DIVERSITY AND DISTRIBUTIONAL PATTERN OF FAMILY GEOMETRIDAE (LEPIDOPTERA) IN GREAT HIMALAYAN NATIONAL PARK CONSERVATION AREA, HIMACHAL PRADESH

A THESIS

Submitted by

KAUSHIK MALLICK

for the award of the Degree of

DOCTOR OF PHILOSOPHY

IN

WILDLIFE SCIENCE

Under the guidance of

Dr S. K. Gupta

Wildlife Institute of India, Dehradun

Saurashtra University

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NOVEMBER 2021

DECLARATION

I declare that the thesis entitled **"Diversity and Distributional Pattern of Family Geometridae (Lepidoptera) in Great Himalayan National Park Conservation Area, Himachal Pradesh"**, submitted by me for the degree of Doctor of Philosophy is the record of research work carried out by me during the period from 2017 to 2021 under the guidance of Dr Sandeep Kumar Gupta, Scientist-E & Nodal Officer, Wildlife Forensic and Conservation Genetics Cell & Dept. of Animal Ecology & Conservation Biology, Wildlife Institute of India and Co-supervision of Dr Virendra Prasad Uniyal, Scientist-G, Head, Department of Landscape Level Planning and Management, Wildlife Institute of India, Dehradun and Dr Kailash Chandra, former Director, Zoological Survey of India, Kolkata and has not formed the basis for the award of any degree, diploma, associateship, fellowship, titles in this or any University or other institutions of higher learning.

I further declare that the material obtained from other sources has been duly acknowledged in the thesis. I shall be surely responsible for any plagiarisms or other irregularities if noticed in the thesis.

Kaushik Mallick

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(Signature of the Co-supervisor)

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I also certify that the Research work was appreciated by all who remain present and there was no comments made for this research work.

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George Francis Hampson. "X. Descriptions of New Heterocera from India.", Transactions of the Royal Entomological Society of London, 04/24/2009

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Keith S. Summerville, Thomas O. Crist. "EFFECTS OF TIMBER HARVEST ON FOREST LEPIDOPTERA: COMMUNITY, GUILD, AND SPECIES RESPONSES", Ecological Applications, 2002

72 words / < 1% match - Crossref
Jan C. Axmacher. "Diversity of geometrid moths (Lepidoptera: Geometridae) along an Afrotropical elevational rainforest transect", Diversity & Distributions, 7/2004

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MICHAEL J. SAMWAYS, NORMA J. SHARRATT. "Recovery of Endemic Dragonflies after Removal of Invasive Alien Trees", Conservation Biology, 2010

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www.degruyter.com

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"Biodiversity of the Himalaya: Jammu and Kashmir State", Springer Science and Business Media LLC, 2020

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Jiang, Nan, Xue, Dayong, Han, Hongxiang. "A review of Biston Leach, 1815 (Lepidoptera, Geometridae, Ennominae) from China, with description of one new species", Pensoft Publishers

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Jeremy Holloway, Geoffrey Kibby, Djunijanti Peggie, David Carter, Scott Miller. "The Families of Malesian Moths and Butterflies", Brill, 2001

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Jan Beck, Christy M. McCain, Jan C. Axmacher, Louise A. Ashton et al. "Elevational species richness gradients in a hyperdiverse insect taxon: a global meta-study on geometrid moths", Global Ecology and Biogeography, 2017

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scholar.sun.ac.za

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Pasi Sihvonen, Leidys Murillo-Ramos, Gunnar Brehm, Hermann Staude, Niklas Wahlberg. "Molecular phylogeny of Sterrhinae moths (Lepidoptera: Geometridae): towards a global classification", Systematic Entomology, 2020

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jhr.pensoft.net

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threatenedtaxa.org

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cmerwebmap.cr.usgs.gov

25 words / < 1% match - Crossref
Jan Beck. "Determinants of regional species richness: an empirical analysis of the number of hawkmoth species (Lepidoptera: Sphingidae) on the Malesian archipelago", Journal of Biogeography, 4/2006

25 words / < 1% match - Crossref
Sei-Woong Choi. "Systematics of the Genus Heterothera Inoue (Lepidoptera, Geometridae: Larentiinae)", Tijdschrift voor Entomologie, 1998

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onlinelibrary.wiley.com

23 words / < 1% match - Crossref
H-X. Han, A. C. Galsworthy, D-Y. Xue. " A survey of the genus Linnaeus (Lepidoptera, Geometridae, Geometrinae) ", Journal of Natural History, 2009

22 words / < 1% match - Crossref
Shao-Ji Hu, Dong-Hui Xing, Zhi-Xian Gong, Jin-Ming Hu. "Projecting Suitability and Climate Vulnerability of Bhutanitis thaidina (Blanchard) (Lepidoptera: Papilionidae) with Conservation Implications", Scientific Reports, 2019

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www.plantbio.ohiou.edu

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www2.wii.gov.in

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Avas Pakrashi, Shantanu Kundu, Jagdish Saini, Koomud Tyagi, Kailash Chandra, Vikas Kumar. "Molecular identification of selected bees from the Indian Himalaya: A preliminary effort", Journal of Asia-Pacific Entomology, 2020

21 words / < 1% match - Crossref
Gunnar Brehm. "Unique elevational diversity patterns of geometrid moths in an Andean montane rainforest", Ecography, 8/2003

21 words / < 1% match - Crossref
Guo-Hua Huang, Zi-You Su, Dieter Stüning. "Taxonomic notes on the genus Orthobrachia Warren, with description of a new species from China and Thailand (Lepidoptera, Geometridae)", ZooKeys, 2016

21 words / < 1% match - Crossref
Xue-Qing Yang, S.P.S. Kushwaha, S. Saran, Jianchu Xu, P.S. Roy. "Maxent modeling for predicting the potential distribution of medicinal plant, Justicia adhatoda L. in Lesser Himalayan foothills", Ecological Engineering, 2013

20 words / < 1% match - Crossref
Lucas Sire, Delphine Gey, Régis Debruyne, Thierry Noblecourt et al. "The Challenge of DNA Barcoding Saproxylic Beetles in Natural History Collections—Exploring the Potential of Parallel Multiplex Sequencing With Illumina MiSeq", Frontiers in Ecology and Evolution, 2019

20 words / < 1% match - Crossref
Nemai Sahani. "Assessment of ecotourism potentiality in GHNPCA, Himachal Pradesh, India, using remote sensing, GIS and MCDA techniques", Asia-Pacific Journal of Regional Science, 2019

19 words / < 1% match - Crossref
H-x. Han, A. Galsworthy, D-y. Xue. " A revision of the genus Warren (Lepidoptera, Geometridae, Geometrinae) ", Journal of Natural History, 2010

19 words / < 1% match - Crossref
Pasi Sihvonen. "Phylogeny and tribal classification of Sterrhinae with emphasis on delimiting Scopulini (Lepidoptera: Geometridae) : Phylogeny of Sterrhinae", Systematic Entomology, 06/14/2004

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Prem Budha, Fred Naggs, Thierry Backeljau. "Annotated Checklist of the Terrestrial Gastropods of Nepal", ZooKeys, 2015

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himtimes.com

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Ana Lucia Henriques-Oliveira, Jorge Luiz Nessimian. "Aquatic macroinvertebrate diversity and composition in streams along an altitudinal gradient in Southeastern Brazil", Biota Neotropica, 2010

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HONGXIANG HAN, ANTHONY C. GALSWORTHY, DAYONG XUE. "The Comibaenini of China (Geometridae: Geometrinae), with a review of the tribe", Zoological Journal of the Linnean Society, 2012

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Chuankun Zhu, Haiyang Liu, Zhengjun Pan, Guoliang Chang, Hui Wang, Nan Wu, Huaiyu Ding, Xiangsheng Yu. "Construction of a high-density genetic linkage map and QTL mapping for growth traits in Pseudobagrus ussuriensis", Aquaculture, 2019

15 words / < 1% match - Crossref
Weiting Zhang, ChungKun Shih, YuHong Shih, Dong Ren. "A new macrolepidopteran moth (Insecta, Lepidoptera, Geometridae) in Miocene Dominican amber", ZooKeys, 2020

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Keith S. Summerville. "Determinants of lepidopteran community composition and species diversity in eastern deciduous forests: roles of season, eco-region and patch size", Oikos, 1/2003

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www.wrd.org

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Yuanjun Zhu, Wei Wei, Hao Li, Baizhu Wang, Xiaohui Yang, Yanshu Liu. "Modelling the potential distribution and shifts of three varieties of Stipa tianschanica in the eastern Eurasian Steppe under multiple climate change scenarios", Global Ecology and Conservation, 2018

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cgwb.gov.in

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84a69b9b8cf67b1fcf87220d0dabdda34414436b-www.googledrive.com

12 words / < 1% match - Crossref
A. P. Rasnitsyn. "On the discussion of the wing venation of (Archae)Orthoptera (Insecta)", Paleontological Journal, 2007

12 words / < 1% match - Crossref
Scott L. Nuismer, Benjamin M. Althouse, Ryan May, James J. Bull, Sean P. Stromberg, Rustom Antia. "Eradicating infectious disease using weakly transmissible vaccines", Proceedings of the Royal Society B: Biological Sciences, 2016

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iopscience.iop.org

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www.europeanjournaloftaxonomy.eu

12 words / < 1% match - Internet from 22-Jan-2013 12:00AM
www.ipef.br

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Jan C. Axmacher. "Determinants of diversity in afrotropical herbivorous insects (Lepidoptera: Geometridae): plant diversity, vegetation structure or abiotic factors?", Journal of Biogeography, 02/2009

11 words / < 1% match - Crossref

John Henry Leech. " LXIX. – . –Part II. Geometridæ: Œnochrominæ, Orthostixinæ, Larentiinæ, Acidaliinæ, and Geometrinæ ", Annals and Magazine of Natural History, 2009

11 words / < 1% match - Crossref
Miranda Pal, Paul Pop, Aksheeta Mahapatra, Radhika Bhagat, Upamanyu Hore. "Diversity and structure of bird assemblages along urban-rural gradient in Kolkata, India", Urban Forestry & Urban Greening, 2019

11 words / < 1% match - Crossref
REGIER, JEROME C., CHARLES MITTER, DONALD R. DAVIS, TERRY L. HARRISON, JAE-CHEON SOHN, MICHAEL P. CUMMINGS, ANDREAS ZWICK, and KIM T. MITTER. "A molecular phylogeny and revised classification for the oldest ditrysian moth lineages (Lepidoptera: Tineoidea), with implications for ancestral feeding habits of the mega-diverse Ditrysia : Molecular phylogeny for Tineoidea (Lepidoptera)", Systematic Entomology, 2014.

11 words / < 1% match - Internet from 22-Nov-2017 12:00AM
edoc.unibas.ch

11 words / < 1% match - Internet
Sellers, Samantha Sue. "Characterization of two distinct hfq genes in Burkholderia cenocepacia HI2424", OpenSIUC, 2011

11 words / < 1% match - Internet from 26-Aug-2021 12:00AM
researchspace.ukzn.ac.za

10 words / < 1% match - Crossref
George F. Hampson. " XV.— Pyralidæ Pyraustinæ ", Annals and Magazine of Natural History, 2009

10 words / < 1% match - Crossref
Konrad Fiedler. "Moths at tropical forest margins — how mega-diverse insect assemblages respond to forest disturbance and recovery", Environmental Science and Engineering, 2007

10 words / < 1% match - Crossref
Romina E. Principe. "Ecological effects of small dams on benthic macroinvertebrate communities of mountain streams (Córdoba, Argentina)", Annales de Limnologie - International Journal of Limnology, 2010

10 words / < 1% match - Crossref
Shantanu Kundu, Shibananda Rath, Kaomud Tyagi, Rajasree Chakraborty, Vikas Kumar. "Identification of penaeid shrimp from Chilika Lake through DNA barcoding", Mitochondrial DNA Part B, 2018

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complete.bioone.org

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9 words / < 1% match - Crossref
John Henry Leech. " XXIII.— ", Annals and Magazine of Natural History, 2009

9 words / < 1% match - Crossref

Shahab Doulabian, Amirhossein Shadmehri Toosi, Giancarlo Humberto Calbimonte, Erfan Ghasemi Tousi, Sina Alaghmand. "Projected climate change impacts on soil erosion over Iran", Journal of Hydrology, 2021

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Www.jagranjosh.com

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Xiao-Qiang Lu, Ji-Ping Wan, Xi-Cui Du. "Three new species of Herpetogramma Lederer (Lepidoptera, Crambidae) from China", ZooKeys, 2019

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datazone.birdlife.org

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dspace.lboro.ac.uk

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Summary Background and objectives: Lepidoptera is a large and diverse group of insects which includes moths (Heterocera) and butterflies (Rhopalocera). Although they play fundamental roles in nature, invertebrates have been systematically

ignored in conservation studies (Franklin, 1993; Kremen et al., 1993

). As the Himalayan environment is unique and delicate in nature, the diversity of the region is also very rich both in terms of culture and biology. Importance should be given to the studies of such taxa which are an indicator in nature and can readily react to small changes in the environment. Moths are one of the best groups to study such patterns. Geometridae consists about 2,002 genera and 23,002 species globally (Nieukerken et al., 2011). Nearly 2041 species are recorded from India (Kirti et al., 2019), of which around 850 species of Geometridae are recorded from the Indian Himalayan Region of that around 234 species are from Himachal Pradesh (Sanyal et al., 2018), and about 17 species from GHNP (Uniyal and Mathur, 1998). The current study aims to give a clear idea of the diversity and distribution pattern of Geometrid moths in the area which will act as a database for future works. It will also assess the environmental factors governing the distribution pattern of Geometrid moths across different vegetation and habitat type in the study area. Understanding the response of moth fauna with respect to various disturbance factors will help in the implication of management plans to protect significant habitats. Methodology: Study area:

The Great Himalayan National Park (GHNP) Conservation Area, **located in Kullu District of Himachal Pradesh** , falls under **the**

North- Western Himalayan Biotic Province- 2A, lies between 31°31'16" and 31°56'41" N and 77°20' to 77°52'11" E, covering an area of 1171 km2 and showing an altitudinal variation of 1300 m to 6110 m. It

is located at **the junction of two great faunal realms: Palaearctic to the north and Oriental to the south (Mackinon et al., 1986**

). A total of 832 plant species were recorded from GHNP, of which,

794 species were **Angiosperms, 11 species** are **Gymnosperms and 27 species** were **Ferns** , including 250 species **of**

medicinal plants traditionally used by local people. Besides, 192 species of Lichens were also reported, highly used by wild ungulates during the winter season.

31 species of mammals, 209 species of birds, 12 Reptilian species

, 9 Amphibians and 125 insects were reported from the park (Gaston et al., 1993; Ramesh et al., 1998; Uniyal & Mathur, 1998). A total of 75 species of butterflies and 17 species of moths

were recorded from the different valleys and altitudinal zones in GHNPCA

(WII, 1998). Sampling and identification: A great diversity in vegetation was found due to the variation in altitude, topography and climate. According to Champion and Seth (1968), total 11 forest types were identified and sampled using traditional light-trap in 27 sampling sites inside Great Himalayan National Park, Himachal Pradesh. They are:

Himalayan Chir Pine Forest (9/C1b), Moist Temperate Deciduous Forest (12 /C1e), Alder Forest

(Riverine) (12/1S1),

Moist Deodar Forest (12 /C1c), Western Mixed Coniferous Forest (12

/C1d), Low Level Blue Pine

Forest (12 /2S1), West Himalayan Upper Oak-Fir Forest (12/C2b

), West

Himalayan Sub-alpine High-Level Fir forest (14 /C1a), Sub-Alpine Pastures (14/DS1), Dwarf Rhododendron Scrub

(15/C2/E1) and Birch Rhododendron Scrub Forest (15/C1). Collected moths were curated according to the standard protocol following Robinson et al., 1994 and then identified by examining external morphology following the descriptions and illustrations given in literature. For the identification of cryptic species, male genitalia were dissected and examined below microscope. To test the effects of different vegetation type on the diversity of Geometrid moths in the area, plant community of each vegetation types were sampled using a series of nested quadrats (Sanyal, 2015) to record the data of following variables: Tree species richness, Tree abundance, the

diameter at breast height (DBH) of all trees greater than 10 cm DBH, Canopy

cover, shrubs species richness, shrubs abundance, Herb

species richness , Herb abundance and percentage cover of the herbaceous layer

. Ambient air temperature and relative humidity, wind velocity were recorded during the light trap in every 60 min with an electronic weather meter and were averaged over all catch nights for every site. Bioclimatic variables extracted from Worldclim data (Fick et al., 2017) Anthropogenic disturbances data, such as logging lopping, the presence of the fallen tree, livestock grazing and the presence of fire sign, were collected during the study period. Topographical variable, such as Altitude, Slope, Hill Shade and Aspect were also noted during sampling. Data analysis: Different diversity measures and analysis were done in PAST 2.17c. Total altitudinal gradient is dived into 6 different altitudinal zones Viz., Zone 1(1500- 1800

m), Zone 2 (1800- 2100 m), Zone 3 (2100- 2400 m), Zone 4 (2400- 2700 m), Zone 5 (2700- 3000 m) and Zone 6

(above 3000 m). Hierarchical Cluster Analysis was used

for finding relatively homogeneous clusters of cases based on measured characteristics . NMDS with

Bray-Curtis similarity index were used to see how different the Geometrid moth assemblages in different altitudinal and habitat zone. The analysis and the 2D plot were done in PAST 2.17c. The dissimilarity of moth communities within and between different altitudinal and habitat zone was investigated by an analysis of similarities (ANOSIM). Particular species contributing to the dissimilarity was revealed by SIMPER using PAST 2.17c. Correlation matrix was developed from overall diversity measures such as Geometridae Species observed, Individuals and Fisher's alpha with major topographical features, microclimate variables, vegetation cover structural factors and disturbance variables using PAST 2.17c (Hammer et al., 2007). Pairwise correlation graphs were used to show significant relationships using MS-Excel2013. Exploration of Geometridae species composition by different factor governing the actual pattern of Geometrid moth diversity, richness and abundance through Canonical Correspondence Analysis (CCA) such as: a) Effect of significant variables of the environment. b) Effect of significant variables of the Topography. c) Effect of significant variables of the vegetation cover structure. d) Effect of significant variables of the Anthropogenic disturbance using PAST 2.17c (Hammer et al., 2007). Indicator species analysis for different habitat types and altitudinal zones was done in PCORD. Climatic suitability model for present and future climatic scenarios of genus Psyra and selected species were done in Maxent software 9Ver. 3.4.1). Result & Discussion: Inventory: Total 516

species of moths under 298 genera belonging to 59 subfamilies of 21 families

belonging to 10 superfamilies were recorded during current course of study, which included Tortricidae (1 species), Cossidae (3), Zygaenidae (1), Callidulidae (1), Pyralidae (4), Crambidae (17), Drepanidae (15), Lasiocampidae (3), Eupterotidae (1), Brahmaeidae (1), Endromidae (3), Bombycidae (2), Saturniidae (1), Sphingidae (8), Uraniidae (3), Geometridae (224), Notodontidae (19), Erebidae (94), Euteliidae (2), Nolidae (4) and Noctuidae (109). Out of these 518 species were recorded from Great Himalayan National Park, 47 species were recorded for the first time from this country and added to Indian moth faunal list. Majority of those species mainly belong to family Geometridae and Noctuidae, consisting 18 and 17 species respectively, novel to India. Another 86 species were reported for the first time from Western Himalaya, while they were restricted previously in other Himalayan biogeographic zones. Among them, majority of the species belong to family Geometridae, with 55 species novel to Western Himalaya. 93 species were reported as new to the state, Himachal Pradesh from this study and majority of the species belongs to family Geometridae, with 44 species. Geometrid moth

Diversity in different elevation zones in GHNP: Geometridae moth diversity was highest in lowest altitudinal zone and gradually decreased with the increasing altitude. Shannon's Index and species richness followed the same trend like Geometrid moth diversity. The abundance of Geometrid moths showed a unique trend along the altitudinal gradient i.e., higher abundance in both lowest and highest altitude but abundance was comparatively low in mid elevational zones. Subfamily Ennominae followed same trend like Geometridae. Larentiinae moth diversity was highest in Zone 2 gradually becoming lower in intermediate zones and reaching lowest in the Zone 5. Shannon's Index and Species richness showed an exactly similar trend like Fisher's alpha. The abundance of Larentiinae moths showed a unique trend along the altitudinal gradient i.e., highest abundance in highest altitude i.e., Zone 6 but abundance was comparatively low in mid and low elevational zones. Overall, Geometridae showed similar pattern with Ennominae, as it influences the distribution pattern of the total Geometrid moths with its large sample size and diversity. From the result, it can be concluded that overall altitudinal distributional pattern of Geometridae as well as Ennominae indicates the mid-altitude preference. Larentiinae showed comparatively higher altitudinal distribution range to indicate its high altitude preference. Comparison of Species assemblages among altitudinal zones: Hierarchical Cluster Analysis showed that Zone 1 had a very unique species assemblage with 85% dissimilarity to all the other zones. Zone 4 and 3 were most similar in terms of species assemblages with 45% species similarity, both of them clustered with Zone 2 with 65% dissimilarity. Zone 5 and 6 clustered together with 45 % similarity between themselves. Variation of species assemblages in different Altitudinal Zones: The Global R statistics from ANOSIM from 1% threshold level was 0.2093 with p= 0.0001 indicating that the overall difference between six altitudinal zones were large and statistically significant.

Pairwise ANOSIM test showed the differences in species composition occurred between

Zone 1 and **Zone 2; Zone 1** and **Zone 3; Zone 1** and **Zone 4; Zone 1** and **Zone 5; Zone 1** and **Zone 6**

. Contributing species for the dissimilarity of assemblages in different Altitudinal Zones in GHNP: a) Between Zone 1 and Zone 2: Eleven species contributed around 90.1% overall dissimilarity between Zone 1 and Zone 2.

These species differed in mean abundance, which was reflected in the degree of group association . Three species

had higher mean abundance in Zone 1 **and** eight **species had higher mean abundance in**

Zone 2. b) Between Zone 1 and Zone 3: Eighteen species contributed around 90.08% to the difference between Zone 1 and Zone 3. Seven

species had higher mean abundance in Zone 1 **and** 11 **species had higher mean abundance in**

Zone 3. c) Between Zone 1 and Zone 4: Twenty species contributed around 93.67% to the difference between Zone 1 and Zone 4. Five

species had higher mean abundance in Zone 1 **and** 15 **species had higher mean abundance in**

Zone 4. d) Between Zone 1 and Zone 5: Twenty species contributed around 95.23% to the difference between Zone 1 and Zone 5. Seven

species had higher mean abundance in Zone 1 **and 7 species had higher mean abundance in**

Zone 5. e) Between Zone 1 and Zone 6: Twenty species contributed around 95.23% to the difference between Zone 1 and Zone 6. Seven

species had higher mean abundance in Zone 1 **and 7 species had higher mean abundance in**

Zone 6. Assemblages of Geometridae in different Altitudinal Zones: The result indicates that sites of Zone 1 (1500- 1800 m) showing very different assemblage from that of other zones as they are showing no overlap in NMDS plot whereas, site of Zone 2 (1800- 2100 m) was also showing the minimum overlap in the NMDS plot, showing its uniqueness in assemblages. Sites of other zones were showing moderate overlap with each other suggesting overall similar assemblage pattern but Zone 3 (2100- 2400m) and Zone 4 (2400- 2700 m) sites were showing maximum overlap between themselves suggesting similar assemblage pattern of Geometridae moth. Major Habitat variables shaping Geometridae diversity: To see the main effects of all major topographic, microclimatic, vegetation structural, compositional and disturbance variables on overall diversity measures such as Geometridae Species richness, abundance and Fisher's alpha, Spearman correlation test were carried out. Altitude, Hill Shade, Aspect, Annual Precipitation (bio12),

Precipitation of Wettest Quarter (bio 16), Precipitation of Driest Quarter (bio 17), Precipitation of Warmest Quarter (bio 18), No **of**

Tree species, Tree Abundance, Avg. Tree Height (m), Avg. Tree GBH (cm), Logging Sign, No of Dead Trees and No of dung/ pellets were showed significant correlation with Geometridae species richness, abundance and Fisher's alpha. Factors determining Geometridae diversity and species composition: a) CCA with major Environmental factors, Geometridae diversity, richness and abundance: CCA result showed that Avg. trap night temperature, Avg. trap night humidity had strong positive influences on Geometridae abundance, species richness and fisher's alpha, whereas

Annual precipitation (bio 12), Precipitation of Wettest Quarter (bio 16), Precipitation of Driest Quarter (bio 17), Precipitation of Warmest Quarter (bio 18

) had strong negative influences on Geometridae abundance, richness and diversity. b) CCA with major topographical factors, Geometridae diversity, richness and abundance: CCA result showed that NDVI had a strong positive influence on Geometridae abundance, species richness and fisher's alpha, whereas Altitude, Slope, Hill Shade, Aspect had negative influence on Geometridae abundance, richness and Diversity. Mainly altitude showed strong negative influence and NDVI showed strong positive influence on Geometridae abundance, richness and Diversity. c) CCA with major Vegetation cover and structural factors on Geometridae diversity: CCA result showed that Number of herb species, Shrub abundance and Herb abundance had prominent negative influences but Average tree height, Average tree GHB, Number of tree species had strong positive impacts on Geometridae moth diversity and abundance (Fig: 5.10). So, it can be concluded that, foliage diversity, especially tree diversity, abundance and structure strongly influence Geometridae moth diversity and abundance as they majorly forest specific and not grass feeders like Noctuidae. d) CCA with anthropogenic disturbance factors, Geometridae Diversity and abundance: CCA result showed that the number of Dead Trees and Logging sign had slight positive influences on Geometridae moth abundance but Number of dung/ pellets, lopping sign and nearest village distance had distinct negative influences on Geometridae moth Diversity. Geometrid moths as an indicator of habitat quality in GHNP: a) Indicator species analysis for different habitat types: Among 266 Geometridae morpho- species recorded from GHNPCA, only 5 species met the criteria of Indicator species and 18 species met the criteria of detector species from this study. Among them, from the subfamily Ennominae, Ourapteryx purissima and Odontopera sp. showed highest indicator value for the Himalayan Chir Pine Forest, followed by Ctenognophos eolaria and Ctenognophos methoria. From the subfamily Larentiinae, Rheumaptera dubiosata showed a good indicator value for Himalayan Chir Pine Forest. b) Indicator species analysis for different altitudinal zones: Only 6 species met the criteria of Indicator species and 17 species met the criteria of detector species from this study. Among them, from the subfamily Ennominae, Ourapteryx purissima and Odontopera sp. showed highest indicator value for the Zone 1, followed by Ctenognophos methoria, Ctenognophos eolaria and Alcis nudipennis. From the subfamily Larentiinae, Rheumaptera dubiosata showed an indicator value of 90.4 for Altitudinal zone 1. Synthesis: Among the total sampled moth assemblage of GHNP, majorly 91% species were found to be Oriental origin, while 83.5% species also had affinities to Palearctic region. In the context of Indian Biogeographic Zones and Provinces, only 21% and 26% species were distributed in two Trans-Himalayan Provinces, Ladakh Mountain (1A) and Tibetan Plateau (1B). Almost 80% species were shared with Western Himalaya (2B) as the landscape located close to that province viz., North-western Himalaya (2A), 72% with Central Himalaya (2C) and 45% species with Eastern Himalaya (2D). 45% species were shared with North-Eastern Hills & Valleys. Chapter 1: General Introduction 1.1. Introduction: Insects being ectotherms with short life-cycles and a huge variety of population in space and time, and their inherent response towards climate change make them a good indicator taxa (Bale et al., 2002). They are the most diverse group of animals in the world and can be found in almost all types of ecosystems playing various vital roles in functioning of the ecosystem. As estimated, in the next few decades, about a quarter of all insect species are leading towards extinction. Sadly, they are the most overlooked faunal taxa when it comes to studying wildlife and conservation. Insects and other invertebrates are facing some special challenges simply due to their large unrecorded diversity, individual variations, highly specific behaviour and overall lack of knowledge about their biology, ecology and taxonomy. It is very important to know about their food habit as they are often very specific or generalist in nature. They can be parasitic or herbivorous as well; some can also be predators or host-specific, depending on their host specificity. So, there is evidently large variations when it comes to their food habits. They can also be very cryptic. Such species are difficult to identify; lack of expert taxonomists in recent times is one of the major reasons for this lacuna. Also, ecological study designing is still lacking in the case of insect research due to the unaccounted variety of habitats and different level of niche partitioning. On earth, organisms are not evenly distributed along the altitude as well as latitude. Most of the insect reach highest species diversity at low latitude, but some insects (Aphids, Bees, Sawflies, Syrphids, Psyllids and Ichneumonid) show the opposite pattern (Brehm et al., 2003). The pattern of distribution of insects along the altitude does not seem to have a clear answer. Some studies showed that species richness decreases with the increasing altitude because favourable habitat area, resource diversity and primary productivity decrease along the elevation. However, some studies revealed that species richness is highest at the mid-elevation not at the lower elevation. Huge anthropogenic pressure and disturbance at the lower elevation may be the reason behind this kind of result (McCoy, 1990). Some insect species having wide altitudinal distribution can face different environmental conditions, especially those living in the upper and lower altitudinal extremities. Varied climate and habitat types may be found within a short geographic distance along an elevational gradient as many environmental factors change along the altitudinal gradients (Brehm et al., 2003; Axmacher et al., 2004). Lepidoptera, in particular, has high species richness and abundance and they significantly respond to idiosyncratic climate and abiotic factors, which makes them potential indicator taxa for studies focusing on environment impact. The members of the Order Lepidoptera characterized by two pairs of membranous wings, contain a long, coiled proboscis as one of their mouthparts, which differentiate them from other groups of insects. Lepidoptera is a well-known and large order of insects including two suborders, i.e., Heterocera (moths) and Rhopalocera (butterflies). Of them, moths are mostly nocturnal and constitute large and diverse group making more than 80% of the order Lepidoptera. About 15,000 species of moths and butterflies are reported from India (Chandra, 2011). One of the preferred target taxa in landscape and community ecology studies are moths, as they represent high abundance to produce large sample sizes giving statistical robustness. They are taxonomically and ecologically hyperdiverse compared to other well-known insect orders in various zoogeographical zones (Dale et al., 2019). About

1,27,000 species of moths are reported **from the world (Alfred et al., 1998**

). At present, the diversity of moth from India is estimated to be more than 15,000 species/subspecies distributed over 84 families and 18 super-families.

Geometridae is one of the major families **of Lepidoptera** , containing about **21,000 species**

and can be found in every zoogeographical zones (Brehm et al., 2003). The concept of the family was first erected by Leach in 1815 and currently known by 23,002 species under 2,002 genera globally (van Nieukerken et al., 2011). Nearly 2041 species are recorded from India (Kirti et al., 2019), of which around 850 species were reported from the Indian Himalayan Region, among which around 234 species are documented from Himachal Pradesh (Sanyal et al., 2018). Geometrid larva being almost exclusive feeders of tree and shrub species, they are mostly associated with areas with dense vegetation cover, like forested areas, and thus are suitable taxa as indicator of the vegetation quality, besides some species being important defoliators and invasive pests in agriculture and forestry. Generally, the caterpillars of geometrids

are host -plant **specific, feed on single plant family or** genus (Beck **et al**

., 2016). Most Geometrid moths have cryptic wing pattern making them very tough group to identify up to species level (deWaard et al., 2011). They are universally most abundant lepidopteran family in many temperate and tropical habitats. The various sub-families of Geometridae show different distributional trend along with the altitudinal gradient making them more interesting for addressing questions like ecological specificities at higher taxonomic level (Brehm et al., 2003). 1.3. Backdrop and justification of the Study: Himalayan ecosystems being unique and delicate in nature host significant level of Lepidopteran richness, which can be used as tools for detecting faunal level impacts of human disturbance including global climate change. Moths, especially of family Geometridae can serve better in this direction, but unfortunately such studies have not been attempted so far. Himachal Pradesh, being a state in North-Western Himalayan sector is in an important junction of faunal mixing of Palaearctic and Oriental origin. Moreover, several interconnected Protected Area systems like GHNPCA provide an undisturbed stretch Himalayan Temperate habitat, important mainly to investigate faunal composition changes along major environmental gradients, altitude being major among them. Currently 850 species of Geometridae moths are known from IHR, while 234 species are reported from Himachal Pradesh. Knowledge on moth fauna of GHNPCA is very poor represented by only 17 species documented by Uniyal and Mathur, 1998. The

Acknowledgements

I started collecting and studying moths from the time of my earlier M.Sc. days in Kolkata, near my locality. Back then we didn't have any light trap equipment except a glass jar with benzene inside it. I had to collect moths from my home and neighborhood randomly, even in the puja-pandals during Durga and Kali Pujas. I didn't expect to continue working with moths for my PhD. But during my study tenure, I had a chance to examine the whole Himalayan moth collection in the Zoological Survey of India. My love for this nocturnal, beautiful creature increased immensely when I saw their different varieties, colours, delicate patterns closely with my own eyes.

Majorly moths were called drab, dark, ugly creatures because of the comparison with their diurnal relatives, Butterfly, by many researchers and even some renowned moth researchers. But, I found moths were very charismatic, beautiful and delicate. Their wings were marked so delicately by nature that no one can mention them to be drab or only dark.

This study is dedicated to those moths, which I had to sacrifice for this study for the betterment of their conservation and to reveal their existence as well as their importance in the ecosystem. This study is also aimed to establish them as charismatic, beautiful and delicate creatures, not as drab, dusky insects.

Once a wise man said that if you want something, do it with passion and love. I worked with passion and love till the last day of this study tenure. A specific goal cannot be attained if without the required effort, passion and love. I felt a strong connection with my work as well as my study site, Great Himalayan National Park, Himachal Pradesh. This beautiful, continuous, mountainous Himalayan Landscape inspired me very much during my field surveys. My love for the area and its amazing people will be the same forever.

Now, I bow to my all well-wishers who have helped, supported and inspired me several times and in different ways till the date to reach this prestigious landmark. However, no words will be sufficient to acknowledge them, but it is my privilege to name them separately as much as possible.

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Lepidoptera is a large and diverse group of insect which includes moths (Heterocera) and butterflies (Rhopalocera). Although they play fundamental roles in nature, invertebrates have been systematically ignored in conservation studies (Franklin, 1993; Kremen *et al.*, 1993). As the Himalayan environment is unique and delicate in nature, the diversity of the region is also very rich both in terms of culture and biology. Importance should be given to the studies of such taxa which are an indicator in nature and can readily react to small changes in the environment. Moths are one of the best groups to study such patterns.

Geometridae consists about 2,002 genera and 23,002 species globally (Nieukerken *et al.*, 2011). Nearly 2041 species are recorded from India (Kirti *et al.*, 2019), of which around 850 species of Geometridae are recorded from the Indian Himalayan Region of that around 234 species are from Himachal Pradesh (Sanyal *et al.,* 2018), and about 17 species from GHNP (Uniyal and Mathur, 1998).

The current study aims to give a clear idea of the diversity and distribution pattern of Geometrid moths in the area which will act as a database for future works. It will also assess the environmental factors governing the distribution pattern of Geometrid moths across different vegetation and habitat type in the study area. Understanding the response of

moth fauna with respect to various disturbance factors will help in the implication of management plans to protect significant habitats.

Methodology:

Study area:

The Great Himalayan National Park (GHNP) Conservation Area, located in Kullu District of Himachal Pradesh, falls under the North- Western Himalayan Biotic Province- 2A, lies between 31°31'16" and 31°56'41" N and 77°20' to 77°52'11" E, covering an area of 1171 km^2 and showing an altitudinal variation of 1300 m to 6110 m. It is located at the junction of two great faunal realms: Palaearctic to the north and Oriental to the south (Mackinon *et al.*, 1986).

A total of 832 plant species were recorded from GHNP, of which, 794 species were Angiosperms, 11 species are Gymnosperms and 27 species were Ferns, including 250 species of medicinal plants traditionally used by local people. Besides, 192 species of Lichens were also reported, highly used by wild ungulates during the winter season.

31 species of mammals, 209 species of birds, 12 Reptilian species, 9 Amphibians and 125 insects were reported from the park (Gaston *et al.*, 1993; Ramesh *et al.*, 1998; Uniyal & Mathur, 1998). A total of 75 species of butterflies and 17 species of moths were recorded from the different valleys and altitudinal zones in GHNPCA (WII, 1998).

***Sampling and identification*:**

A great diversity in vegetation was found due to the variation in altitude, topography and climate. According to Champion and Seth (1968), total 11 forest types were identified and sampled using traditional light-trap in 27 sampling sites inside Great Himalayan National Park, Himachal Pradesh. They are: Himalayan Chir Pine Forest (9/C1b), Moist Temperate Deciduous Forest (12/C1e), Alder Forest (Riverine) (12/1S1), Moist Deodar Forest (12/C1c), Western Mixed Coniferous Forest (12/C1d), Low Level Blue Pine Forest (12/2S1), West Himalayan Upper Oak-Fir Forest (12/C2b), West Himalayan Sub-alpine High-Level Fir forest (14/C1a), Sub-Alpine Pastures (14/DS1), Dwarf Rhododendron Scrub (15/C2/E1) and Birch Rhododendron Scrub Forest (15/C1).

Collected moths were curated according to the standard protocol following Robinson *et al.,* 1994 and then identified by examining external morphology following the descriptions and illustrations given in literature. For the identification of cryptic species, male genitalia were dissected and examined below microscope.

To test the effects of different vegetation type on the diversity of Geometrid moths in the area, plant community of each vegetation types were sampled using a series of nested quadrats (Sanyal, 2015) to record the data of following variables: Tree species richness, Tree abundance, the diameter at breast height (DBH) of all trees greater than 10 cm DBH, Canopy cover, shrubs species richness, shrubs abundance, Herb species richness, Herb abundance and percentage cover of the herbaceous layer.

Ambient air temperature and relative humidity, wind velocity were recorded during the light trap in every 60 min with an electronic weather meter and were averaged over all catch nights for every site. Bioclimatic variables extracted from Worldclim data (Fick *et al.*, 2017)

Anthropogenic disturbances data, such as logging lopping, the presence of the fallen tree, livestock grazing and the presence of fire sign, were collected during the study period.

Topographical variable, such as Altitude, Slope, Hill Shade and Aspect were also noted during sampling.

***Data analysis*:**

Different diversity measures and analysis were done in PAST 2.17c. Total altitudinal gradient is dived into 6 different altitudinal zones Viz., Zone 1(1500- 1800 m), Zone 2(1800- 2100 m), Zone 3(2100- 2400 m), Zone 4(2400- 2700 m), Zone 5(2700- 3000 m) and Zone 6(above 3000 m).

Hierarchical Cluster Analysis was used for finding relatively homogeneous clusters of cases based on measured characteristics.

NMDS with Bray-Curtis similarity index were used to see how different the Geometrid moth assemblages in different altitudinal and habitat zone. The analysis and the 2D plot were done in PAST 2.17c.

The dissimilarity of moth communities within and between different altitudinal and habitat zone was investigated by an analysis of similarities (ANOSIM). Particular species contributing to the dissimilarity was revealed by SIMPER using PAST 2.17c.

Correlation matrix was developed from overall diversity measures such as Geometridae Species observed, Individuals and Fisher's alpha with major topographical features, microclimate variables, vegetation cover structural factors and disturbance variables using PAST 2.17c (Hammer *et al.,* 2007). Pairwise correlation graphs were used to show significant relationships using MS-Excel2013.

Exploration of Geometridae species composition by different factor governing the actual pattern of Geometrid moth diversity, richness and abundance through Canonical Correspondence Analysis (CCA) such as:

a) Effect of significant variables of the environment.

b) Effect of significant variables of the Topography.

c) Effect of significant variables of the vegetation cover structure.

d) Effect of significant variables of the Anthropogenic disturbance using PAST 2.17c (Hammer *et al.*, 2007).

Indicator species analysis for different habitat types and altitudinal zones was done in PCORD.

Climatic suitability model for present and future climatic scenarios of genus *Psyra* and selected species were done in Maxent software 9Ver: 3.4.1).

Result & Discussion:

Inventory: Total 516 species of moths under 298 genera belonging to 59 subfamilies of 21 families belonging to 10 superfamilies were recorded during current course of study, which included Tortricidae (1 species), Cossidae (3), Zygaenidae (1), Callidulidae (1), Pyralidae (4), Crambidae (17), Drepanidae (15), Lasiocampidae (3), Eupterotidae (1), Brahmaeidae (1), Endromidae (3), Bombycidae (2), Saturniidae (1), Sphingidae (8), Uraniidae (3), Geometridae (224), Notodontidae (19), Erebidae (94), Euteliidae (2), Nolidae (4) and Noctuidae (109).

Out of these 518 species were recorded from Great Himalayan National Park, 47 species were recorded for the first time from this country and added to Indian moth faunal list. Majority of those species mainly belong to family Geometridae and Noctuidae, consisting 18 and 17 species respectively, novel to India.

Another 86 species were reported for the first time from Western Himalaya, while they were restricted previously in other Himalayan biogeographic zones. Among them, majority of the species belong to family Geometridae, with 55 species novel to Western Himalaya.

93 species were reported as new to the state, Himachal Pradesh from this study and majority of the species belongs to family Geometridae, with 44 species.

***Geometrid moth Diversity in different elevation zones in GHNP*:**

Geometridae moth diversity was highest in lowest altitudinal zone and gradually decreased with the increasing altitude. Shannon's Index and species richness followed the same trend like Geometrid moth diversity. The abundance of Geometrid moths showed a unique trend along the altitudinal gradient i.e., higher abundance in both lowest and highest altitude but abundance was comparatively low in mid elevational zones. Subfamily Ennominae followed same trend like Geometridae.

Larentiinae moth diversity was highest in Zone 2 gradually becoming lower in intermediate zones and reaching lowest in the Zone 5. Shannon's Index and Species richness showed an exactly similar trend like Fisher's alpha. The abundance of Larentiinae moths showed a unique trend along the altitudinal gradient i.e., highest abundance in highest altitude i.e., Zone 6 but abundance was comparatively low in mid and low elevational zones.

Overall, Geometridae showed similar pattern with Ennominae, as it influences the distribution pattern of the total Geometrid moths with its large sample size and diversity. From the result, it can be concluded that overall altitudinal distributional pattern of Geometridae as well as Ennominae indicates the mid-altitude preference. Larentiinae showed comparatively higher altitudinal distribution range to indicate its high altitude preference.

***Comparison of Species assemblages among altitudinal zones*:**

Hierarchical Cluster Analysis showed that Zone 1 had a very unique species assemblage with 85% dissimilarity to all the other zones. Zone 4 and 3 were most similar in terms of species assemblages with 45% species similarity, both of them clustered with Zone 2 with 65% dissimilarity. Zone 5 and 6 clustered together with 45 % similarity between themselves.

***Variation of species assemblages in different Altitudinal Zones*:**

The Global R statistics from ANOSIM from 1% threshold level was 0.2093 with p= 0.0001 indicating that the overall difference between six altitudinal zones were large and statistically significant. Pairwise ANOSIM test showed the differences in species composition occurred between Zone 1 and Zone 2; Zone 1 and Zone 3; Zone 1 and Zone 4; Zone 1 and Zone 5; Zone 1 and Zone 6.

***Contributing species for the dissimilarity of assemblages in different Altitudinal Zones in GHNP*:**

a) Between Zone 1 and Zone 2:

Eleven species contributed around 90.1% overall dissimilarity between Zone 1 and Zone 2. These species differed in mean abundance, which was reflected in the degree of group association. Three species had higher mean abundance in Zone 1 and eight species had higher mean abundance in Zone 2.

b) Between Zone 1 and Zone 3:

Eighteen species contributed around 90.08% to the difference between Zone 1 and Zone 3. Seven species had higher mean abundance in Zone 1 and 11 species had higher mean abundance in Zone 3.

c) Between Zone 1 and Zone 4:

Twenty species contributed around 93.67% to the difference between Zone 1 and Zone 4. Five species had higher mean abundance in Zone 1 and 15 species had higher mean abundance in Zone 4.

d) Between Zone 1 and Zone 5:

Twenty species contributed around 95.23% to the difference between Zone 1 and Zone 5. Seven species had higher mean abundance in Zone 1 and 7 species had higher mean abundance in Zone 5.

e) Between Zone 1 and Zone 6:

Twenty species contributed around 95.23% to the difference between Zone 1 and Zone 6. Seven species had higher mean abundance in Zone 1 and 7 species had higher mean abundance in Zone 6.

***Assemblages of Geometridae in different Altitudinal Zones*:**

The result indicates that sites of Zone 1 (1500- 1800 m) showing very different assemblage from that of other zones as they are showing no overlap in NMDS plot whereas, site of Zone 2 (1800- 2100 m) was also showing the minimum overlap in the NMDS plot, showing its uniqueness in assemblages. Sites of other zones were showing moderate overlap with each other suggesting overall similar assemblage pattern but Zone 3 (2100- 2400m) and Zone 4 (2400- 2700 m) sites were showing maximum overlap between themselves suggesting similar assemblage pattern of Geometridae moth.

***Major Habitat variables shaping Geometridae diversity*:**

To see the main effects of all major topographic, microclimatic, vegetation structural, compositional and disturbance variables on overall diversity measures such as Geometridae Species richness, abundance and Fisher's alpha, Spearman correlation test were carried out. Altitude, Hill Shade, Aspect, Annual Precipitation (bio12), Precipitation of Wettest

Quarter (bio 16), Precipitation of Driest Quarter (bio 17), Precipitation of Warmest Quarter (bio 18), No of Tree species, Tree Abundance, Avg. Tree Height (m), Avg. Tree GBH (cm), Logging Sign, No of Dead Trees and No of dung/ pellets were showed significant correlation with Geometridae species richness, abundance and Fisher's alpha.

Factors determining Geometridae diversity and species composition:

a) CCA with major Environmental factors, Geometridae diversity, richness and abundance:

CCA result showed that Avg. trap night temperature, Avg. trap night humidity had strong positive influences on Geometridae abundance, species richness and fisher's alpha, whereas Annual precipitation (bio 12), Precipitation of Wettest Quarter (bio 16), Precipitation of Driest Quarter (bio 17), Precipitation of Warmest Quarter (bio 18) had strong negative influences on Geometridae abundance, richness and diversity.

b) CCA with major topographical factors, Geometridae diversity, richness and abundance:

CCA result showed that NDVI had a strong positive influence on Geometridae abundance, species richness and fisher's alpha, whereas Altitude, Slope, Hill Shade, Aspect had negative influence on Geometridae abundance, richness and Diversity. Mainly altitude showed strong negative influence and NDVI showed strong positive influence on Geometridae abundance, richness and Diversity.

c) CCA with major Vegetation cover and structural factors on Geometridae diversity:

CCA result showed that Number of herb species, Shrub abundance and Herb abundance had prominent negative influences but Average tree height, Average tree GHB, Number of tree species had strong positive impacts on Geometridae moth diversity and abundance (Fig: 5.10). So, it can be concluded that, foliage diversity, especially tree diversity, abundance and structure strongly influence Geometridae moth diversity and abundance as they majorly forest specific and not grass feeders like Noctuidae.

d) CCA with anthropogenic disturbance factors, Geometridae Diversity and abundance:

CCA result showed that the number of Dead Trees and Logging sign had slight positive influences on Geometridae moth abundance but Number of dung/ pellets, lopping sign and nearest village distance had distinct negative influences on Geometridae moth Diversity.

***Geometrid moths as an indicator of habitat quality in GHNP*:**

a) Indicator species analysis for different habitat types:

Among 266 Geometridae morpho- species recorded from GHNPCA, only 5 species met the criteria of Indicator species and 18 species met the criteria of detector species from this study. Among them, from the subfamily Ennominae, *Ourapteryx purissima* and *Odontopera sp.* showed highest indicator value for the Himalayan Chir Pine Forest, followed by *Ctenognophos eolaria* and *Ctenognophos methoria*. From the subfamily

Larentiinae, *Rheumaptera dubiosata* showed a good indicator value for Himalayan Chir Pine Forest.

b) Indicator species analysis for different altitudinal zones:

Only 6 species met the criteria of Indicator species and 17 species met the criteria of detector species from this study. Among them, from the subfamily Ennominae, *Ourapteryx purissima* and *Odontopera sp.* showed highest indicator value for the Zone 1, followed by *Ctenognophos methoria*, *Ctenognophos eolaria* and *Alcis nudipennis*. From the subfamily Larentiinae, *Rheumaptera dubiosata* showed an indicator value of 90.4 for Altitudinal zone 1.

Synthesis:

Among the total sampled moth assemblage of GHNP, majorly 91% species were found to be Oriental origin, while 83.5% species also had affinities to Palearctic region.

In the context of Indian Biogeographic Zones and Provinces, only 21% and 26% species were distributed in two Trans-Himalayan Provinces, Ladakh Mountain (1A) and Tibetan Plateau (1B). Almost 80% species were shared with Western Himalaya (2B) as the landscape located close to that province viz., North-western Himalaya (2A), 72% with Central Himalaya (2C) and 45% species with Eastern Himalaya (2D). 45% species were shared with North-Eastern Hills & Valleys.

Chapter 1: General Introduction

1.1. Introduction:

Insects being ectotherms with short life-cycles and a huge variety of population in space and time, and their inherent response towards climate change make them a good indicator taxa (Bale *et al.*, 2002). They are the most diverse group of animals in the world and can be found in almost all types of ecosystems playing various vital roles in functioning of the ecosystem. As estimated, in the next few decades, about a quarter of all insect species are leading towards extinction. Sadly, they are the most overlooked faunal taxa when it comes to studying wildlife and conservation. Insects and other invertebrates are facing some special challenges simply due to their large unrecorded diversity, individual variations, highly specific behaviour and overall lack of knowledge about their biology, ecology and taxonomy. It is very important to know about their food habit as they are often very specific or generalist in nature. They can be parasitic or herbivorous as well; some can also be predators or host-specific, depending on their host specificity. So, there is evidently large variations when it comes to their food habits. They can also be very cryptic. Such species are difficult to identify; lack of expert taxonomists in recent times is one of the major reasons for this lacuna. Also, ecological study designing is still lacking in the case of insect research due to the unaccounted variety of habitats and different level of niche partitioning.

On earth, organisms are not evenly distributed along the altitude as well as latitude. Most of the insect reach highest species diversity at low latitude, but some insects (Aphids, Bees, Sawflies, Syrphids, Psyllids and Ichneumonid) show the opposite pattern (Brehm *et al*., 2003). The pattern of distribution of insects along the altitude does not seem to have a clear answer. Some studies showed that species richness decreases with the increasing altitude because favourable habitat area, resource diversity and primary productivity decrease along the elevation. However, some studies revealed that species richness is highest at the mid-elevation not at the lower elevation. Huge anthropogenic pressure and disturbance at the lower elevation may be the reason behind this kind of result (McCoy, 1990). Some insect species having wide altitudinal distribution can face different environmental conditions, especially those living in the upper and lower altitudinal extremities. Varied climate and habitat types may be found within a short geographic distance along an elevational gradient as many environmental factors change along the altitudinal gradients (Brehm *et al*., 2003; Axmacher *et al*., 2004).

Lepidoptera, in particular, has high species richness and abundance and they significantly respond to idiosyncratic climate and abiotic factors, which makes them potential indicator taxa for studies focusing on environment impact. The members of the Order Lepidoptera characterized by two pairs of membranous wings, contain a long, coiled proboscis as one of their mouthparts, which differentiate them from other groups of insects. Lepidoptera is a well-known and large order of insects including two suborders, i.e., Heterocera (moths) and Rhopalocera (butterflies). Of them, moths are mostly nocturnal and constitute large and diverse group making more than 80% of the order Lepidoptera. About 15,000 species of moths and butterflies are reported from India (Chandra, 2011). One of the preferred target taxa in landscape and community ecology studies are moths, as they represent high abundance to produce large sample sizes giving statistical robustness. They are taxonomically and ecologically hyperdiverse compared to other well-known insect orders in various zoogeographical zones (Dale *et al.,* 2019).

About 1,27,000 species of moths are reported from the world (Alfred *et al.*, 1998). At present, the diversity of moth from India is estimated to be more than 15,000 species/subspecies distributed over 84 families and 18 super-families. Geometridae is one of the major families of Lepidoptera, containing about 21,000 species and can be found in every zoogeographical zones (Brehm *et al.*, 2003). The concept of the family was first erected by Leach in 1815 and currently known by 23,002 species under 2,002 genera globally (van Nieukerken *et al.*, 2011). Nearly 2041 species are recorded from India (Kirti *et al.*, 2019), of which around 850 species were reported from the Indian Himalayan Region, among which around 234 species are documented from Himachal Pradesh (Sanyal *et al.,* 2018).

Geometrid larva being almost exclusive feeders of tree and shrub species, they are mostly associated with areas with dense vegetation cover, like forested areas, and thus are suitable taxa as indicator of the vegetation quality, besides some species being important defoliators and invasive pests in agriculture and forestry. Generally, the caterpillars of geometrids are host-plant specific, feed on single plant family or genus (Beck *et al.,* 2016). Most Geometrid moths have cryptic wing pattern making them very tough group to identify up to species level (deWaard *et al.*, 2011). They are universally most abundant lepidopteran family in many temperate and tropical habitats. The various sub-families of Geometridae show different distributional trend along with the altitudinal gradient making them more interesting for addressing questions like ecological specificities at higher taxonomic level (Brehm *et al.*, 2003).

1.2. Review of Literature:

1.2.1. International studies:

Studies on taxonomy of moths started long back in the early 18th century by Linnaeus (1758). After that, in 19th century Hubner (1806-1823), Boisduval (1829), Herich-Schaffer (1854), Wallengren (1856 and 1860), Felder (1874) and Snellen (1884-1890) did some major taxonomic works on moths. In the early twentieth century, Forbes (1923) published a valuable document on the Lepidoptera of United States. From the late 20th century till date, Holloway is among the one of the pioneering names publishing several family-wise taxonomic accounts of Bornean moths, which are considered to be the principal references for Oriental taxa. Yang from the Beijing Agricultural University published two volumes of 'Moths of Northern China' in 1978. Barlow (1982) published detailed genital studies on the moths of south-east Asia. Common (1990) published the first comprehensive, illustrated book describing the diversity, distribution, larval host plants and behaviour of Australian Moth. Haruta produced comprehensive accounts of Moths of Nepal, producing first ever inventory of Himalayan moths from 1994 to 2002. Kitching, a world-renowned expert of biosystematics and phylogeny of Spingidae in British Natural History Museum published an illustrated book on world Sphingids in the year 2000.

Omura pioneered the genitalia-based taxonomy of moth and in 1938, published the structure and function of the female genitalia system of *Bombyx mori*. Clarke (1941), Busck (1942) and Hardwick (1950) designed a detailed methodology to prepare genitalia slides of Lepidoptera. Ueda (1981) investigated the genitalia structures of some Hepialid moths to understand their copulatory mechanism. Lodl (2001) from the Natural history Museum Wien, Austria, published an interesting document on morphometry and patterns of the male genitalia of the Geometrid moths. Mutanen and Kaitala (2006) worked on the genitalia variation in a dimorphic geometrid moth *Selenia tetralunaria*. In the same year, Mutanen *et al.,* (2006) published a paper on the genital variation of three closely related species of genus *Exua*. In another paper published in 2007, Mutanen *et al.,* showed genitalia variation in a Tortricid moth species of Finland. Scoble (2002) revised genera belonging to the Tribe Macariini of subfamily Ennominae based on genitalia morphology. Sihvonen (2005) published phylogeny and classification of the Scopulini moths (Geometridae: Sterrhinae) based on genitalic characters.

In recent times, molecular techniques are providing novel insights to the taxonomic research in various ways. Numerous studies are available on phylogenetic reconstruction of moths of different families through DNA barcoding viz. Janzen *et al.*, (2009), Zahiri *et al.*, (2011), Wilson *et al.*, (2011), Zahiri (2012), Regier *et al.*, (2012), etc. Abraham *et al.*, (2001), Ounap *et al.*, (2005), Yamamoto *et al.*, (2007), deWaard *et al.*, (2011), Sihvonen *et al.*, (2011), Strutzenberger *et al.*, (2011 and 2012), Hausmann *et al.*, (2009 and 2011) are among pioneering works on molecular taxonomy of the family Geometridae revealing several cryptic groups otherwise extremely difficult to identify solely at morphological and genitalia level.

Apart from taxonomy, ecological study focusing moth started much late in the 20th century. Holloway is among the most pioneering names again producing two important papers (1997 and 1999) on the impacts of forest management practices and logging on Geometrid moth diversity and population in Peninsular Malaysia. They have also investigated the effects of seasons on the Geometrid moth population in Malaysia. Ricketts *et al.*, (2001) investigated the countryside biogeography of moths in a fragmented landscape in native and agricultural habitats in the Andean Montane forest. Brehm and Fiedler (2004) assessed morphometry of some Geometrid moths along an elevational gradient in the Andean rainforest. Summerville and Crist (2004) assessed the suitability of forest moths as an indicator of habitat disturbance. Hilt (2005) also focused on Andean moths in which he studied the diversity and composition of Arctiidae along a successional gradient.

Beck and Khen (2007) investigated on the beta diversity of Geometrid moths from northern Borneo. Beck *et al.*, studied the link between the environment and diversity and abundance of Andean moths in 2010. Brehm *et al.*, (2013) assessed the patterns of phylogenetic diversity of geometrid moths along the elevation in the tropical Andes. In 2016, Beck *et al.,* produced elevational species richness gradients of the geometrid moth in a global scale. Dale *et al.,* 2019, studied the spatio-temporal patterns of moths and elevational assemblage indicators of moths in Pyrénées Mountains.

1.2.2. National Studies:

A major contribution to the taxonomy of moth fauna of India was pioneered by the Britishers in the pre-independence era. The mention of Indian Lepidoptera can be traced long back in Linnaeus (1758), Cramer (1775) and Fabricius (1775), and afterwards Kollar (1844), Donovan (1800), Cotes and Swinhoe (1886), Butler (1883) and Swinhoe (1885) wrote many significant taxonomic accounts of Indian moths. Moore (1886) worked on many lepidopteran specimens collected by Hockings and others in the British Museum. Snellen (1890) studied Pyralid specimens collected by Elwes and Moller from Sikkim. In 1891, Hampson published an account of the Lepidoptera Fauna of Nilgiris. Hampson (1892, 1894, 1895 and 1896) published the till date most consolidated accounts of Indian moth fauna in four volumes of the 'Fauna of British India' and several supplementary papers in the Journal of Bombay Natural History Society. Warren (1888) and Rothchild (1920) provided significant contribution towards the understanding of biology of the Indian crop pests. In 1956, Sevastopulo documented moth fauna of Kolkata.

Indian authors have also contributed significantly to the taxonomic research of moths of the country. Arora and Gupta (1979) published a monograph of Indian Saturniidae. Mandal and Bhattacharya (1980) studied subfamily Pyraustinae from Andaman & Nicobar Island. Arora and Chaudhury (1982) contributed to the moth fauna of Arunachal Pradesh and in adjoining areas of Assam in North-East India. Arora (1983) prepared the first document on the moth fauna of Andaman & Nicobar. Mandal and Ghosh (1997), Mandal and Maulik (1997), Ghosh and Choudhury (1997) and Bhattacharya (1997) contributed considerably to the moth fauna of West Bengal. Moth fauna of Meghalaya and Sikkim are well documented by Mandal & Ghosh (1998) and Ghosh (2003), respectively. Srivastava (2002) published a book titled 'Taxonomy of Moths in India'. Rose (2001) prepared an inventory of the moth fauna of Jatinga, Assam. Kirti and Sodhi (2003) contributed to the documentation of the Arctiidae of Sikkim. Mathew (2006) prepared a consolidated account on the Indian pyralids. Sanyal *et al.*, (2013) documented the diversity and distribution pattern of moths in Gangotri Landscape. Biswas *et al.*, (2015), studied the taxonomy of Erebidae moths in the tea gardens of North Bengal. Biswas *et al.*, (2016) also documented the moth diversity of Sunderban Biosphere Reserve. Singh *et al.,* (2016- 2021) added significantly towards the knowledge of Indian Arctiinae producing taxonomic review of several Arctiinae genus, describing many new species of Arctiinae as well as of family Limacodidae, Bombycidae, Pyralidae and Nolidae. Uniyal *et al.*, (2016), contributed to the documentation of the diversity of moth fauna in the different protected areas of Uttarakhand. Shah *et al.*, (2016) published a checklist of moths from the Kolkata metropolitan region. Sanyal *et al.,* (2018) published species inventory extracted from literature review on moths of Indian Himalayan Landscape. Raha (2018) documented the Moths of Chhattisgarh focusing on their taxonomy and seasonal diversity fluctuations. Indian Notodontidae fauna was catalogued by Chandra *et al.,* (2018) and further added with new distribution records and new species by Mazumder *et al.,* 2019. Lepidopteran assemblages in different protected areas in different biogeographic sectors of Indian Himalaya were published by Chandra et al. 2019. Bandyopadhyay *et al.,* 2021 investigated taxonomy and ecology of the genus *Phlogophora* (Noctuidae), describing a new species from Indian Himalaya.

1.2.3. Studies on Himachal Pradesh moth fauna:

The earliest reference on moths of Himachal Pradesh can be extracted from A.G. Butler's seminal publication "On the Collection of Lepidoptera from India" (1886), where collections from Dharamshala were included. Frederick Moore published a list of Lepidoptera collected by Rev. J.H. Hocking (1888), chiefly from Kangra district. Cotes & Swinhoe in their "Catalogue of Indian Moth" (1887-1889) mentioned several species from Kullu. In Hampson's Fauna of British India (1892-1896) and subsequent supplementary manuscripts in the Journal of Bombay Natural History

Society, several species from Himachal Pradesh were included, mainly from Shimla, Kullu, Dharamshala, Kangra and Dalhousie. Mani & Singh (1962), in the survey of High-altitude insects of nival zones of North-West Himalaya, listed few species from Kullu, Kangra, and Dharamshala. Kapur & Arora (1967) documented several Noctuidae species from Himachal Pradesh. Pajni & Walia (1983-1984), Walia & Pajni (1984-1987) and Walia (1988-2005) reported around 281 species of Geometridae from Himachal Pradesh. Microlepidopteran families like Gelichiidae, Lecithoceridae, and Oecophoridae were extensively worked out from Shivalik Himalayas of Himachal Pradesh by Pathania & Rose (2004), Pathania *et al.* (2006-2009), Pathania (2010). Sekhon (2015) published faunistic records of Noctuidae moths from Chamba. Moths from GHNP are very poorly studied except a mention of 17 species by Uniyal & Mathur (1998).

1.3. Backdrop and justification of the Study:

Himalayan ecosystems being unique and delicate in nature host significant level of Lepidopteran richness, which can be used as tools for detecting faunal level impacts of human disturbance including global climate change. Moths, especially of family Geometridae can serve better in this direction, but unfortunately such studies have not been attempted so far. Himachal Pradesh, being a state in North-Western Himalayan sector is in an important junction of faunal mixing of Palaearctic and Oriental origin. Moreover, several interconnected Protected Area systems like GHNPCA provide an undisturbed stretch Himalayan Temperate habitat, important mainly to investigate faunal composition changes along major environmental gradients, altitude being major among them. Currently 850 species of Geometridae moths are known from IHR, while 234 species are reported from Himachal Pradesh. Knowledge on moth fauna of GHNPCA is very poor represented by only 17 species documented by Uniyal and Mathur, 1998.

The current study aims to provide a primary moth inventory of GHNP among its various altitudinal and habitat zones. The study specifically focussed on family Geometridae, providing their in-depth taxonomic account including genitalia illustration, so that it can act as future reference on further taxonomic investigation. Moreover, to understand the biotic-abiotic factors governing diversity and richness of Geometrid moths in finer taxonomic scale, sampling was carried out across different vegetation and habitat types in the study area. Additionally, species characteristic of each vegetation and habitat types were explored in order to make a database of indicator taxa which can be further monitored to understand anthropogenic as well as climate related changes happening in Himalayan ecosystems.

1.4. Objectives:

The current thesis-work was initiated with following objectives in mind:

1) To document the taxonomic inventory of moths, with special reference to Family Geometridae of Great Himalayan National Park Conservation Area (GHNPCA).

2) To assess diversity and distribution of Geometrid moths among different altitude zones in Great Himalayan National Park Conservation Area.

3) To assess the factors such as climatic factors, vegetation type and anthropogenic disturbances that govern the altitudinal diversity and distribution pattern of Family Geometridae.

4) To assess the potential of Geometrid moths as an indicator of habitat quality in GHNP.

1.5. Thesis organization:

The thesis is organized into following seven chapters:

Chapter I: General Introduction: Current scenario of insect conservation, difficulties, importance of insect conservation and global, Indian works on morphological, ecological and molecular studies of moth has been discussed in this chapter. Justification of this study and objectives are also mentioned in this chapter.

Chapter II: Study area and Methodology: The overview of Great Himalayan National Park, including vegetation types, sampling localities, history of the National Park, along with general methodology, have been discussed in this chapter.

Chapter III: Moth inventory with special reference to Family Geometridae of Great Himalayan National Park, along with taxonomic accounts and diagnosis of Geometridae, have been included here.

Chapter IV: Diversity and distribution of Geometrid moths among different altitude zones in Great Himalayan National Park is discussed here.

Chapter V: The biotic and abiotic factors governing the diversity and distribution pattern of Geometridae moths in GHNP are discussed in this chapter.

Chapter VI: Potential of Geometrid moths as indicator of habitat quality in GHNP is assessed in this chapter.

Chapter VII: Synthesis, stressing upon the major findings of the study, biogeographic pattern of GHNP moth assemblage as well as suitability of Geometrids and moths as a whole for monitoring climate change are discussed in this concluding chapter.

Chapter 2: Study Area and Methodology

2.1. Great Himalayan National Park: Landscape:

The Great Himalayan National Park (GHNP), located in the Kullu district of Himachal Pradesh, comes under the North- Western Himalayan Biogeographic Province- 2A, lies between 31°31'16" and 31°56'41" N and 77°20' to 77°52'11" E, covering an area of 1171 km^2 and showing an altitudinal variation of 1300 m to 6110 m. It is located at the junction of two great faunal realms: Palaearctic to the north and Oriental to the south (MacKinnon *et al.*, 1986).

Initially constituted in 1984, the Park was formally notified in 1999 and was subsequently awarded World Heritage Natural Site in 2014, including Sainj and Tirthan Wildlife Sanctuary (WLS). It is a relatively recent addition to the network of protected areas in northern India and adjacent countries which progressively provides protection to the Himalayan biodiversity. The park is adjacent to the Sainj Wildlife Sanctuary, Tirthan Wildlife Sanctuary and Eco-development Zone and the four areas are together known as the Great Himalayan National Park Conservation Area (Fig. 2.1), which is interchangeably referred to as the Great Himalaya National Park (Miller *et al.,* 2008).

The park is surrounded by three protected areas: Rupi Bhaba WLS in the east, Pin Valley National Park in the north-east and Kunawar WLS in North West, and together these areas form a large, contiguous area of natural wilderness. This park consists of the catchment areas of the four tributaries of Beas River, viz. Jiwanal, Sainj, Parvati and Tirthan.

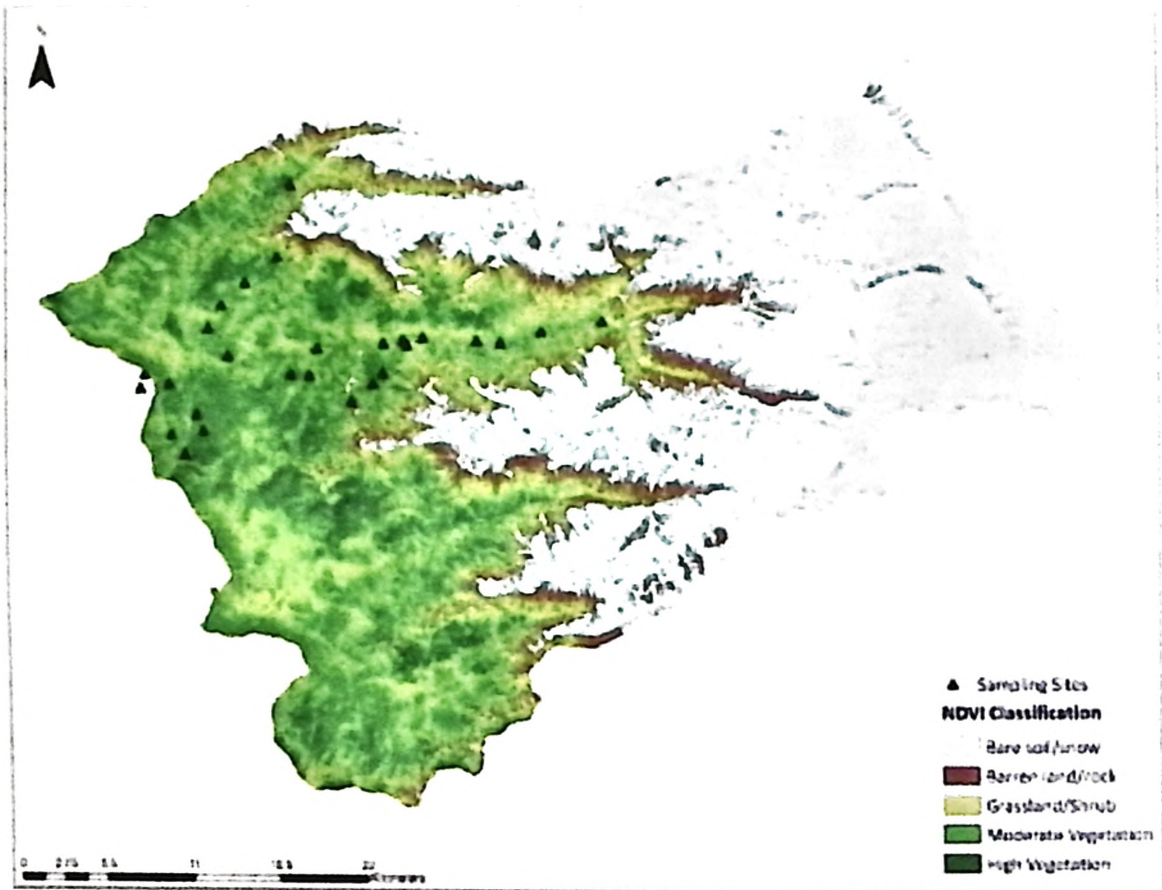

Fig. 2.1: Great Himalayan National Park Conservation Area map on NDVI layer with sampling points

Around 50% of GHNP is above 4000 m altitude and the entire terrain is characterized by high ridges, rocky caves, glaciers, narrow valleys and deep gorges. The highest peak of the area is unnamed in Khirganga area (6248 m). Permanently snow bound area of the park lies in the Eastern region. Avalanches and landslides have a great influence on the topography of the area (Singh and Rawat, 2000). Mainly, three prominent seasons can be identified i.e. summer (April- June), Monsoon (July- September) and winter (October- March). Mean Annual Temperature varies from 9.59- 16.38 °C with Mean Annual Precipitation ranging between 1000- 2000 mm. The winter precipitation is mainly in the form of snow when the Park receives 5- 7 m deep snow.

Around 68% area of the park falls under the alpine zone, while only 17% area is under forest cover, the remaining area remains under permanent snow cover. Five successive altitudinal zones have been considered for faunal sampling: Lower Temperate (1500- 2000 m), Mid- Temperate (2000- 2800 m), Upper Temperate (2800- 3300 m), Subalpine (3300- 3600 m) and Alpine (above 3600 m) (Gaston *et al*., 1981; Uniyal & Mehra, 1996; Singh & Rawat, 2000).

2.2. Brief Note on Important Flora & Fauna:

A total number of 832 plant species are reported from GHNP, of which, 794 species are Angiosperms, 11 species are Gymnosperms and 27 species are Ferns, including 250 species of medicinal plants traditionally used by local people, prominent among which are Hathpanja, Brahma Kamal, Ban Kakri, Jatamansi, Dhoop, Atees and Blue Poppy. Important tree species are Silver Fir, Maple, Horse Chestnut, Alder, Birch, Deodar, Hazelnut, Blue Pine, Kharsu Oak, Rhododendron, whereas shrubs include *Aconitum*, *Atropa*, *Saussurea*, *Berberis*, *Polygonatum*, *Taxus*, *Juniperus* etc. Besides, 192 species of Lichens are also reported including *Usnea longissimi*, highly used by wild ungulates during the winter season.

31 species of mammals are reported which include Snow Leopard, Brown Bear, Himalayan Black Bear, Red Fox, Himalayan Musk Deer, Blue Sheep, Serow, and Himalayan Tahr. 209 species of birds are reported

including Western Tragopan, Himalayan Monal, Koklash Pheasant, Cheer Pheasant, Golden Eagle, and Griffon Vulture. Besides 12 Reptilian species, 9 Amphibians and 125 insects are reported from the park (Gaston *et al.*, 1993; Ramesh *et al.*, 1998; Uniyal & Mathur, 1998).

A total of 75 species of butterflies belonging to 48 genera are documented from different altitudes of GHNP. 10 species belonging to 5 genera of family Papilionidae are recorded from various forest community and vegetation. The Common blue Apollo (*Parnassius hardwickei*) and Regal Apollo (*Parnassius charltonius*) are recorded from the alpines above 3500m altitude. (Uniyal, 2007). 17 species of moths representing eight families viz. Saturniidae, Lasiocampidae, Geometridae, Arctiidae, Noctuidae, Sphingidae, Lymantriidae and Zygaenidae are till now known from the different valleys and altitudinal zones in GHNPCA (WII, 1998).

2.3. Major Forest Types in Great Himalayan National Park:

A great diversity in vegetation was found due to the variation in altitude, topography and climate. According to Champion and Seth (1968), following forest types were identified and sampled inside Great Himalayan National Park, Himachal Pradesh (Fig. 2.2 & 2.3).

Himalayan Chir Pine Forest (9/C1b):

High forest of *Pinus roxburghii,* predominant between 1200-1800 m on easy sloping grounds with scanty shrub undergrowth and grass-cover growing during monsoon only. Three sampling sites fell under this category.

Moist Temperate Deciduous Forest (12/C1e):

A high deciduous forest of *Acer caesium*, *A. pictum*, *Aesculus indica*, *Betula alnoides*, *Juglans regia*, *Pyrus lanata*, *Cornus*, *Corylus*, *Ulmus* sp., grown on gentler slopes between 1800-2700 m. The undergrowth is rather thin and consists mainly of *Berberis*, *Cotoneaster*, *Aconitum* and *Impatiens* etc. Five sampling sites came under this category.

Alder Forest (Riverine) (12/1S1):

A pure forest of *Alnus nitida*, *Populus ciliata*, *Ulmus villosa* grown along stream sides on moist unstable hill slopes between 1800-2200 m. Only one sampling site was categorized under this.

Moist Deodar Forest (12/C1c):

A pure forest of mainly Deodar, with occasional Blue Pine, Oaks and Rhododendrons grown on cool and moist slopes between 1700-2500 m, with tall shrub layer, mainly of *Parrotia*. Two sampling site were categorized under this.

Western Mixed Coniferous Forest (12/C1d):

Varying mixture of conifer trees like *Picea*, *Cedrus*, *Abies pindrow*, *Pinus wallichiana* with varying mixture of broadleaved like *Quercus dilatata*, *Q. incana*, *Q. semicarpifolia* grown between 2400-3000 m, often broken by open grassy meadows. Two sampling sites fell under this category.

Low-Level Blue Pine Forest (12/2S1):

Typically, of pure *Pinus wallichiana*, sometimes intermixed with Deodar and grown on cool, moist sites between 1600-2800 m. Undergrowth mainly of *Berberis, Indigofera* and *Desmodium*. Four sampling sites came under this group.

West Himalayan Upper Oak-Fir Forest (12/C2b):

A two-storied high forest with *Abies pindrow* standing singly over *Quercus semicarpifolia*, *Acer*, *Taxus*, *Corylus* grown on sheltered slopes between 2600-3400 m. Generally associated with good shrub cover of *Rosa*, *Rubus*, *Viburnum* and luxuriant herbaceous growth of *Galium*, *Fragaria*, *Ainsliaea*, *Valeriana*. Four sampling sites fell under this category.

West Himalayan Sub-alpine High-Level Fir forest (14/C1a):

An irregular forest consisting of *Abies spectabilis*, *Pinus wallichiana*, *Picea smithiana* and *Betula utilis* with dense undergrowth of *Rhododendron campanulatum, Strobilanthes, Smilax* grown on snow-free slopes above 3000 m. Three sampling sites fell under this group.

Sub-Alpine Pastures (14/DS1):

A degraded type of subalpine forest with predominating grass covers mainly of *Agropyron*, *Brachypodium*, *Bromus* etc. Single site was categorized under this.

Dwarf Rhododendron Scrub (15/C2/E1):

Characterized by dense patches of *Rhododendron anthopogon*/ *R. lepidotum*/ *R. campanulatum* grown on dry and arid alpine ground chiefly between 3200-4100 m. Single site was categorized under this.

Birch Rhododendron Scrub Forest (15/C1):

A very dense thicket of *R. campanulatum* associated with *Betula utilis*, *Sorbus foliolosa*, *Viburnum nervosum* and *Primula denticulata* grown on thick layer of black humus on very wet soil which remain under snow-cover for most of the year. Only one site was categorized under this type.

Fig. 2.2: Major vegetation types sampled in GHNPCA: (Clockwise) Chir Pine Forest; Moist Temperate Deciduous Forest; Western Mixed Coniferous Forest; Low-Level Blue Pine Forest

Fig. 2.3: Major vegetation types sampled in GHNPCA: (Clockwise) West Himalayan Upper Oak-Fir Forest; West Himalayan Sub-alpine High-Level Fir forest; Dwarf Rhododendron Scrub; Birch Rhododendron Scrub Forest

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2.4. Methodology:

2.4.1. Study design:

Moths were sampled from different sampling areas based on elevation, vegetation type and land use practices to maximize spatial coverage. Sample collection was done using traditional light trap method and sites were chosen randomly along a selected altitudinal gradient. Two or three sampling sites were selected in every habitat for encountering ample representation of different moth species. Trap sites were chosen such that the immediate surrounding area of the trap was to provide moths shelter from wind or rain, and giving extreme probable light catchments area.

Stratified Random sampling strategy was adopted to have wide altitudinal representation. For this, along a transect ranging from lowest to highest altitude point random sites were selected at every 300 m vertical distance. If a gradient started from 1500 m and extended up to 4000 m, nine sites were selected at 1500 m, 1800 m, 2100 m, 2400 m and so on. One or two light trap stations were established and at each site, two to three nightly catches were executed until at least 50 individuals were sampled. Sites which did not reach minimum 50 individual count were not included in the further statistical analysis.

Sampling were made in such a way that two neighbouring elevational sites were never sampled one after another to minimize species overlap. A gradient was covered in a descending manner, i.e., beginning at the peak altitudinal site, i.e., 4000 m and sampling downhill moving to lower areas.

This was to minimize species accumulation from two adjacent altitudinal sites. This simple study strategy as a flexible tactic to generate robust data on moth diversity and factors affecting their distribution pattern along elevational gradient was repeated along the whole landscape studied.

A total of 27 sampling sites (Fig. 2.1) in GHNP (Table 2.1) were scattered along three major gradients, all originating from Ropa at 1500 m; Dhel gradient, Parkachi gradient and Thihnhi gradient. Light trapping were completed in these 27 sampling locations in the period of 2016–2019 covering all the main seasons.

The data on biotic factors suspected to affect moth diversity like vegetation diversity and anthropogenic disturbances were collected in nested quadrates of 20 square meter (sq. m) adjoining light trapping sites. Within a similar vegetation type, one set of quadrates were centred on the location of the light trapping sites and the two others were randomly placed 50 m from the midpoint (Fig. 2.4). 20x20 m^2 quadrats were used to measure species richness, abundance and the diameter at breast height (DBH) of all trees greater than 10 cm DBH. Canopy cover were measured using a densitometer. Within 20x20 m^2 quadrats, a pair of 5x5 m^2 quadrats were used to measure species richness and abundance of shrubs and saplings. A pair of 1 sq. m quadrats within every shrub plot was selected to quantify species richness, abundance, and percent cover of herbaceous layer. Ambient air temperature and relative humidity, wind velocity were recorded during the light trap in every 60 min with an electronic weather meter and was averaged over all catch nights for every site. Sample collection was avoided during the full moon period (3 days before and after full moon). Cloud cover was noted every hour for each light trap catch. Anthropogenic disturbance data, such as logging and lopping, presence of fallen tree, livestock grazing and presence of fire sign were collected within the nested quadrate and analysed to determine the key factor governing diversity pattern of moths in the study area.

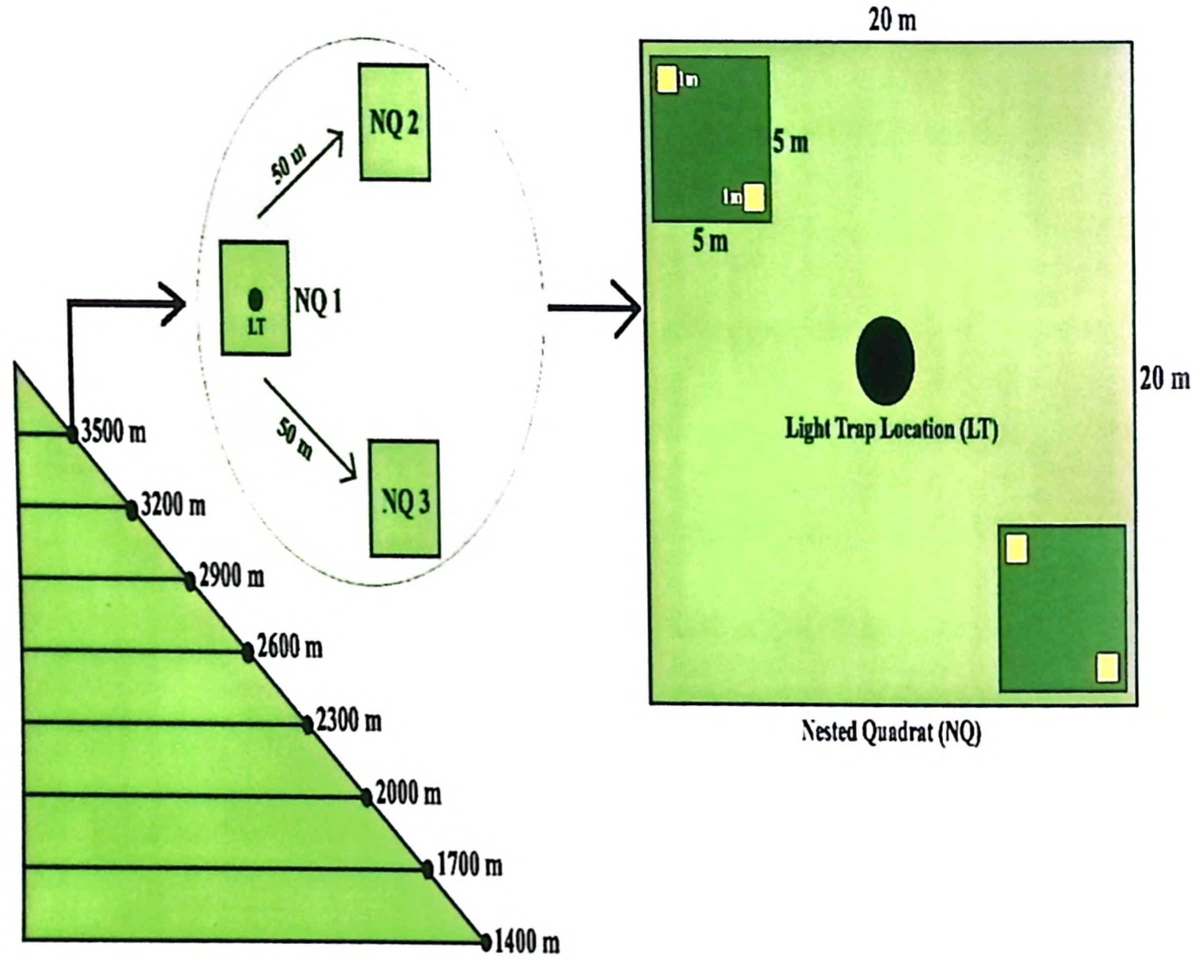


Fig. 2.4: Schematic representation of sampling design

Table 2.1: Details of Sampling Sites, Dates and Weather parameters in Great Himalayan National Park Conservation Area (GHNPCA), Himachal Pradesh

Sl. no.	Location	Date	Location Code	Details						
				Latitude	Longitude	Altitude (m)	Habitat	Avg. Temp. (°C)	Avg. Hum. (%)	Moon Phase
1	Ropa FRH	26.viii.2016	GH01A	31.7655	77.3576	1515	Himalayan Chir Pine Forest (9/C1b)	19.3	79.1	WN viii
		04.ix.2016	GH01B					18.2	89.7	WX iii
		11.ix.2016	GH01C					18.9	88.2	WX x
		01.vi.2017	GH01D					18.5	84.2	WX vi
		02.iv.2018	GH01E					15.3	72.1	WN ii
		03.iv.2018						14.9	75.3	WN iii
		23.iv.2018	GH01F					15.7	76.8	WX vii
		19.ix.2019	GH01G					18.67	82.03	WN v
		23.ix.2019	GH01H					18.37	83.33	WN ix
2	Jungla	16.vi.2017	GH02A	31.7802	77.3917	1751		17.25	99	WN vii
		16.x.2019	GH02B					11.08	84.48	WN ii
3	Kathyaugi	11.x.2019	GH03A	31.76984	77.34417	1812		11.6	78.63	WX xii
		13.x.2019	GH03B					11.05	80.86	WX xiv
		14.x.2019	GH03C					12.46	77.6	FM
4	Denga Pool	04.iv.2018	GH04A	31.7841	77.4424	1970	Moist Temperate Deciduous Forest (12/C1e)	12.3	82.8	WN iv
		26.v.2018	GH04B					17.1	52.6	WX xi
		20.x.2019	GH04C					8	90.02	WN vi
5	Khain	15.vi.2017	GH05A	31.7942	77.3806	2072		14.5	76.4	WN vi

Sl. no.	Location	Date	Location Code	Details						
				Latitude	Longitude	Altitude (m)	Habitat	Avg. Temp. (°C)	Avg. Hum. (%)	Moon Phase
6	Kleuen	26.vi.2018	GH06A	31.76281	77.34169	2109	Moist Deodar Forest (12/C1c)	20.1	75.1	WX xii
7	Raghdhini	14.vi.2018	GH07A	31.7701	77.4376	2112	Alder Forest (Riverine) (12/1S1)	16.1	88.1	NM
8	Shakti	30.viii.2016	GH08A	31.7883	77.4908	2137	Moist Temperate Deciduous Forest (12/C1e)	11.3	92.7	WN xii
		07.iv.2018	GH08B					11.4	72	WN vi
		13.iv.2018						9.6	80.1	WN xiii
		04.vi.2018	GH08C					18.2	89.5	WN vi
9	Shakti Water Fall	27.v.2018 - 28.v.2018	GH09A	31.7867	77.4798	2200		12.7	60.5	WX xii
10	Lapah	27.viii.2016	GH10A	31.7708	77.4271	2247	Moist Deodar Forest (12/C1c)	12.6	83.6	WN ix
11	Shakti-II	26.ix.2019	GH11A	31.78993	77.50203	2288	Moist Temperate Deciduous Forest (12/C1e)	13.64	94.66	WN xi
		27.ix.2019						14.03	94.5	WN xii
12	Riush Thatch	11.iv.2018	GH12A	31.7861	77.4927	2425	Western Mixed Coniferous Forest (12/C1d)	10.9	79.4	WN x
		06.vi.2018	GH12B					17.2	88.5	WN viii
s13	Bhagisaree	02.vi.2017	GH13A	31.8063	77.388	2432	Western Mixed Coniferous Forest (12/C1d)	13.1	89.1	WX vii
14	Padhar	06.ix.2016	GH14A	31.7499	77.3732	2437	Low-Level Blue Pine Forest (12/2S1)	12.2	87.1	WX v
		19.vi.2018	GH14B					14.9	84.7	WX v
15	Marrorh	02.vi.2018	GH15A	31.7882	77.5318	2480		15.9	71	WN iv
16	Sudra budra	02.x.2019	GH16A	31.78743	77.54527	2577		7.18	93.86	WX iii
17	Gajnao	20.vi.2018	GH17A	31.7413	77.3772	2618	West Himalayan Upper Oak-Fir Forest (12/C2b)	15.5	68.9	WX vi
18	Baghi Thatch	03.vi.2017	GH18A	31.8181	77.4019	2663		17.6	61.3	WX viii

Sl. no.	Location	Date	Location Code	Details						
				Latitude	Longitude	Altitude (m)	Habitat	Avg. Temp. (°C)	Avg. Hum. (%)	Moon Phase
19	Kherchar	15.iv.2018	GH19A	31.7933	77.5679	2742	Low-Level Blue Pine Forest (12/2S1)	9.7	81.6	WN xiv
		30.v.2018	GH19B					16.3	58.1	WN i
		05.x.2019	GH19C					6.6	88.84	WX vi
20	Vred Nala	08.vi.2018	GH20A	31.7713	77.4792	2800	West Himalayan Upper Oak-Fir Forest (12/C2b)	14.9	90.3	WN x
21	Thati	08.ix.2016	GH21A	31.7391	77.3587	2917		10.2	92.1	WX vii
		22.vi.2018	GH21B					13.2	67.3	WX viii
22	Parkachi	17.ix.2016	GH22A	31.7987	77.6016	3033	West Himalayan Sub-Alpine High-level Fir forest (14/C1a)	8.9	82.3	FM
		18.iv.2018	GH22B					7.3	87.2	WX ii
		01.vi.2018	GH22C					10.5	70	WN iii
23	Dawada	08.vi.2017	GH23A	31.8686	77.4284	3049	Sub-Alpine Pastures (14/DS1)	10.2	74.5	WX xiii
24	Majan Golu	10.vi.2018	GH24A	31.7662	77.4734	3166	West Himalayan Sub-Alpine High-level Fir forest (14/C1a)	13.1	88	WN xii
25	Thihnhi	07.ix.2016	GH25A	31.7293	77.3665	3226	Dwarf Rhododendron Scrub (15/C2/E1)	8.1	89.9	WX vi
		21.vi.2018	GH25B					11.6	85.25	WX vii
26	Dhung	05.vi.2017	GH26A	31.8314	77.4201	3324	West Himalayan Sub-Alpine High-level Fir forest (14/C1a)	14	84.6	WX x
27	Dhel Hut	29.viii.2016	GH27A	31.7568	77.4614	3567	Birch Rhododendron Scrub Forest (15/C1)	7.9	91.3	WN xi
		12.vi.2018	GH27B					9.3	78.5	WN x

***WX= Waxing Phase, i.e. New Moon to Full Moon Period (e.g. WX iii refers to the 3rd day after No Moon); WN= Waning Phase, i.e. Full Moon to New Moon Period (e.g. WN iii refers to the 3rd day after Fool Moon); NM= No Moon.**

2.4.2. Basic Light Trapping:

Moths were collected from different habitats installing light traps running for 4 hours, in two sessions at a particular site for two consecutive nights, e.g. first night from 8 pm to 12'O clock night and second night from 12'o clock night to 4 am. This was to confirm recording all the moths flying in a specific habitat in different quarters of night. For setting light traps, Mercury bulb (160W) or CFL bulb (more than 40W) or a solar-powered lantern equivalent to 80 Watt White Actinic bulb and gas petromax were used in front of a white cloth measuring 1.5 m x 2 m. The cloth was fixed vertically between two poles or trees and the bulb was hanged in such a way that it reached nearly half the length of the cloth with a gap of at least 1 ft. between the bulb and the cloth (Fig. 2.5).

Netting was done primarily during the day time for day-flying species of moth. Small clean vials or glass jars were used as killing bottles in which Ethyl Acetate or Benzene vapour was used as a killing agent, evaporating from a cotton soaked in liquid killing agent and placed at the bottom of a killing bottle. Filter paper was placed above cotton swab to prevent the direct contact of moth with killing agent. After sorting, collected specimens were kept in insect envelopes made of oil paper with the proper label of date and site of collection and the envelopes were kept in ordinary cardboard boxes and curation was done following Dickson (1976).

2.4.2. Specimen curation:

Collected samples were exposed to sunlight for warm for some time to avoid the growth of fungus. These boxes also contained sufficient quantity of naphthalene powder. Moths were pinned with entomological pins of different sizes, depending on their thorax width, through the centre of the thorax such that twice the length of the pin protruded below and above the specimen. The angle of the pin above was tilted slightly forward. The moth was then pinned into the foam with the pin vertical so that the body comes firmly up against the surface and one third of the pin kept above the specimen (Robinson *et al.,* 1976). The wings and the legs were manipulated on either side into a roughly spread position. Blunt forceps were used to handle the specimens during stretching process.

Spreading strips of butter paper or oil paper were used for the setting of moths according to their body size. Pinned moth specimen was placed in the groove of the stretch board in central and vertical position confirming that legs were not attached under the wings. Then spreading strips were placed on either side of the wings and fixed with bell pins after the spreading process of wings completed correctly (Fig. 2.6). After that, stretch board with specimens were kept for 2 weeks in dry chamber for drying and permanent fixation. Then, setting pins and spreading papers were removed and specimens were also removed from stretch board.

Any specimen without proper collection locality details has no value in the study of biology and taxonomy. A proper specimen tag should have information of the collection date, site GPS co-ordinate, and collector's name, collection site details (Country, State, District & locality name) and habitat information. Dried specimens were then tagged with proper labels and stored in permanent storage box.

Permanent storage was done in larger insect cabinets with glass top drawers and grooved sides for filling with sufficient naphthalene and cotton balls dipped in Carbolic Acid (Phenol and Camphor solution) and then specimens were arranged and tagged with the collection locality details with proper codes in the appropriate orientation. After completion of the identification, all the specimens were deposited in the Lepidoptera Section of Zoological Survey of India, Kolkata.

Fig. 2.5: Light trap using petromax and solar lamp

Fig. 2.6: Specimens on stretch board

Fig. 2.7: *Anonychia* species copulating on the white sheet during light-trap

Fig. 2.8: Storage box with properly arranged specimens

2.4.4. General Morphology of Moth:

Moths belongs to order Lepidoptera along with Butterfly, sharing a common character, i.e., having a scales clothed on body and wings, but can be distinguished by their antennae; moths lack the club-shaped tip of antenna. Mainly the total body is divided into head, thorax and abdomen. Adults can be found in various size as well as morphs. Life cycle has four different stages, i.e., egg, larvae (caterpillar), pupae and adult. Adults are generally non-feeding, but may also have long, coiled proboscis to suck honey from flower, so can also be act as pollinator.

Head:

Head is comparatively small, round and with large compound eyes, which may be hairy or hairless. Between the two large compound eyes, vertex is present at the top, covered with scales, arrangement of scales may be differ from species to species. Below the vertex, in the frontal side and between compound eyes frons is present.

A pair of long, segmented, scaled antennae present at the sides of vertex, their shape, size and structure can be different among genera and families of moths. They can be simple, thread- like i.e., Filiform; unipectinte, bipectinate, setose-ciliate, ciliate, lamellate. Sexual dimorphism is also observed in the antennal shape. In subfamily Ennomine, more specifically in tribe Boarmiini, female individuals have filiform antennae but in males, different pectinations, majorly bipectination can be seen.

Maxillary palpi are usually reduced in moths but labial palpi are well developed, bearing scales and three segments, can be projecting upward, backward or forward (porrect) and can be found with different lengths. For the identification of different Hypeninae and Pyralidae species, labial palpi is very significant.

Thorax:

Thorax is composed of three parts; prothorax, mesothorax and metathorax, each of which bears a pair of legs and last two have a pair of wings. In the base of the forewing tegulae present and can be observed when wings are spread. Wings are covered with scales and veins. Usually, frenulum is present in the base of hindwing and can act to couple together the wings. Patagia is found in some families, mainly directed backward, present on prothorax. Tympanum is present in the either side of metathorax and can detect the ultrasonic calls of bats (Barlow, 1982).

Wings are well developed, very rarely vestigial (Females of Lymantriinae and Psychidae), forewings are usually larger than the hindwings. Wing pattern, colour, venation can act as important character for the species identification. Costal fold, forewing notch, raised scales in particular area can be an important species character. Different type of basal, sub-basal, antemedial, medial, postmedial, submarginal and marginal line can be found in both the wings. Different types of spots i.e, reniform, claviform, orbicular, basal, subapical, apical, tornal, costal and in cell- can be found in different species. Colour of the wings, streaks, striations, irroration, colour of the fringes, costal colour and formation of hindwing tail can also be a significant character.

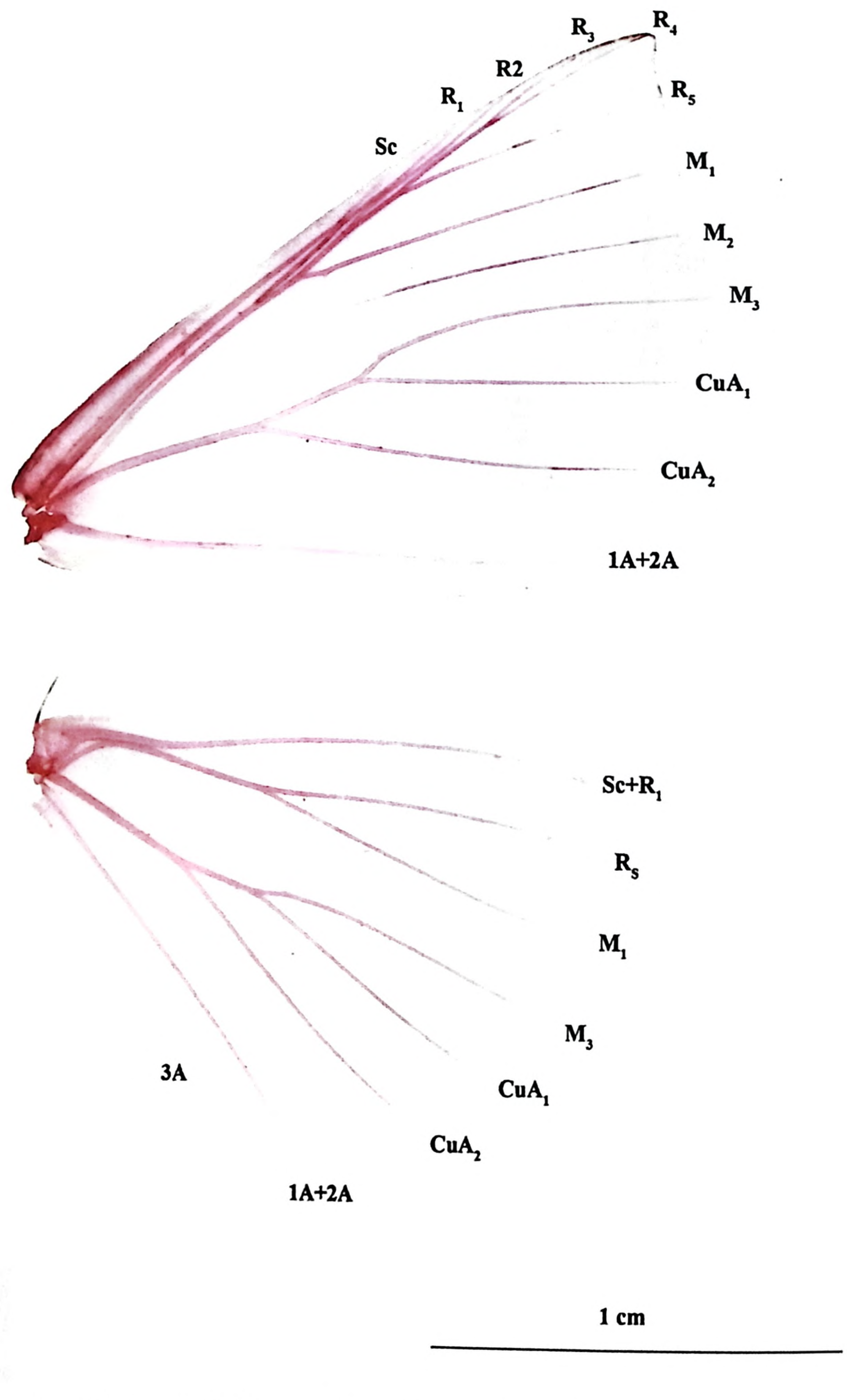


Fig. 2.9: Typical Geometridae wing venation (Ennominae: *Psyra*)

Venation of wing are very important for the identifications of any moth species. Lepidopteran wing venation is based on Comstock-Needham System (Scoble, 1995). Six different types of veins are present in moth wing (Fig. 2.9): Costal (C), Subcostal (Sc), Radial (R), Median (M), Cubital (Cu) and Anal vein (A). Costal vein runs along the costa and provide strength to the costa. Sc runs from the base of wing, parallel to costa then finally reaches to the costal margin. R_1 and R_S are the main two branches of radial vein, later can be again branched up to four veins (R_2- R_5) or they can also be fused with one another. In hindwing, R_1 usually merged with Sc and R_S usually unbranched. Medial vein has two main branches i.e., anterior branch (MA) and posterior branch (MP) and each of these can have again two branches each, M_1, M_2, M_3 and M_4. Generally, M_4 is absent in Lepidoptera and other branches can be fused or separated. Cubital veins divides near the base of the wing into anterior (CuA) and posterior branch (CuP), generally CuA again divided into CuA_1 and CuA_2. The area between R and CuA is called as cell.

Legs are mainly composed of five parts, i.e., coxa, trochanter, femur, tibia and tarsus. Tibia sometimes bears different number of spurs and hair pencils in male hind tibia.

Abdomen:

Ten movable segments are present in abdomen. Tympanum is present in Geometridae near the 1st abdominal spiracle. Spiracles are the respiratory organs of moths, present in the lateral sides of the abdominal segments 1- 7. Genitalia structures present in the 7th and 8th abdominal segments.

Male genitalia:

Characters of male genitalia are very significant for the identification of cryptic and confusing species. When outer morphological characters are not sufficient for the identification of a species, then dissection is needed to see the internal characters of male genitalia.

Tegumen and vinculum is formed by the division of the 9th abdominal segment. Harpe or clasper is a ring-like, lateral clasping organ. The central penetrating organ is aedeagus. Beak- like, pointed, may be long or short uncus is present dorsally. Lateral pair of membranous process named as valvae is a significant part of the genitalia, sometimes bearing costal spine, saccular process and ampulla. Juxta is situated in the base of aedeagus to act as a controller of the aedeagus.

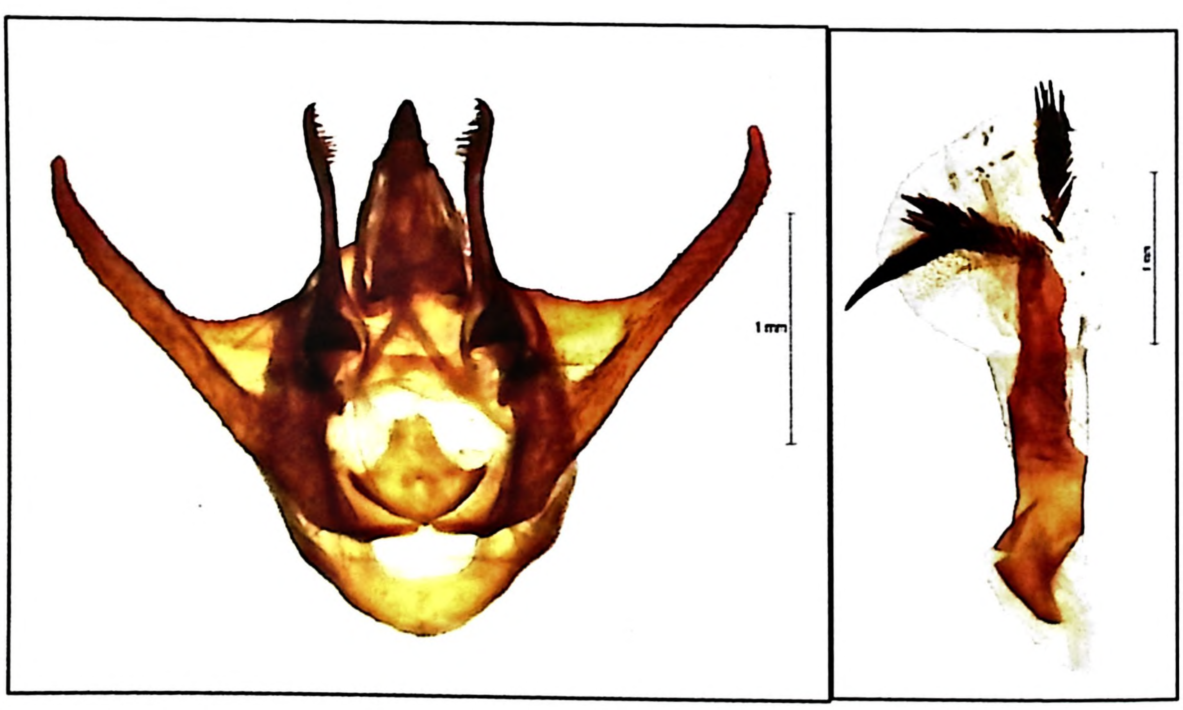


Fig. 2.10: Male genitalia of Geometridae moths (Ventral view in left, aedeagus in right)

Chapter 3: Moth Inventory with special reference to Family Geometridae of Great Himalayan National Park, Himachal Pradesh

3.1. Introduction:

Moths constitute a large and diverse group making about 80% of the Order Lepidopteraand are mostly nocturnal. They are the largest phytophagous insect group, can act as a good pollinator, major defoliator as well as pest for some economically important plant species. It is a good indicator taxon for the study of climate change (Ronkay, 2004) and reacts with the changes in temperature or rainfall (Bale *et al.*, 2002). Habitat-specificity based on their strict host-plant choice makes them good indicators of forest/vegetation types. Conservation of this ecologically important taxa is still in a very nascent state in the Indian as well as Himalayan landscape context as the baseline information is in dire need to be generated.

Huge diversity at the local and global scale, inadequate taxonomic literature, the extremely large size of population and biomass, extremely variable and diverse niche requirements and functional role, very little ecological information are the main difficulties for the study of this beautiful scale-bearing insects. The extinction of these creatures due to the global impact of environmental degradation and habitat fragmentation and destruction by anthropogenic activities is often very difficult to recognize at all. Lack of experts in the taxonomic field and inadequate ecological knowledge is also a big concern in the field of moth conservation.

An inventory of taxa for a particular conservation area is very important as it not only gives a baseline information about the taxa for the area but also gives an idea about their habitat. This baseline information can be a stepping stone for future research, as well as advocating for better management practices.

The present study aimed to generate a complete inventory of moth fauna present in the different altitudinal and vegetation zones of the Great Himalayan National Park, Himachal Pradesh, with a special focus on the taxonomy of Family Geometridae with habitus and male genitalia photographs. Intraspecific variation in the male genitalia of some highly cryptic group of family Geometridae is also discussed in the current study. This study also attempted to produce a barcode database of Geometridae moths and looked into the applicability of DNA barcoding in dealing with cryptic species complexes. Moreover species delimitation supported by Neighbour-Joining tree was also attempted along with novel submission to the Barcode of Life Database (BOLD).

3.2. Specimen Identification:

Collected voucher specimens were sorted according to their respective families to carry on further taxonomic examination for species-level identification. The voucher specimens were photographed using the Nikon camera apparatus and a digital database was prepared. These images were used for the preparation of photographic plates.

Following morphological characters were studied for specimen identification: Vertex, Frons, Antennal type and length and length of Labial Palps, Proboscis, Tibial spurs and spines, dorsal thoracic scale tufts, abdominal pattern, Fore and Hindwing venation and markings (reniform, orbicular, claviform, discal spots and antemedial, medial, postmedial and subterminal lines). Where morphological description was not enough to confirm a species identity, which is especially common in the case of geometrid moths, genitalia dissection was performed.

For the genitalia study, the abdomens from specimens (preferably male) were cut from the 4th segment and soaked overnight in 20% potassium hydroxide (KOH) solution. The next morning, the soaked abdominal segments were dissected carefully in 20% Ethyl Alcohol (Robinson, 1796) using fine forceps and a soft brush for cleaning the fats and excess tissues. The dissected genitalia was observed and photographed under Leica S8AP0 HD binocular microscope. After examination, the genitalia were stored in 70% alcohol and specimens were deposited at the National Zoological Collection, ZSI, Kolkata.

In general, moths were initially identified following keys, descriptions and illustrations given in published literature by Hampson (1892-1896), Barlow (1982), Haruta (1992-2000), Holloway (1987-2011), Robinson *et al.* (1994); also, recent works by Kendrick (2002), Sanyal (2015) and Raha (2018)were helpful in the identification process. The higher classification was followed after van Nieukerken *et al.*, (2011). The current valid names for the species were followed as per the latest references and the LepIndex website (Beccaloni *et al.* 2003). Genus-level literature consulted especially for family Geometridae included: *Biston*: Jiang *et al.*, (2011); *Cleora*: Sato (1991); *Hypomecis*: Sato (1984); *Krananda*: Jiang *et al.*, (2017); *Cidaria*: Choi (1998); *Timandra*: Cui *et al.*, (2019a); *Problepsis*: Xue *et al.*, (2018); *Synegiodes*: Cui *et al.*, (2018); *Rhodostrophia*: Cui *et al.*, (2019b); *Comibaena*: Han *et al.*, (2012); *Chlororithra*: Hong-xiang *et al.*, (2006); *Timandromorpha*: Hong-Xiang & Da-Yong (2004); *Psyra*: Liu *et al.*, (2013); *Luxiaria*: Jiang *et al.*, (2014); *Ophthalmitis*: Jiang *et al.*, (2011); *Fascellina*: Cui *et al.*, (2014); *Thalassodes*: Han & Xue (2011); *Astygisa*: Stuning & Walia (2009).

DNA Barcoding:

After taking out two or three leg samples from the morphologically identified specimens with sanitized forceps, the legs were stored in molecular grade 70% ethanol at 4 °C. The standard protocol of Phenol Chloroform-Isoamyl alcohol (Sambrook & Russell 2001) was used to extract genomic DNA from the legs. The primer pair, LepF1: 5' ATTCAACCAATCATAAAGATATTGG-3' and LepR1: 5'- TAAACTTCTGGATGTCCAAAAAATCA-3' (Hebert *et al.*, 2004) was used to amplify the 648 bp barcode region (COX1) of the mitochondrial DNA. The total volume of PCR reaction was 30 µl containing: 20 picomoles of each primer, 20 mM Tris-HCl (pH 8.0), 100 mM KCl, 0.1 mM

EDTA,1 mM DTT, 1.8 mM MgCl2, 0.25 mM of each dNTP and 1 µl of Taq polymerase (Takara Bio Inc., Shiga, Japan). The Veriti VR Thermal Cycler (Applied Biosystems, Foster City, CA) was used for the amplification with the following thermocycling profile: first cycle of 5 min at 94 °C, followed by 5 cycles of 1 min at 94 °C, 1 min 30 sec at 45 °C, 1 min 30 sec at 72 °C; followed by 30 cycles of 1 min at 94 °C, 1 min 30 sec at 51 °C, 1 min 30 sec at 72 °C, and final extension for 5 min at 72 °C. QIAquick Gel Extraction Kit (Qiagen Inc., Germantown, MD) was used to purify the PCR products. The cycle sequencing of the purified PCR products was performed with BigDye® Terminator ver. 3.1 Cycle Sequencing Kit (Applied Biosystems Inc., California, USA) and finally sequenced using 48 capillary ABI 3730 Genetic analyzer in ZSI, Kolkata. Kimura-2-parameter model was used to calculate the evolutionary genetic divergences and neighbour-joining (NJ) phylogenetic tree was constructed in the software MEGA X with 1,000 bootstraps of replications (Tamura *et al.*, 2013).

3.3. Results & Discussions:

3.3.1. Moth Inventory of GHNP:

Total 516 species of moths, under 298 genera belonging to 59 subfamilies of 21 families belonging to 10 superfamilies, were recorded during the current course of study, which included Tortricidae (1 species), Cossidae (3), Zygaenidae (1), Callidulidae (1), Pyralidae (4), Crambidae (17), Drepanidae (15), Lasiocampidae (3), Eupterotidae (1), Brahmaeidae (1), Endromidae (3), Bombycidae (2), Saturniidae (1), Sphingidae (8), Uraniidae (3), Geometridae (224), Notodontidae (19), Erebidae (94), Euteliidae (2), Nolidae (4) and Noctuidae (109) (Table 3.1).

Table 3.1: Family-wise genus, species and relative abundance of moths

Sl. No.	Family	Subfamily	No. of Genera	No. of species
1	Tortricidae	Tortricinae	1	1
2	Cossidae	Catoptinae	1	1
		Zeuzerinae	1	2
3	Zygaenidae	Chalcosiinae	1	1
4	Callidulidae	Callidulinae	1	1
5	Pyralidae	Pyralinae	2	2
		Phycitinae	1	1
		Epipaschiinae	1	1
6	Crambidae	Acentropinae	1	1
		Glaphyriinae	1	1
		Spilomelinae	15	15
7	Drepanidae	Drepaninae	7	8
		Thyatirinae	7	7
8	Lasiocampidae	Lasiocampinae	3	3
9	Eupterotidae	Unassigned	1	1
10	Brahmaeidae	Unassigned	1	1
11	Endromidae	Oberthuerinae	3	3
12	Bombycidae	Bombycinae	2	2
13	Saturniidae	Saturniinae	1	1
14	Sphingidae	Macroglossinae	5	6
		Smerinthinae	2	2
15	Uraniidae	Epipleminae	3	3
16	Geometridae	Sterrhinae	6	11
		Larentiinae	38	79
		Geometrinae	10	11
		Ennominae	56	123
17	Notodontidae	Heterocampinae	1	1

Sl. No.	Family	Subfamily	No. of Genera	No. of species
		Notodontinae	7	8
		Periergosinae	3	3
		Phalerinae	1	1
		Pygaerinae	2	3
		Spataliinae	1	1
		Thaumetopoeinae	1	2
18	Erebidae	Aganainae	1	1
		Arctiinae	21	44
		Boletobiinae	1	1
		Calpinae	3	3
		Erebinae	7	11
		Herminiinae	2	2
		Hypeninae	3	12
		Lymantriinae	9	16
		Scoliopteryginae	2	2
		Toxocampinae	1	2
19	Euteliidae	Euteliinae	2	2
20	Nolidae	Chloephorinae	1	1
		Eariadinae	1	1
		Nolinae	2	2
21	Noctuidae	Acronictinae	2	5
		Bagisarinae	1	1
		Bryophilinae	1	1
		Condicinae	1	1
		Eriopinae	1	1
		Eustrotiinae	1	1
		Hadeninae	11	25
		Heliothinae	1	1
		Noctuinae	12	35
		Plusiinae	6	9
		Xyleninae	16	29

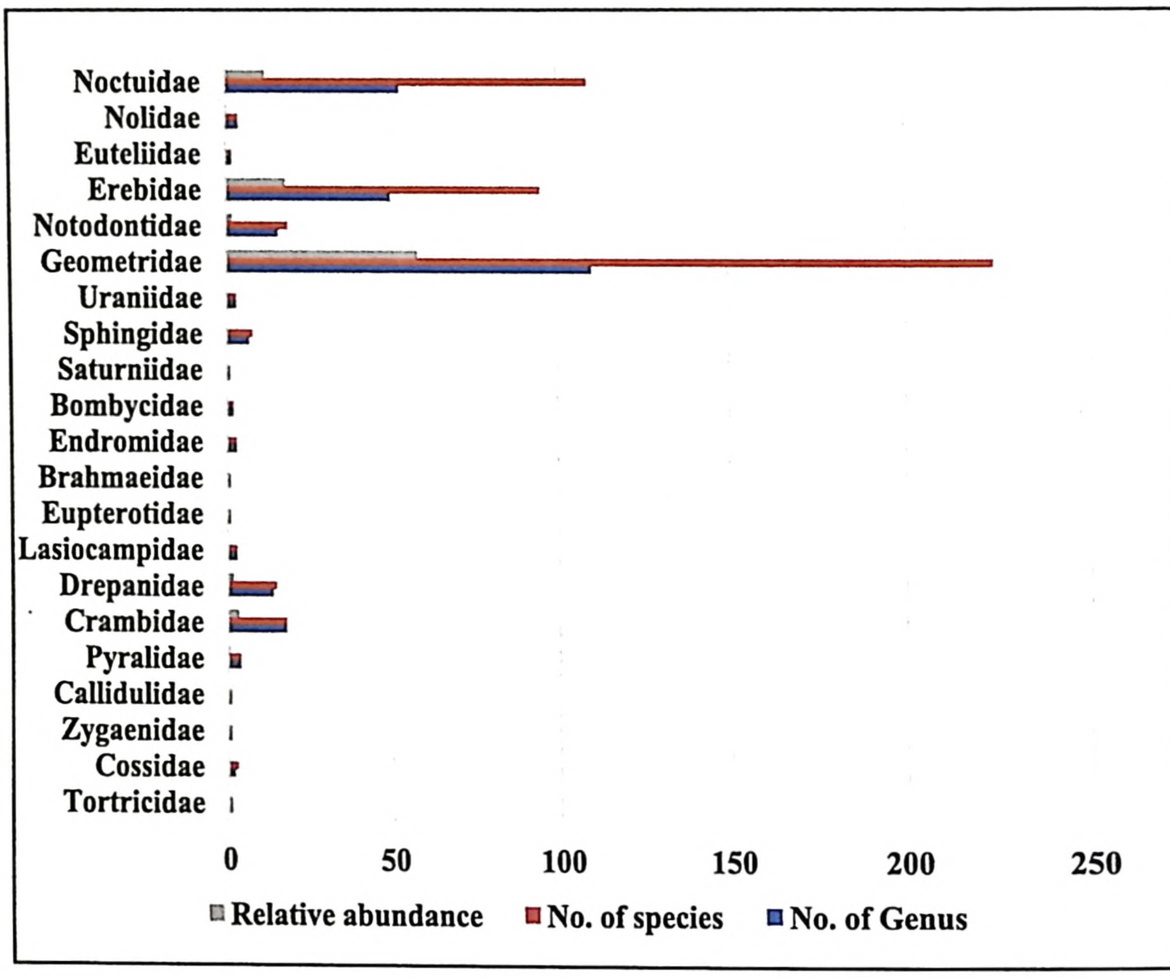


Fig. 3.1: Family-wise species and genus richness and relative abundances of moth families.

Species richness of the Family Geometridae was highest, having 224 species under 110 genera followed by Noctuidae, having 109 species under 53 genera and Erebidae, having 94 species under 50 genera (Fig. 3.1). Subfamily Ennominae hold the highest number of species and individuals among Geometridae, i.e., 123 species under 56 genera followed by Larentiinae, having 79 species under 38 genera (Fig. 3.2).

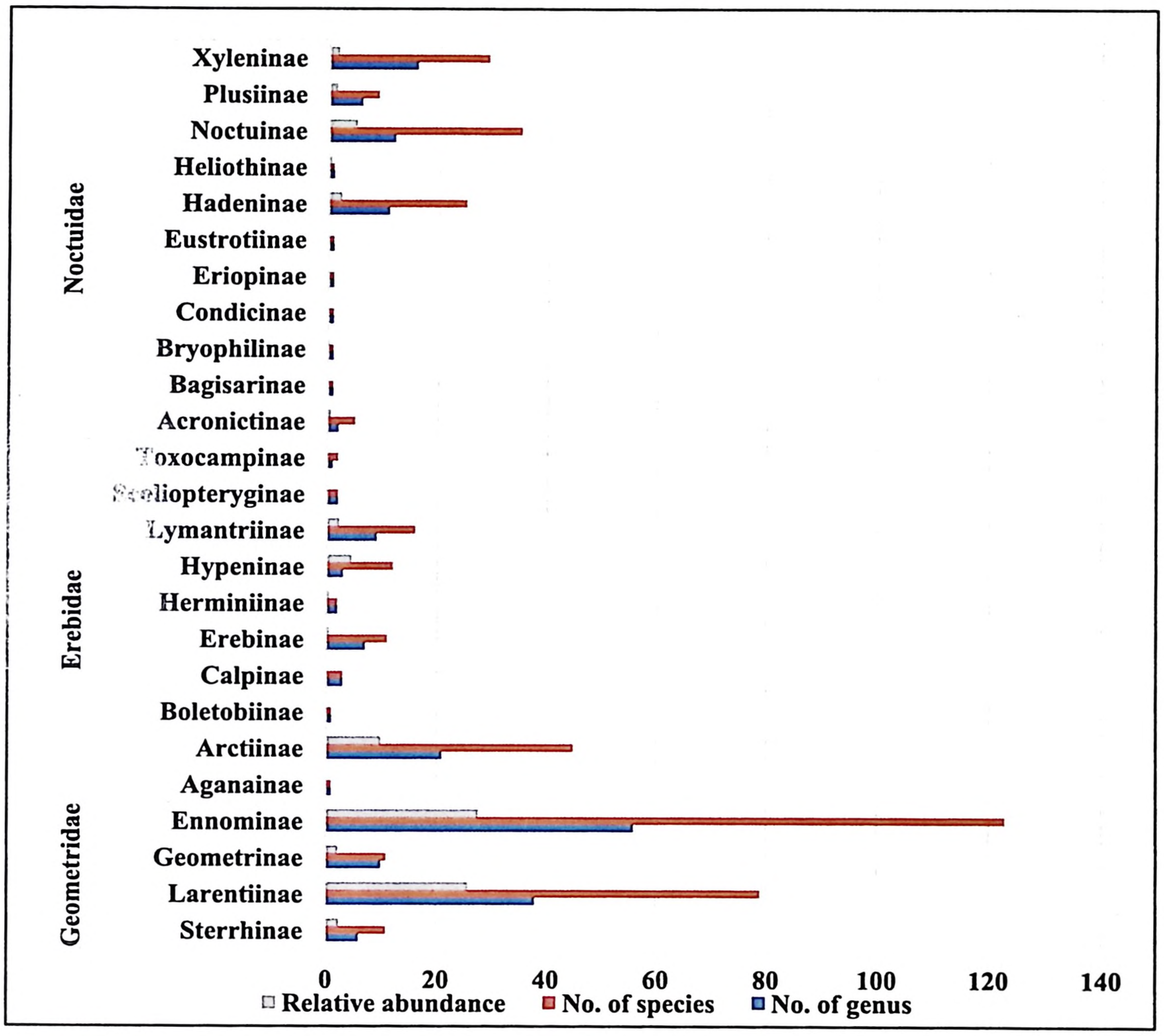


Fig. 3.2: Subfamily-wise species and genus assemblages and relative abundances of three major moth families.

Among subfamily Ennomine, *Anonychia lativitta, Myrioblephara gandakiensis, Alcis nudipennis, Parectropis conspurcata, Micrabraxas melanodonta, Heterolocha falconaria, Odontopera lentiginosaria, Menophra subplagiata, Ctenognophos eolaria, Myrioblephara duplexa* and *Alcis paghmana* were recorded in very high abundance, while *Alcis admissaria, Alcis subnitida, Heterolocha phoenicotaeniata, Myrioblephara xanthozonea* and *Lomographa platyleucata* were superabundant.

In the case of Larentiinae, *Photoscotosia amplicata, Rheumaptera dubiosata, Perizoma fulvimacula, P. antisticta, P. peculiare, Venusia roseicosta* and *Neotephria ramalaria* were superabundant while, *Xanthorhoe hampsoni* and *Perizoma variabilis* were found in high abundance. *Chlorissa gelida* of Geometrinae was also recorded in high abundance.

In the case of Family Noctuidae, the species richness and abundance of subfamily Noctuinae was highest, having 35 species under 12 genera, followed by Xyleninae, having 29 species under 16 genera, and Hadeniinae, having 25 species under 11 genera. Among Noctuinae, *Xestia c-nigrum* and *Athetis lineosa* were found to be superabundant, whereas, *Agrotis ipsilon* and *Diarsia nigrosigna* were recorded in high abundance. In the case of Xyleninae, *Elaphria conjucata* was recorded in high numbers. In Hadeninae, *Polia culta, Mythimna separata, M. sinuosa* and *Tiracola plagiata* were recorded in very high numbers. *Thysanoplusia orichalcea* of Plusiinae and *Helicoverpa armigera* of Heliothinae were found to be superabundant as expected, indicating the site was disturbed and near to human habitat as they are known to be a major pest for the crops as well as they are always been a major indicator of disturbance or agricultural intensification.

In family Erebidae, subfamily Arctiinae (44 species under 21 genera) having the highest number of species and with the highest abundance, followed by Lymantriinae and Erebinae, having 16 species under 9 genera and 11 species under 7 genera, respectively. Among Arctiinae, *Spilarctia melanostigma, Cyana* *adita, Barsine pretios, Spilosoma erythrozona* and *Ghoria postfusca* were found to be superabundant. In Lymantriinae, *Somena scintillans* and *Calliteara horsfieldii* were recorded in high numbers. *Hypena obductalis* of Hypeninae was recorded in very high abundance may be due to their seasonal blooming.

A total of 19 species of Notodontidae were recorded belonging to 7 subfamilies, among which Notodontinae was most diverse with 8 species, with the most abundant species being *Syntypistis umbrosa. Micromelalopha undulata* of Pygaerinae and *Gazallina chrysolopha, G. apsara* of Thaumetopoeinae were also found to be abundant.

Overall, 17 species of Crambidae were recorded, with Spilomelinae being the most diverse with a species richness of 15. *Nomophila noctuella* and *Patania ruralis* of Spilomeilinae were found to be superabundant.

About, 15 species of Drepanidae were recorded, with *Oreta vatama* of Drepaninae being found to be superabundant.

3.3.2. Taxonomic accountof Moths of GHNP:

Signs used in the Taxonomic account: *- New record to India; #- New record to Western Himalaya; ^- New record to Himachal Pradesh.

Superfamily GEOMETROIDEA Leach, 1815

Family GEOMETRIDAE Leach, 1815

These moths are characterized by the presence of structurally unique tympanal organs present at the base of the abdomen (Cook and Scoble, 1992). Forewing with vein 3A forming a basal fork with 2A; 1A absent (Triplehorn and Johnson, 2005). They can be easily identified as, at rest, the wings are typically held outspread, wings are neither usually folded over the body nor held vertically with the dorsal surfaces of wing touching.

Subfamily STERRHINAE Meyrick, 1892

Sterrhinae can be characterized by the following characters:

1) Forewing with most anterior discocellular vein (vein between areole and the base of M_1) long and oriented almost parallel with Medial veins (Forbes, 1948).

2) Forewing with single fasciae (Minet & Scoble, 1999).

3) Hindwing cell spot with pale marking in darker surround (Holloway, 1997).

4) Forewing with one or two areoles (absent in Mecoceratini).

5) Point of origin of M_1 is either proximal or distal areole in forewing.

6) 2nd abdominal sternite without anterolateral extensions in male specimens (Sihvonen & Kaila, 2004; Sihvonen et al. 2020).

A hammer-headed tip in tympanal organ's ansa is a common character shared by Sterrhinae and Larentiinae (Cook & Scoble, 1992; Viidalepp, 2011) and a few other characters (Hausmann, 2004; Murillo-Ramos *et al.,* 2021)

A total of 11 species belonging to 6 genera under 4 tribes recorded from the current study from Great Himalayan National Park. *Idaea falcipennis* and *Lophophleps informis* were recorded for the first time from the Western Himalayan Landscape, previously reported from Sikkim and Meghalaya (Khasi Hill) respectively. *Rhodostrophia cinerascens* was reported for the first time from the state of Himachal Pradesh, previously reported from Kashmir, Sikkim, West Bengal (Darjeeling) and Afghanistan.

Tribe: IDAEINI Butler, 1881

Genus: *Idaea* Treitschke, 1825

1. *Idaea falcipennis* Warren 1893#

(Habitus Plate No: 1.1 & Genitalia Plate No: 1.1)

1893. *Idaea falcipennis* Warren, *Proc. Zool. Soc. Lond.,* : 362.

1895. *Acidalia falcipennis*; Hampson, *Fauna Brit. India Moths,* **3:** 439.

Material examined: GH01A (2 ex.), GH01B (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 24 mm.

Diagnosis: Ground colour cremy white, suffused with cinereous; forewing costa strongly curved; apex blunty falcate and inner margin straight but oblique; submarginal line denticulated and dark. Hindwing with outer margin rounded and elbowed at middle.

Valvae with two apical processes, ventral one strongly sclerotized and apically pointed and curved; dorsal one slender, apically blunt, longer than ventral one, not sclerotized. Juxta 'V' shaped, moderately sclerotized; Uncus with two long slender processes with apex round; saccus broad and round. Aedeagus long, slender, apically pointed and moderately sclerotized. Eighth Sternite with two slender, moderately sclerotized, asymmetric cerata; right one longer than the apex and left one shorter thans the apex of sternite.

Distribution: India: Himachal Pradesh (GHNP) and Sikkim.

Genus: *Lophophleps* Hampson, 1891

2. *Lophophleps informis* (Warren, 1897)#

(Habitus Plate No: 1.2 & Genitalia Plate No: 1.2)

1897. *Strophoptila informis* Warren, *Nov. Zool.*, **4**: 225.

1992. *Idaea informis*; Yazaki, *Tinea,* **13**(suppl. 2): 16.

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

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

Material examined: GH26A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a).

Wing expanse: 20 mm.

Diagnosis: Ground colour ochreous grey with slight olive tinge; costa and lines pale ochreous; basal line curved, antemedial straight, submarginal sinuous at CuA_2 and M_3; fringes ochreous with dark line; Hindwing similar.

Valvae apically broad, curved inward with a sclerotized hook-like process, costal margin strongly sclerotized; Uncus broad at the base, apically pointed, sclerotized; Gnathos slender, apically pointed, as long as uncus. Aedeagus long, slender and vesica with five long sclerotized cornuti at apex and few small cornuti at the base.

Distribution: India: Himachal Pradesh (GHNP) and Meghalaya (Khasi). **Elsewhere:** Nepal and Taiwan.

Tribe: SCOPULINI Duponchel, 1845

Genus: *Scopula* Schrank, 1802

3. *Scopula achrosta* Prout, 1935

(Habitus Plate No: 1.3 & Genitalia Plate No: 1.3)

1935. *Scopula moorei achrosta* Prout, Seitz, *Macro Lep. Supl.*, **4**: 45.

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

Material examined: GH01D (1 ex.), GH01E (7 ex.), GH01F (1 ex.), GH02A (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04A (2 ex.), GH04B (1 ex.), GH05A (2 ex.), GH08B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH06A (1 ex.): Moist Deodar Forest (12/C1c).

Wing expanse: 38 mm.

Diagnosis: Ground colour pale brown with slight dark irroration; forewing with large, indistinct cell-speck; forewing with an indistinct antemedial and double medial curved lines; postmedial line dentate, more distinct and with orange spots on the middle and inner margin; Hindwing with small cell-speck with orange scale; traces of a waved medial line and slightly dentate postmedial line, with orange spot at middle.

Valve broad at the base, moderately sclerotized, with two finger-like apical arm, ventral one broader and stouter than the dorsal one; Uncus slender, apically pointed; saccus broad, 'U' shaped. Aedaegus stout, moderately sclerotized, vessica with two pointed sclerotized cornuti. Eighth Sternite with two long, slender, asymmetric cerata, right one longer than the apex and left one shorter than apex of sternite.

Distribution: India: Kashmir, Himachal Pradesh (Shimla, GHNP) and Uttarakhand (Massuri). **Elsewhere:** Pakistan (Murree).

4. *Scopula butleri* (Prout, 1913)

(Habitus Plate No: 1.4 & Genitalia Plate No: 1.4)

1913. *Acidalia butleri* Prout, Seitz, *Macro Lep.*, **4**: 78.

1889. *Craspedia insolata* Butler, *Ill. typical Spec. Lep. Het. Colln Br. Mus.*, **7**: 22.

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

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 15 mm.

Diagnosis: Ground colour pale white; postmedian line reaches the inner margin close to tornus and with dentate blackis subtermen; markings grey brown, fringes blackish, forewing underside with dark costal spots.

Valvae with short, distally tapered fibula and thumb-like, strongly sclerotized valvula; Juxta 'V' shaped, strongly sclerotized; long digitate socii; Saccus round, broad. Aedaegus long, slender, moderately sclerotized, apically pointed; Eighth Sternite with a short claw-like left and long, medially bent right cerata.

Distribution: India: Himachal Pradesh (Dharamshala, GHNP). **Elsewhere:** China, Japan and Korea.

5. *Scopula pallida* (Warren, 1888)

(Habitus Plate No: 1.5 & Genitalia Plate No: 1.5)

1888. *Idaea pallida* Warren, *Proc. Zool. Soc. Lond.,* : 322.

1895. *Craspedia pallida*; Hampson, *Fauna Brit. India Moths,* **3**: 433.

2003. *Scopula pallida*; Ghosh, *Fauna of Sikkim*, **4**: 268.

2005. *Scopula pallida*; Walia, *Fauna of West. Himalaya,* **2**: 181.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (1 ex.), GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH10A (1 ex.): Moist Deodar Forest (12/C1c).

Wing expanse: 26 mm.

Diagnosis: Ground colour ochreous-white and minutely irrorated with black; forewing with oblique, ochreous antemedial line; sinuous, oblique, ochreous postmedial line and three slightly waved lines on outer area. Underside with the costa suffused with black; brown postmedial and three lines on outer area. Hindwing antemedial line ochreous, outer area like forewing. Bothwings with black cell speck.

Valvae with distally tapered, slender, fibula and apically pointed, curved, strongly sclerotized valvula; Juxta 'U' shaped, moderately sclerotized; very long, slender, digitate socii; Saccus round, broad. Aedaegus long, slender, moderately sclerotized, apically pointed; Eighth Sternite with two long, medially bent, similar cerata.

Distribution: India: Himachal Pradesh (Shimla, Chambaghat, Sarahan, Kharapathar, GHNP) and Sikkim. **Elsewhere:** Pakistan.

Tribe: RHODOSTROPHIINI Prout, 1935

Genus: *Rhodostrophia* Hübner, [1823]

6. *Rhodostrophia cinerascens* (Moore, 1888)^

(Habitus Plate No: 1.6 & Genitalia Plate No: 1.6)

1888. *Phyletis cinerascens* Moore, *Descr. Ind. Lep. Atk.,* : 264.

1893. *Rhodostrophia subflavida* Warren, *Proc. Zool. Soc. Lond.,* : 360.

1895. *Rhodostrophia cinerascens*; Hampson, *Fauna Brit. India Moths,* **3**: 458.

Material examined: GH04B (2 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 38 mm.

Diagnosis: Ground colour olive-grey; straight postmedial and submarginal lines forms a slight oblique band in forewing; hidwing pale white, with dark tinge on inner margin; postmedial and submarginal lines indistinct on costal margin; cilia fuscous; underside with the costal and outer margin of forewing and whole hind wing orange-yellow.

Valvae long, apically and costally swollen, apex sclerotized with a slight notch; ventral margin with finger like process; costal margin of valvae basally concave; gnathos highly sclerotized, triangular; uncus long, slender, gradually becoming broad apically, apex "M" shaped; saccus narrow, "V" shaped. Aedegus long, slender, with a single cornutii on vesica.

Distribution: India: Kashmir, Himachal Pradesh (GHNP), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Afghanistan.

7. *Rhodostrophia herbicolens* (Butler, 1883)

(Habitus Plate No: 1.7 & Genitalia Plate No: 1.7)

1883. *Delocharis herbicolens* Butler, *Proc. Zool. Soc. Lond.,* : 1720.

1895. *Rhodostrophia herbicolens*; Hampson, *Fauna Brit. India Moths,* **3**: 457.

Material examined: GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 34 mm.

Diagnosis: Ground colour ochreous, irrorated and suffused with brown; forewing with narrow, indistinct, brown antemedial band, a diffused medial band and a waved submarginal line with slight brown tinge beyond it; hindwing with sinuous submarginal line with pinkish-brown suffusion beyond it.

Male genitalia vesry similar with *R. cinerascens* but apical notch much more distinct and ventral process of valvae not finger like in *R. herbicolens.* Gnathos longer and not triangular as in *cinerascens* but more apically longer in this species. Aedeagus similar but vesica cornutii much broader apically.

Distribution: India: Himachal Pradesh (Solan, Dalhousie, GHNP).

8. *Rhodostrophia pelloniaria* (Guenée, 1858)

(Habitus Plate No: 1.8 & Genitalia Plate No: 1.8)

1858. *Phyletis pelloniaria* Guenée, *Spec. Gen.* **10**: 169.

1895. *Rhodostrophia pelloniaria*; Hampson, *Fauna Brit. India Moths,* **3:** 456.

1935. *Rhodostrophia pelloniaria*; Seitz, *Macro Lep. Supl.*, **4**: 25.

2017. *Rhodostrophia pelloniaria*; Sanyal *et al.*; *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Rhodostrophia pelloniaria*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 234.

Material examined: GH09A (2 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 32 mm.

Diagnosis: Ground colour dull ochreous, with fuscous suffusion; frons and legs pinkish; forewing apex produced and acute, costa pink; an oblique postmedial pink band broader in forewing but narrower and indistinct in hindwing; cilia pinkish and underside suffused with pink.

Valvae apically acute and costal margin in basal area slightly concave; gnathos apically long. Aedeagus long, slender, slightly bent and moderately sclerotized.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand and Meghalaya.

Elsewhere: Pakistan, China and Tibet.

9. *Rhodostrophia stigmatica* Butler, 1889

(Habitus Plate No: 1.9 & Genitalia Plate No: 1.9)

1889. *Rhodostrophia stigmatica* Butler, *Ill. typical Spec. Lep. Het. Colln Br. Mus.*, **7**: 110.

1992. *Rhodostrophia stigmatica*; Yazaki, *Tinea* **13**(suppl. 2): 16.

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

Material examined: GH01A (1 ex.), GH01C (1 ex.), GH01D (4 ex.), GH01E (1 ex.), GH02A (2 ex.): Himalayan Chir Pine Forest (9/C1b); GH04C (1 ex.), GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH10A (1 ex.): Moist Deodar Forest (12/C1c).

Wing expanse: 30 mm.

Diagnosis: Ground colour ochreous with slight fuscous irroration; frons brown, legs yellow; forewing with costa pink; antemedial line curved, pink; postmedial line oblique, sinuous and submarginal line sinuous. Hindwing with a subbasal line, pink medial line, sinuous postmedial line, cilia pink. Underside yellow with pink suffusion and all the veins pink.

Valvae apically narrow, bilobed, pointed, apical margin with spines; ventral margin concave before apex; gnathos triangular; uncus broader than all the preceeding species. Aedeagus long, slender, narrow in the middle.

Distribution: India: Himachal Pradesh (Dharamshala, GHNP) and Uttarakhand (Bhimtal). **Elsewhere:** Nepal.

10. *Rhodostrophia tristrigalis* Butler, 1889

(Habitus Plate No: 1.10 & Genitalia Plate No: 1.10)

1889. *Rhodostrophia tristrigalis* Butler, *Ill. typical Spec. Lep. Het. Colln Br. Mus.*, **7**: 110.

1895. *Rhodostrophia tristrigalis*; Hampson, *Fauna Brit. India Moths,* **3:** 456.

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

2019. *Rhodostrophia tristrigalis*; Cui *et al., Zootaxa,* **4563**(2): 349.

Material examined: GH01D (2 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 30 mm.

Diagnosis: Ground colour greyish; similar to preceeding species but differs in having straight antemedial line, not reaching upto costa; cell spot much reduced; postmedial band broad, oblique and submarginal line straight. Hindwing with medial band oblique and straight submarginal line.

Male genitalia is also very similar with *R. stigmatica* but differs in having a finger-like projection on the costal basal margin of valvae and gnathos is slightly longer and more acute apically.

Distribution: India: Himachal Pradesh (Dharamshala, GHNP) and Uttarakhand (Bhimtal). **Elsewhere:** China and Tibet.

Tribe: TIMANDRINI Stephens, 1850

Genus: *Timandra* Duponchel, 1829

11. *Timandra correspondens* Hampson, 1895

(Habitus Plate No: 1.11 & Genitalia Plate No: 1.11)

1895. *Timandra correspondens* Hampson, *Fauna Brit. India Moths,* **3:** 459.

1992. *Timandra correspondens*; Yazaki, *Tinea* **13**(suppl. 2): 16.

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

Material examined: GH01G (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH05A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH07A (1 ex.): Alder Forest (Riverine) (12/1S1); GH18A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 38 mm.

Diagnosis: This species is typically characterized by the straight postmedial line of hindwing and without any protusion; frons with a sharp protusion.

In male genitalia, the species characterized by the arm between valvula and sacculus slightly curved and reaches to the apex of sacculus.

Distribution: India: Himachal Pradesh (Shimla, GHNP), Uttarakhand (Munsiyari, Mussoorie), West Bengal (Kalimpong), Arunachal Pradesh (Eaglenest WLS), Assam, Manipur, Nagaland, Tamil Nadu and Kerala. **Elsewhere:** China, Tibet, Myanmar and Vietnam.

Subfamily LARENTIINAE Duponchel, 1845

Larentiinae can be characterized by following characters:

1) Veins Sc + R_1 and R_s fused for long-distance in hindwing (Meyrick, 1892; Hausmann & Viidalepp, 2012).

2) Fasciae are multiple in forewing composed of of closely juxtaposed lines (Minet & Scoble, 1999).

3) Forewing with radial veins R_1–R_4 or R_2–R_4 starting from the areole and are stalked with M_1, or, if separate, M_1 continues in line with the anterior margin of the cell (Õunap *et al.,* 2008).

4) Both wings without subcostal accessory cell (between Sc and R).

5) M_2 thinner than M_1 and M_3 in both wings.

6) In Male genitalia, socii absent (Hausmann & Viidalepp, 2012) and gnathos generally strongly reduced (Schmidt, 2015; Murillo-Ramos *et al.,* 2021).

A total of 79 species of Larentiinae under 38 genera belonging to 11 tribes were recorded in this study from Great Himalayan National Park. Among the tribes, Cidariini was the most diverse with species richness of 25, followed by Larentiini with species richness of 13. Out of them 19 species were reported for the first time from Western Himalaya and 9 species were reported for the first time from the Himachal Pradesh.

Tribe: XANTHORHOINI Pierce, 1914

Genus: *Orthonama* Hübner, [1825]

12. *Orthonama obstipata* (Fabricius, 1794)*

(Habitus Plate No: 1.12)

1794. *Phalaena obstipata* Fabricius, *Ent. Syst.,* **3**(2): 199.

1992. *Orthonama obstipata*; Yazaki, *Tinea,* **13**(suppl. 2): 17.

2004. *Orthonama obstipata*; Schulze & Fiedler, *Nachr. entomol. Ver. Apollo, N. F.* **25**(3): 153.

Material examined: GH04A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 19 mm.

Diagnosis: Ground colour yellowish-brown with darker transverse area between the base and the medial line; discoidal spot small, black, surrounded by white; transverse bands very dark, alternate with light coloured line.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal, China, Indonesia (Borneo), Turkey, Iran, Turkmemistan, Kasakhstan, Afghanistan, Buryatia, Irkutsk, Transbaikalia, Sakhalin, Amur, Primorye, Mongolia, Korea, Japan, Austria, Germany, Poland and Switzerland.

Genus: *Xanthorhoe* Hübner, [1825]

13. *Xanthorhoe castanea* Warren, 1901^

(Habitus Plate No: 1.13 & Genitalia Plate No: 2.1)

1901. *Xanthorhoe castanea* Warren, *Nov. Zool.,* **8**: 3

Material examined: GH24A (2 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27B (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 30 mm.

Diagnosis: Forewing ground colour pale whitish with brownish-gery suffusion; basal patch large, pale brown, outer edge darker and slight curve; median fascia chestnut-brown, twice broader on costa than on inner margin; its outer edge bluntly round below costa then angularly projecting at M_3; a broad pale band beyond the fascia, traversed by a dark line near the fascia and edged outwardly by a lunulate dentate line, marked by dark on the veins projecting inward; a lunulate submarginal line, paler than the greyish-brown outer area, preceded on costa by a brown blotch. Underside dirty white, sprinkled with grey, lines slightly marked with grey.

Valvae with the costal margin sclerotized, tip pointed, slightly curved; saccular process membranous; saccus slender, stalk-like; uncus long, slender, sclerotized, curved. Aedeagus long, slender, sclerotized, with series with apical spines.

Distribution: India: Kashmir and Himachal Pradesh (GHNP).

14. *Xanthorhoe griseiviridis* (Hampson, 1895)*

(Habitus Plate No: 1.4 & Genitalia Plate No: 2.2)

1895. *Cidaria griseiviridis* Hampson, *Trans. Ent. Soc. Lond.,* : 312.

1896. *Cidaria griseiviridis*; Hampson, *Fauna Brit. India Moths,* **4:** 557.

Material examined: GH08B (3 ex.): Moist Temperate Deciduous Forest (12/C1e); GH21A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 28 mm.

Diagnosis: Head, thorax green; abdomen black; forewing with many waved, indistinct, black lines; basal area rufous-green; medial area fuscous, with a large grey patch on the disk, bounded by the postmedial line, i.e., slightly angled at M_1 and M_3, then highly crenulated upto inner margin; outer area green, with a rufous patch on costa beyond postmedial; a black subapical patch. Hindwing fuscous, with an indistinct cell-speck and waved lines, those markings are more distinct on the underside.

Male genitalia are very similar with to previous species but the saccus very thin, slender and narrower than previous species; costal margin less sclerotized and aedeagus with apical spine much reduced.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Bhutan.

15. *Xanthorhoe hampsoni* Prout, 1925

(Habitus Plate No: 2.1 & Genitalia Plate No: 2.3)

1925. *Xanthorhoe hampsoni* Prout, *Novit. Zool.*, **32**: 39.

1995. *Xanthorhoe hampsoni*; Yazaki, *Tinea*, **14**(suppl. 2): 6.

Material examined: GH12B (2 ex.): Western Mixed Coniferous Forest (12/C1d); GH15A (4 ex.), GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH22C (1 ex.), GH24A (2 ex.), GH26A (2 ex.): West Himalayan Sub-Alpine

High-level Fir forest (14/C1a); GH23A (1 ex.): Sub-Alpine Pastures (14/DS1); GH27B (14 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 33 mm.

Diagnosis: Ground colour of forewing glossy green; basal and medial area brownish-black, edged with a white line; succeeding green area with lines and black blotches; antemedial line angled in cell and toothed outward on fold; large, black cell-spot, a row of irregular, blackish blotches beyond it; sinuate postmedial line, bilobed behind R_3; submarginal line slightly lunulate, interrupted by an oblique dash from apex; a dark costal patch on SC_5 and a pair of broad, black, wedge-shaped marks between the radials before it. Hindwing white with grey posterior suffusion and white postmedial and submarginal lines on it.

Male genitalia similar with preceeding two species but differs in having "V" shaped saccus and aedeagus with no apical spine but a strong cornuti at the middle.

Distribution: India: Himachal Pradesh (Shimla, Dalhousie, GHNP). **Elsewhere:** Nepal.

16. *Xanthorhoe saturata* (Guenée, 1858])[#]

(Habitus Plate No: 2.2 & Genitalia Plate No: 2.4)

1858. *Larentia saturata* Guenée, *Spec. Gen.* **10**: 269.

1895. *Cidaria saturata*; Hampson, *Fauna Brit. India Moths,* **3:** 362.

2021. *Xanthorhoe saturata*; Chettri & Yonle, *International Journal of Entomology Research,* **6**(3): 94.

Material examined: GH01E (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 28 mm.

Diagnosis: Ground colour pale rufous; forewing with numerous pale, waved line; median band blackish, broad with waved edges, becoming narrower from vein CuA_1 to inner margin; some diffuse, fuscous patches on costa before apex and below apex on the outer area; a waved, grey submarginal line on both wings. Hindwing with slight fuscous suffusion; medial area with three indistinct waved lines.

Male genitalia similar with preceeding three species but differs in having truncate valvae apex and moderately long saccus; aedeagus with numerous vesica spines.

Distribution: India: Himachal Pradesh (GHNP), West Bengal (Darjeeling), Meghalaya (Khasi) and Tamil Nadu (Nilgiri, Pondichery). **Elsewhere:** Pakistan, China, Vietnam, Taiwan, Japan and Korea.

Tribe: EUPHYIINI Herbulot, 1961

Genus: *Euphyia* Hübner, [1825]

17. *Euphyia cinnamifusa* Prout, 1939^

(Habitus Plate No: 2.3)

1939. *Euphyia cinnamifusa* Prout, *in Seitz, Macrolep. World,* **12**: 281.

Material examined: GH20A (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 32 mm.

Diagnosis: Very similar with *E. subangulata,* but differs in having the area between basal and median bands more heavily lined, the intermediate brown band broad; curved antemedial line; orange-cinnamon suffusion present on the cell-dot and on submarginal area, especially as two longitudinal, broad patches on the fold; underside less bright.

Valvae with a costal sclerotized, slender, apically round process; ventral margin of valvae creates an acute angle at middle; uncus toungue-shaped; aedeagus long, slender, sclerotized, with apical bunch of small spines.

Distribution: India: Kashmir and Himachal Pradesh (GHNP).

18. *Euphyia goniodes* Prout, 1926^

(Habitus Plate No: 2.4 & Genitalia Plate No: 2.5)

1926. *Euphyia goniodes* Prout, *Novit. Zool.,* **33**: 8.

1938. *Euphyia goniodes*; Prout, *in Seitz, Macrolep. World,* **4(Suppl)**: 148.

Material examined: GH20A (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH23A (2 ex.): Sub-Alpine Pastures (14/DS1); GH24A (2 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH25B (1 ex.): Dwarf Rhododendron Scrub (15/C2/E1).

Wing expanse: 33 mm.

Diagnosis: Very close to *E. subangulata* and *E. mediovittaria,* but in having fore and midlegs slightly darker and rings at joints more conspicuous; forewing apex more produced; outer and inner area less ochreous; submarginal line more lunulate than in *E. mediovittaria.* Hindwing with termen straighter; fringe less yellow.

Valvae with apex pointed, slender, sclerotized; uncus apically long, curved, slender, sclerotized; saccus long, broad, tongue-shaped.

Distribution: India: Kashmir, Himachal Pradesh (GHNP) and Sikkim. **Elsewhere:** Tibet.

19. *Euphyia subangulata* (Kollar, [1844])

(Habitus Plate No: 2.5 & Genitalia Plate No: 2.6)

1844. *Cidaria subangulata* Kollar, *Hugel's Kashmir*, **4**: 490.

1895. *Cidaria subangulata*; Hampson, *Fauna Brit. India Moths*, **3**: 356.

2017. *Euphyia subangulata*; Sanyal *et al*., *SHILAP Revta. lepid*., **45**(177): 157.

2019. *Euphyia subangulata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 231.

Material examined: GH06A (2 ex.): Moist Deodar Forest (12/C1c); GH07A (2 ex.): Alder Forest (Riverine) (12/1S1); GH08A (1 ex.), GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH10A (1 ex.): Moist Deodar Forest (12/C1c); GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH14B (2 ex.), GH15A (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH20A (1 ex.):

West Himalayan Upper Oak-Fir Forest (12/C2b); GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a).

Wing expanse: 34 mm.

Diagnosis: Basal area of forewing grey with two waved, dark lines followed by an antemedial grey band with rufous in the middle; medial band dark, with waved grey edge and two black lines on it; outer area grey, with indistinct waved lines on it; a red costal patch before apex; a submarginal series of white specks; underside with prominent waved, white lines; outer area chestnut.

Valvae with apex lobe-like broad, membranous; costal process pointed, sclerotized; uncus long, slender, sclerotized; saccus "V" shaped.

Distribution: India: Kashmir, Himachal Pradesh (GHNP) and Uttarakhand (Mussoouri, Nanda Devi Biosphere Reserve). **Elsewhere:** Afghanistan, Pakistan, Nepal and Bhutan.

20. *Euphyia variegata* (Moore, 1868)

(Habitus Plate No: 2.6 & Genitalia Plate No: 2.7)

1868. *Larentia variegata* Moore, *Proc. Zool. Soc. Lond.,* : 653.

1895. *Cidaria variegata*; Hampson, *Fauna Brit. India Moths*, **3**: 353.

1915. *Euphyia variegata*; Prout, *in Seitz, Macrolepid. World,* **12**: 280.

Material examined: GH01E (1 ex.), GH01F (1 ex.), GH02B (2 ex.), GH03B (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH07A (1 ex.): Alder Forest (Riverine) (12/1S1); GH13A (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 40 mm.

Diagnosis: Larger than preceding species with forewing ground colour dull greenish; a broad, dark median band, its distal edge with teeth at veins. Hindwing grey; submarginal line white. Underside of forewing less marked but the hidwing strongly marked.

Valvae with costal process sclerotized, with a finger-like process; valvae apex round, membranous; uncus rounded, slight apical invagination at middle.

Distribution: India: Himachal Pradesh (Shimla, GHNP), Sikkim and West Bengal. **Elsewhere:** Bhutan and China.

Tribe: CIDARIINI Duponchel, 1845

Genus: *Colostygia* Hübner, [1825]

21. *Colostygia albigirata* (Kollar, 1844)

(Habitus Plate No: 2.7 & Genitalia Plate No: 2.8)

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

1895. *Colostygia albigirata*; Hampson, *Fauna Brit. India Moths*, **3**: 367.

1914. *Colostygia albigirata*; Prout, *in Seitz*, *Macro Lep*., **4**: 229.

1995. *Lampropteryx albigirata*; Kollar, *Tinea,* **14**(Suppl. 2): 6.

2017. *Colostygia albigirata*; Sanyal *et al*., *SHILAP Revta. lepid*., **45**(177): 157.

2019. *Colostygia albigirata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 229.

Material examined: GH03C (1): Himalayan Chir Pine Forest (9/C1b); GH19A (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 36 mm.

Diagnosis: Ground colour deep brown with grey irroration and numerous dark waved lines; antemedial line toothed on median fold; postmedial angled on M_3 and with a inward projection at CuA_1; cell-speck black with the edge grey; submarginal line waved, grey and gery subapical streak. Underside with dentate postmedial line with its inner edge black.

Valvae broad, membranous, apex round; juxta with symmetrical dumble-like process, with long spines arising from the apex; uncus long, slender, sclerotized.

Distribution: India: Kashmir, Himachal Pradesh (GHNP), Uttarakhand and Sikkim. **Elsewhere:** Afghanistan, Nepal, Myanmar, China, Japan, Mongolia and Russia.

Genus: *Dysstroma* Hübner, 1825

22. *Dysstroma dentifera* (Warren, 1896)#

(Habitus Plate No: 2.8 & Genitalia Plate No: 2.9)

1896. *Polyfasia dentifera* Warren, *Novit. Zool.,* **3**: 387.

2000. *Dysstroma dentifera*; Yazaki, *Tinea,* **16**(suppl. 1): 10.

Material examined: GH04C (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 42 mm.

Diagnosis: Forewing pale yellow and basal area grey with the lines blackish; medial band with outer egde black, edged with white below costa and toothed in lower half; a black wedge-shaped mark on the submedian vein near tornus formed by submarginal line. Hindwing greyish-yellow.

Valvae broad, apex round; vinculum ventrally produced; uncus apically very long, slender, sclerotized, apex blunt.

Distribution: India: Himachal Pradesh (GHNP) and West Bengal (Darjeeling).

Elsewhere: Nepal.

23. *Dysstroma fulvipennis* (Hampson, 1902)^

(Habitus Plate No: 2.9 & Genitalia Plate No: 2.10)

1902. *Larentia fulvipennis* Hampson, *Journ. Bomb. Nat. Hist. Soc.,* **14**: 517.

1934. *Cidaria fulvipennis*; Prout, *in seitz, Macrolep. World,* **4**(suppl): 122.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH11A (2 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 40 mm.

Diagnosis: Forewing grey with brown suffusion; antemedial band rufous, constricted in submedian fold and edged by grey waved and dark lines; medial area with two waved dark lines, inner one angled outwards in cell and submedian fold; outer one oblique from costa to M_3, where it is acutely angled, then retracted; dark postmedial line with black suffusion before it and oblique beween M_3 to costa but angled inward at M_1, below M_3 oblique and highly dentate to CuA_1.

Male genitalia is very similar with previous species but differs in having more protusion of the vinculum with apex of it having long bristles.

Distribution: India: Kashmir and Himachal Pradesh (GHNP).

24. *Dysstroma planifasciata* (Prout, 1914)

(Habitus Plate No: 2.10)

1914. *Cidaria planifasciata* Prout, *in seitz, Macrolep. World,* **4**: 220.

2000. *Dysstroma planifasciata*; Yazaki, *Tinea,* **16**(suppl. 1): 10.

2019. *Dysstroma planifasciata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 230.

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

Material examined: GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a).

Wing expanse: 40 mm.

Diagnosis: Similar with *D. citrata*, but differs in having broader median area; subbasal and antemedial lines less angulated, more oblique, brownish shade between them; white median area with slight tinge of brown; slender dark band distally to antemdian and a costal, broad half band proximal to postmedian.

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand (Nanda Devi Biosphere Reserve). **Elsewhere:** Nepal.

25. *Dysstroma shirakawai* Yazaki, 2000*

(Habitus Plate No: 2.11 & Genitalia Plate No: 3.1)

2000. *Dysstroma shirakawai* Yazaki, *Tinea,* **16**(suppl. 1): 10.

Material examined: GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH16A (2 ex.): Low-Level Blue Pine Forest (12/2S1); GH27A (2 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 32 mm.

Diagnosis: Very similar with *D. subapicaria,* but differs in having ground colour darker and less brownish; postmedial line slightly more proximal, with a white patch on costa more prominent; hindwing blackish-brown instead of pale brown.

Valvae somewhat less broad in the mid-portion and aedeagus with vesica cornuti much longer and thicker bunch of spines.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal.

26. *Dysstroma sikkimensis* Heydemann, 1932#

(Habitus Plate No: 2.12 & Genitalia Plate No: 3.2)

1932. *Dysstroma sikkimensis* Heydemann, *Int. ent. Z.,* **26**: 22.

1995. *Dysstroma sikkimensis*; Yazaki, *Tinea,* **14**(suppl. 2): 6.

Material examined: GH04C (3 ex.), GH11A (3 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH16A (1 ex.), GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 31 mm.

Diagnosis: Forewing iron-gery, basal area dark gery from costa to median fold, then brown; antemedian area brown; a broad, greyish-black medial band broadest at M_2, but broader at costa and narrowest at inner margin, outer edge bent outwardly from costa to M_2, then gradually incurved upto inner margin;

submarginal area brown with sinuous, pale submarginal line; a triangular dark patch below apex upto M_1; fringes brown but interrupted with black in vein endings.

Male genitalia are very similar with previously discussed species but differs in having vinculum more sclerotized and produced; valvae with ventral margin undulating.

Distribution: India: Himachal Pradesh (GHNP) and Sikkim. **Elsewhere:** Nepal.

Genus: *Ecliptopera* Warren, 1894

27. *Ecliptopera fulvotincta* (Hampson, 1895)

(Habitus Plate No: 2.13 & Genitalia Plate No: 3.3)

1895. *Cidaria fulvotincta* Hampson, *Fauna Brit. India Moths*, **3**: 354.

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

Material examined: GH01E (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 36 mm.

Diagnosis: Basal black patch on forewing with a waved line and waved outer edge; antemedial line double, fulvous, waved; medial band broad, black with two waved lines, inner edgesinuous, angled at CuA_1 and outer edge crenulated irregularly from M_3 to inner margin; outer area with three indistinct waved lines; black patch on outer margin below apex. Hindwing whitish.

Valvae broad, apex rounded, with a finger-like process at the base of costal margin; saccus Trapezoid- shaped, apically broad, lower half narrower;

uncus sclerotized, long, slender, with pointed apex. Aedeagus long, slender, with three bunches of vesica spines.

Distribution: India: Himachal Pradesh (Shimla, GHNP) and Uttarakhand.

28. *Ecliptopera postpallida* (Prout, 1938)^

(Habitus Plate No: 2.14 & Genitalia Plate No: 3.4)

1938. *Cidaria postpallida* Prout, *in seitz, Macrolep. World,* **4**(Suppl): 154.

2017. *Ecliptopera postpallida*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 160.

2019. *Ecliptopera postpallida*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 230.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH10A (1 ex.): Moist Deodar Forest (12/C1c); GH11A (3 ex.): Moist Temperate Deciduous Forest (12/C1e); GH15A (2 ex.), GH16A (1 ex.), GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH25B (1 ex.): Dwarf Rhododendron Scrub (15/C2/E1); GH27B (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 34 mm.

Diagnosis: Forewing with basal area not distinctly marked; median area broad, outer edge wider than closely related species, straight upto R_3, then a small indentation, bent inward afterwards up to M_2; submarginal line highly dentate near costa with a wedge-shaped mark before it.

Male genitalia are very similar with previous species but differs in having broad U-shaped, tongue-like saccus instead of trapezoid-shaped.

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand (Govind WLS, Gangotri NP). **Elsewhere:** Nepal, Bhutan and China.

29. *Ecliptopera relata* (Butler, 1880)^

(Habitus Plate No: 2.15 & Genitalia Plate No: 3.5)

1880. *Cidaria relata* Butler, *Ann. Mag. nat. Hist.*, **6**: 229.

1895. *Cidaria relata*; Hampson, *Fauna Brit. India Moths*, **3**: 359.

1992. *Ecliptopera relata*; Yazaki, *Tinea,* **13**(suppl. 2): 18.

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

2019. *Ecliptopera relata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 230.

Material examined: GH12B (2 ex.): Western Mixed Coniferous Forest (12/C1d); GH14A (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 36 mm.

Diagnosis: Ground colour dark-brown; antemedial band brownish-white, curved; medial band highly angled below cell, sending a line to join the curved postmedial band, then conjoined to antemedial band above inner margin; all the bands traversed by a dark line.

Male genitalia very similar with preceeding two species but differs in having much produced costal basal process of valvae and saccus much less broad and sclender.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Kumaon), Sikkim and Meghalaya (Khasi). **Elsewhere:** Nepal and Bhutan.

30. *Ecliptopera substituta* (Walker, 1866)^

(Habitus Plate No: 3.1 & Genitalia Plate No: 3.6)

1866. *Cidaria substituta* Walker, *List Spec. Lepid. Insects Colln Br. Mus*. **35**: 1691.

1992. *Ecliptopera substituta*; Yazaki, *Tinea,* **13**(suppl. 2): 18.

2019. *Ecliptopera substituta*; Dey *et al., Spixiana*, **42**:52.

2019. *Ecliptopera substituta*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 230.

Material examined: GH01E (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12B (3 ex.): Western Mixed Coniferous Forest (12/C1d); GH15A (2 ex.), GH19B (4 ex.): Low-Level Blue Pine Forest (12/2S1); GH20A (5 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27B (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 34 mm.

Diagnosis: Forewing with an indistinct subbasal line, slightly angled below costa; antemedial band grey, edged by sinuous white line, outer edge strongly toothed at median nervure; median line double, indistinct, dark, waved, they meet in places to enclose a black cell-speck; postmedial line double, white, sending teeth inwards at CuA_1 and M_3, and with a series of dentate, black marks beyond it, which gradually decreases in size to the inner margin.

Male genitalia very similar with previously discussed species but differs in having larger, globular costal basal lobe and slightly pointed apex; saccus U-shaped, broad.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand and Sikkim. **Elsewhere:** Nepal and Bhutan.

Genus: *Electrophaes* Prout, 1923

31. *Electrophaes aliena* (Butler, 1880)

(Habitus Plate No: 3.2 & Genitalia Plate No: 3.7)

1880. *Cidaria aliena* Butler, *Ann. Mag. nat. Hist.*, **6**: 229.

1995. *Electrophaes aliena*; Yazaki, *Tinea,* **14**(suppl. 2): 8.

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

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

2017. *Electrophaes aliena*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 160.

2019. *Electrophaes aliena*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 230.

Material examined: GH01E (2 ex.), GH03B (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04A (1 ex.), GH05A (1 ex.), GH08B (1 ex.), GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 30 mm.

Diagnosis: Very similar with *E. aurata* & *E. corylata*, but differs in having olive-brown areas more golden-brown, dark areas blacker and shape of the median band; the apical streak white; the three anterior submarginal marks are thicker, united to a single blotch.

Valvae long, slender, costal margin sclerotized; gnathos with ventral long, slender, sclerotized, apically globular process; uncus long, very slender.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal and Arunachal Pradesh. **Elsewhere:** Nepal and Bhutan.

32. *Electrophaes fulgidaria* (Leech, 1897)#

(Habitus Plate No: 3.2 & Genitalia Plate No: 3.8)

1897. *Cidaria fulgidaria* Leech, *Ann. Mag. Nat. Hist.,* **19**(6): 641.

1992. *Electrophaes fulgidaria*; Yazaki, *Tinea,* **13**(suppl. 2): 19.

2021. *Electrophaes fulgidaria*; Chettri & Yonle, *International Journal of Entomology Research,* **6**(3): 94.

Material examined: GH07A (1 ex.): Alder Forest (Riverine) (12/1S1).

Wing expanse: 32 mm.

Diagnosis: Very similar with *E. aurata* & *E. aliena,* but differs in having dark brown basal patch, externally bounded by angulated and silvery-white line; central fascia broad on costa and narrow at inner margin, both side bounded by wavy, silvery-white line; outer one highly indented below costa and the inner one indented at the middle; outer area brownish, traversed by an oblique streak at apex.

Male genitalia are very similar with previous species but differs in having the ventral process of gnathos longer, slender and not apically globular; saccus broader and longer.

Distribution: India: Himachal Pradesh (GHNP) and West Bengal (Darjeeling). **Elsewhere:** Nepal and China.

33. *Electrophaes niveonotata* (Warren, 1901)^

(Habitus Plate No: 3.4 & Genitalia Plate No: 3.9)

1901. *Cidaria niveonotata* Warren, *Nov. Zool.,* **8**: 26.

1992. *Electrophaes niveonotata*; Yazaki, *Tinea,* **13**(suppl. 2): 19.

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

2019. *Electrophaes niveonotata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 230.

Material examined: GH01E (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 30 mm.

Diagnosis: Closely related with previous two species but differs in having all the dark markings olive-brown and pale markings snow-white with no yellow shade; hindwing with taces of postmedian and submarginal curved lines.

Male genitalia is very similar with preceeding two species but differs in having the ventral process of the gnathos very thinner, shorter and not apically globular; valvae apically narrow; uncus apically stouter and shorter.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal and Arunachal Pradesh. **Elsewhere:** Nepal and Bhutan.

34. *Electrophaes recta* Yazaki, 1994^

(Habitus Plate No: 3.5 & Genitalia Plate No: 3.10)

1994. *Electrophaes recta* Yazaki, *Tinea*, **14**(suppl. 1): 15.

2017. *Electrophaes recta*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 160.

2019. *Electrophaes recta*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 230.

Material examined: GH01F (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 26 mm.

Diagnosis: Very similar with *E. zaphenges*, ground colour of forewing more brownish; median band with distal margin strongly produced outwards below cell; medial band broader. Hindwing less yellowish.

Male genitalia similar with *E. aliena,* but differs in having shorter uncus, strongly curved at basal third, straightish in apical two-third; valvae narrower in distal half; costa narrower at apex; aedeagus slightly shorter.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind WLS, Nanda Devi Biosphere Reserve), West Bengal and Arunachal Pradesh. **Elsewhere:** Nepal.

Genus: *Eustroma* Hübner, [1825]

35. *Eustroma aurigena* (Butler, 1880)

(Habitus Plate No: 3.6)

1880. *Cidaria aurigena* Butler, *Ann. Mag. Nat. Hist.*, **6**(5): 230.

1895. *Cidaria aurigena*; Hampson, *Fauna Brit. India Moths*, **3**: 360.

1992. *Eustroma aurigena*; Yazaki, *Tinea*, **13**(suppl. 2): 18.

Material examined: GH10A (1 ex.): Moist Deodar Forest (12/C1c).

Wing expanse: 30 mm.

Diagnosis: Very similar with *E. inextricata*, but differs in havig stripes on thorax and forewing markings being bright brassy-yellow; base of the wing brassy-yellow; antemdial band broader, with brassy suffusion on it, beyond it and before it, less angled on CuA_1, not joined to markings of outer area except by brassy-yellow suffusion; postmedial band broader, inner edge not dentate, joined to the medial patch by yellow suffusion. Hindwing dark fuscous.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP), Sikkim and Meghalaya (Khasi). **Elsewhere:** Nepal.

Genus: *Heterothera* Inoue, 1943

36. *Heterothera consimilis* (Warren, 1888)

(Habitus Plate No: 3.7 & Genitalia Plate No: 4.1)

1888. *Thera consimilis* Warren, *Proc. Zool. Soc. Lond.*, (3): 326.

1895. *Larentia consimilis*; Hampson, *Fauna Brit. India Moths*, **3**: 380.

1941. *Thera consimilis*; Prout, *in Seitz, Gross-Schmett. Erde,* **12**: 324.

1895. *Larentia consimilis*; Hampson, *Fauna Brit. India Moths,* **3**: 380.

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

1998. *Heterothera consimilis*; Choi, *Tijdschr. Ent.*, **141**: 37.

2019. *Heterothera consimilis*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 231.

Material examined: GH01D (1 ex.), GH01E (3 ex.), GH01F (1 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (5 ex.), GH05A (1 ex.), GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH15A (1 ex.), GH19A (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 28 mm.

Diagnosis: This species is easily identified by the dentate, black basal line and wavy central fascia; antemedial line costally slanted, dorsally and medially waved; postmedial line costally straight, often bent, slanting, medially and dorsally bulged, below waved; dorsum with large reddish dot; termen dark greyish with white undulating submarginal line.

Valvae with ventral part distally little expanded, costal margin sclerotized, wider at middle; sacculus triangular, dorsal border waved, with a large, distal, sclerotized spine; anellus lobe small, digitiform; tegumen triangular; uncus sclerotized, long, slightly bent at middle; aedeagus with distal scobination and round vesica with two bundles of cornuti.

Distribution: India: Kashmir, Himachal Pradesh (Shimla, Dalhousie, GHNP), Uttarakhand (Bhimtal) and West Bengal (Darjeeling). **Elsewhere:** Afghanistan, Pakistan and Nepal.

37. *Heterothera dentifasciata* (Hampson, 1895)

(Habitus Plate No: 3.8 & Genitalia Plate No: 4.2)

1895. *Larentia dentifasciata* Hampson, *Fauna Brit. India Moths,* **3**: 379.

1914. *Cidaria (Thera) dentifasciata*; Prout, *in Seitz, Die Gross Schmett. Erde,* **4**: 219.

1941. *Thera dentifasciata*; Prout, *in Seitz, Gross-Schmett. Erde,* **12**: 324.

1995. *Viidaleppia dentifasciata*; Yazaki, *Tinea*, **14**(suppl. 2): 6.

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

1998. *Heterothera dentifasciata*; Choi, *Tijdschr. Ent.*, **141**: 31.

2017. *Heterothera dentifasciata*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Heterothera dentifasciata*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 231.

Material examined: GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH15A (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH27B (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 33 mm.

Diagnosis: The typical character of this species is central fascia of the forewing greatly reduced dorsally; black interantennal fillet; black postmedial line with costal part greatly slanting; discal dot of forewing large, black.

Valvae with ventral part wider distally with long hair; sclerotized costa, distally expanded; sacculus triangular, with a distal spinular process; saccus medially concave; anellus lobe small, digitiform; uncus long, slender, basally tapered; aedeagus basally tapered, distally scobinated, vesica with two bundle of spines.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP), Uttarakhand (Govind WLS) and Arunachal Pradesh. **Elsewhere:** Pakistan and Nepal.

Genus: *Hysterura* Warren, 1895

38. *Hysterura multifaria* (Swinhoe, 1889)

(Habitus Plate No: 3.9 & Genitalia Plate No: 4.3)

1889. *Cidaria multifaria Proc. Zool. Soc. Lond.*, : 429.

1992. *Hysterura multifaria*; Yazaki, *Tinea*, **13**(suppl. 2): 18.

2019. *Hysterura multifaria*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 231.

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

Material examined: GH01C (1 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04A (1 ex.), GH04B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH20A (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH25B (1 ex.): Dwarf Rhododendron Scrub (15/C2/E1).

Wing expanse: 38 mm.

Diagnosis: Forewing with many purplish-black patches; one at the base with a subbasal series; two somewhat conjoined irregular antemedial patches; antemedial band purplish, a series of small black spots on it; medial area black, broad at costa, narrow at inner margin; median nervure and base of M_3 streaked with ochreous; medial Y-shaped purplish, black mark from costa to lower angle of cell; submarginal line with an irregular black patch on its costal half and few black specks above inner margin; a black apical spot. Hindwing greyish, with waved indistinct postmedial and submarginal lines.

Valvae apically narrow with ventral margin slightly sclerotized; two parir of ventral process of gnathos with apical long spines; uncus long, slender, apically pointed; saccus round, broad; aedeagus long, slender; vesica with two bunch of spines.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, West Bengal (Darjeeling), Arunachal Pradesh and Assam. **Elsewhere:** Nepal, China, Vietnam and Russia.

Genus: *Lampropteryx* Stephens, 1831

39. *Lampropteryx siderifera* (Moore, 1888)#

(Habitus Plate No: 3.10 & Genitalia Plate No: 4.4)

1888. *Eustroma siderifera* Moore, *Descr. Ind. Lep. Atk.*, : 276.

1895. *Larentia siderifera;* Hampson, *Fauna Brit. India Moths,* **3**: 368.

1994. *Lampropteryx siderifera*; Yazaki, *Tinea*, **14**(suppl. 1): 14.

Material examined: GH01C (1 ex.), GH01E (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 38 mm.

Valvae with ventral part distally little expanded, costal margin sclerotized, wider at middle; sacculus triangular, dorsal border waved, with a large, distal, sclerotized spine; anellus lobe small, digitiform; tegumen triangular;

uncus sclerotized, long, slightly bent at middle; aedeagus with distal scobination and round vesica with two bundles of cornuti.

Valvae with round apex; long ventral process of gnathos with apical very long, curved spine; uncus long, slender, sclerotized.

Distribution: India: Himachal Pradesh (GHNP), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Nepal.

Genus: *Lobogonodes* Bastelberger, 1909

40. *Lobogonodes multistriata* (Butler, 1889)

(Habitus Plate No: 3.11 & Genitalia Plate No: 4.5)

1889. *Cidaria multistriata* Butler, *Ill. typical Spec. Lep. Het. Colln Br. Mus.*, **7**: 119.

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

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

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

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

1937. *Lobogonodes (Microlygris) multistriata clasis*; Prout, *in Seitz, The Macrolepidoptera of the World,* **4**(Suppl.): 105.

1940. *Lobogonodes (Microlygris) multistriata tensa*; Prout, *in Seitz, Gross-Schmett. Erde* **12**: 309.

2001. *Lobogonodes multistriata*; Choi, *Amer. Mus. Novitates No.*, **3318**: 34.

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

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

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

Material examined: GH02B (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH09A (2 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 28 mm.

Diagnosis: Very similar with *L. porphyriata,* but can be identified by the black cell spot; postmedial line sinuous from median nervure to inner margin.

Male genitalia characterized by slightly sclerotized subscaphium and anellus well-separated, bilobed.

Distribution: India: Himachal Pradesh (Dharamshala, GHNP), Uttarakhand, Sikkim and Meghalaya (Shillong). **Elsewhere:** Nepal, China, Japan, Korea and Algeria.

Genus: *Protonebula* Inoue, 1986

41. *Protonebula cupreata* (Moore, 1868)#

(Habitus Plate No: 3.12 & Genitalia Plate No: 4.6)

1868. *Melanippe cupreata* Moore, *Proc. Zool. Soc. Lond.,* : 655.

1895. *Larentia cupreata*; Hampson, *Fauna Brit. India Moths,* **3**: 369.

2000. *Nebula cupreata*; Yazaki, *Tinea,* **16**(Suppl. 1): 9.

Material examined: GH07A (1 ex.): Alder Forest (Riverine) (12/1S1).

Wing expanse: 38 mm.

Diagnosis: Ground colour rufous, with slight grey irroration; forewing with waved, indistinct, white line at base; subbasal line double and antemedial lines white, waved; medial band dark rufous, forking near costa and inner margin, a slight rufous shade beyond this area and also near apex and tornus; a dark, double series of postmedial specks on the veins and indistinct, double, waved, white lines.

Valvae broad, long, with round apex; anellus slender, double; uncus long, slender, strongly sclerotized; aedeagus long, slender, vesica with a bunch of small spines.

Distribution: India: Himachal Pradesh (GHNP), Sikkim and West Bengal. **Elsewhere:** Nepal.

Genus: *Costicoma* Choi, 2000

42. *Costicoma exangulata* (Warren, 1909)^

(Habitus Plate No: 3.13 & Genitalia Plate No: 4.7)

1909. *Perizoma exangulata* Warren, *Novit. zool.*, **16**: 127.

1938. *Cidaria (Thera) exangulata*; Prout, *in Seitz, Gross-Schmett., Erde* **4**(Suppl.): 113.

1941. *Thera exangulata*; Prout, *in Seitz, Gross-Schmett., Erde* **12**: 323.

1998. *Thera exangulata*; Choi, *Tijdschr. Ent.* **141**: 44.

2000. *Costicoma exangulata*; Choi, *Amer. Mus. Novitates*, **3295**: 19.

2021. *Costicoma exangulata*; Dey & Hausmann, *Journal of Threatened Taxa*, **13**(7): 18820.

Material examined: GH04B (1 ex.), GH04C (1 ex.), GH09A (4 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12B 91 ex.): Western Mixed Coniferous Forest (12/C1d); GH15A (5 ex.): Low-Level Blue Pine Forest (12/2S1); GH19B (2 ex.): Low-Level Blue Pine Forest (12/2S1); GH20A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 40 mm.

Diagnosis: Ground colour pale grey with slight olive-brown irroration; median fascia black-brown, from costa to middle and again from CuA_2 to inner margin; its outer edge straight after cell and deeply angled outwards below M_3, then concave; inner edge outcurved, with a bulge above middle; basal patch dark grey, traversed by four brownish, parallel lines; a whitsh, lunulate submarginal line, lunules preceded by darker one.

Valvae long, costal margin sclerotized and with long spine-like process; anellus broad, with long apical spine; uncus long, slender, apically narrow and pointed.

Distribution: India: Kashmir (Srinagar), Himachal Pradesh (GHNP) and Uttarakhand.

Genus: *Xenortholitha* Inoue, 1944

43. *Xenortholitha falcata* Yazaki, 1993*

(Habitus Plate No: 3.14 & Genitalia Plate No: 4.8)

1993. *Xenortholitha falcata* Yazaki, In: *Haruta, Tinea*, **13**(Suppl. 3): 110.

Material examined: GH01E (1 ex.), GH01F (1 ex.), GH01G (1 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH14B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 27 mm.

Diagnosis: *X. falcata* superficially resembles *X. propinguata epigrypa* but the species can be easily distinguished based on the following characters: wing size much larger; forewing apex strongly falcate, ground colour of forewing dark fuscous brown instead of pale brown; discal dot larger, darker and more prominent; terminal area of forewing irrorated with grey instead of pale ochreous; Hindwing ground colour pale fuscous brown, darker than sister species. This species can be distinguished from *X. propinguata propinguata* by the much darker terminal area and lacking any triangular marking in the forewing apex. *Xenortholitha falcata* also differs from *X. latifusata* by the hindwing discal spot not biangulate as in *latifusata*.

Xenortholitha falcata can be easily identified by its very long uncus, longer than the closely related sister species.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal.

44. *Xenortholitha latifusata* (Walker, 1862)

(Habitus Plate No: 3.15 & Genitalia Plate No: 4.9)

1862. *Melanippe latifusata* Walker, *List. Spec. Lepid. Ins. Coll. Brit. Mus.*, **25**: 1298.

1895. *Larentia latifusata*; Hampson, *Fauna Brit. India Moths,* **3**: 370.

2019. *Xenortholitha latifusata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 233.

Material examined: GH03A (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04C (1 ex.), GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH14B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 27 mm.

Diagnosis: see previous species.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP) and Uttarakhand.

Elsewhere: Pakistan and Taiwan.

45. *Xenortholitha propinguata* (Kollar, 1844)^

(Habitus Plate No: 4.1 & Genitalia Plate No: 4.10)

1844. *Cidaria propinguata* Kollar, *Hugel's Kashmir*, **4**: 485.

1878. *Eubolia niphonica* Butler, *Ann. Mag. nat. Hist.,* (5)**1**: 452.

1931. *Eubolia niphonica*; Sterneck, *Dt. ent. Z. Iris,* **45**: 80.

1881. *Cidaria suavata* Christoph, *Bull. Soc. imp. Nat. Moscou,* **55**(3). 101.

1949. *Cidaria suavata*; Bryk, *Ark. Zool.*, **41**(1): 165.

2004. *Xenortholitha propinguata*; Choi, *Entomological Research,* **34**(1): 34.

2019. *Xenortholitha propinguata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 233.

Material examined: GH07A (1 ex.): Alder Forest (Riverine) (12/1S1); GH20A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a).

Wing expanse: 27 mm.

Diagnosis: see *X. falcata*

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand. **Elsewhere:** Nepal, China, Japan, Korea, Mongolia, Russia and Tajikistan.

Tribe: LARENTIINI Duponchel, 1845

Genus: *Amnesicoma* Warren, 1895

46. *Amnesicoma simplex* Warren, 1895

(Habitus Plate No: 4.2 & Genitalia Plate No: 5.1)

1895. *Amnesicoma simplex* Warren, *Novit. zool.*, **2**(2): 113.

1995. *Amnesicoma simplex*; Yazaki, *Tinea,* **14**(suppl. 2): 5.

2019. *Amnesicoma simplex*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 229.

Material examined: GH10A (1 ex.): Moist Deodar Forest (12/C1c).

Wing expanse: 55 mm.

Diagnosis: Forewing ground colour ochreous-grey, with dark fuscous lines; basal area fuscous, with a succession of dark fuscous, wavy lines, becoming deeper brown towards sinuous outer edge; exterior line black, internally edged with fuscous and with a narrow, pale external line; two subcostal teeth outward the exterior line; marginal area suffused with fuscous and a pale submarginal line; a pale triangular subapical space, an oblique streak from apex. Hindwing dull orange with fuscous-gery inner area.

Valvae long, apically triangular, ventral margin undulating; costal margin with medial sclerotized, large, globular protusion and with long hairs; juxta strongly sclerotized, long, basally broad, medially very narrow, slender and again apically broad and flat; uncus long, slender, apically pointed and curved. Aedeagus long, slender, dorsally sclerotized with a long bunch of vesica spines.

Distribution: India: Kashmir, Himachal Pradesh (GHNP) and Uttarakhand. **Elsewhere:** Pakistan, Nepal, China and Tibet.

Genus: *Atopophysa* Warren, 1894

47. *Atopophysa indistincta* (Butler, 1889)

(Habitus Plate No: 4.3 & Genitalia Plate No: 5.2)

1889. *Scotosia indistincta* Butler, *Ill. typical Spec. Lep. Het. Colln Br. Mus.,* **7**: 118.

1895. *Larentia indistincta*; Hampson, *Fauna Brit. India Moths*, **3**: 369.

1994. *Atopophysa indistincta indistincta*; Yazaki, *Tinea,* **14**(suppl. 1): 16.

Material examined: GH07A (2 ex.): Alder Forest (Riverine) (12/1S1).

Wing expanse: 34 mm.

Diagnosis: Ground colour blackish-grey; forewing with indistinct, waved, olive-brown lines: one subbasal, three antemedial, four post-medial and two submarginal; black patches on the last postmedial and below apex on submarginal line; a black, small subapical spot. Hindwing with double postmedial and submarginal very indistinct, wave lines.

Valvae long, apically rounded, with two saccular spines, one at mid portion and second on before apex; costal margin sclerotized and with a spine before apex; saccus U-shaped; juxta ventrally elongated, medially very narrow, apically slight broad; uncus sclerotized, long, apically bent and pointed.

Distribution: India: Himachal Pradesh (Dharamshala, Shimla, GHNP) and Meghalaya (Khasi). **Elsewhere:** Nepal, China and Myanmar.

Genus: *Coenolarentia* Aubert, 1959

48. *Coenolarentia argentiplumbea* (Hampson, 1903)*

(Habitus Plate No: 4.4 & Genitalia Plate No: 5.3)

1903. *Astheniodes argentiplumbea* Hampson, *J. Bombay nat. Hist. Soc.* **14**: 64.

1959. *Coenolarentia argentiplumbea*; Aubert, *Z. wien. ent. Ges.*, **44**: 199.

Material examined: GH01C (1 ex.), GH03A (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04C (4 ex.), GH11A (3 ex.): Moist Temperate Deciduous Forest (12/C1e); GH16A (5 ex.): Low-Level Blue Pine Forest (12/2S1); GH27A (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 34 mm.

Diagnosis: Ground colour greyish, with diffused basal and sub-basal black lines; antemedial line double, waved, fine; medial area suffused with fuscous, defineD by fine, waved, black line with series of black points at veins; fine, waved postmedial line with dark suffusion beyond it on apical area and towards tornus.

Hindwing greyish with discoidal speck and with double, indistinct postmedial and a submarginal line.

Valvae medially broad, ventral margin sinuous, apex rounded, costal margin highly sclerotized, concave with a spine before apex; juxta basally broad, medially narrow but apically broad; uncus apically long, slender, sclerotized, curved and pointed.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Bhutan and Tibet.

Genus: *Neotephria* Prout, 1914

49. *Neotephria ramalaria* (Felder & Rogenhofer, 1875)

(Habitus Plate No: 4.5 & Genitalia Plate No: 5.4)

1875. *Cidaria ramalaria* Felder & Rogenhofer, *Reise Fregatte Novara*, **2**(5): pl. 132, f. 31.

1895. *Cidaria ramalaria*; Hampson, *Fauna Brit. India Moths*, **3**: 369.

1995. *Neotephria ramalaria*; Yazaki, *Tinea,* **14**(suppl. 2): 8.

Material examined: GH09A (4 ex.): Moist Temperate Deciduous Forest (12/C1e); GH20A (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH23A (1 ex.): Sub-Alpine Pastures (14/DS1); GH24A (5 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27B (19 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 40 mm.

Diagnosis: Ground colour greyish, with thick irroration of black and few ochreous; subbasal band fuscous with waved edges and a similar medial band, widest at costa with a discocellular lunule; traces of a sinuous submarginal line. Hindwing pale grey, with postmedial curved lines and traces of a cell-speck.

Valvae apically broad, long, ventral margin angled just before apex; anellus well developed; uncus long, slender, sclerotized, bent medially, apex pointed. Aedeagus with two bunches of vesica spines.

Distribution: India: Himachal Pradesh (Kullu, Dharamshala, GHNP). **Elsewhere:** Nepal.

Genus: *Parentephria* Yazaki, 1995

50. *Parentephria stellata* (Warren, 1893)#

(Habitus Plate No: 4.6 & Genitalia Plate No: 5.5)

1893. *Glaucopteryx stellata* Warren, *Proc. zool. Soc. Lond.*, (2): 367.

1895. *Cidaria stellata*; Hampson, *Fauna Brit. India Moths*, **3**: 369.

1995. *Parentephria stellata*; Yazaki, *Tinea*, **14**(suppl. 2): 7.

Material examined: GH20A (1 ex.), GH21B (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH25B (4 ex.): Dwarf Rhododendron Scrub (15/C2/E1).

Wing expanse: 42 mm.

Diagnosis: Forewing olive-green, with eight series of grey specks on veins and a submarginal crenulated line; series of marginal white specks; antemedial and medial dark band and with some waved submarginal lines. Hindwing white, with an indistinct submarginal line.

Valvae apically broad, rounded; saccular process with a minute spine; gnathos with a ventral, long process with medialLy narrow and slender area.

Distribution: India: Himachal Pradesh (GHNP) and Sikkim. **Elsewhere:** Nepal.

Genus: *Photoscotosia* Warren, 1888

51. *Photoscotosia amplicata* (Walker, 1862)

(Habitus Plate No: 4.7 & Genitalia Plate No: 5.6)

1862. *Cidaria amplicata* Walker, *Cat. Het.*, **25**: 1404.

1895. *Photoscotosia amplicata*; Hampson, *Fauna Brit. India Moths*, **3**: 382.

1914. *Photoscotosia amplicata*; Seitz, *Macro Lep.,* **4**: 203.

2014. *Photoscotosia amplicata*; Xiong *et al.*, *Chinese Journ. of Ecology*, **33**(11): 3033-3042.

1995. *Photoscotosia amplicata amplicata*; Yazaki, *Tinea*, **14**(suppl. 2): 4.

2017. *Photoscotosia amplicata*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Photoscotosia amplicata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 232.

Material examined: GH01A (2 ex.), GH01C (2 ex.): Himalayan Chir Pine Forest (9/C1b); GH04C (2 ex.), GH08A (1 ex.), GH11A (5 ex.): Moist Temperate Deciduous Forest (12/C1e); GH15A (2 ex), GH16A (9 ex.), GH19C (1 ex.): Low Level-Blue Pine Forest (12/2S1); GH21A (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH24A (5 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH25A (2 ex.), GH25B (1 ex.): Dwarf Rhododendron Scrub

(15/C2/E1); GH27A (26 ex.), GH27B (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 52 mm.

Diagnosis: Forewing ground colour greyish-black with numerous black, waved lines; rufous suffusion between two subbasal and on median area, defined by irregularly grey, waved lines; medial area traversed by a waved, grey line, a white patch inside it below costa; submarginal line grey, waved. Hindwing greyish, costal half whitish; traces of a grey, submarginal line.

Valvae apically rounded, ventral margin slight undulating, costal margin sclerotized; juxta apically slender, long, sclerotized, basaly broad; uncus long, slender, sclerotized, apically pointed. Aedeagus long, sclerotized, bent with a bunch of vesica spines.

Distribution: India: Kashmir, Himachal Pradesh (GHNP), Uttarakhand (Govind WLS), Sikkim, West Bengal, Arunachal Pradesh, Assam and Meghalaya. **Elsewhere:** Pakistan, Nepal, Bhutan, Myanmar, China and Tibet.

52. *Photoscotosia dejuncta* Prout, 1937

(Habitus Plate No: 4.8 & Genitalia Plate No: 5.7)

1937. *Photoscotosia dejuncta* Prout, *in Seitz, Macrolep. World,* **4**(Suppl.): 103.

2021. *Photoscotosia dejuncta*; Dey & Hausmann, *Journal of Threatened Taxa*, **13**(7): 18822.

Material examined: GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH27A (7 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 50 mm.

Diagnosis: Forewing uniformly blackish-brown, with no variegation; subapical streak prominent upto R_3; apical streak indistinct. Hindwing with apical orange suffusion dusted with fuscous. Underside of forewing with two confluent marking forming a triangular apical patch.

Male genitalia very similar with *P. dejuta,* but differs in having costal margin of valvae more sclerotized and the protusion more elongated and with a spine like process just before valvae apex; juxta basally broader and stout.

Distribution: India: Kashmir, Himachal Pradesh (Spiti Valley, GHNP) and Uttarakhand (Nanda Devi Biosphere Reserve).

53. *Photoscotosia dejuta* Prout, 1937^

(Habitus Plate No: 4.9 & Genitalia Plate No: 5.8)

1937. *Photoscotosia dejuta* Prout, *in Seitz, Macrolep. World,* **4**(Suppl.): 103.

1995. *Photoscotosia dejuta*; Yazaki, *Tinea,* **14**(suppl. 2): 5.

2019. *Photoscotosia dejuta*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 232.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04C (4 ex.), GH11A (4 ex.): Moist Temperate Deciduous Forest (12/C1e); GH15A (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27A (4 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 48 mm.

Diagnosis: Forewing with three prominent marginal white specks and hindwing with the orange blotch restricted more or less upto M_1. Undeside like *P. isosticta,* but with the marginal plae specks prominent.

Male genitalia similar with *P. amplicata,* but differs in having apical process of juxta longer, slenderer and more curved; uncus apically shorter; Valvae costal margin with a sclerotized protusion; aedeagus with apical portion having small spines at dorsal edge.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim and Arunachal Pradesh. **Elsewhere:** Nepal and Bhutan.

54. *Photoscotosia miniosata* (Walker, 1862)

(Habitus Plate No: 4.10 & Genitalia Plate No: 5.9)

1862. *Scotosia miniosata* Walker, *List. Spec. Lepid. Ins. Coll. Brit. Mus.*, **25**: 1354.

1893. *Scotosia miniosata*; Warren, *Proc. zool. Soc. Lond.*, (2): 369.

1895. *Photoscotosia miniosata*; Hampson, *Fauna of Brit. India.*, **3**: 380.

1914. *Photoscotosia miniosota*; Seitz, *Macro Lep.*, **4**: 202.

1998. *Photoscotosia miniosota*; Yazaki, *Tinea,* **15**(suppl. 1): 7.

2003. *Photoscotosia miniosata*; Ghosh, *Fauna of Sikkim*, **4**: 217-342.

2017. *Photoscotosia miniosata*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Photoscotosia miniosata*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 232.

Material examined: GH01E (1 ex.), GH01F (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (1 ex.), GH04C (1 ex.), GH09A (2 ex.), GH11A (2 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH15A (2 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 52 mm.

Diagnosis: Very similar with *P. dejuta,* but characterized by a forewing subapical pale speck and underside with the postmedian black costal bar within the orange patch, not connected with a marginal black band.

Male genitalia similar with preceeding three species but differs in having broader valvae and with sclerotized spine-like process at the costal margin of valave.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal, Arunachal Pradesh and Punjab. **Elsewhere:** Pakistan, Nepal, Bhutan, Bangladesh, China, Taiwan and Phillipines.

55. *Photoscotosia multilinea* Warren, 1893^

(Habitus Plate No: 4.11 & Genitalia Plate No: 5.10)

1893. *Photoscotosia multilinea* Warren, *Proc. Zool. Soc. Lond.* **25**: 369.

1998. *Photoscotosia multilinea*; Yazaki, *Tinea,* **15**(suppl. 1): 8.

2003. *Photoscotosia multilinea*; Ghosh, *Fauna of Sikkim*, **4**: 217-342.

2017. *Photoscotosia multilinea*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Photoscotosia multilinea*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 232.

Material examined: GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 46 mm.

Diagnosis: Forewing postmedial line with a reddish-brown costal patch just before it, numerous lines before and after medial unmarked area; hindwing grey-brown with apical half whitish.

Male genitalia is very similar with previous species but the sclerotization on the costal margin of valvae lesser and spine absent; uncus curved, apically pointed, slender; juxta tongue-shaped.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand and Sikkim. **Elsewhere:** Nepal, Bhutan, China and Tibet.

56. *Photoscotosia nitida* Inoue, 1982*

(Habitus Plate No: 4.12 & Genitalia Plate No: 6.1)

1982. *Photoscotosia nitida* Inoue, *Bull. Fac. Domest. Sci. Otsuma Wom. Univ.*, **18**: 145.

1998. *Photoscotosia nitida*; Yazaki, *Tinea,* **15**(suppl. 1): 8.

Material examined: GH15A (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 48 mm.

Diagnosis: Forewing ground colour grey with a subbasal, a medial and a postmedial dark, highly dentate fasia and a white, dentate submarginal line. Hindwing white with inner area with fuscous tinge.

Male genitalia similar with previous species but juxta apically pointed and basall oval; valvae medially slightly constricted; saccus broader and roundish.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal.

57. *Photoscotosia pallidimaculata* Yazaki, 1995*

(Habitus Plate No: 4.13 & Genitalia Plate No: 6.2)

1995. *Photoscotosia pallidimaculata* Yazaki, *Tinea*, **14**(suppl. 2): 5.

2019. *Photoscotosia pallidimaculata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 232.

Material examined: GH21B (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 46 mm.

Diagnosis: Very similar with *P. dejuta,* but differs having the following characters: forewing tornus incised and apically slightly elongated; basal third of forewing paler; median fascia running smoother; pale greyish band instead of fuscous-brown; distal orange patch of hindwing paler and larger, enlarged beyond CuA_1; posterior yellowish-brown area much paler.

Male genitalia differs from *P. dejuta* in the following characters: Valvae with costal margin broader in apical fourth; uncus shorter; juxta short, dialated caudally, bearing a conical process at middle; aedeagus slightly longer, cornuti spines longer.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal.

58. *Photoscotosia polysticha* Prout, 1940#

(Habitus Plate No: 4.14 & Genitalia Plate No: 6.3)

1940. *Photoscotosia polysticha* Prout, *in Seitz, Grosschmett. Erde,* **12**: 314.

1995. *Photoscotosia polysticha*; Yazaki, *Tinea,* **14**(suppl. 2): 4.

2019. *Photoscotosia polysticha*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 232.

Material examined: GH24A (4 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27A (1 ex.), GH27B (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 50 mm.

Diagnosis: Forewing ground colour greyish-brown with russet suffusion; submarginal line punctiform with distinct whitish dots; Hindwing suffused with brown and with two whitish tornal spots and only the apex orangish.

Male genitalia is very similar with previous species but juxta triangular caudally and with membranous, slender distal long process; uncus shorter.

Distribution: India: Himachal Pradesh (GHNP) and Sikkim. **Elsewhere:** Nepal, Bhutan, China and Tibet.

Tribe: RHEUMAPTERINI Herbulot, 1961

Genus: *Rheumaptera* Hübner, 1822

59. *Rheumaptera cinerea* Yazaki, 1995*

(Habitus Plate No: 4.15 & Genitalia Plate No: 6.4)

1995. *Rheumaptera cinerea* Yazaki, *Tinea*, **14**(suppl. 2): 3.

Material examined: GH04C (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH16A (2 ex.), GH19C (9 ex.): Low-Level Blue Pine Forest (12/2S1); GH27B (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 33 mm.

Diagnosis: Ground colour of forewing grey, with fuscous-brown irroration; broad, pale fuscous brown fasciae present on sub-basal, antemedial and postmedial area; a slender, pale fuscous brown median line; submarginal line creamy-white, slightly sinuous; small, blackish-brown discal spot; fringes white, dotted with pale brown on vein endings. Hindwing white, irrorated with blackish-brown scales in terminal area.

Male genitalia of this species characterized by the shape of uncus and sacculus and lacking a long spine-like cornutus on vesica.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal.

60. *Rheumaptera dubiosata* (Walker, 1862)

(Habitus Plate No: 5.1 & Genitalia Plate No: 6.5)

1862. *Scotosia dubiosata* Walker, *List Spec. Lepid. Insects Colln Br. Mus.*, **25**: 1352.

1895. *Scotosia dubiosata*; Hampson, *Fauna Brit. India Moths*, **3**: 344.

1995. *Rheumaptera dubiosata*; Yazaki, *Tinea,* **14**(suppl. 2): 15.

2019. *Triphosa dubiosata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 231.

Material examined: GH01E (38 ex.), GH01F (9 ex.), GH01H (1 ex.), GH02B (1 ex.), GH03A (2 ex.): Himalayan Chir Pine Forest (9/C1b); GH04A (6 ex.), GH08B (1 ex.), GH08C (1 ex.), GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 44 mm.

Diagnosis: Very similar with *R. tremodes*, but can be identified by having uniformly dark forewing with more obscure transverse lines; lacking hair tuft on hindwing anal margin and male genitalia characterized by longer and more slender uncus; sacculus with longer process.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, Punjab and Tamil Nadu. **Elsewhere:** Afghanistan and Nepal.

61. *Rheumaptera nigralbata* (Warren, 1888)^

(Habitus Plate No: 5.2)

1888. *Scotosia nigralbata* Warren, *Proc. Zool. Soc. Lond.*, (3): 327.

1895. *Larentia nigralbata*; Hampson, *Fauna Brit. India Moths*, **3**: 370.

2017. *Larentia nigralbata*; Sanyal *et al*., *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH16A (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 47 mm.

Diagnosis: Ground colour fuscous with few white irrorations; subabasal and antemedial fascia marked by white scales on veins, slightly angled below costa;

an oblique, large, white patch on postmedial from costa to CuA_1, crossed by a sinuous postmedial line; a series of white specks on subapical area, with larger spots at middle. Hindwing with submarginal series of white specks.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Nanda Devi Biosphere Reserve), Sikkim and Pujab. **Elsewhere:** Pakistan.

Genus: *Triphosa* Stephens, 1829

62. *Triphosa rubrodotata* (Walker, 1862)^

(Habitus Plate No: 5.3 & Genitalia Plate No: 6.6)

1862. *Scotosia rubrodotata* Walker, *List. Spec. Lepid. Ins. Coll. Brit. Mus.*, **25**: 1353.

1895. *Triphosa rubrodotata*; Hampson, *Fauna Brit. India Moths*, **3**: 345.

1914. *Triphosa rubrodotata*; Seitz, *Macro Lep.*, **4**: 198.

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

2017. *Triphosa rubrodotata*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Triphosa rubrodotata*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 233.

Material examined: GH08C (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH17A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 62 mm.

Diagnosis: Forewing with numerous waved lines and medial band dark crimson; ante and postmedial lines demarkating a slight darker medial area; veins speckled with white in outer area. Hindwing with traces of numerous waved lines on outer area and veins speckled with white.

Valvae broad, long, apex round, costal margin with a sclerotized lobe at middle; uncus long, medially broad, slightly bent, apically pointed, sclerotized; juxta tongue-shaped, narrower caudally.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal, Arunachal Pradesh and Punjab. **Elsewhere:** Nepal and Taiwan.

Tribe: MELANTHIINI Duponchel, 1845

Genus: *Horisme* Hübner, [1825]

63. *Horisme plurilineata* (Moore, 1888)

(Habitus Plate No: 5.4 & Genitalia Plate No: 6.7)

1888. *Phibalapteryx plurilineata* Moore, *Descr. Indian lep. Atkinson,* (3): 273.

1895. *Phibalapteryx plurilineata*; Hampson, *Fauna Brit. India Moths*, **3**: 346.

1995. *Horisme plurilineata*; Yazaki, *Tinea,* **14**(suppl. 2): 10.

2019. *Horisme plurilineata*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 231.

Material examined: GH01E (1 ex.), GH01F (1 ex.), GH01G (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 34 mm.

Diagnosis: Ground colour red-brown, with slight fuscous suffusion; a black band on prothorax and 1st segment of abdomen; numerous oblique, waved line on forewing and veins speckled with black and grey; a black cell speck and a black mark beyond lower angle; submarginal line indistinct, irregular, waved grey.

Male genitalia characterized by long, ponted, sclerotized saccular process and a long, slender, sclerotized, apically round costal basal process of valvae.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand and Meghalaya (Cherrapunjee, Khasi). **Elsewhere:** Nepal.

Genus: *Melanthia* Duponchel, 1829

64. *Melanthia catenaria* (Moore, 1868)

(Habitus Plate No: 5.5 & Genitalia Plate No: 6.8)

1868. *Melanthia catenaria* Moore, *Proc. Zool. Soc. Lond.,* : 655.

1895. *Cidaria catenaria*; Hampson, *Fauna Brit. India Moths*, **3**: 354.

1992. *Melanthia catenaria catenaria*; Yazaki, *Tinea,* **13**(suppl. 2): 20.

2019. *Melanthia catenaria*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 232.

2021. *Melanthia catenaria*; Chettri & Yonle, *International Journal of Entomology Research,* **6**(3): 94.

Material examined: GH07A (3 ex.): Alder Forest (Riverine) (12/1S1); GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a).

Wing expanse: 42 mm.

Diagnosis: A red subcostal streak from base to beyond middle; basal patch rufous, with dark lines; antemedial, medial, postmedial line indistinct, waved;

costal medial patch rufous, with black cell-spot and waved lines; apical area and tornus rufous, with submarginal white specks.

Valvae very long, slender, apex round, costal margin sclerotized, saccular process sclerotized, pointed; juxta distally elongated, tongue-shaped; aedeagus with a series of small spines at apical ridge.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal (Darjeeling), Arunachal Pradesh (Tawang) and Meghalaya (Khasi). **Elsewhere:** Nepal, Bhutan, China, Taiwan and Japan.

Tribe: ASTHENINI Warren, 1894

Genus: *Agnibesa* Moore, 1888

65. *Agnibesa recurvilineata* Moore, 1888

(Habitus Plate No: 5.6 & Genitalia Plate No: 6.9)

1888. *Agnibesa recurvilineata* Moore, *Descr. Ind. Lep. Atk.*, : 256.

1895. *Hydrelia recurvilineata*; Hampson, *Fauna Brit. India Moths*, **3**: 415.

1992. *Agnibesa recurvilineata*; Yazaki, *Tinea,* **13**(suppl. 2): 20.

2002. *Agnibesa recurvilineata*; Xue & Scoble, *Bulletin of the Natural History Museum: Entomology Series*, **71**(1): 89.

2019. *Agnibesa recurvilineata*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 229.

Material examined: GH07A (3 ex.): Alder Forest (Riverine) (12/1S1); GH08C (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 36 mm.

Diagnosis: Forewing ground colour white, with curved, black subbasal line; antemedial line double, highly curved; a cell-speck; medial line excurved, with an orange patch on it beyond cell; postmedial line double, sinuous, outer one orange with black specks and the inner one orange from costa to CuA_1; submarginal line maculate, black, double and slightly angled near apex. Hindwing with blackish medial, postmedial and submarginal waved bands.

Valvae long, broad, costal margin sclerotized, saccular process long, sclerotized; aedeagus long, slender, with small sclerotized spines in the apical ridges.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal (Darjeeling) and Arunachal Pradesh. **Elsewhere:** Nepal and China.

Genus: *Hastina* Moore, 1888

66. *Hastina pluristrigata* (Moore, 1868)#

(Habitus Plate No: 5.7 & Genitalia Plate No: 6.10)

1868. *Hyria pluristrigata* Moore, *Proc. Zool. Soc. Lond.,* : 643.

1895. *Cambogia pluristrigata*; Hampson, *Fauna Brit. India Moths,* **3:** 419.

2002. *Hastina pluristrigata*; Xue & Scoble, *Bulletin of the Natural History Museum: Entomology Series*, **71**(1): 99.

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

Material examined: GH07A (1 ex.): Alder Forest (Riverine) (12/1S1).

Wing expanse: 22 mm.

Diagnosis: Ground colour brownish, with bright yellow markings; forewing subbasal line yellow; antemedial and postmedial narrow bands, with two sinuous lines between them; two waved lines between subbasal line and antemedial band; submarginal line indistinct, waved. Hindwing with three lines on basal area; antemedial band narrow, oblique with a series of specks beyond it; submarginal line sinuous, curved; cilia yellowish with brown patches.

Valvae long, costal margin bound by strong sclerotization, saccular process long, pointed, strongly sclerotized; juxta with the distal long process, apically bulged; aedeagus long, apically narrow, bent, with strong sclerotization.

Distribution: India: Himachal Pradesh (GHNP), Sikkim and West Bengal (Darjeeling). **Elsewhere:** China.

Genus: *Hydrelia* Hübner, [1825]

67. *Hydrelia bicolorata* (Moore, 1868)

(Habitus Plate No: 5.8 & Genitalia Plate No: 7.1)

1867. *Hyria bicolorata* Moore, *Proc. Zool. Soc. Lond.,* : 642.

1895. *Hydrelia bicolorata*; Hampson, *Fauna Brit. India Moths*, **3**: 413.

1914. *Hydrelia bicolorata*; Prout, *Macro Lep.*, **4**: 269.

1992. *Hydrelia bicolorata*; Yazaki, *Tinea,* **13**(suppl. 2): 19.

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

2017. *Hydrelia bicolorata*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Hydrelia bicolorata*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 231.

2021. *Hydrelia bicolorata*; Chettri & Yonle, *International Journal of Entomology Research,* **6**(3): 92.

Material examined: GH07A (1 ex.): Alder Forest (Riverine) (12/1S1).

Wing expanse: 22 mm.

Diagnosis: Ground colour rufous, irrorated with black; forewing with base black, subbasal, antemedial, postmedial and submarginal line waved, yellow-edged, postmedial angled at vein M_3; a medial patch blackish from costa to median nervure. Hindwing with postmedial and submarginal somewhat similar lines; marginal series of black specks on both wings.

Valvae long, broad, apex round, costal margin strongly bordered by sclerotization, saccular process broad with finger-like spine at apex; uncus with apex rounded; aedeagus long, apically narrow and moderately sclerotized.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal, Arunachal Pradesh, Assam, Meghalaya and Nagaland. **Elsewhere:** Nepal, Myanmar, China and Taiwan.

68. *Hydrelia sericea* (Butler, 1880)#

(Habitus Plate No: 5.9 & Genitalia Plate No: 7.2)

1880. *Noreia sericea* Butler, *Ann. Mag. nat. Hist.*, **6**: 225.

1992. *Hydrelia sericea*; Yazaki, *Tinea*, **13**(suppl. 2): 19.

2021. *Hydrelia sericea*; Chettri & Yonle, *International Journal of Entomology Research,* **6**(3): 94.

Material examined: GH08A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH15A (3 ex.), GH19B (7 ex.): Low-Level Blue Pine Forest (12/2S1); GH20A (4 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH24A (2 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH25B (1 ex.): Dwarf Rhododendron Scrub (15/C2/E1).

Wing expanse: 34 mm.

Diagnosis: Ground colour pinkish-grey; three antemedial orange lines in forewing, angled on subcostal amd median nervure; a cell-speck; postmedial band oblique from forewing costa (before apex) to middle of anal argin of hindwing, with slight orange in its outer edge; submarginal line waved, orange andged below M_3 on hindwing.

Very similar with *H. bicolorata,* but differs in having saccular process of valvae longer, more slender, more apically pointed and curved.

Distribution: India: Himachal Pradesh (GHNP) and West Bengal (Darjeeling).

Elsewhere: Nepal.

Genus: *Laciniodes* Warren, 1894

69. *Laciniodes plurilinearia* (Moore, 1868)

(Habitus Plate No: 5.10 & Genitalia Plate No: 7.3)

1868. *Somatina plurilinearia* Moore, *Proc. zool. Soc. Lond.*, : 645.

1895. *Laciniodes plurilinearia*; Hampson, *Fauna Brit. India Moths*, **3**: 417.

1914. *Laciniodes plurilinearia*; Seitz, *Macro Lep.*, **4**: 273.

2005. *Laciniodes plurilinearia*; Walia, *Fauna of West. Himalaya,* **2**: 186.

1995. *Laciniodes plurilinearia*; Yazaki, *Tinea*, **14**(suppl. 2): 10.

2017. *Laciniodes plurilinearia*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Laciniodes plurilinearia*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 231.

Material examined: GH07A (5 ex.): Alder Forest (Riverine) (12/1S1); GH15A (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 35 mm.

Diagnosis: Ground colour pale olivaceous; forewing with numerous sinuous, dark lines; a dark costal patch at the base; subbasal line curved; antemedial line angled below costa; cell-speck black; postmedial line angled on M_3; two prominent waved lines on outer area, with a series of white spots beyond them, those from costa to M_3 being on a dark patch.

Valvae long, slender, broad at base, apex roundish, costal margin sclerotized; anellus long, apically globular; uncus strongly sclerotized, triangular, apically pointed.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal (Darjeeling) and Meghalaya. **Elsewhere:** Nepal, Myanmar, China, Japan, Korea and Russia.

Genus: *Venusia* Curtis, 1839

70. *Venusia roseicosta* Yazaki, 1994^

(Habitus Plate No: 5.11 & Genitalia Plate No: 7.4)

1994. *Venusia roseicosta* Inoue, *Tinea,* **14**(Suppl. 1): 16.

2017. *Venusia roseicosta*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Venusia roseicosta*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 233.

Material examined: GH07A (8 ex.): Alder Forest (Riverine) (12/1S1); GH08C (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12B (3 ex.): Western Mixed Coniferous Forest (12/C1d); GH14B (3 ex.), GH15A (4 ex.): Low-Level Blue Pine Forest (12/2S1); GH20A (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH21B (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH25B (3 ex.): Dwarf Rhododendron Scrub (15/C2/E1).

Wing expanse: 22 mm.

Diagnosis: Ground colour creamy-white, with slight blackish-brown irroration; forewing costa tinged with rosy-pink; sinuous, pale ochreous, indistinct, transverse lines; medial line prominent.

Valvae long, costal margin sclerotized, slightly bulged at middle; sacculus with short, slender, curved ventrally- curved apical process; juxta long, apically pointed, caudal half with spine.

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand (Govind WLS). **Elsewhere:** Nepal.

Tribe: PERIZOMINI Herbulot, 1961

Genus: *Perizoma* Hübner, [1825]

71. *Perizoma albofasciata* (Moore, 1888)

(Habitus Plate No: 5.12 & Genitalia Plate No: 7.5)

1888. *Cidaria albofasciata* Moore, *Lep. Atk.* : 277.

1895. *Larentia albofasciata*; Hampson, *Fauna Brit. India Moths*, **3**: 374.

1914. *Perizoma albofasciata*; Seitz, *Macro Lep.*, **4**: 259.

1994. *Perizoma albofasciata*; *Tinea,* **14**(Suppl. 1): 17.

2019. *Perizoma albofasciata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 232.

Material examined: GH01A (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (1 ex.), GH04C (3 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 28 mm.

Diagnosis: A basal black patch on forewing, bound by a white line; antemedial line rufous; medial and postmedial area white, elongated upto margin on middle of wing; outer area rufous except middle.

Valvae broad, apex roundish, costal margin sclerotized, saccular process with a pointed, finger-like apical process; juxta distally long; uncus long; aedeagus with a long, highly sclerotized vesica spine.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind WLS), Sikkim and West Bengal. **Elsewhere:** Nepal, Myanmar and Taiwan.

72. *Perizoma antisticta* (Prout, 1938)*

(Habitus Plate No: 5.13 & Genitalia Plate No: 7.6)

1938. *Cidaria antisticta* Prout, *Macrolep. World,* **4**(Suppl.): 164.

2000. *Perizoma antisticta dentivalva* Inoue, *Tinea,* **16**(Suppl. 1): 46.

Material examined: GH04C (1 ex.), GH09A (19 ex.), GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12B (13 ex.): Western Mixed Coniferous Forest (12/C1d); GH15A (1 ex.), GH19B (3 ex.): Low-Level Blue Pine Forest (12/2S1); GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH25B (1 ex.): Dwarf Rhododendron Scrub (15/C2/E1); GH26A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27A (2 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 20 mm.

Diagnosis: Very similar with *P. schistacea,* but differ in having red-brown ground colour of forewing; oblique subbasal black band; white spot at middle of outer margin.

Differs from other congeners in having a ventral margin of valvae strong dentate.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Pakistan and Nepal.

73. *Perizoma bicolor* Warren, 1893#

(Habitus Plate No: 5.14 & Genitalia Plate No: 7.7)

1893. *Perizoma bicolor* Warren, *Proc. zool. Soc. Lond.*, : 369.

1895. *Larentia bicolor*; Hampson, *Fauna Brit. India Moths*, **3**: 373.

1989. *Perizoma argentipuncta* Inoue, : 164.

2000. *Perizoma bicolor*; Inoue, *Tinea,* **16**(Suppl. 1): 48.

Material examined: GH17A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH27A (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 26 mm.

Diagnosis: Forewing ground colour ochreous-brown, with clear median band, sometime indistinct; basal patch fuscous, clear with proximal border angled below cell, distal border anteriorly crenulated; submarginal series of white specks incomplete.

Valvae with costa straight, apex somewhat angled, ventral margin with basal expansion; juxta bowl-shaped; Saccus broad, caudally round; aedeagus apically broad, with a sclerotized spine at middle.

Distribution: India: Himachal Pradesh (GHNP) and Sikkim. **Elsewhere:** Nepal.

74. *Perizoma fulvimacula* (Hampson, 1896)#

(Habitus Plate No: 5.15 & Genitalia Plate No: 7.8)

1896. *Larentia fulvimacula* Hampson, *Fauna Brit. India Moths*, **4**: 557.

2000. *Perizoma fulvimacula*; Inoue, *Tinea,* **16**(Suppl. 1): 49.

Material examined: GH01C (1 ex.), GH01D (1 ex.), GH02B (2 ex.), GH03A (1 ex.), GH03B (1 ex.), GH03C (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (3 ex.), GH05A (1 ex.), GH09A (4 ex.), GH11A (3 ex.): Moist Temperate Deciduous Forest (12/C1e); GH10A (2 ex.): Moist Deodar Forest

(12/C1c); GH12A (1 ex.), GH12B (5 ex.): Western Mixed Coniferous Forest (12/C1d); GH14B (2 ex.), GH15A (1 ex.), GH16A (3 ex.), GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH20A (3 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH22C (7 ex.), GH24A (2 ex.), GH26A (3 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH23A (3 ex.): Sub-Alpine Pastures (14/DS1); GH27A (1 ex.), GH27B (3 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 28 mm.

Diagnosis: Ground colour of forewing greyish-fuscous; basal patch with curved grey edges and medial band edged by double grey lines, with punctiform black marks on vein; a rufous line beyond medial band and a rufous patch at the middle of outer area.

Sacculus sclerotized, with its dorsal margin produced at middle; juxta apically M-shaped, caudally roundish, vinculum highly sclerotized; Valvae with costal margin sclerotized and apex round; aedeagus sclerotized apically with a strong cornuti.

Distribution: India: Himachal Pradesh (GHNP) and West Bengal (Darjeeling). **Elsewhere:** Nepal.

75. *Perizoma hockingii* (Butler, 1889)

(Habitus Plate No: 6.1 & Genitalia Plate No: 7.9)

1889. *Eupithecia hockingii* Butler, *Ill. typical Spec. Lep. Het. Colln Br. Mus.*, **7**: 115.

1895. *Larentia hockingii*; Hampson, *Fauna Brit. India Moths*, **3**: 376.

2000. *Perizoma hockingii*; Inoue, *Tinea,* **16**(Suppl. 1): 47.

2021. *Perizoma hockingii*; Dey & Hausmann, *Journal of Threatened Taxa*, **13**(7): 18823.

Material examined: GH04C (2 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 20 mm.

Diagnosis: Forewing with black basal patch, bound by an oblique line; medial lines double, indistinct; inner one angled below the costa, a triangular, black patch between those lines near costa and an oval similar patch on inner margin; submarginal line diffuse, with a dark patch on costa and a spot below apex.

Valvae narrower and less sclerotized overall; saccus broader, larger; vinculum like previous species but slightly less scletotized.

Distribution: India: Himachal Pradesh (Dharamshala, GHNP), Uttarakhand (Kedarnath WLS), Sikkim and Nagaland. **Elsewhere:** Nepal.

76. *Perizoma peculiare* Inoue, 2000#

(Habitus Plate No: 6.2 & Genitalia Plate No: 7.10)

2000. *Perizoma peculiare* Inoue, *Tinea,* **16**(Suppl. 1): 51.

2019. *Perizoma peculiare*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 232.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (2 ex.), GH04C (7 ex.), GH05A (2 ex.), GH08B (1 ex.), GH11A (1 ex.):

Moist Temperate Deciduous Forest (12/C1e); GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH14A (1 ex.), GH14B (1 ex.), GH15A (5 ex.), GH16A (2 ex.): Low-Level Blue Pine Forest (12/2S1); GH20A (1 ex.), GH21A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH23A (1 ex.): Sub-Alpine Pastures (14/DS1); GH24A (1 ex.), GH26A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27A (2 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 20 mm.

Diagnosis: Similar with *P. seriata,* but differs in having distal and proximal areas of forewing bordered by central ochreous-brown band instead of blackish band; mid-terminal spot pale brown rather than white in *seriata.*

Differs from *seriata*, in having aedeagus surrounded by a pair of spatula, edges with strong serrations.

Distribution: India: Kashmir, Himachal Pradesh (GHNP) and West Bengal (Darjeeling). **Elsewhere:** Nepal and Thailand.

77. *Perizoma plumbeata* (Moore, 1888)

(Habitus Plate No: 6.3)

1888. *Anticlea plumbeata* Moore, *Descr. Indian lep. Atkinson,* (3): 273.

1895. *Larentia plumbeata*; Hampson, *Fauna Brit. India Moths*, **3**: 376.

2000. *Perizoma plumbeata*; Inoue, *Tinea,* **16**(Suppl. 1): 46.

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

Material examined: GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH15A (2 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 30 mm.

Diagnosis: Basal patch of forewing angled below median nervure and with slight rufous tinge; medial band broad, tinged with fuscous, with sinuous fulvous edges; outer edge of medial band angled below costa and bordering a triangular dark patch on costa; white speck below apex.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Kedarnath WLS), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Nepal.

78. *Perizoma quadrinotata* (Warren, 1896)[#]

1896. *Perizoma quadrinotata* Warren, *Novit. Zool.,* **3**: 123.

2000. *Perizoma quadrinotata*; Inoue, *Tinea,* **16**(Suppl. 1): 47.

Material examined: GH15A (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 16 mm.

Diagnosis: Ground colour of forewing bright straw; basal patch, central band, truncated subapical fascia and apical triangular spot black; two diffuse, sinuous, pale orange lines between basal patch and central band.

Distribution: India: Himachal Pradesh (GHNP) and West Bengal (Darjeeling). **Elsewhere:** Nepal and Thailand.

79. *Perizoma schistacea* (Moore, 1888)

(Habitus Plate No: 6.4 & Genitalia Plate No: 8.1)

1888. *Anticlea schistacea* Moore, *Descr. Indian lep. Atkinson,* (3): 273.

1895. *Larentia schistacea*; Hampson, *Fauna Brit. India Moths*, **3**: 376.

2000. *Perizoma schistacea*; Inoue, *Tinea,* **16**(Suppl. 1): 46.

Material examined: GH01A (1 ex.), GH01D (1 ex.), GH02B (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04C (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH07A (1 ex.): Alder Forest (Riverine) (12/1S1); GH20A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 24 mm.

Diagnosis: Ground colour of forewing greyish; blackish basal patch edged with white; medial band white-edged, suffused with fuscous, broadest at costa; submarginal spots white above middle and near tornus.

Valvae with costal margin strongly sclerotized, apex round; juxta Y-shaped, broad, sclerotized.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Nepal.

80. *Perizoma seriata* (Moore, 1888)#

(Habitus Plate No: 6.5 & Genitalia Plate No: 8.2)

1888. *Cidaria seriata* Moore, *Descr. Indian lep. Atkinson,* (3): 273.

1895. *Larentia seriata*; Hampson, *Fauna Brit. India Moths*, **3**: 373.

2000. *Perizoma seriata*; Inoue, *Tinea,* **16**(Suppl. 1): 50.

Material examined: GH04C (3 ex.), GH05A (1 ex.), GH08C (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH07A (1 ex.): Alder Forest (Riverine) (12/1S1); GH15A (3 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 20 mm.

Diagnosis: see *Perizoma peculiare.*

Distribution: India: Himachal Pradesh (GHNP) and West Bengal (Darjeeling).

Elsewhere: Pakistan and Nepal.

81. *Perizoma variabilis* Warren, 1893#

(Habitus Plate No: 6.6)

1893. *Perizoma variabilis* Warren, *Proc. zool. Soc. Lond.*, : 377.

1895. *Larentia variabilis*; Hampson, *Fauna Brit. India Moths*, **3**: 373.

2000. *Perizoma variabilis*; Inoue, *Tinea,* **16**(Suppl. 1): 48.

Material examined: GH01C (4 ex.): Himalayan Chir Pine Forest (9/C1b); GH04C (2 ex.): Moist Temperate Deciduous Forest (12/C1e); GH16A (5 ex.): Low-Level Blue Pine Forest (12/2S1); GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27A (12 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 26 mm.

Diagnosis: Ground colour fuscous-brown; basal patch and medial band as previous species; a large, white spot on the middle of oute area, sometimes tinged with ochreous.

Distribution: India: Himachal Pradesh (GHNP), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Nepal.

Tribe: EUPITHECIINI Tutt, 1896

Genus: *Eupithecia* Curtis, 1825

82. *Eupithecia albigutta* Prout, 1958

(Habitus Plate No: 6.7 & Genitalia Plate No: 8.3)

1958. *Eupithecia albigutta* Prout, *Bull. Br. Mus. nat. Hist (Ent.),* **6**(12): 393.

1988. *Eupithecia pulla* Vojnits, *Acta zool. Acad. Sci. hung.,* **34**(1): 38.

2000. *Eupithecia albigutta*; Inoue, *Tinea,* **16**(suppl. 1): 28.

2007. *Eupithecia albigutta*; Mironov & Galsworthy, *Trans. lepid. Soc. Japan,* **58**(3): 360.

2008. *Eupithecia albigutta*; Mironov, Galsworthy & Ratzel, *Trans. lepid. Soc. Japan,* **59**(1): 62.

Material examined: GH04B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH07A (1 ex.): Alder Forest (Riverine) (12/1S1); GH08C (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 23 mm.

Diagnosis: Ground colour of forewing brownish with a white, large spot at base, below the subcostal vein; antemedial and basal fascia white, marked only in costa, submedian fold and inner margin; median area clearly defined.

Valvae elongated, apex narrow, costal margin sclerotized; juxta with distal process; uncus membranous.

Distribution: India: Kashmir and Himachal Pradesh (Shimla, GHNP). **Elsewhere:** Pakistan, Nepal and Taiwan.

83. *Eupithecia conjunctiva* Hampson, 1895

(Habitus Plate No: 6.8 & Genitalia Plate No: 8.4)

1895. *Eupithecia conjunctiva* Hampson, *Fauna Brit. India (Moths),* **3**: 400.

2000. *Eupithecia conjunctiva*; Inoue, *Tinea,* **16**(suppl. 1): 31.

2008. *Eupithecia conjunctiva*; Mironov, Galsworthy & Ratzel, *Trans. lepid. Soc. Japan,* **59**(2): 125.

2012. *Eupithecia conjunctiva*; Mironov & Ratzel, *Nota lepidopterologica,* **35**(2): 204.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH14A (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 24 mm.

Diagnosis: Similar with *E. rajata,* but much greyer; antemdial line of forewing highly anged at cell to cell-tuft, then becoming waved upto inner margin; medial line angled outward beyond the tuft and inward on median nervure, almost to the antemedial; postmedial line angled at M_1, then oblique and straight upto inner margin, conjoined to the antemdial by a black streak in interno-median interspace.

Valvae ample, saccular process with a spinule at one-third from base; uncus short, sclerotized, apex bifurcate; aedeagus with a mass of six spines from the tip of band like cornutus and another cornutus is belt-like.

Distribution: India: Kashmir, Himachal Pradesh (Dharamshala, GHNP), Uttarakhand (Mussouri) and Sikkim. **Elsewhere:** Afghanistan, Pakistan and Nepal.

84. *Eupithecia rubridorsata* Hampson, 1895#

(Habitus Plate No: 6.9 & Genitalia Plate No: 8.5)

1895. *Eupithecia rubridorsata* Hampson, *Fauna Brit. India (Moths),* **3**: 403.

1983. *Eupithecia circumscriptrix* Vojnits, *Acta zool. Acad. Sci. hung.,* **29**(1-3): 279.

1984. *Eupithecia acerba* Vojnits, *Acta zool. Acad. Sci. hung.,* **30**(1-2): 228.

2000. *Eupithecia rubridorsata*; Inoue, *Tinea,* **16**(suppl. 1): 41.

2013. *Eupithecia rubridorsata*; Mironov & Galsworthy, *The Eupithecia of China: a revision*: 34.

Material examined: GH08B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH14B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 28 mm.

Diagnosis: Head, thorax and abdomen orange-red; forewing with outer-third dark rufous and basal two-third dark-fuscous; an orange-red basal patch; indistinct antemedial, four medial and a submarginal sinuous, white line.

Valvae leaf-shaped with apex narrow, elongated; aedeagus basally sclerotized.

Distribution: India: Himachal Pradesh (GHNP) and Sikkim. **Elsewhere:** Nepal and China.

85. *Eupithecia ustata* Moore, 1888#

(Habitus Plate No: 6.10)

1888. *Eupithecia ustata* Moore, *Descr. Indian lep. Atkinson,* (3): 268.

1895. *Eupithecia ustata*; Hampson, *Fauna Brit. India (Moths),* **3**: 402.

1976. *Eupithecia delaeveri* Vojnits, *Acta zool. Acad. Sci. hung.*, **22**: 201.

2008. *Eupithecia ustata*; Mironov, Galsworthy & Ratzel, *Trans. lepid. Soc. Japan*, **59**(1): 62.

Material examined: GH02B (1 ex.), GH03A (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH19C (2 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 20 mm.

Diagnosis: Thorax and abdomen white; forewing rufous-brown, the basal band with confluent strigae except costal patches, bordered by an oblique, indistinct medial line; a waved, white-speckled submarginal line.

Distribution: India: Kashmir, Himachal Pradesh (GHNP), Sikkim and West Bengal (Darjeeling). **Elsewhere:** China.

Genus: *Pasiphila* Meyrick, 1883

86. *Pasiphila palpata* (Walker, 1862)

(Habitus Plate No: 6.11 & Genitalia Plate No: 8.6)

1862. *Cidaria palpata* Walker, *List Spec. Lepid. Insects Colln Br. Mus.*, **25**: 1404.

1887. *Eupithecia variegata* Moore, *Lep. Ceylon,* **3**: 479.

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

1895. *Chloroclystis palpata*; Hampson, *Fauna Brit. India (Moths),* **3**: 391.

1958. *Chlorocystis palpata diechusa* Prout, *Bull. Br. Mus. nat. Hist. (Ent.),* **6**: 422-3.

1976. *Chloroclystis palpata wongi* Holloway,: 68

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

1995. *Rhinoplora [sic] palpata*; Yazaki, *Tinea,* **14**(suppl. 2): 17.

Material examined: GH02B (2 ex.): Himalayan Chir Pine Forest (9/C1b); GH04C (1 ex.), GH08B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH17A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 24 mm.

Diagnosis: Ground colour grass-green, suffused with red and irrorated with black, veins speckled with black; a subbasal line and an antemdial black band, with a line beyond it; medial area black; a postmedial series of black specks; submarginal band vinuous with a black line.

Valvae asymmetrical, right one having a costal basal pointed, outwardly curved process;saccus with a stick like process in the caudal half; uncus long, slender; aedeagus basally sclerotized and with two bunches of apical spines.

Distribution: India: Himachal Pradesh (Dharamshala, GHNP), Sikkim and Tamil Nadu. **Elsewhere:** Nepal, China, Sri Lanka, Indonesia (Borneo) and Japan.

Tribe: CHESIADINI Stephens, 1850

Genus: *Docirava* Walker, [1863]

87. *Docirava aequilineata* Walker, [1863]

(Habitus Plate No: 6.12)

1863. *Docirava aequilineata* Walker, *List Spec. Lepid. Insects Colln Br. Mus.*, **26**: 1635.

1895. *Anaitis aequilineata*; Hampson, *Fauna Brit. India Moths*, **3**: 341.

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

2017. *Docirava aequilineata*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Docirava aequilineata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 230.

Material examined: GH04B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH13A (1 ex.): Western Mixed Coniferous Forest (12/C1d).

Wing expanse: 40 mm.

Diagnosis: Ground colour brown with grey irroration; an oblique, ochreous, rufous-edged medial band on forewing from subcostal to inner margin; a similar band from apex upto inner margin just beyond the middle. Hindwing with curved postmedial line.

Valvae with apex pointed, serration from apex to costal margin, saccular process with slightly pointed, makes an angle while reaching apex; uncus long, slender, apically bulged.

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand (Govind WLS, Gangotri NP). **Elsewhere:** Nepal.

Tribe: TRICHOPTERYGINI Warren, 1894

Genus: *Trichopterigia* Hampson, 1895

88. *Trichopterigia decorata* (Moore, 1888)^

(Habitus Plate No: 6.13 & Genitalia Plate No: 8.7)

1888. *Lobophora decorata* Moore, *Descr. Ind. Lep. Atk.*, : 272.

1895. *Trichopterigia decorata*; Hampson, *Fauna Brit. India Moths*, **3**: 403.

1992. *Trichopterigia decorata*; Inoue, *Tinea*, **13**(2): 16.

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

Material examined: GH08B (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 30 mm.

Diagnosis: Ground colour of forewing grey with olive and black irroration and with some costal black spots; base ochreous, bordered by oblique, black line; medial line and discocellular line indistinct; a sinuous, irregular submarginal line, with series of crimson spots beyond it.

Valvae long, sclerotized, apex with a spine, costal basal process membranous; uncus pointed apically, broad at base, medially slender; anellus long, membranus.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal (Darjeeling) and Meghalaya (Khasi). **Elsewhere:** Nepal.

89. *Trichopterigia macularia* (Moore, 1868)#

(Habitus Plate No: 6.14 & Genitalia Plate No: 8.8)

1868. *Oporobia macularia* Moore, *Proc. Zool. Soc. Lond.,* : 653.

1895. *Trichopteryx macularia*; Hampson, *Fauna Brit. India Moths*, **3**: 405.

Material examined: GH19A (3 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 36 mm.

Diagnosis: Forewing ground colour ochreous-brown with subbasal, antemedial, medial, postmedial and submarginal bands, made of indistinct, ill-defined, irregular, sinuous, black line, interrupted below costa; outer area with olive green suffusion and veins speckled with black.

Valvae long, costal margin bordered with sclerotization, apex round, saccular process sclerotized, short; uncus long, apically broad, bent, slightly sclerotized.

Distribution: India: Himachal Pradesh (GHNP), Sikkim and West Bengal.

Tribe: Unassinged

Genus: *Physetobasis* Hampson, 1895

90. *Physetobasis dentifascia* Hampson, 1895

(Habitus Plate No: 6.15 & Genitalia Plate No: 8.9)

1895. *Physetobasis dentifascia* Hampson, *Fauna Brit. India Moths*, **3**: 386.

2007. *Physetobasis dentifascia*; Kamaluddin *et al.*, *INT. J. BIOL. BIOTECH.*, **4**(2-3): 113-119.

2019. *Physetobasis dentifascia*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 233.

Material examined: GH17A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse:

Diagnosis: Ground colour of forewing fuscous-brown with dark white-edged, sinuous antemedial line; medial area darker, with a oblique, large, black, discocellular spot and edged by black lines; outer one sinuous, dentate, angled at M_3 and M_1, then bent inward to send teeth on CuA_2; submarginal line plae, indistinct, crenulated.

Valvae long, apex narrow, costal margin sclerotized; juxta with a pair of distal, slender process; saccus broad, roundish; aedeagus with a long apical vesica spine and three bunches of small spines.

Distribution: India: Himachal Pradesh (Dharamshala, GHNP), Uttarakhand, Meghalaya and Tamil Nadu. **Elsewhere:** Pakistan, Nepal, Sri Lanka, Taiwan, Hong Kong, Vietnam, Indonesia, Australia, Fiji and Japan.

Subfamily GEOMETRINAE Stephens, 1829

Geometrinae can be characterized by the following characters:

1) Green pigment (geoverdin) is predominant in external morphology (Cook *et al.,* 1994).

2) Hindwing with M_2 arises nearer to M_1 rather than to M_3 (Minet & Scoble, 1999).

3) Ansa is basally narrow, medially broad and tapered at the apex (Cook & Scoble, 1992).

4) Frenulum reduced and in male, paried setal spots on 3rd sternite. In Male genitalia, socii well developed and aedeagus with reduced sclerotization to a ventral ridge along the length (Holloway, 1996).

5) In female, pheromone glands are long (Bendib, 2001). In female genitalia, ovipositor with papillate, oblique lobes and corpus bursae with a bicornuate signum (Holloway, 1996; Murillo-Ramos *et al.*, 2021).

Total, 11 species of Geometrinae under 10 genera belonging to 5 tribes were recorded from Great Himalayan National Park in this study. Among the tribes, Hemitheini was most diverse with the species richness of 4. *Maxates iridescens* was reported for the first time from the Western Himalaya, previously reported only from Assam. *Iotaphora iridicolor*, *Comibaena pictipennis* and *Chlorissa distinctaria* were reported for the first time from Himachal Pradesh.

Tribe: PSEUDOTERPNINI Warren, 1893

Genus: *Herochroma* Swinhoe, 1893

91. *Herochroma crassipunctata* (Alpheraky, 1888)

(Habitus Plate No: 7.1 & Genitalia Plate No: 8.10)

1888. *Gnophos crassipunctata* Alpheraky, : 68.

1912. *Archaeobalbis crassipunctata*; Prount, : 25.

1928. *Archaeobalbis sordida* Wehrli, **21**: 455.

1988. *Archaeobalbis crassipunctata*; Viidaleopp, :6.

1999. *Herochroma crassipunctata*; Inoue, *Tinea*, **16**(2): 97.

Material examined: GH01A (1 ex.), GH01B (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 47 mm.

Diagnosis: Very similar with *H. usneata.* Ground colour pale olive-grey; forewing with antemedial sinuated line almost vertical to innermargin, postmedial line highly dentate in both wings edged with lighter ground colour distally; indistinct subterminal line, marked with dark grey dotted line distally; underside white, faintly suffused with grey with large discal spot.

Male genitalia is also very similar to *usneata,* but differs having shorter uncus, basal plate of transtilla with less slender processes. Valvae broader and ventral edge with tiny triangular plate. Aedeagus with the appendage of manica similar with *H. usneata.*

Distribution: India: Himachal Pradesh (Lahol, GHNP). **Elsewhere:** Turkestan and Tajiikistan, Afghanistan.

Genus: *Pingasa* Moore, [1887]

92. *Pingasa pseudoterpinaria* (Guenée, 1858)

(Habitus Plate No: 7.2 & Genitalia Plate No: 9.1)

1858. *Hypochroma pseudoterpinaria* Guenée, *Spec. Gen. Lep.,* **9**: 276.

2019. *Pingasa pseudoterpinaria*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 229.

Material examined: GH05A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 47 mm.

Diagnosis: Very similar with *P. chlora* but differs in having much more irrorated with black; underside with no traces of yellow but with slight grey tinge; a much reduced, narrow, fuscous submarginal band present.

Valvae with a strong, pointed apical spine; three small spines just before the apex of valvae at ventral margin; costal basal process of valvae broad, with two spines at the apex; gnathos sclerotized with two small processes at the apex; uncus apically bifurcated and narrow. Aedeagus long, slender, moderately sclerotized.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Meghalaya and Nagaland. **Elsewhere:** Nepal, China, Japan and Korea.

Tribe: GEOMETRINI Stephens, 1829

Genus: *Geometra* Linnaeus, 1758

93. *Geometra flavifrontaria* Guenée, 1858

(Habitus Plate No: 7.3 & Genitalia Plate No: 9.2)

1858. *Nemoria flavifrontaria* Guene′e, *Hist nat Insectes* (Spec. ge′n. Le′pid.), **9**:346.

1881. *Loxochila mutans* Butler, *Proc. Zool. Soc. Lond.,* :615.

1912. *Hipparchus pratti* Prout, *in Wytsman, Genera Insectorum*, **129**:71.

1957. *Geometra flavifrontaria*; ICZN, *Opin Decl ICZN* **15**(Opinion 450): 254.

2009. *Geometra flavifrontaria*; Han *et al., Journal of Nat. Hist.*, **43**(13-14): 908.

Material examined: GH05A (6 ex.): Moist Temperate Deciduous Forest (12/C1e); GH07A (1 ex.): Alder Forest (Riverine) (12/1S1).

Wing expanse: 43 mm.

Diagnosis: Ground colour bluish-green; forewing apex somewhat falcate; antemedial line of forewing white, slender, oblique anteriorly; postmedial line in forewing parallel to outer margin, indistinct near costa, but in hindwing it is white, much broader, almost straight; fringes white; underside whitish-green.

Uncus somewhat convex with socii long, slender and sclerotized; gnathos broad basally, median process highly sclerotized with apex hook-like; Valvae with apex round, costa concave; sacculus with a small pointed apical process; Aedeagus with slightly tapered tip but apically blunt. Eighth sternite depressed at middle, weakly sclerotized.

Distribution: India: Himachal Pradesh (Sabathu, Dalhousie, Shimla, GHNP) and Uttarakhand (Bhimtal, Nainital). **Elsewhere:** Nepal, China and Pakistan.

Genus: *Iotaphora* Warren, 1894

94. *Iotaphora iridicolor* (Butler, 1880)^

(Habitus Plate No: 7.4 & Genitalia Plate No: 9.3)

1880. *Panaethia iridicolor* Butler, *Ann. Mag. nat. Hist.*, **6**(33): 227.

1895. *Iotaphora iridicolor*; Hampson, *Fauna Brit. India Moths*, **3**: 322.

2008. *Iotaphora iridicolor*; Smetacek, *Bionotes,* **10**(1): 7.

2003. *Iotaphora iridicolor*; Ghosh, *Fauna of Sikkim*, **4**: 268.

2019. *Iotaphora iridicolor*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 228.

Material examined: GH07A (1 ex.): Alder Forest (Riverine) (12/1S1).

Wing expanse: 55 mm.

Diagnosis: Ground colour plae greenish-blue. Forewing costa white with a black spot at base; antemedial line curved, orange; medial band broad; a black, distinct lunule on discocellulars; postmedial line on both wings orange, excurved between CuA_2 and M_3; series of black submarginal streaks on the veins and internomedian-interspaces.

Valvae long, membranous, broad, with a small, basal saccular process; gnathos stout, strongly sclerotized, tip pointed; uncus with 3 long socii, median one thinner than both the lateral socii; aedeagus long, with triangular, broad, apical, sclerotized process and with two cornutus at vesica.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Devalsari), Sikkim, West Bengal (Darjeeling, Neora Valley NP), Arunachal Pradesh (Eaglenest WLS), Meghalaya and Manipur. **Elsewhere:** Nepal, Bhutan, China, Tibet and Vietnam.

Genus: *Tanaorhinus* Butler, 1879

95. *Tanaorhinus reciprocata* (Walker, 1861)

(Habitus Plate No: 7.5 & Genitalia Plate No: 9.4)

1861. *Geometra reciprocata* Walker, *List Spec. Lepid. Insects Colln Br. Mus.*, **22**: 515.

1895. *Tanaorhinus reciprocatus*; Hampson, *Fauna Brit. India Moths*, **3**: 493.

2019. *Tanaorhinus reciprocata*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 229.

Material examined: GH01G (1 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 70 mm.

Diagnosis: Ground colour grass-green; forewing with antemedial line waved, bent outward below cell; cell-speck black; oblique, white, lunulate postmedial line, with deffused whitish lunules beyond it, prominent on forewing; postmedial line produced to an angle on CuA_1 on forewing and becoming medial on hind wing; indistinct submarginal series of white marks; cilia white. Underside with black cell specks and oblique postmedial dark line.

Valvae with saccular process long, moderately sclerotized; gnathos apically long, pointed, slender, scletotized; uncus with two long socii, sclerotized. Aedeagus long, slender, moderately sclerotized.

Distribution: India: Himachal Pradesh (Shimla, Dharamshala, GHNP), Uttarakhand, Sikkim, West Bengal, Arunachal Pradesh and Meghalaya (Khasi).

Elsewhere: Nepal, Bhutan, China, Taiwan, Thailand, Japan and Korea.

Tribe: COMIBAENINI Inoue, 1961

Genus: *Comibaena* Hübner, [1823]

96. *Comibaena pictipennis* (Butler, 1880)^

(Habitus Plate No: 7.6 & Genitalia Plate No: 9.5)

1880. *Geometra pictipennis* Butler, *Ann. Mag. Nat. Hist.*, **6**(5): 215.

1895. *Geometra pictipennis*; Hampson, *Fauna Brit. India Moths*, **3**: 496.

1935. *Chlorochaeta pictipennis*; Prout, *In* Seitz *Macro Lep. Suppl.*, **4**: 11.

2013. *Chlorochaeta pictipennis*; Chandra & Sambath, *Jour. of Threat. Taxa*, **5**(1): 3565.

2012. *Comibaena pictipennis*; Han *et al., Zoological Journal of the Linnean Society*, **165**(4): 744.

2017. *Comibaena pictipennis*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH01E (1 ex.), GH01G (1 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH07A (2 ex.): Alder Forest (Riverine) (12/1S1); GH12B (2 ex.): Western Mixed Coniferous Forest (12/C1d); GH14B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 35 mm.

Diagnosis: Ground colour pale yellow-green; frons rufous; head and fore-tibia black; forewing with antemedial line oblique, white, the area inside whitish; postmedial and submarginal line white, waved, the area inside them mostly white; large, pink patch on inner margin before outer margin. Hind wing with pink scale on cell; a large, pink patch on costa before apex and another at anal angle; these two marking embraced by a ferruginuous submarginal line, with two inward protusion on CuA_2 and M_3 to the cell. Underside white.

Male genitalia is very similar with *Comibaena ornataria* but differs in having ventral tooth on the costal lobe is longer and vinculum more deeply concave and not truncate.

Distribution: India: Kashmir, Himachal Pradesh (GHNP), Uttarakhand (Govind WLS), West Bengal (Darjeeling) and Arunachal Pradesh (Tawang). **Elsewhere:** Nepal, Bhutan, China, Taiwan and Tibet.

Tribe: COMOSTOLINI Inoue, 1961

Genus: *Comostola* Meyrick, 1888

97. *Comostola subtiliaria* (Bremer, 1864)

(Habitus Plate No: 7.7 & Genitalia Plate No: 9.6)

1864. *Euchloris subtiliaria* Bremer, *Mém. Acad. Sci. St. Pétersb.*, **8**(1): 76.

1895. *Euchloris subtiliaria*; Hampson, *Fauna Brit. India Moths*, **3**: 500.

1917. *Comostola demeritaria* Prout, *Novit. Zool.*, **24**: 304.

1996. *Cosmostola subtiliaria*; Holloway, *The Moths of Borneo*, **9**: 293.

1963. *Comostola subtiliaria insulata* Inoue, *Tinea,* **6**(1/2): 29.

1963. *Comostola subtiliaria kawazoei* Inoue, *Tinea,* **6**(1/2): 29.

2013. *Comostola subtiliaria*; Chandra & Sambath, *Jour. of Threat. Taxa,* **5**(1): 3566.

2017. *Comostola subtiliaria*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH01A (1 ex.), GH01E (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 16 mm.

Diagnosis: Ground colour emerald-green; frons and palpi orange; vertex white; forewing costa ochreous; antemedial white-ringed orange specks on median nervure and inner margin; large, orange white-ringed silvery-centred spot on cell on both wings; postmedial slightly curved series of white-ringed specks; margin ochreous.

Valvae with ventral margin sclerotized, costal margin undulating, costal lobe concave; gnathos with apically long, sclerotized process; uncus apically long, slightly bifurcate and with two membranous socii.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind WLS), Sikkim, Arunachal Pradesh (Tawang) and Tamil Nadu. **Elsewhere:** Sri Lanka, Siberia, China, Korea, Japan and Australia.

Tribe: HEMITHEINI Bruand, 1846

Genus: *Chlorissa* Stephens, 1831

98. *Chlorissa distinctaria* (Walker, 1866)^

(Habitus Plate No: 7.8 & Genitalia Plate No: 9.7)

1866. *Hemithea distinctaria* Walker, *List Spec. Lepid. Insects Colln Br. Mus.*, **35**: 1607.

1894. *Hemithea rubrifrons* Warren, *Nov. Zool.*: 393.

1895. *Hemithea distinctaria*; Hampson, *Fauna Brit. India Moths*, **3**: 491.

2008. *Hemithea distinctaria*; Smetacek, *Bionotes:* **10**(1):5-15.

2016. *Chlorissa distinctaria*; Singh & Ranjan, *Rec. zool. Surv. India*, **116**(Part-4): 329.

2017. *Chlorissa distinctaria*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH01E (3 ex.): Himalayan Chir Pine Forest (9/C1b); GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 35 mm.

Diagnosis: Ground colour grey-green; frons dark olive; forewing costa with indistinct dark specks; antemedial line sinuous, pale, indistinct; cell-specks on both wings and distinct, white, nearly straight postmedial line; underside white.

Valve slender; saccular process long, upwardly directed; costal basal lobe of valvae highly sclerotized, concave; uncus long, sclerotized, apically pointed and with two long socii. Aedeagus slender, sclerotized, with vesica spines.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind WLS), Sikkim and Jharkhand. **Elsewhere:** Bhutan.

99. *Chlorissa gelida* (Butler, 1889)

(Habitus Plate No: 7.9 & Genitalia Plate No: 9.8)

1889. *Nemoria gelida* Butler, *Ill. Het.*, **7**: 21.

1895. *Nemoria gelida*; Hampson, *Fauna Brit. India Moths,* **3**: 502.

1935. *Chlorissa gelida*; Seitz, *Macro Lep. Supl.*, **4**: 15.

2013. *Chlorissa gelida*; Chandra & Sambath, *Jour. of Threat. Taxa*, **5**(1): 3565.

2017. *Chlorissa gelida*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH01B (2 ex.), GH01C (1 ex.), GH01D (1 ex.), GH01E (21 ex.), GH01F (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH05A (3 ex.), GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH06A (2 ex.): Moist Deodar Forest (12/C1c); GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 27 mm.

Diagnosis: Ground colour blue-green; frons and fore legs chestnut; vertex white; forewing costa pale brown; antemedial line white, sinuous, curved; both wings with oblique, straight postmedial line.

Male genitalia is very similar with previous species but only the costal basal lobe of valvae more apically produced.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind WLS) and Arunachal Pradesh (Tawang).

Genus: *Maxates* Moore, [1887]

100. *Maxates glaucaria* (Walker, 1866)

(Habitus Plate No: 7.10 & Genitalia Plate No: 9.9)

1866. *Thalera glaucaria* Walker, *List Spec. Lepid. Insects Colln Br. Mus.*, **35**: 1613.

1895. *Thalassodes glaucaria*; Hampson, *Fauna Brit. India Moths,* **3:** 509.

1998. *Maxates glaucaria*; Yazaki, *Tinea* **15**(suppl. 1): 5.

Material examined: GH03C (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 37 mm.

Diagnosis: Very similar with *Maxates thetydaria,* but differs in being more thickly irrorated and suffused with dark olive; forewing antemedial line waved, dark, white-edged; postmedial line similar in both wings.

Valvae long, broad; uncus long, apically produced, sclerotized; gnathos apically long; juxta long, tongue-shaped. Aedeagus long, moderately sclerotized.

Distribution: India: Himachal Pradesh (Dharamshala, GHNP) and Sikkim. **Elsewhere:** Nepal.

101. *Maxates iridescens* (Warren, 1896)#

(Habitus Plate No: 7.11 & Genitalia Plate No: 9.10)

1896. *Iodis iridescens* Warren, *Novit. Zool.,* **3**: 108.

1992. *Jodis iridescens*; Yazaki, *Tinea* **13**(suppl. 2): 14.

Material examined: GH01E (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 26 mm.

Diagnosis: Ground colour opalescent green, dusted with white scales; forewing costa dark greyish-green; lunules forming the outer line more uniform in direction and the last two beneath costa approaching apex, so that the width of central area inside the two lines is much greater on the costa; hindmargin preceeded by a narrow band of unsuffused darker green. Underside white.

Valvae with apical sacclur process membranous; gnathos apically elongated, sclerotized; uncus long, sclerotized, apically pointed; juxta tongue-shaped. Aedeagus long, slender, moderately sclerotized.

Distribution: India: Himachal Pradesh (GHNP) and Assam. **Elsewhere:** Nepal.

Subfamily ENNOMINAE Duponchel, 1845

Ennominae can be recognized by the following characters:

1) Hindwing without vein M_2.

2) In male, a fovea or pit of hyaline membrane on the ventral side of the forewing, acting as a tympanum is developed.

3) In male, transverse setae on the 3rd sternite.

4) In female genitalia, corpus bursae with stellate signum (Holloway, 1994; Murillo-Ramos *et al.,* 2021).

A total of 123 species of Ennominae under 56 genera belonging to 13 tribes were recorded in this study from Great Himalayan National Park. Among the tribes, Boarmiini was the most diverse with species richness of 44, followed by Gnophini with species richness of 15. Out of them 33 species were reported for the first time from Western Himalaya and 23 species were reported for the first time from Himachal Pradesh.

Tribe: HYPOCHROSINI Guenée, 1858

Genus: *Apoheterolocha* Wehrli, 1937

102. *Apoheterolocha patalata* (Felder & Rogenhofer, 1875)

(Habitus Plate No: 8.1 & Genitalia Plate No: 10.1)

1875. *Heterolocha patalata* Felder & Rogenhofer, *Nov. Zool.,*: 132.

1895. *Heterolocha patalata*; Hampson, *Fauna Brit. India Moths,* **3:** 180.

1897. *Heterolocha patalata*; Leech, *Ann. Mag. Nat. Hist.,* **19**(6): 232.

1926. *Heterolocha patalata*; Prout, *The journal of the Bombay Natural History Society*, **31**: 791.

2000. *Apoheterolocha patalata*; Stuning, *Tinea* **16**(suppl. 1): 101.

Material examined: GH23A (1 ex.): Sub-Alpine Pastures (14/DS1); GH25B (1 ex.): Dwarf Rhododendron Scrub (15/C2/E1).

Wing expanse: 36 mm.

Diagnosis: Ground colour distinctly green; forewith with basal costal black spot; hindwing with strongly curved postmedial line; tornal area without any black spot.

Valvae apically narrow, ventral margin concave, costal margin sclerotized; saccus caudally expanded slightly; uncus triangular, sclerotized, apically narrow; gnathos like uncus, slightly shorter but almost reaching the length of uncus; juxta heart-shaped; aedeagus with a strong, long, pointed, slightly curved apical spine and with a bunch of vesica spines.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, Arunachal Pradesh and Meghalaya (Khasi). **Elsewhere:** Nepal, Bhutan, Myanmar, China, Taiwan and Indonesia (Borneo).

103. ***Apoheterolocha quadraria* (Leech, 1897)**

(Habitus Plate No: 8.2 & Genitalia Plate No: 10.2)

1897. *Heterolocha quadraria* Leech, *Ann. Mag. nat. Hist.* **19**(6): 231, pl.6, fig.8.

1999. *Apoheterolocha quadraria*; Parsons *et al.*, *Geometrid Moths of the World: a Catalogue.,*: 29.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 32 mm.

Diagnosis: Ground colour olive-yellow, traversed by two blackish lines, strating from a quadrate, black spot on costa; 1st line straight but the 2nd one is angled twice below costa, then obliquely wavy upto inner margin. Hindwing yellow, irrorated with grey and traversed by a grey band.

Male genitalia very similar with previous species but differs in having valvae, uncus, gnathos slightly longer and slenderer; saccus with two caudal protusion instead of one.

Distribution: **India:** Himachal Pradesh (GHNP). **Elsewhere:** China.

Genus: *Corymica* Walker, 1860

104. *Corymica pryeri* (Butler, 1878)#

(Habitus Plate No: 8.3 & Genitalia Plate No: 10.3)

1878. *Thiopsyche pryeri* Butler, *Ann. Mag. Nat. Hist.*, **1**(5): 393; TL: Japan, Yokohama.

1889. *Corymica vitrigera* Butler, *Ill. typical Spec. Lep. Het. Colln Br. Mus.*, **7**: 101.

1896. *Corymica oblongimacula* Warren, *Novit. zool.*, **3**: 305.

1928. *Corymica prattorum* Prout, *Bull. Hill Mus.* **2**(1): 59.

1976. *Corymica oblongimacula* Holloway, *Moths of Borneo with special reference to Mt. Kinabalu*: 75.

1993. *Corymica pryeri*; Holloway, *Moths of Borneo.* **11**: 51, f. 66, pl. 2.

Material examined: GH01C (1 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 34 mm.

Diagnosis: A large quadrate mark on dorsum; forewing with the apical patch indistinct and large on upperside and with the two spots on inner margin large and conjoined; a larger, red, marginal patch on forewing underside.

Valvae leaf like, apically pointed, broad at middle; juxta with a pair of very long, thin distal processes; uncus slender, short, sclerotized, medially broad, narrow at apex; aedeagus slender, basally broad, apically thin, slightly sclerotized.

Distribution: India: Himachal Pradesh (GHNP), Arunachal Pradesh and Assam. **Elsewhere:** Pakistan, Japan, Korea, Taiwan, Thailand, Indonesia (Borneo, Sumatra), New Guinea and Australia.

Genus: *Garaeus* Moore, [1868]

105. *Garaeus apicata* (Moore, 1868)

(Habitus Plate No: 8.4 & Genitalia Plate No: 10.4)

1868. *Auzea apicata* Moore, *Proc. zool. Soc. Lond.,*: 617.

1895. *Garaeus apicatus*; Hampson, *Fauna Brit. India Moths,* **3:** 235.

1976. *Garaeus apicata*; Holloway, *Moths of Borneo with special reference to Mt. Kinabalu*: 77.

2000. *Garaeus apicata apicata*; Stuning, *Tinea* **16**(suppl. 1): 98.

1993. *Garaeus apicata*; Holloway, *Moths of Borneo.* **11**: 42, f. 45, pl. 2.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 34 mm.

Diagnosis: Forewing ground colour olive-brown suffused with purple, with postmedial line double, pale, more or less straight into the inner margin; some pale patches on costa near apex with absence of subapical spot.

Valvae broad at middle, apically narrow; uncus long, sclerotized, apically pointed; gnathos ring-like, slightly pointed at apex; juxta with an asymmetrical distal spine on the right side; saccus with two caudal protusions at sides and strong invagination at middle; aedeagus with a apical spine but vesica without spines.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Devalsari), Sikkim and West Bengal. **Elsewhere:** Pakistan, Nepal, Myanmar, Taiwan, Malaysia, Indonesia (Borneo, Sumatra) and Philippines.

Genus: *Heterolocha* Lederer, 1853

106. *Heterolocha falconaria* (Walker, 1866)^

(Habitus Plate No: 8.5 & Genitalia Plate No: 10.5)

1866. *Aspilates falconaria* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* **35**: 1665.

1895. *Heterolocha falconaria*; Hampson, *Fauna Brit. India Moths,* **3:** 179.

1993. *Heterolocha falconaria*; Holloway, *Moths of Borneo,* **11**: 36.

2000. *Heterolocha falconaria*; Stuning, *Tinea* **16**(suppl. 1): 102.

2019. *Heterolocha falconaria*; Dey *et al.*, *Spixiana*, **42**:52.

Material examined: GH01C (1 ex.), GH01D (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (3 ex.), GH05A (3 ex.), GH08A (1 ex.), GH09A (2 ex.): Moist Temperate Deciduous Forest (12/C1e); GH07A (2 ex.): Alder Forest (Riverine) (12/1S1); GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH15A (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH18A (1 ex.), GH20A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 36 mm.

Diagnosis: Ground colour deep orange-yellow; differs from *H. phoenicotaeniata* in having an oblique band narrower, with some dark spots on it near apex of forewing; dark spot above inner margin absent.

Male genitalia with furca arms asymmetrical, left one longer, curved, slender; right arm shorter, stout, more curved, a apical strong spine and some smaller subapical spines. Aedeagus with a lateral spine near apex; vesica unsclerotized.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal (Darjeeling) and Punjab. **Elsewhere:** Nepal.

107. *Heterolocha phoenicotaeniata* (Kollar, 1844)

(Habitus Plate No: 8.6 & Genitalia Plate No: 10.6)

1844. *Aspilates phoenicotaeniata* Kollar, *in Hugel, Kaschmir und das Reich Siek,* **4**: 487.

1894. *Heterolocha incolorata* Warren, *Novit. zool.* **1**(2): 449.

1895. *Heterolocha phoenicotaeniata*; Hampson, *Fauna Brit. India Moths,* **3:** 179.

1993. *Heterolocha phoenicotaeniata*; Holloway, *Moths of Borneo,* **11**: 37.

1992. *Heterolocha phoenicotaeniata*; Yazaki, *Tinea* **13**(suppl. 2): 39.

2017. *Heterolocha phoenicotaeniata*; Sanyal *et al.*; *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH01E (8 ex.), GH02B (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH06A (1 ex.): Moist Deodar Forest (12/C1c); GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH15A (10 ex.), GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a).

Wing expanse: 32 mm.

Diagnosis: Ground colour straw-yellow; forewing with costal basal area pinkish; antemedial band pink; both wings with a cell speck and a band from apex to inner margin beyond middle, expanding into a dark spot above inner margin. Hindwing with a postmedial band.

Male genitalia very similar with previous species but differs in having a pair of symmetrical furca arm instead of an asymmetrical one; ventral margin of valvae makes an acute angle just before apex.

Distribution: India: Kashmir, Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal and Arunachal Pradesh. **Elsewhere:** Pakistan, Nepal, Bhutan and Vietnam.

Genus: *Mimomiza* Warren, 1894

108. *Mimomiza cruentaria* (Moore, 1867)

(Habitus Plate No: 8.7 & Genitalia Plate No: 10.7)

1867. *Cimicodes cruentaria* Moore, *Proc. zool. Soc. Lond.*, : 616.

1895. *Heteromiza cruentaria*; Hampson, *Fauna Brit. India Moths,* **3:** 237.

2000. *Mimomiza cruentaria*; Stuning, *Tinea* **16**(suppl. 1): 100.

2019. *Mimomiza cruentaria*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 222.

Material examined: GH01A (2 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 46 mm.

Diagnosis: Ground colour yellowish, with grey or reddish-brown irroration; an oblique, double line from forewing apex to anal margin of hindwing before middle, beyond this line, the area is suffused with rufous; a roufous apical blotch with hyaline spot on it.

Male genitalia is very similar with *M. flavescens*, but differs in having symmetrical furca with long curved spines instead of spiral furca, without apical spine.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Kedarnath WLS), West Bengal, Arunachal Pradesh (Eaglenest WLS) and Meghalaya. **Elsewhere:** Nepal, Bhutan, Myanmar, China, Vietnam and Thailand.

109. *Mimomiza leucogonia* Hampson, 1895

(Habitus Plate No: 8.8 & Genitalia Plate No: 10.8)

1895. *Heteromiza leucogonia* Hampson, *Trans. Ent. Soc. Lond.,* :311.

1896. *Heteromiza leucogonia*; Hampson, *Fauna Brit. India Moths*, **4**: 554.

1992. *Pseudomiza leucogonia*; Yazaki, *Tinea* **13**(suppl. 2): 38.

2000. *Mimomiza leucogonia*; Stuning, *Tinea* **16**(suppl. 1): 100.

Material examined: GH12A (1 ex.), GH12B (2 ex.): Western Mixed Coniferous Forest (12/C1d).

Wing expanse: 48 mm.

Diagnosis: Very similar with previous species but differs in having rufous dorsal marks in abdomen; basal and inner area of forewing thickly spotted with rufous; an oblique, large spot from costa to lower angle of cell; postmedial oblique line absent; a greyish, large patch on costa just before apex, with silvery-white claviform mark on its lower edge.

Male genitalia is very similar with previous species but the furca with no apical spine.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP), Arunachal Pradesh (Sessa Orchid Sanctuary, Tenga Valley) and Meghalaya (Khasi). **Elsewhere:** Nepal.

Genus: *Plagodis* Hübner, [1823]

110. *Plagodis reticulata* Warren, 1893

(Habitus Plate No: 8.9 & Genitalia Plate No: 10.9)

1893. *Plagodes reticulata* Warren, *Proc. Zool. Soc. Lond.,* : 408.

1895. *Eurymene reticulata*; Hampson, *Fauna Brit. India Moths*, **3**: 178.

2008. *Plagodis reticulata*; Smetacek, *Bionotes,* **10**(1):5-15.

2017. *Plagodis reticulata*; Sanyal *et al.*; *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Plagodis reticulata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 224.

Material examined: GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d).

Wing expanse: 38 mm.

Diagnosis: Similar with *P. inustaria*, but differs in having head and collar pink; forewing without band and suffusion on margin; hindwing with uniform striation and no markings and slight trace of purple at anal margin.

Valvae long, apex narrow, broad at middle, ventral margin makes a inward curve just after middle, going towards apex; a pair of symmetrical furca; uncus long, slender, apically pointed, sclerotized; gnathos apically pointed, sclerotized; aedeagus with a series of long vesica spines.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind WLS), Sikkim and Arunachal Pradesh. **Elsewhere:** Pakistan, Nepal, Bhutan, China, Taiwan and Indonesia (Borneo).

Tribe: OURAPTERYGINI Bruand, 1846

Genus: *Artemidora* Meyrick, 1892

111. *Artemidora disistaria* (Walker, 1862)^

(Habitus Plate No: 8.10 & Genitalia Plate No: 10.10)

1862. *Aspilates disistaria* Walker, *List Spec. Lepid. Ins. Colln. Br. Mus.,* **24**: 1075.

1895. *Heterolocha disistaria*; Hampson, *Fauna Brit. India Moths,* **3:** 180.

2000. *Artemidora disistaria*; Stuning, *Tinea* **16**(suppl. 1): 101.

Material examined: GH05A (4 ex.): Moist Temperate Deciduous Forest (12/C1e); GH06A (3 ex.): Moist Deodar Forest (12/C1c); GH08B (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 30 mm.

Diagnosis: Very similar with *A. epicryta,* but differs in having smooth antemedial line instead of outwardly dentate one.

In male genitalia, this species is characterized by the apically bifurcated and more narrowly invaginated juxta.

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand. **Elsewhere:** Nepal.

Genus: *Leptomiza* Warren, 1893

112. *Leptomiza calcearia* (Walker, 1860)

(Habitus Plate No: 8.11 & Genitalia Plate No: 11.1)

1860. *Hyperythra calcearia* Walker, *List Spec. Lepid. Insects Colln Br. Mus*. **20**: 132.

1895. *Leptomiza calcearia*; Hampson, *Fauna Brit. India Moths,* **3:** 180.

2016. *Leptomiza calcearia*; Sondhi & Sondhi, *Journal of Threatened Taxa,* **8**(5): 8768.

Material examined: GH01C (2 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 30 mm.

Diagnosis: Very similar with *L. dentilinea,* but differs in having forewing termen deeply incurved twice and dentate on M_3 and M_1; discoidal spot large, round, yellowish.

Male genitalia also similar with *dentilinea,* but differs in valvae being narrower, longer, with a pair of small, globular processes at base; aedeagus vesica with basal spine longer.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal (Darjeeling), Arunachal Pradesh (Eaglenest WLS) and Assam. **Elsewhere:** Nepal, Bhutan, Myanmar, China and Taiwan.

Genus: *Opisthograptis* Hübner, [1823]

113. *Opisthograptis luteolata* (Linnaeus, 1758)

(Habitus Plate No: 8.12 & Genitalia Plate No: 11.2)

1758. *Phalaena luteolata* Linnaeus, *Syst. Nat.*, (Edn 10) **1**: 525.

1761. *Phalaena crataegata* Linnaeus, *Fauna Suecica* (Edn 2): 336.

1908. *Opisthograptis luteolata flavissima* Krulikowsky, *Soc. Ent.* **23**(2): 12.

2017. *Opisthograptis luteolata*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Opisthograptis luteolata*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 223.

Material examined: GH01G (1 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH14B (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH18A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 40 mm.

Diagnosis: Ground colour bright sulphur-yellow; basal rufous patch on costa of forewing; antemedial double costal spots with grey waved lines from them to inner margin, a rufous spot between them. Hindwing with oblique, waved medial and curved, sinuous postmedial line.

Valvae simple, apex narrow, basally broad; uncus long, slender, apically round, not pointed, sclerotized; gnathos apically pointed, sclerotized; aedeagus apically pointed, sclerotized.

Distribution: India: Kashmir, Himachal Pradesh (GHNP) and Uttarakhand (Nanda Devi Biosphere Reserve). **Elsewhere:** Pakistan, Kyrgyzstan, Russia, Iran, Turkey, Syria, Georgia, United Kingdom, Germany, Italy, France, Spain, Norway, Netherland, Austria, Poland, Finland and Labanon.

114. *Opisthograptis moelleri* Warren, 1893

(Habitus Plate No: 8.13 & Genitalia Plate No: 11.3)

1893. *Opisthograptis moelleri* Warren, *Proc. zool. Soc. Lond.,* (2): 403.

1895. *Rumia moelleri*; Hampson, *Fauna Brit. India Moths,* **3:** 184.

2019. *Opisthograptis moelleri*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 223.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 54 mm.

Diagnosis: Forewing with traces of two waved, grey antemedial lines; a tridentate, chocolate, large spot from costa to lower angle of cell; an oblique, very indistinct line from a brown speck on costa near apex of forewing to middle of inner margin of hindwing; a crenulated, indistinct postmedial line on hindwing.

Male genitalia is very similar with previous species but differs in having gnathos less sclerotized, not pointed apically; uncus shorter, not medially narrow.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP), Uttarakhand, Sikkim, West Bengal and Arunachal Pradesh. **Elsewhere:** Nepal, Bhutan, Myanmar, China, Taiwan and Vietnam.

115. *Opisthograptis tridentifera* (Moore, 1888)^

(Habitus Plate No: 8.14 & Genitalia Plate No: 11.4)

1888. *Rumia tridentifera* Moore, *Descr. Ind. Lep. Atk.*, : 230.

1895. *Rumia tridentifera*; Hampson, *Fauna Brit. India. Moths*, **3**: 184.

1915. *Opisthograptis tridentifera*; Seitz, *Macro Lep.*, b: 339.

1994. *Opisthograptis tridentifera*; Yazaki, *Tinea* **14** (suppl. 1): 28.

1997. *Opisthograptis tridentifera*; Mandal & Ghosh, *Fauna of West Bengal,* **7**: 491-532.

2017. *Opisthograptis tridentifera*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Opisthograptis tridentifera*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 223.

Material examined: GH27A (2 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 50 mm.

Diagnosis: Closely related to *O. luteolata*, but differs in having rufous suffusion in shoulder; fuscous irroration of forewing much reduced; costa rufous; sinuous lines very indistinct and only represented by series of red and dark specks; broader red patch at end of cell.

Male genitalia also similar with *luteolata,* but gnathos is not apically pointed, rather roundish with small bristles; uncus slightly longer and valvae also longer.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind WLS), Sikkim, West Bengal (Darjeeling) and Arunachal Pradesh. **Elsewhere:** Nepal, Bhutan, China and Tibet.

Genus: *Ourapteryx* Leach, 1814

116. *Ourapteryx caschmirensis* Bastelberger, 1911

(Habitus Plate No: 8.15 & Genitalia Plate No: 11.5)

1911. *Urapteryx caschmirensis* Bastelberger, *Int. ent. Z.*, **5**: 157.

1915. *Ourapteryx ebuleata caschmirensis*; Prout, *in Seitz, Macrolepid. World.*, **4**: 335.

1935. *Ourapteryx caschmirensis*; Wehrli, *ibid.* (Suppl.): 354.

1994. *Ourapteryx caschmirensis*; Stuning, *Nachr. entomol. Ver. Apollo, Frankfurt/Main, N.F.*, **15**(1/2): 115.

1995. *Ourapteryx caschmirensis*; Inoue, *Tinea* **14**(suppl. 2): 126.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 59 mm.

Diagnosis: Similar with *O. ebuleata,* but larger, pure white, sometime yellowish in the area close to the tail of hindwing; less striated in the area close to forewing costa; transverse line broad, grey; hindwing tail broad at base, tip rounded; 1st basal spot of tail large, red, edged with black interiorly; 2nd spot smaller, black, not connected with 1st with grey band; fringes in forewing orange-yellow and hindwing reddish.

Male genitalia characterized by the strongly inwardly curved furca at apex.

Distribution: India: Kashmir (Srinagar, Bandipur), Himachal Pradesh (Shimla, GHNP), West Bengal (Kurseong) and Sikkim (Lachung). **Elsewhere:** Nepal and Pakistan.

117. *Ourapteryx chrisbahri* Stuning, 2000#

(Habitus Plate No: 9.1 & Genitalia Plate No: 11.6)

2000. *Ourapteryx chrisbahri* Stuning, *Tinea* **16**(suppl. 1): 107.

Material examined: GH03B (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 46 mm.

Diagnosis: Closely related to *O. contronivea*, but can be characterized by narrower transverse lines, less striated wings and hindwing tail narrower and shorter.

Male genitalia characterized by shorter uncus; medial dentate plate of gnathos much wider; furca gently curved, slightly thickened apically.

Distribution: India: Himachal Pradesh (GHNP) and West Bengal (Darjeeling). **Elsewhere:** Nepal.

118. *Ourapteryx ebuleata* (Guenée [1858])

(Habitus Plate No: 9.2 & Genitalia Plate No: 11.7)

1858. *Urapteryx ebuleata* Guenée, *Spec. Gen.* **9**: 32.

1895. *Urapteryx ebuleata*; Hampson, *Fauna Brit. India Moths,* **3**: 145.

1900. *Ourapteryx ebuleata*; Swinhoe, *Cat. Lep. Pxf. Mus.*: 2318.

1994. *Ourapteryx ebuleata*; Stuning, *Nachr. entomol. Ver. Apollo, Frankfurt/Main, N.F.*, **15**(1/2): 111.

1995. *Ourapteryx ebuleata*; Inoue, *Tinea* **14**(suppl. 2): 128.

2008. *Ourapteryx ebuleata*; Smetacek, *Bionotes,* **10**(1):5-15.

2017. *Ourapteryx ebuleata*; Sanyal *et al.*; *SHILAP Revta. lepid.*, **45**(177): 159.

2019. *Ourapteryx ebuleata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 224.

Material examined: GH01C (2 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH05A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH08A (1 ex.), GH11A (2 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 55 mm.

Diagnosis: Forewing ground colour greyish-yellow to greyish-brown, hindwing pale ochreous; discoidal streak of forewing very faint; hingwing tail with shoulder; 1st basal spot of tail red, black-circled and 2nd one black, not connected by greyish band.

Male genitalia characterized by long, slender, recurved distal part of the furca and the long, triangular, sclerotized vesica plate.

Distribution: India: Kashmir, Himachal Pradesh (Shimla, GHNP), Uttarakhand (Govind WLS, Gangotri NP), Sikkim, West Bengal, Arunachal Pradesh, Meghalaya, Maharashtra and Tamil Nadu. **Elsewhere:** Pakistan, Nepal, Bhutan, Myanmar, China and Kyrgyzstan.

119. *Ourapteryx kantalaria* (Felder & Rogenhofer, 1875)^

(Habitus Plate No: 9.3 & Genitalia Plate No: 11.8)

1875. *Urapteryx kantalaria* Felder & Rogenhofer, *Reise ost. Fregatte Novara (Zool.)* **2**(Abt. 2): pl. 122, fig. 3.

1995. *Ourapteryx kantalaria*; Inoue, *Tinea* **14**(suppl. 2): 125.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH21A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 46 mm.

Diagnosis: Similar with *O. purissima,* but larger, forewing less elongated; two basal spots of hindwing tail more reduced, dorsal one red-edged grey dash, ventral one almost vanished.

Male genitalia is characterized by furca not strongly curved like *purissima.*

Distribution: India: Kashmir (Gilgit) and Himachal Pradesh (GHNP). **Elsewhere:** Nepal.

120. *Ourapteryx leucopteron* Inoue, 1995#

(Habitus Plate No: 9.4 & Genitalia Plate No: 11.9)

1995. *Ourapteryx leucopteron* Inoue, *Tinea* **14**(suppl. 2): 129.

Material examined: GH15A (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH21A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH27A (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 46 mm.

Diagnosis: Very similar to *O. kantalaria* and *nakajimai,* but wings shorter and broader, vertex ochreous-brown; forewing costa strongly arched near apex, termen gently excurved, tornus round; fringe more ochreous.

Male genitalia with furca slender, strongly incurved around middle of gnathos-arm.

Distribution: India: Himachal Pradesh (GHNP) and Sikkim. **Elsewhere:** Nepal.

121. *Ourapteryx multistrigaria* (Walker, 1866)

(Habitus Plate No: 9.5 & Genitalia Plate No: 11.10)

1866. *Urapteryx multistrigaria* Walker, *List Spec. Lepid. Insects Colln Br. Mus.*, **35**: 1535.

1994. *Ourapteryx multistrigaria*; Stüning, *Nachr. Ent. Ver. Apollo NF.,* **15**(1/2): 122.

Material examined: GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 52 mm.

Diagnosis: Very similar to *O. ebuleata*, but surface of the wings slightly shining; grey-scaled band connects the basal spots at hindwing tail.

Male gentalia differs mainly from congeners by the shape of furca being straight, and with cornuti smaller, largest one having no lateral branches.

Distribution: India: Himachal Pradesh (Kullu, Shimla, GHNP) and Uttarakhand (Mussoorie, Bhimtal). **Elsewhere:** Pakistan and Nepal.

122. *Ourapteryx nepalensis* Inoue, 1995

(Habitus Plate No: 9.6 & Genitalia Plate No: 12.1)

1995. *Ourapteryx nepalensis* Inoue, *Tinea* **14**(suppl. 2): 129.

Material examined: GH01C (2 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 50 mm.

Diagnosis: Very similar to *O. contronivea*, but strigulation of wings weaker; hindwing tail longer and robust, two basal spots of hindwing tail connected by dark greyish dash.

Male genitalia with furca much thicker and shorter, atrongly downcurved at apex.

Distribution: **India:** Himachal Pradesh (Shimla, GHNP), Uttarakhand (Mussoorie, Bhimtal), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Nepal and Thailand.

123. *Ourapteryx purissima* (Thierry-Mieg, 1905)*

(Habitus Plate No: 9.7 & Genitalia Plate No: 12.2)

1905. *Ourapteryx multistrigaria purissima* Thierry-Mieg, *Le Naturaliste* **27**(442): 181.

1915. *Ourapteryx purissima*; Prout, *in Seitz, Macrolep.*, **4**: 335.

Material examined: GH01G (2 ex.), GH02A (2 ex.), GH03A (2 ex.), GH03C (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 48 mm.

Diagnosis: see *O. kantalaria*

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Kyrgyzstan.

124. *Ourapteryx yerburii* (Butler, 1886)^

(Habitus Plate No: 9.8 & Genitalia Plate No: 12.3)

1886. *Urapteryx yerburii* Butler, *Proc. zool. Soc. Lond.*, (3): 388.

1915. *Ourapteryx ebuleata ab. yerburii*; Prout, *in Seitz, Macrolepid. World*, **4**: 335.

1940. *Ourapteryx sinata* Wehrli, *in Seitz, Macrolepid. World*, **4**: 352.

1981. *Ourapteryx ebuleata szechuana*; Chu *et al.*, *Icon Heteroc. Sinica.,* **1**: 125.

1993. *Ourapteryx yerburii*; Inoue, *Tyo Ga,* **44**: 107.

1995. *Ourapteryx yerburii yerburii*; Inoue, *Tinea,* **14**(suppl. 2): 132.

Material examined: GH01C (4 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 48 mm.

Diagnosis: This species is characterized by transverse line of forewing approaching each other at innermargin; antemedial line slightly S-shaped, postmedial line slightly concave, outwardly directed after CuA_1; basal spots of hindwing tail heavy, dorsal one red-black, ventral one pure black, not connected; striae at submarginal area of hindwing coalescent.

Male genitalia characterized by broad furca, curved inward at apex, reaching a little above the tip of gnathos.

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand (Bhimtal). **Elsewhere:** Pakistan, Nepal and China.

Tribe: ENNOMINI Duponchel, 1845

Genus: *Eilicrinia* Hübner, [1823]

125. *Eilicrinia cordiaria signigera* Butler, 1889

(Habitus Plate No: 9.9 & Genitalia Plate No: 12.4)

1889. *Eilicrinia signigera* Butler, *Ill. Spec. Lep. Het. Coll. Brit. Mus.,*: 112.

Material examined: GH04B (2 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 36 mm.

Diagnosis: Ground colour pale grey, irrorated with fuscous; traces of curved antemedial line in forewing; a large red-brown patch on cell; postmedial line indistinct, oblique, sinuous, and arising from a brown spot on costa.

Valvae apically broad, costal margin sclerotized, ventral margin froms an angle at apex; uncus long, slender, apically pointed; aedeagus long, slender, with a buch of vesica spines.

Distribution: India: Himachal Pradesh (Dharamsala, Kullu, GHNP).

Tribe: PLUTODINI Warren, 1894

Genus: *Plutodes* Guenée, 1857

126. *Plutodes warreni* Prout, 1923

(Habitus Plate No: 9.10 & Genitalia Plate No: 12.5)

1923. *Plutodes warreni* Prout, *A.M.N.H.,* **11**(9): 322.

2019. *Plutodes warreni*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 225.

Material examined: GH01A (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 38 mm.

Diagnosis: Very similar with *P. costatus,* but smaller, antennal pectinations shorter; ground colour paler; antemedial triangular area larger and with antemedian line from its inner side; postmedial triangle narrower; hindwing with apical patch bordered by a sinuous dark line; underside more weakly marked, central line of forewing obsolete.

Valve very long, apically broad, costal margin sclerotized, saccular process with two finger like spines, one short at base and another longer; uncus long, slender, apically pointed, sclerotized; gnathos ring like.

Distribution: India: Himachal Pradesh (GHNP), Sikkim, Arunachal Pradesh and Meghalaya. **Elsewhere:** Myanmar, China, Vietnam, Laos and Vietnam.

Tribe: THINOPTERYGINI Holloway, 1994

Genus: *Thinopteryx* Butler, 1883

127. *Thinopteryx crocoptera* (Kollar, 1844)

(Habitus Plate No: 9.11 & Genitalia Plate No: 12.6)

1844. *Urapteryx crocoptera* Kollar, *in Hügel, Kaschmir und das Reich der Siek.,* **4**: 483.

1916. *Thinopteryx crocopterata[sic] padanga* Swinhoe, *Ann. Mag. Nat. Hist.,* **18**(108): 487.

1916. *Thinopteryx crocopterata[sic] assamensis* Swinhoe, *Ann. Mag. Nat. Hist.,* **18**(108): 487.

1993. *Thinopteryx crocopterata[sic, recte crocoptera]*, Holloway, *Moths of Borneo*, **11**: 108.

2019. *Thinopteryx crocoptera*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 226.

Material examined: GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 70 mm.

Diagnosis: Ground colour orange-yellow; costa of forewing white, irrorated with fuscous; antemedial and postmedial slightly curved, oblique, fuscous lines; a fuscous line on cell; submarginal line lunulate, indistinct towards costa; hindwing with double submarginal line angled at the tail base; a fuscous patch on tail.

Valvae very long, slender, narrow at apex, tip rounded, costal margin strongly sclerotized and with a strong ventral-facing spine at middle, ventral margin irregularly dentate.

Distribution: India: Khasmir, Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal, Arunachal Pradesh, Assam, Meghalaya and Andaman Island. **Elsewhere:** Pakistan, Nepal, Bhutan, Bangladesh, China, Taiwan, Hong Kong, Vietnam, Malaysia, Indonesia (Java, Sumatra), Japan, Korea and Russia.

Tribe: GONODONTINI Forbes, 1948

Genus: *Odontopera* Stephens, 1831

128. *Odontopera bilinearia* (Swinhoe, 1889)

(Habitus Plate No: 9.12 & Genitalia Plate No: 12.7)

1889. *Crocallis bilinearia* Swinhoe, *Proc. Zool. Soc. Lond.,* :423.

1992. *Odontopera bilinearia bilinearia*; Yazaki, *Tinea* **13**(suppl. 2): 36.

Material examined: GH20A (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 53 mm.

Diagnosis: Ground colour fawn-yellow, with thick irroration of black atoms; forewing cell-spot black, white-centered; antemdial line brown, erect, indistinct, outwardly curved; postmedial line brown, indistinct, edged outwardly with white, recurved in forewing and slightly wavy in hindwing; hindwing slightly paler; a reddish-brown, marginal line.

Valvae long, apically pointed, costal margin strongly sclerotized with an slight apical protrusion, ventral margin smooth; a pair of long, slender, sclerotized, apically-pointed furca; uncus long, slender, apically pointed; gnathos apically long, slender, sclerotized; aedeagus with apical bunch of strong spines at dorsal ridge and with a bunch of long vesica spines.

Distribution: India: Himachal Pradesh (Kullu, GHNP), Sikkim and Arunachal Pradesh (Eaglenest WLS). **Elsewhere:** Nepal, Bhutan, China and Taiwan.

129. *Odontopera heydena* (Swinhoe, 1894)^

(Habitus Plate No: 9.13 & Genitalia Plate No: 12.8)

1894. *Crocallis heydena*; Swinhoe, *Trans. Ent. Soc. Lond.*, : 203.

1994. *Odontopera heydena*; Yazaki, *Tinea* **14**(suppl. 1): 27.

2017. *Odontopera heydena*; Sanyal *et al.*; *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Odontopera heydena*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 223.

Material examined: GH03B (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 44 mm.

Diagnosis: Ground colour ochreous-grey, with dense irroration of brown scales; similar with previous species but antemedial band outwardly curved and straight postmedial line, slightly curved at middle.

Male genitalia differs from previous species by the gnathos apically longer and pointed; aedeagus with less spines at dorsal apical ridge and vesica with spines shorter and less denser.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind WLS), Arunachal Pradesh (Eaglenest WLS) and Meghalaya (Khasi). **Elsewhere:** Nepal and Bhutan.

130. *Odontopera kametaria* (Felder & Rogenhofer, 1875)

(Habitus Plate No: 9.14 & Genitalia Plate No: 12.9)

1893. *Crocallis kametaria* Felder & Rogenhofer, *Reis Nov.*, **23**: 28.

1895. *Crocallis kametaria*; Hampson, *Fauna Brit. India Moths,* **3**: 233.

1998. *Odontopera kametaria*; Yazaki, *Tinea* **15**(suppl. 1): 14.

2017. *Odontopera kametaria*; Sanyal *et al.*; *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Odontopera kametaria*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 223.

Material examined: GH01A (1 ex.), GH01B (2 ex.), GH01C (2 ex.), GH01E (6 ex.): Himalayan Chir Pine Forest (9/C1b); GH04A (1 ex.), GH04B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH06A (1 ex.): Moist Deodar Forest (12/C1c); GH07A (3 ex.): Alder Forest (Riverine) (12/1S1); GH14B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 38 mm.

Diagnosis: Ground colour fulvous-yellow; forewing costa fulvous; medial band fulvous, widest at costa, narrow at middle; outer area with fulvous irroration; hindwing pale, medial band indistinct, oblique, fulvous.

Male genitalia differs from previous two species by valvae apex being rounded, costal margin of valvae less sclerotized and without any apical protusion; uncus longer, broader; gnathos much longer apically, and more curved.

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand (Govind WLS, Nanda Devi Biosphere Reserve). **Elsewhere:** Pakistan and Nepal.

131. *Odontopera kanchai* Yazaki, 1994*

(Habitus Plate No: 9.15 & Genitalia Plate No: 12.10)

1994. *Odontopera kanchai*; Yazaki, *Tinea* **14**(suppl. 1): 32.

Material examined: GH01C (1 ex.), GH01G (1 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 34 mm.

Diagnosis: Similar with *O. veneris,* but smaller, forewing ochreous-brown but paler; hindwing postmedial line rufous-brown instead of fuscous-brown.

Valvae asymmetrical, right one elongated but left one much shorter, truncate at apex; caudal process of juxta shorter.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal.

132. *Odontopera lentiginosaria* (Moore, 1867)

(Habitus Plate No: 10.1 & Genitalia Plate No: 13.1)

1867. *Crocalis lentiginosaria* Moore, *Proc. Zool. Soc. Lond.,* :622.

1895. *Odontopera lentiginosaria*; Hampson, *Fauna Brit. India Moths*, **3**: 231.

2005. *Odontopera lentiginosaria*; Walia, *Fauna of West. Himalaya,* **2**: 181.

2017. *Odontopera lentiginosaria*; Sanyal *et al.*; *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Odontopera lentiginosaria*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 223.

Material examined: GH15A (4 ex.), GH19B (5 ex.): Low-Level Blue Pine Forest (12/2S1); GH20A (5 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH24A (5 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH25B (1 ex.): Dwarf Rhododendron Scrub (15/C2/E1); GH26A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a).

Wing expanse: 56 mm.

Diagnosis: Similar with *O. bilinearia,* but ground colour ochreous-brown with fuscous irroration; ante and postmedial line indistinct and approaches each other at inner margin; hindwing postmedial line indistinct; outer margin of forewing angled at M_3.

Valave apically pointed and with costal margin strongly sclerotized, with a pointed protrusion at apex and also with a backwardly pointed flap-like process; fucra symmetrical, short but pointed apically and slightly curved; uncus long, apically narrow, not pointed, blunt at tip; aedeagus similar with *bilinearia.*

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind WLS), Sikkim, West Bengal and Meghalaya.

133. *Odontopera obliquaria* (Moore, 1868)

(Habitus Plate No: 10.2 & Genitalia Plate No: 13.2)

1867. *Crocalis obliquaria* Moore, *Proc. Zool.Soc. Lond.,* :622.

1888. *Crocalis obliquaria*; Cotes & Swinhoe, *Cat. Moths India,* : 3170.

1895. *Odontopera obliquaria*; Hampson, *Fauna Brit. India Moths*, **3**: 232.

2005. *Odontopera obliquaria*; Walia, *Fauna of West. Himalaya,* **2**: 181-190.

2017. *Odontopera obliquaria*; Sanyal *et al.*; *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Odontopera obliquaria*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 223.

Material examined: GH01C (2 ex.), GH01E (1 ex.), GH03A (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH05A (3 ex.), GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH10A (1 ex.): Moist Deodar Forest (12/C1c); GH20A (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH22B (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27A (3 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 54 mm.

Diagnosis: Differs from the previous species by the prominent postmedial line and paler outer area; margin crenulated.

Male genitalia characterized by costal process just before apex and gnathos very long and curved, pointed.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, West Bengal, Arunachal Pradesh and Meghalaya. **Elsewhere:** Nepal and Japan.

134. *Odontopera similaria* (Moore, 1888)[#]

(Habitus Plate No: 10.3 & Genitalia Plate No: 13.3)

1888. *Crocallis similaria* Moore, *Descr. Ind. Lep. Atk.,*: 227.

1994. *Odontopera similaria*; Yazaki, *Tinea* **14**(suppl. 1): 27.

2013. *Odontopera similaria*; Chandra & Sambath, *Journal of Threatened Taxa,* **5**(1): 3567.

2019. *Odontopera similaria*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 223.

Material examined: GH02B (2 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 44 mm.

Diagnosis: Very similar with *O. lentiginosaria,* but smaller, wings darker; transverse lines with more prominent white points; hindwing with a white-centred black cell-spot and a slightly sinuous, blackish medial line.

Male genitalia differs from *lentiginosaria* by having a bifurcated broad subapical costal process of valvae and fuca longer, broader, more curved.

Distribution: India: Himachal Pradesh (GHNP), West Bengal and Arunachal Pradesh (Tawang). **Elsewhere:** Nepal and Bhutan.

Tribe ABRAXINI Warren, 1893

Genus *Abraxas* Leach, [1815]

135. *Abraxas leopardina* (Kollar, [1844])

(Habitus Plate No: 10.4 & Genitalia Plate No: 13.4)

1844. *Zerene leopardina* Kollar; in Hügel, *Kaschmir und das Reich der Siek* **4**: 490

1970. *Abraxas (Calospilos) aphorista*; Inoue, *Spec. Bull. lepid. Soc. Japan* (4): 208

1995. *Abraxas (Calospilos) leopardina*; Inoue, *Tinea* **14** (suppl. 2): 124, pl. 121, f. 9-10

2012. *Abraxas leopardina*; Kirti, Kaur & Goyal, *Indian Journal of Entomology*, **73**(4): 303.

Material examined: GH01G (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH05A (4 ex.): Moist Temperate Deciduous Forest (12/C1e); GH07A (1 ex.): Alder Forest (Riverine) (12/1S1); GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH20A (3 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH21B (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 52 mm.

Diagnosis: This species is characterized by the golden tornal patch, which is extended on the postmedial line upto M_3 and above which, it is represented by three golden-brown dots; marginal greyish lunules of hindwing upto M_2.

Valvae broad, ventral margin straight with two triangular spines at middle and makes an acute angle with convexity reaching valvae apex; valvae apex pointed and with a serrated ventral process originating from that; harpe long, slender, apically pointed; aedeagus with an apical spine at dorsal ridge.

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand (Mussouri).

Elsewhere: Nepal.

136. *Abraxas neomartaria* Inoue, 1970#

(Habitus Plate No: 10.5 & Genitalia Plate No: 13.5)

1970. *Abraxas (Calospilos) neomartaria* Inoue; *Spec. Bull. lepid. Soc. Japan* (4): 207; TL: Kambachen, 3950m

1995. *Abraxas (Calospilos) neomartaria*; Inoue, *Tinea* **14** (suppl. 2): 124, pl. 7, f. 3, pl. 121, f. 7-8

2013. *Abraxas neomartaria*; Chandra & Sambath, *Journal of Threatened Taxa,* **5**(1): 3567.

Material examined: GH02A (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 52 mm.

Diagnosis: Very similar with *A. martaria,* but differs in the ground colour being leaden grey instead of pale grey; outer edge of median grey-contaminated area straight instead of ingressed with white at CuA_2.

In male genitalia of *neomartaria*, the ventral margin of valve possesses larger subapical row of sclerotized teeth than that of *martaria*. Also, the apical hook of the dorsal arm of bifurcated valvae is much more acute and pronounced in *neomartaria*.

Distribution: India: Himachal Pradesh (GHNP), Sikkim, West Bengal (Darjeeling) and Arunachal Pradesh (Tawang). **Elsewhere:** Nepal.

137. *Abraxas peregrina* Inoue, 1995^

(Habitus Plate No: 10.6 & Genitalia Plate No: 13.6)

1995. *Abraxas (Calospilos) peregrina* Inoue; *Tinea* **14** (suppl. 2): 123, pl. 120, f. 15-16; TL: Godavari, 1600m

2017. *Abraxas peregrina*; Sanyal *et al.*; *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH01D (3 ex.), GH01G (2 ex.), GH01H (1 ex.), GH03C (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 44 mm.

Diagnosis: This species is characterized by most white wings with least markings; median blotch of forewing narrow, containing the white discocellular, scarcely connected with costal small blotch; marginal series of specks in hindwing between CuA_1 to M_2.

Harpe with dorsal margin gently downcurved, strongly produced into a spine-like process, apex truncate; outer margin deeply incurved, angled at ventral end.

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand (Bhimtal, Govind Wildlife Sanctuary). **Elsewhere:** Nepal and Thailand.

138. *Abraxas picaria* Moore, [1868]

(Habitus Plate No: 10.7 & Genitalia Plate No: 13.7)

1867. *Abraxas picaria* Moore; *Proc. zool. Soc. Lond.*: 652; TL: Bengal

1893. *Abraxas semilugens* Warren; *Proc. zool. Soc. Lond.* (2): 393.

1895. *Abraxas picaria*; Hampson, *Fauna Brit. India Moths.*, **3**: 301.

1995. *Abraxas (Abraxas) picaria*; Inoue, *Tinea* **14**(suppl. 2): 119.

2017. *Abraxas picaria*; Sanyal *et al.*; *SHILAP Revta. Lipid.,* **45**(177): 157.

Material examined: GH08A (3 ex.), GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH10A (1 ex.): Moist Deodar Forest (12/C1c); GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH14B (2 ex.): Low-Level Blue Pine Forest (12/2S1); GH17A (2 ex.), GH21B (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 40 mm.

Diagnosis: Recurved postmedial band of forewing forming a Y near costa; almost complete, double-maculate postmedial yellow band on hindwing, marked by black on both edges; this line reaching the innermargin of hindwing at the tornal angle; yellow postmedial line is complete on underside of hindwing.

Male genitalia is very similar with *superpicaria* but differs in having valvae apex truncated instead of pointed, curved with a sclerotized spine.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind Wildlife Sanctuary, Nanda Devi Biosphere Reserve), Sikkim and West Bengal. **Elsewhere:** Nepal.

139. *Abraxas superpicaria* Inoue, 1970#

(Habitus Plate No: 10.8 & Genitalia Plate No: 13.8)

1970. *Abraxas (Abraxas) superpicaria* Inoue; *Spec. Bull. lepid. Soc. Japan* (4): 204; TL: Nepal, 2450m

1995. *Abraxas (Abraxas) superpicaria*; Inoue, *Tinea* **14**(suppl. 2): 119, pl. 119, f. 7-9

2019. *Abraxas superpicaria*; Dey *et al., Spixiana*, **42**:52.

Material examined: GH01G (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH11A (5 ex.): Moist Temperate Deciduous Forest (12/C1e); GH27A (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 40 mm.

Diagnosis: Very similar with previous species but differs in having postmedial band of forewing not recurved, reaching the inner margin less obliquely; hindwing postmedial line not marked with yellow and reaching inner margin well above the tornus and more angular at middle and area beyond that more densely striated with fuscous.

Male genitalia discussed in previous species.

Distribution: India: Himachal Pradesh (GHNP), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Nepal and Bhutan.

Genus: *Ligdia* Guenée, 1857

140. *Ligdia coctata* Guenée, 1857

(Habitus Plate No: 10.9 & Genitalia Plate No: 13.9)

1857. *Ligdia coctata* Guenée, *in* Boisduval & Guenee, *Hist. nat. Insectes* (Spec. gen. Lepid.), **10**: 210.

1993. *Ligdia coctata*; Yazaki, *Tinea* **13**(suppl. 3): 112.

2019. *Ligdia coctata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 221.

Material examined: GH04A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 30 mm.

Diagnosis: Wings yellowish-white; basal area of forewing white, with leaden irroration, narrowing to inner margin; medial series of specks; a brown postmedial band, diffused outwards to the margin except apex, its inner edge sinuous with a leaden line; submarginal line white.

Valvae with apex pointed, saccular process makes a thumb like structure at tip, joined with valvae apex with a narrow invagination; herpe long, slender, outwardly bent; uncus triangular, sclerotized, apically elongated, tip rounded; aedeagus with an apical spine at the dorsal edge and with three long vesica spines.

Distribution: India: Himachal Pradesh (Chamba, GHNP), Uttarakhand, Punjab and Madhya Pradesh. **Elsewhere:** Pakistan, Nepal, Kyrgyzstan, Uzbekistan, Tajikistan and Bulgaria.

Tribe: CASSYMINI Holloway, 1994

Genus: *Hydatocapnia* Warren, 1895

141. *Hydatocapnia marginata* (Warren, 1893)

(Habitus Plate No: 10.10)

1893. *Zamarada marginata* Warren, *Proc. zool. Soc. Lond.* (2): 388.

1895. *Stegania marginata*; Hampson, *Fauna Brit. India Moths,* **3:** 164.

1993. *Hydatocapnia marginata*; Yazaki, *Tinea* **13**(suppl. 3): 112.

Material examined: GH07A (1 ex.): Alder Forest (Riverine) (12/1S1).

Wing expanse: 28 mm.

Diagnosis: Forewing ground colour ochreous, with thick rufous irroration, base and costa brown; cell-spot rufous; a dark line from costa before apex excurved near outer margin and curved inward near inner margin, beyond this area is brown; hindwing with a double brown marginal line.

Distribution: India: Himachal Pradesh (Shimla, GHNP), Uttarakhand, Sikkim, Meghalaya (Khasi) and Nagaland. **Elsewhere:** Nepal.

Genus: *Peratophyga* Warren, 1894

142. *Peratophyga hyalinata* (Kollar, 1844)

(Habitus Plate No: 10.11 & Genitalia Plate No: 13.10)

1844. *Idaea hyalinata* Kollar, *in Hügel, Kaschmir und das Reich der Siek,* **4**: 491.

1868. *Acidalia aerata* Moore, *Proc. zool. Soc. Lond.,*: 643.

1966. *Zamarada ionephela* Wiltshire, *Z. wien. ent. Ges.*, **51**(9–11): 148.

1939. *Peratophyga hyalinata*; Wehrli, *in* Seitz, *Gross-Schmett.*, **4**(Suppl.): 293.

2009. *Peratophyga hyalinata*; Kirti *et al., Journal of Threatened Taxa*, **1**(9): 485.

2012. *Peratophyga hyalinata*; Jiang *et al., Zootaxa*, **3478**(1): 405.

2019. *Peratophyga hyalinata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 224.

Material examined: GH01E (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH06A (2 ex.), GH10A (1 ex.): Moist Deodar Forest (12/C1c).

Wing expanse: 27 mm.

Diagnosis: Very similar with *P.grata,* but can be distinguished by the more indistinct discal spot of forewing; medial line of each wing wavy; greyish-brown band outside the postmedial line of both wings narrower.

In male genitalia, ventral lobe of valvae is broad, triangular and with apex pointed; aedeagus with a single, basal cornutus on vesica.

Distribution: India: Himachal Pradesh (Shimla, Nauni, Sabathu, GHNP), Uttarakhand, West Bengal (Darjeeling) and Meghalaya (Khasi). **Elsewhere:** Afghanistan, Nepal, Bhutan, China, Tibet, Myanmar, Vietnam and Japan.

Tribe: EUTOEINI Holloway, 1994

Genus: *Luxiaria* Walker, 1860

143. *Luxiaria amasa* (Butler, 1878)

(Habitus Plate No: 10.12 & Genitalia Plate No: 14.1)

1878. *Bithia amasa* Butler, *Ann. Mag. Nat. Hist.*, **1**(5): 405.

1888. *Luxiaria fasciosa* Moore, *Descr. Indian lep. Atkinson,* (3): 254.

1928. *Luxiaria amasa noda* Prout, *Bull. Hill Mus.,* **2**: 250.

1894. *Luxiaria fulvifascia* Warren, *Novit. zool.* **1**(2): 440.

1976. *Luxiaria amasa*; Holloway, *Moths of Borneo with special reference to Mt. Kinabalu,*: 78.

1993. *Luxiaria amasa*; Holloway, *Moths of Borneo,* **11**: 151.

2014. *Luxiaria amasa*; Jiang *et al., Zootaxa,* **3856**(1): 73.

2019. *Luxiaria amasa*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 222.

Material examined: GH05A (3 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 38 mm.

Diagnosis: Externally very similar with *L. mitorrhaphes* and *L. acutaria*, but can be distinguished by a small protusion in the outer margin at end of M_3 of female; the dark band beyond postmedial line of each wings are reddish-brown instead of greyish; the area beyond the submarginal line, especially below M_1 and apex of hindwing suffused with reddish-brown scales.

Male genitalia is similar with *L. mitorrhaphes*, but can be distinguished by presence of triangular lobes on juxta and a short finger-like process of aedeagus and shorter cornutus.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, West Bengal, Arunachal Pradesh and Mizoram. **Elsewhere:** Nepal, Bhutan, China, Tibet, Taiwan, Vietnam, Malaysia, Indonesia (Sumatra, Borneo, Java), Japan, Korea and Russia.

Tribe: MACARIINI Guenée, 1858

Genus: *Chiasmia* Hübner, [1823]

144. *Chiasmia azataria* (Swinhoe, 1893)

(Habitus Plate No: 10.13 & Genitalia Plate No: 14.1)

1893. *Gonodela azataria* Swinhoe, *Ann. Mag. Nat. Hist.,* **12**(6): 154.

1895. *Macaria azataria*; Hampson, *Fauna Brit. India Moths,* **3**: 205.

1998. *Gonodela azataria*; Yazaki, *Tinea,* **15**(suppl. 1): 12.

Material examined: GH01E (3 ex.), GH01F (1 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 28 mm.

Diagnosis: Ground colour rufous-yellow; an indistinct antemedial and medial lines on forewing with a white quadrate spot between the origin of CuA_1 and CuA_2; postmedial line indistinct, double, highly excurved below costa, the area beyond is suffused with purplish-grey; a single, white subapical speck. Hindwing with indistinct antemedial line and double postmedial lines and indistinct dark line beyond it with a spot at middle.

Distribution: India: Himachal Pradesh (GHNP) and Meghalaya (Khasi). **Elsewhere:** Nepal.

Genus: *Hypephyra* Butler, 1889

145. *Hypephyra terrosa* Butler, 1889

(Habitus Plate No: 10.14 & Genitalia Plate No: 14.2)

1889. *Hypephyra terrosa* Butler, *Ill. Het.,* **7**: 101.

1895. *Hypephyra terrosa*; Hampson, *Fauna Brit. India Moths,* **3**: 218.

1992. *Hypephyra terrosa*; Yazaki, *Tinea,* **13**(suppl. 2): 28.

Material examined: GH01A (2 ex.), GH01C (1 ex.), GH01E (1 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 40 mm.

Diagnosis: Forewing with slivery irroration; antemedial and medial line rufous, sinuous; a dark cell-spot; postmedial line crenulated, black with some rufous inside it and some dark suffusion with dentate outer edge beyond inner area; hindwind with indistinct, waved antemedial, medial and submarginal line. Underside yellowish, with black cell-speck; postmedial line with black patch beyond it on inner area of forewing and hindwing with black irroration.

Male genitalia characterized by sclerotized saccular process with apex bent distally and tip with few small spines; dorsal arm of valvae slender, apically rounded and with a ventral finger-like process; ventral arm triangular, apically pointed, triangular; uncus apically bilobed, pointed, sclerotized; aedeagus long with strong cornutus at vesica.

Distribution: India: Himachal Pradesh (Shimla, Dharamsala, GHNP) and Uttarakhand. **Elsewhere:** Nepal.

Genus: *Oxymacaria* Warren, 1894

146. *Oxymacaria brunneata* (Warren, 1896)#

(Habitus Plate No: 10.15 & Genitalia Plate No: 14.3)

1896. *Semiothisa brunneata* Warren, *Novit. Zool.,* **3**: 140.

1999. *Oxymacaria maculosata brunneata*; Parsons *et al.*, *Geometrid Moths of the World: a Catalogue.,*: 29.

2000. *Oxymacaria brunneata*; Yazaki, *Tinea,* **16**(Suppl. 1): 12.

Material examined: GH05A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH10A (1 ex.): Moist Deodar Forest (12/C1c); GH12B (2 ex.): Western Mixed Coniferous Forest (12/C1d); GH15A (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 32 mm.

Diagnosis: Very similar to *O. penumbrata*, but can be distinguished by a large, blackish-brown patch on postmedial line of forewing and medial line of hidwing less sinuous.

Male genitlia characterized by long, slender, sclerotized, outwardly bent dorsal arm of valvae and triangular ventral lobe of valvae, with its dorsal margin with two dentations; uncus triangular, tip blunt; gnathos apically long, tip pointed; aedeagus with dorsal ridge sclerotized and with an apical vesica spine.

Distribution: India: Himachal Pradesh (GHNP) and Meghalaya (Khasi). **Elsewhere:** Nepal.

147. *Oxymacaria maculosata* (Warren, 1896)#

(Habitus Plate No: 11.1 & Genitalia Plate No: 14.4)

1896. *Semiothisa maculosata* Warren, *Novit. zool.*, **3**: 141.

1995. *Oxymacaria maculosata*; Yazaki, *Tinea,* **14**(suppl. 2): 18.

2019. *Oxymacaria maculosata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 224.

Material examined: GH01H (2 ex.): Himalayan Chir Pine Forest (9/C1b); GH05A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 38 mm.

Diagnosis: Differs from previous species by more oblique outer margin of forewing which is produced at M_3, apex is also much produced.

Very similar with previous species but differs by having ventral arm less broad and uncus with apex round; gnathos apically elongated with apex blunt.

Distribution: India: Himachal Pradesh (GHNP) and Meghalaya (Khasi). **Elsewhere:** Nepal.

148. *Oxymacaria temeraria* (Swinhoe, 1891)

(Habitus Plate No: 11.2)

1891. *Macaria temeraria* Swinhoe, *Trans. ent. Soc. Lond.*, (4): 492.

1895. *Macaria temeraria*; Hampson, *Fauna Brit. India Moths*, **3**: 207.

1896. *Semiothisa temeraria ab. fumosa* Warren, *Novit. zool.* **3**: 320.

1915. *Macaria temeraria*; Prout, *In* Seitz: *Macro Lep.*, **4**: 347.

1935. *Semiothisa temeraria cruda* Prout, *Novit. zool.* **39**: 237.

1976. *Semiothisa temeraria*; Holloway, *Moths of Borneo with special reference to Mt. Kinabalu,*: 78.

1993. *Oxymacaria temeraria*; Holloway, *Moths of Borneo,* **11**: 160.

2013. *Heterocallia temeraria*; Chandra & Sambath, *Jour. of Threat. Taxa*, **5**(1): 3568.

2017. *Heterocallia temeraria*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Oxymacaria temeraria*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 224.

Material examined: GH01D (1 ex.), GH01E (5 ex.), GH02A (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 35 mm.

Diagnosis: Very similar to *O. penumbrata*, but can be distinguished by variegated greyish-brown colouration with white ground colour and having prominent, linear submarginal line to each wings.

Distribution: India: Kashmir, Himachal Pradesh (GHNP), Uttarakhand, Arunachal Pradesh (Tawang), Meghalaya, Nagaland and Andaman Island. **Elsewhere:** Pakistan, Bhutan, China, Hong Kong, Taiwan, Thailand, Malaysia, Indonesia (Borneo, Java) and Japan.

Tribe BOARMIINI Duponchel, 1845

Genus *Alcis* Curtis, 1826

149. *Alcis admissaria* Guenée, [1858]

(Habitus Plate No: 11.3 & Genitalia Plate No: 14.5)

1858. *Alcis admissaria* Guenee, *in* Boisduval & Guenee, *Hist. nat. Insectes* (Spec. gen. Lepid.), **9**: 239.

1895. *Boarmia admissaria*; Hampson, *Fauna Brit. India Moths.,* **3**: 269.

2012. *Alcis admissaria*; Kirti *et al., Journal of Entomological Research*, **36**(1): 90.

Material examined: GH01A (2 ex.), GH01C (7 ex.), GH01E (1 ex.), GH01G (1 ex.), GH01H (3 ex.), GH02B (6 ex.), GH03A (2 ex.), GH03B (3 ex.), GH03C (7 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (7 ex.), GH04C (1 ex.), GH08A (2 ex.), GH09A (2 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12B (1 ex.), GH13A (1 ex.): Western Mixed Coniferous Forest (12/C1d); GH14B (1 ex.), GH15A (3 ex.), GH19B (3 ex.): Low-Level Blue Pine Forest (12/2S1); GH20A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH27A (9 ex.), GH27B (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 44 mm.

Diagnosis: Differs from *A. perspicuata*, by having olive tinge instead of yellowish-orange-brown suffusion; forewing with postmedial rufous shade and darker clouding on distal area on both surface.

Male genitalia differs from *perspicuata,* by a pair of projections of juxta much shorter and narrower; aedeagus with a single cornutus shorter, apex pointed.

Distribution: India: Ladakh, Himachal Pradesh (GHNP), Uttarakhand, Meghalaya, Karnataka, Tamil Nadu and Kerala. **Elsewhere:** Kyrgyzstan, Afghanistan, Bhutan, China, Tibet, Taiwan and Japan.

150. *Alcis leucophaea* Fletcher, 1961^

(Habitus Plate No: 11.4 & Genitalia Plate No: 14.6)

1961. *Alcis leucophaea* Fletcher, *Veroff. Zool. Staat. Munchen.,* **6**:175.

1995. *Alcis leucophaea*; Sato, *Tinea,* **14**(suppl. 2): 28, pl. 73, f. 10-11.

2019. *Alcis leucophaea*; Dey *et al., Spixiana*, **42**:51.

Material examined: GH02B (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (1 ex.), GH04C (1 ex.), GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1);

Wing expanse: 46 mm.

Diagnosis: Very similar with *A. trikotaria*, but differs in colour and reduced pattern; underside of both wings with much less yellowish suffusion.

Male genitalia characterized by medial process on valvae asymmetrical and with variable outlines. It differs from *trikotaria* by more slender cornutus of aedeagus.

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand. **Elsewhere:** Nepal.

151. *Alcis limbui* Sato, 1994*

(Habitus Plate No: 11.5 & Genitalia Plate No: 14.7)

1994. *Alcis limbui* Sato, *Tinea,* **14**(suppl. 1): 43, pl. 73, f. 8.

Material examined: GH01H (1 ex.), GH03C (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH19C (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 46 mm.

Diagnosis: Very similar with *A. perspicuata,* but can be distinguished by yellow hind-tibial hair-pencil instead of black.

Male genitalia differs from *perspicuata,* by gnathos with medial plate wider; more slenderer valvae; ampulla with two digitate projections, more slenderer; juxta with a pair of projections well-developed and swollen at apex; aedeagus with much shorter cornutus.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal.

152. *Alcis macroclarata* Sato, 1993#

(Habitus Plate No: 11.6 & Genitalia Plate No: 14.8)

1993. *Alcis macroclarata* Sato, *Tinea,* **13**(suppl. 3): 11, pl. 35, f. 11, 12.

Material examined: GH01A (1 ex.), GH01C (1 ex.), GH01E (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH15A (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 40 mm.

Diagnosis: Similar to *A.semiclarata, A. neoclarata, A. quadrifera* and *A. paraclarata*, but little larger in size and differs in being more strongly tinged with orange-yellow.

Differs from congeners by very short lateral projection of aedeagus.

Distribution: India: Himachal Pradesh (GHNP), West Bengal (Darjeeling) and Sikkim. **Elsewhere:** Thailand.

153. *Alcis neoclarata* Sato, 1993#

(Habitus Plate No: 11.7 & Genitalia Plate No: 14.9)

1993. *Alcis neoclarata* Sato, *Tinea,* **13**(suppl. 3): 11, pl. 35, f. 7, 8.

2021. *Alcis neoclarata*; Chettri & Yonle, *International Journal of Entomology Research,* **6**(3): 92.

Material examined: GH01A (1 ex.), GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (1 ex.), GH08C (1 ex.), GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 36 mm.

Diagnosis: Similar to *A.semiclarata, A. neoclarata, A. quadrifera* and *A. paraclarata*, but differs in having most whitish hindwing.

Male genitalia characterized by two shorter lateral projections of aedeagus.

Distribution: India: Himachal Pradesh (GHNP) and West Bengal (Darjeeling). **Elsewhere:** Nepal.

154. *Alcis nigralbata* Warren, 1893#

(Habitus Plate No: 11.8 & Genitalia Plate No: 14.10)

1893. *Alcis nigralbata* Warren, *Proc. Zool. Soc. Lond.,*: 424.

1895. *Alcis nigralbata*; Hampson, *Fauna Brit. India Moths,* **3**: 266.

1994. *Alcis nigralbata*; Sato, *Tinea,* **14**(suppl. 1): 44, pl. 74, f. 4.

Material examined: GH01B (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH16A (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH27A (5 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 40 mm.

Diagnosis: Ground colour white, with thick irroration of grey atoms; subbasal and outer area of forewing suffused with black and with a black cell-speck; submarginal line white, crenulated to both wings. In hindwing, thick irroration from lower angle of cell to anal angle.

Male genitalia characterized by juxta with a pair of distal arms, slender, sclerotized, broad; uncus triangular, beak-like; gnathos apically much elongated, sclerotized, tip rounded; Valvae with ampulla not digitate but with a sclerotized, quadrate projection; aedeagus with lateral long spine and with a short subapical projection.

Distribution: India: Himachal Pradesh (GHNP) and Sikkim. **Elsewhere:** Nepal.

155. *Alcis nigridorsaria* (Guenée, [1858])

(Habitus Plate No: 11.9 & Genitalia Plate No: 15.1)

1857. *Cleora nigridorsaria* Guenée, *Hist. nat. Ins. Spec. gén. Lépid.,* **9**: 232.

1860. *Cleora nigridorsaria*; Walker, *List Spec. Lepid. Ins. Coll. Brit. Mus.,* **21**:333.

1895. *Boarmia nigridorsaria*; Hampson, *Fauna Brit. India Moths,* **3**: 267.

1993. *Alcis nigridorsaria*; Sato, *Tinea,* **13**(suppl. 3): 8, pl. 34, f. 26.

Material examined: GH10A (1 ex.): Moist Deodar Forest (12/C1c).

Wing expanse: 34 mm.

Diagnosis: Ground colour white, with black irroration; a diffused black basal patch, with a white spot on it; indistinct antemedial and medial lines arising from black patches on costa; indistinct postmedial line angled at M_2 and with greyish-black suffusion beyond this upto a submarginal white, waved line; some rufous-blackish patch beyond submarginal line at middle of wing.

Male genitalia characterized by costal margin of valvae strongly sclerotized; ampulla triangular; uncus apically elongated, triangular, tapering at tip; gnathos very long apically, tip rounded.

Distribution: India: Himachal Pradesh (GHNP) and Sikkim. **Elsewhere:** Nepal and Tibet.

156. *Alcis nudipennis* Warren, 1888^

(Habitus Plate No: 11.10 & Genitalia Plate No: 15.2)

1888. *Alcis nudipennis* Warren, *Proc. Zool. Soc. Lond.,*: 320.

1895. *Alcis nudipennis*; Hampson, *Fauna Brit. India Moths,* **3**: 269.

2007. *Alcis nudipennis*; Kamaluddin *et al.*, *INT. J. BIOL. BIOTECH.*, **4**(2-3): 113-119.

2019. *Alcis nudipennis*; Dey *et al., Spixiana*, **42**:51.

Material examined: GH01C (3 ex.), GH01H (1 ex.), GH02B (1 ex.), GH03A (6 ex.), GH03A (2 ex.), GH03A (6 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (1 ex.), GH04C (2 ex.), GH08C (1 ex.), GH09A (1 ex.), GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH13A (2 ex.): Western Mixed Coniferous Forest (12/C1d); GH15A (1 ex.), GH16A (1 ex.), GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH21B (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH27A (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 47 mm.

Diagnosis: This species is characterized by double antemedial line approaching each other towards inner margin, filled with black.

Male genitalia characterized by juxta with a pair of strongly sclerotized, slender, apically pointed processes; uncus triangular, tip rounded; gnathos apically much elongated, tip pointed; valvae long, costal margin sclerotized, ampulla with three arms; aedeagus with a long cornutus and tip bent outward.

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand. **Elsewhere:** Pakistan (Thundiani).

157. *Alcis perspicuata* (Moore, 1868)^

(Habitus Plate No: 11.11 & Genitalia Plate No: 15.3)

1868. *Boarmia perspicuata* Moore, *Proc. Zool. Soc. Lond.,*: 630.

1888. *Alcis vicina* Moore, *Descr. Ind. Lep. Atk.,*: 243.

1993. *Alcis perspicuata*; Sato, *Tinea,* **13**(suppl. 3): 6, pl. 34, f. 12, 13.

2019. *Alcis perspicuata*; Dey *et al., Spixiana,* **42**:51.

Material examined: GH01A (1 ex.), GH01C (1 ex.), GH03A (1ex.), GH03B (1 ex.), GH03C (6 ex.): Himalayan Chir Pine Forest (9/C1b); GH04C (1 ex.), GH08A (2 ex.), GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH16A (1 ex.), GH19C (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH27A (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 48 mm.

Diagnosis: see *A. admissaria* and *A. limbui.*

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, West Bengal (Darjeeling) and Meghalaya (Khasi). **Elsewhere:** Nepal.

158. *Alcis quadrifera* (Walker, 1866)#

(Habitus Plate No: 11.12 & Genitalia Plate No: 15.4)

1866. *Scotosia quadrifera* Walker, *List Spec. Lepid. Ins. Coll. Brit. Mus.,* **35**:1687.

1896. *Poecilalcis semiclarata* ab. *Fasciata* Warren, *Novit. Zool.,***3**: 405.

1993. *Alcis quadrifera*; Sato, *Tinea,* **13**(suppl. 3): 9, pl. 35, f. 1-4.

Material examined: GH01C (4 ex.), GH01E (3 ex.), GH01F (1 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04A (1 ex.), GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 34 mm.

Diagnosis: Forewing with basal area black; antemedial line curved with diffused black inside it; cell-speck black; postmedial line angled at M_1, with black suffusion beyond it; submarginal line pale, waved, with black patch beyond it below apex and yellowish patch at middle.

Male genitalia very similar with *A. semiclarata*, but differs in having a pair of projections in juxta, dialated distally.

Distribution: India: Himachal Pradesh (GHNP), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Nepal.

159. *Alcis subnitida* Warren, 1893#

(Habitus Plate No: 11.13 & Genitalia Plate No: 15.5)

1893. *Alcis subnitida* Warren, *Proc. Zool. Soc. Lond.,*: 421.

1994. *Alcis subnitida*; Sato, *Tinea,* **14**(suppl. 1): 44, pl. 73, f. 13.

Material examined: GH01C (4 ex.), GH01G (1 ex.), GH02B (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH08A (2 ex.), GH09A (2 ex.), GH11A (7 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12B (3 ex.), GH13A (2 ex.): Western Mixed Coniferous Forest (12/C1d); GH15A (4 ex.), GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH18A (3 ex.), GH21A (1 ex.), GH21B (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH25A (2 ex.): Dwarf

Rhododendron Scrub (15/C2/E1); GH26A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27A (27 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 47 mm.

Diagnosis: Forewing pale grey with ochreous and darker grey irroration; costa, base, inner margin and outer margin darker; blackish bloch at middle of costa, enclosing a dark cell-spot, double dark spots obliquely below it and on inner margin, representing a central shade; submarginal line pale, waved.

Male genitalia characterized by a pair of short, slender, sclerotized processes of juxta; valvae with ampulla digitate; uncus triangular, sclerotized, tip pointed; gnathos triangular, sclerotized, almost reaching the length of uncus; aedeagus with cornutus short and apex curved outward.

Distribution: India: Himachal Pradesh (GHNP) and Sikkim. **Elsewhere:** Nepal.

160. *Alcis variegata* (Moore, 1888)#

(Habitus Plate No: 11.14 & Genitalia Plate No: 15.6)

1888. *Pseudocoremia variegata* Moore, *Descr. Ind. Lep. Atk.*,: 240.

1891. *Cleora nebulosa* Swinhoe, *Trans. Ent. Soc. Lond.*,: 488.

1928. *Cleora hypopoecila* Prout, *Bull. Hill Mus. Witley.*, **2**(2):151.

1991. *Alcis variegata*; Sato, *Tyo Ga*: 285.

1999. *Alcis hypopoecila*; Parsons *et al.*, *Geometrid Moths of the World: a Catalogue.*,: 29.

1999. *Alcis variegata*; Parsons *et al.*, *Geometrid Moths of the World: a Catalogue.,*: 33.

1995. *Alcis variegata*; Sato, *Tinea* **14**(suppl. 2): 28, pl. 34, f. 16.

Material examined: GH01G (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 36 mm.

Diagnosis: Abdomen with a dark band on 1st segment; forewing with all the lines indistinct, the stigma at end of cell without centre; postmedial line reduced to a series of specks, not angled below cell.

Male genitalia characterized by a pair of long, slender projections of juxta; ampula slender, long.

Distribution: India: Himachal Pradesh (GHNP), Sikkim and Meghalaya (Khasi). **Elsewhere:** Nepal, Myanmar, China, Taiwan, Laos, Java, Vietnam, Thailand, Malaysia and Sumatra.

Genus: *Arichanna* Moore, [1868]

161. *Arichanna flavinigra* Hampson, 1907

(Habitus Plate No: 11.15 & Genitalia Plate No: 15.7)

1907. *Arichanna flavinigra* Hampson, *J. Bombay nat. Hist. Soc.* **18**(1): 42.

1933. *Arichanna (Epicterodes) flavinigra*; Wehrli, *Ent. Z., Frankf. a. M.* **47**(4): 41.

2000. *Arichanna flavinigra*; Stuning, *Tinea* **16**(suppl. 1): 129.

2018. *Arichanna (Epicterodes) flavinigra*; Li *et al.*, *Journal of Asia-Pacific Entomology,* **21**:506.

2019. *Arichanna flavinigra*; Dey *et al.*, *Spixiana*, **42**:51.

Material examined: GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH15A (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH27A (11 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 60 mm.

Diagnosis: Externally similar with *A. sinica,* but differis in having darker forewing; postmedial band of hindwing black, formed of confluent spots; forewing underside yellowish.

Male genitalia is characterized by sort median process of gnathos and longer cucullus.

Distribution: India: Kashmir, Himachal Pradesh (Chamba, Dharamsala, Dalhousie, GHNP), Uttarakhand (Nanda Devi NP, Ralam Valley, Yamunotri) and Sikkim (Yatang), Punjab. **Elsewhere:** Nepal, Bhutan, Myanmar, China and Tibet.

162. *Arichanna interplagata* (Guenée, [1858])#

(Habitus Plate No: 12.1 & Genitalia Plate No: 15.8)

1857. *Cidaria interplagata* Guenée, *Hist. nat. Ins. Spec. gén. Lépid.,* **10**: 465.

2000. *Arichanna interplagata*; Stuning, *Tinea* **16**(suppl. 1): 125.

2021. *Arichanna interplagata*; Chettri & Yonle, *International Journal of Entomology Research,* **6**(3): 92.

Material examined: GH12B (10 ex.): Western Mixed Coniferous Forest (12/C1d); GH14B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 45 mm.

Diagnosis: Characterized by having forewing with transverse line obscured, marked with yellow and olive; hindwing yellowish-white with submarginal dots smaller.

Male genitalia with ampulla strong, having many spines; uncus triangular, tip tapering; gnathos with an apical protrusion; aedeagus with two bunches of long spines.

Distribution: India: Himachal Pradesh (GHNP), Sikkim, West Bengal (Darjeeling) and Arunachal Pradesh. **Elsewhere:** Nepal and China.

163. *Arichanna tenebraria* (Moore, 1868)^

(Habitus Plate No: 12.2 & Genitalia Plate No: 15.8)

1868. *Abraxas tenebraria* Moore, *Proc. zool. Soc. Lond.,*: 652.

1895. *Arichanna tenebraria*; Hampson, *Fauna Brit. India Moths,* **3**: 293.

1995. *Arichanna (Paricterodes) tenebraria*; Sato, *Tinea* **14**(suppl. 2): 28, pl. 73, f. 5.

2000. *Arichanna (Paricterodes) tenebraria*; Stuning, *Tinea* **16**(suppl. 1): 129.

2017. *Arichanna tenebraria*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

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.

Male genitalia with triangular uncus with tapering tip; gnathors apically long and broad, tip triangular; aedeagus with two bunches of vesica spines.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind WLS, Nanda Devi Biosphere Reserve), Sikkim and Meghalaya (Khasi). **Elsewhere:** Nepal, China and Taiwan.

Genus: *Ascotis* Hübner, [1825]

164. *Ascotis selenaria* (Denis & Schiffermuller, 1775)

(Habitus Plate No: 12.3 & Genitalia Plate No: 15.10)

1775. *Geometra selenaria* Denis & Schiffermüller, *Ankundung syst. Werkes Schmett. Wienergegend,*:101.

2013. *Ascotis selenaria*; Chandra & Sambath, *Journal of Threatened Taxa,* **5**(1): 3567.

Material examined: GH01A (1 ex.), GH01F (1 ex.), GH02B (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 50 mm.

Diagnosis: Forewing ground colour greyish and abdomen with paired dark dorsal spots; forewing medial line indistinct, waved, curved, becoming straight and antemedial on hindwing; grey-centered lunule at end of cell in both wings;

postmedial line crenulated, distinct; submarginal line sinuous, pale, indistinct; underside of forewing with a diffused subapical black patch.

Male genitalia characterized by strong saccular process with tip sclerotized and pointed; uncus triangular, with apex slender, long, bifurcated; aedeagus with tip of vesica strongly sclerotized and dorsal ridge of aedeagus sclerotized.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Arunachal Pradesh (Tawang), Meghalaya (Khasi), Gujrat, Maharashtra and Haryana. **Elsewhere:** Austria, France, Germany, Greece, Hungary, Serbia, Russia, Italy, Poland, Amur, Japan, China, Nepal, Congo and S. Africa.

Genus: *Biston* Leach, 1815

165. *Biston falcata* (Warren, 1893)^

(Habitus Plate No: 12.4 & Genitalia Plate No: 16.1)

1893. *Eubyjodonta falcata* Warren, *Proc. zool. Soc. Lond.*, (2): 416.

1895. *Biston falcata*; Hampson, *Fauna Brit. India Moths,* **3**: 246.

1897. *Biston emarginaria* Leech, *Ann. Mag. nat. Hist.*, **19**(6): 322.

1910. *Amphidasis erilda* Oberthür, *Études Lépid. comp.*, **4**: 677.

1910. *Amphidasis clorinda* Oberthür, *Études Lépid. comp.*, **4**: 677.

1995. *Biston falcata*; Yazaki, *Tinea* **14** (suppl. 2): 11, pl. 70, f. 14.

1999. *Biston falcata clorinda*: Parsons et al., *Geometrid Moths of the World, a Catalogue*, **1**: 86.

2011. *Biston falcata*; Jiang *et al., ZooKeys,* **139**: 72.

2017. *Biston falcata*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH15A (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH20A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 62 mm.

Diagnosis: Externally similar with *B. quercii,* but can be identified by less undulating outer margin and without any marginal process; discal spot of hindwing absent.

Male genitalia differs from *B. quercii* by having broader juxta and shorter cornutus.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim and Arunachal Pradesh. **Elsewhere:** Nepal, Bhutan, China and Tibet.

166. *Biston regalis* (Moore, 1888)

(Habitus Plate No: 12.5 & Genitalia Plate No: 16.2)

1888. *Amphidasys regalis* Moore, in Hewitson & Moore, *Descr. new Indian lepid. Insects Colln late Mr W.S. Atkinson*, (3): 234.

1895. *Biston regalis*; Hampson, *Fauna Brit. India Moths,* **3**: 245.

1897. *Biston regalis*; Leech, *Ann. Mag. nat. Hist.*, **19**(6): 323.

1915. *Biston regalis*; Prout, *in Seitz, Macrolepid. World,* **4**: 359, pl.19: h.

2011. *Biston regalis*; Jiang *et al., ZooKeys,* **139**: 68.

Material examined: GH02A (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 74 mm.

Diagnosis: Very similar with *B. exalbescens,* but differs in having antemedial line of forewing thinner, basal dark brown band also thinner; both wings with medial lines less conspicuous.

Male genitalia differs from *exalbescens* by much stronger central setose area of valva; gnathos with medial process spatulate terminally; juxta narrower and longer.

Distribution: India: Kashmir, Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal (Darjeeling), Arunachal Pradesh and Meghalaya. **Elsewhere:** Pakistan, Nepal, Myanmar, China, Taiwan, Thailand, Malaysia, Russia, Japan, Korea, Philippines and USA.

Genus: *Calichodes* Warren, 1897

167. *Calichodes ochrifasciata* (Moore, 1888)

(Habitus Plate No: 12.6 & Genitalia Plate No: 16.3)

1888. *Cleora ochrifasciata* Moore, in Hewitson & Moore, *Descr. new Indian lepid. Insects Colln late Mr W.S. Atkinson*, (3): 240.

1895. *Boarmia ochrifasciata*; Hampson, *Fauna Brit. India Moths,* **3**: 259.

1987. *Aethalura ochrifascia*; Inoue, *Bull. Fac. Domest. Sci. Otsuma Wom. Univ.,* **23**: 266.

1993. *Calichodes ochrifasciatus*; Sato, *Tinea* **13**(suppl. 3): 18.

Material examined: GH01B (1 ex.), GH01E (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH05A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH07A (1 ex.): Alder Forest (Riverine) (12/1S1).

Wing expanse: 28 mm.

Diagnosis: Ground colour reddish-brown, with fuscous irroration; forewing antemedial line curved, black, with an indistinct fuscus- yellow -band inside it; medial line indistinct with a black cell-spot on it; postmedial line black, highly angled below the cell and on CuA_1, with a yellowish-fuscous band inside it; submarginal line pale, waved, with dark blotch beyond it at middle. Hindwing pale, irrorated with fuscous; postmedial line and a cell-speck, traces of antemedial and submarginal lines.

Valvae long, apically pointed, costal basal process club-like, apically swollen; uncus with two long, slender, apically pointed serci.

Distribution: India: Himachal Pradesh (Dalhousie, Dharamsala, GHNP), Sikkim, West Bengal (Darjeeling) and Meghalaya (Khasi). **Elsewhere:** Nepal.

Genus: *Chorodna* Walker, 1860

168. *Chorodna creataria* (Guenée, 1858)[#]

(Habitus Plate No: 12.7 & Genitalia Plate No: 16.4)

1857. *Hemerophila creataria* Guenée, *Hist. nat. Ins., Spec. gén. Lépid.* **9**: 217.

1895. *Medasina creataria*; Hampson, *Fauna Brit. India Moths,* **3**: 286.

1894. *Medasina creataria*; Swinhoe, *Trans. Ent. Soc. Lond.*,**42**: 217.

1995. *Chorodna creataria*; Sato, *Trans. lepid. Soc. Japan* **46**(4): 223.

2013. *Medasina creataria*; Chandra & Sambath, *Journal of Threatened Taxa,* **5**(1): 3567.

2021. *Chorodna creataria*; Chettri & Yonle, *International Journal of Entomology Research,* **6**(3): 92.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 90 mm.

Diagnosis: Ground colour reddish-brown, with black striation and irroration; both wings with postmedial line crenulated, curved, indistinct and a pale submarginal line; a broad, fuscous band beyond postmedial line and a white apical patch at middle of forewing on underside.

Valvae with saccular process long, sclerotized; costal margin medially slightly protruded, with long bristles; ampulla long, slender, sclerotized, with bristles; uncus beak-like, apically pointed; gnathos apically long, pointed; juxta heart-shaped. Aedeagus long, apically pointed, vesica without spines, membranous.

Distribution: India: Himachal Pradesh (GHNP), Sikkim, West Bengal (Darjeeling), Arunachal Pradesh (Tawang), Assam and Meghalaya (Shilong, Cherrapunji). **Elsewhere:** Nepal, Bangladesh, China, Taiwan, Hong Kong, Vietnam, Laos and Thailand.

Genus: *Dalima* Moore, [1868]

169. *Dalima patularia* (Walker, 1860)^

(Habitus Plate No: 12.8)

1860. *Omiza patularia* Walker, *List Spec. Lepid. Ins. Coll. Br. Mus.* **20**: 247.

1894. *Catascia eolaria*; Swinhoe, *Trans. Ent. Soc. Lond.,*:197.

1895. *Dalima patularia*; Hampson, *Fauna Brit. India Moths,* **3**: 240.

1976. *Dalima patularia*; Holloway, *Moths of Borneo with special reference to Mt. Kinabalu*: 76.

1993. *Dalima patularia*; Holloway, *Moths of Borneo.* **11**: 177.

1992. *Dalima patularia*; Yazaki, *Tinea* **13**(suppl. 2): 31.

2016. *Dalima patularia*; Sondhi & Sondhi, *Journal of Threatened Taxa,* **8**(5): 8768.

2021. *Dalima patularia*; Chettri & Yonle, *International Journal of Entomology Research,* **6**(3): 92.

Material examined: GH01H (2 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 64 mm.

Diagnosis: Ground colour brownish; forewing with an oblique antemedial line and a rufous medial line, black near inner margin and joined by a grey-brown, indistinct line from costa near apex; submarginal line indistinct. Hindwing with medial line curved, oblique and rufous; postmedial line rufous, curved; underside orange.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Dehradun, Bhimtal), Sikkim, West Bengal (Darjeeling), Arunachal Pradesh and Meghalaya (Khasi, Shillong, Cherrapunji). **Elsewhere:** Nepal, Thailand, China and Indonesia (Borneo, Sumatra, Sulawesi).

Genus: *Ectropis* Hübner, [1825]

170. *Ectropis bhurmitra* (Walker, 1860)#

(Habitus Plate No: 12.9 & Genitalia Plate No: 16.5)

1860. *Boarmia bhurmitra* Walker, *List Spec. Lep. Ins. Coll. Br. Mus.*, **21**: 381.

1860. *Boarmia diffusaria* Walker, *List Spec. Lep. Ins. Coll. Br. Mus.*, **21**: 381.

1895. *Boarmia bhurmitra*; Hampson, *Fauna Brit. India Moths,* **3**: 260.

1897. *Ectropis sabulosa* Warren, *Novit. zool.*, **4**: 99.

1897. *Scioglyptis semifascia* Warren, *Novit. zool.*, **4**: 248.

1900. *Heterostegane semifasciata* Warren, *Novit. zool.*, **7**: 111.

1912. *Ectropis brevifasciata* Wileman, *Entomologist,* **45**: 69.

1993. *Ectropis bhurmitra*; *Moths of Borneo,* **11**: 221, f. 484, pl. 14.

1993. *Ectropis bhurmitra*; Sato, *Tinea* **13**(suppl. 3): 19.

2021. *Ectropis bhurmitra*; Chettri & Yonle, *International Journal of Entomology Research,* **6**(3): 92.

Material examined: GH01B (1 ex.), GH01D (1 ex.), GH01E (2 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 44 mm.

Diagnosis: Differs from *dentilineata* by having much browner and less grey wings and also similar with *longiscapia,* but smaller, less strongly fasciated and irrorated with brown.

Male genitalia differs from *longiscapia* and *dentilineata* by shorter vesica spine of aedeagus and less slender valvae with sclerotized, short processes at the base of valvae.

Distribution: India: Himachal Pradesh (GHNP), Sikkim, West Bengal (Darjeeling), Punjab, Maharashtra, Tamil Nadu, Kerala and Andaman Island. **Elsewhere:** Nepal, Sri Lanka, China, Singapore, Indonesia (Borneo, Java), Solomon Island, New Guinea and Australia.

171. *Ectropis dentilineata* (Moore, 1868)[#]

(Habitus Plate No: 12.10 & Genitalia Plate No: 16.6)

1867. *Tephrosia dentilineata* Moore, *Proc. Zool. Soc. Lond.,*: 631.

1894. *Ectropis dentilineata*; Swinhoe, *Trans. Ent. Soc. Lond.,*: 221.

1895. *Boarmia crepuscularia*; Hampson, *Fauna Brit. India Moths,* **3**: 260.

1926. *Ectropis dentilineata*; Prout, *The journal of the Bombay Natural History Society*, **31**: 937.

1993. *Ectropis dentilineata*; Sato, *Tinea* **13**(suppl. 3): 19.

Material examined: GH01D (4 ex.), GH01E (2 ex.), GH02A (3 ex.), GH02B (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH05A (1 ex.), GH08B (2 ex.): Moist Temperate Deciduous Forest (12/C1e); GH07A (3 ex.): Alder Forest (Riverine) (12/1S1); GH12A (1 ex.): Western Mixed Coniferous Forest (12/C1d).

Wing expanse: 44 mm.

Diagnosis: see *E. bhurmitra.*

Distribution: India: Himachal Pradesh (GHNP), Sikkim, West Bengal and Meghalaya (Khasi Hill). **Elsewhere:** Nepal, Myanmar, China and Japan.

Genus: *Gasterocome* Warren, 1894

172. *Gasterocome pannosaria* (Moore, 1868)

(Habitus Plate No: 12.11 & Genitalia Plate No: 16.7)

1868. *Cleora pannosaria* Moore, *Proc. zool. Soc. Lond.*,: 629.

1895. *Boarmia pannosaria*; Hampson, *Fauna Brit. India Moths,* **3**: 281.

1897. *Boarmia sinicaria* Leech, *Ann. Mag. Nat. Hist.*, **19**(6): 421.

1899. *Diplurodes contacta* Warren, *Novit. zool.* **6**: 53.

1911. *Boarmia orta* Bastelberger, *Ent. Rundschau,* **28**(3): 22.

1976. *Gasterocome pannosaria*; Holloway, *Moths of Borneo with special reference to Mt. Kinabalu*: 82

1993. *Gasterocome pannosaria*; Holloway, *Moths of Borneo.* **11**: 223, f. 481, pl. 15.

1993. *Gasterocome pannosaria*; Sato, *Tinea* **13**(suppl. 3): 17.

2016. *Gasterocome pannosaria*; Sondhi & Sondhi, *Journal of Threatened Taxa,* **8**(5): 8768.

Material examined: GH01C (2 ex.), GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 40 mm.

Diagnosis: Vertex and metathorax with pale spots; a paired, black specks on abdomen; ground colour of forewing greenish and with the outer area purplish;

antemedial line double, waved; medila line from inner margin to cell; a black patch at end of cell; postmedial line double, indistinct; submarginal line lunulate. Hindwing ochreous-white, but the outer area purplish; a brown streak at anal angle.

Valvae long, apex rounded, saccular process with a spine; ventral surface of valvae with few small cornutus just above the ampulla; furca apically bulged; uncus beak-like, apically pointed; aedeagus with an apical spine.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP), Uttarakhand (Kedarnath WLS), Sikkim, West Bengal, Arunachal Pradesh (Pakke Tiger Reserve) and Meghalaya (Khasi). **Elsewhere:** Nepal, China, Taiwan, Hong Kong, Thailand, Malaysia, Indonesia (Java, Borneo) and Philippines.

Genus: *Harutalcis* Sato, 1993

173. *Harutalcis vialis* (Moore, 1888)[#]

(Habitus Plate No: 12.12 & Genitalia Plate No: 16.8)

1888. *Boarmia vialis* Moore, *Descr. Indian lep. Atkinson* (3): 238, pl. 8, f. 9.

1895. *Boarmia vialis*; Hampson, *Fauna Brit. India Moths,* **3:** 268.

1993. *Harutalcis vialis*; Sato, *Tinea,* **13**(Suppl. 3): 13, pl. 35, f. 16.

1995. *Harutalcis vialis*; Sato, *Tinea,* **14**(suppl. 2): 29.

Material examined: GH01D (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 42 mm.

Diagnosis: Very similar with *H. atrostipata,* but lacks antemedial band on forewing; postmedial band straight, oblique and broader in forewing; postmedial band on hindwing much broader.

Male genitalia characterized by long, slender, sclerotized apex of saccular process.

Distribution: India: Himachal Pradesh (GHNP), Sikkim, West Bengal (Darjeeling), Arunachal Pradesh (Eaglenest WLS, Pakke Tiger Reserve) and Meghalaya (Khasi). **Elsewhere:** Nepal.

Genus: *Hypomecis* Hübner, 1821

174. *Hypomecis lioptilaria* (Swinhoe, 1903)#

(Habitus Plate No: 12.13 & Genitalia Plate No: 16.9)

1903. *Boarmia lioptilaria* Swinhoe, *in Annandale & Robinson, Fasc. Malay Zool.* **1**: 91.

1976. *Boarmia uoptilaria*[sic]; Holloway, *Moths of Borneo with special reference to Mt. Kinabalu*: 82.

1993. *Hypomecis lioptilaria*; Holloway, *Moths of Borneo*, **11**: 242, f. 515, pl. 16.

1995. *Hypomecis lioptilaria*; Sato, *Tinea* **14**(suppl. 2): 31, pl. 35, f. 23.

Material examined: GH01D (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 56 mm.

Diagnosis: This species is characterized by dark brown wings, prominent discal spot on hind wing and the veins distal to the cell spot of forewing underside dark.

Valvae long, medially broad, apex rounded, costal margin straight, ventral margin with spinous ridge at the middle, ampulla with three spines; uncus triangular, sclerotized, tip pointed; gnathos apically bifurcated, with two lobes; furca very long, slender, outwardly bent. Aedeagus with a bunch of vesica spines.

Distribution: India: Himachal Pradesh (GHNP) and Arunachal Pradesh (Namdhapa NP). **Elsewhere:** Nepal, China, Thailand, Malaysia and Indonesia (Borneo, Java, Sumatra).

175. *Hypomecis ratotaria* (Swinhoe, 1894)

(Habitus Plate No: 12.14 & Genitalia Plate No: 16.10)

1894. *Boarmia ratotaria* Swinhoe, *Tans. Ent. Soc. Lond.,* :216.

2017. *Hypomecis ratotaria*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

1994. *Hypomecis ratotaria*; Sato, *Tinea* **14**(suppl. 1): 46.

Material examined: GH01E (4 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 42 mm.

Diagnosis: Ground colour brown; a lunular-shaped ringlet at end of cell in both wings; wings crossed by many dark-brown lines; antemedial line indistinct; medial line outwardly dentate, regularly curved on hindwing outside the cell, double on forewing, distance widest at costa; submarginal line outwardly dentate; marginal line sinuous, dark-brown.

Valvae long, medially broad, ampulla slender with spines, saccular process with spines; uncus triangular, tip pointed; aedeagus apically sclerotized, long, slender.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, Assam, Meghalaya and Tamil Nadu. **Elsewhere:** Nepal, Bhutan, Sri Lanka, Myanmar and Indonesia (Java).

Genus: *Lassaba* Moore, 1888

176. *Lassaba albidaria* (Walker, 1866)

(Habitus Plate No: 12.15 & Genitalia Plate No: 17.1)

1866. *Boarmia albidaria* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* **35**: 1582.

1895. *Medasina albidaria*; Hampson, *Fauna Brit. India Moths,* **3**: 289.

1995. *Lassaba albidaria albidaria*; Sato, *Trans. lepid. Soc. Japan* **46**(4): 224.

2000. *Lassaba albidaria*; Stuning, *Tinea* **16**(suppl. 1): 121.

2017. *Medasina albidaria*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 159.

2019. *Lassaba albidaria*; Kumar *et al.*, *Mitochondrial DNA Part B*, **4**(1): 310.

Material examined: GH01E (1 ex.), GH01H (1 ex.), GH02A (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 60 mm.

Diagnosis: Ground colour white, with pale brown irroration and striation; antemedial, medial, postmedial and submarginal indistinct, fuscous lines on both wings; in forewing lines arising from the blackish patches on costa; postmedial line with a black mark between CuA_2 and M_3; underside with three lunulate marks below forewing apex.

Valvae long, apex pointed, costal margin sclerotized, straight; saccular process with apex sclerotized, round; uncus triangular, tip pointed, sclerotized; aedeagus long, dorsal edge sclerotized, vesica without any spine.

Distribution: India: Himachal Pradesh (Shimla, Chamba, Dharamsala, GHNP), Uttarakhand (Devalsari, Govind WLS, Gangotri NP, Nanda Devi Biosphere Reserve, Kedarnath WLS), Sikkim, West Bengal, Arunachal Pradesh (Eaglenest WLS, Pakke Tiger Reserve, Namdhapa NP) and Meghalaya. **Elsewhere:** Pakistan, Nepal, Myanmar, China, Taiwan, Vietnam and Thailand.

177. *Lassaba cervina* (Warren, 1893)^

(Habitus Plate No: 13.1 & Genitalia Plate No: 17.2)

1893. *Deinotrichia cervina* Warren, *Proc. Zool. Soc. London* : 419.

1905. *Medasina pallidimargo* Swinhoe, *Ann. Mus. Nat. Hist.*, 16: 627.

1995. *Deinotrichia cervina*; Sato, *Tinea* **14**(suppl. 2): 29, pl. 76, f. 1-2.

2000. *Lassaba cervina*; Stuning, *Tinea* **16**(suppl. 1): 119.

2017. *Medasina cervina*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 159.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH21B (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH27B (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 62 mm.

Diagnosis: Externally similar with *L. contaminata,* but differs in having more or less uniform greyish-brown colour in both wings instead of whitish in *contaminata.*

Differs from previous species by having much longer, slender and pointed apex of saccular process; ampulla short, finger-like; uncus not pointed and apex gently invaginated at middle; aedeagus with three spines on distal edge.

Distribution: India: Kashmir, Himachal Pradesh (GHNP), Uttarakhand (Govind WLS, Nanda Devi Biosphere Reserve), Sikkim and Arunachal Pradesh. **Elsewhere:** Nepal and Bhutan.

178. *Lassaba dissimilis* (Moore, 1888)#

(Habitus Plate No: 13.2)

1888. *Medasina dissimilis* Moore, *Descr. Ind. Lep. Atk.*,: 235.

2000. *Lassaba dissimilis*; Stuning, *Tinea* **16**(suppl. 1): 119.

2019. *Lassaba dissimilis*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 221.

Material examined: GH21B (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 62 mm.

Diagnosis: Externally similar with *L. interruptaria,* but differs in having without any trace of pale fascia on forewing; antemedial line black, sinuous, arising from a black blotch on costa; a medial patch with a spot below it on cell; a postmedial line also arising from black spot on costa; underside with the ground colour pale.

Distribution: India: Himachal Pradesh (GHNP), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Nepal.

179. *Lassaba interruptaria* (Moore, 1868)^

(Habitus Plate No: 13.3 & Genitalia Plate No: 17.3)

1868. *Hemerophila interruptaria* Moore, *Proc. zool. Soc. Lond.* : 626.

1895. *Medasina interruptaria*; Hampson, *Fauna Brit. India Moths,* **3**: 287.

1994. *Chorodna interruptaria*; Sato, *Tinea,* **14**(Suppl. 1): 54, pl. 76, f. 3.

1995. *Deinotrichia interruptaria*; Sato, *Tinea,* **14**(suppl. 2): 33.

2000. *Lassaba interruptaria*; Stuning, *Tinea* **16**(suppl. 1): 120.

2019. *Lassaba interruptaria*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 221.

Material examined: GH07A (2 ex.): Alder Forest (Riverine) (12/1S1); GH11A (3 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 62 mm.

Diagnosis: see previous species.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim and West Bengal. **Elsewhere:** Nepal.

180. *Lassaba parvalbidaria nepalensis* Sato, 1993#

(Habitus Plate No: 13.4 & Genitalia Plate No: 17.4)

1993. *Lassaba parvalbidaria nepalensis* Sato, *Tinea,* **13**(suppl. 3): 22.

2000. *Lassaba parvalbidaria nepalensis*; Stuning, *Tinea,* **16**(suppl. 1): 121.

Material examined: GH01D (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 54 mm.

Diagnosis: Closely similar with *L. albidaria,* but differs in having more whitish wings and differs from its nominotypical subspecies by having paler ground colour; bluish submarginal band less defiend; more whitish at underside, with black markings less developed on both wings, large rectangular patch below apex replaced by small lunulate one on forewing.

Male genitalia distinctive with a slender process of harpe shorter and broader than nominotypical subspecies from Taiwan.

Distribution: India: Himachal Pradesh (GHNP), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Nepal.

181. *Lassaba anepsia* (Wehrli, 1941)

(Habitus Plate No: 13.5)

1941. *Medasina anepsia* Wehrli, *in Seitz, Gross-Schmett. Erde.,* **4**(Suppl.): 445.

2000. *Lassaba anepsia*; Stuning, *Tinea,* **16**(suppl. 1): 120.

Material examined: GH06A (8 ex.): Moist Deodar Forest (12/C1c).

Wing expanse: 56 mm.

Diagnosis: Externally similar with *L. stolidaria,* but with darker ground colour and with typical waved, white submarginal line which is absent in *stolidaria.*

Male genitalia characterized by long, slender, apically pointed valvae; uncus triangular with lateral projections, not apically bilobed; saccular process slender, medium in size and with moderate amount of spines.

Distribution: India: Himachal Pradesh (Shimla, GHNP), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Nepal and China.

Genus: *Menophra* Moore, [1887]

182. *Menophra subplagiata* (Walker, 1860)

(Habitus Plate No: 13.6 & Genitalia Plate No: 17.5)

1860. *Hemerophila subplagiata* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* **21**: 319.

1895. *Boarmia subplagiata*; Hampson, *Fauna Brit. India Moths,* **3**: 275.

2017. *Menophra subplagiata*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 159.

2019. *Menophra subplagiata*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 222.

Material examined: GH01D (4 ex.), GH01E (5 ex.), GH01F (1 ex.), GH01G (2 ex.), GH01H (1 ex.), GH02A (2 ex.): Himalayan Chir Pine Forest (9/C1b); GH05A (7 ex.), GH08B (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 42 mm.

Diagnosis: Ground colour grey-brown, with dark striations and irrorations; antemedial line on forewing black, angled on subcostal and median nervure, then oblique and waved to inner margin; a cell-speck; postmedial line highly angled at R_5, then oblique to inner margin and with some dark suffusion beyond it below apex. A waved, black line from near apex to inner margin just before anal angle on hindwing.

Valvae with ventral margin straight, apically elongated, with a finger like protrusion; a strongly sclerotized, long, slender, apically pointed, costal basal process of valvae, with a dorsal sclerotized spine-bearing process; uncus triangular, apically rounded; gnathos tongue-shaped, sclerotized.

Distribution: India: Himachal Pradesh (Chamba, GHNP), Uttarakhand (Devalsari, Kausani), Sikkim, West Bengal and Meghalaya. **Elsewhere:** Pakistan, Nepal, Bhutan, Taiwan, Vietnam, Japan and Korea.

Genus: *Myrioblephara* Warren, 1893

183. *Myrioblephara albibasis* (Hampson, 1895)^

(Habitus Plate No: 13.7 & Genitalia Plate No: 17.6)

1895. *Boarmia albibasis* Hampson, *Fauna Brit. India Moths,* **3**: 278.

1978. *Myrioblephara albibasis*; Inoue, *Bull. Fac. Dom. Sci. Otsu. Wom. Uni.* **14**: 247.

1998. *Myrioblephara albibasis*; Sato, *Tinea,* **15**(suppl. 1): 24.

2016. *Myrioblephara albibasis*; Sondhi & Sondhi, *Journal of Threatened Taxa,* **8**(5): 8768.

Material examined: GH01G (3 ex.), GH02B (2 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 28 mm.

Diagnosis: Basal half of both the wings white, with fuscous striation; outer half rufous, with fuscous irrorations; basal half bound by a slight dark line angled at

M_3; postmedial series of black specks and indistinct, maculate submarginal line in forewing.

Valvae long, broad, apex triangular, saccular process sclerotized, and tip pointed; long, sclender, sclerotized harpe; uncus scletotized, slender, tip pointed. Aedeagus with a single spine at dorso-apical ridge.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal, Arunachal Pradesh and Assam. **Elsewhere:** Nepal and Taiwan.

184. *Myrioblephara duplexa* (Moore, 1888)#

(Habitus Plate No: 13.8 & Genitalia Plate No: 17.7)

1888. *Cleora duplex* Moore, *Descr. Ind. Lep. Atk.,*: 239.

1895. *Boarmia duplex;* Hampson, *Fauna Brit. India Moths,* **3**: 258.

1897. *Boarmia nigrilinearia* Leech, *Ann. Mag. Nat. Hist.*, **19**(6): 341.

1943. *Boarmia duplexa eoduplexa* Wehrli, *in Seitz, Gross-Schmett.* **4** (Sup.): 543.

1987. *Myrioblephara duplexa*; Inoue, *Bull. Fac. Dom. Sci. Otsu. Wom. Uni.* **23**: 266.

1995. *Myrioblephara nigrilinearia*; Sato, *Tinea,* **14**(suppl. 2): 32.

1995. *Myrioblephara duplexa*; Sato, *Tinea,* **14**(suppl. 2): 29.

Material examined: GH01B (1 ex.), GH01D (1 ex.), GH01E (5 ex.), GH01F (2 ex.): Himalayan Chir Pine Forest (9/C1b); GH04A (3 ex.), GH04B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH07A (4 ex.): Alder Forest (Riverine) (12/1S1).

Wing expanse: 36 mm.

Diagnosis: Externally similar with *M. enormis,* but differs in being olive-green and forewing lacking the fuscous suffusion; antemedial band double, black; submarginal band waved, with a patch beyond it upto margin below apex.

Valvae long, broad apically, saccular process apically bulged, sclerotized, harpe slender, broader apically, with a spine at ventral edge at subapical area.

Distribution: India: Himachal Pradesh (GHNP) and West Bengal (Darjeeling). **Elsewhere:** Nepal and China.

185. *Myrioblephara gandakiensis* Sato, 1998*

(Habitus Plate No: 13.9 & Genitalia Plate No: 17.8)

1998. *Myrioblephara gandakiensis* Sato, *Tinea,* **15**(suppl. 1): 23.

Material examined: GH01E (1 ex.), GH02A (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH06A (1 ex.): Moist Deodar Forest (12/C1c); GH18A (1 ex.), GH20A (19 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH24A (9 ex.), GH26A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH25B (3 ex.): Dwarf Rhododendron Scrub (15/C2/E1).

Wing expanse: 29 mm.

Diagnosis: Externally similar with *M. xanthozonea,* but smaller, more elongated forewing, colour much paler with olive tinge and shorter antennal ciliation.

Male genitalia similar with *M. xanthozonea, M. duplexa, M. duplexodes, M. microduplexa,* but differs by having shorter cucullus like *duplexodes,* and its ventral margin incurved medially; Harpe shortest and swollen apically.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal.

186. *Myrioblephara harutai* Sato, 1994*

(Habitus Plate No: 13.10 & Genitalia Plate No: 17.9)

1994. *Myrioblephara harutai* Sato, *Tinea,* **14**(suppl. 1): 49.

Material examined: GH04A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH20A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 37 mm.

Diagnosis: Forewing with antemedial and postmedial line black, banded with grass-green; submarginal area mottled with grass-green; other area grey or brown, sparsely irrorated with black; antemedial line excurved medially; postmedial line excurved below cell-speck and CuA_1 and CuA_2. Hindwing similar, postmedial line crenulated; medial line broad, black.

Uncus triangular, tip blunt; gnathos medially rectangular; cucullus abruptly swollen distally, forming an elbow-like projection; harpe long, bearing long spines apically; aedeagus short, without cornutus.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal.

187. *Myrioblephara idaeoides* (Moore, 1888)#

(Habitus Plate No: 13.11 & Genitalia Plate No: 17.10)

1888. *Cleora idaeoides* Moore, *Descr. Ind. Lep. Atk.*,: 239.

1895. *Boarmia idaeoides*; Hampson, *Fauna Brit. India Moths,* **3**: 259.

1994. *Myrioblephara idaeoides*; Sato, *Tinea,* **14**(suppl. 1): 49.

Material examined: GH01E (2 ex.), GH01F (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH08B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH21B (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 26 mm.

Diagnosis: Ground colour pale grey with fuscous irroration; antemedial line indistinct, curved in forewing but prominent in hindwing; cell-speck in both wings; postmedial line curved, waved, with some rufous on its outer edge; submarginal line crenulated, with pale outer edge.

Male genitalia characterized by finger-like ampulla, apically bulged; harpe apically swollen, slender; uncus triangular, apically pointed; gnathos very long, broad, triangular.

Distribution: India: Himachal Pradesh (GHNP), Sikkim, West Bengal (Darjeeling), Meghalaya (Khasi) and Nagaland. **Elsewhere:** Nepal and Myanmar.

188. *Myrioblephara xanthozonea* (Hampson, 1907)#

(Habitus Plate No: 13.12 & Genitalia Plate No: 18.1)

1907. *Boarmia xanthozonea* Hampson, *Journ. Bomb. Nat. Hist. Soc.,* **18**: 34.

1987. *Myrioblephara xanthozonea*; Inoue, *Bull. Fac. Dom. Sci. Otsu. Wom. Uni.* **23**: 266.

1995. *Myrioblephara xanthozonea*; Sato, *Tinea,* **14**(suppl. 2): 29.

Material examined: GH04A (1 ex.), GH05A (1 ex.), GH08B (2 ex.), GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH07A (1 ex.): Alder Forest

(Riverine) (12/1S1); GH12A (4 ex.), GH12B (17 ex.): Western Mixed Coniferous Forest (12/C1d); GH17A (1 ex.), GH20A (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 34 mm.

Diagnosis: see *M. gandakiensis.*

Distribution: India: Himachal Pradesh (GHNP) and Sikkim. **Elsewhere:** Nepal and Tibet.

Genus: *Parectropis* Sato, 1980

189. *Parectropis conspurcata* (Walker, 1866)#

(Habitus Plate No: 13.13 & Genitalia Plate No: 18.2)

1866. *Scotosia conspurcata* Walker, *List Spec. Lepid. Ins. Coll. Brit. Mus.,* **35**:1685.

1895. *Boarmia conspurcata*; Hampson, *Fauna Brit. India Moths,* **3**: 257.

1993. *Parectropis conspurcata*; Sato, *Tinea,* **13**(suppl. 3): 16.

Material examined: GH07A (1 ex.): Alder Forest (Riverine) (12/1S1); GH12B (23 ex.): Western Mixed Coniferous Forest (12/C1d); GH14B (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 42 mm.

Diagnosis: Ground colour red-brown, irrorated with dark; antemedial line double, indistinct, oblique, angled below costa in forewing; medial line single, bordering the black cell-speck, then oblique and curved upto the inner margin; a postmedial line excurved between M_1 and CuA_2; submarginal line waved, indistinct.

Valvae long, apically narrow; uncus triangular, tip pointed; gnathos apically elongated, sclerotized; aedeagus long, slender, two bunches of spines on dorso-apical ridge and with a long vesica spine.

Distribution: India: Himachal Pradesh (GHNP), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Nepal.

Genus: *Psilalcis* Warren, 1893

190. *Psilalcis breta* (Swinhoe, 1890)[#]

(Habitus Plate No: 13.14 & Genitalia Plate No: 18.3)

1890. *Narapa breta*; Swinhoe, *Proc. Zool. Soc. Lond.,* : 426.

1894. *Psilalcis breta*; Swinhoe, *Trans. Ent. Soc. Lond.,*: 222.

1895. *Psilalcis inceptaria*; Hampson, *Fauna Brit. India Moths,* **3:** 262.

1993. *Psilalcis breta*; Sato, *Tinea,* **13**(Suppl. 3): 13.

Material examined: GH01E (2 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 33 mm.

Diagnosis: Ground colour pinkish-grey; forewing with an antemedial line outwardly curved, slightly waved, broader near costa; another black, crenulated line starting from the middle of inner margin, recurved and ending on costa; submarginal line whitish, crenulated in both wings.

Valvae long, costal margin highly sclerotized, with an apical sclerotized protrusion; saccular process with long bunch of spines at apex.

Distribution: India: Himachal Pradesh (GHNP), West Bengal and Tamil Nadu.

Elsewhere: Nepal and Thailand.

Genus: *Xandrames* Moore, [1868]

191. *Xandrames albofasciata* Moore, 1868

(Habitus Plate No: 13.15 & Genitalia Plate No: 18.4)

1868. *Xandrames albofasciata* Moore, *Proc. zool. Soc. Lond.* : 635.

1895. *Xandrames albofasciata*; Hampson, *Fauna Brit. India Moths,* **3**: 251.

2013. *Xandrames albofasciata*; Chandra & Sambath, *Journal of Threatened Taxa,* **5**(1): 3567.

2019. *Xandrames albofasciata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 226.

Material examined: GH01A (1 ex.), GH01D (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04B (1 ex.), GH04C (3 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 98 mm.

Diagnosis: Externally similar with *X. latiferaria and X. dholaria,* but differs in having more black striation on forewing; white band well-defined, narrowing towards outer angle and beyond this olive-yellow below M_3.

Valvae long, apically narrow, apex rounded, costal margin sclerotized; ampulla triangular with distal dentation; uncus triangular, apex bifurcated slightly; gnathos apically broad and elongated, tongue-shaped.

Distribution: India: Himachal Pradesh (GHNP), Sikkim, West Bengal and Arunachal Pradesh (Eaglenest WLS). **Elsewhere:** Nepal, Myanmar, China, Vietnam and Thailand.

192. *Xandrames dholaria* Moore, 1867^

(Habitus Plate No: 14.1 & Genitalia Plate No: 18.5)

1867. *Xandrames dholaria* Moore, *Proc. zool. Soc. Lond.*, : 634.

2019. *Xandrames dholaria*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 226.

Material examined: GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 85 mm.

Diagnosis: see previous species

Male genitalia differs from previous species by having prominent, apically pointed saccular process and without having ampulla.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Devalsari, Munsiari, Kedarnath WLS), Sikkim, West Bengal, Arunachal Pradesh (Pakke Tiger Reserve), Assam and Nagaland (Kohima). **Elsewhere:** Nepal, China, Taiwan, Thailand, Japan and Korea.

Tribe: GNOPHINI Duponchel, 1845

Genus: *Ctenognophos* Prout, 1915

193. *Ctenognophos altissimus* Herbulot, 1995

(Habitus Plate No: 14.2 & Genitalia Plate No: 18.6)

1995. *Ctenognophos altissimus* Herbulot, *Bull. Soc. ent. Mulhouse,*: 22.

2003. *Ctenognophos altissimus*; Sato, *Lepidoptera Science*, **54**(4): 244.

Material examined: GH04B (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 58 mm.

Diagnosis: Differs from its congeners by having wings paler grey, with postmedial and submarginal crenulated, white lines to both wings; underside whitish with the area between postmedial and submarginal comprising a dark band.

Male genitalia characterized by long, broad valave, apex rounded, saccular process short, finger-like, a short costal basal process, with three apical long spines, ampulla with short spines, left valave with some sclerotization just below ampulla; gnathos long, triangular, apex pointed, tip hook-like; uncus triangular; aedeagus long, slender, dorso-apical ridge sclerotized with short spines; vesica with a bundle of long spines.

Distribution: India: Himachal Pradesh (Spiti Valley, GHNP).

194. *Ctenognophos eolaria* (Guenée, 1857)

(Habitus Plate No: 14.3 & Genitalia Plate No: 18.7)

1857. *Gnophos eolaria* Guenée, *Hist. nat. Ins., Spec. gén. Lépid.* **9**: 294.

1894. *Catascia eolaria*; Swinhoe, *Trans. Ent. Soc. Lond.,*:218.

1895. *Gnophos eolarius*; Hampson, *Fauna Brit. India Moths,* **3**: 253.

1915. *Gnophos* (*Ctenognophos*) *eolaria*; Prout, *in* Seitz, *Gross-Schmett. Erde*, **4**: 384.

1941. *Ctenognophos eolaria*; Wehrli, *in* Seitz, *Gross-Schmett. Erde*, **4** (Suppl.): 459.

1998. *Ctenognophos eolaria*; Sato, *Tinea* **15**(suppl. 1): 25.

Material examined: GH01C (1 ex.), GH01D (1 ex.), GH01H (1 ex.), GH02B (6 ex.), GH03A (3 ex.), GH03B (5 ex.), GH03C (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04C (1 ex.), GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH14A (1 ex.): Low-Level Blue Pine Forest (12/2S1).

Wing expanse: 54 mm.

Diagnosis: Ground colour brownish-grey, with thick fuscous irroration and suffusion; antemedial line of forewing indistinct; postmedial line crenulated, dark; submarginal line grey, waved; hindwing with medial line indistinct; postmedial line crenulated and pale, waved, indistinct submarginal line; underside with a broad, fuscous marginal band.

Male genitalia differs from previous species by the absence of ampulla and much shorter saccular process; costal basal process with more than three apical spines; gnathos longer than uncus, tip swollen; aedeagus with two bunches of dorso-apical spines and a bunch of vesica spine.

Distribution: India: Kashmir, Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal (Darjeeling), Meghalaya and Punjab. **Elsewhere:** Nepal, China (Tibet), Tajikistan and Kyrgyzstan.

195. *Ctenognophos methoria* Prout, 1926*

(Habitus Plate No: 14.4 & Genitalia Plate No: 18.8)

1926. *Ctenognophos methoria* Prout, *J. Bombay. Nat. Hist. Soc.* **31**: 798.

1994. *Ctenognophos methoria*; Sato, *Tinea* **14**(suppl. 1): 53.

Material examined: GH01D (1 ex.), GH01H (2 ex.), GH02B (4 ex.), GH03B (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 64 mm.

Diagnosis: Differs from *eolaria* by the larger size, transverse line not arising from the costal spots and postmedial line slightly distally placed; submarginal line pale, indistinct, broken into spots; marginal black line scarcely differentiated.

Male genitalia is very similar with previous species but the left valave with some sclerotization just below ampullar region much broader and with more spines.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal and Myanmar.

Genus: *Gnophos* Treitschke, 1825

196. *Gnophos accipitraria* Guenée, [1858]#

(Habitus Plate No: 14.5 & Genitalia Plate No: 18.9)

1858. *Gnophos accipitraria* Guenée, *Hist. nat. Ins., Spec. gén. Lépid.* **9**: 300.

1895. *Gnophos accipitrarius*; Hampson, *Fauna Brit. India Moths,* **3**: 252.

1995. *Gnophos accipitraria*; Sato, *Tinea,* **14**(suppl. 2): 29, pl. 76, f. 10.

Material examined: GH02B (1 ex.), GH03B (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH13A (1 ex.): Western Mixed Coniferous Forest (12/C1d).

Wing expanse: 70 mm.

Diagnosis: Ground colour grey, with fuscous striation and irroration; antemedial line of forewing indistinct, oblique and curved; medial line broken up into spots and became antemedial in hindwing; postmedial line crenulated, incurved below CuA_1 on forewing; submarginal line waved, grey and marginal series of specks. Underside with a postmedial band and a marginal band.

Valvae basally broad, apically narrow, slender, costal margin sclerotized, saccular process with a blunt, broad, sclerotized apical end; juxta tongue-shaped; uncus triangular, tip pointed, sclerotized; gnathos triangular, apically narrow, tip blunt.

Distribution: India: Himachal Pradesh (GHNP), Meghalaya (Shillong) and Assam. **Elsewhere:** Nepal, China and Tibet.

197. *Gnophos albidior* (Hampson, 1895)^

(Habitus Plate No: 14.6 & Genitalia Plate No: 18.10)

1895. *Medasina albidior* Hampson, *Fauna Brit. India Moths,* **3**: 290.

1995. *Gnophos albidior*; Sato, *Tinea,* **14**(suppl. 2): 32, pl. 102, f. 17.

2017. *Gnophos albidior*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH02B (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 78 mm.

Diagnosis: Similar with *G. obliterata,* but without any rufous suffusion; abdomen without black specks and with orange at extremity; inner and outer areas of forewing suffused and irrorated with fuscous-grey, few fulvous scales on veins; antemedial, medial and postmedial lines indistinct, single, arising from black patches on costa; hindwing with an indistinct antemedial line and blackish cell-speck; postmedial line single and reduced to a series of specks.

Male genitalia differs from previous species by having saccular process pointed, much more sclerotized and uncus with tip blunt; juxta broader.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Arunachal Pradesh and Nagaland. **Elsewhere:** Nepal and Bhutan.

Genus: *Hirasa* Moore, 1888

198. *Hirasa muscosaria* (Walker, 1866)^

(Habitus Plate No: 14.7 & Genitalia Plate No: 19.1)

1866. *Gnophos muscosarius* Walker, *List Spec. Lepid. Ins. Colln. Br. Mus.,* **35**: 1596.

1867. *Scotosia vitreata* Moore, *Proc. Zool. Soc. Lond.,* : 656.

2017. *Hirasa muscosaria*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH02A (1 ex.), GH03A (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04C (2 ex.), GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 55 mm.

Diagnosis: Ground colour dark olive-green, irrorated with fuscous and a few white scales; forewing with a waved antemedial line; medial and postmedial line crenulated, postmedial line incurved at M_3; submarginal line indistinct and irregular; hindwing slightly brownish, with medial line crenulated and traces of submarginal line; underside with crenulated postmedial line.

Valvae long, apically narrow, basally broad, saccular process apically blunt and broad; costal margin sclerotized and with a slight dorso-medial bulge; uncus triangular, tip pointed; gnathos apically elongated and rectangular medially, tip blunt; aedeagus sclerotized on the dorsal ridge, vesica with two spinose bundles.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind WLS), Sikkim, West Bengal (Darjeeling) and Arunachal Pradesh. **Elsewhere:** Nepal.

Genus: *Loxaspilates* Warren, 1893

199. *Loxaspilates dispar* Warren, 1893#

(Habitus Plate No: 14.8 & Genitalia Plate No: 19.2)

1893. *Loxaspilates dispar* Warren, *Proc. zool. Soc. Lond.*, (2): 413.

1895. *Loxaspilates dispar*; Hampson, *Fauna Brit. India Moths,* **3**: 182.

Material examined: GH27A (11 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 40 mm.

Diagnosis: Ground colour chestnut-yellow; antemedial, postmedial and submarginal lines diffused, fuscous and oblique; postmedial line with a semicircular, large, fuscous patch on its outer edge; submarginal line sinuous and with a dark spot at M_2; hindwing with postmedial line curved, oblique.

Differs from *L. obliquaria* by the absence of lateral process of tegumen.

Distribution: India: Himachal Pradesh (GHNP) and Sikkim.

200. *Loxaspilates hastigera* (Butler, 1889)

(Habitus Plate No: 14.9)

1889. *Aspilates hastigera* Butler, *Ill. typical Spec. Lep. Het. Colln Br. Mus.* **7**: 112.

1895. *Loxaspilates hastigera*; Hampson, *Fauna Brit. India Moths,* **3**: 182.

1995. *Loxaspilates hastigera*; Yazaki, *Tinea,* **14**(suppl. 2): 12.

2017. *Loxaspilates hastigera*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Loxaspilates hastigera*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 222.

Material examined: GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH23A (1 ex.): Sub-Alpine Pastures (14/DS1); GH24A (3 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a).

Wing expanse: 40 mm.

Diagnosis: Similar to *L. obliquaria,* but differs in having sinuous postmedial line and the series of black spots very prominent and dentate; hindwing with the irroration and medial band obsolete.

Distribution: India: Kashmir, Himachal Pradesh (Dharamsala, GHNP), Uttarakhand (Dehradun, Govind WLS, Nanda Devi Biosphere Reserve) and Sikkim. **Elsewhere:** Afghanistan, Nepal, China and Tibet.

201. *Loxaspilates obliquaria* (Moore, 1868)

(Habitus Plate No: 14.10 & Genitalia Plate No: 19.3)

1868. *Aspilates obliquaria* Moore, *Proc. zool. Soc. Lond.* : 649.

1895. *Loxaspilates obliquaria*; Hampson, *Fauna Brit. India Moths,* **3**: 181.

1994. *Loxaspilates hastigera*; Yazaki, *Tinea,* **14**(suppl. 1): 25.

2017. *Loxaspilates obliquaria*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Loxaspilates obliquaria*; Dey *et al., Spixiana,* **42**:51.

Material examined: GH01C (2 ex.): Himalayan Chir Pine Forest (9/C1b); GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH10A (1 ex.): Moist Deodar Forest (12/C1c); GH20A (2 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH22B (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27A (3 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 44 mm.

Diagnosis: Ground colour of wings ochreous with fuscous irrorations; costa blackish at base; black, more or less triangular spots on cell, origin of CuA_1, on 1A at middle, sometimes on Sc; postmedial line oblique with brownish suffusion beyond it; submarginal band sinuous, brown, with four black spots on it before apex and two near outer angle. Hindwing ochreous and with a half median band from anal margin.

Valave with long, pointed, slender, sclerotized saccular process; uncus medially flat with two short, lateral serci ; gnathos triangular, apically pointed; tegumen with long, apically pointed, medially borad lateral process at both sides; juxta apically bifurcated, strongly sclerotized; aedeagus with a strong spine at dorsal ridge and with a long vesica spine. 8th sternite with two strong, apical protrusions.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Nanda Devi Biosphere Reserve) and Sikkim. **Elsewhere:** Afghanistan and Nepal.

Genus: *Phthonandria* Warren, 1894

202. *Phthonandria atrilineata* Butler, 1881

(Habitus Plate No: 14.11 & Genitalia Plate No: 19.4)

1881. *Hemerophila atrilineata* Butler, *Trans. Ent. Soc. Lond.,* (3): 405.

1894. *Phthonandria atrilineata*; Warren, *Nov. Zool.*, **1**: 438.

1895. *Boarmia atrilineata*; Hampson, *Fauna Brit. India Moths*, **3**: 279.

1900. *Phthonandria atrilineata*; Swinhoe, *Cat. East Lep. Ext. Mus.*, **2**: 299.

2010. *Phthonandria atrilineata*; Liao et al., *Int. J. Biol. Sci.*, **6**(2):172-186.

2017. *Phthonandria atrilineata*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Phthonandria atrilineata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 224.

Material examined: GH05A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 58 mm.

Diagnosis: Ground colour reddish-grey, suffused and irrorated with fuscous; forewing with costal area greyish and wide at basal region; medial line black, dentate, from costa to lower angle of cell, then oblique and sinuous to inner margin; postmedial line similar, angled outwards to outer margin below costa. Hindwing with an oblique, sinuous, black line from near apex to inner margin beyond middle; marginal area darker; submarginal line pale, sinuous, indistinct.

Valvae long, apex round, costal margin medially protruded with three apical strong spines; uncus triangular; gnathos triangular, apex rounded; aedeagus with a long vesica spine.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Govind WLS), Sikkim and West Bengal. **Elsewhere:** Nepal, Bhutan, China, Korea and Japan.

Genus: *Psyra* Walker, 1860

203. *Psyra angulifera* (Walker, 1866)

(Habitus Plate No: 14.12 & Genitalia Plate No: 19.5)

1866. *Scotosia angulifera* Walker, *List Specimens lepid. Insects Colln Brit. Mus.*, **35**: 1687.

1867. *Psyra angulifera*; Moore, *Proc. Zool. Soc. Lond.*: 659.

1889. *Psyra angulifera*; Butler, *Ill. Typ. Lep. Het. B. M.,* **7**: 20.

1895. *Psyra angulifera*; Hampson, *Fauna Brit. India Moths*, **3**: 222.

1920. *Psyra angulifera*; Prout, *in Seitz, Macrolepid. World,* **4**: 410.

1992. *Psyra angulifera*; Yazaki, *in Haruta, Tinea,* **13**(Suppl. 2): 34.

2013. *Psyra angulifera*; Lui *et al*, *Zootaxa*, **3682**(3): 461.

Material examined: GH12B (1 ex.): Western Mixed Coniferous Forest (12/C1d).

Wing expanse: 44 mm.

Diagnosis: Very similar to *P. cuneata* and *P. szetschwana* but differs in the ground colour of forewing being pale to dark purplish-brown, instead of ochreous. The golden-brown outline of the black patches in the forewing is unique to *P. angulifera.*

In male genitalia, *P. angulifera* differs from its most closely related *P. szetschwana* having relatively shorter valvae and rounder saccus, which in case of *P. szetschwana* is expanded, projecting into a triangle; also the aedeagus vesica contains two bunches of spines as in *P. szetschwana* but more in number and the cornutus is shorter, thicker and less pointed.

Distribution: India: Himachal Pradesh (Kangra, GHNP), Uttarakhand (Uttarkashi, Tehri Garhwal, Pithoragarh), Sikkim (West, North), West Bengal (Darjeeling, Kalimpong), Arunachal Pradesh (Tawang, Dibang Valley) and Assam. **Elsewhere:** Nepal, China and Tibet.

204. *Psyra crypta* Yazaki, 1994

(Habitus Plate No: 14.13 & Genitalia Plate No: 19.6)

1994. *Psyra crypta* Yazaki, *Tinea*, **14**(Suppl. 1): 26.

2017. *Psyra crypta*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH04C (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 46 mm.

Diagnosis: In outer appearance, *P. crypta* is almost identical with *P. spurcataria*, but can be distinguished from it by the character of hindwing medial band which is distinctly double in both upper and underside, with the outer line much crenulated in *crypta*, whereas, in *spurcataria*, the medial band is compact and without any crenulated outer line.

Male genitalia is similar with *P. spurcataria* but uncus is broader in apical half than *P. spurcataria;* the medial process of gnathos is longer and stouter in *P. crypta*, whereas, the process is shorter, not reaching the length of uncus in *spurcataria*; costal margin of valvae in *crypta* is much more concave giving it a narrower appearance; moreover, the bend in costal basal process is much more medial in position in *crypta* rather than more towards tip in *spurcataria.* Apical spine or cornutus is shorter and stouter than *P. spurcataria.*

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Chamoli, Pithoragarh), Sikkim (West, North), West Bengal (Darjeeling) and Arunachal Pradesh (Dibang Valley). **Elsewhere:** Nepal.

205. *Psyra debilis indica* (Butler, 1889)

(Habitus Plate No: 14.14 & Genitalia Plate No: 19.7)

1889. *Tetracis indica* Butler, *Ill. Spec. Lepid. Het. Coll. Br. Mus*. **7**:20.

1895. *Psyra indica*; Hampson, *Fauna Brit. India Moths*, **3**: 222.

1998. *Psyra indica*; Yazaki, *Tinea*, **15**(Suppl. 1): 14.

1999. *Psyra debilis indica:* Parsons, *Geometrid moths of the world: a Catalogue (Lepidoptera, Geometridae),* :806

Material examined: GH04B (1 ex.), GH08B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH12A (1 ex.), GH12B (3 ex.): Western Mixed Coniferous Forest (12/C1d); GH19B (1 ex.): Low-Level Blue Pine Forest (12/2S1); GH25B (2 ex.): Dwarf Rhododendron Scrub (15/C2/E1).

Wing expanse: 50 mm.

Diagnosis: In wing morphology *P. debilis indica* can be differentiated from the nominotypical subspecies in following features: generally larger size, average male forewing length 23-25 mm; forewing ground colour darker vinous-brown irrorated with fuscous; hindwing with slightly wavy, straight medial line almost touching the cell speck and immediately followed by a crenulated postmedial line prominent up to CuA_1; in hindwing underside postmedial line is represented only by black specks in each vein.

In male genitalia, *P. debilis* is typically characterized by basally broad uncus; tongue like gnathos, apically bulbous costal basal process and 'U' shaped saccus.

Distribution: India: Himachal Pradesh (Kangra, GHNP) and Uttarakhand (Uttarkashi). **Elsewhere:** Nepal.

206. ***Psyra similaria*** Moore, 1868

(Habitus Plate No: 14.15 & Genitalia Plate No: 19.8)

1868. *Psyra similaria* Moore, *Proc. zool. Soc. Lond.*, (3): 659.

1888. *Psyra similaria*; Cotes & Swinhoe, *Moths of India*, **4**: 513.

1889. *Psyra similaria*; Butler, *Ill. Typ. Lep. Het.*, **7**: 20.

1894. *Psyra similaria*; Swinhoe, *Trans. Ent. Soc. Lond.*: 202.

1895. *Psyra similaria*; Hampson, *Fauna Brit. India Moths*, **3**: 223.

1994. *Psyra similaria*; Yazaki, *Tinea*, **14**(Suppl. 1): 26.

2013. *Psyra similaria*; Lui et al, *Zootaxa*, **3682**(3): 467.

Material examined: GH04B (1 ex.), GH04C (3 ex.): Moist Temperate Deciduous Forest (12/C1e); GH20A (1 ex.), GH21A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 40 mm.

Diagnosis: In outer morphology *P. similaria* is most similar to *P. fulvaria,* but can be easily separable from it by having prominent hindwing medial and *submarginal* band, while in latter, the hindwing is uniformly dull fuscous; the underside is also much contrastingly patterned in *similaria.*

Male genitalia very similar with *P. fulvaria* but valvae is not so long in *P. similaria*, saccus is medially protruded in *similaria*, while it is with pointed tip in *fulvaria*; uncus as in *P. fulvaria* but gnathos relatively less broad; Aedeagus with two bundles of spines like *P. szetschwana* and *P. angulifera* instead of one as in *P. fulvaria.*

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Uttarkashi, Pithoragarh), Sikkim, West Bengal (Darjeeling), Arunachal Pradesh (Dibang Valley) and Meghalaya (East Khasi). **Elsewhere:** Nepal, China and Tibet.

207. *Psyra spurcataria* (Walker, 1863)

(Habitus Plate No: 15.1 & Genitalia Plate No: 19.9)

1863. *Hyperythra spurcataria* Walker, *List Spec. Lepid. Ins. Coll. Brit. Mus.*, **26**: 1498.

1867. *Hyperythra spurcataria*; Moore, *Proc. Zool. Soc. Lond.*: 619.

1888. *Hyperythra spurcataria*; Cotes and Swinhoe, *Cat. Moths of India*, **4**: 478.

1889. *Psyra spurcataria*; Butler, *Ill. Typ. Lep. Het., B. M.*, **7**: 20.

1894. *Orbasia spurcataria*; Swinhoe, *Trans. Ent. Soc. Lond.*: 222.

1895. *Psyra spurcataria*; Hampson, *Fauna of Brit. India, Moths*, **3**: 221.

1911. *Zethenia florida* Bastelberger, *Ent. Rdsch.*, **28**: 22.

1927. *Psyra spurcataria*; Prout, *Jour. Bom. Nat.l His. Soc.*, **31**(3&4): 795.

1992. *Psyra spurcataria*; Yazaki, *Tinea*, **13**(Suppl. 2): 35.

2013. *Psyra spurcataria*; Liu et al, *Zootaxa*, **3682**(3): 469.

Material examined: GH20A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 47 mm.

Diagnosis: *P. spurcataria* is almost identical in wing pattern with *P. crypta* but in hindwing, postmedial line is less serrated, slightly waved, obscure, while it is strongly serrated in *P. crypta*; the oblique apical streak of *P. spurcataria* is replaced by a submarginal discontinuous line in *P. crypta*; also the postmedial crenulated line of hindwing underside is very prominent and complete in *P. crypta* but it is obsolescent and incomplete in *P. spurcataria.*

The male genitalia is distinct from all other species of the genus by having a pair of spine like processes in the eighth sternite; uncus narrower in apical half than *P. crypta;* medial process of gnathos much shorter and not reaching the length of uncus but in *P. crypta,* it is longer than uncus; aedeagus with three bundles of vesica spines and one very long apical spine (cornutus) instead of one bundle of spine in *P. crypta.*

Distribution: India: Himachal Pradesh (Kangra, GHNP), Uttarakhand (Chamoli, Nainital, Pithoragarh), Sikkim (West, North), West Bengal (Darjeeling, Kalimpong), Arunachal Pradesh (Dibang Valley), Assam and Meghalaya (East Khasi). **Elsewhere:** Nepal, Myanmar, China and Tibet.

Tribe: BAPTINI Forbes, 1948

Genus: *Aplochlora* Warren, 1893

208. *Aplochlora dentisignata* (Moore, 1868)

(Habitus Plate No: 15.2 & Genitalia Plate No: 19.10)

1868. *Geometra dentisignata* Moore, *Proc. Zool. Soc. Lond.,*: 636.

1895. *Caberodes dentisignata*; Hampson, *Fauna Brit. India Moths,* **3:** 158.

1992. *Nothomiza dentisignata*; Yazaki, *Tinea* **13**(suppl. 2): 38, pl. 12, f. 10.

2013. *Nothomiza dentisignata*; Chandra & Sambath, *Journal of Threatened Taxa,* **5**(1): 3567.

Material examined: GH11A (2 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 50 mm.

Diagnosis: Ground colour glaucous-green with slight rufous striation; forewing with antemedial line indistinct, sinuous, rufous, angled below costa; a dark cell-speck; postmedial line angled below costa, oblique to inner margin, became medial on hindwing.

Valvae long, broad, apex rounded, costal margin sclerotized, with a medial curved, finger-like protrusion; uncus triangular, tip pointed; aedeagus long, slender, vesica with two long spines.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP), Uttarakhand, Sikkim, West Bengal (Darjeeling) and Arunachal Pradesh (Tawang). **Elsewhere:** Nepal, Bhutan, Myanmar and Vietnam.

Genus: *Lomographa* Hübner, [1825]

209. *Lomographa platyleucata* (Walker, 1866)#

(Habitus Plate No: 15.3 & Genitalia Plate No: 20.1)

1866. *Acidalia platyleucata* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* **35**: 1628.

1895. *Bapta platyleucata*; Hampson, *Fauna Brit. India Moths,* **3:** 155.

1992. *Lomographa platyleucata*; Yazaki, *Tinea* **13**(suppl. 2): 24.

2019. *Lomographa platyleucata*; Chandra *et al.*, *Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 221.

Material examined: GH05A (1 ex.), GH08C (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH07A (1 ex.): Alder Forest (Riverine) (12/1S1); GH12B (12 ex.): Western Mixed Coniferous Forest (12/C1d); GH14B (2 ex.): Low-Level Blue Pine Forest (12/2S1); GH18A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH20A (2 ex.), GH21B (4 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH25B (1 ex.): Dwarf Rhododendron Scrub (15/C2/E1).

Wing expanse: 32 mm.

Diagnosis: Ground colour white, with thick fuscous irroration; forewing costa fulvous; cell-speck dark; indistinct medial, postmedial and submarginal slightlyfuscous bands; hindwing with a postmedial and submarginal band of fuscous specks.

Valave long, slender, medially broad, apex triangular; saccular process with a ridge at middle of valvae; uncus long, slender, sclerotized, apically pointed, curved at middle.

Distribution: India: Kashmir, Himachal Pradesh (GHNP), Sikkim, West Bengal and Meghalaya. **Elsewhere:** Nepal, Bhutan, China and Taiwan.

Tribe: UNASSIGNED

Genus: *Anonychia* Warren, 1893

210. *Anonychia grisea* (Butler, 1883)

(Habitus Plate No: 15.4 & Genitalia Plate No: 20.2)

1883. *Nadagara grisea* Butler, *Proc. Zool. Soc. Lond.,*: 172.

1887. *Onychia grisea* Swinhoe and Cotes, *Moths of India,*: 574.

1895. *Anonychia grisea* Hampson, *Fauna Brit. India Moths,* **3:** 178.

1897. *Anonychia grisea*; Leech, *Ann. Mag. Nat. Hist.,* **20**(6): 225.

1926. *Anonychia grisea*; Prout, *The journal of the Bombay Natural History Society*, **31**: 790.

1992. *Anonychia grisea*; Yazaki, *Tinea* **13**(suppl. 2): 27, pl. 8, f. 3.

Material examined: GH03A (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 32 mm.

Diagnosis: Similar to *A. rostifera* and *A. lativitta*, but differs in the forewing band without having any dark suffusion, only a narrow, dark belt inside the rufous edges, inner edge straight, outer edge with an even curve from the point to inner margin. Hindwing with the straight postmedial line.

Valvae slender, long, costal margin sclerotized, a bunch of spine before valave apex; uncus long, slender, apically pointed; gnathos with a slight medial protrusion; juxta with long, slender, sclerotized distal process; aedeagus with a long, slender apical process.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, Meghalaya (Khasi) and Arunachal Pradesh. **Elsewhere:** Nepal, China and Myanmar.

211. ***Anonychia lativitta* (Moore, 1888)**

(Habitus Plate No: 15.5 & Genitalia Plate No: 20.3)

1888. *Onychia lativitta* Moore, *Descr. Ind. Lep. Atk.*,: 279.

1895. *Anonychia lativitta*; Hampson, *Fauna Brit. India Moths,* **3:** 178.

1995. *Anonychia lativitta*; Yazaki, *Tinea* **14**(suppl. 2): 11, pl. 70, f. 5.

2017. *Anonychia lativitta*; Sanyal *et al.*; *SHILAP Revta. lepid.*, **45**(177): 157.

Material examined: GH01C (7 ex.), GH01E (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH04A (1 ex.), GH04C (7 ex.), GH08A (1 ex.), GH11A (5 ex.): Moist Temperate Deciduous Forest (12/C1e); GH14A (1 ex.), GH15A (1 ex.), GH16A (5 ex.): Low-Level Blue Pine Forest (12/2S1); GH21B (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH25B (5 ex.): Dwarf Rhododendron Scrub (15/C2/E1); GH27A (3 ex.), GH27B (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 38 mm.

Diagnosis: Similar to *A. rostrifera* and *A. grisea*, but differs in having red-brown ground colour; forewing with a broad, dark band in the medial area, with two curves below the angle; margin with dark suffusion below apex.

Differs from previous species by having much longer juxta and tegumental process at each side which is lacking in previous species.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP), Uttarakhand (Govind WLS, Nanda Devi Biosphere Reserve), Sikkim and West Bengal (Darjeeling). **Elsewhere:** Nepal.

Genus: *Antipercnia* Inoue, 1992

212. *Antipercnia belluaria* (Guenée, 1858)

(Habitus Plate No: 15.6 & Genitalia Plate No: 20.4)

1857. *Percnia belluaria* Guenée, *Hist. nat. Ins. Spec. gén. Lépid.,* **10**: 217.

1895. *Percnia belluaria*; Hampson, *Fauna Brit. India Moths,* **3:** 308.

1897. *Percnia belluaria*; Leech, *Ann. Mag. Nat. Hist.,* **20**(6): 455.

1992. *Percnia belluaria*; Yazaki, *Tinea* **13**(suppl. 2): 30, pl. 9, f. 2.

2016. *Percnia belluaria*; Sondhi & Sondhi, *Journal of Threatened Taxa,* **8**(5): 8768.

2017. *Percnia belluaria*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Antipercnia belluaria*; Kumar *et al.*, *Mitochondrial DNA Part B*, **4**(1): 310.

Material examined: GH01C (1 ex.), GH01G (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 72mm.

Diagnosis: Externally very similar with *A. felinaria* but differs in having paler wings with the spots smaller.

Valvae long, broad, apically bifurcated; costal margin medially slightly protruded, with three spines; saccular process forming a finger-like process;

uncus slender, apex blunt; gnathos long, triangular, apically protruded; aedeagus long slender with dorso-lateral series of spines at ridges.

Distribution: India: Khasmir, Himachal Pradesh (Dalhousie, GHNP), Uttarakhand (Devalsari, Govind WLS), Sikkim, West Bengal (Darjeeling), Arunachal Pradesh (Pange, Eaglenest WLS, Namdhapa NP), Assam, Meghalaya (Cherrapunjee), Nagaland (Pangti, Kigwema) and Mizoram. **Elsewhere:** Nepal, Bhutan, China, Thailand and Malaysia.

Genus: *Micrabraxas* Butler, 1889

213. *Micrabraxas grandis* Yazaki, 1995*

(Habitus Plate No: 15.7 & Genitalia Plate No: 20.5)

1995. *Micrabraxas grandis* Yazaki, *Tinea,* **14**(suppl. 2): 11.

Material examined: GH20A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 37 mm.

Diagnosis: Similar to *M. incolorata,* but much larger, forewing paler gray, irrorated with fuscous-brown, greenish tinge absent; submarginal fascie represented by a series of fuscous vein dots. Hindwing more sparsely irrorated. Male genitalia differs from *incolorata* by having uncus smaller, with a pair of trigonate, small lateral lobes; gnathos with central process shorter, much more slender in apical half; valvae broader at middle; sacculus with a short process at apex; aedeagus shorter, without subapical trigonate process; vesica shorter, broader, with a stout, apical cornutus.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal.

214. *Micrabraxas melanodonta* (Hampson, 1907)^

(Habitus Plate No: 15.8 & Genitalia Plate No: 20.6)

1907. *Boarmia melanodonta* Hampson, *Journ. Bobmay, Nat. Hist. Soc.,* **18**: 40.

1995. *Micrabraxas melanodonta*; Yazaki, *Tinea,* **14**(suppl. 2): 11.

2019. *Micrabraxas melanodonta*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 222.

Material examined: GH05A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH20A (4 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b); GH23A (1 ex.): Sub-Alpine Pastures (14/DS1); GH24A (11 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH25B (1 ex.): Dwarf Rhododendron Scrub (15/C2/E1).

Wing expanse: 38 mm.

Diagnosis: Forewing golden-yellow, with a cupreous tinge; a black spot at base and subbasal spots on costa and below cell; a small antemedial spot on costa and a series of curved smaller spots on veins and in submedian interspaces; a double postmedial series of small spots on veins, oblique below M_3.

Male genitalia differs from previous species by the uncus without any triangular lateral process; gnathos longer, slender.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand and Sikkim. **Elsewhere:** Nepal.

215. *Micrabraxas seriopuncta* (Hampson, 1902)*

(Habitus Plate No: 15.9 & Genitalia Plate No: 20.7)

1902. *Loxaspilates seriopuncta* Hampson, *Journ. Bobmay, Nat. Hist. Soc.,* **14**: 498.

1994. *Micrabraxas seriopuncta*; Yazaki, *Tinea,* **14**(suppl. 1): 25.

Material examined: GH01A (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27A (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 40 mm.

Diagnosis: Forewing pale ochreous with blackish-brown irroration; forewing with antemedial line erect, brown, diffused with series of blackish points on the outer edge; cell-spot obscure; postmedial band rather oblique, brownish, with series of longitudinal striae on its inner edge, outer edge waved; submarginal band sinuous, brown, diffused, with four black points on it towards costa and two above inner margin.

Male genitalia with saccular process pointed, valvae apically long, slender, costal margin sclerotized; uncus triangular, sclerotized; gnathos apically elongated; aedeagus with strong apical spine on vesica, with tip serrated.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal and Tibet.

Genus: *Mimochroa* Warren, 1894

216. *Mimochroa gynopteridia* (Butler, 1880)[#]

(Habitus Plate No: 15.10 & Genitalia Plate No: 20.8)

1880. *Epione gynopteridia* Butler, *Ann. Mag. Nat. Hist.* **6**(5): 123.

1895. *Pericallia gynopteridia*; Hampson, *Fauna Brit. India Moths,* **3:** 224.

2000. *Mimochroa gynopteridia*; Stuning, *Tinea,* **16**(suppl. 1): 100.

Material examined: GH01B (1 ex.), GH01C (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 36 mm.

Diagnosis: Externally similar with *M. lugens,* in being pale rufous, with no purple –grey markings; forewing antemedial line straight, angled below costa; a dark spot at apex. Hindwing with triangular medial band.

Valvae long, broad at middle; uncus apically long, slender, apically bulged; gnathos apically slight protruded; saccus with a medial invagination.

Distribution: India: Himachal Pradesh (GHNP), Sikkim and Meghalaya (Khasi). **Elsewhere:** Nepal.

Genus: *Sirinopteryx* Butler, 1883

217. *Sirinopteryx ablunata* (Guenée, 1858)

(Habitus Plate No: 15.11 & Genitalia Plate No: 20.9)

1858. *Rumia ablunata* Guenée, *Hist. nat. Ins. Spec. gén. Lépid.,* **9**: 110.

1895. *Stenorumia ablunata*; Hampson, *Fauna Brit. India Moths,* **3:** 183.

1998. *Sirinopteryx ablunata*; Yazaki, *Tinea,* **15**(suppl. 1): 16.

Material examined: GH01D (5 ex.), GH02A (2 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 26 mm.

Diagnosis: Externally related to *S. duplicilinea*, but differs in being lemon-yellow and without fuscous irroration; forewing costa rufous; cell-speck fuscous; a curved line before apex to inner margin near base; outer line less oblique.

Male genitalia differs from *duplicilinea,* by having more slender valvae; uncus longer and juxta broader.

Distribution: India: Himachal Pradesh (Dharamsala, Dalhousie, GHNP). **Elsewhere:** Nepal.

218. ***Sirinopteryx duplicilinea*** **(Hampson, 1895)**

(Habitus Plate No: 15.12 & Genitalia Plate No: 20.10)

1895. *Stenorumia duplicilinea* Hampson, *Fauna Brit. India Moths,* **3:** 183.

1998. *Sirinopteryx duplicilinea*; Yazaki, *Tinea,* **15**(suppl. 1): 17.

2019. *Sirinopteryx duplicilinea*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 225.

Material examined: GH01E (2 ex.): Himalayan Chir Pine Forest (9/C1b); GH08B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH23A (1 ex.): Sub-Alpine Pastures (14/DS1); GH24A (1 ex.): West Himalayan Sub-Alpine High-level Fir forest (14/C1a); GH27A (1 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 42 mm.

Diagnosis: see previous species.

Distribution: India: Himachal Pradesh (Dalhousie, GHNP) and Uttarakhand.

Elsewhere: Nepal.

219. *Sirinopteryx harutai* Yazaki, 1998^

(Habitus Plate No: 15.13 & Genitalia Plate No: 21.1)

1998. *Sirinopteryx harutai* Yazaki, *Tinea,* **15**(suppl. 1): 16.

2019. *Sirinopteryx harutai*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 225.

Material examined: GH01E (1 ex.): Himalayan Chir Pine Forest (9/C1b); GH08B (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH23A (1 ex.): Sub-Alpine Pastures (14/DS1); GH27B (5 ex.): Birch Rhododendron Scrub Forest (15/C1).

Wing expanse: 35 mm.

Diagnosis: Similar to *S. longipennis*, but much paler wings, with pale brown shading; ante and postmedial lines greyish-brown, oblique, postmedial angled at middle.

Male genitalia similar with previous species but uncus shorter; gnathos with median plate tongue-like; saccular process longer.

Distribution: India: Himachal Pradesh (GHNP) and Uttarakhand. **Elsewhere:** Nepal.

220. *Sirinopteryx quadripunctata* (Moore, 1868)#

(Habitus Plate No: 15.14 & Genitalia Plate No: 21.2)

1868. *Urapteryx quadripunctata* Moore, *Proc. zool. Soc. Lond.,*: 613.

2019. *Sirinopteryx quadripunctata*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 226.

Material examined: GH07A (2 ex.): Alder Forest (Riverine) (12/1S1); GH11A (1 ex.): Moist Temperate Deciduous Forest (12/C1e).

Wing expanse: 46 mm.

Diagnosis: Similar with *S. rufivinctata,* but differs in having rufous spots at end of cell of each wing; oblique line indistinct, obsolescent; postmedial line waved.

Valvae long, slender; furca long, slender, with hairs at apex; uncus long, slender, tip blunt; gnathos with medial protrusion; aedeagus long, slender, vesica with a bunch of spines.

Distribution: India: Himachal Pradesh (GHNP), Sikkim, West Bengal, Arunachal Pradesh, Nagaland and Meghalaya.

221. *Sirinopteryx undulifera* Warren, 1893^

(Habitus Plate No: 15.15 & Genitalia Plate No: 21.3)

1893. *Sirinopteryx undulifera* Moore, *Proc. zool. Soc. Lond.,*: 385.

1895. *Sirinopteryx undulifera*; Hampson, *Fauna Brit. India Moths,* **3:** 148.

1998. *Sirinopteryx undulifera*; Yazaki, *Tinea,* **15**(suppl. 1): 16.

2019. *Sirinopteryx undulifera*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 226.

Material examined: GH01H (1 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 50 mm.

Diagnosis: Very similar with previous species but differs in being ochreous; the lines more oblique; forewing with postmedial line waved, arising from apex; a speck at end of cell.

Very similar with previous species but differs in having medial plate of gnathos elongated, tongue-like.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim and West Bengal. **Elsewhere:** Nepal.

Genus: *Tanaoctenia* Warren, 1894

222. *Tanaoctenia haliaria* (Walker, 1861)^

(Habitus Plate No: 16.2 & Genitalia Plate No: 21.4)

1861. *Geometra haliaria* Walker, *List Spec. Lepid. Insects Colln Br. Mus.*, **22**: 518.

1866. *Geometra decoraria* Walker, *List Spec. Lepid. Insects Colln Br. Mus.*, **35**: 1601.

1895. *Heterocampa haliaria*; Hampson, *Fauna Brit. India Moths*, **3**: 157.

1926. *Tanaoctenia haliaria*; Prout, *J. Bombay Nat. Hist. Soc.*, **31**: 786.

1994. *Tanaoctenia haliaria*; Yazaki, *Tinea,* **14**(suppl. 1): 27.

2003. *Tanaoctenia haliaria*; Ghosh, *Fauna of Sikkim*, **4**: 217-342.

2017. *Tanaoctenia haliaria*; Sanyal *et al.*, *SHILAP Revta. lepid.*, **45**(177): 157.

2019. *Tanaoctenia haliaria*; Chandra *et al., Assemblages of Lepidoptera in Indian Himalaya through Long Term Monitoring Plots*: 226.

Material examined: GH17A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 46 mm.

Diagnosis: Ground colour bright green; palpi, frons and antennae rufous; vertex and shaft of antennae white; forewing costa white, rufous at base; antemedial line indistinct, outwardly oblique, white, reaches inner margin by a prominent line from apex; cell-speck rufous. Hindwing with antemedial line white, with a large rufous patch below cell.

Valvae long, slender, apically bifurcated; costal margin sclerotized; uncus long, triangular, slender apically, tip pointed; aedeagus sclerotized at dorso-apical ridge.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand (Kedarnath WLS, Govind WLS, Nanda Devi Biosphere Reserve), Sikkim, West Bengal, Arunachal Pradesh (Eaglenest WLS) and Meghalaya. **Elsewhere:** Nepal, Bhutan, Myanmar, China, Taiwan, Vietnam and Japan.

223. *Tanaoctenia dehaliaria* (Wehrli, 1936)

(Habitus Plate No: 16.1 & Genitalia Plate No: 21.5)

1936. *Metrocamoa (Tanaoctenia) dehaliaria* Wehrli, *Ent. Rdsch.,* **54**: 2.

1994. *Tanaoctenia dehaliaria*; Yazaki, *Tinea,* **14**(suppl. 1): 27.

Material examined: GH09A (1 ex.): Moist Temperate Deciduous Forest (12/C1e); GH17A (1 ex.): West Himalayan Upper Oak-Fir Forest (12/C2b).

Wing expanse: 46 mm.

Diagnosis: Differs from previous species by having no rufous markings at discocellulars of each wing.

Distribution: India: Himachal Pradesh (GHNP). **Elsewhere:** Nepal.

Genus: *Xenoplia* Warren, 1894

224. *Xenoplia maculata* (Moore, 1868)^

(Habitus Plate No: 16.3 & Genitalia Plate No: 21.6)

1868. *Rhyparia maculata* Moore, *Proc. zool. Soc. Lond.,*: 651.

1894. *Xenoplia subfumida*; Warren, *Novit. Zool.* **1**(2): 415.

1895. *Percnia maculata*; Hampson, *Fauna Brit. India Moths,* **3:** 307.

1992. *Percnia maculata*; Yazaki, *Tinea* **13**(suppl. 2): 31, pl. 8, f. 24.

2016. *Percnia maculata*; Sondhi & Sondhi, *Journal of Threatened Taxa,* **8**(5): 8768.

2021. *Percnia maculata*; Chettri & Yonle, *International Journal of Entomology Research,* **6**(3): 93.

Material examined: GH01F (1 ex.), GH01G (2 ex.): Himalayan Chir Pine Forest (9/C1b).

Wing expanse: 42 mm.

Diagnosis: Similar with *X. foraria,* but differs in having fuscous suffusion in the interspaces of forewing, except basal and outer area; costal and outer areas irrorated with black.

Valvae long, broad, apically pointed; costal margin sclerotized up to subapical region, a spionose bundle just below it; uncus apically elongated, slender, sclerotized, basally triangular; aedeagus long, slender, with two broad spines.

Distribution: India: Himachal Pradesh (GHNP), Uttarakhand, Sikkim, West Bengal (Darjeeling), Arunachal Pradesh and Meghalaya (Khasi). **Elsewhere:** Nepal.

Table 3.2: Species List with Material Examined & Distribution of other moth families except Geometridae recorded from Great Himalayan National Park

(**Abbreviations/ Signs used**: AN- 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, ME- 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, *- New record to India; #- New record to Western Himalaya; ^- New record to Himachal Pradesh.)

Sl. No.	Scientific name	Material Examined	Distribution	
			India	**Elsewhere**
Superfamily: Tortricoidea Latreille, 1803				
Family: Tortricidae Latreille, 1803				
Subfamily: Tortricinae Latreille, 1803				
1	***Dynatocephala omophaea* (Meyrick, 1926)#**	GH12B(1)	**HP, SK**	Nepal, Thailand, Malaysia, Vietnam, Indonesia (Borneo, Sarawak, Sumatra)
Superfamily: Cossoidea Leach, [1815]				
Family: Cossidae Leach, 1815				
Subfamily: Catoptinae Yakovlev, 2009				

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
2	*Catopta cashmirensis* (Moore, 1879)^	GH01A(2), GH01B(1), GH04A(1), GH10A(1), GH14A(1), GH15A(1)	JK, **HP**, UT	Afghanistan, Pakistan, Nepal, Bhutan, China
Subfamily: Zeuzerinae Boisduval, [1828]				
3	*Zeuzera multistrigata* Moore, 1881	GH01G(1)	JK, HP, UT, SK, WB, AR, NL, KL, AN	Pakistan, Bangladesh, Sri Lanka, Myanmar, China (Tibet), Taiwan, Japan, Korea, Vietnam, Cambodia, Thailand, Malaysia, Mongolia, Russia
4	***Zeuzera nepalense* Daniel, 1962***	GH09A(1)	**HP**	Pakistan, Nepal, Bhutan
Superfamily: Zygaenoidea Latreille, 1809				
Family: Zygaenidae Latreille, 1809				
Subfamily: Chalcosiinae Walker, 1865				
5	***Agalope eroniodes* (Moore, 1879)#**	GH04C(1)	**HP**, WB, AR	Vietnam
Superfamily: Calliduloidea Moore, 1877				
Family: Callidulidae Moore, 1877				
Subfamily: Callidulinae Moore, 1877				
6	*Pterodecta anchora* Moore, 1887	GH18A(3)	JK, HP, UT, SK	Nepal, Bhutan
Superfamily: Pyraloidea Latreille, 1809				
Family: Pyralidae Latreille, 1809				
Subfamily: Epipaschiinae Meyrick, 1884				
7	***Teliphasa similalbifusa* Li, 2016^**	GH01B(1), GH01G(2), GH07A(1)	**HP**, UT, WB, AR	China
Subfamily: Phycitinae Zeller, 1839				
8	*Dioryctria abietella* (Denis & Schiffermuller, 1775)	GH01F(1)	HP	USA, Europe, Japan
Subfamily: Pyralinae Latreille, 1809				
9	***Diloxia fimbriata* Hampson, 1896^**	GH02A(1), GH06A(1), GH07A(1)	**HP**, UT, TN	

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
10	***Heterocrasa expansalis* Warren, 1896**^	GH03A(1), GH04C(1)	**HP**, UT, AS, ME	Indonesia (Sumatra)
Family: Crambidae Latreille, 1810				
Subfamily: Acentropinae Stephens, 1836				
11	*Eoophyla peribocalis* (Walker, 1859)	GH01C(1)	HP, UT, SK, MN, CT, KL, TN	Nepal, Bhutan, Sri Lanka, Myanmar, China, Vietnam, Philippines, Yemen
Subfamily: Glaphyriinae Forbes, 1923				
12	***Evergestis forficalis* (Linnaeus, 1758)**#	GH07A(1)	**HP**, SK	China, Korea, Japan, Russia, North America
Subfamily: Spilomelinae Guenée, 1854				
13	*Bradina diagonalis* Guenée, 1854	GH01C(1)	HP, UT, AR	Myanmar, Indonesia (Sumatra, Java, Sambawa)
14	*Cnaphalocrocis medinalis* Guenée, 1854	GH01C(1)	HP, SK, AR, ME, MH	Sri Lanka, Myanmar, China, Taiwan, Japan, Korea, Vietnam, Malaysia, Indonesia (Borneo, Java, Sumatra), New Guinea, Australia, Russia, North America
15	*Cotachena histricalis* (Walker, 1859)	GH01A(1)	HP, UT, SK, AR, NL, TN	Sri Lanka, Myanmar, China, Hong Kong, Indonesia, New Guinea, Australia, Solomon Islands, Africa
16	*Lamprosema commixta* (Butler, 1879)	GH01E(1)	HP, UT, AS, NL, ME, TN	Nepal, Sri Lanka, China, Hong Kong, Japan, Vietnam, Malaysia
17	***Maruca vitrata* (Fabricius, 1787)**^	GH01C(2)	**HP**, UT, WB, AR, CT, AN	Nepal, Bhutan, Sri Lanka, China, Taiwan, Korea, Japan, Malaysia, Philippines, Laos, Australia, Africa, Tanzania, Madagascar, North America, Mexico, Brazil, Colombia, Costa Rica

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
18	*Nomophila noctuella* (Denis & Schiffermüller, 1775)	GH01C(1), GH01D(9), GH01E(4), GH04A(3)	HP, UT	Pakistan, Nepal, China, Australia, Iran, Yemen, Turkey, UAE, Denmark, Netherlands, France, Finland, Portugal, Germany, Sweden, Norway, Austria, Bulgaria, Greece, Norway, Kenya, South Africa, USA, Canada, Argentina
19	***Notarcha aurolinealis* (Walker, 1859)^**	GH01F(1)	**HP**, AR, MH, TN	Pakistan, Sri Lanka, Hong Kong, Thailand, Philippines, Australia
20	***Patania ruralis* (Scopoli, 1763)^**	GH01C(6), GH04A(2), GH08A(1)	**HP**, UT, SK, AR, ME, MH, TN	Pakistan, Indonesia (Borneo, Java), Fiji, New Guinea, Solomon Islands, Finland, Sweden, Germany, Estonia, United Kingdom, Italy, Russia, Denmark, Austria, Norway
21	*Patania verecunda* (Warren, 1896)	GH11A(4)	HP, UT, SK, WB, AR, ME, TN	Nepal, Sri Lanka
22	*Polythlipta cerealis* Lederer, 1863	GH01G(1)	HP, UT, SK, WB, AR, AS, ME, MI	Nepal, Bhutan, Taiwan, Thailand, Malaysia, Indonesia (Borneo)
23	***Spoladea recurvalis* (Fabricius, 1775)^**	GH01C(2)	**HP**, UT, SK, WB, AR, HR, CT, MP, MH, KA, TN, AN	Pakistan, Nepal, Bhutan, Bangladesh, Sri Lanka, China, Taiwan, Hong Kong, Japan, Korea, Vietnam, Phillipines, Fiji, Australia, Syria, UAE, Spain, Portugal, Greece, Germany, South Africa, Nigeria, Kenya, Madagaskar, Canada, USA, Mexico, Cuba, Brazil, Costa Rica

Sl. No.	**Scientific name**	**Material Examined**	**Distribution**	
			India	**Elsewhere**
24	*Syngamia falsidicalis* (Walker, 1859)	GH01B(6), GH04A(1), GH22A(2)	HP, UT, WB, AR, AS, ME, MI, TN, KL	Pakistan, Nepal, Sri Lanka, China, Taiwan, Hong Kong, Congo, Zimbabwe
25	***Udea prunalis* (Denis & Schiffermuller, 1775)***	GH02B(1)	**HP**	China, Europe
26	*Udea ferrugalis* (Hübner, 1796)	GH01E(1)	HP, UT, SK, TN	Afghanistan, Pakistan, Nepal, Sri Lanka, Myanmar, China, Japan, UAE, Denmark, Finland, Portugal, Spain, Greece, Italy, Austria, Norway, Germany, United Kingdom, Belgium, Kenya, South Africa
27	***Udea stigmatalis* (Wileman, 1911)***	GH02B(1), GH03A(1), GH03C(1), GH04C(1), GH20A(1)	**HP**	Japan, Taiwan, Russia
Superfamily: Drepanoidea Boisduval, 1828				
Family: Drepanidae Boisduval, 1828				
Subfamily: Drepaninae Boisduval, 1828				
28	*Auzata semipavonaria* Walker, 1862	GH01F(1)	JK, HP, UT, SK	Nepal, China, Ghana, Cameroon
29	***Auzata simpliciata* Warren, 1897#**	GH01H(1)	**HP**, ME	China, Taiwan
30	***Callidrepana patrana* (Moore, 1867)#**	GH01G(2), GH01H(1)	**HP**, WB	Bhutan, Myanmar, China, Taiwan, Japan, Laos, Malaysia, Indonesia
31	***Ditrigona diana* Wilkinson, 1968#**	GH01G(1), GH01H(1)	**HP**, WB, ME, NL	Bhutan, Nepal
32	***Drepana pallida* Moore, 1879#**	GH01E(4), GH02A(1), GH03A(1), GH12A(2)	**HP**, UT, SK, WB, AR, NL, MN	Nepal, Bhutan, Myanmar, China, Taiwan
33	*Macrocilix mysticata* (Walker, [1863])	GH04A(1)	HP, UT, SK, WB, AR,	Pakistan, Nepal, Bhutan, Myanmar, China, Taiwan, Vietnam, Japan, Korea

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
34	*Microblepsis violacea* (Butler, 1889)	GH01C(2)	HP, UT, NL	Nepal, China, Taiwan
35	*Oreta vatama* Moore, 1866	GH06B(1), GH07A(2), GH12A(4), GH16A(2)	JK, HP, UT, SK, WB, AR, MN	Pakistan, Nepal, Bhutan, Bangladesh, Myanmar, China
Subfamily: Thyatirinae Smith, 1893				
36	***Gaurena florens* Walker, 1864[^]**	GH16A(2)	**HP**, UT, SK, WB, AR, MN	Nepal, Bhutan, Myanmar, China, Vietnam, Thailand
37	***Habrosyne indica* (Moore, 1867)[^]**	GH01C(1)	JK, **HP**, SK, WB, AR	Nepal, Myanmar, China (Tibet), Taiwan, Japan, Vietnam, Thailand
38	***Habrosyne intermedia conscripta* Warren, 1912[^]**	GH15A(1), GH17B(1)	**HP**, UT	Nepal, China (Tibet)
39	***Isopsestis meyi* Ronkay, Ronkay & Witt, 2007[*]**	GH07A(1), GH12B(5), GH20A(1)	**HP**	China, Vietnam
40	***Paragnorima fuscescens* (Hampson, 1893)[#]**	GH07A(1)	**HP**, SK, NL	China, Nepal, Myanmar, Vietnam, Thailand
41	***Spica luteola* Swinhoe, 1889[^]**	GH07A(1)	**HP**, UT, SK	Nepal, China, Tibet
42	*Thyatira batis* (Linnaeus, 1758)	GH01H(2)	HP, UT, SK, AR	Nepal, China, Taiwan, Japan, Korea, Malaysia, Indonesia (Sumatra, Java), Russia, Mongolia, Turkey, Iran, Germany, Portugal, United Kingdom, Finland, Norway, Austria, Italy, France, Netherlands, Algeria
Superfamily: Lasiocampoidea Harris, 1841				
Family: Lasiocampidae Harris, 1841				
Subfamily: Lasiocampinae Harris, 1841				
43	***Euthrix inobtrusa* (Walker, 1862)[#]**	GH01G(1)	**HP**, SK, AR, MI	Nepal, Bhutan, Bangladesh, Myanmar, China, Vietnam, Laos, Malaysia, Indonesia (Sumatra)

Sl. No.	**Scientific name**	**Material Examined**	**Distribution**	
			India	**Elsewhere**
44	***Kunugia sinjaevi* Zolotuhin & Witt, 2000***	GH01G(1), GH01H(1)	**HP**	Vietnam
45	*Trabala vishnou* (Lefèbvre, 1827)	GH02A(3), GH04A(1)	HP, UT, SK, WB, AR, AS, ME, MN, BH, DL, JH, MH, KA, TN, AN	Pakistan, Nepal, Bhutan, Sri Lanka, Myanmar, China (Tibet), Taiwan, Hong Kong, Japan, Vietnam, Laos, Thailand, Malaysia, Indonesia (Java, Sumatra)
Superfamily: Bombycoidea Latreille, 1802				
Family: Eupterotidae Swinhoe, 1892				
Subfamily: Unassigned				
46	***Apona caschmirensis* (Kollar, [1844])^**	GH01H(1), GH04C(1), GH11A(3), GH16A(1)	JK, **HP**, UT, SK, AR, ME, NL	Pakistan, Nepal
Family: Brahmaeidae Swinhoe, 1892				
Subfamily: Unassigned				
47	*Brahmaea wallichi* (Gray, 1831)	GH16A(2)	JK, HP, UT, SK, WB, AR, AS, ME	Pakistan, Nepal, Bhutan, Myanmar, China, Taiwan, Japan, Vietnam, Laos, Thailand, Philippines
Family: Endromidae Boisduval, 1828				
Subfamily: Oberthuerinae Kuznetzov & Stekolnikov, 1985				
48	*Comparmustilia sphingiformis* (Moore, 1879)	GH01F(2)	HP, UT, SK, WB, AR	Nepal, Bhutan, Myanmar, China, Vietnam, Thailand, Malaysia
49	***Mustilia falcipennis* Walker, 1865^**	GH01F(1)	**HP**, UT, WB, AR	Pakistan, Nepal, Bhutan, Myanmar, China, Taiwan, Vietnam, Thailand
50	***Mustilizans hepatica* (Moore, 1879)^**	GH04A(1)	**HP**, UT, SK, WB, AR	Pakistan, Nepal, Bhutan, China, Taiwan, Vietnam, Laos, Malaysia, Indonesia (Borneo, Sumatra)
Family: Bombycidae Latreille, 1802				
Subfamily: Bombycinae Latreille, 1802				

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
51	*Bombyx huttoni* Westwood, 1847	GH01G(1), GH01H(1)	JK, HP, UT, SK, WB, AR, AS	Pakistan, Nepal, Bhutan, Taiwan, Vietnam
52	***Penicillifera apicalis* (Walker, 1862)^**	GH01G(2)	**HP**, UT, WB, AS, KL	Bhutan, Myanmar, Vietnam, Thailand, Malaysia, Indonesia (Sumatra, Java), Brunei, Philippines
Family: Saturniidae Boisduval, 1837				
Subfamily: Saturniinae Boisduval, 1837				
53	***Saturnia rosalata* Naumann & Näsig, 2010^**	GH02A(1), GH15A(1)	**HP**, UT	Nepal
Family: Sphingidae Latreille, 1802				
Subfamily: Macroglossinae Harris, 1839				
54	*Cechetra scotti* (Rothschild, 1920)	GH01B(1)	**HP**, UT, NL	Pakistan, Nepal, Bhutan, China, Laos, Vietnam
55	*Deilephila rivularis* (Boisduval, [1875])	GH04A(1)	HP, UT, SK, WB, ME, PB	Afghanistan, Pakistan, Nepal, Turkey
56	*Macroglossum nycteris* Kollar, 1844	GH18A(2)	JK, HP, UT, SK, ME	Afghanistan, Pakistan, Nepal, Myanmar, China, Japan
57	*Pergesa acteus* (Cramer, 1779)	GH01H(1)	JK, HP, UT, SK, WB, AR, AS, ME, TR, NL, MN, MI, JH, PB, MH, KA, TN, AN	Nepal, Bhutan, Bangladesh, Sri Lanka, China, Myanmar, China, Taiwan, Japan, Vietnam, Laos, Cambodia, Thailand, Malaysia, Indonesia (Borneo, Java), Philippines
58	*Rhagastis confusa* Rothschild & Jordan, 1903	GH04A(1)	HP, UT, SK, WB, AR, AS, ME	Nepal, Bangladesh, China, Vietnam, Thailand
59	*Rhagastis olivacea* (Moore, 1872)	GH02A(1)	HP, UT, SK, WB, AR, AS, ME	Pakistan, Nepal, Bhutan, Bangladesh, Myanmar, China, Korea, Vietnam, Laos, Thailand, Malaysia, Indonesia (Borneo)
Subfamily: Smerinthinae Grote & Robinson, 1865				

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
60	*Anambulyx elwesi* (Druce, 1882)	GH02A(2)	HP, UT, SK, WB, AS, ME	Pakistan, Nepal, Bhutan, Myanmar, China, Vietnam, Thailand
61	*Clanis deucalion* (Walker, 1856)	GH04A(1)	HP, UT, AR, ME, PB, GJ	Pakistan, China (Tibet), Japan, Korea, Laos, Thailand
Superfamily: Geometroidea Leach, 1815				
Family: Uraniidae Leach, 1815				
Subfamily: Epipleminae Hampson, 1892				
62	***Epiplema adamantina* Inoue, 1998***	GH01E(1)	**HP**	Nepal
63	*Phazaca reticulata* (Moore, 1888)	GH01B(1), GH01C(1), GH02A(1), GH07A(1), GH08A(1)	HP, UT, SK	Nepal
64	*Sylviplema bicaudata* (Moore, 1867)	GH07A(1), GH11A(1), GH21B(1)	HP, UT, SK, ME	Nepal
Superfamily: Noctuoidea Latreille, 1809				
Family: Notodontidae Stephens, 1829				
Subfamily: Heterocampinae Neumoegen & Dyer, 1894				
65	*Neopheosia fasciata fasciata* (Moore, 1888)	GH01E(1), GH01F(1), GH04A(2)	HP, UT, SK, AR	Pakistan, Nepal, Myanmar, China, Taiwan, Japan, Vietnam, Indonesia (Sulawesi, Java), Philippines
Subfamily: Notodontinae Stephens, 1829				
66	*Acmeshachia gigantea* (Elwes, 1890)	GH01G(1)	HP, UT, SK, WB, AR, AS, ME	Pakistan, Nepal, Myanmar, China, Taiwan, Vietnam, Thailand
67	*Euhampsonia niveiceps* (Walker, 1865)	GH04A(1)	HP, UT, SK, AS	Nepal, China
68	*Formofentonia orbifer orbifer* (Hampson, 1892)	GH01A(1)	HP, UT, SK, WB, AR	Nepal, Myanmar, China, Taiwan, Indonesia (Borneo, Sulawesi)
69	***Pheosia albivertex* (Hampson, 1892)^**	GH01E(1), GH01F(1)	JK, **HP**	Pakistan, Nepal, Bhutan, China (Tibet), Taiwan

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
70	***Ptilodon flavistigma* (Moore, 1879)^**	GH09A(1), GH12B(1), GH15A(1)	**HP**, UT, SK, WB	China, Taiwan
71	***Ptilodon spinosa spinosa* Schintlmeister, 2007^**	GH15A(1)	**HP**, UT, ME	Thailand, Vietnam
72	*Stauropus berberisae* Moore, 1888	GH01E(1), GH01F(1)	HP, UT	Afghanistan, Pakistan
73	***Syntypistis umbrosa* (Matsumura, 1927)^**	GH01E(3), GH01F(2), GH01G(1), GH01H(2)	HP, UT, WB, NL, UP	Pakistan, Nepal, Myanmar, China, Taiwan, Malaysia, Indonesia, Philippines
Subfamily: Periergosinae Kobayashi, 2016				
74	***Chadisra bipartita* (Matsumura, 1925)#**	GH07A(1)	**HP**, NE India, MH	Pakistan, Nepal, Myanmar, China, Taiwan, Japan, Malaysia, Indonesia (Sumatra)
75	***Periergos kamadena* (Moore, 1866)^**	GH01D(1)	**HP**, UT, NE India	Nepal, Myanmar, China (Tibet), Taiwan, Vietnam, Laos, Thailand
76	***Rachia plumosa* Moore, 1879^**	GH07A(3), GH09A(1), GH12B(1), GH17A(1)	**HP**, UT, SK, WB	Nepal, China (Tibet), Taiwan
Subfamily: Phalerinae Butler, 1886				
77	***Phalera parivala* Moore, 1860^**	GH06A(1)	**HP**, UT, WB, SK, NE India	Pakistan, Nepal, Bhutan, China, Taiwan, Myanmar
Subfamily: Pygaerinae Duponchel, 1845				
78	*Clostera anachoreta anachoreta* (Denis & Schiffermüller, 1775)	GH01B(2), GH01E(2), GH04A(1)	JK, HP, UT	China, Taiwan, Japan, Korea, Russia, Turkey, Austria, Bulgaria, England, Finland, Sweden, Spain
79	*Clostera fulgurita fulgurita* (Walker, 1865)	GH01E(2), GH04A(1)	HP, UT, UP, S India	Nepal, Sri Lanka, Myanmar, China, Indonesia (Borneo, Java, Sulawesi), Papua New Guinea
80	*Micromelalopha undulata* (Hampson, 1891)	GH01E(3), GH02A(1), GH03B(1), GH12A(2), GH17B(1)	HP, UT, TN	Afghanistan, Pakistan, Nepal

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
Subfamily: Spataliinae Matsumura, 1929				
81	*Saliocleta ochracea* (Moore, 1879)	GH01B(1)	HP, SK, WB	Myanmar, China, Vietnam, Laos, Thailand, Indonesia (Sumatra)
Subfamily: Thaumetopoeinae Aurivillius, 1889				
82	***Gazalina apsara* (Moore, 1859)^**	GH04A(3), GH09A(1), GH11B(2)	**HP**, UT, SK, WB, AR	Pakistan, Nepal, China
83	*Gazalina chrysolopha* (Kollar, 1844)	GH05A(2), GH11B(4), GH13A(2), GH17B(7)	JK, HP, UT, SK, WB, AR	Pakistan, Nepal, Myanmar, China, Taiwan, Thailand
Family: Erebidae Leach, 1815				
Subfamily: Aganainae Lafontaine & Fibiger, 2006				
84	*Asota caricae* Fabricius, 1775	GH01C(1)	JK, HP, UT, WB, AS, NL, TR, RJ, MP, CT, MH, GA, KA, TN, KL, AN	Nepal, Sri Lanka, Myanmar, China, Taiwan, Hong Kong, Japan, Vietnam, Thailand, Malaysia, Indonesia (Borneo, Java, Sumatra), Timor Philippines Australia
Subfamily: Arctiinae Leach, 1815				
85	*Alphaea impleta* (Walker, 1864)	GH05A(1)	JK, HP, UT, SK, WB, AR, AS, ME, NL	Nepal, China (Tibet)
86	*Barsine linga* Moore, 1859	GH01B(1)	JK, HP, UT, SK, WB, AR, AS, ME. MI	Nepal, Bhutan, China, Laos, Thailand
87	***Barsine mactans* Butler, 1877^**	GH01C(1)	**HP**, SK, WB	Nepal, China
88	***Barsine orientalis bigamica* Cerny, 2009^**	GH01D(17), GH04A(5)	**HP**, UT, WB, SK, AR, AS, CT	Nepal, China, Cambodia, Thailand
89	*Barsine pretiosa* Moore, 1879	GH01A(4), GH01C(3), GH01D(17), GH03C(1)	HP, UT, SK, WB, AR, AS, MN, TN, AN	Nepal, Sri Lanka, Myanmar, China, Japan, Indonesia (Borneo)

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
90	*Barsine pseudomactans* Volynkin & Cerný, 2016	GH01A(1)	SK	Nepal, Bhutan, China
91	*Brunia antica* (Walker, 1854)	GH01C(1), GH01G(1), GH06A(2), GH09A(1), GH12B(2)	India	Sri Lanka, China, Thailand, Laos, Vietnam, Cambodia, Peninsular Malaysia, Taiwan, Sundaland, Nikobar Is., Philippines-Palawan, Luzon
92	*Callindra similis* (Moore, 1879)	GH02A(4), GH03B(1), GH05A(6)	HP, UT, SK, WB	Nepal, Bhutan, China (Tibet), Costa Rica
93	*Chrysorabdia bivitta* (Walker, 1856)	GH01B(3), GH02A(1)	JK, HP, UT, SK, WB, AR, AS, ME, MN	Pakistan, Nepal, Bhutan, Myanmar
94	*Chrysorabdia viridata* (Walker, [1865])	GH05A(4), GH06A(1), GH06B(1)	HP, UT, SK, WB, AR, AS, ME	Pakistan, Bhutan, Bangladesh, Myanmar, China
95	***Churinga beema* (Moore, 1865)^**	GH07A(1)	**HP**, UT, SK, WB	Nepal
96	***Creatonotos transiens* (Walker, 1855)#**	GH01C(2), GH01F(2)	**HP**, SK, WB, AR, AS, CT, MP	Afghanistan, Pakistan, Nepal, Bhutan, Bangladesh, Myanmar, China, Japan, Vietnam, Thailand, Malaysia, Indonesia (Sumatra, Sulawesi, Borneo, Lombok), Philippines, Queensland
97	*Cyana adita* Moore, 1859	GH01A(1), GH01B(2), GH01D(1), GH02A(7), GH03B(3), GH04A(20), GH11A(1), GH12A(1)	HP, UT, SK, WB, AR, AS, ME	Nepal, Bhutan, China, Vietnam, Thailand
98	*Cyana arama* (Moore, 1859)	GH01C(1)	HP, UT, SK, WB, AR, AS, ME, NL, MI	

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
99	*Cyana candida* (Felder, 1874)	GH06A(2)	JK, HP, UT, SK, WB, AR, ME	China (Tibet)
100	*Cyana detrita* Walker, 1854	GH01D(1), GH02A(2)	JK, HP, UT, SK, WB, AR, AS, ME, NL	Afghanistan, Nepal, Bhutan, Bangladesh, Sri Lanka, Myanmar, China, Indonesia (Java, Sumatra), Madagascar
101	*Cyana dohertyi* (Elwes, 1890)	GH01B(1)	HP, UT, SK, AR, AS, ME, NL, MN	Nepal, China, Thailand
102	*Cyana gazella* (Moore, 1872)	GH01G(1)	JK, HP, UT, SK, WB, ME, AS	Nepal, China, Thailand, Vietnam
103	*Cyana khasiana* Hampson, 1897	GH08A(1)	**HP**, SK, WB, AR, AS, ME	China, Thailand, Vietnam
104	*Cyana signa* Walker, 1854	GH06A(1)	JK, HP, UT, SK, WB, AR, AS, ME, MN, CT	Nepal, Bangladesh, Myanmar, China (Tibet), Vietnam, Thailand
105	*Dolgoma reticulata* (Moore, [1866])	GH07A(8), GH14B(2), GH15A(1)	JK, **HP**, SK, AR, KA	Thailand
106	*Eilema basinota* (Moore, 1865)	GH07A(2), GH12B(1), GH15A(1)	HP, UT, SK, WB	
107	*Ghoria postfusca* (Hampson, 1894)	GH12A(1), GH16A(4), GH17B(3)	HP, UT, SK, AR	China (Tibet), Japan
108	*Katha conformis* (Walker, 1854)	GH01B(1), GH01D(1)	JK, HP, UT, SK, WB, ME	Bhutan, China, Japan, Thailand
109	*Katha montana* Bucsek, 2012	GH01E(1), GH10A(1)	**HP**, AR	Malaysia
110	*Lemyra melanosoma* (Hampson, 1894)	GH01C(1), GH07A(1)	HP, SK, WB, ME	Pakistan, Myanmar, Thailand, China (Tibet)
111	*Lemyra multivittata* (Moore, 1865)	GH01D(1)	JK, HP, UT, SK, WB, AR, AS, ME, NL, UP	Nepal, Myanmar, China, Vietnam, Thailand

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
112	*Lemyra neglecta* (Rothschild, 1910)	GH01D(1), GH01E(1), GH05A(9)	**HP**, SK, AS	Nepal, China, Myanmar
113	*Lemyra punctilinea* (Moore, 1879)	GH01C(1)	JK, **HP**, AS	Pakistan, China, Nepal
114	*Lemyra rhodophila* (Walker, [1865])	GH01C(1), GH01D(1), GH02A(2)	HP, SK	Pakistan, China (Tibet), Nepal, Myanmar
115	*Lemyra stigmata* (Moore, 1865)	GH01C(1), GH01H(1), GH07A(1), GH12B(1), GH20A(3)	JK, HP, UT, SK, WB, AR, AS	Pakistan, Nepal, Bhutan, Myanmar, China, Taiwan, Vietnam, Thailand
116	***Macotasa nubecula* (Moore, 1879)[#]**	GH07A(10)	**HP**, AR, NL, MN, KA, TN, AN	Nepal, Myanmar, Indonesia (Borneo)
117	*Macrobrochis pallens* Hampson, 1894	GH01D(2)	HP, UT	Nepal, Myanmar, China
118	*Miltochrista calamaria* (Moore, 1888)	GH01E(1)	HP, AS, ME	Nepal, Indonesia (Borneo)
119	*Miltochrista dasara* (Moore, [1860])	GH01E(1)	HP, SK, AS, TN	Nepal, Indonesia (Sumatra, Java)
120	*Miltochrista dharma* (Moore, 1879)	GH01C(2)	HP	Japan
121	***Nyctemera adversata* (Schaller, 1788)[^]**	GH04A(1)	**HP**, UT, SK, WB, AR, AS, ME, NL, MN, TR	Nepal, Bhutan, Bangladesh, Myanmar, China, Taiwan, Hong Kong, Japan, Korea, Vietnam, Thailand, Malaysia, Indonesia (Sumatra, Borneo), Philippines
122	*Spilarctia casigneta* (Kollar, [1844])	GH01A(1), GH02A(1)	HP, UT, SK, WB, AR, AS, ME, MN, NL, PB, MH, TN, KL	Pakistan, Nepal, Bhutan, China (Tibet)
123	*Spilarctia comma* (Walker, 1856)	GH01F(4)	JK, HP, UT, SK, AR	Nepal, Bhutan, China

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
124	*Spilarctia leopardina* (Kollar, [1844])	GH16A(3)	JK, HP, UT, SK, AR, AS, ME, MN	Nepal, China (Tibet)
125	***Spilarctia melanostigma*** **(Erschoff, 1872)^**	GH16A(5)	JK, **HP**, UT, SK, AS, NL	Afghanistan, Pakistan, Uzbekistan, Kyrgyzstan, Tajikistan
126	***Spilarctia obliqua*** **(Walker, 1855)^**	GH01A(1), GH06A(1)	**HP**, UT, SK, WB, AR, AS, BH, PB, CT, KA, TN, KL	Afghanistan, Pakistan, Nepal, Bhutan, Bangladesh, Myanmar, China, Australia, Russia
127	*Spilarctia sagittifera* Moore, 1888	GH01F(1), GH06A(1), GH07A(1)	HP, UT, SK, WB, AR	Afghanistan, Pakistan, Nepal, Bhutan, Bangladesh, Myanmar, China, Taiwan, Hong Kong
128	***Spilosoma erythrozona*** **(Kollar, 1844)^**	GH03B(1), GH07A(1), GH12A(4), GH15A(6), GH18C(3)	JK, **HP**, UT, ME	Afghanistan, Pakistan, China
Subfamily: Boletobiinae Guenée, [1858]				
129	***Zurobata reticulata*** **(Moore, 1882)#**	GH12B(2)	**HP**, WB	Nepal, Indonesia (Borneo)
Subfamily: Calpinae Boisduval, 1840				
130	*Calyptra bicolor* (Moore, 1883)	GH09A(1)	JK, UT, HP, SK, WB, PB	Nepal, China
131	*Eudocima homaena* (Hubner, [1823])	GH19C(1)	**HP**, UT, WB, AS, NL, GJ, CT, MH, GA, KA, KL, TN, OR	Nepal, China, Bangladesh, Sri Lanka, Vietnam, Cambodia, Thailand, Malaysia, Indonesia (Borneo), Timor, Flores, Philippines, Taiwan, Hong Kong, Japan
132	*Plusiodonta coelonota* (Kollar, 1844)	GH01B(1)	**HP**, WB	Nepal, China, Taiwan, Sri Lanka, Malaysia, Vietnam, Indonesia, Phillipines, New Guinea, Australia, Japan, Korea
Subfamily: Erebinae Leach, 1815				

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
133	***Bamra lepida* (Moore, 1867)^**	GH02A(1)	**HP**, UT, SK, WB	Nepal, Taiwan, Hong Kong
134	*Catocala inconstans* Butler, 1889	GH27A(1)	HP	Nepal
135	***Catocala patala* Felder, 1874^**	GH23A(3)	JK, **HP**, UT, AR, PB	China, Japan, Korea
136	*Catocala prolifica* Walker, [1858]	GH03C(1)	India	Nepal
137	***Daddala lucilla* (Butler, 1881)^**	GH03C(1), GH08B(1)	**HP,** UT, SK, WB, AR, AS, ME, PB	Nepal, Myanmar, China, Taiwan, Hong Kong, Japan, Korea, Thailand, Malaysia, Indonesia (Borneo, Java, Bali, Sumatra, Sulawesi), Papua New Guinea
138	*Ericeia inangulata* (Guenée, 1852)	GH01E(1)	HP, UT, WB, AR, JH, MH, TN, KL	Nepal, Bangladesh, Sri Lanka, Myanmar, China, Taiwan, Hong Kong, Thailand, Malaysia, Indonesia (Borneo), Fiji, New Guinea, Australia, Africa, Brazil
139	*Mocis frugalis* (Fabricius, 1775)	GH03B(1)	HP, UT, SK, WB, AR, AS, ME, MN, TR, JH, UP, PB, CT, MH, KA, TN, KL, OD, AN	Pakistan, Nepal, Sri Lanka, China, Taiwan, Hong Kong, Japan, Vietnam, Laos, Cambodia, Malaysia, Thailand, Indonesia, Phillipines, Australia, Fiji, Egypt, South Africa
140	*Spirama helicina* (Hübner, 1827)	GH01H(1)	HP, UT, SK, AS, ME, NL, JH, DL, MP, MH, TN	Pakistan, Nepal, Myanmar, China, Taiwan, Japan, Korea, Laos, Thailand, Malysia, Indonesia, Russia

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
141	*Spirama retorta* (Clerck, 1764)	GH01E(1), GH04A(1)	JK, HP, UT, SK, WB, AS, ME, NL, DL, CT, AD, MH, GA, KA, TN, KL	Nepal, Bhutan, Bangladesh, Myanmar, China, Taiwan, Hong Kong, Japan, Korea, Cambodia, Thailand, Malaysia, Indonesia (Java), Philippines
142	***Sypnoides cyanivitta* (Moore, 1867)^**	GH01H(1)	**HP**, UT, SK, WB, AR	Nepal, Bangladesh, China, Thailand
143	***Sypnoides kirbyi* (Butler, 1881)#**	GH02A(3)	**HP**, SK, WB	China, Thailand
Subfamily: Herminiinae Leach, 1815				
144	***Bertula hadenalis* (Moore, 1867)#**	GH07A(2)	**HP**, WB, TN	Taiwan
145	***Simplicia xanthoma* Prout, 1928#**	GH01B(1), GH01C(1)	**HP**, CT	Nepal, China, Taiwan, Japan, Korea, Thailand, Malaysia, Indonesia
Subfamily: Hypeninae Herrich-Schäffer, 1851				
146	***Dichromia thermesialis* (Walker, [1866])#**	GH08B(1), GH12B(5), GH18A(1), GH19B(1)	**HP**, WB, ME, TN	China, Sri Lanka, Indonesia (Sumatra, Borneo, Buru), New Guinea
147	***Hypena albisigna* Moore, 1882^**	GH01G(1)	**HP**, UT, ME	Hong Kong
148	*Hypena indicatalis* Walker, [1859]	GH01E(1)	HP	Japan. Indonesia (Borneo, Sarawak, Java)
149	*Hypena labatalis* Walker, 1858	GH07A(1), GH12A(1)	**HP**, SK, ME, TN	Sri Lanka, Thailand, China, Hong Kong, Australia
150	*Hypena longipennis* Walker, 1865	GH12A(1)	HP, UT, SK, WB, ME, TN	Bangladesh, Thailand, China, Taiwan
151	*Hypena obductalis* Walker, 1859	GH03B(4), GH05A(25), GH06B(3), GH09A(3), GH12A(82)	HP, SK, WB, ME, MH	China, Japan
152	*Hypena robustalis* Snellen, 1880	GH01E(1)	HP	Thailand, Indonesia (Borneo)
153	***Hypena tristalis* Lederer, 1853***	GH08C(1), GH27A(1)	**HP**	Siberia, Peking

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
154	*Hypena vestita* (Moore, [1885])	GH01D(1)	HP, WB, ME	Sri Lanka, Thailand, Malaysia, Indonesia (Borneo, Molucca, Seram), Philippines, China (Tibet)
155	*Rhynchina caerulescens* Butler, 1889	GH12A(1), GH18A(1)	HP, SK, PB	
156	*Rhynchina rivuligera* Butler, 1889	GH22C(1)	HP, AS, ME, TN	Thailand
157	*Rhynchina sagittata* Butler, 1889	GH12B(4)	JK, HP	Pakistan
Subfamily: Lymantriinae Hampson, 1893				
158	*Arctornis cygna* (Moore, 1879)	GH01C(1), GH10A(1)	SK, WB, ME	Nepal, China
159	***Arctornis l-nigrum* (Müller, 1764)***	GH05A(2)	**HP**	Nepal, Russia, Japan, Taiwan, Sweden, Denmark
160	*Artaxa comparata* (Walker, 1865)	GH11A(1)	India	
161	*Calliteara cerebosa* (Swinhoe, 1903)	GH01E(1), GH01F(1)	HP, UT, SK	Nepal
162	***Calliteara horsfieldi* (Saunders, 1851)^**	GH16A(6)	**HP**, UT, WB, AR, AS, NL, TN	Laos, Thailand, Malaysia, Indonesia (Java, Sarawak, Celebs, Sulawesi), Papua, New Guinea, Australia
163	*Calliteara strigata* (Moore, 1879)	GH01E(1)	HP, UT, SK, WB, ME	Thailand, Malaysia, Indonesia (Borneo, Java, Sumatra), China
164	***Euproctis anguligera* (Butler, 1886)^**	GH01C(1), GH01F(2)	**HP**, UT, ME, AN	
165	***Euproctis divisa* Walker, 1855^**	GH01A(1), GH01G(1)	**HP**, UT, SK, WB, AR, NL, PB	Pakistan, Nepal, Bhutan, Bangladesh, Malaysia, Indonesia (Sumatra, Borneo), China, Japan, Africa
166	*Euproctis latifascia* Walker, 1855	GH01A(1), GH01G(1)	HP, SK	Nepal, Bhutan, Taiwan
167	*Euproctis postica* Walker, 1865	GH03C(1)	India	Nepal

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
168	*Laelia exclamationis* (Kollar, 1848)	GH01F(1)	HP, UT, SK, PB, MH	Nepal, Sri Lanka, Taiwan
169	*Laelia umbrina* (Moore, 1888)	GH01F(1)	HP	Nepal, Hong Kong, Laos
170	*Lymantria concolor concolor* Walker, 1855	GH01C(3), GH01D(1), GH02A(3), GH04A(2)	HP, UT, SK, WB, AR, AS, ME, NL, MN, KA, KL	Pakistan, Nepal, Bangladesh, Myanmar, China, Taiwan, Vietnam, Thailand, Australia, Brazil
171	*Lymantria moesta* Swinhoe, 1903	GH01E(3), GH01F(5)	HP	
172	***Pida decolorata* (Walker, 1869)[#]**	GH01H(1)	**HP**, ME	Nepal, Taiwan
173	***Somena scintillans* Walker, 1856[^]**	GH01B(1), GH01C(4), GH01D(1), GH02A(1), GH04A(1)	JK, **HP**, UT, WB, AR, AS, RJ, MH, KA, KL, AN	Pakistan, Nepal, Sri Lanka, Myanmar, China, Taiwan, Japan, Korea
Subfamily: Scoliopteryginae Herrich-Schäffer, [1852]				
174	*Anomis flava* (Fabricius, 1775)	GH01B(1)	HP, UT, WB, TR, CT, MH, TN	Pakistan, Nepal, China, Taiwan, Hong Kong, Japan, Korea, Vietnam, Thailand, Malaysia, Indonesia, Philippines, Papua New Guinea, Australia, Micronesia, Samoa, Tonga, New Zealand, Solomon Island, Russia, Saudi Arabia, Oman, Morocco, South Africa, Kenya, Zimbabwe, Ethiopia, Ghana, Nigeria, Cameroon, Madagascar, Mauritius, Hawaii, United States, Costa Rica

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
175	*Gonitis mesogona* Walker, 1858	GH01E(4), GH01F(2)	HP, UT, SK, WB, ME, MP, MH, TN	Pakistan, Nepal, Sri Lanka, Myanmar, China, Taiwan, Hong Kong, Japan, Korea, Vietnam, Laos, Thailand, Malaysia, Indonesia (Sumatra, Java, Bali, Sulawesi, Sumbawa), Philippines, New Guinea, Russian, Africa
Subfamily: Toxocampinae Guenée, 1852				
176	***Lygephila dorsigera* (Walker, 1865)^**	GH01C(1), GH02B(1), GH08A(1), GH10A(2), GH14A(1)	**HP**, UT	Pakistan, Nepal, Sri Lanka, Myanmar, Thailand, China, Taiwan
177	***Lygephila intermedia* Pekarsky, 2016***	GH01G(1)	**HP**	Pakistan, Afghanistan, Nepal, China, Iran, Turkmenistan, Kyrgyzstan
Family: Euteliidae Grote, 1882				
Subfamily: Euteliinae Grote, 1882				
178	***Anuga japonica* (Leech, 1889)***	GH01A(1)	**HP**	China, Japan, Korea
179	***Eutelia blandiatrix* Hampson, 1912***	GH01A(1), GH01B(1)	**HP**	Nepal, Sri Lanka, China, Japan, Russia
Family: Nolidae Bruand, 1847				
Subfamily: Chloephorinae Stainton, 1859				
180	***Gelastocera castanea* (Moore, 1879)#**	GH01E(2), GH01F(1), GH03A(1)	**HP**, SK, WB, AR	Nepal, Thailand, Malaysia, Indonesia (Sumatra, Borneo, Bali), Brunei
181	***Earias roseifera* Butler, 1881***	GH07A(1)	**HP**	Japan, Russia, Korea
Subfamily: Nolinae Hampson, 1894				
182	*Meganola scripta* (Moore, 1888)	GH04A(1)	HP, AR	Pakistan, Nepal, Vietnam, Thailand
183	***Tympanistes testacea* Moore, 1867^**	GH02A(1)	**HP**, UT, SK, WB, AR	Nepal, Vietnam, Tawian, China
Family: Noctuidae Latreille, 1809				
Subfamily: Acronictinae Smith & Dyar, 1898				

Sl. No.	Scientific name	Material Examined	Distribution	
			India	**Elsewhere**
184	*Acronicta gastridia* (Swinhoe, 1895)	GH15A(2), GH20A(5), GH22C(2)	JK	Pakistan
185	*Acronicta grumi bicolor* Moore, 1881	GH05A(1)	HP	China
186	***Acronicta pulverosa* (Hampson, 1909)***	GH01B(2)	**HP**	Nepal, China, Japan, Taiwan
187	***Diphtherocome diverticulata* Hreblay & Kononenko, 1999***	GH20A(1), GH21B(1), GH24A(1), GH25B(1), GH27A(1)	**HP**	China
188	*Diphtherocome pallida* (Moore, 1867)	GH16A(1), GH17B(1), GH18C(1), GH20A(1), GH21B(2), GH23A(2)	HP, UT, SK, WB, AR, NL	Pakistan, Nepal, China (Tibet),
Subfamily: Bagisarinae Crumb, 1956				
189	*Amyna stellata* Butler, 1878	GH02A(1), GH04B(2)	MH, GJ	Nepal, China, Japan, Taiwan,
Subfamily: Bryophilinae				
190	*Bryophila literata* Moore, 1881	GH03B(1), GH15A(1)	JK, HP	
Subfamily: Condicinae Poole, 1995				
191	*Condica capensis* (Guenée, 1852)	GH01B(1), GH03A(1)	HP, UT, SK, WB, AS, NL, MH, TN, KL	Sri Lanka, Myanmar, China, Indonesia (Borneo, Sarawak), Hong Kong, Singapore, Taiwan, Australia, Spain, Morocco, Mauritania, Arabia, Egypt, Congo, Eritrea, Somalia, Kenya, Burundi, Zaire, Equatorial Guinea, Zambia, S.Africa, Ghana, Cape Verde, Comoros, Madagascar
Subfamily: Eriopinae Herrich-Schäffer, 1851				
192	*Callopistria repleta* Walker, 1858	GH01H(1)	HP, UT, AS, ME, TN, KA	Pakistan, Nepal, China, Taiwan, Japan, Korea, Vietnam, Laos, Thailand, Malaysia, Indonesia (Sumatra, Borneo), Russia

Sl. No.	Scientific name	Material Examined	Distribution	
			India	**Elsewhere**
Subfamily: Eustrotiinae Grote, 1882				
193	*Maliattha vialis* (Moore, 1882)	GH03B(1)	HP, UT, SK, WB, ME	Pakistan, Nepal, China, Taiwan, Japan, Korea, Vietnam, Thailand, Russia
Subfamily: Hadeninae Guenée, 1837				
194	*Anapoma albicosta* (Moore, 1881)	GH02B(1), GH03A(6)	JK, HP, UT, SK, WB, ME, NL	Nepal, Bhutan, Sri Lanka, China (Tibet), Japan
195	*Anapoma unicorna* (Berio, 1973)	GH05A(1)	AS	Nepal, Myanmar, Vietnam, Sri Lanka
196	*Dicerogastra ferrisparsa* (Hampson, 1892)	GH01E(1), GH01H(2),	HP	Pakistan, Nepal, Bhutan
197	***Ebertidia haderonides* Boursin, 1968^**	GH19A(1)	**HP**, UT	Nepal, China
198	***Harutaeographa brahma* Hreblay & Ronkay, 1998***	GH01E(1), GH08B(2), GH19A(1), GH20A(1)	**HP**	Nepal
199	*Hypobarathra repetita* (Butler, 1889)	GH07A(1)	HP, UT, SK	Pakistan, Nepal, Bhutan, China (Tibet)
200	*Leucania loreyi* (Duponchel, 1827)	GH01F(1)	HP, SK, KA, MH	Pakistan, Nepal, Myanmar, Sri Lanka, Indonesia (Borneo), Cape Verde, Italy, Croatia, Greece, Austia, Bulgaria, Mauritania, Iran, Arabia, Eritrea, S.Sudan, Ethiopia, Somalia, Kenya, Uganda, Zaire, Tanzania, S.Africa, Gambia, Ivory Coast, Mauritius, Seychelles.
201	*Mythimna bifasciata* (Moore, 1888)	GH18A(1)	HP	Nepal
202	*Mythimna bistrigata* (Moore, 1881)	GH01E(4), GH02B(1)	**HP**, WB	Nepal
203	*Mythimna consanguis* (Guenée, 1852)	GH01E(1)	HP	Nepal, Australia

Sl. No.	**Scientific name**	**Material Examined**	**Distribution**	
			India	**Elsewhere**
204	*Mythimna decisissima* (Walker, 1865)	GH06A(1)	HP, SK, WB	Nepal, Sri Lanka, Taiwan, Japan, Australia
205	***Mythimna kambaitiana* (Berio, 1973)***	Gh02B(1), GH03A(1)	**HP**	Nepal, Myanmar
206	***Mythimna laxa* Hreblay & Yoshimatshu, 1996#**	GH01B(2)	**HP**, SK	Nepal
207	*Mythimna modesta* (Moore, 1881)	GH01D(1)	HP, SK, WB	Nepal
208	*Mythimna nepos* (Leech, 1900)	GH01D(2), GH06A(1), GH18A(1)	HP	Nepal, China, Myanmar, Thailand, Vietnam, Indonesia (Java)
209	*Mythimna obscura* (Moore, 1882)	GH01D(1)	HP, SK, WB	Nepal, Vietnam, Indonesia (Java)
210	*Mythimna percisa* (Moore, 1888)	GH02A(1), GH02B(1), GH03A(1)	HP, UT	
211	*Mythimna separata* (Walker, 1865)	GH01E(1)	JK, HP, UT, SK, PB, MP, MH	Afghanistan, Pakistan, Nepal, Sri Lanka, China, Taiwan, Hong Kong, Japan, Korea, Vietnam, Laos, Thaiand, Malaysia, Indonesia (Borneo), Philippines, Fiji, Australia, New Zealand, Russia
212	*Mythimna sinuosa* (Moore, 1882)	GH01B(1), GH01C(1), GH01D(2), GH02A(3)	HP, UT, SK, WB, TN	Pakistan, Nepal, Myanmar, China, Taiwan, Vietnam, Thailand
213	***Mythimna undina* (Draudt, 1950)***	GH01H(2), GH03C(1), GH06A(1)	**HP**	China
214	***Orthosia limbata himalaya* Hreblay & Ronkay, 1998^**	GH22B(1)	**HP**, PU	Nepal
215	*Polia culta* (Moore, 1881)	GH09A(2), GH12A(1), GH17B(2), GH18C(2), GH23A(2)	JK, HP, UT, SK	Pakistan, Nepal, China (Tibet)

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
216	*Tiracola aureata* Holloway, 1989	GH01F(1)	N. E. Himalaya, TN	Nepal, China, Sundaland, Indonesia (Sarawak), Philippines, Sulawesi, S.Maluku, New Guinea, Japan, Taiwan
217	*Tiracola plagiata* (Walker, 1857)	GH01A(1), GH01D(5), GH02A(1)	HP, UT, SK, WB, AR, AS, ME, NL, TR, DL, MH, KA, TN, KL, OD, GA	Nepal, Sri Lanka, Myanmar, China, Taiwan, Vietnam, Laos, Thailand, Malaysia, Indonesia (Java, Sulawesi), Philippines, Papua New Guinea, Australia, Mexico, Paraguay, Cuba
218	*Tricheurois cuprina* (Moore, 1881)	GH27A(1)	SK	Nepal, China
Subfamily: Heliothinae Boisduval, 1829				
219	*Helicoverpa armigera* (Hübner, [1805])	GH01D(3), GH01E(2), GH01F(1), GH04A(4)	JK, HP, UT, HP, WB, AR, AS, BH, PB, CT, MP, MH, KA, TN	Afghanistan, Pakistan, Nepal, Sri Lanka, Myanmar, China, Taiwan, Hong Kong, Japan, Korea, Thailand, Indonesia (Borneo, Java), Philippines, Papua New Guinea, Australia, New Zealand, Germany, Denmark, Portugal, Italy, France, Spain, Norway, Finland, Austria, Netherlands, United Kingdom, Turkey, UAE, South Africa, Kenya, Tanzania, Uruguay, Peru
Subfamily: Noctuinae Latreille, 1809				
220	***Agrotis exclamationis* (Linnaeus, 1758)***	GH01E(1), GH09A(1)	**HP**	Afghanistan, Japan, Morocco, Iran, Iraq, Turkey, Mongolia, Russia, England, France, Germany, Finland, Austria, Italy, Netherlands, Norway, Portugal, Bulgaria, Spain, France, Finland, Sweden, Denmark, Norway, Africa
221	***Agrotis fraterna* Moore, 1882#**	GH01C(1), GH01E(1)	**HP**, WB, PU	Nepal

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
222	*Agrotis ipsilon* (Hufnagel, 1766)	GH01D(2), GH01E(1), GH02A(1), GH04A(1)	JK, HP, UT, WB, AR, AS, ME, BH, JH, UP, PB, RJ	Pakistan, Nepal, Myanmar, China, Taiwan, Japan, Korea, Thailand, Australia, New Zealand, United Kingdom, Romania, Turkey, Iran, Turkey, Denmark, Serbia, Portugal, Ireland, Israel, Poland, Malta, Jordan, Cyprus, Tajikistan, Austria, Galapagos, Egypt, Namibia, United States, Canada, Mexico, Ecuador, Brazil, Argentina, Costa Rica, Ecuador
223	*Agrotis segetum* (Denis & Sch, 1775)	GH01C(1)	HP, UT, SK, WB, AS, NL, PB, JH, CT, MP, MH	Pakistan, Nepal, Sri Lanka, China, Taiwan, Japan, Korea, Thailand, Indonesia (Java), Philippines, New Guinea, United Kingdom, Austria, Italy, France, Norway, Spain, Netherland, Germany, Portugal, Iran, Turkey, Bulgaria, UAE, Africa, Kenya, Madagascar
224	*Agrotis violacea* (Butler, 1889)	GH27A(2)	HP	Nepal
225	*Athetis bremusa* (Swinhoe, 1885)	GH02B(2)	HP, UP, MH, TN, KL	Sri Lanka, Myanmar
226	*Athetis delecta* (Moore, 1881)	GH01E(4), GH01F(1)	HP, SK, WB, UP, HR, MH	Nepal, Myanmar, China, Hong Kong, Vietnam, Thailand, Mexico
227	*Athetis divisa* (Moore, 1882)	GH02B(1), GH14A(1)	JK, HP, WB	Nepal
228	*Athetis lineosa* (Moore, 1881)	GH01A(1), GH01B(2), GH01E(19), GH01F(5)	HP, UT, AR	Nepal, Myanmar, China, Taiwan, Japan, Korea, Russia
229	*Athetis sincera* (Swinhoe, 1889)	GH01E(1), GH03C(1)	HP	

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
230	*Athetis stellata* (Moore, 1882)	GH01C(3)	HP, SK, WB, AS, ME, NL	Nepal, Taiwan, Indonesia (Borneo), New Guinea
231	*Axylia putris* (Linnaeus, 1761)	GH01A(1)	HP, UT	Pakistan, Nepal, Taiwan, Japan, Korea, Indonesia (Java), Armenia, Sweden, Ukraine, Serbia, United Kingdom, Netherlands, Austria, Finland, Denmark, France, Spain, Norway, Germany, Mongolia, Kazakhstan
232	*Diarsia cerastioides* (Moore, 1867)	GH09A(1)	HP, WB	Nepal
233	***Diarsia claudia* Boursin, 1963***	GH27A(4)	**HP**	Nepal
234	*Diarsia erubescens* (Butler, 1880)	GH03A(3), GH03C(2), GH16A(1)	JK, HP, TN	Nepal
235	*Diarsia nigrosigna* (Moore, 1881)	GH01E(3), GH06B(1)	JK, HP, UT, SK, WB, AR, TN	Pakistan, Nepal, Bhutan, Myanmar, China, Taiwan, Hong Kong, Vietnam, Thailand, Indonesia (Sulawesi), Philippines
236	***Diarsia stictica* (Poujade, 1887)#**	GH08B(1), GH12B(1), GH20A(1)	**HP**, HR	Nepal, Tibet, Indonesia (Borneo)
237	***Diarsia vulpina* (Moore, 1882)#**	GH01C(2), GH02B(1)	**HP**,WB	Nepal
238	*Dichagyris flammatra* (Schiffermüller, 1775)	GH02B(1)	JK, HP, UT, SK, WB, AS, BH, UP, DL, PB, RJ, GJ, MP, AP, MH, KA, TN, KL	Afghanistan, Pakistan, Bhutan, China (Tibet), Iraq, Iran, Jordan, Kazakhstan, Russia, Turkey, Spain, France, Germany, Italy, Switzerland, Austria, United Kingdom, Syria, Lebanon, Armenia, Morocco, Algeria, Egypt, Brazil
239	***Dichagyris stentzi* (Lederer, 1853)***	GH12B(1)	**HP**	Pakistan, Nepal, China, Tibet, Turkestan.

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
240	*Dichagyris triangularis* (Moore, 1867)	GH23A(1)	JK, HP, UT, SK, AS, NL, MH	Pakistan, Nepal, Bhutan, Myanmar, China (Tibet), Taiwan, Japan, Korea, Thailand, Russia, Mongolia, Turkestan
241	***Euxoa aquilina* (Denis & Schiffer, 1775)***	GH01E(1)	**HP**	China (Tibet), Austria, Germany, Iran, Turkey, Spain, Romania, Czeck, Hungary, France, Switzerland, Russia, Kazakhstan, Jordan
242	***Hermonassa anthracina* Boursin, 1967***	GH27A(4)	**HP**	Nepal, China
243	***Hermonassa chagyabensis* Chen, 1983#**	GH27A(2)	**HP**, WB	Nepal, China
244	*Hermonassa consignata* Walker, 1865	GH01C(1), GH14A(1), GH14B(1)	JK, HP, UT, SK, WB, NL, TN	Pakistan, Nepal, Bhutan, China (Tibet), Thailand
245	***Hermonassa divida* Hreblay & Ronkay, 1998***	GH27A(1)	**HP**	Nepal, China
246	***Hermonassa oxyspila* Boursin, 1968***	GH23A(3)	**HP**	Nepal
247	*Peridroma saucia* (Hubner, [1808])	GH02A(1)	JK, HP	Nepal, Sri Lanka, China, Taiwan, Japan, Iran, Israel, Syria, Arabia, S.Africa, Asia, USA, S.Canada, Mexico - Colombia, Venezuela, Brazil, Argentina, Chile.
248	***Perissandria sikkima* (Moore, 1867)^**	GH23B(2)	**HP**, UT, SK, WB, AR	Nepal, China (Tibet)
249	***Xestia bdelygma* (Boursin, 1963)***	GH24A(1), GH26A(1)	**HP**	Nepal, China

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
250	*Xestia c-nigrum* (Linnaeus, 1758)	GH01E(23), GH01F(7), GH03A(1), GH06B(13), GH09A(1), GH15A(2), GH18B(1)	JK, HP, PY	Pakistan, Nepal, China, Japan, Korea, Russia, Turkey, Germany, United Kingdom, Italy, Austria, Norway, Portugal, France, Netherlands, Spain, Finland, Canada, United States, Mexico
251	***Xestia nepalensis* (Boursin, 1964)***	GH22B(1), GH27B(1)	**HP**	Nepal
252	***Xestia renalis* (Moore, 1867)#**	GH01B(1)	**HP**, WB	Nepal, China
253	*Xestia semiherbida* (Walker, 1857)	GH01B(1), GH01C(1)	HP, UT, SK, KA	Nepal, China, Taiwan, Japan, Korea
Subfamily: Plusiinae Boisduval, 1829				
254	*Antoculeora ornatissima* (Walker, 1858)	GH02B(7), GH03B(3)	JK, HP, UT, SK	Pakistan, Nepal, China, Japan, Russia
255	*Autographa nigrisigna* (Walker, 1857)	GH01F(1)	JK, HP, UT, SK, WB, HR, PB	Pakistan, Nepal, China, Tibet, Japan, Korea
256	*Chrysodeixis acuta* (Walker, 1857)	GH01B(1), GH03A(1)	HP, UT, WB, MH, KA	Pakistan, Nepal, Sri Lanka, China, Taiwan, Hong Kong, Japan, Vietnam, Thailand, Indonesia (Sumatra, Borneo, Bali, Timur, Flores), Philippines, Papua & New Guinea, Australia, UAE, Cameroon, Namibia, Zimbabwe, Congo, Kenya, Nigeria, Ethiopia, Ghana, S Africa, Uganda, Europe
257	*Chrysodeixis chalcites* (Esper, 1789)	GH01E(1), GH03C(1)	**HP**, UT	Germany, Italy, Croatia, France, Switzerland, Greece, Austria, Africa, Asia

Sl. No.	**Scientific name**	**Material Examined**	**Distribution**	
			India	**Elsewhere**
258	*Chrysodeixis eriosoma* (Doubleday, 1843)	GH01C(1)	JK, **HP**, UT, SK, WB, TR, RJ, CT, MP, MH, KA, KL	Pakistan, Nepal, Myanmar, China, Hong Kong, Taiwan, Japan, Korea, Cambodia, Vietnam, Malaysia, Thailand, Indonesia (Java, Sumatra, Timor, Flores, Sumbawa, Borneo), Philippines, Russia, Germany, Oman, Syria, Papua New Guinea, Australia, Fiji, New Ireland, New Caledonia, New Zealand, Norfolk Island, Polynesia, Egypt, USA, Hawaii,
259	***Cornutiplusia circumflexa* (Linnaeus, 1767)#**	GH01F(1), GH14A(1)	**HP**, WB, MP, TN	Afghanistan, Nepal, China, Mongolia, Thailand, Portugal, Spain, Finland, Russia, Siberia, Yemen, UAE, Cyprus, Iran, Turkmenistan, Tajikistan, Turkey, Egypt, S Africa, Ethiopia
260	*Ctenoplusia furcifera* (Walker, [1858])	GH01F(1)	HP, WB, KL, TN	Pakistan, Nepal, Taiwan, New Guinea, Burkina Faso, Nigeria, Ivory Coast, Gabon, Equatorial Guinea, Cameroon, Arabia, Ethiopia, Kenya, Tanzania, Zambia, Zimbabwe, S.Africa, Comoros, Madagascar
261	*Ctenoplusia placida* (Moore, 1884)	GH01F(2)	HP, WB, ME, KA, TN	Pakistan, Nepal, Sri Lanka, China, Taiwan, Japan, Thailand, Indonesia (Sumatra), Australia, New Caledonia

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
262	*Thysanoplusia orichalcea* (Fabricius, 1775)	GH01D(7), GH01E(5), GH01F(8), GH02A(1), GH04A(6)	HP, UT, WB, AR, AS, ME, MN, NL, BH, UP, RJ, MP, MH, KA, TN	Pakistan, Nepal, Bangladesh, Sri Lanka, Mayanmar, China, Hong Kong, Taiwan, Japan, Indonesia, Philippines, Switzerland, New South Wales, UK, Netherlands, Portugal, Israel, Iran, Spain, Serbia, Papua New Guinea, Australia, New Zealand, Brazil, Ethiopia, South Africa, Zimbabwe, Acension Island, Hawaii
Subfamily: Xyleninae Guenée, 1852				
263	*Conservula indica* (Moore, 1867)	GH01B(1)	JK, HP, UT, SK, WB, AR, NL, TN	Pakistan, Nepal, Bangladesh, Sri Lanka, China, Taiwan, Vietnam, Laos, Thaiand, Malayasia, Philippines
264	***Dasypolia templi* (Thunberg, 1792)***	GH19A(2), GH22B(3)	**HP**	Germany, Austria, Switzerland, Italy
265	*Elaphria conjugata* (Moore, 1881)	GH02A(1), GH04A(1)	HP, UT, SK, WB	Nepal
266	***Euplexia annapurna* Hreblay & Ronkay, 1998***	GH07A(1)	**HP**	Nepal
267	*Feliniopsis leucostigma* (Moore, 1867)	GH01D(1)	HP, SK, WB, NL	Bangladesh, Nepal, China
268	*Feliniopsis opposita* (Walker, 1865)	GH01F(1)	HP, TN	Sri Lanka, Kenya, Somalia, Yemen
269	*Feliniopsis siderifera* (Moore, 1881)	GH01C(1), GH01E(1), GH19B(1)	HP, UT, SK	Nepal, China
270	***Hyalobole nigripalpis* (Warren, 1911)#**	GH02B(1)	**HP**, WB	Nepal
271	***Hygrostola robusta* (Hampson, 1894)#**	GH02A(1)	**HP**, SK, AS, ME	Nepal

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
272	***Oroplexia hampsoni* Leech, 1900***	GH09A(1), GH12B(2), GH15A(4), GH19B(1), GH22C(1), GH23A(1), GH24A(2), GH26A(2), GH27B(14)	**HP**	Nepal, China
273	***Oroplexia luteifrons* (Walker, 1857)^**	GH21B(2)	JK, **HP**, UT, ME, PB	
274	***Oroplexia pectinosa* Hreblay & Plante, 1996***	GH25B(2)	**HP**	Nepal
275	***Pareuplexia erythriris* (Hampson, 1908)#**	GH01B(1)	**HP**, ME	Nepal
276	*Phlogophora conservuloides* (Hampson, 1898)	GH07A(1), GH17A(1)	HP, UT, SK, AR	Nepal, China, Taiwan
277	*Phlogophora pectinata* (Warren, 1888)	GH23A(1)	HP, UT, AR, HR, TN	Pakistan, Nepal
278	*Phlogophora striatovirens* (Moore, 1867)	GH12B(2)	HP, SK, WB, AR, NL	Nepal, China, Mongolia, Korea, Russia
279	*Phlogophora subpurpurea* Leech, 1900	GH06A(1)	HP, UT	Nepal, China
279	*Spodoptera cilium* Guenée, 1852	GH03A(1), GH03C(1)	HP, UT	Nepal, Indonesia (Borneo), Greece, Italy, Spain, Albania, Turkey, Portugal, Afganisthan, Africa
280	*Spodoptera litura* (Fabricius, 1775)	GH01B (1)	HP, UT, WB, AR, AS, NL, TR, DL, PB, CT, MH, AD, KA, TN, KL, OD, GA	Pakistan, Nepal, Sri Lanka, China, Taiwan, Hong Kong, Vietnam, Japan, Korea, Thailand, Laos, Malaysia, Indonesia (Borneo, Sarawak), Timor, Philippines, New Guinea, Melanesia, Fiji, Solomon Island, Vanuatu, New Hebrides, New Caledonia,

Sl. No.	Scientific name	Material Examined	Distribution	
			India	Elsewhere
				Polynesia, Samoa, Tonga, Australia, New Zealand, Russia, UAE
281	*Spodoptera pecten* Guenée, 1853	GH01D(1), GH02A(1)	HP, SK, WB, NL	Nepal, Myanmar, Taiwan, Korea, Singapore, Indonesia (Borneo, Sumatra, Java), Australia,
282	*Sydiva stoliczkae* (Felder & Rogenhofer, 1874)	GH15A(1)	JK, HP, WB	Pakistan, Nepal
283	*Trachea aurigera* (Walker, 1858)	GH24A(1)	SK, WB	Nepal
284	*Trachea auriplena* (Walker, 1857)	GH01E(6), GH01G(1)	JK, HP, UT, SK, TN, KL	Pakistan, Nepal, Bhutan, Sri Lanka, China, Taiwan, Hong Kong, Vietnam, Thailand, Malaysia, Japan
285	*Trachea microspila* Hampson, 1908	GH01D(1), GH01G(1)	HP	Nepal, China
286	***Trachea tibetensis* (Warren, 1912)^**	GH24A(1)	**HP,** UT	Nepal, Tibet
287	***Trichoridia canosparsa* (Hampson, 1897)#**	GH27A(1)	**HP**, SK	Nepal
288	***Trichoridia cuprescens* Hampson, 1906#**	GH27A(1)	**HP**, SK	Nepal
289	***Trichoridia herchatra* (Swinhoe, 1893)#**	GH27A(1)	**HP**, SK	Nepal
290	*Triphaenopsis inepta* Butler, 1889	GH02B(1)	HP	
291	*Valeriodes heterocampa* (Moore, 1882)	GH23B(3)	HP, UT, SK, WB, AR, NL	Nepal, China (Tibet)

3.3.3. Novel Records to the Country, Western Himalaya & Himachal Pradesh:

Out of the 516 species recorded from Great Himalayan National Park, 47 species are recorded for the first time from this country and added to Indian moth faunal list. Majority of those species mainly belongs to family Geometridae and Noctuidae, consisting 18 and 17 species novel to India respectively.

Zeuzera nepalense, a Cossidae species, novel to Indian Fauna, previously reported from Pakistan, Nepal, Bhutan; *Udea prunalis* and *Udea stigmatalis* of Crambidae was previously known from China, Europe and Japan, Russia, Taiwan respectively; *Isopsestis meyi* of family Drepanidae was earliar restricted to China and Vietnam; *Kunugia sinjaevi* of Lasiocampidae was previously known only from Vietnam; *Epiplema adamantina,* a Uraniidae species, previously reported only from Nepal; Larentiinae species *Orthonama obstipata,* previously known from Nepal, Japan, Afghanistan, China, Borneo and Europe; *Xanthorhoe griseiviridis,* only reported from Bhutan; *Photoscotosia pallidimaculata, Photoscotosia nitida, Rheumaptera cinerea, Xenortholitha falcata* and *Dysstroma shirakawai*, only reported from Nepal; *Coenolarentia argentiplumbea*, previously reported from Bhutan and Tibet; *Perizoma antisticta,* recorded previously from Pakistan and Nepal; Ennominae species *Ourapteryx purissima,* previously reported from Kyrgyzstan; *Odontopera kanchai, Myrioblephara gandakiensis, Myrioblephara harutai, Micrabraxas grandis, Tanaoctenia dehaliaria and Alcis limbui,* only reported from Nepal;

Ctenognophos methoria, previously reported from Nepal and Myanmar; *Micrabraxas seriopuncta,* previously restricted upto Nepal and Tibet; *Hypena tristalis,* Hypeninae species, previously known from Siberia; *Arctornis l-nigrum,* a Lymantriinae species, previously known from Nepal, Russia, Japan, Taiwan, Sweden and Denmark; *Lygephila intermedia,* an Erebidae species, previously known from Pakistan, Afganistan, Nepal, China, Iran; Eutellidae species *Anuga japonica* and *Eutelia blandiatrix,* added as a novel to Indian moth fauna, previously known from China, Japan, Korea and Nepal, Sri Lanka, Russia; Noctuidae species *Harutaeographa brahma, Diarsia claudia, Hermonassa oxyspila, Xestia nepalensis, Euplexia annapurna* and *Oroplexia pectinosa*, only recorded from Nepal; *Earias roseifera,* previously reported from Japan, Russia, Korea; *Acronicta pulverosa,* previously reported from Nepal, China, Japan and Taiwan; *Diphtherocome diverticulata* and *Mythimna undina,* only reported from China previously; *Mythimna kambaitiana,* previously reported from Nepal and Myanmar; *Agrotis exclamationis,* known from Japan, Afghanistan, Europe and middle east; *Dichagyris stentzi,* previously reported from Pakistan, Nepal, china, Tibet, Turkestan; *Euxoa aquilina,* known from Europe, China; *Hermonassa anthracina, Hermonassa divida, Oroplexia hampsoni* and *Xestia bdelygma,* with the past distributional record in Nepal and China; previously recorded from Europe, was recorded as a novel addition to Indian Moth Fauna.

Another 86 species were reported for the first time from Western Himalaya, while they were restricted previously in other Himalayan biogeographic zones. Among them, majority of the species belongs to family Geometridae, with 55 species novel to Western Himalaya.

93 species were reported as new to the state, Himachal Pradesh from this study and majority of the species i.e, 44 species belongs to family Geometridae.

3.3.4. DNA Barcoding on Geometridae of GHNP:

Arctopsyche amurensis (order Trichoptera) (NCBI Accession no. KX107486.1) was used as outgroup for this study. In the final dataset, 87 sequences were aligned using Clustal X and finally, 602 bp of mtCOI were opted to estimate the genetic divergence and phylogeny.

The preliminary study generated 86 sequences of 33 Geometridae species from GHNP with an overall mean genetic distance of 11.8% within the dataset. All the sequences were submitted to the Barcode of Life Database (BOLD) and the unique BOLD Process IDs of each generated DNA barcode sequence were acquired from BOLD. Based on the 10 analogous and 23 singletons barcode index numbers (BINs), the BOLD data system revealed a total of 32 operational taxonomic units (OTUs) in the dataset (Table. 3.3). Out of the 602 bp, 384 sites were found to be conserved and the rest variable. 186 sites were parsimony informative.

Table 3.3.: List of generated sequences of Geometridae moths of GHNP with Bold ID, BIN and OTU

Sl. No.	BIN	BOLD ID	Subfamily	Species	OTU
1	ADF4977	ZSILH054-17	Ennominae	*Odontopera kametaria* (Felder & Rogenhofer, 1875)	23
2	ADF2763	ZSILH058-17	Ennominae	*Alcis nigralbata* Warren, 1893	14
3	ADF4071	ZSILH079-17	Ennominae	*Loxaspilates obliquaria* (Moore, 1868)	19
4	ADF3070	ZSILH080-17	Ennominae	*Loxaspilates dispar* Warren, 1893	16
5	ADF3070	ZSILH081-17	Ennominae	*Loxaspilates straminearia* Leech, 1897	16
6	ADF4671	ZSILH082-17	Ennominae	*Loxaspilates obliquaria* (Moore, 1868)	22
7	AAJ3727	ZSILH083-17	Ennominae	*Alcis subnitida* Warren, 1893	4
8	ADF3070	ZSILH084-17	Ennominae	*Loxaspilates dispar* Warren, 1893	16
9	ABA3697	ZSILH086-17	Ennominae	*Arichanna flavinigra* Hampson, 1907	10
10	ADF4307	ZSILH103-17	Ennominae	*Opisthograptis tridentifera* (Moore, 1888)	20
11	ADF4071	ZSILH104-17	Ennominae	*Loxaspilates obliquaria* (Moore, 1868)	19
12	ADF3070	ZSILH105-17	Ennominae	*Loxaspilates dispar* Warren, 1893	16
13	ADF3070	ZSILH106-17	Ennominae	*Loxaspilates dispar* Warren, 1893	16
14	ADF3070	ZSILH111-17	Ennominae	*Loxaspilates dispar* Warren, 1893	16
15	AEF9102	ZSILH1169-20	Ennominae	*Psyra similaria* Moore, 1868	32
16	ABA3697	ZSILH134-17	Ennominae	*Arichanna flavinigra* Hampson, 1907	10
17	AAJ3727	ZSILH142-17	Ennominae	*Alcis admissaria* Guenée, [1858]	4
18	AAJ3727	ZSILH144-17	Ennominae	*Alcis admissaria* Guenée, [1858]	4
19	AAJ3733	ZSILH158-17	Ennominae	*Alcis subnitida* Warren, 1893	5
20	AAJ3727	ZSILH184-17	Ennominae	*Alcis subnitida* Warren, 1893	4
21	ABA3697	ZSILH194-17	Ennominae	*Arichanna flavinigra* Hampson, 1907	10
22	ABA3697	ZSILH195-17	Ennominae	*Arichanna flavinigra* Hampson, 1907	10

Sl. No.	BIN	BOLD ID	Subfamily	Species	OTU
23	ABA3697	ZSILH196-17	Ennominae	*Arichanna flavinigra* Hampson, 1907	10
24	AAJ3727	ZSILH202-17	Ennominae	*Alcis subnitida* Warren, 1893	4
25	ADF2763	ZSILH203-17	Ennominae	*Alcis nigralbata* Warren, 1893	14
26	ADF2763	ZSILH204-17	Ennominae	Alcis nigralbata Warren, 1893	14
27	AAJ3727	ZSILH205-17	Ennominae	*Alcis subnitida* Warren, 1893	4
28	AAJ3727	ZSILH208-17	Ennominae	*Alcis subnitida* Warren, 1893	4
29	AAJ3727	ZSILH209-17	Ennominae	*Alcis subnitida* Warren, 1893	4
30	AAJ3727	ZSILH221-17	Ennominae	*Alcis admissaria* Guenée, [1858]	4
31	AAJ3727	ZSILH222-17	Ennominae	*Alcis subnitida* Warren, 1893	4
32	ADF2763	ZSILH224-17	Ennominae	*Alcis nigralbata* Warren, 1893	14
33	ABA3697	ZSILH225-17	Ennominae	*Arichanna flavinigra* Hampson, 1907	10
34	AAJ3727	ZSILH239-17.	Ennominae	*Alcis subnitida* Warren, 1893	4
35	AAN4607	ZSILH245-17	Ennominae	*Ourapteryx ebuleata ebuleata* (Guenée, [1858])	6
36	ADF3555	ZSILH249-17	Ennominae	*Abraxas picaria* Moore, [1868]	17
37	AAJ3727	ZSILH251-17	Ennominae	*Alcis perspicuata* (Moore, 1868)	4
38	AAH0758	ZSILH311-17	Ennominae	*Hypephyra terrosa* Butler, 1889	3
39	AAQ2620	ZSILH315-17	Ennominae	*Ctenognophos eolaria* (Guenée, [1858])	9
40	ADF4977	ZSILH325-17	Ennominae	*Odontopera kametaria* (Felder & Rogenhofer, 1875)	23
41	ABA5041	ZSILH344-17	Ennominae	*Antipercnia belluaria* (Guenée, 1858)	11
42	ADG3991	ZSILH356-17	Ennominae	*Garaeus apicata* (Moore, 1868)	25
43	AAJ3727	ZSILH359-17	Ennominae	*Alcis subnitida* Warren, 1893	4
44	ADG6507	ZSILH361-17	Ennominae	*Ourapteryx leucopteron* Inoue, 1995	28
45	ADH2369	ZSILH371-17	Ennominae	*Mimochroa gynopteridia* (Butler, 1880)	31

Sl. No.	BIN	BOLD ID	Subfamily	Species	OTU
46	ADH1884	ZSILH372-17	Ennominae	*Alcis paghmana* Wiltshire, 1967	29
47	AAP2275	ZSILH391-17	Ennominae	*Leptomiza calcearia* (Walker, 1860)	8
48	AAE0868	SILH198-17	Larentiinae	*Photoscotosia dejuta* Prout, 1937	1
49	AAP2250	ZSILH059-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
50	ACI9408	ZSILH061-17	Larentiinae	*Perizoma fulvimacula* (Hampson, 1896)	13
51	ADF3878	ZSILH067-17	Larentiinae	*Eupithecia asempiterna* Inoue, 2000	18
52	ADF3010	ZSILH068-17	Larentiinae	*Perizoma variabilis* Warren, 1893	15
53	ADF3010	ZSILH069-17	Larentiinae	*Perizoma variabilis* Warren, 1893	15
54	ADF3010	ZSILH070-17	Larentiinae	*Perizoma variabilis* Warren, 1893	15
55	ADF3878	ZSILH073-17	Larentiinae	*Eupithecia asempiterna* Inoue, 2000	18
56	ADF3010	ZSILH074-17	Larentiinae	*Perizoma variabilis* Warren, 1893	15
57	AAP2250	ZSILH085-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
58	ADF3010	ZSILH087-17	Larentiinae	*Perizoma variabilis* Warren, 1893	15
59	ADF3010	ZSILH088-17	Larentiinae	*Perizoma variabilis* Warren, 1893	15
60	ADF5196	ZSILH092-17	Larentiinae	*Perizoma peculiare* Inoue, 2000	24
61	ADF3010	ZSILH093-17	Larentiinae	*Perizoma variabilis* Warren, 1893	15
62	ADF3878	ZSILH108-17	Larentiinae	*Eupithecia asempiterna* Inoue, 2000	18
63	ADF3878	ZSILH112-17	Larentiinae	*Eupithecia asempiterna* Inoue, 2000	18
64	ADF4593	ZSILH113-17	Larentiinae	*Dysstroma shirakawai* Yazaki, 2000	21
65	AAP2250	ZSILH127-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
66	AAP2250	ZSILH128-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
67	AAP2250	ZSILH130-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
68	AAE6530	ZSILH131-17	Larentiinae	*Photoscotosia dejuncta* Prout, 1937	2
69	AAP2250	ZSILH132-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7

Sl. No.	BIN	BOLD ID	Subfamily	Species	OTU
70	AAE6530	ZSILH143-17	Larentiinae	*Photoscotosia dejuncta* Prout, 1937	2
71	AAP2250	ZSILH145-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
72	AAP2250	ZSILH147-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
73	AAE6530	ZSILH175-17	Larentiinae	*Photoscotosia dejuncta* Prout, 1937	2
74	AAP2250	ZSILH183-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
75	AAE6530	ZSILH197-17	Larentiinae	*Photoscotosia dejuncta* Prout, 1937	2
76	AAP2250	ZSILH206-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
77	AAP2250	ZSILH207-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
78	AAP2250	ZSILH210-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
79	AAE0868	ZSILH211-17	Larentiinae	*Photoscotosia dejuta* Prout, 1937	1
80	AAP2250	ZSILH218-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
81	ADG5308	ZSILH248-17	Larentiinae	*Eustroma aurigena* (Butler, 1880)	26
82	ADG6167	ZSILH313-17	Larentiinae	*Eupithecia raniata* Prout, 1958	27
83	ABW9619	ZSILH364-17	Larentiinae	*Xanthorhoe griseiviridis* (Hampson, 1895)	12
84	AAP2250	ZSILH365-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
85	AAP2250	ZSILH366-17	Larentiinae	*Photoscotosia amplicata* (Walker, 1862)	7
86	ADH3582	ZSILH387-17	Larentiinae	*Perizoma schistacea* (Moore, 1888)	30

The genus *Photoscotosia* consisting of species *P. amplicata*, *P. dejuta* and *P. dejuncta* in the present dataset shows a cohesive clustering in the NJ tree with 3.1% genetic divergence within the genus and mean inter-specific divergence of 5.8-6.6%. *Eupithecia asempiterna* is seen to be forming sister clades with *E. raniata*, distant by 10.5% genetic divergence between them. *Arichanna flavinigra* also shows cohesive clustering among themselves with inter-specific divergence ranging from 8.4-14.6%, lowest with *Hypephyra terrosa* and the highest with *Perizoma peculiare*. *Xanthorhoe griseiviridis* shows high genetic divergence (11.14-18.44%) with other Geometridae species in the dataset and depicts a distinct clade in the NJ tree. *Perizoma fulvimacula* clades separately from the rest of the *Perizoma* species, *P. variabilis, P. peculiare* and *P. schistacea* with an inter-specific divergence of 12.9%, 11.1% and 12.5% respectively. The intra-generic distance of the genus *Perizoma* was found to be 5.7%. *Eustroma aurigena* forming a separate clade in the NJ tree has the highest divergence of 15.9% with *Alcis admissaria* and the lowest being 9.2% with *P. amplicata*. With a divergence of 4.31% between them, *Ourapteryx ebuleata ebuleata* forms sister clade with *O. leucopteron*. *Odontopera kametaria* forms a distinct clade with 9.9-14.5% inter-specific divergence.

The intra-generic genetic divergence of *Loxaspilates* was found to be 3.3%. The generated sequence of *Loxaspilates obliquaria* (ZSILH082-17) shows sister cladding with the rest two *L. obliquaria* sequences (ZSILH079-17 and ZSILH104-17) having a mean intra-specific divergence of 1.8% between them. Also, the BIN generated against this barcode sequence is different than the rest. The low intra-specific divergence with different BIN numbers suggests the particular specimen to be a sub-species, though collected from same locality. Due to lack of enough generated barcodes, the sub-species status for this specimen cannot be established now. The generated sequence of *L. dispar* (ZSILH080-17) clades separately, though closely from the other four sequences of *L. dispar* with a mean genetic divergence between the sequences being 0.83%. The very low intra-specific genetic divergence of 0.33% within *L. dispar* and the BIN number generated against ZSILH082-17 being same as that of the other barcodes of *L. dispar* confirms the specimen to be the same. The sequence for the morphologically identified specimen of *L. straminearia* (ZSILH081-17) clades with the sequences of *L. dispar* and the mean genetic divergence between them was found to be 0.17%. Further, the BIN for *L. straminearia* barcode was found to similar to those of *L. dispar*, thus confirming the specimen to be *L. dispar* through molecular taxonomy approaches. *Loxaspilates* being a cryptic group, is often difficult to identify precisely through morpho-taxonomy.

Similar ambiguities was also observed in the highly cryptic genus *Alcis* having an intra generic genetic distance of 3.7%. The barcode sequences for morphologically identified specimens of *A. admissaria, A. subnitida* (except ZSILH158-17) and *A. perspicuata*, all of which formed a single clade was also found to be having the same BIN. Interspecific divergence between these 3 species ranged from 0.46%-0.55% which is very low to consider them as different species. Morphologically, these 3 species can be identified by diagnostic character i.e., discussed in taxonomic account. To solve this species-complex and uncertain cladding, it is necessary to generate more barcodes and integrate traditional morpho-taxonomy with molecular taxonomy approaches. Further, the barcode of *A. subnitida* (ZSILH158-17) shows separate cladding from the rest of the *subnitida* species with high intraspecific divergence ranging from 2.7%-3.6%. The BIN is also unique. The sequence (ZSILH058-17) of *A. nigralbata*, though forming a sister clade with the rest of the *nigralbata* sequences, show a very low intra-specific genetic divergence of 0.5% and similar BIN. *A. paghmana* shows distinct clade with highest inter-specific divergence of 8.3% with *A. nigralbata* and 7.5% with *A. subnitida.*

The singleton barcodes generated for *Opisthograptis tridentifera, Dysstroma shirakawai, Abraxas picaria, Hypephyra terrosa, Ctenognophos eolaria, Antipercnia belluaria, Garaeus apicata, Mimochroa gynopteridia, Leptomiza calcearia, Psyra similaria* shows distinct and separate clades in the NJ tree.

Due to limited species coverage, the study could not discuss the in-depth phylogenetic relationship at any hierarchical level of Geometridae moths. The species of subfamily Larentiinae and Ennominae was found to be clustering separately. The genetic divergence within the two subfamilies was found to be 9.2% and 10.5% respectively, with divergence between them as 13.5%. Further integrative taxonomic approach is needed to solve the species complexes of *Alcis* and *Loxaspilates*.

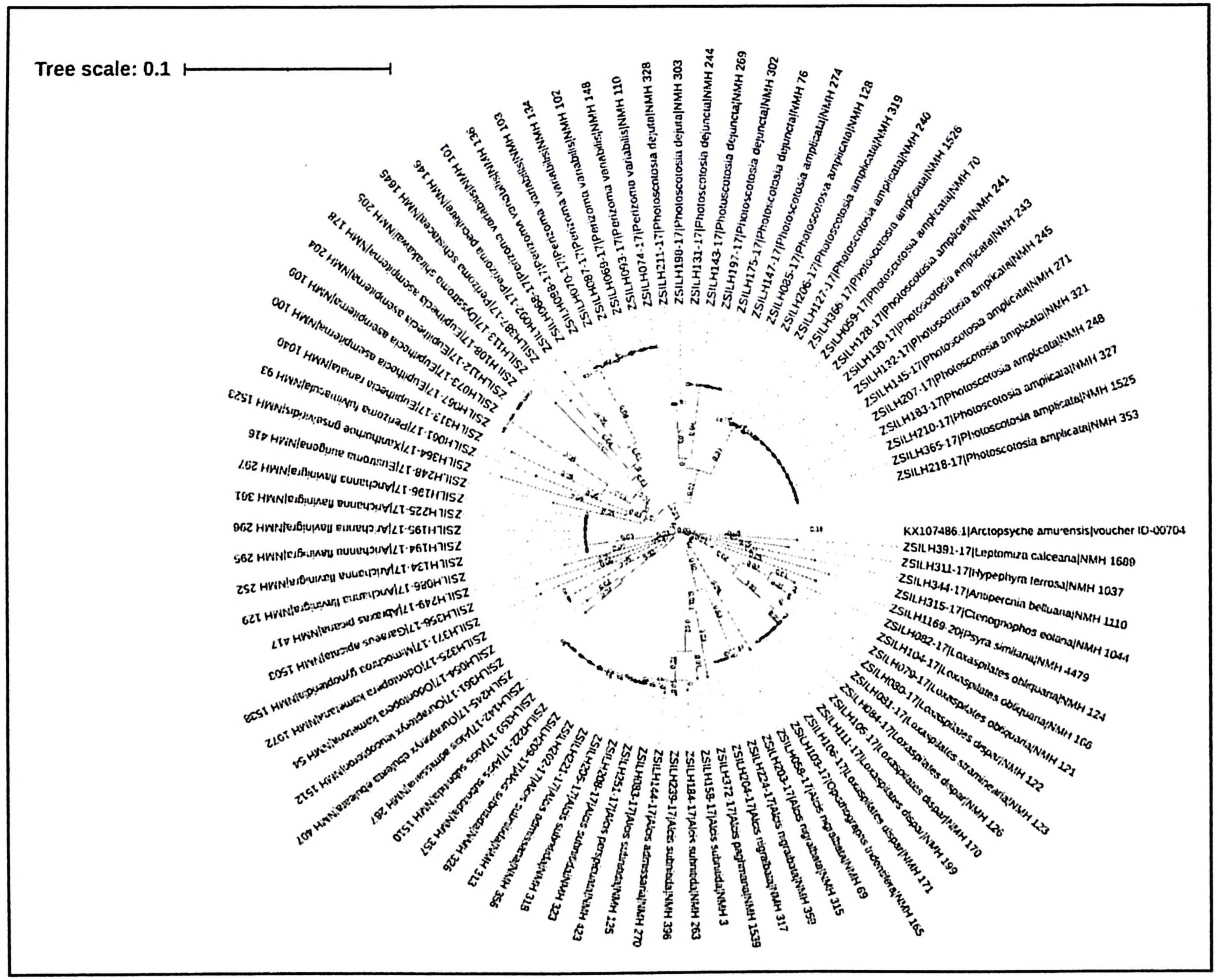


Figure. 3.3. Neighbour-joining (NJ) tree of the Geometridae species of GHNP

3.3.5. DNA Barcoding of cryptic genus *Psyra*:

The generated 8 DNA barcodes can be accessed in NCBI with respective accession numbers, as novel submissions of *P. crypta*, *P. similaria*, *P. spurcataria* and *P. gracilis* to the database. As per the NJ Tree (Figure 3.4), cohesive clustering was seen for all 7 species. The overall mean distance in the final dataset comprising of the generated sequences aligned with all the available sequences of *Psyra* (3 species) from the global database was found to be 5.17%. *P. spurcataria* was found to be forming sister clades with *P. crypta* with a divergence of 3.05% between them. Intra-specific divergence was found to be 0.35% for both species. For *P. gracilis*, the inter-specific divergence was found to be the highest (6.44%) with *P. similaria* and the lowest (4.41%) with *P. spurcataria*. The mean within-group divergence for *P. similaria* was found to be 2.27%. Out of the 3 generated sequences for this species, one (accession no MZ353671) was found to be forming a sister clade with the other two with the respective divergence of 2.3% and 3.2%. This particular specimen was collected from the Eastern Himalaya, while the rest two are from the Western Himalaya. Because of this high intra-specific divergence and distant collection localities, we suspect that this specimen might be an undescribed species/subspecies, but could not be established for now primarily due to lack of enough specimens and generated barcodes, further confounded by the absence of commendable morphological differences with other *P. similaria* except numbers and arrangement of spines in the aedeagus vesica.

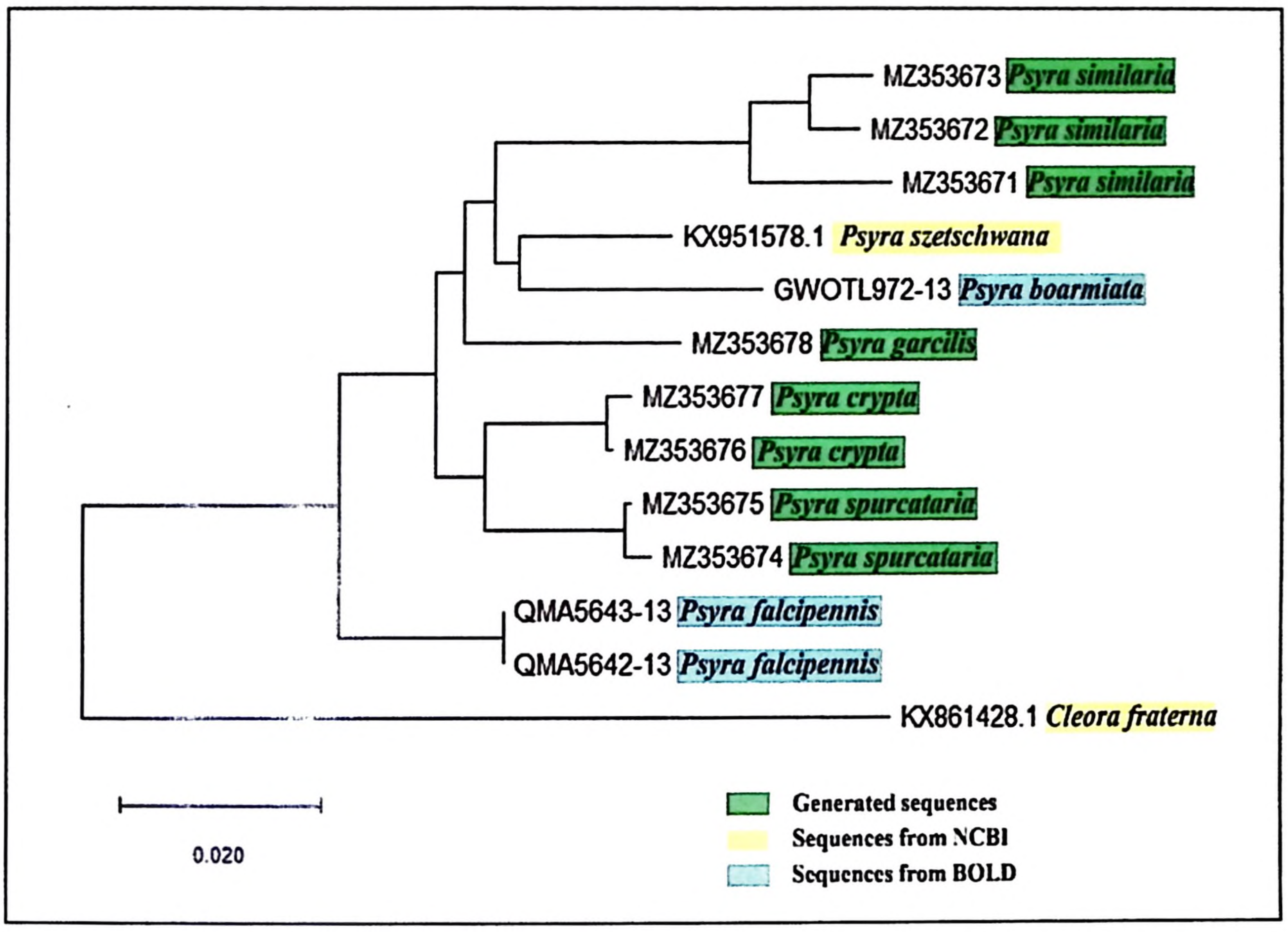


Figure. 3.4. Neighbour-joining (NJ) tree of the *Psyra* species with bootstrap supports

3.3.6. Intraspecific variations in the Himalayan cryptic genus *Psyra:*

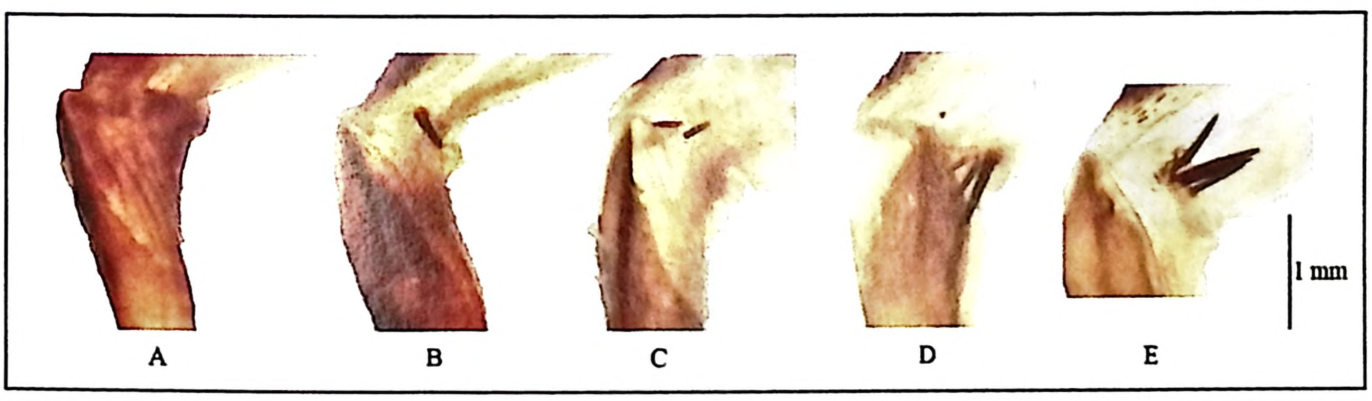
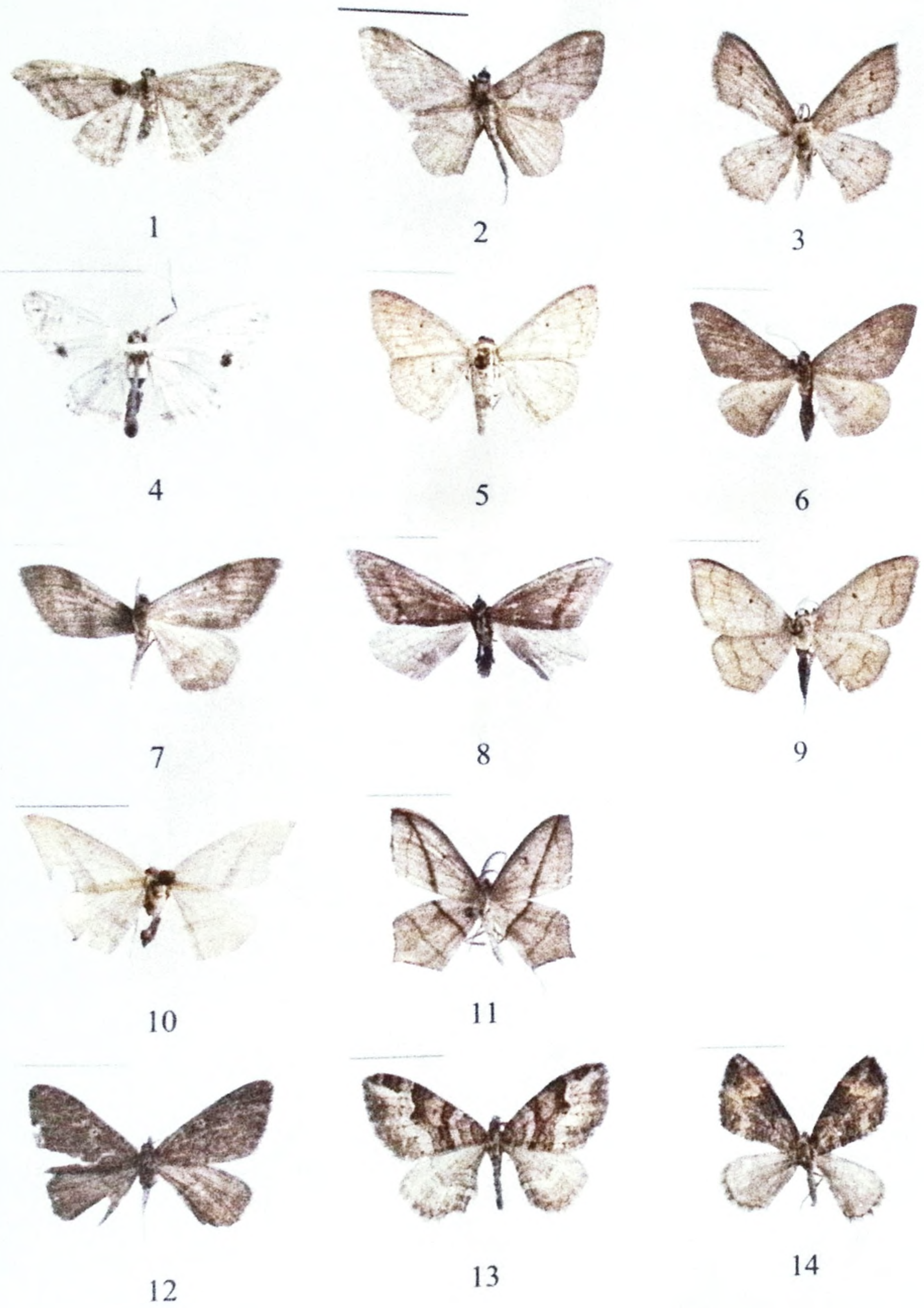


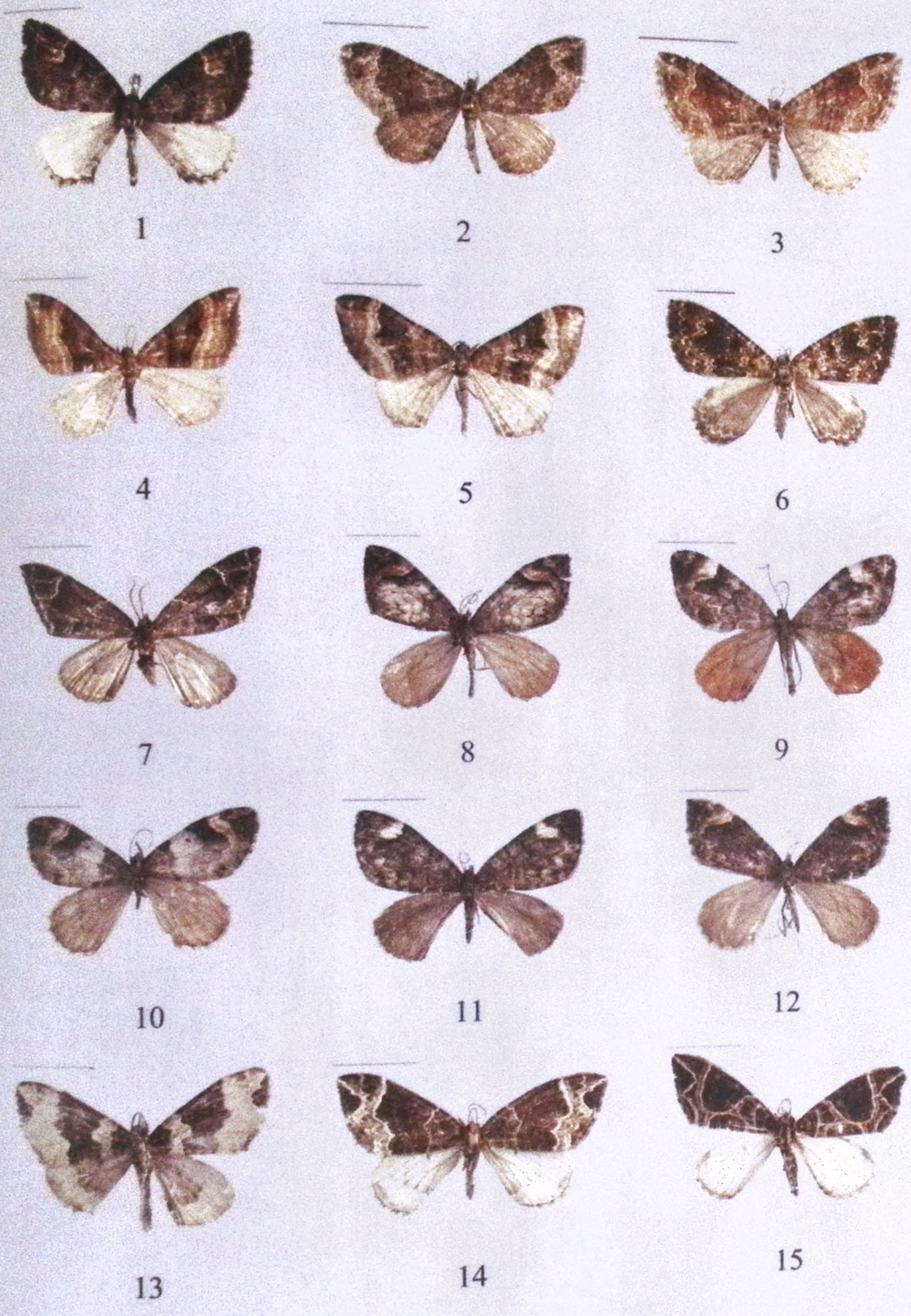
Figure 3.5. Variation of Basal spine of vesica in aedeagus in *Psyra crypta.*
A. Absence of spine B. A single spine C. Double spine D. Triple spine E. Multiple spine.

Basal spines in the aedeagus of *P. crypta* may vary in numbers within and between populations, while other morphological and genitalia characters remain the same. The number of spines may be single, double or triple and sometimes even up to five larger and three shorter ones (Figure 3.5).



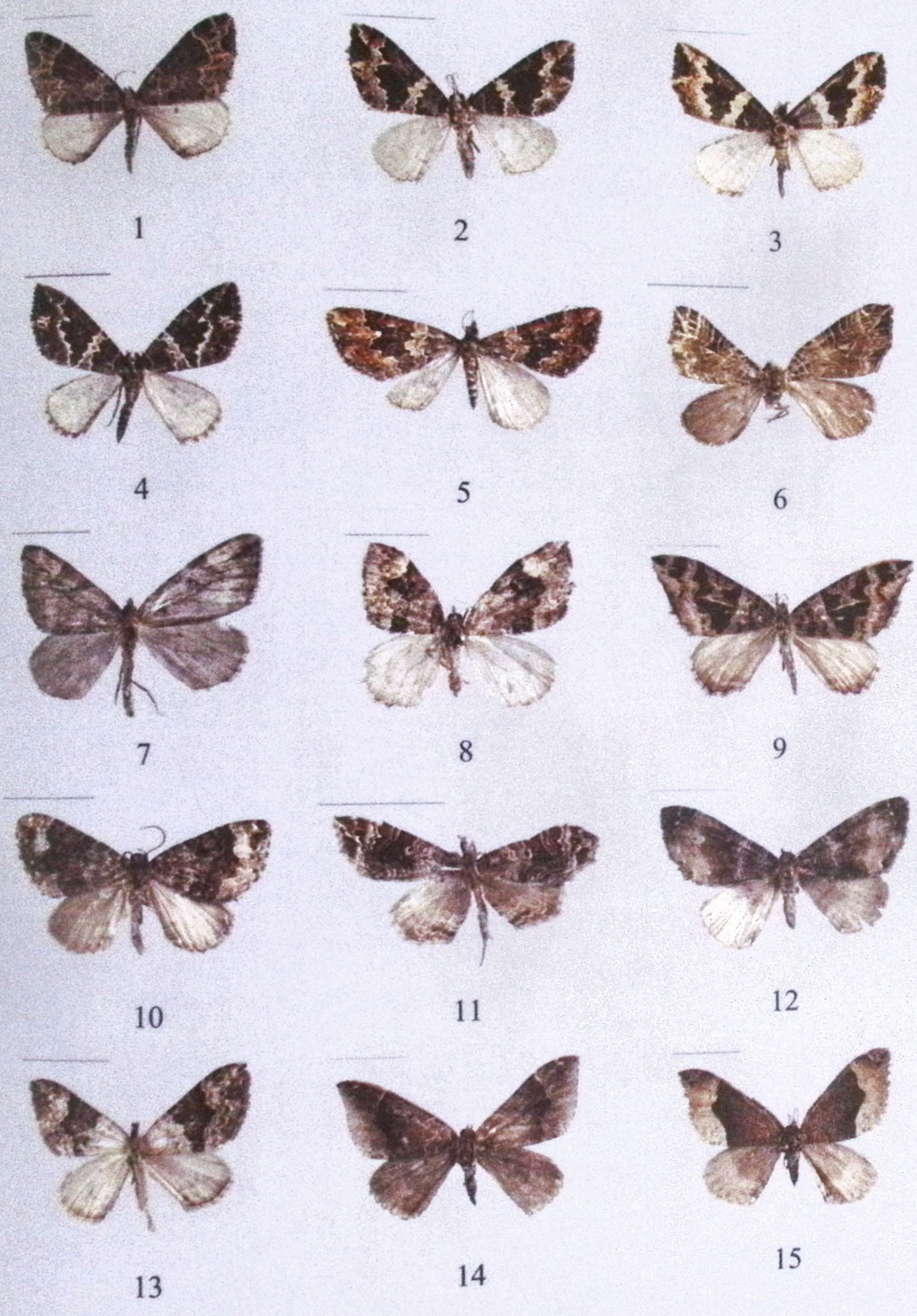
Habitus Plate 1: Sterrhinae (1-11), Larentiinae (12-14)

1. *Idaea falcipennis*, 2. *Lophophleps informis*, 3. *Scopula achrosta*, 4. *S. butleri*, 5. *S. pallida*, 6. *Rhodostrophia cinerascens*, 7. *R. herbicolens*, 8. *R. pelloniaria*, 9. *R. stigmatica*, 10. *R. tristrigalis*, 11. *Timandra correspondens*, 12. *Orthonama obstipata*, 13. *Xanthorhoe castanea*, 14. *X. griseiviridis*



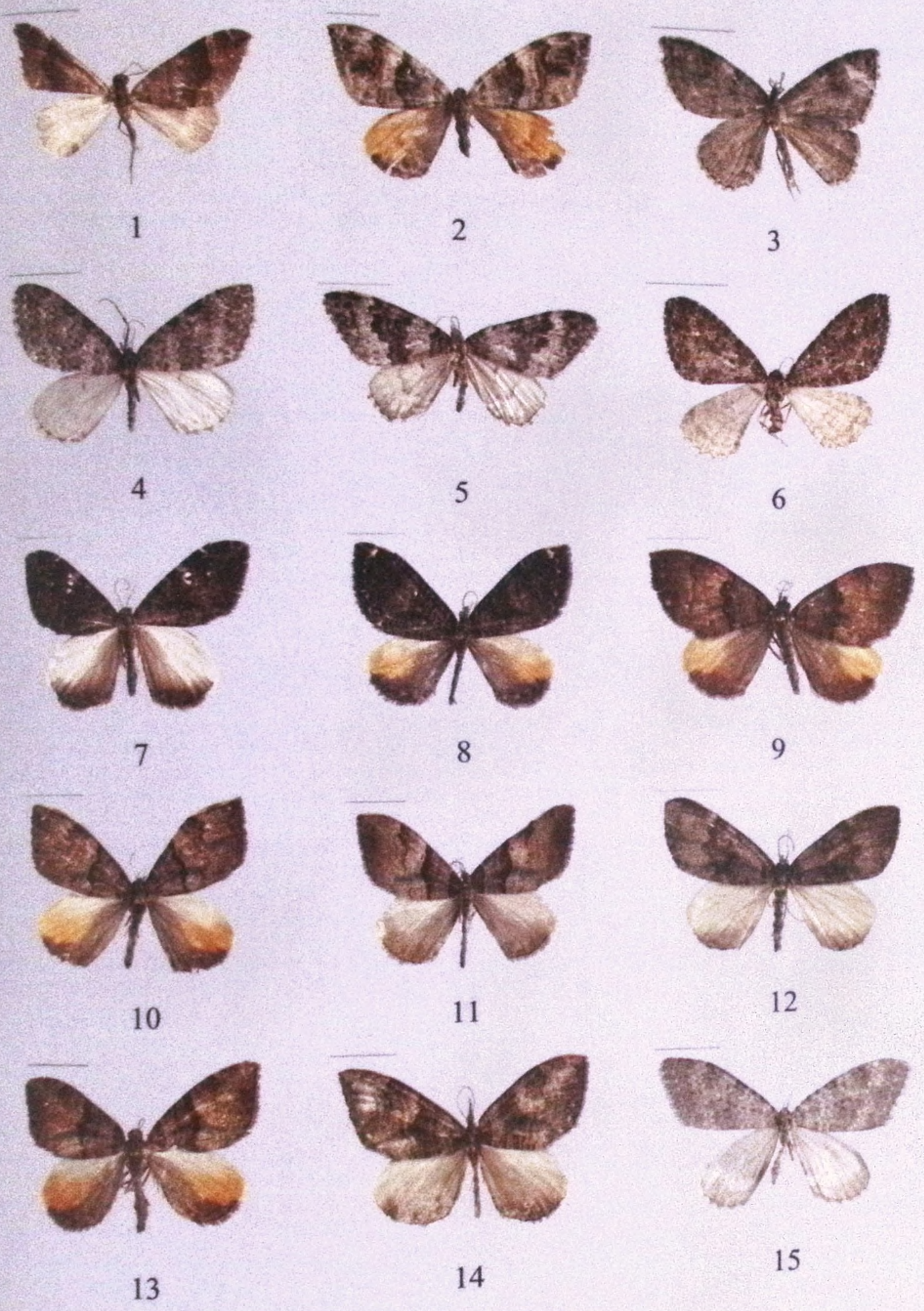
Habitus Plate 2: Larentiinae (1-15)

1. *Xanthorhoe hampsoni*, 2. *X. saturata*, 3. *Euphyia cinnamifusa*, 4. *E. goniodes*, 5. *E. subangulata*, 6. *E. variegata*, 7. *Colostygia albigirata*, 8. *Dysstroma dentifera*, 9. *D. fulvipennis*, 10. *D. planifasciata*, 11. *D. shirakawai*, 12. *D. sikkimensis*, 13. *Ecliptopera fulvotincta*, 14. *E. postpallida*, 15. *E. relata*



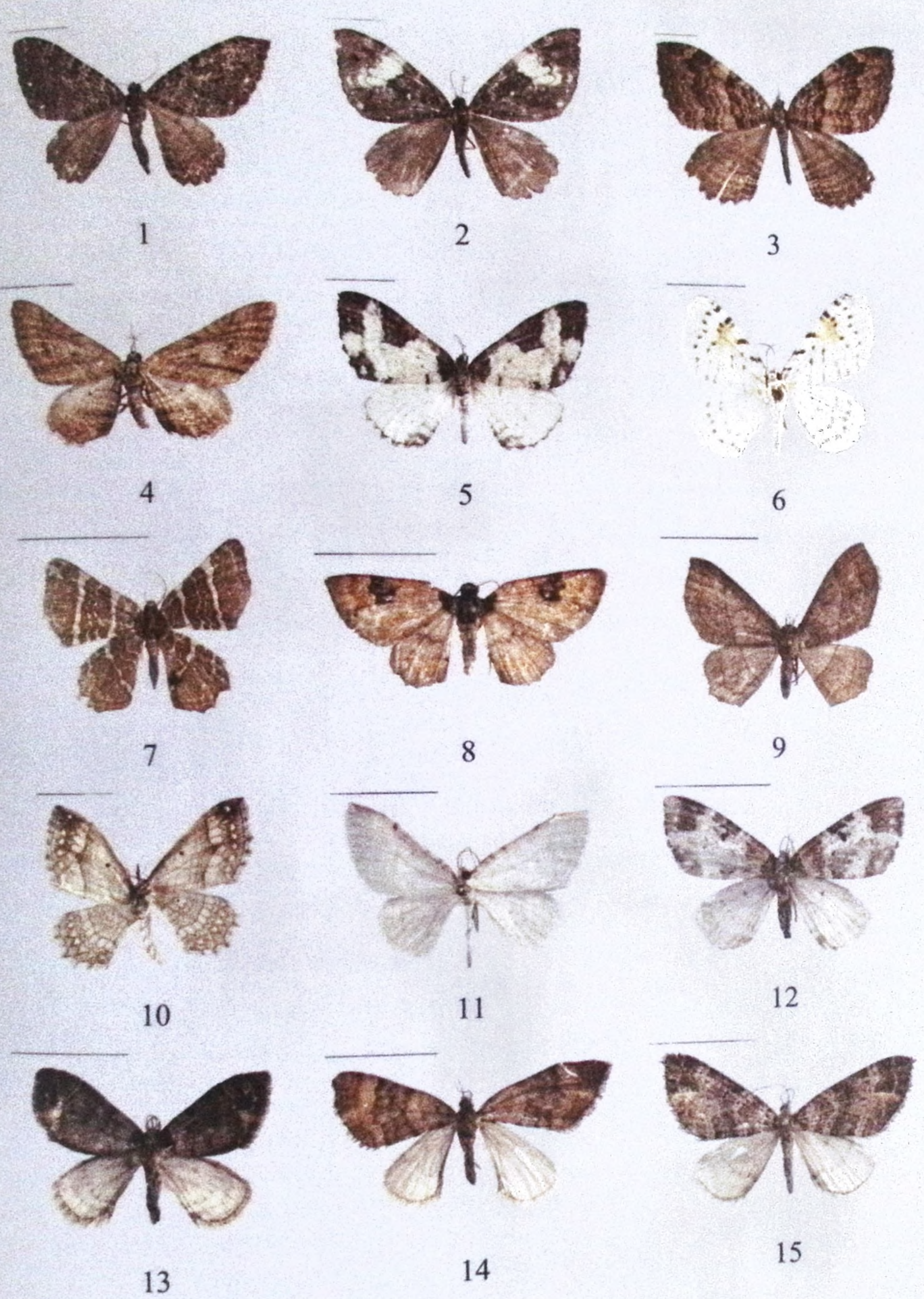
Habitus Plate 3: Larentiinae (1-15)

1. *Ecliptopera substituta*, 2. *Electrophaes aliena*, 3. *E. fulgidaria*, 4. *E. niveonotata*, 5. *E. recta*, 6. *Eustroma aurigena*, 7. *Heterothera consimilis*, 8. *H. dentifasciata*, 9. *Hysterura multifaria*, 10. *Lampropteryx siderifera*, 11. *Lobogonodes multistriata*, 12. *Protonebula cupreata*, 13. *Costicoma exangulata*, 14. *Xenortholitha falcata*, 15. *X. latifusata*



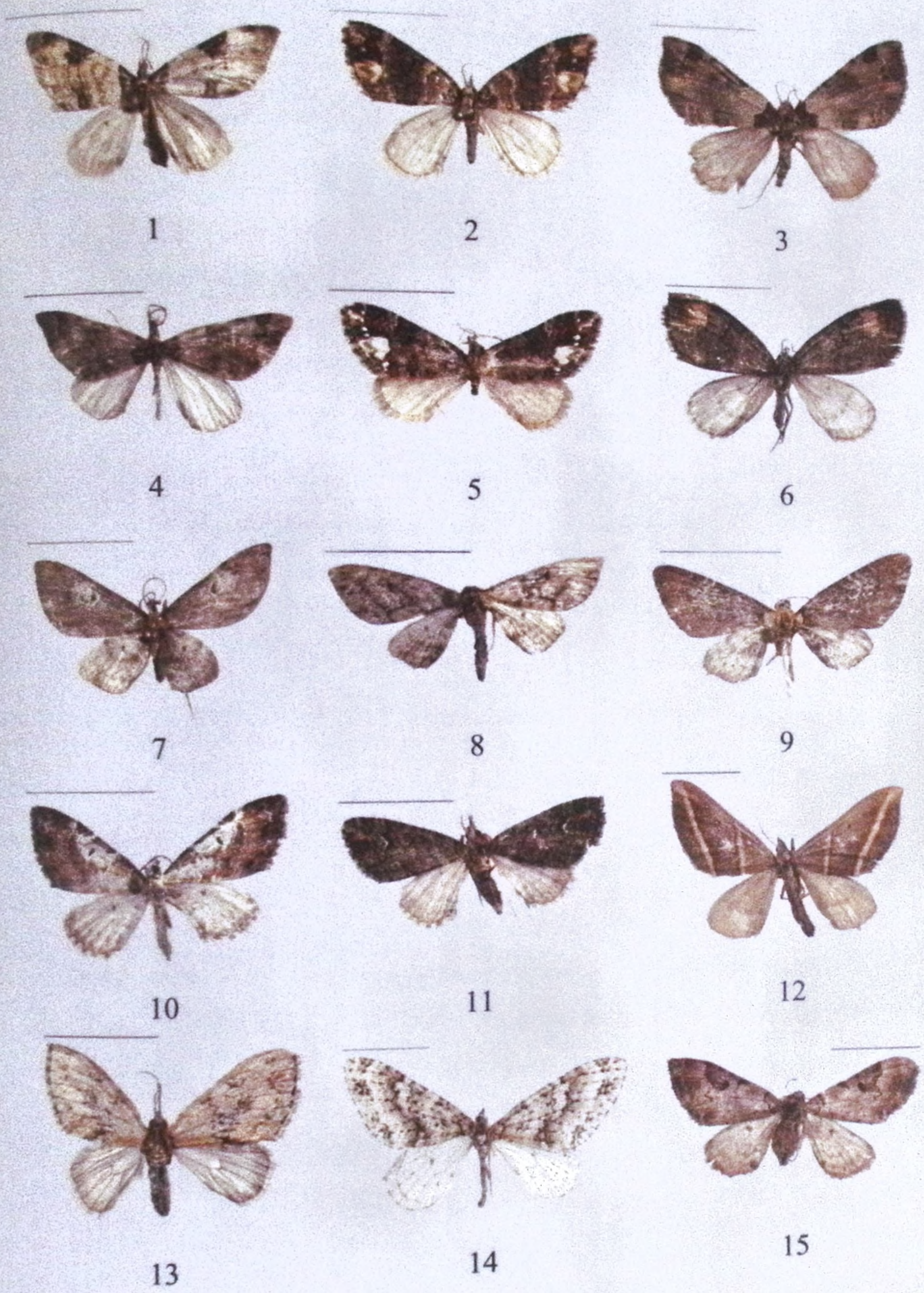
Habitus Plate 4: Larentiinae (1-15)

1. *Xenortholitha propinguata*, 2. *Amnesicoma simplex*, 3. *Atopophysa indistincta*, 4. *Coenolarentia argentiplumbea*, 5. *Neotephria ramalaria*, 6. *Parentephria stellata*, 7. *Photoscotosia amplicata*, 8. *P. dejuncta*, 9. *P. dejuta*, 10. *P. miniosata*, 11. *P. multilinea*, 12. *P. nitida*, 13. *P. pallidimaculata*, 14. *P. polysticha*, 15. *Rheumaptera cinerea*



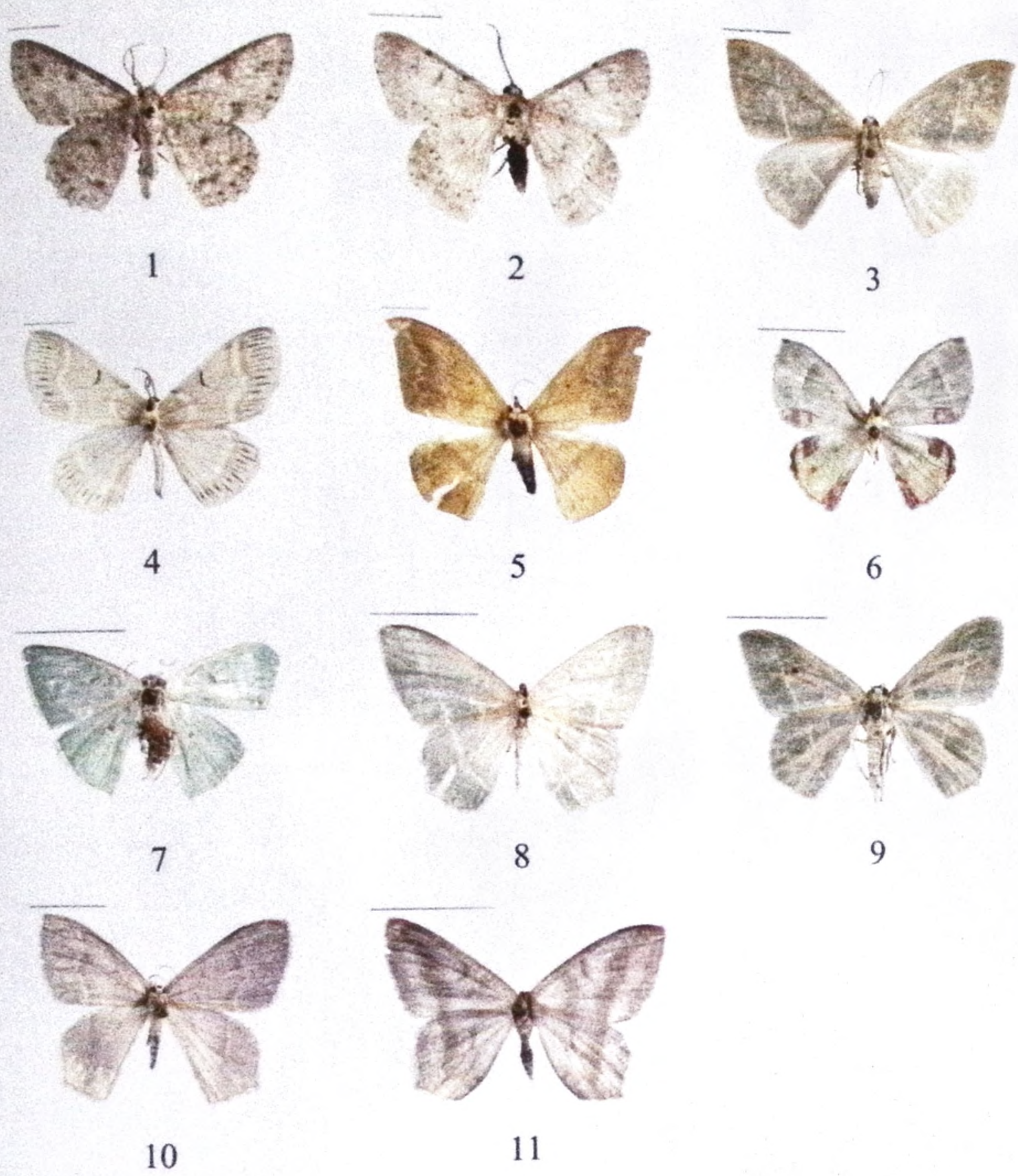
Habitus Plate 5: Larentiinae (1-15)

1. *Rheumaptera dubiosata*, 2. *R. nigralbata*, 3. *Triphosa rubrodotata*, 4. *Horisme plurilineata*, 5. *Melanthia catenaria*, 6. *Agnibesa recurvilineata*, 7. *Hastina pluristrigata*, 8. *Hydrelia bicolorata*, 9. *H. sericea*, 10. *Laciniodes plurilinearia*, 11. *Venusia roseicosta*, 12. *Perizoma albofasciata*, 13. *P. antisticta*, 14. *P. bicolor*, 15. *P. fulvimacula*



Habitus Plate 6: Larentiinae (1-15)

1. *Perizoma hockingii*, 2. *P. peculiare*, 3. *P. plumbeata*, 4. *P. schistacea*, 5. *P. seriata*, 6. *P. variabilis*, 7. *Eupithecia albigutta*, 8. *E. conjunctiva*, 9. *E. rubridorsata*, 10. *E. ustata*, 11. *Pasiphila palpata*, 12. *Docirava aequilineata*, 13. *Trichopterigia decorata*, 14. *T. macularia*, 15. *Physetobasis dentifascias*

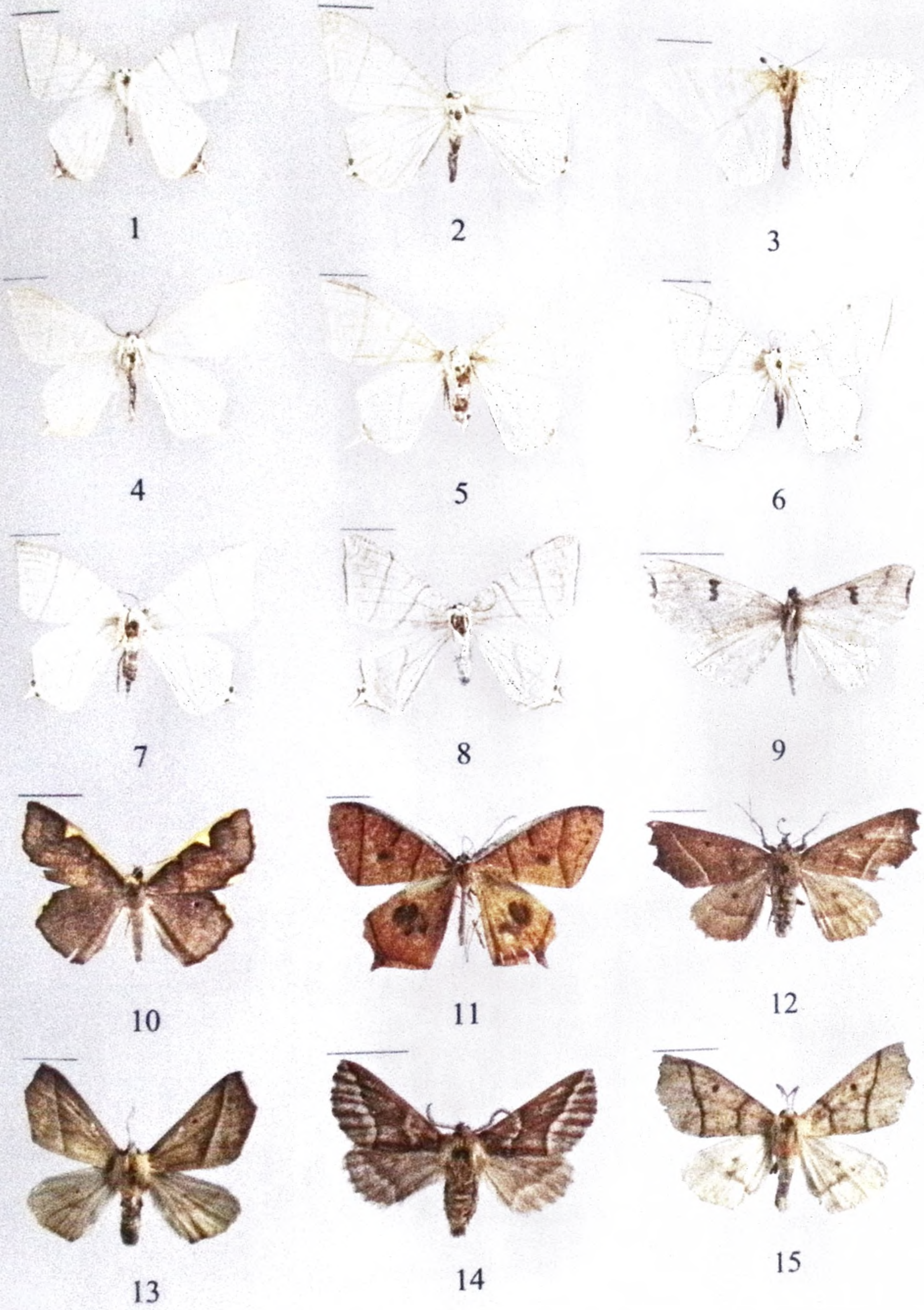


Habitus Plate 7: Geometrinae (2-12)

1. *Herochroma crassipunctata*, 2. *Pingasa pseudoterpinaria*, 3. *Geometra flavifrontaria*, 4. *Iotaphora iridicolor*, 5. *Tanaorhinus reciprocata*, 6. *Comibaena pictipennis*, 7. *Comostola subtiliaria*, 8. *Chlorissa distinctaria*, 9. *C. gelida*, 10. *Maxates glaucaria*, 11. *M. iridescens*

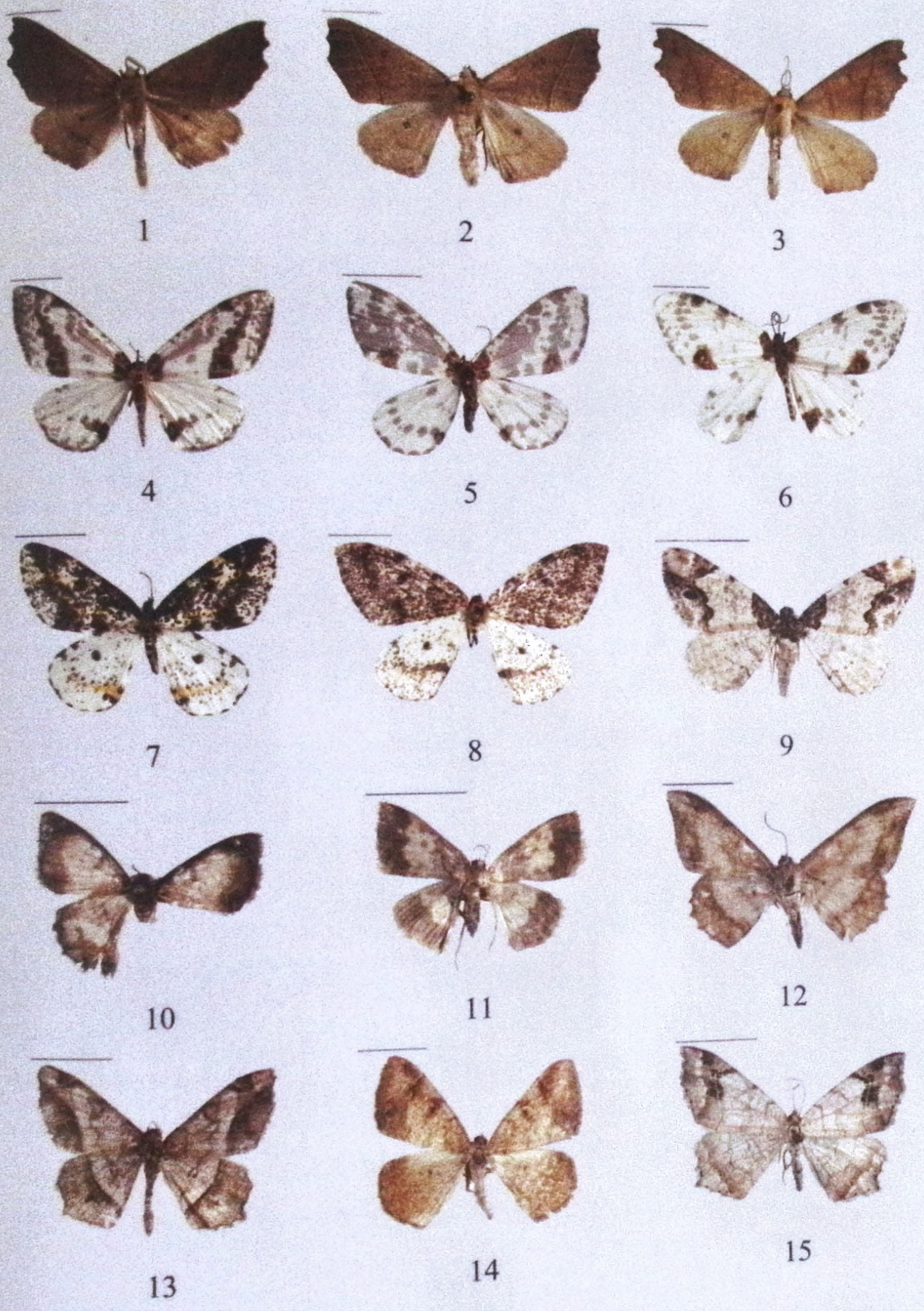
Habitus Plate 8: Ennominae (1-15)

1. *Apoheterolocha patalata*, 2. *A. quadraria*, 3. *Corymica pryeri*, 4. *Garaeus apicata*, 5. *Heterolocha falconaria*, 6. *H. phoenicotaeniata*, 7. *Mimomiza cruentaria*, 8. *M. leucogonia*, 9. *Plagodis reticulata*, 10. *Artemidora disistaria*, 11. *Leptomiza calcearia*, 12. *Opisthograptis luteolata*, 13. *O. moelleri*, 14. *O. tridentifera*, 15. *Ourapteryx caschmirensis*



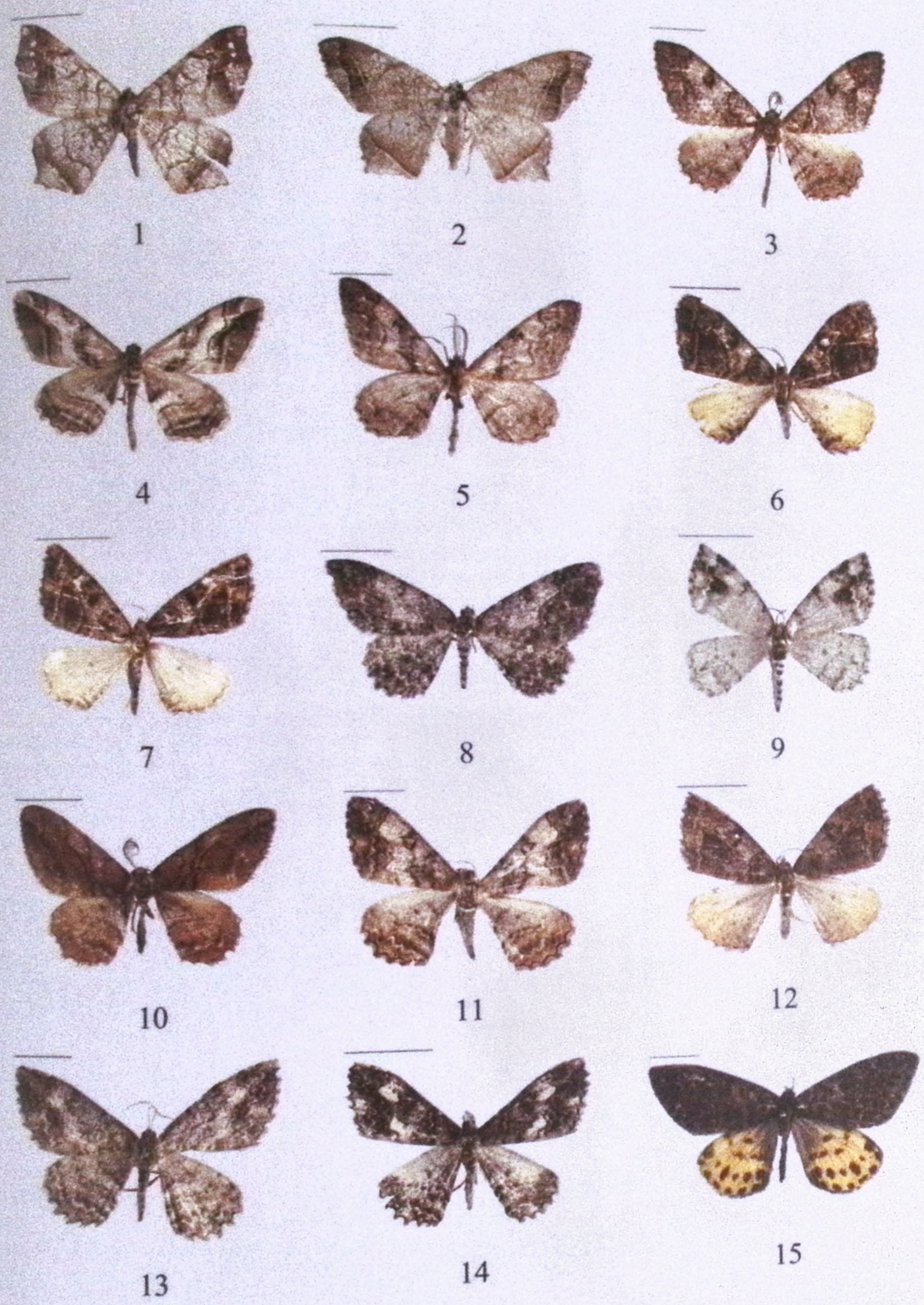
Habitus Plate 9: Ennominae (1-15)

1. *Ourapteryx chrisbahri*, 2. *O. ebuleata ebuleata*, 3. *O. kantalaria*, 4. *O. leucopteron*, 5. *O. multistrigaria*, 6. *O. nepalensis*, 7. *O. purissima*, 8. *O. yerburii*, 9. *Eilicrinia cordiaria signigera*, 10. *Plutodes warreni*, 11. *Thinopteryx crocoptera*, 12. *Odontopera bilinearia*, 13. *O. heydena*, 14. *O. kametaria*, 15. *O. kanchai*



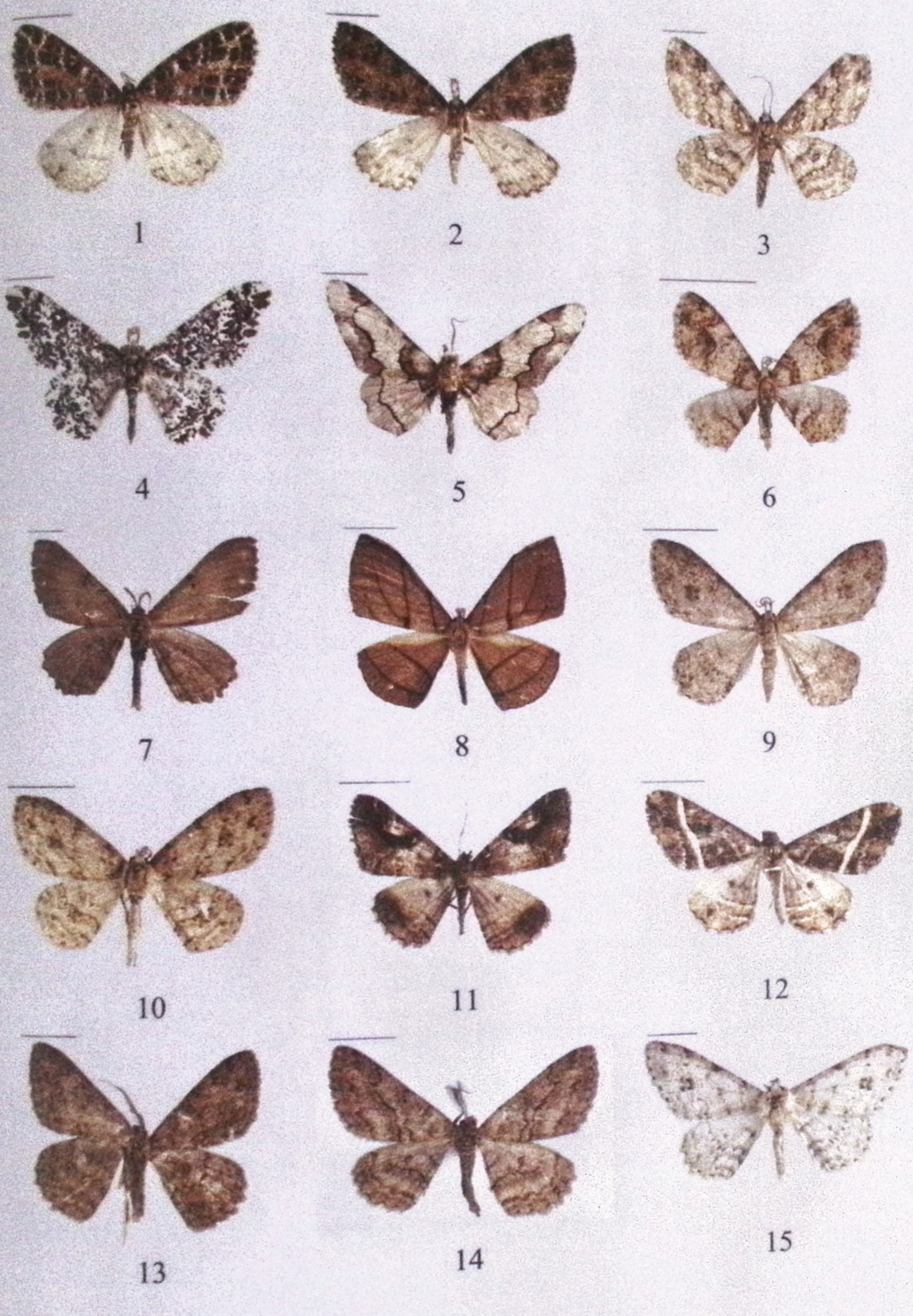
Habitus Plate 10: Ennominae (1-15)

1. *Odontopera lentiginosaria*, 2. *O. obliquaria*, 3. *O. similaria*, 4. *Abraxas leopardina*, 5. *A. neomartaria*, 6. *A. peregrina*, 7. *A. picaria*, 8. *A. superpicaria*, 9. *Ligdia coctata*, 10. *Hydatocapnia marginata*, 11. *Peratophyga hyalinata*, 12. *Luxiaria amasa*, 13. *Chiasmia azataria*, 14. *Hypephyra terrosa*, 15. *Oxymacaria brunneata*



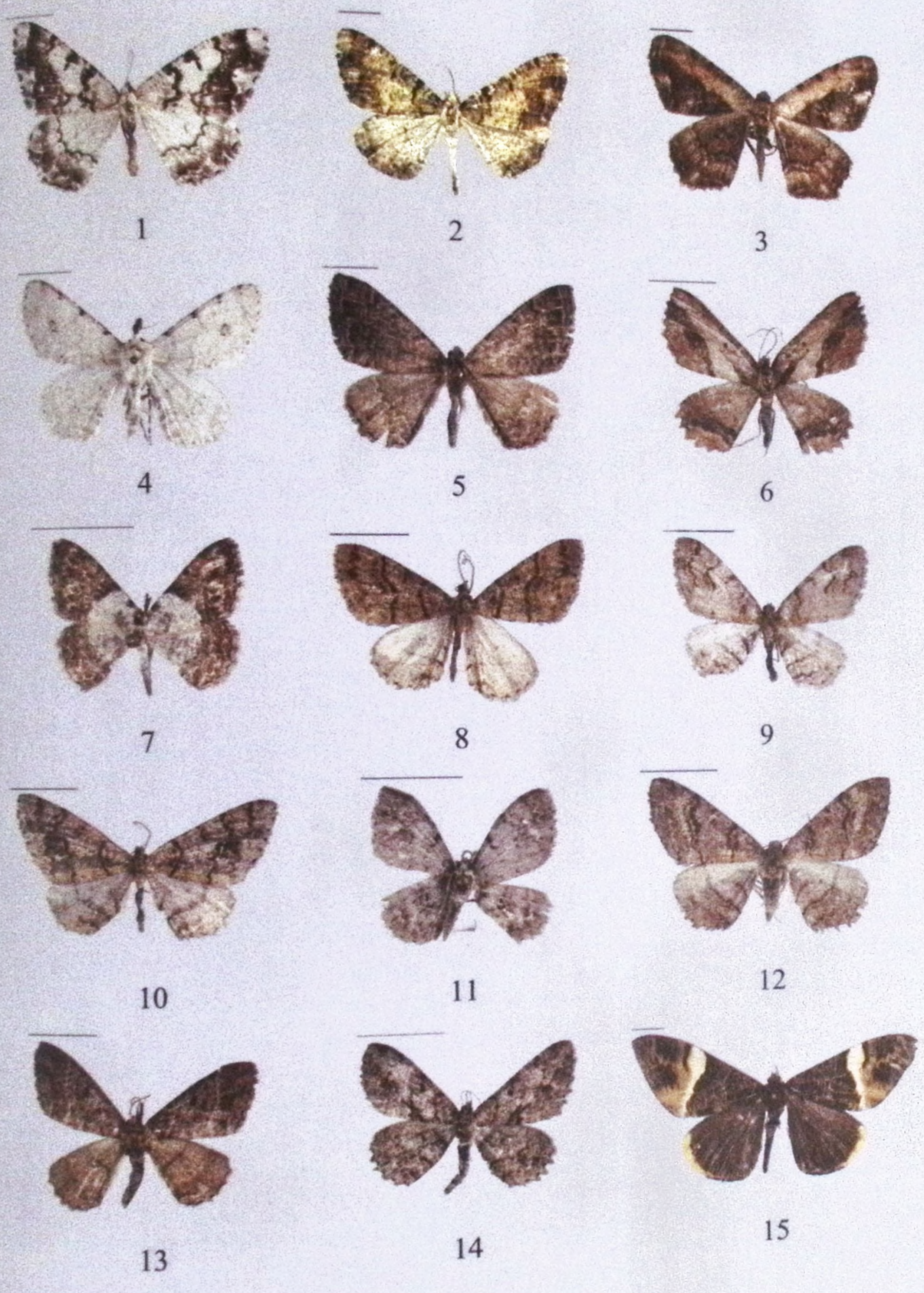
Habitus Plate 11: Ennominae (1-15)

1. *Oxymacaria maculosata*, 2. *O. temeraria*, 3. *Alcis admissaria*, 4. *A. leucophaea*, 5. *A. limbui*, 6. *A. macroclarata*, 7. *A. neoclarata*, 8. *A. nigralbata*, 9. *A. nigridorsaria*, 10. *A. nudipennis*, 11. *A. perspicuata*, 12. *A. quadrifera*, 13. *A. subnitida*, 14. *A. variegata*, 15. *Arichanna flavinigra*



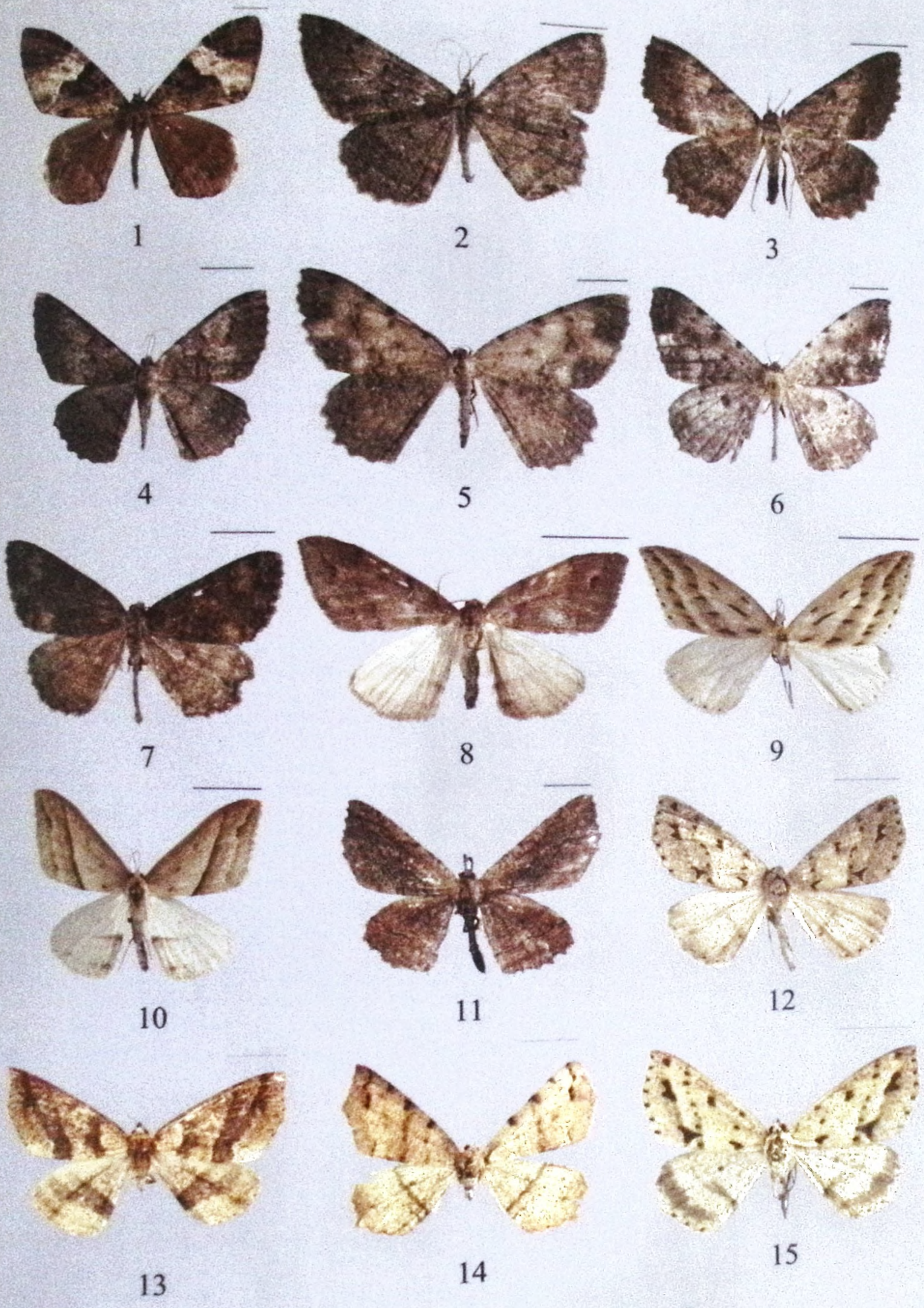
Habitus Plate 12: Ennominae (1-15)

1. *Arichanna interplagata*, 2. *A. tenebraria*, 3. *Ascotis selenaria*, 4. *Biston falcata*, 5. *B. regalis*, 6. *Calichodes ochrifasciata*, 7. *Chorodna creataria*, 8. *Dalima patularia*, 9. *Ectropis bhurmitra*, 10. *E. dentilineata*, 11. *Gasterocome pannosaria*, 12. *Harutalcis vialis*, 13. *Hypomecis lioptilaria*, 14. *H. ratotaria*, 15. *Lassaba albidaria*



Habitus Plate 13: Ennominae (1-15)

1. *Lassaba cervina*, 2. *L. dissimilis*, 3. *L. interruptaria*, 4. *L. parvalbidaria nepalensis*, 5. *L. anepsia*, 6. *Menophra subplagiata*, 7. *Myrioblephara albibasis*, 8. *M. duplexa*, 9. *M. gandakiensis*, 10. *M. harutai*, 11. *M. idaeoides*, 12. *M. xanthozonea*, 13. *Parectropis conspurcata*, 14. *Psilalcis breta*, 15. *Xandrames albofasciata*



Habitus Plate 14: Ennominae (1-15)

1. *Xandrames dholaria*, 2. *Ctenognophos altissimus*, 3. *C. eolaria*, 4. *C. methoria*, 5. *Gnophos accipitraria*, 6. *G. albidior*, 7. *Hirasa muscosaria*, 8. *Loxaspilates dispar*, 9. *L. hastigera*, 10. *L. obliquaria*, 11. *Phthonandria atrilineata*, 12. *Psyra angulifera*, 13. *P. crypta*, 14. *P. debilis indica*, 15. *P. similaria*

Habitus Plate 15: Ennominae (1-15)

1. *Psyra spurcataria*, 2. *Aplochlora dentisignata*, 3. *Lomographa platyleucata*, 4. *Anonychia grisea*, 5. *A. lativitta*, 6. *Antipercnia belluaria*, 7. *Micrabraxas grandis*, 8. *M. melanodonta*, 9. *M. seriopuncta*, 10. *Mimochroa gynopteridia*, 11. *Sirinopteryx ablunata*, 12. *S. duplicilinea*, 13. *S. harutai*, 14. *S. quadripunctata*, 15. *S. undulifera*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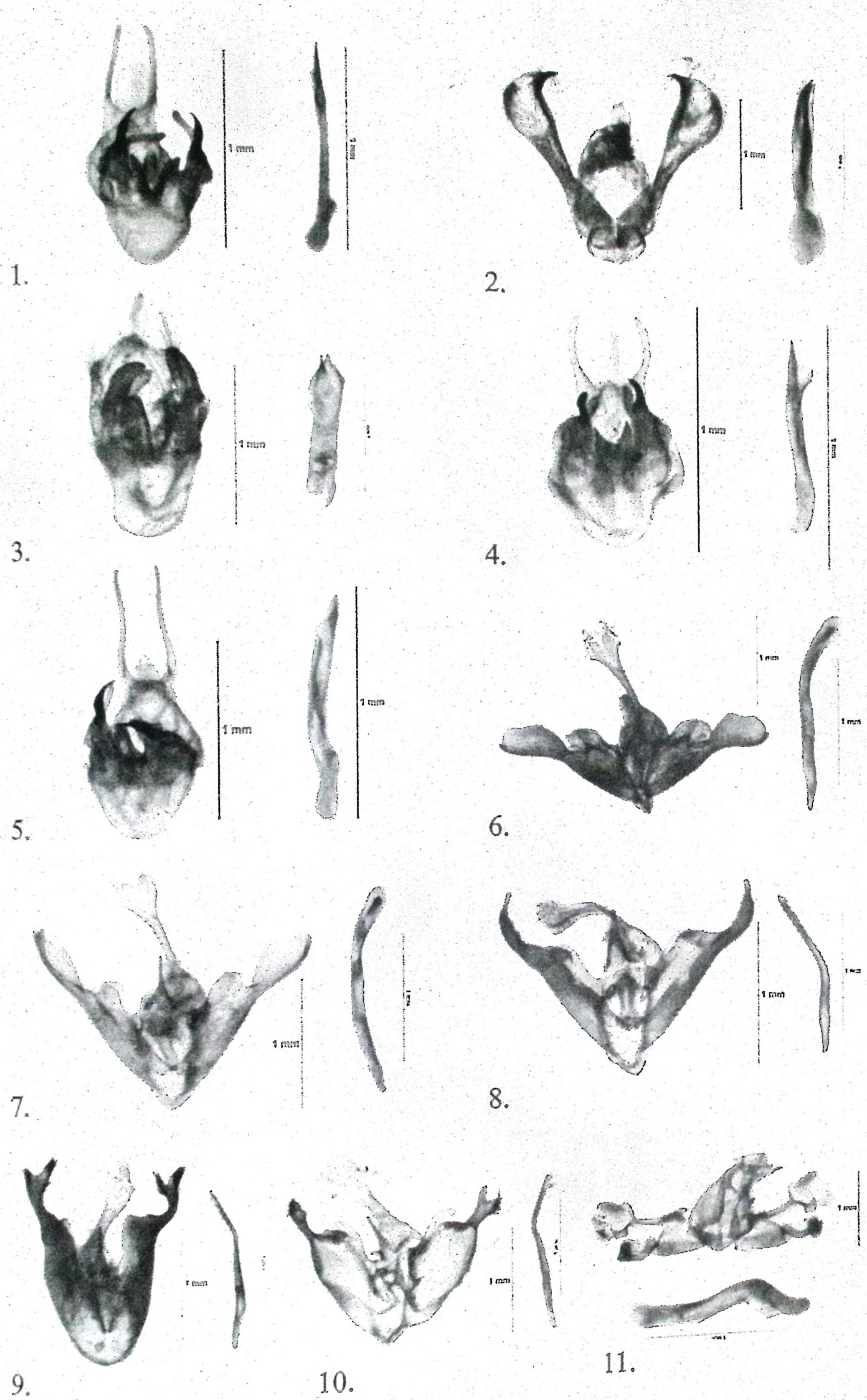
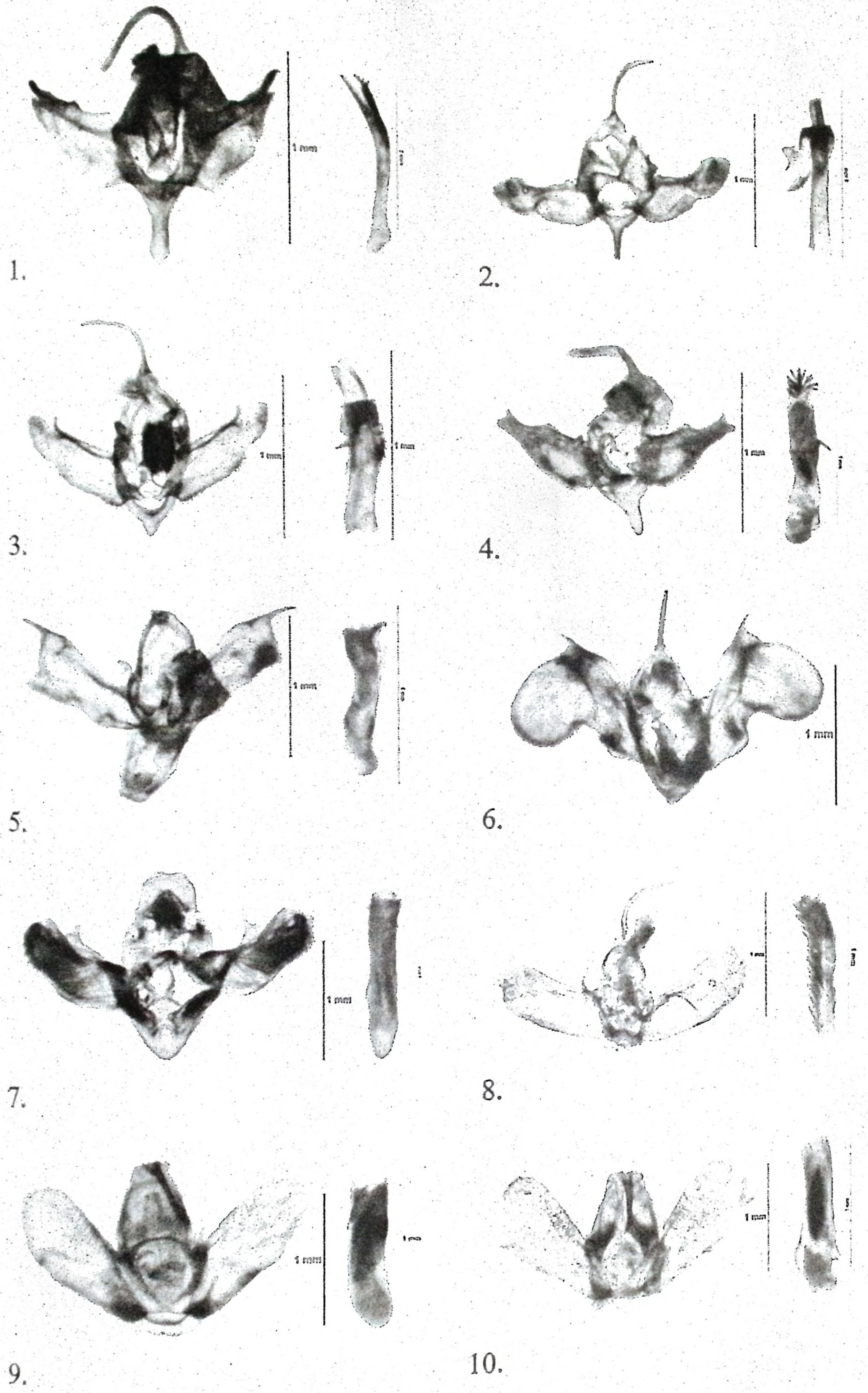
Habitus Plate 16: Ennominae (1-3)

1. *Tanaoctenia dehaliaria,* 2. *T.haliaria,* 3. *Xenoplia maculata*



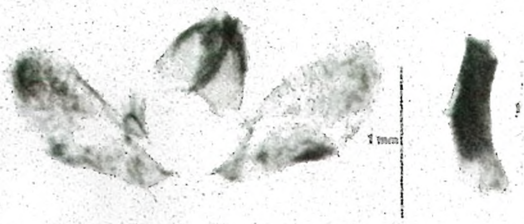
Genitalia Plate No.: 1

1. *Idaea falcipennis* 2. *Lophophleps informis* 3. *Scopula achrosta* 4. *S. butleri* 5. *S.pallida* 6. *Rhodostrophia cinerascens* 7. *R. herbicolens* 8. *R. pelloniaria* 9. *R. stigmatica* 10. *R. tristrigalis* 11. *Timandra correspondens*



Genitalia Plate No.: 2

1. *Xanthorhoe castanea* 2. *X. griseiviridis* 3. *X. hampsoni* 4. *X. saturata* 5. *Euphyia goniodes* 6. *E. subangulata* 7. *E. variegata* 8. *Colostygia albigirata* 9. *D. dentifera* 10. *D. fulvipennis*



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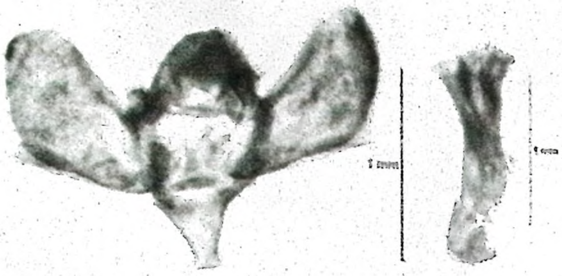

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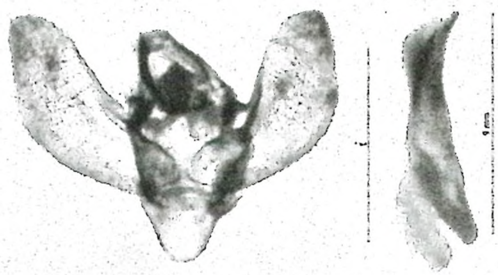

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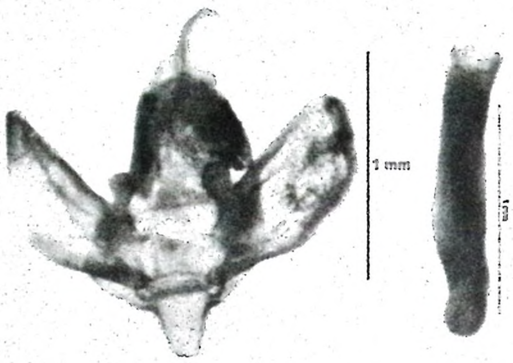

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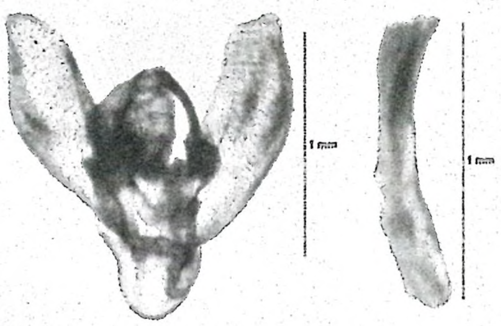

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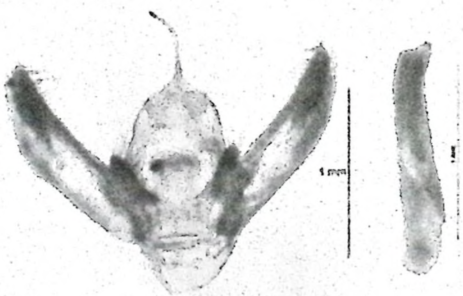

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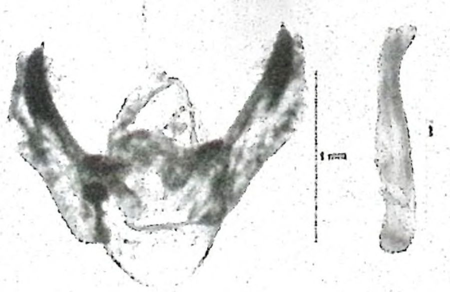

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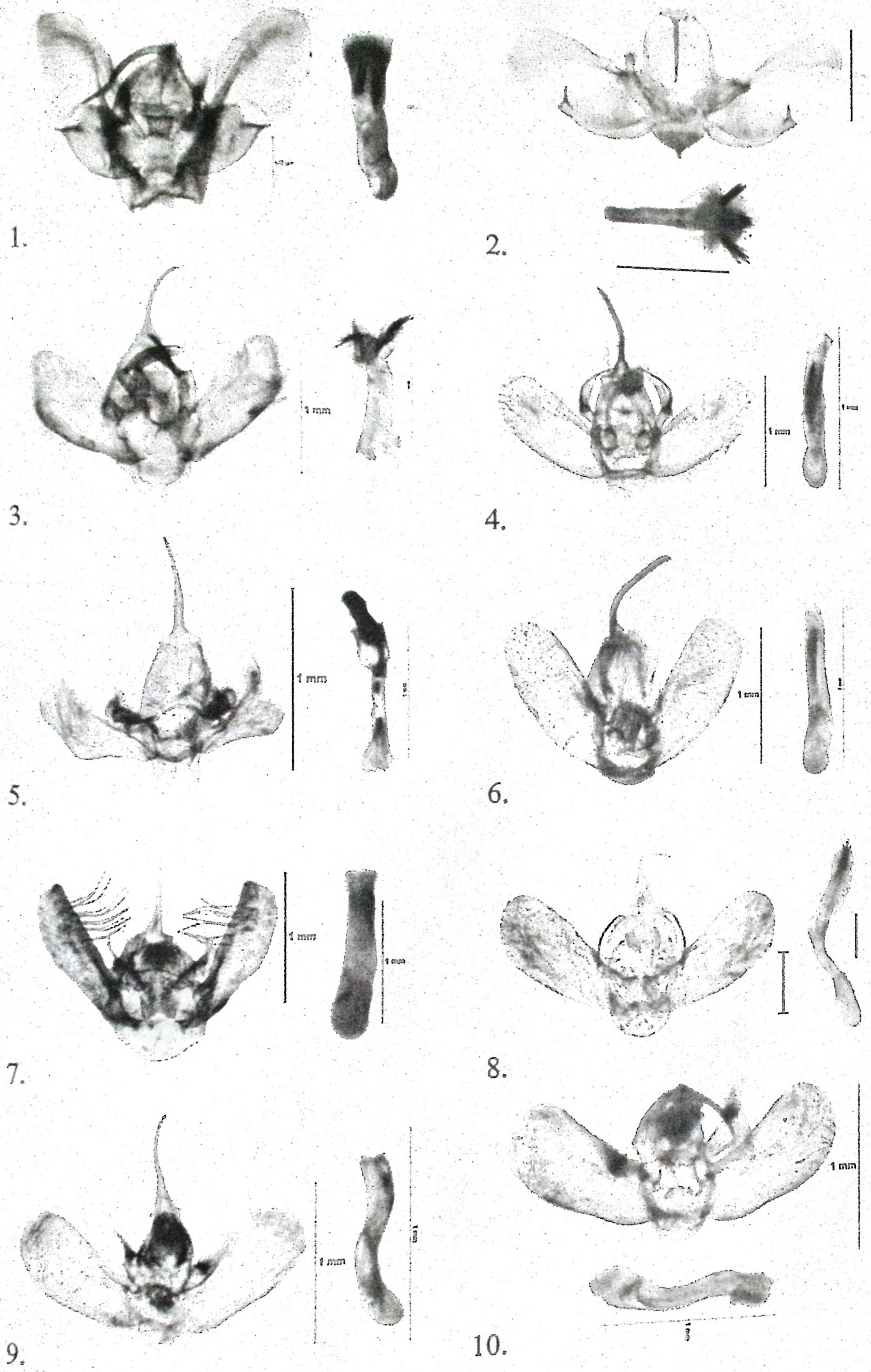
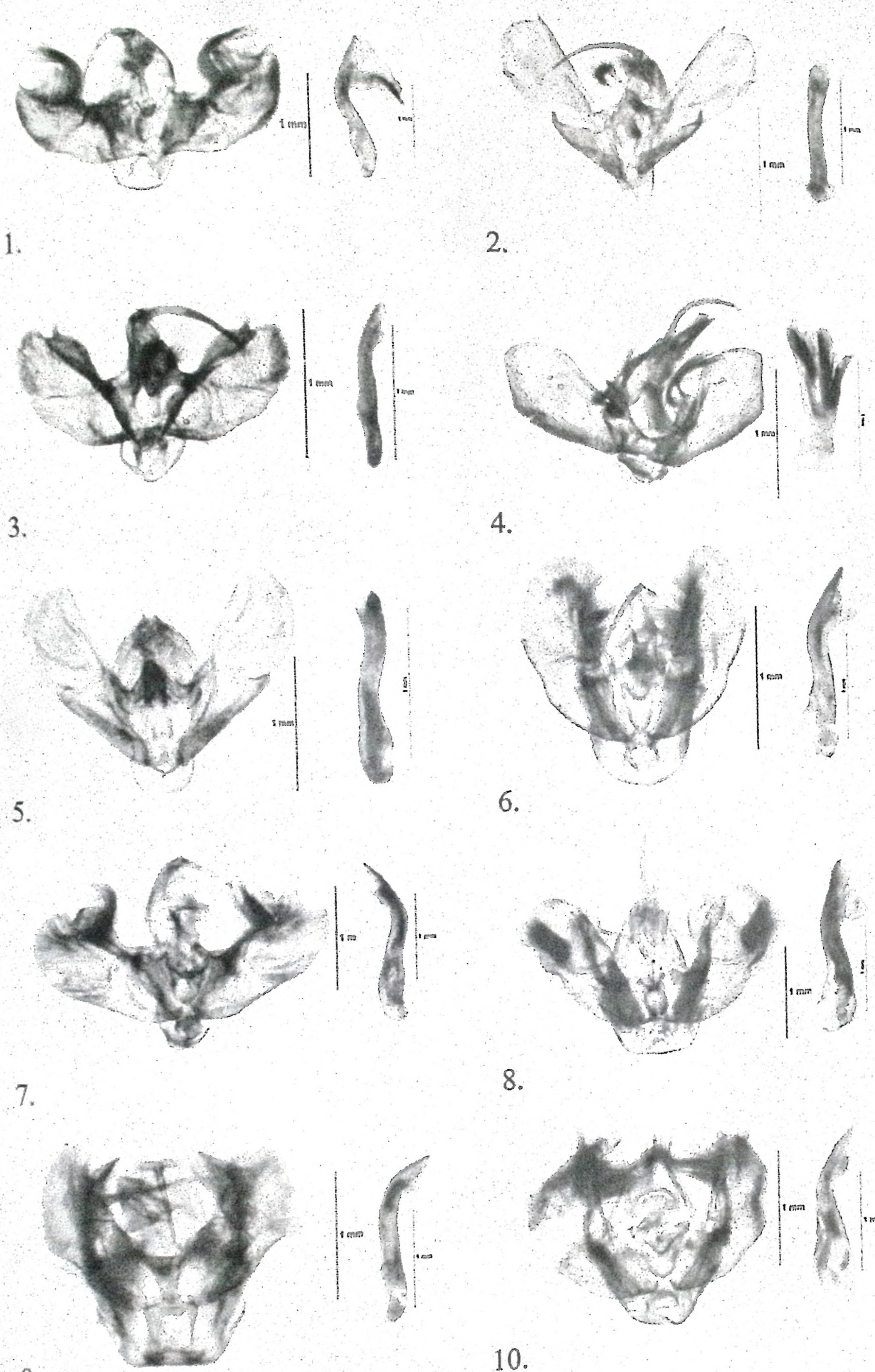
Genitalia Plate No.: 3

1. *Dysstroma shirakawai* 2. *D. sikkimensis* 3. *Ecliptopera fulvotincta* 4. *E. postpallida* 5. *E. relata* 6. *E. substituta* 7. *Electrophaes aliena* 8. *E. fulgidaria* 9. *E. niveonotata* 10. *E. recta*



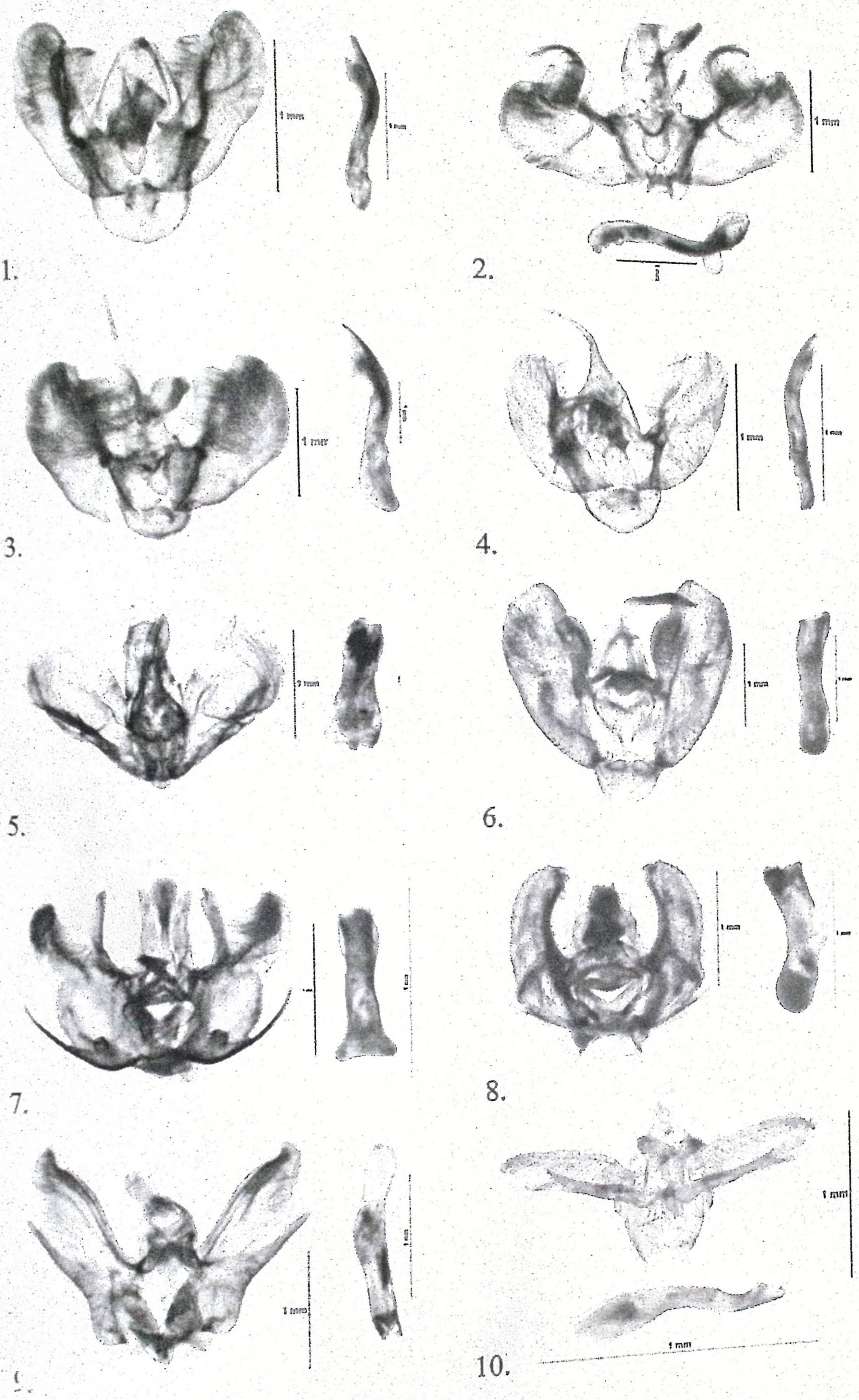
Genitalia Plate No.: 4

1. *Heterothera consimilis* 2. *H. dentifasciata* 3. *Hysterura multifaria* 4. *Lampropteryx siderifera* 5. *Lobogonodes multistriata* 6. *Protonebula cupreata* 7. *Costicoma exangulata* 8. *Xenortholitha falcata* 9. *X. latifusata* 10. *X. propinguata*



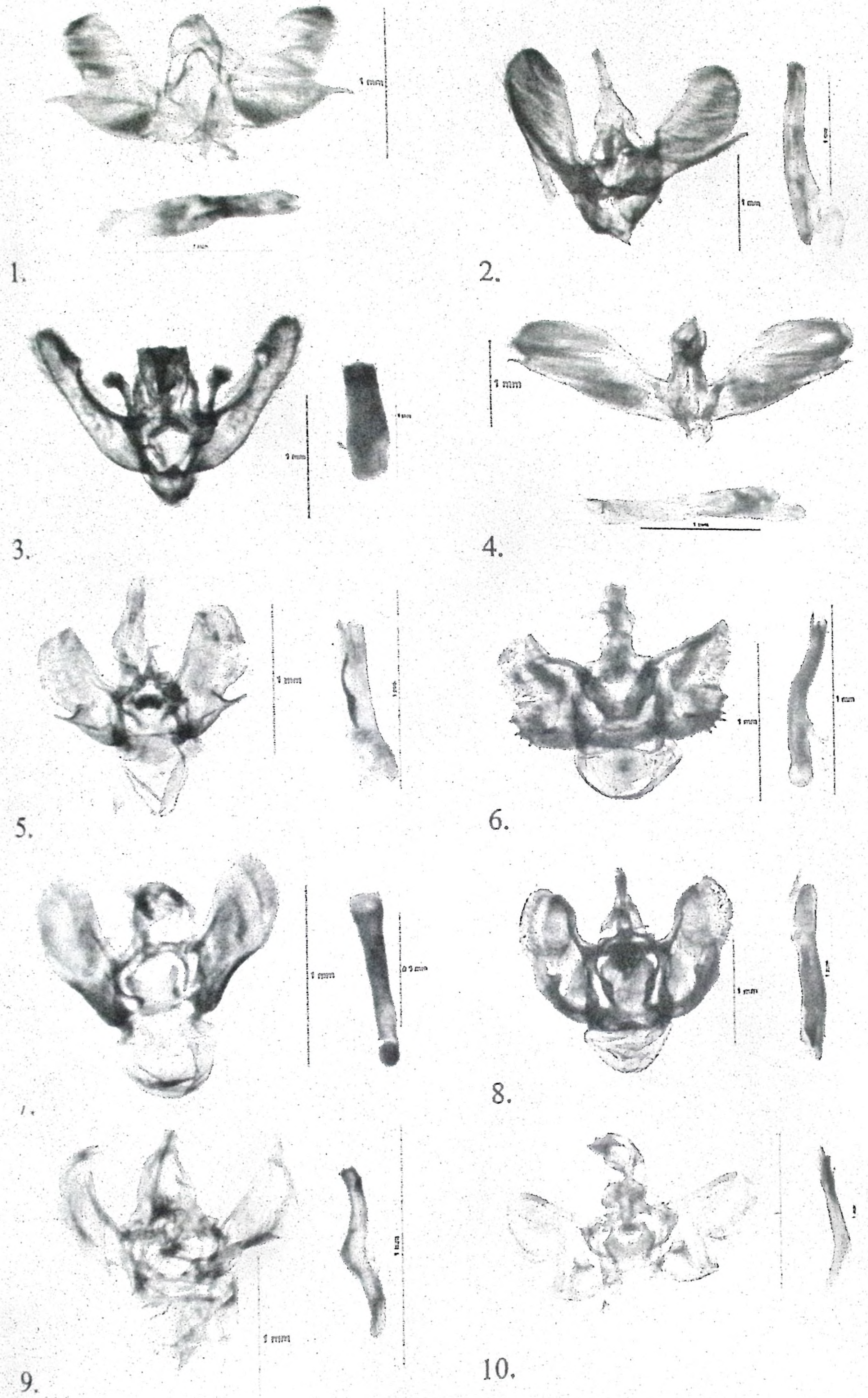
Genitalia Plate No.: 5

1. *Amnesicoma simplex* 2. *Atopophysa indistincta* 3. *Coenolarentia argentiplumbea* 4. *Neotephria ramalaria* 5. *Parentephria stellata* 6. *Photoscotosia amplicata* 7. *P. dejuncta* 8. *P. dejuta* 9. *P. miniosata* 10. *P. multilinea*



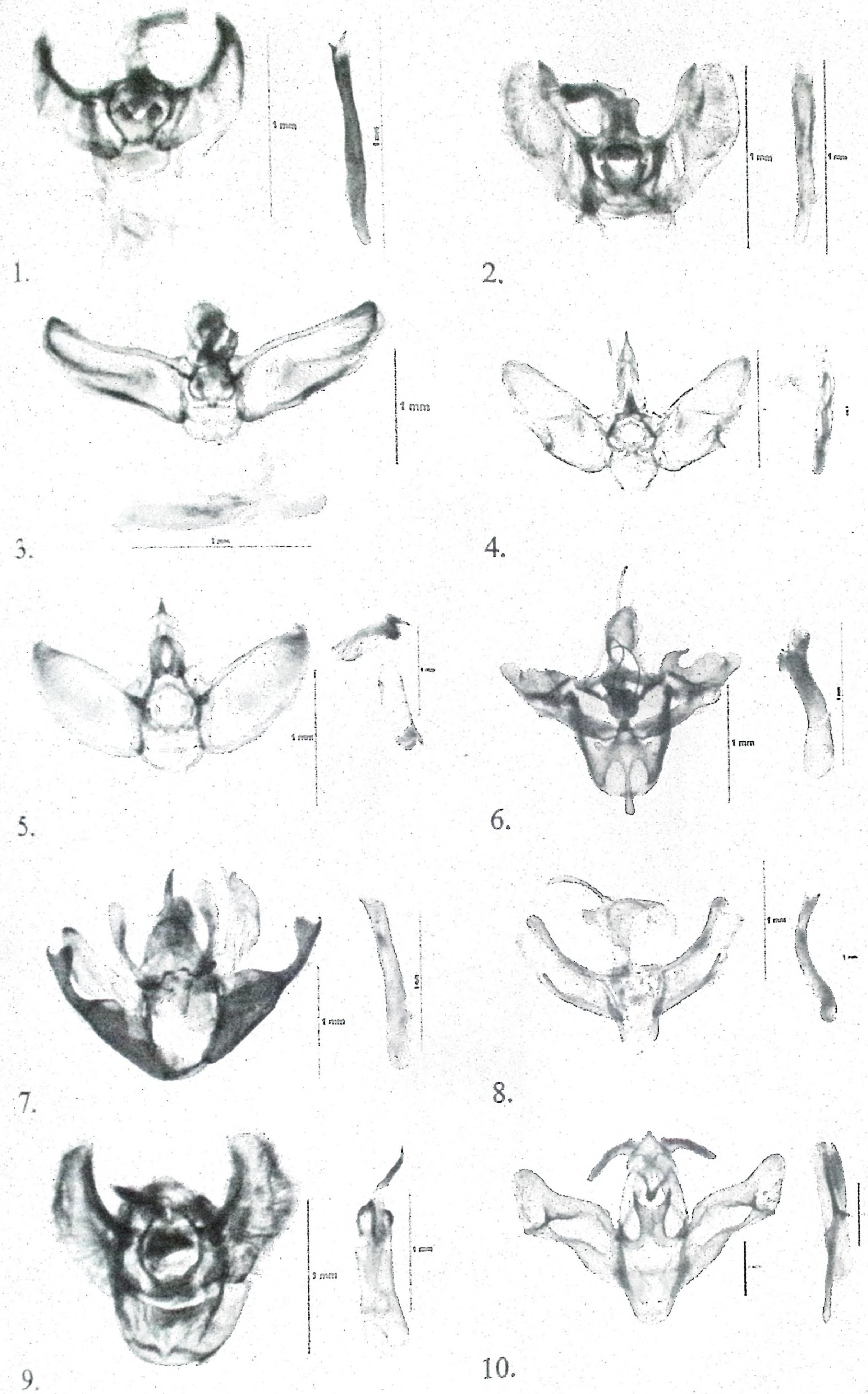
Genitalia Plate No.: 6

1. *Photoscotosia nitida* 2. *P. pallidimaculata* 3. *P. polysticha* 4. *R. cinerea* 5. *R. dubiosata* 6. *Triphosa rubrodotata* 7. *Horisme pluri-lineata* 8. *Melanthia catenaria* 9. *Agnibesa recurvilineata* 10. *Hastina pluristrigata*



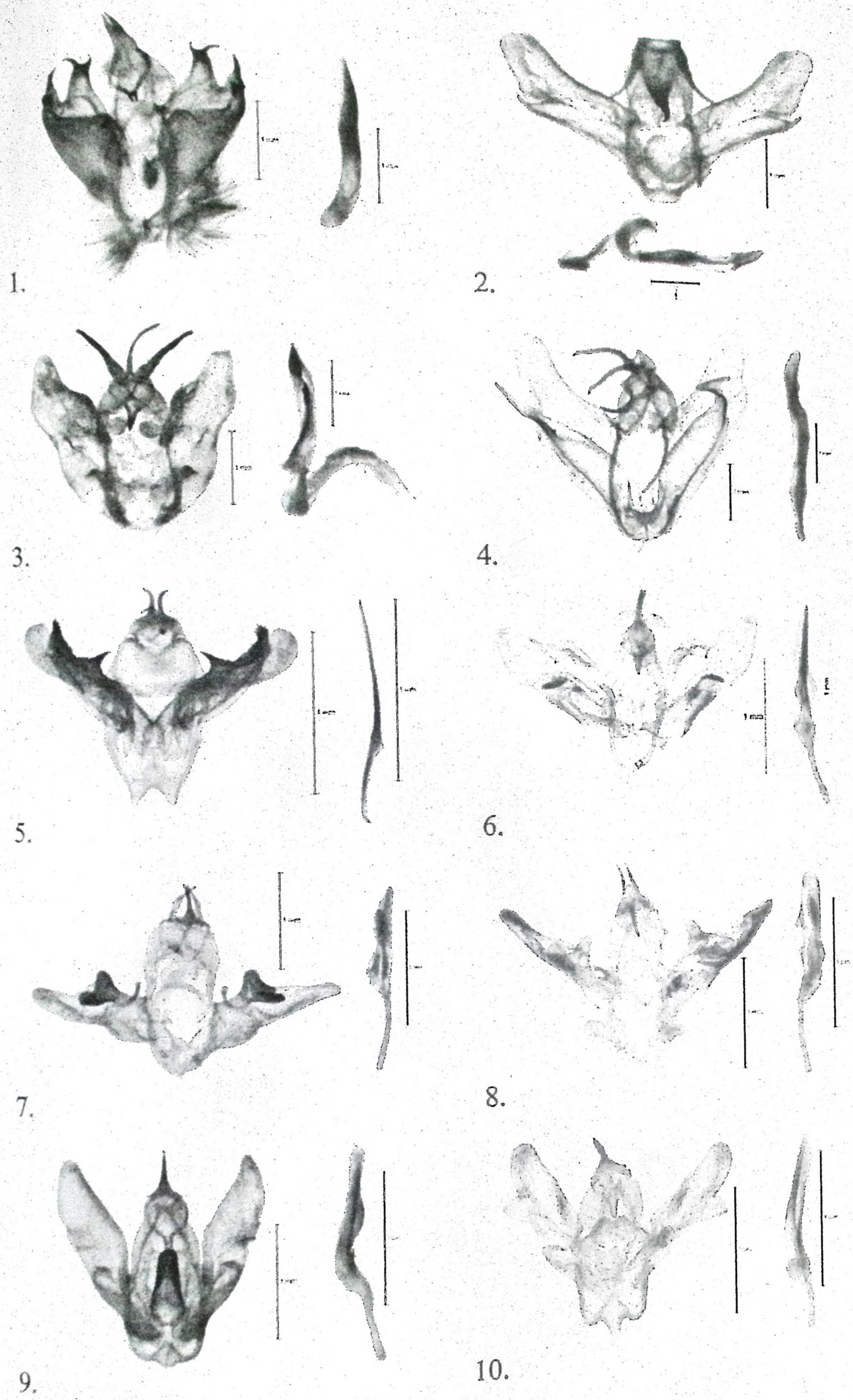
Genitalia Plate No.: 7

1. *Hydrelia bicolorata* 2. *H. sericea* 3. *Laciniodes plurilinearia* 4. *Venusia roseicosta* 5. *Perizoma albofasciata* 6. *P. antisticta* 7. *P. bicolor* 8. *P. fulvimacula* 9. *P. hockingii* 10. *P. peculiare*



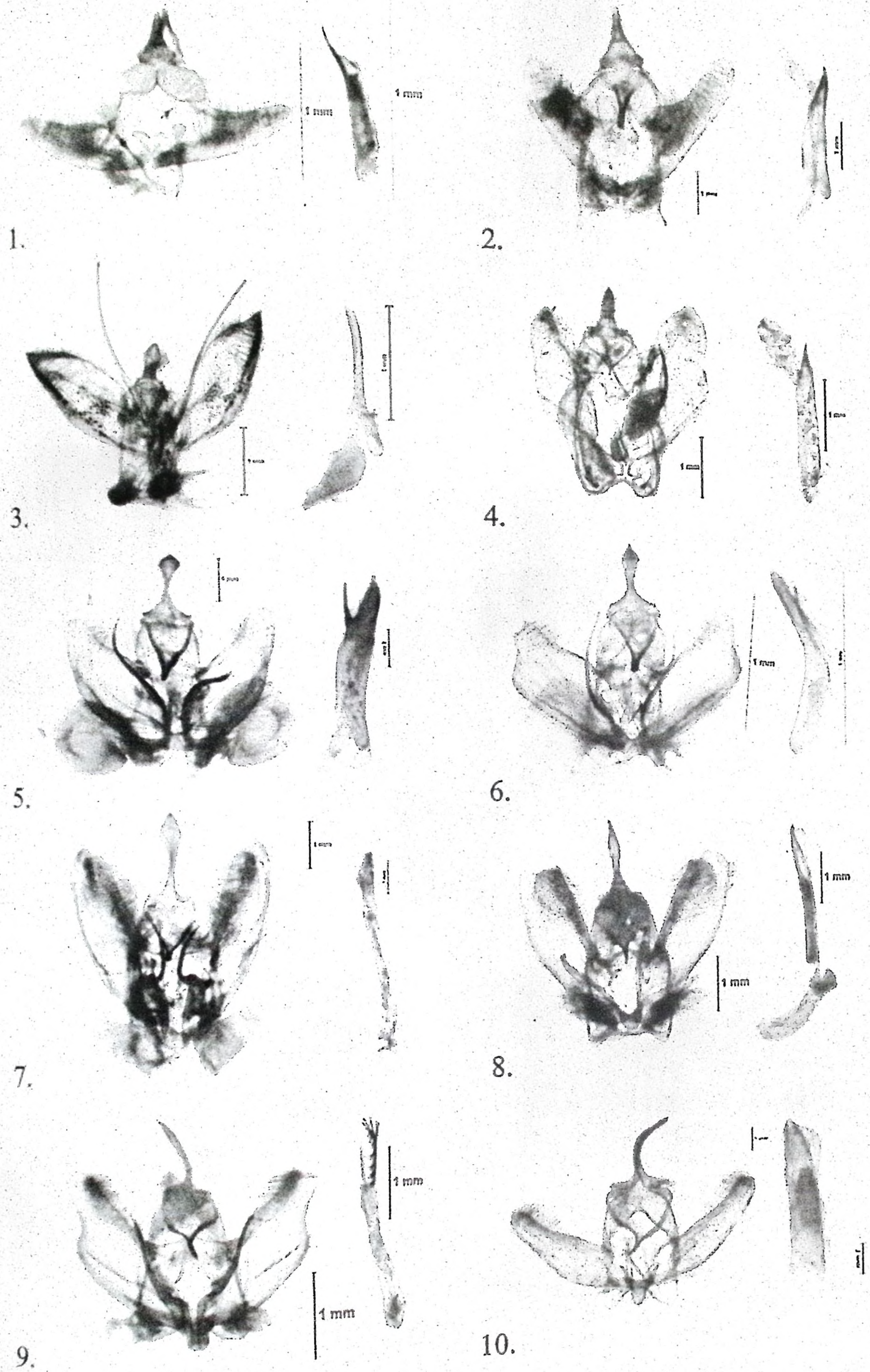
Genitalia Plate No.: 8

1. *Perizoma schistacea* 2. *P. seriata* 3. *Eupithecia albigutta*
4. *E. conjunctiva* 5. *E. rubridorsata* 6. *Pasiphila palpata*
7. *Trichopterigia decorata* 8. *T. macularia* 9. *Physetobasis dentifascia*
10. *Herochroma crassipunctata*



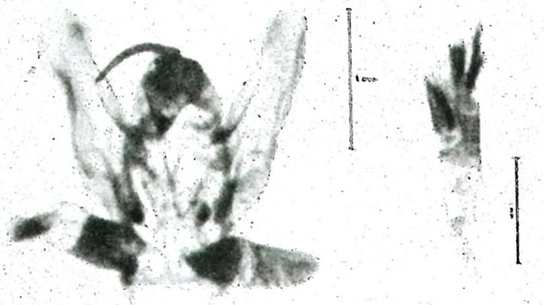
Genitalia Plate No.: 9

1. *Pingasa pseudoterpinaria* 2. *Geometra flavifrontaria* 3. *Iotaphora iridicolor* 4. *Tanaorhinus reciprocata* 5. *Comibaena pictipennis* 6. *Comostola subtiliaria* 7. *Chlorissa distinctaria* 8. *Chlorissa gelida* 9. *Maxates glaucaria* 10. *Maxates iridescens*



Genitalia Plate No.: 10

1. *Apoheterolocha patalata* 2. *A. quadraria* 3. *Corymica pryeri* 4. *Garaeus apicata* 5. *Heterolocha falconaria* 6. *H. phoenicotaeniata* 7. *Mimomiza cruentaria* 8. *M. leucogonia* 9. *Plagodis reticulata* 10. *Artemidora disistaria*



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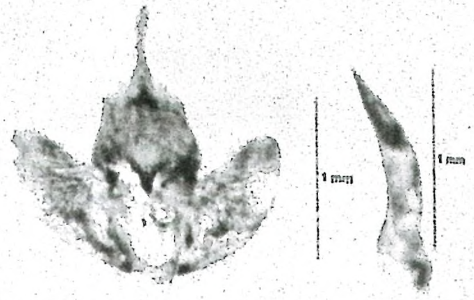

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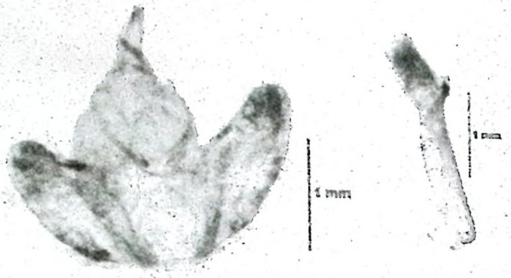

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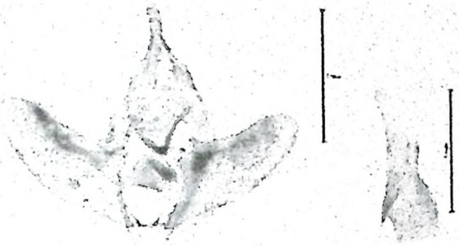

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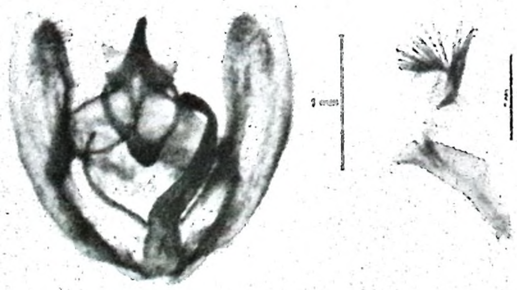

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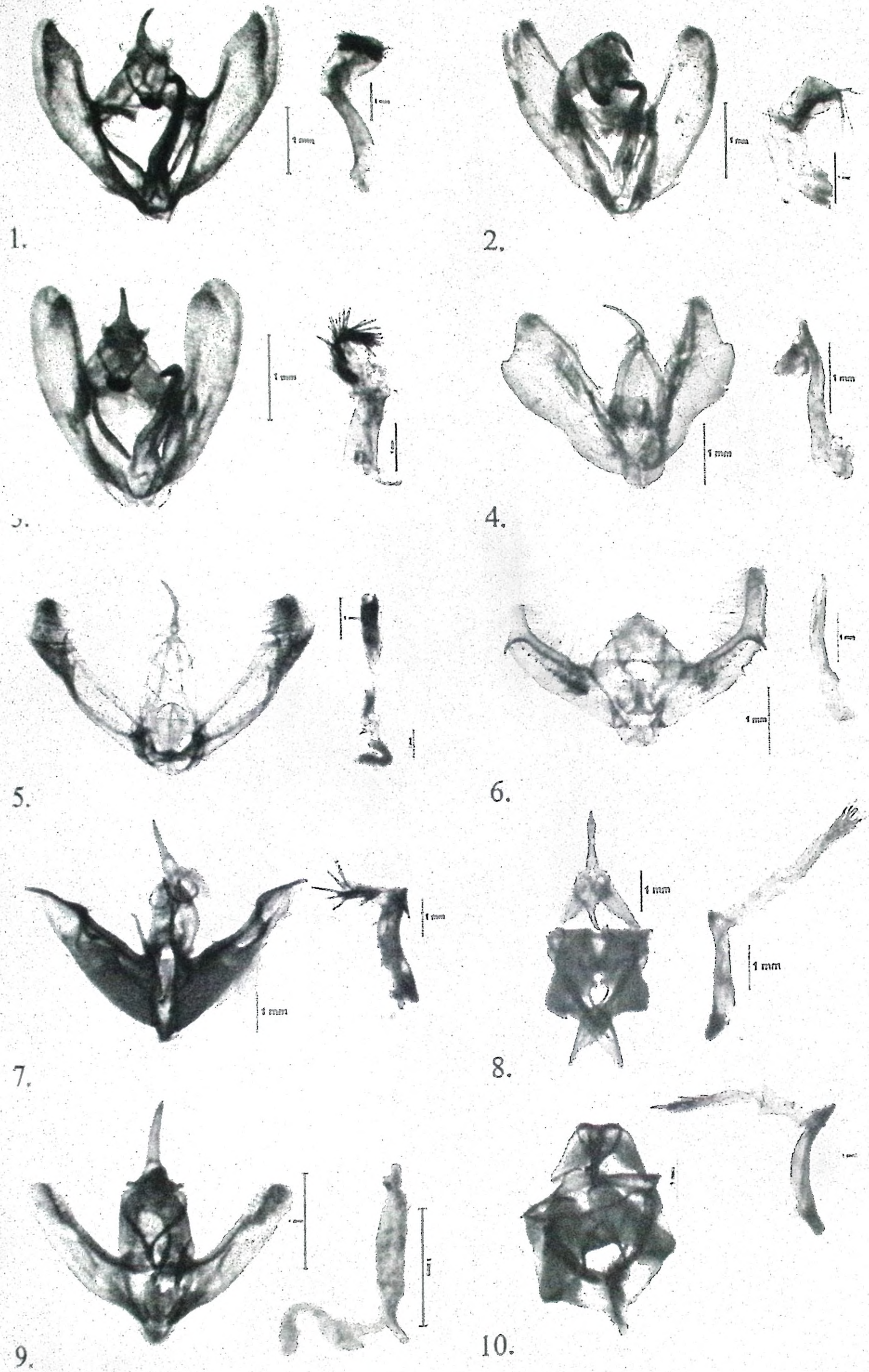
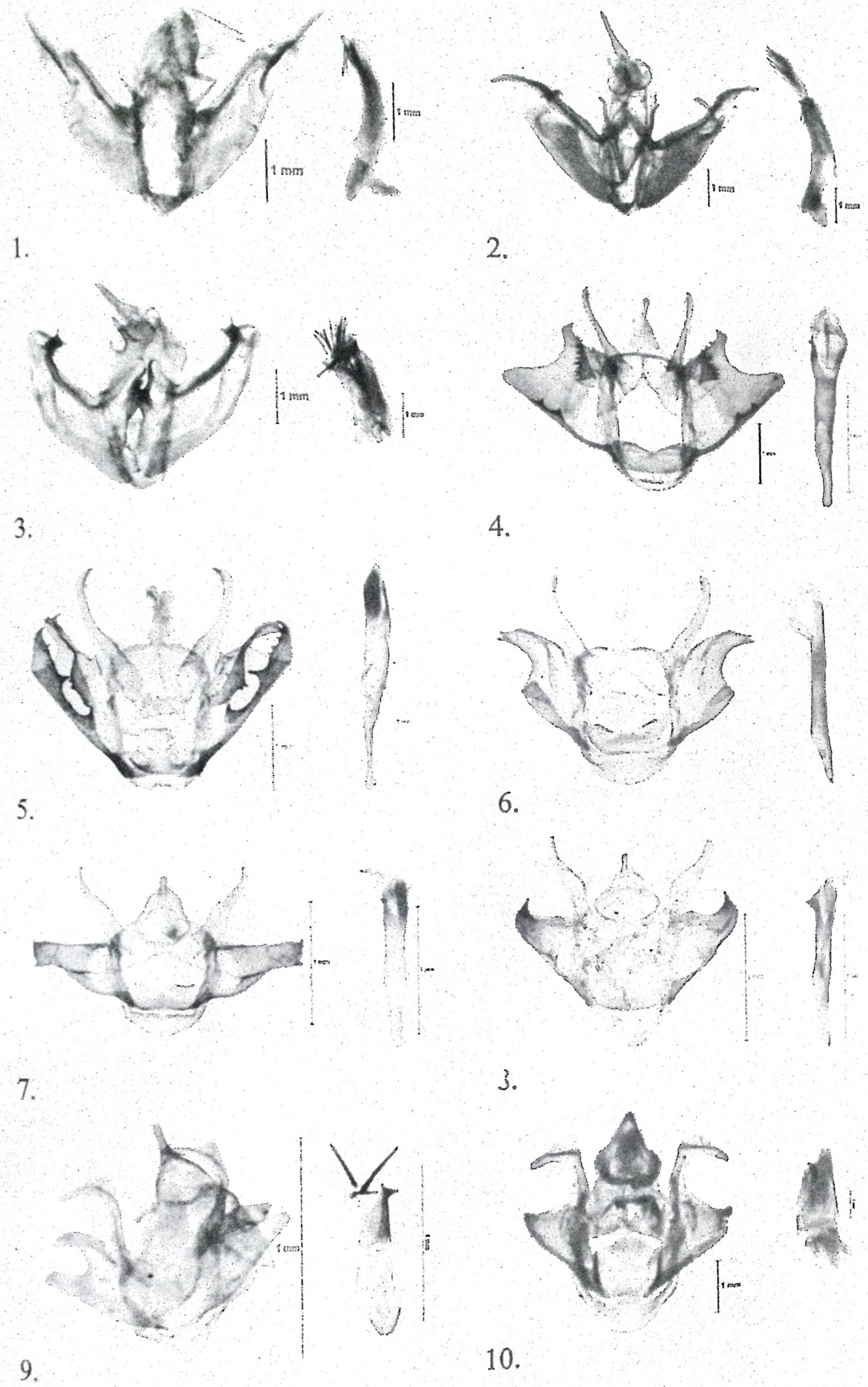
Genitalia Plate No.: 11

1. *Leptomiza calcearia* 2. *Opisthograptis luteolata* 3. *O. moelleri* 4. *O. tridentifera* 5. *Ourapteryx caschmirensis* 6. *O. chrisbahri* 7. *O. ebuleata ebuleata* 8. *O. kantalaria* 9. *O. leucopteron* 10. *O. multistrigaria*



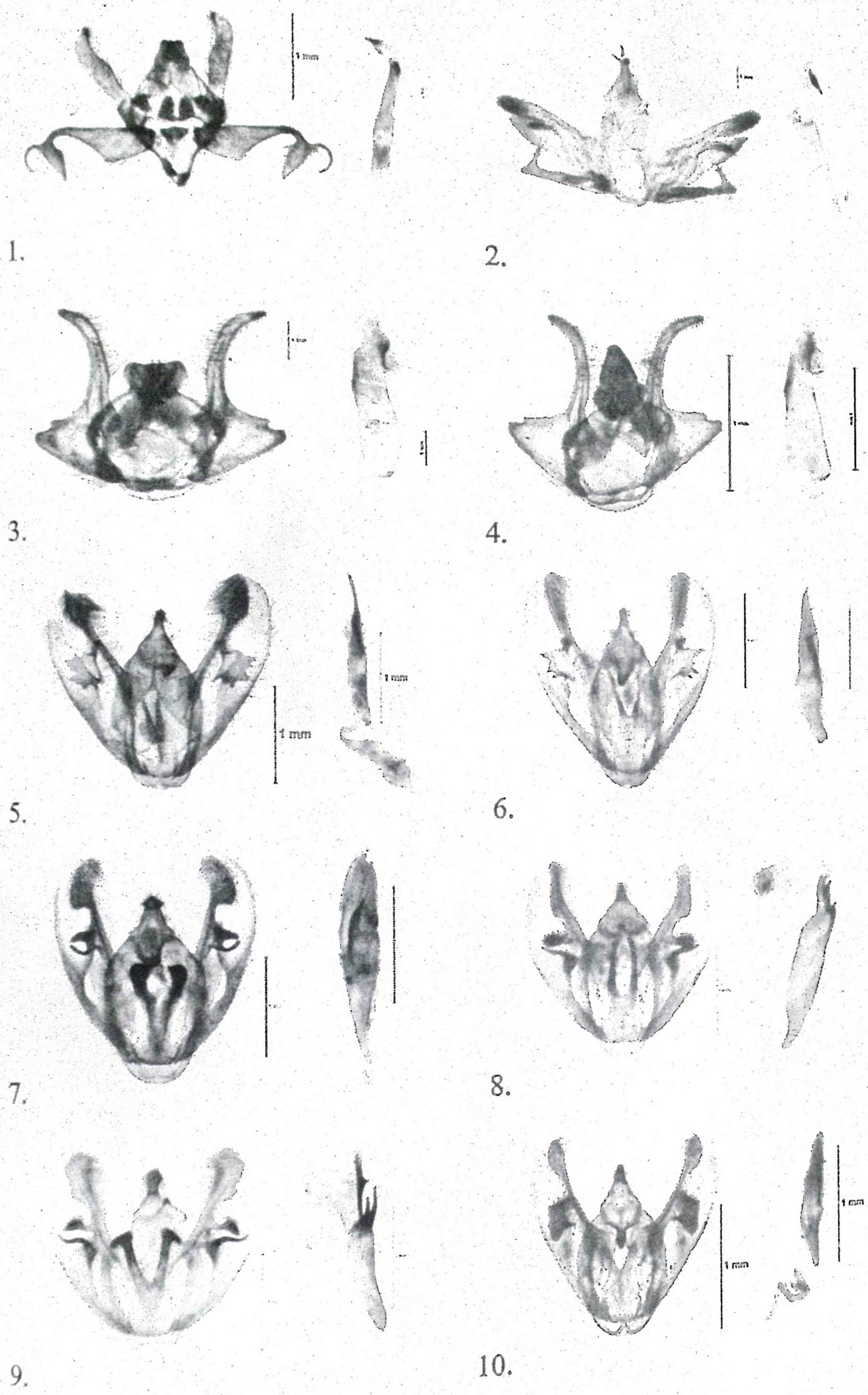
Genitalia Plate No.: 12

1. *Ourapteryx nepalensis* 2. *O. purissima* 3. *O. yerburii* 4. *Eilicrinia cordiaria signigera* 5. *Plutodes warreni* 6. *Thinopteryx crocoptera* 7. *Odontopera bilinearia* 8. *O. heydena* 9. *O. kametaria* 10. *O. kanchai*



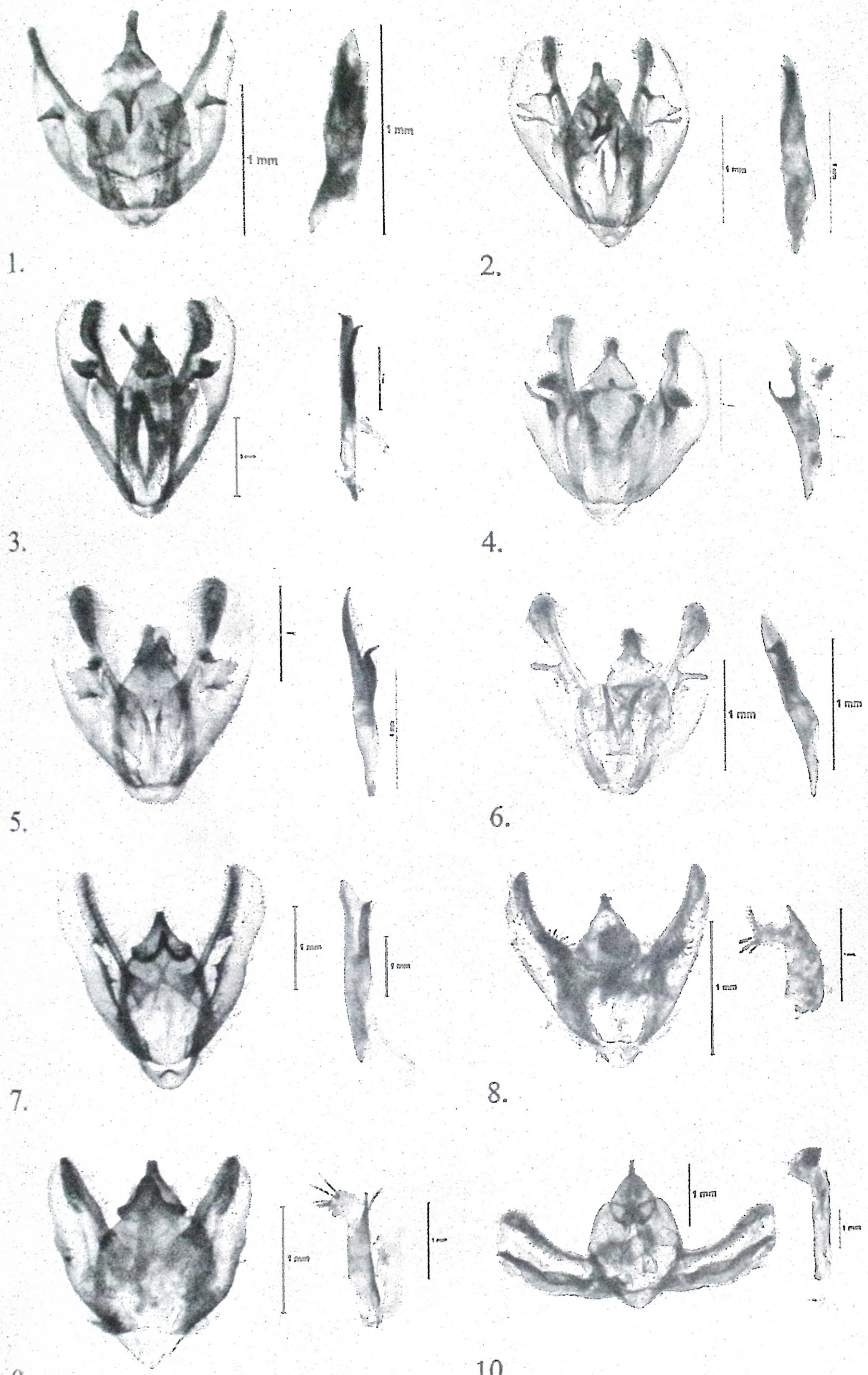
Genitalia Plate No.: 13

1. *Odontopera lentiginosaria* 2. *O. obliquaria* 3. *O. similaria* 4. *Abraxas leopardina* 5. *A. neomartaria* 6. *A. peregrina* 7. *A. picaria* 8. *A. superpicaria* 9. *Ligdia coctata* 10. *Peratophyga hyalinata*



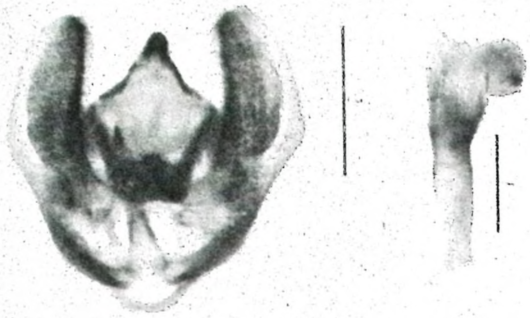
Genitalia Plate No.: 14

1. *Luxiaria amasa* 2. *Hypephyra terrosa* 3. *Oxymacaria brunneata* 4. *O. maculosata* 5. *Alcis admissaria* 6. *A. leucophaea* 7. *A. limbui* 8. *A. macroclarata* 9. *A. neoclarata* 10. *A. nigralbata*



Genitalia Plate No.: 15

1. *Alcis nigridorsaria* 2. *A. nudipennis* 3. *A. perspicuata* 4. *A. quadrifera* 5. *A. subnitida* 6. *A. variegata* 7. *Arichanna flavinigra* 8. *A. interplagata* 9. *A. tenebraria* 10. *Ascotis selenaria*



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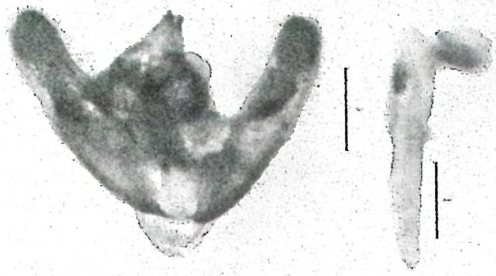

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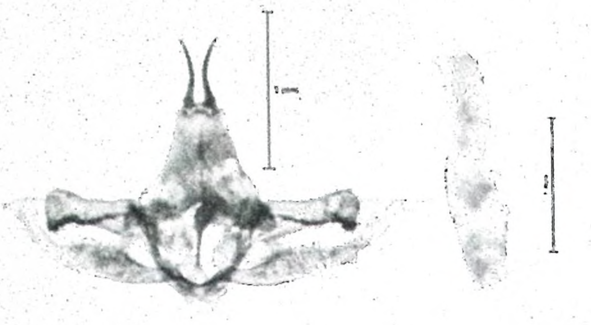

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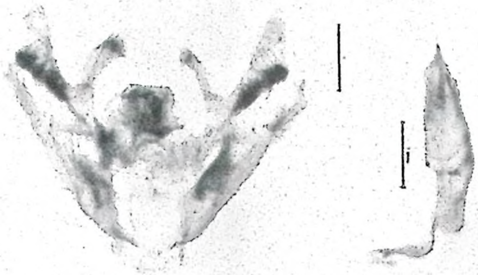

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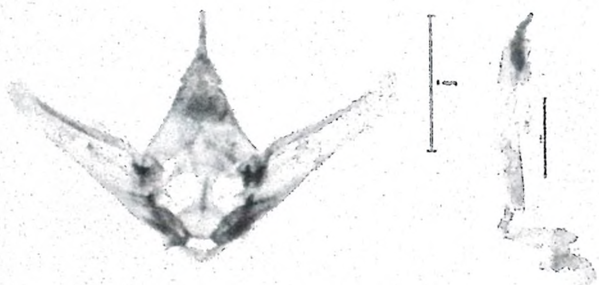

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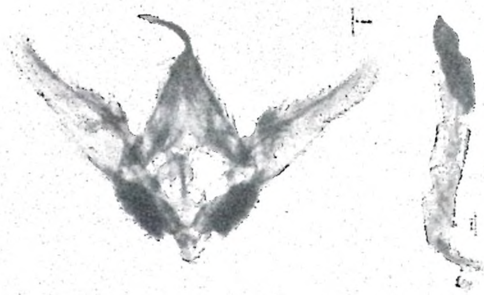

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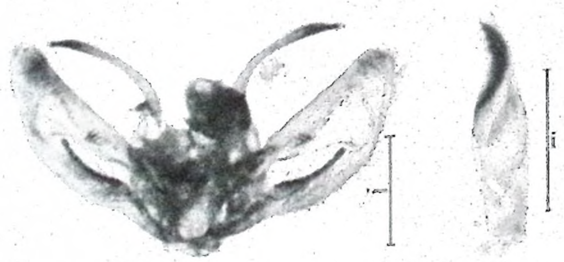

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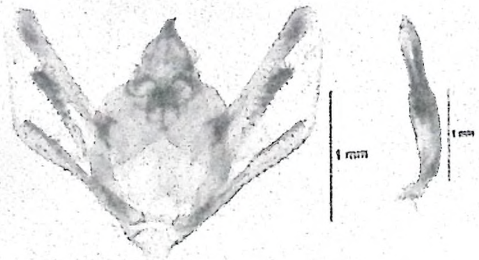

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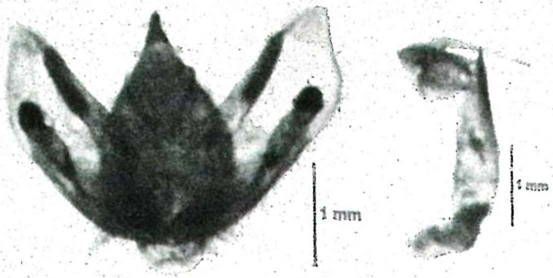
Genitalia Plate No.: 16

1. *Biston falcata* 2. *B. regalis* 3. *Calichodes ochrifasciata* 4. *Chorodna creataria* 5. *Ectropis bhurmitra* 6. *E. dentilineata* 7. *Gasterocome pannosaria* 8. *Harutalcis vialis* 9. *Hypomecis lioptilaria* 10. *H. ratotaria*



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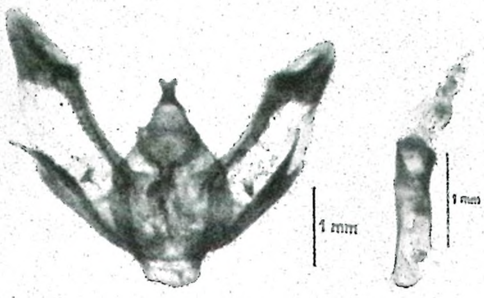

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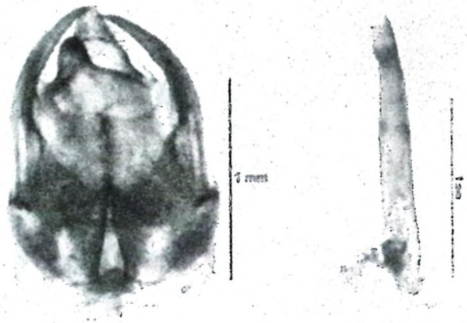

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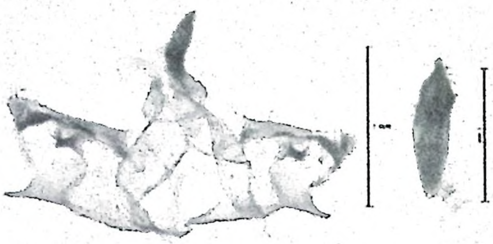

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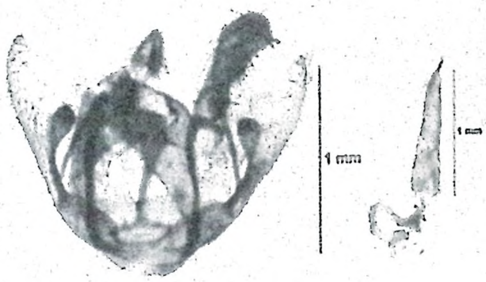

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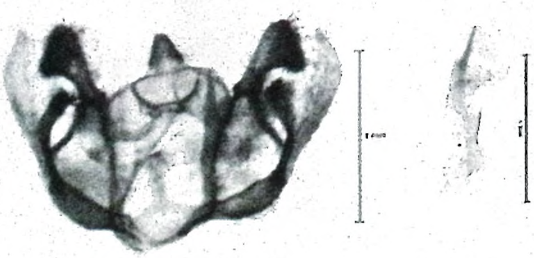

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Genitalia Plate No.: 17

1. *Lassaba albidaria* 2. *L. cervina* 3. *L. interruptaria* 4. *L. parvalbidaria nepalensis* 5. *Menophra subplagiata* 6. *Myrioblephara albibasis* 7. *M. duplexa* 8. *M. gandakiensis* 9. *M. harutai* 10. *M. idaeoides*

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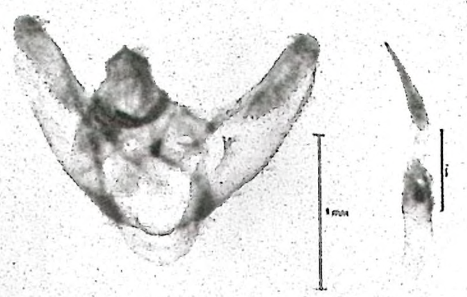

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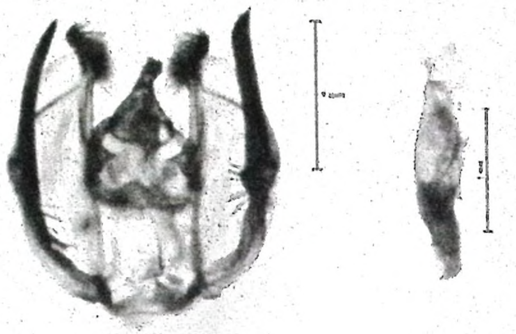

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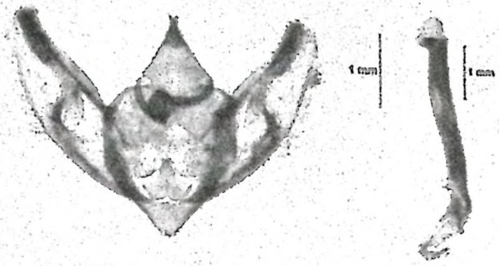

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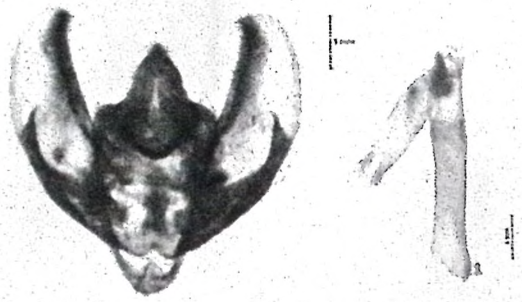

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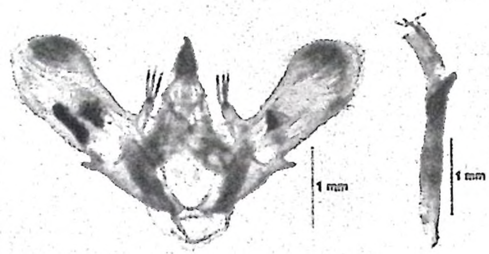

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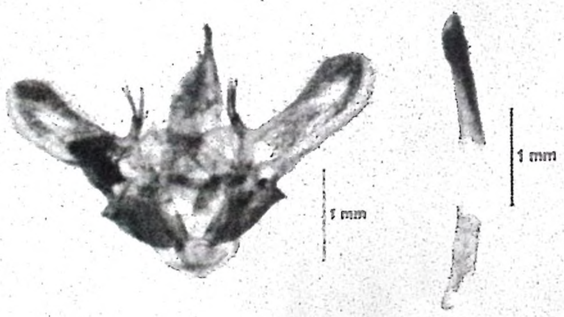

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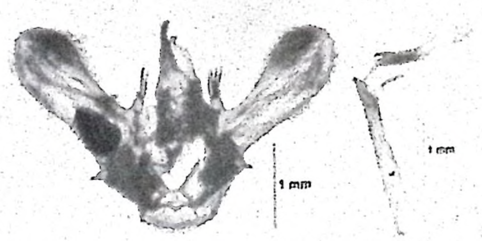

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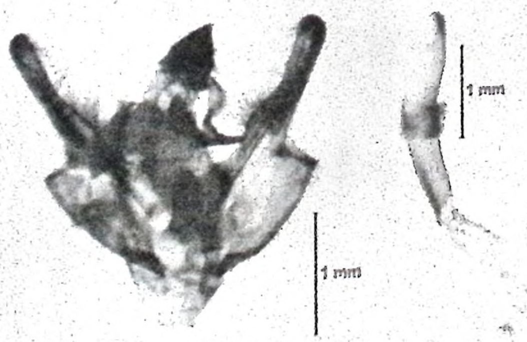

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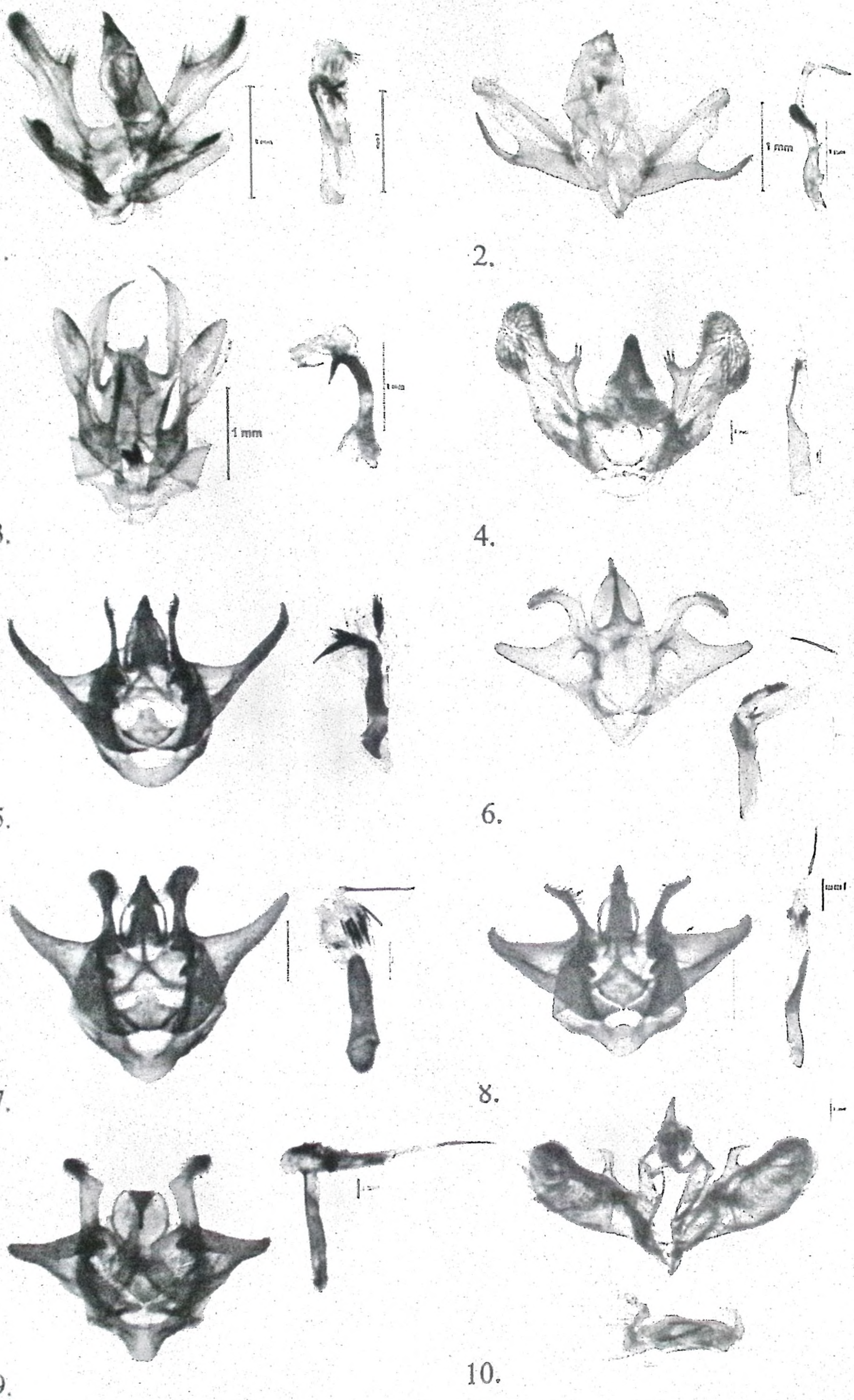
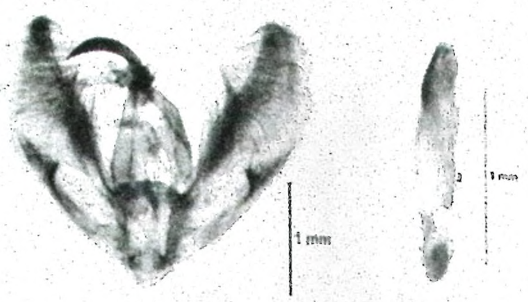
Genitalia Plate No.: 18

1. Myrioblephara xanthozonea 2. Parectropis conspurcata
3. Psilalcis breta 4. Xandrames albofasciata 5. X dholaria
6. Ctenognophos altissimus 7. C. eolaria 8. C. methoria
9. Gnophos accipitraria 10. G. albidior



Genitalia Plate No.: 19

1. *Hirasa muscosaria* 2. *Loxaspilates dispar* 3. *L. obliquaria* 4. *Phthonandria atrilineata* 5. *Psyra angulifera* 6. *P. crypta* 7. *P. debilis indica* 8. *P. similaria* 9. *P. spurcataria* 10. *Aplochlora dentisignata*



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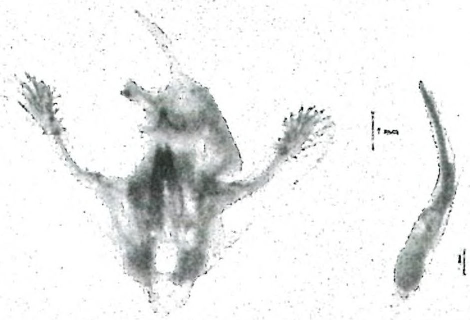

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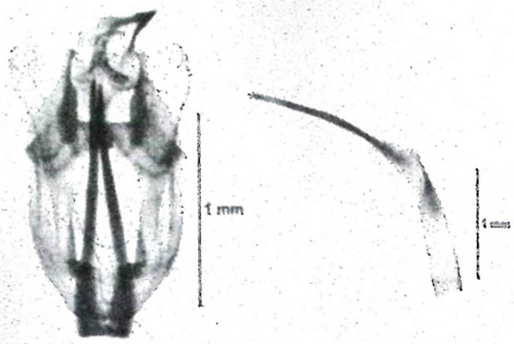

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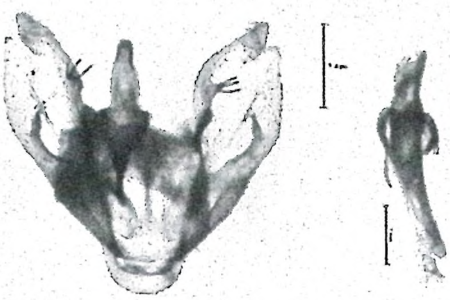

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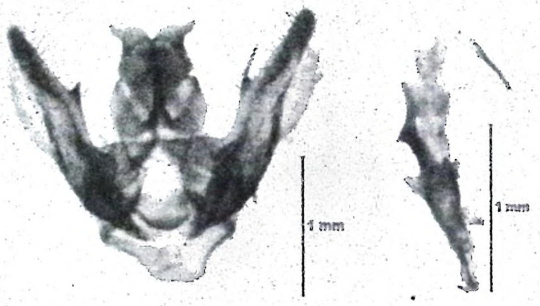

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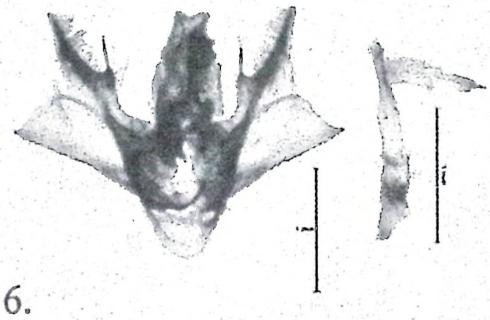

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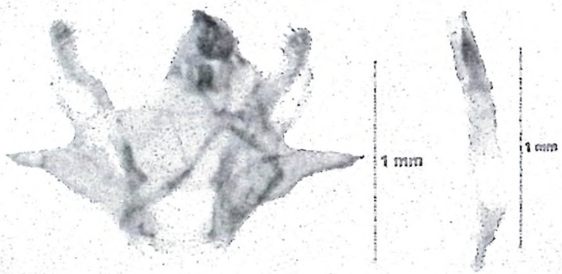

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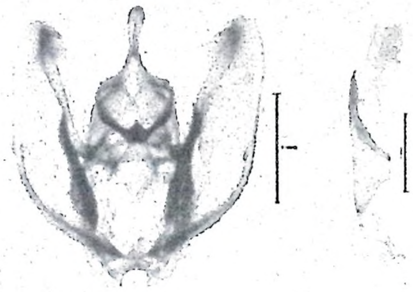

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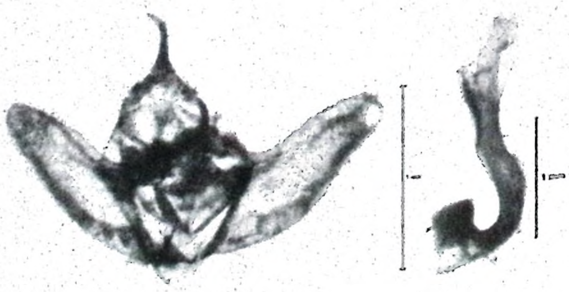
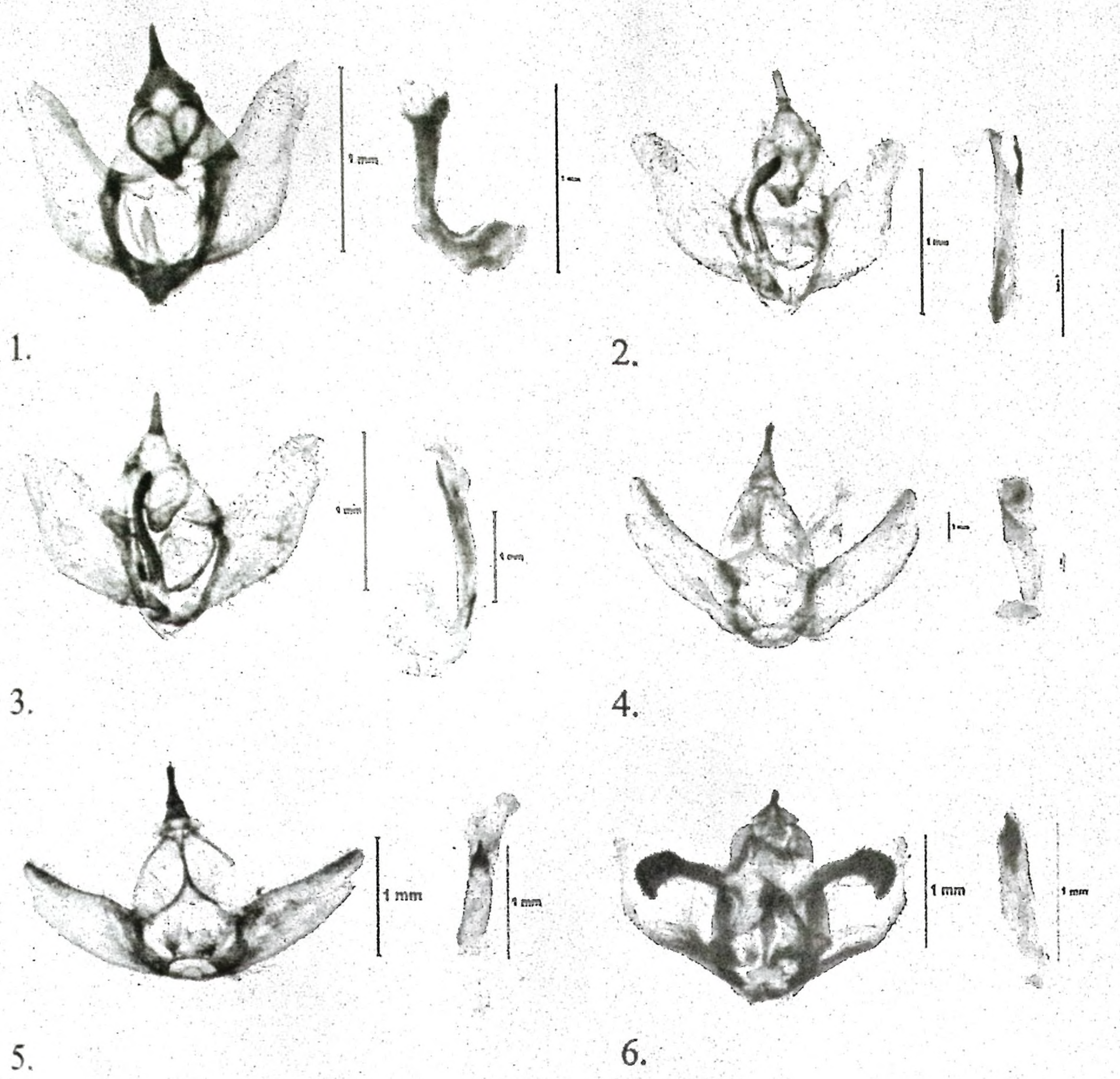


9.

10.

Genitalia Plate No.: 20

1. *Lomographa platyleucata* 2. *Anonychia grisea* 3. *A. lativitta* 4. *Antipercnia belluaria* 5. *Micrabraxas grandis* 6. *M. melanodonta* 7. *M. seriopuncta* 8. *Mimochroa gynopteridia* 9. *Sirinopteryx ablunata* 10. *S. duplicilinea*



Genitalia Plate No.: 21

1. Sirinopteryx harutai 2. S. quadripunctata 3. S. undulifera 4. Tanaoctenia dehaliaria 5. T. haliaria 6. Xenoplia maculata

Chapter 4: Diversity and distribution of Geometrid moths among different altitude zones in GHNP

4.1. Introduction:

Moths can be used as suitable model organism for the research in community and Landscape ecology, due to their large taxonomic diversity and huge abundance to produce robust sample size; they are taxonomically far better known globally than any other such large group of organism; though nocturnal, they can be sampled using a light trap to generate a large number of samples for the study of spatial and temporal patterns (Common, 1990; Scoble, 1992, Kitching *et al.*, 2000; Dale *et al.*, 2019). Moths are largely herbivorous in comparison to the other three mega- orders, viz., Coleoptera, Diptera and Hymenoptera, which associate them with the immediate vegetation diversity and habitat type (Common, 1990; Kitching *et al.*, 2000; Dale *et al.*, 2019).

Mountains offer distinctive microhabitats to study the effect of the environment on the spatial variation in the taxonomic structure of insect species assemblages. Major elevational and climatic tendencies are generally related to other factors at local geographical scale, such as differences in regional environmental trends, soil features, vegetation type (Sanyal, 2015; Korner, 2007).

Geometrid moths, having caterpillars mainly known as loopers or inchworms, are hyperdiverse taxa with about 23,000 described and above 40,000 expected species (Miller *et al.*, 2016; Beck *et al.*, 2016). They are the most abundant lepidopteran family and are mostly nocturnal, with considerably short generation time. Their caterpillars are mainly host-plant specific, feed on a particular host-plant family or genus of shrubs or trees, which directly connects them with the immediate vegetation type or forest communities of plants, which changes with local environmental conditions such as temperature seasonality, yearly rainfall distribution, soil type etc. as elevation changes (Ward & Spalding, 1993; Novotny *et al.*, 2006; Bodner *et al.*, 2012).

Studies across the globe have suggested that among subfamilies of Geometridae, species richness of Larentiinae peaks in highest altitude while in other subfamilies, species richness peaks at the mid-elevation, but patterns are more or less similar to those in Geometridae as a whole, as observed in Northern Borneo, Malaysia (Beck *et al.,* 2008). In south-western slopes of Mt. Kilimanjaro, Tanzania, subfamily Sterrhinae and Ennominae had high proportions of species richness only at the lowest elevations which strongly decreased with increasing elevation, while on the opposite, diversity of Larentiinae moth, , increased with increasing elevation, with species of this subfamily becoming dominant at all sites above 2000 m (50%) (Axmacher *et al.*, 2004). In South America, species of the subfamily Ennominae were found in highest richness at lower elevational levels. While species richness of Ennominae, Geometrinae and Sterrhinae steadily decreases, the proportion of Larentiinae species richness increases towards high altitudes (Brehm *et al.*, 2003). In similar studies conducted in Western Himalaya, species richness of Larentiinae was found highest in the highest altitude zone (2900m-3400m) and Ennominae species diversity was found highest in the lower altitude region (1400 m-1900 m) and reported lowest in the highest altitude zone (2900 m-3400 m) (Sanyal, 2015).

Diversity measurements for the tropical insect communities are each time a huge methodical challenge, a number of the sample may often vary significantly between different sites (Schulze & Fiedler, 2002). Furthermore, tropical insect communities are characterized by a high percentage of rare species that can't be excluded in the time of analysis. Statistical analyses were done at the different zones of altitude as well as at the zones of different habitats found all through the gradients.

The goal of the experiment was to generate the Geometridae species composition in different altitudinal zones and habitat types within a Himalayan ecosystem and to compare sites in terms of their species composition. The objective was to define the diversity and features of species assemblages found in six altitudinal zones (Table 4.1). This information was used to compare the Geometrid moth assemblages in different vegetation types found in different altitudinal zones.

4.2. Methodology:

4.2.1. Sampling design:

Along the altitude gradient, random sites were selected at every 300 m vertical distance according to vegetation type. Per altitudinal site, 2-3 sampling plots were established for Light trapping until at least 70% of all species had been assembled and were pooled for analysis. Random stratified sampling was done along with transects ranging from 1500m to 4000m for the entire study area. Specimens were collected from different habitats installing light traps running for 4 hours, in two sessions at a particular site for two consecutive nights, e.g. first night from 8 pm to 12'O clock midnight and second night from 12'o clock midnight to 4 am. This was to ensure recording all the moths flying in a particular site or habitat in different hours of night.

Table 4.1: Different altitudinal sites and Habitat types sampled in GHNP.

Site	Altitude	Altitudinal Zone	Habitat type
Ropa FRH	1515	**Zone 1**	Himalayan Chir Pine Forest (9/C1b)
Jungla	1751	**Zone 1**	
Kathyaugi	1812	**Zone 1**	
Denga Pool	1970	**Zone 2**	Moist Temperate Deciduous Forest (12/C1e)
Khain	2072	**Zone 2**	
Kleuen	2109	**Zone 2**	Moist Deodar Forest (12/C1c)
Raghdhini	2112	**Zone 2**	Alder Forest (Riverine) (12/1S1)
Shakti	2137	**Zone 2**	Moist Temperate Deciduous Forest (12/C1e)
Shakti Water Fall	2200	**Zone 3**	
Lapah	2247	**Zone 3**	Moist Deodar Forest (12/C1c)
Shakti-II	2288	**Zone 3**	Moist Temperate Deciduous Forest (12/C1e)
Riush Thatch	2425	**Zone 3**	Western Mixed Coniferous Forest (12/C1d)
Bhagisaree	2432	**Zone 3**	
Padhar	2437	**Zone 3**	Low Level Blue Pine Forest (12/2S1)
Marrorh	2480	**Zone 4**	
Sudra budra	2577	**Zone 4**	
Gajnao	2618	**Zone 4**	West Himalayan Upper Oak-Fir Forest (12/C2b)
Baghi Thatch	2663	**Zone 4**	
Kherchar	2742	**Zone 4**	Low Level Blue Pine Forest (12/2S1)
Vred Nala	2800	**Zone 5**	West Himalayan Upper Oak-Fir Forest (12/C2b)
Thati	2917	**Zone 5**	

Parkachi	3033	**Zone 5**	West Himalayan Sub-Alpine High-level Fir forest (14/C1a)
Dawada	3049	**Zone 5**	Sub-Alpine Pastures (14/DS1)
Majan Golu	3166	**Zone 6**	West Himalayan Sub-Alpine High-level Fir forest (14/C1a)
Thihnhi	3226	**Zone 6**	Dwarf Rhododendron Scrub (15/C2/E1)
Dhung	3324	**Zone 6**	West Himalayan Sub-Alpine High-level Fir forest (14/C1a)
Dhel Hut	3567	**Zone 6**	Birch Rhododendron Scrub Forest (15/C1)

4.2.2. Statistical Analysis:

Fisher's alpha of the log series distribution was used as a measure of alpha diversity (Brehm *et al.*, 2003b; Schulze & Fiedler, 2003; Axmacher *et al.*, 2004). Estimated species richness was used to measure inventory completeness of moth assemblages at both local and regional levels. Non-parametric species richness estimator Chao 1, as well as individual Rarefaction methods were used to get an idea about the species richness and sampling success. These two diversity indices were selected as they have proved to be widely independent of the sample size, and a comparison of the results by the three mathematically completely different approaches will allow conclusions about the robustness of the expected results. Dominance D, Simpson_1-D, Shannon H, Evenness e^H/S were also calculated to compare between sites or zonal diversity. All the diversity indices for the Geometridae family as a whole and of different subfamilies werewere measured site-wise which were grouped into different Altitudinal Zones as well as Habitat types according to respective altitude. Diversity indices were calculated using program PAST version 2.17c (Hammer *et al.*, 2007).

Hierarchical Cluster Analysis was used to measure the dissimilarities or distances based on species composition between each altitudinal zone.

NMDS with Bray-Curtis similarity index was used to see how different the Geometrid moth assemblages are in different altitudinal and habitat zone. The analysis and the 2D plot were generated in PAST 2.17c.

The dissimilarity of moth communities within and between different altitudinal and habitat zone was investigated by an analysis of similarities (ANOSIM). The Global R-value generated from ANOSIM is a measure of the distance between a pair of a group. R-value nearly close to zero indicates assemblage hardly separable, whereas R-value approaching one indicates strongly distinct assemblages (Clarke, 1993). Particular species contributing to the dissimilarity were revealed by SIMPER in PAST 2.17c.

In this coming section, different diversity indices and measures, species richness and abundance of family Geometridae and ofsubfamilies Ennominae and Larentiinae is discussed and compared between six different elevational zones found in GHNP. Subfamily Sterrhinae and Geometrinae was omitted due to their low species richness and abundance and was considered only while calculating overall Geometridae data. Result is divided into three sub-sections: a) Altitudinal zone wise diversity of Geometridae. b) Altitudinal zone wise diversity of subfamily Ennominae. c) Altitudinal zone wise diversity of subfamily Larentiinae.

4.3. Results and Discussion:

Altogether 55 trapping nights were performed to record 267 morpho-species of Geometridae and 3,069 individuals representing 4 subfamilies. The number of moth species and the number of individuals trapped varied considerably between the altitude classes and different vegetation zones. The wide altitudinal range (1500-3600 m) was divided into 6 zones (Table 4.1).

4.3.1. Diversity in different elevation zones in GHNP:

a) Altitudinal zone wise diversity of family Geometridae:

Geometridae moth diversity was highest in the lowest altitudinal zone and gradually decreased with the increasing altitude. Fisher's alpha was very high in Zone 1 (1500-1800 m) and Zone 2 (1800- 2100 m) i.e., 61.38 and 48.79 respectively; lowest in Zone 6 (above 3000m) i.e., 23.63. Shannon's Index showed a similar trend as Fisher's alpha i.e., lowest in the higher altitude zones, as gradually decreasing with increasing altitude.

Table 4.2: Alpha diversity indices, Chao-1, dominance and evenness of Geometridae moths in six different altitudinal zones at GHNPCA, HP.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Species richness	157	127	108	79	62	74
Abundance	731	610	524	417	261	518
Dominance D	0.018	0.018	0.027	0.029	0.040	0.033
Simpson_1-D	0.983	0.982	0.974	0.970	0.960	0.967
Shannon H	4.54	4.384	4.081	3.882	3.635	3.738
Evenness e^H/S	0.597	0.631	0.548	0.614	0.611	0.568
Fisher's alpha	61.38	48.79	41.26	28.86	25.71	23.63
Percentage of completeness	84.545	86.512	79.237	84.546	70.720	77.829
Chao-1	185.7	146.8	136.3	93.44	87.67	95.08

Species richness also followed the same trend as Fisher's alpha and showed the highest richness at the lowest altitude i.e., Zone 1 and gradually decreasing with increasing altitude but showed the lowest richness value in Zone 5 (2700- 3000 m) and Zone 4 (2400- 2700 m) (Table 4.2).

Estimated species richness measured by Chao-1 did not vary too much with the observed species richness. It showed 70% sampling completeness viz., in all the zones along the gradient.

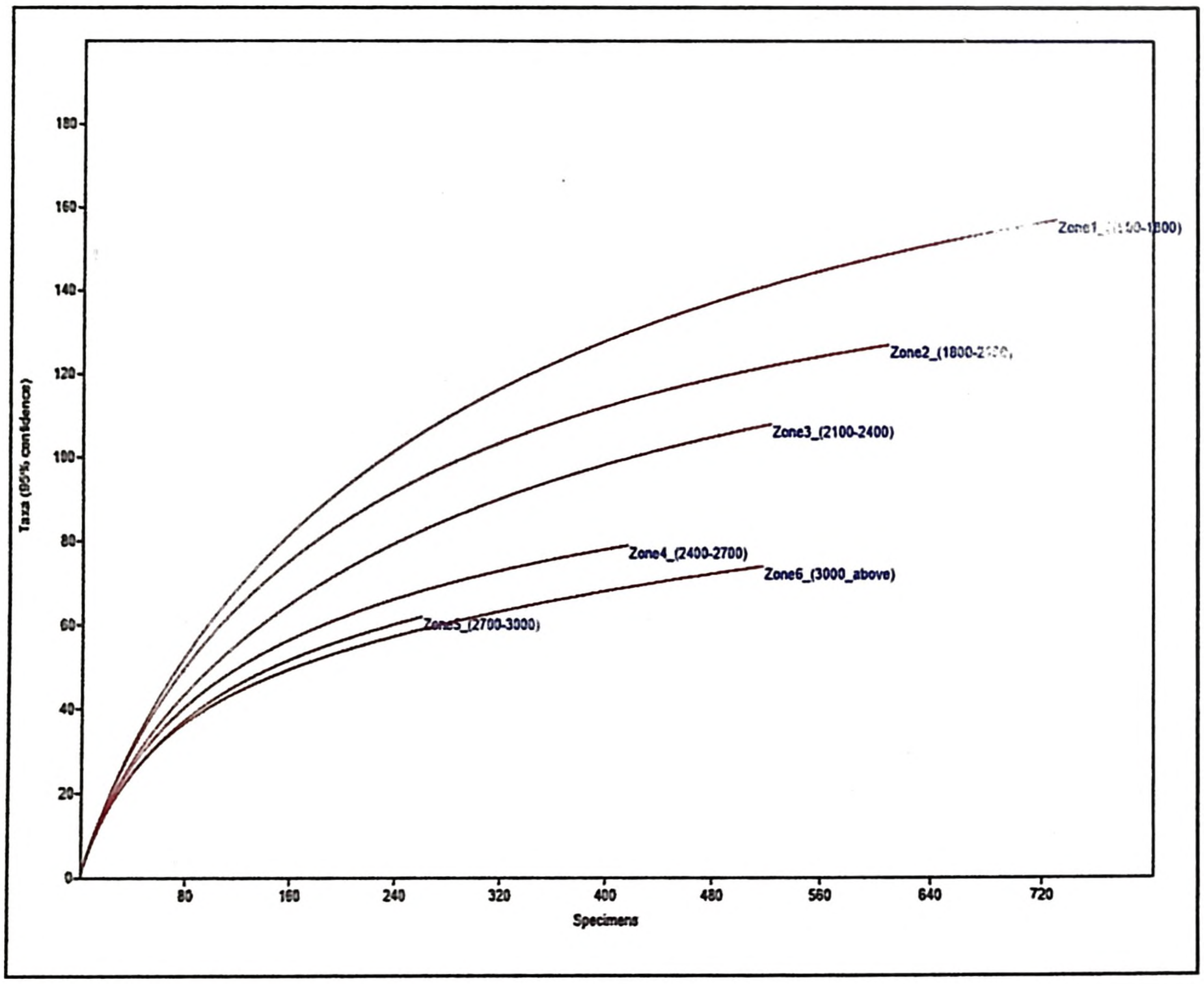


Fig. 4.1: Individual-based rarefaction curve of Geometridae assemblages in six altitudinal zones at GHNP

The abundance of Geometrid moths showed a unique trend along the altitudinal gradient i.e., higher abundance in both lowest and highest altitude zones but abundance was recorded as comparatively low in mid elevational zones i.e., Zone 4 (2400- 2700 m) and Zone 5 (2700- 3000 m).

Individual-based rarefaction curve showed that maximum specimens were accumulated in Zone 1, whereas, lowest in Zone 5. A more or less comparable number of specimens (300 to 400) were accumulated in all the other zones, thus gaining near asymptote. (Fig. 4.1).

b) Altitudinal zone wise diversity of subfamily Ennominae:

A total of 140 morpho-species of Ennominae with 1,202 individuals representing 13 tribes were recorded from GHNP during this present study.

Fisher's alpha was highest in Zone 1 (1500-1800 m) i.e., 42.52 gradually becoming lower in intermediate zones and reaching lowest values in Zone 6 (above 3000m) i.e., 10.17. Shannon's Index showed a similar trend to Fisher's alpha with lowest value in Zone 4.

Table 4.3: Alpha diversity indices, Chao-1, dominance and evenness of Ennominae moths in six different altitudinal zones at GHNPCA, HP.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Species richness	96	55	48	29	33	30
Abundance	364	213	212	130	99	184
Dominance D	0.02319	0.04084	0.07169	0.1137	0.0852	0.0794
Simpson_1-D	0.9768	0.9592	0.9283	0.8863	0.9148	0.9206
Shannon H	4.122	3.575	3.147	2.637	2.944	2.832
Evenness e^H/S	0.6428	0.6487	0.4849	0.4815	0.5754	0.5662
Fisher's alpha	42.52	24.03	19.34	11.59	17.33	10.17
Percentage of completeness	81.356	72.264	57.048	62.366	60.153	81.345
Chao-1	118	76.11	84.14	46.5	54.86	36.88

Species richness also followed the same trend as Shannon's Index and showed the highest richness at the lowest altitude i.e., Zone 1 and gradually decreasing with increasing altitude. In this case also, lowest richness value was obtained in Zone 4 (2400- 2700 m) and Zone 6 (above 3000 m) (Table 4.3).

Estimated species richness measured by Chao-1 did not vary too much with the observed species richness in the lower altitudinal areas like Zone 1 and Zone 2 as well as in the highest altitudinal area i.e., Zone 6. It showed varying trend in the mid-altitudinal areas. Zone 4, 5 and Zone 6 showed sampling incompleteness represented in the table as a percentage of completeness.

The abundance of Ennominae moths showed a unique trend along the altitudinal gradient i.e., higher abundance in both lowest and highest altitude but abundance was comparatively low in mid elevational zones i.e., Zone 4 (2400- 2700 m) and Zone 5 (2700- 3000 m). The trend recorded for this subfamily is almost similar with the trend of Family Geometridae.

c) Altitudinal zone wise diversity of subfamily Larentiinae:

A total of 98 morpho-species of Larentiinae with 1,547 individuals representing 11 tribes were recorded from GHNP during this present study.

Fisher's alpha was highest in Zone 2 (1800-2100 m) i.e., 21.39, gradually becoming lower in intermediate zones and reaching lowest value in Zone 5 i.e., 10.52. Shannon's Index and Species richness showed an exactly similar trend to Fisher's alpha.

Estimated species richness, Chao-1 was very similar to the observed species richness in all the zones except zone 6, where the sampling completeness is not reached like other areas as the percentage of completeness showed the lowest value i.e. 76%, whereas in other zones the value reached close to 90%.

Table 4.4: Alpha diversity indices, Chao-1, dominance and evenness of Larentiinae moths in six different altitudinal zones at GHNPCA, HP.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Species richness	41	59	52	43	28	42
Abundance	237	316	268	261	140	325
Dominance D	0.08052	0.03988	0.04631	0.04543	0.07286	0.0589
Simpson_1-D	0.9195	0.9601	0.9537	0.9546	0.9271	0.9411
Shannon H	3.114	3.603	3.462	3.383	2.997	3.172
Evenness e^H/S	0.5491	0.6221	0.613	0.685	0.7152	0.5681
Fisher's alpha	14.31	21.39	19.23	14.65	10.52	12.85
Percentage of completeness	87.234	93.755	91.905	94.236	93.333	76.087
Chao-1	47	62.93	56.58	45.63	30	55.2

The abundance of Larentiinae moths showed a unique trend along the altitudinal gradient i.e., highest abundance in highest altitude Zone 6, but abundance was comparatively low in mid and low elevational zones i.e., Zone 5 (2700- 2400 m) and Zone 1 (1500- 1800 m).

4.3.2. Comparison of distribution pattern along the altitudinal gradient between the subfamilies:

The box plot representing altitudinal distribution of different subfamilies showed that members of of Geometrinae are mostly distributed in lower altitudinal areas ranging from 1500- 2200 m. Subfamily Sterrhinae showed a distribution range from 1500- 2400 m, with a mean at 2100 m. The distribution of Ennominae ranged from 1750- 2600 m, with a mean at 2200 m (Fig. 4.2). Larentiinae showed a distribution range from 2000- 2800 m, with a mean at 2500 m.

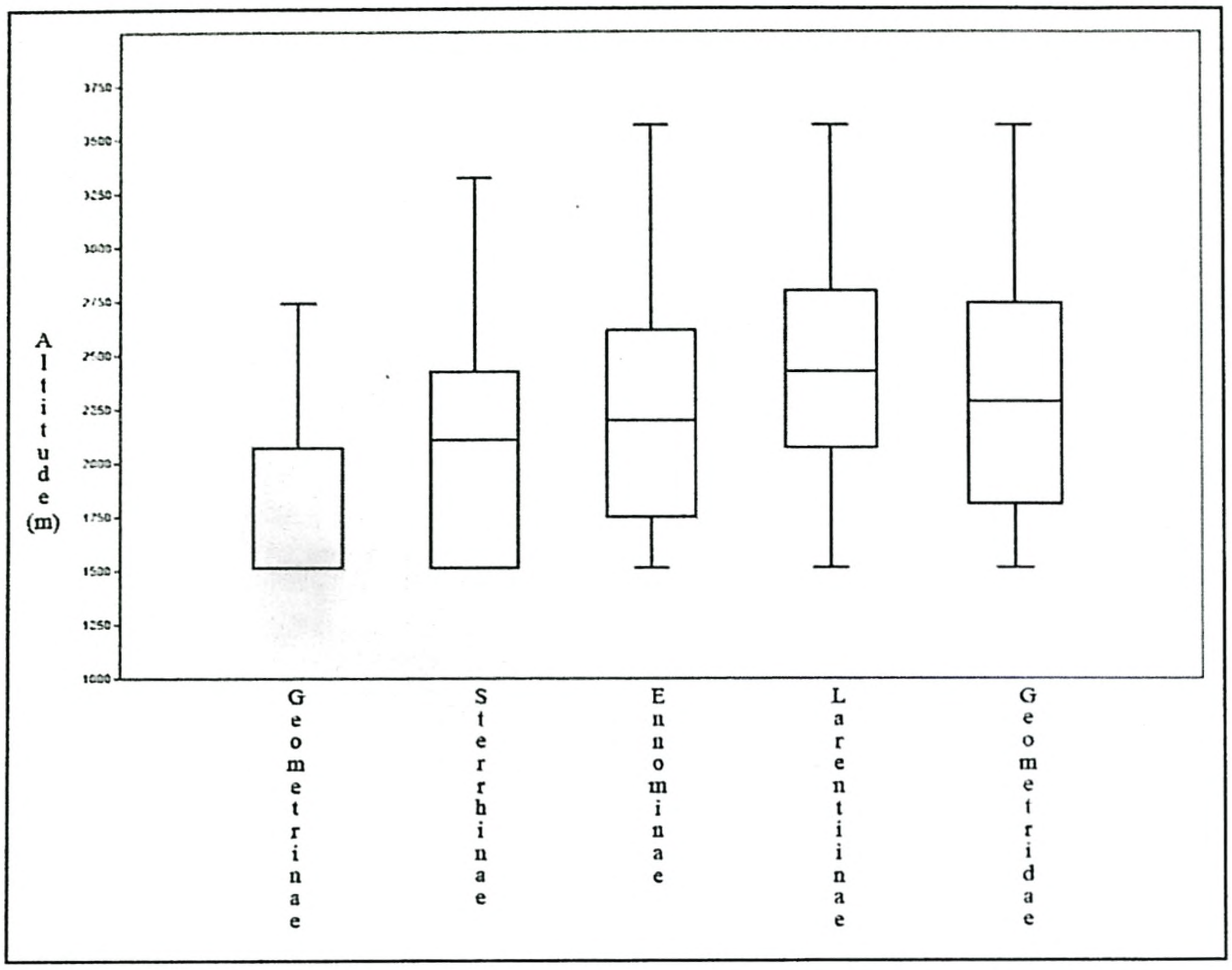


Fig. 4.2: Altitudinal distribution of Geometridae along with its major subfamilies.

Overall, Geometridae showed a similar pattern with Ennominae, as it influences the distribution pattern of the overall family with its large species numbers and abundance. From the result of altitudinal distribution data, it can be concluded that the overall pattern of Geometridae, as well as Ennominae indicates the mid-altitude preference. Larentiinae showed preference towards higher altitude, as their abundance increases with altitude.

4.3.3. Comparison of Species assemblages among altitudinal zones:

Hierarchical Cluster Analysis showed that Zone 1 (Lowest Zone) had a very unique species assemblage with 85% dissimilarity to all the other zones sampled. Zone 4 and 3 were most similar in terms of species assemblages with 45% species similarity, both of them clustered with Zone 2 with 65% dissimilarity. Zone 5 and 6 clustered together with 45 % similarity between themselves (Fig. 4.3).

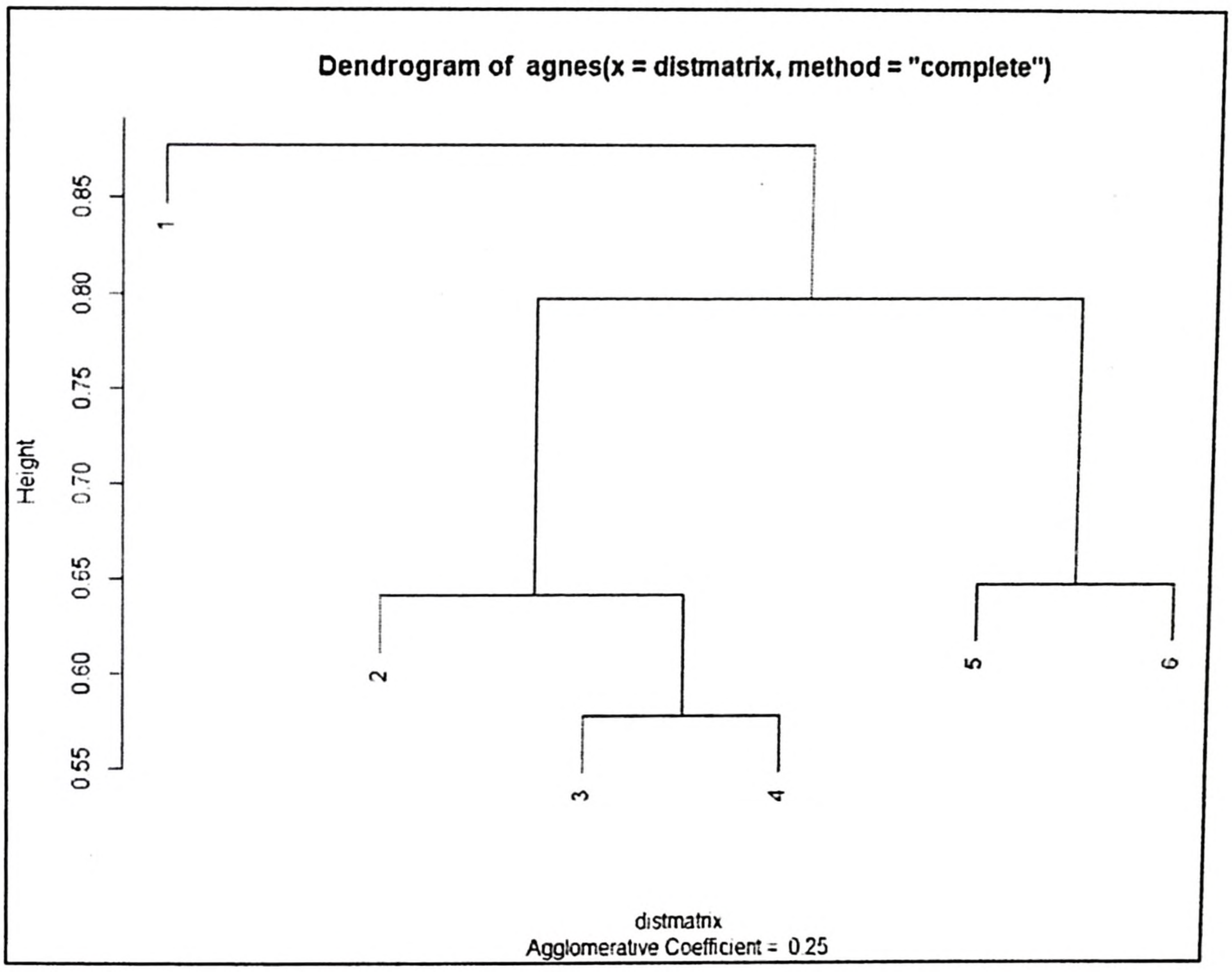


Fig. 4.3.: Hierarchical Cluster Analysis of Geometrid moth in six different altitudinal zones at GHNP

4.3.4. Variation of species assemblages in different Altitudinal Zones:

The Global R statistics from ANOSIM from 1% threshold level was 0.2093 with p= 0.0001 indicating that the overall difference between six altitudinal zones were large and statistically significant. Pairwise ANOSIM test showed that most difference in species composition occurred between Zone 1 and Zone 6 (R= 0.6128, P= 0.0004) and least between Zone 3 and Zone 6. The result observed between zone pairs is given in (Table 4.5).

Table 4.5.: Comparison of each pair similarity of Geometridae moth assemblages in six different altitudinal zones from ANOSIM (Analysis of Similarity) [Highlighted cells represent significance level (bold: $p<0.05$); Bold cells are R values) with Mean R value =0.2093 mean p value= 0.0001

0	**Zonel**	**Zone2**	**Zone3**	**Zone4**	**Zone5**	**Zone6**
Zonel	0	0.0094	0.0007	0.0001	0.0001	0.0004
Zone2	**0.2015**	0	0.8343	0.1979	0.0842	0.0804
Zone3	**0.3151**	**-0.07813**	0	0.6727	0.6602	0.4517
Zone4	**0.5463**	**0.08104**	**-0.04592**	0	0.7804	0.8835
Zone5	**0.5622**	**0.1273**	**-0.03972**	**-0.0758**	0	0.8828
Zone6	**0.6128**	**0.1601**	**0.008236**	**-0.1276**	**-0.1204**	0

4.3.5. Contributing species for the dissimilarity of assemblage among different Altitudinal Zones in GHNP:

To identify the species contributing to the assemblage differences between elevation zones that differed significantly i.e., between Zone 1 and Zone 2; Zone 1 and Zone 3; Zone 1 and Zone 4; Zone 1 and Zone 5; Zone 1 and Zone 6, similarity percentage analysis (SIMPER) was performed and discussed for each pair.

a) Geometrid species contributing for differences of moth assemblages between Zone 1 and Zone 2:

Eleven species contributed around 90.1% overall dissimilarity between Zone 1 and Zone 2 (Table 4.6). These species differed in mean abundance, which was reflected in the degree of group association. Three species had higher mean abundance in Zone 1 and eight species had higher mean abundance in Zone 2.

Table 4.6: SIMPER analysis of differences in the species of Geometrid moth assemblage contributing to the dissimilarity (90.01%) between Zone 1 and Zone 2

Sl. No.	Species	Av. dissim	Con trib. %	Cumu lative %	Mean abund. Zone 1	Mean abund. Zone 2
1	*Rheumaptera dubiosata*	2.744	3.045	6.215	3.85	0.778
2	*Psyra debilis indica*	1.547	1.717	21.1	0	1.67
3	*Ctenognophos eolaria*	1.49	1.653	24.43	1.38	0
4	*Perizoma peculiare*	1.483	1.646	26.08	0.0769	2
5	*Chlorissa gelida*	1.468	1.63	27.71	1.62	0.889
6	*Laciniodes plurilinearia*	1.286	1.427	29.14	0	3.22
7	*Artemidora disistaria*	1.262	1.401	30.54	0.0769	1.11
8	*Sirinopteryx quadripunctata*	1.153	1.279	34.55	0	2.89
9	*Venusia roseicosta*	1.117	1.24	37.06	0	2.44
10	*Myrioblephara duplexa*	1.104	1.226	38.29	0.692	1.22
11	*Anonychia lativitta*	0.9827	1.091	40.52	0.615	1

Rheumaptera dubiosata had the highest mean abundance and was prevalent in Zone 1 than Zone 2. *Psyra debilis indica, Laciniodes plurilinearia, Sirinopteryx quadripunctata* and *Venusia roseicosta* were predominant in Zone 2, but absent in Zone 1 whereas, *Ctenognophos eolaria* were abundant in Zone 1 but absent in Zone 2.

b) Geometrid species contributing for differences of moth assemblages between Zone 1 and Zone 3:

Eighteen species contributed around 90.08% to the difference between composition of Zone 1 and Zone 3 (Table 4.7). Seven species had higher mean abundance in Zone 1 and 11 species had higher mean abundance in Zone 3.

Table 4.7: SIMPER analysis of differences in the species of Geometrid moth assemblage contributing to the dissimilarity (90.08%) between Zone 1 and Zone 3

Sl. No.	Species	Av. dissim	Con trib. %	Cumu lative %	Mean abund. Zone 1	Mean abund. Zone 3
1	*Myrioblephara xanthozonea*	3:419	3.765	3.765	0	4.13
2	*Rheumaptera dubiosata*	2.455	2.704	15.56	3.85	0.125
3	*Perizoma antisticta*	2.083	2.294	17.86	0	3.88
4	*Alcis admissaria*	1.976	2.176	22.3	1.77	0.625
5	*Alcis nudipennis*	1.812	1.996	24.29	1.46	0.375
6	*Perizoma peculiare*	1.613	1.776	26.07	0.0769	2.25
7	*Perizoma fulvimacula*	1.591	1.752	27.82	0.462	2.38
8	*Ctenognophos eolaria*	1.57	1.729	29.55	1.38	0.25
9	*Venusia roseicosta*	1.544	1.7	31.25	0	2.75
10	*Lomographa platyleucata*	1.517	1.671	32.92	0	3.25
11	*Parectropis conspurcata*	1.454	1.601	36.17	0	3.38
12	*Scopula achrosta*	1.302	1.434	39.16	1.54	0
13	*Menophra subplagiata*	1.061	1.168	41.56	1.15	0
14	*Chlorissa gelida*	1.002	1.104	42.67	1.62	0.375
15	*Heterolocha phoenicotaeniaea*	0.9349	1.03	46.89	0.769	1.38
16	*Euphyia subangulata*	0.7329	0.807 1	56.82	0	1.13
17	*Arichanna interplagata*	0.6592	0.725 9	62.05	0	1.38
18	*Heterolocha falconaria*	0.5107	0.562 4	67.61	0.0769	1

Rheumaptera dubiosata, Alcis admissaria, Alcis nudipennis, Ctenognophos eolaria, Scopula achrosta, Menophra subplagiata and *Chlorissa gelida* were predominant in Zone 1 whereas, *Myrioblephara xanthozonea, Perizoma antisticta, Perizoma peculiare, Perizoma fulvimacula, Venusia roseicosta, Lomographa platyleucata, Parectropis conspurcata, Heterolocha phoenicotaeniaea, Euphyia subangulata,* *Arichanna interplagata* and *Heterolocha falconaria* were predominant at zone 3.

c) Geometrid species contributing for differences of moth assemblages between Zone 1 and Zone 4:

Table 4.8: SIMPER analysis of differences in the species of Geometrid moth assemblage contributing to the dissimilarity (93.67%) between Zone 1 and Zone 4.

Sl. No.	Species	Av. dissim	Con trib. %	Cumu lative %	Mean abund. Zone 1	Mean abund. Zone 4
1	*Hydrelia sp*	4.134	4.413	4.413	0.231	4
2	*Rheumaptera dubiosata*	2.553	2.726	13.41	3.85	0.143
3	*Photoscotosia amplicata*	2.517	2.687	16.1	0.538	2.43
4	*Heterolocha phoenicotaeniaea*	2.228	2.379	21.03	0.769	4.57
5	*Rheumaptera cinerea*	2.073	2.213	23.25	0	1.29
6	*Perizoma peculiare*	2.01	2.145	25.39	0.0769	3.57
7	*Alcis nudipennis*	1.828	1.952	27.34	1.46	0.429
8	*Odontopera lentiginosaria*	1.715	1.831	29.17	0	2.43
9	*Ctenognophos eolaria*	1.673	1.786	30.96	1.38	0
10	*Chlorissa gelida*	1.242	1.326	39.59	1.62	0.571
11	*Hydrelia sericea*	1.218	1.301	40.89	0	1.86
12	*Perizoma fulvimacula*	1.211	1.293	42.19	0.462	1.43
13	*Heterolocha falconaria*	1.159	1.237	44.69	0.0769	2.29
14	*Menophra subplagiata*	1.117	1.192	47.09	1.15	0
15	*Lomographa platyleucata*	1.094	1.168	49.43	0	1
16	*Ecliptopera substituta*	0.7702	0.822	56.74	0.0769	1
17	*Perizoma plumbeata*	0.7473	0.797	57.54	0	1.43
18	*Xanthorhoe hampsoni*	0.5818	0.621	68.91	0	1.43
19	*Euphyia subangulata*	0.5315	0.567	70.62	0	1.14
20	*Venusia roseicosta*	0.5237	0.559	71.74	0	1.29

Twenty species contributed around 93.67% to the difference between Zone 1 and Zone 4 (Table 4.8). Five species had higher mean abundance in Zone 1 and 15 species had higher mean abundance in Zone 4.

Rheumaptera dubiosata, Alcis nudipennis, Ctenognophos eolaria, Chlorissa gelida and *Menophra subplagiata* were predominant in Zone 1.

Hydrelia sp, Photoscotosia amplicata, Heterolocha phoenicotaeniaea, Rheumaptera cinerea, Perizoma peculiare, Odontopera lentiginosaria, Hydrelia sericea, Perizoma fulvimacula, Heterolocha falconaria, Lomographa platyleucata, Ecliptopera substituta, Perizoma plumbeata, Xanthorhoe hampsoni, Euphyia subangulata and *Venusia roseicosta* were predominant at zone 4.

d) Geometrid species contributing for differences of moth assemblages between Zone 1 and Zone 5:

Twenty species contributed around 95.23% to the difference between Zone 1 and Zone 5 (Table 4.9). Seven species had higher mean abundance in Zone 1 and 7 species had higher mean abundance in Zone 5.

Perizoma fulvimacula, Myrioblephara gandakiensis, Micrabraxas melanodonta, Euphyia goniodes, Venusia roseicosta, Perizoma schistacea and *Psyra spurcataria* were predominant at zone 5.

Table 4.9: SIMPER analysis of differences in the species of Geometrid moth assemblage contributing to the dissimilarity (95.23%) between Zone 1 and Zone 5.

Sl. No.	Species	Av. dissim	Con trib. %	Cumu lative %	Mean abund. Zone 1	Mean abund. Zone 5
1	*Rheumaptera dubiosata*	3.157	3.316	12.14	3.85	0
2	*Alcis admissaria*	3.039	3.191	15.34	1.77	0.714
3	*Perizoma fulvimacula*	2.868	3.011	18.35	0.462	1.86
4	*Alcis nudipennis*	2.432	2.553	20.9	1.46	0.143
5	*Ctenognophos eolaria*	2.21	2.321	25.7	1.38	0.143
6	*Scopula achrosta*	1.706	1.792	27.49	1.54	0
7	*Menophra subplagiata*	1.459	1.532	29.02	1.15	0
8	*Myrioblephara gandakiensis*	1.408	1.478	30.5	0.154	2.71
9	*Micrabraxas melanodonta*	1.161	1.219	34.2	0	2.29
10	*Chlorissa gelida*	1.008	1.058	43.5	1.62	0
11	*Euphyia goniodes*	0.9794	1.028	45.57	0	1
12	*Venusia roseicosta*	0.8177	0.858	56.01	0	1.14
13	*Perizoma schistacea*	0.7402	0.777	57.56	0.231	1.14
14	*Psyra spurcataria*	0.4502	0.472	74.49	0	1

e) Geometrid species contributing for differences of moth assemblages between Zone 1 and Zone 6:

Twenty species contributed around 95.23% to the difference between Zone 1 and Zone 6 (Table 4.10). Seven species had higher mean abundance in Zone 1 and 7 species had higher mean abundance in Zone 6.

Neotephria ramalaria, Photoscotosia amplicata, Alcis subnitida, Alcis admissaria, Xanthorhoe hampsoni, Myrioblephara gandakiensis, Anonychia lativitta, Sirinopteryx harutai, Photoscotosia polysticha, Perizoma fulvimacula, Micrabraxas melanodonta, Eupithecia cf *asempiterna, Perizoma variabilis, Photoscotosia dejuncta* and *Arichanna flavinigra* were predominant at zone 6.

Table 4.10: SIMPER analysis of differences in the species of Geometrid moth assemblage contributing to the dissimilarity (95.23%) between Zone 1 and Zone 6.

Sl. No.	Species	Av. dissim	Con trib. %	Cumu lative %	Mean abund. Zone 1	Mean abund. Zone 6
1	*Hydrelia sp*	4.057	4.311	8.831	0.231	4.5
2	*Neotephria ramalaria*	3.865	4.107	12.94	0	7
3	*Photoscotosia amplicata*	3.433	3.648	16.59	0.538	5.83
4	*Alcis subnitida*	3.249	3.452	20.04	0.538	5.17
5	*Alcis admissaria*	3.062	3.253	23.29	1.77	3.67
6	*Rheumaptera dubiosata*	2.209	2.347	25.64	3.85	0
7	*Xanthorhoe hampsoni*	2.166	2.302	27.94	0	4
8	*Perizoma sp*	1.693	1.799	31.72	0.769	2
9	*Myrioblephara gandakiensis*	1.606	1.707	33.43	0.154	2.17
10	*Anonychia lativitta*	1.514	1.609	35.04	0.615	1.5
11	*Sirinopteryx harutai*	1.513	1.608	36.65	0.154	2.67
12	*Alcis nudipennis*	1.482	1.575	38.22	1.46	0.167
13	*Photoscotosia polysticha*	1.481	1.574	39.79	0	2.83
14	*Ctenognophos eolaria*	1.374	1.46	41.25	1.38	0
15	*Perizoma fulvimacula*	1.248	1.326	45.31	0.462	1.5
16	*Micrabraxas melanodonta*	1.147	1.219	47.75	0	2
17	*Eupithecia cf asempiterna*	1.1	1.169	50.1	0	2.17
18	*Perizoma variabilis*	1.025	1.09	52.32	0	2.17
19	*Photoscotosia dejuncta*	1.018	1.081	53.4	0	2.17
20	*Arichanna flavinigra*	0.9392	0.998	55.47	0	2

4.3.6. Assemblage of Geometridae in different Altitudinal Zones:

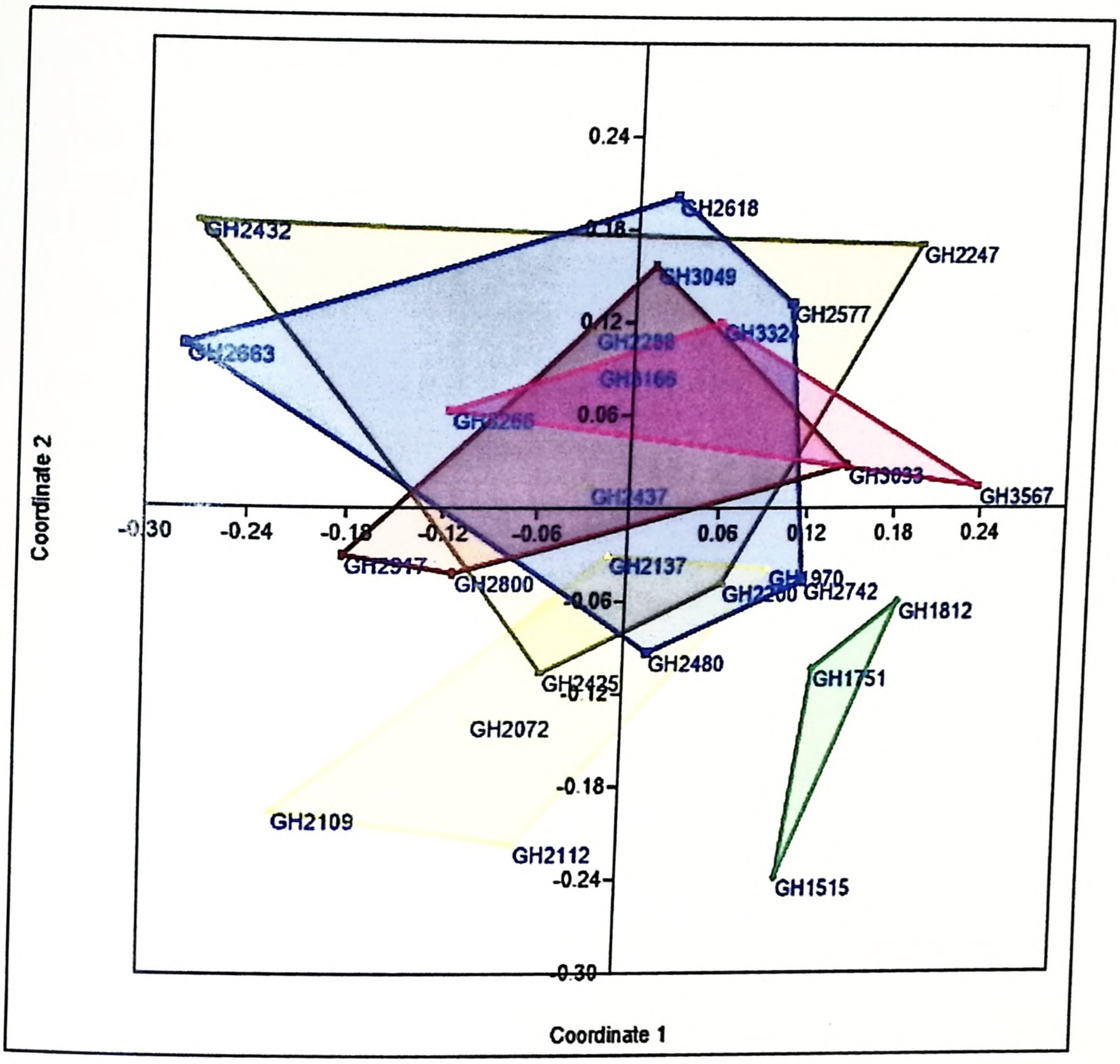


Fig. 4.4.: Non-Metric Multidimensional Scaling (NMDS) of Geometrid moth assemblages in different Altitudinal Zones (Green= Zone 1, Yellow= Zone 2, Olive= Zone 3, Blue= Zone 4, Red= Zone 5, Pink= Zone 6)

Non-metric multidimensional scaling (NMDS) with the Bray-Curtis similarity index was used to see the difference in assemblage pattern of Geometridae moth in six different altitudinal zones at GHNP. Axis values of sites thus obtained were plotted in the multidimensional space generated through NMDS and represented in a 3D graph. Sites were labelled and grouped according to altitude and coloured with six different colours. The result indicates that sites of Zone 1 (1500- 1800 m) had most different assemblage composition compared to other zones as they showed no overlap in the NMDS plot whereas, the sites of Zone 2 (1800- 2100 m) was also showed minimum overlap showing its uniqueness in assemblage. Sites of other zones showed moderate overlap with each other suggesting an overall similar assemblage pattern. Sites of Zone 3 (2100- 2400m) and Zone 4 (2400- 2700 m) showed maximum overlap between themselves suggesting almost similar assemblage pattern of Geometrids (Fig. 4.4).

Chapter 5: Factors governing the diversity and distribution pattern of Geometridae in GHNP

5.1. Introduction:

Being one of the most hyperdiverse taxa among the well-known insect groups (Novotny *et al.,* 2006; Lewinsohn & Roslin, 2008), moths can have an extraordinary perspective to act as a model in the study focusing on the effects of environmental gradient on the diversity and distribution pattern of animals, due to their intermediate position at the trophic level as a primary consumer (Sanyal, 2015).

Diversity, distribution and assemblages of many taxa alters along with the major environmental gradients like climate, topography (Chown & Gaston 2000; Willig *et al*., 2003; Currie *et al.,* 2004), productivity (Bonn *et al.,* 2004; Gaston & Evans, 2004), disturbance (Lawton *et al.,* 1998; Beck *et al.,* 2002; Schulze *et al.,* 2004), and, obviously, with altitude (Holloway, 1987; McCoy, 1990). Microclimatic variables may have high importance and effect on moths rather than the large-scale factors (Sanyal, 2015). Disturbance at the local scale, forest patch size and structure can directly regulate the richness and abundance of moth species (Hamer & Hill, 2000; Summerville & Crist, 2002; Usher & Keiller, 1998; Davies *et al.,* 2001).

The primary aim of this study is to find the effects of different categories of factors like vegetation, topography, climatic as well as anthropogenic disturbances, influencing the Geometrid moth diversity and richness.

5.2. Methodology:

5.2.1. Data Collection:

To test the effects of different vegetation types on the diversity of Geometrid moths in the area, the plant community of each vegetation type were sampled using a series of nested quadrats (Sanyal, 2015). Each series was designed within a vegetation type, centring one quadrat on the position of the light-trapping station and the two others randomly located 50 m from the centre. 20x20 m quadrats were used to quantify species richness, abundance and the diameter at breast height (DBH) of all trees greater than 10 cm DBH. Canopy cover was measured using a densitometer at 8 points spaced at 10 m intervals along the perimeter of each 20x20 m quadrat. Within 20x20 m quadrats, two 5x5 m quadrats were used to quantify species richness and abundance of shrubs and saplings. Two 1 sq. m quadrats within each shrub plot were taken into account to measure species richness, abundance and percentage cover of the herbaceous layer.

Ambient air temperature, relative humidity and wind velocity was recorded during the light trap at every 60 min with an electronic weather meter and were averaged over all catch nights for every site. Sample collections were avoided during the full moon period (3 days before and after the full moon). Cloud cover was also noted every hour for each light trap catch. Bioclimatic variables were also extracted from Worldclim database (Fick *et al.*, 2017) and used as governing factors of diversity and richness.

Anthropogenic disturbance data, such as logging, lopping, presence of the fallen tree, livestock grazing and presence of fire signs were collected within the 20x20 m quadrat and was analysed to determine the key disturbance factor affecting diversity pattern of Geometrid moths in the study area.

Topographical variables, such as Altitude, Slope, Hill Shade and Aspect was also noted during sampling. Raw satellite images downloaded from USGS Landsat 8 OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor) Level-1 Data Products were used to calculate and generate the NDVI map for May 2018 using the formulae (NIR-R)/(NIR+R) (NIR-Near Infrared band and R-Red Band) in ArcMap 10.4.

5.2.2. Analysis:

A correlation matrix was developed between overall Geometridae diversity measures such as observed Species, Individuals and Fisher's alpha with major groups of environmental variable like topographical features, microclimate variables, vegetation structural factors and disturbance variables using PAST 2.17c (Hammer *et al.,* 2007). Pairwise correlation graphs were used to show significant relationships using MS Excel 2013.

Exploration of Geometridae species composition in different altitudinal zones and effects of significant environmental, topographical, vegetation-structural and disturbance variables on Geometrid diversity, richness and abundance was done through Canonical Correspondence Analysis (CCA) using PAST 2.17c (Hammer *et al*., 2007).

5.3. Results & discussion:

5.3.1. Major Habitat variables shaping Geometridae diversity:

Table 5.1: Correlation matrix of overall diversity measures (Species richness, abundance and Fisher's alpha of Geometridae) with significant habitat variables

Significant correlated variables	Species richness	Abundance	Fisher's alpha
Altitude	-0.47262	-0.28132	-0.57927
Hill Shade	0.43392	0.40964	0.45104
Aspect	0.35186	0.35834	0.3196
Annual Precipitation (bio12)	-0.31016	-0.3156	-0.22419
Precipitation of Wettest Quarter (bio 16)	-0.31872	-0.323	-0.22826
Precipitation of Driest Quarter (bio 17)	-0.32093	-0.316	-0.26222
Precipitation of Warmest Quarter (bio 18)	-0.35855	-0.36366	-0.2353
Number of Tree species	0.39004	0.49677	0.26915
Tree Abundance	0.26683	0.14455	0.3433
Avg. Tree Height (m)	0.28553	0.20081	0.3503
Avg. Tree GBH (cm)	0.32566	0.31356	0.33951
Logging Sign	0.31266	0.16581	0.3994
No of Dead Tree	0.58725	0.52741	0.5228
No of Dung/ Pellets	-0.33901	-0.41669	-0.16067

To see the main effects of all the major topographic, microclimatic, vegetation structural, compositional and disturbance variables on overall diversity measures such as Geometridae Species richness, abundance and Fisher's alpha, Spearman correlation test was carried out. Altitude, Hill Shade, Aspect, Annual Precipitation (bio12), Precipitation of Wettest Quarter (bio 16), Precipitation of Driest Quarter (bio 17), Precipitation of Warmest Quarter (bio 18), No. of Tree species, Tree Abundance, Avg. Tree Height (m), Avg. Tree GBH (cm), Logging Sign, No. of Dead Trees and No of dung/ pellets were found to have significant correlations with Geometridae species richness, abundance and Fisher's alpha (Table 5.1). Pairwise correlation graphs were produced to show the trend of all those significant relationships (Fig.5.1, 5.2, 5.3, 5.4, 5.5, 5.6 & 5.7).

Altitude showed a significant negative correlation with Fisher's alpha (-0.57927), species richness (-0.47262) and negative correlation with abundance (-0.28132). Hill shade and Aspect showed a significant positive correlation with all three diversity measures.

Annual Precipitation (bio12), Precipitation of Wettest Quarter (bio 16), Precipitation of Driest Quarter (bio 17) and Precipitation of Warmest Quarter (bio 18) showed negative correlation with all three measures.

The number of Tree species showed a significant positive correlation with Geometridae abundance (0.4967) and a positive correlation with the other two diversity measures. Tree Abundance, Avg. Tree Height (m), Avg. Tree GBH (cm) and Logging Sign showed a positive correlation with all three measures.

The number of Dead Trees showed a significantly positive correlation with all three measures, whereas, number of dung or Pellets showed a negative correlation with all the diversity measures.

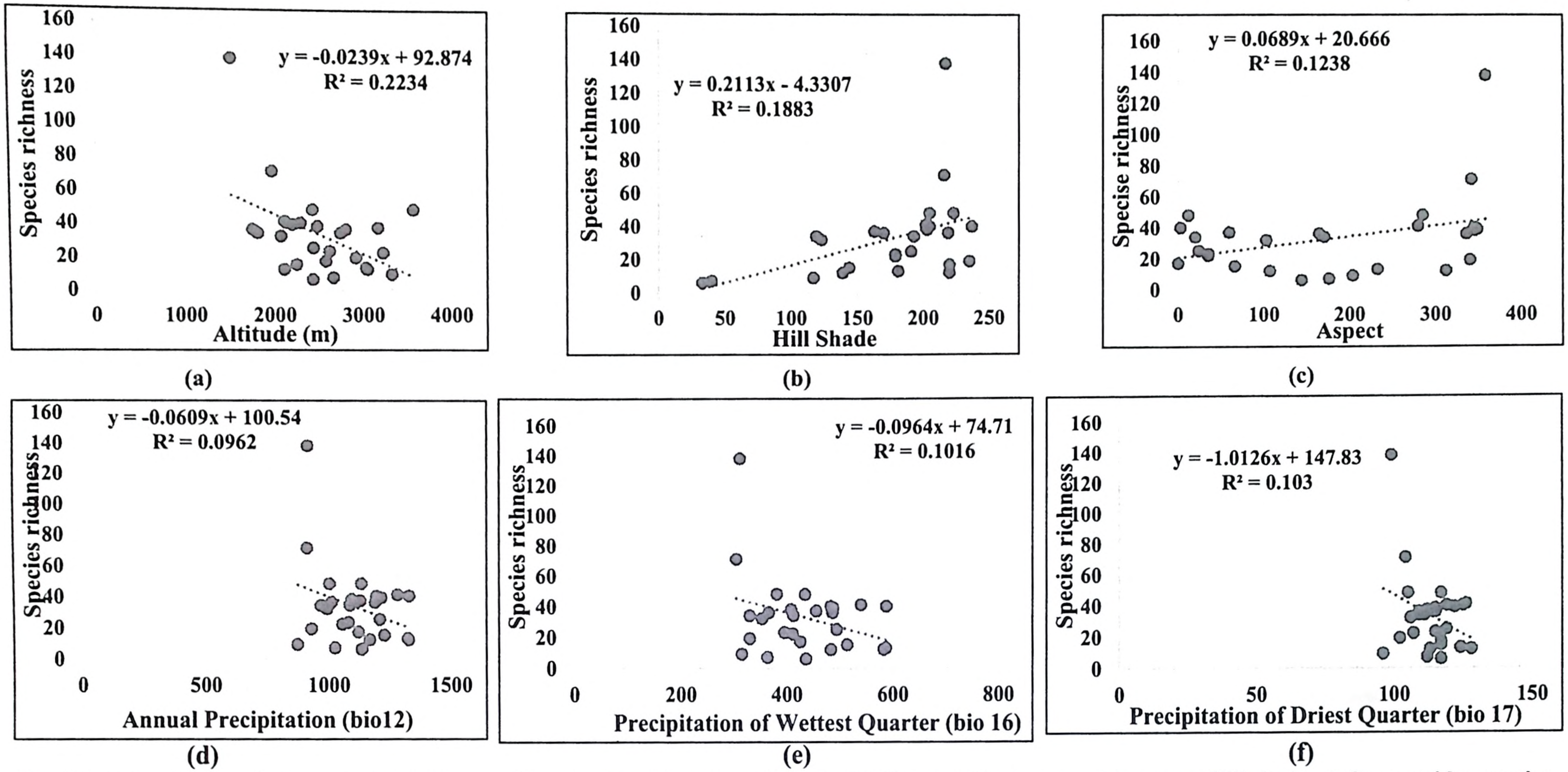


Fig. 5.1: Pair wise correlation graph: a) Geometridae species richness vs. Altitude. b) Geometridae species richness vs. Hill shade. c) Geometridae species richness vs. Aspect. d) Geometridae species richness vs. Annual precipitation (bio 12). e) Geometridae species richness vs. Precipitation of Wettest Quarter (bio 16). f) Geometridae species richness vs. Precipitation of Driest Quarter (bio 17).

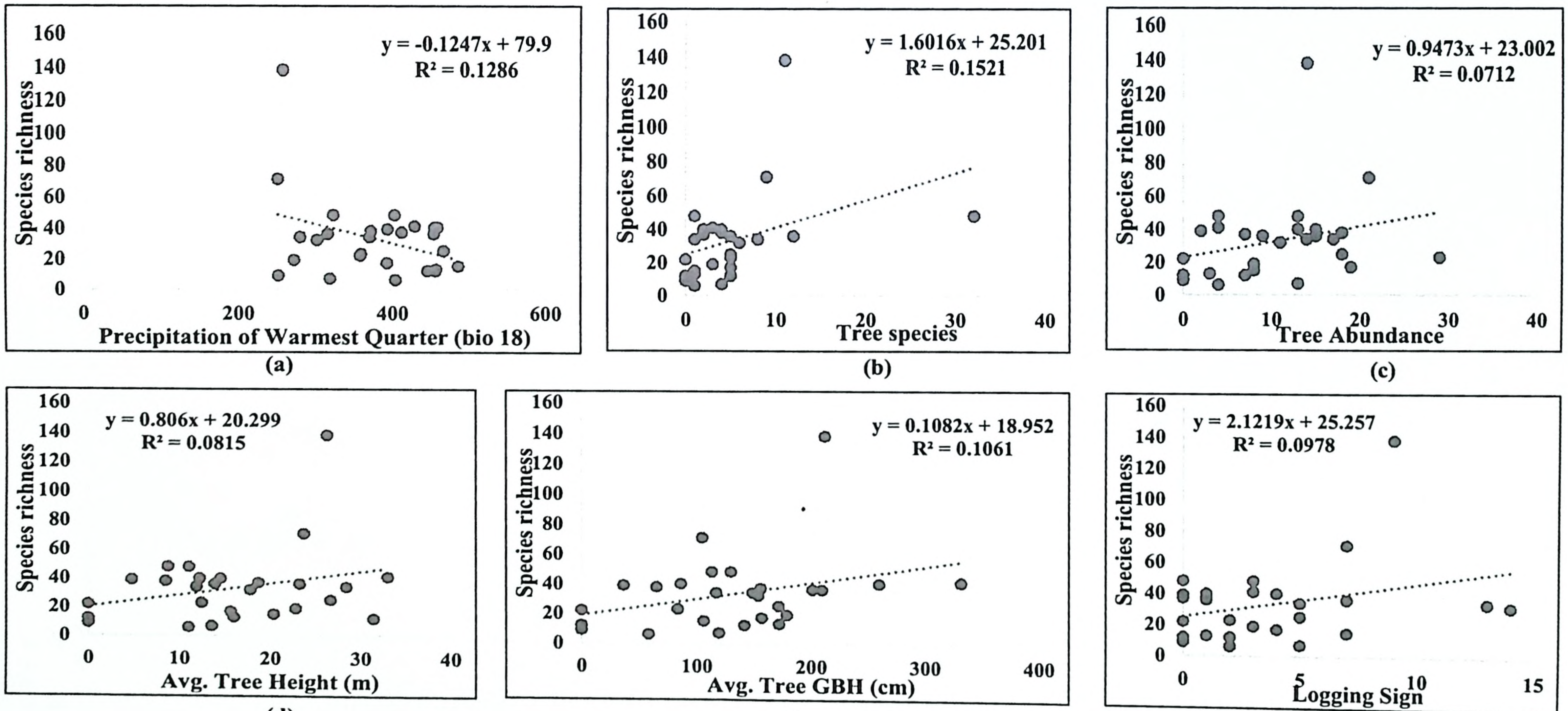


Fig. 5.2: Pair wise correlation graph: a) Geometridae species richness vs. Precipitation of Warmest Quarter (bio 18). b) Geometridae species richness vs. Number of tree species. c) Geometridae species richness vs. Tree abundance. d) Geometridae species richness vs. Avg. tree height (m). e) Geometridae species richness vs. Avg. tree GBH (cm). f) Geometridae species richness vs. Number of logging sign.

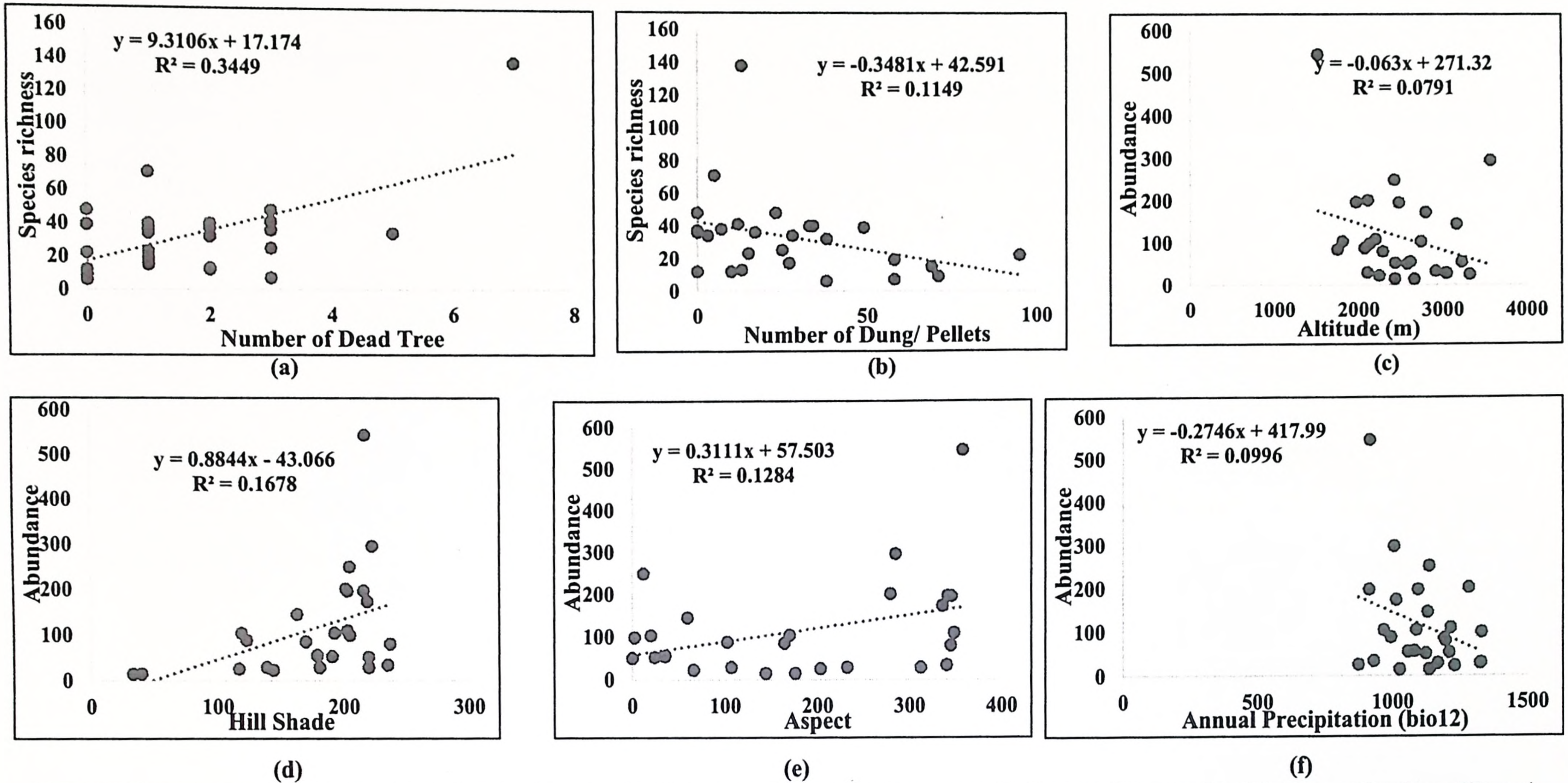


Fig. 5.3: Pair wise correlation graph: a) Geometridae species richness vs. Number of dead tree. b) Geometridae species richness vs. Number of Dung/ pellets. c) Abundance vs. Altitude (m). d) Abundance vs. Hill shade. e) Abundance vs. Aspect. f) Abundance vs. Annual precipitation (bio 12).

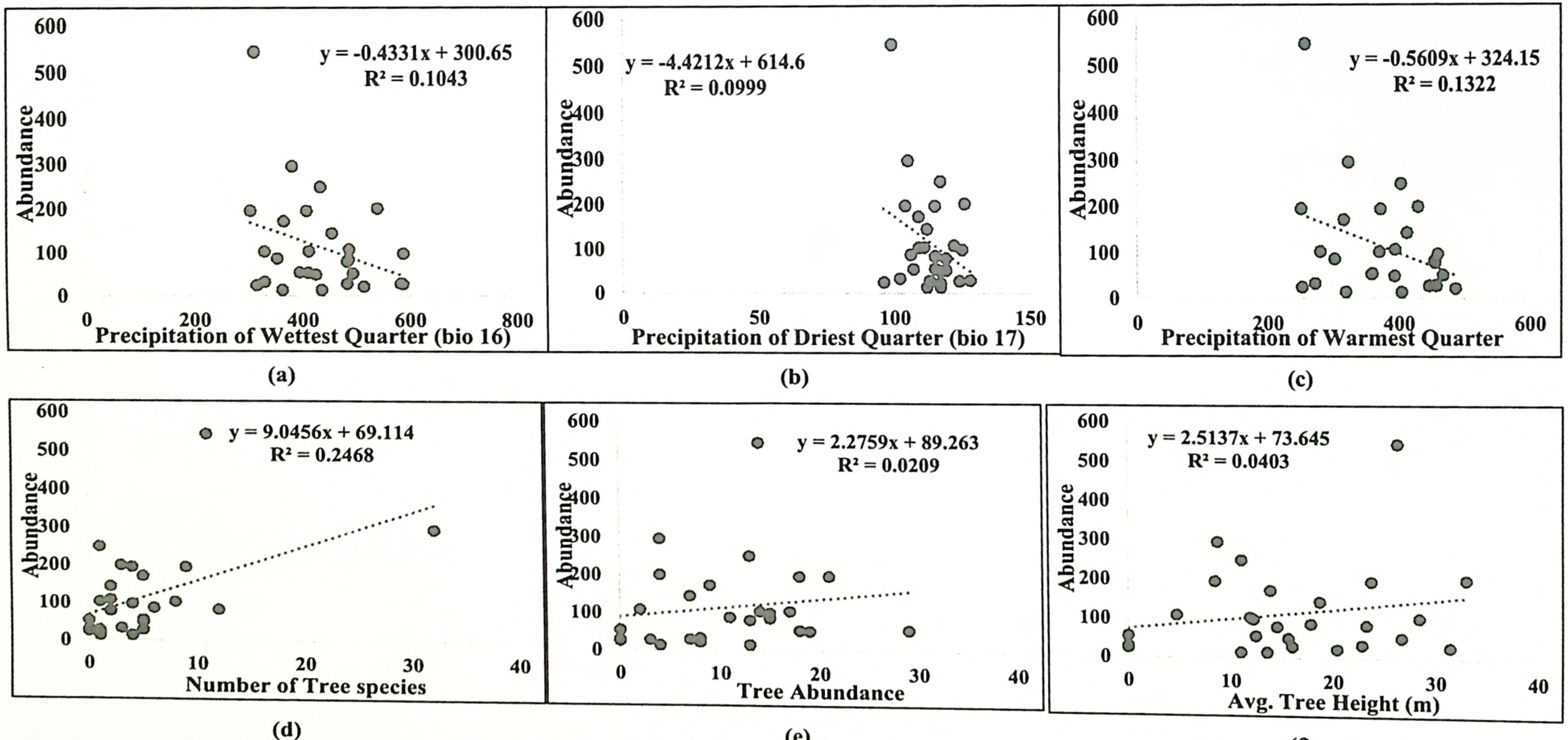


Fig. 5.4: Pair wise correlation graph: a) Abundance vs. Precipitation of Wettest Quarter (bio 16). b) Abundance vs. Precipitation of Driest Quarter (bio 17). c) Abundance vs. Precipitation of Warmest Quarter (bio 18). d) Abundance vs. Number of tree species. e) Abundance vs. Tree abundance. f) Abundance vs. Avg. tree height (m).

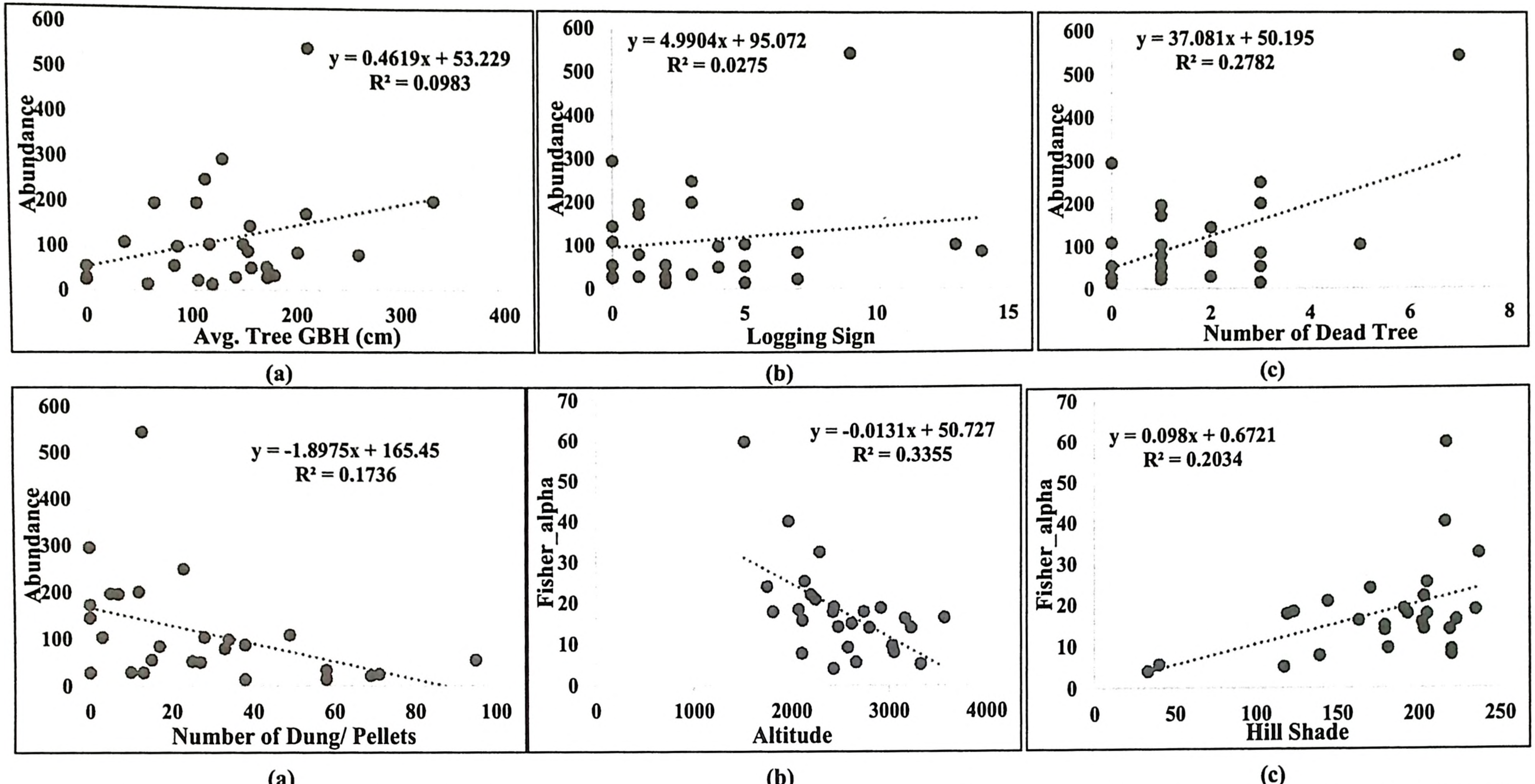


Fig. 5.5: Pair wise correlation graph: a) Abundance vs. Avg. tree GBH (cm). b) Abundance vs. Logging sign. c) Abundance vs. Number of dead tree. d) Abundance vs. Number of dung/ pellets. e) Fisher's alpha vs. Altitude. f) Fisher's alpha vs. Hill shade.

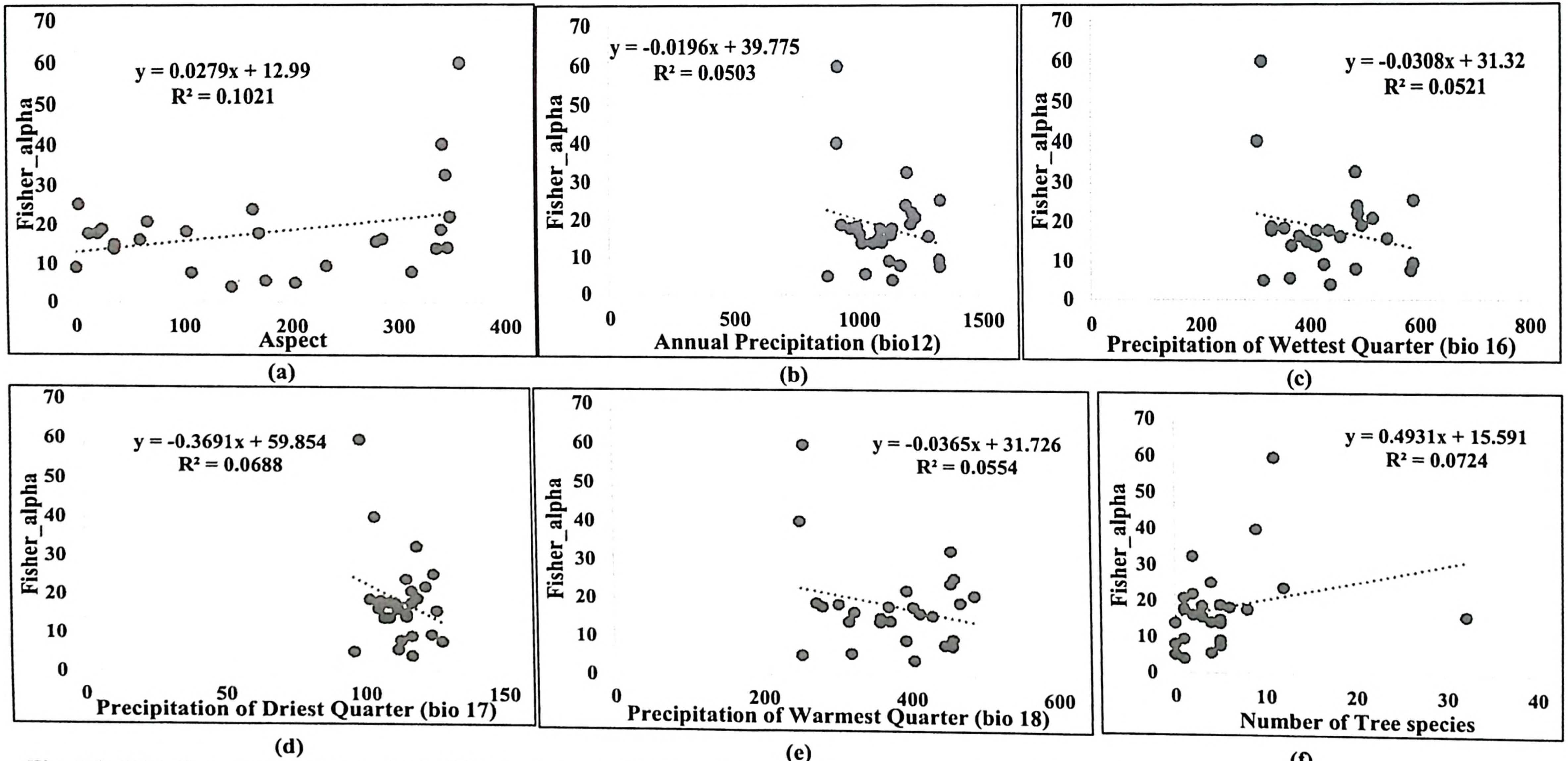


Fig. 5.6: Pair wise correlation graph: a) Fisher's alpha vs. Aspect. b) Fisher's alpha vs. Annual precipitation (bio 12). c) Fisher's alpha vs. Precipitation of Wettest Quarter (bio 16). d) Fisher's alpha vs. Precipitation of Driest Quarter (bio 17). e) Fisher's alpha vs. Precipitation of Warmest Quarter (bio 18). f) Fisher's alpha vs. Number of tree species.

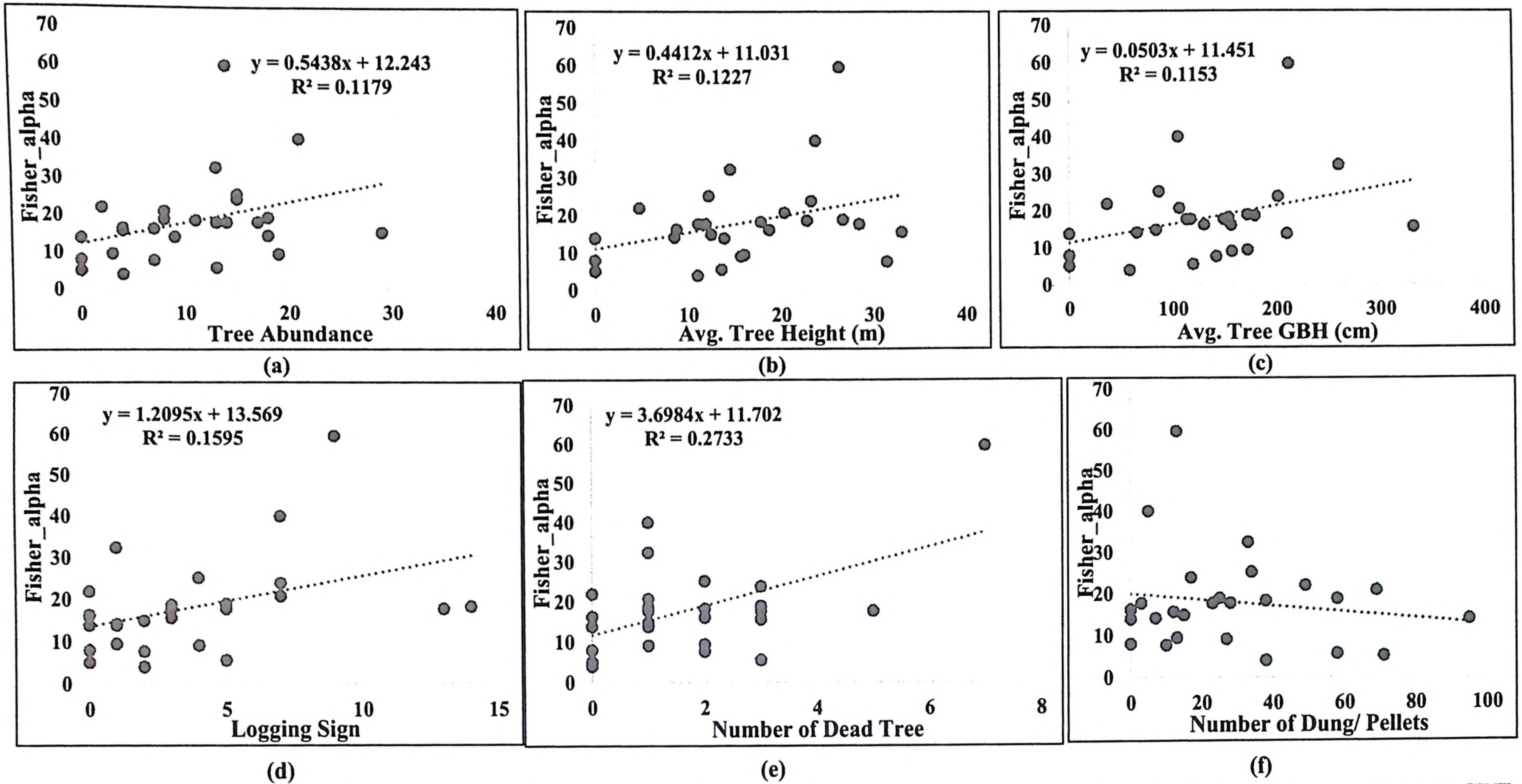


Fig. 5.7: Pair wise correlation graph: a) Fisher's alpha vs. Tree abundance. b) Fisher's alpha vs. Avg. tree height (m). c) Fisher's alpha vs. Avg. tree GBH (cm). d) Fisher's alpha vs. Logging sign. e) Fisher's alpha vs. Number of dead tree. f) Fisher's alpha vs. Number of dung/ pellets.

5.3.2. Factors determining Geometridae diversity and species composition:

CCA was performed with four different categories of variables to show the effect of most significant variables of the environment, Topography, vegetation- structure and anthropogenic disturbance on overall diversity measures such as Geometridae Species richness, abundance and Fisher's alpha.

a) CCA with major Environmental factors, Geometridae diversity, richness and abundance:

Annual precipitation (bio 12), Precipitation of Wettest Quarter (bio 16), Precipitation of Driest Quarter (bio 17), Precipitation of Warmest Quarter (bio 18), Average Trap Night Temperature (ATNT) and Average Trap Night Humidity (ATNH) were used as environmental variables with Geometridae alpha diversity (Fisher's alpha), richness and abundance as depending variables to perform the CCA.

Table 5.2.: Summary of Canonical correspondence Analysis (CCA) for species abundance, richness and diversity of Family Geometridae with axes related to the environmental variables.

Axis	Eigenvalue	% explained
1	0.51964	21.61
2	0.42957	17.86

In this CCA, the first two synthetic axis showed total 40% of the variation, of which the 1st and 2nd axis represented by 22% and 18% respectively (Table: 5.2). The 1st axis was only positively influenced by ATNT (r= 0.6697) whereas negatively influenced by bio18 (r= - 0.1292), bio 12 (r= -0.0480), bio 16 (r= -0.0363), bio 17 (r= -0.0888) and ATNH (r= -

0.0817). Geometridae species richness (r= 0.2846), fishers' alpha (r= 0.3750) and abundance (r= 0.1094) showed positive influence on 1st axis.

The 2nd synthetic axis was positively influenced by ATNH (r= 0.1209), whereas negatively influenced by ATNT (r= - 0.7004), bio17 (r= - 0.2593), bio 12 (r= -0.1474), bio 16 (r= -0.1342), bio 18 (r= -0.0032) (Table 5.3). Geometridae species richness (r= 0.2378), Fisher's alpha (r= 0.4104), abundance (r= 0.1308) again showed positive influence on the 2nd axis.

Table 5.3: Intraset correlations between environmental variables and ordination axes resulting from the CCA, with Geometridae species abundance, richness and fisher's alpha

Explanatory variables	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5
bio 12	-0.0480	-0.1474	0.3644	-0.3329	0.1812
bio 16	-0.0363	-0.1342	0.4438	-0.3473	0.1159
bio 17	-0.0888	-0.2593	0.2305	-0.3919	0.3178
bio 18	-0.1292	-0.0032	0.3017	-0.1681	0.1054
ATNT	0.6697	-0.7004	0.1767	0.0840	0.3224
ATNH	-0.0817	0.1209	0.2469	0.1920	-0.6553
Species richness	0.2846	0.2378	0.0917	-0.0057	0.3258
Abundance	0.1094	0.1308	0.1818	0.1961	0.3345
Fisher's alpha	0.3750	0.4104	0.0899	-0.2217	0.3128

So, the CCA result showed that Avg. trap night temperature, Avg. trap night humidity had a strong positive influence on Geometridae abundance, species richness and diversity, whereas Annual precipitation (bio 12), Precipitation of Wettest Quarter (bio 16), Precipitation of Driest Quarter (bio 17), Precipitation of Warmest Quarter (bio 18) had strong negative influence on Geometridae abundance, richness and diversity (Fig: 5.3).

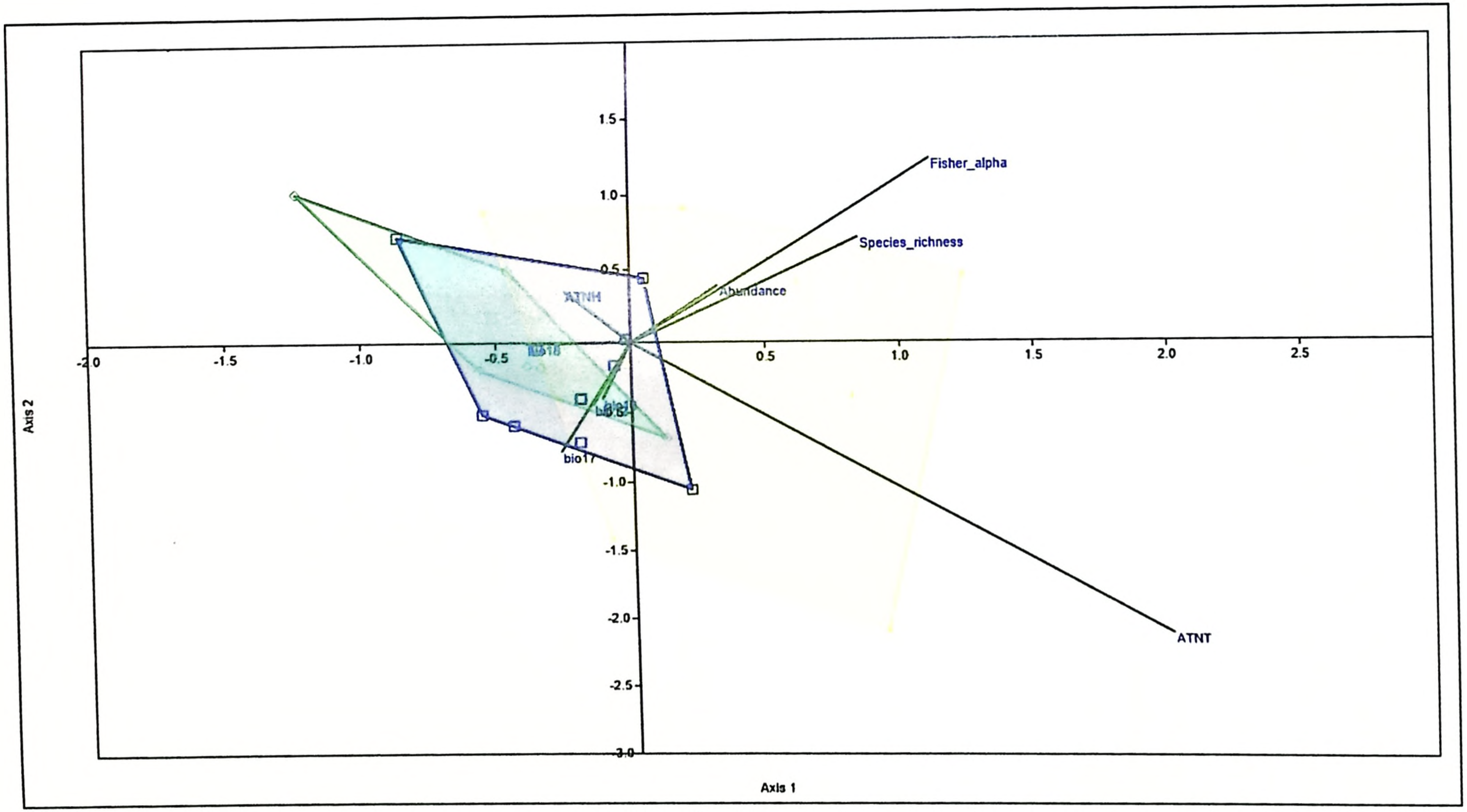


Fig. 5.8: CCA biplot based on species abundance, richness and diversity of Family Geometridae & major environmental variables with sites (Yellow= altitudinal site between 1500- 2300m, Blue= altitudinal site between 2301- 3000m, Green= altitudinal site above 3000m).

b) CCA with major topographical factors, Geometridae diversity, richness and abundance:

Altitude, Slope, Hill Shade, Aspect and NDVI were used as topographical variables along with Geometridae species richness, alpha diversity (Fisher's alpha) and abundance to perform the CCA.

Table 5.4: Summary of Canonical correspondence Analysis (CCA) for species abundance, richness and diversity of Family Geometridae with axes related to the Topographical variables.

Axis	Eigenvalue	% explained
1	0.5288	24.77
2	0.3904	18.29
3	0.31359	14.69
4	0.28199	13.21
5	0.22214	10.41
6	0.21095	9.883

In this CCA, the first two synthetic axis showed total 44% of the variation, of which the 1^{st} and 2^{nd} axis represented by 25% and 19% respectively (Table: 5.4).

The 1^{st} axis was positively influenced by NDVI (r= 0.6582), whereas negatively influenced by Altitude (r= -0.7635), Hill shade (r= -0.2693), Slope (r= -0.1302) and Aspect (r= -0.0981). Fisher's alpha (r= 0.3841), species richness (r= 0.2505) and abundance (r= 0.0675) of Geometridae showed positive influence on the 1^{st} axis.

The 2^{nd} synthetic axis was positively influenced by NDVI (r= 0.4686), whereas, was negatively influenced by Slope (r= -0.3534), Aspect (r= -0.2963), Hill shade (r= -0.1389) and Altitude (r= -0.0361). Fisher's alpha (r= -0.4484), species richness (r= -0.3376) and abundance (r= -0.2479) again showed negative influence on the 2nd axis (Table: 5.5).

Table 5.5: Intraset correlations between Topographical variables and ordination axes resulting from the CCA, with Geometridae species abundance, richness and fisher's alpha.

Explanatory variables	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5
Altitude	-0.7635	-0.0361	0.2864	0.1519	-0.2133
Slope	-0.1302	-0.3533	-0.0760	0.2895	-0.7181
Hill Shade	-0.2693	-0.1389	-0.3760	-0.4149	0.8338
Aspect	-0.0981	-0.2963	0.3487	-0.1094	0.2211
NDVI	0.6581	0.4685	-0.1341	0.2526	-0.2365
Species richness	0.2505	-0.3376	-0.0142	-0.0978	0.4634
Abundance	0.0676	-0.2479	0.0989	0.1022	0.4735
Fisher's alpha	0.3841	-0.4484	-0.2831	-0.2055	0.4224

So, the CCA result showed that NDVI had a strong positive influence on Geometridae diversity, abundance and species richness, whereas Altitude, Slope, Hill Shade, Aspect had negative influence on all the faunal indexes (Fig: 5.9). Majorly altitude showed strong negative influence and NDVI showed strong positive influence on Geometridae abundance, richness and diversity.

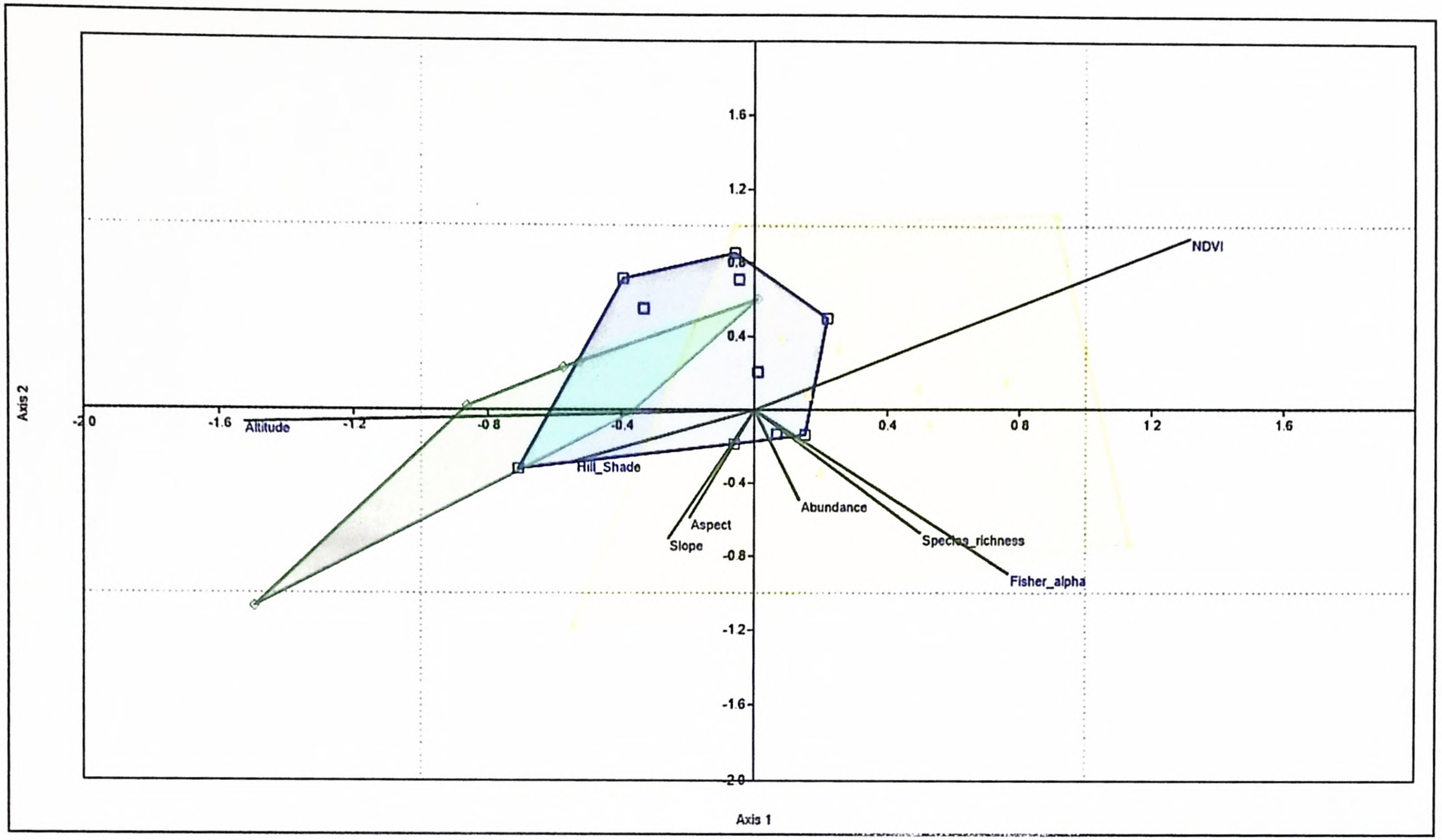


Fig. 5.9: CCA biplot based on species abundance, richness and diversity of Family Geometridae & major topographic variables with sites (Yellow= altitudinal site between 1500- 2300m, Blue= altitudinal site between 2301- 3000m, Green= altitudinal site above 3000m).

c) CCA with major Vegetation cover and structural factors on Geometridae diversity:

Variables related to vegetation cover like Number of tree species, Tree abundance, Shrub abundance, Number of Herb species and Herb abundance; and related to vegetation structure like Average tree Height, Average tree GBH, , were used as explanatory variables affecting Geometridae diversity (Fisher's alpha), species richness and abundance to perform the CCA.

Table 5.6: Summary of Canonical correspondence Analysis (CCA) for species abundance, richness and diversity of Family Geometridae with axis related to the Vegetation cover and structural factors.

Axis	Eigenvalue	% explained
1	0.47302	17.73
2	0.45323	16.99
3	0.378	14.17
4	0.29843	11.19
5	0.27107	10.16

In this CCA, the first two synthetic axis showed total 35% of the variation, of which the 1^{st} and 2^{nd} axis represented by 18% and 17% respectively (Table: 5.6).

The 1^{st} axis was positively influenced by Number of herb species (r= 0.3888), Herb abundance (r= 0.067), Average Tree Height (r= 0.0457) and Average Tree GBH (r= 0.0078), whereas negatively influenced by Number of Tree species (r= -0.5528), Tree abundance (r= - 0.0517), shrub abundance (r= -0.0067). Fisher's alpha (r= -0.309), species richness (r= -0.188) and abundance (r= -0.0748) was showed negative influence on the 1^{st} axis.

The 2nd synthetic axes was positively influenced by Average Tree Height (r= 0.4176), Average Tree GBH (r= 0.0866) and Tree abundance (r= 0.0841) but negatively influenced by Number of Tree species (r= -0.2549), Number of herb species (r= - 0.1944), Herb abundance (r= -0.198) and Shrub abundance (r= -0.1786). Fisher's alpha (r= 0.453), species richness (r= 0.3921) and abundance (r= 0.1844) showed positive influence on the 2nd axis (Table: 5.7).

Table 5.7: Intraset correlations between Vegetation related variables and major ordination axes resulting from the CCA, with Geometridae species richness, abundance and fisher's alpha ordination.

Explanatory variables	Axis 1	Axis 2	Axis 3
Tree abundance	-0.0516	0.0841	0.4554
Average Tree Height	0.0457	0.4176	-0.2616
Average Tree GBH	0.0078	0.0866	-0.3805
Shrub abundance	-0.0066	-0.1786	0.1982
Number of Herb species	0.3888	-0.1944	0.2540
Herb abundance	0.0669	-0.1980	0.4570
Species richness	-0.1880	0.3920	0.0704
Abundance	-0.0748	0.1843	-0.0597
Fisher's alpha	-0.3090	0.4530	0.2596

So, the CCA result showed that Number of herb species, Shrub abundance and Herb abundance had a prominent negative influence but Average tree height, Average tree GBH, Number of tree species had a strong positive impact on Geometridae moth diversity and abundance (Fig: 5.10). So, it can be suggested that, mature, primary forest habitats with high foliage diversity, especially trees with high girth-size strongly influence Geometridae moth diversity and abundance as larvae of this family feed on the forest trees, not like grass-feeding Noctuidae who prefers open kind of habitats with less trees and more herb covers.

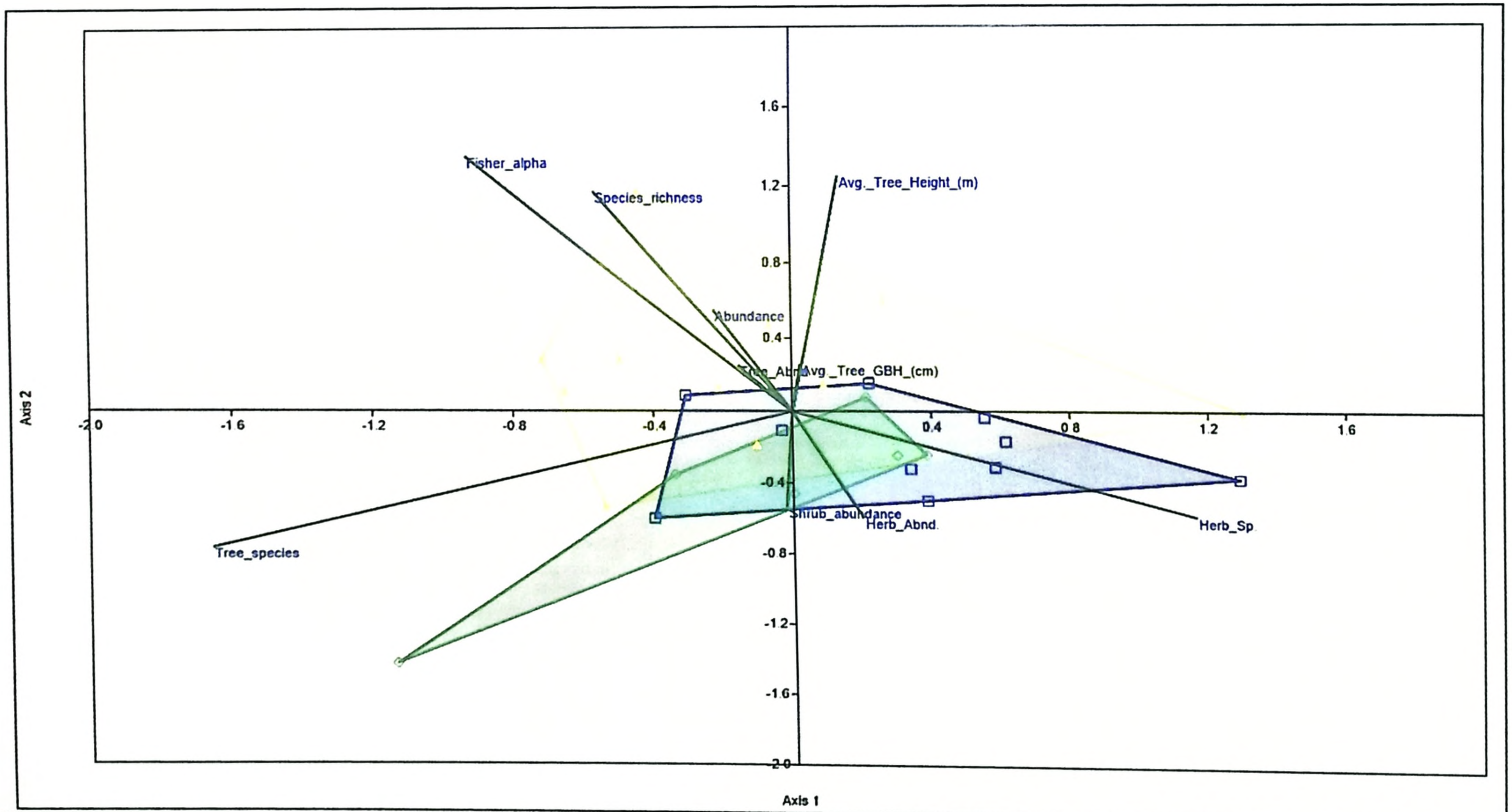


Fig. 5.10: CCA biplot based on species abundance, richness and diversity of Family Geometridae & major vegetation structural variables with sites (Yellow= altitudinal site between 1500- 2300m, Blue= altitudinal site between 2301- 3000m, Green= altitudinal site above 3000.

d) CCA with anthropogenic disturbance factors, Geometridae Diversity and abundance:

Logging sign, lopping sign, number of dead trees, Number of dung/ pellets and Nearest village distance (m) were used as Anthropogenic disturbance factors affecting Geometridae diversity (Fisher's alpha), species richness and abundance in the CCA.

Table 5.8: Summary of Canonical correspondence Analysis (CCA) for species abundance, richness and diversity of Family Geometridae with axes related to the Disturbance factors.

Axis	Eigenvalue	%
1	0.5332	25.46
2	0.3351	16
3	0.3212	15.34
4	0.28077	13.41
5	0.25966	12.4

In this CCA, the first two synthetic axis showed total 42% of the variation, of which the 1st and 2nd axis represented by 26% and 16% respectively (Table: 5.8).

The 1st axis was positively influenced by Nearest Village (r= 0.789) and negatively influenced by Logging sign (r= -0.6848), Number of dead tree (r= -0.5111), Lopping sign (r= -0.318) and Number of dung/ pellets (r= -0.1348). Fisher's alpha (r= -0.3495), species richness (r= -0.2613) and abundance (r= -0.0868) was also showed negative influence on the 1st axis.

The 2nd synthetic axes was positively influenced by Lopping sign (r= 0.7329), Number of dung/ pellets (r= 0.3923), Logging sign (r= 0.085) and

Nearest village distance (r= 0.0027) but negatively influenced by number of dead tree (r= -0.7267). Species richness (r= -0.252), abundance (r= -0.25) and Fisher's alpha (r= 0.1415) showed negative influence on the 2nd axis (Table: 5.9).

Table 5.9: Intraset correlations between Disturbance variables and ordination axes resulting from the CCA, with Geometridae species richness, diversity and abundance

Explanatory variables	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5
Logging sign	-0.6848	0.0851	-0.2845	-0.4649	-0.0856
Lopping sign	-0.3180	0.7329	-0.3120	-0.5559	0.5462
Dead Tree	-0.5111	-0.0727	0.3031	0.1196	-0.0977
Number of Dung/ Pellets	-0.1348	0.3923	-0.0068	-0.4111	0.2339
Nearest Village distance	0.7886	0.0027	0.1474	0.6190	-0.2065
Species richness	-0.2613	-0.2521	-0.0671	0.3379	0.1539
Abundance	-0.0868	-0.2501	0.1458	0.3792	0.1022
Fisher's alpha	-0.3495	-0.1415	-0.3036	0.1523	0.3693

So, the CCA result showed that the number of Dead Trees and Logging sign had positive influence on Geometridae diversity supporting mid-disturbance hypothesis which says diversity increases with mild level of disturbance as they created more spaces for regeneration. All the other disturbance factors like number of dung/ pellets, lopping sign and Nearest village distance had distinctly negative influence on Geometridae diversity (Fig: 5.11).

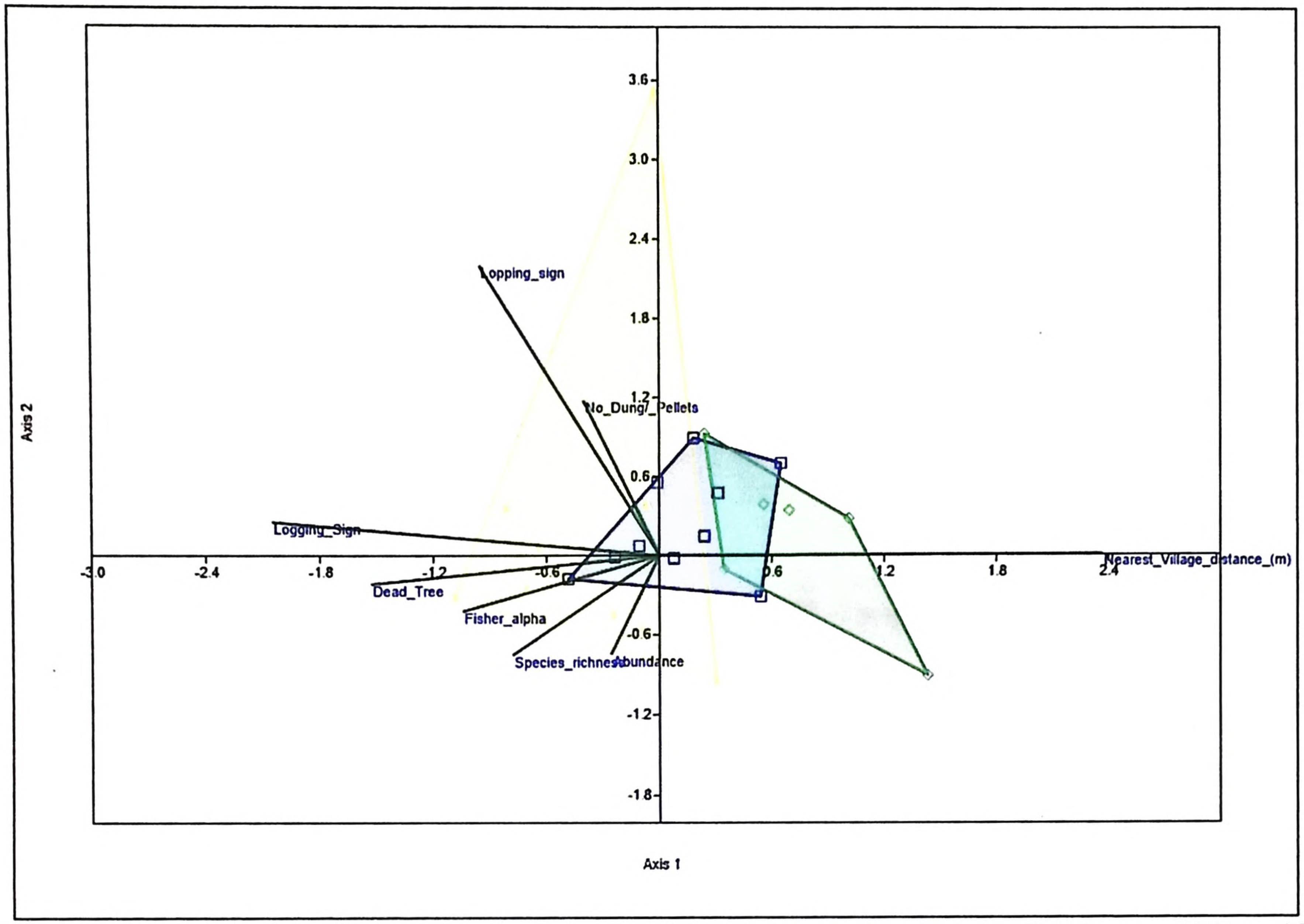


Fig. 5.11: CCA biplot based on species abundance, richness and diversity of Family Geometridae & major disturbance variables with sites (Yellow= altitudinal site between 1500- 2300m, Blue= altitudinal site between 2301- 3000m, Green= altitudinal site above 3000.

Chapter 6: Potential of Geometrid moths as an indicator of habitat quality in GHNP

6.1. Introduction:

Lepidoptera, especially Butterflies have been advocated as ideal indicators of ecological impact assessment, but they are generally poorly represented in closed-forest environments, moreover, they are not easy to trap or attract in considerable abundance for data robustness. On the contrary, setting a light trap give the opportunity to have a quantifiably huge of abundance of moths in much more species richness, thus can be more appropriate in giving insights about finer level ecosystem impacts on animal diversity (Ehrhardt, 1985; Ehrhardt & Thomas, 1991; Daily & Ehrlich, 1995; Hill *et al.*, 1995; Hill & Hamer, 1998; Holloway, 1977 & 1985; Sanyal, 2015). Moths are majorly herbivorous and may denote a measure of the quality of the foliage/vegetation in any area.

"Bio-indicator value" of systematically sampled insect taxa can be quantified using Indicator Species Analysis (ISA) or Indicator Value method (IndVal) designed by Dufrêne & Legendre (1997). This method can be measured by combining dimensions of the degree of specificity of a taxon to an ecological state, like, different habitat zone and its accuracy within that state (Dufrêne & Legendre, 1997; Sanyal, 2015). High specificity and High frequency of occurrence within a habitat or forest type of a species will have a high indicator value. By this method, indicator species can be detected for a particular habitat, moreover, detector species can be also identified to provide complementary information with indicator species.

The main aim of this study is to identify the indicator species and detector species for every vegetation type, altitudinal zones in the Great Himalayan National Park to find the species of conservation significance. Moreover, to understand climatic and habitat specificity of a model Geometridae genus, habitat-suitability model of the selected species under Ennominae genus *Psyra* were generated under current climatic conditions

6.2. Methodology:

6.2.1. Indicator species Analysis:

A total of seven habitat zones from the study area are considered as habitat categories/types for performing ISA: Himalayan Chir Pine Forest (HCP), Moist Temperate Deciduous Forest (MTD), Moist Deodar Forest (MDF), Western mixed Coniferous Forest (WMC), Western Himalayan Upper Oak Fir Forest (WHOF), Sub-alpine Forest (SAF) and Alpine Forest (AF). Six altitudinal zones also had been classified from the study area as previously (Table 6.1). A total of 266 morpho-species of Geometrid moth was taken for the Indicator Species Analysis (ISA).

Table 6.1.: Sampling sites grouped into different habitat class, altitudinal zones in GHNP

Site	Habitat Class	Altitude class
Ropa FRH	HCP	1500-1800
Jungla	HCP	1500-1800
Kathyaugi	HCP	1500-1800
Denga Pool	MTD	1800-2100
Khain	MTD	1800-2100

Site	Habitat Class	Altitude class
Kleuen	MDF	1800-2100
Raghdhini	MDF	1800-2100
Shakti	MTD	1800-2100
Shakti Water Fall	MTD	2100-2400
Lapah	MDF	2100-2400
Shakti-II	MTD	2100-2400
Riush Thatch	WMC	2100-2400
Bhagisaree	WMC	2100-2400
Padhar	WMC	2100-2400
Marrorh	WMC	2400-2700
Sudra budra	WMC	2400-2700
Gajnao	WHOF	2400-2700
Baghi Thatch	WHOF	2400-2700
Kherchar	WMC	2400-2700
Vred Nala	WHOF	2700-3000
Thati	WHOF	2700-3000
Parkachi	SAF	2700-3000
Dawada	SAF	2700-3000
Majan Golu	SAF	above 3000
Thihnhi	AF	above 3000
Dhung	SAF	above 3000
Dhel Hut	AF	above 3000

ISA was performed in software PCORD to produce the Indicator value of each species pertaining to a particular site. The Indicator value was calculated as percentage value accounting for species specificity, A_{ij} and fidelity, Bij.

Specificity measure: A_{ij} = N individuals$_{ij}$/N individuals$_i$

Where *Nindividualsij* is the mean number of species *i* across sites of group *j*, and *Nindividualsi* is the sum of the mean numbers of individuals of species *i* overall groups:

Fidelity measure: Bij = *N sites*$_{ij}$/N *sites*$_j$

Where *Nsitesij* is the number of sites in the cluster (habitat) *j* where species *i* is present, and *Nsites*j is the total number of sites in that cluster. The percentage indicator value for species *i* in the cluster (habitat) *j* is then:

$$IndValij = Aij \times Bij \times 100$$

For testing the significance of Indicator value for each species, a random reallocation procedure of sites among site groups was used (Dufrêne & Legendre's, 1997) in PCORD. Good indicator species was defined by higher Indicator score with statistical significance. From the significant Indicator Value (IV) percentage produced from this analysis, characteristic moth species were then identified (McGeoch *et al.,* 2002). Species were regarded as good Indicators for a particular habitat if Indicator values reaches more than 70% whereas, species with the 50% -70% score are regarded as detector species significant as detectors of changes in a particular habitat (McGeoch *et al.* 2002).

6.2.2. Distribution Modelling:

Combining both primary and geo-referenced secondary locations along with the spatial environmental variables, the presence-only MaxEnt software (Ver: 3.4.1) was used to predict and quantify the present suitable habitat areas for the Genus *Psyra* and futuristic model predictions for selected species. Out of the 5 species discussed here species having the highest unique occurrence locations (*Psyra angulifera*) and a range-restricted species (*P. debilis indica*) were chosen for the candidates of future models for better understanding of their habitat changes during the years 2041–2060. For better prediction, the occurrence locations should be spatially independent (Hijmans, 2012). Thus, for improved calibration and model development, the "spatially rarefy occurrence data" tool of SDM Toolbox v2.4 (Brown, 2014; http://sdmtoolbox.org/) was used to remove spatially auto-correlated points at a resolution of 2 kms (reducing occurrence localities to a single point within 2 km) using ArcMap 10.4. 19 bioclimatic variables used to represent the current climate features (averaged over 1970–2000) with 30 arc seconds resolution were obtained from the WorldClim database Version 2.1 (Fick & Hijmans, 2017; www.worldclim.org).

Following CMIP6, the future projections of the *Psyra* species were based on two carbon emission scenarios of Shared Socioeconomic Pathways (SSPs): SSP2–4.5, defined as the moderate optimistic scenario where emissions continue to increase through the end of the century, with resulting warming of 3.8–4.2 °C; and SSP5–8.5, the pessimistic "worst-case" scenario to have a resultant warming of 4.7–5.1 °C (www.Carbonbrief.org). The future bioclimatic variables of respective scenarios were downloaded from Worldclim for 2041–2060 at a resolution of 2.5 arc minutes. The General Circulation Models (GCMs) of BCC-CSM2-MR (The Beijing Climate Center Climate System Model) was used for the future prediction.

Values for all the climatic variables were extracted against each unique locality and after Principal Component Analysis (PCA), the variables having strong auto-correlation (correlation coefficient > 0.9) were removed.

Finally, the non-correlated variables and Digital Elevation Model (DEM) (USGS Landsat data; United States Geological Survey 2017) were used for the analysis. All the climatic and topographical variables thus used were cropped according to the species-specific biogeographical unit.

For the model of the genus and *P. angulifera*, 25 replicated models were generated by subsample method with a maximum of 5000 iterations, 10000 background points and MaxEnt cloglog function.

For *P. debilis indica*, the settings cross-validate was used. Out of the generated models, model validation was performed through threshold-independent evaluation using Receiver operating characteristics (ROC) from Area under ROC curve (AUC) value ranging from 0 to 1 where 0.5 resembles complete random model predictions (Phillips *et al.*, 2006). To calibrate and validate the robustness of results for the Maxent model, threshold-dependent True Skill Statistics (TSS) score was also employed. The final potential species distribution map had a range of values from 0 to 1, which were regrouped into four classes of habitat suitability: Unsuitable (0–0.25), Low (0.25–0.5), Moderate (0.5–0.75) and High (0.75–1). All the related GIS works were performed using ArcMap 10.4. For estimating the niche overlap, Schoener's D (as per Schoener, 1968) was calculated using the software ENM Tools v1.3 (Warren *et al.*, 2010).

6.3. Results and Discussion:

6.3.1. Indicator species of Geometridae for different habitat types:

Among 266 Geometridae morpho- species recorded from GHNPCA, only 5 species met the criteria of Indicator species and 18 species met the criteria of detector species from this study (Table: 6.2). Among them, four species from the subfamily Ennominae, *Ourapteryx purissima* and *Odontopera sp.* showed highest indicator value (100) with significant p value (0.001) for the Himalayan Chir Pine Forest, followed by *Ctenognophos eolaria* (90.7) and *Ctenognophos methoria* (93). *Rheumaptera dubiosata* of the subfamily Larentiinae showed an indicator value of 90 for Himalayan Chir Pine Forest.

Table 6.2: Indicator species of moths for different habitat types of GHNP (Indicator value bold for the Indicator species).

Sl. No.	Subfamily	Species	Habitat type	Observed Indicator value	p value
1	Ennominae	*Abraxas peregrina*	HCP	51.9	0.055
2	Ennominae	*Alcis nudipennis*	HCP	68.5	0.009
3	Ennominae	*Alcis subnitida*	AF	66.1	0.012
4	Ennominae	*Ascotis selenaria*	HCP	66.7	0.029
5	**Ennominae**	***Ctenognophos eolaria***	**HCP**	**90.7**	**0.001**
6	**Ennominae**	***Ctenognophos methoria***	**HCP**	**93**	**0.001**
7	Ennominae	*Ctenognophos sp*	HCP	66.7	0.025
8	Ennominae	*Ectropis dentilineata*	HCP	52.3	0.048
9	Ennominae	*Gnophos accipitraria*	HCP	53.3	0.024
10	Ennominae	*Gnophos albidior*	HCP	53.3	0.024
11	Ennominae	*Lassaba albidaria*	HCP	66.7	0.029
12	Ennominae	*Myrioblephara albibasis*	HCP	66.7	0.029
13	**Ennominae**	***Odontopera sp***	**HCP**	**100**	**0.001**
14	**Ennominae**	***Ourapteryx purissima***	**HCP**	**100**	**0.001**
15	Ennominae	*Oxymacaria temeraria*	HCP	66.7	0.029
16	Ennominae	*Sirinopteryx ablunata*	HCP	66.7	0.029
17	Larentiinae	*Electrophaes aliena*	MTD	61	0.022

Sl. No.	Subfamily	Species	Habitat type	Observed Indicator value	p value
18	Larentiinae	*Euphyia variegata*	HCP	55	0.027
19	Larentiinae	*Neotephria ramalaria*	AF	66.4	0.027
20	Larentiinae	*Photoscotosia amplicata*	AF	59.6	0.02
21	**Larentiinae**	***Rheumaptera dubiosata***	**HCP**	**90**	**0.024**
22	Larentiinae	*Costicoma exangulata*	HCP	66.7	0.029
23	Sterrhinae	*Rhodostrophia stigmatica*	HCP	58.8	0.045

Among 18 detector species, 12 species were belonging to Ennominae, 5 species were Larentiinae and one species from Sterrhinae. Among Ennominae, *Abraxas peregrina, Alcis nudipennis, Ascotis selenaria, Ectropis dentilineata, Gnophos accipitraria, Gnophos albidior, Lassaba albidaria, Myrioblephara albibasis, Oxymacaria temeraria* and *Sirinopteryx ablunata* were found to be detector species for the Himalayan Chir Pine forest type, whereas, *Alcis subnitida* was found to be a detector species for the Alpine forest.

Among Larentiinae, *Euphyia variegata* and *Costicoma exangulata* were found to be detector species for the Himalayan Chir Pine forest, whereas, *Electrophaes aliena* was found to be a detector species for Moist Temperate Deciduous Forest. *Neotephria ramalaria* and *Photoscotosia amplicata* were found to be detector species for Alpine forest.

Rhodostrophia stigmatica, a Sterrhinae species, was found to be a detector species for Himalayan Chir Pine Forest.

6.3.2. Indicator species of Geometridae for different altitudinal zones:

Among 266 Geometridae morpho- species recorded from GHNPCA, only six species met the criteria of Indicator species and 17 species met the criteria of detector species from this study (Table: 6.3). Among them, from the subfamily Ennominae, *Ourapteryx purissima* and *Odontopera sp.* showed highest indicator value (100) with significant p value (0.001) for the Zone 1 (1500- 1800m), followed by *Ctenognophos methoria* (93), *Ctenognophos eolaria* (91.1) and *Alcis nudipennis* (70.9). From the subfamily Larentiinae, *Rheumaptera dubiosata* showed an indicator value of 90.4 for Altitudinal zone 1.

Table 6.3: Indicator species of moths for different Altitudinal zones of GHNP (Indicator value bold for the Indicator species).

Sl. No.	Subfamily	Species	Habitat type	Observed Indicator value	p value
1	Ennominae	*Abraxas peregrina*	Zone 1	56.9	0.025
2	**Ennominae**	***Alcis nudipennis***	**Zone 1**	**70.9**	**0.002**
3	Ennominae	*Artemidora disistaria*	Zone 2	51.4	0.035
4	Ennominae	*Ascotis selenaria*	Zone 1	66.7	0.008
5	**Ennominae**	***Ctenognophos eolaria***	**Zone 1**	**91.1**	**0.001**
6	**Ennominae**	***Ctenognophos methoria***	**Zone 1**	**93**	**0.001**
7	Ennominae	*Ctenognophos sp*	Zone 1	66.7	0.005
8	Ennominae	*Ectropis dentilineata*	Zone 1	53.7	0.038
9	Ennominae	*Gnophos accipitraria*	Zone 1	53.3	0.021
10	Ennominae	*Gnophos albidior*	Zone 1	53.3	0.021
11	Ennominae	*Lassaba albidaria*	Zone 1	66.7	0.008
12	Ennominae	*Myrioblephara albibasis*	Zone 1	66.7	0.008
13	**Ennominae**	***Odontopera sp***	**Zone 1**	**100**	**0.001**
14	**Ennominae**	***Ourapteryx purissima***	**Zone 1**	**100**	**0.001**
15	Ennominae	*Oxymacaria temeraria*	Zone 1	66.7	0.008
16	Ennominae	*Sirinopteryx ablunata*	Zone 1	66.7	0.008
17	Larentiinae	*Euphyia variegata*	Zone 1	57	0.014
18	Larentiinae	*Eupithecia albigutta*	Zone 2	60	0.008
19	Larentiinae	*Neotephria ramalaria*	Zone 6	65.3	0.019
20	**Larentiinae**	***Rheumaptera dubiosata***	**Zone 1**	**90.4**	**0.004**

Sl. No.	Subfamily	Species	Habitat type	Observed Indicator value	p value
21	Larentiinae	*Costicoma exangulata*	Zone 1	66.7	0.008
22	Sterrhinae	*Rhodostrophia stigmatica*	Zone 1	61.5	0.014
23	Sterrhinae	*Scopula pallida*	Zone 1	50.5	0.033

Among 17 detector species, 12 species were belonged to Ennominae, 5 species were Larentiinae and one species from Sterrhinae. Among Ennominae, *Abraxas peregrina, Ascotis selenaria, Ctenognophos sp, Ectropis dentilineata, Gnophos accipitraria, Gnophos albidior, Lassaba albidaria, Myrioblephara albibasis, Oxymacaria temeraria* and *Sirinopteryx ablunata* were found to be a detector species for Zone 1, whereas, *Artemidora disistaria* was found to be a detector species for the Zone 2.

Among Larentiinae, *Euphyia variegata* and *Costicoma exangulata* were found to be detector species for the Zone 1, whereas, *Eupithecia albigutta* was found to be a detector species for Zone 2 and *Neotephria ramalaria* was found to be detector species for Zone 6.

Rhodostrophia stigmatica and *Scopula pallida* of Sterrhinae species were found to be detector species for Zone 1.

6.3.3. Habitat suitability of genus *Psyra* and other selected species:

The individual climatic suitability models generated for the genus *Psyra* and the selected species showed AUC values above 0.8 with a SD of 0.05—0.28 and TSS scores within 0.72–0.81, thus indicating good model predictions (Phillips *et al.,* 2006).

a) Climatic suitability model of Genus *Psyra*:

Mean Temperature of Warmest Quarter (BIO10) (28.5 %), Precipitation of Coldest Quarter (BIO19) (20.6 %), Temperature seasonality (BIO4) (20.1 %) and Precipitation of Driest Month (BIO14) (11.4 %) were found to be major bioclimatic variables accounting for 80 % cumulative influence on the overall distribution of the genus (Figure 6.1). Mean temperature of 0.5–3.0 °C in the warmest quarter was seen to be preferred by the *Psyra* species, along with precipitation of coldest quarter in the range of 0–700 mm, and 0–140 mm precipitation of the driest quarter. 80 % of the species occurrence probability was found to be rising sharply from 0-50 mm precipitation of the coldest quarter, after which there is a decline to 45 % occurrence probability till 120 mm, followed by 100 % occurrence probability peaking at 290 mm, finally to be stable at 40 % occurrence probability beyond 650 mm. It was found that 2–9 % temperature seasonality governs the occurrence probability, indicating moderate climatic conditions are optimal for the *Psyra* species.

18.9 X 10^4 sq. Km of presently high suitable area for the genus *Psyra* was found to stretch across the entire Himalayan Biodiversity Hotspot, along with the Garo-Khasi Hills, the Naga-Patkai hill Range of North-East India, the Arakan Mountain Range of Myanmar, the Hengduan Range in the border areas of Myanmar-China and Chungyang Shan of Taiwan, Akaishi Mountains and Mount Nikko-Shirane in Japan. 22.9 X 10^4 sq. Km of moderately suitable areas was found to be spread across the Hindu Kush range of South-Eastern and Eastern Afghanistan, Hindu Kush-Karakoram-Pamir landscape along the country borders of Afghanistan and Tajikistan, Kashmir Valley and the Zanskar Range in the erstwhile Indian state of Jammu & Kashmir, and the Dafla-Abor-Miri Ranges of North-East India, the Greater and Lesser Himalayan Range of Southern and Eastern Bhutan and the Hengduan Range of China.

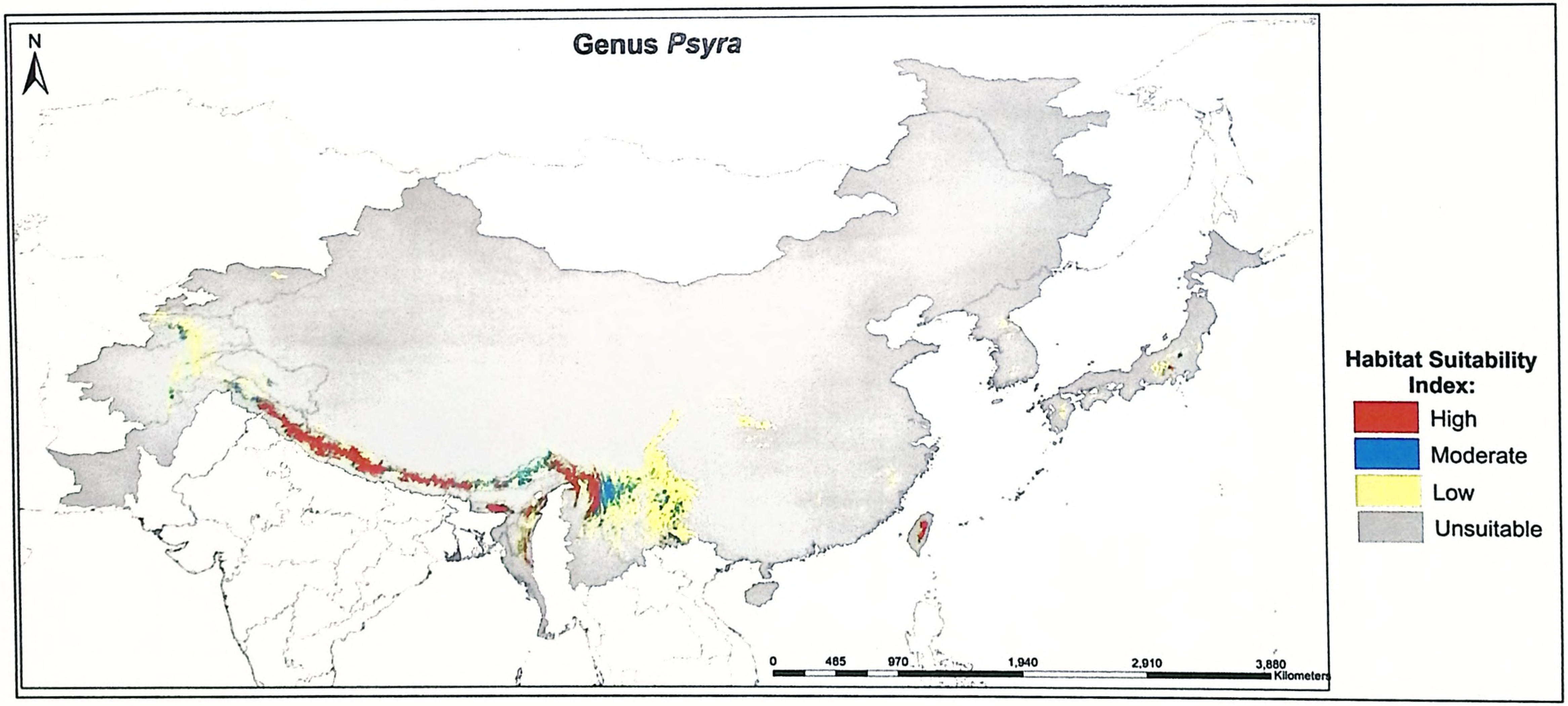


Figure 6.1.: Distribution area of genus *Psyra* under current climatic condition.

b) Climatic suitability model of *Psyra angulifera*:

The major bioclimatic variables governing the distribution for this species were found to be Annual Precipitation (BIO12), Elevation and Precipitation of Driest Month (BIO14) with 56.7 %, 35.9 %, 3.5 % contribution respectively (Fig. 6.2). Based on the response curves, this species is predicted to occur in areas having an annual precipitation range of 0–6500 mm and an elevation range of 1000– 4500 m with the highest species occurrence probability being at 2000 mm annual precipitation and 2300 m elevation. Additionally, very low precipitation of 2–52 mm in the driest month favours the distribution of this species.

In the present scenario, patchy distribution of 46.2 X 10^3 sq. Km of the highly suitable area occupied the entire HBH: border areas of Jammu & Kashmir and Himachal Pradesh; the entire state of Uttarakhand; Western, Central and Eastern Nepal; Sikkim and North Bengal; Western and Central Bhutan; and few scattered areas in West-Kameng, Lower Subansiri, Dibang Valley and Anjaw districts of Arunachal Pradesh. A total loss of 12.5 % area has been projected in 2041–60 under scenario SSP2–4.5. Major loss was projected from areas in Uttarakhand, Western and Central Nepal. Area gain was detected around all the presently suitable areas in Arunachal Pradesh. Under the scenario SSP5–8.5, the projected area was further reduced to 35.4 X 10^3 sq. Km with a total loss of 23.3 % making the overall distribution of *Psyra angulifera* highly disjunct.

11.3 X 10^4 sq. Km of present moderately suitable areas for the species stretched continuously along the entire stretch of HBH, Khasi Hills and the Hengduan Mountain range. In both the futuristic scenarios of SSP2–4.5 and SSP5–8.5, 15.3 % and 3 % area gain were projected respectively along the Khasi Hills, Naga-Patkai Hills, Arakan and Hengduan Mountain Range in Myanmar-China border, although few areas were predicted to be lost in Zanskar range and Khasi Hills under SSP5–8.5.

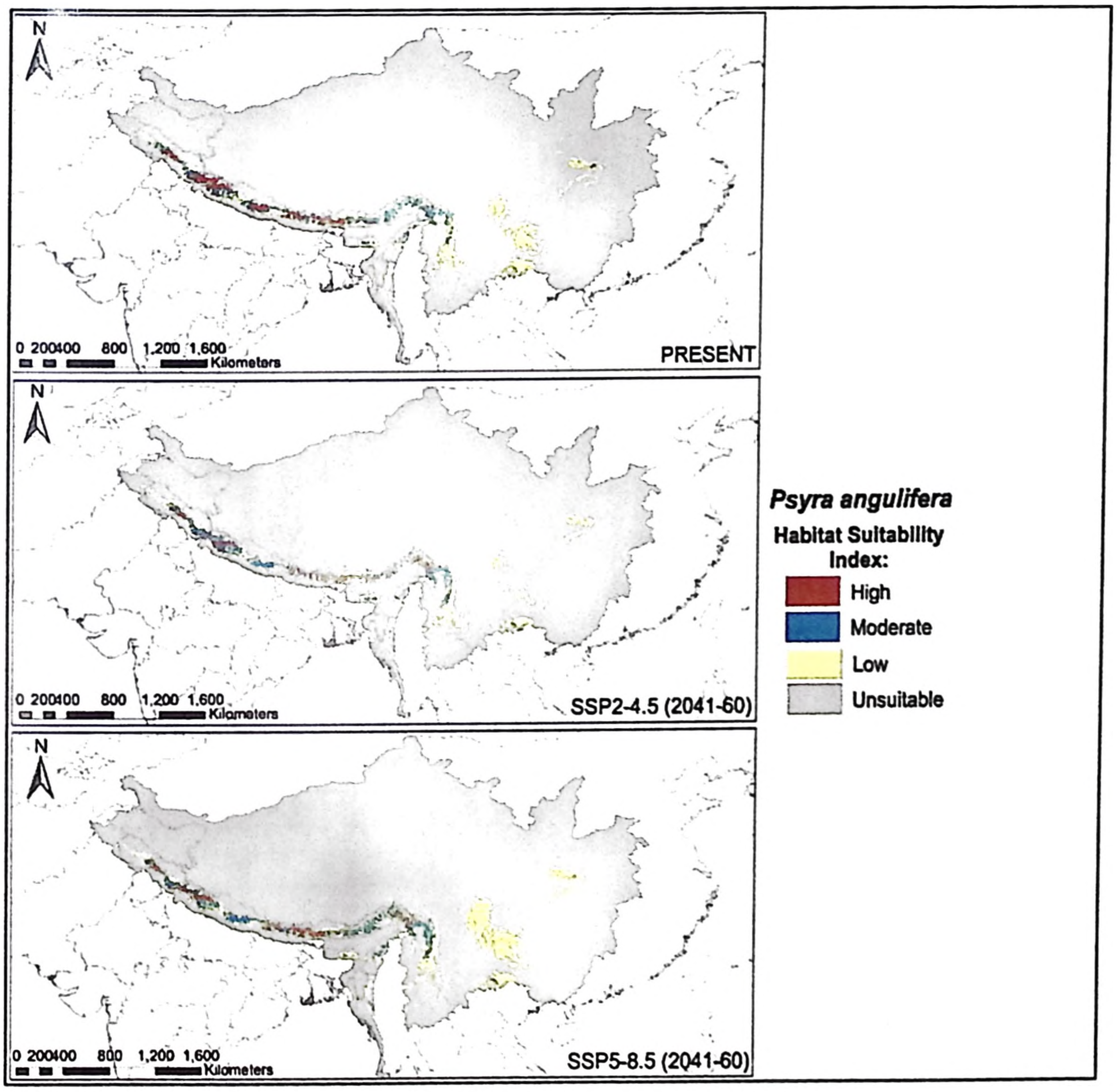


Figure 6.2.: Distribution area of *P. anguilifera* under current and future climatic scenarios of SSP2-4.5 & SSP5–8.5 in 2041–60.

c) Climatic suitability model of *Psyra debilis indica:*

Precipitation of Driest Quarter (BIO17) and Mean Diurnal Range (BIO2) of temperature was found to be affecting 90 % of the distribution for this species. Based on the response curves, a gradual gain in the occurrence probability of the species till 90 % was found to increase with increasing precipitation in the driest quarter, being stabilized at 120mm. The mean diurnal range was projected to have an inverse effect on the occurrence probability of the species, which kept on decreasing till 0 as the diurnal range increased from 0.5 to 1.3 °C.

An almost continuous highly suitable areas of 16.1 X 10^3 sq. Km stretches from Zanskar valley in Kashmir up till Chamoli district in Uttarakhand under the present scenario (Fig. 6.3). In the years 2041–60 under scenario SSP2–4.5, 18.9 % area loss was projected. Under scenario SSP5—8.5, area loss projected was 60.7 % making the previously continuous population broken into disjunct patches concentrated mainly in Shimla and Kullu district of Himachal Pradesh and Uttarkashi district of Uttarakhand. 24.5 X 10^3 sq. Km of present moderately suitable areas for the species was projected to undergo 3.7 % area gain under SSP2–4.5 and 3.3 % area loss under SSP5–8.5 in 2041–2060 (Table. 1).

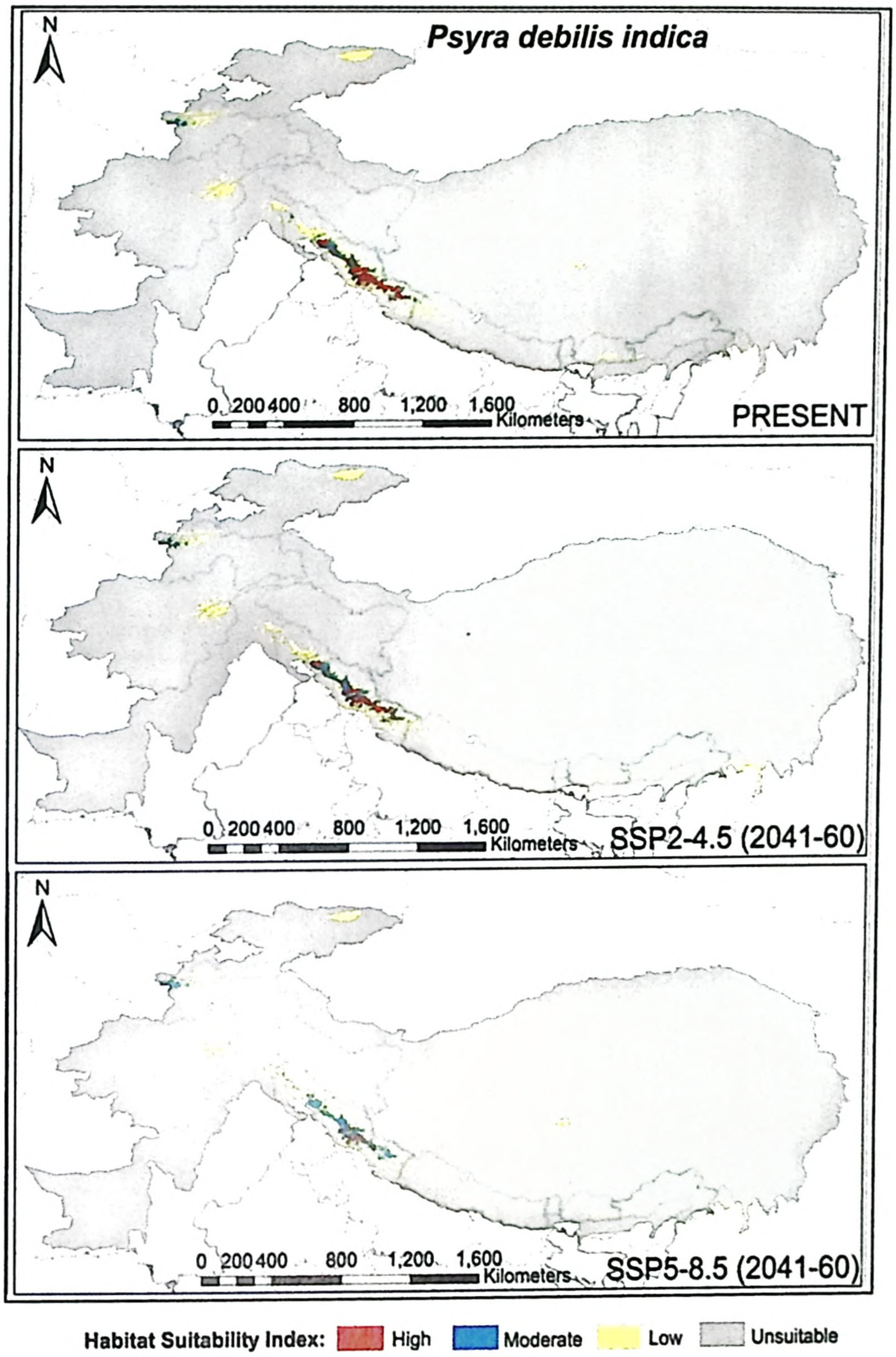


Figure 6.3.: Distribution area of *P. debilis indica* under current and future climatic scenarios of SSP2–4.5 & SSP5—8.5 in 2041–60.

Table 6.4: Area of present suitable habitats for the genus *Psyra* and selected species with percentage area gain or loss under different future climatic scenarios in 2041–60.

	SCENARIO	HABITAT SUITABILITY (sq.km)			HABITAT GAIN/LOSS (%)		
		High	Moderate	Low	High	Moderate	Low
Genus *Psyra*	**Present**	189661	229899	550238			
P. angulifera	**Present**	46190.25	112691.25	220887			
	SSP2–4.5 (2041–60)	40439.25	129883.5	180042.75	-12.45067953	15.25606469	-18.49101577
	SSP5—8.5 (2041–60)	35417.25	116012.25	247657.5	-23.3231039	2.946990117	12.11954529
P. debilis indica	**Present**	16038	24482.25	57165.75			
	SSP2–4.5 (2041–60)	13000.5	25373.25	59656.5	-18.93939394	3.639371381	4.35706695
	SSP5—8.5 (2041–60)	6297.75	23672.25	52994.25	-60.73232323	-3.308519438	-7.297201559

Chapter 7: Synthesis

7.1. Overview:

Moths are a much-neglected group compared to their close diurnal relative, butterflies in terms of the studies on species conservation, ecology and taxonomy due to their vast diversity, lack of base-line information on their biology, ecology as well as crypticism making identification difficult. They can be very difficult to identify up to species level externally due to their morphological variations, where genitalia dissection becomes necessary. Study on these herbivorous insect is in budding stage in our country as well as in Himalayan context. A few works have been started in recent years on their ecology and biology, so, the information is still insufficient and needs to be enhanced.

In this backdrop, current study aimed to generate a species inventory of all the major macro-moth families of the study area with an extra focus on taxonomy and ecology of family Geometridae, largest among moth families universally and in this study. Besides providing a complete species inventory with site codes and distribution worldwide and within India, the study gave a detailed taxonomic account of all the Geometridae species sampled from different altitudinal zones and habitat, with their: Most recent current valid name, detailed synonymy with complete reference list, habitus and genitalia illustrations, external morphological as well as genitalia diagnosis differentiating with most closely related species, altitude sites and habitat zones in GHNP from where the species is recorded with complete and updated in-depth distribution of the species.

Thus, entire sampling effort spanning 2016-2019 resulted in overall, 516 species of moths belonging to 21 families. Among them, 47 species were recorded for the first time from India and added as new to Indian moth list; 86 species were reported for the first time from Western Himalaya, while they were restricted previously in other Himalayan biogeographic zones; 93 species were reported as new to the state of Himachal Pradesh from this study. A total of 224 species of Geometridae species were reported with representation of two major subfamilies as 123 species of Ennominae under 56 genera, among which 8 species are new records to the country, followed by 79 species of Larentiinae under 38 genera with 9 among them as first record to the country. Besides reporting this large species richness data, molecular techniques were applied to generate barcode sequences of identified specimens to be submitted to global BOLD database, and to have an insight about intra- and inter-specific divergences among Geometridae moths. Preliminary yet diverse data showed clear phylogenetic positions among two major subfamilies. Among genus cladding, some ambiguities came to be noticed pertaining to the genera *Alcis* and *Loxaspilates*, which should be subjects of further in-depth taxonomic research involving both genitalia and molecular approach. Their taxonomic accounts have been discussed along with their genitalia and habitus images. Major ecological aspects also had been discussed in three separate chapter.

7.2. Distribution pattern of geometrid moths in different Altitudinal zones:

Family Geometridae's large species richness data and their counted abundance (*n*=3069) were used to ask relevant ecological questions concerning diversity trends along elevation gradients within respective habitat types. Overall distribution pattern of Geometridae showed a comparatively high diversity and abundance in lower and mid altitudinal zones, indicating close affinity with the lower and mid altitudinal habitat types like, Himalayan Chir Pine Forest, Moist Temperate Deciduous Forest, Moist Deodar Forest and Western Mixed Coniferous Forest. Three among the most abundant subfamilies Ennominae, Sterrhinae and Geometrinae also showed similar distributional pattern along the elevational gradient. But, second largest subfamily Larentiinae showed a unique distribution pattern along the altitude. Diversity of Larentiinae was highest in lower altitudinal area and moderate in highest altitudes but their abundance was highest in the alpine zones. Alpine and subalpine areas characterized by tree and shrub species of Birch-Fir-Oak-Rhododendron habitats hold significant host plant populations of different Larentiinae species. Moreover, the trend can be interpreted from a different perspective as that the key to the species survival in harsh subalpine and alpine areas is evolutionary fixed with high population size.

From the context of generalist or specialist species, *Rheumaptera dubiosata*, *Ctenognophos eolaria* (Ennominae) and *Chlorissa gelida* were (Geometrinae) seen to be the generalist species associated with variety of habitats like Chir Pine, Temperate Deciduous, Deodar, Alder and Mixed Coniferous Forest spanning lower and mid altitudinal areas, and abundance of these species got much reduced in the high altitudinal zones.

On the other hand, among the set of specialist species, which are also of more conservation significance, are *Psyra debilis indica, Laciniodes plurilinearia* and *Sirinopteryx quadripunctata* with Zone 2, i.e., 1800-2100 m altitudinal range, showing their affinity towards Moist Temperate Deciduous Forest (12/C1e) and Moist Deodar Forest (12/C1c).

Myrioblephara xanthozonea, Perizoma antisticta, Lomographa platyleucata, Parectropis conspurcata and *Arichanna interplagata* were found to be specialist species group for Zone 3, i.e., 2100-2400 m altitudinal range, showing their preference towards Alder Forest (Riverine) (12/1S1), Moist Temperate Deciduous Forest (12/C1e) and Moist Deodar Forest (12/C1c).

Neotephria ramalaria, Xanthorhoe hampsoni, Photoscotosia polysticha, Micrabraxas melanodonta, Eupithecia cf asempiterna, Perizoma variabilis, Photoscotosia dejuncta and *Arichanna flavinigra* were found to be set of specialist species for Zone 6 i.e., highest altitudinal zone above 3000 m altitude, showing their preference towards alpine and subalpine habitats. This set of species are of higher conservation importance, as of being at the edge of available habitat on mountain tops, how they will respond to the ongoing climate changes will be major focus of future research.

7.3. Factors governing geometrid moths' diversity and distribution pattern:

Besides recording faunal data, their immediate habitats were characterized by collecting a variety of topographical-climatic-vegetation-disturbance parameters collected from immediate vicinity of the species-catch, to do a comparative analysis to see effect of each explanatory variables. Overall result showed that climatic factors like Average trap night temperature, Average trap night humidity, topographic feature NDVI as a proxy of habitat-cover, variables indicating mature, primary forest habitats like Average tree height, Average tree GHB, Number of tree species had a strong positive influence on Geometridae abundance, species richness and Diversity (fisher's alpha).

On the other hand, all the precipitation related variables like Annual precipitation, Precipitation of Wettest Quarter, Precipitation of Driest Quarter, Precipitation of Warmest Quarter as well as Altitude, Number of herb species, Shrub abundance, Herb abundance, Number of dung/ pellets, lopping and Nearest village distance had strong negative influence on Geometridae abundance, richness and diversity.

It can be concluded that Geometrid moths being mainly associated with forest cover and structural variables, have a strong preference for lower to mid altitudinal, natural, undisturbed, forested habitats rather than grassland or alpine habitats associated with higher altitudes. Higher precipitation may be related to over-explosive bloom in foliage diversity, which may in turn affect undergrowth and forest openness and subsequent regeneration which jointly disfavour Geometridae diversity. Besides grazing, branch-lopping which are obviously sign of presence of nearby villages negatively influenced Geometridae diversity. All the dataset analysed indicated altitude negatively influenced Geometridae richness and abundance, only exception observed in case of subfamily Larentiinae.

7.4. Biogeographic Affinity among moths of GHNP:

Among the total sampled moth assemblage of GHNP, 91% species were found to be of Oriental origin, while 83.5% species had affinities to Palearctic region. 14% species were distributed up to Australian Realm, while only 10% species had Ethiopian similarities.

In the context of Indian Biogeographic Zones and Provinces, only 21% and 26% species were distributed in two Trans-Himalayan Provinces, Ladakh Mountain (1A) and Tibetan Plateau (1B). Almost 80% of species were shared with Western Himalaya (2B), 72% with Central Himalaya (2C) and 45% species with Eastern Himalaya (2D). 45% of species were shared with North-Eastern Hills & Valleys, whereas 18% and 17% species were shared with the Western Ghats and Deccan Peninsula, respectively (Figure 7.1).

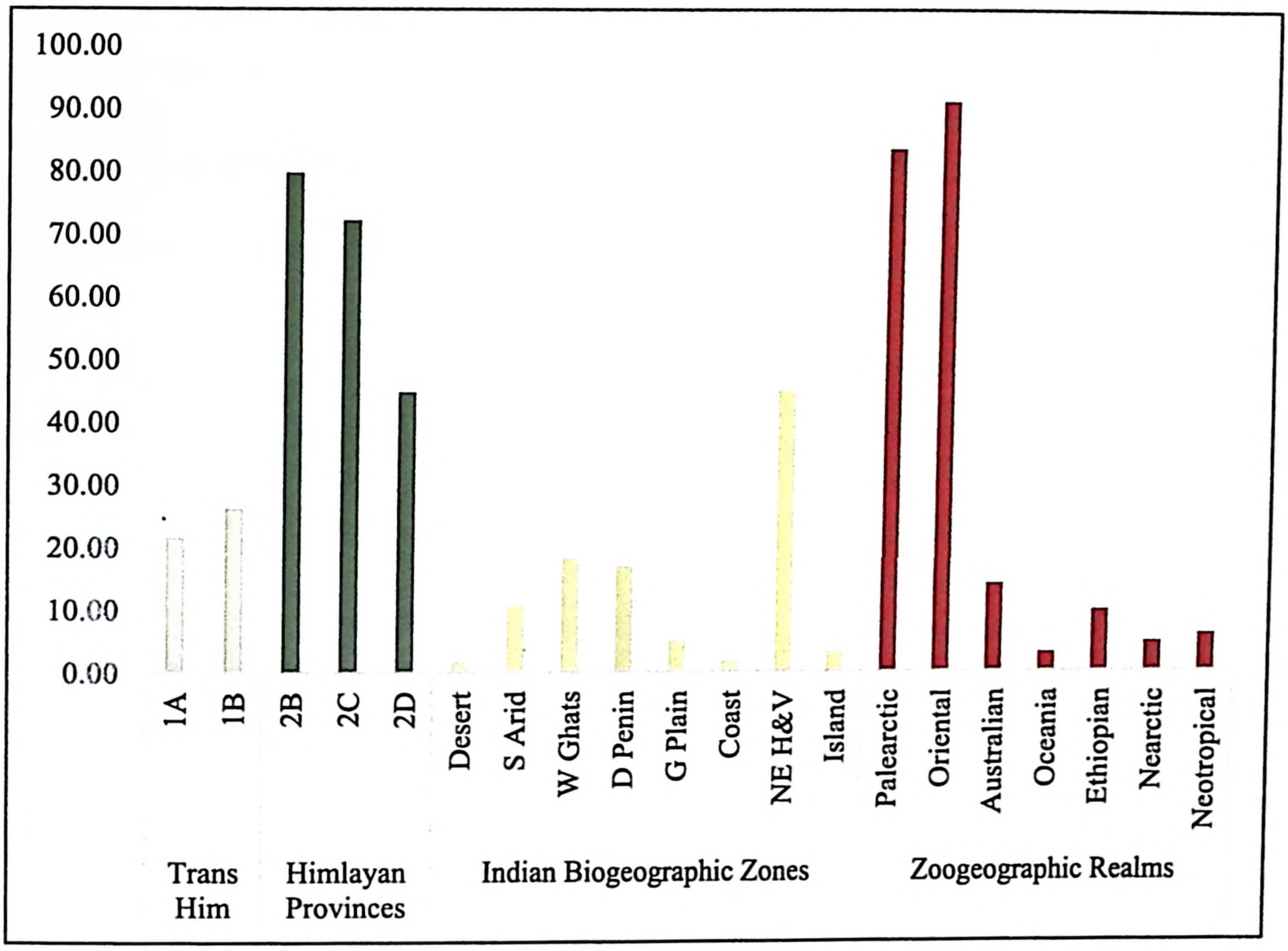


Figure 7.1.: Biogeographic affinities (% representation) of GHNP Moths with other Himalayan Provinces, Indian Biogeographic Zones and World Zoogeographic Realms

7.5. Gap areas and Future scopes:

The current study is the first-ever extensive documentation on the taxonomy and ecology of moth assemblages, particularly of family Geometridae in a mountainous landscape of Himachal Pradesh. Clearly, several important aspects could not be covered in this study, due to the limitation of time and scope. The study presents an inventory of 516 species, which is only a fraction of the huge diversity of herbivorous, nocturnal, hyperdiverse taxon like moth, from a vast Himalayan mountainous ecosystem and a World Heritage Site, like Great Himalayan National Park.

Micro-moth diversity comprises a huge portion of the moth assemblages in any habitat and they can be good indicators for degraded forest type but was overlooked due to deficiency of the taxonomic expertise of those group. More systematic and repeat sampling was required for addressing in-deapth ecological questions and with better representations and interpretations. For such kind of study and climate change related experimentation, more time and long-term survey is primarily required for the better interpretations of results. This study can however act as excellent baseline information for the future researchers working on Climate change related faunal study in North-western Himalayan ecosystems.

Species distribution and Climate Envelope Modelling of range restricted species recorded in the current study were also attempted to assess species responses under future climatic scenario. The modelling will not only favour policy makers in designing effective conservation strategies for the management of this susceptible Himalayan ecosystems, but also agricultural sectors in agreeing with the best approach for Integrated Pest Management. Furthermore, knowledge on family-wise species status of moths of all the major families is required for real assessment of Lepidoptera richness of India which is unfortunately still reflected by the approximate numbers of species in majority of the cases.

References:

1. 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.
2. Alfred, J. R. B., Das, A. K., Sanyal, A. K. 1998. Faunal Diversity of India. ENVIS Centre. *Zoological Survey of India*, pp 311-318.
3. Anonymous. 2021. *Antipercnia belluaria* (Guenée, [1858]). *In* Sondhi, S., Y. Sondhi, P. Roy and K. Kunte (Chief Editors). *Moths of India, v. 2.41*. Indian Foundation for Butterflies.
4. Arora, G. S. 1983. On the Lepidopterous fauna of Andaman and Nicobar group of Island (India), Family Arctiidae. *Zoological Survey of India,* **60**: 1-49.
5. Arora, G. S., Gupta, I. J. 1979. Taxonomic Studies on Some of the Indian Nonmulberry Silkmoths (Lepidoptera: Saturniidae). *Memorandum of Zoological Survey of India*, **16**: 1-63.
6. Arora, G. S. and Chaudhury, M. 1982. Arctiidae of North-East India. *Technical Monograph. Zoological Survey of India,* **6**: 14.
7. Axmacher, J. C., Holtmann, G., Scheuermann, L., Brehm, G., Muller-Hohenstein, K.,Fiedler, K. 2004a. Diversity of Geometrid Moths (Lepidoptera: Geometridae) along an Afrotropical Elevational Rainforest Transect. *Diversity and Distributions,* **10**: 293-302.

8. Axmacher, J. C., Tu¨nte, H., Schrumpf, M., Mu¨ller-Hohenstein, K., Lyaruu, H.V.M., Fiedler, K. 2004b. Diverging diversity patterns of vascular plants and geometrid moths during forest regeneration on Mt Kilimanjaro, Tanzania. *Journal of Biogeography,* **31**: 895–904.

9. Bale, J.S., Masters, G.J., Hodkinson, I.D., Awmack, C., Bezemer, T.M., Brown, V.K., Butterfield, J., Buse, A., Coulson, J.C., Farrar, J. and Good, J.E., 2002. Herbivory in global climate change research: direct effects of rising temperature on insect herbivores. *Global change biology*, **8**(1): 1-16.

10. Bandyopadhyay, U., Dey, R., Bhattacharyya, K., Mallick, K., Mazumder, A., Gayen, S., Das, M., Raha, A., Sanyal, A. K., Kumar, V., Uniyal, V. P., Chandra, K. 2021. Taxonomy and Ecology of Genus *Phlogophora* Treitschke, 1825 (Lepidoptera: Noctuidae) in Indian Himalaya. *Zootaxa*, **5004**(2): 311–342.

Barlow, H. S. 1982. *An Introduction to the Moths of South East Asia*. The Malayan Nature Society, Kualalumpur. 1-292.

11. Bastelberger, M.J. 1911. Neue Geometriden vom Arisan (Formosa). Entomologische Rundschau. **28**:22–3.

12. Bastelberger, S.R. 1909. Beitrage zur Konntnis der Geometriden-Fauna der Insel Formosa. *Deutsche Entomologische Zeitschrift Iris.* **22**: 166–92.

13. Beck, J. and Chey, V. K. 2007. The Species Richness of Endemic Geometrid Moths in Northern Borneo. In Kendrick, R. C. (Ed.).

Proceedings of the First South East Asian Lepidoptera Conservation Symposium, Hong Kong, **2006**: 37-46.

14. Beck, J., Brehm, G. and Fiedler, K. 2011. Links between the environment, abundance and diversity of Andean moths. *Biotropica*, **43**: 208–217.

15. 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.

16. Beck, J., Schulze, C.H., Linsenmair, K.E., Fiedler, K. 2002. From forest to farmland: diversity of geometrid moths along two habitat gradients on Borneo. *Journal of Tropical Ecology*, **17**: 33–51.

17. Beeson, C. F. C. 1941. The Ecology and control of the forest insects of India and the Neighbouring countries. Bishen Singh Mahendra Pal Singh. Dehradun. India.

18. Bell, T. R. D. and Scott, F. B. 1937. Fauna of British India: Moths V. Taylor and Francis. 533 pp.

19. Bhattacharya. D. P. 1997. Fauna of West Bangal (Pyralidae). *Zoological Survey of India*, **7**: 319-408.

20. Biswas, O., Modak, B.K., Mazumder, A. and Mitra, B., 2016. Moth (Lepidoptera: Heterocera) diversity of Sunderban Biosphere Reserve,

India and their pest status to economically important plants. *Journal of Entomology and Zoology Studies*, **4**(2): 13-19.

21. Biswas, O., Shah, S.K., Mishra, P., Mallick, K. and Mitra, B., 2015. Taxonomic Account of Erebidae (Lepidoptera: Noctuoidea) Pests of Tea gardens of West Bengal, India. *Journal of Entomology and Zoology Studies*, **3**(5): 185-192.

22. Bodner, F., Strutzenberger, P., Brehm, G. and Fiedler, K., 2012. Species richness and host specificity among caterpillar ensembles on shrubs in the Andes of southern Ecuador. *Neotropical entomology*, **41**(5): 375-385.

23. Boisduval, J. B. A. D. 1829. *Essai sur una Monographie des Gygenides, suivi, du Tableau Methodique, des Lepidoptera d'Europe Paris.* De Plassan. **13**: 114.

24. Bonn, A., Storch, D., Gaston, K. J. 2004. Structure of the species energy relationship. *Proceedings of the Royal Society B: Biological Sciences*, **271**: 1685–1691.

25. Braham, 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.

26. Brehm, G. and Fiedler, K. 2004. Bergmann's Rule does not apply to Geometrid Moths along an Elevational Gradient in an Andean Montane Rainforest. *Global Ecology & Biogeography,* **13**: 7-14.

27. Brehm, G., Strutzenberger, P. and Fiedler, K. 2013. Phylogenetic diversity of geometrid moths decreases with elevation in the tropical Andes. *Ecography,* **36**: 1–7.

28. Brehm, G., Sussenbach, D., Fiedler, K. 2003. Unique Elevational Diversity Patterns of Geometrid Moths in an Andean Montane Rainforest. *Ecography,* **26**: 456- 466.

29. Brown, J.L. 2014. SDM toolbox: a python-based GIS toolkit for landscape genetic, biogeographic and species distribution model analyses. *Methods in Ecology and Evolution.* **5**(7): 694–700. https://doi.org/10.1111/2041-210X.12200

30. Busck, A. 1942. On the making of genitalia slides of Lepidoptera. Proc. *Hawaiian Ent. Soc.,* **11**(2): 157-163

31. Butler, A. G. 1878. Descriptions of new Species of Heterocera from Japan. Part III. Geometrites. - *The Annals and Magazine of Natural History Including Zoology, Botany, and Geology.* Fifth Series **1**: 392-407, 440-452. London (Taylor and Francis).

32. Butler, A.G. 1883. On a collection of Indian Lepidoptera received from Lieut, Colonel Charles Swinhoe; with numerous notes by the collector. *Proceedings of Zoological Society of London,*: 144-174.

33. Butler, A.G., Walsingham, T.D. and Hampson, G.F. 1889. Illustrations of typical specimens of Lepidoptera Heterocera in the collection of the British Museum. Order of the Trustees.

34. Camacho-García, J., Baixeras, J., Cordero, C. 2018. Males of the tortricid moth *Amorbia cuneana* (Walsingham, 1879) shed their genital spines inside the female during copulation. *Zoologischer Anzeiger.* **277**:197–202.

35. Champion, S.H. and Seth, S.K., 1968. A revised survey of the forest types of India. *A revised survey of the forest types of India.*

36. Chandra, K. 1993. New Records of Moths of Bay Islands. *Journal of Andaman Science Association*, **9**: 44-49.

37. Chandra, K. & S. Sambath. 2013. Moth diversity of Tawang District, Arunachal Pradesh, India. *Journal of Threatened Taxa*, **5**(1): 3565–3570. doi:10.11609/ JoTT.o2718.966

38. Chandra, K. 1996. Moths of Great Nicobar Biosphere Reserve, India. *Malyan Nature Journal,* **50**: 109-116.

39. Chandra, K., 2011. Insect fauna of states and Union Territories in India. *Arthropods and their Conservation in India (Insects & Spiders); ENVIS Bulletin*, **14**(1): pp.189-218.

40. Chandra, K., Mazumder, A., Sanyal, A. K., Ash, A., Bandyopadhyay, U., Mallick, K. & Raha, A. 2018. Catalogue of Indian Notodontidae Stephens, 1829 (Lepidoptera: Noctuoidea). *Zootaxa*, **4505**(1): 001-084.

41. Chettri, P. and Yonle, R. 2021. Partial checklist of moths (Lepidoptera) of Darjeeling hills, West Bengal, India. *International Journal of Entomology Research,* **6**(3): 89-99.

42. Chown, S.L., Gaston, K.J. 2000. Areas, cradles and museums: the latitudinal gradient in species richness. *Trends in Ecology and Evolution*, **15**: 311–315.

43. Clarke, J.F. 1941. "The preparation of slides of the genitalia of Lepidoptera." *Bulletin of the Brooklyn Entomological Society*, **36.4**: 149-161.

44. Colwell, R. K. 2006. EstimateS: Statistical estimation of species richness and shared species from samples. Version 8. User's Guide and Application. Online at http://purl.oclc.org/estimates.

45. Common, I. F. B. 1990. Moths of Australia. Melbourne University Press, Carlton. Victoria.

46. Cotes, E. C. and Swinhoe, C. 1886. A catalogue of Moths of India. 801 pp.

47. Cotes, E.C. & Swinhoe, C. 1888. Geometrites. In: *A Catalogue of the Moths of India. Trustees 1673 of the Indian Museum, Calcutta*; **IV**: 463–589.

48. Cramer, P. 1775. De Uitlandsche Kapellan Voorkomende in Drie Waereld Deaelen Asia, Africa en America Amserdam, S. J. Baalde and Utrecht, Barthelemy Wild. 399 pp.

49. Cui, L., Xue, D. and Jiang, N., 2019. A review of *Timandra* Duponchel, 1829 from China, with description of seven new species (Lepidoptera, Geometridae). *ZooKeys*, **829**: 43–74.

50. Cui, Le, Xue, Dayong & Jiang, Nan, 2019, Description of two new species of *Rhodostrophia* Hübner, 1823 from China (Lepidoptera, Geometridae), *Zootaxa,* **4563**(2): 337-353.

51. Currie, D. J., Mittelbach, G. G., Cornell, H. V. 2004. Predictions and tests of climate based hypotheses of broad scale variation in taxonomic richness. *Ecology Letters,* **7**: 1121- 1134.

52. Daily, G.C., Ehrlich, P.R. 1995. Preservation of biodiversity in small rain-forest patches: rapid evaluations using butterfly trapping. *Biodiversity and Conservation,* **4**: 35-55.

53. Dale, E.J., Kitching, R.L., Thebaud, C., Maunsell, S.C. and Ashton, L.A., 2019. Moths in the Pyrénées: spatio-temporal patterns and indicators of elevational assemblages. *Biodiversity and Conservation*, **28**(6): 1593-1610.

54. Davies, K., Melbourne, B., Margules, C. 2001. Effects of within and between-patch processes on community dynamics in a fragmentation experiment. *Ecology*, **82**: 1830–1846.

55. Devaraju, N., Bala, G., Modak, A. 2015. Effects of large-scale deforestation on precipitation in the monsoon regions: remote versus local effects. *Proc Natl Acad. Sci.* 2015, **112**(11): 3257–3262. https://doi.org/10.1073/pnas.1423439112

56. deWaard J. R, Hebert P. D. N., Humble L. M. 2011. A Comprehensive DNA Barcode Library for the Looper Moths (Lepidoptera: Geometridae) of British Columbia, Canada. *PLoS ONE.* **6**(3): e18290.

57. 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.

58. Dey, P., Hausmann, A. and Uniyal, V.P. 2019. Towards creating a DNA barcode reference library of geometrid moths from western Himalaya, India. *Spixiana*, **42**:47-59.

59. Dey, P., Uniyal, V. P., Chandra, K. & Hausmann, A. 2019. Patterns along the elevation and DNA barcoding of Geometridae moths from the Western Himalaya, India. Pp. 315 in: Hausmann, A. & Rajaei, H. (eds). *Proceedings of the tenth Forum* Herbulot 2018 (Stuttgart, Germany, 11-16 June 2018). *Spixiana* **42**(2).

60. Dickson, R. A. 1976. *Lepidopterist's Handbook.* The Amateur Entomologists, Orpington.

61. Didan, K. 2015. MOD13Q1 MODIS/Terra Vegetation Indices 16-Day L3 Global 250m SIN Grid V006. Distributed by NASA EOSDIS Land Processes DAAC. https://doi.org/10.5067/MODIS/MOD13Q1.006.

62. Donovan, E. 1800. An Epitome of the Natural History of the Iinsects of India and the Islands in the India Seas. London. T. Bensley.

63. Dufrene, M., Legendre, P. 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs,* **67**: 345-366.

64. Ehrardt, A. 1985. Diurnal Lepidoptera: sensitive indicators of cultivated and abandoned grasslands. *Journal of Applied Ecology,* **22**: 849-861.

65. Ehrhardt, A., Thomas, J.A. 1991. Lepidoptera as indicators of change in the semi-natural grasslands of low-land and upland Europe. *The Conservation of Insects and Their Habitats* (eds N.M. Collins & J.A. Thomas), pp 213-236. Academic Press, London, UK.

66. Fabricius, J. C. 1775. Systeam Entomologiae sistens insectorum classes, ordines Genera, Species, adiectis synonymis, locis Descdriptionibus, *Observationibus. Lipsiae* (Leipzig): 542-641.

67. Felder, C. 1874. Reise Oesterreichischen Fregatte Novara um die Erde in den jahran 1857, 1859. Zoologischer Theil, Zweite Abtheilung, Lepidoptera Heft 4 Wien Carl Gerold's Sohn plates: 75-135.

68. Fick, S.E. and Hijmans, R.J. 2017. WorldClim 2: new 1km spatial resolution climate surfaces for global land areas. *International Journal of Climatology.* **37**(12): 4302-4315.

69. Fleishman, E., Ray, C., Sjögren-Gulve, P., Boggs, C.L. and Murphy, D.D., 2002. Assessing the roles of patch quality, area, and isolation in predicting metapopulation dynamics. *Conservation Biology*, **16**(3): 706-716.

70. Forbes, W. 1923. The Lepidoptera of New York and Neighboring States. Part I: The Primitive Forms. Cornell University Agricultural Experiment Station Memoir no. 65. Ithaca New York, 729 pp.

71. Franklin, J.F., 1993. Preserving biodiversity: species, ecosystems, or landscapes. *Ecological applications*, **3**(2): 202-205.

72. Gaston, A.J., Garson, P.J. and Pandey, S., 1993. Birds recorded in the Great Himalayan National Park, Himachal Pradesh, India. *Forktail*, **9**: 45-57.

73. Gaston, K.J., Evans, K.L. 2004. Birds and people in Europe. *Proceedings of the Royal Society, London B,* **271**: 1649–55.

74. Ghosh, S. K. 2003. Fauna of Sikkim, *Zooogical Survey of India,* **9**: 217- 342.

75. Ghosh, S. K. and Choudhury, M. 1997. Fauna of West Bengal (Arctiidae). *Zooogical Survey of India,* **7**: 247-274.

76. Graeser L. Beitrage zur Kenntniss der Lepidopteren-Fauna des Amurlandes v. Berliner Entomologische Zeitschrift, 1892; **37**(2), 209–234. http://dx.doi.org/10.1002/mmnd.18920370208

77. Guenée, 1857. In Boisduval & Guenée, Histoire Naturelle des Insectes. Species Général des Lépidoptéres. Uranides et Phalénites. *Hist. nat. Ins., Spec. gén. Lépid.,* **9**: 1-514.

78. Gupta, S. L., Farooqi, S. I. and Chaudhary, H. S. 1984. Taxonomic Studies on some of Syntype of Indian Lymantriidae in British Musium (Nat. Hist.) London Part 5: Lymantria Sp. Reichenbachia Mus Ticrk Dresden. **22**: 23-29.

79. Hamer, K.C., Hill, J.K. 2000. Scale dependent effects of habitat disturbance on species richness in tropical forests. *Conservation Biology*, **14**: 1435-1440.

80. Hampson, G. F., 1891. The Lepidoptera Heterocera of the Nilgiri District. 111. Typological Specimen Heterocera of British Museum. **8**: 1-144.

81. Hampson, G.F. 1892. *Fauna of British India including Ceylon and Burma (Moths)*, Part I, Taylor and Francis, London pp 527.

82. Hampson, G.F. 1894. *Fauna of British India including Ceylon and Burma (Moths)*, Part II, Taylor and Francis, London pp 528.

83. Hampson, G.F. 1895. *Fauna of British India including Ceylon and Burma (Moths)*, Part III. Taylor and Francis, London pp 517.

84. Hampson, G.F. 1896. *Fauna of British India including Ceylon and Burma (Moths)*, Part IV. Taylor and Francis, London, pp 595.

85. Han, H., Galsworthy, A.C. and Xue, D., 2012. The Comibaenini of China (Geometridae: Geometrinae), with a review of the tribe. *Zoological Journal of the Linnean Society*, **165**(4): 723-772.

86. Han, H.X., Galsworthy, A.C. and Xue, D.Y., 2009. A survey of the genus *Geometra* Linnaeus (Lepidoptera, Geometridae, Geometrinae). *Journal of Natural History*, **43**(13-14): 885-922.

87. Hardwick D. F. 1950. Preparation of slide mounts of lepidoterous genitalia. *Canadian Entomologist*, **82**: 231–235.

88. Haruta, T. (ed.), 1994a. Noctuidae: Catocalinae and Ophiderinae. In Haruta, T. (ed.) Moths of Nepal, part 3 *Tinea* **14,** (Suppl. 2): pp 140-153.

89. Haruta, T. (ed) 2002. Moths of Nepal, part 6 *Tinea* **16,** (Suppl. 1): pp 163.

90. Haruta, T. (ed.), 1994b. Sphingidae. In Haruta, T. (ed.) Moths of Nepal, part 3 *Tinea* **14,** (Suppl. 2): pp 154-158.

91. Haruta, T. (ed.), 1994c. Saturniidae. In Haruta, T. (ed.) Moths of Nepal, part 3 *Tinea* **14,** (Suppl. 2): pp 159.

92. Hausmann, A., Haszprunar, G., Segerer, A.H., Speidel, W., Behounek, G. and Hebert, P.D., 2011. Now DNA-barcoded: the butterflies and larger moths of Germany. *Spixiana*, **34** (1): 47-58.

93. Hausmann, A., Hebert, P.D., Mitchell, A., Rougerie, R., Sommerer, M., Edwards, T. and Young, C.J., 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): 1-21.

94. He, X., Burgess, K.S., Yang, X.F., Ahrends, A., Gao, L.M. and Li, D.Z. 2019. Upward elevation and northwest range shifts for alpine Meconopsis species in the Himalaya–Hengduan Mountains region. *Ecology and evolution*. **9**(7):4055-64.

95. Hebert, P. D., Penton, E. H., Burns, J. M., Janzen, D. H., and Hallwachs, W. 2004. Ten species in one: DNA barcoding reveals cryptic species in the Neotropical skipper butterfly *Astraptes fulgerator*. *Proc. Natl. Acad. Sci. U.S.A*, **101**: 14812–14817.

96. Hebert, P.D., Stoeckle, M.Y., Zemlak, T.S., Francis, C.M. 2004. Identification of birds through DNA barcodes. *Plos biol.* **2**(10):e312.

97. Hebert, P.D.N., Cywinska, A., Ball, S.L. and deWaard, J.R. 2003. Biological identifications through DNA barcodes. *Proceedings of the Royal Society London* B, **270**:313–321.

98. Herbulot, C. 1995. Un nouveau *Ctenognophos* du nord-ouest de I'nde (Lepidoptera: Geometridae). *Bull. Soc. ent. Mulhouse,*:22.

99. Herich-Schaffer, G. A. W. 1854. *Sammlung never oder Wenig bekannter auserauropaischer Schmetterlinge.* **vol.1**, series 1. Regensburg G. J. Manz.

100. Hijmans, R.J. 2012. Cross-validation of species distribution models: removing spatial sorting bias and calibration with a null model. *Ecology*, **93**(3):679–88.

101. Hill, C. J. 1993. The species composition and seasonality of an assemblage of tropical Australian dung beetles (Coleoptera: Scarabaeidae: Scarabaeinae). *Australian Entomology,* **20**: 121–126.

102. Hill, J.K., Hamer, K.C. 1998. Using species-abundance models as indicators of habitat disturbance in tropical forests. *Journal of Applied Ecology,* **35**: 458-460.

103. Hill, J.K., Hamer, K.C., Lace, L.A., Banham, W.M.T. 1995. Effects of selective logging on tropical forest butterflies, Indonesia. *Journal of Applied Ecology,* **32**: 754-760.

104. Hilt, N. and Fieldler, K. 2005. Diverssity and Composition of Arctiidae moth Ensembles along a Successional Gradient in the Ecudorian Andes. *Diversity and Distributions* **11**: 387-398.

105. Himachal Wildlife Project, Gaston, A.J., Hunter, M.L. and Garson, P.J., 1981. The Wildlife of Himachal Pradesh, Western Himalayas: Report of the Himachal Wildlife Project. School of Forest Resources, University of Maine.

106. Holloway, J. D. 1983. The Moths of Borneo: part 4; Family Notodontidae. *Malayan Nature Journal,* **37**: 1-107.

107. Holloway, J. D. 1985. The Moths of Borneo: Part 14; Family Noctuidae: Subfamilies Euteliinae, Stictopterinae, Plusiinae, Pantheninae. *Malayan Nature Journal.* **38**: 157-317

108. Holloway, J. D. 1986. The Moths of Borneo: Part 1; Key to families; Cossidae, Metarbelidae, Ratardidae, Dudgeoneidae, Epipyropidae and Limacodidae. *Malayan Nature Journal,* **40**: 1-165.

109. Holloway, J. D. 1987b. The Moths of Borneo: Part 3; Laciocampidae, Eupterotidae, Bombycidae, Brahmaedidae, Saturniidae, Shingidae. Southdene Sdn. Bhd., Kuala Lumpur, Malaysia, pp 199.

110. Holloway, J. D. 1988. The Moths of Borneo: Part 6; Arctiidae: Arctiinae, Sytominae, Aganinae (to Noctuidae). Southdene Sdn. Bhd., Kuala Lumpur, Malaysia, pp 101.

111. Holloway, J. D. 1989. The Moths of Borneo: Part 12; Noctuidae: Noctuinae, Heliothinae, Hadeninae, Arconictinae, Amphipyrinae, Agaristinae. *Malayan Nature Journal,* **43**: 57-226.

112. Holloway, J. D. 1993-94. The Moths of Borneo: Part 11; Family Geometridae: Subfamily Ennominae. *Malayan Nature Journal,* **47**: 1-309.

113. Holloway, J. D. 1996. The Moths of Borneo: Part 9; Family Geometridae: Subfamily Oenochrominae, Desmobathrinae, Geometrinae. *Malayan Nature Journal.* **49**: 147-326.

114. Holloway, J. D. 1998b. The Moths of Borneo: Part 8; Family Castniidae, Callidulidae, Drepanidae, Uraniidae. *Malayan Nature Journal,* **52**: 1-155.

115. Holloway, J. D. 1999. The Moths of Borneo: Part 5; Family Lymantriidae. *Malayan Nature Journal,* **53**: 1-188.

116. Holloway, J. D. 2011. The Moths of Borneo (part 2): families Phaudidae, Himantopteridae and Zygaenidae; revised and annotated checklist. *Malayan Nature Journal,* **63**: 1–548.

117. Holloway, J.D. 1997. The moths of Borneo: family Geometridae, subfamilies Sterrhinae and Larentiinae. *Malayan Nature Journal,* **51**: 1-242.

118. Hübner, J. 1806. *Sammlung exotischer Schmetterlinge*. Augsburg. **1**: 36.

119. Hübner, J. 1816. *Verzeichniss bekannter Schmettlinge* [sic]. Augsburg [no publisher listed].431 pp.

120. Hübner, J. 1819. *Sammlung exotischer Schmetterlinge*. Augsburg. **2**: 44.

121. Hübner, J. 1823. *Zuträge zur Sammlung exotischer Schmettlinge [sic], bestehend in Betundigung einzeiner Fliegmuster neuer oder rarer Nichteuropäischer Gattungen. Zwentes Hundert*. Augsburg. 32 pp.

122. Inoue, H. 1954. A new species of the Geometridae. *Tinea*, **1**(2):38–39.

123. Inoue, H. 1970. Geometridae of eastern Nepal based on the collection of the Lepidopterological research expedition to Nepal Himalaya by the Lepidopterological society of Japan in 1963: Part I: Genera *Abraxas* Leach and *Arichanna* Moore *Spec. Bull. lepid. Soc. Japan* (4): 203-239.

124. Inoue, H. 1982. Geometridae of Eastern Nepal based on the collection of the Lepidopterological Research Expedition to Nepal Himalaya by the Lepidopterological Society of Japan in 1963. part II. *Bulletin of Faculty of Domestic Sciences, Otsuma Woman's University*, **18**:129–190.

125. Inoue, H. 1982. Geometridae. In: Inoue, H. et al. (Eds.), Moths of Japan. **1**:425–573.

126. Inoue, H. 1982. Geometridae. In: Inoue, H. et al. (Eds.), Moths of Japan. **2**:263–310.

127. Inoue, H. 1983. Eleven new species of the Geometridae from Taiwan. *Tinea*, **11**(16): 139–154.

128. Inoue, H. 1995. The genera *Abraxas* and *Ourapteryx* from Nepal (Geometridae: Ennominae): In: *Haruta T (Ed.), Moths of Nepal Part-IV. Tinea*, **14**(Suppl. 2): 119–139.

129. Inoue, H. 1999. Revision of the genus *Herochroma* Swinhoe (Geometridae, Geometrinae). *Tinea*, **16**(2): 76–105.

130. Intachat, J., Holloway, J. D. and Speight, M. R. 1997. The Effects of Different Forest Management Practices on Geometrid Moth Populations and their Diversity in Peninsular Malaysia. *Journal of Tropical Forest Science*, **9**: 411-430.

131. Intachat, J., Holloway, J. D. and Speight, M. R. 1999. The Impact of Logging on Geometroid Moth Populations and their Diversity in Lowland Forests of Peninsular Malaysia. *Journal of Tropical Forest Science,* **11**: 61-78.

132. Janzen, D. H., Hallwachs, W., Blandin, P. 2009. Integration of DNA barcoding into an ongoing inventory of complex tropical biodiversity. *Molecular Ecology Resources*, **9**: 1-26.

133. Jiang, N., Li, X., Hausmann, A., Cheng, R., Xue, D., Han, H. A. 2017. Molecular phylogeny of the Palaearctic and Oriental members of the

tribe Boarmiini (Lepidoptera: Geometridae: Ennominae). *Invertebrate Systematics*. **31**(4): 427–41.

134. Jiang, N., Xue, D. and Han, H., 2012. A review of *Peratophyga* Warren, 1894 in China, with descriptions of two new species (Lepidoptera: Geometridae, Ennominae). *Zootaxa*, **3478**(1): 403-415.

135. Jiang, N., Xue, D. and Han, H., 2014. A review of *Luxiaria* Walker and its allied genus *Calletaera* Warren (Lepidoptera, Geometridae, Ennominae) from China. *Zootaxa*, **3856**(1): 73-099.

136. Jiang, N., Xue, D., Han, H. 2011. A review of *Biston* Leach, 1815 (Lepidoptera, Geometridae, Ennominae) from China, with description of one new species. *ZooKeys*, **139**: 45–96. doi: 10.3897/zookeys.139.1308

137. Kamaluddin, S., Viqar, S.N., Khan, S. and Ali, A., 2007. Check List of the Moths (Lepidoptera: Heterocera) of Pakistan. *Int. J. Biol. Biotech*, **4**(3): 113-119.

138. Kirti, J. G. and Sodhi, J. S. 2003. Inventory of Tiger Moths of Sikkim (Arctiinae: Arctiidae: Lepidoptera). *Zoo's Print Journal*, **18**(7): 1143-1146.

139. Kirti, J. S., Kaur, M. and Goyal, T. 2011. Reporting of Unusual Testes in Three Species of Subfamily Ennominae (Lepidoptera: Geometridae). *Indian Journal of Entomology*, **73**(4): 303-307.

140. Kirti, J.S., Chandra, K., Saxena, A. and Singh, N. 2019. *Geometrid Moths of India*. Nature Books India. 296 pp

141. Kirti, J.S., Goyal, T. and Kaur, M., 2009. Morphology of the external male genitalia of five Indian geometrid species (Lepidoptera). *Journal of Threatened Taxa*, **1**(9): 484-487.

142. Kirti, J.S., Goyal, T. and Kaur, M., 2012. An inventory of family Geometridae (Lepidoptera) from Western-Ghats of India. *Journal of Entomological Research*, **36**(1): 83-94.

143. Kitching, I. J. and Rawlins, J. E. 1999. The Noctuoidea. In Kristensen, N. P. (Ed), Handbook of Zoology. Lepidoptera, Moths and Butterflies, vol. 1. Berlin, New York, Walter de Gruyter: 355-401.

144. Kitching, R.L., Orr, A.G., Thalib, L., Mitchell, H., Hopkins, M.S. and Graham, A.W., 2000. Moth assemblages as indicators of environmental quality in remnants of upland Australian rain forest. *Journal of applied Ecology*, **37**(2): 284-297.

145. Kollar, V. 1844. In: *Hügel, Kashmir und das Reich der Siek*. **4**(2): 395–496.

146. Körner, C. 2007. The use of 'altitude' in ecological research. Trends. *Ecol. Evol.*, **22**: 569–574. https://doi.org/10.1016/j.tree.2007.09.006

147. Körner, C., 2007. The use of 'altitude'in ecological research. *Trends in ecology & evolution*, **22**(11): 569-574.

148. Kremen, C., Colwell, R.K., Erwin, T.L., Murphy, D.D., Noss, R.A. and Sanjayan, M.A., 1993. Terrestrial arthropod assemblages: their use in conservation planning. *Conservation biology*, pp.796-808.

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

150. 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., Watt, A.D. 1998. Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. *Nature.* **391**: 72-75.

151. Leech JH. 1897. On Lepidoptera Heterocera from China, Japan, and Corea. *Annals and Magazine of Natural History*, **20**(6): 65–111,228–248. http://dx.doi.org/10.1080/00222939708680601

152. Lewinsohn, T.M. and Roslin, T., 2008. Four ways towards tropical herbivore megadiversity. *Ecology Letters*, **11**(4): 398-416.

153. Li, H., Jiang, N., Cheng, R., Zhang, C. and Han, H., 2018. A review of the subgenus *Epicterodes* of *Arichanna* (Lepidoptera, Geometridae, Ennominae), with description of one new species. *Journal of Asia-Pacific Entomology*, **21**(2): 501-512.

154. Linnaeus, C. 1758. Systema Naturae per Regnua Tria Naturae, Secundum classes, ordines, Genera, species, cum characteribus, Difffemtiis, Synonymis, locis. Tomis 1, 10th Edition: 492-596.

155. Liu, Z., Xue, D., Wang, W. and Han, H., 2013. A review of *Psyra* Walker, 1860 (Lepidoptera, Geometridae, Ennominae) from China, with description of one new species. *Zootaxa*, **3682**(3): 459-474.

156. Lodl, M. 2001. Morphometry and relation patterns in male genitalia of noctuids (Lepidoptera: Noctuidae). *Quadrifina,* **4**: 5-33.

157. MacKinnon, J., MacKinnon, K., Child, G. and Thorsell, J., 1986. *Managing protected areas in the tropics*. IUCN.

158. Mandal, D. K. and Bhattacharya. 1980. Pyraustinae from Andaman Island. *Zoological Survey of India,* **77**: 293-342.

159. Mandal, D. K. and Ghosh, S. K. 1991. On little-known Moths of Tripura, India. *Zoological Survey of India,* **88**: 299-334.

160. Mandal, D. K. and Ghosh, S. K. 1997. Fauna of West Bengal (Geomtridae). *Zoological Survey of India,* **7**: 491-532.

161. Mandal, D. K. and Ghosh, S. K. 1998. Fauna of Meghalaya (Geomtridae). *Zoological Survey of India,* **6**: 405-465.

162. Mandal, D. K. and Maulik, D. R. 1997. Fauna of West Bengal (Sphingidae, Lasiocampidae, Lymantridae). *Zoological Survey of India,* **7**: 613-688.

163. Mathew, G. 2006. An Inventory of Indian Pyralids (Lepidoptera: Pyralidae). *Zoo's Print Journal,* **18** (7): 2245-2258.

164. Mayr, E. 1971. Methods and strategies in taxonomic research. Syst. Zool., **20**: 426-433.

165. Mazumder, A., Raha, A., Sanyal, A. K., Gayen, S., Mallick, K., Bandyopadhyay, U., Chandra, K., Schintlmeister, A. 2019. A New Species of *Nerice* Walker, 1855 and Additions to the Catalogue of Indian Notodontidae Stephens, 1829 (Lepidoptera: Noctuoidea) from Himalaya with Report of Range Extensions. *Zootaxa*, **4748**(1): 119-140.

166. McCoy, E.D., 1990. The distribution of insects along elevational gradients. *Oikos*, 313-322.

167. Meyrick, E. 1910a. Description of Indian Micro-lepidoptera. *Journal of Bombay Natural History Society*, **20** (1): 140-168.

168. Meyrick, E. 1910b. Description of Indian Micro-lepidoptera. *Journal of Bombay Natural History Society*, **20** (2): 435-462.

169. Meyrick, E. 1911a. Description of Indian Micro-lepidoptera. *Journal of Bombay Natural History Society*, **20** (3): 706-736.

170. Meyrick, E. 1911b. Description of Indian Micro-lepidoptera. *Journal of Bombay Natural History Society*, **21** (1): 104-131.

171. Meyrick, E. 1912. Description of Indian Micro-lepidoptera. *Journal of Bombay Natural History Society*, **21** (3): 852-877.

172. Meyrick, E. 1913. Description of Indian Micro-lepidoptera. *Journal of Bombay Natural History Society*, **22** (1): 160-182.

173. Meyrick, E. 1914a. Description of Indian Micro-lepidoptera. *Journal of Bombay Natural History Society*, **22** (4): 771-781.

174. Meyrick, E. 1914b. Description of Indian Micro-lepidoptera. *Journal of Bombay Natural History Society,* **23** (1): 118-130.

175. Miller, J.R.B., Ramesh, K. and Rawat, G.S., 2008. Pheasant population recovery as an indicator of biodiversity conservation in the Great Himalayan National Park, India. *The Wildlife Institute of India.*

176. Miller, S.E., Hausmann, A., Hallwachs, W. and Janzen, D.H., 2016. Advancing taxonomy and bioinventories with DNA barcodes. *Philosophical Transactions of the Royal Society B: Biological Sciences*, **371**(1702): 20150339.

177. Mironov, V. and Galsworthy, A.C., 2013. *The Eupithecia of China: a revision*. Brill.

178. Mironov, V. and Ratzel, U. 2012. *Eupithecia* Curtis, 1825 of Afghanistan (Geometridae: Larentiinae). *Nota lepidopterologica,* **35**(2): 197-231.

179. Moore, F. 1868. On the Lepidopterous Insects of Bengal. Part- III. *Proceedings of the Zoological Society of London,*: 612-686, pl. 32-33.

180. Moore, F. 1888. Description of New Genera and Species of Lepidoptera Heterocera, collected by Rev. J. H. hocking chiefly in the Kangra district, N. W. Himalaya. *Proceedings of the Zoological Society of London,* 390 pp.

181. Moore, F., 1888. Descriptions of Indian Lepidoptera Heterocera from the collection of the late Mr. WS Atkinson. *Descriptions of new Indian*

lepidopterous Insects from the Collection of the late Mr. WS Atkinson, **5**, pp.pls-2.

182. Mutanen, M. and Kaitala, A. 2006. Genital variation in a dimorphic moth *Selenia tetralunaria* (Lepidoptera: Geometridae). *Biol. J. Linn. Soc.,* **87**: 297–307.

183. Mutanen, M., Kaitala, A. and Mönkkönen, M. 2006. Genital variation within and between three closely related *Euxoa* moth species: testing the lock-and-key hypothesis. *J. Zool.*, **268**: 109-119.

184. Mutanen, M., Rytkönen, S., Lindén, J. and Sinkkonen, J. 2007. Male genital variation in a moth *Pammene luedersiana* (Lepidoptera: Tortricidae). *Eur. J. Entomol,* **104**: 259-265.

185. Nandy, S., Singh, C., Das, K.K., Kingma, N.C. and Kushwaha, S.P.S., 2015. Environmental vulnerability assessment of eco-development zone of Great Himalayan National Park, Himachal Pradesh, India. *Ecological Indicators*,_**57**: 182-195.

186. Narendran, T.C. 2006. An Introduction to Taxonomy: 1-80 (Published by the Director, Zool. Surv. India, Kolkata)

187. Negi, A.S., 1996. Assessment of Issues related to soil erosion, landslides and to provide technical support to park management. *Wildlife Institute of India, Dehra Dun, India.*

188. Novotny, V., Drozd, P., Miller, S.E., Kulfan, M., Janda, M., Basset, Y., Weiblen, G.D. 2006. Why are there so many species of herbivorous insects in tropical rainforests? *Science*, **313**: 1115–1118.

189. Oberthür, C. 1910. Explication des planches publiées dans la IVe livraison des Études de Lépidoptères comparée. *Études de Lépidoptérologie compare* **4**: 665–682.

190. Omura, S. 1938. Studies of the reproductive system of the male of *Bombyx mori* II, Posttesticular organs and post-testicular behaviour of the spermatozoa. *Journal of Faculty of Agriculture, Hokkaido Imperial University*. **40**: 129-170

191. Ounap, E.R.K.I., Viidalepp, J.A.A.N. and Saarma, U.R.M.A.S., 2005. Phylogenetic evaluation of the taxonomic status of Timandra griseata and T. comae (Lepidoptera: Geometridae: Sterrhinae). *European Journal of Entomology,* **102** (4): 607.

192. Parsons, M.S., Scoble, M.J., Honey, M.R., Pitkin, L.M. & Pitkin, B.R. 1999. The catalogue. In: Scoble, M.J. (Ed.), *Geometrid moths of the world: a Catalogue (Lepidoptera, Geometridae).* CSIRO, Collingwood, 1–1016.

193. Phillips, S.J., Anderson, R.P., Schapire, R.E. 2006. Maximum entropy modeling of species geographic distributions. *Ecological modelling.* **190**(3-4): 231–59.

194. Prout, L.B. 1912–1916. The Palaearctic Geometrae. *In: Seitz A (Ed) The Macrolepidoptera of the World.* Vol. **4**, Verlag A. Kernen, Stuttgart, 1–479, pls. 1–25.

195. Prout, L.B. 1926. On a collection of moths of the family Geometridae from Upper Burma made by Captain A. E. Swann, *The journal of the Bombay Natural History Society*, **31**: 780–799.

196. Prout, L.B. 1928. New Sumatran Geometridae in the Joicey collection, *Bull. Hill Mus. Witley*, **2**(2): 142–160.

197. Püngeler, R. 1904. Neue palaearctische Macrolepidopteren. *Deutsche Entomologische Zeitschrift Iris*, **16**: 286–301.

198. Raha, A. 2018. Taxonomic studies on moths (Lepidoptera: Heterocera) emphasizing on genitalia and season-wise diversity fluctuations in Chhattisgarh, India. Thesis submitted to Calcutta University, Kolkata, India.

199. Ramesh, K., Sathyakumar, S. and Rawat, G. S. 1998. Recent trends in the Pheaant population in Great Himalayan National Park, Western Himalaya. *National seminar on Wildlife research and conservation and conservation.* WII, Dehradun.

200. Rana, S.K., Rana, H.K., Luo, D., Sun, H. 2021. Estimating climate-induced 'Nowhere to go' range shifts of the Himalayan *Incarvillea* Juss. Using multi-model median ensemble species distribution models, *Ecological Indicators*. **121**: 107127, ISSN 1470-160X, https://doi.org/10.1016/j.ecolind.2020.107127.

201. Rebel, H. 1901. Family Papilionidae–Hepialidae. In: Staudinger O & Rebel H (Eds.), *Catalog der Lepidopteren des palaearctischen Faunengebietes. Berlin*. **1**:1–411.

202. Regier, J. C., Brown, J. W., Mitter, C., Baixeras, J., Cho, S., Cummings, M. P., Zwick, A. 2012. A molecular phylogeny for the leaf-roller moths (Lepidoptera: Tortricidae) and its implications for classification and life history evolution. *PLoSONE,* **7**(4): e35574.

203. Ricketts, T. H., Daily, G. C., Ehrlich, P. R. and Fay, J. P. 2001. Countryside Biogeography of Moths in a Fragmented Landscape: Biodiversity in Native and Agricultural Habitats. *Conservation Biology*, **15**: 378-388.

204. Robinson, G. S. 1976. The preparation of slides of Lepidoptera genitalia with special reference to Microlepidoptera. *Entomologists Gazette Gaz.,* **27**: 127-132.

205. Robinson, G.S., Ackery, P.R., Kitching, I.J., Beccaloni, G.W. & Hernández, L.M. 2012. HOSTS – a database of the world's Lepidopteran hostplants. Available from: http://www.nhm.ac.uk/researchcuration/research/projects/hostplants/ (accessed on 5th June 2021 at 16:03 IST)

206. Rodgers, W.A. and Panwar, S.H., 1988. Biogeographical classification of India. *New Forest, Dehra Dun, India.*

207. Ronkay, L. (2004): Jelenkori faunaváltozások a Kárpát-medence belső területein: tények, jelenségek és értékelhetőségük. (Lepkék, elsősorban Macroheterocera) – Esettanulmány A globális klímaváltozás hatásai Magyarország faunájára" c. kérdéskörről. Kézirat, 22 p.

208. Rose, H. S. 2001. An Inventory of the Moth Fauna (Lepidoptera) of Jatinga, Assam, India. *Zoo's Print Journal,* **17**(2): 707-721.

209. Rothchild, W. 1920. Heterocera collected in Kornchi, West Sumatram by Messrs H. C. Robunson and C. Boden Kloss. *Journal of the Federated Malay Sates Museum,* **8**: 1-139.

210. Sambrook, J., Russel, D.W. 2001. *Molecular Cloning: A Laboratory Manual,* Cold Spring Harbor Laboratory Press, New York. 112pp.

211. Sanyal, A. K. 2015. Diversity and distribution of moth assemblages along altitudinal gradient in Gangotri landscape, India. Thesis submitted to Saurashtra University, Rajkot, India.

212. Sanyal, A.K., Dey, P., Uniyal, V.P., Chandra, K. and Raha, A., 2017. Geometridae Stephens, 1829 from different altitudes in Western Himalayan Protected Areas of Uttarakhand, India. (Lepidoptera: Geometridae). *SHILAP Revista de Lepidopterología*, **45**(177): 143-163.

213. 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). *Faunal Diversity of Indian Himalaya*, 651-726.

214. 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.

215. Sato, R. 1993. Geometridae: Ennominae: In: *Haruta T (Ed.), Moths of Nepal Part-II. Tinea*, **13**(Suppl. 3): 5–30.

216. Sato, R. 1994. Geometridae: Ennominae: In: *Haruta T (Ed.), Moths of Nepal Part-III. Tinea*, **14**(Suppl. 1): 41–62.

217. Sato, R. 1995. Geometridae: Ennominae: In: *Haruta T (Ed.), Moths of Nepal Part-IV. Tinea*, **14**(Suppl. 2): 28–37.

218. Sato, R. 1995. Records of the Boarmiini (Geometridae; Ennominae) from Thailand II *Trans. lepid. Soc. Japan,* **46**(4): 209-226.

219. Sato, R., 1991. Records of the genera *Hypomecis*, *Cleora* and *Alcis* (Geometridae; Ennominae) from Thailand, with descriptions of three new species and one new subspecies. *Tyo Ga*, **42**(4): 271-288.

220. Sato, R., 2003. Two new species of the genus *Ctenognophos* Prout (Geometridae, Ennominae) from the Himalayas. *Lepidoptera Science*, **54**(4): 241-247.

221. Schoener, T.W. 1968. The Anolis lizards of Bimini: resource partitioning in a complex fauna. *Ecology*. **49**(4):704–26.

222. Schulze, C.H. and Fiedler, K., 2004. *Orthonama obstipata* Fabricius, 1794 (Geometridae: Larentiinae)—new for the fauna of Borneo. *Nachr. entomol. Ver. Apollo, N. F.* **25**(3): 153–154.

223. Schulze, C.H., 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. (Ed), Arthropods of tropical forests: Spatio-temporal dynamics and resource use in the canopy, Cambridge University Press, Cambridge, 69-85.

224. Schulze, C.H., Waltert, M., Kessler, P.J.A., Pitopang, R., Shahabuddin, V., Mühlenberg, M., Gradstein, S.R., Leuschner, C., Steffan-Dewenter, I., Tscharntke, T. 2004. Biodiversity indicator groups of tropical land-use systems: comparing plants, birds, and insects. *Ecological Applications,* **14**: 1321–1333.

225. Scoble, M. J. and KRÜGER, M., 2002. A review of the genera of Macariini with a revised classification of the tribe (Geometridae: Ennominae). *Zoological Journal of the Linnean Society,* **134**(3): 257-315.

226. Scoble, M.J., 1992. *The Lepidoptera. Form, function and diversity.* Oxford University Press.

227. Sevastopulo, D. G. 1956. Notes on Heterocera of Kolkata. *Journal of Bombay Natural History Society,* **54**: 292-308.

228. Shah, S. K., Mitra, B., Mallick, K., Bhattacharya, M. 2016. Moths of Kolkata Metropolitan Region. *Z.S.I. ENVIS Newsletter.* **22**(1): 2-7.

229. Sihvonen, P. 2005. Phylogeny and classification of the Scopulini moths (Lepidoptera: Geometridae, Sterrhinae). *Zoological Journal of the Linnean Society,* **143**(4): 473-530.

230. Sihvonen, P., Mutanen, M., Kaila, L., Brehm, G., Hausmann, A. and Staude, H.S., 2011. Comprehensive molecular sampling yields a

robust phylogeny for geometrid moths (Lepidoptera: Geometridae). *PloS ONE,* **6**(6): e20356.

231. Singh, N. and Ranjan, R., 2016. Additions to the moth fauna of Dalma Wildlife Sanctuary, Jharkhand (India). *Records of the Zoological Survey of India*, **116**(4): 323-336.

232. Singh, S.K. and Rawat, G.S., 2000._*Flora of Great Himalayan National Park: Himachal Pradesh.*

233. Smetacek, P. and Smetacek, R. 2011. Additions to the known larval host plants of Indian Lepidoptera. *Journal of Threatened Taxa*, **26**: 2272–6.

234. Snellen, P. C. T. 1884. Lepidoptera van Celenbes Verzameld door. *Tijdschrift Voor Entomologia*: 28-39.

235. Snellen, P. C. T. 1890. A catalogue of the Pyralidina of Sikkim collected by Henry J. Elwes and the late Otto Moller. *Transactions of Entomological Society London*: 557-647.

236. Sondhi, Y. and Sondhi, S. 2016. A partial checklist of moths (Lepidoptera) of Dehradun, Mussoorie and Devalsari in Garhwal, Uttarakhand, India. *Journal of Threatened Taxa,* **8**(5): 8756–8776. http://dx.doi.org/10.11609/jott.2814.8.5.8756-8776

237. Southwood, T. R. E., Brown, V. K. and Reader, T. C. 1979. The Relationship of Plant and Insect Diversities in Succession. *Biological Journal of Linnaean Society*, **12**: 327-348.

238. Srivastava, A. 2002. *Taxonomy of Moths in India.* International Book Destributors. 9, Rajpur Road, Dehradun.

239. Strutzenberger, P., Brehm, G. and Fiedler, K., 2011. DNA barcoding-based species delimitation increases species count of Eois (Geometridae) moths in a well-studied tropical mountain forest by up to 50%. *Insect Science,* **18** (3): 349-362.

240. Strutzenberger, P., Brehm, G., Fiedler, K. 2012. DNA Barcode Sequencing from Old Type Specimens as a Tool in Taxonomy: A Case Study in the Diverse Genus *Eois* (Lepidoptera: Geometridae). *PLoS ONE*, **7**(11): e49710.

241. Stüning, D., 1994. On the identity of *Ourapteryx ebuleata* Guenee, 1857, *O. multistrigaria* Walker, 1866, and *O. caschmirensis* Bastelberger, 1911, with description of two new species (Lepidoptera: Geometridae: Ennominae). *Nachrichten des Entomologischen Vereins Apollo (NF)*, **15**: 109-134.

242. Summerville, K. S. and Crist, T. O. 2001. Effects of Experimental Habitat Fragmentation on Patch Use by Butterflies and Skippers (Lepidoptera). *Ecology*, **82**: 1360-1370.

243. Summerville, K. S. and Crist, T. O. 2004. Contrasting Effects of Habitat Quantity and Quality on Moth Communities in Fragmented Landscapes. *Ecography* **27**: 3-12.

244. Summerville, K. S., Boulware, M. J., Veech, J. A. and Crist, T. O. 2003. Spatial Variation in Species Diversity and Composition of

Forest Lepidoptera in Eastern Deciduous Forests of North America. *Conservation Biology,* **17**: 1045-1057.

245. Summerville, K. S., Crist, T. O. 2002. Effects of timber harvest on forest Lepidoptera: community, guild, and species responses. *Ecological Applications,* **12**: 820-835.

246. Summerville, K.S., Crist, T.O. 2002. Effects of timber harvest on forest Lepidoptera: community, guild, and species responses. *Ecological Applications,* **12**: 820-835.

247. 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.

248. Swinhoe, C. 1891. New species of Heterocera from the Khasia Hills, Part I, *Trans. Ent. Soc. Lond.,*: 473-495, pl. 19.

249. Swinhoe, C. 1894. A list of the Lepidoptera of the Khasia Hills. Pt. II, *Trans. Ent. Soc. Lond.*, **42**: 145-223.

250. Swinhoe, C., 1885. On the Lepidoptera of Bombay and the Deccan Hetrocera, Part 2. *Proceeding of the Zoological Scoiety of London*: 1-307.

251. Tamura, K,, Stecher, G., Peterson, D., Filipski, A., Kumar, S. 2013. MEGA6: molecular evolutionary genetics analysis version 6.0. *Molecular biology and evolution.* **30**(12): 2725–29.

252. Thierry-Mieg, P. 1905. Description de lépidoptères nouveaux. *Le Naturaliste* **27**(442): 181-182.

253. Thomas, C.D. and Kunin, W.E., 1999. The spatial structure of populations. *Journal of Animal Ecology*, **68**(4): 647-657.

254. Thompson, J.D., Gibson, T.J., Plewniak, F., Jeanmougin, F., Higgins, D.G. 1997. The CLUSTAL_X windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. *Nucleic acids research.* **25**(24): 4876–82.

255. Ueda, K. 1981. On the mechanism of copulation in Hepialid moths, *Endoclita excrescens* (Butler) and *Hepialus fusconebulosa* (De Geer) (Lepidoptera: Hepialidae). *Bull. Kitakyushu Mus. Nat. Hist.*, **3**: 27-39.

256. Uniyal, V.P. and Mehra, B.S., 1996. Preliminary observations on the diversity of butterflies (lepidoptera: insecta) in high altitude grazing pasture in Great Himalayan National Park. *Zoo's Print (September)*, pp.7-11.

257. Uniyal, V.P., Dey, P. and Sanyal, A.K. 2016. Diversity of moths Lepidoptera: Heterocera) and their potential role as a conservation tool in different protected areas of Uttarakhand. Wildlife Institute of India, Dehradun (DST Project Completion Report).

258. Usher, M.B., Keiller, S.W. 1998. The macrolepidoptera of farm woodlands: determinants of diversity and community structure. *Biodiversity and Conservation,* **7**(6): 725-748.

259. van Nieukerken, E. J., Kaila, L., Kitching, I. J., Kristensen, N. P., Lees, D. J., Minet, J., …, Zwick, A. (2011). Order Lepidoptera

Linnaeus, 1758. In Z-Q. Zhang (Ed.), Animal Biodiversity: An outline of higher-level classification and survey of taxonomic richness. *Zootaxa*, **3148**: 212-221.

260. Viidalepp, J., Tammaru, T., Snäll, N., Ruohomäki, K., Wahlberg, N. 2007. *Cleorodes* Warren, 1894 does not belong in the tribe Boarmiini (Lepidoptera: Geometridae). *European Journal of Entomology*. **104**(2): 303.

261. Vinod, T.R., Goyal, S.P. and Sathyakumar, S., 1997. Habitat use by ungulates, bears and pheasants in Great Himalayan National Park, Western Himalaya. *Interim Report. Wildlife Institute of India, Dehradun.*

262. Walker, F. 1860. *List of the specimens of lepidopterous insects in the collection of the British Museum,* **21**: 333.

263. Walker, F. 1863. *List of the Specimens of Lepidopterous Insects in the Collection of the British Museum. British Museum, London*, **26**: 1479–1796.

264. Walker, F. 1866. *List of the specimens of lepidopterous insects in the collection of the British Museum,* **35**: 1687.

265. Wallengren, H. D. J. 1856. Anteckningar I Zoologien 1 Kafferlandets Macrolepidopt Fauna.

266. Wallengren, H. D. J. 1860. Lepidopterologische Mittheilunggen Wiener *Entomologische Monatschrift*. **4**: 31-176.

267. Ward, L.K. and Spalding, D.F., 1993. Phytophagous British insects and mites and their food-plant families: total numbers and polyphagy. *Biological Journal of the Linnean Society*, **49**(3): 257-276.

268. Warren, D.L., Glor, R.E., Turelli, M. 2010. ENMTools: a toolbox for comparative studies of environmental niche models. *Ecography.* **33**(3): 607–11.

269. Warren, W. 1888. On Lepidoptera collected by Major Yerbury in Western India in 1886 and 1887. *Proceedings of the Zoological Society of London,*: 290-338.

270. Warren, W. 1893. On new genera and species of moths of the family Geometridae from India, in the collection of HJ Elwes. In *Proceedings of the Zoological Society of London*: 341-434.

271. Warren, W. 1894. New genera and species of Geometridae. *Novit. Zool.,* **1**(2): 366-466.

272. Warren, W. 1896. New species of Drepanulidae, Thyrididae, Uraniidae, Epiplemidae and Geometridae in the Tring Museum., *Novit. zool.,* **3**: 335-419.

273. Wehrli E. 1953. Subfamily: Geometrinae. In: Seitz A. (Ed.), *Die Grossschmetterlinge der Erde.* **4**: 254–766.

274. Willig, M. R., Kaufman, D. M., Stevens, R. D. 2003. Latitudinal gradients of biodiversity: pattern, process, scale, and synthesis. *Annual Review of Ecology & Evolutionary Systematics*, **34**: 273-309.

275. Wilson, J. J., Rodolphe, R., Justin,S., Janzen, D.H., Hallwachs, W., Hajibabaei, M.,Kitching, I.J., Haxaire, J., Hebert, P.N. 2011. "When species matches are unavailable are DNA barcodes correctly assigned to higher taxa? An assessment using sphingid moths." *BMC Ecology*, **11**(1): 18.

276. Wiltshire, E. P. 1967. Middle East Lepidoptera XX. A third contribution to the fauna of Afghanistan. *Beitr. naturk. Forsch. SW-Deutschl.* **26**, H. 3, 137-169.

277. Wu, S. and Chang, W.C., 2018. Revising the generic characters of *Lobogonodes* Bastelberger, 1909, with description of a new species from Taiwan (Lepidoptera: Geometridae: Larentiinae). *Zootaxa*, **4433**(3): 434-444.

278. Wu, S., Fu, C.M., Tzuoo, H.R., Shih, L.C., Chang, W.C. and Lin, H.H. 2020. An Annotated Checklist of Macro Moths in Mid- to High-Mountain Ranges of Taiwan (Lepidoptera: Macroheterocera). *Formosan Entomologist.* **40**: 10-83.

279. Xue, D. and Scoble, M.J., 2002. A review of the genera associated with the tribe Asthenini (Lepidoptera: Geometridae: Larentiinae). *Bulletin of the Natural History Museum: Entomology Series*, **71**(1): 77-133.

280. 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.

281. Yazaki, K. 1992. Geometridae. In: *Haruta T (Ed.), Moths of Nepal Part-I. Tinea*, **13**(Suppl. 2): 5–46.

282. Yazaki, K. 1994. Geometridae. In: *Haruta T (Ed.), Moths of Nepal. Part- III,* Tinea. **14**(Suppl. 1):5–40.

283. Yazaki, K. 1995. Geometridae. In: *Haruta T (Ed.), Moths of Nepal Part-IV. Tinea*, **14**(Suppl. 2): 2–27.

284. Yazaki, K. 1998. Geometridae. In: *Haruta T (Ed.), Moths of Nepal. Tinea.* **5**(15) (Suppl. 1):3–18.

285. You, J., Qin, X,. Ranjitkar, S. et al. 2018. Response to climate change of montane herbaceous plants in the genus Rhodiola predicted by ecological niche modelling. *Sci. Rep.* **8**: 5879. https://doi.org/10.1038/s41598-018-24360-9

286. Zahiri, R. 2012. Molecular phylogenetics of Erebidae (Lepidoptera: Noctuoidea). *Systematic Entomology*, **37**: 102-124.

287. Zahiri, R., Kitching, I. J., Lafontaine, J. D., Mutanen, M., Kaila, L., Holloway, J. D., Wahlberg, N. 2011. A new molecular phylogeny offers hope for a stable family level classification of the Noctuoidea (Lepidoptera). *Zoologica Scripta*. **40**(2): 158-173.

288. Zhu, Y., Wei, W., Li, H., Wang, B., Yang, X., Liu, Y. 2018. Modelling the potential distribution and shifts of three varieties of *Stipa tianschanica* in the eastern Eurasian Steppe under multiple climate

change scenarios, *Global Ecology and Conservation*. **16**: e00501. https://doi.org/10.1016/j.gecco.2018.e00501.

289. Zwiener, V.P., Padial, A.A., Marques, M.C., Faleiro, F.V., Loyola, R., Peterson, A.T. 2017. Planning for conservation and restoration under climate and land use change in the Brazilian Atlantic Forest. *Diversity and Distributions*. **23**(8): 955-66.

APPENDIX: LIST OF PUBLICATIONS

Published article:

- Bandyopadhyay, U., Dey, R., Bhattacharyya, K., **Mallick, K.**, Mazumder, A., Gayen, S., Das, M., Raha, A., Sanyal, A. K., Kumar, V., Uniyal, V. P., Chandra, K. 2021. Taxonomy and Ecology of Genus *Phlogophora* Treitschke, 1825 (Lepidoptera: Noctuidae) in Indian Himalaya. *Zootaxa,* **5004**(2): 311–342.
- Mazumder, A., Raha, A., Sanyal, A. K., Gayen, S., **Mallick, K.**, Bandyopadhyay, U., Chandra, K., Schintlmeister, A. 2019. A New Species of *Nerice* Walker, 1855 and Additions to the Catalogue of Indian Notodontidae Stephens, 1829 (Lepidoptera: Noctuoidea) from Himalaya with Report of Range Extensions. *Zootaxa*, **4748**(1):119-140.
- Chandra, K., Mazumder, A., Sanyal, A. K., Ash, A., Bandyopadhyay, U., **Mallick, K.** & Raha, A. 2018. Catalogue of Indian Notodontidae Stephens, 1829 (Lepidoptera: Noctuoidea). *Zootaxa*, **4505**(1): 001-084.

Accepted article:

- **Mallick, K.,** Bandyopadhyay, U., Mazumder, A., Dey, R., Raha, A., Sanyal, A. K., Gupta, S.K., Uniyal, V.P., Chandra, K. First Record of *Xenortholitha falcata* Yazaki, 1993 (Geometridae: Larentiinae) from India. Submitted to *Records of Zoological Survey of India.*

Commumicated article:

- **Mallick, K.,** Dey, R., Sanyal, A. K., Raha, A., Mazumder, A., Bandyopadhyay, U., Gayen, S., Ali, M., Kumar, V., Gupta, S.K., Uniyal, V.P., Chandra, K. Review of Genus *Psyra* from Indian Himalaya. Submitted in *Plosone*.

Book Chapters:

- Sanyal, A.K., **Mallick, K.,** Khan, S., Bandyopadhyay, U., Mazumder, A., Bhattacharyya, K., Pathania, P.C., Raha, A., Chandra, K. 2018. Insecta: Lepidoptera (Moths). In: *Faunal Diversity of Indian Himalaya*: 651-726 (Published by the Director, Zool. Surv. India, Kolkata).
- Ali, M., Das, G.N., **Mallick, K.,** Mazumder, A., Bhattacharyya, K., Bandyopadhyay, U. 2019. Ladakh, Jammu & Kashmir, Trans-Himalaya. In: Chandra et al. (Eds.). *Assemblage of Lepidoptera in Selected Protected Areas across Indian Himalaya through Long Term Ecological Monitoring Plots*: 25- 38. Published by Director, Zoological Survey of India, Kolkata, India.
- **Mallick, K.,** Mazumder, A., Bandyopadhyay, U., Sajan, S., Ghosh, D. 2019. Great Himalayan National Park, Himachal Pradesh, North-Western Himalaya. In: Chandra et al. (Eds.). *Assemblage of Lepidoptera in Selected Protected Areas across Indian Himalaya through Long Term Ecological Monitoring Plots*: 39- 54. Published by Director, Zoological Survey of India, Kolkata, India.

- Das, G.N., **Mallick, K.,** Mazumder, A., Bhardwaj, M., Ali, M. 2019. Govind Wildlife Sanctuary, Uttarakhand, Western Himalaya (Garhwal). In: Chandra et al. (Eds.). *Assemblage of Lepidoptera in Selected Protected Areas across Indian Himalaya through Long Term Ecological Monitoring Plots*: 55- 70. Published by Director, Zoological Survey of India, Kolkata, India.
- Bandyopadhyay, U., Das, G.N., Gayen, S., **Mallick, K.,** Bhattacharyya, K. Askot Wildlife Sanctuary, Uttarakhand, Western Himalaya (Kumaon). In: Chandra et al. (Eds.). *Assemblage of Lepidoptera in Selected Protected Areas across Indian Himalaya through Long Term Ecological Monitoring Plots*: 71- 86. Published by Director, Zoological Survey of India, Kolkata, India.
- Mazumder, A., Das, G.N., Payra, A., Deepak C.K., Majumder, A., **Mallick, K.** 2019. Namdapha National Park, Arunachal Pradesh, Eastern Himalaya. In: Chandra et al. (Eds.). *Assemblage of Lepidoptera in Selected Protected Areas across Indian Himalaya through Long Term Ecological Monitoring Plots*: 103- 116. Published by Director, Zoological Survey of India, Kolkata, India.
- Gayen, S., Das, G.N., Ranjan, R., **Mallick, K.,** Bhattacharyya, K., Mazumder, A. 2019. Dihang-Dibang Biosphere Reserve, Arunachal Pradesh, Eastern Himalaya. In: Chandra et al. (Eds.). *Assemblage of Lepidoptera in Selected Protected Areas across Indian Himalaya through Long Term Ecological Monitoring Plots*: 117- 132. Published by Director, Zoological Survey of India, Kolkata, India.

- Sanyal, A.K., Raha, A., **Mallick, K.,** Mazumder, A., Bandyopadhyay, U., Das, G.N., Singh, N. & Chandra, K. 2019. Assemblage Pattern & Biogeographic Affinities of Himalayan Lepidoptera. In: Chandra et al. (Eds.). *Assemblage of Lepidoptera in Selected Protected Areas across Indian Himalaya through Long Term Ecological Monitoring Plots*: 135- 148. Published by Director, Zoological Survey of India, Kolkata, India.

Abstract/Conference Paper:

- Presented an abstract at the 5th **Asian Lepidoptera Symposium**, 2018: Impacts of Climate Change on Asian Lepidoptera held at The University of Hong Kong, Hong Kong.

Topic: **Altitudinal and Biogeographic Distribution of Indo-Chinese Genus *Psyra* (Geometridae: Ennominae) from Indian Himalaya**. 2018. ALCS 5, Hong Kong.

- Presented an abstract at the 1st Himalayan Researchers Consortium, 2018 at Dehradun, India conducted by National Mission of Himalayan Studies.

Topic: **Diversity and Distribution Patterns of Family Geometridae (Lepidoptera) in Great Himalayan National Park Conservation Area, Himachal Pradesh**.

- **Mallick, K.,** Kumar, V. and Chandra, K. 2020. A preliminary study of the Diversity and Distributional Pattern of Geometridae moths in Great Himalayan National Park, Himachal Pradesh. In: Verma, R.K., Sirari, P and Kumar, K (Eds.). *Proceedinds of the 1st Himalayan*

Researchers Consortium, 2018.Vol-II: 76-85. NMHS, G.B. Pant National Institute of Himalayan Environment: Almora, Uttarakhand, India.

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1 message

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Fri, Sep 17, 2021 at 5:31 PM

Mr. Kaushik Mallick:

We have reached a decision regarding your submission to Records of the Zoological Survey of India, "First Record of Xenortholitha falcata Yazaki, 1993 (Geometridae: Larentiinae) from India".

Our decision is to: Accepted for Publication

Managing Editor
Zoological Survey of India, Kolkata
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First Record of *Xenortholitha falcata* Yazaki, 1993 (Geometridae: Larentiinae) from India

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Abstract

The genus *Xenortholitha* Inoue, 1944 is mainly distributed in the Sino-Japanese and Indian Himalayan region (IHR). The current communication reports the first distributional record of *Xenortholitha falcata* Yazaki, 1993 from western Himalaya, India extending its range far westwards from its previously known range in Eastern Nepal. We provide a brief differential diagnosis of both external and male genitalia morphology of the species along with their photographic illustrations.

Key Words: Larentiinae, Cidariini, *Xenortholitha*, Lepidoptera fauna, Range extension.

Introduction

The genus *Xenortholitha*, belonging to one of the largest tribes Cidariini of subfamily Larentiinae, was established by Inoue in 1944 with the type species *Cidaria propinguata* Kollar Currently, the genus consists of 13 known species/subspecies worldwide including 3 species/subspecies from mainland India (Table 1). Inoue (1944) suggested the genus members to be separated from the ancestor genus *Ortholitha* Hübner, 1821 mainly based on the male genitalia characters, like the shape of uncus and valvae. Although the monophyly of the genus has not yet been defined (Choi, 2004), the members of the genus can be easily diagnosed by having dark greyish wings, a smooth blackish postmedial line, a row of white dots on subterminal area and often having a strongly falcate forewing apex with an apical streak. The majority of the species are described from the Sino-Himalayan region, with few species known from Taiwan, Japan, Russia and Philippines. The species of the genus shows many geographical variations, most prominent in case of

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Taxonomy and ecology of genus *Phlogophora* Treitschke, 1825 (Lepidoptera: Noctuidae) in Indian Himalaya with description of a new species

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Abstract

The Genus *Phlogophora* Treitschke, 1825 (Noctuidae: Xyleninae), widely distributed in Palaearctic and Oriental realms, is especially diverse within Indian Himalaya with 12 known species till now. Current communication reports three species new to India viz. *P. meticulodina* (Draudt, 1950), *P. nobilis* Hreblay & Ronkay, 1998 and *P. szecsenyii* Hreblay & Ronkay, 1998 and a new species *P. similis* Bandyopadhyay, Mallick, Sanyal & Chandra **sp. nov.**, thus bringing the species number to 16 for the country, along with taxonomic key with morphology and genitalia-based diagnosis for all the Indian/ Himalayan species. Out of those species, partial mitochondrial Cytochrome C Oxidase I (COI) sequences were generated for 6 species, of which 5 were novel to the NCBI GenBank. The genus had maximum species richness and abundance in Eastern Himalayan Temperate Forest spanning 1800–2500 m in Central Himalayan landscape of Darjeeling-Sikkim and Nepal. Current Habitat suitability model of six *Phlogophora* species indicated that temperature dependent variables like Temperature Annual Range, Temperature Seasonality and Elevation are the most contributing factors for their predicted distribution range. The genus comprising of both Polycyclic and Monocyclic species became most abundant during Post-monsoon, in cold (9–11 °C) and humid (87–91%) nights, in areas with Annual Mean Temperature ranging within 4.6–19.9 °C and Annual Precipitation of 1000–2800 mm.

Key words: Phlogophorini, Central Himalaya, DNA Barcoding, Himalayan Temperate Forest, Seasonality, Habitat Suitability

Introduction

The genus *Phlogophora* Treitschke, 1825 (Noctuidae, Xyleninae: Phlogophorini) with designated type species *Phlaena meticulosa* Linnaeus, 1758 is widely distributed throughout zoogeographic realms of the world, especially diverse within few specific "centres of diversity". Within Palaearctic region, Western-Central Europe including Azores group of islands and Japan, Korea extending to South East Siberia are two major centres. In the transition zone of Palaearctic and Oriental realm, another diversity hotspot exists centred around Central/Southern Himalayan

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A new species of *Nerice* Walker, 1855 and further additions to the catalogue of Indian Notodontidae Stephens, 1829 (Lepidoptera: Noctuoidea) from Himalaya with report of range extensions

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Abstract

The present work deals with the additional species of Notodontidae recorded from different provinces of Indian Himalaya subsequent to the publication of Catalogue of Indian Notodontidae which provided systematic account of 242 species and 10 subspecies. Current communication comprises: (I) Description of a new species of genus *Nerice* Walker, 1855, *Nerice (Nerice) mishmiensis* Mazumder, Raha, Chandra & Schintlmeister **sp. nov.**, from Eastern Himalayan landscape of Dihang-Dibang Biosphere Reserve, Arunachal Pradesh, along with a comparative diagnosis with two other congeners viz. *N. aemulator* Schintlmeister & Fang, 2001 and *N. upina* Alphéraky, 1892; (II) Reporting of 3 species new to the Indian fauna from Eastern and Western Himalaya: *Periergos genitale* Schintlmeister, 2002, *Honveda nepalina* Nakamura, 1976 and *Syntypistis nigribasalis tropica* (Kiriakoff, 1974) with their diagnosis and genitalic illustrations; (III) Addition of 5 species and 1 more subspecies to the existing list from various literature; (IV) Additional distribution records of 40 species detected through primary sampling along with details of the materials examined; among which 3 species viz. *Pseudallata laticostalis* (Hampson, 1900), *Baradesa lithosioides lithosioides* Moore, 1883 and *Ptilodon flavistigma* (Moore, 1879) showed unusual altitudinal records around 3000 m. Thus, altogether Indian Notodontidae fauna has been updated to 247 species (including nominotypical subspecies) and 15 subspecies under 116 genera of 10 subfamilies.

Key words: Notodontids, Himalaya, Altitudinal Record, New Locality Report, Dihang-Dibang Biosphere Reserve, Himalayan Biogeographic Provinces

Introduction

Notodontidae fauna of India has so far been represented by 242 species (including nominotypical subspecies) and 10 subspecies under 116 genera of 10 subfamilies (Chandra *et al.* 2018), which includes 162 species from Himalayan region. Subsequent field sampling and light trapping sessions in selected Protected Areas falling under different Biogeographic Provinces of Indian Himalaya, viz. Trans Himalaya (1A & 1B): Hemis National Park (NP) and adjacent areas in Jammu & Kashmir; North-West Himalaya (2A): Great Himalayan NP in Himachal Pradesh; West Himalaya (2B): Govind Wildlife Sanctuary (WLS) and Askot WLS in Uttarakhand; Central Himalaya (2C): Neora Valley NP and Singalila NP in West Bengal; East Himalaya (2D): Dihang-Dibang Biosphere Reserve and Namdapha NP in Arunachal Pradesh, resulted in further additional materials, details of which are compiled in present communication. Hence, focus of this communication are as follows: (I) Description of a new species of genus *Nerice* Walker, 1855 from Eastern Himalayan landscape of Dihang-Dibang BR, Arunachal Pradesh, (II) Reporting of 3 species as new records to the Indian Notodontid fauna from primary sampling (Fig. 1), (III) Addition of 5 species and 1 more subspecies to the existing list from various literature and (IV) Additional distribution records of 40 species detected through primary sampling along with comments on their range extensions. Altogether, the present

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Catalogue of Indian Notodontidae Stephens, 1829 (Lepidoptera: Noctuoidea)

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