (2022). They have listed 23,872 species and 3,123 subspecies (totalling 27,006 valid species-group names) within the family and have released their list as an online searchable catalogue (https://geometroidea.smns-bw.org/geometridae/Catalogue/). In India, 2,041 species have been listed by Kirti et al. (2019). Of these, 879 have been documented to date in the Indian Himalayan region (Sanyal et al. 2018) and 23 new records have been added by Chandra et al. (2019). Walia (2005) listed 185 species, and Pathania et al. (2022) compiled a list of 275 species in 145 genera from Himachal Pradesh.

Taxonomic studies

The history of taxonomic studies and classification in the order Lepidoptera can be traced back to the time of Carls Linnaeus (Father of Taxonomy) (Linnaeus 1758). The taxon name “Lepidoptera” was first used by him to refer to both butterflies and moths. He divided the Lepidoptera into three genera: *Papilio*, *Sphinx*, and *Phalaena* (further divided into seven subdivisions: Bombyces, Noctuae, Geometrae, Tortrices, Pyrales, Tineae, and Alucitae). Of these, *Sphinx* and *Phalaena* were defined to include moth species. These nine divisions (two genera and seven subdivisions) were later used to form a foundation for naming the nine moth superfamilies, as follows: Papilionoidea, Sphingoidea, Bombycoidea, Noctuoidea, Geometroidea, Tortricoidea, Pyraloidea, Tineoidea, and Alucitoidea. The subdivision Geometrae in the Linnaean system of classification was upgraded to the superfamily Geometroidea and had 76 species described under the single genus name *Phalaena*. These species are now classified into different families both inside and outside the superfamily Geometroidea (now includes families Epicopiidae, Sematuridae, Uraniidae, and Geometridae) (van Nieukerken et al. 2011).

Taxonomically, the family Geometridae was initially referred to as the superfamily Pyraloidea along with other families such as Pyralidae, Uraniidae, Drepanidae, and Cymatophoridae (= Thyatirinae and Cyclidiinae), based on the common location of tympanal organs (complex hearing organs) at the base of the abdomen (Borner 1939). Minet (1983) later challenged the unification of these families based on a single characteristic. He further added differences in structure, position, and both structure and position for taxonomic differentiation among families, and separated these families into four superfamilies: Pyraloidea, Geometroidea, Drepanoidea, and Uranioidea. This is the first time that the family Geometridae has been positioned in the superfamily Geometroidea. Subsequently, based on synapomorphies in characteristics, such as the larval spinneret and tegula of adults, he added the family Uraniidae to the superfamily Geometroidea (Minet 1991). Cook and Scoble (1992) added all the families Drepanidae, Uraniidae, Thyatiridae, and others without tympanal organs under a single superfamily Geometroidea in their classification system.

The Tympanal organs are the "complex hearing organs" which are known to exist in fifteen families of Lepidoptera (Common 1990). The most speciose families, such as Noctuidae, Geometridae, and Pyralidae are among them, constitute nearly half of the order bearers of these organs. They are vastly present among moths, and due to their complex structure and variability, these organs were earlier considered to have "good taxonomic value", mostly at "higher taxonomic levels" (Borner 1925, 1939; Kennel and Eggers 1933; Minet 1983). They were suggested to provide "a source of autapomorphic characters, particularly for higher taxa", but had limited value in determining phylogenetic relationships among them. However, these structures were specifically used to distinguish the taxonomic position of the family Geometridae from the rest of the moth families (Cook and Scoble 1992). Other important taxonomic characteristics, such as wing venation and genitalia, were added later with advancements in morphological studies using microscopy.

After all these taxonomic studies, in the modern classification, the family Geometridae (Lepidoptera: Heterocera) has been placed in the Macroheterocera clade of the order Lepidoptera (van Nieukerken et al. 2011) under the superfamily Geometroidea. Its members are traditionally defined by i) the location of its tympanal organs at the base of the abdomen, ii) a typical tympanic handle or ansa in its tympanal organ, and iii) its forewing venation, with vein 3A forming a basal fork with 2A and absence of 1A (Cook and Scoble 1992; Triplehorn and Johnson 2005). (Other characteristics are discussed in detail in Chapter 2).

At the world level, major contributions to the taxonomy of Geometridae moths were made by Linnaeus (1758), Fabricius (1775–1798), Stoll (1782–1790), Hübner (1825–26), Warren (1839–1914), Walker (1854–1866), Guénée (1856–1859), Moore (1859–1887), Prout (1864–1943), Butler (1877–1889), Swinhoe (1886-1906). Among them, two British authors, William Warren (1839–1914) and L. B. Prout (1864–1943) have made a very significant contribution by describing nearly 30% of the total described species (Kirti et al. 2019).

The documentation of the Indian Geometridae has been majorly done by British scientists during the colonial period or later, based on the material deposited in the Natural History Museum, London. Very few Indian scientists have dealt with the taxonomy of the Indian Geometridae in the post-colonial period. These works mostly done towards the end of the 20^{th} century and include the works of Pajni and Walia (1983, 1984, 1984a, 1984b), Walia and Pajni (1984, 1985, 1987), Walia (1988, 1994, 1994a, 1994b, 1995, 1995a, 2000, 2004, 2005), Rose and Davinder (1985), Mathew and Rahamathulla (1995), Chandra (1997, 2013), Mathew (2004), Walia and Nisha (2004), Walia and Anju (2005), Smetack (2004), Kirti et al. (2007, 2008, 2008a, 2009), Kirti and Saxena (2012), Sood et al. (2009), Stunning and Walia (2009), Schmidt (2009), Giyal and Kirti (2016), Goyal et al. (2018) (from Kirti et al. 2019). A detailed work by Kirti et al. (2019) is worth mentioning. They published a major work, a systematic account of 150 species under 100 genera, and also reviewed and prepared a consolidated checklist of 2,041 species reported from India in their book entitled '*Geometrid Moths of India*' (this work has also formed the basis for the majority of the review of literature discussed in this section). Furthermore, Chandra et al. (2018) reviewed the literature documenting the Geometridae moths from the entire Indian Himalayan region (IHR) and provided the number of reported species richness from each of the Himalayan biogeographic provinces.

Additionally, there are studies that documented the distributional records of Indian Geometridae moths. These include works by Inoue (1972–1990, 1992, 1999, 2000, 2000a, 2003, 2003a), Inoue and Stunning (2003), Holloway (1976, 1994, 1996, 1997), Choi (1998, 2002, 2002a, 2012, 2013. 2014), Choi and Stunning (2011), Sato (1987-2016), Han and Xue (2009, 2011, 2011a), Han et al. (2005, 2005a, 2006, 2009, 2009a, 2012), Mironov and Galsworthy (2007, 2009, 2009a, 2010, 2010a, 2012, 2013), Mironov et al. (2004, 2004a, 2004b, 2004c, 2008, 20008a, 2008b), Yazaki (1992-2000), Orhant (2000, 2014, 2014a), Sato and Wang (2004-2007, 2016), Stunning (2000), Pitkin et al. (2007), Liu et al. (2014), Huang and Stunning (2016), Jiang et al. (2011-2017), Xiang et al. (2017), Cui et al. (2018), Li et al. (2018), Shipher and Chang (2018), Xue et al. (2018) (from Kirti et al. 2019).

Phylogenetic studies

The pioneer work on the phylogenetic relationship among different subfamilies of Geometridae was done by Holloway (1997). He used morphological characteristics to decide the relationship. His classification system was upgraded following advancements in molecular analysis techniques. The latest phylogenetic classification of the family is more robust. According to this, the family Geometridae has nine subfamilies (in the order of their phylogenetic relationship): Sterrhinae (3000 spp.), Larentiinae (6300 spp.), Archiearinae (18 spp.), Epidesmiinae (102 spp.), Desmobathrinae (200 spp.), Oenochrominae (300 spp.), Eumeleinae (13 spp.), Geometrinae (2600 spp.), and Ennominae (10600 spp.) (Sihvonen et al. 2011; Brehm et al. 2019; Murillo Ramos et al. 2019; Sihvonen et al. 2020; Murillo-Ramos et al. 2021; Murillo-Ramos et al. 2023) and ninety-three tribes (Murillo-Ramos et al. 2019).

Overall, Geometridae moths constitute a monophyletic assemblage at the family level based on morphological (Cook and Scoble 1992; Scoble 1992; Minet and Scoble 1999) as well as molecular evidence (Sihvonen et al. 2011; Murillo-Ramos et al. 2019). However, at the subfamily level, the picture is less clear and there are many unresolved and unspecified phylogenetic positions and relationships at lower taxonomic levels (Murillo-Ramos et al. 2019). The most comprehensive work to resolve the phylogenetic relationship within a family includes Abraham et al. (2001), Yamamoto and Sota (2007), Sihvonen et al. (2011), Murillo-Ramos et al. (2019), Sihvonen et al. (2020), Murillo-Ramos et al. (2021) and Murillo-Ramos et al. (2023). However, efforts have also been made for resolving the phylogeny of specific subfamilies, including Sterrhinae (Holloway 1997; Hausmann, 2004; Sihvonen and Kaila 2004; Õunap, Viidalepp and Saarma 2008), Larentiinae (Holloway 1997; Mironov 2003; Viidalepp 2006, 2011; Hausmann and Viidalepp 2012; Õunap, Viidalepp and Truuverk 2016), Epidesmiinae (Murillo-Ramos et al. 2021), Desmobathrinae (Holloway 1996; Hausmann, 2001), Archiearinae (Hausmann, 2001; Young 2006), Oenochrominae (Holloway 1996; Scoble and Edwards 1990; Cook and Scoble 1992; Hausmann 2001; Young 2006), Eumeleinae (Murillo-Ramos et al. 2023), Geometrinae (Cook et al. 1994; Pitkin 1996; Hausmann 2001; Ban et al. 2018), and Ennominae (Holloway 1994; Pitkin 2002; Beljaev 2006; Young 2006; Wahlberg et al. 2010; Õunap et al. 2011; Skou and Sihvonen 2015; Sihvonen, Staude and Mutanen 2015).

Nevertheless, the phylogeny of Geometridae moths is much more resolved than that of any other insect taxa. However, to establish robust phylogenetic relationships and solve unresolved issues, it is necessary to sample its members more evenly across the globe with equal representation from each biogeographic region. This calls for further systematic studies of geometrid moths, especially in the tropical regions of Asia and Africa (Murillo-Ramos et al. 2019).

Ecological studies

The history of ecological studies on Lepidoptera can be traced back to the late 20th century. Among the most pioneering work is from the Indo-Australian biogeographic region by Holloway (Holloway 1969, 1970, 1973, 1974, 1977, 1979, 1982, 1984, 1985a, 1985b; Holloway et al. 1992). The potential role of moths as an environmental indicator was first investigated and reported by Holloway (1984) in the tropical rainforests of Borneo, Southeast Asia. Holloway (1983) noted that moderately specific phytophagous feeding habits (either on living plants or plant material) and rapid sensitivity (susceptibility) of moths to environmental changes (with good habitat fidelity) are important characteristics. This, combined with the relative ease of sampling (by light-trapping), makes moths the most suitable model indicator taxon in biomonitoring studies. (Holloway 1983). Subsequently, various aspects and potential roles of moths, particularly of macro-moths in biomonitoring studies, have been evaluated, including: i) the characterisation of different tropical rain forests and monitoring changes over time and with succession (Holloway 1984); ii) comparison of the impact of different traditional as well as modern cultivation and forestry techniques on diversity, iii) their potential as indicators of biodiversity loss (Holloway and Barlow 1992); and iv) the effects of logging and plantation (Holloway et al. 1992). Chey (1994) studied moths as an indicator for comparing the biodiversity of primary rain forests with that of plantation forests. Chey et al. (1997) studied the conservation importance of primary natural, secondary regenerated, and plantation (fast-growing exotic species) forests in Sabah, Malaysia. They reported a positive effect of understory diversity and architectural complexity on moth diversity in forest habitats (plantation forests).

Role as an Indicator Taxon

J. D. Holloway, while studying moth communities of different forest types, observed communities of the Geometridae family categorising the forests and responding sensitively to external disturbances in his pilot surveys. Later, based on his further studies, he proposed geometrid moths as a suitable model insect herbivore taxon to monitor the effects of ecological and environmental changes in forests on their faunal components (Holloway 1992). Chey et al. (1997) also confirmed the role of geometrid moths in categorising different forest plantations and understanding the role of different forest plantation methods on insect herbivore diversity. Intachat et al. (1999) investigated the effect of two types of plantation methods- one with indigenous and the other involving exotic fast-growing species on geometrid moth communities. These studies have demonstrated the conservation importance of forest plantations with native species and secondary forests with comparatively more diverse understory (as such habitats hold high geometrid moth diversity, sometimes even comparable to that of old-primary forests) (Intachat et al. (1997, 1999; Chey et al. 1997; Beck et al. 2002).

To summarise, the studies involving Geometridae moths as a “model insect herbivore taxon” mostly investigated, reported and monitored the effect of forest plantations (Chey et al. 1997; Intachat et al. 1999), disturbances (Brehm and Fiedler 2005), fire (Axmacher et al., 2004), environmental quality (An and Choi 2013), fragmented landscape (Summerville et al. 2001), season and ecoregions (Summerville and Crist 2003), compared different forest management techniques (Intachat 1997a; Kitching et al. 2000) and the temporal pattern of accumulation (Summerville and Crist 2005). These studies have confirmed the potential of geometrid moths as suitable ecological, environmental, and biodiversity indicators for representing the herbivore community of primary natural forests and monitoring their response to changes in habitat conditions (An and Choi 2013; Chen et al. 2009). Moreover, these studies have global coverage and were conducted worldwide from different biogeographic regions like South and Central America (Brehm et al. 2003b, 2007; Hilt et al. 2006), South-East Asia (Holloway 1985; Chey et al. 1997; Intachat et al. 1997, 1999a, b; Willott 1999; Beck et al. 2002), Australia (Kitching et al. 2000), and Africa (Axmacher et al. 2004a, b).

The aforementioned studies observed comparatively low diversity of Geometridae moths in agricultural lands, secondary forests, clear-felled forest patches, and selectively logged and mixed plantations with indigenous forests. The studies from South East Asia and Australia (Holloway et al. 1999; Kitching et al. 2000; Beck et al. 2002; Intachat et al. 1997, 1999) observed a decreased proportional contribution of geometrid moths to the total macro-lepidopteran assemblage at the disturbed sites. The community structure and species composition in disturbed habitats were also found to be affected by the regional species pool which determines the similarity between disturbed habitats (Kitching et al. 2000; Beck et al. 2002). Also, the importance of intact forest patches in primary and old forests compared to those remnants in secondarily managed forests for the conservation of the regional species pool (Beck et al. 2002) were underlined through these studies.

At the subfamily level, among the nine different subfamilies, a close association of the Ennominae subfamily has been found with the intact forest habitats. Moreover, this subfamily was also found to characterise different forest types and elevations. Overall, a smaller number of species as well as the individual proportion of Ennominae, accompanied by an increased proportional contribution of the tribes in Geometrinae and Sterrhinae observed at disturbed sites. In addition, particularly for the Larentiinae subfamily, such a disturbed site was shown to harbour a large proportion of the *Eupithecia* genus and a decreasing fraction of the *Eois* genus. Overall, there was a moderate loss of diversity, with a low number of species exclusive to disturbed sites, and these changes in community structure (species richness and composition) were affected by the presence of a suitable host plant among the sites (Holloway 1997; Summerville et al. 2004; Axmacher et al. 2004; An and Choi 2013).

The factors that have been documented to influence the diversity and species richness of Geometridae moths are habitat features such as species richness (Chey 1994) and the architectural and spatial complexity of the forest understory (Chey et al. 1997). Among the weather parameters, rainfall and phenological events, such as high flowering and flushing of the previous month, were reported as important factors affecting the abundance and diversity of geometrid moths (Intachat et al. 1999; Holloway and Intachat 2003).

Overall, studies involving geometrid moths as an indicator taxon helped conservationists and forest managers find effective forest management techniques and practices to effectively conserve native local and regional diversity. Also, their long-term monitoring studies have helped track the effect and response of insect herbivore taxa to climate change.

As a model insect herbivorous taxon to study the ADGs

Geometrid moths also have some characteristic features which make them an important insect herbivore surrogate taxon to study the diversity and distribution patterns along latitudinal and elevational gradients. These include i) high species richness and abundance at temperate high latitudes and high elevation areas of mountains, ii) taxonomic and biogeographic soundness, iii) easy sampling by light traps, and the generation of large ecological data sets. All of these features help to perform a more comprehensive statistical analysis of diversity patterns (Hausmann 2001; Haussman et. al. 2003; Summerville et al. 2004; Beck and Chey 2007; Paknia and Sh 2015; Beck et al. 2017). Therefore, globally, studies have been conducted along different elevational and latitudinal gradients in an attempt to document and analyse species richness and diversity patterns and to understand the role of different underlying forces. To summarise, these studies were conducted from South and Central America (in Andean montane by Brehm and Fiedler 2003; Brehm et al. 2003a, 2003b; Hilt et al. 2006, in Costa Rica by Brehm, 2007; Brehm et al., 2007), South East Asia (in Australia by Kitching et al. 2000, in Borneo by Schulze 2000; Beck et al. 2002; Beck and Chey 2007a, 2007b; Beck and Chey 2008; Intachat et al. 1997, 1999; Willott 1999, in China Zhang et al. 2016), Africa (in Tanzania by Axmacher et al. 2004a, 2004b, Axmacher et al. 2009) and Caucasus and Irano-Anatolian (Middle Palearctic) (Paknia and Sh 2015).

These studies established a characteristic community structure and composition patterns for the family along both elevational and latitudinal gradients. Although different patterns were documented, each pattern was explained based on regional characteristics. However, in a global meta-analysis, the "mid-elevational peak" pattern was characteristic of geometrid moths along elevational gradients (Beck et al. 2017). At the subfamily level, Ennominae shows dominance at lower elevations but mostly displays a wide elevational distribution along the gradient. Among others, the relative proportions of Geometrinae and Sterrhinae decreased with elevation, whereas an increasing trend was apparent in the case of the Larentiinae subfamily with complete dominance at higher elevations. The more delicate body form (which further enables them to take flight at low temperatures), predator-free environment (Brehm and Fiedler 2003), herbaceous food preferences (Skou 1996), and increasing proportion of such food sources toward high latitudes and elevations are among the reasons thought to be associated with the increasing diversity of Larentiinae moths in these habitats. Similar trends were observed along the latitudinal gradient. Important studies from the Indian Himalayan and Trans Himalayan region with special emphasis on Himachal Pradesh

Important studies from the Indian Himalayan and Trans Himalayan region with special emphasis on Himachal Pradesh

Chandra et al. (2018) compiled information on Geometridae moths for the IHR. They prepared a list of 879 species in 309 genera from seven subfamilies, namely, Ennominae, Larentiinae, Geometrinae, Sterrhinae, Desmobathriinae, Oenochrominae, and Orthostixinae. Additionally, in the Western Himalayan region, important work was done by Sanyal et al. (2011, 2013, 2017) and Dey et al. (2015, 2017). They researched the diversity and distribution of Geometridae moths, and Dey et al. (2018) established a DNA barcode library for the species documented in their studies from the same region. Furthermore, new country records were added by Dey et al. (2018), Dey and Haussman (2021) and Mallick et al. (2022), and new species were discovered by Dey et al. (2021) and Mallick et al. (2022) from IHR.

From the state of Himachal Pradesh, Thakur and Kumar (2014) studied the diversity, species richness and evenness of Geometridae moths in the different conifer forests of Seraj Valley. The status of geometrid diversity in the Chir Pine forest of three districts, Bilaspur, Solan, and Shimla, was studied by Kumar et al. (2018), who described 36 species from 27 genera of the family. Mallick (2021) studied diversity and distribution as well as the potential of Geometridae moths as an indicator for the Great Himalayan National Park (GHNP), Western Himalayan (2B) biogeographic province.

1.3 Justification of the study

The Himalaya is situated at the confluence point of four zoogeographic realms (the Palearctic, Saharo-Arabian, Sino-Japanese, and Oriental). It also has a wide gradient of bioclimatic conditions associated with a complex topography. Moreover, its long geological history provided sufficient time for the colonisation and evolution of the species, resulting in unique assemblages and therefore earning it the status of "a biodiversity hot spot of global importance" (Holt et al. 2013; White et al. 2019; Myers et al. 2000), which is highly vulnerable. Although a large number of studies were found to be concentrated in the Himalaya on the different aspects, this region is still 'data- and information-deficient' (Kier et al. 2005; Singh and Thadani 2015) for making effective conservation decisions. National Institution for Transforming India (NITI Aayog), the Government of India's think tank for development, has listed five key areas for achieving sustainable development in the Himalaya. One of them highlights the need for making the relevant data available to support informed decision-making. Also, the wide gradient of bioclimatic conditions along the breadth of the Himalaya holds great potential to serve as an important experimental setup (model system) for studying the distribution patterns of biodiversity and underlying factors.

The present study was conducted to study and establish Geometridae moths as a model insect herbivore taxon to document and study the diversity and distribution patterns in the Himalayan ecosystem of Himachal Pradesh. The Dhauladhar Mountain Range (DMR) in Himachal Pradesh constitutes the North Western Himalayan biogeographic province. This mountain range also holds some important type localities for moths, especially for Geometridae moths. Such species descriptions and documentation are more than a century old and lack crucial information, such as the exact geographical locations of specimen collections and details of associated habitat features. Also, till date, no study has documented and studied the diversity pattern from the region and for the entire North Western Himalayan Province. Therefore, this study aimed and structured with a standardized ecological approach to generate information on the diversity and distribution of Geometridae moths among different forest types along the elevational gradient of the DMR. The information generated would also help validate and re-establish the >100-year-old information by Britishers and some studies that followed, with detailed, ecologically sound baseline data.

We have further added the Lahaul and Spiti region (the Trans Himalayan region) of the state which presents a very unique geographical set-up. There is a dearth of literature on the entomofaunal component characteristic of this region. Therefore, we also took this opportunity to document and assess in the first-ever attempt, the potential of macro moth assemblage (with special emphasis on Geometridae moths) as a model taxon for the long-term monitoring of the anthropogenic and climatic perturbations.

1.4 Aims and Objectives

The following objectives were selected to accomplish and answer the questions on the diversity and distribution of the Geometridae moths in the above-mentioned study areas:

1. To study the diversity and species richness of Geometridae (Lepidoptera: Heterocera) moths along the altitudinal gradient in the Dhauladhar Mountain Range of Himachal Pradesh.
2. To identify the potential indicator species of Geometridae for different habitat types (altitude) and environmental variables affecting their distribution pattern.
3. Assessment of high-altitude Geometrid moth assemblage of the Trans Himalaya (Lahaul and Spiti) region of Himachal Pradesh.

Thesis organisation

This thesis comprised of the following chapters:

Chapter 1: Introduction; this chapter discusses the mountains, their biodiversity and the importance of the altitudinal gradients in biodiversity studies. Moths have been discussed as the largest and most important indicators of insect taxa in biodiversity studies. Literature has been reviewed concerning the taxonomic introduction, diversity documentation, and ecological significance of the family Geometridae in community ecology and conservation studies.

Chapter 2: Study area and methodology; discusses the overview of the two study areas—Dhauladhar Mountain Range (DMR) and Lahaul and Spiti Valleys (LSVs)—including their geographic and administrative boundaries, biogeography, forest types and climate in Himachal Pradesh. It also details the overall study design, the general methodology followed, the sampling localities, and the maps.

Chapter 3: Taxonomic inventory along with seasonality and biogeographic affinity of Geometridae moths from DMR; provide a complete list of the geometrid moth species with their detailed systematic accounts along with distribution details. It also discusses the total species richness (observed as well as estimated), seasonal comparison of the species richness and diversity and biogeographic affinity of the documented assemblage of geometrid moths from the DMR.

Chapter 4: Patterns along the altitudinal gradient of DMR and underlying drivers; species richness and alpha and beta diversity patterns along the elevational gradient have been evaluated and discussed along with the potential role of the different biotic and abiotic factors governing these patterns.

Chapter 5: Potential Indicator Species of Geometridae moths from DMR; for different forest types and altitudinal zones have been assessed in this chapter.

Chapter 6: High-altitude moth fauna of LSVs with special emphasis on family Geometridae; lists the species identified and documented from the region; species richness, abundances and composition of different altitudinal zones and forest types and biogeographic affinity of the total assemblage.

Chapter 7: Conclusion: provides the final crux of the major findings of this study, acknowledges its limitations and also suggests the scope for future research.

2.1 Dhauladhar Mountain Range (District Kangra, Himachal Pradesh)

The Dhauladhar Mountain range (DMR) begins from the Chamba district (at the North Western end of Himachal Pradesh) near Dalhousie and passes through the Kangra district until the vicinity of the river Beas in Kullu. It follows a curvilinear path and forms a steep wall from North Western to South Eastern end of the Kangra district. The word “Dhauladhar” means “white or grey range” and represents the light-coloured granite rocky surface and white snow-caps at the top of this mountain range. Additionally, it also serves as the basis for the political boundary of district Kangra with its nearby districts namely Chamba (on the Northern side), Lahaul and Spiti (on the North and North Eastern side), Kullu (on the Eastern side) and Mandi (on South Eastern side). Its parallel is the Great Himalayan Mountain chain in the north and the lower Shivalik or Outer Himalayan range in the south. Also, its geographic location separates Chamba’s Ravi River system from Kangra’s Beas River system.

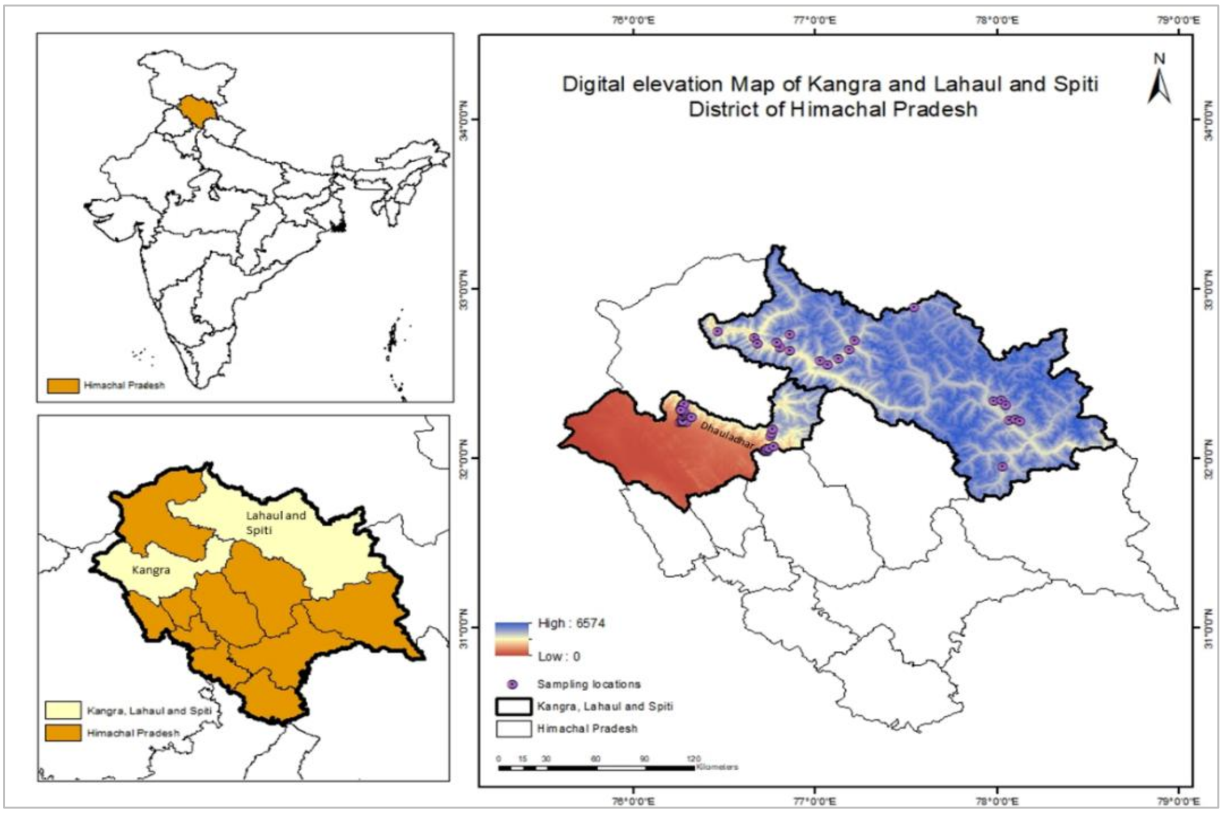
Geographically, the DMR lies between 31° 2' to 32° 5' N latitudes and 75° to 77° 45' E longitudes and exhibits a marked variation in elevation from 800 m to around 5600 m—the highest peak being the Hanuman ka Tibba or White Mountain, at about 5,639 m asl. The entire range (on its southern escarpment) is drained by the river Beas and its tributaries which constitute the major drainage system, while its northern side is drained by the river Ravi. The major southernly flowing tributaries of Beas are Neugal, Awa, Binnu, Baner, Naker, Gaj, and Dehar Khads, all of which are snow-fed and perennial.

Administratively, DMR comprises Shahpur (245 km^2), Dharamshala (338 km^2), Palampur (429 km^2), Baijnath (296 km^2) and Multhan (979 km^2) (Source: https://villageinfo.in/himachal-pradesh/kangra.html) subdivisions in the Kangra district with total area of ~1,600 km^2. The forest region of the DMR falls under two forest divisions, namely, Dharamshala and Palampur divisions. The protected area network in the region consists of the Dhauladhar Wildlife Sanctuary (DWLS), officially delineated in 1994. This sanctuary lies on the South Eastern end of the DMR with 982.86 km^2 area. It is the only protected area in the DMR and falls under the jurisdiction of the Hamirpur Division.

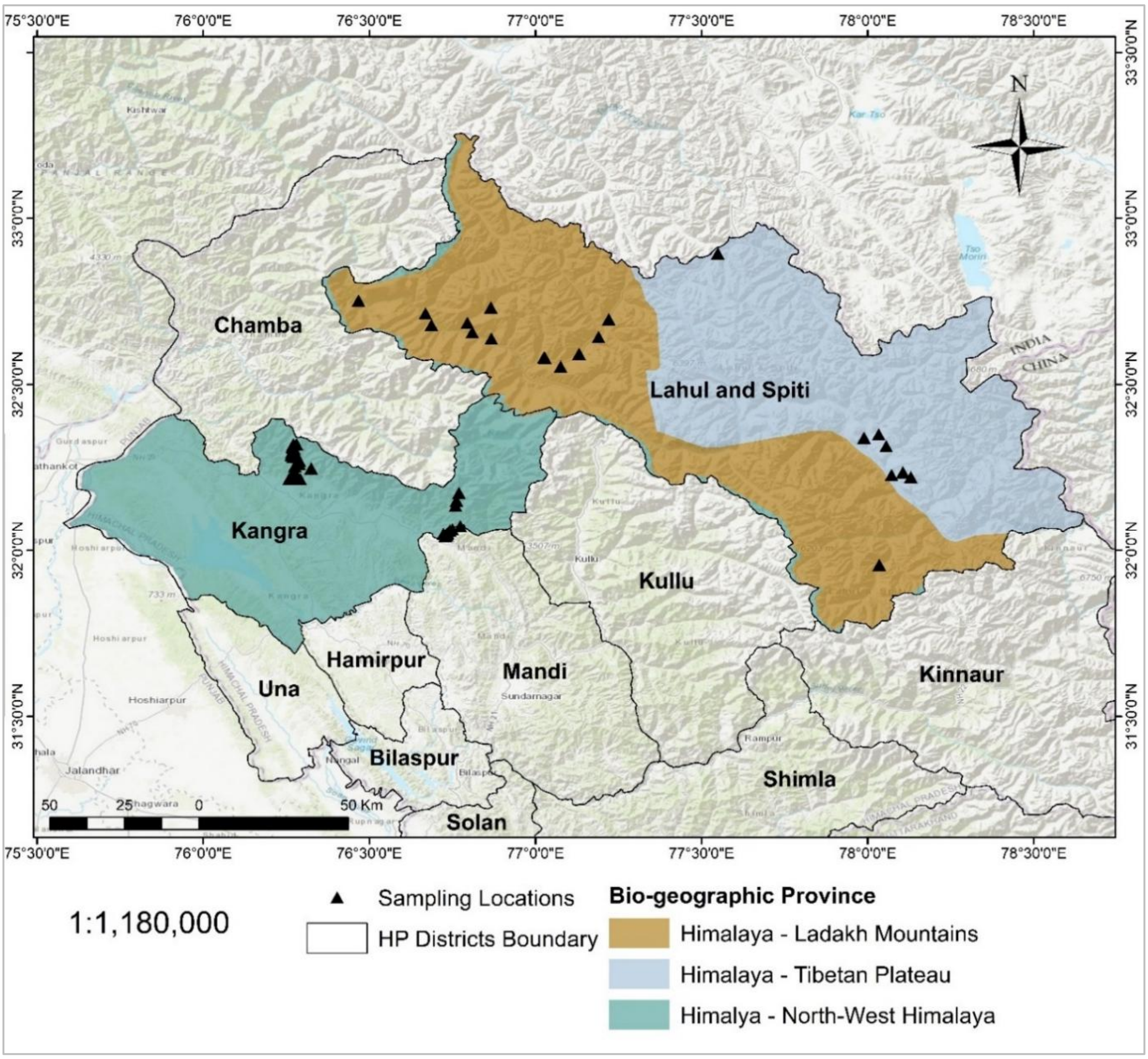
Biogeographically, DMR constitutes the North Western Himalayan biogeographic province (2A) (Rodger and Panwar, 1988). This range is a part of the group of Lesser

Himalayan Mountain ranges (Mani 1974). The defile of the river Sutlej (an antecedent river, older than the Himalayas) forms the basis for defining the North Western Himalayan region, which represents the region lying to the west of the river between 30° to almost 36° N latitude with southeast to northwest alignment (Mani 1994).

The climate in the district Kangra exhibits marked variations from subtropical in foothills and valleys, sub-humid in mid-hills, and temperate to alpine in upper hills. The district receives an average annual rainfall of about 205 cm (2,050 mm) that goes up from about 100 cm (1000 mm) in the Southern parts to about 250 cm (2,500 mm) in North Eastern areas. Most of the rainfall, about 80 per cent, is received during the months of June through September. The average maximum temperature ranges from about 35°C in Southern parts to around 25°C in Northern areas. The region experiences the following seasons: Summer or Pre-monsoon (April–June), Monsoon (June–September), Post-monsoon (September–November) and winters (December–March). The distribution of rainfall and mean temperature varies across the region, with the sub-humid and sub-tropical zones having an average rainfall of 1,000–2,500 mm and temperatures of 20°C to 24°C, and the wet temperate zone having an average rainfall of 2,500–2,800 mm and temperatures of 15°C to 19°C.



a)



b)

Fig. 2.1 (a-b): Study area maps with sampling points: **a.** Map showing an overview of the study area locations along with sampling points **b.** An enlarged view of the study area with the spatial distribution of the sampling points.

2.1.1 Forest Types Classification

According to Champion and Seth's (1968) classification of the forest types of India, vegetation in the DMR can be grouped broadly as follows: Tropical Dry deciduous forests (Group 5), Subtropical Pine Forests (Group 9), Himalayan Moist Temperate Forests (Group 12) and Moist Alpine scrub (Group 15). The major forest types documented in these major groups are defined as follows:

Group 5: Tropical Dry deciduous forests [named "Subtropical broad-leaved hill forests" by Reddy et al. (2015)].

1) 5B: Northern Tropical Dry Deciduous Forests with the following subtypes:

a) **Northern Mixed Deciduous Forests (5B/C2)** (pp. 201) – 5 (2+3)

the northern tropical dry deciduous forest is mostly distributed in the lower riverbed valley region and is highly disturbed by human activities, with larges patches having been cleared for creating land for building human settlements, pasture and agricultural land. This forest type does not show any clearcut demarcation with the subtropical chir pine forest. It is dominated by — *Senegalia chundra* in riverbeds, *Mallotus philippensis*, *Nyctanthes arbor-tristis*, *Dendrocalamus strictus* (Bamboo), —*Carissa spinarum*, *Woodfordia fruticosa*, *Justicia adhatoda* (Malabar Nut – Basoonti), —*Pueraria tuberosa*, *Phanera vahlii* (Maloo creeper, Pattal), *Senegalia caesia*. Around agricultural land and human settings, species used as a fodder have been planted, which include, —*Grewia optiva*, *Bauhinia* sp., *Albizia* sp., etc.

Group 9: Subtropical Pine Forests

These forests are characterised by the single dominant top canopy of Chir pine, *Pinus roxburghii*. In the lower zone, the forest has comparatively greater intermingling with the "deciduous trees of the tropical mixed deciduous forest" than the upper zone— "with restricted transition to the oak forest" (and require different management practices) (Champion and Seth, 1968).

2) C1: Himalayan Sub-tropical Pine forests (9/C1) with following subtypes:

a) **Lower or Siwalik Chir Pine Forests (9/C1a)** (pp. 270) - below 1,000 m - 4

A pure or mixed patch of Chir pine, *Pinus roxburghii*, with an understory of scattered lower deciduous tree species (more numerous in cool aspects, depressions, and seasonal nallahs), and a fairly continuous low scrub growth of xerophytic shrubs — usually on "steep dry slopes below 1,000 m". This forest type is mostly dominated by the —*Pinus roxburghii*, —*Mallotus philippensis*, *Pyrus pashia*, *Ficus* sp., and *Cassia fistula* — *Carissa spinarum*, *Rubus ellipticus*, *Colebrookea* sp., *Berberis* sp., *Indigofera cassioides*, *Bergera koenigii*, — *Crysopogon fulvus*, *Cymbopogon* sp., *Dichanthium* sp., *Heteropogon* sp., *Themeda* sp., —*Rosa moschata*.

Fig. 2.2: Major Forest Types sampled in the Dhauladhar Mountain Range (DMR): **1.** Northern Tropical Dry Deciduous Forest (5B/C2), **2.** Lower or Siwalik Chir Pine Forest (9/C1a), **3.** Upper or Himalayan Chir Pine Forest (9/C1b), **4.** Ban Oak Forest (12/C1a), **5.** Moist Deodar Forest (12/C1c), **6.** West Himalayan Upper Oak-Fir Forest (12/C2b), **7.** Kharsu Oak Forest (12/C2a), **8.** Birch-Rhododendron scrub forest (15/C1).

b) **Upper or Himalayan Chir Pine Forests (9/C1b)** (pp. 272) – 1,200–1,800 m – 3

Typical chir pine forest of about 20–35 m height lying between 1,200–1,800 m elevation on gently sloped dry ground (sun-faced slopes) with a very scattered understorey and scanty shrub undergrowth. On their lower boundary, they overlap with tropical deciduous forest; the upper boundary gives way to temperate broadleaved or coniferous forest. This forest is mostly dominated by *Pinus roxburghii*, *Ficus auriculata*, *Quercus leucotrichophora*, *Rhododendron arboreum*, *Pyrus pashia*, *Rubus ellipticus*, *Berberis* sp.

Group 12: Himalayan Moist Temperate Forests (Broadleaved and coniferous)

3) C1: Lower/Western Himalayan Temperate Forests (12/C1) with following subtypes:

a) C1a: **Ban Oak Forests (12/C1a)** (pp. 296) – 8

A more or less pure patch of Ban/Banj oak, *Quercus leucotrichophora* in the damp ravines and "are absent on the dry hot slopes" (and often overlapped with chir pine forest) between ~1,500–2,300 m (depending on the slope and aspects) and often associated with *Rhododendron arboreum* and *Lyonia ovalifolia* (very rarely). As the altitudinal distribution of these forests coincides and provides favourable conditions for human settlement and cultivation, these forests are highly disturbed, with upward shifting of their lower limit (completely replaced with human settlements and agricultural land in the study area).

(Along the river streams where the moist and cool conditions prevail) – (3)

b) C1c: **Moist Deodar Forests (12/C1c)** (pp. 301) – 2

Almost a pure forest (30–40 m) of deodar with scattered ban oak and *Rhododendron* in the understory (on the riverside or moist leeward slopes). Usually lying on the cool and moist slopes between 1,700–2,100 m in the study area.

4) C2: Upper West Himalayan Temperate Forests (12/C2) with the following subtypes:

a) **Kharsu Oak (12/C2a)** (pp. 310) – 3

This forest is characterised by a dense growth of Kharsu oak, *Quercus semecarpifolia* of about 15–20 m and rarely 30 m in height. Usually found on the very steep moist zone between 2,500–2,900 m elevation on southern aspects. Occasionally, Fir, *Abies* sp., is distributed sparsely in the patch and along with *Rhododendron campanulatum*.

b) **West Himalayan Upper Oak-Fir Forests (12/C2b)** (pp. 312) – 5

It is a two-storied forest with fir standing singly over oak (*Quercus semecarpifolia*), distributed on the northern aspects and sheltered sites between 2,600–3,400 m, and has a ense mat of herbaceous growth with little or more shrub growth.

Group 15: Moist Alpine scrub

5) C1: **Birch-Rhododendron scrub Forests (15/C1)** (pp. 338) – 1

With a very dense growth of the *Rhododendron campanulatum* associated with birch, *Betula utilis*, and other deciduous trees like Kharsu oak, *Quercus semecarpifolia.* Found above 3000 m elevation on the very wet, and dark thick soil, rich in humus and mostly remains covered

Table 2.1: Sampling locations' details for DMR

Sr. No.	Location name	Location Code	Latitude (° N)	Longitude (° E)	Elevation (m)	Forest type
1	Rakh	KAR08A	32.21597	76.25905	849	Northern Mixed Deciduous Forests (5B/C2)
2	Kent Nala	KAR08C	32.22994	76.27905	1008	Northern Mixed Deciduous Forests (5B/C2)
3	Paroh Bari	KAR08B	32.21791	76.26783	1018	Lower or Siwalik Chir Pine Forests (9/C1a)
4	Sudher	KAR08D	32.21486	76.292257	1064	Lower or Siwalik Chir Pine Forests (9/C1a)
5	Maiti	KAR11C	32.2192	76.27902	1084	Lower or Siwalik Chir Pine Forests (9/C1a)
6	Maniyana	KAR11A	32.2282	76.27434	1118	Northern Mixed Deciduous Forests (5B/C2)
7	Dhanoti	KAR11B	32.23231	76.27047	1170	Lower or Siwalik Chir Pine Forests (9/C1a)
8	Baladi Mod	KAR11D	32.25391	76.276034	1217	Northern Mixed Deciduous Forests (5B/C2)
9	Ghera	KAR14A	32.26017	76.288707	1404	Upper or Himalayan Chir Pine Forests (9/C1b)
10	Nora	KAR14B	32.26927	76.28972	1455	Northern Mixed Deciduous Forests (5B/C2)
11	Bir14A	RAJ14A	32.04972	76.72281	1565	Upper or Himalayan Chir Pine Forests (9/C1b)
12	Bir14B	RAJ14B	32.04328	76.72807	1625	Ban Oak Forests (12/C1a)

13	Gunehar	RAJ17A	32.04738	76.7302	1754	Ban Oak Forests (12/C1a)
14	Harnala	KAR17B	32.28126	76.27037	1796	Upper or Himalayan Chir Pine Forests (9/C1b)
15	Billing 4 No turn	RAJ17B	32.04629	76.73251	1875	Ban Oak Forests (12/C1a)
16	Kareri Khas	KAR17A	32.28283	76.28059	1870	Ban Oak Forests (12/C1a)
17	Nauhali Bridge	KARDEOA	32.28683	76.2655	1940	Moist Deodar Forests (12/C1c)
18	Dharamkot	KARDEOB	32.24719	76.324656	1948	Moist Deodar Forests (12/C1c)
19	Billing20A	RAJ20A	32.0488	76.73376	1990	Ban Oak Forests (12/C1a)
20	Nauhali Above Bridge	KAR20A	32.29255	076.26679	2032	Ban Oak Forests (12/C1a)
21	Bharodi	KAR20B	32.29584	76.26673	2111	Ban Oak Forests (12/C1a)
22	Billing 8 No turn	RAJ20B	32.05121	76.73567	2099	Ban Oak Forests (12/C1a)
23	Above Bharodi	KAR23A	32.2975	76.27121	2308	Ban Oak Forests (12/C1a)
24	Billing23A	RAJ23A	32.05978	76.74229	2341	Ban Oak Forests (12/C1a)
25	Rheoti	KAR23B	32.30436	76.273801	2478	Ban Oak Forests (12/C1a)
26	Billing23B	RAJ23B	32.06312	76.74973	2572	Ban Oak Forests (12/C1a)
27	Uttawala	KAR26A	32.31167	76.26834	2667	West Himalayan Upper Oak-Fir Forests (12/C2b)
28	Chaina Pass	RAJ26A	32.07276	76.77355	2677	West Himalayan Upper Oak-Fir Forests (12/C2b)
29	Upparala Uttawala	KAR26B	32.30952	76.27013	2730	West Himalayan Upper Oak-Fir Forests (12/C2b)
30	Rasoi	RAJ26B	32.13408	76.75936	2782	West Himalayan Upper Oak-Fir Forests (12/C2b)
31	Palachak	RAJ29A	32.14997	76.76223	2834	Kharsu Oak (12/C2a)
32	Kareri Lake	KAR29A	32.31947	76.27126	2892	Kharsu Oak (12/C2a)
33	Mundkallan	KAR29B	32.32031	76.2807	3066	Kharsu Oak (12/C2a)
34	Jhoardi	RAJ29B	32.17296	76.769531	3168	Birch-Rhododendron scrub Forests (15/C1)

2.2 Lahaul and Spiti Valleys (District Lahaul and Spiti, Himachal Pradesh)

Lahaul and Spiti Valleys (LSVs) constitute the Lahaul and Spiti district, the largest (area-wise) district of Himachal Pradesh. It is situated in the North Eastern part of the state and lies between 31° 44' 57" and 32° 59' 57" N latitudes and 76° 46' 29" and 78° 41' 34" E longitudes. It has a 13,833 km² area which is 24.85 % of the state's total geographical area.

The district consists of two major valleys viz., Lahaul and Spiti Valleys (LSVs). The two valleys have 8,251 km^2 and 5,582 km^2 of area respectively.

It is a semi-arid to arid cold desert region which comprises 1A (Trans Himalayas - Ladakh Mountains) and 1B (Trans Himalayas- Tibetan Plateau) biogeographic provinces of the Trans-Himalayan biogeographic zone of India (Rodger and Panwar 1988; Kumar et al. 2017). As per the FSI Report 2019, only 1.16 % of the district area is covered with forests. The protected area network in the district consists of two wildlife sanctuaries viz., Chandra Tal (38.56 km^2 +11.53 km^2 for consideration) and Kibber (2220.12 km^2, largest in the state), and one national park i.e., Pin Valley national park (675 km^2) (https://hpforest.nic.in/), all found within the Spiti valley. Overall, the entire protected area network is a part of the Cold Desert Biosphere Reserve (CDBR). The CDBR was the 16th biosphere reserve of India in 2009 and has also recently been proposed to be included in UNESCO's World Heritage list because of the region's cultural importance and ecological uniqueness and sensitivity.

LSVs are connected through the Kunzum pass lying at around 4,950 m elevation. Both the valleys show marked differences in terms of their cultural and biological components, and the overall ecology of these landscapes. The Lahaul valley lies towards the west side of Kunzum pass. The valley is drained by the Chandra-Bhaga or Chenab River system consisting of Chandra and Bhaga rivers and their tributaries all flowing westwards. It is comparatively greener with less harsh climatic conditions and a longer growing season than the Spiti valley.

The Spiti valley is locally called the "Piti" which means a 'middle country', as this valley lies in the middle of the Indian and Tibet region and is drained by the Spiti River system i.e., Spiti River and its tributaries. The Spiti river flows eastward and meets Sutlej finally in the Kinnaur district. The climatic conditions in the Spiti valley are relatively harsher than in the Lahaul valley with a shorter growing season. The region almost lacks trees except for the stunted shrub-like growth of the *Salix* sp. near the streams or on the moistened gorges and river beds, both naturally or planted.

2.2.1 Forest Types classification

The "relictual" vegetation in the region is mainly represented by the stands of Juniper, *Juniperus seravschanica* (mostly on relatively dry and sun-facing slopes), Birch, *Betula utilis* (in remote, relatively wet, shady and deep river gorges) (Bhardwaj and Sen 2021) and the pure stands of Deodar, *Cedrus deodara* (below 3000 m elevation). Moreover, this vegetation was earlier associated with traditional subsistence-based farming, especially the dense and thick *Juniperus* forests and alpine bushy scrub (in Spiti). But with increasing human population and development, the natural vegetation has been overexploited for human needs and is now reduced to more thin and scattered patches. Human activities have brought many major changes in the regional natural vegetation pattern. Hence, the current vegetation pattern of the region is mostly anthropogenically driven and can be found distributed sparsely among one of the three systems discussed below: agroforestry, forestry, and forests (Rawat et al. 2010).

1. **Agroforestry system**

The agriculture (in addition to tourism) forms the core of the regional economy. Therefore, to reduce the dependency on the forests for fuelwood and fodder, people undertake willow and poplar plantations on the boundaries of their terraced agricultural fields. This is also associated with the thick growth of *Hippophae rhamnoides* on the boundaries sometimes. It has now become a “basic cold desert vegetation element” (Rawat et al. 2006).

2. **Forestry system**

The pressure exerted by the increasing human population and developmental projects in the region has led to the degradation of the environmental quality and reduced natural vegetation cover in the region. To compensate for this loss, the forest department has undertaken plantation of trees in the region, mainly involving the species of willow (mostly), poplar, and pine (*Pinus wallichiana*).

3. **Forest land**

The natural forest land in the region mainly consists of sparsely distributed *Juniperus seravschanica,* sometimes associated with *Crataegus songarica* and *Rosa webbiana*. Additionally, dense mixed or pure coniferous forests (Deodar, Blue Pine, and Birch forests) are also found on relatively humid slopes (Rawat et al. 2010).

However, according to Champion and Seth's (1968) classification, the natural vegetation of the Lahaul and Spiti region has been classified into the following broad forest types: Himalayan dry Temperate forests (Group 13), Moist alpine scrub (Group 15) and Alpine scrub (Group 16).

Fig. 2.3: Major Forest Types sampled in Lahaul and Spiti Valleys (LSVs): 1. Dry Deodar Forest (13/C2b), **2.** West Himalayan High-level Dry Blue Pine Forest (13/C4), **3.** West Himalayan dry Juniper Forest (13/C5), **4.** Birch-Rhododendron scrub Forest (15/C1), **5.** Dry Alpine Scrub (16/C1), **6–7.** Dwarf Juniper Scrub (16/E1), **8.** Mixed Agroforestry system.

Group 13: Himalayan dry Temperate forests

Generally distributed in the dry inner valleys of the western Himalayan region with very little or no influence of the southwestern monsoon—precipitation being under 1000 mm and mostly in the form of snowfall during winters. Both broadleaved and coniferous trees are found, but conifers mostly dominate and form more or less a closed canopy on favourable sites. While the broadleaved are mostly stunted and occur either scattered among the coniferous species or form a more or less complete patch. They are usually found above 1700 m altitude. As they grow on the inner dry (rain shadow) valleys of the western part of the Himalayas, their sustenance is entirely dependent on the slow melting snow cover. The following types were sampled for moths' diversity in LSVs:

1) **C2: Dry Temperate Coniferous Forests** with the following subtype:

    a) **Dry Deodar forests (13/C2b)** (pp. 326) – 2

Nearly a pure dry coniferous forest of deodar, *Cedrus deodara*, or found mixed with blue pine, *Pinus wallichiana* with height ranging between 14–20 m. The forest is distributed between 2100–3250 m elevation in the inner dry valleys with rainfall between 500–1000 mm and often as snowfall during winters with short dry summers. These are found to be restricted towards the western end of the region. The forest has sparse ground vegetation as the soil is mostly covered with a thick layer of dry needles.

2) **C4: West Himalayan High-level Dry Blue pine forests (13/C4)** (pp. 328) – 2

A pure or mixed forest of blue pine, *Pinus wallichiana* with *Abies sp., Betula utilis, Juniperus communis* and *Rhododendron campanulatum.* It usually grows on moist slopes between 3000–3600 m elevation and with rainfall below 500 mm.

3) **C5: West Himalayan dry Juniper Forest (13/C5)** (pp. 328) – 5

An open and low height (5–8 m) evergreen forest of Juniper, *Juniperus seravschanica.* with sparsely distributed undergrowth (*Rosa webbiana, Rosa sericea, Ribes uva-crispa* subsp. *uva-crispa* lies between 2500–4300 m and rainfall under 300 m (usually on the dry sun-facing slopes in Lahaul).

Group 15: Moist Alpine Scrub

1) C1: **Birch-Rhododendron scrub Forests (15/C1)** (pp. 338) – 2

This exists as a pure growth of *Betula utilis* and a complete absence of the Kharsu oak, *Quercus semecarpifolia* and sparsely distributed *Rhododendron campanulatum* in the understorey. It is found above 3000 m elevation on the very wet, and dark thick soil, rich in humus and mostly remains covered with snow during the year.

2) **C3: Alpine pasture (15/C3)** (pp. 341)

"The undulating meadows are mostly composed of perennial mesophytic herbs like *Anemone, Fritillaria, Gentiana* etc. with little grass cover".

Group 16: Alpine Scrub

1) C1: **Dry alpine Scrub (16/C1)** (pp. 341)

"A xerophytic dwarf shrub associated with occasional herbs like *Rhodiola wallichiana, Primula minutissima, Dasiphora fruticosa* etc."

2) E1: **Dwarf Juniper Scrub (16/E1)** (pp. 341)

Characterized by the mat-like dominant patches of the *Juniperus communis* with scattered and very scanty herbs and completely lacking grass cover altogether".

Table 2.2: Sampling locations' details for LSVs.

Sr. No.	**Location Name**	**Location code**	**Latitude (° N)**	**Longitude (° E)**	**Elevation (m)**	**Forest Type**
1	Tindi	Lah25	32.7522	76.46735	2498	Dry Deodar Forest (13/C2b)
2	Lobar	Lah27	32.7134	76.66903	2773	West Himalayan dry Juniper Forest (13/C5)
3	Jahalman	Lah29	32.638	76.8669	2973	Agroforestry System
4	Duling	Lah30	32.6568	76.80959	3047	West Himalayan dry Juniper Forest (13/C5)
5	Chokhang	Lah31	32.6853	76.79481	3193	West Himalayan High-level Dry Blue pine forests (13/C4)
6	Trilokinath	Lah32	32.6788	76.68676	3238	West Himalayan High-level Dry Blue pine forests (13/C4)
7	Pyukar	Lah32.2	32.5536	77.07565	3289	Birch-Rhododendron scrub Forests (15/C1)
8	Jispa	Lah33	32.6426	77.18973	3327	West Himalayan dry Juniper Forest (13/C5)
9	Shashur Gompa.2	Lah34	32.5791	77.02896	3470	Agroforestry System
10	Naingaar	Lah34.2	32.7317	76.86569	3491	Birch-Rhododendron scrub Forests (15/C1)

11	Kolong	Lah35	32.5922	77.13137	3519	West Himalayan dry Juniper Forest (13/C5)
12	Shashur Gompa	Lah35.2	32.5806	77.02552	3534	West Himalayan dry Juniper Forest (13/C5)
13	Dhok	Lah37	32.6959	77.2206	3736	West Himalayan dry Juniper Forest (13/C5)
14	Sarchu	Lah43	32.8946	77.54891	4343	Dwarf Juniper Scrub (16/E1)
15	Chicham	Spiti01	32.339	77.98894	4026	Dry alpine Scrub (16/C1)
16	Kibber	Spiti02	32.3491	78.03315	4516	Dwarf Juniper Scrub (16/E1)
17	Tashigang	Spiti03	32.3139	78.05563	4870	Dwarf Juniper Scrub (16/E1)
18	Mudh	Spiti04	31.9563	78.03462	3760	Dry alpine Scrub (16/C1)
19	Kaza	Spiti05	32.2269	78.07137	3665	Dry alpine Scrub (16/C1)
20	Komic	Spiti06	32.2353	78.10598	4504	Dwarf Juniper Scrub (16/E1)
21	Komic.2	Spiti07	32.2206	78.12991	4847	Dwarf Juniper Scrub (16/E1)

2.3 Methodology

2.3.1 Sampling design and method

The mountains, due to their complex topographical features (slope, aspect, relief, elevation), exhibit great environmental heterogeneity. Moreover, the regular variation in the environmental factors along the elevational gradient of these systems forms a continuous gradient. This gradient serves as a perfect natural experimental set-up for studying, exploring, and documenting different natural phenomena and their generality. Consequently, any study aiming to explore this intricate and highly diverse system should address its inherent heterogeneity comprehensively.

The study was designed based on the stratified sampling design for accommodating the heterogeneity (altitude and forest types) of both the landscapes (DMR and LSVs). The stratification was done based on the "altitude and forest types". Besides, the "gradsect (gradient-based transect) survey design" (Austin and Heyligers 1989) was exercised for conducting field surveys along the elevational gradient. The different forest types in these landscapes were defined based on the dominant tree species in the habitat–the criteria used and followed in Champion and Seth's (1968) system of classification for defining Indian forest types (different forest types documented in each landscape are discussed above separately for each study area).

The primary field data collection surveys were conducted by combining the random sampling strategy with the stratified study design. The “elevational gradsects– “transects covering a complete elevational gradient”– (Chandra et al. 2019) were selected in each landscape. Initially, the gradsects were divided into 300 m altitudinal belts, and different forest types within each 300 m altitudinal belt were sampled randomly. Overall, the sampling was performed within the time frame of September 2020 to June 2022. The yearly sampling was divided into two seasons i.e., pre-monsoon (April to June) and post-monsoon season (September to November) in the DMR, and a single growing season from June to August in the LSVs.

2.3.2 Light Trapping and sample collection

The moths mostly exhibit strong positive phototactic behaviour–i.e., they tend to fly towards the source of light (Verheijen 1960). This knowledge has resulted in the use of light for studying moths in different aspects, i.e., for general observations, diversity studies, and population control measures (Gardiner 1995). Light trapping has now become a well-established sampling method for moths and other nocturnal insect groups. All the important environmental and other factors affecting its efficiency and sample size are well-studied and established (Bowden 1984; Yela and Holyoak 1997; Butler et. al. 1999). Additionally, it helps to sample a relatively large number of individuals in less damaged conditions (Holloway et al. 2001; Montgomery et al. 2021). This helps to generate larger, ecologically sound datasets and less-damaged specimens in identifiable conditions. Although, it has some species-specific biases within families (Muirhead-Thomson 1991; Beck and Linsenmair 2006), and also attracts more males than females (Altermatt et al. 2009). Despite these setbacks, it is the most efficient method available. Other methods like caterpillar search, bait trapping (Yela and Holyoak 1997; Niermann and Brehm 2019) and Malaise traps (Butler et.al. 1999) etc. are less efficient, more biased and often generate very poor datasets.

Globally, different designs have been used in different studies (Singh et al. 2022), with limited studies comparing the efficiencies of different trap types. However, it has been found that instead of the choice of the light trap, the choice of site in a habitat has a more significant effect on the sample size, i.e., the number of individuals and species captured. This helps to compare the results even when the studies differ in terms of methodology. Moreover, the sampling success can be maximized either by taking multiple sites in a habitat or by selecting a moderately sheltered site in case of open and semi-open habitats

(Niermann and Brehm 2022). In the case of the 'effective sampling radius', according to the Weber-Fechner law, an insect's eye perceives the linear increases in radiation as log-transformed (Brehm et al. 2021). Therefore, it can be assumed that the attraction radius will decrease with distance squared and hence, will typically reach less than 10–20 m (Truxa and Fiedler 2012). The low attraction radii can further help to compare the different habitats under investigation.

For our sampling, we performed light trapping using LepiLED (Brehm 2017) light trap for attracting and trapping the moths. This light trap is specially designed and developed by Dr. Gunnar Brehm for the sampling of nocturnal insects, particularly moths. The lamp has LEDs with peaks at 368 nm (ultraviolet), 450 nm (blue), 530 nm (green), and 550 nm (cool white), and emits more radiation in the range between 300 and 400 nm (Brehm, 2017, Brehm et al. 2021). This emission spectrum corresponds to the peak sensitivity in most Lepidopteran eye receptors (ultraviolet, blue and green) (Briscoe and Chittka 2001; Lebhardt and Desplan 2017). The trap is available in three types of models: LepiLED mini (energy-saving model, can run for longer periods), LepiLED maxi (powerful model) and LepiLED maxi switch UV mode, i.e., it can be operated both in either pure UV mode or mixed radiations mode. Out of these models, maxi has been reported to perform significantly better only at exposed or open habitats (due to greater effective radius) while UV lamp has been found to have comparable efficacy for moderately sheltered and sheltered sites (Niermann and Brehm 2022).

For setting up the light trap, a vertical white chequered sheet of 3 m×1.5 m size was outspread using ropes and the LepiLED was hung down at about ~1.5 m height above the ground at some distance in front of the sheet. For each sampling night, the light trap session was started shortly after sunset and ran for 7–8 hours overnight (mostly up to 3 a.m.).

The individuals of the targeted taxon were initially identified based on their characteristic sitting posture and body build. The same were sampled and collected manually using glass killing jars charged with ethyl acetate vapours. For collecting different-sized geometrids, killing jars of various sizes were prepared and used to minimize the damage (descaling and wing breakage) caused to specimens during collection.

For data collection, the number of individuals observed for each morphospecies along with the hourly data on the selected environmental variables (atmospheric temperature, relative humidity, wind speed and cloud cover) were collected and recorded.

For this, the individuals attracted towards the light trap were first sorted based on external morphological characteristics, and were provided with a unique reference ID number for future references. The collected specimens were stored in well-labelled oilpaper envelopes which were further stored in the zip-locked pouches with naphthalene balls and silica gel. Furthermore, to avoid the growth of fungus, the collected samples were regularly exposed to sunlight. The voucher specimens for future reference and species identification were prepared from this sample.

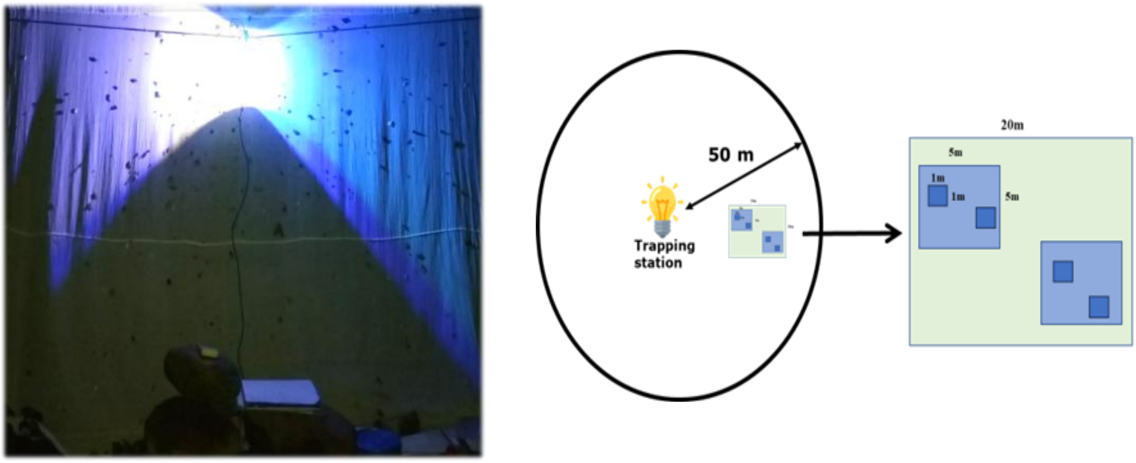


Fig 2.4: Light trapping set-up with vertical (white-chequered) sheet method and LepiLED light trap (on left) and Nested quadrate method for vegetation sampling (on right).

2.3.3 Vegetation sampling

Nested quadrates method

For each sampling point, data on vegetation and disturbance factors were recorded using the nested quadrates method. At each sampling point, sampling was performed in a 50 m radius around the light-trapping point. A 20×20 m^2 quadrate for trees and associated disturbance factors, and successionally nested quadrates of 5×5 m^2 for shrubs and 1x1 m^2 for herbs were used for collecting data.

These variables have been noted down to determine vegetation structure and composition, and the level of disturbance at the sampling location, along with their effect on the observed diversity and composition of the Geometridae moths. These can further be grouped as follows:

- Physico-environmental variables - ambient temperature, relative humidity, wind speed and cloud cover recorded during light trapping, at every hour and then averaged for one trap night.

- Habitat vegetation variables – tree species richness, abundance, GBH (girth at breast height) and height; shrub species richness, abundance/percent coverage, height; herb species richness and abundance/percent cover and distance from the water body. The vegetation data collected from nested quadrat sampling was used to further calculate the above-listed variables.
- Disturbance variables - logging or lopping sign, litter cover, bare soil percentage, ground, presence of the felled trees, grazing signs and intensity, distance from human habitation/roads and fire sign.
- Canopy cover – visual estimation (as a proxy of the vegetation density).

2.4 Voucher Specimen Preparation

The primary collection containing at least one representative for each morphospecies was prepared in the field/lab (mostly in the lab). Mostly, multiple specimens were prepared for each species, and single voucher specimens were prepared only in the case of singleton species (Ashton et al. 2011). The specimens were kept dry in the temporary field storage box and had their wings folded. However, storing the specimens like this tends to obscure features of taxonomic significance. Hence, to prepare the specimens for the taxonomic identification process, they were first rehydrated by placing them inside the rehydration chamber (rehydration time depends on the size of the specimen). The pinning was done in the middle of the thorax. For pinning, entomological pins of different sizes (depending on the width of the thorax and the abdomen of the specimen) were used. The pinning was done in such a way that one-third of the pin protruded above rather than below the specimen. The wings of the pinned specimen were then spread using an insect stretching board. For spreading, firstly, the head, thorax and abdomen of the specimen constituting the longitudinal axis of the pinned specimen were placed in the central groove of the stretching board. The wings of the specimen were then spread as per standards and fixed with the help of oil paper strips (to prevent the descaling). The spread specimens were dried out (the drying period depended on the size of the specimen), removed from the stretching board and tagged with a well-prepared label that included all collection details. The dried and well-labelled specimens were then stored in the permanent insect storage wooden boxes with all necessary precautions to prevent future attacks of ants and fungus.

2.5 Species identification

For taxonomic identification, the initial morphology-based sorting was done in the field. Each morphospecies (i.e., taxonomic unit sorted based on morphological differences and equivalent to species) was given a unique ID code, photographed (photo number or ID) and a database was maintained. The voucher specimens in the primary collections were initially identified using different field guides, available secondary literature with the pictorial representation of the species, online resources like the 'Moths of India' website, etc. The confirmation of identification up to the genus/species level was done by studying and comparing the specimens for the original description of the species. The morphological features of the specimens were observed and studied under the stereomicroscope. Additionally, the genitalia features (more reliable for species differentiation) were studied only for the complex species groups (where the morphology-based delineation was not reliable). The identification of the members in the cryptic genera was done based on the latest genus-specific revisionary works. The original descriptions of the species were accessed from the literature available on the Biodiversity Heritage Library (https://www.biodiversitylibrary.org/) website. The status of the species name was validated using the LepIndex website (https://www.nhm.ac.uk/our-science/data/lepindex/advanced) and the recently released online database for Geometridae moths (https://geometroidea.smns-bw.org/) (Rajaei et al. 2022).

Furthermore, for the identification of members in the Sterrhinae subfamily, the Geometridae collection at the Natural History Museum, London, United Kingdom (NHMUK) was consulted through personnel visits and digital loans (loan number: 2023-403). The largest and most prestigious collection of Geometridae, the Herbulot collection at Zoologische Staatssammlung München (ZSM), Munich, Germany, was also visited personally and referred for identification. The digital photographs of the habitus of each species were taken using a DSLR Nikon D7500 and Tokina AT-X Macro 90 f 2.5 macro setup. The genitalia features were studied by following the standard method discussed in Robinson (1976) with slight modifications. Temporary slides were prepared by sandwiching genitalia in between two glass slides submerged in water (as a mounting medium). The examination and photography of the genitalia features was done using an Olympus SZX16 stereo-zoom binocular microscope, followed by the storage of the genitalia in glass vials using absolute ethanol along with few drops of glycerol. All the information was entered and maintained on a database in excel sheet.

2.5.1 Characteristic features of Lepidoptera (butterflies and moths)

Moths belong to the order Lepidoptera of the insects. The members in this order, butterflies and moths, are characterized by the following characteristics:

- Body and wings covered with scales or hairs or both.
- Body divisible into three parts: head, thorax and abdomen.
- Mouthparts modified as proboscis or absent altogether in some cases.
- Antennae, **mostly** club-shaped in butterflies and variously shaped in moths but not clubbed (with some exceptions).
- Larvae with five pairs of abdominal prolegs, four on A3–A6 abdominal segments (abdominal prolegs) and the fifth one on the last segment (anal prolegs).

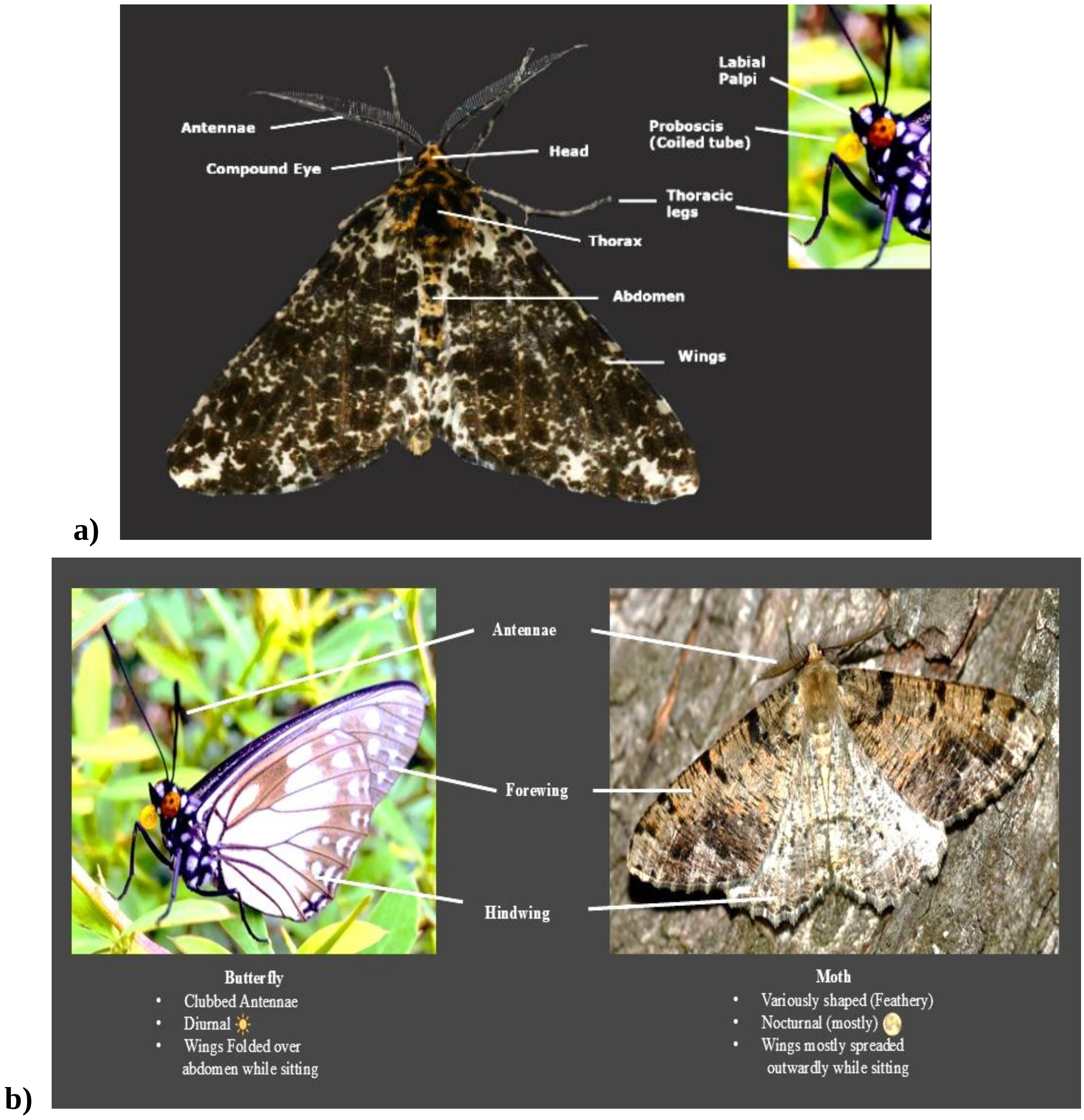


Fig. 2.5: General morphological features of the order Lepidoptera: **a.** General body plan **b.** Diagnostic features of Butterfly and Moth.

2.2.1 Characteristic features of family Geometridae and its subfamilies

The members of the family Geometridae can be easily identified based on their characteristic "looping" walking gait in larvae and a characteristic body build and sitting posture in adults.

Larva: The larvae of Geometridae moths are easily recognizable with a distinctive arrangement of their abdominal prolegs. They often only have two pairs of abdominal prolegs—one on the A6 (sixth abdominal segment) and the other on the final segment, i.e., A10—and lack the first three, i.e., on A3–A5. This arrangement of their abdominal prolegs helps them to move in a leech-like "looping" gait. They complete their one step by first bringing their anal section close to the thoracic region, creating an arch or loop (therefore, called 'loopers'), and then stretching the thoracic region out in front. They repeat this process again and again, supposed to cover one inch in a single step (also called 'inchworms') and appear to measure the earth ('earth measurers') while travelling to their destination.

Adult: The adults are characteristically built, usually small- to medium-sized, slender-bodied and with relatively large, broad wings. They typically rest in a planiform sitting posture, i.e., both the wings outspread at the right angle to the longitudinal body axis and held flat and parallel to the resting surface. Also, their wings are mostly with cryptic colour and pattern. The forewing features, vein 3A forming a basal fork with 2A; 1A absent (Triplehorn and Johnson 2005), are used in the traditional taxonomy.

Members of the four major subfamilies can be easily differentiated in the field based on their distinctive sitting postures and specific morphological characteristics (Fig. ??):

Subfamily: Sterrhinae Meyrick, 1892

The adults of the subfamily Sterrhinae (except those of Cyllopodini and Rhodometrini) are characterized by a dark, discal spot on the hind wing with pale surrounding distinct from that of general background and pale markings in darker surrounding (Holloway 1997). The members are commonly called 'the waves' because of the numerous wavy fasciae (darker than the ground colour of the wings) on their fore and hindwings (Sihvonen et al. 2020). Also, the males of the tribes Scopulini, Sterrhini and Cyllopodini have the following secondary sexual characteristics: hair pencil (long scent pencil) on the hind tibia; hind legs shortened with tarsi reduced and apex of leg upturned and in Cosymbiini, a thick tuft of scales on the hind tibia and a pair of corematous structures on the 4th sternite. When at rest, the adults mostly spread their wings outward in a characteristic posture of the family.

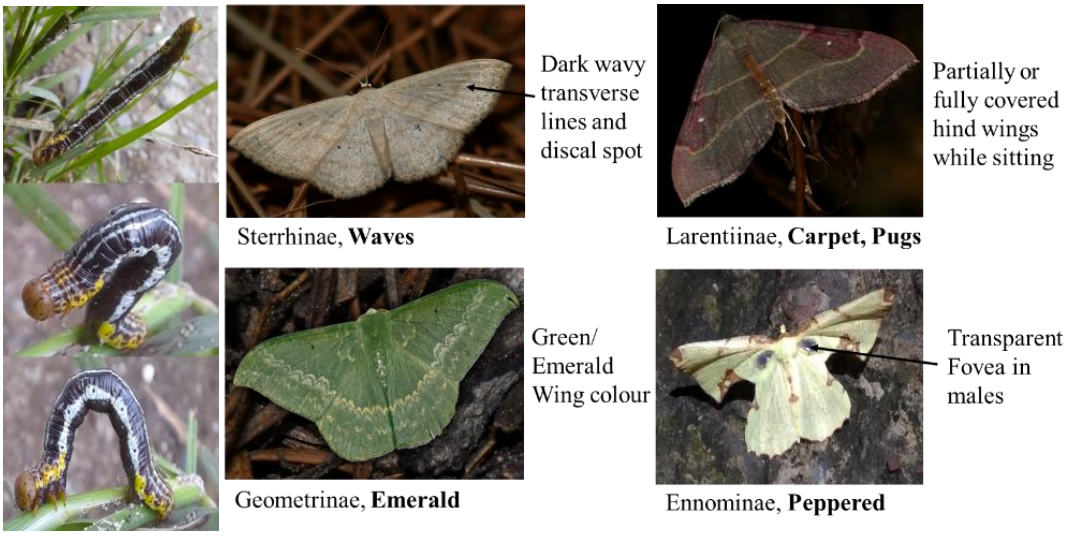


Fig. 2.6: Larval and adult characteristics of the members in the family Geometridae and its four major subfamilies, Sterrhinae, Larentiinae, Geometrinae and Ennominae, documented during the study.

Subfamily: Larentiinae Duponchel, 1845

Subfamily Larentiinae was defined by Minet (1983) based on the possession of a hammer-headed ansa. But this also occurs amongst the sterrhines (Holloway, Bradley and Carter 1987; Cook and Scoble, 1992), and in the geometrines of the genus *Dysphania* Hübner (Cook and Scoble 1992; Holloway 1996a). Therefore, Holloway, Bradley and Carter (1987) defined more reliable facies character for distinguishing the group, i.e., each fascia of the forewing tends to be multiple rather than single which meets the dorsum at right angles rather than obliquely. A high proportion of the species rests with the forewing mostly or wholly covering the hindwing (Common 1990) and expose the hindwings only where the pattern is as strong as that of the forewing (see Tweedie and Emmet 1991). Males lack hair pencil on the hind tibia which is found to occur either on the hind wing or in the form of coremata towards the distal end of the abdomen.

Subfamily: Geometrinae Stephens, 1829

The members are famously called the “emerald moths”. They are mostly green or emerald coloured (due to the single green pigment, named, geoverdin). Males are generally with paired setal patches on the 3rd abdominal sternite (with some variations), and are often associated with the presence of sheathed hair pencil in the hind tibia (Holloway 1996).

Subfamily: Ennominae Duponchel, 1845

It is the largest subfamily of Geometridae and holds an immense ecological and biological diversity. The loss (or reduction to a fold) of the M2 vein on the hindwing is a characteristic diagnostic feature in traditional taxonomy. Adults are mostly strongly built compared to the other subfamilies and males are often with a transparent membranous fovea at the base of the forewings (Holloway 1993).

Chapter 3
Taxonomic Inventory along with Seasonality and Biogeographic affinity of Geometridae moths from DMR

3.1 **Introduction**

Species is the fundamental unit of any natural system. Most natural systems on Earth are well-studied for their underlying processes, dynamics, and characteristic features. But at the same time, these systems are hardly ever completely evaluated for their living components i.e., species. In addition, when species lists are prepared, the focus is mainly on plant and animal taxa, especially those which are larger in size and more charismatic. Taxa that are smaller in size and less popular are rarely included in such studies. Moreover, owing to their small size, the role of microfauna in an ecosystem remains unnoticed and is neither realised nor appreciated by the general public. For a more comprehensive understanding of any given natural system, it is important to delve deeply into fundamental questions. Some of them include recognising the key components or processes at play and, most notably, discerning the overall conservation value of the system. Answering these questions requires knowledge of the fundamental elements (species) within these systems. This is where the importance of species inventories comes into the spotlight.

The species inventories are "the complete lists of species recorded for a specific place in a specific time frame" (Guralnick et al. 2018). Such lists, when prepared following standard methods, are more than just a simple compilation of species names. They can help to understand the system as a whole—its biological and ecological importance, the factors and processes important for its maintenance, conservation needs and planning—and contribute significantly to the long-term monitoring and conservation of the system (Spehn and Korner 2005; Gjerde et al. 2007; Bungartz et al. 2012; Guralnick et al. 2018). Also, their importance becomes manyfold to the protected, sensitive, threatened, and unique ecosystems, such as the Himalaya.

Insects are the most abundant and diverse component of any natural system. Despite their ecological and biological importance, the lack of ecological data—the Linnean (inadequacy of species richness data and incomplete inventorisation of diversity) (Brown and Lomolino 1998) and Wallacean shortfalls (inadequacy of species distributional data) (Lomolino 2004)—hampers the evaluation of their conservation status and planning of conservation measures. Moreover, the conservation status of insects in this Anthropocene is more anecdotal and has only been narrated by some, based on their observations (not in a scientific manner mostly). This makes the knowledge of the rate of population decline or species extinction, its spatial and temporal scale, underlying causes, and most threatened groups unclear in the absence of any long-term standardised data (Fox 2013; Wagner 2020). There are only a few long-term projects which monitor insect population trends and are mostly country-, region-, or taxon-specific (Montgomery et al. 2021).

Preparing a complete list of insect taxa for a given habitat or landscape is infeasible. The huge abundance and diversity of insects, associated taxonomic impediments, constraints of time, finances, and personnel limitations (Ehrlich 1992, 2003; Kitching 1993a, b; Kitching et al. 2001; Spector 2006), make the process very complicated and humongous. Also, we could not know the exact number of species in a particular habitat or landscape to evaluate the completeness of the documented species diversity. Henceforth, in the case of insect inventory studies, the concept of studying an 'umbrella' taxon or biodiversity indicators, for estimating the broad spatial patterns of insect diversity is comparatively more meaningful and achievable (Samways 2005, 2007). These 'umbrella' taxon or biodiversity indicators are the well-studied and established taxon mostly with a significant taxonomic ratio, i.e., the diversity in these taxa is established to represent the diversity of other organisms (Spehn and Korner 2005) and the relative biodiversity of the sampled sites. These taxa can be selected based on three crucial criteria defined by Fattorini (2013): "(1) good taxonomic knowledge of the group; (2) a proven record as informative bioindicators, with context elsewhere, and (3) performing a critical role in ecological processes".

Method standardisation helps not only save but also makes effective use of resources such as time and money, especially in the case of insect studies where even small efforts result in huge datasets. It also provides an opportunity to increase the spatial and temporal scales of the study and data for extracting ecological information through statistical analysis (Pimm et al. 2015). However, in the case of insect studies, seasonal variation in species richness also needs to be accounted for during the standardisation process. The process of inventorying insect taxa collected through standardised methods is still very time-consuming because of the involvement of steps such as specimen preparation and identification. These limitations can soon be overcome by technological advances. The so far developed automated and semi-automated tools such as metabarcoding, camera traps, computer vision, and machine learning tools will help digitise the entire identification process. This will speed up the overall identification process (by reducing the need for lengthy specimen preparation), metadata capture, and data accessibility. Furthermore, it will also reduce the time gap between data collection and analysis and help expand the overall scope of new as well as existing studies with comparable resources (Braby et al. 2016; Montgomery et al. 2021).

The Geometridae family of moths is a well-established surrogate and indicator taxon globally. Previously, several species of the Geometridae were described with their type localities in the IHR. Out of these species, many were described from the localities which now constitute the North Western Himalayan biogeographic province (2A) of Himachal Pradesh, especially from Dharamshala, which falls in the DMR. These earlier studies were opportunistic and were conducted out of interest by the then-British officers who were posted in these regions. Therefore, such documentation, in the absence of technology and scientific advancements, lacked important ecological details, scattered here and there, and is mostly in the untraceable or inaccessible literature.

This chapter focuses to i) provide a detailed list of all the identified and documented species of this study along with their brief diagnostic features and documented distributional range, ii) evaluate the total species richness and diversity of Geometridae moths in DMR (γ-diversity), iii) the seasonal differences in the geometrid assemblage in the area and ii) assessment of the biogeographic affinity of the total assemblage based on the distributional ranges of the recorded species.

3.2 Materials and Methods

3.2.1 Data collection

Altogether, 34 sites were sampled, with a total of 144 light trapping sessions across two distinct seasons: the pre-monsoon (70 sessions) and post-monsoon (74 sessions) seasons. A nearly equal number of night sessions were performed at each site, except for a few sites towards the lower elevations where the same efforts resulted in very few individuals. Therefore, supplementary sampling was performed at these sites to reduce the chances of undersampling and unequal representation of sites. This resulted in sampling efforts in the range of four to six sampling nights at each point.

3.2.2 Data analysis

Inventory preparation

The reference collection was prepared from field survey samples at the Wildlife Biology Laboratory of the Wildlife Institute of India, Dehradun, India. The collection was established by preparing at least one voucher specimen for each morphologically sorted species (morphospecies) that was differentiated earlier during the field surveys. All specimens were prepared following standard protocols defined for the order Lepidoptera and tagged appropriately with the details of sample collection.

Species identification and verification were performed based on the original descriptions of the species. The specimens of each species were studied for their morphological characteristics (described in Chapter 2), while the genitalia features were studied in the case of the complex species groups (where morphology-based delineation was not reliable). All secondary literature was searched to compile the documented distributional details for each species. Habitus photographs for each species were taken using a DSLR Nikon D7500 and Tokina AT-X Macro 90 f 2.5 macro setup. To study the genitalia features, the standard method discussed in Robinson (1976) was followed, with slight modifications. The current valid names for every species were followed as per the latest references in the Forum Herbulot (Rajaei et al. 2022) and the LepIndex websites (Beccaloni et al. 2003).

DNA barcoding

Sterrhinae moths constitute a well-supported monophyletic lineage, the most basal and sister to the rest of the subfamilies in the family Geometridae (Murillo-Ramos et al. 2019; Sihvonen et al. 2020). The members are comparatively smaller < 20 mm (Sihvonen et al. 2020), delicately built and mostly with numerous wavy transverse fasciae usually darker than the ground colour of the wings and commonly called as ‘the waves’ (Holloway 1997). Taxonomic delineation of the species in this subfamily is comparatively more difficult. Therefore, are heavily understudied worldwide leading to the largest knowledge gap in the study of geometrid moths (Hausmann 2004). The modern taxonomic revisions, combining the traditional morphology-based taxonomic studies with the advanced molecular tools of DNA barcoding often help in revealing new species in the cryptic species groups. Therefore, DNA barcoding was used as an additional tool for differentiating the members of the Sterrhinae moths present in both landscapes (DMR as well as LSVs).

For DNA barcoding, one or two leg samples from a single dry specimen of each morphologically differentiated species was taken. After the necessary approval from the

National Biodiversity Authority (NBA), India (letter no. Appl/9/Form B/INBAB202204169/22/22–23/4321), the samples were transported to SNSB-ZSM (Staatliche Naturwissenschaftliche Sammlungen Bayerns-Zoologische Staatssammlung München) Munich, Germany. The sample was subsequently forwarded to the Canadian Centre for DNA Barcoding (CCDB), University of Guelph, Canada where DNA extraction, amplification and sequencing was done by following the established high-throughput protocol for DNA barcode (mitochondrial cytochrome c oxidase I, COI 5′; 658 base pairs) (Ivanova et al. 2006; deWaard et al. 2008; also accessible at http://ccdb.ca/resources/). For each sample, a partial fragment of the Cytochrome c oxidase subunit I (COI 5′) from the mitochondrial genome was sequenced and the generated sequences were released online on BOLD (Barcode of Life Data Systems).

Alpha (α) and Gamma (γ) diversity measures, seasonality and biogeographic affinity

Species richness is the most fundamental measure of the diversity within an assemblage (Chao and Chiu 2016). The simple count method used to measure the species richness is often inaccurate and tends to underestimate the true number of species. This is because it heavily relies on sampling efforts and sample completeness. Also, diverse assemblages, like moths, often contain many rare species. As a result, methods that estimate species richness (based on both observed and undetected species), are important to fairly compare multiple assemblages that are possibly incompletely sampled or sampled with unequal sampling efforts (Chao and Chiu 2016). Therefore, three different approaches were employed to measure both site-wise (α-diversity) and total (γ) diversity of the DMR.

As a first approach, the observed species number and diversity indexes like Dominance (D), Simpson's (1-D), Shannon (H) and Evenness (e^H/S) were calculated. However, these numbers can be misleading and biased due to the different sampling successes among the sites. Therefore, in the second approach, different non-parametric richness estimators were employed to get a fair number of species for further comparison. The estimated species number based on the iChao-1 index (Chao and Chiu 2016) was used as a standard to compare the sampling completeness for DMR as well as every sampling site. For the third approach, α-diversity was estimated using Fisher's alpha of the log-series distribution. All the measures were calculated in Past4 software.

Seasonality plays an important role in shaping the overall diversity of temperate landscapes such as the Himalaya. Therefore, this needs to be addressed when preparing the study design. The total sampling duration was divided into two major seasons—pre-monsoon (April–June) and post-monsoon (September–October)—and every site was sampled at least twice for each season. The dataset for each season was pooled and seasonal differences in alpha and gamma diversity were evaluated. For comparison, the season-wise pooled data was used to calculate all the species richness and diversity measures for each season. Additionally, the species compositional differences between the two seasons were assessed using ANOSIM (Analysis of Similarity) and SIMPER (Similarity Percentage) analysis in Past4 software. ANOSIM provides the statistical significance value (p-value) and Global R-value. The R-value is the measure of distance between a pair of sites; its value close to zero indicates similarity between the sites while close to one or one indicates strongly distinct communities (Clarke 1993). While SIMPER analysis reveals the species contributing to the dissimilarity between a pair of sample units. For biogeographic affinity analysis, the distribution data of every species were gathered from the secondary literature.

3.3 Results

3.3.1 Species Inventory

A total of 280 species of the Geometridae family were documented. They belong to four major subfamilies: Sterrhinae (7 tribes, 15 genera, 33 species), Larentiinae (10 tribes, 37 genera, 75 species), Geometrinae (4 tribes, 16 genera, and 24 species), and Ennominae (12 tribes, 75 genera, 148 species). Among the four documented subfamilies, Ennominae was the most species-rich and abundant subfamily, followed by Larentiinae, Sterrhinae, and Geometrinae. The documented species also includes seven species as new to India and fifty-six species as new records for the Himachal Pradesh’s moth fauna from DMR (Appendix 1).

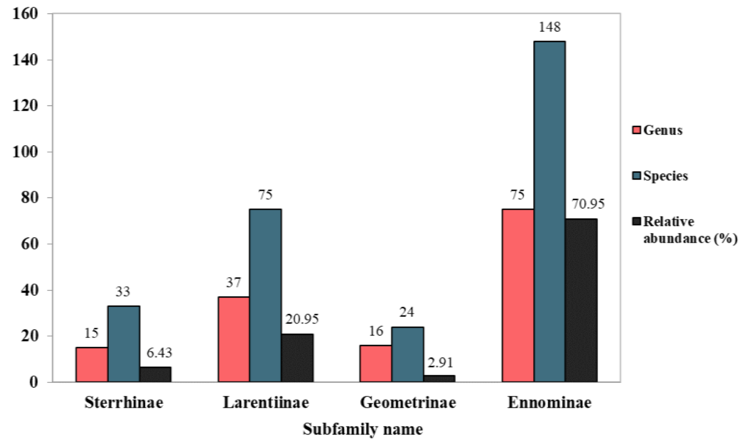


Fig. 3.1: Total number of genera, species and relative abundance of the individuals documented among the four major subfamilies of Geometridae moths.

Taxonomic account

Kingdom Animalia

Phylum Arthropoda (Latreille, 1829)

Class Insecta (Linnaeus, 1758)

Order Lepidoptera Linnaeus, 1758

Superfamily Geometroidea Leach, 1815

Family Geometridae Leach, 1815

Subfamily Sterrhinae Meyrick, 1892

Tribe Cosymbiini Prout, 1911 (Cosymbiinae)

Genus *Chrysocraspeda* Swinhoe, 1893

1. ***Chrysocraspeda faganaria* (Guenée, [1858])** [Plate 1.1, 1.2]

[TL: Brazil]

= *amoenaria* (Snellen, 1890) (*Acidalia*); [TL: Sumatra, Java (Indonesia)]

= *auricincta* (Hampson, 1893) (*Hyria*); [TL: Ceylon (Sri Lanka)]

= *deviaria* (Walker, 1861) (*Hyria*); [TL: Hindostan (India)]

= *rhodinaria* (Walker, 1861) (*Hyria*?); [TL: Ceylon (Sri Lanka)]

= *togata* (Fabricius, 1798) (*Phalaena*); [TL: India]

Hyaria faganaria Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 430.*Chrysocraspeda faganaria*; Koli and Prajapati 2021; *Records of the Zoological Survey of India*, 121 (2): 241–256.

Wing expanse: 20 mm (Forewing length: 9–10 mm).

Diagnosis: Female: Wings with straight edges, slightly angled at middle, pale reddish-brown, a very narrow yellow marginal border with pinkish inner edge. Underside suffused with pink.

Male: Wings bright yellow, irrorated and patterned with pink. Forewing with indistinct, sinuous, yellow ante medial line; and an irregular yellow post medial patch.

Distribution: India: Gujarat (Gohil et al. 2022; Vaghela et al. 2023), **Himachal Pradesh**, Kerala (Das et al. 2020), Meghalaya (North East hill) (Joshi et al. 2021), Orissa (Pattanaik et al. 2021), Rajasthan (Koli and Prajapati 2021), Tamil Nadu (Chennai) (Nagarajan et al. 2021), Uttar Pradesh (Varanasi) (Nayak and Ghosh, 2020; Pattanaik et al. 2021; Farooqui and Parwez 2022), West Bengal (Nayak and Sasmal 2020). **Global:** Brazil (TL), China, Hong Kong, Indonesia, Sri Lanka.

Remarks: It is a new record to Himachal Pradesh.

2. *Chrysocraspeda olearia* (Guenée, [1858]) [Plate 1.3]

[TL: North India]

= *cerasina* Swinhoe, 1893; [TL: Ceylon (Sri Lanka)]

Hyaria olearia Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 430.

Chrysocraspeda olearia; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma,* 3: 444.

Chrysocraspeda olearia; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 160, pl.15 (g).

Chrysocraspeda olearia; Singh, 1953; *Indian Forest Records,* 8 (7); 13, fig. 44 (Larva).

Chrysocraspeda olearia; Mathur, 1960; *Indian Forest Leaflet* (Entomology): 161.

Chrysocraspeda olearia; Koli and Prajapati, 2021; *Records of the Zoological Survey of India*, 121 (2): 241–256.

Wing expanse: 22 mm.

Diagnosis: Wings with outer margin slightly bent in the middle, apex of the forewing and anal angle of hindwing slightly acute; ochreous-orange irrorated with brown and suffused with greyish-lilac, yellow outer marginal borders. Both wings with indistinct, sinuous, yellow sub marginal line; forewing with black discal spot and hindwing with a characteristic white “circumflex accent form”.

Distribution: India: Himachal Pradesh (GHNP) (Singh et al. 2022), Jammu and Kashmir, Jharkhand (Keshari 2016), Kerala (Das et al. 2020), Maharashtra (Subhalaxmi et al. 2011), Rajasthan (Koli and Prajapati, 2021), Sikkim, Uttarakhand (Govind WLS, Dehradun) (Uniyal et al. 2016; Sanyal et al. 2017; Chandra et al. 2019). **Global:** China, Hong Kong, Sri Lanka, Thailand.

Remarks: The species has been documented as a defoliator of the *Syzigium cumini* (Jamun) in Jharkhand (Keshari 2016).

Genus *Cyclophora* Hübner, 1822

3. *Cyclophora obstataria obstataria* (Walker, 1861) [Plate 1.4]

[TL: Borneo]

= *acuta* (Moore, [1887]) (*Anisodes*); [TL: Ceylon (Sri Lanka)]

= *ignorata* (Walker, [1863]) (*Anisodes*); [TL: Ceylon (Sri Lanka)]

Acidalia obstataria Walker, 1861; *List Species Lepidoptera Insects Collection British Museum*, 23: 769.

Anisodes obstataria; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 167, pl. 17 (i).

Cyclophora obstataria; Holloway, 1997; *Moths of Borneo*, Part-10.

Wing expanse: 26-28 mm.

Diagnosis: Pale reddish-pink wings with fuscous-grey irrorations; forewing with faded greyish highly undulating postmedial line which continue as medial line in the hindwing; an indistinct discal spot and an antemedial, submarginal and marginal series of black spots. Hindwing similar to forewing.

Distribution: India: Arunachal Pradesh (Subansiri) (Sonne and Gaikwad 2021), **Himachal Pradesh** (Dhauladhar mountains-current study), Meghalaya (Joshi et al., 2021), Tamil Nadu (Das et al. 2020). **Global:** Borneo (Sarawak), Indonesia (Sumatra), Sri Lanka (Ceylon), Thailand (Malay Peninsula) (Holloway 1997).

Remarks: It is a new record to Himachal Pradesh.

Genus *Perixera* Meyrick, 1886

4. *Perixera niveopuncta* (Warren, 1897) [Plate 1.5]

[TL: Nord-Australien]

= *decolorata* (Warren, 1897) (*Brachycola*); [TL: Loyalty Islands (Loyauti)]

= *indigens* (Warren, 1906) (*Perixera*?); [TL: British New Guinea (Papua New Guinea)]

= *paucinotata* (Warren, 1901) (*Anisodes*); [TL: Celebes (Sulawesi)] (south)

Brachycola niveopuncta Warren, 1897; *Novitates zoologicae*, 4: 48.

Anisodes niveopuncta; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 170, pl. 18 (e).

Cyclophora niveopuncta; Holloway, 1997; *Moths of Borneo*, Part-10.

Wing expanse: 32 mm.

Diagnosis: It is very similar to the previous species but is comparatively larger in size and with white centered discal spots which sometime have indistinct faded black outline.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study). **Global: A**ustralia, Borneo (Holloway 1997), Indonesia (Celebes), Malaysia (Sabah) (Abang et al. 2000), New Caledonia (Loyalty Islands), Papua New Guinea.

Remarks: The species is a new record to India.

Tribe Timandrini Stephens, 1850

Genus *Timandra* Duponchel, 1829

5. *Timandra convectaria convectaria* Walker, 1861 [Plate 1.6]

[TL: Sylhet, Bangladesh]

Timandra convectaria Walker, 1861; *List Species Lepidoptera Insects Collection British Museum*, 23: 800.

Calothysanis convectaria; Prout, 1920–1941; in Seitz, *The Macrolepidoptera of the world*, 12: 153, pl. 16 (f).

Timandra convectaria; Cui et al., 2019; *ZooKeys*, 829: 53.

Wing expanse: 24–26 mm.

Diagnosis: Looks alike to the previous species (*Timandra correspondence*) but differs in being smaller in size and the postmedial line on the hindwing comparatively more protruded in middle while almost straight in *T. correspondens*.

Distribution: India: Assam, **Himachal Pradesh** (Dhauladhar mountains-current study), Maharashtra, Sikkim, Tamil Nadu, West Bengal (Subhalaxmi et al. 2011; Shah et al. 2018; Chandra et al. 2019). **Global:** Bangladesh (TL: Sylhet), China (Fujian, Guangxi, Hubei, Hunan, Hainan, Sichuan, Tibet, Yunnan, Zhejiang), Hong Kong, Indonesia, Japan, Korea (Byun et al. 2009), Philippines, Russia, Taiwan, Vietnam (Cui et al. 2019).

Remarks: New record to Himachal Pradesh.

6. *Timandra correspondens* Hampson, 1895 [Plate 1.7]

[TL: Dharmsala, Himachal Pradesh, India]

Timandra correspondens Hampson, 1895; The *Fauna of British India, including Ceylon and Burma* **3:** 459.

Calothysanis correspondens; Prout, 1920–1941; in Seitz, *The Macrolepidoptera of the world*, **12:** 153, pl. 16 (f).

Timandra correspondens; Yazaki, 1992; *Tinea*, *13* (suppl. *2*)*; Moths of Nepal*, Part-1: 14, pl. 5 (10).

Timandra correspondens; Cui *et al.*, 2019; *ZooKeys*, **829**: 54.

Wing expanse: 38 mm.

Diagnosis: Discussed in the *Timandra convectaria*.

Distribution: India: Arunachal Pradesh (Eaglenest WLS), Assam, Himachal Pradesh (Dharamshala, Shimla, GHNP) (Kumar et al. 2018; Mallick 2021), Kerala, Manipur, Meghalaya, Nagaland, Rajasthan (Koli and Prajapati, 2021), Tamil Nadu, Uttarakhand (Munsiyari, Mussoorie, NDBR) (Dey 2018), West Bengal (Kalimpong) (Shah et al. 2018; Chandra et al. 2019; Chettri and Yonle 2021). **Global:** Bhutan, China, Myanmar, Nepal (Yazaki 1992), Vietnam (Tonkin) (Cui et al. 2019)

Genus *Rhodometra* Meyrick, 1892

7. *Rhodometra sacraria* (Linnaeus, 1767) [Plate 1.8]

[TL: Barbaria [North Africa]

= *fulvaria* (Fabricius, 1794) (*Phalaena*); [TL: Italy]

= *labda* (Cramer, [1777]) (*Phalaena*] *Geometra*]); [TL: Surinam]

= *minervae* (Gistel, 1856) (*Aspilates*); [TL: Europe]

= *sacralis* (Thunberg, 1784) (*Pyralis*); [TL: Sweden]

= *sanguinaria* (Esper, [1801]) (*Phalaena*, *Geometra*); [TL: Europe].

Phaelena sacraria Linnaeus, 1767; *Systema Naturae*, (ed. 12), 1: 2, p. 863.

Wing expanse: 22–26 mm (Forewing length: 10–12 mm).

Diagnosis: Pale ochreous-yellow forewing, hindwing paler and whitish. Forewing with a characteristic reddish-pink diffused, narrow, oblique band starting from costa just before apex towards inner margin near anal angle and similar coloured discal spot.

Distribution: India: Himachal Pradesh, Madhya Pradesh, Maharashtra (Gurule 2013), Meghalaya (Joshi et al. 2021), Punjab (Vattakaven et al. 2016), Tamil Nadu (Das et al. 2020), Uttarakhand, Uttar Pradesh (Farroqui and Parwez 2021), West Bengal (Shah et al. 2018; Chandra et al. 2019). **Global:** Afghanistan, Algeria, Australia, Botswana, Chile (King and Viejo Montesinos 2014), Congo, Denmark, Ethiopia, France, Greece, Ireland, Italy, Kenya, Libya, Madagascar, Morocco, Mozambique, Namibia, Netherland, Nigeria, Norway (Johanson 1993), Pakistan, Poland (Bury et al. 2017), Portugal, Spain, South Africa (Scott and Way 1898), Sudan, Tanzania, Tunisia, UAE, Uganda, United Kingdom, Zambia, Zimbabwe.

Remarks: It is a cosmopolitan species with some migratory behaviour.

Genus *Traminda* Saalmüller, 1891

8. *Traminda mundissima mundissima* (Walker, 1861) [Plate 1.9]
[TL: South Hindostan, India]

= *burmana* (Swinhoe, 1890) (*Timandra*); [TL: Burma]

= *diatomata* (Walker, [1863]) (*Timandra*?); [TL: Hindostan (India)]

= *malacopis* (Lower, 1902) (*Timandra*); [TL: Australia]

= *semicompleta* (Walker, [1863]) (*Timandra*); [TL: Hindostan (India)].

Acidalia mundissima Walker, 1861; *List Species Lepidoptera Insects Collection British Museum*, **23:** 795.

Timandra mundissima; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 460.

Traminda mundissima; Prout, 1920–1941; in Seitz, *The Macrolepidoptera of the world,* 12: 164, pl. 17 (g).

Traminda mundissima; Singh, 1953; *Indian Forest Records*, 8 (7): 110 (Larva).

Traminda mundissima mundissima; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 15, pl. 5 (24).

Wing expanse: 26 mm.

Diagnosis: The species is similar in size and shape to *T. convectaria*. However, *T. mundissima* have green to dull green wings with an oblique, pale ochreous white postmedial line with dark brown shade on its outer edge (and almost disappear towards costa) which also continue in the hindwings. Hind wing with a white centered discal spot encircled with dark brown.

Distribution: India: Throughout India: Delhi (Paul et al. 2017), Himachal Pradesh (Dhauladhar Mountains-current study), Gujarat (Koli and Prajapati 2021; Gohil et al. 2022; Patel et al. 2023; Vaghela et al. 2023), Karnataka (Mishra et al. 2016; Ravindrakumar 2021), Kerala (Shamsudeen and Pathania 2022), Maharashtra (Subhalaxmi et al. 2011; Gurule 2013), Rajasthan (Koli and Prajapati, 2021; Jain and Verma 2023), Punjab (Paunikar and Sharma 2022), Tamil Nadu (Iyer et al. 2021; Nagarajan et al. 2021), Uttarakhand (Dehradun) (Uniyal et al. 2016; Sanyal et al. 2017), Uttar Pradesh (Nayak and Ghosh 2020; Farooqui and Parwez 2021), West Bengal (Shah et al. 2018). **Global:** Australia (Marohasy 1995), Myanmar, Nepal (Yazaki 1992), Sri Lanka, UAE (Legrain and Wiltshire 1998).

Tribe Cylllopodini Kirby, 1892

Genus *Organopoda* Hampson, 1893

9. *Organopoda carnearia himalaica* Prout, 1938 [Plate 1.10]

[TL: Khasi Hill, Meghalaya, India]

Organopoda carnearia himalaica; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 147, pl. 16 (a).

Wing expanse: Forewing length: Male: 15 mm; Female: 16 mm.

Diagnosis: The subspecies *O. c. himalaica* can be distinguished from the similarly looking species *O. annulifera* as it is more brightly coloured with greater reddish and grey suffusion; larger discal spot of the hind wing which is not pure white.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Meghalaya (Khasi Hills), Sikkim. **Global:** Borneo (Kinabalu), China (Hainan), Formosa, Indonesia (Java, Sumatra, Mentawi), Japan (RyuKyu).

Remarks: New record to Himachal Pradesh. Need further investigation.

Genus *Rhodostrophia* Hübner, [1823]

10. *Rhodostrophia herbicolens* (Butler, 1883) [Plate 1.11]

[TL: Solun, North Western India, India]

Delocharis herbicolens Butler, 1883; *Proceedings of the Zoological Society of London:* 1720.

Rhodostrophia herbicolens; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma,* 3: 457.

Rhodostrophia herbicolens; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 42.

Rhodostrophia herbicolens; Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary:* 25, pl. 4 (a).

Rhodostrophia herbicolens; Prout, Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 144, pl. 15 (b).

Wing expanse: Forewing length: Male: 14–17 mm, Female: 13–16 mm.

Diagnosis: See *Kumari et al.* 2024.

Distribution: India: Himachal Pradesh (Solan, Shimla, Dalhousie, Kasauli, GHNP) (Mallick 2021), Uttarakhand (NDBR) (Dey 2018). **Global:** No documentation.

11. *Rhodostrophia pelloniaria* (Guenée, 1858) [Plate 1.12]

[TL: Indes orientales]

= *pelloniaria meonodes* Prout, 1935 [TL: Kashmir; Kulu, North Western India, India]

Phyletis pelloniaria Guenée, [1858]; in Boisduval and Guenée: *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 10: 169. [Holotype ♂, Indes orientales (NHM)].

Rhodostrophia pelloniaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma,* 3: 456.

Rhodostrophia pelloniaria meonodes Prout, 1934–1938; in *Seitz, The Macrolepidoptera of the world, 4, supplementary*: 25, pl. 4 (a). [TL: Kullu, North Western India].

Rhodostrophia pelloniaria; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world,* 12: 145, pl. 15(d).

Rhodostrophia pelloniaria; Sanyal *et al.* 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: Forewing length: Male: 14–16 mm, Female: 13–14 mm.

Diagnosis: See *Kumari et al.* 2024

Distribution: India: Himachal Pradesh (Kullu, Dalhousie), Jammu and Kashmir Union Territory (Kashmir), Meghalaya, Uttarakhand (Kumaon) (Chandra et al. 2019; Joshi et al. 2021). **Global:** Pakistan.

12. *Rhodostrophia stigmatica* Butler, 1889 [Plate 1.13]
[TL: Dharmsala, North Western India, India]

Rhodostrophia stigmatica Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 110, pl. 136: 19, 20.

Rhodostrophia stigmatica; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 43, pl. 3 (e).

Rhodostrophia stigmatica; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 14, pl. 5: 14.

Rhodostrophia stigmatica; Smetacek, 2008; *Bionotes,* 10 (1): 7.

Wing expanse: Forewing length: Male: 12–13 mm, Female: 14–16 mm.

Diagnosis: See *Kumari et al.* 2024

Distribution: India: Himachal Pradesh (Dharamshala), Uttarakhand (Kumaon) (Smetacek 2008). **Global:** Nepal (Yazaki 1992)

13. *Rhodostrophia tristrigalis* Butler, 1889 [Plate 1.14]
[TL: Dharmsala, N. W. India, India]

Rhodostrophia tristrigalis Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 22, 110, pl. 137 (1).

Rhodostrophia tristrigalis; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 456.

Rhodostrophia tristrigalis; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 42, pl. 3 (e).

Rhodostrophia tristrigalis; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 144, pl. 15 (c).

Rhodostrophia tristrigalis; Smetacek, 2008; *Bionotes,* 10 (1): 7.

Wing expanse: Forewings length: Male: 12–13 mm, Female: 13–15 mm.

Diagnosis: See *Kumari et al.* 2024

Distribution: India: Himachal Pradesh (Dharamshala), Uttarakhand (Kumaon) (Smetacek 2008). **Global:** Bhutan, China (Sichuan, Tibet), Myanmar (Shan State, average elevation 1200–1500 m), (Cui et al. 2019); Sultanpur.

14. *Rhodostrophia vinacearia* (Moore, 1868) [Plate 1.15]
[TL: North East Bengal, India]

Anisodes vinacearia Moore, 1867, *Proceedings of the Zoological Society of London*: 642.

Rhodostrophia vinacearia; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world,* 4: 42.

Rhodostrophia vinacearia; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world,* 12: 145, pl. 15 (d).

Rhodostrophia vinacearia; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 455.

Wing expanse: Forewing length: Female: 14 mm.

Diagnosis: See *Kumari et al.* 2024.

Distribution: India: Meghalaya (Joshi et al. 2021), West Bengal (TL). **Global:** No documentation.

Genus *Tanaotrichia* Warren, 1893

15. *Tanaotrichia prasonaria trilineata* Warren, 1893 [Plate 1.16]
[TL: Sikkim, India]

Tanaotrichia prasonaria trilineata Warren, 1893; *Proceedings of the Zoological Society of London*: 361.

[Tanaotrichia trilineata; Leech, 1897; VIII-Lepidoptera Heterocera from China, Japan, and Corea. –Part 11, Family Geometriae; Subfamilies: Oenochromiae, Orthostixinae, Larentiinae, Acidaliinae, and Geometriae. *Journal of Natural History*, Series 6, 20 (115), 65–110. Doi:l O. 1080/00222939708680601.- Later on described as a new species named as *Tanaotrichia orientis* by Prout, 1912–1916]

Wing expanse: Forewing length: Male: 15 mm, Female: 15–17 mm.

Diagnosis: See *Kumari et al.* 2024

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), North Western Himalayas, Sikkim (TL). **Global:** No documentation.

Remarks: The species is a new record to Himachal Pradesh.

Tribe Sterrhini Meyrick, 1892

Genus *Idaea* Treitschke, 1825

16. *Idaea grisescens* (Warren, 1896) [Plate 1.17]

[TL: Khasi Hills, Meghalaya, India]

Ptychopoda grisescens Warren, 1896, *Novitates zoologicae,* 3: 313.

Wing expanse: 20 mm.

Diagnosis: Wings pale, dirty ochreous. Forewing with black highly denticulated ante medial line; medial line instinct; post medial line sinuous followed by diffused, fuscous fascia with irregular, pale, lunulate edges formed by the sub marginal line and interrupted opposite to cell.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Meghalaya (Khasi Hills, TL). **Global:** No documentation.

Remarks: New record to Himachal Pradesh.

17. *Idaea macrospila* (Prout, 1926) [Plate 1.18]

[TL: Bombay, Mumbai, India]

Sterrha macrospila Prout, 1926; *Memoirs of the Department of Agriculture in India* (*Entomology*), 9: 8, p 250.

Sterrha macrospila; Prout, 1920–1941; in Seitz: The Macrolepidoptera of the world, 12: 31, fig. 23 (k).

Wing expanse: Forewing length: 8 mm.

Diagnosis: Wings snow white with some tint of pale ochreous. Both wings with a characteristic fuscous and brown post median band having a metallic grey patch in the middle, highly sinuous margins with a pale transverse line near and parallel to its outer margin.

Distribution: India: Andaman, **Himachal Pradesh** (Dhauladhar mountains-current study), Kerala (Coimbatore) (Prout 1920–1941; Das et al. 2020), Maharashtra (Bombay, TL), Rajasthan (Koli and Prajapati 2021), West Bengal (Shah et al. 2018). **Global:** No documentation.

Remarks: New record to Himachal Pradesh.

18. *Idaea persimilis* (Warren, 1896) [Plate 1.19]

[TL: Assam; Khasi Hills, Meghalaya, India]

Arhostia (?) *persimilis* Warren, 1896, *Novitates zoologicae,* 3: 109.

Wing expanse: 20 mm.

Diagnosis: Pale dirty ochreous with dense, dark fuscous-grey irrorations. Forewing with three dark, prominent, transverse lines: ante medial strongly bent below costa, medial slightly wavy, post medial darker and the most prominent one with a characteristic fuscous fascia above inner margin with sinuous outer edges; marginal line interrupted at veins; outer fringes with fuscous dots at the ends of the veins.

Distribution: India: Assam, **Himachal Pradesh** (Dhauladhar mountains-current study), Meghalaya. **Global:** No documentation.

Remarks: New record to Himachal Pradesh.

19. *Idaea protensa* (Butler, 1889) [Plate 1.20]

[TL: Nordwest Indien, Dharmsala, Himachal Pradesh, India]

Eois protensa Butler, 1889, *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 107, pl. 136 (12).

Wing expanse: 19 mm.

Diagnosis: Looks similar to the *I. persimilis* but wings with slightly yellowish-orange hue, purplish-brown marking and apical region of forewing slightly produced. Forewing with the outer marginal line complete (interrupted at veins in *I. persimilis*), two characteristic fascia: one below the apex and other near the anal angle.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh (TL). **Global:** Nepal (Ratnasingham and Hebert, 2007).

20. *Idaea ruptifascia* (Warren, 1896) [Plate 2.1]

[TL: Khasis, Meghalaya, India]

Janarda ruptifascia Warren, 1896, *Novitates zoologicae*, 3: 112.

Wing expanse: 21 mm.

Diagnosis: Looks similar to *I. grisescens* but forewing in *I. ruptifascia* has two fuscous fasciations on the submarginal line: one below the costa and other on the inner margin.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Meghalaya (Khasi, TL). **Global:** Not documented.

Remarks: New record to Himachal Pradesh.

Genus *Lophophleps* Hampson, 1891

21. *Lophophleps informis* (Warren, 1897) [Plate 2.2]

[TL: Khasi Hills, Assam; Meghalaya]

Strophoptila informis Warren, 1897; *Novitates zoologicae*, 4: 225.

Idaea informis informis; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 16, pl. 5 (26).

Lophophleps informis; Holloway, 1997; *Moths of Borneo*, 10: 95.

Lophophleps informis; Wu et al., 2020; *Formosan Entomologist*, 40: 21.

Wing expanse: 20 mm.

Diagnosis: Wings pale ochreous, suffused with olive tinged-grey only absent on the pale, slightly wavy, transverse lines.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Khasi). **Global:** Indonesia (Borneo), Nepal (Yazaki 1992), Taiwan (Wu et al. 2020).

Tribe Scopulini Duponchel, 1845

Genus *Problepsis* Lederer, 1853

22. *Problepsis albidior albidior* Warren, 1899 [Plate 2.3]

[TL: Kulu, Himachal Pradesh, India]

Problepsis albidior albidior Warren, 1899; *Novitates zoologicae*, 6: 33.

Problepsis albidior; Jinbo et al., 2014; *Memoirs of the National Museum of Nature and Science*, 50: 129-137.

Problepsis albidior albidior; Yazaki, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), *Moths of Nepal*, Part-3: 10, pl. 67 (12).

Problepsis albidior; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 143–163.

Wing expanse: 34 mm.

Diagnosis: Snow-white wings; resembles *P. vulgaris* and *P. deliaria* except for the forewing ocelli which is more circular as that of *P. magna*. The rest of the marking quite similar to the two species.

Distribution: India: Arunachal Pradesh, Himachal Pradesh, Mizoram, Uttarakhand (Askot WLS, Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Chandra et al. 2019; Singh and Lekhendra 2023). **Global:** China (Tibet), Indonesia, Japan (Jinbo et al. 2014), Korea, Nepal (Yazaki 1994), New Guinea, Taiwan, Thailand.

23. *Problepsis vulgaris* Butler, 1889 [Plate 2.4]
[TL: Kangra, Himachal Pradesh, India]

= *attenuata* Warren, 1909; [TL: India (South)]

Problepsis vulgaris Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 43, pl. 125 (2).

Problepsis vulgaris; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 14, pl. 5 (11).

Wing expanse: 33–34 mm.

Diagnosis: Snow-white wings; marking superficially resembling *P. deliaria* but can be distinguished based on its smaller size, forewing with narrower and elongated ocelli, more black-spotted and more brilliantly sprangled with silver and a concavity on their proximal side.

Distribution: India: Arunachal Pradesh, Assam (Tinsukia) (Arandhara et al. 2017; Deb and Chakraborty 2023), Delhi, Gujarat, Himachal Pradesh (TL: Kangra, GHNP) (Kumar et al. 2018; Singh et al. 2022), Karnataka (Ravindrakumar 2021), Kerala, Maharashtra (Shubhalaxmi et al. 2011), Manipur, Meghalaya, Punjab (Paunikar and Sharma 2022), Tamil Nadu, Uttarakhand (Askot WLS, Govind WLS, Dehradun) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal, (Shah et al. 2018; Chandra et al. 2019; Das et al. 2020; Joshi et al. 2021). **Global:** Bangladesh, China, Hong Kong, Malaysia, Myanmar, Nepal (Yazaki 1992), Sri Lanka, Thailand, Vietnam.

Genus *Scopula* Schrank, 1802

24. *Scopula achrosta* Prout, 1935 [Plate 2.5]

[TL: Kashmir, Jammu and Kashmir, India]

Scopula moorei achrosta Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary*: 45, pl. 5 (d).

Scopula moorei achrosta Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 203.

Scopula achrosta; Sihvonen, 2005; *Zoological Journal of the Linnean Society*, 143: 478.

Wing expanse: 38 mm.

Diagnosis: It can be distinguished from *S. moorei* based on its comparatively pale color, weaker suffusion and irroration, large but indistinct discal spot of forewing and small, distinct black discal spot of hind wing (orange in *S. moorei*).

Distribution: India: Himachal Pradesh (Shimla, GHNP) (Mallick 2021), Jammu and Kashmir **(**Kashmir, TL: 7000 ft), Uttarakhand (Massuri). **Global:** Pakistan (Murree).

25. *Scopula bispurcata* (Warren, 1898) [Plate 2.6]

[TL: Assam; Khasi Hills, Meghalaya, India]

Craspedia bispurcata Warren, 1898, *Novitates zoologicae*, 5: 239.

Wing expanse: Male: 26 mm, Female: 28 mm.

Diagnosis: Very similar to *S. achrosta* but can be distinguished based on its smaller size, whitish-ochreous wing colour and black discal spot, comparatively larger on hind wing.

Distribution: India: Assam, **Himachal Pradesh** (Dhauladhar mountains-current study), Meghalaya (Khasi Hills). **Global:** Not documented yet.

Remarks: New record to Himachal Pradesh.

26. *Scopula butleri* (Prout, 1913) [Plate 2.7]

[TL: Dharmsala, Himachal Pradesh, India]

= *insolata* (Butler, 1889) (*Craspedia*) [TL: [India]

Acidalia butleri Prout, 1912–1916; in Seitz, *The Macrolepidoptera of the world*, 4: 78, pl. 7 (c).

Craspedia insolata Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 22, pl. 136 (17).

Scopula butleri; Choi and Kim, 2016; *Zootaxa*, 4178: 134.

Scopula butleri; Expósito-Hermosa and Viidalepp 2019; *SHILAP Revista de lepidopterologia*, 47 (185): 29–32.

Wing expanse: 21–22 mm.

Diagnosis: *S. butleri* looks close to *S. satsumaria* but differs as it has snow-white wings, forewing with post medial line reaching inner margin with a dentate, black fasciation; subterminal, greyish-brown, wavy, transverse fascia. Underside of forewing with dark black spot corresponding to the origin of post medial line on upper side (genitalia features dicussed in Choi and Kim 2016 and Expósito-Hermosa and Viidalepp 2019).

Distribution: India: Himachal Pradesh (Dharamshala) (TL). **Global:** China, Japan, Korea (Choi and Kim 2016), Russia (Expósito-Hermosa and Viidalepp 2019).

Bionomy: It has been documented to feed on the *Bryophyte* species in Japan (Kaneko 2011).

27. *Scopula cuneilinea* (Walker, [1863]) [Plate 2.8]
[TL: India]

Geometra cuneilinea Walker, 1862; *List Species Lepidoptera Insects Collection British Museum*, 26: 1752.

Antitrygodes cuneilinea; Yazaki 1994; in Haruta T (ed.): Tinea 14, (suppl. 2), *Moths of Nepal*, Part-3: 10, pl. 67 (14).

Wing expanse: 34 mm.

Diagnosis: White wings with dense, fine, reddish-brown and black irrorations. Both wings with a characteristic reddish-brown bordered green patches in the medial region; a slightly curved ante medial line, absent in hindwing; highly excurved postmedial and slightly waved submarginal lines followed by a dentate line fading towards costal and inner margin. Underside white with faded, postmedial series of black spots on the veins which disappear near inner margin.

Distribution: India: Assam, Himachal Pradesh, Manipur, Maharashtra (Subhalaxmi et al. 2011), Meghalaya, Mizoram, Nagaland, Punjab (Paunikar and Sharma 2022), Tripura, Uttarakhand, Uttar Pradesh (Nayak and Ghosh 2020; Farooqui and Parwez 2022), West Bengal, Western Ghats (Shah et al. 2018; Das et al. 2020; Joshi et al. 2021; Singh and Lekhendra 2023). **Global:** Nepal (Yazaki 1994).

28. ***Scopula emissaria emissaria*** **(Walker, 1861)** [Plate 2.9]

[TL: Hindostan, India]

= *defamataria* (Walker, 1861) (*Acidalia*); [TL:Ceylon (Sri Lanka)]

= *mollis* (Warren, 1896) (*Lycauges*); [TL: India]

Acidalia emissaria Walker, 1861; *List Species Lepidoptera Insects Collection British Museum*, 22: 751.

Wing expanse: 20 mm (Forewing length: 9 mm).

Diagnosis: Wings pale ochreous. Forewing long, narrow with pointed tip, a characteristic pale greyish-brown, diffused, oblique band, starts just below the apex on outer margin towards middle of the inner margin and further continue in hindwing. Hindwing with a dark black, discal spot at the start of the band.

Distribution: India: Gujarat (Vaghela et al. 2023), Karnataka (Ravindrakumar 2021), Maharashtra, Meghalaya (Joshi et al. 2021), Orissa (Pattanaik et al. 2021), Tamil Nadu (Das et al. 2020), Uttar Pradesh (Nayak and Ghosh, 2020; Farooqui and Parwez 2022), West Bengal (Shah et al. 2018; Yonle 2022). **Global:** China, Hong Kong, Korea (Choi and Kim 2016), Myanmar, Sri Lanka, Vietnam (Kendrick, 2002).

Remarks:

29. ***Scopula fibulata*** **(Guenée, [1858])** [Plate 2.10]

[TL: Ceylon, Sri Lanka]

Acidalia fibulata Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 490, pl. 15 (5).

Craspedia fobulata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 432.

Scopula jibulata, Mandal and Ghosh, 1997; *Fauna of West Bengal*, Zoological Survey of India, 7: 508.

Wing expanse: 23 mm.

Diagnosis: Wings pale greyish-ochreous, suffused and irrorated with fine fuscous. Forewing with basal half of the costa brownish-black; marked with four wavy transverse lines with some ochraceous hue, the last one with diffused, greyish-fuscous shade with irregularly undulating outer edges.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Kerala (Das et al. 2020), Maharashtra, Madhya Pradesh (Indore) (Chandra and Nema 2007), Meghalaya, Punjab, Tamil Nadu (Iyer et al.2021), West Bengal (Darjiling). **Global:** Hainan, Myanmar, Pakistan, Sri Lanka (Ceylon), Tonkin (Chandra and Nema 2007).

Remarks: New record to Himachal Pradesh.

30. ***Scopula idearia*** **(Swinhoe, 1886)** [Plate 2.11]
[TL: Poona, Bombay, India]

Idaea idearia Swinhoe, 1886; *Proceedings of the Zoological Society of London*: 857, pl. 56 (15).

Craspedia idearia; Hampson 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 429.

Wing expanse: 22 mm.

Diagnosis: Like *S. bispurcata* but comparatively smaller, wings ochreous-white and with no rufous or brownish-black patches beyond postmedial line but instead with a characteristic reddish-orange apical streak.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Maharashtra (Puna) (TL) (Das et al. 2020). **Global:** No documentation.

Remarks: New record to Himachal Pradesh.

31. ***Scopula terminata mechadoi*** **(Hausmann, 1993)** [Plate 2.12]
[TL: Hindukusch, Kashmir, Pakistan]

Glossotrophia terminata mechadoi Hausmann, 1993; *Mitteilungen der Münchner Entomologischen* Gesellschaft, 83: 94.

Wing expanse: 26–28 mm.

Diagnosis: Wings ochreous-white, with fine, dense, fuscous-grey irroration. Forewing with four wavy, transverse lines with dense irroration and ochreous hue; discal spot black and indistinct. Hindwing with similar marking except for the ante medial line.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study). **Global:** Pakistan (Karakoram and Hindukush).

Genus *Somatina* Guenée, [1858]

32. *Somatina anthophilata* Guenée, [1858] [Plate 2.13]

[TL: Bombay (Lectotype), India]

Somatina anthophilata Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 10: 11, pl. 18 (2).

Somatina anthophilata; Cotes and Swinhoe, 1889; *Catalogue Moths of India*: 776.

Somatina anthophilata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 33: 464.

Somatina anthophilata; Yazaki, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), Moths of Nepal, Part-3: 10, pl. 67 (11).

Somatina anthophilata; Vietta, 1950; *Bulletin Mensuel de la Société Linnéenne de Lyon*, 19: 204.

Somatina anthophilata; Kamaluddin et al., 2007; *International Journal of Biology and Biotechnology*, 4 (3): 113-119.

Somatina anthophilata; *Wanke et al*., 2021; *Nota Lepidopterologica*, 44: 175–192.

Wing expanse: 33 mm.

Diagnosis: Snow-white wings with faded brownish and black suffusion which appear as undulating bands; a broad, pale brown, medial band fading towards costa; very distinct black discal spots. Underside white with very sparsely distributed black scales; pale ochreous-brown costa; marginal series of black dots and highly crenulated fuscous-black post medial line disappearing towards inner margin.

Distribution: India: Andaman, Assam, Chattisgarh (Raipur), **Himachal Pradesh** (Dhauladhar mountains-current study), Kerala, Madhya Pradesh, Maharashtra [Lectotype: Bombay (Guenee)], Manipur, Mizoram, Nagaland, Tripura (Throughout India), West Bengal (Chandra and Nema 2004; Chandra and Nema 2007; Shah et al. 2018; Das et al. 2020). **Global:** Bangladesh (Sylhet), Myanmar (Rangoon), Nepal (Yazaki 1994), Pakistan (Kamaluddin et al. 2007), Sri Lanka.

Remarks: New record to Himachal Pradesh.

33. *Somatina plynusaria* (Walker, F., [1863]) [Plate 2.14]

[TL: North India; Sylhet, Bangladesh]

Anisodes plynusaria Walker, 1862; *List Species Lepidoptera Insects Collection British Museum*, 26: 1581.

Wing expanse: 34–36 mm

Diagnosis: Very dull brick-red wings dusted with fine black scales and brown patchy suffusion towards outer margin of forewing; forewing acute, slightly falcate with pale fuscous-brown, indistinct antemedial and highly undulating postmedial and submarginal lines; an indistinct brownish discal spot and subapical black patch. Hindwing marking similar to forewing except antemedial line. Underside pale whitish.

Distribution: India: North India: Assam (Joshi et al. 2021), **Himachal Pradesh** (Dhauladhar mountains-current study), Kerala, Tamil Nadu (Das et al. 2020). **Global:** Bangladesh (Sylhet, TL).

Remarks: New record to Himachal Pradesh.

Subfamily Larentiinae Duponchel, 1845

Tribe Trichoptrygini Warren, 1894

Genus *Trichopterigia* Hampson, 1895

34. *Trichopterigia decorata* (Moore, 1888) [Plate 2.15]

[TL: Darjiling, West Bengal, India]

Lobophora decorata Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 272.

Trichopterigia decorata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 403.

Trichopterigia decorata; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2), *Moths of Nepal*, Part-1: 16, pl. 5 (30).

Trichopterigia decorata; Smetacek, 2008; *Bionotes,* 10 (1): 7.

Wing expanse: 30 mm.

Diagnosis: Forewing semi-hyaline grey with olive and slightly black suffusion, with numerous indistinct waved lines, some forming a diffused fuscous medial band forking towards costa, an irregularly sinuous submarginal line with a series of red spots beyond it. Hindwing semi-hyaline white, veins and outer area blackish in both wings.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Khasi) (Joshi et al. 2021), Sikkim, Uttarakhand, West Bengal (Darjeeling, TL) (Shah et al. 2018; Smetacek 2008). **Global:** Nepal (Yazaki 1992).

35. *Trichopterigia macularia* (Moore, 1868) [Plate 2.16]
[TL: Bengal, (West Bengal), India]

= *multipunctata* Hampson, 1903 [TL: India]

Oporobia macularia Moore, 1868; *Proceedings of the Zoological Society of London*: 653.

Trichopteryx macularia; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 405.

Wing expanse: 36 mm.

Diagnosis: Superficially resembles *T. decorata* but can be distinguished as following: slightly larger in size, pale-greenish grey forewing with very slight olive suffusion especially in the outer region and black specks along the veins. The spots beyond the submarginal line are black and not red (as in *T. decorata*).

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, West Bengal (TL). **Global:** No documentation.

36. *Trichopterigia rufinotata* (Butler, 1889) [Plate 2.17]
[TL: Kulu, Himachal Pradesh, India]

Lobophora rufinotata Butler, 1888; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 116, pl. 137 (13).

Trichopterigia rufinotata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 404.

Trichopterigia rufinotata: Prout, 1912–1916; in Seitz, *The Macrolepidoptera of the world*, 4: 187, pl.13 (a).

Trichopterigia rufinotata; Yazaki 1994; in Haruta T (ed.): Tinea 14, (suppl. 2), *Moths of Nepal*, Part-3: 12, pl. 67 (28).

Wing expanse: 40 mm.

Diagnosis: Very similar to the *T. decorata* but larger in size with pale greenish-grey forewing which has red spots beyond the submarginal line, one below costa and four at middle.

Distribution: India: Arunachal Pradesh, Himachal Pradesh (Kullu, TL), Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018; Chandra et al. 2019). **Global:** Bhutan, Nepal (Yazaki 1994), Taiwan (Wu et al. 2020), Tibet (Yatung).

Genus *Tristeirometa* Holloway, 1997

37. *Tristeirometa decussata* (Moore, 1868) [Plate 2.18]

[TL: Bengal, (West Bengal), India]

Sauris decussata Moore, 1868; *Proceedings of the Zoological Society of London*: 655, pl. 33 (10).

Phthonoloba decussata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 407.

Hypocometa decussata; Inoue, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2), *Moths of Nepal*, Part-1: 17, pl. 6 (4).

Wing expanse: Male: 34 mm, Female: 40 mm.

Diagnosis: Bright green forewing with many indistinct, diffused black, wavy transverse lines forming sub basal, ante, medial and post medial bands and patchy submarginal lines. Hindwing white with black suffusion except on the costal margin and traces of postmedial lines. Underside of the wings with uniform black suffusion, distinct discal spots and diffused traces of postmedial lines.

Distribution: India: Arunachal Pradesh, Assam, Himachal Pradesh, Kerala (Travancore), Meghalaya (Khasi), Sikkim, Tamil Nadu (Nilgiri) (Das et al. 2020), Uttarakhand, West Bengal (TL) (Chandra et al. 2019; Joshi et al. 2021). **Global:** Indonesia (Borneo, Sarawak), Malaysia, Nepal (Godavari) (Yazaki 1992), Taiwan (Wu et al. 2020).

Tribe Chesiadini Stephens, 1850

Genus *Docirava* Walker, [1863]

38. *Docirava aequilineata* Walker, [1863] [Plate 2.19]

[TL: North Hindostan, India]

Docirava aequilineata Walker, 1863; *List Species Lepidoptera Insects Collection British Museum*, 26: 1635.

Anaitis aequilineata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 341.

Anaitis aequilineata; Prout, 1914; in Seitz, *The Macrolepidoptera of the world,* 4: 178, pl. 8 (c).

Docirava aequilineata; Yazaki 1994; in Haruta T (ed.): Tinea 14, (suppl. 2), *Moths of Nepal*, Part-3: 13, pl. 68 (3).

Docirava aequilineata; Walia, 2005; *Fauna of Western Himalaya*, 2: 181-190.

Docirava aequilineata; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 40 mm.

Diagnosis: Brown background colour with grey irroration, oblique ochreous and rufous-edged bands; medial one from subcostal and other one from apex towards inner margin beyond middle. Hindwing ochreous and indistinct curved post medial line.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Uttarakhand (Govind WLS and Gangotri NP) (Uniyal et al. 2016; Sanyal et al. 2017; Chandra et al. 2019). **Global:** Nepal (Yazaki 1994).

39. *Docirava postochrea* Hampson, 1893 [Plate 2.20]
[TL: Kulu, Himachal Pradesh, India]

Anaitis postochrea Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 343.

Anaitis postochrea; Prout, 1914; in Seitz, *The Macrolepidoptera of the world,* 4: 178, pl. 11(c).

Carsia postochrea; Yazaki, 1995; in Haruta T (ed.): Tinea, **14** (suppl. 2), *Moths of Nepal*, Part 4: 3, pl. 97 (17).

Wing expanse: 38 mm.

Diagnosis: Bright chestnut forewing with purple-grey suffusion, many transverse lines and a characteristic greyish, triangular apical patch. Hindwing bright ochreous. Underside of the both wings with bright ochreous suffusion.

Distribution: India: Himachal Pradesh (TL: Kulu, Koksar, 9000 feet), Uttarakhand (Chandra et al. 2019). **Global:** Nepal (Yazaki 1995).

40. *Docirava pudicata* (Guenée, [1858]) [Plate 3.1]

[TL: Inde Central, Central India]

= *uvaria* (Walker, [1863]) (*Aspilates*); [TL: India]

= *vastata* (Walker, 1866) (*Anaitis*); [TL: India]

Anaitis pudicata Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 10: 497.

Anaitis pudicata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma,* 3: 341.

Anaitis pudicata; Prout, 1914; in Seitz, *The Macrolepidoptera of the world,* 4: 178, pl.8 (b).

Docirava pudicata; Yazaki 1994; in Haruta T (ed.): Tinea 14, (suppl. 2), *Moths of Nepal*, Part-3: 13, pl. 68 (2).

Wing expanse: 42 mm (34–50 mm in Hampson, 1895)

Diagnosis: Crimson (or rose colour) irroration on the sides of palpi, costal and outer area above and subcostal area on the underside of forewing. Hindwings with crimson tinge on upper and irrorated on lower side except the narrow margins. Fore wing with pure white discal spot and two oblique ochreous antemedial and postmedial strongly bent outwards at first radial line.

Distribution: India: Arunachal Pradesh, Himachal Pradesh (Dharamshala), Sikkim, Uttarakhand (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018; Chandra et al. 2019), West Bengal (Chettri and Yonle 2021). **Global:** Afghanistan, Nepal (Yazaki 1994), Vietnam.

Tribe Asthenini Warren, 1894

Genus *Asthena* Hübner, [1825]

41. *Asthena albosignata* (Moore, 1888) [Plate 3.2]

[TL: Darjiling, West Bengal, India]

Idaea ? albosignata Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*, 3: 253.

Asthena albosignata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 418.

Asthena albosignata; Prout, 1934–1938; in Seitz, *The Macrolepidoptera of the world*, 4, supplementary: 181, pl 16 (i).

Asthena albosignata; Yazaki 1994; in Haruta T (ed.): Tinea 14, (suppl. 2), *Moths of Nepal*, Part-3: 16, pl. 68 (22).

Asthena albosignata; Xue et al., 2002; *Bulletin of the Natural History Museum: Entomology Series*, 71 (1): 83.

Wing expanse: 30 mm.

Diagnosis: White wings with greyish-brown suffusion and with many ochreous-brown specks mostly along the dark, diffused, sinuous, transverse lines, however, leaves a characteristic white, oval area nearly in the middle or at the lower angle of the cell.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Jammu and Kashmir (Kashmir, 6500-8500 ft.), Sikkim, West Bengal (Darjeeling, TL) (Shah et al. 2018). **Global:** China (Xue et al. 2002), Nepal (Yazaki 1994).

Remarks: New record to Himachal Pradesh.

Genus *Hydrelia* Hübner, [1825]

42. *Hydrelia bicolorata* (Moore, 1868) [Plate 3.3]
[TL: Bengal, (West Bengal), India]

= *ferruginaria* (Moore, 1868) (*Eupithecia*); [TL: India]

Hyria bicolorata Moore, 1867; *Proceedings of the Zoological Society of London*: 642.

Hydrelia bicolorata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 413.

Hydrelia bicolorata; Prout, 1912-1916; *The Macrolepidoptera of the world*, 4: 269.

Hydrelia bicolorata Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary*: 178, pl. 16 (g).

Hydrelia bicolorata; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2), *Moths of Nepal,* Part-1: 19, pl. 6 (30).

Hydrelia bicolorata; Mandal and Ghosh, 1997; *Fauna of West Bengal*, 7: 520.

Hydrelia bicolorata; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 22 mm.

Diagnosis: Wings pale reddish-ochreous with fuscous irroration and shade; forewing with sub basal, ante and post medial, equidistant, zigzag or lunulated, narrow, yellow-coloured bands with reddish-ochreous outer borders; a basal fuscous black area and diffused black lines from costa upto median nervure in the middle between ante and post medial bands. Hind wing with postmedial band similar as in forewing. Underside pale with greyish-fuscous suffusion and markings.

Distribution: India: Arunachal Pradesh, Assam, Himachal Pradesh (Dalhousie, Dharamshala, GHNP) (Mallick 2021), Meghalaya, Nagaland, Sikkim, Uttarakhand (Govind WLS, NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018), West Bengal (Chandra et al. 2019; Chettri and Yonle 2021). **Global:** China, Myanmar, Nepal (Yazaki 1992), Taiwan (Wu et al. 2020).

43. *Hydrelia sericea pampesia* Prout, 1938 [Plate 3.4]
[TL: Kashmir Valley, Jammu and Kashmir, India]

Hydrelia sericea pampesia Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary*: 179, pl. 16 (g).

Wing expanse: 26 mm.

Diagnosis: Looks very similar to *Hydrelia subobliquaria* in basic wing colour while the markings more alike as in nominottpical subspecies *Hydrelia sericea sericea*.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Jammu and Kashmir (Kashmir Valley). **Global:** Not Documented.

Remarks: New record to Himachal Pradesh. (Although the nominotypical species has been described from North East India. Looks very much alike to that of *Hydrelia subobliquaria* and need to be further investigated more carefully)

Tribe Perizomini Herbulot, 1961

Genus *Gagitodes* Warren, 1893 (Perizoma)

44. *Gagitodes parvaria* (Leech, 1891) [Plate 3.5]
[TL: Yokohama, Japan]

= *albidivisa* (Warren, 1893) (*Perizoma*); [TL: India]

= *ablegata* (Staudinger, 1897) (*Cidaria*); [TL: Russia]

Cidaria parvaria Leech, 1891; *Entom*. suppl. 24: 52.

Larentia albidivisa; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 375.

Cidaria parvaria; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 261, pl. 7 (k).

Perizoma parvaria; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 276.

Cidaria parvaria; Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world*, 4, supplementary: 167.

Perizoma parvaria; Inoue, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1), *Moths of Nepal, Part-6*: 47, pl. 166 (31).

Wing expanse: 18 mm.

Diagnosis: Brown-blackish wings with slightly black-greyish ante and post medial bands with white borders. It is easily distinguishable with its postmedial band of the forewing which has its white outer border line sharply bent with the region beyond the angle also partly white.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Meghalaya (Khasi), Nagaland (Naga Hills, 6000 ft.), North West India. **Global:** China, Japan, Korea (Toth et al. 2018), Nepal (Inoue 2000), Russia.

Remarks: New record to Himachal Pradesh.

45. *Gagitodes plumbeata* (Moore, 1888) [Plate 3.6]
[TL: Darjiling, West Bengal, India]

Anticlea plumbeata Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*, 3: 273.

Larentia plumbeata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 376.

Perizoma plumbeata; Yazaki, 1993; in Haruta T (ed.): Tinea 13, (suppl. 3), Moths of Nepal, Part-2: 111, pl. 60 (7).

Perizoma plumbeata; Inoue, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1), *Moths of Nepal, Part-6*: 45, pl. 166 (23).

Perizoma plumbeata; Dey and Hausmann, 2021; *Journal of Threatened Taxa*, 13 (7): 18822.

Wing expanse: 30 mm.

Diagnosis: Greyish-lilac forewing and paler hindwing. Forewing with a black basal patch, an indistinct (almost fades away towards costal margin), clouded medial band with ochreous border and sometimes white dots and a very distinct almost triangular subapical patch with ochreous inner border.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand (Kedarnath WLS), West Bengal (Darjeeling) (Dey and Hausmann 2021). **Global:** Nepal (Inoue 2000).

46. *Gagitodes saxicola* (Tikhonov, 1994) [Plate 3.7]
[TL: Nordkaukasus, Tschetschnja, Skalistyi Chrebet, Fl. Armchy, 1900 m]

= *schistacea* (Moore, 1888) (*Anticlea*); [TL: India]

Anticlea schistacea Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*, 3: 273.

Larentia schistacea; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 376.

Perizoma schistacea; Yazaki 1994; in Haruta T (ed.): Tinea, 16 (suppl. 1), *Moths of Nepal, Part*-3: 17, pl. 69 (8).

Perizoma schistacea; Inoue, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1), *Moths of Nepal, Part-6*: 46, pl. 166 (24).

Wing expanse: 24 mm.

Diagnosis: Looks very much alike with the previous species but smaller in size and lacks the ochreous edges on the bands.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP) (Mallick 2021), Sikkim (Hampson 1895), West Bengal (Darjeeling) (Shah et al. 2018). **Global:** Nepal (Yazaki 1994; Inoue 2000), Russia (North Caucacus) (TL).

Genus *Martania* Mironov, 2000

47. *Martania albofasciata* (Moore, 1888) [Plate 3.8]

[TL: Darjiling, West Bengal, India]

= *albofasciata* mixtifascia (Prout, 1938) (*Cidaria*); [TL: Burma]

= *rantaizanensis* (Wileman, 1915) (*Perizoma*); [TL: Formosa (Taiwan)]

Cidaria albofasciata Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 277.

Larentia albofasciata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 374.

Perizoma albofasciata; Seitz, 1912-1916; *The Macrolepidoptera of the world*, 4: 259.

Perizoma albofasciata; Yazaki 1994; in Haruta T (ed.): Tinea, 16 (suppl. 1), *Moths of Nepal, Part*-3: 17, pl. 69 (10).

Perizoma albofasciata; Inoue, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1); *Moths of Nepal*, Part-6: 48, pl. 167 (1).

Wing expanse: 28 mm.

Diagnosis: Ochreous-brown forewing with a distinct black basal patch, an ochreous-brown antemedial band with white inner and black outer border, broad white medial band with a large black discal spot and brownish-black undulating outer border, a white medial patch extending towards outer margin with a submarginal series of minute white spots and a white apical patch. Hind wing white with some pale grey hue and distinct discal spots. Underside with black sufussion, black discal spots and faded series of postmedial black spots on the veins in hindwing.

Distribution: India: Himachal Pradesh (Dharamshala, GHNP) (Mallick 2021), Sikkim, Uttarakhand (Govind WLS, NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018), West Bengal (Darjeeling, TL) (Chandra et al. 2019). **Global:** Myanmar, Nepal (Yazaki 1994), Taiwan (Wu et al. 2020).

48. *Martania antisticta* (Prout, 1938) [Plate 3.9]

[TL: Thundiani, (Punjab) Pakistan]

Cidaria antisticta Prout, 1934–1938; *in Seitz: The Macrolepidoptera of the world, 4, supplementary:* 164, pl. 16 (a).

Wing expanse: 23–27 mm.

Diagnosis: The nominotypical subspecies can be distinguished from the *M. a. dentivalva* by its paler forewing colour, comparatively straighter subbasal black band (obllique in *M. a. dentivalva*), the larger and more distinct ochreous-white spot near the middle of the outer margin (smaller and often vestigial in *M. a. dentivalva*). Also, very similar to *G. saxicola* (or *P. schictacea*) but the forewing with ochreous-brown hue.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021). **Global:** Pakistan (TL).

Remarks: The subspecies *M. a. dentivalva* Inoue, 2000 [Moths of Nepal, Part-6: 46pp., pl. 166 (25)] has been described from Nepal with its elevational range 2600–3200 m.

49. *Martania fulvimacula* (Hampson, 1896) [Plate 3.10]
[TL: Thundiani, (Punjab) Pakistan]

Larentia fulvimacula Hampson, 1896; *The Fauna of British India, including Ceylon and Burma*, 4: 557.

Cidaria fulvimacula; Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world*, 4, supplementary: 164, pl. 16 (a).

Perizoma fulvimacula; Inoue, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1), *Moths of Nepal, Part-6*: 49, pl. 167 (12).

Wing expanse: 23–27 mm.

Diagnosis: Typical greyish-fuscous wings, characterised by an ochreous medial streak on the outer area of the forewing.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), West Bengal (Darjeeling) (Inoue 2000). **Global:** Nepal (Inoue 2000).

50. *Martania micropunctum* (Inoue, 2000) [Plate 3.11]
[TL: Darjeeling, West Bengal, India]

Martania micropunctum Inoue, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1), *Moths of Nepal, Part-6*: 52, pl. 167 (29-30).

Wing expanse: Male: 16–19 mm, Female: 20–21 mm.

Diagnosis: Purplish-grey forewing with ochreous-black transverse bands (basal, antemedial, medial and marginal) with black edges. It is easily distinguishable based on the subterminal white spots with a larger ochreous-white spot in the middle. Hindwing white with slight greyish-black suffusion and without black discal spot.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Uttarakhand (Dey 2018), Sikkim, West Bengal (Darjeeling, TL). **Global:** Nepal (Inoue 2000).

Remarks: New record to Himachal Pradesh.

51. *Martania seriata* (Moore, 1888) [Plate 3.12]
[TL: Darjiling, West Bengal, India]

Cidaria seriata Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson,* 3: 278.

Larentia seriata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 373.

Cidaria seriata Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world,* 4, supplementary: 165, pl. 7 (h).

Perizoma seriata; Yazaki, 1993; in Haruta T (ed.): Tinea 13, (suppl. 3), Moths of Nepal, Part-2: 111, pl. 60 (6).

Perizoma seriata; Inoue, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1), *Moths of Nepal, Part-6*: 50, pl. 167 (19-21).

Wing expanse: 24–26 mm.

Diagnosis: Discussed in the diagnosis of *P. peculiare*.

Distribution: India: Himachal Pradesh (Dalhousie, Dharamshala, Khajjiar, GHNP) (Mallick 2021), Uttarakhand (Dey 2021), West Bengal (Darjeeling) (Inoue 2000). **Global:** Nepal, Pakistan, Taiwan (Yazaki 1993; Inoue 2000; Wu et al. 2020).

52. *Martania variabilis* (Warren, 1893) [Plate 3.13]
[TL: Sikkim, India]

Perizoma variabilis Warren, 1893; *Proceedings of the Zoological Society of London*: 377.

Larentia variabilis; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 373.

Perizoma variabilis; Inoue, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1), *Moths of Nepal, Part-6*: 48, pl. 167 (2).

Wing expanse: 22–26 mm.

Diagnosis: Purplish-grey forewing with ochreous-brown and fuscous suffusion and indistinct fuscous-black transverse lines.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim (TL), Uttarakhand (Dey 2021), West Bengal (Darjeeling) (Inoue 2000). **Global:** Nepal (Inoue 2000).

Genus Perizoma Hübner, [1825]

53. *Perizoma peculiare* Inoue, 2000 [Plate 3.14]

[TL: Nepal]

Perizoma peculiare Inoue, 2000; in Haruta T (ed.): *Tinea*, **16** (suppl. 1), *Moths of Nepal, Part-6*: 51, pl. 167 (25-27).

Wing expanse: Male: 19–20 mm, Female: 21 mm.

Diagnosis: Looks very similar to *M. seriata* but can be distinguished based on its smaller size, the medial black band bounded by black bordered narrow ochreous bands (brown in *M. peculiare*) and the spot on the middle of the outer margin is pale brownish and not white (in *M. seriata*).

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir), West Bengal (Darjeeling). **Global:** Nepal (TL), Thailand**.**

Tribe Eupitheciini Tutt, 1896

Genus *Eupithecia* Curtis, 1825

54. *Eupithecia albigutta* Prout, 1958 [Plate 3.15]

[TL: Simla, Himachal Pradesh, India]

= *pulla* Vojnits, 1987; [TL: Nepal (East)]

Eupithecia albigutta Prout, 1958; Bulletin of the British Museum (Natural History) Entomology, 6 (12): 393.

Eupithecia pulla Vojnits, 1988; *Acta Zoologica Academiae Scientiarum Hungaricae*, 34 (1): 38.

Eupithecia albigutta; Inoue, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1), *Moths of Nepal*, Part-6: 28, pl. 165 (3) (Genitalia figures: 1283, 1325).

Eupithecia albigutta; Mironov and Galsworthy, 2007; *Transactions of the Lepidopterological Society of Japan*, 58 (3): 360.

Eupithecia albigutta; Mironov, 2008; *Transactions of the Lepidopterological Society of Japan*, 59 (1): 62.

Wing expanse: 23 mm.

Diagnosis: Fuscous-brown forewing and can be easily diagnosed with its characteristic ochreous-white basal patch, medial white patch with black discal spot (below subcostal vein).

Distribution: India: Himachal Pradesh (Shimla, GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir). **Global:** Nepal (Inoue 2000), Pakistan, Taiwan (Mironov et al. 2008; Wu et al. 2020).

55. *Eupithecia maculosa* Vojnits, 1981 [Plate 3.16]
[TL: Nepal]

= *flavitornata* Herbulot, 1984; [TL: Nepal]

Eupithecia maculosa Vojnits, 1981; *Acta zoologica Hungarica*, 27: 230, fig. 14.

Eupithecia maculosa; Inoue, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1); *Moths of Nepal*, Part-6: 36, pl. 165 (29).

Wing expanse: 18–24 mm.

Diagnosis: The members are easily distinguishable based on the fuscous-brown forewings; large, fuscous black discal spot. Hindwings whitish with fuscous-brown suffusion towards inner margin. Both the wings with a characteristic series of a subterminal series of pale, ochreous-white spot with an enlarged spot above tornal angle.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Jammu and Kashmir, West Bengal (Darjeeling, 2573 m). **Global:** Nepal (Inoue 2000), Pakistan (Mironov et al. 2008).

Remarks: New record to Himachal Pradesh. **(**Species card not available, see moths of Nepal).

56. *Eupithecia melanolopha* Swinhoe, 1895 [Plate 3.17]

[TL: Cherri Punji, Meghalaya, India]

Eupithecia melanolopha Swinhoe, 1895; *The Annals and Magazine of Natural History*, 6 (16): 296.

Eupithecia melanolopha; Hampson, 1896; *The Fauna of British India, including Ceylon and Burma*, 3, 4: 559.

Eupithecia melanolopha; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: pl. 38 (l).

Eupithecia melanolopha; Inoue, 1963; Tinea 6: 34, pl. 7 (9).

Eupithecia melanolopha; Inoue, 1979; *Bulletin of Faculty of Domestic Sciences, Otsuma Woman's University,* 15: 190.

Eupithecia melanolopha; Inoue, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1); *Moths of Nepal*, Part-6: 37, pl. 165 (30).

Wing expanse: 18 mm.

Diagnosis: Brownish fuscous forewings with a characteristic dark black, discal spot, a series of pale cochreous-white submarginal spots and a larger one near tornal angle. Hindwing white, suffused with fuscous, more towards inner margin, lack discal spot but with a tornal patch similar to the forewing.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Meghalaya (Khasi, Cherrapunji, TL) (Joshi et al. 2021). **Global:** Nepal (Inoue 2000), Sri Lanka (Ceylon) Taiwan (Wu et al. 2020).

Remarks: New record to Himachal Pradesh.

Genus *Pasiphila* Meyrick, 1883

57. *Pasiphila palpata* (Walker, 1862) [Plate 3.18]

[TL: Hindostan]

= *variegata* (Moore, [1887]) (*Eupithecia*); [TL: Ceylon, Sri Lanka]

= *virescens* (Moore, [1887]) (*Eupithecia*); [TL: Ceylon, Sri Lanka]

Cidaria palpata Walker, 1862; *List Species Lepidoptera Insects Collection British Museum*, 25: 1404.

Eupithecia variegata Moore, 1887; *Lepidoptera Ceylon*, 3: 479.

Eupithecia virescens Moore, 1887; *Ibid*, 3: 479.

Chloroclystis palpata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 391.

Chlorocystis palpata diechusa Prout, 1958; Bulletin of the British Museum (Natural History) Entomology, 6: 422-3.

Chloroclystis palpata wongi Holloway, 1976; *Moths of Borneo* with special reference to Mt. Kinabalu: 68

Rhinoplora [sic] *palpata*; Yazaki, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part-4: 17.

Pasiphila palpata; Holloway, 1997; *Moths of Borneo*.

Wing expanse: 24 mm.

Diagnosis: Grass-green coloured background with black irroration and more or less vinous-red suffusion; a black band on 2nd abdominal segment. Forewings with black specks on veins; a black sub-basal line, vinous black antemedial band with a line beyond it; vinous black medial area with a black cell spot and outer and inner edges lined by black lines, the outer edges being angled at veins 6 and 4 and with white in between; a postmedial series of black specks and a vinous submarginal band with a black line on it and on its inner edge, and white crenulate line on outer edge. Hindwings pale fuscous or whitish with traces of waved lines on outer area.

Distribution: India: Himachal Pradesh (Dharamshala, GHNP) (Mallick 2021), Sikkim, Tamil Nadu, Uttarakhand (Dey 2018). **Global:** China, Indonesia (Borneo), Japan, Nepal, Sri Lanka, Taiwan (Yazaki 1995; Holloway 1997; Wu et al. 2020).

Tribe Triphosini Tutt, 1896

Genus *Triphosa* Stephens, 1829

58. *Triphosa dubiosata* (Walker, 1862) [Plate 3.19]

[TL: Punjaub, India]

Scotosia dubiosata Walker, 1862; *List Species Lepidoptera Insects Collection British Museum*, 25: 1352.

Scotosia dubiosata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 344 (fig. 173).

Rheumaptera dubiosata; Yazaki, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part-4: 15.

Wing expanse: 38-40 mm.

Diagnosis: Looks close to *R. tremodes* but has somewhat apically rounded forewing which is more uniformly marked with dark obscure transverse lines; a characteristic pale greyish-white submarginal line slightly expanded in the middle and near inner margin and lack hair tuft on the anal angle of underside of hindwing.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Punjab, Sikkim, Tamil Nadu (Das et al. 2020), Uttarakhand (NDBR) (Dey 2018). **Global:** Afghanistan, Nepal (Yazaki 1995).

59. *Triphosa rubrodotata* (Walker, 1862) [Plate 3.20]

[TL: Hindostan]

Scotosia rubrodotata Walker, 1862; *List Species Lepidoptera Insects Collection British Museum*, 25: 1353.

Triphosa rubrodotata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 345.

Triphosa rubrodotata; Prout, 1912-1916; in Seitz; *The Macrolepidoptera of the world*, 4: 198.

Triphosa rubrodotata; Ghosh, 2003; *Fauna of Sikkim*, 4: 217-342.

Triphosa rubrodotata; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 62 mm.

Diagnosis: Wings glossy grey-brown. Forewing with characteristic dark-crimson medial band with ante and postmedial lines forming the inner and outer boundaries respectively, white specks on the veins in the outer area and a whitish, crenulated submarginal line. Hind wing paler with many darker and paler whitish crenulated lines.

Distribution: India: Arunachal Pradesh, Himachal Pradesh (GHNP) (Mallick 2021), Punjab, Sikkim, Uttarakhand (Govind WLS, Gangotri NP) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Chandra et al. 2019; Chettri 2022). **Global:** Nepal, Taiwan.

Tribe Cidariini Duponchel, 1845

Genus *Colostygia* Hübner, [1825]

60. *Colostygia albigirata* (Kollar, 1844) [Plate 4.1]

[TL: Massuri, Himalaya (Uttarakhand, India)]

= *signata* (Moore, 1868) (*Cidaria*); [TL: India]

= *thomasata* (Warren, 1888) (*Cidaria*); [TL: India (Western) Pakistan]

Cidaria albigirata Kollar, 1844; *Hugel's Kashmir,* 4: 489.

Colostygia albigirata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 367.

Colostygia albigirata; Prout, 1912–1916; in Seitz, *The Macrolepidoptera of the world*, 4: 229.

Lampropteryx albigirata; Yazaki, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part- 4: 6, pl. 99 (8).

Colostygia albigirata; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Colostygia albigirata; Gyula et al., 2018; in Fibigeriana Supplement: *The Vartian Collection, Geometridae,* Part-4: 32, pl. 32 (6).

Wing expanse: 36 mm.

Diagnosis: Greyish-brown wing colour, with many darker, often indistinguishable highly undulating transverse lines; hindwings paler whitish. Forewing with whitish antemedial line toothed on median fold; postmedial angled on M3 and with multi inward projection at CuA1; a subapical whitish streak between post medial and submarginal lines.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir), Sikkim, Uttarakhand (Govind WLS, Gangotri NP) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018; Chandra et al. 2019), West Bengal (Shah et al. 2018). **Global:** Afghanistan, China, Japan, Mongolia, Myanmar, Nepal, Russia (Gyula et al. 2018).

Genus *Dysstroma* Hübner, 1825

61. *Dysstroma dentifera dentifera* (Warren, 1896) (*Polyphasia*) [Plate 4.2]

[TL: Darjeeling, West Bengal, India]

Polyfasia dentifera Warren, 1896; *Novitates zoologicae*, 3: 387.

Dysstroma dentifera; Yazaki, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1); *Moths of Nepal*, Part-6: 10.

Wing expanse: 42 mm.

Diagnosis: Comparatively larger and distinct from others species in the genus, characterised by a black "wedge-shaped" mark formed by the submarginal line on the submedian vein near the anal angle.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Uttarakhand (Dey 2021), West Bengal (Darjeeling, TL)**. Global:** Nepal (Yazaki 2000), Taiwan (Wu et al. 2020).

62. *Dysstroma fulvipennis* (Hampson, 1902) [Plate 4.3]

[TL: Kashmir, Jammu and Kashmir, India]

= *flavidula* (Bastelberger, 1907) (*Polyphasia*); [TL: India]

Larentia fulvipennis Hampson, 1902; *Journal Bombay Natural History Society*, 14: 517.

Cidaria fulvipennis; Prout, 1934; in Seitz, *The Macrolepidoptera of the world*, 4, supplementary: 122.

Wing expanse: 40 mm.

Diagnosis: Forewing bluish-grey with brown suffusion. Hind wing orange-ochreous with very pale, fuscous suffusion towards basal region.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir, TL), Uttarakhand (Dey 2018). **Global:** No documentation.

63. *Dysstroma planifasciata* (Prout, 1914) [Plate 4.4]

[TL: Kashmir, Jammu and Kashmir, India]

Cidaria planifasciata Prout, 1912-1916; in Seitz, *The Macrolepidoptera of the world*, 4: 220.

Dysstroma planifasciata; Yazaki, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1); *Moths of Nepal*, Part-6: 10, pl. 162 (8).

Dysstroma planifasciata; Dey and Hausmann, 2021; *Journal of Threatened Taxa*, 13 (7): 18820.

Wing expanse: 38–40 mm.

Diagnosis: Forewing with white median area, sometimes with pale brown suffusion.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir, TL), Uttarakhand (NDBR) (Dey and Hausmann 2021). **Global:** Nepal (Yazaki 2000).

64. *Dysstroma shirakawai* Yazaki, 2000 [Plate 4.5]

[TL: Nepal]

Dysstroma shirakawai Yazaki, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1), *Moths of Nepal, Part-6*: 10, pl. 162 (12).

Wing expanse: Male: 27–29 mm, Female: 29–31 mm.

Diagnosis: Very similar to *D. subapicaria* but differs as following: forewing comparatively less brown and, darker and more fuscous; hindwing blackish-brown (pale whitish-brown with fuscous-grey suffusion in *D. subapicaria*).

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Uttarakhand (Dey 2018). **Global:** Nepal (TL).

65. *Dysstroma subapicaria* (Moore, 1868) [Plate 4.6]

[TL: Darjeeling, West Bengal, India]

Cidaria subapicaria Moore, 1868; *Proceedings of the Zoological Society of London*: 663.

Dysstroma subapicaria; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: pl. 32 (i).

Dysstroma subapicaria; Yazaki, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), *Moths of Nepal*, Part-3: 15, pl. 68 (16).

Dysstroma subapicaria; Yazaki, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1), *Moths of Nepal, Part-6*: 15, pl. 68 (16).

Wing expanse: Forewing length: 16–17 mm.

Diagnosis: Discussed in *D. shirakawaii*.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), West Bengal (Darjeeling, TL) (Shah et al 2018). **Global:** Nepal (Yazaki 1994; Yazaki 2000).

Remarks: New record to Himachal Pradesh.

Genus *Ecliptopera* Warren, 1894

66. *Ecliptopera dentifera* Moore, 1888 [Plate 4.7]
[TL: Darjiling, West Bengal, India]

= *nivicincta* (Butler, 1889) (*Cidaria*); [T.l. in: India]

Eustroma dentifera Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson,* 3: 275.

Cidaria dentifera; Prout, 1912–1916; in Seitz, *The Macrolepidoptera of the world*, 4: 251.

Cidaria dentifera; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 305, pl. 30 (d).

Wing expanse: Male: 30–36 mm, Female: 30–40 mm.

Diagnosis: *E. dentifera* easily distinguishable by its antemedial line on the forewing which is white, slightly oblique outwardly and has a characteristic acute indentation below the sub median and follows straight course towards inner margin afterwards.

Distribution: India: Assam, Himachal Pradesh (Dharamshala), Meghalaya (Joshi et al. 2021), Sikkim, West Bengal (Darjeeling, TL). **Global:** Not documented yet.

67. *Ecliptopera relata* (Butler, 1880) [Plate 4.8]
[TL: North East Himalayas]

Cidaria relata Butler, 1880; *The Annals and Magazine of Natural History*, 6: 229.

Cidaria relata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 359.

Ecliptopera relata; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 18, pl. 6 (15).

Ecliptopera relata; Smetacek, 2008; *Bionotes*, 10 (1): 7.

Wing expanse: 36 mm.

Diagnosis: Forewing dark brown with narrow pinkish-white band enclosing brown line, the ante medial and postmedial one joining with each other through a longitudinal band and forming a characteristic “8”-shaped figure in the middle region, also, a pale whitish line arising from apex firstly much incurved, then angles outwards to the margin at middle and again slightly incurves towards inner margin.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021; Singh et al. 2022), Meghalaya (Khasi) (Joshi et al. 2021), Sikkim, Uttarakhand (Kumaon) (Chandra et al. 2019). **Global:** Bhutan, Nepal (Yazaki 1992).

68. ***Ecliptopera triangulifera*** **(Moore, 1888)** [Plate 4.9]
[TL:Darjiling, West Bengal, India]

= *phrice* (West, 1929) (Euphyia); [TL: Formosa (Taiwan)]

Eustroma triangulifera Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson,* 3: 275.

Cidaria triangulifera; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 358.

Cidaria triangulifera; Prout, 1912-1916; in Seitz, *The Macrolepidoptera of the world*, 4: 250, pl 8 (e), supl. 152 (1938), 12, pl. 30 (f): 306 (1940).

Ecliptopera triangulifera; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: pl. 6 (16).

Wing expanse: Male: 36 mm, Female: 42 mm.

Diagnosis: Forewing ferruginous coloured with somewhat acute and produced apex, indistinct waved sub basal and antemedial lines angled at middle, two obscure medial lines meeting in places and a postmedial line. A characteristic ochreous-white oblique band with white edges from costa before middle joining similar kind of band (which occupies the whole outer area except a dark brown, irregular, triangular patch on margin below apex) near outer angle.

Distribution: India: Himachal Pradesh (Dharamshala), Meghalaya (Joshi et al. 2021), Sikkim (Khasi), West Bengal (Darjeeling, TL) (Shah et al. 2018; Chettri and Yonle 2021; Yonle 2022). **Global:** Nepal (Yazaki 1992).

Genus *Electrophaes* Prout, 1923

69. *Electrophaes aliena aliena* (Butler, 1880) [Plate 4.10]

[TL: Bhutan]

Cidaria aliena Butler, 1880; *The Annals and Magazine of Natural History*, 6: 230.

Electrophaes aliena; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 19, pl. 6 (26).

Electrophaes aliena; Yazaki, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part-4: 8.

Electrophaes aliena; Ghosh, 2003; *Fauna of Sikkim*, 4: 268.

Electrophaes aliena; Smetacek, 2008; *Bionotes*, 10 (1): 7.

Electrophaes *aliena*; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 160.

Wing expanse: 33 mm.

Diagnosis: Looks very similar to *E. aurata* and *E. corylata* but forewing darker black and with golden-brown ante and postmedial bands rather than olive-brown.

Distribution: India: Arunachal Pradesh, Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Chandra et al. 2019). **Global:** Bhutan (TL), Nepal (Yazaki 1992; Yazaki 1995).

70. *Electrophaes marginata* Yazaki, 1994 [Plate 4.11]

[TL: Nepal]

Electrophaes marginata Yazaki, 1994; in Haruta T (ed.): Tinea 14 (suppl. 1); *Moths of Nepal*, Part-3: 30, pl. 69 (4) (genitalia figures: 344, 350).

Wing expanse: 22–24 mm.

Diagnosis: Looks very similar to *E. zaphenges* but with comparatively broader and darker subbasal and medial bands.

Distribution: India: Himachal Pradesh (Djauladhar mountains-current study), Uttarakhand (NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018). **Global:** Nepal (TL).

Remarks: New record to Himachal Pradesh.

71. *Electrophaes niveonotata* (Warren, 1893) [Plate 4.12]

[TL: Sikkim, India]

Cidaria niveonotata Warren, 1901; *Novitates zoologicae*, 8: 26.

Electrophaes niveonotata; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 19, pl. 6 (28)

Electrophaes niveonotata; Smetacek, 2008; *Bionotes*, 10 (1): 7.

Wing expanse: Forewing length: Male: 15 mm.

Diagnosis: *E. niveonotata* is easily distinguishable from the other closely related species based on its characteristic of the colour of markings ie., in having "all the dark markings olive-brown and all the pale markings snow-white" without any shade of yellow (original description). Hindwing white and slightly suffused with greyish-ochreous towards the inner margin and showing the traces of post medial line (darker nad prominent on underside). Underside pale ochreous, hindwing with darker, dense irroration; a large discal spot and and a highly irregular post medial line.

Distribution: India: Arunachal Pradesh, Himachal Pradesh (GHNP) (Mallick 2021), Sikkim (TL), Uttarakhand (Dey 2018), West Bengal (Chandra et al. 2019). **Global:** Bhutan, Nepal (Yazaki 1992).

Genus *Eustroma* Hübner, [1825]

72. *Eustroma aurigena* (Butelr, 1880) [Plate 4.13]

[TL: North East Himalayas]

Cidaria aurigena Butler, 1880; *The Annals and Magazine of Natural History*, 6 (5): 230.

Cidaria aurigena; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 360.

Eustroma aurigena; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 18.

Wing expanse: 28 mm.

Diagnosis: Looks similar to *E. inextricata* but distinguishable as *E. aurigena* is comparatively smaller in size and has brighter brassy-yellow colouration and marking and ante medial band comparatively broader.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP) (Mallick 2021), Meghalaya (Khasi) (Joshi et al. 2021), Sikkim, West Bengal (Shah et al. 2018). **Global:** Nepal (Yazaki 1992).

73. *Eustroma chalcoptera* (Hampson, 1896) [Plate 4.14]

[TL: Sikkim, India]

Cidaria aurigena; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 360.

Eustroma chalcoptera; Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world*, 4, supplementary: 106, pl. 10 (f).

Eustroma chalcoptera; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 308.

Eustroma chalcoptera; Yazaki, 1995; in Haruta T (ed.): Tinea 14, (suppl. 2), *Moths of Nepal*, Part-4: 6, pl. 99 (3).

Wing expanse: 32 mm.

Diagnosis: Looks similar *E. aurigena* but distinguishable as following: forewing darker chestnut coloured and without golden-yellow hue, medial band irregular, some irregular, yellowish-green suffusion along the ante and post medial band. Hind wing whitish with four pale chestnut, narrow, indistinct, waved bands towards outer marginal area.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Sikkim (TL, 10,000 ft), Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017). **Global:** Nepal (Yazaki 1995).

Remarks: New record to Himachal Pradesh.

Genus Heterothera Inoue, 1943

74. *Heterothera consimilis* (Warren, 1888) [Plate 4.15]

[TL: Thundiani, Pakistan; North West India]

Thera consimilis Warren, 1888; *Proceedings of the Zoological Society of London* (3): 326.

Larentia consimilis; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 380.

Thera consimilis; Prout, 1941; in Seitz, *The Macrolepidoptera of the world*, 12: 324.

Heterothera consimilis; Choi, 1997; *Syst. Ent.*, 22(4): 311.

Heterothera consimilis; Choi, 1998; *Tijdschrift voor entomologie,* 141: 37.

Wing expanse: Male: 32 mm, Female: 40 mm.

Diagnosis: Forewing greyish-fuscous; the central black fascia with highly irregular boundaries; a slightly waved or zigzag shaped, black apical streak which runs obliquely towards medial band.

Distribution: India: Himachal Pradesh (Shimla, Dalhousie, GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir), Uttarakhand (Bhimtal, NDBR) (Dey 2018), West Bengal (Darjeeling) (Hampson 1895). **Global:** Afghanistan, Nepal, Pakistan (Thundiani, TL) (Choi 1998).

75. *Heterothera dentifasciata* (Hampson, 1895) [Plate 4.16]
[TL: Dalhousie, Himachal Pradesh, India]

Larentia dentifasciata Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 379.

Cidaria (*Thera*) *dentifasciata*; Prout, 1914; in Seitz, *The Macrolepidoptera of the world*, 4: 219.

Thera dentifasciata; Prout, 1941; in Seitz, *The Macrolepidoptera of the world*, 12: 324.

Viidaleppia dentifasciata; Yazaki, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part-4: 6.

Heterothera dentifasciata; Choi, 1997; *Syst. Ent.*, 22 (4): 311.

Heterothera dentifasciata; Choi, 1998; *Tijdschrift voor entomologie,* 141: 31.

Heterothera dentifasciata; Sanyal et al. 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: Male: 36 mm, Female: 40 mm.

Diagnosis: Forewing reddish-brown, the postmedial line; central black fascia with comparatively less irregular boundaries—the inner one almost straight, outer first obliquely curved outward and then dentate and inwardly oblique to inner margin; lunulate, black discal spot and a black apical streak.

Distribution: India: Arunachal Pradesh, Himachal Pradesh (Dalhousie, GHNP) (Mallick 2021), Uttarakhand (Govind WLS, NDBR) (Dey 2018; Chandra et al. 2019). **Global:** Nepal (Yazaki 1995), Pakistan (Murree) (Choi 1998).

Genus *Hysterura* Warren, 1895

76. *Hysterura multifaria* (Swinhoe, 1889) [Plate 4.17]

[TL: Darjeeling, West Bengal, India]

Cidaria multifaria Swinhoe, 1889; *Proceedings of the Zoological Society of London*: 429.

Hysterura multifaria; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 18, pl. 6 (20).

Hastina pluristrigata; Chettri and Yonle, 2021; *International Journal of Entomology Research*, 6(3): 92.

Wing expanse: Forewing length: Male: 17–20 mm.

Diagnosis: Wings very pale purplish-grey with brownish shade and large ochreous edged, dark black patches. Forewing has a characteristic medial Y-shaped purplish mark which forms between large black patches from costa to lower angle of cell.

Distribution: India: Arunachal Pradesh, Assam, Himachal Pradesh (GHNP) (Mallick 2021), Uttarakhand, West Bengal (Darjeeling, TL) (Chandra et al. 2019; Chettri and Yonle 2021). **Global:** China, Nepal (Yazaki 1992), Russia, Vietnam.

Genus *Lobogonodes* Bastelberger, 1909

77. *Lobogonodes multistriata* (Butler, 1889) [Plate 4.18]

[TL: India]

= *multistriata atherma* Prout, 1937; [TL: Kwanhsien]

= *multistriata clasis* Prout, 1937; [TL: Japan]

= *multistriata tensa* Prout, 1940; [TL: India]

Cidaria multistriata Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 119.

Microlygris multistriata multistriata; Inoue, 1982; *Moths of Japan*, 1: 282.

Microlygris multistriata multistriata; Parsons et al., 1999; *Geometrid Moths of the World: a Catalogue*: 602.

Lobogonodes (*Microlygris*) *multistriata atheroma*; Prout, 1937; in Seitz, *The Macrolepidoptera of the world*, 4, supplementary: 105.

Microlygris multistriata atherma; Xue and Zhu, 1999; Fauna sinica (Insecta), 15: 484.

Lobogonodes (Microlygris) *multistriata tensa*; Prout, 1940; in Seitz, *The Macrolepidoptera of the world*,12: 309.

Lobogonodes multistriata; Choi, 2001; *American Museum Novitates*, 3318: 34.

Lobogonodes multistriata; Nakajima and Yazaki, 2011; Larentiinae. In: Kishida, Y. (ed.), The standard of moths in Japan, 1: 274.

Lobogonodes multistriata; Choi, 2012; *Insect fauna of Korea*, 16 (5): 48.

Lobogonodes multistriata; Wu and Chang, 2018; *Zootaxa*, 4433 (3): 442.

Wing expanse: 24 mm.

Diagnosis: The discal spot is bordered with white and followed by a broad, angular medial fascia which is broader toward costa, almost straight inner edge while outer edge acutely angles near the lower edge of the cell.

Distribution: India: Himachal Pradesh (Dharamshala, GHNP) (Mallick 2021), Meghalaya (Shillong), Sikkim, Uttarakhand, West bengal (Shah et al. 2018). **Global:** Algeria, China, Japan, Korea, Nepal.

Genus *Nebula* Braund, 1846

78. *Nebula brevifasciata* (Warren, 1888) [Plate 4.19]

TL: India, [(Western) Pakistan]

Cidaria brevifasciata Warren, 1888; *Proceedings of the Zoological Society of London*: 330.

Larentia brevifasciata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 371.

?? brevifasciata; Prout, 1934–1938; in Seitz, *The Macrolepidoptera of the world*, 4, *supplementary*: 168, pl. 16 (b).

Nebula brevifasciata; Yazaki, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1); *Moths of Nepal*, Part-6: 10, pl. 162 (17).

Wing expanse: 30 mm.

Diagnosis: Forewing fuscous black, narrow, white ante and post medial bands with fuscous central line; ante medial band almost straight and sends two white spurs outwardly, lower one close to inner margin joining the postmedial band; post medial band angled outwardly to outer margin near the middle; white, highly crenulated submarginal line. Hind wing with some fuscous suffusion and traces of post medial and submarginal line.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study). **Global:** Nepal (Yazaki 2000), Pakistan (Thundiani).

Remarks: New record to India.

79. ***Nebula cupreata*** **(Moore, 1868)** [Plate 4.20]
[TL: Bengal, (West Bengal) India]

Melanippe cupreata Moore, 1868; *Proceedings of the Zoological Society of London:* 655.

Larentia cupreata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 369.

Nebula cupreata; Yazaki, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1); *Moths of Nepal*, Part-6: 9, pl. 162 (7).

Wing expanse: 38 mm.

Diagnosis: Wings grey with glossy golden-brown pattern. Forewing with whitish-grey waved lines consist of an indistinct basal, double sub-basal and antemedial line followed by a dark brownish, slightly waved medial band.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, West Bengal. **Global:** Nepal (Yazaki 2000).

80. ***Nebula homophana*** **(Hampson, 1895)** [Plate 5.1]
[TL: Simla, Himachal Pradesh, India]

Larentia homophana Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 369.

Coenotephria homophana; Prout 1920–1941; in Seitz, *The Macrolepidoptera of the world, 4, supplementary*: 268.

Coenotephria homophana; Prout, 1934–1938; in Seitz, *The Macrolepidoptera of the world, 4, supplementary*: 140, pl. 13 (i).

Nebula homophana; Gyula et al., 2018; in Fibigeriana Supplement: *The Vartian Collection, Geometridae*, Part-4: 33, pl. 32 (51–53).

Wing expanse: Male: 34 mm, Female: 40 mm.

Diagnosis: Almost inseparable from *Colostygia albigirata* but can be distinguished on the close examination of the male antennae and the forewing's markings. The antennae in the *N. homophana* are with shorter cilia and almost simple; forewing has less angled sub-basal line; antemedial with an additional tooth about the fold and both ante and postmedial lines with comparatively less irregularities than the former. Underside of the wings with less fuscous irrorations in *N. homophana*.

Distribution: India: Himachal Pradesh (Shimla, Dalhousie), Jammu and Kashmir (Kashmir) (Gyula et al. 2018). **Global:** Pakistan (Gyula et al. 2018).

Genus *Xenortholitha* Inoue, 1944

81. *Xenortholitha falcata* Yazaki, 1993 [Plate 5.2]
[TL: Nepal; Godavari]

Xenortholitha falcata Yazaki, 1993; in Haruta T (ed.): *Tinea*, 13 (suppl. 3); *Moths of Nepal*, Part-2: 110, pl. 59 (33).

Xenortholitha falcata; Mallick et al., 2021; *Records of the Zoological Survey of India*, 483-486.

Wing expanse: 27 mm.

Diagnosis: Looks very close to *X. latifusata* but differs as the forewing in *X. falcata* lacks two dark, black triangular apical patches.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Uttarakhand (Govind and Askot WLS) (Dey 2018; Mallick et al. 2021). **Global:** Nepal (Yazaki 1993).

82. *Xenortholitha latifusata latifusata* (Walker, 1862) [Plate 5.3]
[TL: India]

Melanippe latifusata Walker, 1862; *List Species Lepidoptera Insects Collection British Museum*, 25: 1298.

Larentia latifusata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 370.

Xenortholitha latifusata; Mallick et al., 2021; *Records of the Zoological Survey of India*, 483-486.

Wing expanse: 27 mm.

Diagnosis: The species is very close to *X. propinguata* and *X. falcata*. *X. latifusata* is similar to *X. propinguata* as both have the two dark, black triangular apical patches on the forewing which are absent in *X. falcata*. The species is distinguishable from *X. propinguata* in the course of the postmedial line: the post medial line in *X. propinguata* follows comparatively more undulating course than in *X. latifusata*.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP) (Mallick 2021), Uttarakhand (Chandra et al. 2019; Mallick et al. 2021). **Global:** Pakistan, Taiwan.

83. *Xenortholitha propinguata propinguata* (Kollar, [1844]) [Plate 5.4]
[TL: India]

Cidaria propinguata Kollar, 1844; *Hugel's Kashmir*, 4: 485.

Eubolia niphonica Butler, 1878; *The Annals and Magazine of Natural History*, (5) 1: 452.

Eubolia niphonica; Sterneck, 1931; *Deutsche entomologische Zeitschrift Iris*, 45: 80.

Cidaria suavata Christoph, 1881; *Bulletin de la Société impériale des naturalistes de Moscou*, 55 (3). 101.

Cidaria suavata; Bryk, 1949; *Arkiv för zoologi*, 41(1): 165.

Xenortholitha propinguata; Choi, 2004; *Entomological Research*, 34(1): 34.

Xenortholitha propinguata; Mallick et al., 2021; *Records of the Zoological Survey of India*, 483-486.

Wing expanse: 27 mm.

Diagnosis: Discussed in the previous species.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Uttarakhand (Dey 2018, Chandra et al. 2019; Mallick et al. 2021). **Global:** China, Japan, Korea, Mongolia, Nepal, Russia, Tajikistan (Choi 2004).

Tribe Euphyiini Herbulot, 1961

Genus *Euphyia* Hübner, [1825]

84. *Euphyia submarginata* (Warren, 1909) [Plate 5.5]

[TL: Srinagar, Kashmir (Jammu and Kashmir, India) (7000 ft)]

Epirrhoe submarginata Warren, 1909; *Novitates zoologicae*, 16: 126pp.

Euphyia submarginata; Prout, 1934–1938; in Seitz, *The Macrolepidoptera of the world*, *4, supplementary*: 282, pl. 7 (i).

Euphiya submarginata; Gyula et al., 2018; in Fibigeriana Supplement: *The Vartian Collection, Geometridae*, Part-4: 30 pp, pl. 27 (27–31).

Wing expanse: 8 mm (Forewing length: 14–15 mm).

Diagnosis: Whitish-grey fore wing with dark olive-green bands, many black wavy or lunulate transverse lines and greyish irroration or suffusion. Hindwing pale olive-greyish except the costal area and a distinct dark greyish lunulate submarginal line. Underside of the wings whitish with pale grey suffusion and dark grey markings as on the upper side. Looks similar to *E. variegata* but is quite small to easily distinguish it from the former.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Jammu and Kashmir (Kashmir). **Global:** Pakistan (Gyula et al. 2018).

85. *Euphyia variegata* (Moore, 1868) [Plate 5.6]

[TL: Bengal, (West Bengal) India]

Larentia variegata Moore, 1868; *Proceedings of the Zoological Society of London:* 653.

Cidaria variegata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 353.

Euphyia variegata; Prout, 1915; in Seitz, *The Macrolepidoptera of the world*, 12: 280.

Wing expanse: 40 mm.

Diagnosis: Discussed in previous species.

Distribution: India: Himachal Pradesh (Shimla, GHNP) (Mallick 2021), Sikkim, Tamil Nadu (Das et al. 2020), West Bengal (TL). **Global:** Bhutan, China.

Tribe Xanthorhoini Pierce, 1914

Genus *Orthonama* Hubner, [1825]

86. *Orthonama obstipata* (Fabricius, 1794) [Plate 5.7, 5.8]

[TL: ??]

= *albicinctata* (Haworth, 1809) (*Phalaena*); [TL: England]

= *angustata* (Haworth, 1809) (*Phalaena*); [TL: England; USA]

= *baccata* (Guenée, [1858]) (*Camptogramma*); [TL: Ceylon, Sri Lanka]

= *brunneipennis* (Hulst, 1896) (*Nycterosea*); [TL: USA]

= *discata* (Warren, 1905) (*Ochyria*); [TL:South Africa]

= *exagitata* (Walker, 1862) (*Camptogramma*); [TL: ??]

= *fluviata* (Hübner, [1799]) (*Geometra*); [TL: Europe]

= *gemmaria* (Boisduval, 1840) (*Larentia*); [TL: ??]

= *gemmata* (Hübner, [1799]) (*Geometra*); [TL: Europe]

= *inconspicua* (Warren, 1896) (*Ochyria*); [TL: India]

= *intrusata* (Walker, 1862) (*Phibalapteryx*); [TL: Brazil]

= *lapillata* (Guenée, [1858]) (*Camptogramma*); [TL: Abyssinie; Ethiopia]

= *obruptata* (Walker, [1863]) (*Coremia*); [TL: Canada]

= *peracutata* (Walker, 1862) (*Cidaria*); [TL: ??]

= *pigrata* (Walker, 1866) (*Coremia*); [TL: North America]

= *plemyrata* (Felder and Rogenhofer, 1875) (*Cidaria*); [TL: Chile]

= *quaerendaria* (Costa, [1850]) (*Larentia*); [TL: Italy]

= *signataria* (Walker, [1863]) (*Camptogramma*); [TL: ??]

Phalaena obstipata Fabricius, 1794; *Ent. Syst*., 3 (2): 199.

Orthonama obstipata; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 17, pl. 6 (5).

Orthonama obstipata; Schulze and Fiedler, 2004; *Nachrichten des Entomologischen Vereins Apollo*, 25 (3): 153.

Orthonama obstipata; El Anbri et al., 2021; *Moroccan Journal of Agricultural Sciences*, 2 (3).

Wing expanse: Yellowish-Brown wing colour; darker transverse area between wing base and the middle line; darker transverse bands alternate with light-coloured lines; central small discoidal black spot surrounded by white. Female: Comparatively darker brown.

Distribution: India: Throughout India, Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Khasi), Uttarakhand (Dey 2018). **Global:** Afghanistan, Amur, Austria, Indonesia (Borneo), Buryatia, China, Germany, Iran, Irkutsk, Japan, Kazakhstan, Korea, Morocco (El Anbri et al. 2021), Nepal (Yazaki 1992), Poland, Primorye, Sakhalin, Switzerland, Transbaikalia, Turkey, Turkmenistan.

Genus *Xanthorhoe* Hubner, [1825]

87. *Xanthorhoe griseiviridis* (Hampson, 1895) [Plate 5.9]
[TL: Bhutan]

Cidaria griseiviridis Hampson, 1895; *Transaction Entomological Society London*: 312.

Cidaria griseiviridis; Hampson, 1896; *The Fauna of British India, including Ceylon and Burma*, 4: 557.

Wing expanse: 28 mm.

Diagnosis: Forewing with ante medial and submarginal region brown and greens with a broad dark bluish fuscous-grey medial region, all marked with many black wavy transverse lines; a characteristic brown apical patch and a whitish, nearly longitudinal streak from apex to the postmedial line. Hind wing whitish with fuscous suffusion, discal spot an post medial wavy transverse lines more prominent on the underside.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021). **Global:** Bhutan (TL).

88. *Xanthorhoe hampsoni* Prout, 1925 [Plate 5.10]
[TL: Simla, Himachal Pradesh, India]

= *placida* Prout, 1925; [TL: Bhutan]

Xanthorhoe hampsoni Prout, 1925; *Novitates zoologicae*, 32: 39.

Xanthorhoe hampsoni; Yazaki, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part-4: 6, 99 (6).

Wing expanse: 33 mm.

Diagnosis: Forewing glossy green with many black, indistinct, wavy, transverse lines and distinct whitish sub basal, ante medial, post medial and crenulated submarginal line with an oblique, white, apical streak towards post medial line. Hind wing white with fuscous suffusion towards basal region. Both wings with paired series of black marginal spots.

Distribution: India: Himachal Pradesh (Shimla, Dalhousie, GHNP) (Mallick 2021), Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017; Chandra et al. 2019). **Global:** Nepal (Yazaki 1995).

89. *Xanthorhoe saturata* (Guenée, [1858]) [Plate 5.11]
[TL: Pondicherry, Tamil Nadu, India]

= *exliturata* (Walker, 1862) (Larentia); [TL: South Hindostan, India]

= *granitalis* (Butler, 1889) (Larentia); [TL: India]

= *inamoena* (Butler, 1879) (Larentia); [TL: Japan]

= *livida* (Butler, 1878) (Coremia); [TL: Japan]

Larentia saturata Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 10: 269.

Cidaria *saturata*; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 362.

Xanthorhoe saturata; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world, 4: 227.*

Xanthorhoe saturata; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 260.

Xanthorhoe saturata; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 1); *Moths of Nepal*, Part-1: 17, pl. 6 (9).

Xanthorhoe saturata; Chettri and Yonle, 2021; *International Journal of Entomology Research*, 6 (3): 94.

Wing expanse: 28 mm.

Diagnosis: Pale greyish white wings with many darker greyish fuscous and undulating transverse lines and a broad medial band, broader towards costa and narrows down from vein CuA1; hindwings paler, transverse marking often indistinct.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Khasi), Tamil Nadu (Nilgiri, Pondichery), Uttarakhand (NDBR) (Dey 2018), West Bengal (Darjeeling) (Chettri and Yonle 2021). **Global:** China, Japan, Korea, Nepal (Yazaki 1992), Pakistan, Taiwan, Vietnam.

Tribe Larentiini Duponchel, 1845

Genus *Amnesicoma* Warren, 1895

90. *Amnesicoma simplex* Warren, 1895 [Plate 5.12]

[TL: Cashmere, Jammu and Kashmir, India]

Amnesicoma simplex Warren, 1895; *Novitates zoologicae*, 2 (2): 113.

Amnesicoma simplex; Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary:* 104, pl. 10 (e).

Amnesicoma simplex; Yazaki, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part-4: 5, pl. 98 (15).

Amnesicoma simplex; Gyula et al., 2018; in Fibigeriana Supplement: *The Vartian Collection, Geometridae*, Part-4: 34, pl. 35 (17).

Wing expanse: Male: 54 mm, Female: 58 mm (Forewing length: Male: 25 mm, Female: 28 mm)

Diagnosis: *A. simplex* can be distinguished from its fellow species in the genus based on its orange hindwings, however, exhibit close resemblance to *Photoscotosia miniosata*. The males can be easily distinguished based on the absence of the hair pencil on the underside of the forewing (present in its close ally genus *Photoscotosia*).

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir, Gurez Valley), Uttarakhand (Chandra et al. 2019). **Global:** China, Nepal (Yazaki 1995), Pakistan, Tibet.

Genus *Atopophysa* Warren, 1894

91. *Atopophysa indistincta indistincta* (Butler, 1889) [Plate 5.13]

[TL: Dharmsala, Himachal Pradesh, India]

= *indistincta micans* Wehrli, 1931; [TL: China]

= *indistincta orphnina* Wehrli, 1931; [TL: China]

= *indistincta proximifascia* Prout, 1926; [TL: India]

Scotosia indistincta Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 118.

Larentia indistincta; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 369.

Atopophysa indistincta indistincta; Yazaki, 1994; in Haruta T (ed.): Tinea, 14 (suppl. 1); *Moths of Nepal*, Part-3: 16.

Wing expanse: 34 mm.

Diagnosis: Wings pale fuscous-grey. Forewing with waved, dark fuscous-brown, many transverse lines as follows: single sub basal, three ante medial, four in the medial region, two submarginal; a paler crenulated submarginal line and black patches on the last line in the medial region and below apex on submarginal line. Hindwing with similar marking, very indistinct and only traceable towards inner margin while absent in the basal region.

Distribution: India: Himachal Pradesh (Dharamshala, Shimla, GHNP) (Mallick 2021), Meghalaya (Khasi). **Global:** China, Myanmar, Nepal (Yazaki 1994), Taiwan (Wu et al. 2020).

Genus *Neotephria* Prout, 1914

92. *Neotephria ramalaria* (Felder and Rogenhofer, 1875) [Plate 5.14]

[TL: Himalaya, India]

Cidaria ramalaria Felder and Rogenhofer, 1875; *Reise Fregatte Novara*, 2 (5): pl.132 (31).

Cidaria ramalaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 353.

Neotephria ramalaria; Yazaki, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part-4: 8, pl. 99 (13).

Wing expanse: 40 mm.

Diagnosis: Forewing ashy-grey with thick, fuscous irroration and traces of ochreous scales; a narrow sub-basal band with waved edges; a broader medial band wider towards costa, traces of waved submarginal whitish line; a series of two black spots in between the veins. Hindwing whitish grey with a discal speck and traces of an outcurved postmedial line. Underside paler, discal speck and post medial lines more prominent.

Distribution: India: Himachal Pradesh (Kullu, Dharamshala, GHNP) (Mallick 2021), Uttarakhand (Dey 2018). **Global:** Nepal (Yazaki 1995).

Genus *Photoscotosia* Warren, 1888

93. *Photoscotosia amplicata* (Walker, 1862) [Plate 5.15]

[TL: Hindostan (India)]

= *dejeani* (Oberthür, 1893) (*Trichopleura*) [TL: China]

= *trisignata* (Moore, 1868) (*Cidaria*) [TL: India]

Cidaria amplicata Walker, 1862; Cat. Het., 25: 1404.

Photoscotosia amplicata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 382.

Photoscotosia amplicata; Prout 1912-1916; in Seitz, *The Macrolepidoptera of the world,* 4: 203.

Photoscotosia amplicata amplicata; Yazaki, 1994; in Tinea, 14 (suppl. 1); *Moths of Nepal*, Part-3: 13, pl. 68 (4).

Photoscotosia amplicata; Xiang et al. 2014; *Chinese Journal Of Ecology*, 33(11): 3033-3042.

Photoscotosia amplicata; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45(177):

157

Wing expanse: 52 mm.

Diagnosis: Forewing pale purplish-grey with black and ochreous-brown transverse, undulating fasciae; a characteristic white, medial patch with a black discal streak. Hind wing with fuscour-grey suffusion, costal region broadly or narrowly white. Underside white with very slight dark irroration and marking towards the outer margin of forewing.

Distribution: India: Arunachal Pradesh, Assam, Himachal Pradesh (GHNP) (Mallick, 2021), Jammu and Kashmir (Kashmir), Meghalaya. Sikkim, Uttarakhand (Govind WLS, NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018), West Bengal (Chandra et al. 2019). **Global:** Bhutan, China, Myanmar, Nepal (Yazaki 1994), Pakistan, Tibet (Xiang et al. 2014).

94. *Photoscotosia chlorochrota* Hampson, 1902 [Plate 5.16]
[TL: Yatong, Tibet, China]

Photoscotosia chlorochrota Hampson, 1902; *Journal Bombay Natural History Society*,14: 518, pl. c (21).

Photoscotosia chlorochrota; Yazaki, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), *Moths of Nepal*, Part-3: 13, pl. 68 (8).

Wing expanse: Male: 48 mm, Female: 54 mm.

Diagnosis: Forewing fuscous brown, greyish green irrorartion between sub basal and ante medial dark, thick lines and beyond post medial line.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study). **Global:** China (TL) (Yatong, Tibet, TL), Nepal (Yazaki 1994).

Remarks: New record to India.

95. *Photoscotosia dejuncta* Prout, 1937 [Plate 5.17]
[TL: Gulmarg, Kashmir (Jammu and Kashmir, India)]

Photoscotosia dejuncta Prout, 1934-1938; in Seitz, *The Macrolepidoptera of the world*, 4, supplementary: 103, pl. 10 (d).

Photoscotosia dejuncta; Dey and Hausmann, 2021; *Journal of Threatened Taxa*, 13 (7): 18822.

Wing expanse:

Diagnosis: Looks similar to *P. funeberis* and *P. dejuta* but distinguishable as follows: the forewing with slightly more acute apex, an ochreous-white subapical streak visible upto R3 vein and similarly coloured but very indistinct apical patch. Underside, streak and apical patch merges to form a large and distinct triangular apical patch.

Distribution: India: Himachal Pradesh (Spiti Valley, GHNP, Lahaul and Spiti Valley-current study) (Mallick 2021), Jammu and Kashmir (Kashmir, Gulmarg), and Uttarakhand (Nanda Devi Biosphere Reserve) (Dey and Hausmann 2021). **Global:** No documentation.

96. *Photoscotosia dejuta* Prout, 1937 [Plate 5.18]
[TL: Wuin-Kin, Western China]

Photoscotosia dejuta Prout, 1934-1938. in Seitz, *The Macrolepidoptera of the world*, 4, supplementary: 103.

Photoscotosia dejuta; Yazaki, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), *Moths of Nepal*, Part-3: 13, pl. 68 (6).

Photoscotosia dejuta; Yazaki, 1995; Tinea, 14 (suppl. 2), *Moths of Nepal*, Part-4: 5, pl. 68 (7) (genitalia figure: 559).

Wing expanse: 48 mm.

Diagnosis: Looks similar to *P. pallidimaculata* but distinguishable because in *P. dejuta* forewing is with three prominent submarginal white specks. Hindwing with orange blotch restricted more or less up to M1.

Distribution: India: Arunachal Pradesh, Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand (Chandra et al. 2021). **Global:** Bhutan, China, Nepal (Yazaki 1994; Yazaki 1995).

97. *Photoscotosia fulguritis* Warren, 1893 [Plate 5.19]
[TL: Sikkim, India]

= *keraria* Swinhoe, 1893; [TL: India]

Photoscotosia fulguritis Warren, 1893; *Proceedings of the Zoological Society of London*, 25: 370, pl. 30. fig. 11.

Photoscotosia fulguritis; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 381.

Photoscotosia fulguritis; Prout, 1920-1941; in Seitz, *The Macrolepidoptera of the world*, 12: 313, pl. 31 (g).

Photoscotosia fulguritis; Yazaki, 1995; in Haruta T (ed.): Tinea 14, (suppl. 2), *Moths of Nepal*, Part-4: 4, pl. 98 (11).

Wing expanse: 46–48 mm.

Diagnosis: Forewings orange-brownish with fuscous-black suffusion, characterized with white transverse lines; sub basal line slightly outcurved; antemedial with a bidentate outward projection on and below medial vein; an apical oblique streak reaching up to post medial line. Hindwing with costal region broadly white, while inner region suffused with smoky fuscous-grey and a lunulated sub terminal line.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Sikkim, West Bengal (Darjeeling). **Global:** Bhutan, Nepal (Yazaki 1995).

Remarks: New record to Himachal Pradesh. Collected from 10,000 ft to 12,000 ft on Nepal frontier in July (Warren, 1893).

98. *Photoscotosia metachryseis* Hampson, 1896 [Plate 5.20]
[TL: India]

Photoscotosia metachryseis Hampson, 1896; *The Fauna of British India, including Ceylon and Burma*, 4: 557.

Photoscotosia metachriseis; Yazaki, 1994; in Haruta T (ed.): Tinea, 14 (suppl. 1); *Moths of Nepal*, Part-3: 13, pl. 68 (6).

Wing expanse: Forewing length: 21–25 mm.

Diagnosis: Forewing brown-fuscous, distinct whitish, sub basal, ante and post medial line s and a characteristic white oblique streak from the apex towards post medial line. Male sometime with white medial costal patch in cellular region.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Sikkim, Uttarakhand (Govind WLS, NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018; Shah et al. 2018; Chandra et al. 2019). **Global:** China, Nepal (Yazaki 1994),

Remarks: New record to Himachal Pradesh.

99. *Photoscotosia miniosata* (Walker, 1862) [Plate 6.1]
[TL: Silhet, Bangladesh]

Scotosia miniosata Walker, 1862; *List Species Lepidoptera Insects Collection British Museum*, 25: 1354.

Scotosia miniosata; Warren, 1893; *Proceedings of the Zoological Society of London*, (2): 369.

Photoscotosia miniosata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 380.

Photoscotosia miniosota; Prout 1914; in Seitz, *The Macrolepidoptera of the world*, 4: 202.

Photoscotosia miniosata miniosata; Yazaki, 1993; in Haruta T (ed.): Tinea 13, (suppl. 3), *Moths of Nepal,* Part-2: 111, pl. 60 (3).

Photoscotosia miniosata; Yazaki, 1994; in Haruta T (ed.): Tinea, 14 (suppl. 1); Moths of Nepal, Part-3: 13, pl. 60 (3)

Photoscotosia miniosota; Yazaki, 1998; in Haruta T (ed.): Tinea, 15 (suppl. 1); *Moths of Nepal*, Part-5: 7.

Photoscotosia miniosata; Ghosh, 2003; *Fauna of Sikkim*, 4: 217–342.

Photoscotosia miniosata; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 52 mm.

Diagnosis: Also, looks similar to *P. dejuta***,** but with olive-greenish suffusion towards outer area. Underside with broad outwardly oblique orange patch and a postmedial black costal bar within this patch (in *P. dejuta* the patch is reduced and restricted below the costal margin).

Distribution: India: Arunachal Pradesh, Himachal Pradesh (GHNP) (Mallick 2021), Punjab, Sikkim, Uttarakhand (Gangotri NP, Govind WLS, NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018), West Bengal (Shah et al. 2018; Chandra et al. 2021; Singh and Lekhendra 2023). **Global:** Bangladesh (TL), Bhutan, China, Nepal (Yazaki 1993; Yazaki 1998), Pakistan, Phillipines, Taiwan.

100. *Photoscotosia nitida* Inoue, 1982 [Plate 6.2]
[TL: Nepal, Central]

Photoscotosia nitida Inoue, 1982; *Bulletin of Faculty of Domestic Sciences, Otsuma Woman's University,* 18: 145.

Photoscotosia nitida; Yazaki, 1998; in Haruta T (ed.): Tinea, 15 (suppl. 1), *Moths of Nepal*, Part-5: 8.

Wing expanse: 48 mm.

Diagnosis: Forewing bluish-grey with well-defined, dentate sub basal, ante and post medial fuscous bands, and a distinct black discal spot. Hindwing white, slight fuscous suffusion towards the inner area.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021). **Global:** Nepal (Yazaki 1998).

101. *Photoscotosia pallidimaculata* Yazaki, 1995 [Plate 6.2]
[TL: Nepal]

Photoscotosia pallidimaculata Yazaki, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2), *Moths of Nepal*, Part-4: 5, pl. 98 (13-Holotype) (genitalia figures: 558).

Wing expanse: 46 mm (FW length: 23 mm)

Diagnosis: Looks somewhat similar to *P. dejuta* but comparatively smaller, forewing pale greyish-brown (fuscous-brown in *P. dejuta*), with paler basal third region, median fascia with smooth course. Hindwing paler, distal orange patch comparatively larger and enlarged beyond CuA1.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Uttarakhand (Chandra et al. 2019). **Global:** Nepal (TL).

Tribe Stamnodini Forbes, 1858

Genus *Stamnodes* Guenée, [1858]

102. ***Stamnodes pauperaria pamphilata*** **(Felder and Rogenhofer, 1875)** [Plate 6.4] **[TL: Lahul, Himalaya (Himachal Pradesh, India]**

Stamnodes pauperaria pamphilata Felder and Rogenhofer, 1875; *Reise der österreichischen Fregatte Novara* (*Zoology*), 2 (5): pl. 132 (34).

Stamnodes pamphilata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 423.

Stamnodes pamphilata; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 168.

Stamnodes pauperaria pamphilata Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world*, 4, supplementary: 81, pl. 8 (d).

Stamnodes pauperaria; Gyula et al., 2018; in Fibigeriana Supplement: *The Vartian Collection, Geometridae*, Part-4: 31, pl. 29 (26–29).

Wing expanse: Male: 34mm, Female: 42mm (FBI)

Diagnosis: It can be distinguished from the nominotypical subspecies with its darker fuscous markings and black suffusion in the antemedial region of forewing and more than the half of the hindwing. Forewing with the third costal black patch prominent, projects upto ?? and is of more uniform width with slightly narrowing posteriorly.

Distribution: India: Himachal Pradesh (Dharamshala, Koksar, Kullu), Jammu and Kashmir, Sikkim, Uttarakhand (Chandra et al. 2019)**. Global:** Afghanistan, Kazakhstan, Kyrgyzstan, Mongolia, Nepal, Russia (Gyula et al. 2018).

UNASSIGNED

Genus *Apithecia* Prout, 1914

103. *Apithecia viridata* (Moore, 1868) [Plate 6.5]

[TL: Darjiling, West Bengal, India]

Cidaria viridata Moore, 1868; *Proceedings of the Zoological Society of London*: 661.

Cidaria viridata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 365.

Apithecia viridata; Prout, 1914; in Seitz, *The Macrolepidoptera of the world*, 4: 266, pl. 13 (e).

Apithecia viridata; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2), Moth of Nepal, Part 1: 17, pl. 6 (10).

Wing expanse: Male: 22 mm, Female: 28 mm

Diagnosis: Bright green forewings with broad pale purplish-grey bands alternating with narrow black bands sometimes lined with green or white lines and a distinct green discal streak. Hindwings white with pale greyish suffusion, less pronounced towards costal margin. Underside of the wings with fuscous-black suffusion with dark and distinct discal dots and postmedial line on the hindwings.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Maharashtra (Yonle 2022), Meghalaya (Khasi) (Joshi et al. 2021), Sikkim, Uttarakhand (Dey 2018), West Bengal (Darjeeling, TL) (Shah et al. 2018). **Global:** Nepal (Yazaki 1992)

Remarks: New record to Himachal Pradesh.

Genus *Callabraxas* Butler, 1880

104. *Callabraxas trigoniplaga* Hampson, 1895 [Plate 6.6]

[TL: Nepal]

Callabraxas trigoniplaga Hampson, 1895; *Transaction of Entomological Society*; 312.

Callabraxas trigoniplaga; Hampson, 1896; *The Fauna of British India, including Ceylon and Burma*, 4: 558.

Callabraxas trigoniplaga; Prout 1934–1938; in Seitz, *The Macrolepidoptera of the world*, suppl. 4: 108, pl. 10 (h).

Chartographa trigoniplaga; Yazaki, 1998; in Haruta T (ed.): Tinea 15, (suppl. 1), Moths of Nepal, Part-5: 8, pl. 129 (20).

Wing expanse: 52 mm.

Diagnosis: White wings. Forewing with a prominent dark, ochreous-brown, triangular fascia enclosed within the fork of the broad white medial band; diffused greyish-brown antemedial and outer area with ochreous-brown patches towards inner margin; outer area with a lunulated white submarginal line. Hindwing with dark patch at the lower angle of the cell and near the middle of inner margin with slightly ochreous patch towards anal angle. Underside the males are characterised by a tuft of long yellow hairs at the base of median vein, greyish-fuscous discal patches, patchy diffused postmedial line and broad apical patch.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Uttarakhand (Chakrata, NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018). **Global:** Myanmar (Upper Burma), Nepal (TL) (Yazaki 1998), Tibet (Choi 2001).

Remarks: New record to Himachal Pradesh.

Genus *Calluga* Moore, [1887]

105. *Calluga* costalis Moore, [1887] [Plate 6.7]

[TL: Ceylon, Sri Lanka]

= *albiviridis* (Warren, 1907) (*Sillophora*); [TL: British New Guinea; Papua New Guinea]

= *cissocosma* (Turner, 1904) (*Chloroclystis*); [TL: Australia]

= *rufifascia* (Hampson, 1893) (*Eupithecia*); [TL: Ceylon, Sri Lanka]

Calluga costalis Moore, [1887]; *Lepidoptera Ceylon*, 3: 480, pl. 206 (1).

Chloroclystis costalis; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 397, fig. 185.

Calluga costalis; Yazaki, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part-4: 17, pl. 100 (8).

Wing expanse: 18 mm.

Diagnosis: Wings pale, ochreous-white with many highly undulating pale olive-green transverse lines (turns ochreous during specimen preparation) often irrorated with black; apex of forewing produced, costal margin slightly bent downward in the middle.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Gujarat (Patel et al. 2023), Meghalaya (Joshi et al. 2021), Nagaland (Nagas), Tamil Nadu (Das et al. 2020). **Global:** Bhutan, Myanmar (Burma), Nepal (Yazaki 1995), Sri Lanka (Ceylon, TL), Taiwan (Wu et al. 2020).

Remarks: New record to Himachal Pradesh.

Genus *Evecliptopera* Inoue, 1982

106. *Evecliptopera decurrens decurrens* (Moore, 1888) [Plate 6.8]
[TL: Nynee Tal, Uttarakhand, India]

Cidaria decurrens Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 276.

Cidaria decurrens; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 361.

Cidaria decurrens Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 250.

Cidaria (*Ecliptopera*) *decurrens* Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary:* 152, pl. 15 (d).

Cidaria decurrens; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 303.

Evecliptopera decurrens; Choi, 2001, *American Museum Novitates,* 3318: 30.

Wing expanse: Male: 30 mm, Female: 34 mm.

Diagnosis: Forewing fuscous-brown; eight outwardly oblique lines all converging towards the anal angle which is with ochreous-brown patch; other similar lines irregularly placed among these. A white line is appearing to run along the mid-dorsal of the body starting from the tip of palpi upto the tip of the abdomen. Hind wings whitish, suffused with fuscous and pale marking towards outer region.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Meghalaya (Joshi et al. 2021), Uttarakhand (Nainital). **Global:** China, Japan, Korea (Choi and An 2010; Lee et al. 2016).

Remarks: New record to Himachal Pradesh.

Genus *Girida* Mironov and Galsworthy, 2012

107. *Girida rigida* (Swinhoe, 1892) [Plate 6.9]

[TL: Khasi Hills, Meghalaya, India]

Eupithecia rigida Swinhoe, 1892; *Transaction Entomological Society London* 1892 (1): 2, pl. 1 (6).

Eupithecia rigida Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 399.

Eupithecia rigida; Inoue, 1979; *Bulletin of Faculty of Domestic Sciences, Otsuma Woman's University*, 15: 188.

Eupithecia rigida; Mironov and Galsworthy, 2007; *Transactions of the Lepidopterological Society of Japan*, 58 (3): 362.

Eupithecia rigida; Holloway, 1976: *Moths of Borneo with special reference to Mt. Kinabalu*: 66.

Eupithecia rigida; Holloway, 1979, *Series Entomology*, 15: 306, pl. 58 (3).

Eupithecia rigida; Mironov and Galsworthy, 2009, *Transactions of the Lepidopterological Society of Japan*, 60 (3): 177.

Girida rigida; Mironov and Galsworthy, 2012, *Zootaxa*, 3587: 58.

Wing expanse: 22 mm.

Diagnosis: "Wings very dark grey, almost black, with a fine, rather punctate double white postmedial on each wing which are more evident at the dorsum of both wings and at the forewing costa; a similar but faint submarginal that is expanded subtornally on the forewing. This is the largest Bornean *Eupithecia*" (from Moths of Borneo).

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Meghalaya (Nilgiri, Khasi, TL). **Global:** Borneo (Kinabalu), Japan, New Caledonia**,** Papua New Guinea (Rossel Island), Philippines, Solomons, Taiwan, Thailand, Timor.

Remarks: New record to Himachal Pradesh.

Genus *Mesoleuca* Hübner, [1825]

108. *Mesoleuca costipannaria* (Moore, 1868) [Plate 6.10]

[TL: Bengal, (West Bengal) India]

Eupithecia costipannaria Moore, 1868; *Proceeding Zoologial Society London*: 654.

Larentia costipannaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 371.

Mesoleuca costipannaria; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world,* 12: 272, pl. 27 (d).

Wing expanse: 28 mm.

Diagnosis: Forewing greyish-brown, characterised by the sinuous outer margins of the wings, especially the hindwing; black basal patch either slightly or not indenteated; the medial band only as a costal triangular patch, the outer, slender white line more closely placed to the outer margin.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Sikkim, West Bengal (TL). **Global:** China (Western China), Formosa.

Remarks: New record to Himachal Pradesh.

Subfamily Geometrinae Stephens, 1829

Tribe Agathiini Ban, Jiang, Yue and Han, 2018

Genus *Agathia* Guenée, [1858]

109. *Agathia hilarata hilarata* Guenée, [1858] [Plate 6.11]

[TL: Inde centrale? (Central India)]

Agathia hilarata Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 381.

Agathia hilarata; Prout, 1932; *Geometridae of Mt. Kinabalu*: 45.

Agathia hilarata; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world,* 12: 70, pl. 9 (d).

Agathia hilarata; Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary:* 9.

Agathia hilarata; Singh, 1953; *Indian Forest Records*, 8 (7): 126 (16, 29, 62).

Wing expanse: 38 mm.

Diagnosis: Wings bright green; forewing with pale ochreous costa irrorated with greyish scales; brown and purplish-grey basal patch, ante and post medial bands brown with purplish-grey center; postmedial band slightly curved outwards towards outer margin and merges with marginal fascia near the middle. Hindwing without any green enclosing near anal angle.

Distribution: India: Central India (TL), Himachal Pradesh (Kaza, Pooh) (Kumar et al. 2018; Kumar and Sharma 2022; Sidhu et al., 2022), Karnataka (Mishra et al. 2016), Uttarakhand (Askot WLS) (Uniyal et al. 2016; Sanyal et al., 2017), West Bengal (Shah et al. 2018). **Global:** No documentation.

Tribe Geometriini Stephens, 1829

Genus *Geometra* Linnaeus, 1758

110. *Geometra flavifrontaria* (Guenée, 1858) [Plate 6.12]

[TL: North West India]

= *mutans* (Butler, 1881) (*Loxochila*); [TL: India]

= *pratti* (Prout, 1912) (*Hipparchus*); [TL: China (central)

Nemoria flavifrontaria Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9:346.

Hipparchus flavifrontaria; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 75, pl. 10 (b).

Hipparchus flavifrontaria; Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary*: 9.

Geometra flavifrontaria; ICZN, 1957; *Opin Decl ICZN 15* (Opinion 450): 254.

Geometra flavifrontaria; Yazaki, 1992; in Haruta T (Ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 9, pl. 3 (16).

Geometra flavifrontaria; Han et al., 2009; *Journal of Natural History*, 43 (13–14): 908.

Wing expanse: 43 mm.

Diagnosis: Wings greyish-green. Forewing slightly produced; ante and post medial lines straight, ante medial runs obliquely outward and post medial inward; submarginal line crenulated and traceable but not much distinct.

Distribution: India: Himachal Pradesh (Sabathu, Dalhousie, Shimla, GHNP) (Mallick 2021), Tamil Nadu (Das et al. 2020), Uttarakhand (Bhimtal, Kumaon, Nainital). **Global:** China, Nepal (Yazaki 1992), Pakistan.

Genus *Iotaphora* Warren, 1894

111. *Iotaphora iridicolor* (Butler, 1880) [Plate 6.13]

[TL: North India]

Panaethia iridicolor Butler, 1880; *The Annals and Magazine of Natural History*, 6 (33): 227.

Iotaphora iridicolor; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 322.

Iotaphora iridicolor; Yazaki, 1992; in Haruta T (Ed.), Tinea, 13 (suppl. 2), *Moths of Nepal*, Part-1: 11, pl. 4 (9).

Iotaphora iridicolor; Smetack, 2008; *Bionotes*, 10 (1): 7.

Iotaphora iridicolor; Ghosh, 2003; *Fauna of Sikkim*, 4: 268.

Wing expanse: 56 mm.

Diagnosis: Wings whitish suffused and marked with orange-yellow. Forewing with a characteristic black basal spot on costa, and other at one third of the costa reprsesenting the traces of an indistinct fuscous, outwardly curved antemedial line and a large, black, lunulated, discal spot.

Distribution: India: Arunachal Pradesh (Eaglenest WLS), Himachal Pradesh (GHNP) (Mallick 2021; Singh et al. 2022), Manipur, Meghalaya (Khasi), Sikkim, Uttarakhand (Devalsari), West Bengal (Darjeeling, Neora Valley NP) (Chandra et al. 2019). **Global:** Bhutan, China, Nepal (Yazaki 1992), Tibet, Vietnam.

Genus *Maxates* Moore, [1887]

112. *Maxates glaucaria* (Walker, 1866) [Plate 6.14]

[TL: North India]

Thalera glaucaria Walker, 1866; *List Species Lepidoptera Insects Collection British Museum*, 35: 1613.

Thalassodes glaucaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 509.

Gelasma glaucaria; Prout, 1912-1916; in Seitz, *The Macrolepidoptera of the world*, 4: 22, pl. 2 (c).

Maxates glaucaria; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 13, pl. 4 (19).

Maxates glaucaria; Yazaki, 1998; in Haruta T (ed.): Tinea 15 (suppl. 1); *Moths of Nepal*, Part-5: 5.

Wing expanse: 30–40 mm.

Diagnosis: Glaucous green wings "thickly irrorated and somewhat suffused with olive-green"**.** Both wings with dark, white-edged ante and post medial lines, post medial well-developed, crenulated and has similar course in both wings. Discal mark slightly darker and indistinct.

Distribution: India: Himachal Pradesh (Dharamshala, GHNP) (Mallick 2021), Sikkim, Tamil Nadu (Nilgiris) (Das et al. 2020). **Global:** Bhutan, Nepal (Yazaki 1992; Yazaki 1998), Taiwan (Wu et al. 2020), Tibet.

113. *Maxates illiturata* (Walker, F., [1863]) [Plate 6.15]
[TL: Shang-hai, China]

= *sasakii* (Matsumura, 1917) (*Hemithea*);[TL: Japan]

Thalassodes illiturata Walker, F., 1863; *List Species Lepidoptera Insects Collection British Museum*, 26: 1563.

Gelasma illiturata; Prout, 1912–1916; in Seitz, *The Macrolepidoptera of the world*, 4: 22, pl. 2 (d).

Wing expanse: 40–42 mm.

Diagnosis: Wings pale glaucous-green with olive-green suffusion and ochreous costal edge irrorated with fuscous. Forewing apex slightly produced; very indistinct, darker, olive-green, ante and crenulated, slightly visible, post medial line edged with white; slightly darker and indistinct discal mark. Hindwing acutely produced near the middle.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study). **Global:** China (Shanghai, TL), Japan (Yoshino), Korea (Byun et al. 2010; Balint and Katona 2011).

Remarks: New record to India.

114. *Maxates iridescens* (Warren, 1896) [Plate 6.16]

[TL: Khasias, Assam, India]

Jodis iridescens Warren, 1896; *Novitates zoologicae*, 3: 108.

Jodis iridescens; Yazaki, 1992; in Haruta T (ed.): Tinea 13 (suppl. 2); *Moths of Nepal*, Part-1: 14.

Jodis iridescens; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 85, pl. 4 (d).

Jodis iridescens; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 14, pl. 5 (8).

Wing expanse: 26 mm.

Diagnosis: Wings pale, glaucous-green. Forewing with costa and ante and post medial fascia darker olive-green, the crenulated outer edge lined by a paler whitish line. Hindwing with similar marking, outer margin crenulated and slightly produced in the middle.

Distribution: India: Assam (TL), Himachal Pradesh (GHNP) (Mallick 2021). **Global:** Nepal (Yazaki 1992).

Genus *Mixochlora* Warren, 1897

115. *Mixochlora vittata vittata* (Moore, 1868) [Plate 6.17]

[TL: Bengal, West Bengal, India]

Geometra vittata Warren, 1868; *Proceedings of the Zoological Society of London*: 636.

Mixochlora vittata; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 11, pl. 4 (6).

Mixochlora vittata; Singh, 1953; Indian Forest Record, 8 (7): 132.

Wing expanse: Male: 35 mm, Female: 44 mm.

Diagnosis: Wings pale glaucous-green. Forewing with four darker green bands, the inner two sub basal and ante medial nearly straight and the outer two post medial and submarginal runs obliquely inward towards inner margin where the post medial band join the ante medial band; one small incurved band joining the postmedial band in the cellular region; marginal band comparatively indistinct. Hind wing with only the outer two and marginal bands. Underside with ochreous-yellow suffusion.

Distribution: India: Arunachal Pradesh, Assam (Tinsukia) (Arandhara et al. 2017), Himachal Pradesh, Manipur, Meghalaya (Joshi et al. 2021), Nagaland, Sikkim, Uttarakhand (Askot and Govind WLS, NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018), West Bengal (Neora Valley NP) (Chandra et al. 2019; Chettri and Yonle 2021). **Global:** Bhutan, China, Indonesia, Japan, Korea, Malaysia (Abang and Karim 2000), Myanmar, Nepal (Yazaki 1992), Philippines, Taiwan, Thailand (Holloway 1996).

Genus *Tanaorhinus* Butler, 1879

116. *Tanaorhinus reciprocata reciprocata* (Walker, 1861) [Plate 6.18]

[TL: North India]

= *dimissa* (Walker, 1861) (*Geometra*); [TL: North Hindostan [India].

Geometra reciprocata Walker, 1861; *List Species Lepidoptera Insects Collection British Museum*, 22: 515.

Tanaorhinus reciprocatus; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 493.

Tanaoshinus reciprocata; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1 :11, pl. 4 (3).

Wing expanse: 70 mm.

Diagnosis: Wings bright green. Forewing with apex produced and straight outer margin, hindwing with rounded outer margin. Both wings with oblique, lunulate, ochreous white or silvery white post medial line with similar diffused lunules beyond it and in submarginal area. Underside with characteristic brown markings as follow: discal dots, an obliquely straight submarginal line on forewing and hindwing with a straight post medial line followed by series of larger, slightly indistinct, submarginal dots.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh (Shimla, Dharamshala, GHNP) (Mallick 2021), Meghalaya (Khasi), Nagaland (Joshi et al. 2021), Sikkim, Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Chandra et al. 2019). **Global:** Bhutan, China, Japan, Korea, Nepal (Yazaki 1992), Taiwan, Thailand.

Tribe Comibaeniini Inoue, 1961

Genus *Comibaena* Hübner, [1823]

117. *Comibaena cassidara* (Guenée, [1858]) (*Phodoresma*) [Plate 6.19]

[TL: North India]

= *detenta* (Walker, 1861) (*Geometra*); [TL: Nepal]

= *discessa* (Walker, 1861) (*Geometra*); [TL: Punjab]

Phorodesma cassidara Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 370.

Comibaena cassidara; Prout, 1920–1941. *The Macrolepidoptera of the world*, 12: 92, pl. 12 (e).

Uliocnemis cassidara; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 488.

Comibaena cassidara; Yazaki, 1998; in Haruta T (ed.): Tinea 15, (suppl. 1), *Moths of Nepal*, Part-5: 4, pl. 129 (5).

Wing expanse: 32 mm.

Diagnosis: *C. cassidara* looks similar to *C. leucospilata* but differs in forewing having the post medial line less sinuous, outer margin with reduced markings and fringes lacking alternate white definite spots.

Distribution: India: Central and North India: Himachal Prdaesh (GHNP) (Singh 2022), Maharashtra (Shubhalaxmi et al. 2011), Karnataka (Ravindrakumar 2021), Kerala (Das et al. 2020; Shamsudeen and Pathania 2022), Uttarakhand, West Bengal (Shah et al. 2018; Singh 2023). **Global:** China (Fujian, Hainan, Yunnan, Tonkin), Indonesia, Malaysia, Nepal (Yazaki 1998), Pakistan, Philippines, Singapore, Sri Lanka (Ceylon), Taiwan, Thailand (Han et al. 2012).

Remarks: Zizyphus and Ixora (Prout 1920-1941).

118. *Comibaena quadrinotata fuscidorsata* Prout, 1912 [Plate 6.20]

[TL: Assam, India]

Comibaena fuscidorsata Prout, 1912; *Gen. Insect.* 129: 101

Comibaena fuscidorsata; Holloway, 1996; *Moths of Borneo*, Part-9: 243, pl. 8 (245).

Comibaena quadrinotata fuscidorsata; Prout, 1920–1941; *The Macrolepidoptera of the world*, 12: 92, pl. 11 (b).

Comibaena quadrinotata fuscidorsata; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 13, pl. 4 (21).

Wing expanse: 26–28 mm.

Diagnosis: *C. quadrinotata fuscidorsata* is characterised by more yellowsish wings rather blue, fuscous black patches on the anal angle of the forewing larger and semicircular (pointed in *C. q. quadrinotata*) and that on the apex of hindwing almost similar with the later species. Underside whitish, with similar patch on the apex of hindwing and green discal lines.

Distribution: India: Arunachal Pradesh, Assam (TL). Himachal Pradesh, Jammu and Kashmir, Meghalaya, Uttarakhand, Uttar Pradesh (Farooqui and Parwez 2022), West Bengal (Chandra et al. 2019). **Global:** China (Hainan, Taiwan, Yunnan) (Han et al. 2012), Indonesia (Borneo, Sumatra) (Holloway 1996), Japan, Malaysia, Nepal (Yazaki 1992), Sri Lanka (Ceylon), Taiwan, Thailand.

119. *Comibaena pictipennis* (Butler, 1880) [Plate 7.1]
[TL: North India]

Geometra pictipennis Butler, 1880; *The Annals and Magazine of Natural History*, 6 (5): 215.

Geometra pictipennis; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 496.

Chlorochaeta pictipennis; Prout, 1935; in Seitz: *The Macrolepidoptera of the world*, 4, *supplementary*: 11.

Comibaena pictipennis; Prout, 1920–1941; *The Macrolepidoptera of the world*, 12: 92, pl. 11 (b).

Comibaena pictipennis; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 12, pl. 4 (16).

Comibaena pictipennis; Han et al., 2012; *Zoological Journal of the Linnean Society*, 165 (4): 744.

Chlorochaeta pictipennis; Chandra and Sambath, 2013; *Journal of Threatened Taxa*, 5 (1): 3565.

Comibaena pictipennis; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 35 mm.

Diagnosis: Looks close to *C. ornataria* but differs as more heavily marks with fury-red with an additional digitate, inward extension from the outer margin in the middle.

Distribution: India: Arunachal Pradesh (Tawang, Tale WLS) (Sondhi et al. 2021, Himachal Pradesh (GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir), Meghalaya (Kahsis), Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Darjeeling) (Chettri and Yonle 2021). **Global:** Bhutan, China (Hunan, Taiwan, Sichuan, Yunnan, Tibet), Formosa, Nepal (Yazaki 1992), Taiwan, Tibet (Han et al. 2012; Wu et al. 2020).

Genus *Linguisaccus* Han, Galsworthy and Xue, 2012

120. *Linguisaccus subhyalina* (Warren, 1899) [Plate 7.2]

[TL: North India]

Comostolodes subhyalina Warren, 1899; *Novitates zoologicae*, 6: 22.

Euchloris inductaria Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 499.

Comibaena subhyalina; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world,* 12: 91, pl. 11 (d).

Comibaena subhyalina; Yazaki 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*; Part-1; 12, pl. 4 (17).

Wing expanse: 36 mm.

Diagnosis: Wings bright green coloured with reddish-brown ringed marking. Forewing white costa with reddish-brown outlines and expanding slightly into ante and post medial spots; narrow white marginal band with crenulated inner edge expanded in the middle and anal angle; other marking involves similar spots one on inner margin (slightly obliquely placed to the ante medial costal spot) and discal spot. Hindwing with discal spot smaller and marginal band as in forewing.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh (Dalhousie, Dharamshala), Nagaland (Nagas), Uttarakhand (Chandra et al. 2019).

Global: Bhutan, China (Hubei, Guangxi, Sichuan, Yunnan, Tibet), Indonesia (Borneo), Nepal (Yazaki 1992), Pakistan (Han et al. 2012).

Tribe Archaeobalbini Viidalepp, 1981

Genus *Dindica* Moore, 1888

121. *Dindica para* Swinhoe, 1891 [Plate 7.3]

[TL: Khasia Hills, Meghalaya, India]

= *erythropunctura* Chu, 1981; [TL: China]

Dindica para Swinhoe, 1891; *Transaction Entomological Society London*, 24: 490.

Dindica para; Prout, 1932; in Seitz, *The Macrolepidoptera of the world*, 12: 58, pl. 8 (h).

Dindica para para; Yazaki 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 9, pl. 3 (11).

Wing expanse: 42–44 mm.

Diagnosis: Forewing olive-green, black and reddish-brown irrorated; fuscous and reddish-brown highly dentated ante medial line, lunulate discal spot and highly bent poste medial line; pale submarginal line only distinct towards costa. Hindwing whitish, with some yellowish hue, green, black and reddish brown towards outer margin, otherwise unmarked. Underside with more or less incomplete darker borders; large fuscous black, discal blotch on forewing and a reddish-pink, fuscous irrorated, indistinct submarginal band, more or less complete in forewing and as a patch near the inner margin in hindwing.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Meghalaya (Khasi Hills, TL). **Global:** Nepal (Yazaki 1992).

Remarks: It is a new record to Himachal Pradesh.

Genus *Herochroma* Swinhoe, 1893

122. *Herochroma cristata cristata* (Warren, 1894) [Plate 7.4]

[TL: Bhutan, Sikkim (India)]

= *subopalina* (Warren, 1894) (Actenochroma); [TL: Khasia Hills, India]

Actenochroma cristata Warren, 1894; *Novitates zoologicae,* 1 (2): 381.

Herochroma cristata; Holloway; *Moths of Borneo,* 9: 199.

Archaeobalbis cristata cristata; Yazaki 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 6, pl. 2 (11).

Wing expanse:

Diagnosis: Wings dull olive-green, with darker green mottling. Underside of the wings with broad black submarginal band suffused with pinkish-red and large black discal spots, that of forewing comparatively larger.

Distribution: India: Assam, Himachal Pradesh (Kumar et al. 2018), Kerala, Meghalaya **(**Khasi Hills) (Joshi et al. 2021), Sikkim, Tamil Nadu, Uttarakhand (Govind WLS, Dehradun) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Chandra et al. 2019; Das et al. 2020). **Global:** Bangladesh, Bhutan, Hong Kong, Indonesia (Borneo, South Celebes) (Warren 1894), Nepal (Yazaki 1992), Sri Lanka, Taiwan, Thailand.

123. *Herochroma usneata* (Felder and Rogenhofer, 1875) [Plate 7.5]
[TL: North India]

= *hypoglauca* (Hampson, 1895) (*Pseudoterpna*); [TL: India]

?? usneata Felder and Rogenhofer, 1875; *Reise Novar Zoology*, 2: pl. 125 (12).

Pseudoterpna usneata Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 479.

Archaeobalbis usneata; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 46, pl. 5 (g).

Archaeobalbis usneata; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 6, pl. 2 (8).

Wing expanse: 64 mm.

Diagnosis: Looks somewhat similar to previous species but can be distinguished based on the comparatively larger size, brighter wing colour, highly crenulated outer margins and bluish-grey irroration instead of rufous and a submarginal series of black spots. Underside with pale greyish-white suffusion and larger, black, discal spots.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Meghalaya (Joshi et al. 2021), Sikkim. **Global:** Nepal (Yazaki 1992).

Remarks: The species is a new record to Himachal Pradesh.

Genus *Lophophelma* Prout, 1912

124. *Lophophelma erionoma* (Swinhoe, 1893) [Plate 7.6]
[TL: Khasi, Meghalaya, India]

= *furvirubens* (Prout, 1934) (*Terpna*); [TL: Borneo]

Pachyodes erionoma Swinhoe, 1893; *The Annals and Magazine of Natural History*, 6 (12): 219.

Terpna erionoma; Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary:* 6, pl. 1 (g)

Pseudoterpna erionoma; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 474.

Terpna erionoma; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 56, pl. 5c.

Prout, 1932; Geometridae of Mount Kinabalu: 44.

Pachyodes erionoma; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 6, pl. 2 (14).

Wing expanse: 46 mm.

Diagnosis: Wings pale olive-green, reddish-brown hue and adrk olive-green, black and reddish-brown striation and irroration. Forewing with a characteristic subapical patch on the outer margin and a highly dentated post medial black line accompanied by a fuscous-grey shade and sinuous submarginal series of white spots. Underside whitish, large black, discal spots; submarginal bands, narrows towards anal angle in the forewing and sending a more or less complete extension towards outer margin below apex.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), **Himachal Pradesh** (Dhauladhar mountains-current study), Meghalaya (Joshi et al. 2021), Sikkim, West Bengal (Chandra et al. 2019). **Global:** China, Indonesia (Borneo), Malaysia (Abang and Karim 200), Nepal (Yazaki 1992).

Remarks: It is a new record to Himachal Pradesh.

125. *Lophophelma luteipes luteipes* (Felder and Rogenhofer, 1875) [Plate 7.7]
[TL: Cochi, China]

= *similis* (Moore, 1888) (*Pingasa*); [TL: India]

Pachyodes luteipes Felder and Rogenhofer, 1875; *Reise Novar Zoology*: 2, pl. 125 (8).

Terpna luteipes Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 56, pl. 5 (c, d) and 8 (f).

Pseudoterpna similis; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 475.

Wing expanse: 46-52 mm.

Diagnosis: Wings pale ochreous, suffused with greenish-grey; an irregular reddish-brown suffusion and striation, especially along the costa of the forewing, discal lunule, ante and post medial, and submarginal lines; inner edge of the ante medial and outer of the post medial line pale. Hindwing markings similar as forewing except sub basal and antemedial lines.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Maharashtra (Bombay), Meghalaya (Khasis) (Joshi et al. 2021), Sikkim, Tamil Nadu (Nilgiris). **Global:** China (TL).

Remarks: New record to Himachal Pradesh.

Genus *Metallolophia* Warren,1895

126. *Metallolophia assamensis* Orhant, 2000 [Plate 7.8]

[TL: Assam, India]

Metallolophia assamensis; Han et al. 2005; *Journal of Natural History*, 39 (2): 165-195.

Wing expanse: Foreiwng length: 17.5-18 mm.

Diagnosis: *M. assamensis* can be easily by its postmedian line on fore wing which is gently curved outwards from costa to M3, and forming a sharp tooth on Cu1, at the nearest point to the terminal margin.

Distribution: India: Assam (Kaziranga and Nameri, TL) (Han et al. 2005; Sondhi et al. 2020), **Himachal Pradesh** (Dhauladhar mountains-current study). **Global:** Not documented yet.

Remarks: New record to Himachal Pradesh.

127. *Metallolophia ornataria* (Moore, 1888) [Plate 7.9]

[TL: North India]

Metallolophia ornataria Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*, 3: 249.

Pseudoterpna ornataria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 476.

Terpna ornataria; Prout, 1932; in Seitz, *The Macrolepidoptera of the world*, 12: 55, pl 5 (c).

Pachyodes ornataria; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 6, pl. 2 (15).

Wing expanse: 62 mm.

Diagnosis: Externally very similar to *M. haemataria* but can be distinguished by following characteristics: the two basal lines on forewings being closer to each other, disposed obliquely outward and are more irregular; purple-brown striation comparatively sparsely dispersed and longer elongated marginal spots. Hindwings with basal clustered brown strigae, comparatively shorter cell-streak and black medial discal streak followed by more prominent succeeding points forming a marginal band on the lower median and internal vein and black centered longitudinal red subanal streak. On the underside of forewings, the costal border is thickly speckled and without lower basal and discal black spot. Hindwings with a small black discal spot midway between the cell and outer margin, an elongated subanal longitudinal spot and two superposed anal spots. Dark brown legs; bells shaped and black edged thoracic and abdominal crests.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), **Himachal Pradesh** (Dhauladhar mountains-current study), Meghalaya (Khasi, Cherra Punji), Sikkim, (Hampson 1895), West Bengal (TL). **Global:** Nepal (Yazaki 1992).

Remarks: It is a new record to Himachal Pradesh.

Tribe Pseudoterpniini Warren, 1893

Genus *Pingasa* Moore, [1887]

128. *Pingasa pseudoterpinaria pseudoterpnaria* (Guenée, [1858]) [Plate 7.10] **[TL: North China]**

= *pryeri* (Butler, 1878) (Hypochroma); [TL: Japan]

Hypochroma pseudoterpinaria Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 276.

Wing expanse: 47 mm.

Diagnosis: Looks similar to *P. chlora* but *P. pseudoterpinaria* is with comparatively greater greyish-fuscous irroration; without any yellow hue on underside and comparatively narrow fuscous-black submarginal bands.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya, Nagaland, Uttarakhand, West Bengal (Chandra et al. 2019; Chettri and Yonle 2021). **Global:** China, Japan (Kamikura and Sakata 2019), Korea, Nepal.

UNASSIGNED

Genus *Chloroglyphica* Warren, 1894

129. *Chloroglyphica variegata* Butler, 1889 [Plate 7.11]

[TL: Dharmsala, Himachal Pradesh, India]

Loxachila variegata Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 104, pl. 136 (3).

Thalassodes variegate; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 514.

Hipparchus variegata; Prout, 1920–1941; in Seitz, *The Macrolepidoptera of the world*, 12: 76, pl. 10 (a).

Chloroglyphica variegate; Yazaki 1992; in Haruta T (ed.): Tinea 13 (suppl. 2); *Moths of Nepal*, Part 1: 10, pl. 4 (2).

Wing expanse: Male: 40 mm, Female: 51 mm.

Diagnosis: Wings emerald-green with grey irroration. Forewing with yellowish-ochreous costa and some also on outer margin, especially on apical region and some rufous marks; grey specks at base; curved grey ante medial band with darker line on it; similarly, a post medial band. Hindwing only with the post medial band.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh (Dharamshala, Subathu), Meghalaya (Khasis) (Joshi et al. 2021)**. Global:** Nepal (Yazaki 1992), Pakistan (Murree).

Genus *Chlororithra* Butler, 1889

130. *Chlororithra fea* (Butler, 1889) [Plate 7.12]

[TL: Dharmsala, Himachal Pradesh, India]

Geometra fea Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 106, pl. 136 (9).

Geometra fea; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 497.

Chlororithra fea; Prout, 1920–1941; in Seitz, *The Macrolepidoptera of the world*, 12: 78, pl. 1 (g).

Chlororithra fea; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 11, pl. 4 (8).

Wing expanse: 36 mm.

Diagnosis: Wings white with pale olive-green suffusion. Forewing with outwardly curved, basal and sub basal white lines; sinuous ante medial with dark olive-green outer border; post medial line inwardly crenulated and dark olive-green inner edge; submarginal line lunulated with spots on the lunules; a marginal series of white spots in between the veins. Underside whitish; forewing with greyish-fuscous discal spot and post medial markings of the posupperside and hindwing with dark, black apical patch.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh (Dharamshala), Meghalaya (Khasi), Punjab, Sikkim, Uttarakhand (Askot WLS, NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018), West Bengal (Chandra et al. 2019). **Global:** Bhutan, China (Tibet), Myanmar, Nepal (Yazaki 1992), Pakistan (Murree) (Han et al. 2006).

Remarks: Larva found on the *Quercus alba* (Butler 1889), is very similar to the flower that it is hard to distinguish.

Genus *Eucyclodes* Warren, 1894

131. *Eucyclodes albisparsa* (Walker, F., 1861) [Plate 7.13]

[TL: Sarawak, Borneo, Indonesia]

Thalera albisparsa Walker, 1861; List *Species Lepidoptera Insects Collection British Museum*, 22: 600.

Chloromachia albisparsa; Yazaki 1995; in Haruta T (ed.): Tinea 14, (suppl. 2), *Moths of Nepal*, Part-4: 13, pl. 97 (7).

Wing expanse: Forewing length: 11 mm.

Diagnosis: Sexual dimorphism. Wings bright green. Forewing costa pale ochreous striated and irrorated with brownish-black. white crenulated ante and post medial lines, a series of submarginal white lunules between veins, a marginal series of spots and a white medial patch on the outer area.

Distribution: India: Andaman, **Himachal Pradesh** (Dhauladhar mountains-current study), Kerala (Das et al. 2020), Tamil Nadu (Iyer et al. 2021). **Global:** Indonesia (Borneo), Malayasia (Sabah) (Chung et al. 2014), Nepal (Yazaki 1995), Sri Lanka (Ceylon).

Remarks: New record to Himachal Pradesh.

132. *Eucyclodes picturata* (Hampson, 1903) [Plate 7.14]
[TL: Ceylon, Sri Lanka]

Thalassodes picturata Hampson, 1903; *Journal Bombay Natural History Society*, 14: 655.

Lophomachia picturata; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 86.

Wing expanse:

Diagnosis: Differs from the similarly looking *E. semialba* as dark fuscous-brown costal patch of the forewing is comparatively narrower and do not expand beyond the discal area of the forewing and the green basal patch is much intermixed with white.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Kerala (Sondhi et al. 2018; Das et al. 2020), Maharashtra (Bombay). **Global:** Sri Lanka (Ceylon, TL).

Remarks: New record to Himachal Pradesh.

Genus *Metaterpna* Yazaki, 1992

133. *Metaterpna differens* (Warren, 1905) [Plate 7.15]
[TL: Kulu, Himachal Pradesh, India]

Terpna differens Warren, 1909; *Novitates zoologicae,* 16: 124.

Metaterpna differens; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1, *Moths of Nepal*, Part-1: 8, pl. 3 (7).

Metaterpna differens; Jiang et al., 2016; *Zootaxa*, 4200 (4): 504.

Wing expanse: 44 mm.

Diagnosis: *M. differens* can be easily distinguished from the closely related species based on its strongly oblique but slightly irregular, black sub basal line and white underside of the wings which lacks the black marginal borders.

Distribution: India: Himachal Pradesh (Kullu, TL). **Global:** China (Tibet) (Jiang et al. 2016), Nepal (Yazaki 1992).

Subfamily Ennominae Duponchel, 1845

Tribe Gonodontini Forbes, 1948

Genus: *Gonodontis* Prout, 1926

134. *Gonodontis aethocrypta* Prout, 1926 [Plate 7.16]

[TL: Hpimaw Fort, (Upper Burma) Myanmar]

Orsonoba aethocrypta Prout; 1926; *Journal Bombay Natural History Society*, 31: 794, pl. 2 (14).

Ephalaenia aethocrypta; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2) *Moths of Nepal*, Part 1: 30, pl. 8 (18).

Gonodontis aethocrypta; Chettri et al., 2021; *Journal of Threatened Taxa*, 13 (12): 19837–19848.

Wing expanse: 40 mm

Diagnosis: Olive-green wings, clouded with olive-brown, pale lilacine shade at base, tornus, inner edge of antemedial line and on outer edge of post medial line; yellowish-green medial patch from inner margin up to cell spot; a subterminal white dot in front of R'. Hindwing with

Distribution: India: Himachal Pradesh (Subathu, Solan), Sikkim (Gopaldhara, Tadong) (Chettri et al. 2021), Uttarakhand (Massuri). **Global:** Myanmar (TL), Nepal (Yazaki 1992).

Tribe Gnophini Duponchel, 1845

Genus *Gnophos* Treitschke, 1825

135. *Gnophos accipitraria* (Guenée, [1858]) [Plate 7.17]

[TL: Western China]

Gnophos accipitraria (Guenée, [1858]); in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 300.

Gnophos accipitraria; Prout, 1912–1916, in Seitz: *The Macrolepidoptera of the world*, 4: 386.

Gnophos accipitrarius; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 252.

Gnophos accipitraria; Sato, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), *Moths of Nepal*, Part-3: 55, pl. 76 (10)

Wing expanse: Forewing length: 29–31 mm, Female: 32–34 mm.

Diagnosis: Wings greyish white with greyish fuscous striations and irrorations. Forewing ante, medial and post medial lines indistinct, appear as dark patches on the costa; post medial line darker and crenulated, submarginal paler and undulating. Underside with large, fuscous black discal patch, smaller on hindwing; post medial band with medial whitish patch on forewing and an apical patch on hindwing; a narrower medial band, often fades away towards inner margin on forewing.

Distribution: India: Assam, **Himachal Pradesh** (Dhauladhar mountains-current study), Meghalaya (Joshi et al. 2021). **Global:** China (TL), Nepal (Sato 1994).

Remarks: New record to Himachal Pradesh.

136. *Gnophos rubefactaria* Püngeler, 1902 [Plate 7.18]

[TL: Central Asia (Togus-Torau)]

= *pervicinaria* Wehrli, 1922 [TL: Central Asia]

= *stshetkini* (Viidalepp, 1988) (*Rhipignophos*) [TL: Kirgizia (Kirghizstan)]

Gnophos rubefactaria Püngeler, 1902; *Iris*: 158.

Gnophos rubefactaria Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 388.

Wing expanse: Forewing length: Female: 18 mm.

Diagnosis: Looks very similar to *G. vastaria* but is brighter and more reddish-brown than the former.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study). **Global:** Central Asia (TL), Kyrgyzstan (Korb 2023).

Remarks: New record for India.

137. *Gnophos tephrosiaria* Moore, 1888 [Plate 7.19]

[TL: Darjiling, West Bengal, India]

= *senicaria* Hampson, 1907; [TL: India]

Gnophos tephrosiaria Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*, 3: 247.

Boarmia tephosiaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 282.

Gnophos tephrosiaria; Sato 1993; in Haruta T (ed.): Tinea 13, (suppl. 3), Moths of Nepal, Part-2: 23, pl. 38 (9).

Wing expanse: 40 mm.

Diagnosis: Wings pale drab-grey with brown irroration on upper side. Forewings with incomplete and very ill-defined antemedial, medial, postmedial (discal) and submarginal black denticulated lines; most apparent and dilated towards costal end; medial line with a dark spot on it at the end of cell. Hind wing with lines similar to forewing but less defined. White underside of wings with an indistinct medial line and a cell spot and a crenulated postmedial line; the area beyond post medial line is suffused with black except a white patch on the middle of outer margin of forewing.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Sikkim, West Bengal (Darjeeling, TL). **Global:** Nepal (Sato 1993).

Remarks: New record to Himachal Pradesh.

Genus *Hirasa* Moore, 1888

138. *Hirasa aereus* Butler, 1886 [Plate 7.20]

[TL: Darjiling, West Bengal, India]

Gnophos aereus Butler, 1886; *Ann. Mab. N. H.* (5) 6: 128.

Gnophos aereus; Butler, 1886; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum* Br., 6: 66, pl. 66 (9).

Gnophos aereus; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 252.

Hirasa aereus; Sato, 1998; in Haruta T (ed.): Tinea, 15 (suppl. 1), *Moths of Nepal,* Part-5: 25, pl. 131 (6).

Wing expanse: 55 mm.

Diagnosis: *H. aereus* can be distinguished from the similarly looking *H. muscosaria* based on its larger size, darker olive-green colouration with comparatively more fuscous irroration; underside of the wings with fuscous tinge and a diffused, fuscous black suffusion beyond a denticulated post medial line.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Meghalaya, Sikkim, West Bengal (Darjeeling, Singallila NP) (Chandra et al. 2019), **Global:** Nepal (Sato 1998).

Remarks: New record to Himachal Pradesh.

139. *Hirasa muscosaria* (Walker, 1866) [Plate 8.1]
[TL: Darjeeling, West Bengal, India]

= *muscosarius* (Hampson, 1895) (*Gnophos*); [TL: ??]

= *vitreata* (Moore, 1868) (*Scotosia*); [TL: India]

Gnophos muscosarius Walker, 1866; *List Species Lepidoptera Insects Collection British Museum,* 35: 1596.

Scotosia vitreata Moore, 1867; *Proceedings of the Zoological Society of London*: 656.

Hirasa muscosaria; Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3), *Moths of Nepal,* Part 2: 21, pl. 37 (17).

Hirasa muscosaria; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 55 mm.

Diagnosis: Discussed above in *H. aereus.*

Distribution: India: Arunachal Pradesh, Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand (Govind WLS, NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018), West Bengal (Darjeeling, TL) (Shah et al. 2018). **Global:** Nepal (Sato 1993).

Genus *Loxaspilates* Warren, 1893

140. *Loxaspilates hastigera hastigera* (Butler, 1889) [Plate 8.2]

[TL: Dharmsala, Himachal Pradesh, India]

Aspilates hastigera Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum* 7: 112.

Loxaspilates hastigera; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 182.

Loxaspilates hastigera; Yazaki, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part-4: 12, pl. 101 (10).

Loxaspilates hastigera; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 40 mm.

Diagnosis: Forewing pale ochreous-yellow; inwardly oblique ante medial, post medial and submarginal greyish-fuscous, diffused shades bearing wedge-shaped dark black spots; and a wedge-shaped discal spot and a marginal series of black dots. Hindwing pale, whitish and without any distinct markings. Underside of wings paler; forewing with fuscous suffusion in the basal region and, post medial and submarginal shades tracing the upper surface's marking.

Distribution: India: Himachal Pradesh (Dharamsala, GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir), Sikkim, Uttarakhand (Dehradun, Govind WLS, NDBR) (Uniyal et al. 2016; Sanyal et al 2017; Dey 2018; Chandra et al. 2019). **Global:** Afghanistan, China, Nepal, Tibet (Yazaki 1995).

141. *Loxaspilates obliquaria* (Moore, 1868) [Plate 8.3]

[TL: India ??]

= *lutea* Thierry-Mieg, 1916; [TL: China]

= *subfalcata* (Poujade, 1895) (*Eusarca*); [TL: China]

Aspilates obliquaria Moore, 1868; *Proceedings of the Zoological Society of London*: 649.

Loxaspilates obliquaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 181.

Loxaspilates obliquaria; Yazaki, 1994; in Haruta T (ed.): Tinea, 14 (suppl. 1); *Moths of Nepal*, Part-3: 25, pl. 71(8).

*L*oxaspilates *obliquaria*; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Loxaspilates obliquaria; Dey et al., 2019; *Spixiana*, 42:51.

Wing expanse: Forewing length: Male: 19 mm; Female: 20–21 mm.

Diagnosis: *L. obliquaria* has similar pattern like *L. hastigera* but differs as the wedge-shaped spots much reduced in size, post medial one get replaced by an obliquely straight, diffused, narrow, fuscous or brown line which fades away towards costa, visible only towards inner margin in hind wings; those on sub marginal area prominent only on below apex and those above inner margin. Underside paler and irrorated; post medial line denticulated near costa; hindwing with series of post medial and submarginal series of brown spots on veins.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim (Hampson 1895), Uttarakhand (NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018). **Global:** Afghanistan, Nepal (Yazaki 1994).

Genus *Phthonandria* Warren, 1894

142. *Phthonandria atrilineata atrilineata* (Butler, 1881) [Plate 8.4]

[TL: Dharmsala, Himachal Pradesh India; Japan, Korea, Western China]

= *brunnearia* (Herz, 1905) (*Hemerophila*); [TL: Korea]

= *emarioides* Wehrli, 1941; [TL: China]

= *emarioides epistygna* Wehrli, 1941; [TL: China]

Hemerophila atrilineata Butler, 1881; *Transaction Entomological Society London*, 3: 405.

Phthonandria atrilineata; Warren, 1894; *Novitates zoologicae*, 1: 438.

Boarmia atrilineata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 279.

Phthonandria atrilineata; Swinhoe, 1900; *List Species Lepidoptera Insects Collection British Museum*, 2: 299.

Phthonandria atrilineata; Liao et al., 2010; *International Journal of Biological Sciences*, 6 (2):172-186.

Phthonandria atrilineata; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 58 mm.

Diagnosis: Ochreous wing colour with brownish striations, suffused with grey except costa and sprinkled with small black scales. Forewing antemedial line distinct, dark black, highly dentate on and below costa than runs obliquely towards inner margin; post medial similar, angled outwardly towards outer margin below costa. Hindwing post medial line almost straight. Underside with black discal spots and slightly irregular post medial lines.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand (Govind WLS) (Sanyal et al. 2017; Chandra et al. 2019), West Bengal. **Global:** Bhutan, China, Japan, Korea, Nepal.

Genus *Psyra* Walker, 1860

143. *Psyra angulifera* (Walker, 1866) [Plate 8.5]

[TL: Dharmsala, Himachal Pradesh, India (North Hindustan)]

Scotosia angulifera Walker, 1866; *List Species Lepidoptera Insects Collection British Museum*, 35: 1687.

Psyra angulifera; Moore, 1867; *Proceedings of the Zoological Society of London*: 659.

Psyra angulifera; Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 20.

Psyra angulifera; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 222.

Psyra angulifera; Prout, 1920; in Seitz, *The Macrolepidoptera of the world*, 4: 410.

Psyra angulifera; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 34.

Psyra angulifera; Lui et al., 2013; *Zootaxa*, 3682 (3): 461.

Psyra angulifera: Mallick et al., 2022; *PLoS ONE*, 17(4): 13.

Wing expanse: Forewing length: Male: 18–21 mm, Female: 21–23 mm.

Diagnosis: Wings pale to dark purplish-grey with some brown hue, black patches with golden-brown outline unique to this species.

Distribution: India: Arunachal Pradesh (Tawang, Dibang Valley) (Chandra and Sambath 2013), Assam, Himachal Pradesh (GHNP, Kangra, Kullu) (Mallick 2021), Sikkim (West, North), Uttarakhand (Govind WLS, NDBR, Uttarkashi, Tehri Garhwal, Pithoragarh) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Darjeeling, Kalimpong) (Shah et al. 2018; Chettri and Yonle 2021; Mallick et al. 2022). **Global:** China (Hubei, Sichuan, Yunnan, Tibet), Nepal (Yazaki 1992; Lui et al. 2013)

144. *Psyra crypta* Yazaki, 1994 [Plate 8.6]

[TL: Nepal]

Psyra crypta Yazaki, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), *Moths of Nepal*, Part-3: 26, pl. 71 (10, 13, 16).

Psyra crypta; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Psyra crypta: Mallick et al., 2022; *PLoS ONE*, 17(4): 32.

Wing expanse: Forewing length: Male: 21–23 mm; Female: 25–27 mm.

Diagnosis: *P*. *crypta* is almost identical with *P*. *spurcataria*, however, can be distinguished as its hindwing with a distinct, double, medial band both on upper as well as underside with its outer border line crenulated (much compact and outer border non-crenulated in *P*. *spurcataria*).

Distribution: India: Arunachal Pradesh (Dibang Valley), Himachal Pradesh (Kullu, GHNP) (Mallick 2021), Sikkim (West, North), Uttarakhand (Chamoli, Pithoragarh, NDBR) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Darjeeling) (Mallick et al. 2022). **Global:** Nepal (Kosi, Janakpur, Godavari) (Yazaki 1994).

145. *Psyra cuneata* Walker, 1860 [Plate 8.7]

[TL: North India]

Psyra cuneata Walker, 1860; *List Species Lepidoptera Insects Collection British Museum*, 21: 483.

Psyra cuneata; Moore, 1867; *Proceedings of the Zoological Society of London*: 659.

Psyra angulifera; Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 20.

Psyra similaria; Swinhoe, 1894; *Transaction Entomological Society London*: 202.

Psyra cuneata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma* 3: 223.

Psyra cuneata; Leech, 1897; *Annals and Magazine of Natural History,* 20 (6): 65–111, 213.

Psyra cuneata; Prout, 1920; in Seitz, *The Macrolepidoptera of the world,* 4: 410.

Psyra cuneata; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal,* Part-1: 34, pl. 11 (6).

Psyra cuneata: 2022; Mallick et al., *PLoS ONE,* 17(4): 16.

Wing expanse: 46 mm.

Diagnosis: This species is morphologically close to *P. gracilis* but forewing has disjoined discal spots and an obscure submarginal band on the underside of hindwing (while in *P. gracilis* the discal spots are conjoined and a dark, broad submarginal band on the underside).

Distribution: India: Arunachal Pradesh (Dibang Valley, Tale WLS) (Sondhi et al. 2021), **Himachal Pradesh** (Dhauladhar mountains-current study), Meghalaya (East Khasi) (Joshi et al. 2021), North-West Himalaya, Sikkim (West, North), Uttarakhand (Dey 2018), West Bengal (Darjeeling) (Shah et al. 2018; Chettri 2022; Mallick et al. 2022). **Global:** Nepal, China (Yunnan, Tibet), Japan, Taiwan (Yazaki 1992).

Remarks: New record to Himachal Pradesh.

146. *Psyra debilis debilis* Warren, 1888 [Plate 8.8]
[TL: Thundiani, Western India, Pakistan]

Psyra debilis debilis Warren, 1888; *Proceedings of the Zoological Society of London*: 319.

Psyra debilis debilis; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma,* 3: 222.

Psyra debilis debilis; Parsons et al., 1999; *Geometrid moths of the world: a Catalogue* (*Lepidoptera, Geometridae*): 807.

Psyra debilis debilis: Mallick et al., 2022; *PLoS ONE* 17(4): 24.

Wing expanse: Forewing length: Male: 18–22 mm.

Diagnosis: *Psyra debilis debilis* can be seaparted from similarly looking *P. debilis indica* as follows: larger in size, darker vinous-brown wings (golden-ochreous in *P. debilis indica*) irrorated with fuscous, hindwing with its medial line almost touching the discal spot and immediately followed by a crenulated post medial line, prominent upto CuA1.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Ladakh, Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017; Mallick et al. 2022). **Global:** Pakistan **(**Thundiani).

Remarks: This is new faunal record to Himachal Pradesh.

147. *Psyra debilis indica* (Butler, 1889) [Plate 8.9]
[TL: ??]

Tetracis indica Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 20.

Psyra indica; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 222.

Psyra indica; Yazaki, 1998; in Haruta T (ed.): Tinea, 15 (suppl. 1); *Moths of Nepal*, Part-5: 14, pl. 130 (2).

Psyra debilis indica: Parsons, 1999; *Geometrid moths of the world: a Catalogue* (*Lepidoptera, Geometridae*): 806.

Psyra debilis indica: Mallick et al., 2022; *PLoS ONE,* 17(4): 26.

Wing expanse: Forewing length: Male: 23–25 mm.

Diagnosis: Discussed in *P. debilis debilis.*

Distribution: India: Himachal Pradesh (Kangra, Kullu, GHNP) (Mallick 2021), Uttarakhand (Uttarkashi) (Dey 2018; Mallick et al., 2022). **Global:** Nepal (Mahakali) (Yazaki 1998).

148. *Psyra gracilis* Yazaki, 1992 [Plate 8.10]
[TL: Nepal]

Psyra gracilis Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 35, pl. 11 (8).

Psyra gracilis; Lui et al, *Zootaxa,* 2013; 3682 (3): 467.

Psyra gracilis; Mallick et al., 2022; *PLoS ONE,* 17(4): 9.

Wing expanse: Forewing length: Male: 19–23 mm; Female: 24–26 mm.

Diagnosis: Discussed in *P. cuneata*.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Sikkim (West), West Bengal (Darjeeling, Kalimpong) (Chettri 2022; Mallick et al. 2022). **Global:** Nepal (Godavari), China (Yunnan) (Yazaki 1992; Lui et al. 2013).

Remarks: This is a new faunal record to Himachal Pradesh.

149. *Psyra similaria* Moore, 1868 [Plate 8.11]
[TL: India]

Psyra similaria Moore, 1868; *Proceedings of the Zoological Society of London*, 3: 659.

Psyra similaria; Cotes and Swinhoe, 1888; *Moths of India*, 4: 513.

Psyra similaria; Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 20.

Psyra similaria; Swinhoe, 1894; *Transaction Entomological Society London*: 202.

Psyra similaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma* 3: 223.

Psyra similaria; Yazaki, 1994; in Haruta T (ed.): Tinea, 14 (suppl. 1); *Moths of Nepal*, Part-3: 26, pl. 71 (7).

Psyra similaria; Lui et al, 2013; *Zootaxa,* 3682 (3): 467.

Psyra similaria: Mallick et al., 2022; *PLoS ONE,* 17 (4): 22.

Wing expanse: Forewing length: Male: 18–21 mm; Female: 21–23 mm.

Diagnosis: *P. similaria* has its forewing with last submarginal black patch never reaching the inner margin and more prominent medial and submarginal bands on hindwing.

Distribution: India: Arunachal Pradesh (Dibang Valley), Himachal Pradesh (Kullu, GHNP) (Mallick 2021), Meghalaya (East Khasi), Sikkim, Uttarakhand (Uttarkashi, Pithoragarh, Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018), West Bengal (Darjeeling) (Mallick et al. 2022). **Global:** Nepal (Kosi, Sagarmatha, Janakpur), China (Tibet) (Yazaki 1994; Lui et al. 2013).

150. *Psyra spurcataria* (Walker, 1863) [Plate 8.12]

[TL: Darjiling, West Bengal, India]

= *florida* (Bastelberger, 1911) (*Zethenia*) [TL: Formosa [Taiwan]

Hyperythra spurcataria Walker,1863; *List Species Lepidoptera Insects Collection British Museum*, 26: 1498.

Hyperythra spurcataria; Moore, 1867; *Proceedings of the Zoological Society of London*: 619.

Hyperythra spurcataria; Cotes and Swinhoe, 1888; *List Species Lepidoptera Insects Collection British Museum, Moths of India*, 4: 478.

Psyra spurcataria; Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 20.

Orbasia spurcataria; Swinhoe, 1894; *Transaction Entomological Society London*: 222.

Psyra spurcataria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 221.

Zethenia florida Bastelberger, 1911; *Ent. Rdsch*., 28: 22.

Psyra spurcataria; Prout, 1927; *Journal Bombay Natural History Society*, 31(3 and 4): 795.

Psyra spurcataria; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 35, pl. 11 (3).

Psyra spurcataria; Liu et al, 2013; *Zootaxa*, 3682(3): 469.

Psyra spurcataria: Mallick et al., 2022; *PLoS ONE*, 17(4): 35.

Wing expanse: Forewing length: Male: 22–23 mm; Female: 24–27 mm.

Diagnosis: Discussed in *P. crypta*.

Distribution: India: Arunachal Pradesh (Dibang Valley, Tawang) (Chandra and Sambath 2013), Assam, Himachal Pradesh (Kangra, Kullu, GHNP) (Mallick 2021), Meghalaya (East Khasi) (Joshi et al. 2021), Sikkim (West, North), Uttarakhand (Chamoli, Nainital, Pithoragarh), West Bengal (Darjeeling, Kalimpong) (Shah et al. 2018; Chettri 2022; Mallick et al. 2022). **Global:** China (Guangxi, Sichuan, Yunnan, Tibet), Myanmar (Siam), Nepal (Mechi, Janakpur, Godavari), Taiwan (Yazaki 1992; Lui et al. 2013; Wu et al. 2020).

Tribe Odontopterini Tutt, 1896

Genus *Odontopera* Stephens, 1831

151. *Odontopera bilinearia* (Swinhoe, 1889) [Plate 8.13]
[TL: North Western Himalayas]

Crocallis bilinearia Swinhoe, 1889; *Proceedings of the Zoological Society of London*: 423.

Odontopera bilinearia bilinearia; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 36, pl. 11 (9).

Wing expanse: 53 mm.

Diagnosis: Wings dark ochreous-yellow, with very minute and indistinct greyish-fuscous irroration. Forewing with indistinct, outwardly curved, dark ante medial line, post medial line slightly sinuous and whitish outer edge, discal spot with white centre and outlined with black. Hindwing paler with comparatively larger discal spot and darker, wavy post medial line.

Distribution: India: Arunachal Pradesh (Eaglenest WLS), Himachal Pradesh (Kullu, GHNP) (Mallick 2021), Sikkim. **Global:** Bhutan, China, Nepal (Yazaki 1992).

152. *Odontopera cervinaria* Moore, 1868 [Plate 8.14]
[TL: Sikkim, India]

Corotia cervinaria Moore, 1868; *Proceedings of the Zoological Society of London*: 625, pl. 32 (10).

Crocallis cervinaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 232.

Odontopera cervinaria; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part 1: 36, pl. 11 (10).

Wing expanse: 50 mm.

Diagnosis: Wings purplish-grey coloured with some fawn hue and, thin and minutely transverse black irroration. Forewing apex produced, outer margin excised below the costa, a characteristic purplish-brown, medial band, broader towards costa lined with pale brownish, slightly outcurved inner and outer edges and a series of whitish dots on veins, discal dot large and grey. Hind wing with an indistinct greyish-fuscous discal dot followed by an outer transverse line.

Distribution: India: Arunachal Pradesh, Meghalaya (Joshi et al. 2021), Nagaland, Sikkim (TL), West Bengal (Chandra et al. 2019). **Global:** Nepal (Yazaki 1992).

153. *Odontopera heydena* (Swinhoe, 1894) [Plate 8.15]
[TL: Khasi Hills, Meghalaya, India]

Crocallis heydena; Swinhoe, 1894; *Transaction Entomological Society London*: 203.

Odontopera heydena; Yazaki, 1994; in Haruta T (ed.): Tinea 14 (suppl. 1); *Moths of Nepal*, Part-3: 27, pl. 72 (7).

Odontopera heydena; Sanyal et al. 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 44 mm.

Diagnosis: Ochreous-yellow forewings with dense pale brownish irroration, and an obliquely straight brownish line with white outer edges. Hindwing paler with an indistinct fuscous discal spot and brownish post medial line which disappear towards costa.

Distribution: India: Arunachal Pradesh (Eaglenest WLS), Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Khasi), Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018; Chandra et al. 2019). **Global:** Nepal (Yazaki 1994).

154. *Odontopera kanchai* Yazaki, 1994 [Plate 8.16]
[TL: Nepal]

1994. *Odontopera kanchai*; Yazaki, 1994; in Haruta T (ed.): *Tinea* **14** (suppl. 1); *Moths of Nepal*, Part-3: 32, pl. 72 (10).

Wing expanse: 34 mm.

Diagnosis: Looks similar to *O. veneris* but *O. kanchai* smaller in size, forewing paler ochreous-brown and the post medial line of hindwing rufous-brown (while forewing darker and post medial line of hindwing fuscous-brown in *O. veneris*).

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021). **Global:** Nepal (Yazaki 1994).

155. *Odontopera lentiginosaria* (Moore, 1867) [Plate 8.17]
[TL: Bengal, (West Bengal) India]

Crocalis lentiginosaria Moore, 1867; *Proceedings of the Zoological Society of London*: 622.

Odontopera lentiginosaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 231.

Odontopera lentiginosaria; Walia, 2005; *Fauna of Western Himalaya*, 2: 181.

Odontopera lentiginosaria; Sanyal et al. 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 54-60 mm.

Diagnosis: *O. lentiginosaria* is externally very similar to *O. similaria* (both with whitish specks on the veins along the post medial line) but is rather larger, brighter and darker; outer margin of forewing angled at M3 vein while it is toothed at M1 vein in *O. similaria*. This species can also be distinguished from the closely looking *O. bilinearia* based on its ochreous-brown wing colour along with dense fuscous irrorations. However, in *O. bilinearia* the wings are ochreous-yellow with minute and indistinct fuscous-grey irroration.

Distribution: India: Himachal Pradesh (Kullu, Dharamshala, GHNP) (Walia 2005; Mallick 2021), Meghalaya, Sikkim, Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Chandra et al. 2019). **Global:** South Korea (Choi and An 2010).

156. *Odontopera obliquaria* (Moore, 1868) [Plate 8.18]

[TL: Bengal, (West Bengal) India]

Crocalis obliquaria Moore, 1867; *Proceedings of the Zoological Society of London*: 622.

Crocalis obliquaria; Cotes and Swinhoe, 1888; *List Species Lepidoptera Insects Collection British Museum, Moths India*: 3170.

Odontopera obliquaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 232.

??? *Moths of Nepal*,

Odontopera obliquaria; Walia, 2005; *Fauna of Western Himalaya*, 2: 181-190.

Odontopera obliquaria; Sanyal et al. 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 54 mm.

Diagnosis: This species looks very similar to the previous species, *O. lentiginosaria* but can be distinguished as follows: wings much yellower in colour; post medial line prominent with outer edge distinct and paler, originate near apex, typically straight below costa and become slightly oblique towards inner margin.

Distribution: India: Arunachal Pradesh (Tawang) (Chandra and Samabath 2013), Himachal Pradesh (GHNP) (Walia 2005; Mallick 2021), Meghalaya (Joshi et al. 2021), Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Chandra et al. 2019). **Global:** Japan, Nepal.

157. *Odontopera rufitinctaria* (Hampson, 1902) [Plate 8.19]
[TL: Shimla, Himachal Pradesh, India, 7000 ft.]

= *perplexa* Yazaki, 1992; [TL: Nepal]

Leptomiza rufitinctaria Hampson, 1902; *Journal Bombay Natural History Society*, 14: 502.

Odontopera perplexa Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2); *Moths of Nepal*, Part 1: 36, pl. 11 (11).

Odontopera rufitinctaria; Yazaki, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1); *Moths of Nepal*, Part-6: 12, pl. 11 (11).

Wing expanse: 36 mm.

Diagnosis: Most distinctly coloured among all the reported species in the genus *Odontopera*. Wings pale purplish-brown in colour. Forewing with greyish suffused and fuscous irrorated region towards outer margin; ante and post medial transverse lines darker brown; discal spot greyish-white and less prominent. Hindwing with prominent black discal spots and traces of post medial line. Underside with characteristic dark discoidal spots prominent and nearly lunulated post medial line, prominent on hindwing.

Distribution: India: Himachal Pradesh (Shimla, 7000 ft). **Global:** Nepal (Godavari), Pakistan (Islamabad, Mt. Margala) (Yazaki 1992).

158. *Odontopera similaria* (Moore, 1888) [Plate 8.20]
[TL: Darjiling, West Bengal, India]

Crocallis similaria Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 227.

Odontopera similaria; Yazaki, 1994; in Haruta T (ed.): Tinea 14 (suppl. 1); *Moths of Nepal*, Part-3: 27, pl. 72 (6).

Odontopera similaria; Chandra and Sambath, 2013; *Journal of Threatened Taxa*, 5(1): 3567.

Wing expanse: 44 mm.

Diagnosis: Discussed in *O. lentiginosaria*.

Distribution: India: Arunachal Pradesh (Tawang) (Chandra and Sambath 2013), Himachal Pradesh (GHNP) (Mallick 2021), West Bengal (Shah et al. 2018; Chandra et al. 2019). **Global:** Bhutan, Nepal (Yazaki 1994).

Tribe Ennomini Duponchel, 1845

Genus *Leptomiza* Warren, 1893

159. *Leptomiza calcearia calcearia* (Walker, 1860) [Plate 9.1]

[TL: India]

= *dentilineata* (Moore, 1888) (*Selenia*); [TL: India]

= *mediolimbata* (Poujade, 1895) (*Heterolocha*); [TL: China]

Hyperythra calcearia Walker, 1860; *List Species Lepidoptera Insects Collection British Museum*, **20**: 132.

Leptomiza calcearia; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 180.

Leptomiza calcearia; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 38, pl. 12 (5).

Leptomiza calcearia; Sondhi and Sondhi, 2016; *Journal of Threatened Taxa*, **8** (5): 8768.

Wing expanse: 30 mm.

Diagnosis: Wings dark orange-yellow with dense orange-brown striation. Forewing with two small excisions below the apex; a large, rounded, yellow, discal spot and an outer broad, oblique, yellow band, broader at costa, starting just before apex to the middle of the inner margin, with its outer, sinuous edge lined with silvery-grey. Hindwing with similar but medial, yellow band of almost uniform width with silvery-grey outer edge.

Distribution: India: Arunachal Pradesh (Eaglenest WLS, Tale WLS) (Sondhi et al. 2021), Assam, Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand (Dehradun) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Darjeeling) (Sondhi and Sondhi 2016; Shah et al. 2018; Chettri 2022). **Global:** Bhutan, China, Myanmar, Nepal (Yazaki 1992), Taiwan (Wu et al. 2020).

Genus *Opisthograptis* Hübner, [1823]

160. *Opisthograptis moelleri* Warren, 1893 [Plate 9.2]

[TL: Sikkim, India]

Opisthograptis moelleri Warren, 1893; *Proceedings of the Zoological Society of London*, 2: 403.

Rumia moelleri; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 184.

Opisthograptis moelleri; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 36, pl. 11 (15).

Wing expanse: 54 mm.

Diagnosis: *O. moelleri* can be easily diagnosed by its large brown-fuscous tridentate, medial spot from costa to the lower angle of cell.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh (Dalhousie, GHNP) (Mallick 2021), Sikkim, Uttarakhand, West Bengal (Chandra et al. 2019). **Global:** Bhutan, China, Myanmar, Nepal (Yazaki 1992), Taiwan (Wu et al. 2020), Vietnam.

161. *Opisthograptis sulphurea* (Butler, 1880) [Plate 9.3]

[TL: Sikkim, India]

Rumia sulphurea Butler, 1880; *The Annals and Magazine of Natural History*, 6 (5): 123.

Rumia sulphurea; Butler, 1886; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 6: 54, pl. 64 (6).

Rumia sulphurea; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 184.

??, 1928; (see species card-for more details).

Opisthograptis sulphurea; Prout, 1915; in Seitz, *The Macrolepidoptera of the world*: 339, pl. 17 (h).

Opisthograptis sulphurea; Sato, 1994; in Haruta T (ed.): Tinea 14 (suppl. 1); *Moths of Nepal*, Part-3; 28, pl. 72 (5).

Opisthograptis sulphurea; Chandra et al. 2019; *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 223.

Wing expanse: Forewing length: 19–21 mm.

Diagnosis: *O. sulphurea* can be diagnosed with its sulphur irroration in the place of ante and postmedial lines, and discal spot.

Distribution: India: Arunachal Pradesh, **Himachal Pradesh** (Dhauladhar mountains-current study**),** Sikkim, Uttarakhand (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018), West Bengal (Shah et al. 2018; Chandra et al. 2019). **Global:** Bhutan, China (Szechuan), Nepal (Sato 1994).

Remarks: The species is a new record to Himachal Pradesh.

162. *Opisthograptis tridentifera* (Moore, 1888) [Plate 9.4]
[TL: Sikkim, India]

Rumia tridentifera Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 230.

Rumia tridentifera; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 184.

Opisthograptis tridentifera; Prout, 1912-1916; in Seitz, *The Macrolepidoptera of the world*, 4: 339.

Opisthograptis tridentifera; Yazaki, 1994; in Haruta T (ed.): Tinea 14 (suppl. 1); *Moths of Nepal*, Part-3: 28, pl. 72 (4).

Opisthograptis tridentifera; Mandal and Ghosh, 1997; *Fauna of West Bengal*, 7: 491-532.

Opisthograptis tridentifera; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 50 mm.

Diagnosis: *O. tridentifera* is much similar with *O. luteolata* but has discal spot larger, apical patch reduced and transverse lines represented by the reddish-brown and fuscous spots on the veins.

Distribution: India: Arunachal Pradesh, Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand (Govind WLS, NDBR) (Uniyal et al. 2016; Sanyal et el. 2017; Dey 2018), West Bengal (Darjeeling) (Mandal and Ghosh 1997; Shah et al. 2018; Chandra et al. 2019). **Global:** Bhutan, China, Nepal (Yazaki 1994), Tibet (Yazaki 1994).

Genus *Ourapteryx* Leach, 1814

163. *Ourapteryx clara* (Butler, 1880) [Plate 9.5]

[TL: North East Himalayas; Sikkim, Assam, Malay Peninsula, South East Sumatra]

Urapteryx clara Butler, 1880; *The Annals and Magazine of Natural History*, 6: 120.

Urapteryx clara; Butler, 1886; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 6: 50. pl. 113.

Ourapteryx clara; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 40, pl. 12 (23).

Ourapteryx clara clara; Inoue, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2); *Moths of Nepal*, Part-4: 131.

Ourapteryx clara; Arya, et al.; 2021; *Uttar Pradesh Journal of Zoology*, 42 (15): 12-22.

Wing expanse: 58-60 mm.

Diagnosis: *O. clara* is very similar with the *O. podaliriata* (Guenee, [1858]) but can be distinguished by its comparatively shorter and wider spatulate tail (Butelr, 1880). The species also resembes with *O. claretta* in having the spots at the base of the tail replaced with bluish blackish streak. However, in *O. clara* the streak is always divided in two (Inoue, 2002).

Distribution: India: Assam, **Himachal Pradesh** (Dhauladhar mountains-current study), Sikkim, Uttarakhand (Dehradun, Nandhaur) (Butler 1886; Uniyal et al. 2016; Sanyal et al. 2017; Arya et al., 2021), West Bengal (Chettri and Yonle 2021). **Global:** Hong Kong, Indonesia (South East Sumatra), Nepal (Godavari), Thailand (Malay Peninsula) (Yazaki 1992; Inoue 1995; Kwok and Tai, 2016)

Remarks: New record to Himachal Pradesh.

164. *Ourapteryx convergens* Warren, 1897 [Plate 9.6]
[TL: Simla, Himachal Pradesh, India]

Ourapteryx convergens Warren, 1897; *Novitates zoologicae*, 4: 75.

Ouratptryx convergens; Gyula et al., 2018; in Fibigeriana Supplement, *The Vartian Collection, Geometridae*, Part-4: 44 pp, pl. 61, fig., 5–8.

Wing expanse: 54 mm (Forewing length: Male: 23–26 mm; Female: 27 mm)

Diagnosis: Although close to *O. excellens* but easily distinguishable as it is fairly larger with white wings having characteristics of dusty-brown bands with an ochreous center (while fuscous black in *O. excellens*). Forewing with a characteristics triangular sub-basal patch; large, slightly lunulated, discal blotch; an irregular, submarginal band tapering towards but not reaching the anal angle and comparatively uniform marginal band. Hindwing with a characteristic "V" shaped mark formed when a narrow, longitudinal, band along the first median vein joined an inwardly curved postmedial band. Outer cilia of the wings bright ochreous than fuscous (in *O. excellens*). Underside paler and marking as on the upper side while in *O. excellens* has some yellow hue, more prominent on the hindwing.

Distribution: India: Himachal Pradesh (Shimla), Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017; Chandra et al. 2019). **Global:** Afghanistan, Nepal, Pakistan (Gyula et al. 2018).

165. *Ourapteryx ebuleata* (Guenée, [1858]) [Plate 9.7]
[TL: Bengal, (West Bengal) India]

Urapteryx ebuleata Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 32.

Urapteryx ebuleata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 145.

Ourapteryx ebuleata; Swinhoe, 1900; *List Species Lepidoptera Insects Collection British Museum*: 2318.

Ourapteryx ebuleata; Stüning, 1994; *Nachr. entomol. Ver. Apollo, Frankfurt/Main, N.F.*, 15 (1/2): 111.

Ourapteryx ebuleata; Inoue, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2); *Moths of Nepal*, Part-4: 128.

Ourapteryx ebuleata; Smetacek, 2008; *Bionotes*, 10 (1): 5–15.

Ourapteryx ebuleata; Sanyal et al. 2017; *SHILAP Revista de lepidopterología*, 45 (177): 159.

Wing expanse: 55 mm.

Diagnosis: Wings snowy-white, hindwing with some ochreous hue towards outer margin. Forewing discoidal streak faint. Hindwing tail with shoulder, the two spots at the base of the tail not connected by a grayish band, upper one red with black encircle, lower one black

Distribution: India: Arunachal Pradesh (Tawang) (Chandra and Sambath 2013), Himachal Pradesh (Shimla, GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir), Manipur, Meghalaya, Maharashtra, Sikkim, Tamil Nadu, Uttarakhand (Govind WLS, Gangotri NP) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Hampson 1895; Smetacek 2008; Chandra et al. 2019; Joshi et al. 2021). **Global:** Bhutan, China, Kyrgyzstan, Myanmar, Nepal (Inoue 1995), Pakistan.

166. *Ourapteryx excellens* Butler, 1889 [Plate 9.8]
[TL: Cashmere, Jammu and Kashmir, India]

Urapteryx excellens Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum* 7: 99, pl. 85 (13).

Urapteryx excellens; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 147.

Ourapteryx excellens; Prout, 1915; in Seitz, *The Macrolepidoptera of the world*, 4: 335, pl. 17 (e).

Wing expanse: 52 mm.

Diagnosis: Discussed in *O. convergens*.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Jammu and Kashmir (Kashmir) (TL). **Global:** No documentation yet.

Remarks: New record to Himachal Pradesh.

167. *Ourapteryx nepalensis* Inoue, 1995 [Plate 9.9]
[TL: Nepal]

Ourapteryx nepalensis Inoue, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2); *Moths of Nepal*, Part-4: 129, pl. 122 (14, 15).

Wing expanse: Male: 43–50 mm, Female: 49–55 mm.

Diagnosis: Hindwing with the tail linger and the two spots at the base of tail (dorsal one reddish with black outline), connected by a dark grey dash.

Distribution: India: Himachal Pradesh (Shimla, GHNP) (Mallick 2021), Sikkim, Uttarakhand (Mussoorie, Bhimtal), West Bengal (Darjeeling) (Chandra et al. 2019). **Global:** Nepal, Thailand (Inoue 1995).

Remarks: Check out for other references.

168. *Ourapteryx pallidula* Inoue, 1985 [Plate 9.10]
[TL: Taiwan]

Ourapteryx pallidula Inoue, 1985; *Bulletin of Faculty of Domestic Sciences, Otsuma Woman's University,* 21: 81–84, fig., 86, 103.

Wing expanse: Forewing length: Male: 24–27 mm, Female: 27–29 mm.

Diagnosis: Wing color varies from white to pale yellow. Hindwing tail with shoulder, moderately long, two spots at the base of the tail fairly distinct, upper (or dorsal) one red with black edge, lower one weakly developed and merely as a dash.

Distribution: India: Arunachal Pradesh (Lower Subansiri) (Sonne and Gaikwad 2021), **Himachal Pradesh** (Dhauladhar mountains-current study). **Global:** Kyrgyzstan (Korb 2023), Taiwan (TL) (Wu et al. 2020).

Remarks: New record to Himachal Pradesh.

169. *Ourapteryx purissima* Thierry-Mieg, 1905 [Plate 9.11]
[TL: Central Asia]

Ourapteryx purissima; Prout, 1915; in Seitz, *The Macrolepidoptera of the world,* 4: 335.

Wing expanse: 48 mm.

Diagnosis: Similar with *O. kantalaria*, smaller in size, forewing elongated. Hindwing with tail comparatively short, two spots at the base of tail, dorsal one red-edged grey dash, ventral one reduced.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021). **Global:** Central Asia (TL), Kazakhstan (Nazymbetova et al. 2016; Naydenov et al. 2020; Knyazev and Ivonin 2023), Kyrgyzstan (Korb 2023).

170. *Ourapteryx yerburii yerburii* (Butler, 1886) [Plate 9.12]

[TL: Murree, Western Pakistan]

= *sinata* Wehrli, 1940; [TL: China]

Urapteryx yerburii Butler, 1886; *Proceedings of the Zoological Society of London*, 3: 388.

Ourapteryx ebuleata ab. yerburii; Prout, 1915; in Seitz, *The Macrolepidoptera of the world*, 4: 335.

Ourapteryx ebuleata szechuana; Chu et al., 1981*; Icon Heterocera Sinica*, 1: 125.

Ourapteryx yerburii; Inoue, 1993; *Tyo Ga*, 44: 107.

Ourapteryx yerburii yerburii; Inoue, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part-4: 132, pl. 123 (2).

Wing expanse: 48 mm.

Diagnosis: Looks close to *O. nepalensis* but separable by its dense, greyish-brown striation and transverse lines, two spots at the base of tail not connected.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Uttarakhand (Bhimtal). **Global:** China, Nepal (Inoue 1995), Pakistan (TL) (Inoue 1993, 1995).

Tribe *Thinopterygini* Holloway, 1994

Genus *Thinopteryx* Butler, 1883

171. *Thinopteryx citrina* Warren, 1894 [Plate 9.13]

[TL: Sikkim, North India]

Thinopteryx citrina Warren, 1894; *Novitates zoologicae*, 1 (2): 401.

Thinopteryx citrina; Prout, 1915; in Seitz, *The Macrolepidoptera of the world*, 4: 337.

Thinopteryx citrina; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 33, pl. 10 (9).

Wing expanse: Forewing length: 32–35 mm.

Diagnosis: *T. citrina* looks very similar to *T. praetoraria* but distinguishable based on its smaller size; antemedial line which is almost straight and reaches the inner margin far before the middle while highly bent outwardly and reaches inner margin almost in the middle.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Sikkim (TL), Indian subregion. **Global:** Indonesia (Borneo, Java, Sumatra), Nepal (Yazaki 1992).

172. *Thinopteryx crocoptera crocoptera* (Kollar, [1844]) [Plate 9.14]
[TL: Massuri, Uttarakhand, India]

= *crocoptera erythrosticta* Wehrli, 1939 [TL: China]

= *crocopterata* (Guenée, [1858]) [(*Ourapteryx* (as: *Urapteryx*)]; [TL: ??]

Urapteryx crocoptera Kollar, 1844; in Hügel, *Kaschmir und das Reich der Siek*, 4: 483.

Thinopteryx crocopterata[sic] padanga Swinhoe, 1916; *The Annals and Magazine of Natural History*, 18 (108): 487.

Thinopteryx crocopterata [sic, recte crocoptera], Holloway, 1993; *Moths of Borneo*, 11: 108.

Wing expanse: 70 mm.

Diagnosis: Wings yellow with brownish-orange striations. This nominotypical subspecies can be easily identified by its forewing which has greyish-white costa; submarginal line gets reduced to series of spots near costa.

Distribution: India: Andaman Island, Arunachal Pradesh, Assam, Himachal Pradesh (GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir), Meghalaya, Sikkim, Uttarakhand (Govind WLS, Dehradun) (Sanyal et al. 2017; Chandra et al. 2019), West Bengal (Chandra et al. 2019). **Global:** Bhutan, Bangladesh, China, Hong Kong, Indonesia (Java, Sumatra), Japan, Korea, Malaysia, Nepal, Pakistan, Russia, Taiwan, Vietnam (Holloway 1993).

173. *Thinopteryx nebulosa* Butler, 1883 [Plate 9.15]
[TL: Eastern India]

Thinopteryx nebulosa Butler, 1883; *Journal Linnean Society London (Zoology)*, 17: 203.

Thinopteryx nebulosa; Holloway, 1976; *Moths of Borneo with special reference to Mt. Kinabalu*: 79.

Wing expanse: 69–71 mm.

Diagnosis: Morphologically looks close to the previous species but *T. nebulosa* is smaller and the wings are more heavily irrorated with grey that the pale yellow wing color is rarely visible.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Kerala (Sondhi et al. 2018), Uttarakhand (Dehradun) (Uniyal et al. 2016; Sanyal et al. 2017), Eastern India: West Bengal (Chettri and Yonle 2021). **Global:** Borneo, Indonesia (Sumatra, Java) ((Holloway 1976; Holloway 1993), Taiwan (Wu et al. 2020).

Remarks: New record to Himachal Pradesh.

Tribe Baptini Forbes, 1948

Genus *Aplochlora* Warren, 1893

174. *Aplochlora dentisignata* (Moore, 1868) [Plate 9.16]

[TL: Darjiling, West Bengal, India]

Geometra dentisignata Moore, 1868; *Proceedings of the Zoological Society of London*: 636.

Caberodes dentisignata; Hampson, 1895. *The Fauna of British India, including Ceylon and Burma*, 3: 158.

Nothomiza dentisignata; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 38, pl. 12 (10).

Nothomiza dentisignata; Chandra and Sambath, 2013. *Journal of Threatened Taxa*, 5 (1): 3567.

Wing expanse: 54 mm.

Diagnosis: Wings pale glaucous-green with some yellow-ochreous hue and brown irrorations and, thick, fuscous irrorations on costal edge. Forewing with an indistinct, brown, sinuous ante medial line and similar obliquely straight post medial line with white inner edge (become visible only below cell), also continue in hind wing. Underside paler white.

Distribution: India: Arunachal Pradesh (Tawang) (Chandra and Sambath 2013), Himachal Pradesh, Sikkim, Uttarakhand, West Bengal (Chandra et al. 2019). **Global:** Bhutan, Myanmar, Nepal (Yazaki 1992), Vietnam.

Genus *Heterostegania* Warren, 1893

175. *Heterostegania lunulosa* (Moore, 1888) [Plate 9.17]

[TL: India]

= *nigrofusa* Warren, 1893; [TL: India]

Anisodes lunulosa Moore, 1888, *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 250, pl. 8 (8).

Synegia lunulosa; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 170.

Heterostegania lunulosa; Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1); *Moths of Nepal*, Part-6: 109, pl. 171 (1).

Wing expanse: 36–40 mm.

Diagnosis: Wings pale yellow, irrorated with black and suffused with dark brown except some parts. Forewing with characteristic whitish-ochreous apical patch. Both wings with lunulated, darker fuscous-brown submarginal line. Underside paler without suffusion and with black discal spots. Looks close to *H. nigrofusa* but *H. lunulosa* is comparatively brighter and larger; "post medial line more strongly excurved on cubital veins and medial area broader" (Stüning 2000).

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Sikkim. **Global:** Nepal (Stüning 2000), Taiwan (Wu et al. 2020),

Remarks: New record to Himachal Pradesh.

Genus *Nothomiza* Warren, 1894

176. *Nothomiza achromaria* (Guenee, [1858]) [Plate 9.18]

[TL: North West Himalayas]

Caberodes achromaria Guenee, 1893. Hist. nat. Ins., in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 136.

Caberodes achromaria, Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 159.

Wing expanse: Forewing length: Male: 13–14 mm, Female: 15–16 mm.

Diagnosis: Wings, whitish with slight greenish-grey tinge. Forewing with nearly straight fuscous and pale ante and postmedial lines (with ochreous inner margin of antemedial line and outer margin of postmedial line). A fuscous speck at the end of cell on both wings. On the underside of hindwing curved fuscous postmedial line.

Distribution: India: Himachal Pradesh (Dharamshala, TL), Meghalaya (Khasi) (Joshi et al. 2021)). **Global:** No documentation.

177. *Nothomiza cinerascens* (Moore, 1888) [Plate 9.19]
[TL: Darjiling, West Bengal, India]

Caberodes cinerascens Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 266.

Caberodes cinerascens; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 159.

Nothomiza cinerascens; Prout, 1926; *Journal Bombay Natural History Society*, 31: 786.

Nothomiza cinerascens; Yazaki, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), *Moths of Nepal*, Part-3: 29, pl. 72 (18).

Wing expanse: 26 mm.

Diagnosis: Wings whitish with slight dirty fuscous tinge, irrorate with clouded fuscous. Forewing with pale yellowish costa, an indistinct and undulating ante medial line; post medial line slightly outcurved, highly undulating and indistinct. Underside paler; discal spots and post medial lines prominent.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Sikkim, West Bengal (TL). **Global:** Nepal (Yazaki 1994).

Remarks: New record to Himachal Pradesh.

178. *Nothomiza costinotata* (Warren, 1893) [Plate 9.20]
[TL: Bhotan]

Caberodes costinotata Moore, 1893; *Proceedings of the Zoological Society of London*; 411.

Caberodes costinotata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 159.

Nothomiza costinotata; Yazaki, 1998; in Haruta T (ed.): Tinea, 15 (suppl. 1); *Moths of Nepal*, Part 5: 8, pl. 129 (24).

Nothomiza costinotata; Stüning, 2000. *Moths of Nepal*, Part 6. Tinea 16 (Supplement 1): 108.

Nothomiza costinotata; Sondhi et al., 2021; Tropical Lepidoptera Research, 31(2):1-53.

Wing expanse: 28 mm.

Diagnosis: Wings ochreous with ferruginous suffusion and irroration, yellowish triangular spot on the postmedial costal region, fuscous-purplish suffusion on costal and apical region. Black speck at the end of cell of both wings. Traces of postmedial line on hindwing, purplish fuscous oblique lines: one antemedial and other postmedial on forewing.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), **Himachal Pradesh** (Dhauladhar mountains-current study), Uttarakhand (Askot WLS) (Chandra et al. 2019). **Global:** Bhutan (TL), Nepal (Yazaki 1998; Stüning 2000).

Remarks: New record to Himachal Pradesh.

Genus *Platycerota* Hampson, 1893

179. *Platycerota vitticostata* (Walker, F., [1863]) [Plate 10.1]

[TL: Darjiling, West Bengal, India]

= *infixaria* (Walker, [1863]) (*Caberodes*) [TL: Venezuela; Misplaced taxonomically, or type locality incorrect]

Hyperythra vitticostata Walker, 1862; *List Species Lepidoptera Insects Collection British Museum*, 16: 1947.

Hyperythra vitticostata; Moore, 1867; *Proceedings of the Zoological Society of London*; 619.

?? vitticostata; Warren, 1894; *Novitates zoologicae*, 1: 407.

Platycerota vitticostata; Yazaki, 1993; in Haruta T (ed.): Tinea 14 (suppl. 2); *Moths of Nepal*, Part-3: 21, pl. 70 (3).

Wing expanse: 38 mm.

Diagnosis: Wings pale yellow with mostly orange and slight fuscous irrorations. Forewing with two-third of the costa suffused with whitish-grey is a characteristic feature of the members in this species.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), West Bengal (Darjeeling, TL). **Global:** Nepal (Yazaki 1993)

Remarks: New record to Himachal Pradesh.

Tribe: Plutodini Warren, 1894

Genus *Plutodes* Guenée, [1858]

180. *Plutodes warreni* Prout, 1923 [Plate 10.2]

[TL: Sabathu (Himachal Pradesh, India)]

Plutodes warreni Prout, 1923; *The Annals and Magazine of Natural History*, 9 (11): 322.

Plutodes warreni; Yazaki, 1993; in Haruta T (ed.): Tinea 13 (suppl. 3); *Moths of Nepal*, Part-2: 112, pl. 7 (24).

Plutodes warreni; Singh et al., 2023; *Zootaxa*, 5323 (4): 506.

Wing expanse: Forewing length: Male: 19–21 mm, Female: 20–21 mm.

Diagnosis: *P. warreni* is externally similar to *P. costatus* but smaller; underside paler, uniformly brown coloured with a faint sub apical blackish patch while lacks discal line (present in *P, costatus*).

Distribution: India: Assam, Arunachal Pradesh, Himachal Pradesh (Subathu, TL), Sikkim, West Bengal (Prout 1923; Singh et al. 2023). **Global:** China, Nepal (Yazaki 1993, Yazaki & Wang 2004)**.**

Tribe Epionini Bruand, 1846

Genus *Apoheterolocha* Wehrli, 1937

181. *Apoheterolocha patalata* (Felder and Rogenhofer, 1875) [Plate 10.3]

[TL: Khasia, Meghalaya, India]

= *varians* (Swinhoe, 1891) (*Marcala*); [TL: India]

Heterolocha patalata Felder and Rogenhofer, 1875; *Novitates zoologicae*: 132.

Heterolocha patalata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 180.

Heterolocha patalata; Leech, 1897; *The Annals and Magazine of Natural History*, 19 (6): 232.

Heterolocha patalata; Prout, 1926; *The Journal of the Bombay Natural History Society*, 31: 791.

Heterolocha patalata; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 40, pl. 12 (19).

Apoheterolocha patalata; Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1); *Moths of Nepal*, Part-6: 101.

Wing expanse: 36 mm.

Diagnosis: Yellowish green forewings, hindwings pale yellow. "Hindwings with strongly curved postmedial line and tornal area without any black spot".

Distribution: India: Arunachal Pradesh, Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Khasi) (Joshi et al. 2021), Sikkim, Uttarakhand (NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018). **Global:** Bhutan, China, Indonesia (Borneo), Myanmar, Nepal, Taiwan (Wu et al. 2020).

Genus *Corymica* Walker, 1860

182. *Corymica deducta* (Walker, 1866) [Plate 10.4]

[TL: Celebes, Indonesia]

= *caustolomaria* Moore, 1888; [TL: Darjiling, West Bengal, India]

= *gensanaria* Leech, 1891; [TL: Korea]

Corymica deducta caustolomaria Yazaki 1993; in Haruta T (ed.): Tinea 13 (suppl. 3); *Moths of Nepal*, Part-2: 114, pl. 60 (26).

Wing expanse: 28 mm.

Diagnosis: Wings dull yellow with dull brown irroration and striation.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Kerala (Sondhi et al. 2018; Das et al. 2020; Shamsudeen and Pathania 2022), Uttarakhand (Dehradun) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Darjeeling) (Shah et al. 2018; Chettri and Yonle 2021). **Global:** Indonesia (Celebes), Nepal (Yazaki 1993).

183. *Corymica pryeri* (Butler, 1878) [Plate 10.5]

[TL: Japan]

Thiopsyche pryeri Butler, 1878. *The Annals and Magazine of Natural History*, 1(5): 393; TL: Japan, Yokohama.

Corymica vitrigera Butler, 1889. *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 101.

Corymica oblongimacula Warren, 1896; *Novitates zoologicae,* 3: 305.

Corymica prattorum Prout, 1928. *Bulletin Hill Museum*, 2 (1): 59.

Corymica oblongimacula Holloway, 1976; *Moths of Borneo* with special reference to Mt. Kinabalu: 75.

Corymica pryeri; Holloway, 1993; *Moths of Borneo*. 11: 51, pl. 2 (66).

Wing expanse: Forewing length: Male: 15 mm, Female: 16–18mm.

Diagnosis: Bright yellow wings. Forewings with a characteristic smaller brown apical patch and two conjoined patches on the inner margin with yellow region in between.

Distribution: India: Arunachal Pradesh, Assam (Tinsukia) (Arandhara et al. 2017; Joshi et al. 2021), Himachal Pradesh (GHNP) (Chandra et al. 2019; Mallick 2021), Kerala (Mathew et al. 1994), West Bengal (Chettri 2022). **Global:** Australia, Indonesia (Borneo, Sumatra), Japan, Korea (Byun et al. 2010; Choi and An 2010; Balint and Katona 2011), New Guinea, Pakistan, Taiwan, Thailand.

Genus *Fascellina* Walker, F., 1860

184. *Fascellina plagiata* (Walker, F., 1866) [Plate 10.6]
[TL: Darjiling, West Bengal, India]

= *plagiata icteria* Wehrli, 1936; [TL: China]

= *plagiata kankozana* Matsumura, 1931; [TL: ??]

= *plagiata subvirens* Wehrli, 1936; [TL: China]

= *viridis* Moore, 1867; [TL: India]

Fascelina plagiata Walker, F., 1866; *List Species Lepidoptera Insects Collection British Museum* 35: 1601.

Fascelina plagiata; Moore, 1867; *Proceedings of the Zoological Society of London*: 79, pl. 7 (4).

Fascelina plagiata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 226.

Fascellina plagiata; Holloway, 1976; 77.

Fascellina plagiata plagiata; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 37, pl. 11 (17).

Wing expanse: 40 mm.

Diagnosis: Wings bright green. This species is easily distinguishable on closer examination of the hindwing. The hindwing of *F. plagiata* characterised by a double, brown, transverse medial lines followed by a highly outwardly curved dark line meeting the medial line at its costal and immer marginal edges.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Assam (Tinsukia) (Arandhara et al. 2017; Joshi et al. 2021), Himachal Pradesh (Shimla), Karnataka (Mishra et al. 2016; Ravindrakumar 2021), Kerala, Meghalaya, Sikkim, Tamil Nadu, Uttarakhand (Askot and Govind WLS, Dehradun) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Chandra et al. 2019; Das et al. 2020; Chettri and Yonle 2021; Yonle 2022). **Global:** Bhutan, Borneo, China, Hong Kong, Indonesia, Myanmar, Malaysia, Nepal (Yazaki 1992), Taiwan.

Genus *Garaeus* Moore, [1868]

185. *Garaeus albipunctatus* Hampson, 1895 [Plate 10.7]
[TL: Dharmsala, Himachal Pradesh, India]

Garaeus albipunctatus Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 234.

Garaeus albipunctatus; Gyula et al., 2018; in Fibigeriana Supplement: *The Vartian Collection, Geometridae*, Part-4: 40, fig. 51 (22–25).

Wing expanse: 34–36mm

Diagnosis: Outer margin of the wings crenulated. Purple fuscous brown background, forewing with chestnut fascia extending to the outer margin below apex, indistinct slightly curved antemedial and oblique slightly sinuous postmedial line, subapical hyaline spot. Underside of wings striated and spotted with fuscous and greater part of hindwing orange.

Distribution: India: Himachal Pradesh (Dharamshala) (TL). **Global:** Afghanistan (Gyula et al. 2018), Pakistan (Murree).

186. *Garaeus apicata* (Moore, 1868) [Plate 10.8]

[TL: Dharmsala, Himachal Pradesh, India; Formosa]

Auzea apicata Moore, 1868; *Proceedings of the Zoological Society of London*: 617.

Garaeus apicatus; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 235.

Garaeus apicata; Holloway, 1976; *Moths of Borneo with special reference to Mt. Kinabalu*: 77.

Garaeus apicata apicata; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 37, pl. 11 (18).

Garaeus apicata apicata; Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1); *Moths of Nepal*, Part-6: 98.

Garaeus apicata; Holloway, 1993; *Moths of Borneo*. 11: 42, pl. 2, fig. 45.

Wing expanse: Male: 34 mm, Female: 44 mm.

Diagnosis: Wings orange-brown with some purple suffusion and black irrorations. Forewing with apex slightly produced with a small, pale pinkish-white blotch; double, paler, obliquely straight post medial line from before apex towards the middle of the inner margin.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sandhi et al. 2021), Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand (Devalsari), West Bengal (Chandra et al. 2021; Chettri 2022). **Global:** Indonesia (Borneo, Sumatra), Malaysia, Myanmar, Nepal (Yazaki 1992; Stüning, 2000), Pakistan, Philippines, Taiwan.

Genus *Heterolocha* Lederer, 1853

187. *Heterolocha falconaria* (Walker, 1866) [Plate 10.9]

[TL: North Hindustan]

Aspilates falconaria Walker, 1866; *List Species Lepidoptera Insects Collection British Museum*, 35: 1665.

Heterolocha falconaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 179.

Heterolocha falconaria; Holloway, 1993; *Moths of Borneo*, 11: 36.

Heterolocha falconaria; Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1), *Moths of Nepal*, Part-6: 102.

Heterolocha falconaria; Dey et al., 2019; *Spixiana*, 42: 52.

Wing expanse: 36 mm.

Diagnosis: Morphologically, close to *H. phoenicotaeniata* but can be diagnosed as follow: slightly larger; forewing slightly produced at apex, outer margin falcate; outer band oblique, inwardly curved, patchy and starts from the apex to the inner margin.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh (GHNP) (Mallick 2021), Punjab, Sikkim, Uttarakhand (Dey 2018), West Bengal (Darjeeling). **Global:** Nepal (Stüning, 2000).

188. *Heterolocha phoenicotaeniata* (Kollar, 1844) [Plate 10.10]
[TL: North West Himalayas]

= *incolorata* Warren, 1894; [TL: India]

Aspilates phoenicotaeniata Kollar, 1844; in Hugel, *Kaschmir und das Reich Siek*, 4: 487.

Heterolocha incolorata Warren, 1894; *Novitates zoologicae*, 1 (2): 449.

Heterolocha phoenicotaeniata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 179.

Heterolocha phoenicotaeniata; Holloway, 1993; *Moths of Borneo*, 11: 37.

Heterolocha phoenicotaeniata; Sanyal et al.; 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Heterolocha phoenicotaeniata; Gyula et al., 2018; in Fibigeriana Supplement: *The Vartian Collection, Geometridae*, Part-4: 40, pl. 50 (38–42).

Wing expanse: 32 mm

Diagnosis: Often have variable forms, pale to bright yellow wing colour; forewing with basal costal area greyish-pink; a pale purplish, outwardly curved antemedial band. Both wings with a discal dot, however, larger and prominent on hindwing; a maculated, pale purplish, outer band from apex to the inner margin, expanding at apex and towards inner margin. Underside bright yellow with greyish-purple irrorations, denser towards the basal region of forewing, markings as on the upper side of wings but brighter.

Distribution: Arunachal Pradesh, Himachal Pradesh (Subathu, Dhauladhar mountains-current study), Jammu and Kashmir, Sikkim, Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018), West Bengal (Hampson 1895; Sanyal et al. 2017; Chandra et al. 2019). **Global:** Afghanistan, Bhutan, Nepal (Yazaki 1992), Pakistan, Vietnam (Yazaki 1992; Holloway 1993; Gyula et al. 2018).

Genus *Mimomiza* Warren, 1894

189. *Mimomiza cruentaria* (Moore, 1867) [Plate 10.11]
[TL: Bengal, (West Bengal), India]

Cimicodes cruentaria Moore, 1867; *Proceedings of the Zoological Society of London*: 616.

Heteromiza cruentaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 237.

Pseudomiza cruentaria; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 38, pl. 12 (2).

Mimomiza cruentaria; Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1); *Moths of Nepal*, Part-6: 100.

Wing expanse: 46 mm.

Diagnosis: Wings bright yellow coloured with orange-brown and greyish striations, especially on the basal and outer area of wings. Forewing with double obliquely straight post medial line from near the apex to the middle of inner margin, become straight and continue as medial line on hindwing; a subapical dark brown blotch with some whitish patches on the costa before the post medial line.

Distribution: India: Arunachal Pradesh (Eaglenest WLS, Tale WLS) (Sandhi et al. 2021), Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Joshi et al. 2021), Uttarakhand (Kedarnath WLS, Govind WLS, NDBR) (Sanyal et al. 2017; Dey 2018), West Bengal (Chandra et al. 2019). **Global:** Bhutan, China, Myanmar, Nepal (Yazaki 1992; Stüning, 2000), Thailand, Vietnam.

Genus *Plagodis* Hübner, [1823]

190. *Plagodis inustaria* (Moore, 1867) [Plate 10.12]

[TL: Bengal, (West Bengal), India]

Eurymene inustaria Moore, 1867; *Proceedings of the Zoological Society of London*: 620.

Eurymene inustaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 177.

Plagodis inustaria; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 38, pl. 12 (8).

Wing expanse: 32 mm.

Diagnosis: Yellow wings with black head and front of the thorax. Forewing is marked with narrow and pale reddish-brown, partly confluent transverse strigae being darkest on the middle of inner margin upward, from where an outwardly oblique postmedial pale-bordered band extends from near middle of the inner margin to the apex; apex with a small black spot. Underside of wings comparatively dark and instead with crimson colour strigae, mostly confluent before the apex.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh, Meghalaya (Khasi) (Joshi et al. 2021), Sikkim, Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (TL) (Chandra et al. 2019). **Global:** Nepal (Yazaki 1992).

Tribe: Caberini Duponchel, 1845

Genus *Astygisa* Walker, 1861

191. *Astygisa orbapicalis* (Herbulot, 1993) [Plate 10.13]

[TL: West Malaysia, Peninsular Malaysia]

Petelia orbapicalis Herbulot, 1993.

Astygisa orbapicalis; Sondhi et al. 2021; *Tropical Lepidoptera Research*, 31 (2): 13.

Wing expanse: Forewing length: 14–16mm.

Diagnosis: The members in this species can be diagnosed based on the pale greyish apical blotch on forewing. Hindwing pale ochreous-white, outer margin with broad dark, greyish, fuscous-brown suffusion. Forewing pattern irregular except a distinct purple-brown edged, pale greyish, sinuous medial band.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Assam, Himachal Pradesh, Meghalaya, West Bengal (Stüning and Walia 2009). **Global:** Malaysia (TL), Nepal, Pakistan (Stüning and Walia 2009).

Tribe Cassymini Holloway, 1994

Genus *Hydatocapnia* Warren, 1895

192. *Hydatocapnia marginata* (Warren, 1893) [Plate 10.14]
[TL: Naga Hills, Nagaland, India]

Zamarada marginata Warren, 1893; *Proceedings of the Zoological Society of London*, 2: 388.

Stegania marginata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 164.

Hydatocapnia marginata; Yazaki, 1993; in Haruta T (ed.): Tinea 13 (suppl. 3); *Moths of Nepal*, Part-2: 112, pl. 60 (13).

Wing expanse: 28 mm.

Diagnosis: Ground colour of the wings ochreous with many fine transverse brown or greenish striae, thicker on hindwings. The species looks similar externally to the one described from Nepal, *H. nebulosa* but can be distinguished by its darker striations and broader marginal bands of the hindwings. Also, on the underside of wings the marginal bands are comparatively broad and appear as smudge along the inner edges of the narrow marginal bands on the upper side of the wings. However, in *H. nebulosa*, the marginal bands on the upper side of the wings are narrower lacking smudge along their inner side.

Distribution: India: Himachal Pradesh (Shimla, GHNP) (Mallick 2021), Meghalaya (Khasi) (Joshi et al. 2021), Nagaland (Naga Hills, TL), Sikkim, Uttarakhand (Singh 2023). **Global:** Nepal (Yazaki, 1993).

Genus *Peratophyga* Warren, 1894

193. *Peratophyga hyalinata hyalinata* (Kollar, [1844]) [Plate 10.15]
[TL: ??]

= *aerata* (Moore, 1868) (*Acidalia*); [TL: India]

= *ionephela* (Wiltshire, 1966) (*Zamarada*); [TL: Afghanistan]

Idaea hyalinata Kollar, 1844; in Hügel, *Kaschmir und das Reich der Siek*, 4: 491.

Acidalia aerata Moore, 1868; *Proceedings of the Zoological Society of London*: 643.

Zamarada ionephela Wiltshire, 1966; *Zeitschrift der Wiener entomologischen Gesellschaft*, 51 (9–11): 148.

Peratophyga hyalinata; Wehrli, 1939; in Seitz, *The Macrolepidoptera of the world*, 4, supplementary: 293.

Peratophyga hyalinata; Kirti et al., 2009; *Journal of Threatened Taxa*, 1 (9): 485.

Peratophyga hyalinata; Jiang et al., 2012; *Zootaxa*, 3478 (1): 405.

Wing expanse: Forewing length: 11–13 mm

Diagnosis: Externally similar to *P. grata* described from Japan, but can be distinguished by its wavy medial line (which form a tooth on M3 in *P. grata*), more indistinct discal spot and comparatively narrow greyish-brown band outside the postmedial line of all wings (Jiang et al., 2012).

Distribution: India: Himachal Pradesh (Shimla, Nauni, Subathu, GHNP) (Mallick 2021; Sidhu et al. 2022), Meghalaya (Khasi) (Joshi et al. 2021), Uttarakhand (Dehradun, Govind WLS, Mussoorie) (Uniyal et al. 2016; Sanyal et al. 2016), West Bengal (Darjeeling) (Shah et al. 2018; Chandra et al. 2019; Chettri and Yonle 2021). **Global:** Afghanistan, Bhutan, China, Japan (Kamikura and Sakata 2019), Korea (Lim et al. 2013), Myanmar, Nepal, Tibet, Vietnam (Jiang et al. 2012).

Tribe Eutoeini Holloway, 1994

Genus *Calletaera* Warren, 1895

194. *Calletaera subexpressa* (Walker, 1861) [Plate 10.16]

[TL: Sarawak, Borneo]

= *digrammata* Wehrli, 1925; [TL: China]

= *angulata* Warren, 1896; [TL: India]

= *ruptaria* (Walker, 1861) (*Macaria*); [TL: Borneo]

Acidalia subexpressa Walker, 1861; *List Species Lepidoptera Insects Collection British Museum*, 23: 773.

Calletaera subexpressa; Holloway, 1976; *Moths of Borneo* with special reference to Mount Kinabalu: 78.

Calletaera subexpressa; 1993; in Haruta: Tinea 13, (suppl. 3); *Moths of Nepal*, Part 2: 113, pl. 60 (20).

Callaetera subexpressa; Jiang et al., 2014; *Zootaxa*, 3856 (1): 85.

Wing expanse: Male: 26 mm, Female: 32 mm.

Diagnosis: Wing pattern alike to *C. basipuncta* but can be distinguished based on the grey whitish colour and black postmedial lines of the wings (pale yellowish-brown wings with brown postmedial line in the later).

Distribution: India: Himachal Pradesh, Uttarakhand (Singh 2023). **Global:** Borneo, China (Fujian, Guangdong, Hainan, Hong Kong, Guangxi), Indonesia, Nepal, Peninsular Malaysia (Idris et al. 2021), Philippines (Jiang et al. 2014).

Genus *Luxiaria* Walker, 1860

195. *Luxiaria amasa* (Butler, 1878) [Plate 10.17]

[TL: Yokohama, Japan]

= *fasciosa* Moore, 1888; [TL: India]

= *fulvifascia* Warren, 1894; [TL: Sumatra]

Bithia amasa Butler, 1878; *The Annals and Magazine of Natural History*, 1 (5): 405.

Luxiaria fasciosa Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*, 3: 254.

Luxiaria amasa noda Prout, 1928; *Bulletin Hill Museum*, 2: 250.

Luxiaria fulvifascia Warren, 1894; *Novitates zoologicae*, 1 (2): 440.

Luxiaria amasa; Holloway, 1976; *Moths of Borneo with special reference to Mt. Kinabalu*: 78.

Luxiaria amasa fasciosa; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 30, pl. 8 (20).

Luxiaria amasa; Holloway, 1993; *Moths of Borneo*, 11: 151.

Luxiaria amasa; Jiang et al., 2014; *Zootaxa*, 3856 (1): 73.

Wing expanse: 38 mm.

Diagnosis: Yellowish-ochreous ground colour with ochreous-brown striations. Forewings with pale, ill-defined purplish, ochreous-brown recurved narrower antemedial and medial, and broader postmedial and submarginal clouded fasciae broken at the apex by a pale whitish apical patch (more prominent on underside). Hindwings with similar narrow medial and broad postmedial and submarginal clouded fasciae as forewings. This species is externally similar to *L. mitorrhaphes* and *L. acutaria*, but can be distinguished by the females with a small protrusion at the end of M3 in their hindwings and the reddish-brown bands outside the postmedial line while greyish brown in others. Also, the presence of reddish-brown scales in between submarginal line and the outer margin of the forewings below M1 and the apex of the hindwings (absent in others two).

Distribution: India: Arunachal Pradesh, Himachal Pradesh (GHNP) (Mallick 2021), Mizoram (Joshi et al. 2021), Uttarakhand, West Bengal (Chandra et al. 2019). **Global:** Bhutan, China, Indonesia (Sumatra, Borneo, Java), Japan (TL), Korea, Malaysia, Nepal (Yazaki1992), Russia, Taiwan (Wu et al. 2020), Tibet, Vietnam (Sutrisno 2005; Jiang et al. 2011).

196. *Luxiaria phyllosaria* (Walker, 1860) [Plate 10.18]
[TL: ??]

= *acutaria* (Pagenstecher, 1888) (*Psamatodes*); [TL: Malaysia]

= *alfenusaria* Walker, 1860; [TL: Borneo]

Drepanodes ? *phyllosaria* Walker, 1860; *List Species Lepidoptera Insects Collection British Museum*, 20: 82.

Luxiaria phyllosaria; Holloway, 1976; *Moths of Borneo* with special reference to Mount Kinabalu: 78.

Luxiaria phyllosaria; Yazaki, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), *Moths of Nepal*, Part-3:23, pl. 70 (13).

Luxiaria phyllosaria; Jiang et al., 2014; *Zootaxa,* 3856 (1): 80.

Wing expanse: 40 mm

Diagnosis: Wings with yellow background. Distinguishable from others in forewing with antemedial and medial lines forming short blackish brown stripes on costa and a black brown semi-circular costal patch near the apex.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Kerala (Das et al. 2020), Meghalaya (Khasi) (Joshi et al. 2018), Uttarakhand (Dehradun) (Uniyal et al. 2016; Sanyal et al. 2017. **Global:** China (Hainan, Guangxi, ? Jilin) (Jiang et al. 2011), Hong Kong (Kendrick 2010), Indonesia (Borneo), Malaysia, Nepal (Yazaki 1994), Philippines, Sri Lanka (TL).

Remarks: It is a new record to Himachal Pradesh.

Tribe Abraxini Warren, 1893

Genus *Abraxas* Leach, [1815]

197. *Abraxas antipusilla* Inoue, 1995 [Plate 10.19]

[TL: Nepal]

Abraxas antipusilla Inoue, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2); Moths of Nepal, Part-4: 124, pl. 120 (9, 10).

Abraxas antipusilla; Gayen and Chandra 2023; *Zootaxa*: 187–194.

Wing expanse: Autumn brood: 37–46, Summer brood: 34–38 mm.

Diagnosis: The members of *A. antipusilla* are significantly larger than the almost identical individuals of *A. pusila* species (for genitalia characteristics see Gayen and Chandra 2023.

Distribution: India: Arunachal Pradesh, **Himachal Pradesh** (Dhauladhar mountains-current study), Sikkim, Uttarakhand, West Bengal (Gayen and Chandra 2023). **Global:** Nepal (TL) (Inoue 1995).

Remarks: This species is a new record to Himachal Pradesh

198. *Abraxas circinata* Wehrli, 1935 [Plate 10.20]

[TL: China]

Abraxas circinata Wehrli, 1935; *Ent. Rdsch*.: 118, pl. 1 (12), pl. 3 (9).

Abraxas circinata; Inoue, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2); *Moths of Nepal*, Part-4: 124, pl. 121 (13, 14)

Wing expanse: Forewing length: 19–25 mm.

Diagnosis: Hindwing has more completely developed double row of the post medial grey spots.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study). **Global:** China (TL), Nepal (Sato 1995).

Remarks: This species is a new record to India.

199. *Abraxas leopardina* (Kollar, [1844]) [Plate 11.1]
[TL: India]

= *leopardinata* Guenée, [1858]; [TL: ??]

Zerene leopardina Kollar, 1844; in Hügel, *Kaschmir und das Reich der Siek*, 4: 490

Abraxas (*Calospilos*) *aphorista*; Inoue, 1970; *Spec. Bull. lepid. Soc. Japan*, (4): 208

Abraxas (*Calospilos*) *leopardina*; Inoue, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2); *Moths of Nepal*, Part-4: 124, pl. 121 (9–10).

Abraxas leopardina; Kirti, Kaur and Goyal, 2011; *Indian Journal of Entomology*, 73 (4): 303.

Wing expanse: 52 mm.

Diagnosis: *A. leopardina* is separable as follows: its golden tornal patch is extended on post medial line up to M3 and three golden-brown dots above it. Hindwing with marginal greyish lunules up to M3.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Uttarakhand (Mussouri). **Global:** Nepal (Inoue 1995).

200. *Abraxas peregrina* Inoue, 1995 [Plate 11.2]
[TL: Nepal]

Abraxas (*Calospilos*) *peregrina* Inoue, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2), *Moths of Nepal*, Part-4: 123, pl. 120 (15-16); TL: Godavari, 1600m.

Abraxas *peregrina*; Sanyal et al. 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 41-46 mm.

Diagnosis: Wings snow-white with very scarce grey spots. Forewing median blotch comparatively narrow with white discocellular and hardly connected with costal blotch; marginal series of specks restricted between CuA1 and M2.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 20221), Uttarakhand (Bhimtal, Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017; Chandra et al. 2019). **Global:** Nepal (Inoue 1995), Thailand.

201. *Abraxas picaria* Moore, 1868 [Plate 11.3]
[TL: Darjiling, West Bengal, India]

= *semilugens* Warren, 1893; [TL: India]

Abraxas picaria Moore, 1867; *Proceedings of the Zoological Society of London*: 652.

Abraxas semilugens Warren, 1893; *Proceedings of the Zoological Society of London*, (2): 393.

Abraxas picaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 301.

Abraxas picaria; Inoue, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2); *Moths of Nepal*; Part-4: 119, pl. 119 (3–6).

Abraxas picaria; Sanyal et al. 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 40 mm.

Diagnosis: Wings whitish with brownish-fuscous irroration. Hind wing with a characteristic more or less yellow, double maculated (i.e., narrowly separated series of black spots with yellow in between) post medial band. Both wings lunulate spots on the outer margin.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand (Govind WLS, Nanda Devi Biosphere Reserve, Kumaon) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018), West Bengal (Darjeeling) (Chandra et al. 2019). **Global:** Nepal (Inoue 1995), China.

202. *Abraxas sublepida* Inoue, 1995 [Plate 11.4]
[TL: Nepal]

Abraxas sublepida Inoue, 1995; Tinea 14 (suppl. 2); *Moths of Nepal*, Part-4: 122, pl. 120 (11-12).

Wing expanse: 39–42 mm.

Diagnosis: "Wings pure white and thickly scaled. Forewing with an irregular, grey band, incomplete and interrupted below cell; hindwing with its costal spot continues to the costa" (Inoue 1995).

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), West Bengal (Darjeeling Hills) (Chettri and Yonle 2021). **Global:** Nepal (TL).

Remarks: The species is a new record to India.

203. *Abraxas superpicaria* Inoue, 1970 [Plate 11.5]

[TL: Nepal]

Abraxas (*Abraxas*) *superpicaria* Inoue, 1970; *Spec. Bull. lepid. Soc. Japan*, (4): 204; TL: Nepal, 2450m

Abraxas (*Abraxas*) *superpicaria*; Inoue, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2), *Moths of Nepal*, Part-4: 119, pl. 119 (7-9).

Abraxas superpicaria; Dey et al., 2019; *Spixiana*, 42: 52.

Wing expanse: 40 mm.

Diagnosis: The overall wing pattern of *A. superpicaria* resembles *A. picaria* but distinguishable

As it is more yellowish in colour. Forewing with postmedial band less recurved, less oblique towards inner margin than in *A. picaria*. Hindwing without yellow marking along post medial series of black dots and area beyond this with dense fuscous-black striations.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand (Nanda Devi Biosphere Reserve) (Dey 2018), West Bengal (Darjeeling). **Global:** Bhutan, Nepal (TL, 2450 m) (Inoue 1995).

204. *Abraxas virginalis* Butler, 1886 [Plate 11.6]

[TL: Murree, Kashmir, Western India (Pakistan)].

Abraxas virginalis Butler, 1886; *Proceedings of the Zoological Society of London*: 392. Pl. 35 (11).

Abraxas virginalis; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 301.

Abraxas virginalis; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 311, pl. 25 (a).

Abraxas virginalis; Gyula et al., 2018; in Fibigeriana Supplement: *The Vartian Collection, Geometridae,* Part-4: 52, pl. 86 (9–12).

Wing expanse: 46 mm

Diagnosis: The members of the species have a very characteristic “ocellated” or “U”-shaped greyish cell mark on the forewing, which is sometimes completely obsolete on the hindwing. The two greyish-dotted postmedial lines with an incomplete and very faint yellow band in between.

Distribution: India: Assam, **Himachal Pradesh** (Dhauladhar mountains-current study), Jammu and Kashmir (Kashmir). **Global:** Myanmar (Burma), Nepal, Pakistan (Murree) (Gyula et al. 2018).

Remarks: The species is a **new record** to Himachal Pradesh.

Tribe Macariini Guenée, 1858

Genus: *Chiasmia* Hübner, [1823]

205. *Chiasmia azataria* (Swinhoe, 1893) [Plate 11.7]

[TL: Khasi Hills, Meghalaya, India]

Gonodela azataria Swinhoe, 1893; *The Annals and Magazine of Natural History*, 12 (6): 154.

Macaria azataria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 205.

Semiothisa azataria; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2), *Moths of Nepal*, Part 1: 27, pl. 7 (29).

Gonodela azataria; Yazaki, 1998; in Haruta T (ed.): Tinea, 15 (suppl. 1); *Moths of Nepal*, Part-5: 12.

Wing expanse: 28 mm.

Diagnosis: Wings pale ochreous-brown irrorated with chestnut-brown and suffused with grey beyond the post medial line. Forewing with brownish subapical patch with a subapical white spot at its base.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Khasi) (Jpshi et al. 2021). **Global:** Nepal (Yazaki 1992).

206. *Chiasmia eleonora eleonora* (Cramer, [1780]) [Plate 11.8]

[TL: India]

= *fasciata* (Fabricius, 1775) (*Phalaena*); [TL: Indiis]

= *fasciosaria* (Hübner, [1823]) (*Semiothisa*); [TL:]

= *subalbataria* (Swinhoe, 1890) (*Gubaria*); [TL: India]

= *victorinata* (Guenée, [1858]) (*Gubaria*); [TL: India (north)]

Phaelena eleonora Cramer, [1780]; *Uitlandshe Kapellen*, 3: 172, pl. 280 (E-G).

Macaria fasciata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma,* 3: 202.

Semiothisa eleonora; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2), *Moths of Nepal*, Part 1: 27, pl. 7 (31).

Chiasmia eleonora; Singh, 1953; *Indian Forest Records*, 8 (7): 88 (fig. 13–14, Larva).

Wing expanse: 42 mm.

Diagnosis: Broad white medial band do not reach the costa, its outer edge lined with black highly bent below the costa almost joining the black speckled orange-yellow blotch on the costa. Hindwing with the two yellow blotches beyond the outer edge of the white medial band speckled with black sometimes with black center. Underside with the wing base suffused with bright yellow.

Distribution: India: Throughout India: Andaman, Assam, Andhara Pradesh (Harinath et al. 2014), Goa (Gurule and Brookes 2021), Himachal Pradesh (Lahaul) (Kumar and Sharma 2022; Sidhu et al. 2022), Karnataka (Ravindrakumar 2021), Kerala (Idukki) (Mathew et al. 218; Sondhi et al. 2018; Das et al. 2020; Shamsudeen and Pathania 2022), Maharashtra (Gurule and Nikam 2011; Gurule and Nikam 2013; Kadam et al. 2018), Manipur, Meghalaya, Mizoram, Nagaland, Rajasthan (Jain and Verma 2023), Tamil Nadu (Nagarajan et al. 2021), Tripura, Uttar Pradesh (Farooqui and Parwez 2022), Uttarakhand (Joshi et al. 2021; Singh et al. 2023), West Bengal (Shah et al. 2018). **Global:** Malaysia, Myanmar (Burma), Sri Lanka (Ceylon).

207. *Chiasmia emersaria* (Walker, 1861) [Plate 11.9]
[TL: Hindostan (Bangladesh)]

Macaria emersaria Walker, 1861; *List Species Lepidoptera Insects Collection British Museum*: 925.

Macaria emersaria; Moore, 1867; *Proceedings of the Zoological Society of London*: 648.

Macaria emersaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma,* 3: 207.

Semiothisa emersaria Warren, 1897; *Novitates zoologicae*, 4: 399.

Macaria emersaria; Hampson, 1891; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 8: 29.

Macaria emersaria; Hampson, 1893; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 9: 142, pl. 170 (18).

Semiothisa emersaria; Prout, 1931; *Novitates zoologicae*, 37: 15.

Chiasmia emersaria; Singh, 1953; *Indian Forest Records*, 8 (7): 90.

Godonela emersaria; Yazaki, 1998; in Haruta T (ed.): Tinea 15, (suppl. 1), *Moths of Nepal*, Part-5: 12, pl. 129 (23).

Wing expanse: 32-34 mm (Male: 32, Female: 40 mm) (Forewing length: 15 mm).

Diagnosis: Wings dull whitish, with very pale greyish irroration. Forewing with its outer margin slightly convex below apex and lined with dark fuscous-brown; post medial line outwardly bends below costa and a dark brown costal and disintegrated medial patch next to it. Hindwing with pale ochreous-yellow suffusion and dark fuscous-brown irroration in between the ochreous-brown post medial and pale whitish submarginal line and also beyond the sub marginal line. Underside with broad dark fuscous-brown post medial band with crenulated outer edges.

Distribution: India: Throughout India: Arunachal Pradesh (Subansiri) (Sonne and Gaikwad 2021), Assam (Arandhara et al. 2017), Gujarat (Patel et al. 2023; Vaghela et al. 2023), Himachal Pradesh (GHNP) (Kumar et al. 2018; Singh et al. 2022), Karnataka (Ravindrakumar 2021), Kerala (Das et al. 2020; Shamsudeen and Pathania 2022), Maharashtra (Shubhalaxmi et al. 2011), Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Tamil Nadu (Pattanaik et al. 2021), Tripura, Uttarakhand, Uttar Pradesh (Farooqui and Parwez 2022) (Joshi et al. 2021; Singh and Lekhendra 2023), West Bengal (Yonle 2021; Chettri 2022). **Global:** Bangladesh (Sylhet), Myanmar (Burma), Nepal (Yazaki 1998), Sri Lanka (Ceylon).

208. *Chiasmia perfusaria* (Walker, 1866) [Plate 11.10]
[TL: Mount Ophir, Peninsular Malaysia**]**

= *subfasciata* (Hampson, 1891) (*Azata*); [TL: India]

Macaria perfusaria Walker, 1866; *List Species Lepidoptera Insects Collection British Museum*, 35: 1659.

Macaria perfusaria Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 208.

Semiothisa perfusaria; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part 1: 27, pl. 7 (28).

Wing expanse: 28–30 mm (Forewing length: 13 mm)

Diagnosis: Wings greyish-brown irrorated with fuscous-brown, underside with bright ochreous suffusion. Forewing with outer margin slightly convex below apex;

Distribution: India: Himachal Pradesh (Dharamshala, GHNP) (Singh et al. 2022), Karnataka, Kerala, Meghalaya (Khasis), Nagaland (Nagas), Sikkim, Tamil Nadu (Hampson 1895; Das et al. 2020; Joshi et al. 2021). **Global:** Sri Lanka (Ceylon), Indonesia (Borneo) Malaysia (Mount Ophir), Myanmar (Rangoon), Malacca.

Genus *Hypephyra* Butler, 1889

209. *Hypephyra terrosa* (Butler, 1889) [Plate 11.11]
[TL: Dharmsala, Himachal Pradesh, India]

Hypephyra terrosa Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 101, pl. 137 (17).

Hypephyra terrosa; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 218.

Hypephyra terrosa; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part 1: 28, pl. 8 (9).

Wing expanse: 40 mm.

Diagnosis: Whitish-brown ground colour of the wings being suffused with pink and irrorated with darker brown with the outer third region of the wings darker than the rest and bounded on its inner edges by slightly irregular, brown and pale transverse lines. Undersides of wings pale creamy straw coloured (pale yellow) and are with very sparse grey irroration; outer area of forewings darker and with a grey-fasciated patch towards inner margin.

Distribution: India: Himachal Pradesh (Shimla, Dharamsala, GHNP) (Mallick 2021), Uttarakhand (Chandra et al. 2019). **Global:** Korea (Jeong et al. 2012; Kim and Yoo 2012; Lee et al. 2016), Nepal (Yazaki 1992).

Genus *Oxymacaria* Warren, 1894

210. *Oxymacaria temeraria temeraria* (Swinhoe, 1891) [Plate 11.12]

[TL: India]

Macaria temeraria Swinhoe, 1891; *Transaction Entomological Society London*, 4: 492.

Macaria temeraria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 207.

Semiothisa temeraria ab. fumosa Warren, 1896; *Novitates zoologicae,* 3: 320.

Macaria temeraria; Prout, 1915; In Seitz: *The Macrolepidoptera of the world*, 4: 347.

Semiothisa temeraria cruda Prout, 1935; *Novitates zoologicae,* 39: 237.

Semiothisa temeraria; Holloway, 1976; *Moths of Borneo with special reference to Mt. Kinabalu*: 78.

Heterocallia temeraria; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 27, pl. 7 (33).

Oxymacaria temeraria; Holloway, 1993; *Moths of Borneo*, 11: 160.

Heterocallia temeraria; Chandra and Sambath, 2013. *Journal of Threatened Taxa*, 5 (1): 3568.

Heterocallia temeraria; Sanyal et al., 2017. *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 35 mm.

Diagnosis: Wings dull whitish, with very pale greyish irroration and fuscous striation beyond post medial line in forewing. Looks similar with *O. penumbrata* but can be distinguished by a very prominent, linear, whitish (with darker greyish shade on its inner edge) submarginal line on both wings, slightly sinuous on forewing.

Distribution: India: Andaman Island (Chandra 1996), Arunachal Pradesh (Tawang), Himachal Pradesh (GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir), Meghalaya, Nagaland, Uttarakhand (Chandra et al. 2019; Joshi et al. 2021). **Global:** Bhutan, China, Hong Kong, Indonesia (Borneo, Java), Japan, Korea (Lim et al. 2013), Malaysia, Nepal (Yazaki 1992), Pakistan, Taiwan (Wu et al. 2020), Thailand.

Tribe Boarmiini Duponchel, 1845

Genus *Abaciscus* Butler, 1889

211. *Abaciscus tristis tristis* Butler, 1889 [Plate 11.13]

[TL: Dharmsala, Himachal Pradesh, India]

Abaciscus tristis Butler, 1889; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 102, pl. 279 (18).

Boarmia tristis; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma, including Ceylon and Burma*, 3: 280.

Abaciscus tristis; Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3), *Moth of Nepal*, Part 2: 19, pl. 37 (5).

Abaciscus tristis; Holloway, 1976; *Moths of Borneo with special reference to Mt. Kinabalu*: 82.

Abaciscus tristis; Holloway, 1993; *Moths of Borneo*, 11.

Abaciscus tristis; Sondhi et al. 2020a; *Moths of India, v. 2.21*. Indian Foundation for Butterflies. (*https: //www.mothsofindia.org*).

Abaciscus tristis; Sondhi et al., 2021; *Tropical Lepidoptera Research*, 31 (2): 1–53.

Wing expanse: 40 mm.

Diagnosis: Wings reddish brown with white ground colour (more evident on hindwing). Forewing with pale whitish patch near the middle of the outer margin. "Hindwing with pale basal zone extending to distal to the postmedial where it is at its clearest, and in patches at the center of the distal margin of each wing".

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al., 2021), Himachal Pradesh (Dharamshala, TL), Uttarakhand (Sondhi et al. 2020a). **Global:** Borneo, China, Nepal, Taiwan (Sato 1993; Holloway 1993; Wu et al. 2020).

Bionomy: "The species is infrequent in upper montane forest, ranging from 1000-2000 m" (Holloway 1976).

Genus *Alcis* Curtis, 1826

212. *Alcis limbui* Sato, 1994 [Plate 11.14]

[TL: Nepal]

Alcis limbui Sato, 1994; in Haruta T (ed.): Tinea, 14 (suppl. 1); *Moths of Nepal*, Part-3: 43, pl. 73 (8, 9).

Wing expanse: 46 mm.

Diagnosis: *A. limbui* looks very much similar to *A. perspicuata* but it is with yellowish-orange-brown suffusion; underside with the marginal black band disappear towards anal angle with medial yellow patch larger, hindwing with a postmedial series of black spots while *A. perspicuata* comparatively less suffused with medial region more prominently white and the marginal band on the underside of the forewing is more or less complete small apical and sometime a medial yellowish patch, hindwing without postmedial series of spots.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021). **Global:** Nepal (Sato 1994).

213. *Alcis nigridorsaria* (Guenée, [1858]) [Plate 11.15]
[TL: ??]

Cleora nigridorsaria Guenée, [1858]; in Boisduval and Guenée, Histoire Naturelle des Insectes (Species général Lépidoptérés, 9: 232.

Cleora nigridorsaria; Walker, 1860; *List Species Lepidoptera Insects Collection British Museum*, 21:333.

Boarmia nigridorsaria; Hampson, 1895; The *Fauna of British India, including Ceylon and Burma*, 3: 267.

Alcis nigridorsaria; Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal*, Part-2: 8, pl. 34 (26).

Wing expanse: 34 mm.

Diagnosis: Wings white, irrorated with black. Forewing marking includes: a diffused black basal patch with white inner edge; an indistinct ante medial and medial lines arising from black patches on costa; indistinct post medial lines with series of black spots angled at M2, with ochreous inner edge followed by greyish-black suffusion up to pale white submarginal line and black irrorated ochreous patch in the middle of outer margin.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim. **Global:** Nepal (Sato 1993), Tibet.

214. ***Alcis perspicuata*** **(Moore, 1868)** [Plate 11.16]

[TL: Bengal, (West Bengal) India]

Boarmia perspicuata Moore, 1868; *Proceedings of the Zoological Society of London*: 630.

Alcis vicina Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 243.

Alcis perspicuata; Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal*, Part-2: 6, pl. 34 (12, 13).

Alcis perspicuata; Dey et al., 2019; *Spixiana*, 42:51.

Wing expanse: 48 mm.

Diagnosis: Discussed in *A. limbui*.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Khasi) (Joshi et al. 2021), Uttarakhand (Dey 2018), West Bengal (Darjeeling) (Shah et al. 2018). **Global:** Nepal (Sato 1993).

215. ***Alcis quadrifera*** **(Walker, 1866)** [Plate 11.17]

[TL: North Hindustan]

Scotosia quadrifera Walker, 1866; *List Species Lepidoptera Insects Collection British Museum*, 35:1687.

Poecilalcis semiclarata ab. *fasciata* Warren, 1896; *Novitates zoologicae*, 3: 405.

Alcis quadrifera; Sato, 1993; *in* Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal*, Part-2: 9, pl. 35 (1–4).

Wing expanse: 34 mm.

Diagnosis: The species is although exhibit some variations among the members but has following distinguishing characteristics: forewing with ante medial line slightly outcurved with diffused black suffusion on inner side; black, elongated, discal spot; post medial line angled at M1 and with black suffusion beyond; pale, crenulated, submarginal line followed by black patch below the apex and a pale yellowish patch at middle on the outer margin.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, West Bengal (Darjeeling) (Chandra et al. 2019). **Global:** Bhutan, Nepal (Sato 1993).

216. ***Alcis variegata*** **(Moore, 1888)** [Plate 11.18]

[TL: Darjiling, West Bengal, India]

= *hypopoecila* (Prout, 1928) (*Cleora*); [TL: Sumatra]

= *variegata nebulosa* (Swinhoe, 1891) (*Cleora*); [TL: India]

Pseudocoremia variegata Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 240.

Alcis variegata; Sato, 1991; *Tyo Ga*: 285.

Alcis variegata; Sato, 1993; in Haruta T (ed.): Tinea 13 (suppl. 3); *Moths of Nepal*, Part-2: 7, pl. 34 (16).

Alcis *variegata*; Sato, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2); *Moths of Nepal*, Part-4: 28, pl. 34 (16).

Alcis hypopoecila; Parsons et al., 1999; *Geometrid Moths of the World: a Catalogue*: 29.

Alcis variegata; Parsons et al., 1999; *Geometrid Moths of the World: a Catalogue*: 33.

Wing expanse: 36 mm.

Diagnosis: Wings white with very pale ochreous hue, marking slightly indistinct and consist of black, bluish-grey and white dense irroration. reddish-ochreous irroration beyond post medial line. Forewing with medial and post medial lines prominent, with comparatively less irrorated white region in between, thick and dense black irroration with some reddish-ochreous shade beyond post medial line; pale, denticulated submarginal line prominent and slightly less irrorated whitish apical and medial patch on outer margin.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Khasi), Sikkim, Uttarakhand (Dehradun) (Uniyal et al. 2016; Sanyal et al. 2017; Singh and Ramola 2021), West Bengal (Shah et al. 2018). **Global:** China, Java, Laos, Malaysia, Myanmar, Nepal (Sato 1993; Sato 1995), Sumatra, Taiwan, Thailand, Vietnam.

Remarks: Its larva is a defoliator (Singh and Ramola 2021).

Genus *Amblychia* Guenée, [1858]

217. *Amblychia pardicelata* (Walker, F., [1863]) [Plate 11.19]

[TL: Hindustan]

= *megaspilata* (Warren, 1894) (*Elphos*) [TL: India]

Elphos pardicelata Walker, 1863; *List Species Lepidoptera Insects Collection British Museum*, 26: 1544.

Elphos pardicelata; Moore, 1867; *Proceedings of the Zoological Society of London*: 635

Elphos pardicelata; Butler, 1886; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*: 65, pl. 116 (7).

Elphos pardicelata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 250.

Elphos pardicelata; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 31, pl. 9 (11).

Wing expanse: Male: 84-110 mm, Female: 110 mm.

Diagnosis: Very similar to *A. nimia* (Prout, 1925), but smaller, paler and more evenly coloured. Can be distinguished based on the underside markings of the wings: the underside of wings is creamy-white; forewings with sparsely mottled with grey and a large spot at the end of cell, a subapical belt and a large blackish spot near external angle; hindwings with a large spot at the end of a cell, an angular subapical patch, one near the middle of the outer margin and the another near the anal angle (in *A. nimia*, the terminal dark spots form almost a complete dark band with terminal interneural white spots on hindwings.

Distribution: India: Arunachal Pradesh, **Himachal Pradesh** (Dhauladhar mountains-current study), Meghalaya (Khasi) (Joshi et al. 2021), Sikkim, Uttarakhand (Govind WLS, Askot WLS) (Uniyal et al. 2016; Sanyal et al. 2017; Chandra et al. 2019). **Global:** Bangladesh (Sylhet), Bhutan, Laos, Myanmar, Nepal (Yazaki 1992), Vietnam.

Remarks: The species has been documented for the first time from Himachal Pradesh.

Genus *Arichanna* Moore, [1868]

218. *Arichanna conspersa* (Butler, 1880) [Plate 11.20]

[TL: Darjiling, West Bengal, India]

Abraxas conspersa Butler, 1880; *The Annals and Magazine of Natural History*, 5 (vi): 225.

Icterodes conspersa; 1888; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 6: pl. 119 (10).

Arichanna conspersa; Sato 1994; in Haruta T (ed.): Tinea 14 (suppl. 1); *Moths of Nepal*, Part-3: 42, pl. 73 (4).

Wing expanse: 55 mm.

Diagnosis: *A. conspersa* is very much similar to *A. schnitzleri* but is much smaller in size, forewing speckled with dark olive-green which merge to give the appearance of five transverse bands- basal, sub basal, ante medial, medial and post medial. Hindwing with dark olive-green discal spot prominent; traces of post medial and submarginal speckled bands.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), **Himachal Pradesh** (Dhauladhar mountains-current study), West Bengal (Darjeeling, TL). **Global:** Nepal (Sato 1994).

Remarks: The species has been documented for the first time from Himachal Pradesh.

219. *Arichanna flavimedia* Hampson, 1895 [Plate 12.1]
[TL: Sikkim, India]

Boarmia flavimedia Hampson, 1895.; *The Fauna of British India, including Ceylon and Burma*, 3: 272.

Arichanna flavimedia; Sato, 1993; in Haruta T (ed.): Tinea 13 (suppl. 3); *Moths of Nepal*, Part-2: 5, pl. 34 (6).

Wing expanse: 40 mm.

Diagnosis: Looks similar with *A. furcifera* but *A. flavimedia* is smaller, forwing brighter, hindwing paler, without dirty fuscous suffusion and without the post medial line.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Sikkim (TL). **Global:** Nepal (Sato 1993).

Remarks: The species has been documented for the first time from Himachal Pradesh.

220. *Arichanna flavinigra* Hampson, 1907 [Plate 12.2]
[TL: Kashmir; Chamba; Duggre; Jumnotri; Punjab, Dalhousie; Dharmsala; Kumaon, Ralam Valley, Yatong (Sikhim/Tibet border); Sikkim]

Arichanna flavinigra Hampson, 1907; *Journal Bombay Natural History Society*, 18 (1): 42.

Arichanna (*Epicterodes*) *flavinigra*; Wehrli, 1933; *Ent. Z., Frankf. a. M.*, 47 (4): 41.

Arichanna (*Epicterodes*) *flavinigra*; Sato, 1993; in Haruta T (ed.): Tinea 13 (suppl. 3); *Moths of Nepal*, Part-2: 5, pl. 34 (1).

Arichanna flavinigra; Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1); *Moths of Nepal*, Part-6: 129.

Arichanna (*Epicterodes*) *flavinigra*; Li et al., 2018; *Journal of Asia-Pacific Entomology*, 21:506.

Arichanna flavinigra; Dey et al., 2019; *Spixiana*, 42: 51.

Wing expanse: 60-66 mm.

Diagnosis: *A. flavinigra* looks similar with *A. sinica* but it has bright yellow wings (both upper and lower side, underside grey in *A. sinica*) with black transverse bands formed from the confluent spots of comparatively larger size with less space in between and hence indistinguishable.

Distribution: India: Himachal Pradesh (Chamba, Dharamsala, Dalhousie, GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir), Punjab, Sikkim (Yatang), Uttarakhand (Nanda Devi NP, Ralam Valley, Yamunotri) (Sanyal et al. 2017; Dey 2018; Chandra et al. 2019; Dey et al. 2019). **Global:** Bhutan, China, Myanmar, Nepal, Tibet (Sato 1993; Stüning, 2000; Li et al. 2018).

Remarks: It has been reported as the most abundance species in its group (Stüning, 2000)

221. *Arichanna marginata* (Warren, 1893) [Plate 12.3]
[TL: Naga Hills, Nagaland, India]

Arichanna marginata Warren, 1893; *Proceedings of the Zoological Society of London*, 2: 423.

Arichanna marginata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 291.

Arichanna marginata; Prout, 1912-1916; in Seitz, *The Macrolepidoptera of the world,* 4: 303, pl. 14 (a).

Arichanna marginata; Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal*, Part-2: 5, pl. 34 (8).

Wing expanse: 36 mm.

Diagnosis: Whitish ochreous wings; largely suffused with olive fasciae and dusted with darker atoms; the black postmedial line near to center and strongly inwardly curved and become thicker behind cell.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Nagaland (TL), Sikkim. **Global:** Bhutan, Nepal (Sato 1993), Taiwan (Wu et al. 2020), Thailand (Sato 1995).

Remarks: The species has been documented for the first time from Himachal Pradesh.

222. *Arichanna schnitzleri* Stüning, 2000 [Plate 12.4]
[TL: Nepal]

Arichanna schnitzleri Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1); *Moths of Nepal*, Part-6: 131, pl. 172 (12-14).

Wing expanse: Male: 32-35 mm, Female: 34–35 mm.

Diagnosis: Almost inseparable from *A. albivertex* but can be distinguished based on dull creamy-white forewing, dark olive-green, dense irroration with some brownish hue except basal area and an irregular, oblique apical streak (while pure white wings with blackish spotted pattern). Hindwing not so strongly spotted with an incomplete post medial band, complete in *A. albivertex*.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), **Himachal Pradesh** (Dhauladhar mountains-current study). **Global:** Nepal (TL).

Remarks: New record to Himachal Pradesh.

223. *Arichanna sparsa* (Butler, 1890) [Plate 12.5]
[TL: Dharmsala, Himachal Pradesh, India]

= *conspersa* (Butler, 1889) (*Icterodes*); [TL: India]

Icterodes sparsa Butler, 1889; Entom. 23: 316.

Arichanna sparsa; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world,* 4: 304.

Arichanna sparsa; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 294.

Arichanna sparsa; Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal*, Part-2: 42, pl. 34 (2).

Wing expanse: 52 mm.

Diagnosis: Looks much closer to *A. melanaria askoldinaria* but their forewing is comparatively more dusted or have clouded bluish-grey suffusion in the spaces between black spots and hindwing with greyish-fuscous suffusion in the basal half up to black discal spot.

Distribution: India: Himachal Pradesh (Dharamshala, TL), Uttarakhand (Dey and Hausmann 2021; Dey 2018). **Global:** Nepal (Sato 1993).

224. *Arichanna tenebraria* (Moore, 1868) [Plate 12.6]
[TL: India]

Abraxas tenebraria Moore, 1868; *Proceedings of the Zoological Society of London*: 652.

Arichanna tenebraria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 293.

Arichanna (*Paricterodes*) *tenebraria*; Sato, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), Moths of Nepal, Part-3: 42, pl. 73 (5).

Arichanna (*Paricterodes*) *tenebraria*; Sato, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2); *Moths of Nepal*, Part-4: 28, pl. 73 (5).

Arichanna (*Paricterodes*) *tenebraria*; Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1); *Moths of Nepal*, Part-6: 129.

Arichanna tenebraria; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 60 mm.

Diagnosis: Larger than *A. luciguttata* and forewing paler than *A. commixta*, and characterized by olive-green forewing, with fuscous and white irroration; indistinct, dark antemedial, medial, postmedial and submarginal bands, medial and postmedial approaching each other below cell. Hindwing whitish, irrorated with fuscous, a cell-spot; postmedial and submarginal line distinct.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Khasi) (Joshi et al. 2021), Sikkim, Uttarakhand (Govind WLS, Nanda Devi Biosphere Reserve) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018; Chandra et al. 2019). **Global:** China, Nepal, Taiwan (Stüning, 2000).

Genus *Biston* Leach, [1815]

225. *Biston betularia napelensis* (Linnaeus, 1758) [Plate 12.7]
TL: Nepal

Biston betularia nepalensis Inoue, 1982; *Bulletin of Faculty of Domestic Sciences, Otsuma Woman's University*, 18: 175, fig., 40 (a,b).

Biston betularia nepalensis; Yazaki, 1995; in Haruta T (ed.): Tinea 14, (suppl. 2), Moths of Nepal, Part-4: 11, pl. 100 (17).

Biston betularia nepalensis; Jiang et al., 2011; *Zookeys*, 139: 45–96.

Wing expanse: Forewing length: Male: 24 mm, Female: 25–29 mm

Diagnosis: Look close to *B. thoracicaria* but larger with greyish-black wings, basal line on the hindwing absent.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study). **Global:** China (Yunnan, Tibet), Nepal (TL) (Yazaki 1995; Jiang et al. 2011).

226. *Biston falcata* (Warren, 1893) [Plate 12.8]
[TL: Sikkim, India]

= *emarginaria* Leech, 1897; [TL: China (western)]

= *erilda erilda* (Oberthür, 1910) (*Amphidasis*); [TL: China (west)]

Eubyjodonta falcata Warren, 1893; *Proceedings of the Zoological Society of London*, 2: 416.

Biston falcata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 246.

Amphidasis clorinda Oberthür, 1910; *Études Lépid. comp.*, 4: 677.

Biston falcata; Yazaki, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2); *Moths of Nepal*, Part-4: 11, pl. 70 (14).

Biston falcata Clorinda; Parsons et al., 1999; Geometrid Moths of the World, *a List Species Lepidoptera Insects Collection British Museum*, 1: 86.

Biston falcata; Jiang et al., 2011; *ZooKeys*, 139: 72.

Biston falcata; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 62 mm.

Diagnosis: *B. falcata* has comparatively less undulating outer margin of the forewing, distinct marginal processes in the center of both wings and hindwing lacks discal spot.

Distribution: India: Arunachal Pradesh, Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand (Chandra et al. 2019). **Global:** Bhutan, China, Nepal (Yazaki 1995), Tibet.

227. *Biston regalis* (Moore, 1888) [Plate 12.9]

[TL: North West Himalayas]

Amphidasys regalis Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*, 3: 234.

Biston regalis; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 245.

Biston regalis; Leech, 1897; *The Annals and Magazine of Natural History*, 19 (6): 323.

Biston regalis; Prout, 1915; in Seitz: *The Macrolepidoptera of the world*, 4: 359, pl.19 (h).

Biston bengaliaria; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 33, pl. 10 (2).

Biston regalis regalis; Yazaki, 1993; in Haruta T (ed.): Tinea 13, (suppl. 3), *Moths of Nepal*, Part-2: 113, pl. 10 (2).

Biston regalis; Jiang et al., 2011; *ZooKeys*, 139: 68.

Wing expanse: 74 mm.

Diagnosis: Wing pattern similar with *B. exalbescens* but its forewing has comparatively thin ante medial line, a narrow brown band basal to it and less conspicuous medial line.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh (GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir), Meghalaya, Sikkim, Uttarakhand, West Bengal (Darjeeling) (Shah et al. 2018; Chandra et al. 2019; Chettri and Yonle 2021). **Global**: China, Japan, Korea (Byun et al. 2010; Choi and An 2010), Malaysia, Myanmar, Nepal (Yazaki 1993), Pakistan, Philippines, Russia, Taiwan, Thailand, USA.

Remarks: The species is a defoliator of blue pine (*Pinus wallichiana*).

228. *Biston suppressaria* (Guenee, [1858]) [Plate 12.10]

[TL: Central India]

= *luculentus* Inoue, 1992; [TL: Thailand]

= *multipunctaria* (Walker, [1863]) (*Buzura*); [TL: Silhet?]

= *suppressaria benesparsa* (Wehrli, 1941) (*Buzura*); [TL: China]

= *suppressaria benescripta* (Prout, 1915) (*Buzura*); [TL: China (West)]

Amphidasys suppressaria Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 210.

Buzura multipunctaria; Walker, 1863. *List Species Lepidoptera Insects Collection British Museum*, 26: 1531.

Biston suppressaria: Hampson, 1895. *The Fauna of British India, including Ceylon and Burma*, 3: 247.

Buzura suppressaria: Prout, 1915; in Seitz: *The Macrolepidoptera of the world,* 4: 360, pl. 19 (i).

Buzura suppressaria benescripta Prout, 1915; in Seitz: *The Macrolepidoptera of the world,* 4: 360.

Biston (Buzura) *suppressaria*: Wehrli, 1941; in Seitz: *The Macrolepidoptera of the world*, 4 (suppl.): 436.

Biston (*Buzura*) *suppressaria f. benesparsa* Wehrli, 1941, in Seitz, *The Macrolepidoptera of the world*, 4 (suppl.): 436, pl. 36 (f).

Biston luculentus Inoue, 1992; *Bulletin of Faculty of Domestic Sciences, Otsuma Woman's University,* 28: 171, figs 59, 60, 62–64.

Biston suppressaria: Yazaki, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), *Moths of Nepal*, Part-3: 25, pl. 71 (3).

Wing expanse: Male: 6–-70mm, Female: 74–80 mm.

Diagnosis: Close to *B. contectaria* but smaller and has blunt or bilobed protrusion between M1 and M3 on forewing (relatively acute in *B. contectaria*).

Distribution: India: Arunachal Pradesh, Assam, Chhattisgarh, Himachal Pradesh, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Nagaland, Sikkim, Tamil Nadu, Tripura, Uttarakhand (Askot and Govind WLS, Dehradun) (Uniyal et al. 2016; Sanyal et al. 2016), West Bengal (Shah et al. 2018; Chandra et al. 2019). **Global:** Bangladesh, Bhutan, Burma, China, Hong Kong, Japan, Laos, Malaysia, Myanmar, Nepal (Yazaki 1994), Pakistan, Sri Lanka, Thailand, Vietnam (Jiang et al. 2011).

Remarks: The species is a tea pest and its larva is famously called as tea looper.

Genus *Calcyopa* Stüning, 2000

229. *Calcyopa ochrifasciata* (Moore, 1888) [Plate 12.11]

[TL: Darjiling, West Bengal, India]

Cleora ochrifasciata Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*, 3: 240.

Boarmia ochrifasciata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 259.

Aethalura ochrifascia; Inoue, 1987; *Bulletin of Faculty of Domestic Sciences, Otsuma Woman's University,* 23: 266.

Calichodes ochrifasciatus; Sato, 1993; in Haruta T (ed.): Tinea 13 (suppl. 3); *Moths of Nepal*, Part-2: 18 pl. 36 (26).

Wing expanse: 26–28 mm.

Diagnosis: Morphologically looks similar to *M. gandakiensis* but much smaller in size, pale ochreous wings with slight olive hue, the borders of the ante and post medial lines bright olive-green.

Distribution: India: Himachal Pradesh (Dalhousie, Dharamsala, GHNP) (Mallick 2021), Meghalaya (Khasi), Sikkim, West Bengal (Darjeeling) (Shah et al. 2018). **Global:** Nepal (Sato 1993).

Genus *Chorodna* Walker, 1860

230. *Chorodna creataria* (Guenée, [1858]) [Plate 12.12]

[TL: Nord de Inde]

= *parisnattei* (Walker, [1863]) (*Elphos*?); [TL: Hindostan (India)]

Hemerophila creataria Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 217.

Medasina creataria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 286.

Medasina creataria; Swinhoe, 1894; *Transaction Entomological Society London*, 42: 217.

Medasina creataria; Sato, 1993; in Haruta T (ed.): Tinea 13, (suppl. 3), Moths of Nepal, Part-2: 23, pl. 38 (10).

Chorodna creataria; Sato, 1995; *Transactions of the Lepidopterological Society of Japan* 46 (4): 223.

Medasina creataria; Chandra and Sambath, 2013; *Journal of Threatened Taxa*, 5 (1): 3567.

Chorodna creataria; Chettri and Yonle, 2021; *International Journal of Entomology Research*, 6 (3): 92.

Wing expanse: 90 mm.

Diagnosis: Wings pale reddish-brown with some olive-green suffusion and black striations. Forewing with a dark black discal spot; an oblique, black, crenulated post medial line followed by a pale, indistinct submarginal line with a very small white blotch near the middle. Underside suffused with fuscous with white, almost rectangular apical patches on both wings.

Distribution: India: Arunachal Pradesh (Tawang) (Chandra and Sambath 2013), Assam, Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Shilong, Cherrapunji), Sikkim, West Bengal (Darjeeling) (Shah et al. 2018; Chandra et al. 2019; Chettri and Yonle 2021; Joshi et al. 2021). **Global:** Bangladesh, China, Hong Kong, Laos, Nepal (Sato 1993), Taiwan, Thailand (Sato 1995), Vietnam.

Genus *Cusiala* Moore, [1887]

231. *Cusiala boarmoides* Moore, [1887] [Plate 12.13]

[TL: Darjiling, West Bengal, India]

= *angulata* (Hampson, 1891); (*Tephrosia*); [TL: India]

= *boarmioides* Moore, 1888; [TL:India]

= *griseifusa* (Sonan, 1938) (*Boarmia*); [TL: Formosa (Taiwan)]

Cusiala boarmoides Moore, [1887]; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*, 3 (4): 407.

Cusiala boarmoides; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 248.

Wing expanse: Male: 46 mm, Female: 60 mm.

Diagnosis: *C. boarmoides* looks similar with *C. raptaria* but distinguishable as the post medial line on the hindwing is angled beyond the cell while curved in *C. raptaria*.

Distribution: India: Himachal Pradesh, Meghalaya (Khasis), Sikkim, Tamil Nadu (Nilgiiris) (Das et al. 2020; Iyer et al. 2021), Uttarakhand, West Bengal (Darjeeling, TL) (Shah et al. 2018; Singh and Lakhendra 2023). **Global:** Indonesia (Sutrisno 2005), Taiwan.

Genus *Dalima* Moore, 1868

232. *Dalima metachromata* (Walker, F., 1862) [Plate 12.14]

[TL: North India]

Abraxas metachromata Walker, F., 1862; *List Species Lepidoptera Insects Collection British Museum*, 24: 1122.

Erebraxas metachromata; Yazaki, 1993; in Haruta T (ed.): Tinea 13 (suppl. 3); *Moths of Nepal*, Part-2: 113, pl. 60 (19).

Wing expanse: 61 mm.

Diagnosis: White ground colour of wings; forewings covered with grey spots and blotches, especially in the antemedial and marginal region; a postmedial grey band with sub-confluent golden-brown spots and white area on each side and outer marginal area below the median area. Hindwings with grey specks at the base and inner area before middle, a grey spot at the end of cell and a broad irregularly sinuated, fulvous marginal band, with grey edges and black lunules; anal half being white and some grey edged fulvous specks. The posterior segments of the abdomen greyish-ochreous on the sides and an ochreous anal tuft. Body below ochreous and spotted with black.

Distribution: India: Arunachal Pradesh, Himachal Pradesh, Sikkim, Uttarakhand, West Bengal (TL) (Chandra et al. 2019). **Global:** Nepal (Yazaki 1993), Vietnam (Chandra et al. 2019).

233. *Dalima patularia* (Walker, F., 1862) [Plate 12.15]

[TL: North India]

Omiza patularia Walker, 1860; *List Species Lepidoptera Insects Collection British Museum*. 20: 247.

Catascia eolaria; Swinhoe, 1894; *Transaction Entomological Society London*:197.

Dalima patularia; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 240.

Dalima patularia; Holloway, 1976; *Moths of Borneo* with special reference to Mt. Kinabalu: 76.

Dalima patularia; Holloway, 1993; *Moths of Borneo*. 11: 177.

Dalima patularia; Yazaki, 1992; in Haruta T (ed.): Tinea 13 (suppl. 2); *Moths of Nepal*, Part-1: 31, pl. 9 (5).

Dalima patularia; Sondhi and Sondhi, 2016; *Journal of Threatened Taxa*, 8(5): 8768.

Dalima patularia; Chettri and Yonle, 2021; *International Journal of Entomology Research*, 6(3): 92.

Wing expanse: 64 mm.

Diagnosis: Wings pale reddish-brown with sparse fuscous irroration. Forewing with dark brown, obliquely straight ante and post medial lines, ante medial with bluish grey inner border and post medial with black irroration near inner margin and joined by an outwardly curved fuscous-brown line (with some bluish-grey inner border) from costa before apex; slightly curved fuscous streak near anal angle. Hindwing with dark brown inwardly curved post medial and outwardly curved submarginal lines. Underside with bright orange suffusion.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Khasi, Shillong, Cherrapunji) (Joshi et al. 2021), Sikkim, Uttarakhand (Dehradun, Bhimtal (Uniyal et al. 2016; Sanyal et al. 2017), West Bengal (Darjeeling) (Chettri and Yonle 2021). **Global:** China, Indonesia Borneo, Indonesia (Sumatra, Sulawesi), Nepal (Yazaki 1992), Thailand (Holloway 1993).

Bionomy: "On G. Kinabalu the species is frequent in the upper montane zone over an altitude range of 1200-2110 m. Two specimens taken on G. Mulu were from 1790m and one on Bukit Retak from 1465 m".

Genus *Gasterocomme* Warren, 1894

234. *Gasterocome pannosaria* (Moore, 1868) [Plate 12.16]

[TL: Bengal, (West Bengal) India]

Cleora pannosaria Moore, 1868; *Proceedings of the Zoological Society of London*: 629.

Boarmia pannosaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 281.

Boarmia sinicaria Leech, 1897; *The Annals and Magazine of Natural History*, 19 (6): 421.

Diplurodes contacta Warren, 1899; *Novitates zoologicae,* 6: 53.

Boarmia orta Bastelberger, 1911; *Ent. Rundschau*, 28(3): 22.

Gasterocome pannosaria; Holloway, 1976; *Moths of Borneo with special reference to Mt. Kinabalu*: 82

Gasterocome pannosaria; Holloway, 1993; *Moths of Borneo*, 11: 223, pl. 15 (481).

Gasterocome pannosaria; Sato, 1993; in Haruta T (ed.): Tinea 13 (suppl. 3); *Moths of Nepal*, Part-2: 17, pl. 36 (12).

Gasterocome pannosaria; Sondhi and Sondhi, 2016; *Journal of Threatened Taxa*, 8 (5): 8768.

Wing expanse: 40 mm.

Diagnosis: Forewing with a distinct, irregular, diffused, greyish-fuscous brown submarginal band sending a broad, longitudinal streak to the white discal spot and two sub basal fuscous-brown diffused lines. Hindwing darker with dense fuscous irroration and broad, diffused, marginal suffusion. Underside marking similar to upper side.

Distribution: India: Arunachal Pradesh (Pakke TR, Tale WLS) (Sondhi et al. 2021), Himachal Pradesh, Kerala (Joshi et al. 2021), Meghalaya, Sikkim (Hampson, 1895), Uttarakhand (Sondhi and Sondhi, 2016), West Bengal (TL) (Chandra et al., 2019; Sondhi et al., 2020a; Chettri 2022). **Global:** Borneo, China, Hong Kong (Wong et al. 2005), Indonesia (Java), Malaysia (Abang and Karim 2000), Nepal (Yazaki, 1998), Philippines (Sato 2002), Sundalan, Taiwan, Thailand (Holloway, 1993; Sato 2002; Chandra et al .2019).

Genus *Hypomecis* Hübner, 1821

235. *Hypomecis cineracea* (Moore, 1888) [Plate 12.17]
[TL: Darjiling, West Bengal, India]

= *ampla* (Moore, 1888) (*Astacuda*); [TL: India

= *decrepitata* (Wileman, 1911) (*Alcis*); [TL: Formosa (Taiwan)]

Astacuda cineracea Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 244.

Hypomecis cineracea; Sato, 1993; in Haruta T (ed.): Tinea 13, (suppl. 3), Moths of Nepal, Part-2: 14, pl. 35 (22).

Hypomecis cineracea; Sato, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2); *Moths of Nepal*, Part-4: 31, pl. 35 (22).

Boarmia cineracea; Hampson, 1895.*The Fauna of British India, including Ceylon and Burma*, 3: 270.

Wing expanse: 62 mm.

Diagnosis: Pale grey ground with thick and even fasciated irroration and slightly brown suffusion. Forewing with fascinated antemedial line from costa to median nervure, a medial costal spot with a disco cellular spot below it, an oblique dentate postmedial line terminating on middle of inner margin and a crenulated submarginal line with a slight which on its outer edges. Hindwing with irregular antemedial series of black spots and dentated postmedial and submarginal lines. Fuscous grey underside with black cell spots, postmedial line and suffusion on outer area, ochreous costal margin of forewing with some black strigae and white apical patch.

Distribution: India: Jammu and Kashmir, Himachal Pradesh (GHNP) (Singh et al. 2022), Kerala (Das et al. 2020), Meghalaya (Joshi et al. 2021), Sikkim, Uttarakhand (Uniyal et al. 2016; Sanyal et al. 2017; Singh et al. 2019), West Bengal (Shah et al. 2018; Chandra et al. 2019; Chettri and Yonle 2021; Singh and Lekhendra 2023). **Global:** China, Hong Kong, Indonesia (Borneo, Sumatra), Malaysia (Sabah) (Abang and Karim 2000), Nepal (Sato 1991; Sato 1993; Sato 1995), Philippines, Taiwan, Thailand.

236. *Hypomecis transcissa* (Walker, 1860) [Plate 12.18]
[TL: Silhet, Bangladesh]

= *latipennis* (Butler, 1889) (*Chogada*); [TL: India].

= *lineataria* (Walker, 1866) (*Boarmia*); [TL: Java.

Boamaia transcissa Walker, 1860; *List Species Lepidoptera Insects Collection British Museum*, 21: 380.

Serraca trenscissa; Moore, [1887]; *Lepidoptera Ceylon*, 3: 416, pl,190: 3, 3 (a).

Hypomecis transcissa; Sato, 1988; *Heterocera Sumatra*, 2: 129.

Hypomecis transcissa; Sato, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), Moths of Nepal, Part-3: 46, pl. 74 (5).

Wing expanse: 38–44 mm.

Diagnosis: Looks similar with *H. infixaria* but differs as follows: forewing ante medial line more irregular and strongly outcurved below costa; submarginal line prominent. Underside pale fuscous, small discal spots and diffused marginal black.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Assam (Joshi et al. 2021), Himachal Pradesh (Dharamshala, GHNP) (Singh et al. 2022), Karnataka, Kerala (Shamsudeen and Pathania 2022), Maharashtra, Meghalaya, Mizoram, Sikkim, Tamil Nadu, Tripura, Uttarakhand, West Bengal (Chandra et al. 2019; Chettri and Yonle 2021; Iyer et al. 2021; Joshi et al. 2021). **Global:** Bangladesh, Bhutan, Hong Kong, Indonesia (Borneo), Malaysia, Myanmar, Nepal, Sri Lanka, Thailand (Sato 1991), Vietnam.

237. *Hypomecis ratotaria* (Swinhoe, 1894) [Plate 12.19]
[TL: Khasi Hills, Meghalaya, India]

Boarmia ratotaria Swinhoe, 1894; *Tansaction Entomological Society London*: 216.

Hypomecis ratotaria; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Hypomecis ratotaria; Sato, 1994; in Haruta T (ed.): Tinea 14 (suppl. 1); *Moths of Nepal*, Part-3: 46, pl. 74 (6).

Wing expanse: 42 mm.

Diagnosis: Pale greyish-ochreous wings with fuscous black irroration. Forewings with an indistinct ante medial line, traces of the post medial line in the form of small, black streaks on the veins; a slightly indistinct, pale submarginal line and a lunular shaped ringlet at the end of cell. Hindwings colour and marking similar to forewing; postmedial line highly curved outside the cell. Underside paler with very fine black irroration and large fuscous black discal spots.

Distribution: India: Assam, Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya, Sikkim, Tamil Nadu, Uttarakhand (Govind WLS) (Uniyal et al. 2016; Sanyal et al. 2017;

Chandra et al. 2019). **Global:** Bhutan, Indonesia (Java), Myanmar, Nepal (Sato 1994), Sri Lanka.

Genus *Hyposidra* Guenée, [1858]

238. *Hyposidra talaca talaca* (Walker, F., 1862) [Plate 12.20]

[TL: Celebes, Indonesia]

= *bombycaria* (Walker, 1866) (*Lagyra*); [TL: Ceylon (Sri Lanka)]

= *deceptatura* (Walker, 1860) (*Chizala*); [TL: Hindostan, India]

= *decipiens* (Walker, 1860) (*Chizala*); [TL: ??]

= *flaccida* (Lucas, 1894) (*Lagyra*); [TL: Australia]

= *myciterna* (Druce, 1889) (*Lagyra*); [TL: Solomon Islands]

= *rigusaria* (Walker, [1863]) (*Lagyra*); [TL: Canara (Kanara)]

= *vampyraria* Snellen, 1881; [TL: Celebes (Sulawesi)]

Hyposidra talaca; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 213.

Wing expanse: Male: 44 mm, Female: 54–60 mm.

Diagnosis: Wings dark brown-fuscous, suffused and irrorated with grey; very faint although darker traces of ante medial, medial and outer crenulated post medial line. Forewing apex produced like hook tip and hindwing with slightly produced medially.

Distribution: India: Andaman and Nicobar, Assam, Chhattisgarh, Gujarat, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Sikkim, Tamil Nadu, Uttarakhand, West Bengal (Chandra et al. 2019). **Global:** Australia, China, Hong Kong, Indonesia (Borneo, Java), Japan, Malaysia, Myanmar, Nepal, Papua New Guinea, Philippines, Sri Lanka, Taiwan, Thailand.

Genus *Lassaba* Moore, 1888

239. *Lassaba albidaria* (Walker, 1866) [Plate 13.1]

[TL: India, China]

Boarmia albidaria Walker, 1866; *List Species Lepidoptera Insects Collection British Museum*, 35: 1582.

Medasina albidaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 289.

Medasin albidaria aalbidaria; Sato, 1993; in Haruta T (ed.): Tinea 13, (suppl. 3), Moths of Nepal, Part-2: 22, pl. 37 (18, 19).

Lassaba albidaria albidaria; Sato, 1995; *Transactions of the Lepidopterological Society of Japan*, 46 (4): 224.

Lassaba albidaria; Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1); *Moths of Nepal*, Part-6: 121.

Medasina albidaria; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 159.

Lassaba albidaria; Kumar et al., 2019; *Mitochondrial DNA Part B*, 4 (1): 310.

Wing expanse: 60 mm (Forewing length: 27–28 mm)

Diagnosis: Morphologically very similar to *L. parvalbidaria nepalensis* but wings dull white, slightly larger; underside with subapical, black patch absent or sometime less developed and replaced by an ill-defined, dense black, irroration while comparatively well defined in *L. parvalbidaria nepalensis*.

Distribution: India: Arunachal Pradesh (Eaglenest WLS, Pakke Tiger Reserve, Namdhapa NP, tale WLS) (Kumar et al. 2019; Sondhi et al. 2021), Himachal Pradesh (Shimla, Chamba, Dharamsala, GHNP), Meghalaya (Joshi et al. 2021), Sikkim, Uttarakhand (Devalsari, Govind WLS, Gangotri NP, Nanda Devi Biosphere Reserve, Kedarnath WLS) (Sanyal et al. 2017; Dey 2018), West Bengal, Western Ghats (Das et al. 2020); (Chandra et al. 2019). **Global:** China, Myanmar, Nepal (Sato 1993; Stüning 2000), Pakistan, Taiwan, Thailand (Sato 1995), Vietnam.

240. *Lassaba anepsia* (Wehrli, 1941) [Plate 13.2]

[TL: Yunnan, China]

Medasina anepsia Prout, 1941; in Seitz: *The Macrolepidoptera of the world*, 4, supplementary: 445, pl. 38 (h).

Lassaba anepsia; Stüning, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1); *Moths of Nepal*, Part-6: 120.

Wing expanse: 56 mm.

Diagnosis: Morphologically much alike *L. stolidaria* but distinguishable as comparatively darker with a typical white, waved submarginal line (absent in the later).

Distribution: India: Himachal Pradesh (Shimla, GHNP) (Mallick 2021), Sikkim, West Bengal (Darjeeling). **Global:** China (Yunnan), Nepal (Stüning 2000).

241. *Lassaba dissimilis* (Moore, 1888) [Plate 13.3]
[TL: Darjiling, West Bengal, India]

Medasina dissimilis Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 235.

Lassaba dissimilis; Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1); *Moths of Nepal*; Part-6: 119.

Wing expanse: 62 mm.

Diagnosis: Discussed below in *L. interrupatria*.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Kerala (Das et al. 2020), Sikkim, West Bengal (Darjeeling) (Chandra et al. 2019). **Global:** Nepal (Stüning, 2000).

242. *Lassaba interruptaria* (Moore, 1868) [Plate 13.4]
[TL: Bengal, (West Bengal) India]

Hemerophila interruptaria Moore, 1868; *Proceedings of the Zoological Society of London*: 626.

Medasina interruptaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 287.

Chorodna interruptaria; Sato, 1994; in Haruta T (ed.): Tinea, 14 (suppl. 1); *Moths of Nepal*, Part-3: 53, pl. 76 (3).

Deinotrichia interruptaria; Sato, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part-4: 33.

Lassaba interruptaria; Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1); *Moths of Nepal*, Part-6: 120.

Wing expanse: 62 mm.

Diagnosis: *L. interrupatria* looks very similar to *L. dissimilis* but is darker brown with dark black irrorations, forewing with a paler fascia from the basal to apical region; ante medial line visible only towards inner margin while sinuous in *L. dissimilis*; double, crenulated post medial line (single in the later); a dark black blotch on the middle of the costa mereging with the discal spot absent in *L. interrupatria*.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018), West Bengal (Chandra et al. 2019). **Global:** Nepal (Stüning 2000).

243. *Lassaba parvalbidaria nepalensis* (Sato, 1993) [Plate 13.5]
[TL: Nepal]

Lassaba parvalbidaria nepalensis Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal*, Part-2: 22, pl. 37 (20, 21).

Lassaba parvalbidaria nepalensis; Stüning, 2000; in Haruta T (ed.): Tinea, 16 (suppl. 1; *Moths of Nepal*, Part-6: 121.

Wing expanse: 54 mm (Forewing length: 25mm)

Diagnosis: Discussed in *L. albidaria*. Furthermore, *L. parvalbidaria nepalensis* can be separated from the nominotypical subspecies by subapical patch on the underside of wings lunulated and comparatively weaker.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, West Bengal (Darjeeling). **Global:** Nepal (Sato 1993; Stüning 2000).

Genus *Microcalicha* Sato, 1981

244. *Microcalicha fimbriata* (Moore, 1868) [Plate 13.6]
[TL: Bengal, (West Bengal) India]

Boarmia fimbriata Moore, 1868; *Proceedings of the Zoological Society of London*: 628.

Boarmia fimbriata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 275.

Microcalicha fimbriata; Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal*, Part-2: 19, pl. 37 (4).

Wing expanse: 38 mm.

Diagnosis: Wings pale ochreous with some brownish hue and greenish-fuscous irroration and striation. Forewing with a characteristic greyish-fuscous patch in the cell area, bounded by ante and post medial lines.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Nagaland (Nagas) (Joshi et al. 2021), Sikkim, West Bengal. **Global:** Nepal (Sato 1993).

Remarks: New record to Himachal Pradesh.

Genus *Myrioblephara* Warren, 1893

245. *Myrioblephara albibasis* (Hampson, 1895) [Plate 13.7]

[TL: Sikkim, India]

Boarmia albibasis Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 278.

Myrioblephara albibasis; Inoue, 1978; Bulletin of Faculty of Domestic Sciences, Otsuma Woman's University 14: 247.

Myrioblephara albibasis; Sato, 1998; in Haruta T (ed.): Tinea, 15 (suppl. 1); *Moths of Nepal*, Part-5: 24.

Myrioblephara albibasis; Sondhi and Sondhi, 2016; *Journal of Threatened Taxa*, 8(5): 8768.

Wing expanse: 28 mm.

Diagnosis: Wings snow-white with grey-fuscous irroration. Forewing has white basal half bounded by a slight dark line angled at M3, distal half beyond this line suffused with pale orange-brown; a slightly outcurved post medial series of black specks and an indistinct, denticulated, pale and maculated submarginal line. Hindwing with pale sub marginal line like forewing, with some pale brownish suffusion around it.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Assam, Himachal Pradesh (GHNP) (Mallick 2021), Sikkim, Uttarakhand, West Bengal (Shah et al. 2018) (Chandra et al. 2019). **Global:** Nepal (Sato 1998), Taiwan (Wu et al. 2020).

246. *Myrioblephara benefica* Sato, 1993 [Plate 13.8]

[TL: Nepal]

Myrioblephara benefica Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal*, Part-2: 18, pl. 36 (21).

Wing expanse: Forewing length: 12–13 mm.

Diagnosis: *M. benefica* looks very similar to *M. albibasis* (discussed previously) but the distal half in *M. benefica* has comparatively more fuscous black suffusion than in *M.*

albibasis; underside pale ochreous, heavily irrorated with fuscous; diffused submarginal black suffusion beyond post medial line, forewing with apical and middle of the outer margin paler.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study). **Global:** Nepal (TL).

Remarks: New distributional record from India.

247. *Myrioblephara gandakiensis* Sato, 1998 [Plate 13.9]
[TL: Nepal]

Myrioblephara gandakiensis Sato, 1998; in Haruta T (ed.): Tinea, 15 (suppl. 1); *Moths of Nepal*, Part-5: 23, pl. 131 (14).

Wing expanse: 30–32 mm (Forewing length: 14–15 mm).

Diagnosis: Morphologically, very similar to *M. xanthozonea* but smaller in size, antennal cilia shorter, forewings more elongated, paler, greyish-white.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021)**. Global:** Nepal (Sato, 1998).

248. *Myrioblephara harutai* Sato, 1994 [Plate 13.10]
[TL: Nepal]

Myrioblephara harutai Sato, 1994; in Haruta T (ed.): Tinea, 14 (suppl. 1), *Moths of Nepal*, Part-3: 49, pl. 75 (2).

Wing expanse: Forewing length: Male: 18–20 mm.

Diagnosis: Forewing grass-green, irrorated with black, wing pattern as in other species of the genus discussed here.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), West Bengal (Chettri 2022). **Global:** Nepal (TL).

249. *Myrioblephara idaeoides idaeoides* (Moore, 1888) [Plate 13.11]
[TL: Darjiling, West Bengal, India]

Cleora idaeoides Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 239.

Myrioblephara idaeoides; Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal*, Part-2: 17, pl. 36 (20).

Wing expanse: 26 mm.

Diagnosis: Wings dull greyish-white, irrorated with fuscous and pale ochreous-brown. Forewing with blackish, bordered with pale ochreous-brown ante medial, medial, post medial and submarginal lines (with white outer border); a characteristic, white patch in the middle of the submarginal line.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Meghalaya, Nagaland, West Bengal (Darjeeling, TL) (Shah et al. 2018; Chettri 2022; Joshi et al. 2021). **Global:** Nepal (Sato 1993), Thailand (Sato 1996).

Remarks: New distributional record to Himachal Pradesh.

250. *Myrioblephara xanthozonea* (Hampson, 1907) [Plate 13.12]
[TL: Sikkim, India]

Boarmia xanthozonea Hampson, 1907; *Journal Bombay Natural History Society*, 18: 34.

Myrioblephara xanthozonea; Inoue, 1987; *Bulletin of Faculty of Domestic Sciences, Otsuma Woman's University,* 23: 266.

Myrioblephara xanthozonea; Sato, 1994; in Haruta T (ed.): Tinea, 14 (suppl. 1), *Moths of Nepal*, Part-3: 49, pl. 75 (3).

Wing expanse: 34–40 mm.

Diagnosis: Discussed in *M. gandakiensis*.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Sikkim (TL). **Global:** Nepal (Sato 1994), Tibet.

Genus *Psilalcis* Warren, 1893

251. *Psilalcis breta breta* (Swinhoe, 1890) [Plate 13.13]
[TL: Nilgiri Hills, Tamil Nadu, India]

Narapa breta; Swinhoe, 1890; *Proceedings of the Zoological Society of London:* 426.

Psilalcis breta; Swinhoe, 1894; *Transaction Entomological Society London:* 222.

Psilalcis breta; Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal*, Part-2: 13, pl. 35 (17, 18).

Wing expanse: 33 mm.

Diagnosis: Wings pale ochreous-white, irrorated with greyish-fuscous, a slight grey suffusion and ochrous-brown cloudy along transverse lines. Forewing ante, medial and post medial lines dark black, outwardly curved, medial and post medial joining towards inner margin; a prominent, dark black discal spot; paler, highly undulating submarginal line, continue on hind wing as well.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Kerala, Tamil Nadu (Nilgiri Hills, TL), West Bengal (Das et al. 2020). **Global:** Nepal (Sato 1993), Thailand.

Genus *Xandrames* Moore, 1868

252. *Xandrames albofasciata* Moore, 1868 [Plate 13.14]

[TL: Sikkim, India]

Xandrames albofasciata Moore, 1868; *Proceedings of the Zoological Society of London*: 635.

Xandrames albofasciata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 251.

Xandrames albofasciata albofasciata; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 31, pl. 9 (10).

Xandrames albofasciata; Chandra and Sambath, 2013; *Journal of Threatened Taxa*, 5 (1): 3567.

Wing expanse: 98 mm.

Diagnosis: *X. albofasciata* is morphologically similar to *X. latiferaria* and *X. dholaria,* but differ as with more black striations on forewings and well-defined white band narrowing towards outer angle, beyond this olive-yellow below M3.

Distribution: India: Arunachal Pradesh (Eaglenest WLS, Tale WLS) (Sondhi et al. 2021), Himachal Pradesh (GHNP) (Mallick 2021), Sikkim (Chandra 2011), West Bengal (Shah et al. 2018; Chandra et al. 2019). **Global:** China, Myanmar, Nepal (Yazaki 1992), Thailand, Vietnam.

253. *Xandrames dholaria* Moore, 1868 [Plate 13.15]

[TL: Darjiling, West Bengal, India]

= *sericea* Butler, 1881; [TL: Japan]

Xandrames dholaria Moore, 1867; *Proceedings of the Zoological Society of London*: 634.

Xandrames dholaria dholaria; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), Moths of Nepal, Part-1: 32, pl. 9 (7).

Wing expanse: 85 mm.

Diagnosis: Discussed in previous species.

Distribution: India: Arunachal Pradesh (Pakke Tiger Reserve, Tale WLS) (Sondhi et al. 2021), Assam (Arandhara 2017), Himachal Pradesh (GHNP) (Mallick 2021), Nagaland (Kohima), Sikkim, Uttarakhand (Devalsari, Munsiari, Kedarnath WLS), West Bengal (Shah et al. 2018; Chettri and Yonle 2021) (Chandra et al. 2019). **Global:** China, Japan (Sato and Fukuda 1985), Korea (Byun et al. 2010; Choi and An 2010; Balint and Katona 2011; Hong et al. 2012; Jung and Oh 2012; Lim et al. 2013), Nepal (Yazaki 1992), Taiwan (Wu et al. 2020), Thailand.

UNASSIGNED

Genus *Abraxesis* Hampson, 1902

254. *Abraxesis melaleucaria* Hampson, 1902 [Plate 13.16]

[TL: Simla, Himachal Pradesh]

Abraxesis melaleucaria Hampson, 1902; *Journal Bombay Natural History Society*, 14: 510.

Abraxesis melaleucaria; Gyula et al., 2018; in Fibigeriana Supplement: *The Vartian Collection, Geometridae*, Part-4: 52, pl. 85 (17–19).

Wing expanse: 54 mm.

Diagnosis: White wings with black irrorations and maculations often coalescing to form irregular patches or bands. On the forewing, these markings form three irregular bands; a curved antemedial band seems connected to the outer highly irregular postmedial band; the subterminal band with its patchy extensions towards the outer margin below the apex and middle. Hindwing with a large black discoidal discal spot, and an incomplete dotted postmedial and subterminal bands, the subterminal band often connected with the marginal black dots. Abdomen with a series of black triangular patches which become almost linear on the last segment.

Distribution: India: Himachal Pradesh (TL: Shimla, 7,000 feet). **Global:** Afghanistan, Pakistan (Gyula et al. 2018).

Genus *Amraica* Moore, 1888

255. *Amraica recursaria* (Walker, 1860) [Plate 13.17]

[TL: Central Hindostan (Central India)]

= *fortissima* Moore, 1888; [TL: India]

Biston recursaria Walker, 1860; *List Species Lepidoptera Insects Collection British Museum*, 21: 374.

Amraica recursaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 246.

Amraica recursaria; 1894; *Novitates zoologicae*: 427.

Buzura recursaria; Sato, 1981; 32: 85.

Amraica recursaria; Sato, 1993; in Haruta T (ed.): Tinea 13, (suppl. 3), Moths of Nepal, Part-2: 24, pl. 38 (11).

Wing expanse: Male: 70–80 mm, Female: 50–90 mm.

Diagnosis: Wings pale greyish-ochreous with grey and brown striations. Male with very long uniseriate pectination. Forewing with brown basal patch outlined by a black line and similar apical costal patch.

Distribution: India: Arunachal Pradesh, **Himachal Pradesh** (Dhauladhar mountains-current study), Maharashtra (Bassein) (Gurule and Nikam 2013), Meghalaya (Khasi) (Joshi et al. 2021), Madhya Pradesh, Sikkim (Hampson 1895), Tamil Nadu, Uttarakhand (Chandra et al. 2019). **Global:** Borneo, Hong Kong, Indonesia (Java, Sumatra), Japan, Malaysia, Myanmar (Hampson 1895), Nepal (Sato 1981; Sato 1993), Pakistan, Taiwan, Thailand.

Remarks: New record to Himachal Pradesh.

Genus *Anonychia* Warren, 1893

256. *Anonychia diversilinea* Warren, 1897 [Plate 13.18]

[TL: Sikkim, India]

Anonychia diversilinea Warren, 1897; *Novitates zoologicae*, 4: 101.

Anonychia diversilinea; Prout, 1926; *Journal Bombay Natural History Society*, 31: 790.

Anonychia diversilinea; Yazaki 1993; in Haruta T (ed.): Tinea 13, (suppl. 3), *Moths of Nepal*, Part-2: 112, pl. 60 (15).

Wing expanse: Male: 32 mm; Female: 38 mm.

Diagnosis: Very similar to *A. grisea* but can be easily distinguished based on its "pale wooden-brown" ground colour of the forewings, an outwardly oblique antemedial line with reddish-brown hue on its outer edge, blackish cell-spot with a brown spot above it on the costa, a brown subapical costal spot with hind margins lacking the distinct grey-brown shade (present in A. grisea). Pale-brown whitish hind wings with a small cell spot and a reddish-brown postmedial line; fairly distinct on the inner margin and disappear towards costal margin. Reddish-ochreous underside with many distinct red-brown striae. On hindwing a sharply bent submarginal brown line.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Sikkim (TL), West Bengal (Shah et al. 2018). **Global:** Nepal (Yazaki 1993).

Remarks: New record to Himachal Pradesh.

257. *Anonychia grisea* (Butler, 1883) [Plate 13.19]
[TL: North Hindustan]

= *exilis* Yazaki, 1994; [TL: Nepal]

Nadagara grisea Butler, 1883; *Proceedings of the Zoological Society of London*: 172.

Onychia grisea Swinhoe and Cotes, 1887; *Moths of India*: 574.

Anonychia grisea Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 178.

Anonychia grisea; Leech, 1897; *The Annals and Magazine of Natural History*, 20b (6): 225.

Anonychia grisea; Prout, 1926; *The Journal of the Bombay Natural History Society*, 31: 790.

Anonychia grisea; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 27, pl. 8 (3).

Wing expanse: 32 mm.

Diagnosis: Forewings with "pearl-grey" ground colour; a broad medial band lined with dark rufous-brown edges with narrow dark belts inner to the edges, the inner one straight and outer one strongly protruded outwards above middle and deeply concave on each side of protrusion with an even curve towards inner margin. Hindwings with a nearly straight postmedial line, almost indistinct near costal margin.

Distribution: India: Arunachal Pradesh, Himachal Pradesh (GHNP) (Mallick 2021), Madhya Pradesh (Indore) (Chandra 2007), Meghalaya (Khasi), Sikkim, Uttarakhand (Dey 2018), West Bengal (Chettri and Yonle 2021) (Chandra et al. 2019; Singh 2023). **Global:** China, Myanmar, Nepal (Yazaki 1992).

258. *Anonychia lativitta* (Moore, 1888) [Plate 13.20]
[TL: Darjiling, West Bengal, India]

Onychia lativitta Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 279.

Anonychia lativitta; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 178.

Anonychia lativitta; Yazaki, 1994; in Haruta T (ed.): Tinea 14, (suppl. 1), *Moths of Nepal*, Part-3: 22, pl. 70 (5).

Anonychia lativitta; Yazaki, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2); *Moths of Nepal*, Part-4: 11, pl. 70 (5).

Anonychia lativitta; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Wing expanse: 38 mm.

Diagnosis: Forewings "pale cinereous ferruginous-brown"; a broad medial band "dark-cuprescent-brown" with its inner edge obliquely outwardly excurved near inner margin, the outer edge protruded as in *A. grisea*; the outer margin with a slight dark suffusion below apex. Hindwing "brownish-cinereous" with a faint spotted recurved postmedial line on underside.

Distribution: India: Himachal Pradesh (TL: Dalhousie, GHNP) (Mallick 2021), Sikkim, Uttarakhand (Govind WLS, Nanda Devi Biosphere Reserve) (Uniyal et al. 2016; Sanyal et al 2017; Dey 2018), West Bengal (Darjeeling, TL) (Shah et al. 2018). **Global:** Nepal (Yazaki 1994; Yazaki 1995).

Genus *Antipercnia* Inoue, 1992

259. *Antipercnia belluaria* (Guenée, 1858) [Plate 14.1]

[TL: North India; West China]

= *guttata* (Felder and Rogenhofer, 1875) (*Percnia*); [TL: India]

= *longimacula* (Warren, 1897) (*Percnia*); [TL: India]

Percnia belluaria Guenée, 1857; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 10: 217.

Percnia belluaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 308.

Percnia belluaria; Leech, 1897; *The Annals and Magazine of Natural History*, 20(6): 455.

Percnia belluaria belluaria; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 30, pl. 9 (2).

Percnia belluaria; Sondhi and Sondhi, 2016; *Journal of Threatened Taxa*, 8 (5): 8768.

Percnia belluaria; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Antipercnia belluaria; Kumar et al., 2019; *Mitochondrial DNA Part B*, 4 (1): 310.

Wing expanse: 72 mm.

Diagnosis: Looks very similar to *A. felinaria* but *A. belluaria* is comparatively paler and with relatively smaller black spots.

Distribution: India: Arunachal Pradesh (Pange, Eaglenest WLS, Namdhapa NP) (Kumar et al. 2019; Sondhi et al. 2021), Assam, Himachal Pradesh (Dalhousie, GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir), Meghalaya (Cherrapunjee) (Joshi et al. 2021), Mizoram, Nagaland (Pangti, Kigwema), Sikkim, Uttarakhand (Devalsari, Govind WLS), West Bengal (Darjeeling) (Shah et al. 2018; Chettri and Yonle 2021; Chandra et al. 2019). **Global:** Bhutan, China (TL), Malaysia, Nepal (Yazaki 1992), Thailand.

Genus *Anydrelia* Prout, 1938

260. *Anydrelia dharamsalae* (Butler, 1883) [Plate 14.2]

[TL: Dharmsala, Himachal Pradesh, India]

Ephyra dharamsalae Butler, 1883; *Proceedings of the Zoological Society of London*: 169.

Venusia dharamsalae; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 417.

Discoloxia dharamsalae; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 271.

Anydrelia dharamsalae; Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary*: 177, pl.16 (f).

Wing expanse: 30 mm.

Diagnosis: Wings very pale reddish-pink with some fuscous irrorations. Both wings with numerous indistinct, slightly darker, transverse lines with well-defined fuscous-grey medial line followed by some darker brownish shade and a submarginal series of slightly indistinct black submarginal spots.

Distribution: India: Himachal Pradesh (Dharamshala, Kullu). **Global:** China (Western).

Genus *Charissa* Curtis, 1826

261. *Charissa crenulata crenulata* (Staudinger, 1871) [Plate 14.3]
[TL: Spain]

= *tormoi* (Expósito Hermosa, 1996) (*Gnophos*); [TL: Spain]

Gnophos crenulata; Guenée, 1857; in Boisduval and Guenée, *Histoire naturelle des insectes* (*Spécies général des lépidoptères*), 9: 306.

Gnophos crenulata; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 389, pl. 25 (k).

Charissa crenulata; Gyula et al., 2018; in Fibigeriana Supplement: *The Vartian Collection, Geometridae*, Part-4: 50, pl. 80 (37–40).

Wing expanse: Forewing length: Male: 18–20 mm, Female: 20–21 mm.

Diagnosis: Antennae filiform. Wings pale ochreous with very dense, darker, greenish-grey irroration. Forewing with dentated ante and post medial lines which sometimes fades away and appears only as a series of spots on the veins; a darker, nearly ovoid, discal ringlet. Underside paler with greenish-grey irroration, especially before the irregularly dentated postmedial line (corresponds to the postmedial line of the upper side).

Distribution: India: India: Himachal Pradesh (Dhauladhar mountains-current study). **Global:** Spain (Gyula et al. 2018)**.**

Genus *Cleora* Curtis, 1825

262. *Cleora propulsaria* (Walker, F., 1860) [Plate 14.4]

[TL: Sarawak, Borneo]

Boarmia propulsaria Walker, 1860; *List Species Lepidoptera Insects Collection British Museum*, 21: 38.

Boarmia propulsaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 265.

Wing expanse: 24-26 mm.

Diagnosis: Wings pale, whitish-ochreous, suffused and irrorated with fuscous-grey and orange-brownish. Forewing with dentated ante and post medial lines accompanied by irregular, narrow, brown bands; submarginal line paler. Hindwing marking similar to forewing. Pale underside, fuscous suffusion; large black discal spot (also on upper side but with pale center), larger those on forewing; more or less complete fuscous-black marginal band beyond post medial line, white patch-one apical and other one on the middle of outer margin of both wings (both appear as pale patches on the upper side of wings).

Distribution: India: Arunachal Pradesh (Namdapha NP) (Kumar et al. 2019), **Himachal Pradesh** (Dhauladhar mountains-current study), Kerala (Das et al. 2020, Meghalaya, Nagaland (Joshi et al. 2021), Sikkim, Tamil Nadu, West Bengal (Chandra et al. 2019). **Global:** Bhutan, China, Indonesia (Borneo, Sumatra), Malaysia, Myanmar, Philippines, Taiwan, Thailand (Holloway 1993).

Remarks: New record to **Himachal Pradesh.**

Genus *Dasyboarmia* Prout, 1928

263. *Dasyboarmia subpilosa* (Warren, 1894) [Plate 14.5]

[TL: Khasia Hills, Meghalaya, India]

= *canidorsata instigata* (Prout, 1929) (*Hemerophila*); [TL: Moluccas]

Hemerophila subpilosa Warren, 1894; *Novitates Zoollogicae*: 434.

Hemerophila canidorsata instigate; Prout, 1929; *Bulletin Hill Museum*, 3: 41.

Menophra subpilosa; Sato, 1987; *Tinea* (suppl. 12): 253.

Dasyboarmia subpilosa; Holloway, 1993; *Moths of Borneo*, Part-11.

Wing expanse: Forewing length: Male:17–18 mm, Female: 17–19 mm.

Diagnosis: The female of the *D. subpilosa* appears similar to that of the *Menophra subsimilis* but distinguishable based on the dark fasciated grey shade beyond postmedial line on the forewing, below the pale apical patch while absent in *D. subpilosa*. Also, on the underside the wings are darker with black irroration in the *M. subsimilis,* absent in the former.

Distribution: India: Himachal Pradesh, Kerala (Das et al. 2020), Meghalaya (Khasia, TL), Uttarakhand (Uniyal et al. 2016; Sanyal et al. 2017; Singh 2023), West Bengal (Chettri 2022). **Global:** Buru, Borneo, Peninsular Malaysia (Abang and Karim 2000), Nepal, Philippines, Sulawesi, Sumatra, Thailand (Holloway 1993).

Genus *Entomopteryx* Guenée, [1858]

264. *Entomopteryx obliquilinea* (Moore, 1888) [Plate 14.6]

[TL: Darjiling, West Bengal, India]

Epione obliquilinea Moore, 1888, *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 229.

Spilopera obliquilinea; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma,* 3: 192.

Callerinnys obliquilinea; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 345.

Callerinnys obliquilinea obliquilinea; Yazaki 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 37, pl. 12 (1).

Wing expanse: 28 mm.

Diagnosis: Wings ochreous-yellow with ochreous-brown strigae especially towards the outer marginal area. Forewing with apex slightly produced, ante medial line ill-defined, bend below costa, an obliquely straight brownish band from apex to near the middle of the inner margin, large black discal spot. Hindwing with brownish medial band narrower towards inner margin. Underside pale, irrorated and a submarginal series of black spots on veins.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Assam, **Himachal Pradesh** (Dhauladhar mountains-current study), Meghalaya (Joshi et al. 2021), Sikkim, Uttarakhand, West Bengal (Darjeeling) (Shah et al. 2018) (Chandra et al. 2019). **Global:** Bhutan, China, Hong Kong, Myanmar, Nepal (Yazaki 1992), Vietnam.

Remarks: New record to Himachal Pradesh.

Genus *Heterostegane* Hampson, 1893

265. *Heterostegane subtessellata* (Walker, F., [1863]) [Plate 14.7]
[TL: India]

= *quadrilineata* (Snellen, 1886) (*Terpnomicta*); [TL: Sumatra].

Macaria subtessellata Walker, 1862; *List Species Lepidoptera Insects Collection British Museum*, 26: 1648.

Stegania subtessellata; Butler, 1889, *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 7: 22.

Stegania subtessellata; Hampson, 1891; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 8: 29, pl. 156 (b).

Heterostegina subtessellata; Singh, 1953; *Indian Forest Records*, 8 (7): 76.

Heterostegane subtessellata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 165, (fig. 92).

Heterostegane subtessellata; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 21, pl. 7 (12).

Wing expanse: 30 mm.

Diagnosis: Wings yellow coloured, irrorated with rusty-red. Forewing with rust coloured antemedial line angled at median nervure, a slightly sinuous medial and lunulated postmedian line, submarginal line being angled towards margin and exterminate in a blotch at outer angle. Hindwing with straight antemedial and curved crenulated postmedial line which arises from a blotch on the costa, slightly sinuous submarginal line.

Distribution: India: Andaman Island (Chandra 1994; Chandra and Rajan 2004), Arunachal Pradesh, Assam, Himachal Pradesh (Dharamshala, Spiti) (Kumar et al. 2018; Sidhu et al. 2022), Karnataka, Kerala, Leh, Maharashtra (Gurule and Nikam 2013), Meghalaya (Khasi), Sikkim, Tamil Nadu (Nilgiris), Uttarakhand (Govind WLS, Dehradun), West Bengal (Uniyal et al. 2016; Sanyal et al. 2017; Mathew et al. 2018; Das et al. 2020; Chandra et al. 2019; Chettri and Yonle 2021; Joshi et al. 2021; Kumar and Sharma 2022; Shamsudeen and Pathania 2022). **Global:** Australia, Bhutan, China (Tibet), Hong Kong, Indonesia (Java, Borneo, Sumatra, Bali), Malaysia (Abang and Kareem 2000), Myanmar, Nepal (Yazaki 1992), Taiwan, Thailand, Vietnam.

Genus *Hyalinetta* Swinhoe, 1894

266. *Hyalinetta circumflexa* (Kollar, [1844]) [Plate 14.8]

[TL: Massuri, Uttarakhand, India]

Ennomos circumflexa Kollar, 1844; in Hugel, *Kaschmir und das Reich Siek*, 4: 485.

Hyalinetta circumflexa; Yazaki 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1; 27, pl. 8 (4).

Wing expanse: Forewing length: Male: 15 mm.

Diagnosis: Wings grey with some fuscous and brown irrorations and crenulated outer margins. Forewing with a dark brown, incomplete and nearly triangular, medial, costal patch with a transparent "circumflex" (^) shaped mark which is a characteristic feature of the species.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh, Meghalaya (Joshi et al. 2021), Uttarakhand (Mussoorie, TL), West Bengal (Moore 1867; Chandra et al. 2019). **Global:** Bhutan, China, Nepal (Yazaki 1992), Thailand.

Genus *Hyperythra* Guenée, [1858]

267. *Hyperythra lutea* (Stoll, 1781) [Plate 14.9]

[TL: Java]

= *ennomaria* Guenée, [1858]; [TL: [India]

= *flauaria* (Fabricius, 1787) (*Phalaena*); [TL: India orientali

= *flavata* (Fabricius, 1794) (*Phalaena*); [TL: India orientali

= *limbolaria* Guenée, [1858]; [TL: Indes Orientales; Ceylon (Sri Lanka); (India), Bengale (Bengal)]

= *lutearia* (Herrich-Schäffer, [1856]) (*Acroleuca*); [TL: ??]

= *luteata* Guenée, [1858]; [TL: ??]

= *penicillaria* Guenée, [1858]; [TL: India]

= *rufifimbria* Warren, 1896; [TL: India]

Phaelena lutea Stoll, 1781; in Cramer, *Uitlandsche Kapellen*, 4 (29-31): 157, pl. 370 (C, D).

Hyperythra lutea; *Proceedings of the Zoological Society of London*: 620.

Hyperythra lutea; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 320.

Hyperythra lutea; Prout, 1926; *Journal Bombay Natural History Society*, 31: 795.

Hyperythra lutea; Prout, 1930; *Bulletin Hill Museum*, 4: 142.

Hyperythra lutea; Warren, 1888; *Proceedings of the Zoological Society of London*: 318.

Hyperythra lutea; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 218 (119).

Hyperythra lutea; Singh, 1953; *Indian Forest Records*, 8 (7): 96 (fig. 45, 46, 75) (Larva).

Wing expanse: 36–42 mm.

Diagnosis: Female bright yellow, male paler and suffused with pink and sparsely irrorated with fuscous scales. Both wings with prominent fuscous-brown, slightly sinuous submarginal line, and obscure ante medial and medal lines. Hindwing with two prominent dark black spots close to post meial line near costa. Underside with dark brown more or less complete, marginal band with a white patch near apex in forewing,

Distribution: India: Throughout India (Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chattisgarh, Himachal Pradesh, Jharakhand, Karnataka, Kerala, Meghalaya, Maharashtra, Punjab, Sikkim, Tamil Nadu, Uttarakhand, West Bengal (Chandra et al. 2019). **Global:** Africa, Australia, Bangladesh, Borneo, Cambodia, China, Hong Kong, Indonesia (Java, Sumatra), Laos, Malaysia, Myanmar (Burma), Nepal, Papua New Guinea, Philippines, Sri Lanka (Ceylon), Thailand.

Genus *Ligdia* Guenée, 1857

268. *Ligdia coctata* Guenée, 1857 [Plate 14.10]

[TL: Chamba, Himachal Pradesh, India]

= *adustata inspersata* (Staudinger, 1879) (*Abraxas*); [TL: [Asia Minor]

= *efferata* (Walker, 1862) (*Melanthia*); [TL: ??]

= *restitutata* (Walker, 1862) (*Melanippe*); [TL: India]

Ligdia coctata Guenée, 1857; in Boisduval and Guenee, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 10: 210.

Ligdia coctata; Yazaki, 1993; in Haruta T (ed.): Tinea 13 (suppl. 3); *Moths of Nepal*, Part-2: 112, pl. 60 (12).

Wing expanse: 30 mm.

Diagnosis: Yellowish-white ground colour of the wings sparsely irrorated with grey. Basal area of forewings and thorax are shiny burnt black which is edged with black on forewings and narrows toward the inner margin, similar burnt (brownish-black) postmedial band diffused outwardly to margins except at apex and with a black irrorated line on its inner edges. Hindwings are stained with light grey-brown especially on postmedial region with its base streaked with black and a medial series of black spots. Both the wings crossed by a white, toothed subterminal line. On underside all are tinged with ochreous and streaked with black; forewing with subterminal black band.

Distribution: India: Himachal Pradesh (TL: Chamba, GHNP) (Mallick 2021), Madhya Pradesh, Punjab, Uttarakhand (Chandra et al. 2019). **Global:** Bulgaria, Kazakhstan, Kyrgyzstan, Nepal (Yazaki 1993), Pakistan, Tajikistan, Uzbekistan.

Genus *Micrabraxas* Butler, 1889

269. *Micrabraxas grandis* Yazaki, 1995 [Plate 14.11]
[TL: Nepal]

Micrabraxas grandis Yazaki, 1995; in Haruta T (ed.): Tinea, 14 (suppl. 2); *Moths of Nepal*, Part-4: 11, pl. 100 (18).

Wing expanse: 35–37 mm,

Diagnosis: Looks somewhat similar to *M. incolorata* (31–35 mm) but *M. grandis* comparatively larger. Wings very pale whitish-ochreous, irrorated and slightly clouded with greenish-fuscous. Forewing with sub basal, ante medial, medial and post medial bands obscure and with a series of dark black spots, submarginal line pale, obscure and with series of black dots, more prominent towards costa and inner margin

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021). **Global:** Nepal (TL).

Remarks: No species card on LepIndex.

270. *Micrabraxas seriopuncta* (Hampson, 1902) [Plate 14.12]
[TL: Yatong, Tibet]

Loxaspilates seriopuncta Hampson, 1902; *Journal Bombay Natural History Society*, 14: 498.

Micrabraxas seriopuncta; Yazaki, 1994; in Haruta T (ed.): Tinea, 14 (suppl. 1); *Moths of Nepal*, Part-3: 25, pl. 71 (6).

Wing expanse: 40 mm.

Diagnosis: Forewing pale ochreous with fine fuscous irroration; pale submarginal line with four black spots below costa and two above the inner margin. Hindwing paler.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Uttarakhand (Dey 2018). **Global:** Nepal (Yazaki 1994), Tibet (Yatong) (TL).

Remarks: This is new faunal record to Himachal Pradesh.

271. *Micrabraxas tenuis* (Warren, 1897) [Plate 14.13]
[TL: North West India]

Ectropis tenuis Warren, 1897; *Novitates zoologicae*, 4: 249.

Micrabraxas tenuis; Gyulai et al., 2018; in Fibigeriana Supplement: *The Vartian Collection, Geometridae*, Part-4: 49, pl. 76 (25).

Wing expanse: 32 mm.

Diagnosis: Forewing elongated, semitransparent, very pale whitish-ochreous, irrorated with fine, fuscous irroration; an obscure, highly outwardly curved and fuscous ante medial line; slightly inwardly curved post medial line; both lines with black longitudinal streaks or narrow wedge-shaped marks on veins, discal spot obscure. Hindwing paler, no prominent marking and black streaks in the submarginal region.

Distribution: India: Himachal Pradesh (Dalhousie, TL). **Global:** Pakistan (Gyula, et al. 2018).

Genus *Sirinopteryx* Butler, 1883

272. *Sirinopteryx ablunata* (Guenée, 1858) [Plate 14.14]
[TL: North Western Himalayas; Central India]

= *kashmirica* (Warren, 1899) (*Stenorumia*); [TL: Kashmir]

= *pangiaria* (Felder and Rogenhofer, 1875) (*Opisthograptis*); [TL: Himalayas]

Rumia ablunata Guenée, 1858; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 110.

Stenorumia ablunata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 183.

Sirinopteryx ablunata; Yazaki, 1998; in Haruta T (ed.): Tinea, 15 (suppl. 1); *Moths of Nepal*, Part-4: 16, pl. 130 (11).

Stenorumia ablunata; Sanyal et al. 2017; *SHILAP Revista de lepidopterología*, 45 (177): 143-163.

Wing expanse: 26 mm.

Diagnosis: Looks similar to *S. duplicilinea* but differs as *S. ablunata* is bright lemon-yellow coloured and without irrorations; forewing costa rufous and two obliquely curved lines starting below apex, inner one towards base and outer to the middle of inner margin and a similar somewhat indistinct discal spot.

Distribution: India: Himachal Pradesh (Dharamsala, Dalhousie, GHNP) (Mallick 2021), Uttarakhand (NDBR) (Uniyal et al. 2016; Sanyal et al. 2017; Dey 2018). **Global:** Nepal (Yazaki 1998).

Genus *Orthobrachia* Warren 1895

273. *Orthobrachia latifasciata* (Moore, 1888) [Plate 14.15]
[TL: Darjiling, West Bengal, India]

Stegania latifasciata Moore 1888, *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 260.

Stegania latifasciata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 167.

Orthobrachia latifasciata; Yazaki, 1992; in Haruta T (ed.); Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 21, pl. 7 (8).

Orthobrachia latifasciata; Huang et al. 2016; *Zookeys*: 121.

Wing expanse: 46 mm.

Diagnosis: Wings ochreous-yellow, irrorated with browns and grey strigae. Looks close to *O. flavidior* but differs as forewing with ante medial line outwardly curved and lunulated, post medial line inwardly sinuous with lunulate discal spot in between and grey and brown irrorations more towards inner margin. Hindwing with white medial band, broader at costa and black discal spot.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), **Himachal Pradesh** (Dhauladhar mountains-current study), Meghalaya (Khasi), Sikkim, West Bengal (Darjeeling) (Hampson 1895). **Global:** China (Huang et al. 2016); Nepal (Yazaki 1992).

Remarks: New record to Himachal Pradesh.

Bionomy: Adults fly in summer and autumn and are "distributed in the high mountains, usually above 2000 m and up to 3000 m in altitude" (Huang et al. 2016).

Genus *Paradarisa* Warren, 1894

274. *Paradarisa comparataria* (Walker, F., 1866) [Plate 14.16]

[TL: North Hindustan]

= *exclusaria* (Walker, 1860) (*Boarmia*?); [TL: Ceylon (Sri Lanka)]

Boarmia comparataria Walker, F., 1866; *List Species Lepidoptera Insects Collection British Museum*, 35: 1582.

Tephrosia comparataria; Moore, 1867; *Proceedings of the Zoological Society of London*: 631.

Boarmia comparataria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 263.

Paradarisa comparataria; Warren, 1894; *Novitates zoologicae*: 433.

Paradarisa comparataria; Sato, 1980; *Japan Heterocist*, 106: 86-88.

Paradarisa comparataria comparataria; Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal, Part*-2: 16, pl. 36 (9).

Wing expanse: 46 mm.

Diagnosis: Wings pale yellow-ochreous, suffused with very pale brownish-green and striated with brownish-fuscous, denser in basal and outer region beyond post medial line. Forewing with costa darker; ante medial line sinuous, fuscous, double and slightly indistinct; medial line indistinct; post medial prominent, obliquely sinuous; pale, sinuous submarginal line. Underside with dark suffusion beyond post medial line. Male with the underside of abdomen clothed with long hairs.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Kerala (Travancore), Sikkim (Hampson 1895), West Bengal (Shah et al. 2018; Das et al. 2020). **Global:** Nepal (Sato 1993).

Remarks: New record to Himachal Pradesh.

Genus *Peratostega* Warren, 1897

275. *Peratostega deletaria deletaria* (Moore, 1888) [Plate 14.17]
[TL: Darjiling, West Bengal, India]

Macaria deletaria Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 261, pl. (14).

Bapta deletaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 155.

Lomographa deletaria; Prout, 1912–1916; in Seitz, *The Macrolepidoptera of the world,* 4: 317, pl.

Cassyma deletaria deletaria; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 26, pl. 7 (20).

Peratostega deletaria; Choi, 2013; *Animal Systematics, Evolution and Diversity*, 29 (1): 94.

Wing expanse: 36 mm.

Diagnosis: Wings very pale ochreous, suffused with very pale brownish-grey, irrorated with fine fuscous scales. Forewing with apex slightly produced, pale ochreous, sinuous ante medial and medial lines and inwardly lunulate, dark brownish-fuscous post medial line, paler subapical patch with traces of sinuous submarginal line and series of black spots. Hindwing slightly produced in the middle with markings almost similar as forewing.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh, Meghalaya (Joshi et al. 2021), Uttarakhand, West Bengal (Shah et al. 2018; Chandra et al. 2019). **Global:** China (Choi 2013), Japan (Jinbo et al. 2014), Korea (Choi et al. 2013; Choi et al. 2014), Nepal (Yazaki 1992), Taiwan.

Genus *Petelia* Herrich-Schäffer, 1855

276. *Petelia riobearia* (Walker, 1860) [Plate 14.18]

[TL: Nepal]

Hyperythra riobearia Walker, 1860; *List Species Lepidoptera Insects Collection British Museum*, 20: 129.

Alana riobearia; Hampson, 1891; *Illustration Typical Specimens Lepidoptera Heterocera Collection British Museum*, 8: 27.

Hyperythra riobearia; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 217.

Hyperythra ? riobearia; Yazaki, 1992; in Haruta T (ed.): Tinea 13, (suppl. 2), *Moths of Nepal*, Part-1: 28, pl. 8 (7).

Wing expanse: 36–42 mm.

Diagnosis: Wings reddish-brown ochreous with some patchy, pale brownish-orange suffusion and sparse fuscous irroration. Forewing with a very dense fuscous irroration on the costa; brownish, straight sub basal and ante medial lines; a black discal dot just after the ante medial line; markings beyond the cellular region very irregular consist of a fuscous-brown, sinuous, indistinct submarginal line with fuscous-grey clouds beyond, below apex and in the middle and, dense brown, patchy irroration before. Hindwing with a very prominent white discal dot.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study), Meghalaya (Khasi), Sikkim, Tamil Nadu (Nilgiris), West Bengal (Chettri 2022). **Global:** Indonesia (Borneo, Celebes), Nepal (TL) (Yazaki 1992), Sri Lanka (Ceylon).

Remarks: New record to Himachal Pradesh.

Genus *Racotis* Moore, [1887]

277. *Racotis boarmiaria* Guenée, [1858] [Plate 14.19]

[TL: India]

= *anaglyptica* Prout, 1935; [TL: Java (East)]

= *quadripunctata* Holloway, [1994]; [TL: Borneo]

Hypochroma boarmiaria Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 9: 282.

Racotis boarmiaria obliterata Warren, 1894; *Novitates zoologicae,* 1 (2): 432.

Racotis boarmiaria plenifasciata Warren, 1894; *Novitates zoologicae,* 1 (2): 432.

Boarmia boarmiaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma,* 3: 261.

Racotis boarmiaria japonica Inoue, 1953; *Tinea*, 1 (1): 16.

Racotis boarmiaria; Holloway, 1976; *Moths of Borneo with special reference to Mt. Kinabalu*: 80.

Racotis boarmiaria; Sato, 1993; in Haruta T (ed.): Tinea 13, (suppl. 3), Moths of Nepal, Part-2: 16, pl. 36 (7).

Racotis boarmiaria; Holloway, 1993; *Moths of Borneo,* Part-11: 194, pl. 10 (408).

Wing expanse: 45 mm.

Diagnosis: Wings pale whitish-ochreous, suffused with pale brownish-green and thickly irrorated with fuscous brown-black. Forewing with black, sinuous, not clearly visible and somewhat confusing ante medial, medial and post medial lines with distinct costal spots at strating point; black discal spot just before medial line (somewhat get mixed with the irroration) and a sinuous, pale submarginal line. Hindwing marking similar to forewing. Underside paler, slight irroration in basal region, large black discal spot comparatively larger on forewing and a broad fuscous-black marginal band on both wings.

Distribution: India: Assam, **Himachal Pradesh** (Dhauladhar mountains-current study), Karnataka (Ravindrakumar 2021), Kerala, Manipur, Nagaland (Nagas), Sikkim, Tamil Nadu, Tripura, West Bengal (Darjeeling) (Shah et al. 2018; Das et al. 2020; Joshi et al. 2021). **Global:** Bhutan, Borneo, Formosa, Indonesia (Java), Japan, Malaysia, Nepal (Sato 1993), Sri Lanka (Ceylon), Taiwan (Holloway 1993; Abang and Kareem 2000; Jinbo et al. 2014; Wu et al. 2020).

Bionomy: *See* Holloway (1993).

Genus *Satoblephara* Holloway, [1994]

278. *Satoblephara nepalensis* Sato, 1993 [Plate 14.20]

[TL: Nepal]

Diplurodes nepalensis Sato, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal*, Part-2: 19, pl. 36 (22) (Genitalia figure: 160-161).

Wing expanse: Forewing length: Male: 13–14 mm; Female: 15 mm.

Diagnosis: Very similar to *S. hollowayi* but differs in having forewings with a distinct postmedial line which strongly outcurves beyond discocellular spot, the region beyond postmedial line less tinged with purple.

Distribution: India: Himachal Pradesh (Dhauladhar mountains-current study). Sikkim (Sato 1993). **Global:** Nepal (TL).

Remarks: New record to Himachal Pradesh.

Genus *Xenoplia* Warren, 1894

279. *Xenoplia foraria* (Guenée, [1858]) [Plate 15.1]

[TL: Indes-Orientales]

= *submissa* (Warren, 1893) (*Percnia*); [TL: India]

Percnia foraria Guenée, [1858]; in Boisduval and Guenée, *Histoire Naturelle des Insectes* (*Species général Lépidoptérés*), 10: 217.

Percnia foraria; Walker, 1862; *List Species Lepidoptera Insects Collection British Museum*, 14: 1133.

Percnia foraria; Cotes and Swinhoe, 1888; *Catalogue Moths India*: 3715.

Percnia foraria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 307.

Percnia foraria; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 306, pl. 14 (e).

Xenoplia foraria; Yazaki, 1993; in Haruta T (ed.): Tinea, 13 (suppl. 3); *Moths of Nepal,* Part-2: 113, pl. 60 (18).

Wing expanse: 48–56 mm (FBI).

Diagnosis: Externally similar to *A. belluaria* but is comparatively smaller and paler.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh (Dharamshala, Shimla), Meghalaya, Sikkim, Uttarakhand (Govind WLS, Askot WLS), West Bengal (Sigalilla NP, Darjeeling Hills) (Chandra et al. 2019; Chettri and Yonle 2021). **Global:** Nepal (Yazaki 1993), China, Hong Kong, Japan, Thailand.

280. *Xenoplia maculata* (Moore, 1868) [Plate 15.2]

[TL: Bengal, (West Bengal) India]

= *subfumida* Warren, 1894; [TL: India]

Rhyparia maculata Moore, 1868; *Proceedings of the Zoological Society of London*: 651.

Xenoplia subfumida; Warren, 1894; *Novitates zoologicae*, 1 (2): 415.

Percnia maculata; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 307.

Percnia maculate; Yazaki, 1992; in Haruta T (ed.): Tinea, 13 (suppl. 2); *Moths of Nepal*, Part-1: 31, pl. 8 (24).

Percnia maculata; Sondhi and Sondhi, 2016; *Journal of Threatened Taxa*, 8 (5): 8768.

Percnia maculata; Chettri and Yonle, 2021; *International Journal of Entomology Research*, 6 (3): 93.

Wing expanse: 42 mm.

Diagnosis: Externally similar to *X. foraria* but differ in being with fuscous suffusion in the interspaces of forewing, except basal and outer area; and black irroration in the costal and outer area.

Distribution: India: Arunachal Pradesh (Tale WLS) (Sondhi et al. 2021), Himachal Pradesh (GHNP) (Mallick 2021), Meghalaya (Khasi) (Joshi et al. 2021), Sikkim, Uttarakhand (Devalsari) (Sondhi and Sondhi 2016; Dey 2021), West Bengal (Darjeeling) (Chandra et al. 2019; Chettri and Yonle 2021). **Global:** Nepal (Yazaki 1992).

3.3.2 DNA barcoding

Of the 94 samples, 84 (68 from DMR and 16 from LSVs) were successfully sequenced and subsequently delimited in 62 species. A total of 55 BINs (Barcode Index Number) were assigned but 7 sequences remained unassigned. The mean genetic distance within the dataset was 7.87%. Species delimitation by the BOLD system was based on the Barcode Index Number (BIN) system, which utilises genetic variations in the barcode region of the COI gene (Ratnasingham and Hebert 2013). This molecular differentiation of the species needs to be further confirmed by morphological studies.

Table 3.1: Comprehensive list of the DNA barcode sequences of Sterrhinae Moths from DMR and LSVs with Bold ID, BIN, initial species identification (based on basic genetic distance % rule) and sequence length.

Sr. no.	**BOLD ID** (Barcode of Life Data Systems)	**BIN** (Barcode Index Number)	**Species**	**Sequence length (bp)**
1	GWOUL666-23	AAJ5407	*Rhodostrophia AH01Pk*	627
2	GWOUL667-23	AFI0862	*Rhodostrophia sp. SK02*	639
3	GWOUL668-23	AAB6574	*Scopula beckeraria*	623
4	GWOUL670-23	Not assigned	*Idaea sp. SK07*	658
5	GWOUL671-23	AFI7941	*Idaea rufaria*	639
6	GWOUL672-23	AFI7941	*Idaea rufaria*	658
7	GWOUL673-23	Not assigned	*Idaea sp. SK10*	364
8	GWOUL674-23	AFI0862	*Rhodostrophia sp. SK02*	658
9	GWOUL675-23	AFI5687	*Rhodostrophia sp. SK04*	658
10	GWOUL676-23	AAJ5407	*Rhodostrophia borealis*	658
11	GWOUL77-23	AAJ5407	*Rhodostrophia borealis*	658
12	GWOUL678-23	AAJ5407	*Rhodostrophia borealis*	658
13	GWOUL679-23	AAJ5407	*Rhodostrophia borealis*	553
14	GWOUL680-23	ACI9411	*Scopula kashmirensisSK01*	658
15	GWOUL681-23	AAH9775	*Scopula sp. SK24*	658
16	GWOUL682-23	AAH9775	*Scopula sp. SK24*	622
17	GWOUL684-23	AFI4473	*Chrysocraspeda faganaria*	658
18	GWOUL685-23	AFH9826	*Scopula moorei*	640
19	GWOUL686-23	AFH9826	*Scopula moorei*	658
20	GWOUL687-23	AFH9826	*Scopula moorei*	658
21	GWOUL688-23	AFE7574	*Scopula AH04Bu*	658
22	GWOUL689-23	AAO0028	*Scopula AH05Pk*	658
23	GWOUL690-23	ACM4266	*Scopula detentata*	658
24	GWOUL691-23	AAZ6199	*Problepsis vulgaris*	658
25	GWOUL692-23	AAZ6198	*Problepsis albidior*	602
26	GWOUL693-23	AFI0500	*Rhodostrophia*	537

27	GWOUL694-23	AAO0147	*Idaea AH01Pk*	658
28	GWOUL695-23	ADJ3489	*Idaea sp. SK12*	658
29	GWOUL696-23	ACI9411	*Scopula kashmirensisSK01*	600
30	GWOUL697-23	AAA8983	*Rhodometra sacraria*	638
31	GWOUL698-23	Not assigned	*Scopula fibulata*	592
32	GWOUL699-23	AFH7238	*Rhodostrophia stigmatica*	657
33	GWOUL700-23	AFH4559	*Scopula sp. SK07*	658
34	GWOUL701-23	ACM3972	*Idaea persimilis*	658
35	GWOUL702-23	AFI2312	*Idaea sp. SK04*	562
36	GWOUL703-23	AFI1989	*Scopula butleri*	636
37	GWOUL704-23	ABZ7606	*Scopula PK03*	656
38	GWOUL706-23	ACW2214	*Scopula emissaria*	632
39	GWOUL707-23	ABU6091	*Scopula achrosta*	658
40	GWOUL708-23	AFH6187	*Erebinae*	645
41	GWOUL709-23	ABA3645	*Organopoda carnearia himalaica*	594
42	GWOUL710-23	AFH6414	*Organopoda carnearia himalaica*	622
43	GWOUL711-23	AFH7022	*Cyclophora obstataria*	522
44	GWOUL713-23	AFI2529	*Rhodostrophia herbicolens*	658
45	GWOUL714-23	AAK1623	*Timandra correspondens*	658
46	GWOUL715-23	Not assigned	*Craspediopsis*	658
47	GWOUL716-23	AFH7247	*Idaea sp. SK05*	635
48	GWOUL717-23	AFH8180	*Idaea sp. SK03*	627
49	GWOUL718-23	Not assigned	*Lophophleps informis*	658
50	GWOUL719-23	AAG1993	*Timandra convectaria*	640
51	GWOUL721-23	ACM1858	*Somatina plynusaria*	658
52	GWOUL722-23	AFI2528	*Rhodostrophia pelloniaria*	658
53	GWOUL723-23	AFI0337	*Idaea macrospila*	658
54	GWOUL724-23	AAN0101	*Somatina anthophilata*	658
55	GWOUL725-23	AAQ0226	*Rhodostrophia tristrigalis*	564
56	GWOUL726-23	AFI5865	*Chrysocraspeda sp. SK01*	658
57	GWOUL727-23	Not assigned	*Anydrelia dharmsalae*	658
58	GWOUL728-23	Not assigned	*Scopula AH01Ch*	658

59	GWOUL729-23	AFH8179	*Idaea sp. SK01*	658
60	GWOUL730-23	ADF3583	*Idaea PD02*	658
61	GWOUL731-23	AFH7765	*Scopula terminata machadoi*	658
62	GWOUL732-23	AFI2017	*Scopula sp. SK18*	607
63	GWOUL733-23	AFH6482	*Scopula sp. SK22*	658
64	GWOUL734-23	AFH4560	*Scopula sp. SK09*	639
65	GWOUL735-23	AFH6482	*Scopula sp. SK22*	658
66	GWOUL736-23	AFH4560	*Scopula sp. SK09*	625
67	GWOUL737-23	AFH4560	*Scopula sp. SK09*	658
68	GWOUL738-23	ABV8238	*Scopula AH07Th*	658
69	GWOUL739-23	AFH8424	*Scopula AH03Ch*	658
70	GWOUL740-23	AFH4561	*Scopula sp. SK05*	658
71	GWOUL741-23	AAC7295	*Scopula latitans*	658
72	GWOUL744-23	ABV8238	*Scopula AH07Th*	658
73	GWOUL745-23	ABV8238	*Scopula AH07Th*	658
74	GWOUL746-23	AAQ0217	*Scopula PK01*	658
75	GWOUL750-23	AFH4560	*Scopula sp. SK09*	658
76	GWOUL751-23	AFH6482	*Scopula sp. SK22*	658
77	GWOUL752-23	AFI2017	*Scopula sp. SK18*	463
78	GWOUL753-23	AFI2016	*Scopula sp. SK16*	658
79	GWOUL754-23	AAQ0217	*Scopula PK01*	602
80	GWOUL755-23	AAC7295	*Scopula latitans*	658
81	GWOUL756-23	AFI7941	*Idaea rufaria*	658
82	GWOUL757-23	AAN5751	*Ennominae*	555
83	GWOUL758-23	AAU3213	*Scopula terminata machadoi*	658
84	GWOUL759-23	AFI2017	*Scopula sp. SK18*	658

3.3.3 γ-diversity (species richness and sampling completeness for DMR)

Altogether, 21, 311 individuals of the Geometridae family were observed in the 34 sampling sites. Out of these, 5, 018 individuals cannot be reliably identified up to species level, representing nearly 23% of the total catch. However, 16, 293 individuals (approximately 77% of the total catch) were assigned to 279 species across four major subfamilies. The estimated species richness was 290 (iChao1, SE: 3.42; lower 95%: 285.5, upper 95%: 299.39) species. Therefore, based on these estimates, the observed species richness for the DMR covered 96% of the estimated species numbers. Among all the species richness estimators, the species number estimates for the region ranged from 284 to 298 (Table 3.2).

Table 3.2: Estimated species richness of Geometridae moths in DMR based on different species richness estimators (iNEXT package, R version 4.2.1).

Species richness estimator	Estimate	Standard Error (SE)	Lower 95%	Upper 95%
Homogeneous Model	283.633	2.514	280.712	291.54
Homogeneous (MLE)	279	2.718	284.216	295.28
Chao1 (Chao, 1984)	288.499	5.766	282.169	307.472
Chao1-bc	287.549	5.318	281.787	305.225
iChao1 (Chiu et al. 2014)	290.54	3.423	285.532	299.39
ACE (Chao & Lee, 1992)	289.068	4.757	283.177	303.269
ACE-1 (Chao & Lee, 1992)	290.396	5.555	283.61	307.17
1st order jackknife	297.999	6.164	289.22	314.32
2nd order jackknife	298	10.676	285.806	332.044

3.3.4 α-diversity (site-wise species richness)

Species richness, abundance and diversity indices and estimators were calculated for 34 sampling sites. Among all the sites, the highest and lowest observed species numbers were 108 (RAJ23B) and 34 species (KAR29B). Similarly, the highest and lowest estimated species richness values were also from these sites as 45 and 143 species, respectively. The total number of individuals observed at different sites ranged from 1809 (RAJ29A) and 135 (KAR08B). The maximum and minimum sampling completeness among the sites (based on the observed and estimated species number) was 42% (KAR11C) and 80% (KARDEOA). The maximum value of Fisher's alpha was 37.31 (RAJ23B) and the minimum was 7.87 (RAJ29B). High dominance index values i.e., 0.79 and 0.69 were reported for Jhoardi and Palachak respectively. This is due to the very high abundance of the *Arichanna flavinigra* species at these sites during the post-monsoon season. All values of species richness (observed and estimated), alpha diversity, evenness, and dominance indices are provided in Table 3.3.

Table 3.3: Site-wise Observed and Estimated Species Richness, α-diversity, Dominance and Evenness measures from DMR.

Site code	Observed	Individuals	iChao-1	Sampling completeness	Fisher's alpha	Dominance_D	Simpson_1-D	Shannon_H	Evenness_e^H/S
KAR08A	55	244	79.72	68.99	22.11	0.07	0.93	3.41	0.55
KAR08B	42	135	53.95	77.85	20.9	0.04	0.96	3.48	0.77
KAR08C	58	227	76.83	75.49	25.17	0.03	0.97	3.74	0.73
KAR08D	65	364	103.1	63.05	23.04	0.09	0.91	3.33	0.43
KAR11A	46	185	94.02	48.93	19.62	0.06	0.94	3.32	0.6
KAR11B	70	431	122.2	57.28	23.69	0.05	0.95	3.59	0.52
KAR11C	49	281	116	42.24	17.16	0.06	0.94	3.3	0.55
KAR11D	69	355	132.5	52.08	25.54	0.04	0.96	3.68	0.58
KAR14A	82	622	109.9	74.61	25.29	0.07	0.93	3.52	0.41
KAR14B	69	433	90.96	75.86	23.15	0.09	0.91	3.38	0.43
KAR17A	75	432	121.7	61.63	26.21	0.05	0.95	3.62	0.5
KAR17B	85	552	116.9	72.71	28.07	0.06	0.94	3.67	0.46
KAR20A	82	463	117.1	70.03	28.94	0.03	0.97	3.85	0.57
KAR20B	73	378	99.62	73.28	26.93	0.03	0.97	3.85	0.64
KAR23A	70	426	116	60.34	23.82	0.04	0.96	3.67	0.56
KAR23B	64	247	97.12	65.9	28.02	0.03	0.97	3.84	0.73
KAR26A	53	293	84.85	62.46	18.91	0.06	0.94	3.33	0.53
KAR26B	63	316	90.2	69.84	23.64	0.07	0.93	3.4	0.48
KAR29A	51	505	88.53	57.61	14.16	0.28	0.72	2.35	0.21
KAR29B	34	243	44.89	75.74	10.76	0.1	0.9	2.88	0.52
KARDEOA	95	508	118.6	80.1	34.47	0.04	0.96	3.96	0.55
KARDEOB	92	683	135.6	67.85	28.63	0.07	0.93	3.49	0.36
RAJ14A	68	236	133.4	50.97	31.99	0.03	0.97	3.95	0.76
RAJ14B	70	344	89.71	78.03	26.56	0.04	0.96	3.78	0.62
RAJ17A	67	344	84.53	79.26	24.83	0.04	0.96	3.78	0.65
RAJ17B	64	376	125.9	50.83	22.15	0.03	0.97	3.68	0.62
RAJ20A	79	398	138.8	56.92	29.57	0.04	0.96	3.76	0.54

RAJ20B	97	600	129.6	74.85	32.76	0.03	0.97	3.96	0.54
RAJ23A	96	595	132.3	72.56	32.39	0.02	0.98	4.12	0.64
RAJ23B	108	637	143.5	75.26	37.31	0.03	0.97	4.19	0.61
RAJ26A	76	587	98.82	76.91	23.26	0.17	0.83	3.04	0.28
RAJ26B	73	934	94.68	77.1	18.53	0.31	0.69	2.41	0.15
RAJ29A	67	1809	84.68	79.12	13.7	0.69	0.31	1.14	0.05
RAJ29B	39	1110	66.12	58.98	7.87	0.79	0.21	0.74	0.05

3.2.5 Seasonal patterns of species richness and diversity

Total, 16, 293 individuals belonging to 279 species of geometrid moths were observed. Out of these, 5305 individuals of 222 species were recorded during pre-monsoon season while 10, 988 individuals of 243 species were documented during post-monsoon season. Both the observed species richness and abundance were higher in the post-monsoon season. However, the iChao1 species richness estimator indicated that the pre-monsoon season had a greater estimated species richness of 257.8, compared to the post-monsoon season with an estimated species richness of 254.9.

Table 3.4: Observed and Estimated Species Richness, α-diversity, Dominance and Evenness measures for the two major seasons, pre- and post-monsoon of DMR.

Season	**Pre-monsoon**	**Post-monsoon**
Observed Species Richness	222	243
Total abundance	5305	10988
Relative abundance	32.56	67.44
iChao-1	257.8	254.9
Fisher alpha	46.85	43.98
Dominance (D)	0.02342	0.1278
Simpson (1-D)	0.9766	0.8722
Shannon (H)	4.463	3.714
Evenness (e^H/S)	0.3908	0.1688

SIMPER analysis investigated the composition of the two seasons and identified the species contributing to the compositional differences between them (Table 3.6) . The analysis indicated the species *Arichanna flavinigra* as the major contributing species chiefly associated with the post-monsoon season. Among the other important species which contributed significantly to the compositional differences between the two seasons are *Alcis perspicuata*, *Xanthorhoe saturata* and *Psilalcis breta breta*, which are associated with the pre-monsoon while *Hyposidra talaca talaca*, *Chiasmia azataria*, *Alcis variegata* and *Antipercnia belluaria* are associated with post-monsoon.

Table 3.5: Results of the pairwise comparison of similarity of geometrid moth assemblages in pre-monsoon and post-monsoon seasons using ANOSIM (Analysis of Similarity). Significant R and p-values indicated in bold.

Permutations (N)		9999
	R-values	**p-values**
	Pre-monsoon	**Pre-monsoon**
Pre-monsoon		
Post-monsoon	**0.2303**	**0.0001**

Table 3.6: Results of the SIMPER analysis demonstrating species contributing to the differences in the geometrid moth assemblages of pre-monsoon and post-monsoon seasons of an overall **88.25%** dissimilarity.

Species name	**Average dissimilarity**	**Contribution %**	**Cumulative %**	**Mean abundance pre-monsoon**	**Mean abundance post-monsoon**
Arichanna flavinigra	11.95	13.54	13.54	0	**113**
Alcis perspicuata	2.556	2.897	16.44	**8.65**	6.71
Xanthorhoe saturata	2.508	2.842	19.28	**12**	2.35
Hyposidra talaca talaca	2.453	2.78	22.06	0.0882	**8.15**
Psilalcis breta breta	2.243	2.542	24.6	**9.91**	2.44
Chiasmia azataria	2.234	2.532	27.14	1.82	**7.79**
Alcis variegata	1.937	2.194	31.75	5.41	**7.62**
Antipercnia belluaria	1.605	1.818	33.57	0.765	**5.53**

3.3.4 Biogeographic affinity

The Geometridae moths' assemblage in the DMR is predominantly of Sino-Japanese origin, with more than 80% of the species shared with this region. Additionally, nearly 48%

of the species were of oriental origin, and 40% were composed of the Palearctic component. Only 2.5% of the species were of Australian origin, and less than 1% each came from the remaining biogeographic regions. Among the Indian Himalayan biogeographic zones, the highest affinity was found in Central (2C), accounting for nearly 64% of the species, while more than 55% of the species were found in Western (2 B), approximately 49% in Trans Himalaya Sikkim (1C), and approximately 32% in Eastern (2D) biogeographic provinces. Other biogeographic zones that have significant influence include the Gangetic Plains accounting for approximately 76%, Coasts comprising 58%, the Deccan Peninsula with 56%, and the Northeast with roughly 54% of its species shared with the regional Geometridae fauna of the DMR.

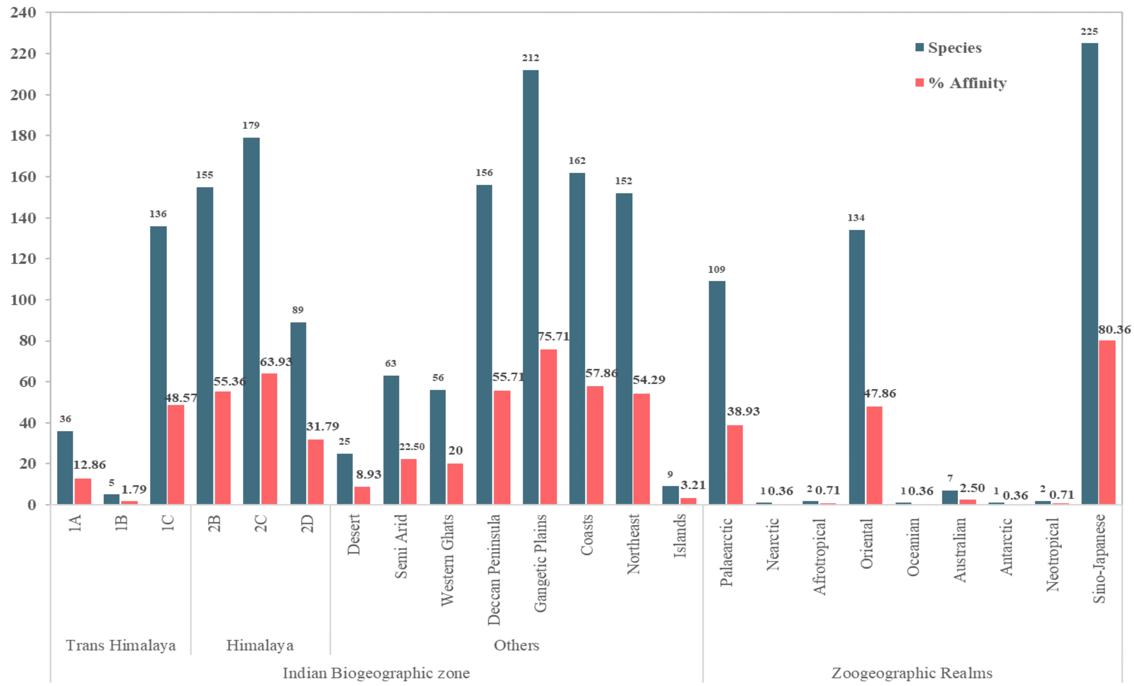


Fig. 3.2: Number of species and % affinity of the North Western Himalayan province (2A) of DMR with other Himalayan provinces, Indian Biogeographic zones, and the world's Zoogeographical realms.

3.4 Discussion

The number of documented species among the four subfamilies followed the overall global richness pattern of the Geometridae family. The overall community of DMR is dominated by the subfamilies Ennominae and Larentiinae, the two largest subfamilies globally. However, owing to the time constraints of this doctoral study and the need to confirm the identities of many remaining morphospecies, the provided list is the initial step towards creating a comprehensive inventory of Geometridae species in the region. The information generated would help validate and re-establish the >100-year-old information by Britishers and other studies that followed. Also, the ecological details like habitat and elevational preferences of the species have been added and all consolidated and updated information has been provided in one place. This information can serve as a baseline for future studies and will also help trace back to past literature. The COI sequences have been submitted to online permanent repositories BOLD and NCBI and can be retrieved and utilized by anyone. These sequences will help resolve taxonomic discrepancies among taxonomically challenged species groups in the Sterrhinae subfamily in the future.

The recorded species richness showed close to 96% success (based on non-parametric species richness estimates) for the documentation of the regional Geometridae moth diversity of the DMR. These measures are based on observed species abundance data, and the original numbers can be higher than those previously mentioned. Nearly 23% of the sample has yet to be identified, with the potential to reveal species new to science from the region. This task requires ongoing and concerted efforts in the future.

The study has also observed marked differences in seasonal species richness and composition. This further implies the importance of temporal factors in the study of moth communities in the Himalayan landscape. This preliminary study successfully documented a sufficient amount of Geometridae moth diversity in the region. However, it did not examine the monthly and annual changes in species richness and composition. Therefore, in the future, more systematically planned and long-term studies can help obtain a finer-scale robust dataset.

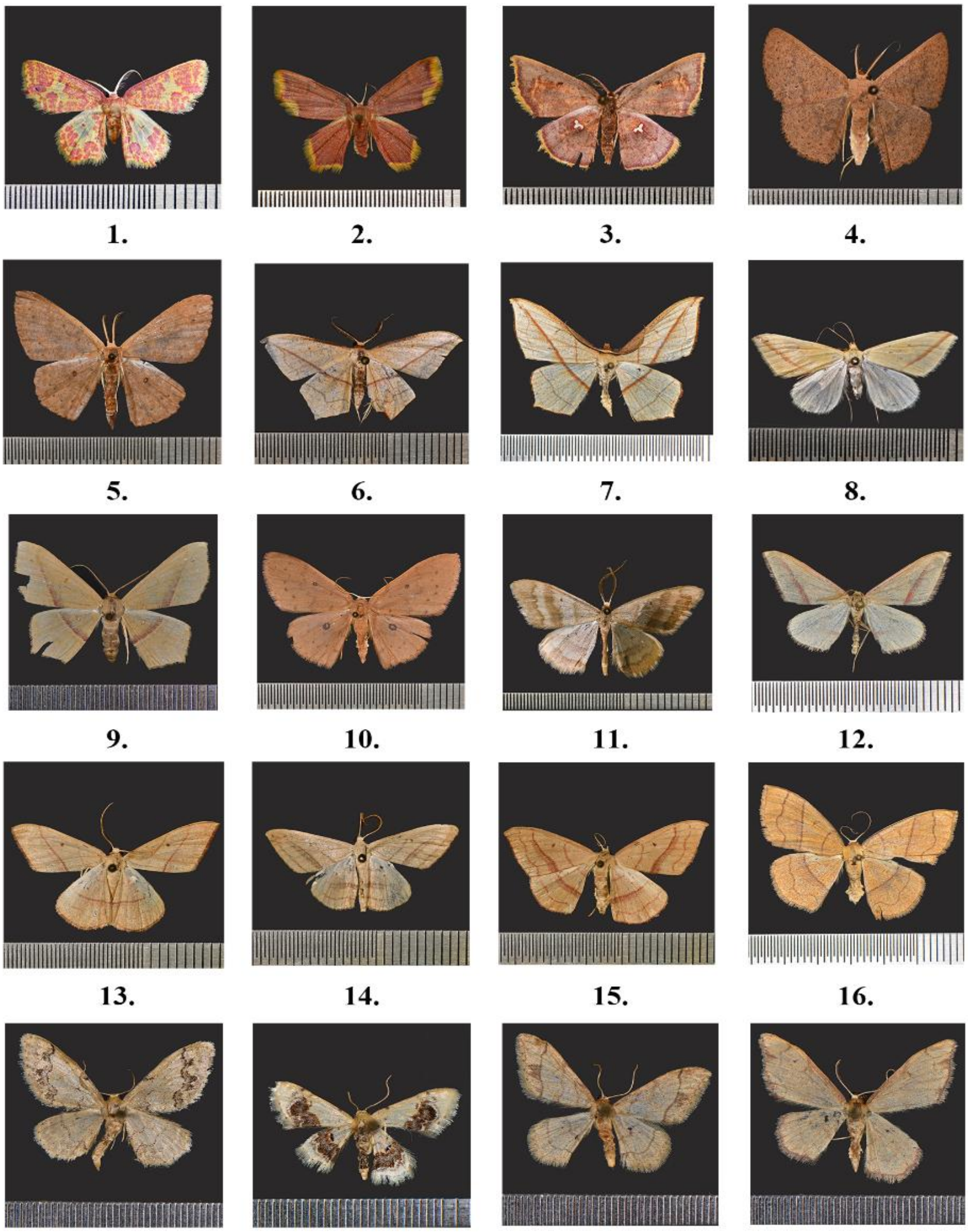


Plate 1
Sterrhinae

1. *Chrysocraspeda faganaria* (♂) 2. *Chrysocraspeda faganaria* (♀) 3. *C. olearia*
4. *Cyclophora obstataria* 5. *Perixera niveopuncta* 6. *Timandra convectaria*
7. *Timandra correspondens* 8. *Rhodometra sacraria* 9. *Traminda mundissima*
10. *Organopoda himalaica* 11. *Rhodostrophia herbicolens* 12. *R. pelloniaria*
13. *R. stigmatica* 14. *R. tristrigalis* 15. *R. vinacearia* 16. *Tanaotrichia trilineata*
17. *Idaea griscens* 18. *I. macrospila* 19. *I. persimilis* 20. *I. protensa*

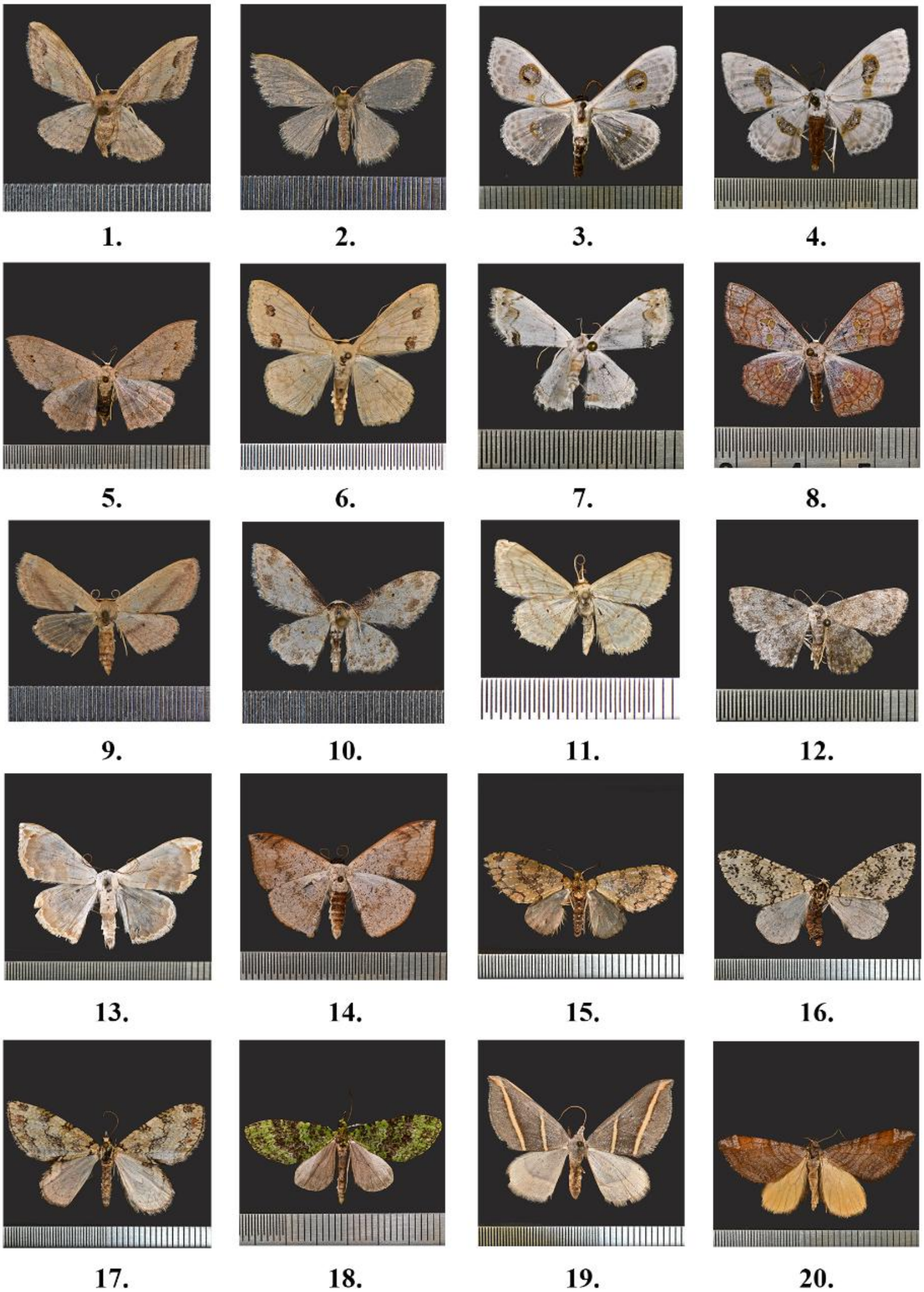


Plate 2
Sterrhinae, Larentiinae

1. *Idaea ruptifascia* 2. *Lophophleps informis* 3. *Problepsis albidior*
4. *P. vulgaris* 5. *Scopula achrosta* 6. *S. bispurcata* 7. *S. butleri* 8. *S. cuneilinea*
9. *S. emissaria* 10. *S. fibulata* 11. *S. idearia* 12. *S. mechadoi* 13. *Somatina anthophilata*
14. *S. plynusaria* 15. *Trichopterigia decoarata* 16.*T. macularia*
17. *T. rufinotata* 18. *Tristeirometa decussata* 19. *Docirava aequilineata* 20. *D. postochrea*

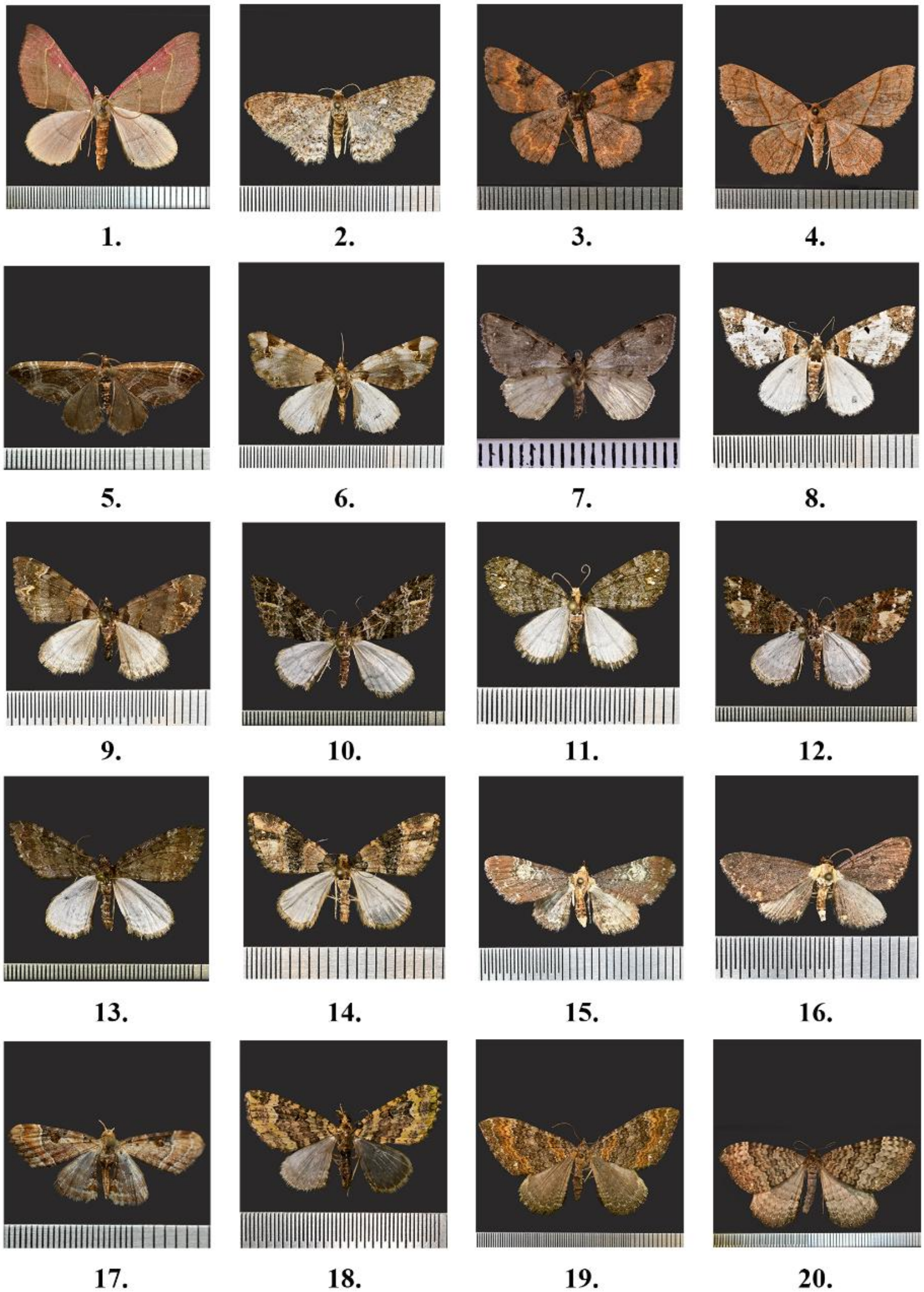


Plate 3
Larentiinae

1. *Docirava pudicata* 2. *Asthena albosignata* 3. *Hydrelia bicolorata* 4. *H. subobliquaria* 5. *Gagetodes parvaria* 6. *G. plumbeata* 7. *G. saxicola* 8. *Martania albofasciata* 9. *M. antisticta* 10. *M. fulvimacula* 11. *M. micropunctum* 12. *M. seriata* 13. *M. variabilis* 14. *Perizoma peculiare* 15. *Eupithecia albigutta* 16. *E. maculosa* 17. *E. melanolopha* 18. *Pasiphila palpata* 19. *Triphosa dubiosata* 20. *T. rubrodotata*

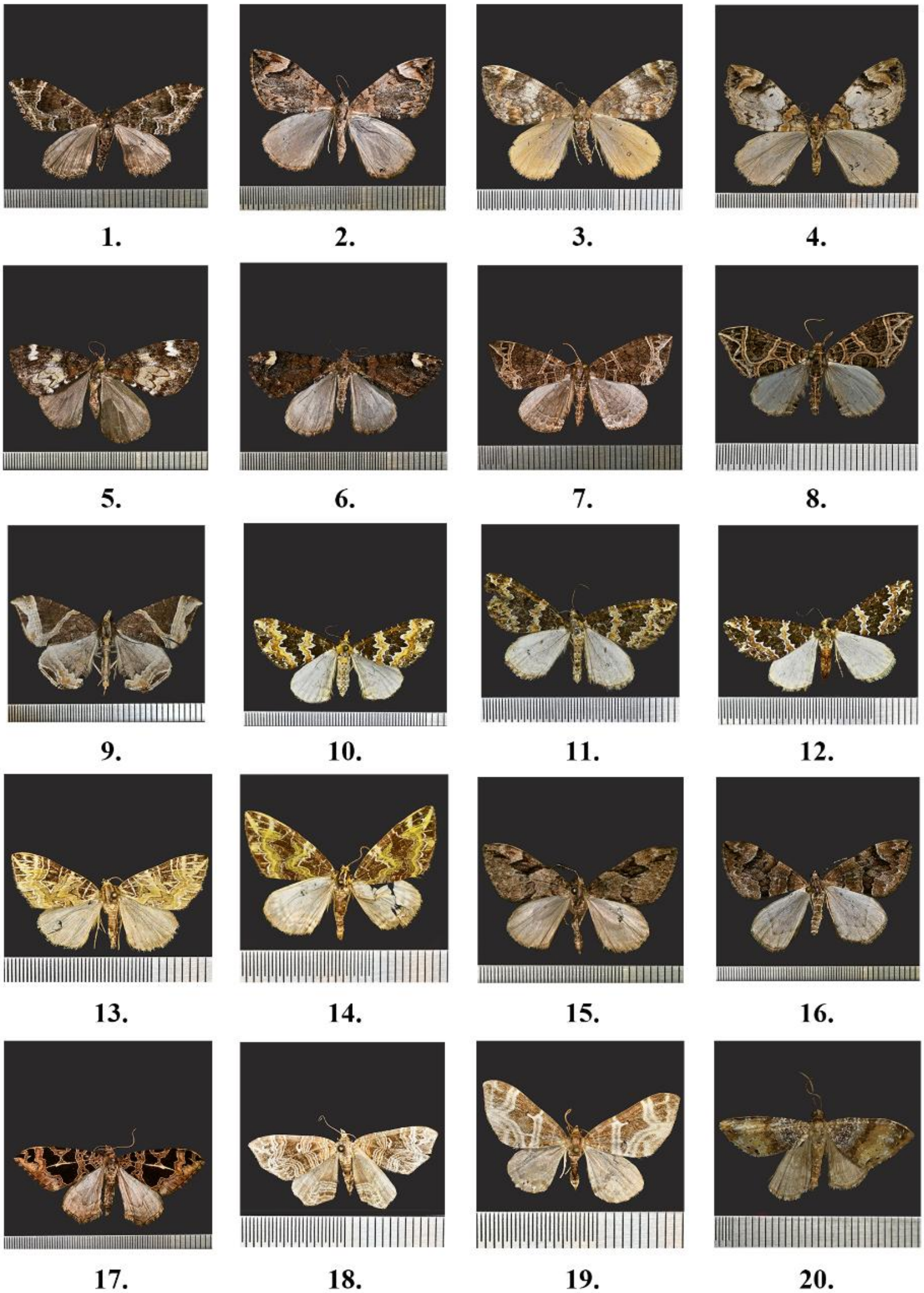


Plate 4
Larentiinae
1. *Colostygia albigirata* 2. *Dysstroma dentifera* 3. *D. fulvipennis* 4. *D. planifasciata*
5. *D. shirakawai* 6. *D. subapicaria* 7. *Ecliptopera dentifera* 8. *E. relata*
9. *E. triangulifera* 10. *Electrophaes aliena* 11. *E. marginata* 12. *E. niveonotata*
13. *Eustroma aurigena* 14. *E. chalcoptera* 15. *Heterothera consimilis* 16. *H. dentifasciata*
17. *Hysterura multifaria* 18. *Lobogonodes multistriata* 19. *Nebula brevifasciata* 20. *N. cupreata*

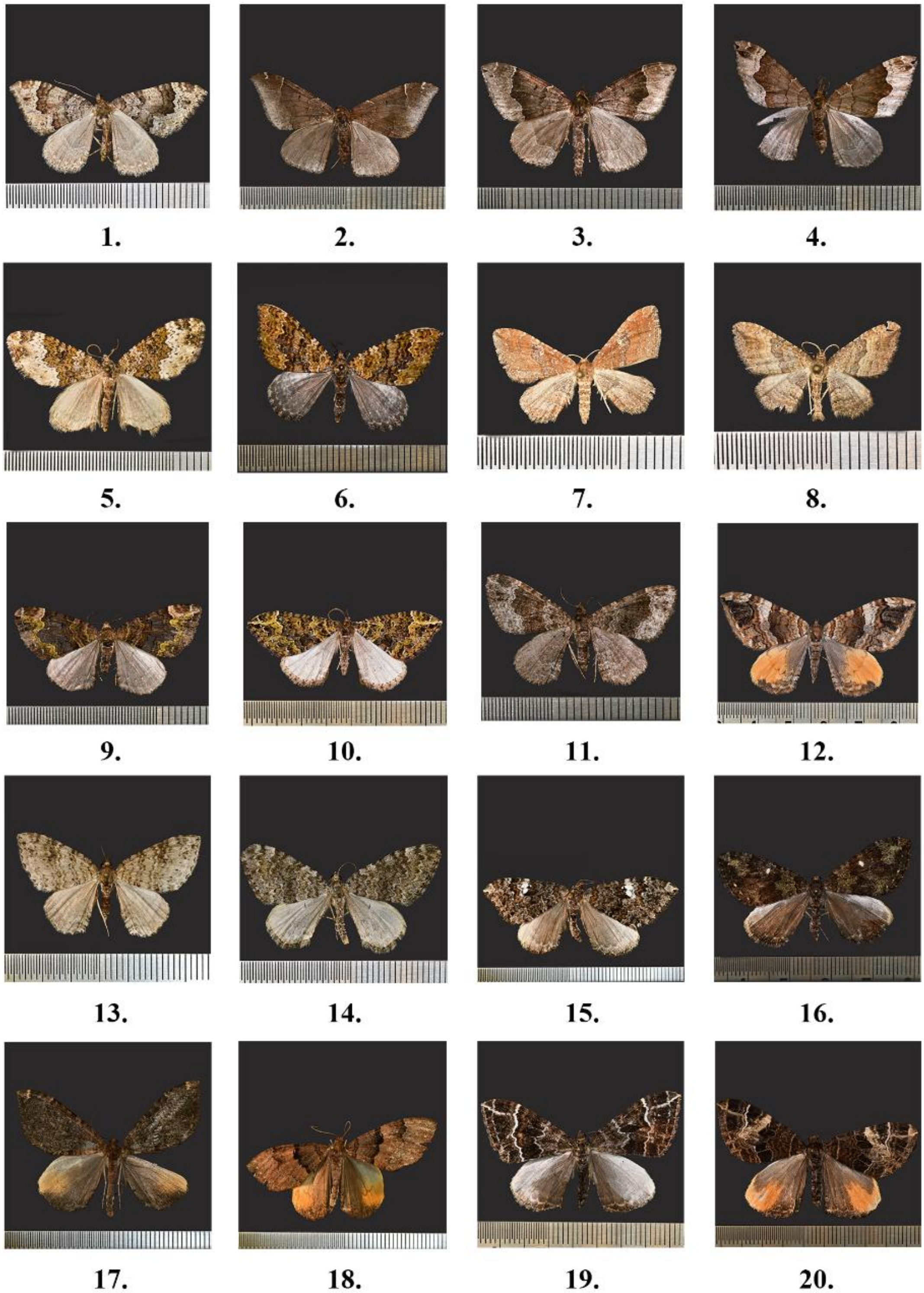


Plate 5
Larentiinae

1. *Nebula homophana* 2. *Xenortholitha falcata* 3. *X. latifusata* 4. *X. propinguata*
5. *Euphyia submarginata* 6. *E. variegata* 7. *Orthonama obstipata* (♀) 8. *Orthonama obstipata* (♂)
9. *Xanthorhoe greisiviridis* 10. *X. hampsoni* 11. *X. saturata* 12. *Amnesicoma simplex*
13. *Atopophysa indistincata* 14. *Neotephria ramalaria* 15. *Photoscotosia amplicata* 16. *P. chlorochrota*
17. *P. dejuncta* 18. *P. dejuta* 19. *P. fulguritis* 20. *P. metachryseis*

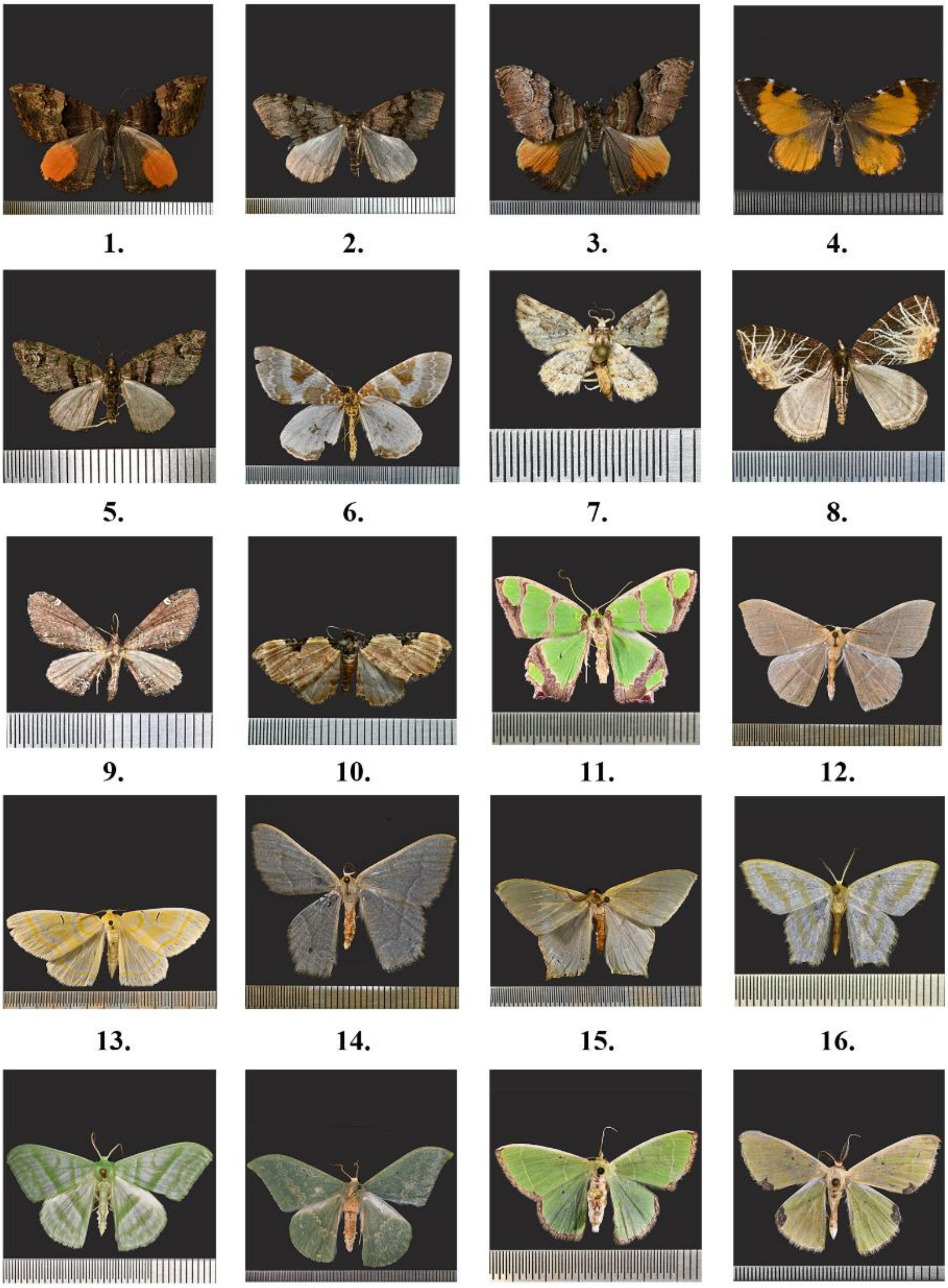


Plate 6

Larentiinae, Geometrinae

1. *Photoscotosia miniosata* 2. *P. nitida* 3. *P.pallidimaculata* 4. *Stamnodes pamphilata* 5. *Apithecia viridata* 6. *Callabraxas trigoniplaga* 7. *Calluga costalis* 8. *Evecliptopera decurrens* 9. *Girida rigida* 10. *Mesoleuca costipannaria* 11. *Agathia hilarata* 12. *Geometra flavifrontaria* 13. *Iotaphora iridicolor* 14. *Maxates glaucaria* 15. *M. illiturata* 16. *M. iridescens* 17. *Mixochlora vittata* 18. *Tanaorhinus reciprocata* 19. *Comibaena cassidara* 20. *C. fuscidorsata*

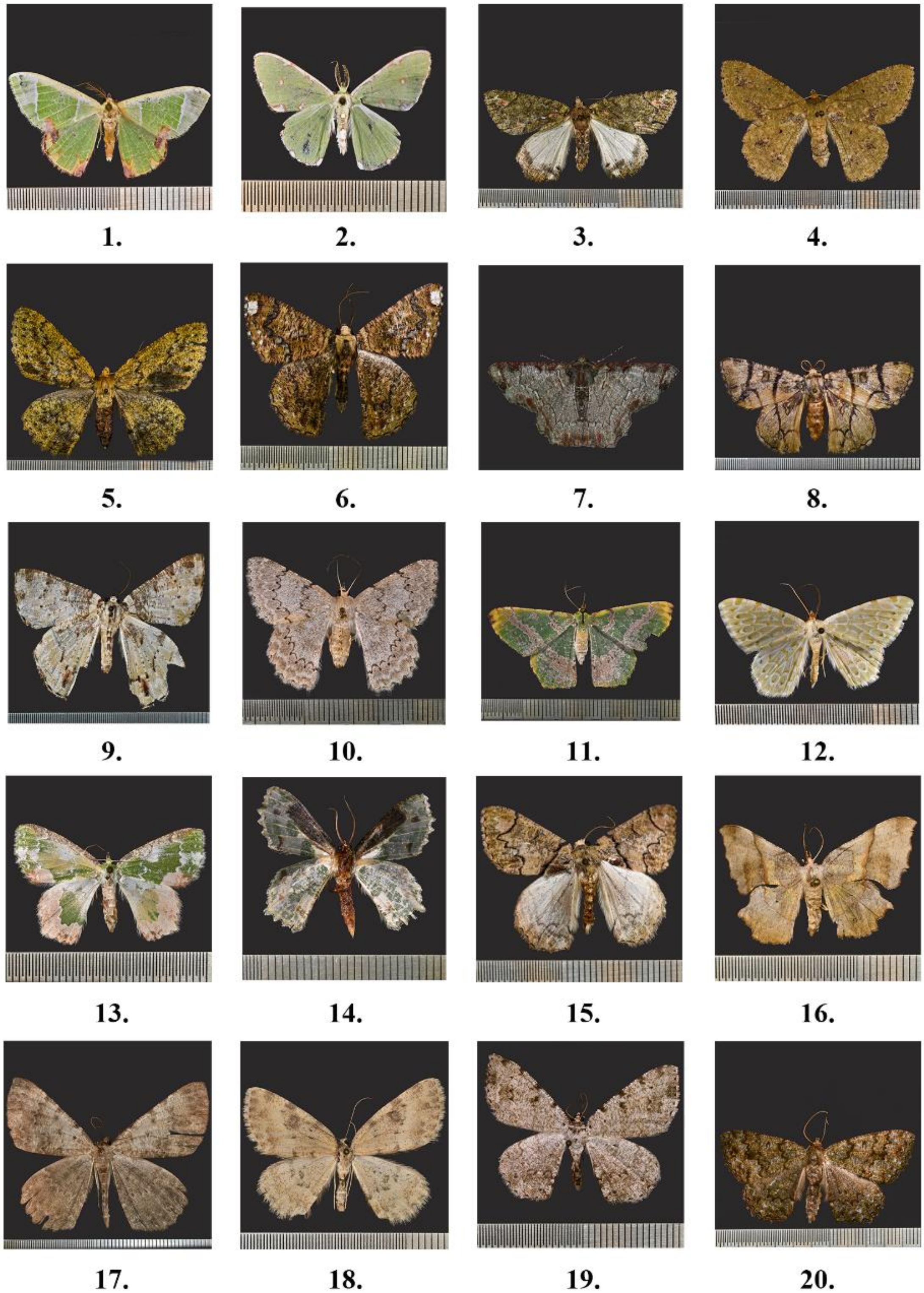


Plate 7
Geometrinae, Ennominae

1. *Comibaena pictipennis* 2. *Linguisaccus subhyalina* 3. *Dindica para* 4. *Herochroma cristata* 5. *Herochroma usneata* 6. *Lophophelma erionoma* 7. *L. luteipes* 8. *Metallolophia assamensis* 9. *M. ornataria* 10. *Pingasa pseudoterpnaria* 11. *Chloroglyphica variegata* 12. *Chlororithra fea* 13. *Eucyclodes albisparsa* 14. *E. picturata* 15. *Metaterpna differens* 16. *Gonodontis aethocrypta* 17. *Gnophos accipitraria* 18. *G. rubefactaria* 19. *G. tephrosaria* 20. *Hirasa aereus*

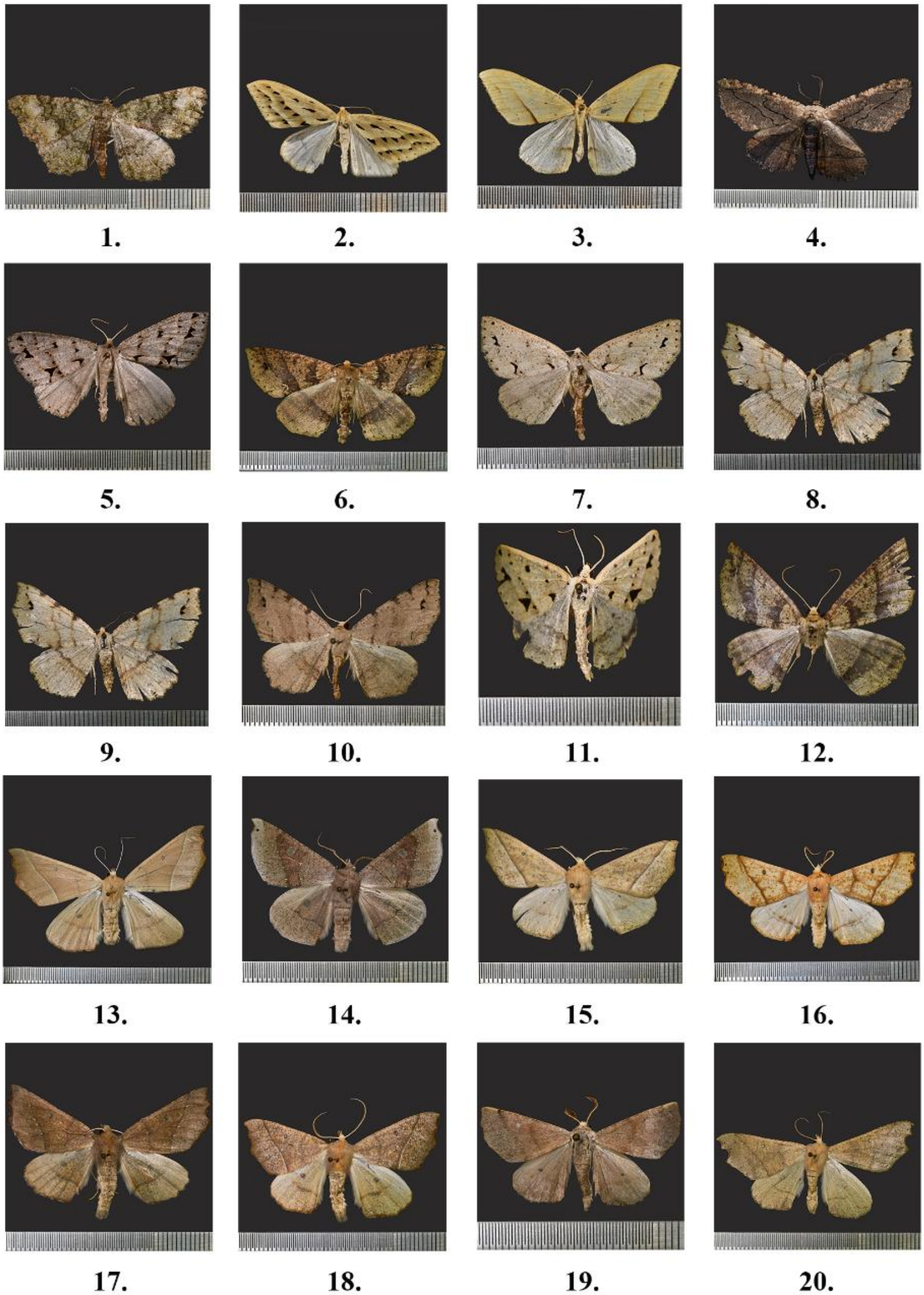


Plate 8

Ennominae

1. *Hirasa muscosaria* 2. *Loxaspilates hastigera* 3. *L. obliquaria* 4. *Phthonandria atrilineata* 5. *Psyra angulifera* 6. *P. crypta* 7. *P. cuneata* 8. *P. debilis* 9. *P. indica* 10. *P. gracilis* 11. *P. similaria* 12. *P. spurcataria* 13. *Odontopera bilinearia* 14. *O. cervinaria* 15. *O. heydena* 16. *O. kanchai* 17. *O. lentiginosaria* 18. *O. obliquaria* 19. *O. rufitinctaria* 20. *O. similaria*

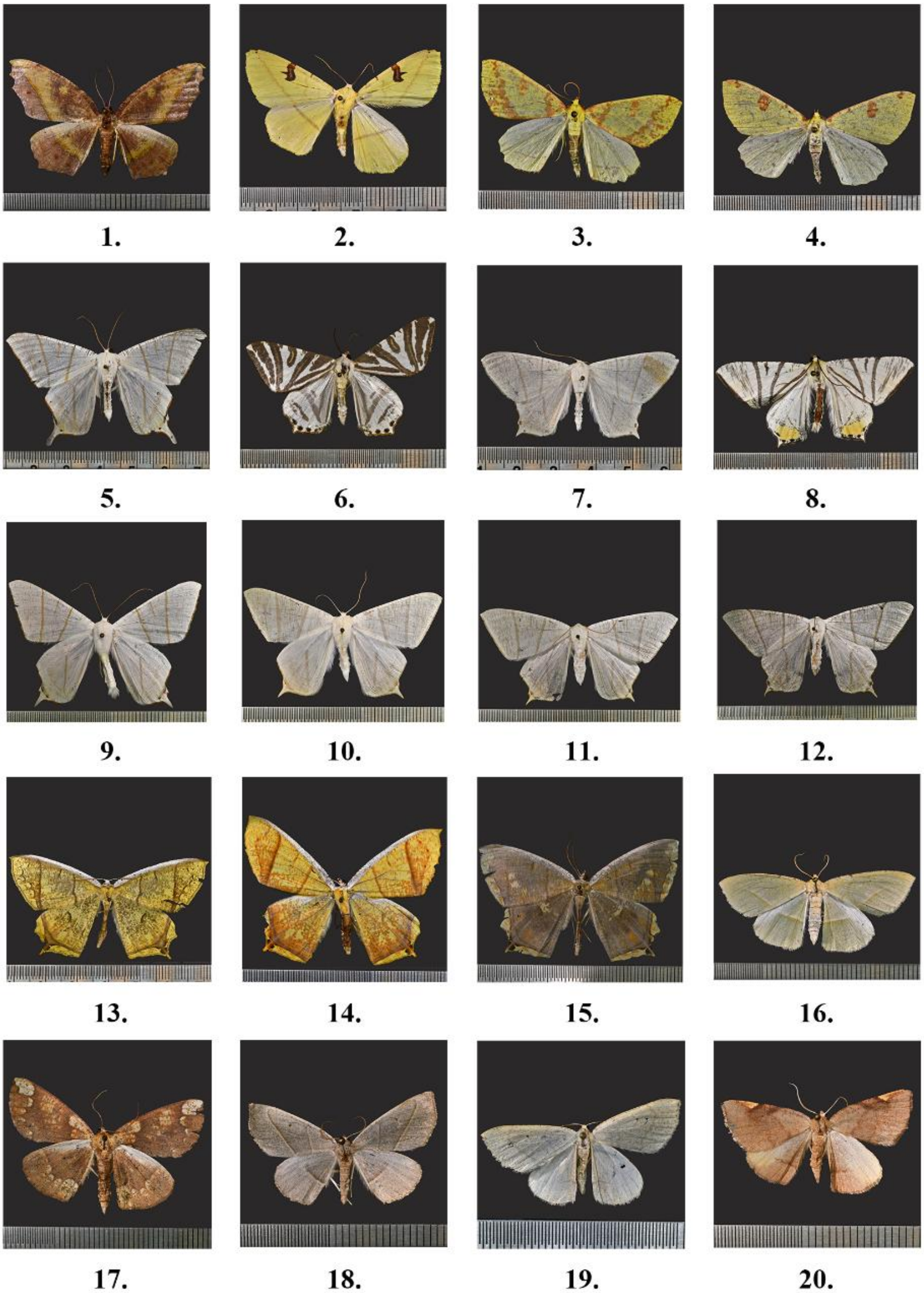


Plate 9
Ennominae

1. *Leptomiza calcearia* 2. *Opisthograptis moelleri* 3. *O. sulphurea* 4. *O. tridentifera*
5. *Ourapteryx clara* 6. *O. convergens* 7. *O. ebuleata* 8. *O. excellens*
9. *O. nepalensis* 10. *O. pallidula* 11. *O. purissima* 12. *O. yerburii*
13. *Thinopteryx citrina* 14. *T. crocoptera* 15. *T. nebulosa* 16. *Aplochlora dentisignata*
17. *Heterostegania lunulosa* 18. *Nothomiza achromaria* 19. *N. cinerascens* 20. *N. costinotata*

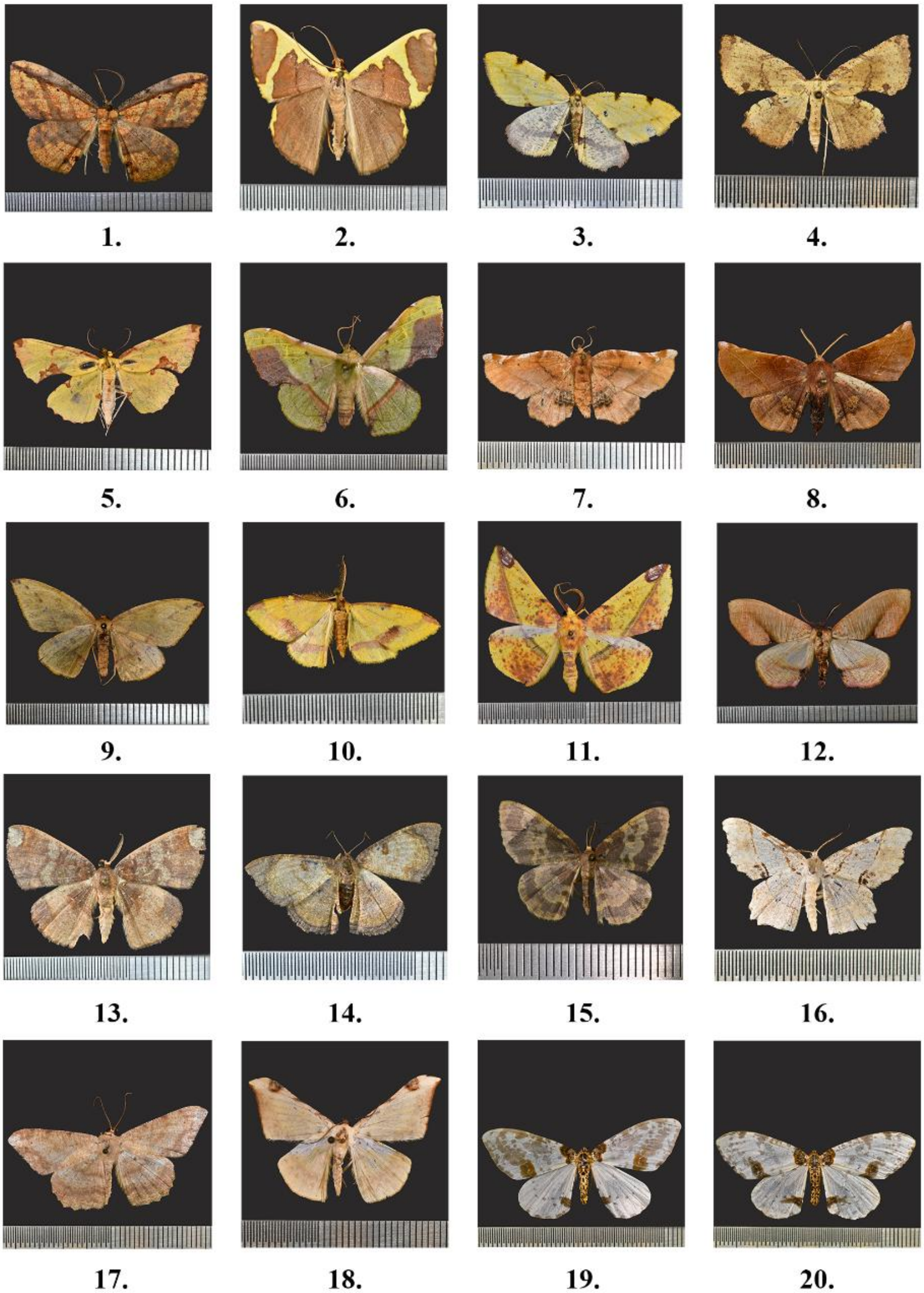


Plate 10
Ennominae

1. *Platycerota vitticostata* 2. *Plutodes warreni* 3. *Apoheterolocha patalata* 4. *Corymica deducta* 5. *C. pryeri* 6. *Fascelina plagiata* 7. *Garaeus albipunctatus* 8. *G. apicata* 9. *Heterolocha falconaria* 10. *H. phoenicotaeniata* 11. *Mimomiza cruentaria* 12. *Plagodis inustaria* 13. *Astygisa orbapicalis* 14. *Hydatocapnia marginata* 15. *Peratophyga hyalinetta* 16. *Callaetera subexpressa* 17. *Luxiaria amasa* 18. *Luxiaria phyllosaria* 19. *Abraxas antipusilla* 20. *A. circinata*

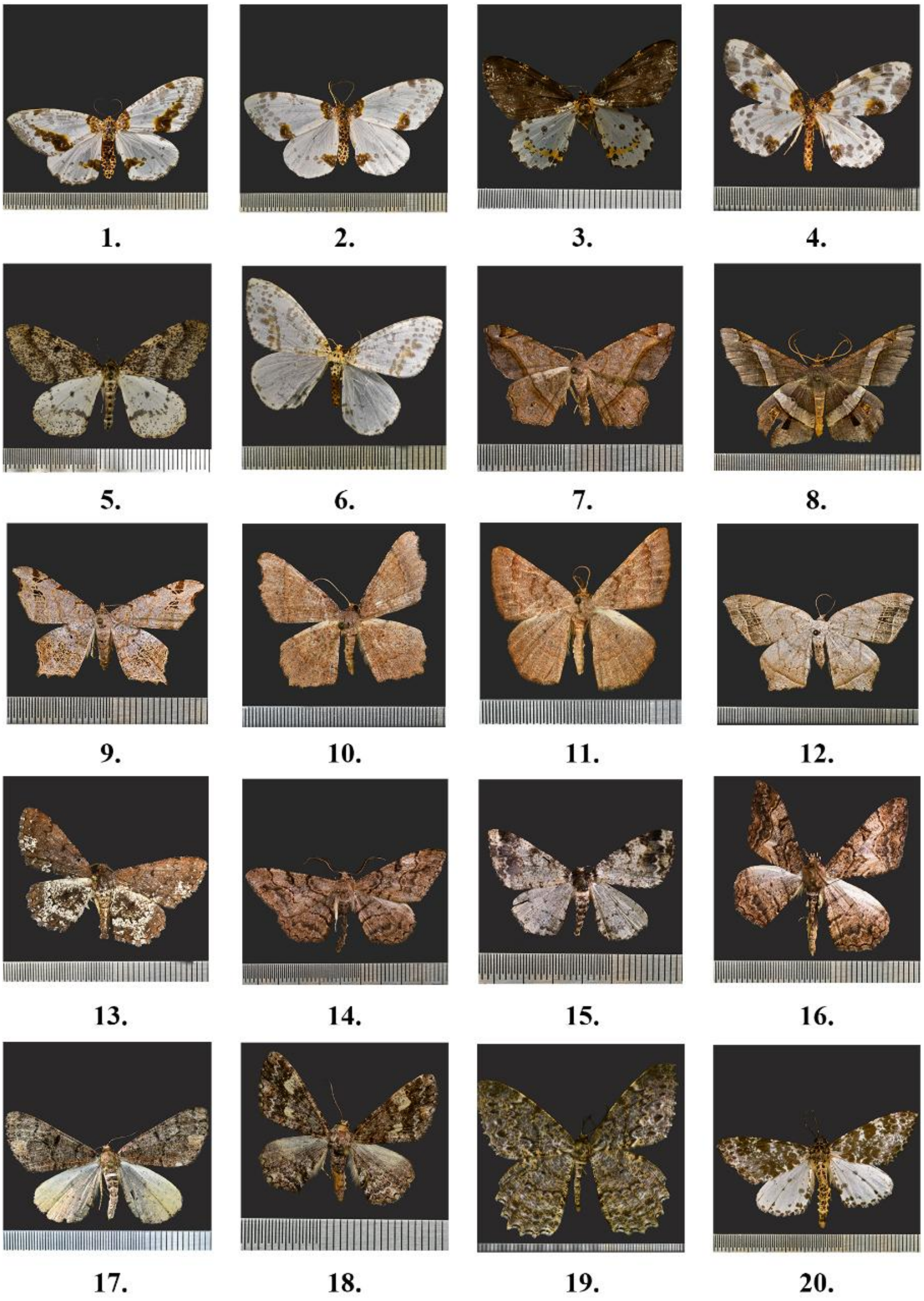


Plate 11
Ennominae

1. *Abraxas leopardina* 2. *A. peregrina* 3. *A. picaria* 4. *A. sublepida*
5. *A. superpicaria* 6. *A. virginalis* 7. *Chiasmia azataria* 8. *C. eleonora*
9. *C. emersaria* 10. *C. perfusria* 11. *Hypephyra terrosa* 12. *Oxymacaria temeraria*
13. *Abaciscus tristis* 14. *Alcis limbui* 15. *A. nigridorsaria* 16. *A. perspicuata*
17. *A. quadrifera* 18. *A. variegata* 19. *Amblychia pardicelata* 20. *Arichanna conspersa*

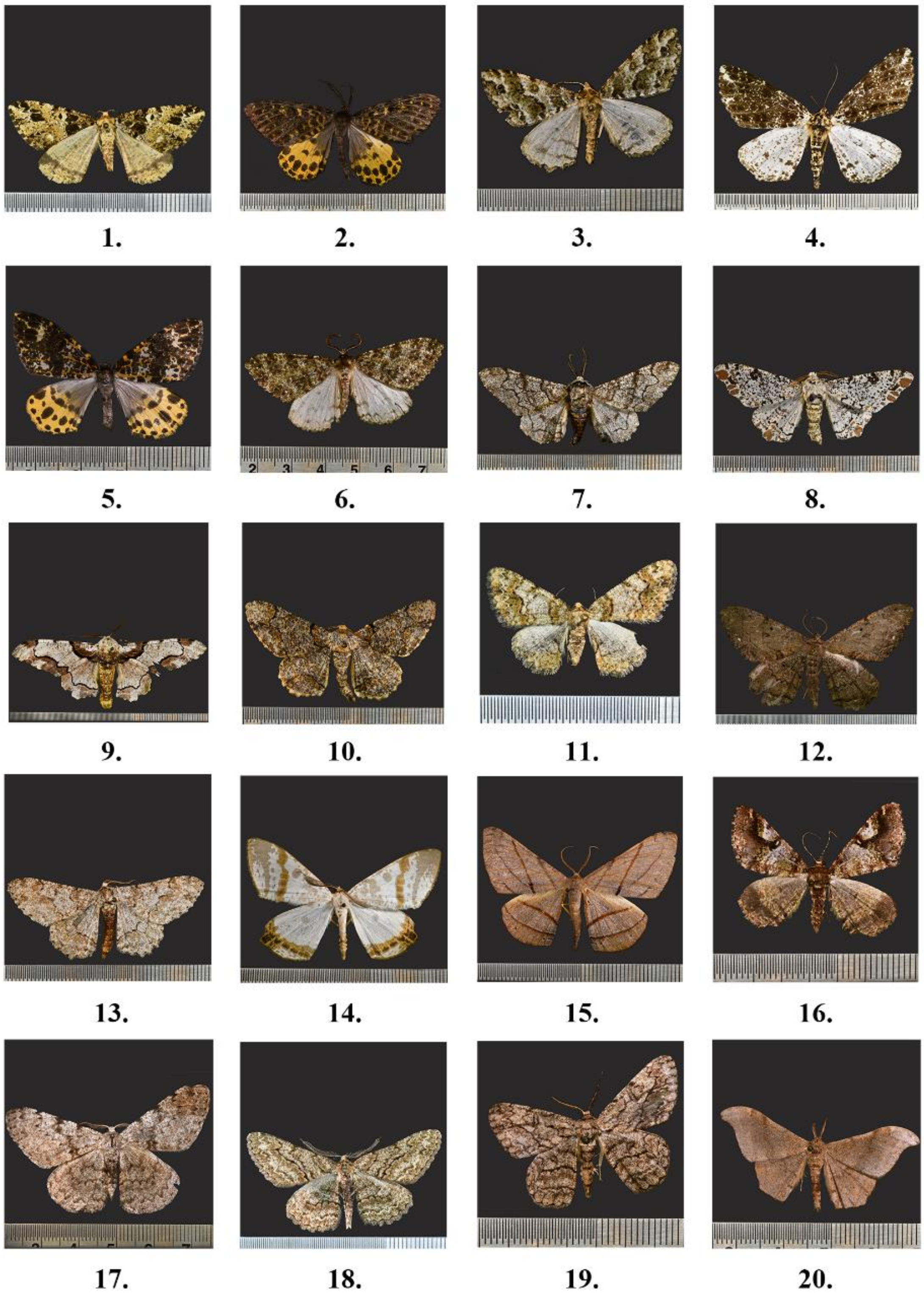


Plate 12
Ennominae

1. *Arichanna flavimedia* 2. *A. flavinigra* 3. *A. marginata* 4. *A. schnitzleri*
5. *A. sparsa* 6. *A. tenebraria* 7. *Biston nepalensis* 8. *B. falcata*
9. *B. regalis* 10. *B. suppressaria* 11. *Calcyopa ohrifasciata* 12. *Chorodna creataria*
13. *Cusiala boarmiodes* 14. *Dalima metachromata* 15. *Dalima patularia* 16. *Gasterocomme pannosaria*
17. *Hypomecis cineracea* 18. *Hypomecis ratotaria* 19. *Hypomecis transcissa* 20. *Hyposidra talaca*

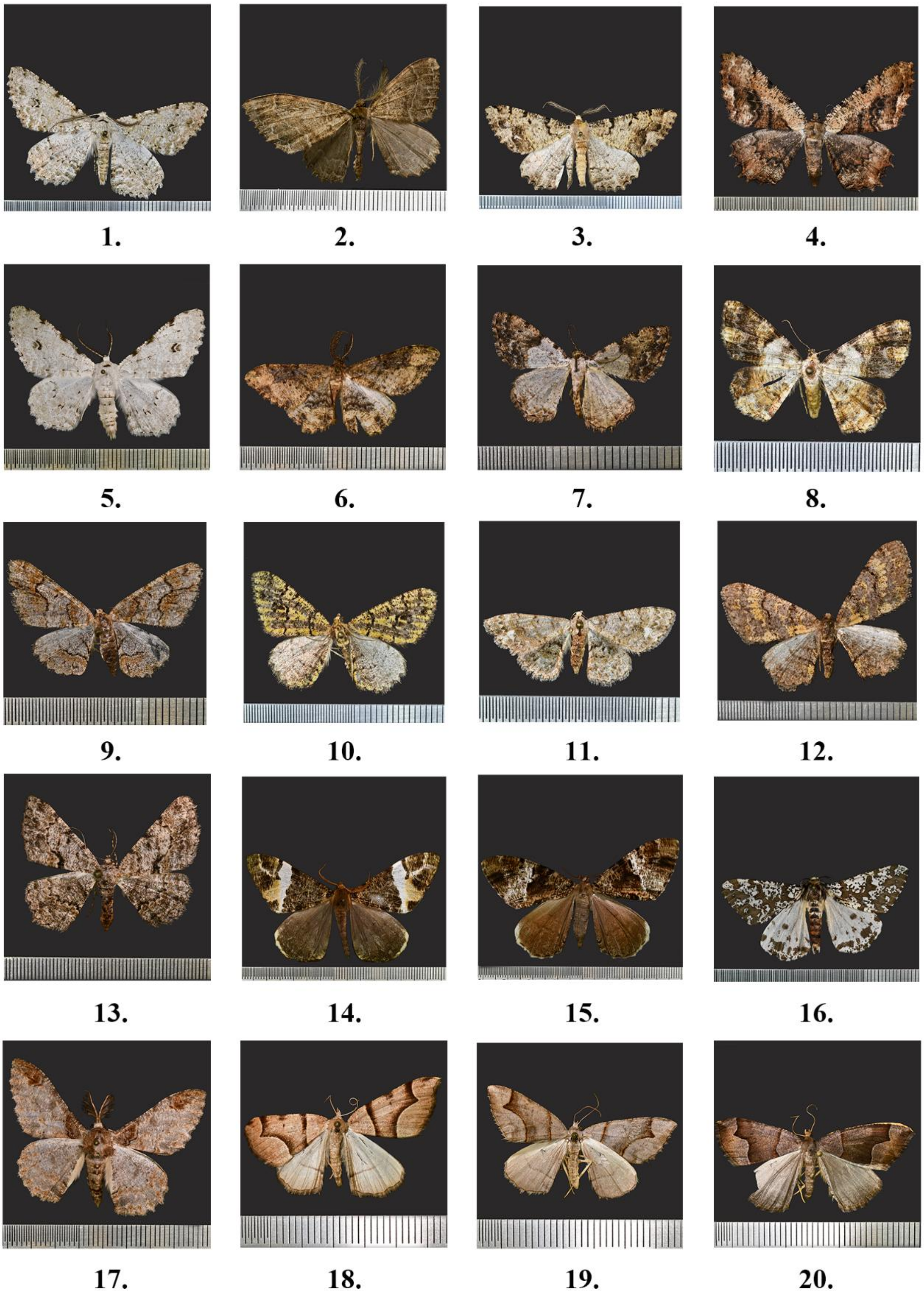


Plate 13
Ennominae

1. *Lassaba albidaria* 2. *L. anepsia* 3. *L. dissimilis* 4. *L. interruptaria*
5. *L. parvalbidaria* 6. *Microcalicha fimbriata* 7. *Myrioblephara albibasis* 8. *M. benefica*
9. *M. gandakiensis* 10. *M. harutai* 11. *M. idaeiodes* 12. *M. xanthozonea*
13. *Psilalcis breta* 14. *Xandrames albofasciata* 15. *X. dholaria* 16. *Abraxesis melaleucaria*
17. *Amraica recursaria* 18. *Anonychia diversilinea* 19. *A. grisea* 20. *A. lativitta*

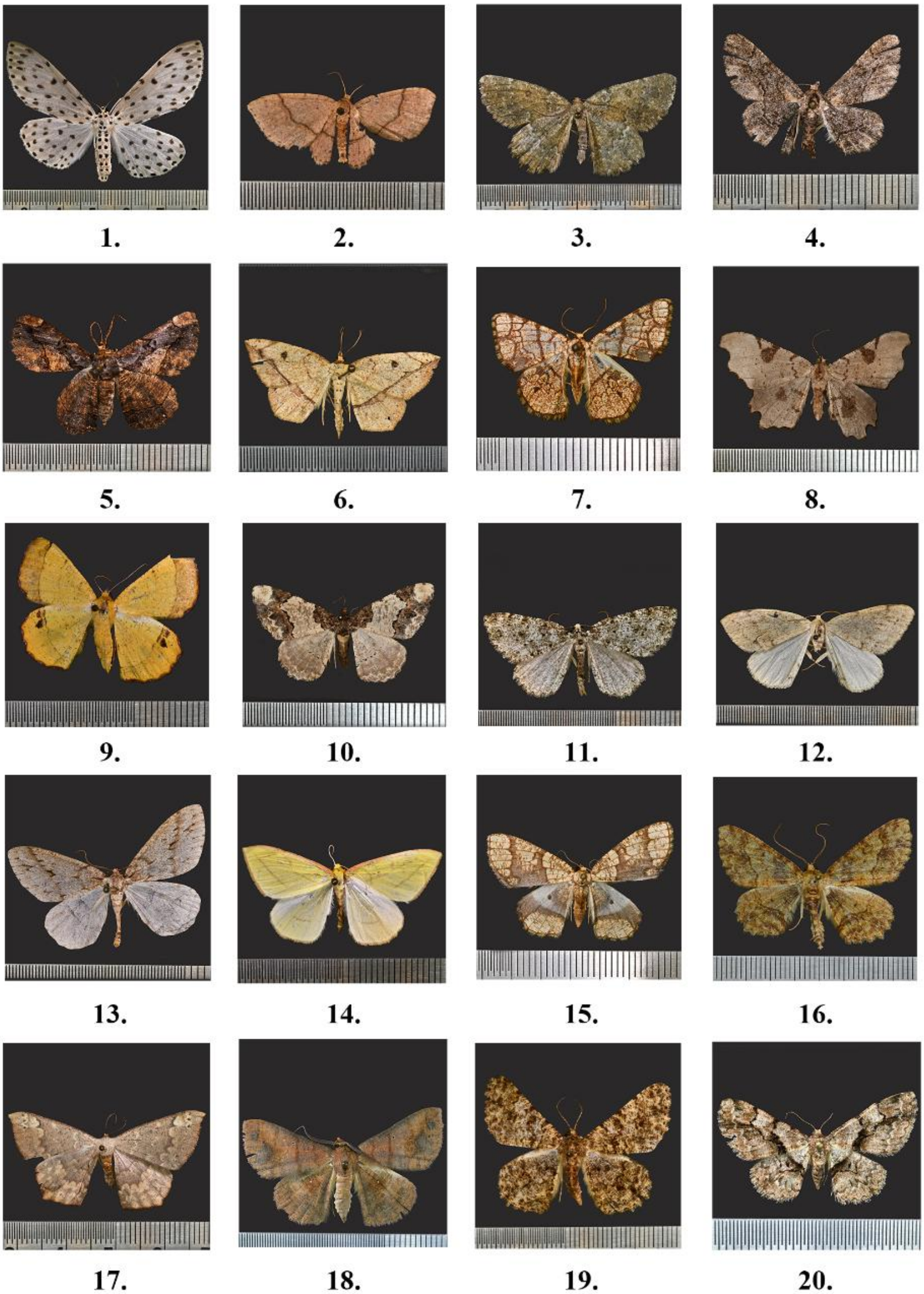


Plate 14

Ennominae

1. *Antipercnia belluaria* 2. *Anydrelia dharamshalae* 3. *Charissa crenulata* 4. *Cleora propulsaria* 5. *Dasyboarmia subpilosa* 6. *Entomopteryx obliquilinea* 7. *Heterostegane subtessellata* 8. *Hyalinetta circumflexa* 9. *Hyperythra lutea* 10. *Ligdia coctata* 11. *Micrabraxas grandis* 12. *M. seriopuncta* 13. *M. tenuis* 14. *Sirinopteryx ablunata* 15. *Orthobrachia latifasciata* 16. *Paradarisa comparataria* 17. *Peratostega deletaria* 18. *Petelia riobearia* 19. *Racotis boarmiaria* 20. *Satoblephara nepalensis*

1.

2.

Plate 15
Ennominae
1. *Xenoplia foraria* 2. *X. maculata*

Chapter 4
Altitudinal diversity patterns of Geometridae moths in DMR and underlying factors

4.1 Introduction

To incorporate all of the fundamental questions and delineate its boundaries firmly, Krebs (2014) defined the field of ecology as "the scientific study of the interactions that determine the distribution and abundance of organisms" (Krebs 2014). Over the period, scientists have identified and established two primary spatial gradients that define and incorporate the major environmental and diversity variations existing on Earth. These are, i) latitudinal gradients (from the tropics to the poles) and ii) altitudinal gradients (from the mountain base to the top). For decades, scientists have widely accepted that altitudinal gradients of mountains are analogous to the latitudinal gradients of the earth. They considered that the extent of variation observed in the diversity and environmental factors along the former was comparable to that in latitudinal gradients. Henceforth, they established two 'generalised geographic diversity patterns'—latitudinal diversity gradients (LDGs) and altitudinal diversity gradients (ADGs)—to define and explain the general patterns of species distributions and changes in space. For both gradients, temperature is considered to play a crucial role in shaping the overall pattern. As a result, the linear decreasing pattern of diversity with decreasing temperature along these gradients is established as a general pattern for species distribution on Earth. Nevertheless, as scientists began to study and document biodiversity patterns from different mountains around the world, they began to notice discrepancies between the observed and conventional patterns. Furthermore, different theories, principles, and processes have been developed and proposed as explanations over two centuries (Rahbek et al. 2019).

There are some fundamental differences between the latitudinal and altitudinal gradients. These are mainly in terms of their spatial scale and the magnitude or rate of change of environmental factors along these gradients (Hodkinson, 2005). Latitudinal gradients represent two of the earth's hemispheres. They span several hundred kilometres and display a gradual shift in environmental conditions over a distance of 100 km. Unlike this, altitudinal gradients are more localised and exhibit a rapid change in environmental conditions over a shorter distance of just a few kilometres. The other differences are in terms of the biogeographic setting and the number of gradients available globally. The Earth has only two latitudinal gradients: one in the Northern Hemisphere and the other in the Southern Hemisphere. Whereas, the altitudinal gradients are more numerous and diverse in terms of temporal and spatial scale, climate and biotic composition, topography, latitudinal location, and distribution (McCain and Grytnes 2010).

In 1799, Alexander von Humboldt went through the world's richest mountains in Latin or South America, the Andes Mountains and was the first to study the change of living world along an Altitudinal gradient of mountains (McCain and Grytnes 2010; Rahbek et al. 2019). His work was the first detailed study to understand the diversity pattern along the altitudinal gradient of mountains and the underlying mechanisms (Rahbek et al. 2019). Scientists consider altitudinal gradients more important in determining the general factors that shape the distribution and abundance of species. Mountains are more diverse and numerous, and exhibit multiplicity and variability in terms of their biogeographic position, historical background, and topo-climatic and biotic features. This can help examine the differences and consistencies of the findings across various mountain systems and disentangle the individual roles of different potential factors and processes (McCain and Grytnes 2010). To date, studies of mountain systems from different biogeographic regions have shown variations at two different levels: i) regional and ii) taxonomic. However, current knowledge is insufficient to explain these variations among different taxa and mountain systems, and this challenge is to provide a more general and unified explanation called “Humboldt’s enigma” (Rahbek et al. 2019).

Mountain regions like that of an island can be viewed as a biogeographical unit. Like islands, in-situ speciation and extinction play an important role in building regional species assemblages in the mountains (Rahbek et al. 2019). However, owing to its regional topographic complexity and biogeographical history, every mountain has a vast volume of unique and rare climatic types. These factors produced an assemblage of mountains with high endemism (Rahbek et al. 2019). Three important factors play an important role in the species richness of mountains; area, productivity, and topographical complexity. Those with larger areas, more topographic complexity, and productivity generally have larger species numbers and more small-range species, with a greater number of species endemic to that mountainous region (Rahbek et al. 2019). However, mountains from different climatic zones of the world—tropical, temperate, and arctic—differ in their overall species diversity and richness. Tropical mountains are comparatively more species-diverse, and many are biodiversity hotspots of the world compared to temperate and arctic mountains (Rickets et al. 2019). The climate of tropical mountains is less seasonal at any altitudinal point compared to temperate and arctic mountains, which makes the species less physiologically tolerant, with narrow physiological ranges. Physiological barriers result in less effective dispersal and low distributional ranges, with increased opportunities for allopatric speciation (Rahbek et al. 2019). Finally, as large species coexist locally, leading to dense packaging of species at the local scale and gradual species turnover over short distances characterises high species diversity in tropical-montane (Rahbek et al. 1997; Hoorn et al. 2018; McFadden et al. 2019). However, compared to tropical mountains, temperate and arctic mountains are species poor. Climatic variations are less pronounced along the altitudinal gradient, and seasonality is more pronounced at any point. Species are exposed to diverse climatic conditions at any location in these systems. Therefore, they have a wider physiological tolerance range and are dispersed over a greater distance. Therefore, species in these mountains generally have a larger altitudinal distribution range, and the overall assemblage has a comparatively gradual species turnover over a larger altitudinal distance (Rahbek et al. 2019).

Four of the most common species richness patterns observed along altitudinal gradients are decreasing, low plateaus with or without a mid-altitudinal peak, and mid-altitudinal peaks (McCain 2010). All of these patterns have been observed among several gradients across the globe with varying climatic, spatial, historical, and biotic settings and for different taxonomic groups (McCain 2010). Among the hypotheses given to explain these patterns mostly are based on factors like climate (temperature, humidity, productivity etc.), space (species-area relationship and spatial constraint hypothesis or geometric constraint or mid-domain effect), evolutionary history (speciation rate, extinction rate, clade age and phylogenetic niche conservation etc.) and biotic processes (ecotone effect, competition, habitat heterogeneity and complexity etc.) (Pianka 1966; Gaston 2000; McCain 2007b, 2010).

The moths family Geometridae is among the favourite and the most studied family has the following characteristics important for macroecological studies as a model insect herbivorous taxon: i) high species richness and abundance, ii) taxonomic and biogeographic soundness, iii) comparatively high species richness and abundance at temperate high latitudes and high Altitude areas of mountains, iv) easy sampling by light traps providing a large data set, and v) more comprehensive statistical analysis of diversity patterns (Hausmann 2001; Haussman et. al. 2003; Summerville et al. 2004; Beck and Chey 2007; Paknia and Sh 2015; Beck et al. 2016). Additionally, studies have been conducted worldwide to document and decipher altitudinal diversity patterns. Previous studies from South America (Brehm and Fiedler 2003; Brehm et al. 2003a, 2003b; Brehm et al. 2007), South East Asia (Schulze 2000), Africa (Axmacher et al. 2004a, 2004b, 2009) and other parts of the world (Paknia and Sh 2015; Beck et al. 2010; Beck and Chey 2008; Beck 2006; Beck and Chey 2007a, 2007b; Zhang et al. 2016) include both tropical and temperate mountains. These studies provided a sufficient dataset to compare the results from the Himalayas.

The Indian Himalayan Region (IHR) offers a unique opportunity to study ADGs across their entire length and breadth. This region lies at the crossroads of different zoogeographical realms, and is critical for ecological and biogeographical research. Along its length, it offers diverse climatic zones along with vast altitudinal ranges and rich biodiversity to serve as an ideal setting for studying altitudinal gradients. This chapter focuses on i) the species richness and diversity changes/patterns along the altitudinal gradient and different forest types of the DMR, ii) the potential role of different habitat covariates in shaping the observed patterns, and iii) the use of appropriate ordination methods to effectively display and easily interpret the observed pattern.

4.2 Materials and Methods

4.2.1 Data collection

Two altitudinal gradients were randomly selected and divided vertically at every 300 m distance. These gradients collectively represent the 800–3200 m altitudinal range of the DMR. The two gradients were named i) the Kareri gradient (from Charri-Kareri Khas-Kareri Lake) with an altitude range of 800–3200 m and ii) the Rajgundha gradient (comprising Bir-Billing-Rajgundha-Palachak) ranges from 1500–3200 m. For each 300 m zone, two sampling sites were randomly chosen and sampled at least twice for each of the two seasons, that is, pre-monsoon (April–June) and post-monsoon (September–November). Every light-trapping session was started soon after sunset up to 3:00 am, and the trapping was refrained two days before and after the full moon.

Habitat covariates

The ambient atmospheric temperature, relative humidity, wind velocity, and cloud cover (measured every hour during light trapping) were averaged for each trapping night. Vegetation data were collected using the Nested Quadrate method within a 50 m radius around the light trapping station. Anthropogenic disturbance variables, logging, lopping signs, number of fallen or dead trees, and livestock grazing signs (pellet numbers) were observed in the 50 m radius circle around the light trapping station. A 20x20 m^2 quadrate was used to quantify tree species richness, abundance and girth at breast height (GBH). Canopy cover was measured visually at eight points on regular intervals of 10 m along the perimeter of the 20x20 m^2 quadrat. Species richness, abundance and percent cover of shrubs and saplings were observed in the two 5x5 m^2 quadrats within the 20x20 m^2. Similarly, for data on herb species richness, abundance and per cent cover, two 1x1 m^2 quadrats were laid in each 5x5 m^2 quadrat.

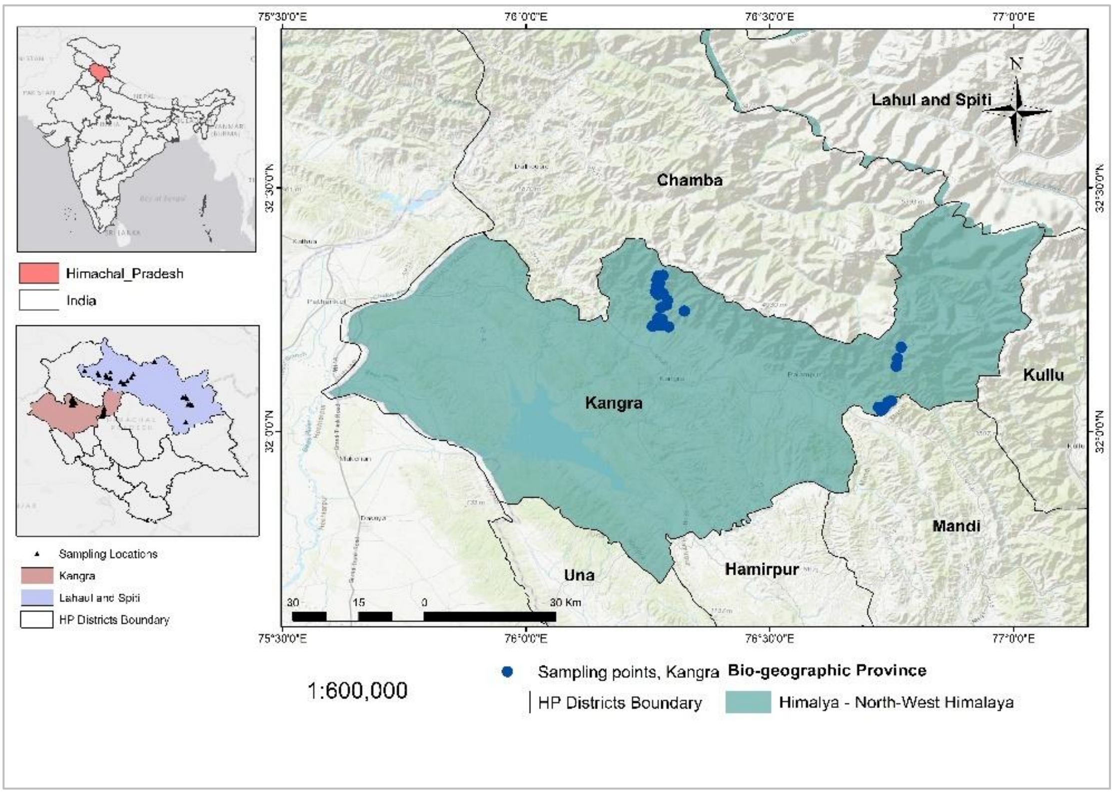


Fig. 4.1: Sampling locations in the DMR, Kangra District, Himachal Pradesh.

Historical climate (nineteen Biovariables) data and monthly weather data were downloaded at 30 arc seconds resolution from WorldClim version 2.1 (Fick et al. 2017). Topographical variables—altitude, aspect and slope—were extracted from the Digital Altitude Model (DEM) (usgs.gov). Normalised Difference Vegetation Index (NDVI) values for each sampling site were calculated as a proxy along with the vegetation data. These variables were extracted across all sampling points using ArcGIS 10.7.

4.2.2 Data analysis

Assemblages of different Altitudinal zones and forest categories

Along the altitudinal gradient, the community assemblage of herbivore taxa was significantly influenced and shaped by two key factors, altitude and forest type. Therefore, to study the community assemblage patterns along the altitudinal gradient of DMR, the communities of the Geometridae moths and the two of its major subfamilies—Ennominae and Larentiinae—were investigated for different altitudinal zones and forest categories. To assess the effects of altitude, the sites were grouped into five major altitudinal zones (Table 4.1); Zone 1 (801–1300 m), Zone 2 (1301–1800 m), Zone 3 (1801–2300 m), Zone 4 (2301–2800 m), and Zone 5 (2801–3300 m). Additionally, to compare different forest types, 34 sampling sites were classified into eight forest types within the four major forest groups viz., Northern Tropical Dry Deciduous Forests (5B), Himalayan Sub-tropical Pine forests (9/C1), Lower/Western Himalayan Temperate Forests (12/C1) and Upper West Himalayan Temperate Forests (12/C2) (Table 4.1). This classification was based on the forest grouping defined in Champion and Seth's (1968) classification of forest types in India.

α (alpha) and β (beta) diversity patterns

Site-wise species abundance data were pooled for each altitudinal zone. The sampling completeness of each zone was visualised using individual-based rarefaction and extrapolation curves. Curves were drawn using the 'iNEXT' R package (Hsieh et al. 2016). Species richness, diversity and abundance were calculated and estimated (as discussed in Chapter 3) for every altitudinal zone and forest type. Bar graphs were prepared (using Microsoft Excel 2016) to visualise the patterns of species richness, relative abundance, and α-diversity for different altitudinal zones.

β (beta) diversity involves the measure of 'species compositional differences' between the sites/communities/habitats. For simplicity, it is the ratio of gamma and alpha diversities. However, in a broader ecological sense, it has two underlying forces/components, namely, species replacement (turnover) and species richness (nestedness). Species replacement is simply the substitution of the species and is measured by considering the species restricted to only one site. However, differences in species richness between habitats result from species loss or the addition of new species. As a result, species-poor assemblages often appear to be the subset or nested within the richest one and this component is also called nestedness.

To study the β (beta) diversity pattern along the altitudinal gradient, pairwise measures of dissimilarities between consecutive pairs of altitudinal zones—between Zone 1-2, Zone 2–3, Zone 3–4, and Zone 4–5 (McCain and Beck 2016; Burner et al. 2018)—were calculated. Three measures of dissimilarities—turnover, nestedness, and total beta diversity—were calculated using two different indices. Sørensen-Simpson's Index was used for species presence-absence data and the Bray-Curtis Index with species abundance data. For the Sørensen-Simpson's Index, **βSIM** measures Simpson's species turnover, **βSNE** measures Sorensen species nestedness, and **βSOR** measures total beta diversity. Similarly, for the Bray-Curtis Index, **βbray.bal** indicates species turnover, **βbray.gra** indicates species nestedness, and **βbray** represents the total beta diversity. These analyses were performed using the "betapart" package (Baselga 2010, 2012; Baselga and Orme 2012) in the R software version 4.2.1. Furthermore, the species compositions of different altitudinal zones were investigated using ANOSIM and SIMPER analyses to reveal the statistical differences and species contributing to the distinctions between them.

Table 4.1: Sampling site details and their classification in different altitudinal zones and forest types of DMR.

<table>
<tr><th>Site code</th><th>Altitude (in m asl)</th><th>Altitudinal Zone</th><th>Forest type</th><th>Major Forest Category</th></tr>
<tr><td>KAR08A</td><td>849</td><td>Zone 1 (801-1300 m)</td><td>Northern Mixed Deciduous Forests (5B/C2) (NMD)</td><td rowspan="5">5B: Northern Tropical Dry Deciduous Forests [NMD]</td></tr>
<tr><td>KAR08C</td><td>1008</td><td>Zone 1 (801-1300 m)</td><td>Northern Mixed Deciduous Forests (5B/C2)</td></tr>
<tr><td>KAR11A</td><td>1118</td><td>Zone 1 (801-1300 m)</td><td>Northern Mixed Deciduous Forests (5B/C2)</td></tr>
<tr><td>KAR11D</td><td>1217</td><td>Zone 1 (801-1300 m)</td><td>Northern Mixed Deciduous Forests (5B/C2)</td></tr>
<tr><td>KAR14B</td><td>1455</td><td>Zone 2 (1301-1800 m)</td><td>Northern Mixed Deciduous Forests (5B/C2)</td></tr>
<tr><td>KAR08B</td><td>1018</td><td>Zone 1 (801-1300 m)</td><td>Lower or Siwalik Chir Pine Forests (9/C1a) (LHC)</td><td rowspan="4">C1: Himalayan Sub-tropical Pine forests (9/C1) [HSC]</td></tr>
<tr><td>KAR08D</td><td>1064</td><td>Zone 1 (801-1300 m)</td><td>Lower or Siwalik Chir Pine Forests (9/C1a)</td></tr>
<tr><td>KAR11C</td><td>1084</td><td>Zone 1 (801-1300 m)</td><td>Lower or Siwalik Chir Pine Forests (9/C1a)</td></tr>
<tr><td>KAR11B</td><td>1170</td><td>Zone 1 (801-1300 m)</td><td>Lower or Siwalik Chir Pine Forests (9/C1a)</td></tr>
</table>

KAR14A	1404	Zone 2 (1301-1800 m)	Upper or Himalayan Chir Pine Forests (9/C1b) **(UHC)**	
RAJ14A	1565	Zone 2 (1301-1800 m)	Upper or Himalayan Chir Pine Forests (9/C1b)	
KAR17B	1796	Zone 2 (1301-1800 m)	Upper or Himalayan Chir Pine Forests (9/C1b)	
RAJ14B	1615	Zone 2 (1301-1800 m)	Ban Oak Forests (12/C1a)	C1: Lower/Western Himalayan Temperate Forests (12/C1) **[LHT]**
RAJ17A	1754	Zone 2 (1301-1800 m)	Ban Oak Forests (12/C1a)	
KAR17A	1870	Zone 3 (1801-2300 m)	Ban Oak Forests (12/C1a)	
RAJ17B	1875	Zone 3 (1801-2300 m)	Ban Oak Forests (12/C1a)	
KARDEOA	1940	Zone 3 (1801-2300 m)	Moist Deodar Forests (12/C1c) **(MD)**	
KARDEOB	1948	Zone 3 (1801-2300 m)	Moist Deodar Forests (12/C1c)	
RAJ20A	1990	Zone 3 (1801-2300 m)	Ban Oak Forests (12/C1a) **(BO)**	
KAR20A	2032	Zone 3 (1801-2300 m)	Ban Oak Forests (12/C1a)	
RAJ20B	2099	Zone 3 (1801-2300 m)	Ban Oak Forests (12/C1a)	
KAR20B	2111	Zone 3 (1801-2300 m)	Ban Oak Forests (12/C1a)	
KAR23A	2308	Zone 4 (2301-2800 m)	Ban Oak Forests (12/C1a)	
RAJ23A	2341	Zone 4 (2301-2800 m)	Ban Oak Forests (12/C1a)	
KAR23B	2478	Zone 4 (2301-2800 m)	Ban Oak Forests (12/C1a)	
RAJ23B	2572	Zone 4 (2301-2800 m)	Ban Oak Forests (12/C1a)	
KAR26A	2667	Zone 4 (2301-2800 m)	West Himalayan Upper Oak-Fir Forests (12/C2b) **(UOF)**	C2: Upper West Himalayan Temperate Forests (12/C2) **[UHT]**
RAJ26A	2677	Zone 4 (2301-2800 m)	West Himalayan Upper Oak-Fir Forests (12/C2b)	
KAR26B	2730	Zone 4 (2301-2800 m)	West Himalayan Upper Oak-Fir Forests (12/C2b)	
RAJ26B	2782	Zone 4 (2301-2800 m)	West Himalayan Upper Oak-Fir Forests (12/C2b)	
RAJ29A	2834	Zone 5 (2801-3300 m)	Kharsu Oak (12/C2a) **(KO)**	
KAR29A	2892	Zone 5 (2801-3300 m)	Kharsu Oak (12/C2a)	
KAR29B	3066	Zone 5 (2801-3300 m)	Kharsu Oak (12/C2a)	
RAJ29B	3168	Zone 5 (2801-3300 m)	Birch-Rhododendron scrub Forests (15/C1) **(BRS)**	

For the eight forest types, similarities or differences in species composition were analysed using cluster analysis. The resulting dendrogram of the cluster analysis possesses a horizontal axis, with values representing the similarity index; higher values indicate greater similarity in species composition between forest types.

Potential drivers of species richness and diversity patterns of Geometridae family in DMR

To determine the potential role of different habitat covariates—topographical, environmental, vegetation, and disturbance variables—on overall diversity measures (observed and estimated species richness, abundance, and Fisher's alpha) and the species assemblages of the five altitudinal classes, a multivariate analysis approach was employed in the PAST4 software. I first checked for the correlation among the variables using Pearson's correlation (r) and among the groups of highly correlated variables ($r > 0.6$), only one was considered for further multivariate analysis. Canonical Correspondence Analysis (CCA) was used as a multivariate analysis with different sets of variables to identify the significant variables and their contribution in shaping the patterns and community assemblages among different altitudinal zones.

4.3 Results

4.3.1 Species richness and distribution patterns along an altitudinal gradient

Distribution of major subfamilies

The altitudinal distribution of individuals within the Geometridae family was studied using a box plot (Fig. 4.2). The plot shows that the individuals were mostly distributed at altitudes of 2100–2200 m. For the four major subfamilies documented from the DMR, Larentiinae, Ennominae, and Geometrinae were distributed throughout the studied altitudinal gradient, ranging from 800 to 3200 m. However, the subfamily Sterrhinae was found only up to an altitude of 2800 m. The highest median altitudinal distribution was observed for Larentiinae at roughly 2300 m. Furthermore, both the Larentiinae and Ennominae subfamilies had their highest abundances at nearly 2300 m altitude. The lowest altitudinal distribution was for the Sterrhinae subfamily at approximately 1600 m, and approximately 2000 m for the subfamily Geometrinae.

Sampling completeness, Species richness and α (alpha) diversity patterns

The individual-based rarefaction and extrapolation curves for the five altitudinal zones indicated that all five zones were adequately sampled. Along the altitudinal gradient of the DMR, a humpback-shaped/unimodal relationship was observed between altitude and the species richness, abundance, and diversity measures of the Geometridae family. Estimated species richness (iChao-1) increased with increasing altitude up to the middle altitudinal zone (Zone-3, 1801–2301 m) and then declined to form an overall bell-shaped curve along the entire studied gradient. However, the observed species richness and relative abundance were the highest next to the middle zone (Zone 4, 2301–2800 m), with values only slightly higher than those in the middle zone. Fisher's alpha (α diversity measure) showed the highest values for Zone 2 (1301–1800), with values only slightly higher than those of Zones 3 and 4.

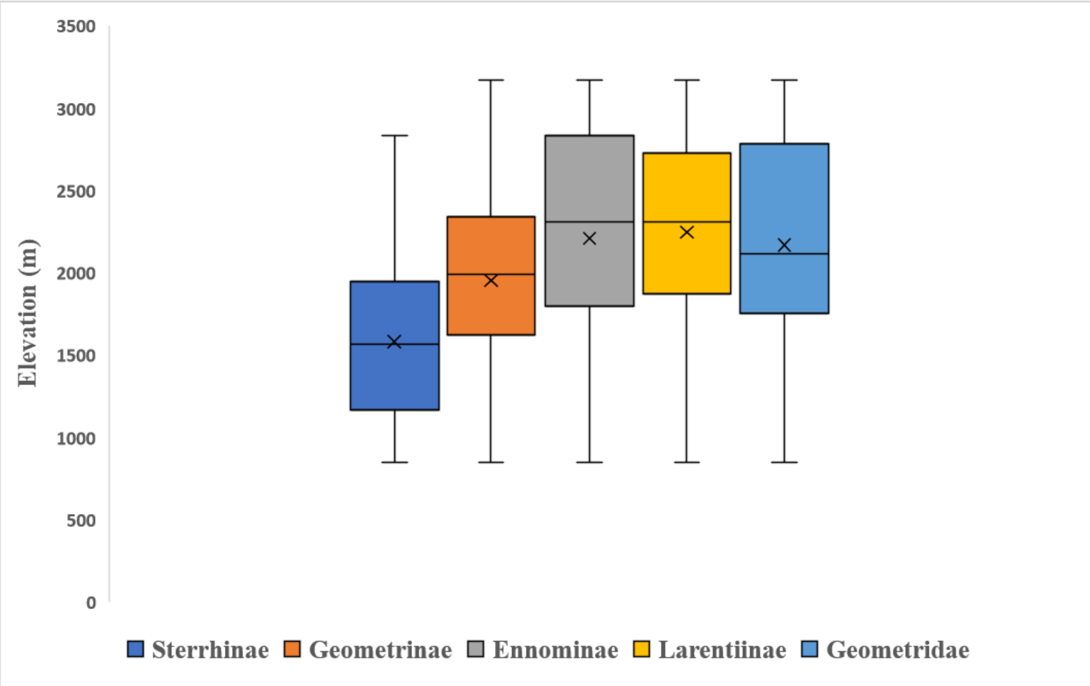


Fig. 4.2: Box plots showing the altitudinal distribution of the family Geometridae and its four major subfamilies, Sterrhinae, Geometrinae, Ennominae and Larentiinae in the DMR. (x indicates the mean value).

Similar patterns were also observed for the subfamily Ennominae; the Fisher's alpha, observed, and estimated species richness, all showing a peak in the middle altitudinal zone. However, the relative abundance of the subfamily Ennominae increased with altitude, with the highest values in the uppermost zone (Zone 5, 2801–3300 m). The subfamily Larentiinae displayed a unimodal pattern, with the highest values for all four measures (Fisher's alpha, estimated and observed species richness, and relative abundance) in the Zone 4 (2301–2800).

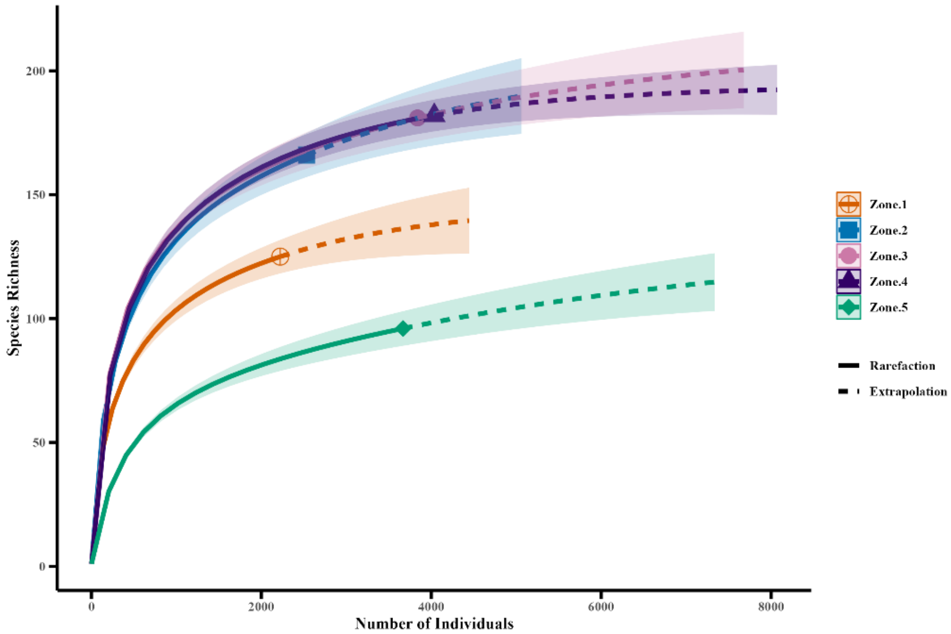


Fig. 4.3: Rarefaction and extrapolation curves for species richness across different altitudinal zones (iNEXT package, R version 4.2.1).

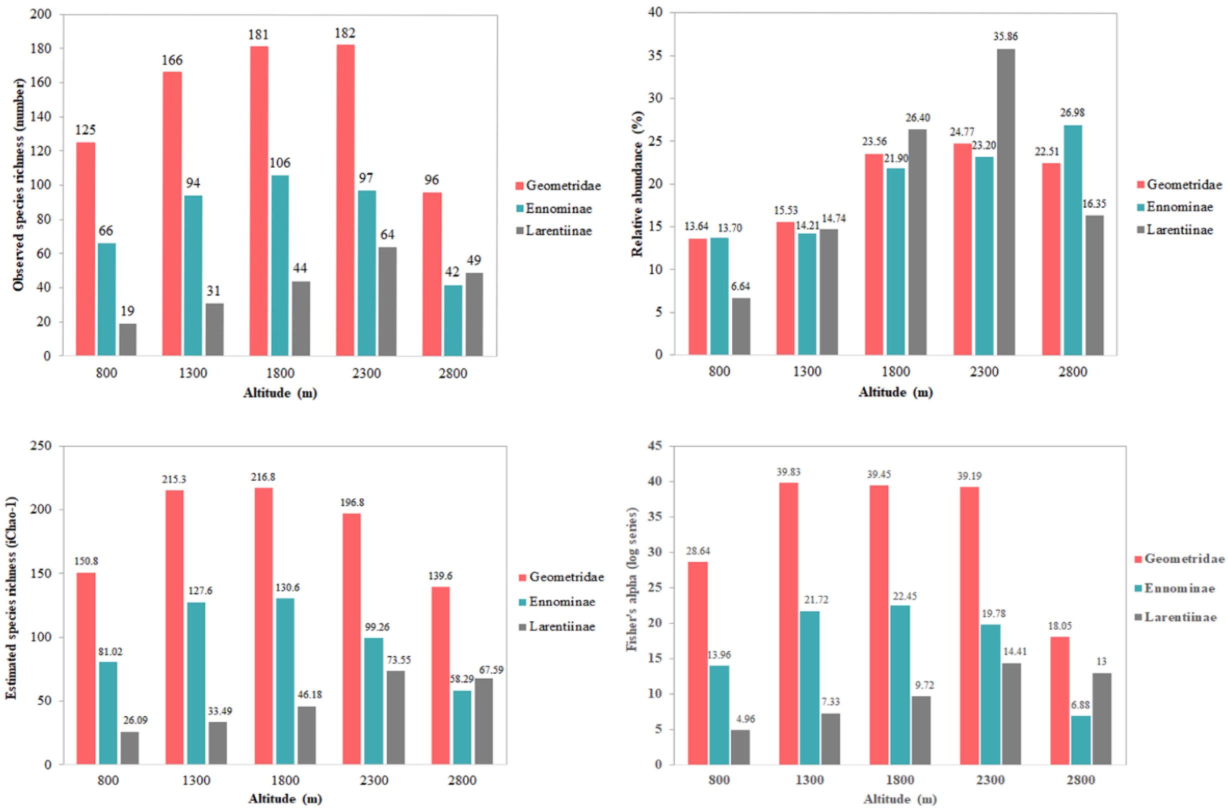


Fig. 4.4: Observed species richness, relative abundance (%), estimated species richness (based on the iChao-1 estimator), and Fisher's alpha (log-series) for the family Geometridae and its two major subfamilies Ennominae and Larentiinae in every 500 m altitudinal zone.

β (beta) diversity patterns

The total β-diversity for the DMR landscape was larger with $\beta_{SOR} = 0.59$ and $\beta_{bray} = 0.8$ and was largely shaped by species turnover (replacement), $\beta_{SIM} = 0.49$, and $\beta_{bray.bal} = 0.76$, rather than by the richness (nestedness) factor $\beta_{SNE} = 0.10$, and $\beta_{bray.gra} = 0.04$.

Sørensen-Simpson's (species presence-absence-based) and Bray-Curtis indices (species abundance-based) revealed distinct patterns of species dissimilarity and turnover along the Altitudinal gradient of DMR. The Sørensen pairwise dissimilarity was the highest between Zone 4 and Zone 5 (Fig. 4.6a), while the Bray-Curtis distance was the maximum between Zones 3 and 4 (Fig. 4.6b). Simpson's pairwise dissimilarity (species-turnover) and Bray-Curtis species-turnover were highest for Zone 3– 4 i.e., 0.27 and 0.57, respectively. Similarly, species-nestedness was highest for Zone 4–5 (0.27) while the Bray-Curtis nestedness measure was highest for Zone 2–3 (0.13). Overall, there was comparatively less congruency between the patterns based on species incidence and abundance data. However, in both cases, the overall patterns of β-diversity (turnover and nestedness) for the Geometridae family were primarily shaped by the underlying changes in the species composition of the most dominant subfamily, Ennominae, along the altitudinal gradient (Figs. 4.6a and 4.6b). The β-diversity patterns (both Sørensen-Simpson's and Bray-Curtis's index) for the subfamily Ennominae were similar to the overall pattern of the family Geometridae.

Species composition of different altitudinal zones

ANOSIM analysis comparing the species assemblages of all combinations of paired altitudinal zones resulted in a highly significant global R-value (0.7886), with a p-value of 0.0001. A higher R-value indicated significant differences in species assemblages across the five altitudinal zones. The highest dissimilarities along the altitudinal gradient were observed in Zones 1–2 and Zones 3–4. The species composition of the lowest altitudinal zone (Zone 1) was unique, based on its high R-values and significant p-values for all other zones. Also, the species composition of Zone 5 had large and significant dissimilarities with that of the rest of the altitudinal zones (except for non-significant differences with Zone 4). The assemblages of Zones 2–3 and 4–5 was least distinct with the lowest R-values. More details on the pairwise R- and p-values for the different combinations of the five altitudinal zones are provided in Table 4.2. SIMPER analysis was used to calculate the percentage contribution of each species to the overall dissimilarity percentage between the geometrid moth assemblage of the two adjacent altitudinal zones. The major species contributing to the differences in Zones 1 and 2 (Table 4.3), Zones 2 and 3 (Table 4.4), Zones 3 and 4 (Table 4.5), and Zones 4 and 5 (Table 4.6) have been listed.

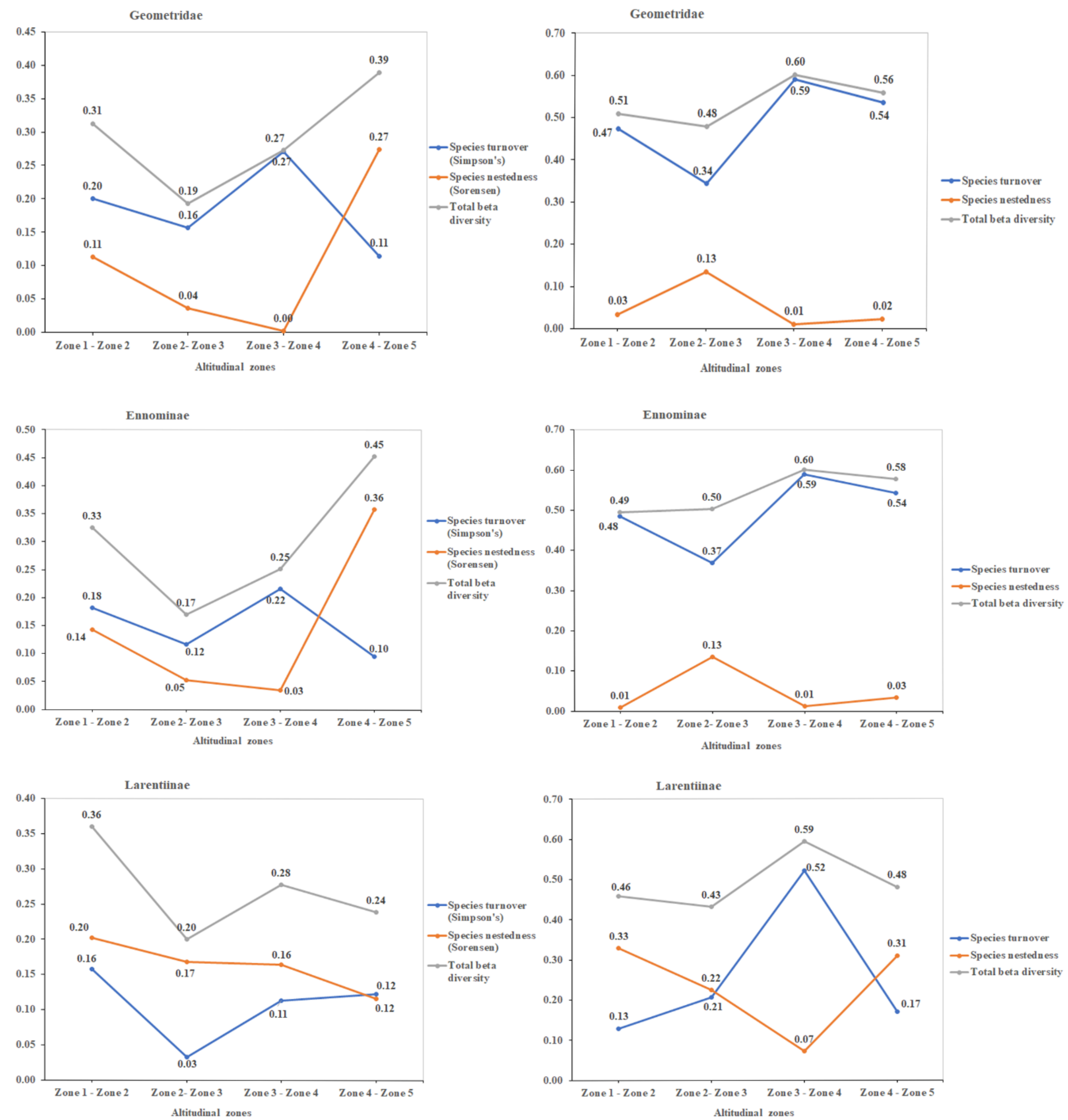


Fig. 4.5: β (beta) diversity patterns along altitudinal gradient—total β (beta) diversity, species turnover, and species nestedness patterns as pair-wise dissimilarities between the adjacent pairs of altitudinal zones, based on the **(left side)** presence-absence (Sørensen-Simpson's Indices) and **(right side)** abundance (Bray-Curtiz Index) data for the total geometrid moth assemblage and its two major subfamilies, Ennominae and Larentiinae.

Table 4.2: Results of the pairwise comparison of geometrid moth assemblage similarity across five altitudinal zones using ANOSIM (Analysis of Similarity). [Mean p- and R-values for ANOSIM among the five altitudinal zones were p = 0.0001 and R-value = 0.7886, respectively]. Values in bold are R-values and others are p-values.

	Zone 1	Zone 2	Zone 3	Zone 4	**Zone 5**
Zone 1	**0**	0.0003	0.0004	0.0005	0.0028
Zone 2	**0.8072**	**0**	0.0194	0.0003	0.005
Zone 3	**0.9955**	**0.3266**	**0**	0.0004	0.0022
Zone 4	**0.9994**	**0.8866**	**0.5831**	**0**	0.0451
Zone 5	**1**	**1**	**0.9908**	**0.3107**	**0**

4.3.2 Species richness, diversity and composition of different forest types

The rarefaction and extrapolation curves for all eight forest types sampled in the DMR are shown in Figure 4.6. Highest sampling effort and species richness were found for Ban Oak (BO) forest type which can be attributed to its broad altitudinal range (~1400 m–2500 m) in the study area, covering most of the sampling points. Furthermore, the observed and estimated species richness and diversity measures also show highest values for BO forests (Fig. 4.7). While relative abundance was higher among higher-altitude forest types (UOF, KO and BRS) compared to lower-altitude forest types (NMD, LCP, UCP and MD). These findings, combined with higher species richness and diversity estimates for lower-altitude forest types, indicate a higher number of singleton records from these forest types. Thus, suggesting the need for increased sampling efforts to adequately represent the diversity of these forest types.

The dendrogram for the cluster analysis of the eight forest types sampled showed a similar species composition for the NMD and LCP forest types. These two forest types at lower altitudes of the DMR do not have sharp boundaries defined between them and share tree species among them. Furthermore, the tree showed two major clusters combining the forest types from the lower and higher altitudinal areas, with a separate branch for the BO forest type. This suggests that the different forest types along the altitudinal gradient play a significant role in shaping species assemblages within various altitudinal zones.

Table 4.3: Species with major contributions to dissimilarity (71.61%) between Zones 1 and 2 based on SIMPER analysis.

Species name	Average dissimilarity	Contrib. %	Cumulative %	Mean Zone 1	Mean Zone 2
Hyposidra talaca talaca	4.978	6.952	6.952	34.5	0
Psilalcis breta breta	4.311	6.021	12.97	24.8	34.3
Chiasmia azataria	3.728	5.206	18.18	16.1	30
Alcis perspicuata	3.532	4.933	23.11	3.75	30.7
Alcis variegate	2.254	3.148	26.26	8.88	23.7
Xanthorhoe saturate	2.204	3.078	29.34	11.5	23.2
Dasyboarmia subpilosa	1.943	2.713	32.05	14.4	7.5

Table 4.4: Species with major contributions to dissimilarity (65.87%) between Zones 2 and 3 based on SIMPER analysis.

Species Name	Average dissimilarity	Contrib. %	Cumulative %	Mean Zone 2	Mean Zone 3
Alcis perspicuata	3.718	5.645	5.645	30.7	32.8
Psilalcis breta breta	3.232	4.906	10.55	34.3	1.63
Chiasmia azataria	3.228	4.901	15.45	30	2
Alcis limbui	2.902	4.405	19.86	7	31.9
Lophophleps informis	2.096	3.182	23.04	7.5	16.5
Calcyopa ochrifasciata	1.928	2.927	25.97	3.17	17.3

Table 4.5: Species with major contributions to dissimilarity (76.59%) between Zones 3 and 4 based on SIMPER analysis.

Species name	Average dissimilarity	Contrib. %	Cumulative %	Mean Zone 3	Mean Zone 4
Arichanna flavinigra	10.46	13.66	13.66	5	123
Alcis perspicuata	2.957	3.86	17.52	32.8	3.75
Alcis limbui	2.743	3.581	21.1	31.9	16.9
Alcis variegata	2.125	2.775	23.87	23.4	5.38
Calcyopa ochrifasciata	1.907	2.49	26.37	17.3	4.63

Table 4.6: Species with major contributions to dissimilarity (71.42%) between Zones 4 and 5 based on SIMPER analysis.

Taxon	Average dissimilarity	Contrib. %	Cumulative %	Mean Zone 4	Mean Zone 5
Arichanna flavinigra	36.85	51.61	51.61	123	703
Aplochlora dentisignata	1.287	1.802	53.41	16.9	0.5
Martania fulvimacula	1.285	1.799	55.21	10.1	19.8

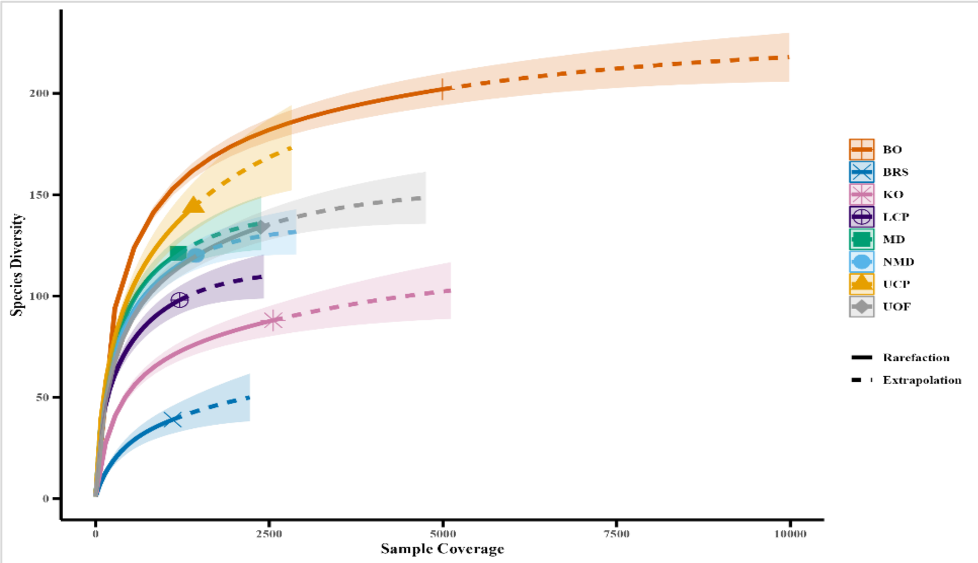


Fig. 4.6: Rarefaction and extrapolation curves for species diversity across different forest types (iNEXT package, R version 4.2.1)

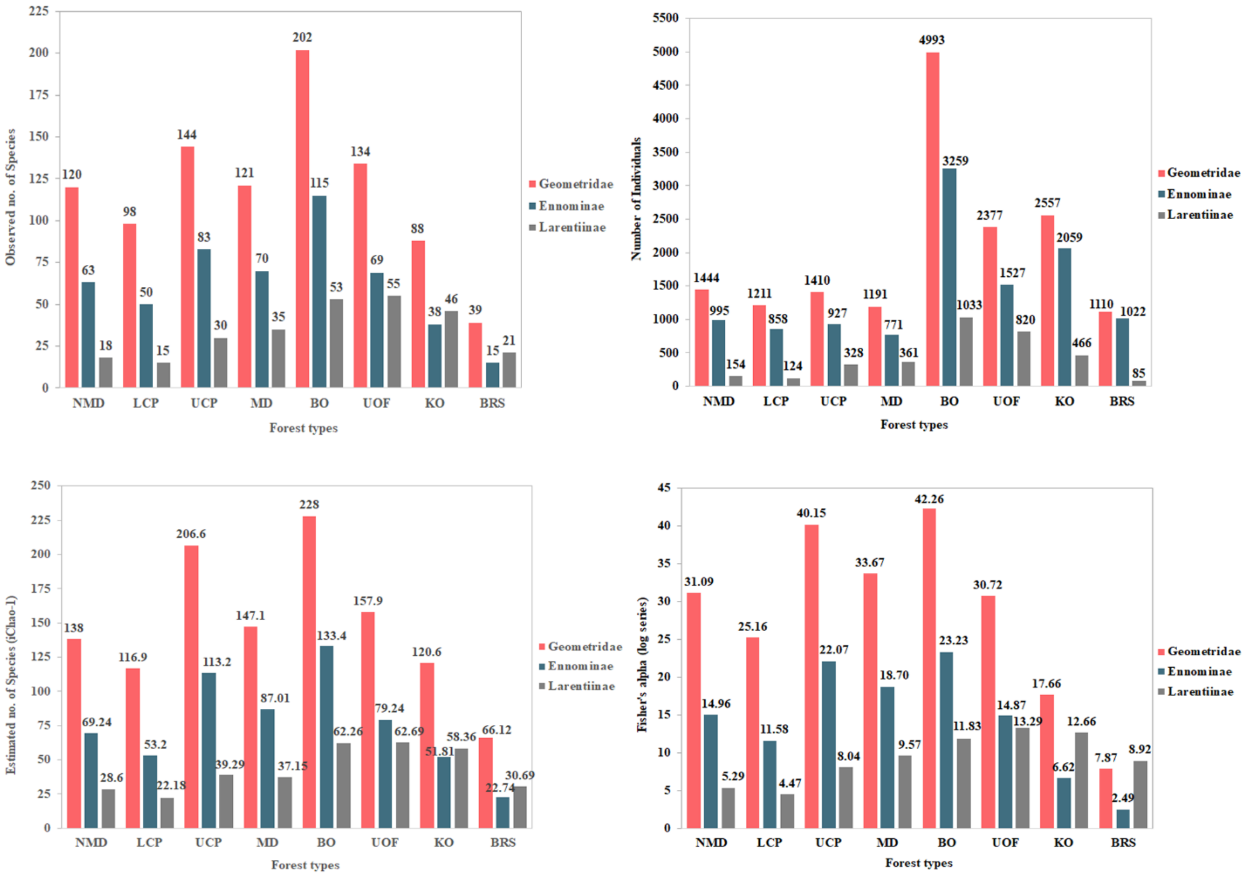


Fig. 4.7: Observed and Estimated species richness (based on iChao-1 measure), number of individuals, and Fisher's alpha values for the Family Geometridae and its two major subfamilies Ennominae and Larentiinae across eight forest types sampled in DMR.

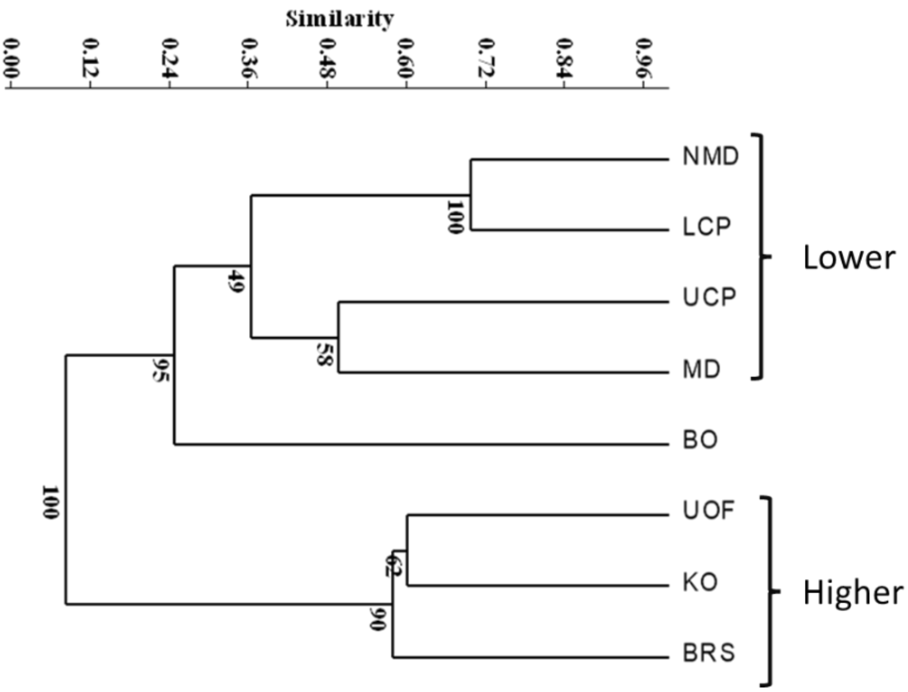


Fig. 4.8: Dendrogram of the Cluster analysis (based on the geometrid assemblage) of the eight forest types of the DMR. (Cophen. Corr: 0.92, Bray-Curtis distances, Paired Groups, UPGMA, Permutations: 999).

4.3.3 Potential drivers for species richness and diversity patterns of Geometridae family in DMR

The relationship between species richness, abundance, and diversity measures of the Geometridae family and among the four different sets of variables, topographical, environmental, vegetation, and disturbance, was analysed using Canonical Correspondence Analysis (CCA). Analyses revealed the most significant variables affecting and shaping the overall species richness, abundance, and diversity patterns of the Geometridae family in the DMR. Among all the CCA biplots, the species composition of the five altitudinal zones was mostly distinct, and sites in each altitudinal zone clustered together. This nearly clear separation of sites among the five zones indicates the significant role of altitude in shaping the Geometridae assemblage in the DMR.

a) CCA with major Topographic variables and NDVI

A CCA biplot (Fig. 4.9) visually illustrates the overall relationship between species data of the Geometridae family and major topographical variables. The eigenvalues of the first two axes are 0.7832 and 0.4228, respectively. The first axis explained 47.98% and the second axis 25.9% (Fig. 4.9) variation with a cumulative of 73.88%.

The first axis was positively associated with altitude (r = 0.966485) and slope (r = 0.475664), and negatively associated with NDVI (r = -0.4286). Similarly, the second axis also had the most significant positive association with altitude (r = 0.57895) and a negative association with NDVI (r = -0.60305) (Table 4.7). Therefore, among the major topographic variables and NDVI, altitude and NDVI were the two most significant variables associated with the species richness and diversity of the Geometridae family in the DMR.

Table 4.7: Explanatory variable loadings on the first two axes from Canonical Correspondence Analysis (CCA) for Species Richness, Abundance and Diversity measures of the Geometridae family to Topographic Variables and NDVI.

Explanatory variables	Axis 1	Axis 2
Altitude	**0.966485**	**0.57895**
Aspect	0.037113	-0.04262
Slope	**0.475664**	0.355132
NDVI	**-0.42806**	**-0.60305**

b) CCA with major Trap Night environmental factors and Worldclim's biovariables

The eigenvalues of the first two axes of the CCA biplot are 0.78427 and 0.44835, respectively. They cumulatively explained 70.85% of the variation, with the first and second axes contributing 45.08% and 25.77%, respectively (Fig. 4.10).

For the first axis, the significant positive association was with BIO 4 (Temperature Seasonality) (r = 0.484047) and negative association with BIO 12 (Annual Precipitation) (r = -0.986657) and Average Trap Night Temperature (ATNT) (r = -0.896289). The second axis exhibited a positive relationship with BIO 4 (r = 0.541681) and BIO 12 (r = 0.432729) (Table 4.8). These relationships and the overall results were visually represented in A CCA biplot (Fig. 4.10).

Table 4.8: Explanatory Variable Loadings on the First Two Axes from Canonical Correspondence Analysis (CCA) for Species Richness, Abundance and Diversity measures of the Geometridae family to Average Trap Night's environmental factors and Worldclim's biovariables.

Explanatory variables	Axis 1	Axis 2
Average Trap Night Temperature (ATNT)	**-0.896289**	0.384403
Average Trap Night Relative Humidity (ATNRH)	0.350878	0.126062
BIO 4 (Temperature seasonality)	**0.484047**	**0.541681**
BIO 12 (Annual Precipitation)	**-0.986657**	**0.432729**

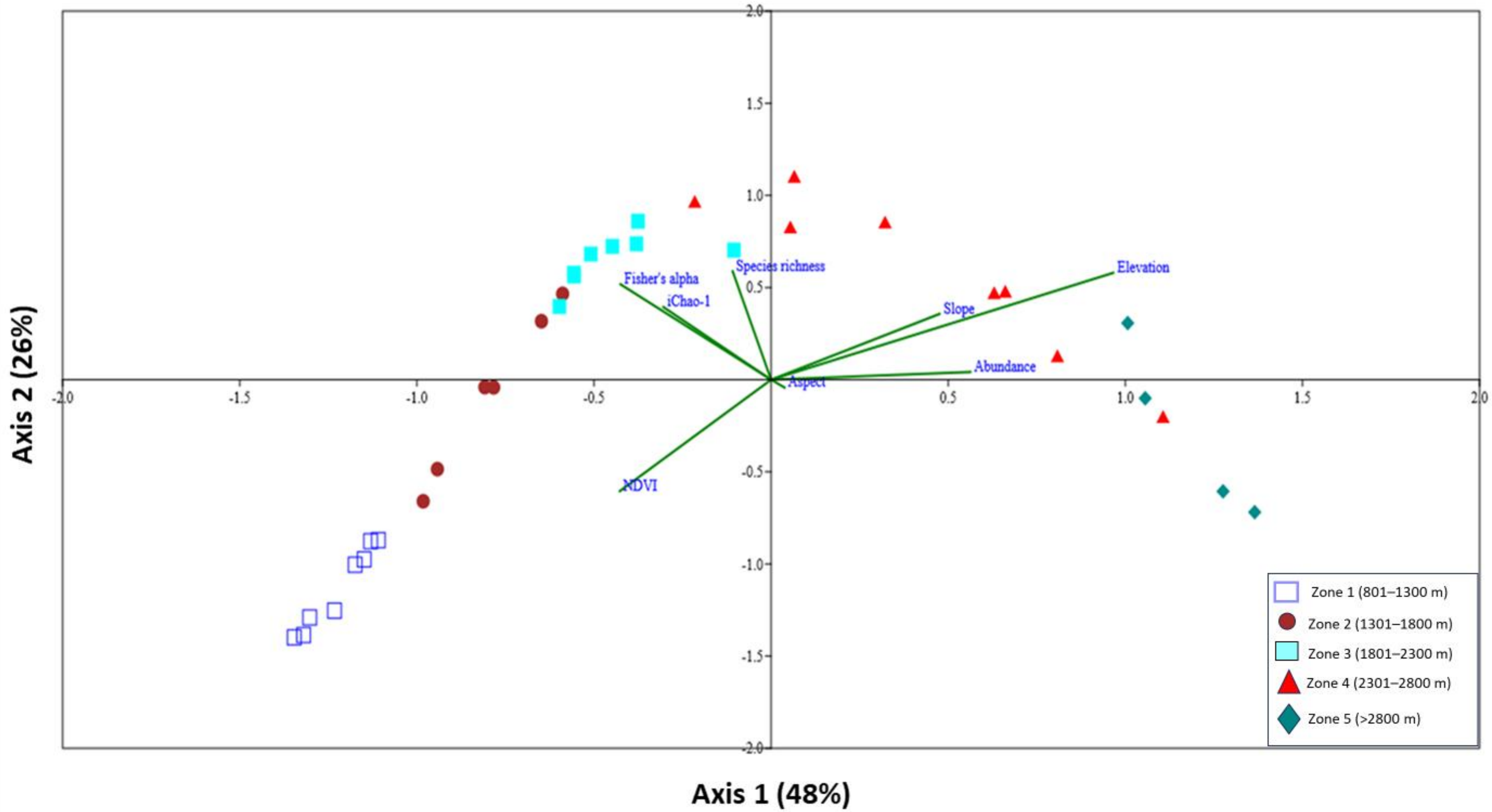


Fig. 4.9: CCA Biplot for Species Richness, Abundance and Diversity measures Geometridae family across the sites in the five altitudinal zones for Topographic Variables and NDVI.

c) CCA with major Vegetation variables

The eigenvalues of the first two axes are 0.75139 and 0.42404, respectively. These cumulatively accounted for 63.85% of the cumulative variation in the dataset. The individual contributions of these axes are 40.82% and 23.03%, respectively (Fig. 4.11).

The first axis was negatively associated with shrub species richness (r = -0.72382), tree species richness (r = -0.52359), and shrub cover (r = -0.4066) and positively associated with herb species richness (r = 0.819487) and herb abundance (r = 0.688703). The second axis was negatively associated with shrub species richness (r = -0.5506) and positively associated with tree abundance (r = 0.637796) and herb species richness (r = 0.533758) (Table 4.9).

Table 4.9: Explanatory variable loadings on the first two axes from Canonical Correspondence Analysis (CCA) for Species Richness, Abundance and Diversity measures to Vegetation Data.

Explanatory variables	**Axis 1**	**Axis 2**
Tree species richness	**-0.52359**	-0.28237
Tree Abundance	0.023652	**0.637796**
Average Tree GBH	**0.446665**	-0.0496
Shrub species richness	**-0.72382**	**-0.5506**
Shrub Cover (%)	**-0.4066**	-0.23362
Herb species richness	**0.819487**	**0.533758**
Herb Abundance	**0.688703**	0.093321

d) CCA with disturbance variables

With the disturbance variables, the eigenvalues of the first two axes were 0.72944 and 0.31145, respectively. A CCA biplot (Fig. 4.12) was 62.5% of the cumulative variation explained in the dataset with the disturbance variables. The first and second axes explain 43.8% and 18.7% of the variation, respectively (Fig. 4.12). Among the most significant variables, the first axis was negatively associated with the lopping sign (r = -0.465922) and positively associated with distance to the nearest village (r = 0.899543). While the second axis was positively associated with the lopping sign (r = 0.655577) (Table 4.10).

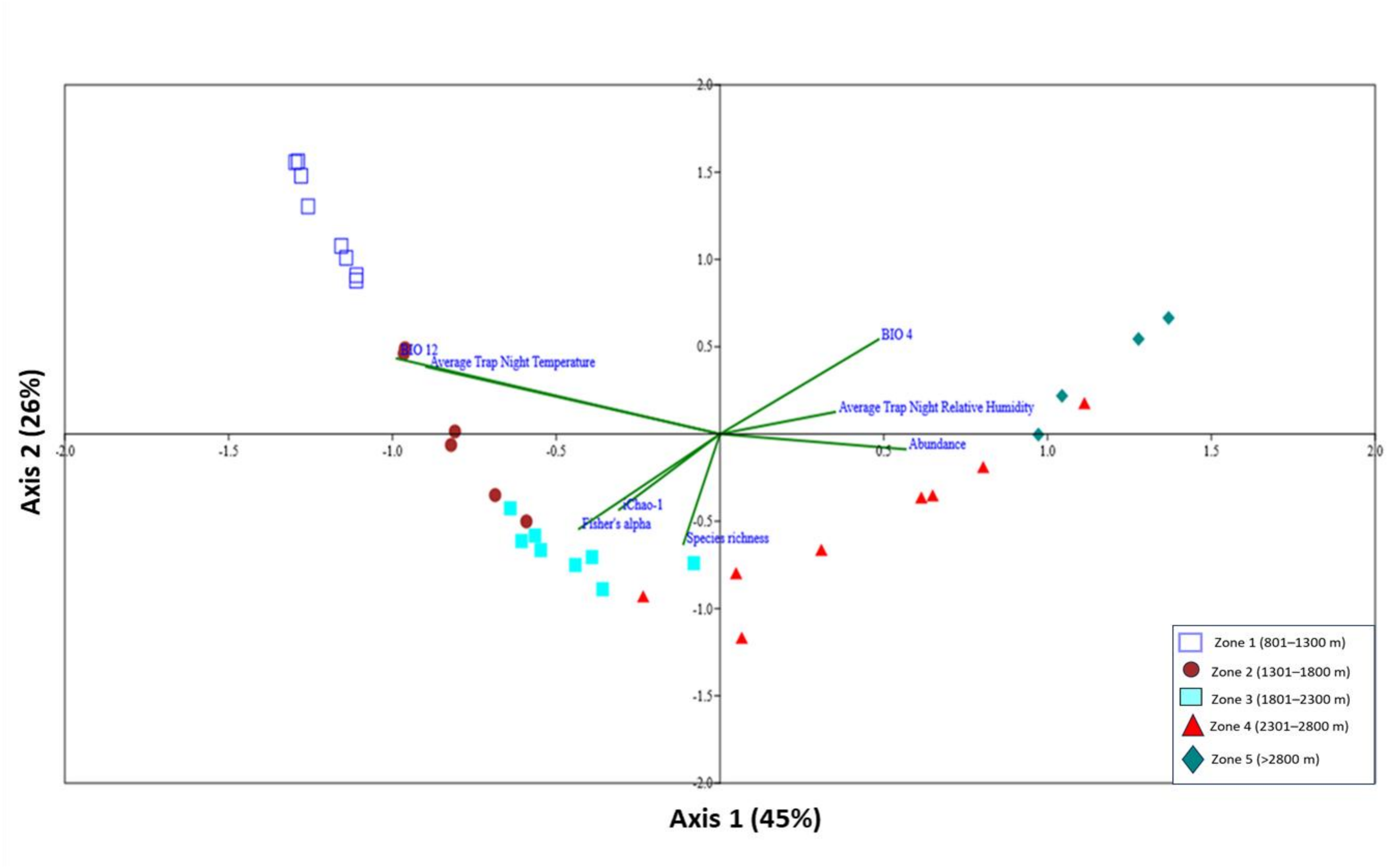


Fig. 10: CCA Biplot for Species Richness, Abundance and Diversity measures of Geometridae family across the sites in the five Altitudinal Zones to Average Trap Night's environmental factors and WorldClim's Biovariables.

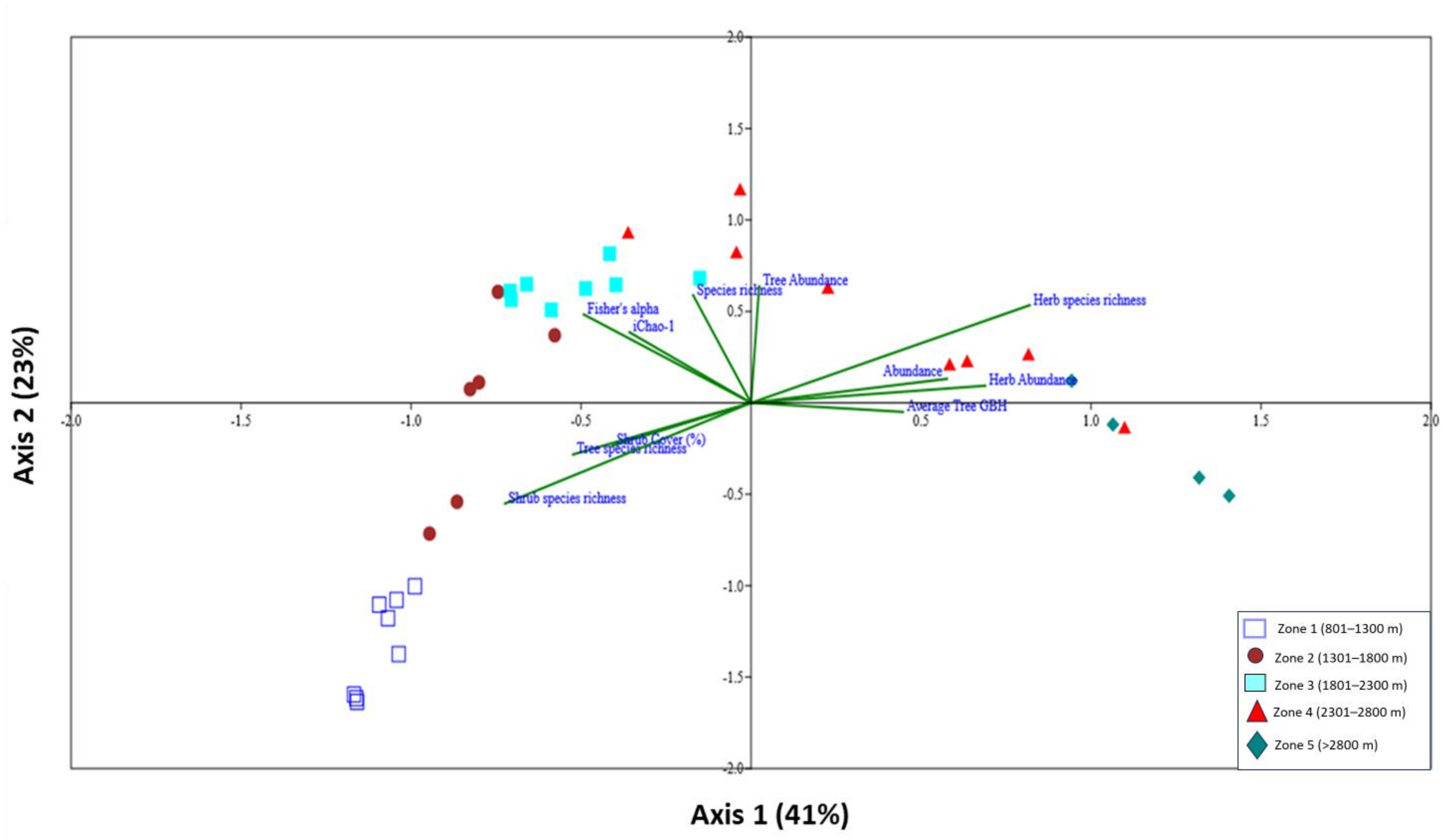


Fig. 4.11: CCA Biplot for Species Richness, Abundance and Diversity measures of the Geometridae family across the sites in the five Altitudinal Zones to Vegetation data.

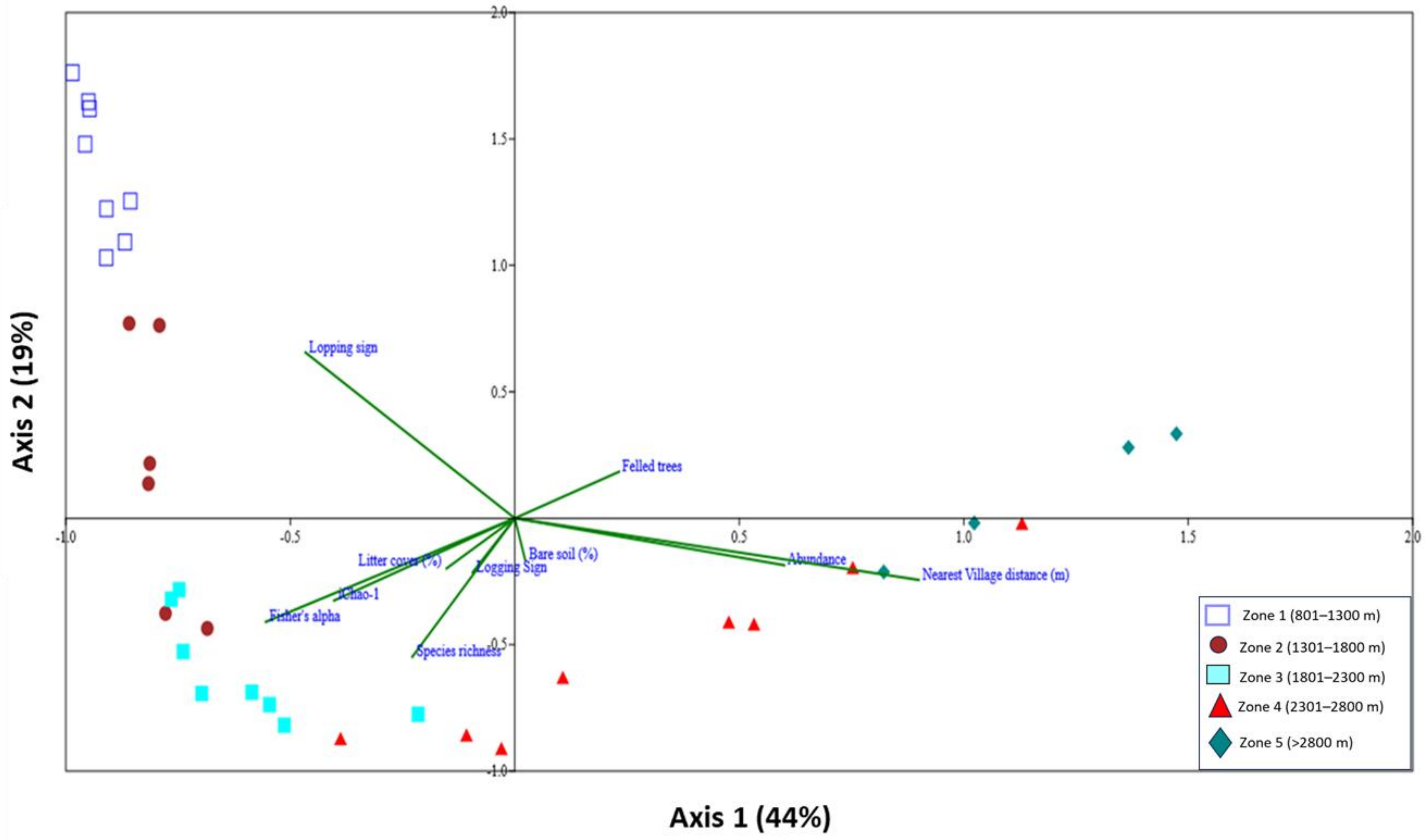


Fig. 4.12: CCA Biplot for Species Richness, Abundance and Diversity measures of the Geometridae family across the sites in the five Altitudinal Zones to Disturbance variables.

Table 4.10: Explanatory variable loadings on the first two axes from Canonical Correspondence Analysis (CCA) for Species Richness, Abundance and Diversity measures to disturbance variables.

Explanatory variables	**Axis 1**	**Axis 2**
Litter cover (%)	-0.152599	-0.198883
Bare soil (%)	0.0229595	-0.162394
Logging Sign	-0.094182	-0.213952
Lopping sign	**-0.465922**	**0.655577**
Felled trees	0.23266	0.184647
Nearest Village distance (m)	**0.899543**	-0.244348
Litter cover (%)	-0.152599	-0.198883

4.4 Discussion

This study is the first attempt to provide a comprehensive insight into the species richness, diversity, and distribution patterns of Geometridae moths along the altitudinal gradient of the DMR. Overall, this study reports a unimodal/humpback-shaped pattern. This finding is in congruence with the mid-altitudinal peak pattern for Geometridae moths identified as characteristic across the world's altitudinal gradients in a meta-analysis (Beck et al. 2016). Additionally, this pattern is often considered common in single-taxon analyses (Peters et al. 2016). For the IHR, only a few studies have explored altitudinal gradients along its breadth to explore species richness and diversity in the Geometridae family. Among these are those by Sanyal et al. (2015) from the protected areas of the Uttarakhand, Western Himalaya. Dey et al. (2017) conducted a preliminary analysis along the altitudinal gradient of the Nanda Devi biosphere reserve (altitudinal range of 2000–3800 m) and reported a declining pattern. Furthermore, a difference of nearly 800 m reported in the median distribution (in terms of abundance) of the Geometridae family between the Western and Eastern Himalayan protected areas of IHR by Chandra et al. (2019). The median distribution of geometrid moths was reported at an altitude of ~ 2500 m in the Western Himalayan region and nearly 1700 m in the Eastern Himalayan region. Mallick (2021) conducted a study on Geometridae moths in the Great Himalayan National Park (GHNP). He also observed a declining pattern in species richness. However, these studies differed in their use of light traps. They have used a 160-watt Mercury Vapour (MV) lamp when electricity was available and combination of a solar-powered Light-Emitting-Diode (LED) lamp and petromax lanterns in remote locations without electricity. However, in the study by Dey (2024) using the LepiLED light trap, a similar declining pattern was observed across altitudinal zones within the 1500 m gradient from 1500 to 3100 m. These patterns are often attributed to incomplete gradient coverage (Nogués-Bravo et al. 2008). For different forest types, Himalayan Chir-Pine forests and Moist Temperate Deciduous forests are the two major forest types with exceptionally high species richness and abundance of the moth species. The latter is reported as the transitional zone between the lower and mid-altitude species assemblages (Chandra et al. 2019).

Chapter 5
Potential Indicator species of Geometridae moths from DMR

5.1 Introduction

An indicator is a measurable change in the characteristics of a living organism, chemical, factor, process, or community that signals a specific change in an associated phenomenon. This basic concept of indicators forms the basis for the widespread development and application of biological indicators or ‘bioindicators’ in the 1960s. Bioindicators are the biological components of natural ecosystems—a biological process, species, or community—that are utilised to assess the environmental (environmental indicators) and ecological health (ecological indicators) and the biodiversity (biodiversity indicators) associated with it in a geographical region. They are selected based on their sensitivity to a particular environmental or ecological attribute. Their follow-up assessment and monitoring (spatially or temporally) help detect early warning signs of a threat and make inferences and informed decisions for wildlife conservation, habitat management, and ecosystem restoration (Simberloff 1998; Morrison 2009; Caro 2010; Holt and Miller 2010).

Traditional environmental monitoring methods involve direct measurement of several chemical and physical parameters. This involves many classical chemical essays and physical instruments (Holt and Miller 2010). These methods are usually complicated with limited sensitivity but are costly. This limits the widespread application and cost effectiveness of these methods. The use of bioindicators offers several advantages. They help i) incorporate temporal components, ii) indicate the indirect effect of chemical and physical factors on the biotic components of the ecosystem, and iii) identify biologically meaningful levels of these factors (Holt and Miller 2010).

The basic principle of using a species as an indicator centre on Shelford's law of tolerance for species existence and survival. According to this law, each species in an ecosystem has specific physiological and behavioural tolerance ranges for physical, chemical, and biotic factors in their surroundings. They perform to their highest capacity within their optimum tolerance ranges. However, conditions outside this range negatively impact their physiology and behaviour and disrupt the population dynamics of the species or the entire community. This sensitivity allows ecologists to monitor changes, especially in species with moderate-to-low tolerance. The shifts in species characteristics reported to indicate a threat are i) complete disappearance or extinction of the species from nature, ii) change in the abundance or population size, iii) change in the phenology or distributional range, or iv) disruption of the associated ecological service or process which it supports. The primary objectives of using bioindicators i) the assessment and documentation of the current ecological and environmental health status of an ecosystem, ii) early threat detection and the study of short- or long-term trends and patterns of change (if any) with underlying causal mechanisms, and iii) the prediction of future conditions (Cairns and Pratt 1993; Bartell 2006; Burger 2006).

Macroinvertebrates hold good potential to serve as biodiversity and ecological indicators at the community level, as well as environmental indicators at the population level. The diverse range of habitats they occupy, their adaptive life-history strategies, and their speciose nature enable them to exhibit a high degree of functional diversity within any ecosystem. Also, their higher abundance in the habitats facilitates their easy monitoring. These properties of macroinvertebrates allow them to capture and represent a myriad of responses to different stressors and disturbances. As a result, invertebrates accounted for approximately 70% of the total number of animal taxa used as indicators (Siddig et al. 2016). However, the selection process for bioindicators is not straightforward and involves many factors, such as the phenomenon to be monitored, purpose of monitoring, type of species present, specific ecological context of the species, and habitats/phenomena to be monitored (Holt and Miller 2010; Siddig et al. 2016). Siddig et al. (2016) proposed a five-step process for effective and efficient selection and use of indicator species in biomonitoring. The five steps of this process involve five different basic questions on biomonitoring from asking what and why to report and dissemination of the findings.

Moths in the family Geometridae fly weakly and have strong climatic and habitat fidelity (Holloway 1984, 1985; Intachat et al. 2001; Thomas 2002). They exhibit high species richness and comparatively greater proportional contributions to the overall moth assemblage in forest ecosystems, particularly in primary undisturbed old forests with rich understory vegetation (Beck et al. 2002; Kitching 2000; Brehm and Fiedler 2005). They are found in high latitudinal and altitudinal habitats, are often found to be associated with a particular vegetation type or altitudinal range, and have the potential to monitor the effects of land use and climate change on herbivores. Their proportion and species diversity decrease with increased disturbance in forest habitats—forest management, fires, or other anthropogenic activities—that affect the ecological and environmental conditions of forests

(Holloway et al. 1999; Kitching et al. 2000; Beck et al. 2002). Henceforth, they have been studied and established globally as a suitable ecological, environmental and biodiversity indicator taxon representing the herbivorous community of primary natural forests and their monitoring for changes (Dar and Jamal 2021).

This chapter will look into the species within the assemblage of Geometridae moths from the DMR with the potential to act as an indicator for a particular forest type or an altitudinal zone.

5.2 Material and Methods

Species abundance data were collected from 34 sampling sites across two altitudinal gradients in the DMR. These sites correspond to the eight major forest types in the landscape. Furthermore, they were grouped in the five 500 m altitudinal zones (as previously from 800 to 3300 m asl). Indicator Species analysis (ISA) was performed to identify the species that showed significant associations with a specific forest type or altitudinal zone. The analysis was performed using the **indicspecies** package in R (Caceres and Legendre 2009)**.** The indicator value (IndVal) index (Dufrene and Legendre 1997) was calculated based on the species abundance matrix, and forest type and altitudinal zone class were used as classification vectors. The analysis takes every species separately and calculates an indicator value after accounting for species specificity and fidelity. The statistical significance of IndVal was determined using the p-value. The IndVal for a species ranged from 0 to 1. Species with a value close to 1 or >0.7 and statistical significance (p-value <0.5) were considered good indicators (Enkhtur et al. 2021) for the habitat type or altitudinal zone in question. Species with good indicator values for a particular habitat or altitudinal zone can help monitor the effects of climate or land-use changes.

5.3 Results

5.3.1 Indicator species for different altitudinal zones

Altogether, 108 species (Table 5.1) were found to show significant associations with five different altitudinal zones of the DMR and therefore exhibited potential as indicator species (Table 5.1). These species were selected based on Indval >0.7 and p-value <0.05. Of these, 46 species were uniquely associated with particular altitudinal zones. Overall, the highest number of indicator species was found in zone 1. A total of 17 species were documented in Zone 1, with an Indval >0.7. Of these, 7 species, *Hyposidra talaca*, *Chiasmia emersaria*, *Hypomecis transcissa*, *Chiasmia perfusaria*, *Calletaera subexpressa*, *Scopula idearia* and *Problepsis vulgaris*, had significantly high indicator values of >0.9.

Table 5.1: List of the Indicator species for different altitudinal zones with Indicator value (IndVal) >0.7 and statistically significant level, p-vale <0.05. The "+" sign marks the species indicators for more than one altitudinal zone.

Sr. No.	Subfamily	Species	Altitudinal Zone	IndVal	p-value
1	Ennominae	*Hyposidra talaca*	Zone 1	0.99	0.001
2	Ennominae	*Chiasmia emersaria*	Zone 1	0.99	0.001
3	Ennominae	*Hypomecis transcissa*	Zone 1	0.98	0.001
4	Ennominae	*Chiasmia perfusaria*	Zone 1	0.98	0.001
5	Ennominae	*Calletaera subexpressa*	Zone 1	0.94	0.001
6	Sterrhinae	*Scopula idearia*	Zone 1	0.92	0.001
7	Sterrhinae	*Problepsis vulgaris*	Zone 1	0.90	0.001
8	Ennominae	*Hyperythra lutea*	Zone 1	0.87	0.001
9	Sterrhinae	*Idaea ruptifascia*	Zone 1	0.83	0.001
10	Sterrhinae	*Chrysocraspeda faganaria*	Zone 1	0.79	0.003
11	Geometrinae	*Comibaena cassidaria*	Zone 1	0.79	0.001
12	Sterrhinae	*Rhodometra sacraria*	Zone 1	0.79	0.001
13	Ennominae	*Biston suppressaria*	Zone 1	0.77	0.003
14	Sterrhinae	*Tanaotrichia prasonaria trilineata*	Zone 1	0.74	0.006
15	Geometrinae	*Eucyclodes albisparsa*	Zone 1	0.72	0.004
16	Ennominae	*Luxiaria phyllosaria*	Zone 1	0.71	0.01
17	Sterrhinae	*Somatina anthophilata*	Zone 1	0.71	0.01
18	Sterrhinae	*Scopula bispurcata*	Zone 2	0.81	0.004
19	Sterrhinae	*Scopula achrosta*	Zone 2	0.78	0.025
20	Larentiinae	*Ecliptopera triangulifera*	Zone 2	0.74	0.013
21	Ennominae	*Oxymacaria temeraria temeraria*	Zone 2	0.71	0.002
22	Ennominae	*Calcyopa ochrifasciata*	Zone 3	0.84	0.002
23	Larentiinae	*Lobogonodes multistriata*	Zone 3	0.82	0.001
24	Ennominae	*Arichanna marginata*	Zone 3	0.82	0.001
25	Larentiinae	*Atopophysa indistincta*	Zone 3	0.78	0.001
26	Ennominae	*Hyalinetta circumflexa*	Zone 3	0.74	0.006
27	Ennominae	*Psyra cuneata*	Zone 3	0.73	0.006
28	Ennominae	*Amblychia pardicelata*	Zone 3	0.70	0.007
29	Ennominae	*Psyra similaria*	Zone 4	0.83	0.002
30	Ennominae	*Alcis nigridorsaria*	Zone 4	0.79	0.003
31	Ennominae	*Microcalicha fimbriata*	Zone 4	0.77	0.003
32	Ennominae	*Nothomiza cinerascens*	Zone 4	0.76	0.004

33	Larentiinae	*Eupithecia flavitornata*	Zone 4	0.75	0.009
34	Larentiinae	*Euphyia submarginata*	Zone 4	0.75	0.01
35	Larentiinae	*Nebula brevifasciata*	Zone 4	0.71	0.008
36	Sterrhinae	*Rhodostrophia pelloniaria*	Zone 4	0.71	0.004
37	Larentiinae	*Photoscotosia fulguritis*	Zone 5	0.87	0.002
38	Ennominae	*Loxaspilates hastigera hastigera*	Zone 5	0.86	0.002
39	Larentiinae	*Neotephria ramalaria*	Zone 5	0.85	0.003
40	Larentiinae	*Dysstroma shirakawai*	Zone 5	0.81	0.001
41	Ennominae	*Odontopera lentiginosaria*	Zone 5	0.81	0.003
42	Larentiinae	*Martania (Perizoma) variabilis*	Zone 5	0.76	0.003
43	Ennominae	*Biston falcata*	Zone 5	0.71	0.012
44	Ennominae	*Chiasmia azataria*	Zone 1+2	0.94	0.001
45	Sterrhinae	*Idaea grisescens*	Zone 1+2	0.93	0.001
46	Ennominae	*Heterostegane subtessellata*	Zone 1+2	0.92	0.001
47	Ennominae	*Chorodna creataria*	Zone 1+2	0.91	0.001
48	Ennominae	*Hydatocapnia marginata*	Zone 1+2	0.91	0.001
49	Sterrhinae	*Idaea persimilis*	Zone 1+2	0.90	0.001
50	Ennominae	*Odontopera rufitinctaria*	Zone 1+2	0.88	0.002
51	Larentiinae	*Calluga costalis*	Zone 1+2	0.88	0.001
52	Ennominae	*Dasyboarmia subpilosa*	Zone 1+2	0.88	0.002
53	Ennominae	*Cleora propulsaria*	Zone 1+2	0.82	0.001
54	Geometrinae	*Comibaena quardinotata fuscidorsata*	Zone 1+2	0.78	0.002
55	Geometrinae	*Pingasa pseudoterpnaria*	Zone 1+2	0.76	0.005
56	Ennominae	*Psilalcis breta breta*	Zone 1+2	0.98	0.001
57	Larentiinae	*Ecliptopera dentifera*	Zone 2+3	0.93	0.001
58	Ennominae	*Alcis perspicuata*	Zone 2+3	0.92	0.027
59	Ennominae	*Ourapteryx nepalensis*	Zone 2+3	0.92	0.001
60	Sterrhinae	*Timandra correspondens*	Zone 2+3	0.89	0.001
61	Ennominae	*Mimomiza cruentaria*	Zone 2+3	0.88	0.001
62	Ennominae	*Corymica pryeri*	Zone 2+3	0.85	0.001
63	Ennominae	*Ourapteryx purissima*	Zone 2+3	0.81	0.01
64	Larentiinae	*Xanthorhoe greisiviridis*	Zone 2+3	0.80	0.001
65	Geometrinae	*Herochroma cristata cristata*	Zone 1+3	0.77	0.003
66	Geometrinae	*Tanaorhinus reciprocata*	Zone 2+3	0.74	0.003
67	Ennominae	*Leptomiza calcearia*	Zone 2+3	0.73	0.005
68	Geometrinae	*Hirasa aereus*	Zone 2+3	0.71	0.011
69	Geometrinae	*Fascellina plagiata*	Zone 2+3	0.71	0.006
70	Larentiinae	*Photoscotosia amplicata*	Zone 4+5	1	0.001
71	Ennominae	*Arichanna flavinigra*	Zone 4+5	0.99	0.001
72	Larentiinae	*Martania (Perizoma) fulvimacula*	Zone 4+5	0.96	0.001
73	Ennominae	*Arichanna tenebraria*	Zone 4+5	0.95	0.001
74	Ennominae	*Loxaspilates obliquaria*	Zone 4+5	0.93	0.001
75	Ennominae	*Anonychia lativitta*	Zone 4+5	0.91	0.001
76	Larentiinae	*Dysstroma planifasciata*	Zone 4+5	0.91	0.001
77	Larentiinae	*Perizoma peculiare*	Zone 4+5	0.90	0.002

78	Ennominae	*Lassaba interruptaria*	Zone 4+5	0.90	0.001
79	Ennominae	*Arichanna sparsa*	Zone 4+5	0.85	0.002
80	Ennominae	*Myrioblephara harutai*	Zone 4+5	0.82	0.001
81	Larentiinae	*Dysstroma fulvipennis*	Zone 4+5	0.82	0.001
82	Larentiinae	*Dysstroma subapicaria*	Zone 4+5	0.82	0.003
83	Larentiinae	*Electrophaes marginata*	Zone 4+5	0.82	0.002
84	Larentiinae	*Martania (Perizoma) antisticta*	Zone 4+5	0.76	0.003
85	Larentiinae	*Abraxas superpicaria*	Zone 4+5	0.71	0.007
86	Ennominae	*Antipercnia belluaria*	Zone 1+2+3	0.96	0.001
87	Larentiinae	*Xenortholitha falcata*	Zone 1+2+3	0.88	0.002
88	Ennominae	*Ligdia coctata*	Zone 1+2+3	0.86	0.032
89	Ennominae	*Peratostega deletaria deletaria*	Zone 1+2+3	0.77	0.021
90	Ennominae	*Luxiaria amasa*	Zone 1+2+3	0.76	0.021
91	Ennominae	*Gnophos tephrosiaria*	Zone 1+2+3	0.71	0.018
92	Ennominae	*Ourapteryx ebuleata*	Zone 2+3+4	0.92	0.001
93	Larentiinae	*Triphosa dubiosata*	Zone 2+3+4	0.91	0.006
94	Larentiinae	*Apithecia viridata*	Zone 2+3+4	0.91	0.003
95	Ennominae	*Psyra angulifera*	Zone 2+3+4	0.83	0.005
96	Ennominae	*Lassaba parvalbidaria nepalensis*	Zone 2+3+4	0.82	0.043
97	Ennominae	*Hirasa muscosaria*	Zone 2+3+4	0.80	0.002
98	Ennominae	*Gasterocomme pannosaria*	Zone 2+3+4	0.80	0.027
99	Ennominae	*Ourapteryx yerburii yerburii*	Zone 2+3+4	0.80	0.008
100	Geometrinae	*Chloroglyphica variegata*	Zone 2+3+4	0.72	0.043
101	Larentiinae	*Hysterura multifaria*	Zone 3+4+5	0.92	0.001
102	Ennominae	*Alcis quadrifera*	Zone 3+4+5	0.88	0.001
103	Ennominae	*Odontopera obliquaria*	Zone 3+4+5	0.86	0.002
104	Larentiinae	*Colostygia albigirata*	Zone 3+4+5	0.85	0.001
105	Larentiinae	*Pasiphila palpata*	Zone 3+4+5	0.84	0.001
106	Larentiinae	*Martania* (*Perizoma*) *seriata*	Zone 3+4+5	0.82	0.001
107	Ennominae	*Myrioblephara gandakiensis*	Zone 3+4+5	0.77	0.004
108	Larentiinae	*Electrophaes aliena*	Zone 2+3+4+5	0.76	0.033

Four species, *Scopula bispurcata*, *Scopula achrosta*, *Ecliptopera triangulifera* and *Oxymacaria temeraria temeraria* showed specific preferences towards Zone 2. Seven species each were highly associated with Zone 3 and Zone 5. Species *Calcyopa ochrifasciata*, *Lobogonodes multistriata*, *Arichanna marginata*, *Atopophysa indistincta*, *Hyalinetta circumflexa*, *Psyra cuneata* and *Amblychia pardicelata* were indicators of zone 3. *Photoscotosia fulguritis*, *Loxaspilates hastigera hastigera*, *Neotephria ramalaria*, *Dysstroma shirakawai*, *Odontopera lentiginosaria*, *Martania* (*Perizoma*) *variabilis*, and *Biston falcata* were found to be indicators of zone 5. Similarly, eight species were highly linked with Zone 4, namely, *Psyra similaria*, *Alcis nigridorsaria*, *Microcalicha fimbriata*, *Nothomiza cinerascens*, *Eupithecia flavitornata*, *Euphyia submarginata*, *Nebula brevifasciata* and *Rhodostrophia pelloniaria*.

The remaining 65 species were indicators for more than one altitudinal zone. Among the four subfamilies, the two major subfamilies Ennominae and Larentiinae were distributed throughout the altitudinal gradient and predominantly contained the indicator species along the entire gradient. Particularly, four species of the Ennominae subfamily, *Hyposidra talaca*, *Chiasmia emersaria*, *Hypomecis transcissa* and *Chiasmia perfusaria* had the IndVal >0.95 and p-value of 0.001. However, the other two subfamilies, with their preference for the lower altitudinal habitats, showed indicator species mostly in the lowermost zone.

5.3.2 Indicator species for different forest types

The results of the indicator species analysis for the eight forest types revealed 138 (Table 5.2) of 279 species as indicators (with an Indval >0.7) for different forest types. Certainly, no species with a particular preference for the Upper Himalayan Chir Pine forest (UCP) was found. While 18 species of the 138 exhibited a specific preference for a particular forest type. The highest 5 species showed a specific preference for the Birch-Rhododendron Scrub (BRS) forest type. Of these, four species—*Apoheterolocha patalata*, *Lassaba anepsia*, *Photoscotosia pallidimaculata* and *Xanthorhoe hampsoni*—are exclusively associated with this forest type with an Indval of 1.

Among the other six forest types, 4 species, *Chlororithra fea*, *Hypomecis cineracea*, *Idaea protensa* and *Lophophleps informis* had high and statistically significant indicator values for Ban oak (BO) forest. For Kharsu Oak (KO) forest, 3 species, *Biston falcata*, *Gnophos rubefactaria* and *Martania variabilis* exhibited strong indicator value. 2 species, *Cusiala boarmoides* and *Maxates iridescens* were highly associated with Northern Mixed deciduous (NMD) forests. The species *Chrysocraspeda faganaria* and *Comibaena* quardinotata *fuscidorsata* were indicators of the Lower Chir Pine forests. Additionally, Abraxas *virginalis* in Moist Deodar and *Docirava postochrea* in Upper-Oak Forest were indicators for these forest types with a significantly large indicator values index (>0.7)

Table 5.2: List of the Indicator species for different forest types with Indicator value (IndVal) >0.7 and statistically significant level, p-vale <0.05. Species that are indicators of more than one forest type are expressed by the "+" sign.

Sr. No.	Subfamily	Species	Forest type	IndVal	p-value
1	Ennominae	*Cusiala boarmoides*	NMD	0.77	0.042
2	Geometrinae	*Maxates iridescens*	NMD	0.72	0.028
3	Sterrhinae	*Chrysocraspeda faganaria*	LCP	0.81	0.012
4	Geometrinae	*Comibaena quardinotata fuscidorsata*	LCP	0.78	0.012
5	Ennominae	*Abraxas virginalis*	MD	0.71	0.074
6	Geometrinae	*Chlororithra fea*	BO	0.80	0.007
7	Ennominae	*Hypomecis cineracea*	BO	0.71	0.043
8	Sterrhinae	*Idaea protensa*	BO	0.74	0.02
9	Sterrhinae	*Lophophleps informis*	BO	0.78	0.019
10	Larentiinae	*Docirava postochrea*	UOF	0.87	0.004
11	Ennominae	*Biston falcata*	KO	0.82	0.012
12	Ennominae	*Gnophos rubefactaria*	KO	0.73	0.083
13	Larentiinae	*Martania variabilis*	KO	0.87	0.005
14	Ennominae	*Apoheterolocha patalata*	BRS	1	0.03
15	Ennominae	*Lassaba anepsia*	BRS	1	0.03
16	Larentiinae	*Neotephria ramalaria*	BRS	0.87	0.035
17	Larentiinae	*Photoscotosia pallidimaculata*	BRS	1	0.03
18	Larentiinae	*Xanthorhoe hampsoni*	BRS	1	0.03
19	Ennominae	*Calletaera subexpressa*	NMD+LCP	0.88	0.001
20	Larentiinae	*Calluga costalis*	NMD+LCP	0.90	0.001
21	Ennominae	*Chiasmia emersaria*	NMD+LCP	0.93	0.001
22	Ennominae	*Chiasmia perfusaria*	NMD+LCP	0.92	0.001
23	Geometrinae	*Comibaena cassidaria*	NMD+LCP	0.75	0.01
24	Ennominae	*Hyperythra lutea*	NMD+LCP	0.82	0.004
25	Ennominae	*Hyposidra talaca talaca*	NMD+LCP	0.94	0.001
26	Sterrhinae	*Idaea ruptifascia*	NMD+LCP	0.89	0.001
27	Sterrhinae	*Problepsis vulgaris*	NMD+LCP	0.85	0.004
28	Sterrhinae	*Rhodometra sacraria*	NMD+LCP	0.75	0.023
29	Sterrhinae	*Scopula idearia*	NMD+LCP	0.87	0.002
30	Larentiinae	*Trichopterigia decorata*	UCP+MD	0.79	0.006
31	Ennominae	*Fascellina plagiata*	UCP+BO	0.71	0.039
32	Ennominae	*Mimomiza cruentaria*	UCP+BO	0.97	0.001
33	Ennominae	*Myrioblephara albibasis*	UCP+BO	0.82	0.007
34	Ennominae	*Ourapteryx nepalensis*	UCP+BO	0.84	0.004
35	Geometrinae	*Tanaorhinus reciprocata*	UCP+BO	0.74	0.016
36	Ennominae	*Anonychia diversilinea*	MD+BO	0.88	0.001
37	Ennominae	*Arichanna marginata*	MD+BO	0.73	0.017
38	Larentiinae	*Atopophysa indistincta*	MD+BO	0.78	0.009

39	Ennominae	*Calcyopa ochrifasciata*	MD+BO	0.95	0.001
40	Larentiinae	*Hydrelia bicolorata*	MD+BO	0.80	0.008
41	Larentiinae	*Lobogonodes multistriata*	MD+BO	0.88	0.001
42	Ennominae	*Nothomiza achromaria*	MD+BO	0.90	0.001
43	Ennominae	*Psyra cuneata*	MD+BO	0.73	0.024
44	Ennominae	*Xandrames albofasciata*	MD+BO	0.75	0.052
45	Larentiinae	*Xanthorhoe greisiviridis*	MD+BO	0.82	0.004
46	Ennominae	*Xenoplia maculata*	MD+BO	0.83	0.005
47	Ennominae	*Abraxas circinata*	BO+UOF	0.81	0.011
48	Ennominae	*Aplochlora dentisignata*	BO+UOF	0.87	0.018
49	Larentiinae	*Dysstroma fulvipennis*	UOF+KO	0.92	0.001
50	Larentiinae	*Dysstroma subapicaria*	UOF+KO	0.80	0.004
51	Larentiinae	*Gagetodes plumbeata*	UOF+KO	0.72	0.035
52	Ennominae	*Lassaba dissimilis*	UOF+KO	0.79	0.021
53	Ennominae	*Myrioblephara harutai*	UOF+KO	0.75	0.014
54	Larentiinae	*Photoscotosia metachryseis*	UOF+KO	0.85	0.004
55	Larentiinae	*Photoscotosia nitida*	UOF+KO	0.71	0.025
56	Ennominae	*Stamnodes pauperaria pamphilata*	UOF+KO	0.79	0.019
57	Larentiinae	*Dysstroma shirakawai*	KO+BRS	0.81	0.001
58	Ennominae	*Loxaspilates hastigera hastigera*	KO+BRS	0.86	0.001
59	Ennominae	*Odontopera lentiginosaria*	KO+BRS	0.81	0.002
60	Larentiinae	*Photoscotosia fulguritis*	KO+BRS	0.87	0.006
61	Ennominae	*Chiasmia azataria*	NMD+LCP+UCP	0.88	0.003
62	Ennominae	*Chorodna creataria*	NMD+LCP+UCP	0.83	0.004
63	Ennominae	*Cleora propulsaria*	NMD+LCP+UCP	0.89	0.001
64	Ennominae	*Dasyboarmia subpilosa*	NMD+LCP+UCP	0.95	0.001
65	Geometrinae	*Eucyclodes albisparsa*	NMD+LCP+UCP	0.71	0.026
66	Ennominae	*Heterostegane subtessellata*	NMD+LCP+UCP	0.95	0.001
67	Sterrhinae	*Idaea grisescens*	NMD+LCP+UCP	0.94	0.001
68	Ennominae	*Odontopera rufitinctaria*	NMD+LCP+UCP	0.95	0.001
69	Geometrinae	*Pingasa pseudoterpnaria*	NMD+LCP+UCP	0.82	0.004
70	Ennominae	*Psilalcis breta breta*	NMD+LCP+UCP	0.96	0.001
71	Sterrhinae	*Scopula fibulata*	NMD+LCP+UCP	0.71	0.038
72	Geometrinae	*Herochroma cristata cristata*	NMD+LCP+MD	0.74	0.039
73	Ennominae	*Hypomecis transcissa*	NMD+LCP+MD	0.95	0.001
74	Ennominae	*Psyra gracilis*	NMD+UCP+MD	0.72	0.015
75	Ennominae	*Garaeus apicata*	NMD+UCP+BO	0.83	0.002
76	Sterrhinae	*Scopula bispurcata*	NMD+UCP+BO	0.77	0.063
77	Larentiinae	*Apithecia viridata*	UCP+MD+BO	0.92	0.007
78	Geometrinae	*Chloroglyphica variegata*	UCP+MD+BO	0.85	0.001
79	Larentiinae	*Ecliptopera dentifera*	UCP+MD+BO	0.90	0.001
80	Geometrinae	*Hirasa muscosaria*	UCP+MD+BO	0.86	0.002

81	Ennominae	*Hyalinetta circumflexa*	UCP+MD+BO	0.83	0.004
82	Larentiinae	*Nebula homophana*	UCP+MD+BO	0.83	0.004
83	Ennominae	*Orthobrachia latifasciata*	UCP+MD+BO	0.71	0.049
84	Ennominae	*Ourapteryx yerburii yerburii*	UCP+MD+BO	0.93	0.001
85	Ennominae	*Psyra angulifera*	UCP+MD+BO	0.88	0.002
86	Larentiinae	*Docirava pudicata*	MD+BO+UOF	0.73	0.057
87	Larentiinae	*Ecliptopera relata*	MD+BO+UOF	0.94	0.001
88	Ennominae	*Heterolocha falconaria*	MD+BO+UOF	0.77	0.017
89	Ennominae	*Microcalicha fimbriata*	MD+BO+UOF	0.71	0.052
90	Ennominae	*Psyra similaria*	MD+BO+UOF	0.78	0.023
91	Larentiinae	*Electrophaes niveonotata*	MD+UOF+KO	0.84	0.003
92	Larentiinae	*Martania albofasciata*	MD+UOF+KO	0.72	0.074
93	Larentiinae	*Perizoma peculiare*	MD+UOF+KO	0.88	0.001
94	Larentiinae	*Dysstroma dentifera*	MD+KO+BRS	0.71	0.041
95	Larentiinae	*Myrioblephara gandakiensis*	BO+KO+BRS	0.79	0.016
96	Ennominae	*Anonychia lativitta*	UOF+KO+BRS	0.98	0.001
97	Ennominae	*Arichanna flavinigra*	UOF+KO+BRS	0.98	0.001
98	Larentiinae	*Dysstroma planifasciata*	UOF+KO+BRS	0.94	0.001
99	Larentiinae	*Electrophaes marginata*	UOF+KO+BRS	0.94	0.001
100	Ennominae	*Lassaba interruptaria*	UOF+KO+BRS	0.86	0.001
101	Larentiinae	*Martania antisticta*	UOF+KO+BRS	0.78	0.011
102	Larentiinae	*Photoscotosia amplicata*	UOF+KO+BRS	0.98	0.001
103	Sterrhinae	*Idaea persimilis*	NMD+LCP+UCP+MD	0.85	0.001
104	Larentiinae	*Orthonama obstipata*	NMD+LCP+UCP+MD	0.95	0.001
105	Sterrhinae	*Tanaotrichia prasonaria trilineata*	NMD+LCP+UCP+MD	0.80	0.003
106	Ennominae	*Hydatocapnia marginata*	NMD+LCP+UCP+BO	0.78	0.048
107	Ennominae	*Luxiaria amasa*	NMD+LCP+UCP+BO	0.78	0.033
108	Ennominae	*Peratostega deletaria deletaria*	NMD+LCP+MD+BO	0.81	0.023
109	Sterrhinae	*Timandra correspondens*	NMD+UCP+MD+BO	0.88	0.009
110	Ennominae	*Anonychia grisea*	LCP+UCP+MD+BO	0.95	0.002
111	Ennominae	*Gasterocomme pannosaria*	LCP+UCP+MD+BO	0.86	0.009
112	Larentiinae	*Gagetodes Perizoma saxicola*	UCP+MD+BO+UOF	0.72	0.051
113	Ennominae	*Lassaba parvalbidaria nepalensis*	UCP+MD+BO+UOF	0.84	0.071
114	Ennominae	*Ourapteryx ebuleata*	UCP+MD+BO+UOF	0.91	0.003
115	Larentiinae	*Triphosa dubiosata*	UCP+MD+BO+UOF	0.90	0.041
116	Ennominae	*Alcis quadrifera*	MD+BO+UOF+KO	0.85	0.004
117	Ennominae	*Psyra crypta*	MD+BO+UOF+KO	0.79	0.018
118	Ennominae	*Odontopera obliquaria*	MD+BO+UOF+BRS	0.89	0.006
119	Larentiinae	*Martania micropunctum*	MD+UOF+KO+BRS	0.71	0.032
120	Larentiinae	*Pasiphila palpata*	MD+UOF+KO+BRS	0.86	0.001
121	Ennominae	*Arichanna sparsa*	BO+UOF+KO+BRS	0.77	0.055

122	Ennominae	*Arichanna tenebraria*	BO+UOF+KO+BRS	0.83	0.002
123	Geometrinae	*Geometra flavifrontaria*	BO+UOF+KO+BRS	0.80	0.024
124	Ennominae	*Loxaspilates obliquaria*	BO+UOF+KO+BRS	0.86	0.003
125	Ennominae	*Alcis variegata*	NMD+LCP+UCP+MD+BO	1	0.001
126	Ennominae	*Antipercnia belluaria*	NMD+LCP+UCP+MD+BO	0.98	0.001
127	Ennominae	*Corymica pryeri*	NMD+LCP+UCP+MD+BO	0.75	0.075
128	Sterrhinae	*Rhodostrophia stigmatica*	NMD+LCP+UCP+MD+BO	0.95	0.001
129	Larentiinae	*Xenortholitha falcata*	NMD+LCP+UCP+MD+BO	0.82	0.032
130	Ennominae	*Ourapteryx purissima*	NMD+UCP+MD+BO+BRS	0.81	0.042
131	Larentiinae	*Electrophaes aliena*	UCP+MD+UOF+KO+BRS	0.80	0.028
132	Larentiinae	*Colostygia albigirata*	MD+BO+UOF+KO+BRS	0.84	0.016
133	Larentiinae	*Hysterura multifaria*	MD+BO+UOF+KO+BRS	0.88	0.001
134	Larentiinae	*Martania fulvimacula*	MD+BO+UOF+KO+BRS	0.92	0.003
135	Larentiinae	*Martania seriata*	MD+BO+UOF+KO+BRS	0.78	0.035
136	Ennominae	*Paradarisa comparataria*	NMD+LCP+UCP+MD+BO+ UOF	0.93	0.013
137	Larentiinae	*Xanthorhoe saturata*	NMD+LCP+UCP+MD+BO+ UOF	0.97	0.018
138	Ennominae	*Alcis limbui*	NMD+UCP+MD+BO+UOF +KO+BRS	0.95	0.098

5.4 Discussion

The Indicspecies analysis for the community matrix of the DMR landscape helped to gain valuable insight into the association or the specificity of the species with different forest types, altitudes or a combination of both. The reported species were selected based on their high indicator (Indval) values and statistically significant p-values. Therefore, the observed species specificity is likely a result of their higher relative abundance or exclusive presence with a higher number of individuals in these altitudinal zones or forest types. This could be further attributed to the species' particular preferences, adaptations to environmental conditions, or the presence of the associated host plant in these particular forest types or altitudes.

Species exclusively linked to particular altitudinal zones or forest types can be used to monitor the effects of climate change and disturbances. These species with their specialised habitats or environmental requirements are very sensitive to even subtle changes in their surroundings. As they respond early to environmental changes, their monitoring helps to target conservation efforts much before complete disruption of the ecosystem. Further analysis must focus on the underlying processes or mechanisms of these specialised species-environmental associations. This requires future natural history studies documenting the host plant and life-history characteristics of these species and their distribution patterns. Also, the use of moths as an indicator is highly sensitive to seasonal fidelity of the species (Nakamura et al. 2016). This needs to be determined in further analyses based on fine temporally resolved data, studying the monthly, seasonal, and annual changes in species occurrence, abundance, and overall species richness and diversity patterns.

Once confirmed as an indicator, follow-up monitoring of the abundance and distributional patterns of such species would be helpful to gain a deeper insight into the broader health of the ecosystem they inhabit. Species with specific altitudinal preferences and narrow altitudinal ranges are particularly helpful for tracking the effects of climate change on species distribution ranges and their overall response to global warming. Those with specialised host-plant and habitat requirements are particularly important in monitoring habitat quality and the effects of disturbances. Therefore, targeting such species in conservation programs not only preserves diversity but also the overall ecological balance within these altitudinal zones or forest types and the resilience of the entire ecosystem.

Chapter 6
High-altitude moth fauna of LSVs with special emphasis on family Geometridae

6.1 Introduction

High-altitude ecosystem: characteristics, fauna and threats

High-altitude mountain ecosystems are the treeless regions that exist above tree line beyond the elevational range of 2500–3000 m above sea level (asl) up to the uppermost limits of life possibilities on mountains, with general environment and life forms significantly different from the surrounding lowland forests, prairies ad plains (Mani 1962, 1968). These areas are characterised by extremely harsh topoclimatic conditions and serve as focal points for microevolution, adaptation, and diversification (Haslett 1997). Furthermore, these habitats are spatially and climatically isolated, resembling island-like ecosystem in high-altitude regions (Billings 2019). The species assemblages of these landscapes are locally isolated with limited habitat availability due to the fixed mountain summits. Consequently, these species are locally adapted and become highly specialised to the surrounding topography and local climatic conditions. Therefore, as the high-altitude fauna does not occur in the regions below, it is designated and recognised as "nival" (Mani 1983) (in particular reference to insects).

The high-altitude ecosystems are fragile and ecologically sensitive due to their harsh environments and spatial and climatic isolation. Perturbations like climate change and anthropogenic pressure in terms of changes in land use patterns, developmental interventions, and overgrazing by livestock, threaten the survival of local species. Moreover, species from lowland habitats are shifting their range upward in response to ongoing climatic warming and interfering with residential species. The primary concern is that such changes in the system can result in the loss of true high-altitude species (Spehn and Körner 2005; Hodkinson and Jackson 2005). These areas were previously inaccessible, with very limited documentation of regional biodiversity, particularly the microfaunal components of these systems lacking any special attention. As changes threaten this fragile system, the documentation of its biodiversity is important before it is too late. This will help to establish baseline data to understand the current status and facilitate future monitoring of the region. Therefore, considering the urgency, these regions with unique assemblages under threat are the priority areas for rapid biodiversity assessment interventions (Prendergast et al. 1993; Reid 1998; Dobson 1997; Howard et al. 1998).

High-altitude entomology: background

The term "High-altitude entomology" was coined by Mani (1954) who is also referred to as the "dean of the high-altitude entomologists" (Singh 1983). The first initiative as a collection effort in the high-altitude ecosystems of the Himalaya was made by von Hugel, during the first half of the 19th century. His collection was subsequently analysed by Kollar and Redtenbacher, who provided the species descriptions. Following this, noteworthy efforts were made by Col. Stoliczka and Guy Babault in the North Western Himalaya for the documentation of high-altitude insects. All of these earlier expeditions were exploratory and lacked ecological details. Mani pioneered ecological studies of high-altitude faunal groups, including insects. He produced several important publications on high-altitude entomology in 1962, 1968, 1974, and 1978, where he primarily focused on the "faunistic, systematics, field ecology and geography of the high-altitude insects" (citations in Singh 1983). These studies now form the fundamental knowledge base for the study of high-altitude entomology in the Indian Himalayan Region (IHR).

Moths as target taxon: in the context of the Trans Himalayan region

Insects play several important roles in ecosystems, including pollination, nutrient recycling and soil aeration, and serve as a crucial food source for many other larger animals. These ectothermic small organisms are tightly linked to their habitat conditions and are very sensitive to changes in their surroundings (Harrison et al. 2012). They are the most abundant, diverse, and dominant components in the community, and there is a weak correlation between vertebrate and invertebrate diversity in a community (Mac Nally et al. 2002).

Insects are also the dominant and key components of high-altitude ecosystems (Mani 1974). High-altitude insect species assemblages are unique, with a high proportion of endemic species. However, these assemblages have very fragmentary and opportunistic documentations because of the inaccessibility, remoteness, and harsh environmental conditions in the region. The high-altitude moth assemblage from the LSVs is very rarely documented previously. These rare documentations are often highly fragmented and scattered, and there is usually inaccessible literature, mostly with ambiguous species descriptions. Moreover, these documentations were exploratory and lacked ecological details, with no accurate description of the collection locality and habitat features. Therefore, this study was designed to perform the first-ever assessment and documentation of the regional macro moths' fauna of the Lahaul and Spiti district (a high-altitude ecosystem in Himachal Pradesh) along with preliminary documentation of their diversity, distribution, and ecological patterns.

This chapter focuses on i) to provide a detailed list of all the identified and documented geometrid moth species of this study along with their brief diagnostic features and documented distributional ranges, ii) evaluating the total species richness and diversity of Geometridae moths in LSVs (γ-diversity), iii) conducting a preliminary analysis of the diversity and distribution of the Geometridae moths in LSVs and iv) assessment the biogeographic affinity of the total assemblage (this include both geometrid and other macro moths families documented during the study) based on the distributional ranges of species compiled from secondary literature.

6.2 Materials and Methods

6.2.1 Data Collection

Altogether, an altitudinal gradient from 2498 m to 4870 m was sampled in the LSVs. For sampling along this gradient, the sites were selected randomly in the different forest types at every 300 m altitudinal zone. Sampling was performed in the year 2021 for a single growing season of these valleys from June to August months. For each sampling night, the light trap session started shortly after sunset and ran for approximately 3–4 h (owing to very high wind speeds and low temperatures during late night hours). Altogether, 21 sites were sampled, with a total of 23 light trapping sessions in the landscape. All sites were sampled for single light-trapping sessions except for some sites where the same efforts had lower trapping success with few individuals. Supplementary sampling was performed at these sites to reduce the chances of under-sampling and unequal representation of sites. Hence, one or two trapping nights occurred across the sampling sites. A reference collection was prepared using the sample, and species identification was performed following the process discussed in Chapter 3.

6.2.2 Data analysis

The total (γ) diversity of the Geometridae family in the landscape and site-wise (α) diversity were calculated. First, the total observed species richness and standard diversity indices, Dominance (D), Simpson's (1-D), Shannon (H) and Evenness (e^H/S) were measured. Next, different non-parametric species richness estimators were calculated to estimate the true (observed and undetected) number of species. The iChao-1 measure was used as the standard estimator to evaluate sampling completeness at both the local and regional levels. For the third approach, Fisher's alpha of the log series distribution was used as an estimator of alpha diversity. For further analysis, the sites were grouped for every forest type and altitudinal zone and compared for diversity, abundance and species richness. The altitudinal gradient was divided into three broad zones; Zone 1 (2500-3000 m), Zone 2 (3000-3500 m), and Zone 3 (> 3500 m) followed by a comparison of species diversity and composition between different zones. Indicator species analysis (ISA) was also done for the combination of forest types and the altitudinal zones as. The analysis was done in R using *indicspecies* package. Biogeographic affinity was assessed and analysed based on the distributional data of each species. All analyses were performed either in Excel or Past4 (Hammer 2001).

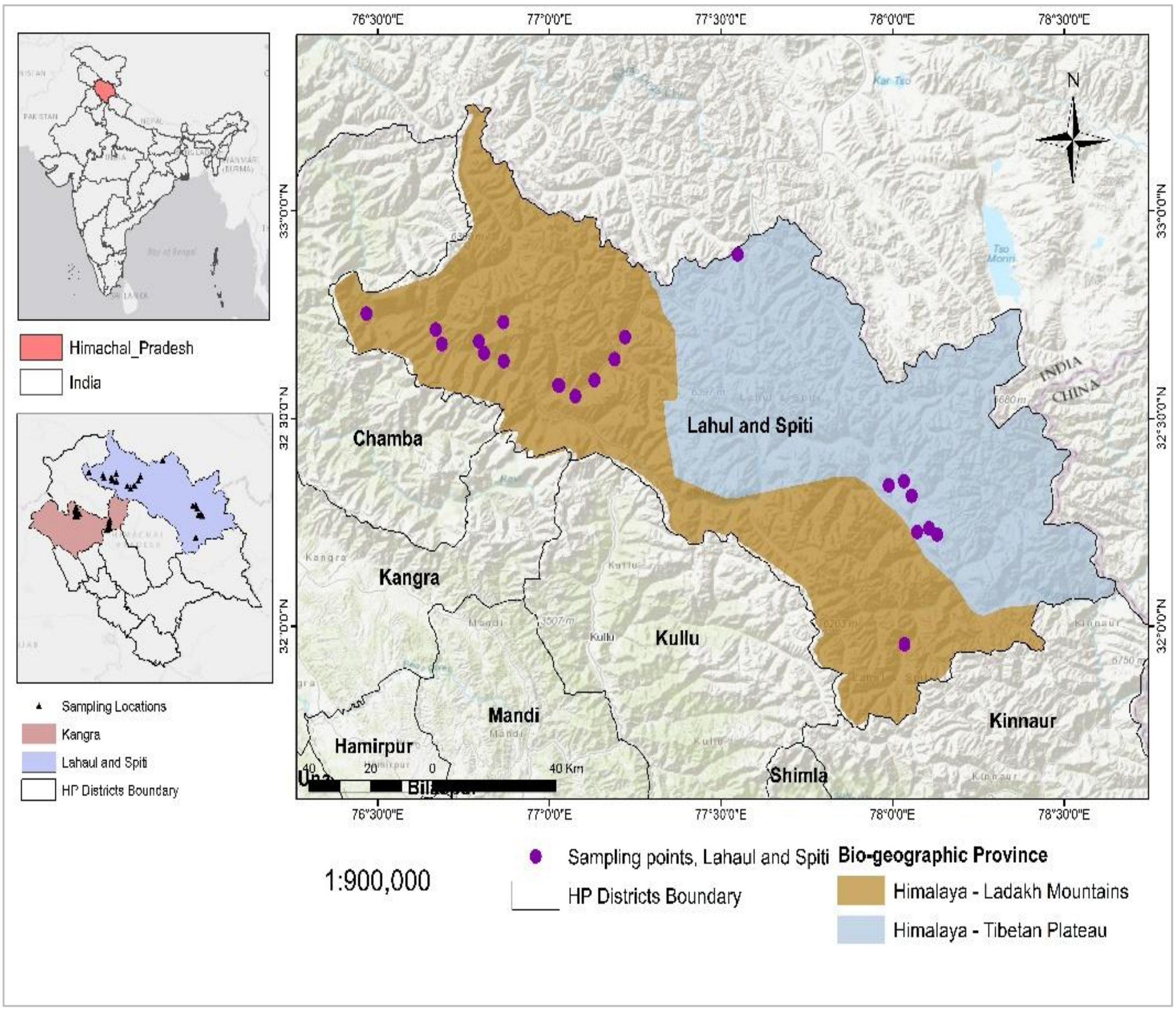


Fig. 6.1: **S**ampling locations in the LSVs.

6.3 Results

6.3.1 Species Inventory

A total of 48 species among 36 genera of the Geometridae family were documented across the four major subfamilies, namely, Sterrhinae (4 species, 2 genera), Geometrinae (4 species, 3 genera), Larentiinae (18 species, 13 genera) and Ennominae (22 species, 18 genera). Additionally, 39 species in four other macro moths' families i.e., Noctuidae (32 species), Erebidae (3 species), Notodontidae (3 species) and Cossidae (1 species) were also documented from these landscapes. Of the total documented species, the highest number of species was reported for the Geometridae (48 species) and Noctuidae (32 species) families, the two high-altitude specialist families of moths. Of all the documented species in the family Geometridae, ten species and subspecies (*Afriberina tenietaria*, *Alcis nobilitaria*, *Artemidora epicyrta*, *Biston betularia nepalensis*, *Charissa crenulata*, *Eupithecia centaureata*, *Eupithecia venosata*, *Gnophos praeauctaria*, *Gnophos rubefactaria* and *Photoscotosia palaearctica*) are the new country records to India from Himachal Pradesh and there are four species and subspecies (*Artemidora disistaria*, *Euphyia submarginata*, *Loxaspilates hastigera punctigera and Scopula terminata mechadoi*) that are the new addition to the geometrid moth fauna of Himachal Pradesh (Appendix 2).

Taxonomic account

Kingdom Animalia

Phylum Arthropoda (Latreille, 1829)

Class Insecta (Linnaeus, 1758)

Order Lepidoptera Linnaeus, 1758

Superfamily Geometroidea Leach, 1815

Family Geometridae Leach, 1815

Subfamily Sterrhinae Meyrick, 1892

Tribe Rhodostrophiini Prout,1935

Genus *Rhodostrophia* Hübner, 1823

1. *Rhodostrophia borealis* (Swinhoe, 1890) [Plate 16.1]

(see Kumari et al. 2024)

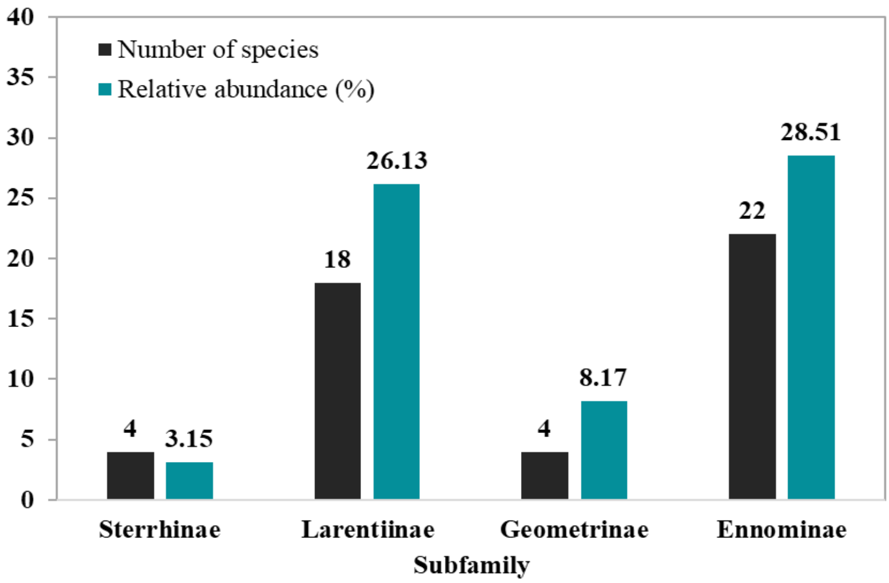


Fig. 6.2: Number of species and relative abundance (%) documented for the family Geometridae and its four major subfamilies from the Lahaul and Spiti landscapes.

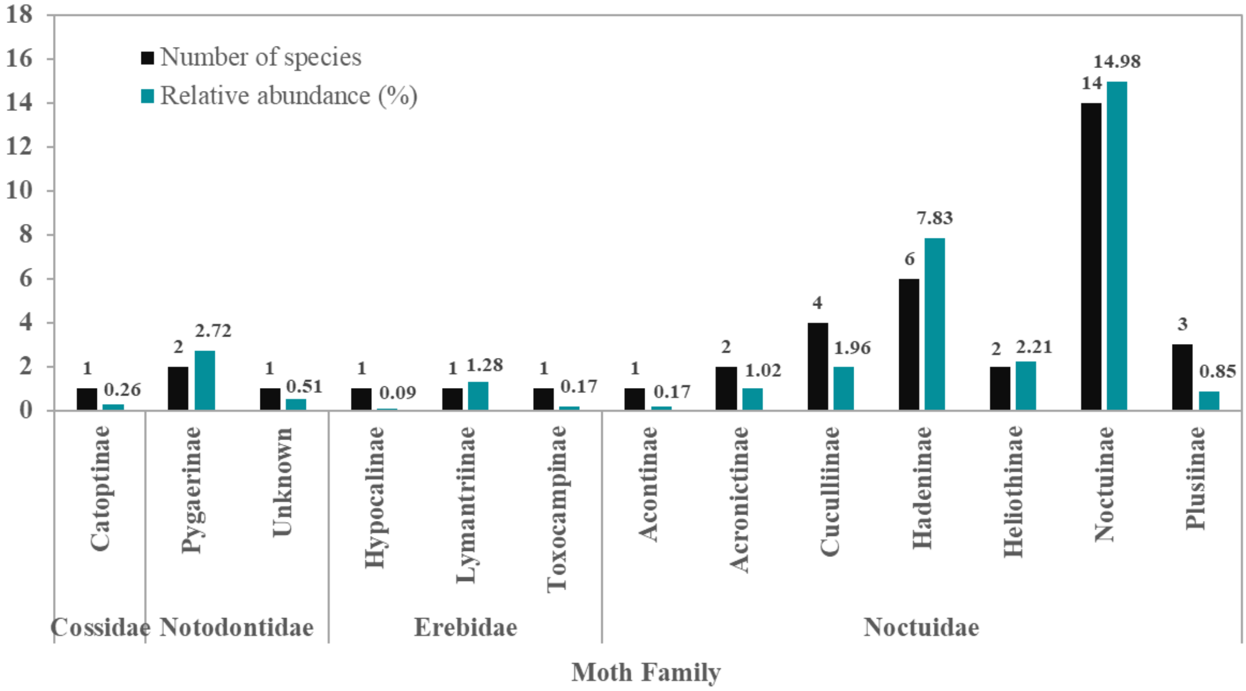


Fig. 6.2: Number of species and relative abundance (%) documented for other macro moths' families and their major subfamilies from the Lahaul and Spiti landscapes.

2. ***Rhodostrophia herbicolens*** **(Butler, 1883)** [Plate 16.2]

(Discussed in Chapter 3, and more details in Kumari et al. 2024)

Tribe Scopulini Duponchel 1845

Genus *Scopula* Schrank, 1802

***3. Scopula terminata mechadoi* (Hausmann, 1993)** [Plate 16.3]

(Discussed in Chapter 3)

4. *Scopula kashmirensis kashmirensis* (Moore, 1888) [Plate 16.4]

[TL: Kashmir (Jammu and Kashmir, India)]

Craspedia kashmirensis Moore, 1888; *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*, (3): 253.

Craspedia kashmirensis; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 430.

Scopula kashmirensis; Prout, 1934–1938; in Seitz, *The Macrolepidoptera of the world, 4, supplementary*: 46, pl., 5 (e).

Scopula kashmirensis; Gyula et al., 2018; in Fibigeriana Supplement, *The Vartian Collection, Geometridae*, Part-4: 25, pl. 15 (1–5).

Wing expanse: 26 mm (Forewing length: Male: 14–15 mm)

Diagnosis: There are three subspecies, among which the nominotypical one is the most sharply marked and externally looks very similar to *S. ornata* Scopoli, 1763. However, in *S. ornata* the marking beyond the postmedial line is ochreous-brown while the *S. kashmirensis* characterised by the diffused and prominent cinereous-ochreous sinuous medial line and the cloudy markings beyond a fuscous black slender postmedial line.

Distribution: India: Himachal Pradesh (Lahaul and Spiti-current study), Jammu and Kashmir (Kashmir, 8500 ft, Atkinson collection, Srinagar), Punjab, Sikkim. **Global:** Afghanistan (Kandahar, ~1010 m), China, Japan, Pakistan (Gyula et al. 2018).

Subfamily Larentiinae Duponchel, 1845

Tribe Eupitheciini Tutt, 1896

Genus *Eupithecia* Curtis, 1825

Type species: *Phalaena absinthiata* (Clerck, 1759)

5. *Eupithecia centaureata centaureata* ([Denis & Schiffermüller], 1775) [Plate 16.5]

[TL: Vienna District, Austria]

= *boloniensis* (Fourcroy, 1785) (*Phalaena*); [TL: France]

= *oblongata* (Thunberg, 1784) (*Geometra*); [TL: ??]

= *oblongata centralisata* Staudinger, 1892; [TL: Palestine, Central Asia]

= *chinae* Vojnits, 1977; [TL: China]

Geometra centaureata Denis & Schiffermüller, 1775; *Ankundung Systematisches Werkes Schmetterlinge Wienergegend*: 114.

Eupithecia centaureata; Prout, 1912–1916; in Seitz, *The Macrolepidoptera of the world*, 4: 281, pl., 12 (d).

Eupithecia centaureata; Prout, 1934–1938; in Seitz, *The Macrolepidoptera of the world, 4, supplementary*: 190.

Eupithecia centaureata; Mironov et al. 2007; *Lepidoptera Science*, 58 (3): 341–363 (genitalia reference).

Eupithecia centaureata; Gyula et al., 2018; in Fibigeriana Supplement, *The Vartian Collection*, *Geometridae*, Part-4: 37, pl., 41 (52–57).

Wing expanse: Forewing length: 11–12 mm.

Diagnosis: The members are easily recognizable with their snow-white or whitish wing colour; forewing with a distinct, dark black lunulate discal spot followed by many undulating black lines prominent only near costa; a pale ochreous-brown postmedial band, similar coloured marginal lunules in between the veins and a subterminal white line in between.

Distribution: India: Himachal Pradesh (Lahaul and Spiti-current study) **Global:** Austria, Central Asia, China, Croatia, France, Iran (Elbrus mountains), Lebanon, Palestine, Sicily, Taiwan (Mironov et al. 2007; Gyula et al. 2018) (Europe, North Africa, Asia Minor).

Remarks: There are a total of three subspecies, the nominotypical discussed here has been described from Austria and the other two viz., *E. c. dagestani* Vojnits, 1977 and *E. c. dsharkendi* Vojnits, 1977 from USSR. The species is a **new record** for India.

6. *Eupithecia nigrilinea* (Warren, 1896) [Plate 16.6]

[TL: Kasauli (Himachal Pradesh, India)]

= ?? *denotata f.difficilis* Dietze, 1911; [TL: Tajikistan]

= *ingrata ingrata* Vojnits, 1981; [TL: Pakistan]

= *ingrata talvei* Viidalepp, 1988; [TL: Tajikistan]

Tephroclystia nigrilinea Warren, 1896; *Novitates zoologicae,* 3: 317.

Eupithecia nigrilinea; Prout 1934–1938; in Seitz, *The Macrolepidoptera of the world*, 4, *supplementary*: 209, pl., 17 (h).

Eupithecia nigrilinea; Inoue, 2000; in Tinea vol. 16 (suppl. 1), *Moths of Nepal*, Part-6: 38, pl., 166 (1) (genitalia figure: 1309).

Wing expanse: 20 mm (Forewing length: 8–10 mm)

Diagnosis: Pale and shiny brownish-grey wings with markings consisting of many dark black transverse lines. Forewing with three to four in the basal area, three very close and in the medial region while three beyond the middle excurving beyond the cell, the later one followed by a comparatively thick line, bent above the inner margin; outer marginal area darker with several indistinct wavy lines and a paler, dentate submarginal line. Discal spot darker, distinct and elongated (on the first of three lines). Hindwing marking indistinct and only visible towards the inner margin representing the traces of three basal lines, one central and darker, and several marginal transverse lines. The abdomen with a characteristic black lateral streak.

Distribution: India: Himachal Pradesh (Kasauli, Lahaul and Spiti-current study), Jammu and Kashmir (Kashmir), Uttarakhand (Kumaon). **Global:** Nepal, Pakistan, Tajikistan (Inoue, 2000).

7. *Eupithecia venosata venosata* (Fabricius, 1787) [Plate 16.7]
[TL: Austria]

= *comparanda* Vojnits, 1981; [TL: Pakistan]

= *decussata* (Donovan, 1799) (*Phalaena*); [TL: United Kingdom]

= *insignata* (Hübner, 1789) ([*Phalaena*] [*Geometra*]); [TL: Austria]

Eupithecia venosata; Prout, 1912–1916; in Seitz, *The Macrolepidoptera of the world*, 4: 279, pl., 12 (e).

Eupithecia venosata; Prout 1934–1938; *The Macrolepidoptera of the world, 4, supplementary*: 189.

Eupithecia venosata; Gyula et al., 2018; in Fibigeriana Supplement, *The Vartian Collection, Geometridae*, Part-4: 36, pl., 38 (33–36).

Wing expanse: Forewing length: 12–13 mm

Diagnosis: The members show variations in size and colour; mostly with pale grey wings and easily recognizable with their characteristic sharp dark black markings as follows: sub basal line slightly thickened and excurved; antemedial line highly dentated towards inner margin with the traces of two other lines in front which are visible only towards the inner margin; medial line sinuous, outcurved in the discocellular region and get thickened as it coalesce with the elongated, discal speck and also is connected with both ante and post medial line towards inner margin; postmedial line dentated and followed by two other similar lines, the outermost one sending black streaks along the veins to outer margin. Hindwing colour and marking similar to the forewing but often faded or indistinct. Underside paler, often suffused with slight fuscous, discal specks elongated and dark black.

Distribution: India: Himachal Pradesh (Lahaul and Spiti-current study). **Global:** Austria, France, Greece, Macedonia, Morocco, Pakistan, Spain, United Kingdom (Gyula et al. 2018)

Remarks: The species is a **new record** to the moth fauna of India.

Tribe Cidariini Duponchel, 1845

Genus *Colostygia* Hübner, [1825]

8. *Colostygia albigirata* (Kollar, [1844]) [Plate 16.8]

(Discussed in Chapter 3).

Genus *Electrophaes* Prout, 1923

9. *Electrophaes niveonotata* (Warren, 1893) [Plate 16.9]

(Discussed in Chapter 3)

Genus *Heterothera* Inoue, 1943

10. *Heterothera consimilis* (Warren, 1888) [Plate 16.10]

(Discussed in Chapter 3)

Genus *Nebula* Braund, 1846

11. *Nebula homophana* (Hampson, 1895) [Plate 16.11]

(Discussed in Chapter 3)

Genus *Xenortholitha* Inoue, 1944

12. *Xenortholitha latifusata latifusata* (Walker, 1862) [Plate 16.12]

(Discussed in Chapter 3)

Tribe Melanthiini Duponchel, 1845

Genus *Horisme* Hübner, [1825]

13. *Horisme nigrovittata* (Warren, 1888) [Plate 16.13]

[TL: Thundiani, Western India (Pakistan)]

= *nigripunctata* (Warren, 1888) (*Phibalapteryx*); [TL: India (Western Pakistan)]

Phibalapteryx nigrovittata Warren, 1888; *Proceedings of the Zoological Society of London*: 327.

Horisme nigrovittata; Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary*: 213, pl. 17 (d).

Wing expanse: 36 mm.

Diagnosis: Wings dull brown with fuscous-greyish suffusion; numerous, indistinct dark and pale, wavy transverse lines; a distinct, large, black discal spot; black speckled veins and a terminal series of thick, black dashes.

Distribution: India: Himachal Pradesh (Lahaul and Spiti-current study), Uttarakhand (Dey 2018). **Global:** Pakistan (Thundiani).

Tribe Triphosini Tutt, 1896

Genus *Triphosa* Stephens, 1829

***14. Triphosa dubiosata* (Walker, 1862)** [Plate 16.14]

(Discussed in Chapter 3)

Tribe Euphyiini Herbulot, 1961

Genus *Euphyia* Hübner, [1825]

15. *Euphyia cinnamifusa* Prout, 1939 [Plate 16.15]

[TL: Gulmarg, Kashmir, Jammu and Kashmir, India]

Euphyia cinnamifusa Prout, 1939; in Seitz, Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 281.

Euphyia cinnamifusa; Gyula et al., 2018; in Fibigeriana Supplement, *The Vartian Collection, Geometridae*, Part-4: 30, pl., 27 (35–37).

Wing expanse: 32 mm (Forewing length: Male: 17–18 mm).

Diagnosis: Looks close to *E. subangulata* but distinguishable as follows: forewing pale whitish-ochreous with brownish-fuscous irrorations and a characteristic orange-cinnamon suffusion on the discal spot and submarginal area, especially "as two broad longitudinal patches about the folds" (original description); male antenna shortly cilliated rather simple (in *E. subangulata*). Underside paler with greyish-fuscous suffusion and irroration, discal dot and post medial line prominent.

Distribution: India: Himachal Pradesh (GHNP) (Mallick 2021), Jammu and Kashmir (Kashmir, Gulmarg), Uttarakhand (Dey 2018). **Global:** Pakistan (Gyula et al. 2018)

16. *Euphyia submarginata* (Warren, 1909) [Plate 16.16]

(Discussed in Chapter 3)

Tribe Larentiini Duponchel, 1845

Genus *Amnesicoma* Warren, 1895

17. *Amnesicoma simplex* Warren, 1895 [Plate 16.17]

(Discussed in Chapter 3)

Genus *Entephria* Hübner, [1825]

18. Entephria poliotaria (Hampson, 1902) [Plate 16.18]

[TL: Kashmir (Jammu and Kashmir, India)]

Larentia poliotaria Hampson, 1902; *Journal Bobmay Natural History Society*, 14: 577.

Cidaria poliotaria; Prout, 1912–1916; in seitz: *The Macrolepidoptera of the world*, 4: 237, pl., 13 (n).

Cidaria poliotaria; Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary*: 139.

Entephria poliotaria; Prout, 1920–1941; in seitz: The Macrolepidoptera of the world, 12: 274.

Entephria poliotaria; Gyula et al., 2018; in Fibigeriana Supplement, *The Vartian Collection, Geometridae*, Part-4: 31, pl., 29 (4).

Entephria poliotaria; Dey et al., 2019; *Spixiana*, 42 (1); 47–59.

Wing expanse: Forewing length: 18–20 mm.

Diagnosis: Forewing very pale, whitish-ochreous with fuscous-greyish irrorations; "the subbasal band (or pair of thick lines) almost as dark as basal, nearly united with it, distal area rather strongly dark-marked, in particular with the lunules on the subterminal line strongly dark filled-in proximally; a black, elongated, discal speck. Hindwing whitish-grey, almost unmarked but with an indistinct cell dot. Underside pale, irrorated with grey, glossy, and almost unmarked; discal specks, more prominent on hindwing; hindwing with postmedian line indicated.

Distribution: India: Himachal Pradesh (Koksar, Lahaul and Spiti-current study), Jammu and Kashmir (Chobia, Kashmir), Uttarakhand (Dey et al. 2019). **Global:** Pakistan (Gyula et al. 2018).

Genus *Photoscotosia* Warren, 1888

19. *Photoscotosia amplicata* (Walker, 1862) [Plate 16.19]

(Discussed in Chapter 3)

20. *Photoscotosia dejuncta* Prout, 1937 [Plate 16.20]

(Discussed in Chapter 3).

21. *Photoscotosia palaearctica* (Staudinger, 1882) [Plate 17.1]

[TL: Saisan (Tarbagatai); Lepsa (Ala Tau); Margelan]

= *palaearctica fusca* Staudinger, 1901; [TL: Kaschgar]

Trichopleura palaearctica Staudinger, 1882; Beitrag zur Lepidopterenfauna Central-Asiens Stettin Entomologische Zeitung, 43: 68.

Photoscotosia palaearctica; Prout, 1912–1916; in Seitz, *The Macrolepidoptera of the world*, 4: 202, pl., 5 (h).

Photoscotosia palaearctica fusca; Prout, 1912–1916; in Seitz, *The Macrolepidoptera of the world*, 4: 203.

Photoscotosia palaearctica; Gyula et al., 2018; in Fibigeriana Supplement, The Vartian Collection, Geometridae, Part-4: 34, pl., 35 (20).

Wing expanse: Forewing length: 23–24 mm, Female: 25–27 mm.

Diagnosis: Very pale, ochreous-white wings with fuscous-grey dense irroration. Looks similar to *P. leechi* but can be distinguished as follows: forewing with the antemedial line crossing the discal spot (while lies proximal in *P. leechi*); the postmedial line visible only towards costa, a black apical, narrow streak with very indistinct marking towards outer margin. Hindwing with a slight pale-greyish, suffusion, an indistinct, faded, narrow postmedial band and a darker, slightly broader marginal band. Underside with fuscous-grey suffusion and irroration, distal costal half of ochreous with a very prominent black patch in the postmedial region, hindwing with a darker postmedial line.

Distribution: India: Lahaul and Spiti-current study. **Global:** Afghanistan (Gyula et al. 2018), Central Asia, China (Kaschgar), Kazakhstan (Tarbagatai Mountains) (Nazymbetova et al. 2016).

Remarks: The species is a **new record** for India and a new addition to the state fauna of Himachal Pradesh.

Tribe Stamnodini Forbes, 1858

Genus *Stamnodes* Guenée, [1858]

Type species: *Fidonia pauperaria* Eversmann, 1848

22. *Stamnodes pauperaria pamphilata* (Felder and Rogenhofer, 1875) [Plate 17.2]
(Discussed in Chapter 3)

Subfamily Geometrinae Stephens, 1829

Tribe Hemitheini Bruand, 1846

Genus *Chlorissa* Stephens, 1831

23. *Chlorissa gelida exsoluta* Prout, 1935 [Plate 17.3]

[TL: Kulu, Himachal Pradesh, India]

Chlorissa gelida exsoluta Prout, 1934–1938; in Seitz: *The Macrolepidoptera of the world, 4, supplementary:* 15, pl., 3 (b).

Chlorissa gelida; Gyula et al., 2018; in Fibigeriana Supplement, *The Vartian Collection, Geometridae, Part-4*: 21, pl., 5 (16).

Wing expanse: Forewing length: 15–18 mm.

Diagnosis: *C. g. exsoluta* can be distinguished from the nominotypical subspecies based on its larger size and postmedial line of the hindwing which is located as exactly the continuation from that of the forewing (while lies well before that of forewing in the nominotypical subspecies).

Distribution: India: Himachal Pradesh (Kullu, Lahaul and Spiti-current study). **Global:** Pakistan (Gyula et al. 2018).

Genus *Hemistola* Warren, 1893

24. ***Hemistola detracta* (Walker, 1861)** [Plate 17.4]

[TL: North India]

= *annuligera* Warren, 1909; [TL: Kashmir]

= *unduligera* (Butler, 1889) (*Thalassodes*); [TL: India]

= *vestigiata* (Swinhoe, 1905) (*Microloxia*); [TL: Kashmir]

Geometra detracta Walker, 1861; List Species Lepidoptera Insects Collection British Museum, 22: 521.

Euchloris detracta; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 498.

Hemistola detracta; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world, 4:* 31, pl. 2 (h).

Hemistola detracta; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 124.

Hemistola detracta; Han and Xue, 2009; *Entomological science*, 12 (4), 382-410 (genitalia reference).

Wing expanse: Forewing length: 13–16 mm.

Diagnosis: Wings dull, bluish-green, forewing with ochreous costal edge and highly dentated ante medial (absent in hind wing) and crenulated silvery-white lines, marginal cilia and discal ring which is comparatively larger in hindwings. The underside of the wings paler white without any marking.

Distribution: India: Himachal Pradesh (Kullu), Jammu and Kashmir (Kashmir), Nagaland (Joshi et al. 2021). **Global:** China (Yunnan) (Xue and Han 2009), Pakistan (Kamaluddin et al. 2007).

25. *Hemistola fletcheri* Prout, 1934 [Plate 17.5]

[TL: Gulmarg, Kashmir, Jammu and Kashmir, India]

= *fletcheri subcaerulea* Prout, 1934; [TL: Kashmir]

Hemistola fletcheri Prout, 1934; in Seitz: *The Macrolepidoptera of the world*, 12: 123, pl 14 (c).

Wing expanse: 28–35 mm **(**Forewing length: Male: 14 mm, Female: 16 mm)

Diagnosis: Very similar to *H. loxiaria* and *H. chrysoprasaria* in the bluish-green wing colour and general wing marking but distinguishable based on its larger wing expanse (25–31 in *H. loxiaria*) and comparatively weaker or narrower discal spot.

Distribution: India: Jammu and Kashmir (Gulmarg, Srinagar), Lahaul and Spiti-current study. **Global:** Pakistan (Kamaluddin et al. 2007).

Remarks: The species has been described originally from Gulmarg 8500 feet.

Tribe Archaeobalbini Viidalepp, 1981

Genus *Herochroma* Swinhoe, 1893

26. *Herochroma crassipunctata crassipunctata* (Alphéraky, 1888) [Plate 17.6]

[TL: Askai (China)]

= *sordida* (Wehrli, 1928) (*Archaeobalbis*); [TL: China]

Gnophos crassipunctata Alphéraky, 1888; *Stett*. *Zg*., 49: 69.

Archaeobalbis crassipunctata; Prout, 1912–1916; in Seitz, *The Macrolepidoptera of the world*, 4: 11, pl., 1 (g).

Archaeobalbis crassipunctata; Viidaalepp, 1988: 6.

Herochroma crassipunctata; Inoue, 1999; *Tinea*, 16 (2): 97.

Herochroma crassipunctata; Gyula et al., 2018; in Fibigeriana Supplement, *The Vartian Collection, Geometridae,* Part-4: 20., pl., 2, fig., 32–33)

Wing expanse: 47 mm.

Diagnosis: Very similar to *Herochroma usneata* in shape and markings but pale ochreous-white, irrorated with very fine fuscous-brown striae especially towards the basal and postmedial region. Forewing with an indistinct antemedial and postmedial faded lines (darker and distinct in *H. usneata*) with black dots on veins followed by a submarginal and marginal series of dots. Hindwing marking similar as forewing except the antemedial line absent. Both the wings with indistinct greyish, faded, large discal spots with a distinct black dot in the center. Underside paler ochreous-white with fuscous-grey irrorations and very large, distinct black discal spot on all wings. The nominotypical subspecies can be distinguished from the similarly looking *H. crassipunctata farinosa* as the later is more greyish-green with black discal dots.

Remarks: There are two subspecies, *H. c. farinosa* has been described from Lahaul, North West India (Inoue 1999).

Distribution: India: Himachal Pradesh (Lahaul, GHNP) (Mallick 2021). **Global:** Afghanistan, China, Kazakhstan (Turkestan), Tajikistan (Inoue 1999; Gyula et al., 2018).

UNASSIGNED

Genus *Thetidia* Boisduval, 1840

27. *Thetidia radiata* Walker, F., [1863] [Plate 17.7]

[TL: North West India (North Hindostan)]

Thetidea ? *radiata* Walker, 1863; *List Species Lepidoptera Insects Collection British Museum*, 26: 1567.

Euchloris radiata Hampson, 1895; The Fauna of British India, including Ceylon and Burma, 3: 498.

Aglossochloris radiata; Prout, 1912–1916; in Seitz, *The Macrolepidoptera of the world*, 4: 29.

Aglossochloris radiata; Prout, 1920–1941; in Seitz, *The Macrolepidoptera of the world*, 12: 121.

Aglossochloris radiata; Prout, 1934–1938; in Seitz, *The Macrolepidoptera of the world*, 4, *supplememntary*: 18, pl., 3 (c).

Thetidia radiata; Gyula et al., 2018; in Fibigeriana Supplement, The Vartian Collection, Geometridae, Part-4: 21, pl., 4, fig., 13–16.

Wing expanse: Male: 30 mm, Female: 36 mm.

Diagnosis: Very similar to *T. correspondens* and *T. crucigerata* but can be distinguished based on the course of the ante and postmedial lines as following: the antemedial line of the forewing very acutely angled on the median vein than in *T. crucigerata* while the postmedial line have two characteristic toothed indentation below the cell; hindwing with comparatively greater green colour than compared to *T. correspondens*.

Distribution: India: Himachal Pradesh (Dharamshala, Kullu, Jammu and Kashmir (Chandra et al. 2019). **Global:** Afghanistan (Kabul), Pakistan, China (Huang-mu-chang).

Subfamily Ennominae Duponchel, 1845

Tribe Gnophini Duponchel, 1845

Genus *Charissa* Curtis, 1826

28. *Charissa crenulate* (Staudinger, 1871) [Plate 17.8]

(Discussed in Chapter 3)

Remarks: The species is a **new** record to India.

Genus *Gnophos* Treitschke, 1825

29. *Gnophos praeacutaria* Wehrli, 1922 [Plate 17.9]

[TL: Central Asia]

Wing expanse: Forewing length: Male: 16 mm, Female: 18 mm.

Diagnosis: Antenna filiform. Pale ochreous wings with greenish grey irroration. Forewing with indistinct ante medial line, represented as darker spot on the costa; traces of outwardly curved post medial line as a series of (sometimes indistinct) darker spots on the veins. Hindwing narrower than the forewing and without any distinct marking. Both wings with greenish-grey discal spot. Underside paler and greyish suffusion towards outer region, especially in the apical region of the wings.

Distribution: India: Himachal Pradesh (Lahaul and Spiti-current study). **Global:** Central Asia.

Remarks: The species is a **new record** to India.

30. *Gnophos rubefactaria* Püngeler, 1902 [Plate 17.10]

(Ddiscussed in Chapter 3)

Remarks: The species is a **new record** to India.

Genus *Loxaspilates* Warren, 1893

31. *Loxaspilates hastigera punctigera* Prout, 1915 [Plate 17.11]

[TL: Kashmir; Sonamarg and Scind Valley (Jammu and Kashmir, India)]

Loxaspilates hastigera punctigera Prout,1912–1916; in Seitz, *The Macrolepidoptera of the World*, 4: 410.

Wing expanse: (Forewing length: Female: 20–22 mm)

Diagnosis: The subspecies *L. h. hastigera* looks very similar to the nominotypical subspecies but differs as follows: forewings bright yellow with wedges (ante, postmedial and subterminal) reduced to dots and with smoky-brown clouding along and beyond the postmedial and subterminal series. Hindwing very pale yellowish-white. Underside of hindwings, an outwardly curved series of postmedial black dots.

Distribution: India: Himachal Pradesh (Lahaul and Spiti-current study), Jammu and Kashmir (Sonamarg, Kashmir; Scind Valley).

32. *Loxaspilates obliquaria* (Moore, 1868) [Plate 17.12]

(Discussed in Chapter 3)

Genus *Psyra* Walker, 1860

33. *Psyra debilis indica* (Butler, 1889) [Plate 17.13]

(Discussed in Chapter 3)

Tribe Odontopterini Tutt, 1896

Genus *Odontopera* Stephens, 1831: 162

34. *Odontopera kametaria* (Felder & Rogenhofer, 1875) [Plate 17.14]

[TL: Rampur, Himalaya (Himachal Pradesh, India)]

Crocallis kametaria Felder and Rogenhofer, 1893; *Reise der österreichischen Fregatte Novara (Zoology)*, 23: 28.

Crocallis kametaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 233.

Odontopera kametaria; Yazaki, 1998; in Tinea vol. 15 (suppl. 1); *Moths of Nepal*, Part-5: 14.

Odontopera kametaria; Sanyal et al., 2017; *SHILAP Revista de lepidopterología*, 45 (177): 157.

Odontopera kametaria; Gyula et al., 2018; in Fibigeriana Supplement, *The Vartian Collection, Geometridae*, Part-4: 41, pl., 52, figs 13–17.

Wing expanse: 38 mm (Forewing length: Male: 17 mm)

Diagnosis: Fulvous-yellow ground colour. Forewings with fulvous costa; dark fulvous medial band widest at costa and narrow at the middle and fulvous irroration and streaks along the veins on the outer area. Hindwings pale and with an oblique, fulvous indistinct medial band.

Distribution: India: Himachal Pradesh (Lahaul and Spiti-current study, GHNP), Uttarakhand (Govind WLS, Nanda Devi Biosphere Reserve) (Sanyal et al. 2017; Dey 2018; Chandra et al. 2019). **Global**: Nepal, Pakistan (Yazaki 1998; Chandra et al. 2019).

Tribe Ennomini Duponchel, 1845

Genus *Ourapteryx* Leach, 1814

35. *Ourapteryx convergens* Warren, 1897 [Plate 17.15]

(Discussed in Chapter 3)

Tribe Epionini Bruand,1846

Genus Garaeus Moore, [1868]

36. *Garaeus albipunctatus* Hampson, 1895 [Plate 17.16]

(Discussed in Chapter 3)

Genus *Heterolocha* Lederer, 1853

Type species: *Hypoplectis laminaria* Herrich-Schäffer, 1852

37. *Heterolocha phoenicotaeniata* (Kollar, 1844) [Plate 17.17]

(Discussed in Chapter 3)

Tribe Abraxini Warren,1893

Genus *Abraxas* Leach, [1815]

38. *Abraxas (Calospilos) antipusilla* Inoue, 1995 [Plate 17.18]

(Discussed in Chapter 3)

39. *Abraxas virginalis* Butler, 1861 [Plate 17.19]

(Discussed in Chapter 3)

Remarks: The species is a **new record** to Himachal Pradesh.

Tribe Boarmiini Duponchel,1845

Genus *Alcis* Curtis, 1826

40. *Alcis granitaria* (Moore, 1888) [Plate 17.20]

[TL: Sind Valleys, Kashmir]

Gnophos granitaria Moore, 1888, *Description of new Indian lepidopterous insects from the collection of the late Mr. W. S. Atkinson*: 246.

Boarmiaria granitaria; Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 372, pl., 21 (b).

Boarmiaria granitaria; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 274.

Alcis granitaria; Gyula et. al., 2018; in Fibigeriana Supplement, *The Vartian Collection, Geometridae*, Part-4: 48, pl., 73 (8–11), (genitalia figures: 23, 24).

Wing expanse: Male: 44 mm, Female: 44–50 mm (Forewing length: Male: 23 mm, Female: 24 mm)

Diagnosis: Wings pale bluish-grey with thick fuscous irroration intermixed with ochreous-brown at some places. Forewing with an indistinct, sinuous, black-speckled, duplex ante medial line; post medial as a series of black spots and a pale grey, sinuous, submarginal line, all bordered or followed by an ochreous-brown shade; a pale bluish-grey sinuous fascia towards the end of cell; distinct black discal spot. Hindwing with the markings of the forewing continuous. Underside paler, irrorated with fuscous striae; a broad, fuscous, marginal band interrupted by pale bluish-grey apical and maedial patch in the forewing; a post medial series of black dots before the band and a large, black discal spot.

Distribution: India: Himachal Pradesh (Chamba, Lahaul and Spiti-current study), Jammu and Kashmir (Kashmir), Uttarakhand (Dey 2018). **Global:** Pakistan (Gyula et al. 2018).

Remarks: The nominotypical subspecies *A. granitaria granitaria* differs from the other *Alcis granitaria klapperichi* in the male genitalia features.

41. *Alcis nobilitaria* (Staudinger, 1892) [Plate 18.1]

[TL: Central Asia]

Boarmia nobilitaria Staudinger, 1892; *Lepidopteren des Kentei-Gebirges Deutsche entomologische Zeitschrift Iris*, 5: 173.

Boarmia nobilitaria; Prout, 1912–1916; in seitz, *The Macrolepidoptera of the world*, 4: 366.

Afriberina nobilitaria; Gyula et. al., 2018; in Fibigeriana Supplement, *The Vartian Collection, Geometridae*, Part-4: 48, pl., 74, fig., 1–4.

Wing expanse: Forewing length: 19-20 mm.

Diagnosis: Whitish-ochreous wings with pale, greyish-fuscous suffusion and irroration. Looks somewhat similar to *Ecleora solieraria* (Rambur 1834). Forewing with two-ante and postmedial, dark black, slightly undulating, parallel, oblique transverse lines which become indistinct or fade away near the costa. Hindwing with an almost straight, fuscous-brown medial line and a dark-black postmedial line. The underside of the wings uniformly suffused with fuscous-grey and lacks markings.

Distribution: India: Himachal Pradesh (Lahaul and Spiti-current study). **Global:** Afghanistan, Kyrgyzstan (Issyk Kul), Uzbekistan (Ferghana) (Gyula et al. 2018).

Remarks: The species is a **new record** to India and a **new addition** to the state fauna of Himachal Pradesh.

Genus *Biston* Leach, 1815

42. *Biston betularia nepalensis* Inoue, 1982 [Plate 18.2]

(Discussed in Chapter 3)

Remarks: Total eight subspecies. (If this documentation confirms the subspecies as *B. betularia nepalensis*, this would be the **first documentation** of the subspecies for **India**).

Genus *Hypomecis* Hübner, 1821

43. *Hypomecis ratotaria* (Swinhoe, 1894) [Plate 18.3]

(Discussed in Chapter 3)

UNASSIGNED

Genus *Abraxesis* Hampson, 1902

44. *Abraxesis melaleucaria* Hampson, 1902 [Plate 18.4]

(Discussed in Chapter 3)

Genus *Anthyperythra* Swinhoe, 1891

Type species: *Anthyperythra hermearia* Swinhoe, 1891

45. *Anthyperythra caladsaota* Hampson, 1902 [Plate 18.5]

[TL: Simla (Himachal Pradesh, India)]

Anthyperythra caladsaota Hampson, 1902; *Journal Bombay Natural History Society*, 14: 501.

Anthyperythra caladsaota; Gyula et al., 2018; in Fibigeriana Supplement, *The Vartian Collection, Geometridae*, Part-4: 40, pl., 50, fig., 43–44.

Wing expanse: 40 mm (Forewing length: 17 mm)

Diagnosis: Wings pale reddish-brown with fuscous streaked irroration. Forewing with slightly irregular but almost straight indistinct whitish antemedial; an outwardly curved and slightly oblique postmedial line which continues as a medial line on the hindwing; a dark fuscous discoidal spot and a dark black streak on the apex. Underside paler, irrorated with black and without any markings.

Distribution: India: Himachal Pradesh (Shimla, Lahaul and Spiti-current study). **Global:** Pakistan (Gyula et al. 2018).

Genus *Artemidora* Meyrick, 1892

46. *Artemidora disistaria* (Walker, 1862) [Plate 18.6]

[TL: North Hindostan (India)]

Aspilates ? *disistaria* Walker, 1862; *List Species Lepidoptera Insects Collection British Museum*, 24: 1075.

Artemidora disistaria; Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1), Moths of Nepal, Part-6; 101, pl. 170 (fig. 11, 12, 15, 16).

Artemidora disistaria; Gyula et al., 2018; in Fibigeriana Supplement: *The Vartian Collection, Geometridae,* Part-4: 40, pl. 51 (fig. 34–37).

Diagnosis: See *A. epicyrta.*

Distribution: India: Himachal Pradesh (North India). **Global:** Nepal (Stüning, 2000), Pakistan (Gyula et al. 2018).

47. *Artemidora epicyrta* (Fletcher, 1961) [Plate 18.7]

[TL: Nepal]

Heterolocha epicyrta (Fletcher, 1961); Veröffentlichungen der Zoologischen Staatssammlung München, 6: 173, pl., 17 (20) (genitalia ref. Fig. 584).

Heterolocha epicyrta; Yazaki, 1995; in Haruta T (ed.): Tinea 14 (suppl. 2), Moths of Nepal, Part-4: 12, pl., 101 (7).

Artemidora epicyrta; Stüning, 2000; in Haruta T (ed.): Tinea 16 (suppl. 1), Moths of Nepal, Part-6; 101.

Wing expanse: Forewing length: 16 mm.

Diagnosis: *A. epicyrta* resembles very close to *A. disistaria* but is distinguishable based on its comparatively larger size, less brownish colouration and an outwardly directed dentation that is absent in *A. disistaria*.

Distribution: India: Himachal Pradesh (Lahaul and Spiti-current study). **Global:** Nepal.

Genus *Scotopteryx* Hübner, [1825]

48. *Scotopteryx nasifera* (Warren, 1888) [Plate 18.8]

[TL: Thundiani (Western India, Pakistan)]

Eubolia nasifera Warren, 1888; *Proceedings of the Zoological Society of London*, (2): 331.

Ortholitha nasifera Prout, 1912–1916; in Seitz: *The Macrolepidoptera of the world*, 4: 161, pl. 11 (a).

Ortholitha nasifera; Prout, 1920–1941; in Seitz: *The Macrolepidoptera of the world*, 12: 262.

Eubolia nasifera; Hampson, 1895; *The Fauna of British India, including Ceylon and Burma*, 3: 343.

? nasifera; Wiltshire, 1970; *Annalen des Naturhistorischen Museums in Wien*, 74: 376, fig. 8.

Scotopteryx nasifera; Gyula et al., 2018; in Fibigeriana Supplement, *The Vartian Collection, Geometridae*, Part-4: 55, pl., 23, fig. 38–41, (Genitalia picture-61).

Wing expanse: 32 mm (Forewing length: 15 mm)

Diagnosis: Externally resembles *S. peribolata* but can be distinguished by the basal line being strongly bent basewards at both ends, the antemedial line angled on the median vein and forming two curves- anterior and posterior to it, comparatively sharper distal projection of the median band, not so straight subterminal line and a second discal dot (absent in the *S. peribolata*).

Distribution: India: Himachal Pradesh (Lahaul and Spiti-current study), Ladakh, Punjab (Chandra et al. 2019), Uttarakhand (Dey 2018). **Global:** Afghanistan, Pakistan (Thundiani, Punjab) (Gyula et al. 2018; Chandra et al. 2019).

6.3.2 γ-diversity (species richness and sampling completeness for LSVs)

Altogether, 1506 individuals belonging to the family Geometridae were observed during the fieldwork. However, only 910 individuals representing more than 60% of the total observed individuals were identified up to the species level. Estimated species richness, iChao-1 was 52 (lower 95%: 48.22; upper 95%: 67.65). The observed species richness based on the number of the identified species was 48 species which represented 92% of the estimated species richness for the LSVs.

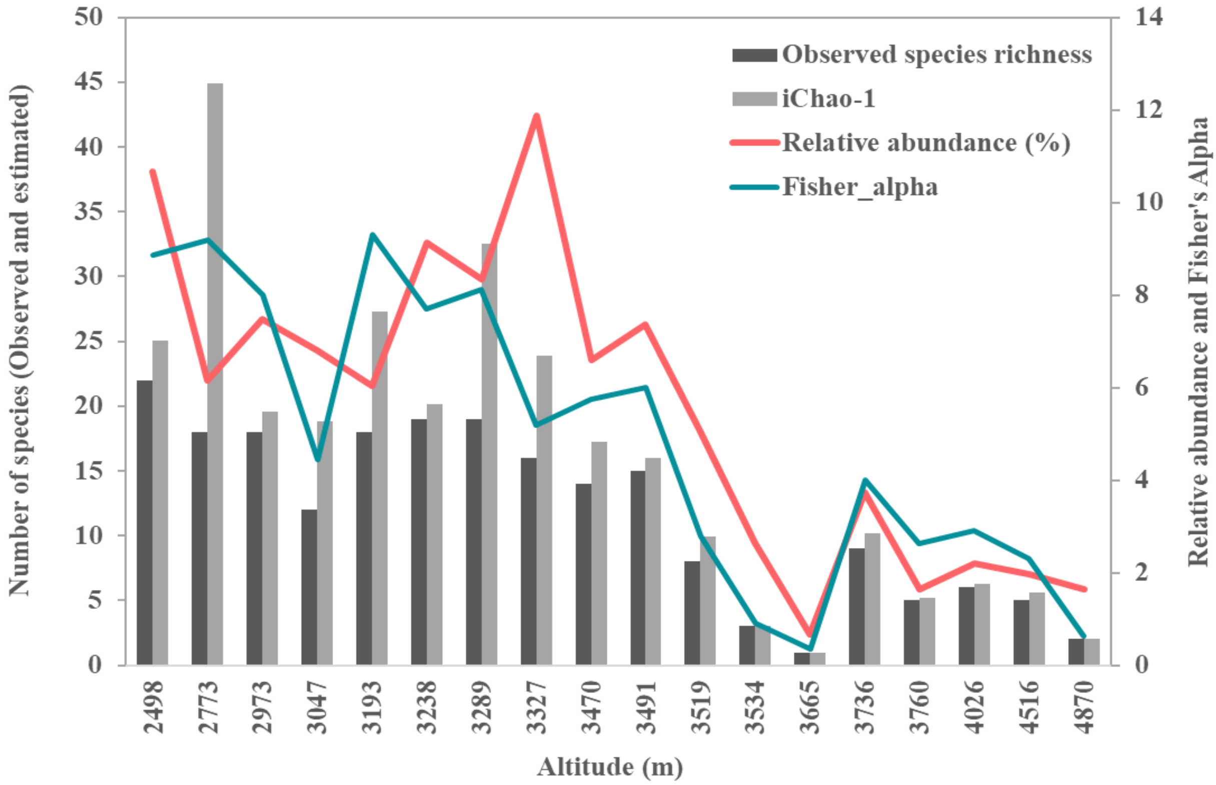


Fig. 6.4: Estimated and observed species richness values, Fisher's alpha and relative abundance of the Geometridae moths for the sites along the altitudinal gradient of the LSVs landscape.

6.3.3 α-diversity (site-wise species richness)

A total of 21 sites were sampled in LSVs. However, in the final dataset, three sites (Sarchu, Komic and Komic.2) did not contain information for the identified species. Therefore, data was used from the remaining 18 sites for the final analysis. Among 18 sites, the highest observed and estimated species number was 22 (Tindi, Lah25) and 44.92 (Lobar, Lah27) respectively (Table 6.1) while the highest abundance was 108 (Jispa, Lah33) individuals. The highest value of Fisher's alpha was 9.32 (Chokhang, Lah31). The sampling completeness (observed and estimated species richness) across all the sampling sites is fairly good with few exceptions (Lobar, Lah27 and Pyukar, Lah32.2). However, these figures can be misleading considering the limited sampling efforts and the fact that nearly 40% of the data has not been included in the final analysis. Therefore, it is important to identify all the remaining morphospecies, analysis of the total dataset and undertake more sampling to better understand the patterns of the diversity and distribution of the geometrid moths in the landscape.

Table 6.1: Species richness, evenness, dominance, alpha diversity indices, estimates and sampling completeness for every sampling site of LSVs.

Site code	Observed species richness	Individuals	iChao-1	Sampling completeness (%)	Fisher alpha	Dominance_D	Simpson_1-D	Shannon_H	Evenness_e^H/S
Lah25	**22**	97	25.02	87.93	8.87	0.08	0.92	2.85	0.78
Lah27	18	56	**44.92**	40.07	9.19	0.07	0.93	2.78	0.90
Lah29	18	68	19.58	91.93	7.99	0.08	0.92	2.72	0.85
Lah30	12	62	18.85	63.66	4.43	0.12	0.88	2.28	0.81
Lah31	18	55	27.33	65.86	**9.32**	0.07	0.93	2.80	0.91
Lah32	19	83	20.11	94.48	7.71	0.07	0.93	2.82	0.88
Lah32.2	19	76	32.54	58.39	8.13	0.09	0.91	2.69	0.77
Lah33	16	**108**	23.93	66.86	5.19	0.09	0.91	2.54	0.79
Lah34	14	60	17.23	81.25	5.74	0.10	0.90	2.44	0.82
Lah34.2	15	67	16.01	93.69	6.01	0.07	0.93	2.67	0.97
Lah35	8	46	9.96	80.35	2.80	0.16	0.84	1.91	0.84
Lah35.2	3	24	3	100	0.91	0.42	0.58	0.98	0.88
Lah37	9	34	10.14	88.76	4	0.17	0.83	2.03	0.84
Spiti01	6	20	6.24	96.18	2.91	0.23	0.77	1.66	0.88
Spiti02	5	18	5.59	89.46	2.29	0.25	0.75	1.51	0.90
Spiti03	2	15	2	100	0.62	0.87	0.13	0.28	0.66
Spiti04	5	15	5.23	95.55	2.63	0.21	0.79	1.58	0.97
Spiti05	1	6	1	100	0.34	1	0	0	1

6.3.4 Assemblage patterns across different altitudinal zones and forest types

Altitudinal Distribution of Geometridae in LSVs

The box plots in Fig. 6.4 showed the altitudinal distribution of the family Geometridae. The median altitudinal distribution for the family was recorded at around 3200 m with an altitudinal range from 2500–4000 m and only a few encounters above 4000 m. At the subfamily level, the highest median altitudinal distribution was observed for Sterrhinae moths followed by Larentiinae, Geometrinae and Ennominae. The observed pattern was due to the high abundance of the genus *Rhodostrophia* in the Sterrhinae subfamily at higher altitudinal dry, cold habitats of the Spiti valleys and species of the genus *Chlorissa* in the Geometrinae subfamily. The subfamily Geometrinae was restricted towards the lower altitudes, below 4000–4100 m, whereas other subfamilies were reported as higher as up to 5000 m asl. The rare encounters of the species above 4000 m altitude could be due to high wind speed and very low temperature observed during the light trap sessions. Because this might have limited the ability of the individuals to fly towards the light trap.

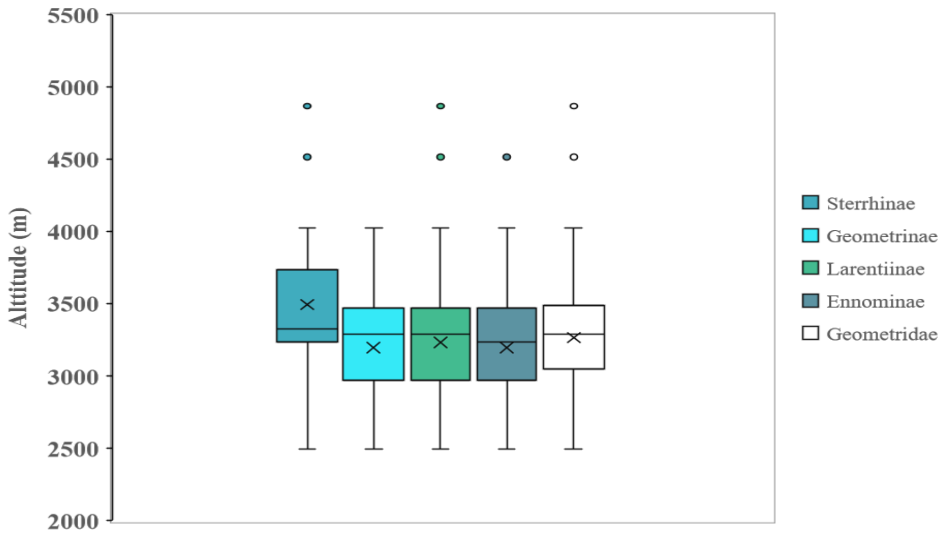


Fig. 6.5: Boxplot showing the altitudinal distribution of the family Geometridae and its four subfamilies recorded along the altitudinal gradient in LSVs (x shows the mean values) (on right).

For the patterns of species richness among the sites along the altitudinal gradient, no consistent pattern was observed. However, the scatter plot with an R^2 value of 0.6136 showed a negative trend for species richness with altitude. Also, among the three altitudinal zones, species richness was lowest in the higher altitudinal zone (Zone 3) than zone 1 and 2. The highest variability in the species richness among the sites was reported for zone 1 followed by zone 2 and zone 3. The median species richness was fairly higher in zone 1 than 2 and 3; showing a declining trend along the altitudinal zones congruent with the scatter plot results. However, the iChao-1 estimates of the species richness for zone 1 and zone 2 are 44.67 and 42.16 respectively; showing only a slight difference between the two zones.

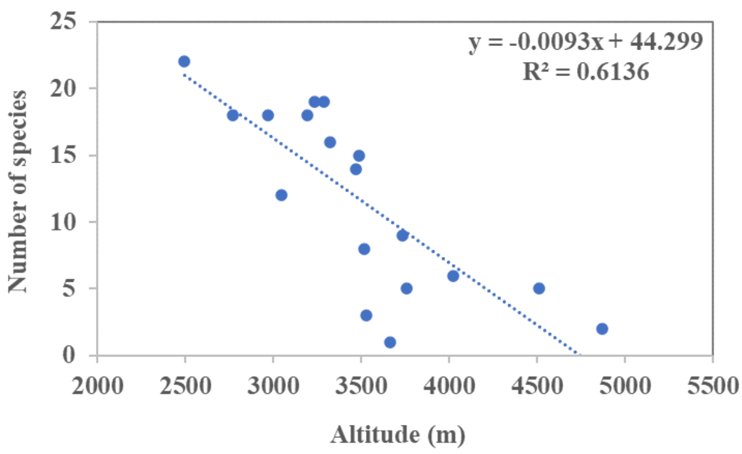
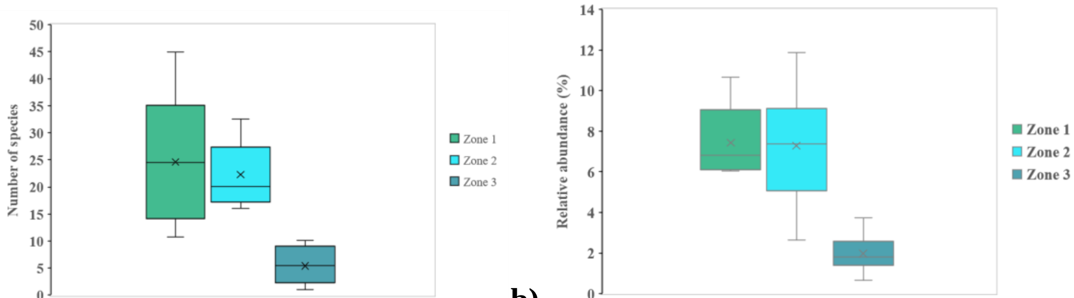


Fig. 6.6: Scatter plot with trend line for the observed species richness and altitudes of the sampling sites in the LSVs.



a) b)

Fig. 6.7: a) Observed species richness and b) relative abundance (%) for the sites in the three altitudinal zones of the LSVs (x shows the mean).

Table 6.2: Species richness and diversity measures of the Geometridae moths for different altitudinal zones of the LSVs.

Altitudinal Zone	**Zone 1**	**Zone 2**	**Zone 3**
Observed species richness	35	40	17
Total abundance	221	511	178
iChao-1	44.67	42.16	19.74
Sampling completeness	78.35	94.88	86.12
Fisher's alpha	11.71	10.16	4.624
Dominance (D)	0.06	0.05	0.18
Simpson (1-D)	0.94	0.95	0.82
Shannon (H)	3.16	3.22	2.20
Evenness (e^H/S)	0.67	0.62	0.53
Sampling Nights	5	7	8

ANOSIM analysis using the Bray-Curtis similarity index to compare the species composition of three zones has shown significant differences (Table 6.3) in the species composition of zone 1 and 2 with zone 3. Although zones 1 and 2 have a rather similar species composition. SIMPER analysis for the species composition of three altitudinal zones has revealed a cumulative 65.24% dissimilarity for zones 1 and 2. These differences were majorly contributed by the species *Ourapteryx convergens*, *Eupithecia nigrilinea*, *Eupithecia venosata*, *Scopula kashmirensis*, chiefly associated with zone 1 and *Alcis nobilitaria* and *Photoscotosia palaearctica* were chiefly associated with zone 2.

Table 6.3: Comparison of the similarity of the Geometridae moth assemblages among three altitudinal zones based on ANOSIM and SIMPER analysis.

p-Values (ANOSIM)				**R-values (ANOSIM)**		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
Zone 1						
Zone 2	0.2232			0.1548		
Zone 3	**0.0063**	**0.0008**		**0.7527**	**0.5313**	

Dissimilarity % (based on SIMPER analysis)			
	Zone 1	Zone 2	Zone 3
Zone 1	0		
Zone 2	65.24	0	
Zone 3	**92.66**	**78.39**	0

Table 6.4: Species identified with highest contributions to dissimilarity (65.24%) between Zone 1 and 2 based on the SIMPER analysis.

Species name	**Average dissimilarity**	**Contrib. %**	**Cumulative %**	**Mean abundance**	
				Zone 1	**Zone 2**
Ourapteryx convergens	4.966	7.613	16.6	**8**	1.14
Eupithecia nigrilinea	4.05	6.209	22.81	**9.33**	5.14
Alcis nobilitaria	3.776	5.788	28.6	0	**5.57**
Eupithecia venosata	2.959	4.536	43.32	**5**	2
Scopula kashmirensis	2.651	4.063	47.38	**5.33**	2.43
Photoscotosia palaearctica	2.069	3.172	57.66	1.33	**3.86**

Table 6.5: Species identified with highest contributions to dissimilarity (92.66 %) between Zone 1 and 3 based on the SIMPER analysis.

Species name	**Average dissimilarity**	**Contrib. %**	**Cumulative %**	**Mean abundance**	
				Zone 1	**Zone 3**
Eupithecia nigrilinea	9.627	10.39	10.39	**9.33**	0

Rhodostrophia borealis	8.772	9.467	19.86	0	**8.38**
Ourapteryx convergens	7.687	8.296	28.15	**8**	0
Heterolocha phoenicotaeniata	6.135	6.621	34.77	**5.33**	0
Scopula kashmirensis	5.251	5.667	40.44	**5.33**	0
Eupithecia venosata	5.043	5.442	51.33	**5**	0.375
Euphyia submarginata	5.022	5.42	56.75	**5**	0.5
Chlorissa gelida exsoluta	4.092	4.416	61.17	**4.33**	2
Hemistola fletcheri	2.749	2.966	64.13	**2.67**	0

Table 6.6: Species identified with highest contributions to dissimilarity (78.39%) between Zone 2 and 3 based on the SIMPER analysis.

Species name	**Average dissimilarity**	**Contrib. %**	**Cumulat ive %**	**Mean abundance**	
				Zone 2	**Zone 3**
Scotopteryx nasifera	5.968	7.613	7.613	**5.43**	2.75
Alcis nobilitaria	5.826	7.433	15.05	**5.57**	0.75
Eupithecia nigrilinea	5.627	7.178	22.22	**5.14**	0
Heterolocha phoenicotaeniata	5.427	6.923	36.28	**4.71**	0
Euphyia submarginata	5.228	6.669	42.94	**4.86**	0.5
Chlorissa gelida exsoluta	5.088	6.49	49.43	**4.86**	2
Photoscotosia palaearctica	4.093	5.222	54.66	**3.86**	1.13
Odontopera kametaria	2.882	3.676	58.33	**2.57**	0
Scopula kashmirensis	2.711	3.459	61.79	**2.43**	0

Similarly, for zones 1 and 3, the total dissimilarity was 92.66 % (Table 6.5). This dissimilarity was majorly contributed by the predominance of the species *Eupithecia nigrlinea*, *Ourapteyx convergens*, *Heterolocha phoenicotaeniata*, *Scopula kashmirensis*, *Eupithecia venosata*, *Euphyia submarginata*, *Chlorissa gelida exsoluta* and *Hemistola fletcheri* in zone 1, and *Rhodostrophia borealis* in zone 3. (Table 6.5) However, between zones 2 and 3, 78.39% of the dissimilarity was observed which was majorly contributed by the species associated with zone 2, namely, *Scotopteryx nasifera*, *Alcis nobilitaria*, *Eupithecia nigrilinea*, *Heterolocha phoenicotaeniata*, *Euphyia submarginata*, *Chlorissa gelida exsoluta*, *Photoscotosia palaearctica*, *Odontopera kametaria* and *Scopula kashmirensis* (Table 6.6).

Assemblage of different Forest types

Among the 7 different forest types in the landscapes of LSVs, the highest estimated species numbers and relative abundance (%) were observed for Juniper Forest (41.93 and 30.11% respectively) and the lowest was for the dry Alpine scrub habitats (9.22 and

4.51%). Cluster analysis of the geometrid assemblage of the seven forests produced three major clusters of similar species compositions. The species composition of the alpine habitats (dwarf juniper and dry alpine scrub) was more similar. Similarly, the second cluster was of Juniper and agroforestry systems and the third was blue pine and deodar forests. Birch forests turned out to have a unique assemblage between the second and third clusters with weak node support values.

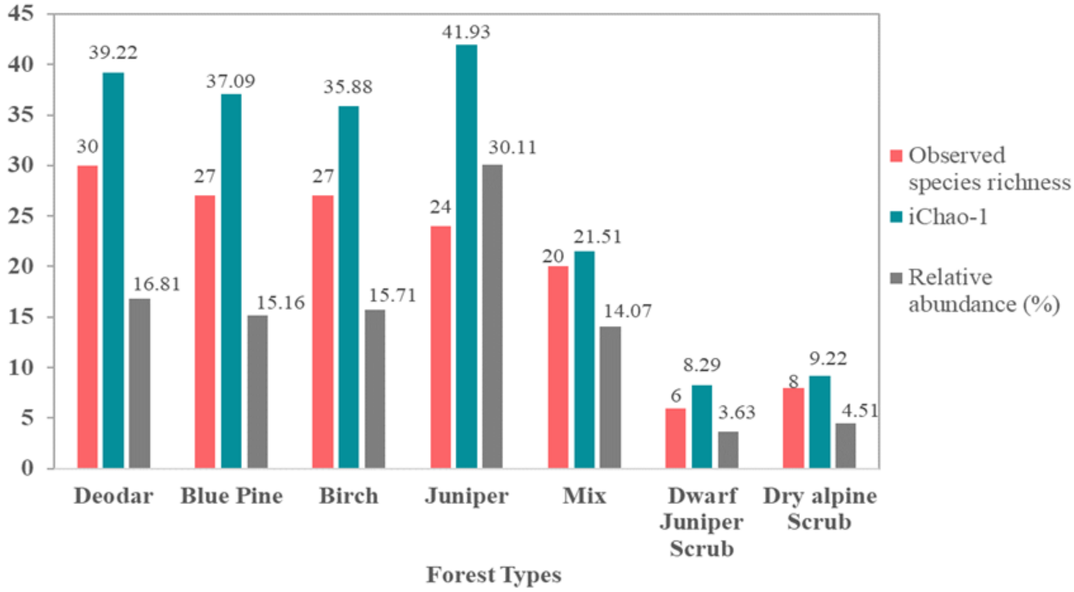


Fig. 6.8: Observed and Estimated (based on iChao-1 measure) species richness and relative abundance (%) of Geometridae moths in different forest types of the LSVs.

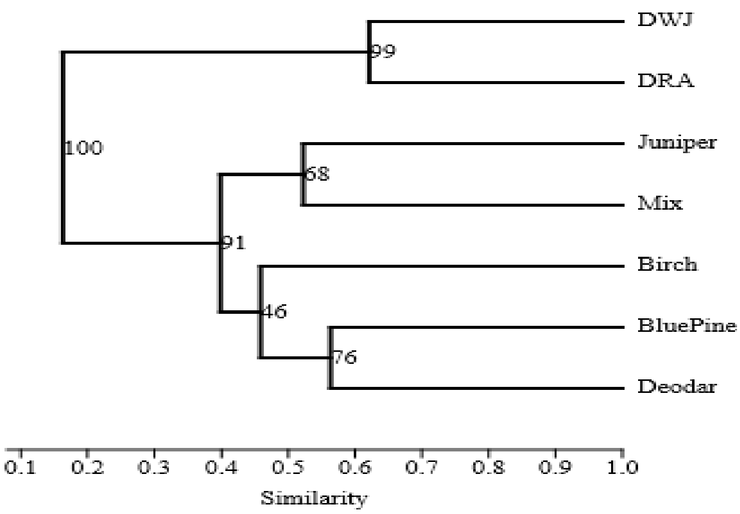


Fig. 6.9: Dendrogram of the Cluster analysis of the geometrid moths in the seven different forest types of LSVs (DWJ – Dwarf Juniper, DRA – Dry Alpine Scrub, Mix - Agroforestry).

6.3.5 Indicator Species Analysis (ISA)

The indicator species analysis revealed 13 indicator species for different combinations of altitudinal zones and forest types of the LSVs landscape. Of these, one species was from the Sterrhinae subfamily, three from Geometrinae, four from Larentiinae and five from the Ennominae subfamily.

Table 6.7: List of the Indicator species of the Geometridae moths with IndVal >0.7 and statistically significant (p-value <0.05) for different combinations of the altitudinal zones and forest types. Species indicators for more than one combination indicated by '+' sign. (DWJ – Dwarf Juniper, DRA – Dry Alpine Scrub, Mix - Agroforestry)

Subfamily	**Species**	**Combination of Altitudinal zone and forest type**	**Ind Val**	**p-value**
Ennominae	***Gnophos praeauctaria***	Zone 3. DRA	0.9	0.02
Larentiinae	***Heterothera consimilis***	Zone 1. Deodar + Zone 2. Blue Pine	1	0.00
Sterrhinae	***Rhodostrophia herbicolens***	Zone 1. Deodar + Zone 2. Blue Pine	0.87	0.05
Larentiinae	***Amnesicoma simplex***	Zone 1. Mix + Zone 2. Birch	0.94	0.02
Geometrinae	***Thetidia radiata***	Zone 1. Mix + Zone 2. Juniper	0.89	0.03
Ennominae	***Odontopera kametaria***	Zone 1. Deodar + Zone 2. Birch + Zone 2. Blue Pine	0.91	0.02
Ennominae	***Alcis nobilitaria***	Zone 2. Blue Pine + Zone 2. Juniper + Zone 2. Mix	0.93	0.01
Geometrinae	***Hemistola fletcheri***	Zone 1. Deodar + Zone 1. Mix + Zone 2. Birch + Zone 2. Blue Pine	0.93	0.01
Ennominae	***Heterolocha phoenicotaeniata***	Zone 1. Deodar + Zone 1. Mix + Zone 2. Birch + Zone 2. Blue Pine + Zone 2. Juniper	1	0.00
Larentiinae	***Euphyia submarginata***	Zone 1. Deodar + Zone 1. Mix + Zone 2. Birch + Zone 2. Blue Pine+ Zone 2. Mix	0.95	0.00
Ennominae	***Scotopteryx nasifera***	Zone 1. Mix + Zone 2. Blue Pine+ Zone 2. Juniper + Zone 2. Mix+ Zone 3. Juniper	0.93	0.01

Larentiinae	***Eupithecia nigrilinea***	Zone 1. Deodar + Zone 1. Mix+ Zone 2. Birch + Zone 2. Blue Pine+ Zone 2. Juniper + Zone 2. Mix	0.89	0.02
Geometrinae	***Chlorissa gelida exsoluta***	Zone 1. Deodar + Zone 1. Mix + Zone 2. Birch + Zone 2. Juniper+ Zone 2. Mix + Zone 3. Juniper	0.89	0.03

6.3.6 Biogeographic affinity

The total macro moths' assemblage of the LSVs is mostly an admixture of Sino-Japanese and Palearctic components, with ~49% and 48% of species, respectively, with their distribution in these regions, whereas only ~19% oriental and 3.5% each shared with Nearctic and Afrotropical realms. Among the Indian Biogeographic zones, the highest ~68% of species are shared with Himalayan, 54% with the Trans Himalaya biogeographic zone followed by Semi-Arid (~51%) and Gangetic plains (~30%). Furthermore, out of 68%, approximately 50% are shared with North Western (2A), 28% with Western (2B), around 24% with Central (2C), and roughly 7% with Eastern (2D) Himalayan biogeographic province.

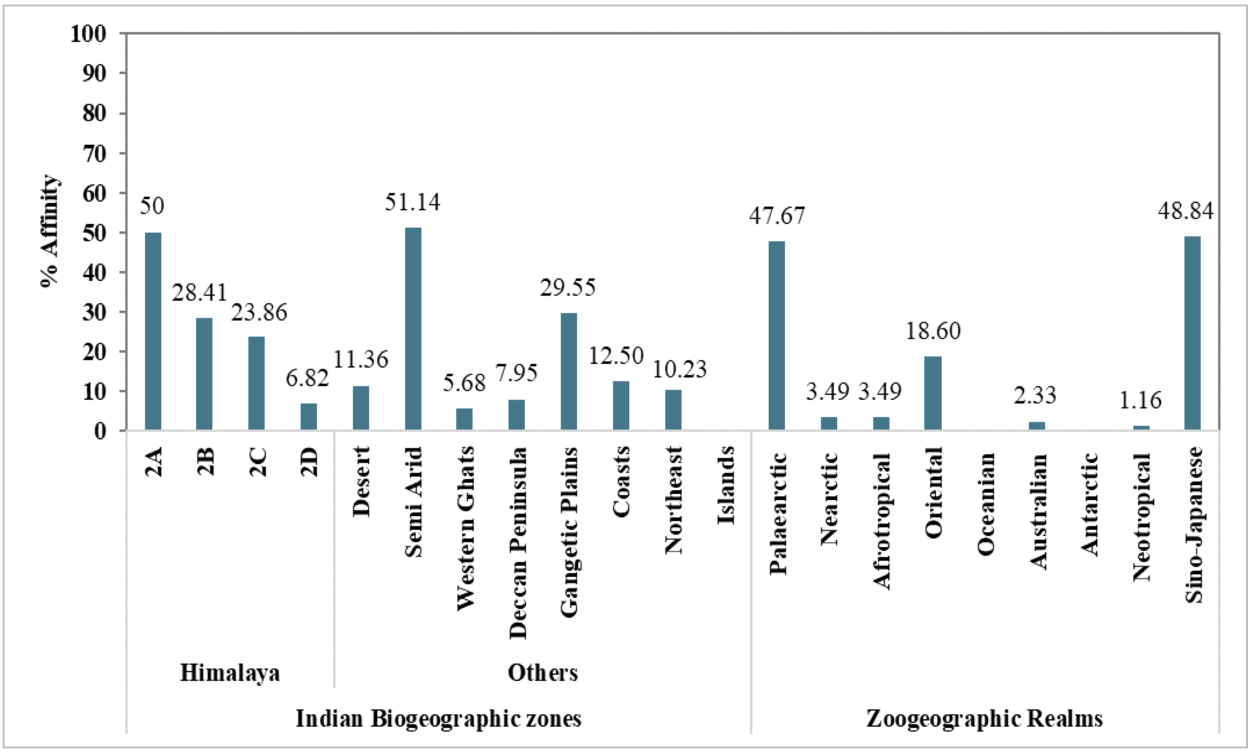
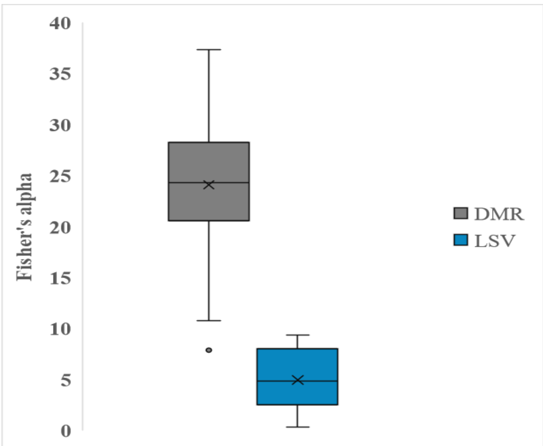


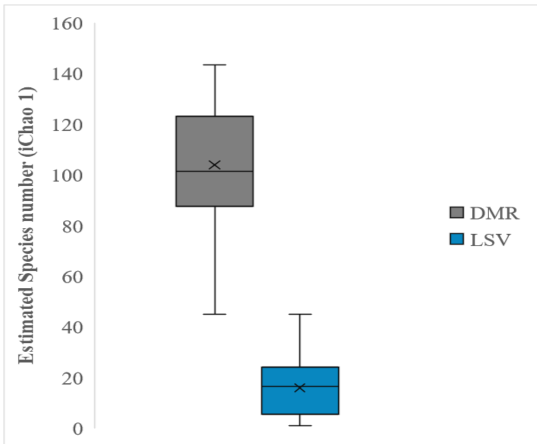
Fig. 6.10: % affinity of the Lahaul and Spiti moths with other Himalayan provinces, Indian Biogeographic zones and World's Zoogeographical realms.

6.4 DMR vs LSVs

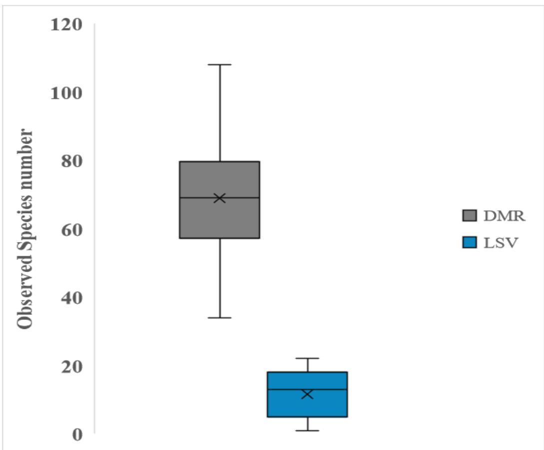
Species richness, diversity and distribution of the Geometridae moths were researched in different forest types along the altitudinal gradients of the two biogeographically distinct landscapes, DMR and LSVs. As these landscapes differ climatically and geographically, different sampling approaches were used leading to variations in the sampling efforts and successes. However, data showed 96% sampling completeness for DMR and 92% for LSVs. The preliminary comparison of the species richness and diversity of the two landscapes researched in this study reveals fairly high species richness and diversity of the Geometridae moths in the DMR, North Western Himalayan biogeographic province. The LSVs, Trans Himalayan biogeographic provinces, were comparatively species poor than DMR but it holds substantial diversity of the Geometridae with nearly 50% species unique to this landscape and absent in DMR. Overall, 25 species were shared between the two landscapes while unique species were 23 for LSVs and 254 for DMR.



a)



b)



c)

Fig. 6.11: Comparison of the a) Fisher's alpha, b) iChao-1 and c) Observed species richness of the DMR and LSVs landscapes.

6.5 Discussion

This study shows the preliminary analysis of the documented and identified species in the family Geometridae from the different altitudinal zones and forest types within LSVs. Overall, the results show high species diversity of the macro moths, especially the geometrid moths in the landscape. However, the findings are only preliminary and based on a very short sampling survey in the region. This chapter serves the purpose of establishing the macro moth assemblage as a target taxon for future long-term monitoring by creating detailed baseline information. The trans-Himalayan region of the LSVs is part of the Saharo-Arabian zoogeographic realm and lies at the junction with the Palearctic, Oriental, Indo-Malayan, and Sino-Japanese realms. Majority of the species of this landscape share their distribution in the Palearctic and Sino-Japanese realms. The unique admixture of species from different realms highlights the ecosystem's complexity and underscores its importance for conservation efforts.

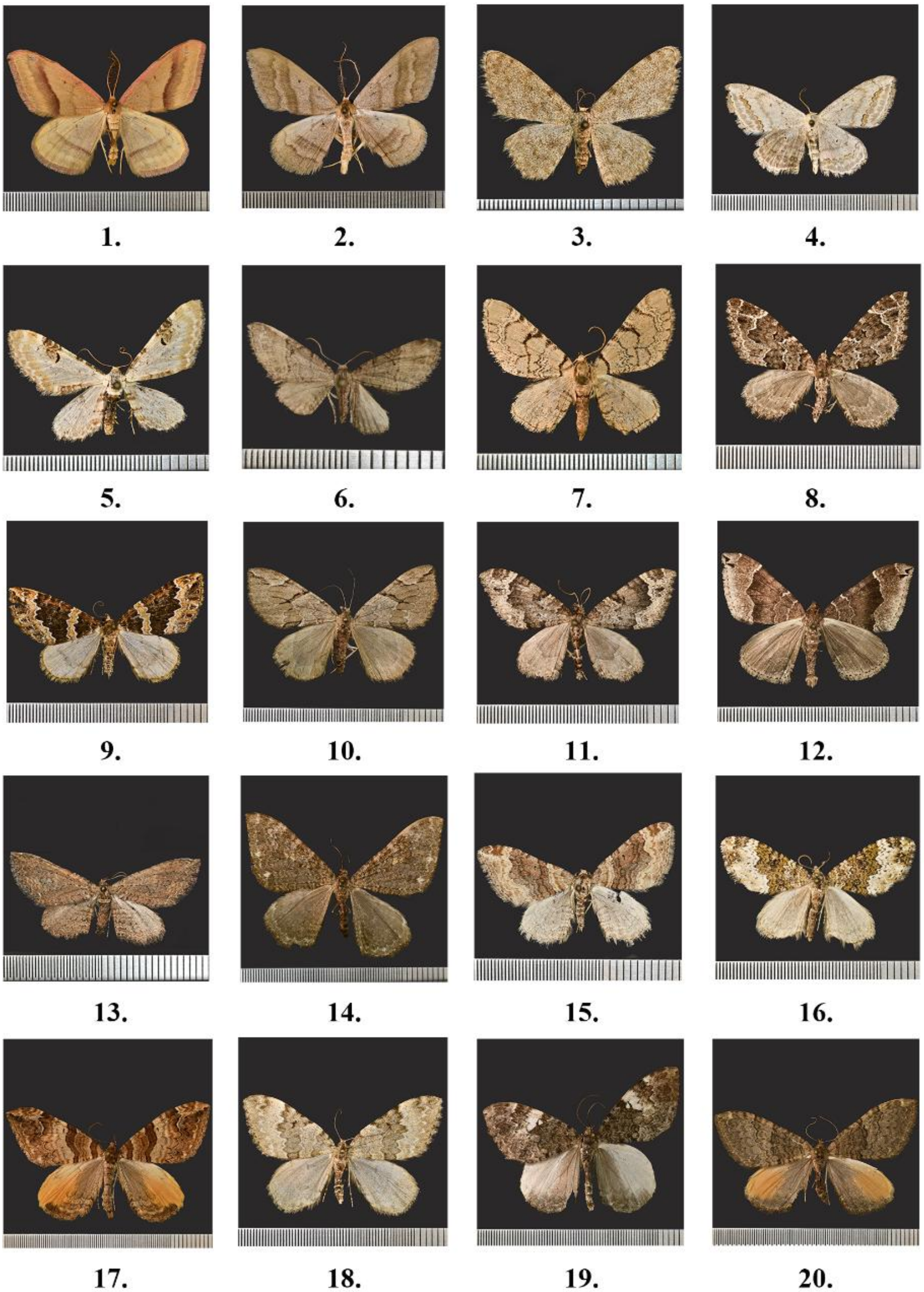


Plate 16

Sterrhinae, Larentiinae

1. *Rhodostrophia borealis* 2. *R. herbicolens* 3. *Scopula kashmirensis* 4. *S. mechadoi*
5. *Eupithecia centaureata* 6. *E. nigrilinea* 7. *E. venosata* 8. *Colostygia albigirata*
9. *Electrophaes niveonotata* 10. *Heterothera consimilis* 11. *Nebula homophana* 12. *Xenortholitha latifusata*
13. *Horisme nigrovittata* 14. *Triphosa dubiosata* 15. *Euphyia cinnamifusa* 16. *Euphyia submarginata*
17. *Amnesicoma simplex* 18. *Entephria ramalaria* 19. *Photoscotosia amplicata* 20. *P. dejuncta*

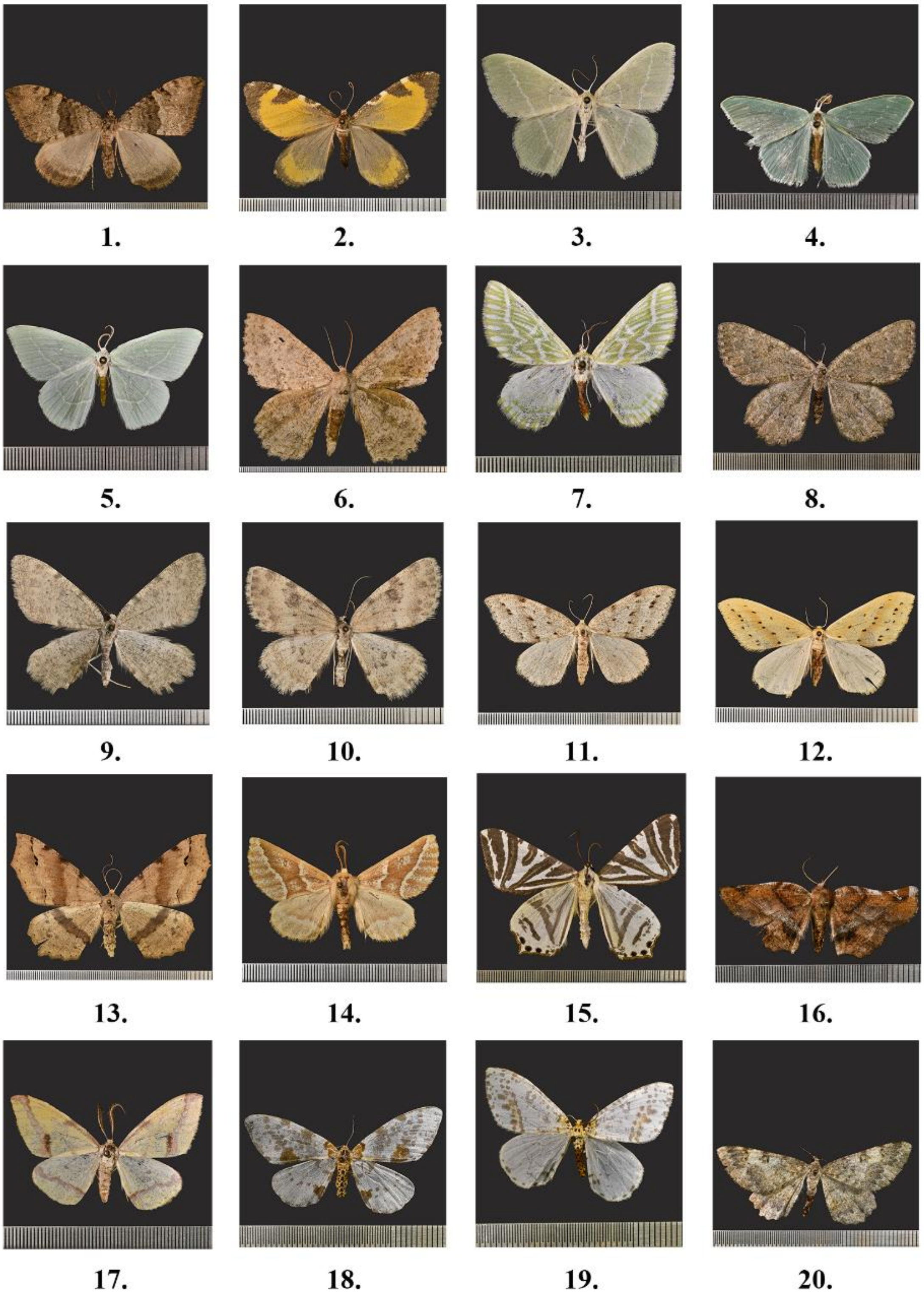


Plate 17

Larentiinae, Geometrinae, Ennominae

1. *Photoscotosia palaearctica* 2. *Stamnodes pamphilata* 3. *Chlorissa exsoluta* 4. *Hemistola detracta* 5. *Hemistola fletcheri* 6. *Herochroma crassipunctata* 7. *Thetidia radiata* 8. *Charissa crenulata* 9. *Gnophos praeacutara* 10. *G. rubefactaria* 11. *Loxaspilates punctigera* 12. *L. obliquaria* 13. *Psyra debilis indica* 14. *Odontopera kametaria* 15. *Ourapteryx convergens* 16. *Garaeus albipunctatus* 17. *Heterolocha phoenicotaeniata* 18. *Abraxas antipusilla* 19. *A. virginalis* 20. *Alcis granitaria*

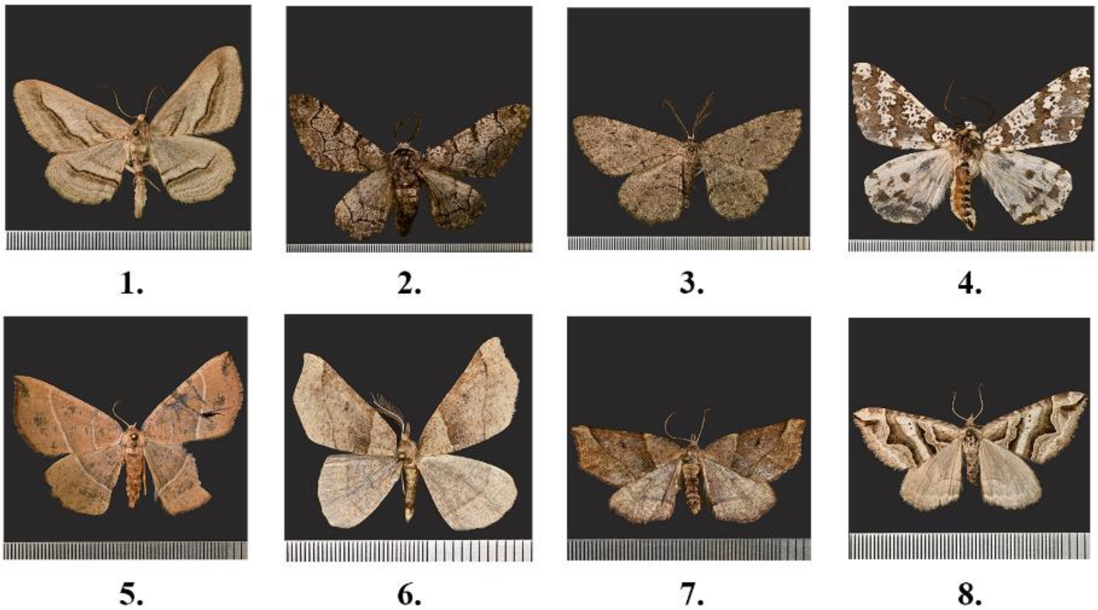


Plate 18
Ennominae
1. *Alcis nobilitaria* 2. *Biston nepalensis* 3. *Hypomecis ratotaria*
4. *Abraxesis melaleucaria* 5. *Anthyperythra caladsaota* 6. *Artemidora epicyrta*
7. *A. disistaria* 8. *Scotopteryx nasifera*

Chapter 7
Conclusion

7.1 Overview

The diversity of moths in the IHR was assessed over a century ago through opportunistic sampling by British officers during the colonial period. They described many species in the region, but these documentations were limited to a few locations and lacked precise georeferenced coordinates and detailed habitat information. Therefore, predicting the species distribution in the region remains challenging. Accurate species distribution details are vital for understanding the ecological processes governing biodiversity patterns, factors that drive the presence or absence of species in a particular habitat and for designing conservation strategies. When undertaken following standardised ecological sampling methodologies, simple biodiversity documentation surveys help obtain a statistically sound dataset for testing ecological theories and serve as baseline information for making informed conservation decisions.

This study examines the Geometridae family, a model insect herbivore taxon owing to its huge diversity and abundance, weak flying nature, and specific habitat association. The primary objective was to study insect ecology and assess their potential as reliable indicators for monitoring environmental changes in IHR. To accomplish this, the study utilised altitudinal gradients of the two biogeographically different landscapes (DMR and LSVs) as a natural experimental setup to explore how altitude, habitat variations, and environmental factors affect species distribution. An additional secondary objective was to establish (and update the century-old species data) extensive baseline ecological information for every documented species in these landscapes. This includes exact geo-climatic information and their abundance status among different habitat types and altitudinal zones. The study also fulfils one of the lacunae in the moth's research from the North Western and Trans Himalayan regions of Himachal Pradesh (Chandra et al. 2019).

This chapter provides important results and conclusions for this study, mentioning the diversity and distribution characteristics of Geometridae moths in DMR and LSVs landscapes. Furthermore, it discusses their potential as indicators for monitoring climate change and anthropogenic perturbations in these regions.

7.2 Taxonomic Inventory and Patterns along the altitudinal gradient of DMR

This research led to the taxonomic inventorisation of 280 species of the Geometridae family from the DMR. This includes 7 species new to India and 56 species as new records for the moth fauna of Himachal Pradesh. For every species, taxonomic and distributional details along with regional distributional details (altitudinal range and forest type) in the DMR and habitus photographs with scale have been provided. This information will assist future fieldworkers and investigators to easily identify the species and minimize the chances of misidentification. The provided species details will expedite future documentation of Geometridae moths in this region and facilitate more accurate documentation and assessment of their ecology.

This study documented marked and statistically significant differences in species composition between the pre- and post-monsoon seasons. Moreover, significant differences were found in the abundance of the species between the two seasons, with a comparatively higher abundance during the post-monsoon season. However, the species richness and diversity estimates were similar between the two seasons (slightly higher during the pre-monsoon season). The lower species abundance observed during the pre-monsoon season may be attributed to the comparatively poor sampling success for this season, which likely resulted from the low temperatures, high wind speeds, and late snowfall in the earlier months of April and May during this study. Future research should focus on studying the important drivers of seasonal differences in species composition, and seasonal differences in abundance must be reassessed.

Analysis of the biogeographic affinities for this region (based on the documented distributional ranges of the species in the secondary literature) has shown a significant influence of the Sino-Japanese realm on the regional geometrid moth diversity with the highest 80% similarity. Other major contributions are by Oriental (48%) and Palearctic (40%) realms. Also, among different biogeographic zones of India, the region shows a high 76% similarity with the Gangetic plains. These significant overlaps of multiple zoogeographic and biogeographic regions in the area suggest its role as an important intersection point for species distributions and its role in maintaining global biodiversity and ecological connectivity among different regions.

Along the altitudinal gradient of DMR, the analyses of species richness, diversity, and relative abundance of geometrid moths have revealed Unimodal/humpback-shaped patterns. Also, the median distribution of the individuals was recorded near 2200 m asl. This unimodal pattern is characteristic of the family Geometridae worldwide along the altitudinal gradients of different mountain systems. This pattern is particularly noteworthy due to its underlying ecological complexity in contrast to monotonic, bimodal and multimodal distribution patterns (Graham and Duda 2011). Furthermore, the species compositions of the lowermost and highest altitudinal zones are unique, with large and significant differences from the rest of the zones. The species dissimilarities and differences in species compositions are highest between Zones 3–4 and Zone 1–2. Overall, the beta diversity patterns across consecutive altitudinal zones (n=5) are shaped more by turnover than by nestedness component. The assemblages of forest types at lower altitudes and those at higher altitudes formed two distinct clusters, whereas the assemblage of the Ban Oak was distinct from both and exhibited a distinct separate branch in the dendrogram.

The unimodal distribution pattern of the family Geometridae moths was significantly explained by specific habitat covariates within each group (topographical, NDVI, environmental, vegetation, and disturbance variables). Among the variables used as proxies for anthropogenic disturbance at each sampling site, the positive influence of distance to the nearest village and the negative impact of lopping explained most of the variations in the species richness and distribution in the dataset. These findings underlie the adverse effects of human presence and highlight the need for conservation strategies to mitigate these impacts and preserve the ecological integrity of these habitats.

7.3 Potential Indicator species

Indicator Species Analysis (ISA) revealed 43 and 18 species with specific preferences for the five altitudinal zones and seven different forest types in the DMR, respectively. However, the nomination of these species as indicators is preliminary. Furthermore, the seasonal fidelity of these species must be assessed. After validation via thorough examination in future studies, these species would be useful in the long-term monitoring and detection of early warning signs of shifts or changes caused by climate change or anthropogenic disturbances in this landscape. These findings can be used as a baseline for comparisons with future research findings. Moreover, climate models can be used to predict the future distribution of species under projected climatic conditions and inform proactive conservation measures based on the findings. To fully understand and decipher the observed statistically significant associations or unique preferences of species for specific altitudinal zones or forest types, host plant specificity and food preferences should also be examined. It is also important to assess their physiological tolerance ranges and the overall environmental conditions required to thrive in their habitats. Species of special concern are those that prefer a particular plant species or environmental condition within a narrow altitudinal distribution range. These factors will help highlight their vulnerability and sensitivity to climate and land-use changes and underscore their potential as indicators of environmental changes.

7.4 High-altitude moth assemblage

A total of 87 species among the five macro moth families have been identified. This comprises 48 species (among 36 genera) in the family Geometridae while the remaining species are documented in the family Noctuidae (32 species), Erebidae (3 species), Notodontidae (3 species) and Cossidae (1 species). Overall, this study adds 10 species and subspecies as new records to India from Himachal Pradesh, and four species and subspecies new to Himachal Pradesh moth fauna. Across the three altitudinal zones, the highest number of species was documented in the lowermost zone, whereas the highest abundance was recorded in the middle altitudinal zone. The uppermost altitudinal zone with scant vegetation in alpine scrub habitats and very harsh climatic conditions supports only a few species. The relict forest types in the LSVs—deodar, blue pine, birch and juniper—support distinct assemblages of geometrid moths, although the moth communities of deodar and blue pine are comparatively similar. Additionally, the alpine geometrid communities in dwarf juniper scrub (DWJ) and dry alpine (DRA) scrub are similar to each other but completely distinct from those in other forests. Overall, the documented macro moth assemblage is found to be an admixture of the Sino-Japanese and Palearctic realms, with only minor contributions from the Oriental realm (in the context of the Indian subcontinent). However, the affinity between these two zoogeographic realms is comparatively low (~49% for Sino-Japanese and 48% for Palaearctic). Also, among the Indian Biogeographic zones, the region shows the highest 68% similarity with the Himalayan zone. These findings highlight the uniqueness of the region. The region not only acts as a refuge but is also an important transition point between different zoogeographic regions. Combining this uniqueness with the harshness, sensitivity, and vulnerability of this area, its preservation is crucial for preserving the local, regional, and broader biogeographic biodiversity.

7.5 Future Research Prospects

This study was the first standardised effort to document Geometridae moths in two biogeographically distinct landscapes of Himachal Pradesh. The results and findings of this study provide baseline information through consolidated inventories of Geometridae moths for the two areas (as well as the major macro moth families of LSVs), community characteristics (species richness, diversity, and abundance) across different altitudinal zones and forest types, major environmental drivers and potential indicator species with specialised habitat (forest type) and environmental (altitude) preferences. However, this study leaves several gaps in moth research for these landscapes that could be targeted in future research projects.

Future studies should aim to conduct similar standardised studies in other less-explored and unique landscapes across the IHR. Such efforts will help to fill the existing research gaps in the documentation of moth diversity across the IHR and improve the resolution of the species distribution map. Additionally, these studies should validate the observed patterns and potential indicator species in these landscapes. Studies should also be conducted for the targeted long-term monitoring of significant indicator species for the detection of early warning signs and for planning effective conservation strategies. Such monitoring should include fine-scale temporal and spatial studies to capture seasonal and interannual variations in moth populations for a comprehensive understanding of the important factors and processes that influence their distribution and abundance in these regions.

Agriculture and forestry practices occupy a significant position in the ecological and economic domains of LSVs, as well as in other high-altitude ecosystems of Himachal Pradesh. Moths are both ecologically and economically important as significant agricultural and forest pests as well as valuable pollinators and vital food sources for other faunal components in their habitat. Therefore, given the dual role of moths as both pests and pollinators, future studies should investigate their ecological and economic impacts in the Lahaul and Spiti Valleys and other parts of Himachal Pradesh. Understanding the balance between their beneficial and harmful roles is crucial for developing integrated pest management strategies and for conserving pollinator populations.

Bibliography

Abraham, D., Ryrholm, N., Wittzell, H., Holloway, J.D., Scoble, M.J. and Löfstedt, C. (2001) Molecular phylogeny of the subfamilies in Geometridae (Geometroidea: Lepidoptera). *Molecular Phylogenetics and Evolution*, 20 (1), 65–77.

Ahlborn, J., von Wehrden, H., Lang, B., Römermann, C., Oyunbileg, M., Oyuntsetseg, B. and Wesche, K. (2020) Climate–grazing interactions in Mongolian rangelands: Effects of grazing change along a large-scale environmental gradient. *Journal of Arid Environments*, 173, 104043.

Altermatt, F., Baumeyer, A. and Ebert, D. (2009) Experimental evidence for male biased flight-to-light behavior in two moth species. *Entomologia experimentalis et applicata*, 130 (3), 259–265.

An, J.S. and Choi, S.W. (2013). Forest moth assemblages as indicators of biodiversity and environmental quality in a temperate deciduous forest. *European Journal of Entomology*, 110 (3), 509–517.

Annual administration Report for the Year, 2009–2010, Forest Department, Himachal Pradesh.

Ashton, L.A., Kitching, R.L., Maunsell, S., Bito, D. and Putland, D. (2011) Macrolepidopteran assemblages along an altitudinal gradient in subtropical rainforest-exploring indicators of climate change. *Memoirs of the Queensland Museum*, 55 (2), 375–389.

Austin, M.P. and Heyligers, P.C. 1989. Vegetation survey design for conservation: gradsect sampling of forests in north-eastern New South Wales. *Biological Conservation*, 50 (1–4), 13–32.

Axmacher, J.C., Holtmann, G., Scheuermann, L., Brehm, G., Muller-Hohenstein, K. and Feidler, K. (2004a) Diversity of geometrid moths (Lepidoptera: Geometridae) along an Afrotropical elevational rainforest transect. *Diversity and Distributions*, 10, 293–302.

Axmacher, J.C., Tünte, H., Schrumpf, M., Müller-Hohenstein, K., Lyaruu, H.V. and Fiedler, K. (2004b). Diverging diversity patterns of vascular plants and geometrid moths during forest regeneration on Mt Kilimanjaro, Tanzania. *Journal of Biogeography*, 31 (6), 895–904.

Axmacher, J.C., Brehm, G., Hemp, A., Tünte, H., Lyaruu, H.V., Müller-Hohenstein, K. and Fiedler, K., 2009. Determinants of diversity in afrotropical herbivorous insects (Lepidoptera: Geometridae): plant diversity, vegetation structure or abiotic factors? *Journal of Biogeography*, 36 (2), 337–349.

Ban, X., Jiang, N., Cheng, R., Xue, D. and Han, H. (2018) Tribal classification and phylogeny of Geometrinae (Lepidoptera: Geometridae) inferred from seven gene regions. *Zoological Journal of the Linnean Society*, 184 (3), 653–672.

Barlow, H.S. 1982. *An introduction to the moths of South East Asia*. Malayan Nature Society, Kuala Lumpur, 305 pp.

Bartell, S.M. (2006) Biomarkers, bioindicators, and ecological risk assessment—a brief review and evaluation. *Environmental Bioindicators*, 1 (1), 60–73.

Barthlott, W., Lauer, W. and Placke, A. (1996) Global distribution of species diversity in vascular plants: Towards a world map of phytodiversity (Globale Verteilung der Artenvielfalt Höherer Pflanzen: Vorarbeiten zu einer Weltkarte der Phytodiversität). *Erdkunde*, 50 (4), 317–327.

Barthlott, W., Rafiqpoor, D., Kier, G. and Kreft, H. (2005) Global centers of vascular plant diversity. *Nova Acta Leopoldina NF*, 92 (342), 61–83.

Baselga, A. (2010). Partitioning the turnover and nestedness components of beta diversity. *Global Ecology and Biogeography*, 19 (1), 134–143.

Baselga, A. 2012. The relationship between species replacement, dissimilarity derived from nestedness, and nestedness. *Global Ecology and Biogeography*, 2 (12), 1223–1232.

Baselga, A. and Orme, C. (2012) betapart: an R package for the study of beta diversity. *Methods in Ecology and Evolution*, 3 (5), 808–812.

Basset, Y., Charles, E., Hammond, D.S., Brown, V.K. 2001. Short-term Effects of Canopy Openness on Insect Herbivores in a Rainforest in Guyana. *Journal of Applied Ecology*, 38, 1045–1058.

Beck, J., Schulze, C.H., Linsenmair, K.E. and Fiedler, K. (2002) From forest to farmland: diversity of geometrid moths along two habitat gradients on Borneo. *Journal of tropical ecology*, 18 (1), 33–51.

Beck, J. & Chey, V.K. (2006) Are rank-abundance distributions a useful tool of assemblage discrimination in tropical moths? *Acta Zoologica Sinica*, 52, 1148–1154.

Beck, J. & Chey, V.K. (2007a) The species richness of endemic geometrid moths in northern Borneo. Proceedings of the First South East Asian Lepidoptera Conservation Symposium, Hong Kong 2006 (ed. by R.C. Kendrick), pp. 37–46. Kadoorie Farm and Botanic Garden, Hong Kong.

Beck, J. & Chey, V.K. (2007b) Beta-diversity of geometrid moths from northern Borneo: effects of habitat, time and space. *Journal of Animal Ecology*, 76, 230–237.

Beck, J. and Chey, V.K. (2008) Explaining the elevational diversity pattern of geometrid moths from Borneo: a test of five hypotheses. *Journal of Biogeography*, 35 (8), 1452–1464.

Beck, J. and Linsenmair, K.E. (2006) Feasibility of light-trapping in community research on moths: attraction radius of light, completeness of samples, nightly flight times and seasonality of Southeast-Asian hawkmoths (Lepidoptera: Sphingidae). *Journal of Research on the Lepidoptera*, 39, 18–37.

Beck, J., McCain, C.M., Axmacher, J.C., Ashton, L.A., Bärtschi, F., Brehm, G., Choi, S.W., Cizek, O., Colwell, R.K., Fiedler, K. and Francois, C.L. (2017). Elevational species richness gradients in a hyperdiverse insect taxon: a global meta-study on geometrid moths. *Global Ecology and Biogeography*, 26 (4),412–424.

Beljaev, E.A. (2006) A morphological approach to the Ennominae phylogeny (Lepidoptera: Geometridae). *Spixiana*, 29 (3), 215–216.

Besten, J.W.D. (2004) *Birds of Kangra*. Mosaic Books, New Delhi. Moonpeak publishers, 157 pp.

Bhardwaj, G.S. and Sen, S. (2021) Bird diversity across the western Trans-Himalaya. *Indian Birds*, 17 (4), 97–103.

Billings, W.D. (2019 High Mountain ecosystems: evolution, structure, operation and maintenance. *In*: *High altitude geoecology*, Routledge, pp. 97–125.

Birkinshaw, N. and Thomas, C.D. (1999) Torch-light Transect Surveys for Moths. *Journal of Insect Conservation*, 3, 15–24.

Bowden, J. (1984) Latitudinal and seasonal changes of nocturnal illumination with a hypothesis about their effect on catches of insects in light-traps. Bulletin of entomological Research, 74 (2), 279–298.

Braby, M.F. and Williams, M.R. (2016) Biosystematics and conservation biology: critical scientific disciplines for the management of insect biological diversity. A*ustral Entomology*, 55 (1), 1–17. https://doi.org/10.1111/aen.12158.

Brehm, G. and Fiedler, K., 2003. Faunal composition of geometrid moths changes with altitude in an Andean montane rain forest. *Journal of Biogeography*, 30 (3), 431–440.

Brehm, G., Sussenbach, D. and Fiedler, K. (2003a) Unique elevational diversity pattern of geometrid moths in an Andean montane rainforest. *Ecography*, 26 (4), 456–466.

Brehm, G., Homeier, J. and Fiedler, K. (2003b) Beta diversity of geometrid moths (Lepidoptera: Geometridae) in an Andean montane rainforest. *Diversity and Distributions*, 9 (5), 351–366.

Brehm, G. and Fiedler, K. (2004). Bergmann's rule does not apply to geometrid moths along an elevational gradient in an Andean montane rain forest. *Global Ecology and Biogeography*, 13 (1), 7–14.

Brehm, G. and Fiedler, K. (2005). Diversity and community structure of geometrid moths of disturbed habitat in a montane area in the Ecuadorian Andes. *Journal of Research on the Lepidoptera*, 38, 1–14.

Brehm, G., Colwell, R.K. and Kluge, J. (2007). The role of environment and mid-domain effect on moth species richness along a tropical elevational gradient. *Global Ecology and Biogeography*, 16, 205–219.

Brehm, G. (2017) A new LED lamp for the collection of nocturnal Lepidoptera and a spectral comparison of light-trapping lamps. *Nota lepidopterologica*, 40 (1), 87–108.

Brehm, G., Murillo-Ramos, L., Sihvonen, P., Hausmann, A., Schmidt, B., Õunap, E., Moser, A., Mörtter, R., Bolt, D., Bodner, F. and Lindt, A. (2019) New World geometrid moths (Lepidoptera: Geometridae): Molecular phylogeny, biogeography, taxonomic updates and description of 11 new tribes. *Arthropod Systematics and Phylogeny*, 77, 457–486.

Brehm, G., Niermann, J., Jaimes Nino, L.M., Enseling, D., Jüstel, T., Axmacher, J.C., Warrant, E. and Fiedler, K. (2021) Moths are strongly attracted to ultraviolet and blue radiation. *Insect Conservation and Diversity*, 14 (2), 188–198.

Briscoe, A.D. and Chittka, L. (2001) The evolution of color vision in insects. *Annual review of entomology*, 46 (1), 471–510.

Brown, J.H. and Lomolino, M.V. (1998) Biogeography. Sinuer Associates Publishers.

Bungartz, F., Ziemmeck, F., Tirado, N., Jaramillo, P., Herrera, H. and Jiménez-Uzcátegui, G. (2012) The neglected majority: Biodiversity inventories as an integral part of conservation biology. *In*: *The role of science for conservation*, Routledge, pp. 119–142.

Burger, J. (2006) Bioindicators: a review of their use in the environmental literature 1970–2005. *Environmental Bioindicators*, 1 (2), 136–144.

Burner, R.C., Styring, A.R., Boer, C. and Sheldon, F.H. (2018). Overlap in avian communities produces unimodal richness peaks on Bornean mountains. *Journal of Tropical Ecology*, 34 (2), 75–92.

Butler, L., Kondo, V., Barrows, E.M. and Townsend, E.C. (1999) Effects of weather conditions and trap types on sampling for richness and abundance of forest Macrolepidoptera. *Environmental Entomology*, 28, 795–811.

Cáceres, M.D. and Legendre, P. (2009) Associations between species and groups of sites: indices and statistical inference. *Ecology*, 90 (12), 3566–3574.

Callicott, J.B. (1986). On the intrinsic value of non-human species. *In*: Norton, B.G. (eds.), *The Preservation of Species*. *The Value of Biological Diversity*, Princeton University Press, pp. 38–72.

Cairns, J. and Pratt, J. R. (1993) A history of biological monitoring using benthic macroinvertebrates. *Freshwater Biomonitoring and Benthic Macroinvertebrates*, 10, 27.

Champion, H.G. and Seth, S.K. (1968) *A revised survey of forest types of India*. Government of India, New Delhi, Reprinted, 2005. 404 pp.

Chandra, K. (1996) New records of Moths from the Andaman and Nicobar Islands, India. *Journal of the Andaman Science Association*, 12 (1 and 2), 31–35.

Chandra, K., Kumar, V., Singh, N., Raha, A., and Sanyal, A.K. (2019) *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*. Published by the Director, Zoological Survey of India, Kolkata, 457 pp.

Chen, I-C., Shiu, H.J., Benedick, S., Holloway, J.D., Chey, V.K., Barlow, H.S., Hill, J.K. and Thomas, C.D. (2009) Elevation increases in moth assemblages over 42 years on a tropical mountain. *Proceedings of the National Academy of Sciences*, 106 (5), 1479– 1483.

Chey, V.K., Holloway, J.D. and Speight, M.R. (1997) Diversity of moths in forest plantation and natural forest in Sabah. *Bulletin of Entomological Research*, 87, 371–385.

Choi, S.W. and An, J.S. (2013) What we know and do not know about moth diversity from seven-year-monitoring in Mt. Jirisan National Park, South Korea. *Journal of Asia-Pacific Entomology*, 16 (4), 401–409.

Clarke, K.R. and Warwick, R.M. (2001) *Change in Marine Communities: An Approach to Statistical Analysis and Interpretation*. PRIMER-E Ltd, Plymouth, 2nd edition.

Colwell, R.K., Mao, C.X. and Chang, J. (2004) Interpolating, Extrapolating and Comparing incidence-based species accumulation curve. *Ecology Society of America*, *Ecology*, 85 (10), 2717–2727.

Conrad, K.F., Warren, M.S., Fox, R., Parsons, M.S. and Woiwod, I.P. (2006) Rapid declines of common, widespread British moths provide evidence of an insect biodiversity crisis. *Biological Conservation*,132, 279–291.

Cook, M.A. and Scoble, M.J. (1992) Tympanal organs of geometrid moths: a review of their morphology, function, and systematic importance. *Systematic Entomology*, 17 (3), 219–232.

Cook, M.A., Harwood, L.M., Scoble, M.J. and McGavin, G.C. (1994) The chemistry and systematic importance of the green wing pigment in emerald moths (Lepidoptera: Geometridae, Geometrinae). *Biochemical Systematics and Ecology*, 22 (1), 43–51.

Cotes, E.C. and Swinhoe, C. (1888). *A Catalogue of The Moths of India* (Part 4-Geometrites). Calcutta, Indian Museum, pp. 463–589.

Dalmolin, D.A., Tozetti, A.M. and Pereira, M.J.R. (2019) Taxonomic and functional anuran beta diversity of a subtropical metacommunity respond differentially to environmental and spatial predictors. bioRxiv preprint 588947.

doi: https://doi.org/10.1101/588947.

Dangles, O., Carpio, C., Barragan, A.R., Zeddam, J.L. and Silvain, J.F. (2008) Temperature as a key driver of ecological sorting among invasive pest species in the tropical Andes. *Ecological Applications*, 18 (7), 1795–1809.

De Caceres, M. (2013) *How to use the indicspecies package* (ver. 1.7.1). 1–29 pp.

De Caceres, M., Legendre, P. and Moretti, M. (2010) Improving indicator species analysis by combining groups of sites. *Oikos*, 119, 1674–1684.

Despland, E., Humire, R. and Martín, S.S. (2012) Species richness and phenology of butterflies along an altitude gradient in the desert of Northern Chile. *Arctic, Antarctic, and Alpine Research*, 44 (4), 423–431.

Dey, P. 2018. *Diversity and molecular characterization of Geometridae moths (Lepidoptera: Heterocera) in Nanda Devi Biosphere Reserve, Uttrakhand*, PhD thesis, Saurashtra University, 221 pp.

Dey, P., Uniyal, V.P. and Sanyal, A.K. 2015. Moth assemblage (Lepidoptera: Heterocera) as a potential conservation tool for biodiversity monitoring – study in Western Himalayan Protected areas. 2015. *Indian Forester*, 141 (9), 985–992.

Dey, P. and Hausmann, A. (2021). New distribution and range extension records of geometrid moths (Lepidoptera: Geometridae) from two western Himalayan protected areas. *Journal of Threatened Taxa*, 13 (7): 18817–18826.

Dey, P., Uniyal, V.P., Hausmann, A. and Stuening, D. (2021). Revision of the genus Prometopidia Hampson, 1902, with description of the new species P. joshimathensis sp. nov. from West-Himalaya and its subspecies P. j. yazakii ssp. nov. from Nepal (Lepidoptera: Geometridae, Ennominae). *Zootaxa*, 4980 (1), 028–044.

Dey, P. (2024) Trait distribution in Geometrid moth assemblages does not vary along a western Himalayan elevational gradient. *bioRxiv*, 2024–04.

Dobson, A., Rodriguez, J.P., Roberts, W.M. and Wilcove, D.S. 1997. Geographic distribution of endangered species in the United States. *Science*, 275, 550–553.

Dorow, W.H.O., Blick, T., Pauls, S.U. and Schneider, A. 2019: *Forest Affinity of Selected Animal Groups in Germany*. BfN Skripten 544, Bundesamt für Naturschutz, Bonn, 359 pp. [in German]

Dufrene, M. and Legendre, P. (1997) Species assemblage and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs*, 67, 345–366.

Dunn, R. 2005. Modern insect extinctions, the neglected majority. *Conservation Biology*, 19, 1030.

Enkhtur, K., Brehm, G., Boldgiv, B. and Pfeiffer, M. (2021) Effects of grazing on macro-moth assemblages in two different biomes in Mongolia. *Ecological Indicators*, 133, 108421.

FAO (2014) Mountains and the Sustainable Development Goals. FAO Policy Brief 8 Jan 2014.

Fattorini, S. 2013. Regional insect inventories require long time, extensive spatial sampling and good will. *PLoS One*, 8 (4), e62118.

https://doi.org/10.1371/journal.pone.0062118.

Fisher, R.A., Corbet, A.S. and Williams, C.B. (1943) The relation between the number of species and the number of individuals in a random sample of an animal population. The *Journal of Animal Ecology*, 12 (1), 42–58.

Fox, R. (2013) The decline of moths in Great Britain: a review of possible causes: the decline of moths in Great Britain. *Insect Conservation and Diversity*, 6, 5–19.

doi: 10.1111/j.1752-4598.2012.00186.x.

Fox, R., Randle, Z. and Hill, L. (2011) Moth count: Recording moths for conservation in the UK. *Journal of Insect Conservation*, 15, 55–68.

Gaston, K.J. (2000) Global patterns in Biodiversity. *Nature*, 405, 220–227.

Ghosh, S.K. (2003) Fauna of Sikkim. Zoological Survey of India, 9, 217–342.

Gjerde, I., Sætersdal, M. and Blom, H.H. (2007) Complementary hotspot inventory–a method for identification of important areas for biodiversity at the forest stand level. *Biological Conservation*, 137 (4), 549–557.

Guralnick, R., Walls, R., and Jetz, W. (2018) Humboldt Core – toward a standardized capture of biological inventories for biodiversity monitoring, modeling and assessment. *Ecography*, 41, 713–725.

Hammond, P.M. (1992) Species inventory, *In*: Groombridge, B. (eds.), Global Biodiversity: Status of the Earth's Living Resources, Chapman and Hall, London, pp. 17–39.

Hampson, G. (1892) *The Fauna of British India including Ceylon and Burma. Moths, Vol. I.* Taylor and Francis Ltd., London, 527 pp.

Hampson, G. (1894) *The Fauna of British India including Ceylon and Burma. Moths, Vol. II.* Taylor and Francis Ltd., London, 609 pp.

Hampson, G. (1895) *The Fauna of British India including Ceylon and Burma. Moths, Vol. III.* Taylor and Francis Ltd., London, 546 pp.

Hampson, G. (1896) *The Fauna of British India including Ceylon and Burma. Moths, Vol. IV.* Taylor and Francis Ltd., London, 594 pp.

Harrison, J.F., Woods, H.A. and Roberts, S.P. (2012) *Ecological and environmental physiology of insects*. OUP Oxford.

Haruta, T. (1994) *Moths of Nepal, Part 3,* Tinea. 14 (Supplement 1), Japan Heterocerists' Society, Tokyo, 171 pp.

Haruta, T. (1995) *Moths of Nepal, Part 4,* Tinea. 14 (Supplement 2), Japan Heterocerists' Society, Tokyo, 206pp.

Haruta, T. (1998) *Moths of Nepal, Part 5,* Tinea. 15 (Supplement 1), Japan Heterocerists' Society, Tokyo, 330 pp.

Haruta, T. (2000) *Moths of Nepal, Part 6,* Tinea. 16 (Supplement 1), Japan Heterocerists' Society, Tokyo, 163 pp.

Haslett, J.R. (1997) Mountain ecology: organism responses to environmental change, an introduction. *Global Ecology and Biogeography Letters*, 3–6.

Hausmann, A. (2001) *The Geometrid Moths of Europe. Vol. 1: Introduction, Archiearinae, Orthostixinae, Desmobathrinae, Alsophilinae and Geometrinae*. Apollo Books, 282 pp.

Hausmann, A. (2004) *Geometrid moths of Europe. Vol. 2: Sterrhinae*. Apollo books. 600 pp.

Hausmann, A. and Viidalepp, J. (2012) *The Geometrid Moths of Europe. Vol. 3: Larentiinae 1*. Apollo Books, 743 pp.

Hausmann, A., Hebert, P.D.N., Mitchell, A., Rougerie, R., Sommerer, M., Edwards, T. and Young, K. (2009) Revision of the Australian Oenochroma vinaria Guenée, 1858 species-complex (Lepidoptera: Geometridae, Oenochrominae): DNA barcoding reveals cryptic diversity and assesses status of type specimen without dissection. *Zootaxa*, 2239, 1–21.

doi: 10.5281/zenodo.190505.

Hilt, N., Brehm, G. and Fiedler, K. (2006) Diversity and ensemble composition of geometrid moths along a successional gradient in the Ecuadorian Andes. *Journal of Tropical Ecology*, 12, 155–166.

Hodkinson, I.D. and Jackson, J.K. (2005) Terrestrial and aquatic invertebrates as bioindicators for environmental monitoring, with particular reference to mountain ecosystems. *Environmental management*, 35, 649–666.

Holloway, J.D. (1969) A numerical investigation of the biogeography of the butterfly fauna of India an its relation to continental drift. *Biological Journal of the Linnean Society*, l: 373—385.

Holloway, J. D. (1970) The biogeographical analysis of a transect sample of the moth fauna of Mount Kinabalu, Sabah, using numerical methods. *Biological Journal of the Linnean Society*, 2: 259—286.

Holloway, J. D. (1973) The taxonomy of four groups of butterflies (Lepidoptera) in relation to general patterns of butterfly distribution in the Indo-Australian area. *Transactions of the Royal Entomological Society of London*, 125, 125-176.

Holloway, J.D. (1974) The biogeography of Indian butterflies. In M. S. Mani (Ed.) Ecology and Biogeography in India: 473—499. *Monographiae Biologicae*, 23. The Hague: W. Junk.

Holloway, J.D. (1977) The Lepidoptera of Norfolk Island, their biogeography and ecology. *Series Entomologica*, 13. The Hague: W. Junk.

Holloway, J.D. (1979) A survey of the Lepidoptera, biogeography and ecology of New Caledonia. *Series Entomologica*, 15. The Hague: W. Junk.

Holloway, J. D. (1982) Mobile organisms in a geologically complex area: Lepidoptera in the Indo-Australian tropics. *Zoological Journal of the Linnean Society*, 76, 353–373.

Holloway, J. D. (1983) Insect surveys-an approach to environmental monitoring. Atti XII Congresso Nazionale Italiano di Entomologia, Roma, 1980, 239–261.

Holloway, J. D. (1984) The larger moths of Gunung Mulu National Park; a preliminary assessment of their distribution, ecology and potential as environmental indicators. In Jermy, A. C. & Kavanagh, K. P. (eds). Gunung Mulu National Park, Sarawak, Part 11, Sarawak Museum Journal 30, Special Issue 2, pp. 149–190.

Holloway, J. D. (1985a) Moth as indicator organism for characterizing rain forest and monitoring changes and regeneration process. *In*: A. C. Chadwick and S.L. Sutton (eds.). *Tropical rain forest: the Leeds Symposium.* Leeds Philosophical and Literary society, pp. 235–242.

Holloway, J. D. (1985b) The moths of Borneo: Family Noctuidae: Subfamilies Euteliinae, Stictopterinae, Plusiinae, Pantheina. *Malayan Nature Journal*, 38: 157–317.

Holloway, J.D., Bradley, J.D. and Carter, D.J. (1987) *CIE Guides to insects of importance to man. I. Lepidoptera.* CAB International.

Holloway, J.D. and Barlow, H.S. (1992) Potential for loss of biodiversity in Malaysia, illustrated by the moth fauna, pp. 293–311 in Aziz, A., Kadir, S.A. & Barlow, H.S. (Eds).

Pest management and the environment in 2000. *CAB International and Agricultural Institute of Malaysia*.

Holloway, J.D. (1994) *The moths of Borneo, Part 11: family Geometridae, subfamily Ennominae.* Malayan Nature Journal, 47, 1–309 pp.

Holloway, J.D. (1996) *The moths of Borneo, part 9: Geometridae (incl. Orthostixini), Oenochrominae, Desmobathrinae, Geometrinae.* Malayan Nature Journal, 49, 147–326 pp.

Holloway, J.D. (1997) *The moths of Borneo, part 10: family Geometridae, subfamilies Sterrhinae and Larentiinae. Addenda to other subfamilies.* Malayan Nature Journal, 51, 1–242 pp.

Holloway, J.D., Kibby, G. and Peggie, D. (2001) The families of Malesian moths and butterflies. Fauna Malesiana Handbook 3. Brill (Leiden, Boston, Köln).

Holloway, J.D. and Intachat, J. (2003) Aspects of the diversity of Geometridae (Lepidoptera) in Pasoh Forest Reserve. Pasoh: ecology of a lowland rain forest in Southeast Asia, 293–313.

Holt, B.G., Lessard, J.P., Borregaard, M.K., Fritz, S.A., Araújo, M.B., Dimitrov, D., and Rahbek, C. (2013) An update of Wallace's zoogeographic regions of the world. *Science*, 339 (6115), 74–78.

Holt, R.D. and Gaines, M.S. (1992) Analysis of adaptation in heterogenous landscapes: implications for the evolution of fundamental niches. *Ecology and Evolution*, 6, 433–447.

Holt, E.A. and Miller, S.W. (2011) Bioindicators: Using organisms to measure. *Nature*, 3, 8–13.

Howard, P.C., Viskanic, P., Davenport, T.R.B., Kigenyi, F.W., Baltzer, M., Dickinson, C.J., Lwanga, J.S., Matthews, R.A., and Balmford, A. (1998) Complementarity and the use of indicator groups for reserve selection in Uganda. *Nature*, 394, 472–475.

Intachat, J., Holloway, J.D. and Speight, M.R. (1997) The effects of different forest management practices on geometrid moth population and their diversity in Peninsular Malaysia. *Journal of Tropical Forest Science*, 9, 411–430.

Intachat, J., Chey, V.K., Holloway, J.D. and Speight, M.R. (1999) The impact of Forest plantation development on the population and diversity of geometrid moths (Leoidoptera: Geometridae) in Malaysia. *Journal of Tropical Forest Science*, 11 (2), 329–336.

Intacaht, J., Holloway, J.D. and Staines, H.J. (2001) Effects of weather and phenology on the abundance and diversity of geometroid moths in a natural Malaysian rain forest. *Journal of Tropical Ecology*, 17 (3), 411–429.

IUCN Red List version 2019-1: Table 1a: Number of species evaluated in relation to the overall number of described species and number of threatened species by major groups of organisms. Last Updated: 21 March 2019.

Janetschek, H. 1956. Das proble der inneralpinen Eiszeituberdauerung durch Tiere (Ein Beitrag zur Geschichte der Nival fauna) *Osterr. Zool. Inst.*, 6 (3/5), 421–506.

Jonason, D., Franzén, M. and Ranius, T. (2014) Surveying moths using light traps: effects of weather and time of year. *PloS one*, 9 (3), e92453.

Joshi, P.K., Rawat, G.S., Padilya, H. and Roy, P.S. (2006) Biodiversity characterization in Nubra Valley, Ladakh with special reference to plant resources conservation and bioprospecting. *Biodiversity and Conservation*, 15, 4253–4270.

Kerr, J.T., Sugar, A. and Packer, L. (2000) Indicator taxa, rapid biodiversity assessment, and nestedness in an endangered ecosystem. *Conservation Biology*, 14, 1726–1734.

Kim, K.C. (1993) Biodiversity, conservation and inventory: why insects matter. *Biodiversity and Conservation*, 2, 191–214.

Kirti, J.S. and Saxena, A. (2012) An inventory of family Geometridae (Lepidoptera) from North-east Inda. *Journal of Applied Bioscience*, 38 (1), 28–43.

Kirti, J.S., Singh, N. and Saxena, A. (2014) Seven New records of Geometrids Moths (Lepidoptera: Geometridae) from India. *Journal of Applied Bioscience*, 40 (2), 113–116.

Kirti, J.S., Chandra, K., Saxena, A. and Singh, N. (2019) *Geometrid Moths of India*. Nature Books India. 296 pp

Kitching, R.L., Orr, A.G., Thalib, L., Mitchell, H., Hopkins, M.S. and Graham, A.W. (2000) Moth assemblage as indicator of environmental quality in remnants of upland Australian rain forest. *Journal of Applied Ecology*, 37, 284–297.

Körner, C. (2004) Mountain biodiversity, its causes and function. *Ambio*, Special issue, 13, 11–17.

Kremen, C. and Chaplin–Kramer, R. (2007) Insects as providers of ecosystem services: crop pollination and pest control. *In*: Stewart A.J.A., New, T.R., Lewis, O.T. (eds). *Insect conservation biology*, Royal Entomological Society, London, pp. 349–382.

Kremen, C., Colwell, R.K., Erwin, T.L., Murphy, D.D., Noss, R.F. and Sanjayan, M.A. (1993) Terrestrial Arthropod Assemblages: Their Use in Conservation Planning. *Conservation Biology*, 7, 796–808.

Kumar, A., Adhikari, B.S. and Rawat, G.S. (2017) Biogeographic delineation of Indian Trans- Himalaa: Need for revision. *Current Science*, 113 (6), 1032.

Kumar, M., Kumar, P. and Kumar, A. (2018) Taxonomic study of Geometrid Moths (Lepidoptera: Geometridae) Diversity in Chirpine Forest of Himachal Pradesh. *Asian Journal of Advanced Basic Sciences*, 6 (1), 49–53.

Lahaul-Spiti district, Government of Himachal Pradesh, online web page, https://hplahaulspiti.nic.in/geographical-conditions/.

Lawton, J.H., Bignell, D.E., Bolton, B., Bloemers, G.F., Eggleton, P., Hammond, P.M., Hodda, M., Holt, R.D., Larsen, T.B., Mawdsley, N.A., Stork, N.E., Srivastava, D.S. and Watt, A.D. (1998) Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. *Nature*, 391, 72–76.

Lebhardt, F. and Desplan, C. (2017) Retinal perception and ecological significance of color vision in insects. *Current opinion in insect science*, 24, 75–83.

Lindenmayer, D.B., Manning, A.D., Smith, P.L., Possingham, H.P., Fischer, J., Oliver, I. and McCarthy, M.A. (2002) The focal-species approach and landscape restoration: a critique. *Conservation Biology*, 16, 338–345.

Lomolino, M.V. 2004. *Conservation biogeography*. Frontiers of Biogeography: new directions in the Geography of Nature, 293 pp.

Mac Nally, R., Bennett, A.F., Brown, G., Lumsden, L.F., Yen, A.L., Hinkley, S., Lilywhite, P. and Ward, D.F. (2002) How well do ecosystem-based planning units represent different components of biodiversity? *Ecological Applications*, 12 (3), 900–912.

Mani, M.S. (1954) Entomological Survey of the Himalaya, Part-1. Introduction and description of gall midges plant galls from western Himalaya. *Agra University Journal Research (Science)*, 3 (1), 13–42.

Mani, M.S. (1962) *Introduction to the High-Altitude Entomology*. London: Metheun and Co., 305 pp.

Mani, M.S. (1968) *Ecology and Biogeography of High-altitude insects*. The Hague: Dr. W. Junk BV Publishers, 524 pp.

Mani, M.S. (1973) *Fundamental of High-altitude Biology*. New Delhi: Oxford and IBH, 196 pp.

Singh, S. (1983) High altitude entomology in India and its scope. *Proceeding workshop High altitude entomology and Wildlife ecology, Zoological Survey of India*: 87–101.

Mani, M.S. (1994) The Himalaya, its ecology and biogeography: A review. *In*: Pangtey, Y.P.S. and Rawal, R.S. (eds.), *High Altitudes of the Himalaya (Biogeography, Ecology and Conservation)*, Delhi: Gyanodaya Prakashan, 1–10 pp.

Mallick, K. (2021) *Diversity and distributional pattern of family Geometridae (Lepidoptera) in Great Himalayan National Park conservation area, Himachal Pradesh*. PhD Thesis, Saurashtra University, 462pp.

Mallick, K., Dey, R., Bandyopadhyay, U., Mazumder, A., Gayen, S., Ali, M., Das, G.N., Raha, A., Sanyal, A.K., Gupta, S.K. and Uniyal, V.P. (2022). Taxonomy and ecology of genus *Psyra* Walker, 1860 (Lepidoptera: Geometridae: Ennominae) from Indian Himalaya. *Plos one,* 17 (4), p.e0266100.

McCain, C.M. (2007b) Could temperature and water availability drive elevational species richness? A global case study for bats. *Global Ecology and Biogeography*, 16, 1–13.

McCain, C.M. 2010. Global analysis of reptile elevational diversity. *Global Ecology and Biogeography*, 19, 541–553.

McCain, C.M. and Beck, J. (2016). Species turnover in vertebrate communities along elevational gradients is idiosyncratic and unrelated to species richness. *Global Ecology and Biogeography*, 25 (3), 299–310.

Mcgeachie, W.J. (1989) The effect of moonlight illuminance, moonlight and wind speed on light trap catches of moths. *Bulletin of Entomological Research*, 79, 185–192.

McGeogh, M. (1998) The selection, testing and application of terrestrial insects as bioindicators. *Biological Reviews*, 73 (2), 181–201.

Miller, J.C. (1993) Insect natural history, multi-species interactions, and biodiversity in ecosystems. *Biodiversity Conservation*, 2, 233–241.

Minet, J. (1983) Etude morphologique et phylogénétique des organes tympaniques des Pyraloidea. Généralités et homologies. (Lep. Glossata). *Annales de la Société entomologique de France*, 19, 175–207,

Minet, J. and Scoble, M.J. (1999) *The Drepanoid/Geometroid assemblage. In:* Kristensen N. P., ed. Handbook of Zoology, Part 35, *Lepidoptera, Moths and Butterflies, Vol. 1, Evolution, Systematics, and Biogeography*. Berlin: De Gruyter, pp. 301–320.

Mironov, V. (2000) *The Geometrid Moths of Europe. Vol. 4: Larentiinae 2 (Perizomini and Eupitheciini)*. Apollo Books, 464 pp.

Montgomery, G.A., Belitz, M.W., Guralnick, R.P. and Tingley, M.W. (2021) Standards and best practices for monitoring and benchmarking insects. *Frontiers in Ecology and Evolution*, 8, 579193. https://doi.org/10.3389/fevo.2020.579193.

Mountain: Definition, Formation, Characteristics and Examples. 2016.

study.com/academy/lesson/mountain-definition-formation-characteristics-examples.html.

Muirhead-Thomson, R.C. (1991) *Trap Responses of Flying Insects*, Academic Press, 287 pp. ISBN 9780125097550, https://doi.org/10.1016/B978-0-12-509755-0.50007-4.

Murillo-Ramos, L., Brehm, G., Sihvonen, P., Hausmann, A., Holm, S., Ghanavi, H.R., Õunap, E., Truuverk, A., Staude, H., Friedrich, E. and Tammaru, T. (2019) A comprehensive molecular phylogeny of Geometridae (Lepidoptera) with a focus on enigmatic small subfamilies. *PeerJ*, 7, p.e7386.

Murillo-Ramos, L., Friedrich, E., Williams, S., Wahlberg, N., Brehm, G. and Sihvonen, P. (2021) A morphological appraisal of the new subfamily Epidesmiinae (Lepidoptera: Geometridae) with an overview of all geometrid subfamilies. *Zoological Journal of the Linnean Society*, 193 (4), 1205–1233.

Murillo-Ramos, L., Twort, V., Wahlberg, N. and Sihvonen, P. (2023) A phylogenomic perspective on the relationships of subfamilies in the family Geometridae (Lepidoptera). *Systematic Entomology*.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Da Fonseca, G.A., and Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature*, 403 (6772), 853–858.

New, T.R. (1996) Taxonomic focus and quality control in insect surveys for biodiversity conservation. *Australian Journal of Entomology*, 35, 97–106.

New, T.R. (2004) Moths (Insecta: Lepidoptera) and conservation: background and perspective. *Journal of Insect Conservation*, 8, 79–94.

Niermann, J., and Brehm, G. (2022) The number of moths caught by light traps is affected more by microhabitat than the type of UV lamp used in a grassland habitat. European Journal of Entomology, 119, 36–42.

Nogués-Bravo, D., Araújo, M.B., Romdal, T. and Rahbek, C. (2008) Scale effects and human impact on the elevational species richness gradients. *Nature*, 453 (7192), 216–219.

Noroozi, J., Talebi, A., Doostmohammadi, M., Rumpf, S.B., Linder, H.P. and Schneeweiss, G.M. (2018) Hotspots within a global biodiversity hotspot-areas of endemism are associated with high mountain ranges. *Scientific Reports*, 8 (1), 10345.

Noss, R.F. (1990) Indicators for monitoring biodiversity: a hierarchical approach, *Conservation Biology*, 4, 355–364.

Novotny, V., Basset, Y., Miller, S.E., Weiblen, G.D., Bremer, B., Cizek, L., Drozd, P. (2002) Low Host Specificity of Herbivorous Insects in a Tropical Forest. *Nature*, 416, 841–844.

Odegaard, F. (2000) How many Species of Arthropods? Erwin's Estimate Revised. *Biological Journal of the Linnean Society*, 71, 583–597.

Olembo, R. (1991) Importance of Microorganisms and invertebrates as components of biodiversity. *In*: Hawksworth, D. L.(eds.), *The Biodiversity of Microorganisms and Invertebrates: its role in Sustainable Agriculture*, Wallingford, UK: CAB, pp. 7–16

Õunap, E. and Viidalepp, J. (2009) Description of Crypsiphona tasmanica sp. nov. (Lepidoptera: Geometridae: Geometrinae), with notes on limitations in using DNA barcodes for delimiting species. *Australian Journal of Entomology*, 48 (2), 113–124.

DOI 10.1111/j.1440-6055.2009.00695. x.

Õunap, E., Javoiš, J., Viidalepp, J. and Tammaru, T. (2011) Phylogenetic relationships of selected European Ennominae (Lepidoptera: Geometridae). *European Journal of Entomology*, 108 (2), 267–273.

Õunap, E., Viidalepp, J. and Saarma, U. (2008) Systematic position of Lythriini revised: transferred from Larentiinae to Sterrhinae (Lepidoptera, Geometridae). *Zoologica Scripta*, 37 (4), 405–413.

Õunap, E., Viidalepp, J. and Truuverk, A. (2016) Phylogeny of the subfamily Larentiinae (Lepidoptera: Geometridae): integrating molecular data and traditional classifications. Systematic Entomology, 21 (4), 824–843.

Öztürk, M., Şimşek, M. and Utlu, M. (2015) Tahtalı Dağları (Orta Toroslar) karst platosu üzerinde dolin ve uvala gelişiminin CBS tabanlı analizi. *Türk Coğrafya Dergisi*, 65, 59–68.

Pajni, H.R. and Walia, Y.K. (1984a) Taxonomic studies on Indian Geometridae 1. Genus Chlorissa Stephens (Subfamily: Geometrinae). *Entomon*, 9 (1), 39–46, 18 figs, 2 ph.

Pajni, H.R. and Walia, V.K. (1984b) Taxonomic studies on Indian Geometridae III. Genus Euchloris Hubner (Subfamily: Geometrinae). *Uttar Pradesh Journal of Zoology*, 4 (2), 175–178, 5 figs.

Pajni, H.R. and Walia, V.K. (1984c) Taxonomic studies on Indian Geometridae IV. On a new species of genus *Chloeres* Truner with comments on the Indian species of this genus. *Geobios New Reports*, 3, 139–141, 3 figs., 1 ph.

Paknia, O. and Rajaei Sh, H. (2015) Geographical patterns of species richness and beta diversity of Larentiinae Moths (Lepidoptera: Geometridae) in two temperate biodiversity hotspots. *Journal of Insect Conservation*, doi: 10. 1007/s10841-015-9795-0.

Parmesan, C. (2006) Ecological and evolutionary responses to recent climate change. *Annual Review of Ecology, Evolution, and Systematics*, 37, 637–669.

Patterson, B.D. (1987) The principles of nested subsets and its implications for biological conservation. *Conservation Biology*, 1, 323–334.

Perrigo, A., Hoorn, C. and Antonelli, A. (2020) Why mountains matter for biodiversity. *Journal of Biogeography*, 47 (2), 315–325.

Pianka, E.R. (1966) Latitudinal gradients in species diversity: a review of concepts. *American Naturalist*, 100, 33–46.

Peters, M.K., Hemp, A., Appelhans, T., Behler, C., Classen, A., Detsch, F., Ensslin, A., Ferger, S.W., Frederiksen, S.B., Gebert, F. and Haas, M. (2016) Predictors of elevational biodiversity gradients change from single taxa to the multi-taxa community level. *Nature Communications*, 7 (1), 13736.

Pimm, S.L. (1991) *The Balance of Nature-Ecological issues in the conservation of species and communities*. Chicago: University of Chicago Press, 448 pp.

Pimm, S.L., Alibhai, S., Bergl, R., Dehgan, A., Giri, C., Jewell, Z., Joppa, L., Kays, R. and Loarie, S. (2015) Emerging technologies to conserve biodiversity. *Trends in Ecology and Evolution*, 30 (11), 685–696.

Pitkin, L.M. (1996) Neotropical emerald moths: a review of the genera (Lepidoptera: Geometridae, Geometrinae). *Zoological Journal of the Linnean Society*, 118 (4), 309–440.

Pollard, E. and Yates, T.J., (1993) *Monitoring Butterflies for Ecology and Conservation*. Chapman and Hall, London, XIV, 274 pp

Prendergast, J.R., Quinn, R.M., Lawton, J.H., Eversham, B.C. and Gibbons, D.W. (1993) Rare species, the coincidence of diversity hotspots and conservation strategies. *Nature*, 365, 335–337.

Price, M.F. (2013) *Mountain geography: Physical and human dimensions*. University of California Press.

Rahbek, C. (2005) The role of spatial scale and the perception of large-scale species-richness patterns. *Ecology Letters*, 8, 224–239.

Rahbek, C., Borregaard, M.K., Colwell, R.K., Dalsgaard, B.O., Holt, B.G., Morueta-Holme, N., and Fjeldså, J. (2019) Humboldt's enigma: What causes global patterns of mountain biodiversity? *Science*, 365 (6458), 1108–1113.

Rahbek, C., Borregaard, M.K., Colwell, R.K., Dalsgaard, B.O., Holt, B.G., Morueta-Holme, N., Nogues-Bravo, D., Whittaker, R.J. and Fjeldså, J. (2019) Humboldt's enigma: What causes global patterns of mountain biodiversity? *Science*, 365 (6458), 1108–1113.

Ratnasingham, S. and Hebert, P.D.N. (2013) A DNA-based registry for all animal species: the Barcode Index Number (BIN) system. *PLoS oNE*, 8 (7), e66213. https://doi.org/10.1371/journal.pone.0066213

Rawat, Y.S., Oinam, S.S., Vishvakarma, S.C., Kuniyal, C.P., and Kuniyal, J.C. (2006) Willow (Salix fragilis Linn.): a multipurpose tree species under pest attack in the cold desert of Lahaul valley, northwestern Himalaya, India. *AMBIO: A Journal of the Human Environment*, 35 (1), 43–48.

Rawat, Y.S., Vishvakarma, S.C.R., Oinam, S.S., and Kuniyal, J.C. (2010) Diversity, distribution and vegetation assessment in the Jahlmanal watershed in cold desert of the Lahaul valley, north-western Himalaya, India. *iForest-Biogeosciences and Forestry*, 3 (3), 65.

Rajaei, H., Hausmann, A., Scoble, M., Wanke, D., Plotkin, D., Brehm, G., Murillo-Ramos, L. and Sihvonen, P. (2022) An online taxonomic facility of Geometridae (Lepidoptera), with an overview of global species richness and systematics. Integrative Systematics: Stuttgart Contributions to Natural History, 5 (2), 145–192.

Reid, W. (1998) Biodiversity hotspots. *Trends in Ecology Evolution*, 13, 275–280.

Ribeiro, D.B., Williams, M.R., Specht, A. and Freitas, A.V. (2016). Vertical and temporal variability in the probability of detection of fruit-feeding butterflies and moths (*Lepidoptera*) in tropical forest. *Austral Entomology*, 55 (1), 112–120.

Richter, A., Hauck, J., Feldmann, R., Kühn, E., Harpke, A., Hirneisen, N., Mahla, A., Settele, J. and Bonn, A. (2018) The social fabric of citizen science-drivers for long-term engagement in the German butterfly monitoring scheme. *Journal of Insect Conservation*, 22, 731–743.

Ricketts, T.H., Dinerstein, E., Olson, D.M., and Loucks, C. (1999) Who's where in North America? *Bioscience*, 49, 369–381.

Robinson, G.S. (1976) The preparation of slides of Lepidoptera genitalia with special reference to the Microlepidoptera. *Entomologist's Gazette*, 27, 127–132.

Rodgers, W.A. and Panwar, S.H. 1998. *Biogeographical classification of India. New Forest, Dehradun, India.*

Rose, H.S. and Davinder. (1986) A new species of the genus *Chlorissa* Stephens from North India (Geometrinae: Geometridae: Lepidoptera). *Journal of the Bombay Natural History Society*, 82 (3), 614–616.

https://eurekamag.com/research/037/209/037209935.php

Samways, M.J. (1989) Insect Conservation and the Disturbance Landscape. *Agriculture, Ecosystems and Environment*, 27, 183–194.

Samways, M.J. (1993) Insects in biodiversity conservation: some perspectives and directives. *Biodiversity Conservation*, 2, 258–282.

Samways, M.J. (2007) Insect conservation: a synthetic management approach. *Annual Revision Entomology*, 52, 465–487.

Sánchez-Bayo, F. and Wyckhuys, K.A.G. (2019) Worldwide decline of the entomofauna: A review of its drivers. *Biological conservation*, 232, 8–27.

Sanyal, A.K., Uniyal, V.P., Chandra, K. and Bhardwaj, M. (2011) Diversity and indicator species of moth (Lepidoptera: Heterocera) assemblages in different vegetation zones in Gangotri Landscape, Western Himalaya, *Indian Journal of Threatened Taxa*, 5 (2), 3646–3653.

Sanyal, A.K., Uniyal, V.P., Chandra, K. and Bhardwaj, M. (2013). Diversity, distribution pattern and seasonal variation in moth assemblages along altitudinal gradient in Gangotri landscape area, Western Himalaya, Uttarakhand, India. *Journal of Threatened Taxa*, 5 (2), 3646–3653.

Sanyal, A.K. (2015) *Diversity and distribution of moth assemblages along altitudinal gradient in gangotri Landscape*, PhD thesis, Saurashtra University, 383 pp.

Sanyal, A.K., Dey, P., Uniyal, V.P., Chandra, K. and Raha, A. (2017) Geometridae Stephens, 1829 from different altitudes in Western Himalaya Protected areas of Uttarakhand, India (Lepidoptera: Geometridae. *SHILAP Revista de Lepidopterogica*, 45 (177), 143–163.

Sanyal, A.K., Mallick, K., Khan, S., Bandyopadhyay, U., Mazumder, A., Bhattacharyya, K., Pathania, P.C., Raha, A. and Chandra, K. 2018. Insecta: Lepidoptera (Moths).

In: *Faunal Diversity of Indian Himalaya*, Published by the Director, Zoological Survey of India, Kolkata, 651–726.

Schowalter, T., Crossley, D. and Hargrove, W. (1986) Herbivory in forest ecosystems. *Annual Review of Entomology*, 31, 177–196.

Schowalter, T.D. (2006) Herbivory. *In*: Entomology Department, Lousiana State University. 2nd edition, *Insect ecology: An ecosystem Approach*. Academic Press. 347–382 pp.

Schulze, C.H. (2000). *Auswirkungen anthropogener Sto¨rungen auf die Diversita¨t von Herbivoren – Analyse von Nachtfalterzo¨nosen entlang von Habitatgradienten in Ost-Malaysia*. Ph.D. thesis, University of Bayreuth. 350 pp.

Schulze, C.H., and Fiedler, K. (2003) Vertical and Temporal Diversity of a Species-rich Moth Taxon in Borneo. *In*: Basset, Y., Novotny, V., Miller, S., Kitching, R.L. (eds.), *Arthropods of Tropical Forests: Spatio-temporal Dynamics and Resource Use in the Canopy*, Cambridge University Press, Cambridge, pp. 69-85.

Scoble, M.J. and Edwards, E.D. (1990) Parepisparis Bethune-Baker and the composition of the Oenochrominae (Lepidoptera: Geometridae). *Entomologica Scandinavica*, 20 (4), 371–399.

DOI 10.1163/187631289X00375.

Scoble, M.J., Gaston, K.J. and Ceook, A. (1995) Using taxonomic data to estimate species richness in Geometridae. *Journal of the Lepidopterists' Society*, 49, 136–147.

Scoble, M.J. (1992) *The Lepidoptera, Form, Function and Diversity*. Oxford: Oxford University Press.

Scoble, M.J. and Hausmann, A. [updated 2007]: Online list of valid and available names of the Geometridae of the World (http://www.herbulot.de/globalspecieslist.html).

Shubhalaxmi, V., Kendrick, R.C., Vaidya, A., Kalagi, N. and Bhagwat, A. (2011) Inventory of moth fauna (Lepidoptera: Heterocera) Of the Northern Western Ghats, Maharashtra, India. *Journal of the Bombay Natural History Society*, 108 (3), 108–135.

Sihvonen, P. and Kaila, L. (2004) Phylogeny and tribal classification of Sterrhinae with emphasis on delimiting Scopulini (Lepidoptera: Geometridae). *Systematic Entomology*, 29 (3), 324–358.

Siddig, A.A., Ellison, A.M., Ochs, A., Villar-Leeman, C. and Lau, M.K. (2016) How do ecologists select and use indicator species to monitor ecological change? Insights from 14 years of publication in Ecological Indicators. *Ecological Indicators*, 60, 223–230.

Sihvonen, P., Mutanen, M., Kaila, L., Brehm, G. and Hausmann, A. (2011) Comprehensive Molecular Sampling Yields a Robust Phylogeny for Geometrid Moths (Lepidoptera: Geometridae). *PLoS ONE*, 6 (6), e20356.

Sihvonen P, Staude H.S. and Mutanen, M. (2015) Systematic position of the enigmatic African cycad moths: an integrative approach to a nearly century-old problem (Lepidoptera: Geometridae, Diptychini). *Systematic Entomology*, 40 (3), 606–627.

Sihvonen, P., Murillo-Ramos, L., Brehm, G., Staude, H. and Wahlberg, N. (2020) Molecular phylogeny of Sterrhinae moths (Lepidoptera: Geometridae): towards a global classification. *Systematic Entomology*, 45 (3), 606–634.

Simberloff, D. 1998. Flagships, umbrellas, and keystones: is single-species management passé in the landscape era? *Biological Conservation*, 83 (3), 247–257.

Singh, R.P., Böttger, D. and Brehm, G. (2022) Moth light traps perform better with vanes: A comparison of different designs. *Journal of Applied Entomology*, 146 (10), 1343–1352.

Skou, P. and Sihvonen, P. (2015) *The Geometrid Moths of Europe. Vol. 5: Ennominae 1*. Brill Publication, 657 pp.

Spadling, A. (1997) The Use of Butterfly Transect Method for the Study of Nocturnal Moth Luperina nickerlii leechi Goater (Lepidoptera: Noctuidae) and its possible Application to other Species. *Biological Conservation*, 80, 147–152.

Spector, S. (2006) Scarabaeine dung beetles (Coleoptera: Scarabaeidae: Scarabaeinae): an invertebrate focal taxon for biodiversity research and conservation. *The Coleopterists Bulletin*, 60 (5), 71–83.

Spehn, E.M. and Körner, C. (2005) A global assessment of mountain biodiversity and its function. *Global change and mountain regions: An overview of current knowledge*, 393–400.

Steinbauer, M.J., Grytnes, J.A., Jurasinski, G., Kulonen, A., Lenoir, J., Pauli, H., Rixen, C., Winkler, M., Bardy-Durchhalter, M., Barni, E. and Bjorkman, A.D. (2018)

Accelerated increase in plant species richness on mountain summits is linked to warming. *Nature*, 556 (7700), 231–234.

Stork, N.E. (1988) Insect diversity: facts, fiction and speculation. *Biological Journal of the Linnean Society*, 35, 321–337.

Summerville, K.S., Metzler, E.H. and Crist, T.O. (2001). Diversity of Lepidoptera in Ohio Forests at Local and Regional ScalesHow Heterogeneous is the Fauna? *Annals of the Entomological Society of America*, 94 (4), 583–591.

Summerville, K.S. and Crist, T.O. (2005) Temporal patterns of species accumulation in a survey of Lepidoptera in a beech-maple forest. *Biodiversity and Conservation*, 14, 3393–3406.

Summerville, K.S., Ritter, L.M. and Crist, T.O. (2004). Forest moth taxa as indicators of lepidopteran richness and habitat disturbance: a preliminary assessment. *Biological Conservation*, 116 (1), 9–18.

Telwala, Y., Brook, B.W., Manish, K. and Pandit, M.K. (2013) Climate-induced elevational range shifts and increase in plant species richness in a Himalayan biodiversity epicentre. *PloS one*, 8 (2), e57103.

ter Braak, C. and Verdonschot, P.F.M. (1995) Canonical correspondence analysis and related multivariate methods in aquatic ecology. *Aquatic Science*, 57(3), 255–289.

Thakur, V. and Kumar, P. (2014) Diversity, species richness and evenness of geometrid fauna of different conifer forests of Seraj valley of Himachal Pradesh. *International Journal of Current Research and Academic Review*, 2(11), 27–32.

Thomas, A.W. (2002) *Moth diversity in a northeastern North American, red spruce forest, II*. The effect of silvicultural practices on geometrid diversity (Lepidoptera: Geometridae). Canadian Forest Service, Atlantic Forestry Service, Fredericton. 25 pp.

Triplehorn, C.A. and Johnson, N.F. (2005) *Borror and DeLong's introduction to the study of insects*. Thomson Brooks/Cole, Belmont, CA.

Truxa, C. and Fiedler, K. (2012) Attraction to light - from how far do moths (Lepidoptera) return to weak artificial sources of light? *European Journal of Entomology*, 109, 77–84.

Tweedie, M.W.F. and Emmet, A.M. (1991) Resting posture in the Lepidoptera. *In*: Emmet, A. M. and Heath, 1. (eds), *The Moths and Butterflies of Great Britain and Ireland*, 7 (2), pp. 46-60.

Harley Common, I.F.B. (1990) *Moths of Australia*. Melbourne University Press. Books, Colchester.

Usher, M.B. and Keiller, S.W.J. (1998) The macrolepidoptera of farm woodlands: determinants of diversity and community structure. *Biodiversity Conservation*, 7, 725–748.

van Nieukerken, E.J., Kaila, L., Kitching, I.J., Kristensen, N.P., Lees, D.C., Minet, J., Mitter, C., Mutanen, M., Regier, J.C., Simonsen, T.J., Wahlberg, N., Yen, S.-H., Zahiri, R., Adamski, D., Baixeras, J., Bartsch, D., Bengtsson, B.A., Brown, J.W., Bucheli, S.R., Davis, D.R., De Prins, W., Epstein, M.E., Gentili-Poole, P., Gielis, C., Hatternschwiler, P., Hausmann, A., Holloway, J.D., Kallies, A., Karsholt, O., Kawahara, A.Y., Koster, J.C., Kozlov, M.V., Lafontaine, J.D., Lamas, G., Landry, J.F., Lee, S., Nuss, M., Park, K.-T., Penz, C., Rota, J., Schintlmeister, A., Schmidt, van Swaay, C.A., Nowicki, P., Settele, J. and Van Strien, A.J. 2008. Butterfly monitoring in Europe: methods, applications and perspectives. *Biodiversity and Conservation*, 17, 3455–3469.

van Swaay, C.A., Nowicki, P., Settele, J. and Van Strien, A.J. (2008) Butterfly monitoring in Europe: methods, applications and perspectives. *Biodiversity and Conservation*, 17, 3455–3469.

Verheijen, F.J. (1960) The mechanisms of the trapping effect of artificial light sources upon animals. *Archives Néerlandaises de Zoologie*, 13, 1–107.

Viidalepp, J. (2011) A morphological review of tribes in Larentiinae (Lepidoptera: Geometridae). *Zootaxa*, 3136 (1), 1–44.

Viidalepp. J. 2006. Cladistic analysis of the subfamily Larentiinae. *In*: Hausmann A, McQuillan P, eds. Proceedings of the Forum Herbulot 2006. *Integration of molecular, ecological and morphological data: recent progress towards the higher classification of the Geometridae* (Hobart, 19–20 January 2006). *Spixiana*, 29, 202–203.

Von Humboldt, A. and Bonpland, A. (2010) *Essay on the Geography of Plants*. University of Chicago Press.

von Humboldt, A., and Bonpland, A. (2009) Essay on the geography of plants—with a physical tableau of the equinoctial regions (1807). *Essay on the Geography of Plants*, pp. 61-155.

Wagner, D.L. 2020. Insect declines in the Anthropocene. *Annual Review of Entomology*, 65, 457–480.

doi: 10.1146/annurev-ento-011019-025151.

Wahlberg, N. Snäll, N. Viidalepp, J. Ruohomäki, K. Tammaru, T. (2010) The evolution of female flightlessness among Ennominae of the Holarctic Forest zone (Lepidoptera, Geometridae). *Molecular Phylogenetics and Evolution*, 55 (3), 929–938.

Walia, V.K. and Pajni H.R. (1987) Studies on the Geometridae (Lepidoptera) of North West India. Subfamily Scopulinae. *Research Bulletin Punjab University, (Science),* 38 (Ill-IV), 9–14.

Walia, V.K. (1998) Studies on the Geometridae of North West India – Subfamily Geometrinae. *Research Bulletin Punjab University, (Science),* 39 (1/2), 101–107.

Walker, B.H. (1992) Biodiversity and ecological redundancy. *Conservation Biology*, 6, 18–23.

Walia, V.K. (2005) Insecta: Lepidoptera: Geometridae (Moths). *In*: *Fauna of Western Himalaya, 2*, Published by the Director, Zoological Survey of India, Calcutta, pp. 181-190.

Wang, B., Tang, H. and Xu, Y. (2017). Integrating ecosystem services and human well-being into management practices: Insights from a mountain-basin area, China. *Ecosystem Services*, 27, 58–69.

Ward, D.F. and Larivière, M.C. (2004) Terrestrial invertebrate surveys and rapid biodiversity assessment in New Zealand: lessons from Australia. *New Zealand Journal of Ecology*, 28 (1), 151–159.

White, A.E., Dey, K.K. Mohan, D. Stephens, M. and Price, T.D. (2019) Regional influences on community structure across the tropical-temperate divide. *Nature Communications*, 10, 2646.

Willott, S.J. (1999). The effects of selective logging on the distribution of moths in a Bornean rain forest. *Philosophical Transactions of the Royal Society of London*, Series B, 354, 1783–1790.

Wilson, E.O. (1992) *The Diversity of Life*. Cambridge, MA: Belknap Press of Harvard University Press, 424 pp.

Wolda, H. (1983) Diversity, diversity indices and tropical cockroaches. *Oecologia*, 58, 290–298.

Wyckhuys, K.A., Sanchez Garcia, F.J., Santos, A.M., Canal, N.A., Furlong, M.J., Melo, M.C., Gc, Y.D. and Pozsgai, G. (2022) Island and mountain ecosystems as testbeds for biological control in the anthropocene. *Frontiers in Ecology and Evolution*, 10.

Yamamoto, S. and Sota, T. (2007) Phylogeny of the Geometridae and the evolution of winter moths inferred from a simultaneous analysis of mitochondrial and nuclear genes. *Molecular Phylogenetics and Evolution*, 44 (2): 711–723.

Yela, J.L. and Holyoak M. (1997) Effects of moonlight and meteorological factors on light and bait trap catches of noctuid moths (Lepidoptera: Noctuidae). *Environmental Entomology*, 26, 1283–1290.

Young, C.J. (2006) Molecular relationships of the Australian Ennominae (Lepidoptera: Geometridae) and implications for the phylogeny of the Geometridae from molecular and morphological data. *Zootaxa*, 1264 (1), 1–147.

Zhang, W., Huang, D., Wang, R., Liu, J. and Du, N. (2016) Altitudinal patterns of species diversity and phylogenetic diversity across temperate mountain forests of northern China. *PloS one*, 11 (7), p. e0159995.

Appendix 1: Comprehensive details of sampling date codes (used in the material examined) and average trap night weather parameter for DMR.

Locality Name	Location code	Sampling date code	Date	Avg. Temperature (°C)	Avg. Relative Humidity (%)	Avg. Wind speed (km/h)	Avg. Cloud cover (%)	Moon Phase
Rakh	KAR08A	KAR08A01	02.V.2022	24.8	58.75	1	2.5	WX I
		KAR08A02	28.V.2022	21.9	90.143	4.2	0	WN XII
		KAR08A03	17.IX.2020	22.89	64.87	0.72	57.44	NM
		KAR08A04	13.X.2020	17.3	80.8	1.4	0	WN XI
		KAR08A05	14.X.2020	15.9	78.6	0.1	0	WN XII
Paroh Bari	KAR08B	KAR08B01	02.IV.2021	11.43	20.57	4.02	0	WN IV
		KAR08B02	05.V.2021	17.13	32.37	3.37	5	WN VIII
		KAR08B03	09.IX.2020	20.67	92.11	1.05	41.66	WN VII
		KAR08B04	10.IX.2020	20.2	88.77	1.78	41.11	WV VIII
		KAR08B05	15.X.2020	15.7	50.7	2	0	WN XIII
Kent nala	KAR08C	KAR08C01	18.IV.2021	12.86	31.38	2.19	27.38	WX VI
		KAR08C02	06.V.2021	16.37	51.13	2.35	74.37	WN IX
		KAR08C03	08.IX.2020	20	91.11	0.4	45.55	WN VI
		KAR08C04	18.IX.2020	17.67	82.11	1.6	27.7	WX I
		KAR08C05	12.X.2020	14.2	80.3	0.1	16.11	WN X
Sudher	KAR08D	KAR08D01	03.V.2022	20.5	56.62	3.8	3.125	WX II
		KAR08D02	25.V.2022	20.1	88	1	22.86	WN IX
		KAR08D03	24.X.2020	17.1	37	4.4	0	WX VII
		KAR08D04	02.X.2021	19.4	93.88	4.53	38.75	WN XI
Maniyana	KAR11A	KAR11A01	16.IV.2021	17.25	31	6.43	89	WX IV

		KAR11A02	01.V.2021	22	13	7.41	71.9	WN IV
		KAR11A03	01.VI.2021	20	13.5	4.85	60.62	WN VI
		KAR11A04	06.IX.2020	20.66	61.66	6.4	61.11	WN IV
		KAR11A05	07.IX.2020	20.5	62.09	7.6	6.1	WN V
		KAR11A06	16.X.2020	17.2	35.2	4	0	WN IV
Dhanoti/Kotla	KAR11B	KAR11B01	03.IV.2021	14.86	17.5	2.73	0	WN V
		KAR11B02	02.V.2021	21.25	14.63	4.1	58.13	WN V
		KAR11B03	11.V.2022	24.43	49.7	1.1	8.6	WX X
		KAR11B04	05.IX.2020	21.3	70.4	1.83	60	WN III
		KAR11B05	16.IX.2019	21.55	70.11	0.4	63.89	WN IV
		KAR11B06	11.X.2020	18.2	42.2	0.6	0	WN IX
Maiti	KAR11C	KAR11C01	09.V.2022	24.16	61	8.16	71.6	WX VIII
		KAR11C02	26.V.2022	22.74	57.7	4.7	12.86	WN X
		KAR11C03	25.X.2020	17.2	18.9	4.3	29.5	WX VIII
		KAR11C04	01.X.2021	20.86	92.87	3.65	66.8	WN X
Baladi Mod	KAR11D	KAR11D01	10.V.2022	20	73.14	2.1	0	WX X
		KAR11D02	27.V.2022	18.9	93.143	1.4	20	WN XI
		KAR11D03	30.IX.2021	20.17	93	3	81.25	WN IX
		KAR11D04	12.X.2021	14.73	79.75	5.63	5	WX VI
Ghera	KAR14A	KAR14A01	04.IV.2021	17	21.75	5.59	70	WN VI
		KAR14A02	03.V.2021	18.9	18.85	4	73.125	WN VI
		KAR14A03	23.X.2020	13.06	43.25	3.81	0	WX VI
		KAR14A04	29.IX.2021	18.01	99	2.85	36.87	WN VIII
Nora	KAR14B	KAR14B01	15.IV.2021	14.88	14	14	64.38	WX III
		KAR14B02	04.V.2021	15	63.87	3.75	71.87	WN VII
		KAR14B03	08.X.2020	13.8	54.9	1.2	0	WN VI
		KAR14B04	09.X.2020	13.5	51.4	1.3	0	WN VII

Kareri Khas	KAR17A	KAR17A01	14.IV.2021	14.06	14	4.45	3.75	WX II
		KAR17A02	19.V.2022	21.1	45.67	4.87	0	WN III
		KAR17A03	05.X.2020	13.1	55.8	2.8	0.5	WN III
		KAR17A04	06.X.2021	14.2	91.13	1.49	0	NM
Harnala	KAR17B	KAR17B01	06.IV.2021	15	45	12.18	87	WN VIII
		KAR17B02	13.IV.2021	13.96	14.13	3.13	3.13	WX I
		KAR17B03	08.V.2021	12.25	36.13	1.78	33.13	WN XI
		KAR17B04	06.X.2020	13.4	76.3	0.1	0	WN IV
		KAR17B05	07.X.2020	13.2	61.2	0.2	0	WN V
Nauhali Bridge	KARDEOA	KARDEOA01	12.IV.2021	13.59	15.5	1	5.6	NM
		KARDEOA02	03.X.2020	13.9	40.33	1.04	2.2	WN I
		KARDEOA03	17.IX.2021	15.38	79.88	20	2.45	WX X
Dharamkot	KARDEOB	KARDEOB01	04.V.2022	16.52	58.57	1.6	5.7	WX III
		KARDEOB02	24.V.2022	12.43	79.17	2.8	21.67	WN VIII
		KARDEOB03	21.X.2020	12.8	0	1.7	1.7	WX IV
		KARDEOB04	03.X.2021	16.56	85.13	2.16	0.5	WN I
Nauhali Bridge.2	KAR20A	KAR20A01	11.IV.2021	12.75	14	3.88	0	WN XIII
		KAR20A02	14.V.2021	11.2	44.2	3	58	WX II
		KAR20A03	15.IX.2020	18.89	70	0.4	18.88	WN XIII
		KAR20A04	04.X.2020	13.4	46.9	1.5	0	WN II
Bharodi	KAR20B	KAR20B01	10.IV.2021	11.44	14.86	3.25	0	WN XII
		KAR20B02	15.V.2021	10.5	33.8	4.61	10	WX III
		KAR20B03	22.IX.2021	13.51	98	2.43	88.13	WN I
		KAR20B04	28.IX.2021	14.79	99	2.33	21.25	WN VII
Above Bharodi	KAR23A	KAR23A01	19.IV.2021	8.45	17.86	3.43	4.34	WX VII
		KAR23A02	05.V.2022	11.9	81.6	5.74	0	WX IV
		KAR23A03	23.IX.2021	12.91	97.5	6.34	72.5	WN II

		KAR23A04	27.IX.2021	15.16	95	5.99	33.75	WN VI
Rheoti	KAR23B	KAR23B01	07.IV.2021	4.64	72	2.19	18.13	WN IX
		KAR23B02	20.V.2022	12.1	61.86	3.7	23.6	WN IV
		KAR23B03	25.IX.2021	9.5	99	3.29	0	WN IV
		KAR23B04	26.IX.2021	11.93	99	2.54	36.88	WN V
Uttawala	KAR26A	KAR26A01	08.IV.2021	3.7	29	2.8	0	WN X
		KAR26A02	23.V.2022	10.6	79.8	0	73	WN VII
		KAR26A03	12.IX.2020	11.44	54.55	1.78	22.5	WN X
		KAR26A04	13.IX.2021	10.75	86.13	3.44	8.75	WX VI
Upparala Uttawala	KAR26B	KAR26B01	09.IV.2021	4.6	14.75	2.6	0	WN XI
		KAR26B02	08.V.2022	11.41	62	3	12	WX VII
		KAR26B03	16.IX.2021	9.54	79.38	3.8	0	WX IX
		KAR26B04	24.IX.2021	10.86	99	2.79	22.5	WN III
Kareri Lake	KAR29A	KAR29A01	07.V.2022	6.8	96.86	5.5	1.4	WX VI
		KAR29A02	21.V.2022	8.96	65.16	5.6	1.17	WN V
		KAR29A03	13.IX.2020	7.78	88.44	2.58	0	WN XI
		KAR29A04	14.IX.2020	7	78	3.35	0	WN XII
Mundkallan	KAR29B	KAR29B01	06.V.2022	2.9	87.5	2.6	2.5	WX V
		KAR29B02	22.V.2022	5.3	81.25	1.9	51.25	WN VI
		KAR29B03	14.IX.2021	6.8	89.38	2.74	36.25	WX VII
		KAR29B04	15.IX.2021	7.38	86.5	4.5	69.38	WX VIII
Bir14A	RAJ14A	RAJ14A01	13.VI.2021	13.94	34.6	5.4	0	WX IV
		RAJ14A02	29.V.2022	18.61	60.63	4.61	0	WN XIII
		RAJ14A03	20.IX.2020	17.33	76.33	4.5	13.3	WX III
		RAJ14A04	12.IX.2021	16.87	89	1.68	85.63	WX V
Bir14B	RAJ14B	RAJ14B01	12.VI.2021	17.26	38.34	4.67	25.84	WX III
		RAJ14B02	09.VI.2022	22.3	36.89	3.3	18.33	WX X

		RAJ14B03	11.IX.2021	16.75	54.25	3.88	73.75	WX IV
		RAJ14B04	11.X.2021	16.65	63.63	3.85	0	WX V
Gunehar	RAJ17A	RAJ17A01	14.VI.2021	18.43	33.72	2	67.15	WX II
		RAJ17A02	08.VI.2022	23.89	30	3.26	8.75	WX IX
		RAJ17A03	27.IX.2020	13.11	84.44	1	0	WX X
		RAJ17A04	10.IX.2021	19.13	63.63	0	75.63	WX III
		RAJ17A05	10.X.2021	15.21	73.63	3.44	0	WX IV
Billing 4 No turn	RAJ17B	RAJ17B01	11.VI.2021	19	31.7	1.42	42.14	WX I
		RAJ17B02	30.V.2022	19.29	37.75	0	10	NM
		RAJ17B03	09.IX.2021	18.8	55.63	0	63.75	WX II
		RAJ17B04	09.X.2021	15.63	92.13	2.94	5	WX III
Billing20A	RAJ20A	RAJ20A01	10.VI.2021	17	39.25	4.1	71.25	NM
		RAJ20A02	31.V.2022	18.73	42.37	1.33	16.25	WX I
		RAJ20A03	26.IX.2020	13.89	45.44	1.4	3.33	WX IX
		RAJ20A04	08.IX.2021	17.5	64.37	3.29	53.75	WX I
Billing 8 No turn	RAJ20B	RAJ20B01	09.VI.2021	18.38	31.13	3.25	12.5	WN XIV
		RAJ20B02	07.VI.2022	21.13	34.13	2.36	20.62	WX VIII
		RAJ20B03	07.IX.2021	17	100	0	83.75	NM
		RAJ20B04	08.X.2021	14.64	89.87	3.66	0	WX II
Billing23A	RAJ23A	RAJ23A01	08.VI.2021	18.38	28	3.16	4.38	WN XIII
		RAJ23A02	01.VI.2022	16.7	33.45	1	0	WX II
		RAJ23A03	06.IX.2021	14.9	54.5	2.85	34.38	WN XV
		RAJ23A04	07.X.2021	14.16	88.12	0	0	WX I
Billing23B	RAJ23B	RAJ23B01	07.VI.2021	14.63	44.36	2.3	33	WN XII
		RAJ23B02	06.VI.2022	16.56	39.14	1.1	34.29	WX VII
		RAJ23B03	21.IX.2020	14.22	62.33	1	0	WX IV
		RAJ23B04	05.IX.2021	14.13	76.23	2.05	8.75	WN XIV

Chaina Pass	RAJ26A	RAJ26A01	03.VI.2021	10.43	32.86	2.63	14.3	WN VIII
		RAJ26A02	02.VI.2022	13.8	37.25	2.1	2.5	WX III
		RAJ26A03	25.IX.2020	11	76.3	1.5	35	WX VIII
		RAJ26A04	04.IX.2021	13	81.5	1.4	0	WN XIII
Rasoi	RAJ26B	RAJ26B01	06.VI.2021	10.13	37.25	2.71	2	WN XI
		RAJ26B02	05.VI.2022	13.85	47.71	0	12.5	WX VI
		RAJ26B03	01.IX.2021	11.89	82.43	0	0	WN X
		RAJ26B04	02.IX.2021	10.84	91.3	3.1	35.84	WN XI
Palachak	RAJ29A	RAJ29A01	04.VI.2021	8.63	35.86	4.29	12.5	WN IX
		RAJ29A02	03.VI.2022	12.01	46.71	2.7	18.76	WX IV
		RAJ29A03	22.IX.2020	10.55	63.44	1.1	0	WX V
		RAJ29A04	30.VIII.2021	11.83	76.5	0	4.46	WN VIII
Jhoardi	RAJ29B	RAJ29B01	05.VI.2021	5.85	47.14	3.14	29.3	WN X
		RAJ29B02	04.VI.2022	8.53	60.86	5.5	7.14	WX V
		RAJ29B03	23.IX.2020	7.83	76.83	1.76	5.33	WX VI
		RAJ29B04	31.VIII.2021	9.04	87.13	3.05	51.88	WN IX

***Abbreviations/signs used*: ANI**- Andaman and Nicobar Islands, **AP**- Andhra Pradesh, **AR**- Arunachal Pradesh, **AS**- Assam, **BH**- Bihar, **CH**- Chandigarh, **CT**- Chhattisgarh, **DL**- Delhi, **GA**- Goa, **GJ**- Gujarat, **HR**- Haryana, **HP-** Himachal Pradesh, **JK**- Jammu and Kashmir, **JH**- Jharkhand, **KA-** Karnataka, **KL**- Kerala, **LD**- Lakshadweep, **MP-** Madhya Pradesh, **MH-** Maharashtra, **MN**- Manipur, **ML**- Meghalaya, **MI**- Mizoram, **NL**- Nagaland, **OD**- Odisha, **PY**- Pondicherry, **PB**- Punjab, **RJ**- Rajasthan, **SK**- Sikkim, **TN-** Tamil Nadu, **TS-** Telangana, TR**-** Tripura, **UP**- Uttar Pradesh, **UT-** Uttarakhand, **WB**- West Bengal,

HP*- New Record to India, **HP**- New Record to Himachal Pradesh.

Appendix 2: List of Identified species of Geometridae moth species/subspecies of DMR

Family: Geometridae Leach, 1815				
Subfamily: Sterrhinae Meyrick, 1892				
Sr. No.	**Scientific name**	**Material Examined**	**Distribution**	
			India	**Global**
1	*Chrysocraspeda faganaria* (Guenée, [1858])	KAR11A05 (1), KAR11B03 (2)	GJ, **HP,** KL, ML, OR, RJ, TN, UP, WB	Brazil (TL), China, Hong Kong, Indonesia, Sri Lanka.
2	*Chrysocraspeda olearia olearia* (Guenée, [1858])	KAR11A05 (2)	HP, JK, JR, KL, MH, RJ, SK, UK	China, Hong Kong, Sri Lanka, Thailand
3	*Cyclophora obstataria obstataria* (Walker, 1861)	RAJ14B03 (1), KAR14A01(1), KAR11D03 (1)	AR, **HP,** ML, TN	Borneo (Sarawak), Indonesia (Sumatra), Sri Lanka (Ceylon), Thailand (Malay Peninsula)
4	*Idaea grisescens* (Warren, 1896)	KAR11D01 (1), KAR11D03 (2), KAR11C01 (1), KAR08A01 (1), KAR14A04 (1), KAR08B02 (1), KAR08C01 (1), KAR08C05 (1),	**HP,** ML	No documentation
5	*Idaea macrospila* (Prout, 1926)	KAR11D03 (1), KAR08D04 (1), RAJ20A03 (1)	ANI, **HP**, KL, MH, RJ, WB	No documentation
6	*Idaea persimilis* (Warren, 1896)	KAR11D03 (2), KAR08A04 (1), KAR08D04 (1), RAJ17A04 (1), KAR11B01 (1), KAR14A01 (1)	AS, **HP,** ML	No documentation

7	*Idaea protensa* (Butler, 1889)	RAJ20A03 (1), RAJ17A04 (1), RAJ17B03 (1)	AR, HP	Nepal
8	*Idaea ruptifascia* (Warren, 1896)	KAR26B02 (1), KAR08A01 (1), KAR08B01 (1), RAJ23A04 (1), KAR14A04 (1), KAR11A06 (1)	**HP**, ML	No documentation
9	*Lophophleps informis* (Warren, 1897)	RAJ14A02 (2), RAJ17B02 (1), RAJ14B02 (1), RAJ20A04 (1)	HP, ML	Indonesia, Nepal, Taiwan
10	*Organopoda carnearia himalaica* Prout, 1938	KAR14A01 (1), KAR17B01 (1), KAR08B04 (1), RAJ23A01 (1)	**HP**, ML, SK	Borneo (Kinabalu), China (Hainan), Formosa, Indonesia (Java, Sumatra, Mentawi), Japan (RyuKyu
11	*Perixera niveopuncta* (Warren, 1897)	KAR11A04 (1), KAR14A04 (1), RAJ14B01 (1), KAR11D03 (1), KAR08C03 (1)	**HP**	**A**ustralia, Borneo, Indonesia (Celebes), Malaysia (Sabah), New Caledonia (Loyalty Islands), Papua New Guinea.
12	*Problepsis albidior* Warren, 1899	RAJ17A04 (2)	AR, HP, MZ, UK, WB	China (Tibet), Indonesia, Japan, Korea, Nepal, New Guinea, Taiwan, Thailand
13	*Problepsis vulgaris* Butler, 1889	KAR08A02 (1), KAR11D03 (2), KAR11B04 (1), KAR08C05 (1), KAR08A05 (1), KAR11C04 (1), KAR08D02 (1), KAR11C03 (1)	AR, AS, DL, HP, GJ, KA, KL, MH, MN, ML, PB, UK, WB	Bangladesh, China, Hong Kong, Malaysia, Myanmar, Nepal, Sri Lanka, Thailand, Vietnam
14	*Rhodometra sacraria* (Linnaeus, 1767)	KAR08A01 (2), KAR08A02 (2), KAR11B03 (2), KAR08D02 (1), KAR08C02 (1), KAR11A02 (1)	HP, MP, MH, ML, PB, TN, UK, UP, WB	Cosmopolitan
15	*Rhodostrophia herbicolens* (Butler, 1883)	Kumari et al. 2024	HP, UK	No documentation
16	*Rhodostrophia pelloniaria* (Guenée, 1858)	Kumari et al. 2024	HP, JK, ML, UK	Pakistan

17	*Rhodostrophia stigmatica* Butler, 1889	Kumari et al. 2024	HP, UK	Nepal
18	*Rhodostrophia tristrigalis* Butler, 1889	Kumari et al. 2024	HP, UK	Bhutan, China, Myanmar, Tibet
19	*Rhodostrophia vinacearia* (Moore, 1868)	Kumari et al. 2024	ML, WB	No documentation
20	*Scopula achrosta* Prout, 1935	KAR14B04 (1), KAR11B06 (1), KAR14A03 (2), RAJ20A03 (1), KARDEOB03 (1), KAR11D03 (2), RAJ26A02 (1), KAR08A05 (1), KAR23B02 (1), KAR11A06 (1), KAR17A01 (1), KAR14B03 (1), KAR11D01 (1)	HP, JK, UK	Pakistan
21	*Scopula bispurcata* (Warren, 1898)	KAR11D03 (2), KAR14B04 (1), KAR17B05 (1), KAR14B01 (1), RAJ20B01 (1), RAJ14B03 (1), RAJ26B01 (1)	AS, **HP,** ML	No documentation
22	*Scopula butleri* (Prout, 1913)	KAR08A01 (1), KAR08C03 (1), KAR08B04 (2)	HP	China, Japan, Korea, Russia
23	*Scopula cuneilinea* (Walker, [1863])	KAR11A (1)	AS, HP, MH, MN, ML, MZ, NL, PB, UK, UP, TR, WB	Nepal
24	*Scopula emissaria emissaria* (Walker, 1861)	KAR08A03 (1), KAR08D04 (1), KAR11B03 (1)	GJ, KA, MH, ML, OD, TN, UP, WB	China, Hong Kong, Korea, Myanmar, Sri Lanka, Vietnam
25	*Scopula fibulata* (Guenée, [1858])	KAR11D03 (1), KAR14A04 (2), KAR14B01 (1), KAR11A02 (1), KAR08D01 (1)	**HP**, KL, MH, MP, ML, PB, TN, WB	Hainan, Myanmar, Pakistan, Sri Lanka (Ceylon), Tonkin
26	*Scopula idearia* (Swinhoe, 1886)	KAR08A03 (1), KAR11B01 (1), KAR11D03 (1),	**HP**, MH	No documentation

		KAR08C03 (1), KAR08A05 (1), KAR08D01 (1), KAR11A05 (1), KAR08A01 (1), KAR08C05 (1), KAR08C02 (1)		
27	*Scopula terminata mechadoi* (Hausmann, 1993)	KAR14B04 (1), KAR11D03 (1), RAJ20B03 (1), RAJ20B03 (1), KAR08D02 (1), KAR14A04 (1)	**HP**	Pakistan (Hindu Kush and Karakoram)
28	*Somatina anthophilata* (Guenée, [1858])	KAR11B06 (1), KAR11A06 (2), KAR08D01 (1), KAR08A02 (1), KAR11C04 (1)	AI, AS, CT, **HP,** KL, MP, MH, MN, MZ, NL, TR, WB	Bangladesh, Myanmar, Nepal, Pakistan
29	*Somatina plynusaria* (Walker, F., [1863])	KAR11C02 (1), RAJ17A02 (1), RAJ14B02 (1),	AS, **HP**, KL, TN	Bangladesh
30	*Tanaotrichia prasonaria trilineata* Warren, 1893	KAR08D04 (1), KAR11B02 (1), KAR08B02 (1), KAR11C04 (1)	**HP,** SK	No documentation
31	*Timandra convectaria* Walker, 1861	KAR14B03 (1), RAJ17A04 (1), KAR14A04 (1)	AS, **HP,** MH, SK, TN, WB	Bangladesh, China, Hong Kong, Indonesia, Japan, Korean Peninsula, Philippines, Russia, Taiwan, Tibet, Vietnam
32	*Timandra correspondens* Hampson, 1895	KAR17B (1), KARDEOB03 (1), RAJ20A04 (1), RAJ23A02 (2), KAR14B04 (1), KAR11D03 (1), KAR17B05 (1), RAJ14B03 (1), RAJ17A04 (1), RAJ26A04 (1),	AR, AS, HP, KL, MA, ML, NL, RJ, TN, UK, WB	Bhutan, China, Myanmar, Nepal, Vietnam
33	*Traminda mundissima* (Walker, F., 1861)	KAR08A04 (2), KAR08A05 (1), KAR08A01 (1)	DL, HP, GJ, KA, KL, MH, RJ, PB, TN, UK, UP, WB (Throughout India)	Australia, Myanmar, Nepal, Sri Lanka, UAE
Subfamily: Larentiinae Duponchel, 1845				

34	*Amnesicoma simplex* Warren, 1895	RAJ29A03 (1)	HP, JK, UK	China, Nepal, Pakistan, Tibet
35	*Apithecia viridata* (Moore, 1868)	RAK23B01 (2), RAJ23B03 (2), KAR14B04 (1), KAR11B06 (1), KAR11D03 (1), KARDEOB01 (2)	**HP,** MH, ML, SK, UK, WB	Nepal
36	*Asthena albosignata* (Moore, 1888)	RAJ29A02 (4)	**HP,** J&K, SK, WB	China, Nepal
37	*Atopophysa indistincta* (Butler, 1889)	RAJ20B03 (2), RAJ17A03 (1), RAJ23A04 (1), KAR20A03 (1),	HP, ML	China, Myanmar, Nepal, Taiwan
38	*Callabraxas (Chalcoptera) trigoniplaga* Hampson, 1895	RAJ26B03 (1)	**HP,** UK	Myanmar, Nepal, Tibet.
39	*Calluga costalis* Moore, [1887]	KAR11D03 (2)	**HP**, GJ, ML, NL, TN	Bhutan, Myanmar (Burma), Nepal, Sri Lanka, Taiwan
40	*Colostygia albigirata* (Kollar, [1844])	RAJ23B03 (2), KARDEOB03 (2), RAJ17B04 (1), KAR29A03 (1), KAR17B05 (1)	HP, J&K, SK, UK, WB	Afghanistan, China, Japan, Mongolia, Myanmar, Nepal, Russia
41	*Docirava aequilineata* Walker, [1863]	RAJ23A04 (1)	HP, UK	Nepal
42	*Docirava postochrea* Hampson, 1893	KAR26A03 (1), KAR26B02 (1), RAJ26A04 (1), KAR29A01 (1),	HP, UK	Nepal
43	*Docirava pudicata* (Guenée, [1858])	RAJ23404 (2), RAJ17B02 (2)	AR, HP, SK, UK, WB	Afghanistan, Nepal, Vietnam
44	*Dysstroma dentifera* (Warren, 1896)	KARDEOB03 (2), RAJ29B03 (2), KAR08D03 (1), KAR26A01 (2), KAR26A03 (1), KAR29A03 (1)	HP, UK, WB	Nepal, Taiwan
45	*Dysstroma fulvipennis* (Hampson, 1902)	KAR2903 (1), RAJ29A04 (2),	HP, J&K, UK	No documentation

		RAJ26B03 (2), RAJ23B04 (3)		
46	*Dysstroma planifasciata* (Prout, 1914)	RAJ23B01 (3), KAR26A03 (1), KAR29A03 (1), RAJ26B04 (1)	HP, JK, UK	Nepal
47	*Dysstroma shirakawai* Yazaki, 2000	RAJ29A04 (1), KAR29A03 (6)	HP, UK	Nepal
48	*Dysstroma subapicaria* (Moore, 1868)	KAR26A03 (2), KAR29A03 (1), RAJ26B03 (1)	**HP,** WB	Nepal
49	*Ecliptopera dentifera* (Moore, 1888)	RAJ17B04 (2), KARDEOB03 (2), KAR11D03 (1), RAJ17B02 (2)	AS, HP, SK, WB	No documentation
50	*Ecliptopera relata* (Butler, 1880)	KAR26A03 (1), RAJ23B03 (2), RAJ20A04 (1)	HP, ML, SK, UK	Bhutan, Nepal
51	*Ecliptopera triangulifera* (Moore, 1888)	RAJ20A04 (2), RAJ17B04 (2), KARDEOB01 (1)	HP, ML, SK, WB	Nepal
52	*Electrophaes aliena* (Butler, 1880)	KARDEOB03 (1), RAJ26A02 (1), KAR14A01 (2), RAJ23B02 (1), KAR29A01 (1), KAR17B05 (1)	AR, HP, SK, UK, WB	Bhutan, Nepal
53	*Electrophaes marginata* Yazaki, 1994	RAJ29B02 (1), RAJ26A02 (2), RAJ29A02 (6), RAJ26B01 (1), KAR29A01 (1)	**HP,** UK	Nepal
54	*Electrophaes niveonotata* (Warren, 1893)	KAR23B02 (1), KARDEOB03 (1), RAJ26A02 (4)	AR, HP, SK, UK, WB	Bhutan, Nepal
55	*Euphyia variegata* (Moore, 1868)	RAJ17B04 (1), KARDEOB03 (2), KAR14A03 (1), RAJ23B04 (1), RAJ20A04 (1)	HP, SK, TN, WB	Bhutan, China
56	*Euphyia submarginata* (Warren, 1909)	KAR26A03 (1), RAJ23B03 (1), RAJ23B04 (1), KARDEOB03 (1), RAJ20A04 (1)	**HP**, JK	Pakistan

57	*Eupithecia albigutta* Prout, 1958	KAR26B02 (1), RAJ14A02 (1), RAJ29A01 (1)	HP, JK	Nepal, Pakistan, Taiwan
58	*Eupithecia maculosa* Vojnits, 1981	RAJ26A04 (3), RAJ29A04 (2)	**HP**, JK, WB	Nepal, Pakistan
59	*Eupithecia melanolopha* Swinhoe, 1895	KAR14B04 (1)	**HP**, ML	Nepal, Sri Lanka
60	*Eustroma aurigena* (Butelr, 1880)	RAJ26B04 (1)	HP, ML, SK, WB	Nepal
61	*Eustroma chalcoptera* (Hampson, 1896)	RAJ29A04 (1), RAJ26B04 (1)	**HP**, SK, UK	Nepal
62	*Evecliptopera decurrens decurrens* (Moore, 1888)	KAR20A03 (1)	**HP**, ML, UK	China Japan, Korea
63	*Gagitodes*(*Perizoma*) *parvaria* (Leech, 1891)	RAJ20B03 (1)	**HP**, ML, NL	China, Japan, Korea, Nepal, Russia
64	*Gagitodes* (*Perizoma*) *plumbeata* (Moore, 1888)	RAJ29A04 (1), KAR29A03 (1), RAJ14A02 (1)	HP, SK, UK, WB	Nepal
65	*Gagitodes* (*Perizoma*) *saxicola* (Tikhonov, 1994)	Photographic evidence	HP, SK, WB	Nepal, Russia
66	*Girida* (*Eupithecia*) *rigida* (Swinhoe, 1892)	KAR08A01 (2), KARDEOB01 (1)	**HP**, ML	Borneo (Kinabalu), Japan, New Caledonia, Papua New Guinea (Rossel Island), Philippines, Solomons, Taiwan, Thailand, Timor.
67	*Heterothera consimilis* (Warren, 1888)	RAJ17B04 (2), RAJ20A04 (1), RAJ29A02 (2)	HP, J&K, UK, WB	Afghanistan, Nepal, Pakistan
68	*Heterothera dentifasciata* (Hampson, 1895)	KAR26A01 (2)	AR, HP, UK	Nepal, Pakistan
69	*Hydrelia bicolorata* (Moore, 1868)	RAJ23B01 (1), RAJ23B04 (3),	AR, AS, HP, ML, NL, SK, WB	China, Myanmar, Nepal, Taiwan

70	*Hydrelia sericea pampesia* Prout, 1938	RAJ23B04 (4), RAJ29A04 (3)	**HP,** JK	No documentation
71	*Hysterura multifaria* (Swinhoe, 1890)	RAJ29B02 (1), RAJ29A02 (1), RAJ29B02 (3), KAR23B02 (1), KAR26A03 (1), KAR29A03 (1)	AR, AS, HP, UK, WB	China, Nepal, Russia, Vietnam
72	*Lobogonodes multistriata* (Butelr, 1889)	KAR20A03 (2), RAJ20A03 (1), KAR17A02 (1)	HP, ML, SK, UK, WB	Algeria, China, Japan, Korea, Nepal
73	*Martania (Perizoma) albofasciata* (Moore, 1888)	KAR26B02 (1), RAJ14A02 (1)	HP, SK, UK, WB	Myanmar, Nepal, Taiwan
74	*Martania (Perizoma) antisticta* (Prout, 1938)	RAJ23B01 (1), RAJ29A04 (1)	HP	Pakistan
75	*Martania (Perizoma) fulvimacula* (Hampson, 1896)	KAR26A03 (2), KAR29A03 (3)	HP, WB	Nepal
76	*Martania (Perizoma) micropunctum* (Inoue, 2000)	KAR26B02 (3), KAR26A03 (1)	**HP,** UK, SK, WB	Nepal
77	*Martania (Perizoma) seriata* (Moore, 1888)	KAR23B01 (1), KAR26A01 (4), KAR29A03 (1)	HP, UK, WB	Nepal, Pakistan, Taiwan
78	*Martania (Perizoma) variabilis* (Warren, 1893)	KAR29A03 (3), RAJ29A01 (1)	HP, SK, UK, WB	Nepal
79	*Mesoleuca costipannaria* (Moore, 1868)	RAJ29A04 (1)	**HP**, SK, WB	China, Formosa
80	*Nebula brevifasciata* (Warren, 1888)	KAR20A03 (1), RAJ23B04 (1), RAJ26A04 (1), RAJ26B04 (1)	**HP***	Nepal, Pakistan
81	*Nebula (Protonebula) cupreata* (Moore, 1868)	RAJ20B03 (1)	HP, SK, WB	Nepal

82	*Nebula homophana* (Hampson, 1895)	KAR17B05 (1), KAR20B01 (1), KARDEOB03 (1)	HP, JK	Pakistan
83	*Neotephria ramalaria* (Felder & Rogenhofer, 1875)	KAR29B01 (1), RAJ29B02 (4)	HP, UK	Nepal
84	*Orthonama obstipata* (Fabrisius, 1794)	KAR08B03 (1), KAR08D01 (2), KAR08D02 (1), KARDEOB01 (1)	Throughout India	Afghanistan, Amur, Austria, Indonesia (Borneo), Buryatia, China, Germany, Iran, Irkutsk, Japan, Kazakhstan, Korea, Morocco, Nepal, Poland, Primorye, Sakhalin, Switzerland, Transbaikalia, Turkey, Turkmenistan.
85	*Pasiphila palpata* (Walker, 1862)	RAJ26B01 (2), KAR29A03 (1), KAR08A04 (1), KAR17A02 (1)	HP, SK, UK, TN	China, Indonesia (Borneo), Japan, Nepal, Sri Lanka, Taiwan
86	*Perizoma peculiare* Inoue, 2000	KAR26B02 (1), KAR26A03 (1), KARDEOB01 (1)	HP, JK, WB	Nepal, Thailand
87	*Photoscotosia amplicata* (Walker, 1862)	KAR29A03 (2), KAR26A03 (4), RAJ29B02 (1)	AR, AS, HP, JK, ML, SK, UK, WB	Bhutan, China, Myanmar, Nepal, Pakistan, Tibet
88	*Photoscotosia chlorochrota* Hampson, 1902	RAJ29B04 (1), RAJ29B04 (2)	**HP**	China, Nepal
89	*Photoscotosia dejuncta* Prout, 1937	RAJ26B03 (1), RAJ29B04 (1)	HP, JK, UK	No documentation
90	*Photoscotosia dejuta* Prout, 1937	KAR29A03 (2)	AR, HP, SK, UK	Bhutan, China, Nepal
91	*Photoscotosia fulguritis* Warren, 1893	KAR29A03 (1), RAJ29A04 (1)	**HP,** SK	Bhutan, Nepal
92	*Photoscotosia metachryseis* Hampson, 1896	KAR26A03 (1), KAR29A03 (1), RAJ29A04 (3)	**HP,** SK, UK	China, Nepal
93	*Photoscotosia miniosata* (Walker, 1862)	KAR11B06 (1), RAJ26B01 (1), KARDEOB03 (1), KAR26A03 (1),	AR, HP, PB, SK, UK, WB	Bangladesh (TL), Bhutan, China, Nepal, Pakistan, Phillipines, Taiwan.

		KAR20A03 (1), RAJ23B03 (1), KAR14A03 (1), KAR26B02 (1)		
94	*Photoscotosia nitida* Inoue, 1982	RAJ29A04 (1)	HP	Nepal
95	*Photoscotosia pallidimaculata* Yazaki, 1995	RAJ29B03 (1)	HP	Nepal
96	*Stamnodes pauperaria pamphilata* (Felder & Rogenhofer, 1875)	KAR26A03 (1), KAR20B04 (1), RAJ26B03 (1), RAJ26B03 (1)	HP, JK, SK, UK	Afghanistan, Kazakhstan, Kyrguzsta, Mongolia, Nepal, Russia
97	*Trichopterigia decorata* (Moore, 1888)	KARDEOB03 (3), KAR17B05 (2), KAR14A03 (1)	HP, ML, SK, UK, WB	Nepal
98	*Trichopterigia macularia* (Moore, 1868)	RAJ29B01 (1)	HP, SK, WB	No documentation
99	*Trichopterigia rufinotata* (Butler, 1889)	KARDEOB03 (3)	AR, HP, UK	Bhutan, Nepal, Taiwan, Tibet
100	*Triphosa dubiosata* (Walker, 1862)	RAJ23B03 (1), KAR17B05 (2), KAR11B06 (1),	HP, PB, SK, TN, UK	Afghanistan, Nepal
101	*Triphosa rubrodotata* (Walker, 1862)	RAJ26B01 (1), RAJ26A02 (1), KAR29A03 (1)	AR, HP, PB, SK, UK, WB	Nepal, Taiwan
102	*Tristeirometa decussata* (Moore, 1868)	KAR20A03 (1), KAR11B06 (1)	AR, AS, HP, KL, ML, SK, TN, UK, WB	Indonesia, Malaysia, Nepal, Taiwan
103	*Xanthorhoe greisiviridis* (Hampson, 1895)	RAJ23B03 (1), KAR26A03 (1), KAR17B05 (1), RAJ23A04 (1),	HP	Bhutan
104	*Xanthorhoe hampsoni* Prout, 1925	RAJ29B01 (1), RAJ29B02 (2)	HP, UK	Nepal
105	*Xanthorhoe saturata* (Guenée, [1858])	KAR26A03 (1), KAR29A03 (1), RAJ23B03 (2), RAJ17B04 (1), KAR14A03 (1),	HP, ML, TN, UK, WB	China, Japan, Korea, Pakistan, Taiwan, Vietnam.

		KAR14B04 (1), KAR11D03 (1)		
106	*Xenortholitha falcata* Yazaki, 1993	RAJ29B03 (1), KAR20B01 (2), KAR14B04 (1), KAR11D03 (1), RAJ20A04 (1), RAJ17B04 (1), RAJ17A04 (1), KAR08D04 (1)	HP, UK	Nepal
107	*Xenortholitha latifusata* (Walker, 1862)	KARDEOB03 (1), KAR17B05 (1), RAJ23B04 (1)	HP, UK	Pakistan
108	*Xenortholitha propinguata* (Kollar, [1844])	KARDEOB03 (1), RAJ20A04 (2)	HP, UK	China, Japan, Korea, Mongolia, Nepal, Russia, Tajikistan
Subfamily: Geometrinae Leach, 1815				
109	*Agathia hilarata hilarata* Guenée, [1858]	KAR11B03 (1), KAR14B04 (1)	Central India, HP, KA, UK	No documentation
110	*Chloroglyphica variegata* Butler, 1889	RAJ23B01 (1), KAR17B05 (1)	AR, HP, ML	Nepal, Pakistan
111	*Chlororithra fea* (Butler, 1889)	RAJ20A02 (1), RAJ20B02 (2)	AR, HP, ML, PB, UK, SK, WB	Bhutan, China, Myanmar, Nepal, Pakistan, Tibet
112	*Comibaena cassidara* (Guenée, [1858])	KAR11D03 (1), KAR11B04 (1), KAR11B06 (1), KAR08D02 (1), KAR08C03 (1), KAR11C01 (1)	Central, North India	China, Nepal, Sri Lanka
113	*Comibaena pictipennis* Butler, 1880	RAJ26A02 (2), KARDEOB03 (1), RAJ23B03 (1), RAJ23B01 (2), RAJ29B04 (1)	AR, HP, J&K, ML, UK, WB	Bhutan, China, Formosa, Nepal, Taiwan, Tibet
114	*Comibaena quardinotata fuscidorsata* Prout, 1912	KAR14B04 (1), KAR11B06 (1), KAR08A04 (1), KAR08D04 (1)	AR, AS, HP, J&K, ML, UK, WB	China, Indonesia (Borneo, Sumatra), Japan, Malaysia, Nepal, Sri Lanka, Taiwan, Thailand
115	*Dindica para* Swinhoe, 1891	RAJ23A01 (2), RAJ23A02 (1)	**HP**, ML	Nepal
116	*Eucyclodes albisparsa* (Walker, F., 1861)	RAJ14A01 (1), KAR11B06 (1), KAR11D03 (1), KAR08D04 (1)	ANI, **HP,** KL, TN	Indonesia, Malaysia, Nepal, Sri Lanka

117	*Eucyclodes picturata* (Hampson, 1903)	KAR08A04 (1), KAR11D03 (2)	**HP,** KL, MH	Sri Lanka
118	*Geometra flavifrontaria* (Guenée, 1858)	RAJ17B04 (1), RAJ17A05 (1), RAJ23B02 (1), RAJ29A02 (1), RAJ17B02 (1), KAR11C02 (1), RAJ29B04 (1)	HP, UK	China, Nepal, Pakistan
119	*Herochroma cristata cristata* (Warren, 1894)	KAR11D03 (2), RAJ20B04 (1), KAR08D02 (1)	AS, HP, KL, ME, SK, TN, UK, WB	Bangladesh, Bhutan, Hong Kong, Indonesia, Nepal, Sri Lanka, Taiwan, Thailand
120	*Herochroma usneata* (Felder & Rogenhofer, 1875)	RAJ29B04 (1), RAJ26B03 (1)	**HP,** ML, SK	Nepal
121	*Iotaphora iridicolor* (Butler, 1880)	RAJ29A02 (1)	AR, HP, MN, ML, SK, UK, WB	Bhutan, China, Nepal, Tibet, Vietnam
122	*Linguisaccus subhyalina* (Warren, 1899)	KAR20A03 (1)	AR, HP, NL, UK	Bhutan, China, Indonesia (Borneo), Nepal, Pakistan
123	*Lophophelma erionoma* (Swinhoe, 1893)	KAR11B01 (1), KAR11D03 (1), KAR17B02 (1)	AR, **HP,** ML, SK, WB	China, Indonesia (Borneo), Malaysia, Nepal
124	*Lophophelma luteipes* (Felder and Rogenhofer, 1875)	Photographic evidence	HP, MH, ML, SK, TN	China
125	*Maxates glaucaria* (Walker, 1866)	RAJ20B04 (2), RAJ23A04 (1)	HP, SK, TN	Bhutan, Nepal, Taiwan, Tibet
126	*Maxates illiturata* (Walker, F., [1863])	RAJ20B02 (2), RAJ20A02 (1)	**HP***	China, Japan, Korea
127	*Maxates iridescens* (Warren, 1896)	KAR08C03 (1), KAR11D03 (2)	AS, HP	Nepal
128	*Metallolophia ornataria* (Moore, 1888)	KAR20A03 (1)	AR, **HP,** ML, SK, WB	Nepal
129	*Metallolophia assamensis* Orhant, 2000	KAR08B03 (1)	AS, HP	No documentation

130	*Metaterpna differens* (Warren, 1905)	RAJ20A02 (1)	HP	China, Nepal
131	*Mixochlora vittata vittata* (Moore, 1868)	KAR17B05 (2)	AR, AS, HP, ML, NL, SK, UK, WB	Bhutan, China, Indonesia, Japan, Korea, Malaysia, Myanmar, Nepal, Philippines, Taiwan, Thailand
132	*Pingasa pseudoterpnaria* (Guenée, [1858])	KAR08A03 (1), RAJ23B01 (2), KAR11D01 (1)	HP, ML, NL, UK, WB	China, Japan, Korea, Nepal
133	*Tanaorhinus reciprocata* (Walker, 1861)	KAR20A03 (1), RAJ20A03 (1), KAR17B05 (1),	AR, HP, ML, NL, SK, UK, WB	Bhutan, China, Japan, Korea, Nepal, Taiwan, Thailand
Subfamily: Ennominae Duponchel, 1845				
134	*Abaciscus tristis tristis* Butler, 1889	RAJ23B02 (1)	AR, HP, SK	Borneo, China, Nepal, Taiwan
135	*Abraxas antipusilla* Inoue, 1995	RAJ23B03 (3), RAJ23B01 (4), RAJ23A01 (1), RAJ29A02 (1), KAR20A01 (1), RAJ26A04 (1), RAJ20B01 (1)	AR, HP, SK, UK, WB	Nepal
136	*Abraxas circinata* Wehrli, 1935	RAJ23B04 (3), RAJ23B01 (4), RAJ23A01 (1), RAJ29A02 (1), KAR20A01 (1), RAJ26A04 (1), RAJ20B01 (1),	**HP***	Nepal
137	*Abraxas leopardina* (Kollar, [1844])	RAJ23B04 (4), RAJ23B02 (2), RAJ23B03 (2), RAJ23B01 (2), RAJ23A01 (2), RAJ26A01 (1), RAJ29A02 (1)	HP, UK	Nepal
138	*Abraxas peregrina* Inoue, 1995	RAJ20B04 (3), KAR23B02 (1), RAJ17A05 (1), KAR14B04 (2), RAJ17B03 (1)	HP, UK	Nepal
139	*Abraxas picaria* Moore, 1868	RAJFRH26 (1)	HP, SK, UK, WB	Nepal, China

140	*Abraxas sublepida* Inoue, 1995	RAJ23B02 (2), RAJ17B04 (1), KAR17B05 (1), KAR14B04 (1), KAR11B01 (1)	**HP,** WB	Nepal
141	*Abraxas superpicaria* Inoue, 1970	RAJ29B04 (1), RAJ23B01 (2)	HP, SK, UK, WB	Bhutan, Nepal
142	*Abraxas virginalis* Butler, 1886	KARDEOA03 (1)	AS, **HP**, J&K	Myanmar, Nepal, Pakistan
143	*Abraxesis melaleucaria* Hampson, 1902	KAR17B01 (1)	HP	Afghanistan, Pakistan
144	*Alcis limbui* Sato, 1994	KAR17B05 (3), RAJ23B03 (2), KARDEOA02 (2), KAR26A03 (2), KAR08B03 (1), RAJ26B01 (1), RAJ20B02 (2), KARDEOB03 (2), RAJ26B01 (2), RAJ17B04 (1), KAR20A03 (1), RAJ29B02 (1), RAJ17A05 (2), RAJ29B01 (1), RAJ20B04 (3), RAJ17B04 (1), KAR23A02 (5), RAJ17B02 (1)	HP	Nepal
145	*Alcis nigridorsaria* (Guenée, [1858])	RAJ29A04 (3), RAJ23B04 (1), RAJ26B03 (1), RAJ26B04 (1)	HP, SK	Nepal,Tibet
146	*Alcis perspicuata* (Moore, 1868)	RAJ17A05 (2), RAJ20B04 (3), KAR17B05 (1), KAR14B04 (1), KAR14A03 (1), RAJ17B04 (1)	HP, ML, UK, WB	Nepal
147	*Alcis quadrifera* (Walker, 1866)	RAJ20B03 (1), RAJ23B04 (3), KAR29A03 (1), KAR23B02 (1), RAJ26B01 (1), RAJ26B04 (1), KAR26A03 (2),	HP, SK, WB	Bhutan, Nepal

		RAJ23B03 (1), RAJ29A02 (4), KAR11B03 (1)		
148	*Alcis variegata* (Moore, 1888)	RAJ14A02 (1), KAR26A03 (1), KAR14B04 (1), KAR11B04 (1), RAJ17B02 (1), KAR17B05 (1), RAJ23B03 (1),	HP, ML, SK, UK, WB	China, Java, Laos, Malaysia, Myanmar, Nepal, Sumatra, Taiwan, Thailand, Vietnam.
149	*Amblychia pardicelata* (Walker, F., [1863])	KAR20B03 (1), KAR20A04 (1), KAR20B04 (1)	AR, HP, ML, SK, UK	Bangladesh (Sylhet), Bhutan, Laos, Myanmar, Nepal, Vietnam
150	*Amraica recursaria* (Walker, 1860)	KAR11 (1)	AR, **HP,** MH, ML, MP, SK, TN, UK	Borneo, Hong Kong, Indonesia (Java, Sumatra), Japan, Malaysia, Myanmar, Nepal, Pakistan, Taiwan, Thailand
151	*Anonychia diversilinea* Warren, 1897	RAJ23B03 (2), RAJ23B01 (1), KAR17B05 (1)	**HP,** SK, WB	Nepal
152	*Anonychia grisea* (Butler, 1883)	KAR17B05 (1), KAR14B04 (1), KAR11D04 (1), KAR23A02 (1)	AR, HP, MP, ML, SK, UK, WB	China, Myanmar, Nepal
153	*Anonychia lativitta* (Moore, 1888)	KAR29A03 (3), RAJ29A04 (1), RAJ26B04 (2)	HP, SK, UK, WB	Nepal
154	*Antipercnia belluaria* (Guenée, 1858)	KAR20A03 (1), KAR11A04 (1)	AR, AS, HP, J&K, ME, MZ, NL, SK, UK, WB	Bhutan, China, Malaysia, Nepal, Thailand
155	*Anydrelia dharmsalae* (Butler, 1883)	KAR11D03 (1), KAR14A04 (2)	HP	China
156	*Aplochlora dentisignata* (Moore, 1868)	KAR20A03 (1), KAR26A03 (2)	AR, HP, SK, UK, WB	Bhutan, Myanmar, Nepal
157	*Apoheterolocha patalata* (Felder & Rogenhofer, 1875)	RAJ29B02 (2)	AR, HP, ML, SK, UK	Bhutan, China, Indonesia (Borneo), Myanmar, Nepal, Taiwan.
158	*Arichanna conspersa* (Butler, 1880)	RAJ23B01 (2), RAJ23B02 (2),	**HP,** WB	Nepal

159	*Arichanna flavimedia* Hampson, 1895	KAR20A03 (1), RAJ26B02 (1)	**HP,** SK	Nepal
160	*Arichanna flavinigra* Hampson, 1907	KAR29A03 (1), KAR26A03 (1), KAR20A03 (1)	HP. J&K, PB, SK, UK	Bhutan, China, Myanmar, Nepal, Tibet
161	*Arichanna marginata* (Warren, 1893)	KAR20A03 (1), KARDEOB03 (1), KAR20B01 (1), KAR17A02 (1)	**HP,** NL, SK	Bhutan, Nepal, Taiwan, Thailand
162	*Arichanna schnitzleri* Stüning, 2000	RAJ23B01 (1), KAR23B01 (2), KAR17B01 (1)	AR, **HP**	Nepal
163	*Arichanna sparsa* (Butler, 1890)	RAJ29A04(1), RAJ23B02 (2), RAJ20B03 (1)	HP, UK	Nepal
164	*Arichanna tenebraria* (Moore, 1868)	KAR29A03 (1), KAR26A03 (2), RAJ23B01 (1), RAJ23B02 (1)	HP, ML, SK, UK	China, Nepal, Taiwan
165	*Astygisa orbapicalis* (Herbulot, 1993)	KAR11D02 (1), RAJ17B02 (1), KAR08A01 (1)	AR, AS, HP, ML, WB	Malaysia, Nepal, Pakistan
166	*Biston betularia nepalensis* Inoue, 1982	KAR11D03 (1), RAJ20A03 (1), RAJ23B03 (1), RAJ29B02 (1)	**HP**	China, Nepal
167	*Biston falcata* (Warren, 1893)	RAJ29A02 (2)	AR, HP, SK, UK, WB	Bhutan, China, Nepal, Tibet
168	*Biston regalis* (Moore, 1888)	RAJ20B02 (4)	AR, HP, J&K, ML, SK, UK, WB	China, Japan, Korea, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Russia, Taiwan, Thailand, USA
169	*Biston suppressaria* (Guenee, [1858])	KAR08D02 (1), RAJ14A02 (1)	AR, AS, CT, HP, JH, KA, MP, MH, NL, SK, TN, TR, UK, WB	Bangladesh, Bhutan, Burma, China, Hong Kong, Japan, Laos, Malaysia, Myanmar, Nepal, Pakistan, Sri Lanka, Thailand, Vietnam
170	*Calcyopa ochrifasciata* (Moore, 1888)	KARDEOB01 (1), KAR20B01 (1), RAJ17B02 (1), KAR17A02 (2), RAJ20A04 (3)	HP, ML, SK, WB	Nepal

171	*Calletaera subexpressa* (Walker, 1861)	KAR08D01 (1), KAR11D01 (1), KAR11C01 (1)	HP, UK	Borneo, China (Fujian, Guangdong, Hainan, Hong Kong, Guangxi), Indonesia, Nepal, Peninsular Malaysia, Philippines.
172	*Charissa crenulata crenulata* (Staudinger, 1871)	RAJ26B04 (1), RAJ26B02 (1), RAJ26B03 (1)	**HP***	Spain
173	*Chiasmia azataria* (Swinhoe, 1893)	KAR11B04 (1), KAR08B03 (1), KAR14B04 (1), KAR11D03 (1), RAJ20A03 (1), RAJ17A04 (1), RAJ20A02 (1), RAJ14A03 (1)	HP, ML	Nepal
174	*Chiasmia eleonora eleonora* (Cramer, [1780])	KAR11D01 (1), KAR11D03 (1), KAR08A01 (1)	Throughout India: AI, AS, AN, GO, HP, KA, KL, MH, MN, ML, MZ, NL, RJ, TN, TR, UP, UK, WB	Malaysia, Myanmar, Sri Lanka
175	*Chiasmia emersaria* (Walker, 1861)	KAR17B05 (1), RAJ17B04 (1), KAR11B06 (1), KAR08A01 (1)	Throughout India: AR, AS, GJ, HP, KA, KL, MH, MN, ML, MZ, NL, OR, TN, TR, UK, UP, WB	Bangladeh, Myanmar, Sri Lanka
176	*Chiasmia perfusaria* (Walker, 1866)	KAR08C03 (1), KAR08D01 (2), KAR11D01 (2), RAJ17B02 (1)	HP, KA, KL, ME, NL, SK, TN	Sri Lanka, Indonesia (Borneo) Malaysia (Mount Ophir), Myanmar (Rangoon), Malacca
177	*Chorodna creataria* (Guenée, [1858])	All are rece specimens	AR, AS, HP, ML, SK, WB	Bangladesh, China, Hong Kong, Laos, Nepal, Taiwan, Thailand, Vietnam
178	*Cleora propulsaria* (Walker, F., 1860)	KAR14B04 (1), KAR11D03 (2), KAR08D04 (1), KAR11B06 (1)	AR, **HP,** ME, NL, SK, TN, WB	Bhutan, China, Indonesia (Borneo), Malaysia, Myanmar, Philippines, Taiwan, Thailand

179	*Corymica deducta* (Walker, 1866)	KAR11B06 (1)	**HP,** KL, UK, WB	Indonesia, Nepal
180	*Corymica pryeri* (Butler, 1878)	KAR08B03 (1), KAR20A03 (2), RAJ26A03 (1), KAR14B04 (1)	AR, AS, HP, KL, WB	Australia, Indonesia (Borneo, Sumatra), Japan, Korea, New Guinea, Pakistan, Taiwan, Thailand.
181	*Cusiala boarmoides* Moore, [1887]	KAR08A03 (2), KAR08A02 (3), KAR11A03 (1)	HP, ML, SK, TN, UK, WB	Indonesia, Taiwan
182	*Dalima metachromata* (Walker, F., 1862)	KAR20B03 (1)	AR, HP, SK, UK, WB	Nepal, Vietnam
183	*Dalima patularia* (Walker, F., 1862)	KAR17B05 (1), KAR11D03 (1)	AR, HP, ML, SK, UK, WB	China, Indonesia Borneo, Indonesia (Sumatra, Sulawesi), Nepal, Thailand
184	*Dasyboarmia subpilosa* (Warren, 1894)	KAR08B03 (1), KAR08A01 (1), KAR11D01 (1), KAR08D01 (1), KAR08D03 (1)	HP, ML, UK, WB	Buru, Borneo, Peninsular Malaysia, Nepal, Philippines, Sulawesi, Sumatra, Thailand.
185	*Entomopteryx obliquilinea* (Moore, 1888)	RAJ14A01 (1)	AR, AS, **HP,** ME, SK, UK, WB	Bhutan, China, Hong Kong, Myanmar, Nepal, Vietnam
186	*Fascellina plagiata* (Walker, F., 1866)	KAR20A03 (1), RAJ17B04 (1), RAJ14B02 (1)	AR, AS, HP, KA, KL, ML, SK, TN, UK, WB	Bhutan, Borneo, China, Hong Kong, Indonesia, Myanmar, Malaysia, Nepal, Taiwan
187	*Garaeus albipunctatus* Hampson, 1895	KAR17A02 (1), RAJ23B02 (1), KAR14B04 (1)	HP	Afghanistan, Pakistan
188	*Garaeus apicata* (Moore, 1868)	KAR11D03 (2), RAJ17B02 (2), RAJ17B04 (1)	HP, SK, UK, WB	Indonesia (Borneo, Sumatra), Malaysia, Myanmar, Nepal, Pakistan, Philippines, Taiwan
189	*Gasterocomme pannosaria* (Moore, 1868)	KAR08B03 (1), KAR11B04 (1), KAR23B02 (1)	AR, HP, KL, ME, SK, UK, WB	Borneo, China, Hong Kong, Indonesia (Java), Malaysia, Nepal, Philippines, Sundaland, Taiwan, Thailand
190	*Gnophos accipitraria* (Guenée, 1858)	KARDEOB03 (1), KAR20B01 (1), RAJ26A02 (1)	AS, **HP*,** ML	China, Nepal

191	*Gnophos rubefactaria* Püngeler, 1902	KAR29A01 (1)	**HP***	Central Asia, Kyrgystan
192	*Gnophos tephrosiaria* Moore, 1888	KAR08D04 (1), KAR08A05 (1), KAR14B04 (1), KAR11D03 (1)	**HP,** SK, WB	Nepal
193	*Gonodontis aethocrypta* Prout, 1926	RAJ20B04 (1), RAJ14B03 (1)	HP, UK	Myanmar, Nepal
194	*Heterolocha falconaria* (Walker, 1866)	KAR20A03 (1), RAJ23A04 (1), KAR26A03 (1), RAJ23B01 (1), RAJ26A02 (1), RAJ29A02 (1)	AR, HP, PB, SK, UK, WB	Nepal
195	*Heterolocha phoenicotaeniata* (Kollar, 1844)	KAR14B04 (1), RAJ29A02 (2)	AR, HP, J&K, SK, UK, WB	Afghanistan, Bhutan, Nepal, Pakistan, Vietnam
196	*Heterostegane subtessellata* (Walker, F., [1863])	KAR11D03 (1), KAR08B03 (1)	AN, AR, AS, HP, KA, KL, MH, ML, SK, TN, UK, WB	Australia, Bhutan, China (Tibet), Hong Kong, Indonesia (Java, Borneo, Sumatra, Bali), Myanmar, Nepal, Taiwan, Thailand, Vietnam
197	*Heterostegania lunulosa* (Moore, 1888)	KAR20A03 (2), RAJ23B04 (1), RAJ20B02 (1)	**HP,** SK	Nepal, Taiwan
198	*Hirasa aereus* Butler, 1886	KAR14B04 (1), RAJ29A02 (1), KARDEOB03 (1), RAJ23B03 (1), RAJ20A04 (1)	**HP,** ML, SK, WB	Nepal
199	*Hirasa muscosaria* (Walker, 1866)	KAR20A03 (1), RAJ23B03 (1), RAJ23B01 (1), KAR17B05 (1)	AR, HP, SK, UK, WB	Nepal
200	*Hyalinetta circumflexa* (Kollar, [1844])	RAJ23B04 (1)	AR, HP, ML, UK, WB	Bhutan, China, Nepal, Thailand
201	*Hydatocapnia marginata* (Warren, 1893)	KAR11D03 (2), RAJ20A04 (1)	HP, ML, NL, SK, UK	Nepal
202	*Hypephyra terrosa* (Butler, 1889)	KAR11D03 (1)	HP, UK	Korea, Nepal

203	*Hyperythra lutea* (Stoll, 1781)	KAR08B03 (1), KAR11C01 (1)	AN, AR, AS, BH, CT, HP, JH, KA, KL, ME, MH, PB, SK, TN, UT, WB.	Africa, Australia, Bangladesh, Borneo, Cambodia, China, Hong Kong, Indonesia, Java, Laos, Malaysia, Myanmar, Nepal, Papua New Guinea, Philippines, Sri Lanka, Sumatra, Thailand.
204	*Hypomecis cineracea* (Moore, 1888)	RAJ17A05 (2), RAJ23B03 (1)	J&K, HP, KL, ML, SK, UK, WB	China, Hong Kong, Indonesia (Borneo, Sumatra), Malaysia, Nepal, Philippines, Taiwan, Thailand
205	*Hypomecis ratotaria* (Swinhoe, 1894)	KAR14A01 (1), KAR17A01 (1), KAR17B03 (1)	AS, HP, ML, SK, TN, UK	Bhutan, Indonesia (Java), Myanmar, Nepal, Sri Lanka.
206	*Hypomecis transcissa* (Walker, 1860)	KAR11D03 (1), KAR08B03 (1), KAR08D01 (1)	AR, AS, HP, KL, MH, ME, MZ, SK, TN, TR, UK< WB	Bangladesh, Bhutan, Hong Kong, Indonesia (Borneo), Malaysia, Myanmar, Nepal, Sri Lanka, Thailand, Vietnam
207	*Hyposidra talaca talaca* (Walker, F., 1862)	KAR11D03 (1)	ANI, AS, CT, GJ, HP, KA, KL, MP, MH, ML, OD, SK, TN, UK, WB	Australia, China, Hong Kong, Indonesia (Borneo, Java), Japan, Malaysia, Myanmar, Nepal, Papua New Guinea, Philippines, Sri Lanka, Taiwan, Thailand
208	*Lassaba albidaria* (Walker, 1866)	RAJ26B01 (1), KAR23B02 (2), KARDEOB01 (1)	AR, HP, ME, SK, UK, WB, Western Ghats	China, Myanmar, Nepal, Pakistan, Taiwan, Thailand, Vietnam
209	*Lassaba anepsia* (Wehrli, 1941)	RAJ29B04 (1)	HP, SK, WB	China, Nepal
210	*Lassaba dissimilis* (Moore, 1888)	KAR26B02 (1), RAJ29A02 (2)	HP, KL, SK, WB	Nepal
211	*Lassaba interruptaria* (Moore, 1868)	KAR29A03 (1), RAJ29A04 (1), RAJ26B03 (1), RAJ26B04 (1)	HP, SK, UK, WB	Nepal
212	*Lassaba parvalbidaria nepalensis* (Sato, 1993)	RAJ17B02 (2), RAJ23B01 (1), KAR23B02 (1), RAJ20B02 (3), KAR11D03 (1), RAJ23B03 (1), RAJ20A03 (1),	HP, SK, WB	Nepal

		KARDEOB03 (1), RAJ29A02 (1)		
213	*Leptomiza calcearia* (Walker, 1860)	KAR17B05 (1), KAR11D03 (1)	AR, AS, HP, SK, UK, WB	Bhutan, China, Myanmar, Nepal, Taiwan, Vietnam
214	*Ligdia coctata* Guenée, 1857	KAR11B06 (1), KAR08A01 (1), KARDEOB01 (1), KAR11D01 (1), KAR11B03 (1), KAR20B01 (1)	HP, MP, PB, UK	Bulgaria, Kazakhstan, Kyrgyzstan, Nepal, Pakistan, Tajikistan, Uzbekistan
215	*Loxaspilates hastigera hastigera* (Butler, 1889)	RAJ29B02 (2), RAJ29A02 (1)	HP, J&K, SK, UK	Afghanistan, China, Nepal, Tibet
216	*Loxaspilates obliquaria* (Moore, 1868)	RAJ29B02 (2), KAR29A03 (1), KAR26A03 (1), RAJ23B03 (1), RAJ29A01 (1), KAR23B02 (1)	HP, SK, UK	Afghanistan, Nepal
217	*Luxiaria amasa* (Butler, 1878)	KAR17B05 (1), KAR11D03 (2), KAR11B06 (1)	AR, HP, MZ, UK, WB	Bhutan, China, Indonesia (Sumatra, Borneo, Java), Japan (TL), Korea, Malaysia, Nepal, Russia, Taiwan, Tibet, Vietnam
218	*Luxiaria phyllosaria* (Walker, 1860)	KAR08A01 (1), KAR08D04 (1), KAR11D03 (1), KAR08D01 (1)	**HP,** KL, ML, UK	China (Hainan, Hong Kong, Guangxi, ? Jilin), Indonesia (Borneo), Malaysia, Nepal, Philippines, Sri Lanka (
219	*Micrabraxas grandis* Yazaki, 1995	RAJ29B02 (2), KAR29A01 (1)	HP	Nepal
220	*Micrabraxas seriopuncta* (Hampson, 1902)	RAJ29B01 (1)	**HP,** UK	Nepal, Tibet
221	*Micrabraxas tenuis* (Warren, 1897)	RAJ29A02 (1), RAJ29B01 (2), RAJ26B01 (1), RAJ26B04 (1)	HP	Pakistan
222	*Microcalicha fimbriata* (Moore, 1868)	RAJ23B03 (3), RAJ26B01 (1), KAR23B02 (1)	**HP,** NL, SK, WB	Nepal
223	*Mimomiza cruentaria* (Moore, 1867)	KAR17B04 (1), KAR20A03 (2), RAJ17B02 (1)	AR, HP, ML, UK, WB	Bhutan, China, Myanmar, Nepal, Thailand, Vietnam

224	*Myrioblephara albibasis* (Hampson, 1895)	KAR17B05 (1), RAJ20A03 (1), RAJ23B03 (2), KAR08C03 (1), RAJ23B04 (1), RAJ20A04 (1)	AR, AS, HP, SK, UK, WB	Nepal, Taiwan
225	*Myrioblephara benefica* Sato, 1993	KAR08C03 (2)	**HP***	Nepal
226	*Myrioblephara gandakiensis* Sato, 1998	RAJ20A02 (2), RAJ26B01 (2), KAR20B01 (1), RAJ29A04 (1), KAR23B02 (1), KAR26B02 (2),	HP	Nepal
227	*Myrioblephara harutai* Sato, 1994	KAR26B02 (1), KAR23B02 (4), KAR26A01 (3), RAJ20A02 (2), RAJ29A02 (1), KAR29B01 (1), RAJ26B01 (1)	HP, WB	Nepal
228	*Myrioblephara idaeoides idaeoid es* (Moore, 1888)	KAR11B04 (1), RAJ29A02 (2), KAR14B01 (1),	**HP,** ML, NL, WB	Nepal, Thailand
229	*Myrioblephara xanthozonea* (Hampson, 1907)	RAJ26B01 (3), RAJ29A02 (1), KAR23B02 (1)	HP, SK	Nepal, Tibet
230	*Nothomiza achromaria* (Guenee, [1858])	KARDEOB03 (2), RAJ26A03 (1), KAR17B05 (1), RAJ23B01 (1), RAJ23B03 (1)	HP, ML	
231	*Nothomiza cinerascens* (Moore, 1888)	RAJ23B01 (1), RAJ23B03 (1), KAR29A03 (1), KAR23B02 (2), RAJ23B01 (1), KAR23A02 (1)	**HP.** SK, WB	Nepal
232	*Nothomiza costinotata* (Warren, 1893)	RAJ23B04 (2), RAJ23B01 (3)	AR, **HP,** UK	Nepal
233	*Odontopera bilinearia* (Swinhoe, 1889)	KARDEOB03 (2), KAR08D03 (1), RAJ20A03 (1)	AR, HP, SK	Bhutan, China, Nepal, Taiwan

234	*Odontopera cervinaria* Moore, 1868	KAR17A01 (1), KAR17B01 (1)	AR, ML, NL, SK, WB	Nepal
235	*Odontopera heydena* (Swinhoe, 1894)	RAJ14A03 (1), KAR17B05 (1), KAR26A01 (1), KAR23B01 (1)	AR, HP, ML, UK	Nepal
236	*Odontopera kanchai* Yazaki, 1994	KAR17B05 (1), KAR14B04 (1), RAJ20A03 (2), KAR11B06 (1)	HP	Nepal
237	*Odontopera lentiginosaria* (Moore, 1867)	RAJ29A04 (1), RAJ29B01 (2), RAJ29B02 (1), RAJ29A02 (1)	HP, ML, SK, UK, WB	South Korea
238	*Odontopera obliquaria* (Moore, 1868)	KAR17B05 (1), KARDEOB03 (1), KAR11B06 (1), RAJ29A04 (1), KAR26B01 (1), RAJ26B01 (1), KAR29A03 (1), KAR20A03 (1), RAJ23B03 (1), KAR26A03 (1), RAJ29B03 (1), RAJ23A04 (2), KAR17A01 (1), KARDEOB03 (1), RAJ23A02 (2), RAJ29B02 (1), RAJ23A01 (1),	AR, HP, ML, UK, WB	Japan, Nepal
239	*Odontopera rufitinctaria* (Hampson, 1902)	KAR08D03 (2), KAR14A03 (1), KAR11B04 (2), KAR14B04 (2), KAR08C03 (1), KAR11D03 (1), RAJ14A02 (1)	HP	Nepal
240	*Odontopera similaria* (Moore, 1888)	KAR11B06 (1), KAR20A04 (1), KARDEOB03 (1), KAR08D03 (1), KAR26B01 (2), KAR14A01 (2)	AR, HP, WB	Bhutan, Nepal
241	*Opisthograptis moelleri* Warren, 1893	KAR17B05 (1), KAR14B04 (1), RAJ23B01 (2)	AR, HP, SK, UK, WB	Bhutan, China, Myanmar, Nepal, Taiwan, Vietnam

242	*Opisthograptis sulphurea* (Butler, 1880)	RAJ26B04 (2)	AR, **HP,** SK, UK, WB	Bhutan, China (Szechuan), Nepal
243	*Opisthograptis tridentifera* (Moore, 1888)	RAJ29A04 (2), RAJ26B03 (2), RAJ26B04 (1)	AR, HP, SK, UK, WB	Bhutan, China Nepal, Tibet
244	*Orthobrachia latifasciata* (Moore, 1888)	KAR20A03 (3), KARDEOB03 (2), RAJ23B04 (1), KAR23A02 (1), KAR17B05 (1)	AR, **HP,** ML, SK, WB	China, Nepal
245	*Ourapteryx clara* (Butler, 1880)	RAJ17A05 (1), KAR11D03 (2)	AS, **HP,** SK, UK, WB	Hong Kong, Indonesia (South East Sumatra), Nepal, Thailand
246	*Ourapteryx convergens* Warren, 1897	RAJ23B02 (1), RAJ29A02 (3)	HP, UK	Nepal, Pakistan
247	*Ourapteryx ebuleata* Guenée, [1858]	KAR14B04 (1), RAJ23B03 (1), KAR20A03 (1), RAJ23A02 (4), RAJ17B02 (1), RAJ23A01 (1), RAJ20B01 (1), RAJ20A02 (1), RAJ23B02 (5), RAJ26A04 (1), RAJ26A02 (1), RAJ14A04 (1)	AR, HP, JK, MN, ML, MH, SK, TN, UK, WB	Bhutan, China, Kyrgyzstan, Myanmar, Nepal, Pakistan
248	*Ourapteryx excellens* Butler, 1889	RAJ23A01 (1)	**HP,** JK	No documentation
249	*Ourapteryx nepalensis* Inoue, 1995	KAR11B01 (1), KAR17B01 (1), RAJ20A03 (2), KAR14B04 (1), KAR20A03 (1), RAJ20B03 (2)	HP, SK, UK, WB	Nepal, Thailand
250	*Ourapteryx pallidula* Inoue, 1985	KAR17B05 (1), RAJ20A02 (2), RAJ23B01 (1), RAJ23B02 (2), KAR11D01 (1), RAJ29A04 (1), KAR08A04 (1)	AR, **HP**	Kyrgyzstan, Taiwan
251	*Ourapteryx purissima*	RAJ23B02 (3), RAJ20B01 (1), RAJ20B04 (2),	HP	Central Asia, Kazakhstan, Kyrgyzstan

	Thierry-Mieg, 1905	RAJ23A01 (1), RAJ26A02 (1), KAR11D03 (1), KAR14B04 (1)		
252	*Ourapteryx yerburii c*(Butler, 1886)	RAJ23B02 (1), RAJ20B01 (1), RAJ17B04 (3), RAJ17A05 (1), RAJ20B04 (1), KAR08D04 (1), KAR17B05 (1), RAJ23A01 (1), KAR20A03 (1), RAJ17A05 (1), RAJ20B04 (2), RAJ20B01 (1), RAJ14B01 (1)	HP, UK	China, Nepal, Pakistan
253	*Oxymacaria temeraria* temeraria (Swinhoe, 1891)	KAR11B06 (1), RAJ14B02 (1), RAJ14A02 (1)	ANI, AR, HP, J&K, ML, NL, UK	Bhutan, China, Hong Kong, Indonesia (Borneo, Java), Japan, Korea, Malaysia, Nepal, Pakistan, Taiwan, Thailand
254	*Paradarisa comparataria* (Walker, F., 1866)	RAJ23B03 (1), KAR08B03 (1), KARDEOB03 (1), KAR17B05 (1), KAR11D03 (1), KAR14A03 (1), KAR23B02 (1), KAR08A05 (1)	**HP,** KL, SK, WB	Nepal
255	*Peratophyga hyalinata hyalinata* (Kollar, [1844])	KAR08D02 (1), RAJ14A02 (1)	HP, ML, UK, WB	Afghanistan, Bhutan, China, Japan, Korea, Myanmar, Nepal, Tibet, Vietnam
256	*Peratostega deletaria deletaria* (Moore, 1888)	KAR14B04 (1), KAR08B03 (1), RAJ17B02 (1)	HP, ML, UK, WB	China, Japan, Korea, Nepal, Taiwan.
257	*Petelia riobearia* (Walker, 1860)	KAR08B01 (1)	**HP,** ML, SK, TN, WB	Nepal, Sri Lanka
258	*Phthonandria atrilineata atrilineata* (Butler, 1881)	KAR14B04 (1), KAR11D03 (1), KAR08D03 (1)	HP, SK, UK	Bhutan, China, Japan, Korea, Nepal
259	*Platycerota vitticostata* (Walker, F., [1863])	KAR11D03 (1), KAR08D01 (1)	**HP,** WB	Nepal

260	*Plutodes warreni* Prout, 1923	RAJ20A04 (1), KAR08D01 (1)	AS, AR, HP, SK, WB	China , Nepal
261	*Plagodis inustaria* (Moore, 1867)	RAJ23B01 (3)	AR, HP, ML, SK, UK, WB	Nepal
262	*Psilalcis breta breta* (Swinhoe, 1890)	KAR14B04 (1), KAR17B05 (1), KAR08B03 (1), KAR11D03 (2)	HP, KL, TN, WB	Nepal, Thailand
263	*Psyra angulifera* (Walker, 1866)	KAR23B02 (1), RAJ23B03 (1), KARDEOB03 (1), KAR17B05 (1), KAR20B01 (2)	AR, AS, HP, SK, UK, WB	China, Nepal
264	*Psyra crypta* Yazaki, 1994	RAJ23B03 (1), KAR26A03 (1), RAJ29A04 (1), RAJ20B04 (1), KAR23B02 (1), RAJ17B02 (1)	AR, HP, SK, UK, WB	Nepal
265	*Psyra cuneata* Walker, 1860	KAR20B01 (1), RAJ20B04 (1), KARDEOB03 (1), RAJ23A01 (1)	AR, HP, ML, SK, UK, WB	China, Nepal, Japan, Taiwan
266	*Psyra debilis debilis* Warren, 1888	RAJ23B04 (2)	**HP,** LD, UK	Pakistan
267	*Psyra debilis indica* (Butler, 1889)	RAJ26B01 (2), RAJ23B02 (1), RAJ29A02 (1)	HP, UK	Nepal
268	*Psyra gracilis* Yazaki, 1992	KAR14B04 (1), KAR08C03 (1), KARDEOB03 (1)	**HP,** SK, WB	Nepal (Godavari), China
269	*Psyra similaria* Moore, 1868	KAR26A03 (1), RAJ23B03 (1)	AR, HP, ML, SK, UK, WB	China, Nepal
270	*Psyra spurcataria* (Walker, 1863)	KARDEOB03 (1), KAR11D03 (1)	AR, AS, HP, ML, SK, UK, WB	China, Myanmar, Nepal, Taiwan
271	*Racotis boarmiaria* Guenée, [1858]	KAR08D01 (2)	AS, **HP,** KA, KL, MN, NL, SK, TN, WB	Bhutan, Borneo, Formosa, Indonesia (Java), Japan, Malaysia, Nepal, Sri Lanka, Taiwan
272	*Satoblephara nepalensis* Sato, 1993	KAR11C02 (1), RAJ23A02 (1), RAJ14B02 (1), KAR11B06 (1)	**HP,** SK	Nepal

273	*Sirinopteryx ablunata* (Guenée, 1858)	KARDEOB03 (1), RAJ23B01 (1), RAJ23B04 (1)	HP, UK	Nepal
274	*Thinopteryx citrina* Warren, 1894	RAJ17B04 (1), KAR14A01 (1)	**HP,** SK	Indonesia (Borneo, Java, Sumatra), Nepal
275	*Thinopteryx crocoptera crocoptera* (Kollar, [1844])	KAR14A01 (1), RAJ17B04 (1)	AI, AR, AS, HP, J&K, ML, SK, UK, WB	Bhutan, Bangladesh, China, Hong Kong, Indonesia (Java, Sumatra), Japan, Korea, Malaysia, Nepal, Pakistan, Russia, Taiwan, Vietnam.
276	*Thinopteryx nebulosa* Butler, 1883	KAR11D03 (1)	**HP,** KL, UK, WB	Nepal, Taiwan
277	*Xandrames albofasciata* Moore, 1868	KAR20A03 (2)	AR, HP, SK, WB	China, Myanmar, Nepal, Thailand, Vietnam.
278	*Xandrames dholaria* Moore, 1868	KAR11B06 (1), RAJ17A03 (2), RAJ23B01 (1)	AR, AS, HP, NL, SK, UK, WB	China, Japan, Korea, Nepal, Taiwan, Thailand
279	*Xenoplia foraria* ([Guenée, 1858])	KAR11D02 (1)	AR, HP, ME, SK, UK, WB	Nepal, China, Hong Kong, Japan, Thailand
280	*Xenoplia maculata* (Moore, 1868)	KARDEOB03 (1), RAJ23A02 (1), KAR17A02 (1)	AR, HP, ME, SK, UK, WB	Nepal

Appendix 3: Comprehensive details of sampling date codes (used in the material examined) and average trap night weather parameter for LSVs.

Locality Name	Location code	Sampling date code	Sampling Date	Avg. Temperature (°C)	Avg. Relative Humidity (%)	Avg. Wind speed (km/h)	Avg. Cloud cover (%)	Moon Phase
Tindi	Lah25	LS2498	08.VII.2021	17.15	18	0.57	10	WN XIII
		LS2498.2	09.VII.2021	16.5	19	1.72	11.25	WN XIV
Lobar	Lah27	LS2773	07.VII.2021	13.75	19.5	0	66.25	WN XII
Jahalman	Lah29	LS2973	04.VII.2021	11.75	16.75	3.22	0	WN IX
		LS2973.2	05.VII.2021	13.75	16.25	2.75	10	WN X
Duling	Lah30	LS3047	11.VII.2021	17.5	15.75	2.25	61.25	WX I
Chokhang	Lah31	LS3193	22.VII.2021	12	37.5	3.05	67.5	WX XII
Trilokinath	Lah32	LS3238	06.VII.2021	12.25	14.5	0.35	15	WN XI
Pyukar	Lah32.2	LS3289	03.VII.2021	10.75	15.75	3.22	15	WN VIII
Jispa	Lah33	LS3327	30.VI.2021	13.25	15.75	4.6	25	WN V
Shashur Gompa.2	Lah34	LS3470	27.VI.2021	5.75	20.25	3.8	0	WN II
Naingaar	Lah34.2	LS3491	23.VII.2021	8.5	45.5	3.42	0	WX XIII
Kolong	Lah35	LS3519	02.VII.2021	7.75	16.25	5.35	37.5	WN VII
Shashur Gompa	Lah35.2	LS3534	26.VI.2021	5.12	21.25	3.3	35	WN I
Dhok	Lah37	LS3736	29.VI.2021	9.5	16.25	7.8	0	WN IV
Sarchu	Lah43	LS4343	28.VI.2021	1.25	18	11	0	WN III
Chicham	Spiti01	SP4026	04.VIII.2021	11.5	15	7.2	66.25	WN XI
Kibber	Spiti02	SP4516	05.VIII.2021	6.5	23.75	5.85	36	WN XII
Tashigang	Spiti03	SP4870	06.VIII.2021	5.5	15.25	12.54	0	WN XIII
Mudh	Spiti04	SP3737	07.VIII.2021	11.5	15.5	11.5	0	WN XIV
Kaza	Spiti05	SP3665	09.VIII.2021	13.8	13.8	9.5	0	WX I
Komic	Spiti06	SP4504	10.VIII.2021	4.75	14.75	15	0	WX II
Komic.2	Spiti07	SP4847	11.VIII.2021	3	14.6	13.2	0	WX III

Appendix 4: List of Identified species of moth species/subspecies of LSVs

Abbreviations/signs used**:** As defined in Appendix 1.

Superfamily: Cossoidea Leach, 1815				
Family: Cossidae Leach, [1815]				
Subfamily: Catoptinae Yakovlev, 2009				
Sr. No.	**Scientific name**	**Material Examined**	**Distribution**	
			India	**Global**
1	*Catopta cashmirensis* (Moore, 1879)	LS3519 (2)	HP, J&K, UT	Afghanistan, Bhutan, China, Nepal, Pakistan
Superfamily: Geometroidea Leach, 1815				
Family: Geometridae Leach, 1815				
Subfamily: Sterrhinae Meyrick, 1892				
2	*Rhodostrophia borealis* (Swinhoe, 1890)	Kumari et al. 2024	HP, J&K, UK	No documentation
3	*Rhodostrophia herbicolens* (Butler, 1883)	Kumari et al. 2024	HP, UK	No documentation
4	*Scopula terminata mechadoi* (Hausmann, 1993)	LS2498 (6)	**HP**	Pakistan (Hindu Kush and Karakoram)
5	*Scopula kashmirensis* (Moore, 1888)	LS3470 (2), LS3289 (1), LS2973 (1), LS2941 (1), LS2773 (1)	**HP,** J&K, Punjab, Sikkim	Afghanistan, China, Japan, Pakistan
Subfamily: Larentiinae Duponchel, 1845				
6	*Amnesicoma simplex* Warren, 1895	LS3289 (1), LS3491 (2), SP4026 (1)	HP, J&K, UK	China, Nepal, Pakistan, Tibet
7	*Colostygia albigirata* (Kollar, [1844])	LS3289 (1)	HP. J&K, SK, UK	Afghanistan, China, Japan, Mongolia, Myanmar, Nepal, Russia
8	*Electrophaes niveonotata* (Warren, 1893)	LS3289 (1)	AR, HP, SK, UK, WB	Bhutan, Nepal
9	*Entephria poliotaria* Aubert, 1959	LS3736 (1), LS3289 (2), LS3491 (1)	HP, J&K, UK	Pakistan
10	*Euphyia cinnamifusa* Prout, 1939	LS3327 (1), LS2498.2 (1)	J&K, HP, UK	Pakistan
11	*Euphyia submarginata* (Warren, 1909)	LS3470 (1), LS3289 (3), LS2973 (1), LS2773 (1), LS3491 (1)	**HP,** J&K	Pakistan

12	*Eupithecia centaureata* ([Denis & Schiffermüller], 1775)	LS3470 (1), LS3736 (2), LS3327 (2)	**HP***	Austria, Central Asia, China, Croatia, France, Iran, Lebanon, Palestine, Sicily, Taiwan (Asia, Europe, North africa)
13	*Eupithecia nigrilinea* (Warren, 1896)	LS3327 (3), LS2941 (2), LS3289 (1), LS2773 (1), LS2498 (4)	HP, J&K, UK	Nepal, Pakistan, Tajikistan
14	*Eupithecia venosata* (Fabricius, 1787)	LS3470 (1), LS3327 (2), LS2941 (1), LS2773 (1), LS2498 (1), LS3491 (1)	**HP***	Austria, France, Greece, Macedonia, Morocco, Pakistan, Spain, United Kingdom
15	*Heterothera consimilis* (Warren, 1888)	LS2773 (4), LS2498 (3)	HP, J&K, UK, WB	Afghanistan, Nepal, Pakistan
16	*Horisme nigrovittata* Prout, 1938	LS2773 (1), LS3491 (1)	**HP,** UK (Dey 2018)	Pakistan
17	*Nebula homophana* (Hampson, 1895)	LS3470 (1), LS3519 (1), LS3289 (2)	HP, J&K	Pakistan
18	*Photoscotosia amplicata* (Walker, 1862)	LS3491 (1)	AR, HP, J&K, MG, SK, UK, WB	Bhutan, China, Myanmar, Nepal, Pakistan, Tibet
19	*Photoscotosia dejuncta* Prout, 1937	LS3491 (1), SP3737 (1)	HP, J&K, UK	No documentation
20	*Photoscotosia palaearctica* (Staudinger, 1882)	LS3470 (1), LS3327 (1), LS3519 (1), LS3289 (1), LS2973 (1)	**HP***	Afghanistan, Central Asia, China, Kazakhstan
21	*Stamnodes pauperaria pamphilata* (Felder & Rogenhofer, 1875)	LS3519 (1), LS3289 (5), LS3491 (1), SP4026 (3), SP4516 (2), SP3737 (1)	HP, J&K, SK, UK	Afghanistan, Kazakhstan, Kyrgyzstan, Mongolia, Nepal, Russia
22	*Triphosa* (*Rheumaptera*) *dubiosata* (Walker, 1862)	LS3289 (3), LS2498.2 (1), LS3491 (5)	HP, PB, SK, TN, UK	Afghanistan, Nepal
23	*Xenortholitha latifusata* (Walker, 1862)	LS3289 (1)	HP, UK	Pakistan, Taiwan
Subfamily: Geometrinae Leach, 1815				
24	*Chlorissa gelida exsoluta* Prout, 1935	LS3470 (1), LS3327 (2), LS3519 (3),	HP	Pakistan

		LS3289 (2), LS2973 (2), LS2941 (1), LS2773 (1), SP4026 (3)		
25	*Hemistola detracta* (Walker, 1861)	LS2498.2 (3)	HP, J&K, NL	China, Pakistan
26	*Hemistola fletcheri* Prout, 1934	LS2941 (1), LS2773 (1), LS2498.2 (1), LS3491 (2)	HP, J&K	Pakistan
27	*Herochroma crassipunctata crassipunctata* (Alphéraky, 1888)	LS2941 (1)	HP	Afghanistan, China, Kazakhstan, Tajikistan
28	*Thetidia radiata* (Walker, [1863])	LS3327 (1), LS2941 (1), LS2498.2 (1)	HP, J&K	Afghanistan, China, Pakistan
Subfamily: Ennominae Duponchel, 1845				
29	*Abraxas antipusilla* Inoue, 1955	LS2498.2 (2)	AR, HP, SK, UK, WB	Nepal
30	*Abraxas virginalis* Butler, 1886	LS2498.2 (2)	AS, HP, J&K	Myanmar, Nepal, Pakistan
31	*Abraxesis melaleucaria* Hampson, 1902	LS3238 (3), LS2773 (1)	HP	Afghanistan, Pakistan
32	*Alcis granitaria* (Moore, 1888)	LS2498.2 (2)	HP, J&K, UK	Pakistan
33	*Alcis nobilitaria* (Staudinger, 1892)	LS3470 (3), LS3327 (1), LS3519 (1)	**HP***	Afghanistan, Kyrgyzstan, Uzbekistan
34	*Anthyperythra caladsaota* Hampson, 1902	LS2973 (2), LS2498.2 (1)	HP	Pakistan
35	*Artemidora disistaria* (Walker, 1862)	LS2498.2 (1)	**HP**, North India	Nepal, Pakistan
36	*Artemidora epicyrta* (Fletcher, 1961)	LS2498 (1)	**HP***	Nepal
37	*Biston betularia nepalensis* Inoue, 1982	LS3470 (1), LS3327 (1), LS2941 (1)	**HP***	China, Nepal, Tibet
38	*Charissa crenulata* (Staudinger, 1871)	LS3736 (1), LS3327 (1), LS3519 (1), LS2941 (1), SP4516 (2), SP3737 (1)	**HP***	Spain
39	*Garaeus albipunctatus* Hampson, 1895	LS2773 (1)	HP	Pakistan

40	*Gnophos praeauctaria* Wehrli, 1922	SP4026 (1), SP3737 (1)	**HP***	Central Asia
41	*Gnophos rubefactaria* Püngeler, 1902	SP4026 (1)	**HP***	Central Asia, Kyrgyzstan
42	*Heterolocha phoenicotaeniata* (Kollar, [1844])	LS3327 (1), LS3289 (2), LS2973 (1), LS2773 (2), LS3491 (2)	AR, HP, J&K, SK, UK, WB	Afghanistan, Bhutan, Nepal, Pakistan, Vietnam
43	*Hypomecis ratotaria* (Swinhoe, 1894)	LS3470 (1), LS3327 (2), LS2973 (3), LS2941 (1)	HP, MG, SK, TN, UK	Bhutan, Indonesia (Java), Myanmar, Nepal, Sri Lanka
44	*Loxaspilates hastigera punctigera* Prout, 1915	LS3491 (3)	**HP,** J&K	No documentation
45	*Loxaspilates obliquaria* (Moore, 1868)	LS3470 (1), LS3289 (1), LS2941 (1), LS3491 (1)	HP, SK, UK	Afghanistan, Nepal
46	*Odontopera kametaria* (Felder & Rogenhofer, 1875)	LS2773 (2), LS3491 (1)	HP, UK	Nepal, Pakistan
47	*Ourapteryx convergens* Warren, 1897	LS2773 (3), LS2498 (2)	HP, UK	Afghanistan, Nepal. Pakistan
48	*Psyra debilis indica* (Butler, 1889)	LS3327 (1), LS3289 (1), LS3491 (1)	HP, UK	Nepal, Pakistan
49	*Scotopteryx nasifera* (Warren, 1888)	LS3736 (1), LS3327 (1), LS3519 (1), LS2941 (1)	HP, Ladakh, PB	Afghanistan, Pakistan
Family: Notodontidae Stephens, 1829				
Subfamily: Pygaerinae Duponchel, [1845]				
50	*Clostera anachoreta* (Denis & Schiffermüller, 1775)	LS3470 (1), LS3289 (1)	**HP,** North Western India	Afghanistan, Austria, Balkan Peninsula, China (Eastern China, Xinjiang), Japan, Korea, middle Parts of Europe (South East Spain), Pakistan, Russia (Siberia, Amur, Primorye, the Kurli Islands), South England, Southern Fennoscandia, Tadshikistan, Taiwan
51	*Micromelalopha undulata* (Hampson, 1891)	LS3327 (1), LS3289 (1), LS3491 (2)	HP, TN, UK (North India)	Afghanistan, Nepal, Pakistan
Subfamily: Unassigned				

52	*Furcula pakistana* Schintlmeister, 1998		**HP,** North Western India	Pakistan
Superfamily: Noctuoidea Latreille, 1809				
Family: Noctuidae Latreille, 1809				
Subfamily: Hypocalinae Guenée, 1852				
53	*Hypocala subsatura* Guenée, 1852	LS3519 (2)	AR, AS, HP, KA, KL, MH, MP, OD, TN, UK, WB	Africa, Australia, Bangladesh, China, Hing Kong, Indonesia (Borneo, Java), Japan, Korea, Myanmar, Nepal, Pakistan, Philippines, Russia, Taiwan, Thailand, Vietnam
Subfamily: Lymantriinae Hampson, 1893				
54	*Dasychira cerebosa* (Swinhoe, 1903)	LS3238 (1)	HP, UK, SK	Bangladesh, Bhutan, Indonesia (Borneo, Java, Sumatra), Nepal, Sri Lanka, Thailand.
Subfamily: Toxocampinae Guenée, 1852				
55	*Lygephila craccae* (Denis & Schiffermüller, 1775)	SP4026 (2)	**HP***	Austria
Family: Noctuidae Latreille, 1809				
Subfamily: Acontiinae Guenée, 1841				
56	*Acontia lucida* (Hufnagel, 1766)	LS2973 (1), LS2498 (1)	**HP,** PB	Algeria, Arabia, China, Egypt. Europe, Iraq, Kazakhstan, Near East, Northern Iran, Oman, Ukraine, Yemen
Subfamily: Acronictinae Harris, 1841				
57	*Acronicta gastridia* (Swinhoe, 1895)	LS3470 (1), LS3327 (2)	HP, J&K, UK	Pakistan
58	*Harmandicrania brunneocinerea* Kiss, 2017	LS2773 (3), LS2498 (1)	**HP***	Pakistan
Subfamily: Cuculliinae Herrich-Schäffer, [1850]				
59	*Cucullia albipennis* Hampson, 1894	LS2941 (1)	HP	China
60	*Cucullia retecta gabrieli* Ronkay and Ronkay, 1998	LS3327 (1)	**HP**	Nepal
61	*Cucullia maracandica* Staudinger, 1888	LS4343 (1)	**HP**	Uzbekistan
62	*Cucullia thomasi* Hacker & Ronkay, 1990	LS3327 (1), LS3534 (1)	**HP,** J&K	Afghanistan, Nepal, Pakistan, Uzbekistan

Subfamily: Hadeninae Guenée, 1857				
63	*Anarta farnhami* (Grote, 1873)	LS3534 (1), LS3470 (1), LS3327 (1)	**HP**, J&K	Afghanistan, Canada, Finland, Kyrgyzstan, Russia, Tajikistan, USA
64	*Hadena albimacula* (Borkhausen, 1792)	LS3327 (2), LS3289 (1)	**HP,** J&K	Algeria, Austria, Bulgaria, Denmark, Finland, France, Germany, Iran, Italy, Kazakhstan, Lebanon, Mongolia, Morocco, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, Yemen
65	*Hadena eximia* (Staudinger, 1895)	LS3289 (1), LS2973 (1)	**HP***	China (Tibet)
66	*Hypobarathra repetita* (Butler, 1889)	LS3534 (1), LS3327 (1)	HP, SK, UK	Bhutan, China (Tibet), Nepal, Pakistan
67	*Polia culta* (Moore, 1881)	LS3491 (1)	HP, J&K, SK, UK	China (Tibet), Nepal, Pakistan
68	*Polia serratilinea tenebricosa* Hacker & Weigert, 1990	LS3327 (3), LS3519 (1), SP3737 (2)	**HP***	Pakistan
Subfamily: Heliothinae Boisduval, [1828]				
69	*Protoschinia scutosa* (Denis & Schiffermuller, 1775)	LS3327 (1), LS2973 (1), LS2941 (1), LS2773 (1)	North India	Afghanistan, Africa, Armenia, Caucasus, Central Asia, China, Europe, Far East, Iran, Kazakhstan, Kyrgyzstan, Levant, Mongolia, Near East, North Africa, North America, Pakistan, Russia, South Siberia, Transcaucasia, Tibet, Turkey, Uzbekistan
70	*Pyrrhia umbra* (Hufnagel, 1766)	LS3327 (1), LS3289 (2)	HP, NL, PB, UK	Austria, China, Denmark, England, Finland, France, Germany, Iran, Italy, Japan, Kazakhstan, Nepal, Netherlands, Norway, Pakistan, Russia, Spain, Sweden
Subfamily: Noctuinae Latreille, 1809				
71	*Agrotis exclamationis* (Linnaeus, 1758)	LS3534 (2)	**HP**, J&K	Afghanistan, Africa, Austria, Bulgaria, Denmark, England, France, Finland, Germany, Iran, Iraq, Italy, Japan, Mongolia, Morocco, Netherlands, Norway,

				Portugal, Russia, Spain, Sweden, Turkey
72	*Agrotis ipsilon* (Hufnagel, 1766)	LS2973 (1), SP4026 (1), SP4847 (1)	AR, AS, BH, HP, JH, JK, ME, PB, RJ, UK, WB	Argentina, Australia, Austria, Brazil, Canada, China, Costa Rica, Cyprus, Denmark, Ecuador, Egypt, Galapagos, Iran, Ireland, Israel, Japan, Jordan, Korea, Malta, Mexico, Myanmar, Namibia, Nepal, New Zealand, Pakistan, Poland, Portugal, Romania, Russia, Taiwan, Tajikistan, Thailand, Turkey, United Kingdom, United States
73	*Apamea exstincta nepalensis* Boursin, 1964	LS4343 (1)	**HP***	Nepal
74	*Axylia putris* (Linnaeus, 1761)	LS2973 (1), LS2941 (1)	HP, UK	Armenia, Austria, Denmark, Finland, France, Germany, Indonesia (Java), Japan, Kazakhstan, Korea, Mongolia, Nepal, Netherlands, Norway, Pakistan, Russia, Spain, Sweden, Taiwan, Ukraine, United Kingdom.
75	*Bryoxena centralasiae* (Staudinger, 1882)	SP3737 (1), SP4847 (1)	**HP,** J&K	Kazakhstan, Mongolia, Turkestan,
76	*Dichagyris himalayensis* Turati, 1933	LS2498 (1), SP4026 (3), SP3737 (2)	**HP,** J&K	Kyrgyzstan, Nepal, Russia, Tajikistan
77	*Euxoa amorpha* Boursin, 1964	LS4343 (1)	HP	China, Nepal
78	*Isochlora viridis* Staudinger, 1882	LS4343 (1)	**HP,** J&K	China (Tibet), France, Kazakhstan, Mongolia, Netherlands, Russia
79	*Mythimna conigera* Moore, 1881	LS3491 (2)	HP, J&K	Austria, Denmark, Finland, Germany, Italy, Japan, Korea, Lithuania, Mongolia, Netherlands, Norway, Russia, Spain, Sweden, Ukraine, United Kingdom
80	*Mythimna ferrago calliginata* Hreblay, 1999	LS3534 (1)	**HP***	Pakistan
81	*Mythimna vitellina* (Hübner, [1808])	LS3534 (1), LS2973 (1),	**HP,** J&K	Algeria, Armenia, Austria, Denmark, France,

		LS3327 (2), SP3737 (3)		Germany, Greece, Iran, Italy, Kyrgyzstan, Morocco, Netherlands, Pakistan, Portugal, Romania, Russia, Spain, Turkey, United Kingdom, Uzbekistan
82	*Polymixis calamistis* (Hampson, 1906)	LS3534 (1), SP4026 (2), SP3737 (3)	**HP,** J&K	No documentation
83	*Trachea melanospila* Kollar, [1844]	LS3519 (1)	HP, J&K, UK	China, Japan, Korea, Russia, Sri Lanka
84	*Valeriodes chlorota* (Hampson, 1909)	LS3470 (1), LS3491 (1)	J&K, **HP**	Pakistan
Subfamily: Plusiinae Boisduval, 1829				
85	*Autographa nigrisigna* (Walker, [1858])	LS3327 (1), SP4026 (1), SP4504 (1)	HP, HR, J&K, PB, SK, UK, WB	China (Tibet), Japan, Korea, Nepal, Pakistan
86	*Chrysodeixis chalcites* (Esper, 1789)	LS3327 (1)	HP, UK	Africa, Asia, Austria, Croatia, France, Germany, Greece, Italy, Switzerland.
87	*Euchalcia cashmirensis* Moore, 1881	LS2973 (2), SP3737 (2)	**HP***	Pakistan

List of Conferences and Publications

Conferences

- Presented an **Oral presentation** at '**The 23rd European Congress of Lepidopterology and 11th Forum Herbulot**' on the "Conservation, Ecology and Systematics of Lepidoptera in a Changing World" theme from 25th–29th September 2023.

Topic: What underlies the unimodal elevational species richness pattern of Geometridae moths (Lepidoptera: Heterocera) in the protected area of the North-western Himalayan Biogeographic province, Himachal Pradesh, India? **Authors:** Kumari, S., Uniyal, V. P. and Chandra, K.

- Presented an **Oral presentation** at the '**9th International Butterfly Conservation Symposium** (BCS)' on the "Conserving Lepidoptera in a Changing World" theme at Wyboston Conference Centre, Bedfordshire from 13th-16th April 2023.

Topic: Macro moths' assemblage from the Indian Trans Himalayan region, Lahaul valley: a way towards identifying the potential indicator species for monitoring climate change. Authors: Kumari, S., Uniyal, V. P. and Chandra, K.

- Presented and Awarded the Best **Oral Presentation** award at the **National Conference** on "Role of Science and Technology in Environmental Conservation & Sustainable Development" held at Himachal Pradesh University, Shimla. (September 2022)

Topic: Diversity and Distribution patterns of Geometridae moths (Lepidoptera: Heterocera) along an altitudinal gradient of Dhauladhar Mountain range in Kangra, North-Western Himalayas, Himachal Pradesh. Authors: Kumari, S., Uniyal, V. P. and Chandra, K

- Participation in the workshop and the symposium in the 6th Asian Lepidoptera Conservation Symposium **(ALCS)** at Zoological Survey of India, Kolkata (September, 2019).
- Participated in International Biodiversity Congress **(IBC)** held at Forest Research Institute (FRI), Dehradun, Uttarakhand India (October, 2018).

Publications

Published

- **Kumari, S.,** Uniyal, V.P. and Singh, A.P. (2022). New record of the genus *Erannis* Hübner, [1825] from India (Lepidoptera: Geometridae, Ennominae). *SHILAP-REVISTA DE LEPIDOPTEROLOGIA*, 50 (197) 27–31.

  https://doi.org/10.57065/shilap.180.

- **Kumari, S.,** Bandyopadhyay, U., Uniyal, V.P., Chandra, K. and Hausmann, A. (2024). Integrative taxonomic review of the genus *Rhodostrophia* Hübner, 1823 and its allied genus *Tanaotrichia* Warren, 1893 (Lepidoptera: Geometridae) from the Western Himalaya. *ZOOTAXA*, 5519 (1), 59–89.

  https://doi.org/10.11646/zootaxa.5519.1.3.

Under preparation

- **Kumari, S.,** Bandyopadhyay, U., Uniyal, V.P. and Chandra, K. Assessing uniqueness of Trans Himalaya: a macro moths' checklist with new species records from the Lahaul and Spiti, Himachal Pradesh.
- **Kumari, S.,** Bandyopadhyay, U., Uniyal, V.P. and Chandra, K. Diversity and distribution patterns of geometrid moths in the Dhauladhar mountain range, North Western Himalaya, Himachal Pradesh.

National Conference on Role of Science and Technology in Environmental Conservation and Sustainable Development

Jointly Organized by

Department of Biosciences & HPU Biological Society
Himachal Pradesh University

In Collaboration with

NITI Aayog, Government of India
Department of Environment, Science and Technology, Govt of H.P.
H.P. State Biodiversity Board and H.P. State Wetland Authority, Govt of H.P.
Himachal Pradesh Council for Science Technology & Environment, Govt of H.P.

September 23-24, 2022

CERTIFICATE BEST RESEARCH PAPER

This is certified that Dr/Mr/Ms. SHABNAM KUMARI participated and presented research paper entitled "DIVERSITY AND DISTRIBUTION PATTERNS OF GEOMETRIDAE MOTHS [LEPIDOPTERA: HETEROCERA] ALONG AN ALTITUDINAL GRADIENT OF DHAULADHAR MOUNTAIN RANGE IN KANGRA, NORTH-WESTERN HIMALAYA, H.P. in the National Conference on "Role of Science & Technology in Environmental Conservation and Sustainable Development" organized by Department of Biosciences, Himachal Pradesh University, Shimla (H.P.) on Sept 23-24, 2022.

He/She has been awarded Best Paper Award under oral/poster category.

Dr Dhiraj S Rawat
Convenor

Dr Rajesh Kumar
Organizing Secretary

Butterfly Conservation

CERTIFICATE OF ATTENDANCE

9th International Symposium

Wyboston Lakes

13th to 16th April 2023

This certificate confirms

Shabnam Kumari

attended Butterfly Conservation's 9th International Symposium

Signed: ....

Julie Williams, Chief Executive

Dated: 16th April 2023

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LE STUDIUM

CONFERENCES

Conservation, Ecology and Systematics of Lepidoptera in a changing world

The 23rd European Congress of Lepidopterology & 11th Forum Herbulot

September 25, 2023 – September 29, 2023

THIS CERTIFICATE IS AWARDED TO

Shabnam Kumari, Wildlife Institute of India - IN, for giving a talk :

"What underlies the unimodal elevational species richness pattern of Geometridae moths (Lepidoptera: Heterocera) in the protected area of the North-western Himalayan Biogeographic province, Himachal Pradesh, India?"

PREMIUM QUALITY 2023

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New record of the genus *Erannis* Hübner, [1825] from India (Lepidoptera: Geometridae, Ennominae)

S. Kumari, V. P. Uniyal & A. P. Singh

Abstract

The genus *Erannis* Hübner, [1825] is typically known to be distributed in the Holarctic region. The present paper represents the first record of *Erannis kashmirensis* László, 2003 from India. The species was described from Pakistan and it was previously known exclusively from its type series collected in the NW Himalayas. A brief diagnosis of the habitus, genitalia and photographic illustrations of the species were provided for the validation of the record from India.
KEY WORDS: Lepidoptera, Geometridae, Ennominae, *Erannis*, India.

Nuevo registro del género *Erannis* Hübner, [1825] para India (Lepidoptera: Geometridae, Ennominae)

Resumen

El género *Erannis* Hübner, [1825] es típicamente conocido por su distribución Holártica. El presente trabajo representa el primer registro de *Erannis kashmirensis* László, 2003 para India. La especie fue descrita de Pakistán y fue previamente conocida exclusivamente de su serie tipo colectada en el NO del Himalaya. Se proporciona una breve diagnóstico sobre su morfología, genitalia e ilustración fotográfica de la especie para la validación del registro para India.
PALABRAS CLAVE: Lepidoptera, Geometridae, Ennominae, *Erannis*, India.

Introduction

The Geometridae is the second largest family of moths with 23,002 (VAN NIEUKERKEN *et al.*, 2011) species described and distributed all over the world except the Antarctica. The genus *Erannis* Hübner, [1825] belongs to the Boarmiini tribe of the subfamily Ennominae (JIANG *et al.*, 2017). A total of 17 species and subspecies belong to this particular genus are known to be distributed mainly in the Holarctic region (RINDGE, 1975; PARSONS *et al.*, 1999; LÁSZLÓ, 2003; MÜLLER *et al.*, 2019). *Erannis kashmirensis* László, 2003 has been so far documented and described by LÁSZLÓ (2003) from the north-western Himalayan region of Pakistan. Only the males of species belonging to the genus *Erannis* have functional wings and can fly towards light traps. The females are known to bear non-functional “short wing-stumps” (MÜLLER *et al.*, 2019) and therefore can’t fly, are still unknown for *E. kashmirensis.* The present paper documents the first distributional record of the genus *Erannis* Hübner, [1825] from India.

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Integrative taxonomic review of the genus *Rhodostrophia* Hübner, 1823 and its allied genus *Tanaotrichia* Warren, 1893 (Lepidoptera: Geometridae) from the Western Himalaya

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Abstract

The genus *Rhodostrophia* Hübner, 1823 and its close ally *Tanaotrichia* Warren, 1893 (Geometridae: Sterrhinae) are reviewed from the North Western and Trans Himalayan regions of the Indian Himalaya along with some specimens from the Pakistan. In total, eight species were studied—seven *Rhodostrophia* spp. and one species of *Tanaotrichia*—with detailed morphological and genital characteristics. *Rhodostrophia borealis* **stat. n.** is raised from subspecies of *R. cinerascens* to species level after studying external morphology and distinct genitalia-based diagnostic features. However, this warrants further validation following the barcode sequencing of *R. cinerascens.* Illustrations of habitus, including type specimens, are provided along with images of genitalia and the sequence data of the mitochondrial cytochrome c oxidase subunit I (COI 5′ terminus) gene. A checklist of Indian *Rhodostrophia* and *Tanaotrichia* species is included with information on their documented distributional range.

Key words: Sterrhinae, Cyllopodini, Cryptic species, DNA barcoding, Bayesian tree, Species delimitation

Introduction

Genus *Rhodostrophia* (Geometridae: Sterrhinae) was established by Hübner (1823) based on the diagnostic features of the designated type species *Phalaena calabraria* Hübner, 1790. However, Hübner's use of the species name *calabraria* was an unjustified alteration of *Phalaena calabra* Petagna, 1786. Consequently, *R. calabra* was listed as a type species of this genus by Hampson (1895) and this change was subsequently upheld by Fletcher (1979) and followed thereafter. Historically, the species of *Rhodostrophia* were described under various genus names, viz., *Pellonia* Duponchel, 1829; *Delocharis* Butler, 1883; *Apostates* Warren, 1897; *Leptosidia* Hampson, 1903. These names are now considered junior subjective synonyms for the genus. Initially, Prout (1935) classified the genus into the tribe Rhodostrophiini. But in the latest comprehensive taxonomic revision, Sihvonen *et al.* (2020) synonymized Rhodostrophiini with the tribe Cyllopodini Kirby, 1892.

There are 99 validated species and subspecies worldwide in the genus *Rhodostrophia* (Rajaei *et al.* 2022b). It is a large genus primarily distributed in the palearctics. However, its wide distribution ranges from westernmost Europe and the North Eastern tip of the African continent, then across the Arabian Peninsula to Eastern Asia and extends further to Taiwan (Suludere 1988; Ramos-González *et al.* 2018; Cui *et al.* 2019; Sihvonen *et al.* 2020; Rajaei *et al.* 2022a). Besides this broad distribution, the three species, namely, *R. cauquenensis* (Butler, 1882), *R.*