Examining the wing venation patterns of different species of moths (Lepidoptera) found in IISER Mohali

Deepak Potyan Negi

A dissertation submitted for the partial fulfilment of BS-MS dual degree in Science

Indian Institute of Science Education and Research Mohali

May, 2020

Acknowledgement

This work would have been difficult to produce without the advice and guidance received from number of people in many ways. Firstly, I would like to express my gratitude to my supervisor, Dr. Manjari Jain (Assistant Prof.) for her valuable guidance, being very nice to me and for allowing me access to the superb moth collection placed in her Behavioural Ecology Lab (BEL), IISER Mohali. Also I would like to thank to the authorities of the Forest Department of Punjab for granting the permission of mothcollection.

I thank Dr N G Prasad and Dr Rhitoban Ray Choudhury for being a part of my project evaluation committee.

I owe very special thank to Dr. Sujata Saini (Post doctoral fellow) of BEL, IISER Mohali whose expert knowledge and editorial assistance have been of value in verifying information and in preparing the text throughout many stages of my master thesis.The guidance she provided was extremely helpful in building my research ideas. I convey my hearty thanks to Anjna Mahi for helping in making beautiful line drawings of wing venation. I express my love and affection towards Nakul Raj, Barsa, Atharva Deshpandey and Geetika Aggarwal for their support and helping me in my moth project. I am thankful to my BEL colleagues Anindya Chaudhari, Richa Singh, Sonam Chorol, Yambem Soniya, Prathibha (PP), Adidtya, Karthik, Pankhuri, Rohit for making the lab an enjoyableworkplace.

I am thankful to Dr. Rajesh Ramachandran for being very nice to me during my degree, I also gained fruitful things from him related to my academic field, which will remain in my mind throughout my life.

Lastly, I express my heartiest regards to my parents for providing me with unfailing support and continuous encouragement throughout the years of my study. This accomplishment would not have been possible without them. Thank you.

Deepak Potyan Negi

List of Figures

List of Tables

List of Plates

Contents

Abstract

Taxonomy is the foundation of all biological sciences, pure and applied alike, including Agriculture, Forestry, Fisheries, Plants, Animals and human health etc. It is vital for the scientific integrity. Without a good, constantly updated taxonomy, biodiversity studies and conservation science become meaningless. Insects are the most cosmopolitan, polyphagous and varied living organisms on earth. Lepidoptera is one of the most dominant groups in the class Insecta, comprising moths, butterflies, and skippers. Moths are among the most abundant, familiar and oldest known insect groups. They play a significant role in the fast emerging field of taxonomy and entomology. Hampson (1892-1896) made an outstanding contribution in the taxonomy of various families of moths including morphology and wing venation. In India, much work has been done to update the taxonomy of numerous moth families but the major work is based on the external genitalia and molecular studies. Therefore, till date negligible work on wing venation especially from Punjab region has been remained neglected from taxonomic point of view. To overcome this gap, this master project has been carried out on wing venation of six moth families from IISER, Mohali. The studied material belonged to 77 species referable to 67 genera out of which out of which 3 genera (3 species), 13 genera (14 species), 10 genera (13 species), 9 genera (12 species), 13 genera (13 species) and 19 genera (22 species) belong to families Lasiocampidae, Noctuidae, Sphingidae, Geometridae, Crambidae and Erebidae respectively. During the present work, wing venation patterns have been studied in elaborate.Dichotomous keys to the studied families, and genera have also been formulated. Before giving detailed wing venation features of each species, genus was represented with its first reference, name of type species and remarks wherever available.

1. INTRODUCTION

1.1 Insects

Insects are significant and integral component of our biodiversity that are incorporate of number of orders which are in turn usually organized into wingless (silverfish) and winged insects (beetles, bugs, butterflies, crickets, flies, moths etc). Insects are the only invertebrates which can fly and seem to advent around 360 million years ago, around much before the Dinosaurs appears on the earth and constitute about more than half the total population. They have significantly managed to survive the onslaught of Homo sapiens. They are the 'boom' to this planet which give rise to different research aspects and proved numerous theories. Hence, is one of the most successful groups among animal. Unfortunately, most of our youngsters are aversion of insects. Most of the time, they found them to throw away as if they are the most poisoned one that give rise to attitudes of both fear and confrontation that passed along from generation to generation. But the reverse is true that the benefits of insects far outweigh the losses caused by them.

1.2 Economic importance of insects including moths

Pollination is often observed to be the most useful and attractive activity of insects and can pollinate almost all variety of fruits, nuts, shrubs, vegetables, herbs, crop plants, ornamental (garden) plants, leguminous plants, drug plants, etc. Active pollination is mainly carried out by the insects of order Hymenoptera (especially, bees), Lepidoptera (butterflies and moths). The members of the family Sphingidae play a significant role in pollination and conservation of plant diversity. The length of sucking proboscis (*Agrius convolvuli* (Linnaeus) 125mm-130mm, *Macroglossum stellatarum* Linnaeus 25mm-28mm) plays a greater role in view of the diversity of the flower structures, position and length of nectar. Insects also act as Biological control agents that involve the use of the predator species and disease, to attack the harmful insects. For instance, reduces the danger of impact on the water quality of the area. Another important role of insects is a Biological indicator, a butterfly (Lepidoptera) are generally regarded as an ecological indicators. On the other hand, one of the important species of moths namely *Bombyx mori* Linnaeus is involved in the production of silk. Moths of the family viz., Lasiocampidae, Noctuidae, Sphingidae, Geometridae, Crambidae, Erebidae are the major and minor pests of plants and trees. Few Noctuid moths have the habit of piercing skin and drinking blood from

vertebrates and are known as "Vampire Moths". One of the Noctuid species *i.e.*, *Calyptera thalictri* Borkhausen is capable of sucking human blood through skin (Banzinger 1989). The hair packed in tufts in members of genus *Lymantria* can cause allergic reactions such as skin or eye rashes and respiratory problems and some are extremely irritating to the skin. Members of genera *Anomis* and *Spodoptera* are a most destructive pest of jute in India.

Surely there are some more several ways that insects including moths are helpful to humankind. In reality, only a fraction of them or less than five per cent, are hazardous for crops, animals or human beings. It is crystal clear from above, that how insects including moths are beneficial in many ways.

1.3 Life cycle of insect with special reference to moths

Insects including beetles, bees, ants, butterflies, moths, mosquitoes etc have a complete or holometabolous metamorphosis which means they are having four stages of their life i.e. egg, larva, pupa and adult. A female insect lays several hundred eggs either on the bottom of a leaf or depend upon species to species. The eggs may be oval/spherical in shape which after a few days/week shaped into larvae. Larva has a very big appetite and can eat several times comparable to their own body weight. Lepidoptera have five larval stages in their entire life. At the end of this stage, an insect form a hard shell and inside it will become a pupa. At this stage the larva will stop eating/moving. The pupa appears one of the nature's most amazing transformations. Inside the pupa, the larva's body will completely change into a fully grown adult. Once the adult leaves the pupa, it slowly stretches out while its exoskeleton dries out and hardens.

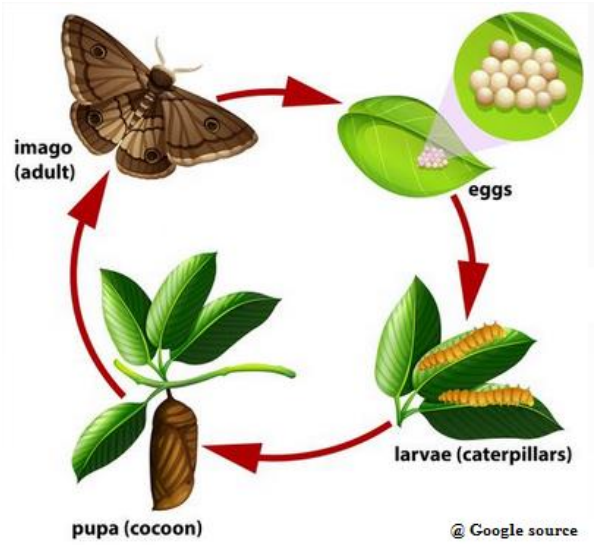


Figure 1: Development stages of moth

1.4 Taxonomy

Taxonomy is the foundation of all biological sciences in other words naming and classifying/ grouping organisms. A well renowned Swedish naturalist named Carl von Linnaeus is known as the 'Father of Taxonomy' because, in the1700s, he evolved the hierarchical classification system and Binomial Nomenclature (organism with two name, genus and species) that we still use today in every field. From Linnaean's system of classification, the science of taxonomy has come out in many efforts as so many organisms were directed towards the goal of providing a title for every living thing and because of him, taxonomy became the key to many biologists to open the doors of many hidden/unlocked doors. Unfortunately, it would seem from past few years that taxonomy is now often seen not as a tool, but as a time consuming hindrance. Building taxonomic capacity in developing countries like India is a vital ingredient to achieve realistic self-reliance in taxonomy to support progress for sustainable growth and development. Insect systematic had a very long journey from classical (wing maculation, venation and external genitalia) to molecular level (genetic studies). It is not difficult to imagine that an ability to fly might have evolved several times but it is unlikely that the same pattern of wing venation would have evolved more than once, which strongly suggests a monophyletic origin of the Pterygota. It was suggests from studies that wing venation played a crucial role in endopterygote evolution. Loss of some veins and modification of others has led to the classification of many orders namely Trichoptera, Lepidoptera, Coleoptera, Orthoptera, Hymenoptera etc. To show again the significant role of taxonomy in case of insects with special moths as a model organism, an idea is initiated in the present manuscript. Moths are the one of the major category of order Lepidoptera other than attractive butterflies and skippers. Moths are one of the mega diverse groups of insects and recent reports have recorded 1, 27,000 species of moths from around the world and is the third largest and diverse group of class Insecta (Zhang 2013). Lepidopteran species are characterized by numerous derived features, the most apparent being the scales covering their bodies and wings. Moths are truly different from butterflies being nocturnal in nature; vary greatly in appearance which has extremely hairy (pectination/bristles) antennae while some wings appearance as leaf-like etc.

1.5 Background

The perusal of relevant literature reveals that Indian Lepidoptera got less attention except from few eminent old taxonomists like Linnaeus (1758, 1764, 1771), Fabricius (1775, 1776, 1781,

1792-98), Moore (1879, 1881, 1888) and Arora and Gupta (1979). Sir George Francis Hampson happens to be one of the pioneer workers, who made an outstanding contribution to the Indian moth fauna. He worked intensively on Heterocera and brought out a monumental series i.e., "*Fauna of British India, Moths"* (1892-1896). He compiled taxonomic account of as many as 5277 moth species from India, Myanmar (Burma), Bhutan and Sri Lanka (Ceylon) in four volumes including wing venation. He described those species by taking an account of morphological as well as wing venation characters. Also most of the work from India has been done on external genitalia and very few studies includes wing venation patterns from Punjab is still insufficient or never been published except Dar (2015), Goyal (2011), Sexana (2016), Muddasar et al. (2018), Saini (2018). In 2017, Tarunkishwor Yumnam, one of the master students of Behavioral Ecology Lab, IISER-M initiated a project on moths as a model organism and did his work on diversity, seasonal variation and dial pattern of these nocturnal creatures. He forms a base line of this project and studied 70 species of moths the campus of IISER Mohali. This manuscript is the continuation of that work which not only resulted in the increase number of species but also elaborated the wing venation patterns which is studied first time from IISER, Mohali.

1.6 Moths: Model organism

Moths are known for their wide geographic distribution and exhibit among themselves immense variety in size, shape and maculation. The large majority are nocturnal, as the name implies, night fliers, hiding during day time among trees and shrubs. Resting with closed/unclosed wings on the trunks of trees or on rocks to which their maculation is assimilated. It has been observed that flight is a key characteristic of all Lepidoptera (Davis et al. 2015). Wings are known as flight appendage which is subjected to significant disparity in appearance, size, markings/patch and vein patterns thus reflecting their specific functional differences. Venation is the name given to the arrangement including the number and origin of veins within an insect's wing. It has been observed that wing morphology and venation in all majorities of insects shows peculiar patterns of variation among insect species. For instance presence of wings not only expands insect's activity, but also raises their ability for foraging, calling, and avoiding predators; nuptial flight is an important phase in the reproduction of most ant, termite, and some bee. Wings plays important role in male crickets in various aspects (Singh and Jain, 2020). In case of male field crickets, forewings are well connected with sound which plays important role in courtship

behavior and thus provide insight to females about divergent aspects of male quality. In beetles, wings are known to provide protective covering. Often colorful wings of butterflies also purpose as visual cues in communication. Likewise in moths, wings which are covered with scales fulfill different functions as they form a morphological background for colored Lepidopteran patterns; scales plays some signal behavior in mating and prevent sticking to resin drops and being caught in spider's trap. It is crystal clear that how wings in insects are the most characteristic features. In this thesis, investigation is done on the moth's venation and try to sent a message, that the studied characters cannot be ignored and should be in prime and trends as rare attempts have been done to connect the wing's study to the taxonomic portion and hasn't been amply covered in literature. Moths has a pair of wings namely forewing and hindwing attached to the thoracic segments of the body. Both forewing and hindwing are covered with thousands of minute colorful scales and due to presence of variant scales on wings the term for order 'Lepidoptera' which was coined in 1735 by Linnaeus and was derived from Greek word means 'scaly wings. The first comprehensive uses of wing venation with respect to moths were given by Hampson (1898) and shows how important are these characters useful in the taxonomic point of view. It is surprising that how little attention has been paid to the wing venation especially in India and details of the ground plan of wing venation in moths remain uncertain, despite approximately a century of study except only thorough/brief studies have been done so far. Furthermore, wing venation is often used to identify fossil insects as moths, because wing scales are not always preserved. The high variability of vein branching patterns among these moths suggests that morphological identification can also be done on the basis of these patterns when classifying Lepidopteran families based on venation alone as done by eminent entomologist, Sir George Francis Hampson. To begin with this, the present Master thesis research work entitled, "**Examining the wing venation pattern of different species of Moths (Lepidoptera) found in IISER Mohali**" was designed to strengthen and update the taxonomic account of 6 moth families namely Lasiocampidae, Erebidae, Sphingidae, Noctuidae, Geometridae and Crambidae. The studied material belonged to 77 species referable to 67 genera out of which out of which 3 genera (3 species), 13 genera (14 species), 10 genera (13 species), 9 genera (12 species), 13 genera (13 species) and 19 genera (22 species) belong to families Lasiocampidae, Noctuidae, Sphingidae, Geometridae, Crambidae and Erebidae respectively. During the present work, wing

venation patterns have been studied in elaborate. Here such venation had not previously been described in detail.

The following classification has been adopted during the present studies:

Kingdom-Animalia (Multicellular Eukaryotes)

Class-Insecta (Hexapods)

Order- Lepidoptera (Scaly Wings)

Suborder- Glossata (Coilable Proboscis)

Infraorder- Heteroneura (Wing Venation different in Forewing and Hindwing)

Division- Ditrysia (Female has two distinct sexual openings: one for mating, and the other for laying eggs in contrast to Monotrysia)

Family- Lasiocampidae, Crambidae, Erebidae, Noctuidae, Geometridae, Sphingidae (presently studied)

Family Lasiocampidae: The family name Lasiocampidae (Lepidoptera: Bombycoidea) was proposed by Thaddeus William Harris in 1841 and are generally called as 'Lappet moths' (due to the decorative skin flaps found on the caterpillar's prologs) or 'snout' moths' (unique protruding mouth parts of some species which resemble a large nose). Hampson (1892) studied 54 species referable to 20 genera including those from Myanmar (Burma), Bhutan and Sri Lanka (Ceylon). At present, this family comprises 1500 species classified into 150 genera (Leurat 2006; Saini 2018).

Family Noctuidae: Noctuids (Lepidoptera: Noctuoidea) fly with their glossy eyes and therefore strongly resemble owls and hence are commonly known as "Owlet moths" and the word 'Noctua' originated from the latin described owl (Pemm 1983). According to Betts (1987), fauna of Noctuidae from world is known by 21000 species. Later on, Kitching and Rawlings (1998) reported 35000 Noctuid species from the Globe.

Family Sphingidae: Sphingids (Lepidoptera: Bombycoidea) are commonly known as "Sphinx" or "Hawk moths" as their larvae have a dorsal horn at the tip of the abdomen and when disturbed the larvae will resume a sphinx-like position by tucking the head and holding the legs off the surface (Triplehorn et al. 2005). These are represented by approximately 10,000 species all over the world (Carter 1992; Saini 2018).

Family Geometridae: Loopers (Lepidoptera: Geometroidea) are well known by their names as 'Looping' or 'earth-measuring' creatures. A total number of 23,002 species are known today,

making Geometridae the third largest family of order Lepidoptera after family Erebidae and Noctuidae (Nieukerken et al. 2011).

Family Erebidae: The family Erebidae (Lepidoptera: Noctuoidea) is the second largest moth family after Noctuidae. Recently, some species of family Noctuidae, Lymantridae, Arctiidae are merged in family Erebidae (Shubhalaxmi 2018). During the present work, same nomenclature has been followed. The Erebidae incorporates 24,569 species worldwide.

Family Crambidae: Crambids (Lepidoptera: Pyraloidea) are represented by 11,630 species worldwide. Adult moths can be well recognized from their resting posture, as the antennas are folded back towards their thorax.

1.7 Objectives

i. To study wing venation pattern in moth (Lepidoptera) families from dry specimens collected from IISER Mohali campus (Guava garden).
ii. To prepare dichotomous keys for the examined taxa through incorporation of wing venation features.
iii. To update the remarks for as many as studied genera.

1.8 Bibliography

1. Arora GS, Gupta IJ (1979) Taxonomic studies of some of the Indian non-mulberry silkmoths (Lepidoptera: Saturniidae). Mem. Zool. Sur. India, 16:1-63.
2. Batzer, Harold O, Robert C (1978) Forest tent caterpillar U.S. department of agriculture forest service, forest insect and disease leaflet 9.8 p.
3. Banzinger E, Harding (1989) An Aqua Flex: a pediatricall plastic prosthetic knee system Jun; 56(3):132-137
4. Betts CR, (1987) Guides to insects of importance to man. Lepidoptera, CAB International Institute of Entomology & British Museum of Natural History London, 261pp.
5. Biswas O, Shah SK, Mishra P, Mallick K, Mitra B (2015) Taxonomic account of Erebidae(Lepidoptera: Noctuoidea) Pests of tea gardens of West Bengal, India. J. Entomol. Zoology Studies, 3(5): 185-192.
6. Capinera JL (2001) Grasshoppers of florida. University Press of Florida, Gainesville. 143pp
7. Carter DJ (1992) Butterflies and moths (Dorling, Kinderslay) New York, 304pp.

8. Dar MA (2015) Diversity in family Noctuidae Lepidoptera from Jammu and Kashmir, Punjabi University Patiala, Punjab India, 198pp.
9. Das S, Mukhopadhyay A, Roy S (2010) Morphological diversity, developmental traits and seasonal occurrence of looper pests (Lepidoptera: Geometridae) of tea crop. J. Biopest. 3(1): 16-19.
10. Davis AK, Holden MT (2015) Measuring intra specific variation in flight-related morphology of monarch butterflies, Danausplexippus, 11: 1-9
11. Fabricius JC (1775) Systema Entomologiae 832pp (in Latin).
12. Fabricius JC (1776) Genera Insectorum chilonii 1776: 1-641.
13. Fabricius JC (1781) Species insectorum exhibenteseorum differentias, specificas, synonyma, auctorum, locanatalia, metamorphosin, adjectis, observationibus. Hamburg and Cologue Karl E. Bohn 8: 1-552.
14. Fabricius JC (1792-98) Entomologia systematics Vol. 4 and Suppl. Hafniae 160pp.
15. Firake DM, Behere GT, Firake PD, Thakur NSA and Dubal ZB (2012) An outbreak of pine lappet moth, *Kunugia latipennis*, in mid-altitude hills of Meghalaya State, India. Phytoparasitica, 40:231-234.
16. Furniss RL, Carolin VM (1977) Western forest insects. U.S.D.A. forest service misc. publ. 1339, 654pp
17. Goyal T (2011) Taxonomic studies on family Geometridae (Lepidoptera) from Western Ghats of India, Patiala University Patiala, 279pp
18. Ghorpade BR, Patil SP (1991) Insect pests recorded on the forest trees in the Konkan region of Maharashtara State (India) Ind. J. For., 14: 245-246.
19. Hampson GF (1892) Fauna of British India including Ceylon and Burma, Moths, 1: 1-527. Taylor and Francis Ltd., London.
20. Hampson GF (1894) Fauna of British India including Ceylon and Burma, Moths, 2: 1-609. Taylor and Francis Ltd., London.
21. Hampson GF (1895) Fauna of British India including Ceylon and Burma, Moths, 3: 1-546. Taylor and Francis Ltd., London.
22. Hampson GF (1896) Fauna of British India including Ceylon and Burma, Moths, 4: 1-594. Taylor and Francis Ltd., London.

23. Hamspon GF (1898) Catalogue of the Lepidoptera phalaena in the British Museum, 15 vols. Natural History Museum, London.
24. Kitching IJ, Rawlins JE (1998) The Noctuoidea. In Lepidoptera: Moths and butterflies. Vol.1.Evolution, Systematics and biogeography. Berlin. N.P. Kristensen. Walter de Gruyter, 355-40.
25. Kumar V, Reddy PVR, Rami PV, Dubedi AK and Nath V (2014) Outbreak of the looprperixeraillepidaria (Lepidoptera: Geometridae) on litchi, *Litchi chinensis* (Sapindales: Sapindaceae)-A new pest record from India. Florida Ento., 97(1): 22.
26. Leurat P (2006) Lepidoptera family-group names proposed by Thaddeus William Harris in (1841) Zookeys, 251: 219-226.
27. Linnaeus C (1758) Systemanaturæ per regna tria nature, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. TomusEditio Decima, Reformata, Holmiæ, 824pp.
28. Linnaeus C (1764) Museum ludovicaeulricaereginae. Holmiae, 6: 384-415.
29. Linnaeus C (1771) Mantissa plantarum (2nd edition). Holmiae, 6: 1-587.
30. Moore F (1879) Description of new Lepidopterous insects from the collection of late Mr. W.S.Atkinson. Asiatic Soc. Bengal, Calcutta, (1879): 1-299.
31. Moore F (1881) Description of new genera and species of Asiatic nocturnal Lepidoptera. Proc. Zool. Soc. London, 15-30.
32. Moore F (1882-1887) Lepidoptera of Ceylon .Heterocera, 1(4): 1-578
33. Moore F (1888) Description of new India Lepidopterous insects from the collection of W.S. Attkinson. Heterocera, Calcutta, 1888: 211.
34. Muddasar V, Kotikal YK (2018) Taxonomic attributes of six species of Erebidae (Lepidoptera: Noctuoidea) from Karnataka. J. Ent. Res., 42(3): 407-416.
35. Nieukerken EJ, Lauri K, Kitching IJ, Zwick A (2011) Order Lepidoptera Linnaeus, 1758 animal biodiversity, an outline of higher classification and survey of taxonomic richness. Zootaxa, 3148:212-221.
36. Parreira DS (2014) Periphobahircia (Lepidoptera: Sphingidae) Defoliating plants of *Acacia mangium* in the state of Roraima, Brazil. Florida Entomol., 97(1): 325-328.
37. Pemm KH (1983) New owlet moth species (Lepidoptera :Noctuidae) in USSR. Ent. Obozr., 62(3): 596-600.

38. Regier JC, Mitter C, Peigler RS, Friedlander TP (2000) Phylogenetic relationships in Lasiocampidae (Lepidoptera) initial evidence from elongation factor-1 alpha sequences. Insect Syst. Evo., 31(2): 179-186.
39. Saxena A (2016) Taxonomic studies on family Geomteridae (Lepidoptera) from North-East India, Punjabi University Patiala, Punjab India, 212pp.
40. Saini S (2018) Taxonomy of superfamily Bombycoidea (Lepidoptera) from North-West India supplemented with molecular studies, Punjabi University Patiala, Punjab India, 414pp.
41. Shubhalaxmi V (2018) Birdwing field guide to Indian moths. 457pp.
42. Singh R, Jain M (2020) Variation in call types, calling activity patterns and relationship between call frequency and body size in a field cricket, *Acanthogryllus asiaticus*. Bioacoustics, 1-19.
43. Solis MA Snout moths: Unraveling the taxonomic diversity of a species group in the Neotropics, 231-242. In: Reaka-Kudla ML, Wilson D, Wilson EO. (eds.). Biodiversity II: Understanding and protecting our biological resources. Joseph henry press, Washington, D. C. 1997,551
44. Triplehorn CA, Charles A and Johnson NF (2005) Introduction to the study of insects. (7th edition) 2005 ISBN 0-03-096835-6.
45. Zahiri R, Holloway JD, Kitching IJ, Lafontaine JD, Mutanen M, 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.
46. Zhang ZQ (2013) Phylum Arthropoda. Zootaxa, 3703(1): 17-26.

2. METHODOLOGY

2.1 Area of study

Indian Institute of Science Education and Research (IISER), Mohali lies in the state of Punjab, which is a part of Northern India and exhibits a varied geography. The word “Punjab” is a Persian word derived from ‘Panj’ (five) and ‘Ab’ (waters). Thus it means "the land of five rivers" namely Sutlej, Beas, Ravi, Chenab and Jehlum. The state, richly endowed with natural resources and competitive advantages, stretches from 31.1471° N, 75.3412° E comprising an area of 50,362 km^2 of land and its altitude is 320 m (above mean sea level). Morphologically, the state of Punjab can be differing from other states not only in topography but also in culture. The sampling was done in the Guava garden of IISER-Mohali, Punjab which is spread over 125 acres of land in the knowledge city, Mohali at sector 81 with coordinates 30.6650° N, 76.7300° E which is adjoined by Indian School of Business (ISB) and an International airport road.

2.2 Sampling site

The sampling was done in Guava garden of IISER Mohali campus (Figure 2) because the location was covered with guava trees and numerous shrubs and herbs (*Lattuce serriola* (Prickly lettuce), *Acrocarpus fraxinifolius* (Red cedar); *Morus alba* (White mulberry) etc). Since, this was the place of the institute which was having good vegetation and moreover isolated from the main city and different unwanted artificial light source as it has been observed that nocturnal animals including moths were distress with the increase of artificial lighting (Cinzano et al. 2001). Also the model organism was moths (nocturnal) and need dark place with good canopy structures, therefore, in 2017, the project was initiated by one of the master student of Behavioral Ecology Lab, IISER Mohali, Tarunkishwor Yumnam. He identified 70 species of moths and my study raised the number of species to 77 along with the detailed description of wing venation of 6 families namely Lasiocampidae, Noctuidae, Sphingidae, Geometridae, Erebidae and Crambidae.

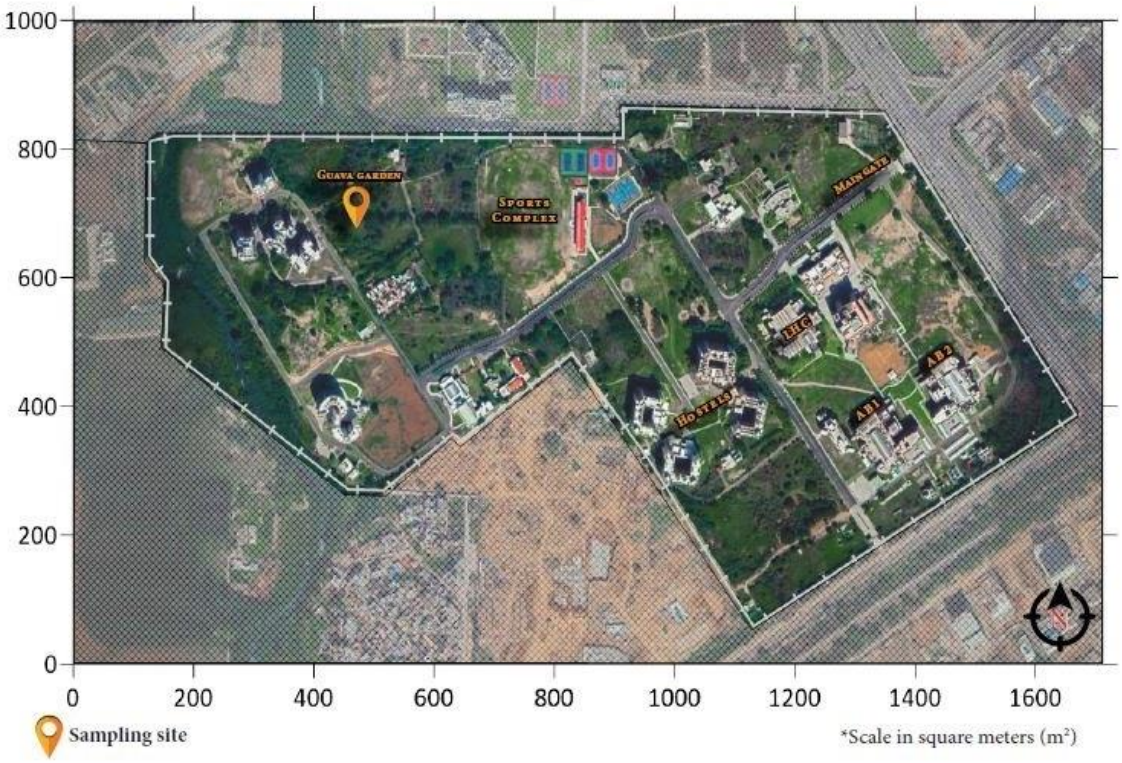


Figure 2: Sampling site (Guava Garden), IISER-M campus

2.3 Sampling duration

The research study was initiated in the month of April, 2019 to observe and collect the moth individuals and it is still an ongoing project work currently perusing by one of the Post Doctoral fellow (Dr. Sujata Saini) in BEL, IISER Mohali. 10 observations (each month) were done with two hour interval (20.00, 22.00 and 00.00). So far, a more than 70 sampling has been done which results as a team work with an active moth project. My research work includes study of only those moth's species, which were collected in between the months of April, 2019 to September, 2019.

2.4 Field work / data collection and preservation

The collection was made with the help of vertical sheet light trap method (Fry and Waring 1996) for six hours (18.00 to 00.00 hrs) by using 125 W Mercury Vapor Lamp (MVL) (Philips, India) with the wavelength (λ) of 442 nm powered by 220V AC source (Figure 3,4 and 5). The collected material was stored with ethyl acetate vapors in bottles (maximum 6 individuals). The

freshly stored specimens were pinned and stretched by using stretching boards and thermocol sheets. Well stretched specimens were preserved in air tight fumigated wooden boxes of insect cabinets placed at Behavioral Ecology Lab, IISER Mohali for photography and other purpose. Each specimen was tagged with important information like date of collection, locality and name of the collector.

Figure 3: Sampling site (Guava Garden)

Figure 4: Light trap

Figure 5: Moth team, BEL, IISER-M

2.5 Preparation of permanent slides and nomenclature of wing venation

In order to have a crystal clear picture of forewing and hindwing venation, permanent slides of 6 studied moth families (Lasiocampidae, Noctuidae, Sphingidae, Geometridae, Erebidae and Crambidae) were prepared by the protocol proposed by Zimmerman (1978). The procedure includes the separation of one pair of wing (right or left) of a species by giving an upward jerk with the help of a fine forceps. The detached wings were dipped in 30% absolute alcohol for descaling followed by 50% absolute alcohol to make them softer. Further descaling was done with the help of Sodium hypochlorite and then washed with distilled water to remove excess of Sodium hypochlorite. Further, wings were dipped in upgrading absolute alcohol up to 100% and then stained in eosin for 12-14 hours. Finally, the wings were cleared in xylene (to avoid bubble during the formation slides) before mounting in DPX (Dibutylphthalate Polystyrene Xylene) (Figure3). The nomenclature for wing venation erected by Miller (1970) (in bold) has been followed in this work (Figure 6).

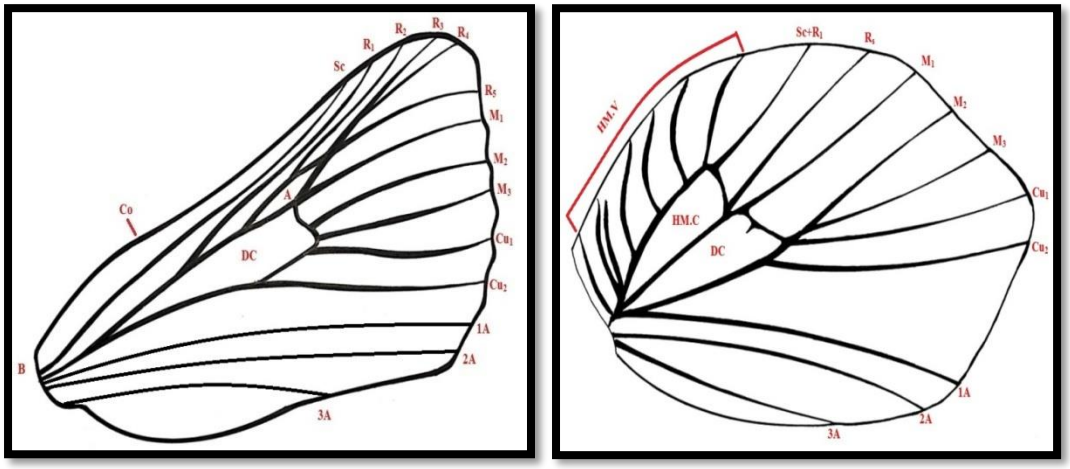
Figure 6: Stained photograph of forewing and hindwing

NOMENCLATURE OF FOREWING VENATION

Hampson (1892)	12	11	10	9	8	7	6	5	4	3	2	1c
												1b
												1a
Miller (1970)	Sc	R_1	R_2	R_3	R_4	R_5	M_1	M_2	M_3	Cu_1	Cu_2	1A
												2A
												3A

NOMENCLATURE OF HINDWING VENATION

Hampson (1892)	8	7	6	5	4	3	2	1c
								1b
								1a
Miller (1970)	$Sc+R_1$	Rs	M_1	M_2	M_3	Cu_1	Cu_2	1A
								2A
								3A



A **B**

Figure 7: Generalized moth venation illustration: A-Forewing; B-Hindwing

2.6 Acronyms and origin of veins

A-Areole; 1A-First anal vein; 2A-Second anal vein; 3A-Third anal vein; B-Base; CO-Costa; CU_1-First cubital vein; CU_2-Second cubital vein; DC-Discal cell; F-Frenulum; HM.C-Humeral cell; HM.V-Humeral vein; M_1-First median vein; M_2-Second median vein; M_3-Third median vein; Pre.Co.S-Pre costal spur; R_1-First radial vein; R_2-Second radial vein; R_3-Third radial vein; R_4-Fourth radial vein; R_5-Fifth radial vein; Rs-Radial Sector; Sc-Subcosta; $Sc+R_1$-Subcosta+First radial vein

Forewing: All Anals (A) and subcostal vein (Sc) were arising from the base (B) of the wing. On the other hand all the cubitals (Cu), medials (M) and radial (R) veins were originating from the discal cell (Dc) (Figure 7).

Hindwing: All Anals (A) and subcostal plus radial vein ($Sc+R_1$) were arising from the base (B) of the wing. While all the cubitals (Cu), medials (M) and radial sector (Rs) veins were originating from the discal cell (Dc) (Figure 7).

2.7 Identification

The identification of 77 moths referable to 67 genera (Table 1 and 2) were done with the help of relevant literature namely "The Fauna of British India including Ceylon and Burma Moths volume I, II, III, IV (Hampson 1892, 1894,1895,1896), 'Fauna of Sphingidae' (Bell and Scott 1937) 'Moths of Borneo (Holloway 1987), 'Moths of Nepal' (Kishida 1993), 'Sphingidae of the Western Palaearctic' (Pittaway 1995), 'Lasiocampidae of Vietnam' (Zolotuhin and Witt 2000), Noctuoidea of Thailand' (Kononenko and Pinratana 2005); Pyraloidea of Bhutan (Irungbam et al. 2016), 'Field guide to Indian Moths' (Shubhalaxmi 2018) as well as other relevant research publications.

Families	No. of Genera	No. of Species
LASIOCAMPIDAE	3	3
NOCTUIDAE	13	14
SPHINGIDAE	10	13
GEOMETRIDAE	9	12
EREBIDAE	19	22
CRAMBIDAE	13	13

Table 1: Moth families referable to their studied no. of genera and species.

Moth Family(s)	Species
LASIOCAMPIDAE (Superfamily Bombycoidea)	1. *Trabala vishnou* Lefebvre 2. *Gastropacha leopoldi* Tams 3. *Streblote siva* Lefebvre
NOCTUIDAE (Superfamily Noctuoidea)	4. *Analetia unicorna* Berio 5. *Athetis flavicolor* Han and Kononeko 6. *Chrysodexis eriosoma* Doubleday 7. *Helicoverpa armigera* Hübner 8. *Ochropleura leucogaster* Freyer 9. *Pericyma umbrina* Guenee 10. *Sesami ainferens* Walker 11. *Spodoptera litura* Fabricius 12. *Trigonodes hypasia* Cramer 13. *Hypocala rostrata* Fabricius 14. *Thysanoplusia orichalcea* Fabricius 15. *Xanthodes intersepta* Guenee 16. *Xestia nigrum* Linnaeus 17. *Xestia tamsi* Wileman and West
SPHINGIDAE (Superfamily Bombycoidea)	18. *Acherontia styx* Westwood 19. *Agrius convolvuli* Linnaeus 20. *Cypa decolor* Walker 21. *Macroglossum belis* Linnaeus 22. *Polyptychus trilineatus undatus* Rothschild & Jordan 23. *Sataspes scotti* Jordan 24. *Daphnis nerii* Linnaeus 25. *Hippotion celerio* Linnaeus 26. *Hippotion rosetta* Swinhoe 27. *Theretra nessus* Drury 28. *Theretra oldenlandiae* Fabricius 29. *Nephele didyma* Fabricius

	30. *Nephele hespera* Fabricius
GEOMETRIDAE (Superfamily Geometroidea)	31. *Ourapteryx clara* Butler 32. *Chiasmia frugaliata* Guenee 33. *Digrammia subminiata* Packard 34. *Rhodometra sacraria* Linnaeus 35. *Spaniocentra pannosa* Moore 36. *Traminda mundissima* Walker 37. *Hypomecis* sp. 38. *Hypomecis transcissa* Walker 39. *Petelia immaculate* Hampson 40. *Petelia medardaria* Herrich-Schaffer 41. *Thalassodes quadraria* Guenee 42. *Thalassodes veraria* Guenee
EREBIDAE (Superfamily Noctuoidea)	43. *Achaea janata* Linnaeus 44. *Aloa lactinea* Cramer 45. *Arctornis bubalina* Chao 46. *Calyptra parva* Banziger 47. *Dasychira* sp. 48. *Digama hearseyana* Moore 49. *Episparis liturata* Fabricius 50. *Utetheisa pulchelloides* Hampson 51. *Leucoma salicis* Linnaeus 52. *Somena scintillans* Walker 53. *Thyas coronate* Fabricius 54. *Lygephila craccae* Denis and Schiffermuller 55. *Spilosoma metarhoda* Walker 56. *Attatha ino* Drury 57. *Grammodes geometrica* Fabricius 58. *Mocis frugalis* Fabricius 59. *Anomis fulvida* Guenee 60. *Anomis lineosa* Walker

	61. *Creatonotos gangis* Linnaeus 62. *Creatonoto stransiens* Walker 63. *Spirama heliciana* Hübner 64. *Spirama retorta* Clerck
CRAMBIDAE (Superfamily Pyraloidea)	65. *Botyodes diniasalis* Walker 66. *Cnaphalocrocis medinalis* Guenee 67. *Diaphania indica* Saunders 68. *Hymenia perspectalis* Hübner 69. *Haritalodes derogata* Fabricius 70. *Microthyris anormalis* Guenee 71. *Omphisa anastomosalis* Guenee 72. *Conogethes punctiferalis* Guenee 73. *Parotis marginata* Hampson 74. *Pygospila tyres* Cramer 75. *Meroctena tullalis* Walker 76. *Palpita asiaticalis* Inoue 77. *Eoophyla sejunctalis* Snellens

Table 2: Examined 77 moth species

2.8 Illustrations and photography

The line drawings of forewing and hindwing venation were completed by using rotring pen (0.2-0.8). The adult moths were also photographed in colour with a digital camera- Nikon D810. The plates were compiled using Adobe Photoshop software (Figure 8).

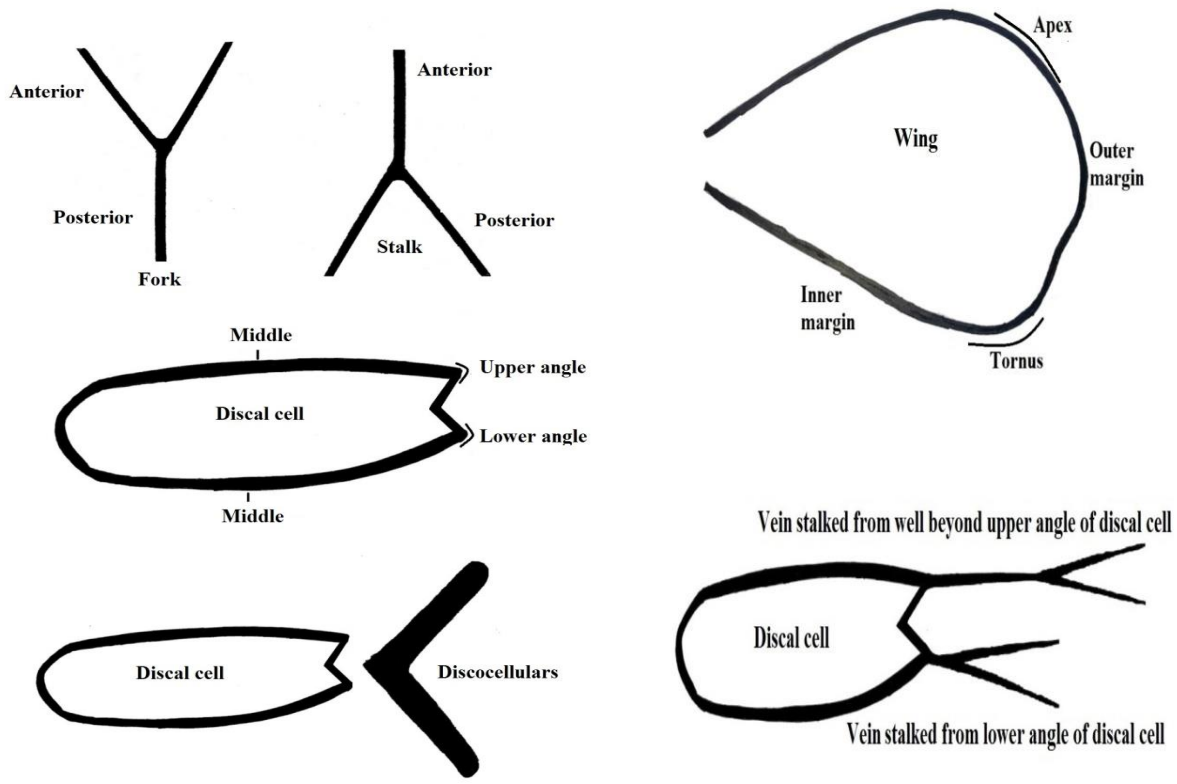


Figure 8: Diagrammatic depiction of terminology used in results

2.9 Bibliography

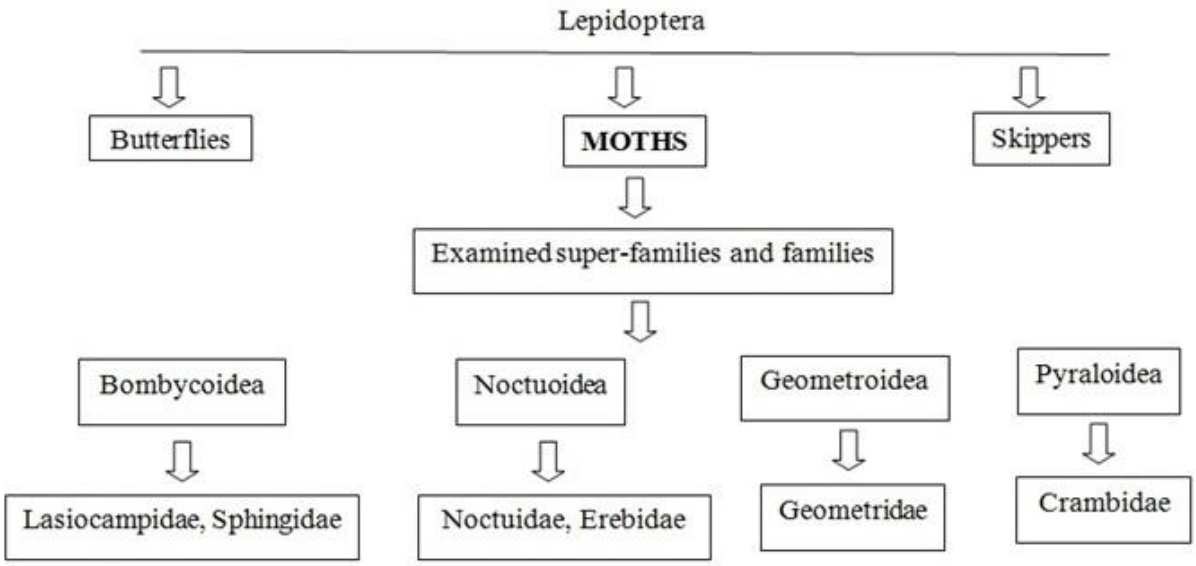
1. Bell TRD, Scott FB (1937) The Fauna of British India, including Ceylon and Burma Moths-Sphingidae Vol 5, 537pp.
2. Cinzano P, Falchi F, Elvidge CD (2001) The first world atlas of the artificial night sky brightness. Mon. Not. R. Astron. Soc 128: 689-707.
3. Fry R and Waring P (1996) A guide to moth traps and their use. Am. Ent., 24: 1-60.
4. Hampson GF (1892) Fauna of British India including Ceylon and Burma, Moths, 1: 1-527. Taylor and Francis Ltd., London.
5. Hampson GF (1894) Fauna of British India including Ceylon and Burma, Moths, 2: 1-609. Taylor and Francis Ltd., London.
6. Hampson GF (1895) Fauna of British India including Ceylon and Burma, Moths, 3: 1-546. Taylor and Francis Ltd., London.
7. Hampson GF (1896) Fauna of British India including Ceylon and Burma, Moths, 4: 1-594.

Taylor and Francis Ltd., London.

8. Holloway JD (1987) Moths of Borneo, 3: 1-199. South dene, Kuala Lumpur, Malaysia.
9. IrungbamJS, Chib MS , Wangdi K (2016)Taxonomic review of the superfamily Kishida Y (1993) Moths of Nepal, 160pp.
10. KononenkoVS, Pinratana BM (2005)Moths of Thailand volume 1 (Lepidiptera: Noctuoidae), 136pp.
11. Miller LD (1970) Nomenclature of wing veins and cells. J. Res. Lepid., 8(2): 37-49.
12. Pyraloidea in Bhutan (Lepidoptera). J. Asia-Pacific Biodiversity, 9: 355-382.
13. Pittaway AR (1995) Sphingidae of the Western Palaearctic: Their ecology and biogeography. PhD Thesis, Imperial College, university of London, UK. 244p.
14. Shubhalaxmi V (2018) Birdwing field guide to Indian moths. 457pp.
15. Yumnam T (2017) Diversity, seasonal, variation and diel pattern of nocturnal moths of IISER Mohali, Master thesis, 45pp.
16. ZimmermanEC (1978) Microlepidoptera Insects of Hawaii. Univ. Press Hawaii Honolulu, xviii+1903pp.
17. Zolotuhin VV, Witt TJ, (2000) Lasiocampidae of Vietnam. Entomofauna, 3(11): 25-104.

3. RESULTS

3.1 Moths (Lepidoptera): Wings of ditrysian group consists of membrane which was wrapped with scales or scales overlap one another like tiles. The membrane was transverse by system of veins containing blood vessels and nerves. The forewing or front-wing typically has twelve veins with internal veins known as anal veins having 1-3 branches (3A, 2A and 1A) and may be one or two of them were absent, may or may not reaches up to tornus or may be minute, forked; above anal veins, cubital veins were always present in the respective moth families and were two in numbers (Cu_2 and Cu_1) followed by median veins with its three branches (M_3, M_2 and M_1), M_3 in majority arising from lower angle of discal cell, and one of the median vein may be absent sometimes; discocellulars may be open or closed by which we can conclude that either discal cell open or closed; radial veins with five branches (R_5, R_4, R_3, R_2 and R_1), it was not mandatory that all the radial veins were present or may be two of them fused sometimes; subcostal vein (Sc) which was always present in forewing, may or may not reaches up to apex, sometimes conjoint with costa or first radial vein (R_1) or with both. Hindwing or lower wing typically consists of eight veins and can be easily distinguished from forewing on the basis of radial veins which were fused in hindwing i.e. sub-costa and first radial vein ($Sc+R_1$) and presence of radial sector (Rs), and sometimes both these two veins were anastomosing with each other to form a bar with discal cell or give rise to humeral cell/veins or a pre-costal spur; rest all veins were having similar pattern/modifications as we can observe in forewing. The forewing and hindwing in majority of the families were united with frenulum (F) arising from the base of costa of hindwing and it's a spine-like structure helps in sexual dimorphism of species (1=♂, >1=♀). In the present manuscript, the wing architecture of six families has been described and first time such study has been made from IISER Mohali (for specific terms, refer Figure 7 in methodology section)



Key to the studied families of moths (Lepidoptera)

1.Forewing with anal veins (3A+2A) fused completely, without forming a basal fork; hindwing with humeral cell and vein…….……..…….…….....Lasiocampidae Harris

- Forewing with anal veins forming a basal fork; hindwing without humeral cell and vein……..2

2. Forewing with R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole; veins showing trifine pattern……..…Noctuidae Latreille

- Forewing without an areole and trifine pattern…….……3

3. Forewing with vein $R_{(3+2)}$ totally fused; hindwing with vein 2A basally forked……..
……...…….Sphingidae Latreille

- Forewing with vein R_3 and R_2 always separate; hindwing with 2A not basally forked ….……4

4. Forewing with vein R_5 arises from R_4 and R_3; hindwing with well developed pre costal spur….
…….Geometridae Leach

- Forewing with vein R_5 not arises from R_4 and R_3; hindwing without pre costal spur…….5

5. Forewing with 3A minute, separate from 2A or absent; quadrifine venation…..Erebidae Leach

-Forewing with 3A not separate from 2A; no quadrifine venation……Crambidae Latreille

FAMILY LASIOCAMPIDAE HARRIS, 1841

(Plates 1-3)

Diagnostic features: Forewing with discal cell closed; vein 3A fused with 2A, without forming a basal fork; 1A present or absent; Cu_2 and Cu_1 present; M_1 stalked with R_5 or from upper angle

of cell; R_4 may arise from the common stalk of M_1 and R_5, sometimes from upper angle of cell; R_3 and R_2 always stalked; R_1 present; Sc from base of wing not reaching up to apex, mostly conjoined with costa. Hindwing with discal cell closed or open; 3A and 2A present separately; 1A present or absent; Cu_2 and Cu_1 present; M_2 from lower angle of cell or stalked with M_3; Sc+R_1 anastomosing with Rs forming a humeral cell; humeral cell may be shorter, longer, narrower or broader than discal cell; humeral veins prominent or indistinct.

Key to the studied species of family Lasiocampidae

1. Forewing with apex circular; Sc conjoined with R_1; hindwing crenulated, humeral cell very small……*Trabala vishnou* Lefebvre
- Forewing with apex triangular; Sc not conjoined with R_1; hindwing not crenulated, discal cell always closed; humeral cell of medium size……..……..……..…2
2. Forewing with vein Cu_1 from well above lower angle of discal cell; hindwing with humeral veins prominent.....*Gastropacha leopoldi* Tams
- Forewing with vein Cu_1 from just above lower angle of discal cell; hindwing with humeral vein absolote.....*Streblote siva* Lefebvre

TRABALA WALKER

Walker, 1856, List Spec. Lepid. IsectsColln. Br. Mus., 7: 1785; Hampson, 1892, Moths India, 1: 421; Holloway, 1987, Moths Borneo, 3:49; Zolotuhin and Pinratana, 2005, Lasiocampidae Thailand, 4: 41.

Type species: *Amydona prasina* Walker

Remarks: Hampson (1892) described two species in this genus and Holloway (1987) added ten more species alongwith one new species namely *bouraq* from Borneo. Youqiao and Chunsheng (2006) reported three more species in this genus. This genus was represented by twenty eight species including *vishnou* Lefebvre (Saini et al. 2019).

Trabala vishnou Lefebvre

Plate 1

Forewing venation: Forewing with apex circular; outer margin crenulated; discal cell less than half the length of wing; vein 3A+2A fused, without forming a basal fork; 1A thin; Cu_2 arising from just above middle of cell; Cu_1 from below middle of cell; M_3 from lower angle of cell; M_2 from just above lower angle of cell, very close to lower angle; M_1 and R_5 stalked from upper

angle of cell; R_4 from just above upper angle of cell; R_3 and R_2 highly stalked from two-thirds of cell; R_1 from before middle of cell; Sc from base of the wing not reaching up to apex, conjoined with R_1.

Hindwing venation: Hindwing oval, outer margin crenulate; discal cell closed one third length of total wing; 3A, 2A, 1A present, 1A indistinct from base up to half of discal cell; Cu_2 from below middle of cell; Cu_1 from just above lower angle of cell; M_3 and M_2 stalked just beyond from lower angle of cell; M_1 from upper angle of cell; Rs from middle of cell; $Sc+R_1$ anastomosing with Rs forming humeral cell, humeral cell shorter and narrower than discal cell; one humeral vein present.

GASTROPACHA OCHSENHEIMER

Ochsenheimer, 1810, Schmett. Eur., 3: 239; Hamspon, 1892, Moths India, 1: 428; Holloway, 1987, Moths Borneo, 3:56; Youqiao and Chunsheng, 2006, Fauna Sinica, 47: 228-229.

Type species: *Phalaena quercifolia* Linnaeus

Remarks: Hampson (1892) studied three species in genus *Gastropacha* Ochsenheimer including *leopoldi* Tams.

Gastropacha leopoldi Tams

Plate 2

Forewing venation: Forewing with apex triangular; discal cell almost half the length of total wing; 3A+2A fused, without forming a fork, reaching up to tornus; 1A present; Cu_2 from two-third of cell; Cu_1 from well above lower angle of discal cell; M_3 from lower angle of cell; M_2 from just above lower angle of cell; M_1, R_5 and R_4 well stalked, R_4 originating from middle of common stalk of M_1 and R_5; R_3 and R_2 highly stalked from before upper angle of cell; R_1 arising from almost middle of cell; Sc from base of wing not reaching up to apex.

Hindwing venation: Hindwing oval, broader, wing extended outward at vein Cu_1; discal cell less than half the length of wing; Cu_2 from well before lower angle of cell; Cu_1 from near base of common stalk of M_3 and M_2; M_3 and M_2 moderately stalked from lower angle of cell; M_1 from upper angle of cell; Rs before upper angle of cell; $Sc+R_1$ anatomizing with Rs to form humeral cell of same size of discal cell; seven prominent humeral veins present, second and third ones arising from common point.

STREBLOTE HÜBNER

Hübner, 1820, Verz. Bek. Schmett., 13: 193

Type species: *Streblote panda* Hübner

Remarks: This genus was known by eleven species including *siva* Lefebvre.

Streblote siva Lefebvre

Plate 3

Forewing venation: Forewing with apex triangular; discal cell closed, less than half the length of total wing; 3A+2A fused, without forming a fork, reaching up to tornus; 1A present up to discocellulars; Cu_2 from before middle of discal cell; Cu_1 just above lower angle of discal cell; M_3 from lower angle of cell; M_2 just above, arising nearly from lower angle of cell; M_1 and R_5 stalked well beyond upper angle of cell; R_4 arising from common stalk of M_1 and R_5; R_3 and R_2 arising from just above upper angle of cell and stalked; R_1 from near middle of discal cell not reaching up to apex; Sc from base of wing reaching up to half portion of costa, conjoint with costa.

Hindwing venation: Hindwing globular, circular at apex; discal cell closed; discocellulars uneven, 3A present not reaching up to tornus; 2A reaching up to tornus; 1A present, thin, obsolete up to antemedial area; Cu_2 from above lower angle of cell; Cu_1 from just above lower angle of cell; M_3 and M_2 stalked from beyond lower angle of cell; M_1 from upper angle of cell; Rs from before middle of discal cell; $Sc+R_1$ anastomosing with Rs forming humeral cell, humeral cell almost half of discal cell; one humeral vein present, obsolete.

FAMILY NOCTUIDAE LATREILLE, 1809

(Plates 4-17)

Diagnostic features: Forewing with discal cell closed; vein 3A slight or absent; 2A present; 1A absent; Cu_2 beyond lower angle of discal cell; Cu_1, M_3, M_2 originating from near or from lower angle of discal cell forming trifine venation; M_1 from upper angle of cell; R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole; R_1 from discal cell; Sc from base of wing, not reaching up to tornus. Hindwing with discal cell closed; vein 3A and 2A present; 1A absent; Cu_2 beyond lower angle of cell; Cu_1 and M_3 from or beyond lower angle of discal cell; M_2 from near lower angle or about middle of discocellulars or absent; Rs and $Sc+R_1$ present.

Key to studied species of family Noctuidae

1.Hindwing with vein Cu_1 hump-like…….....……..…….....*Analetia unicorna* Berio

- Hindwing with vein Cu_1 not hump-like …….....……..……..…2

2. Forewing with R_1 arising from just below middle of discal cell……..……

……...*Athetis flavicolor* Hans & Kononeko

- Forewing with R_1 not arising from just below middle of discal cell…….…….……...3

3. Forewing with Cu_2 emerging from one-fifth middle of discal cell….....

……..….*Chrysodexis eriosoma* Doubleday

-Forewing with Cu_2 emerging from nearly middle or one-fourth of discal cell……..4

4. Hindwing with vein Cu_1 and M_3 stalked from lower angle of discal cell……..……

……...…….……*Helicoverpa armigera* Hübner

- Hindwing with vein Cu_1 and M_3 not stalked…….…….…….…..….5

5. Hindwing with vein M_1 and Rs stalked from beyond upper angle of discal cell……

……..……..…*Ochropleura* leucogaster Freyer

- Hindwing with vein M_1 and Rs stalked not from beyond upper angle of discal cell…..…….….6

6. Forewing with smallest areole……...…….……*Pericyma umbrina* Guenee

- Forewing with areole not too small…….……..……7

7. Hindwing with vein M_2 from middle of discocellulars…….....….*Sesamia inferens* Walker

- Hindwing with vein M_2 not from middle of discocellulars……..…..……..…….…8

8. Hindwing with M_2 just below middle of discocellulars….....….*Spodoptera litura* Fabricius

- Hindwing with M_2 not from below middle of discocellulars…….…….…..…9

9. Forewing with vein 3A absent……..…..……*Trigonodes hypasia* Cramer

- Forewing with vein 3A present…….……..10

10. Hindwing with vein 3A not reaching up to tornus…….……*Hypocala rostrata* Fabricius

- Hindwing with vein 3A reaching up to tornus……11

11. Hindwing with vein Cu_1 just above lower angle of cell and M_3 from lower angle of cell….……..……...……..*Thysanoplusia orichalcea* Fabricius

- Hindwing with veins Cu_1 and M_3 from lower angle of discal cell……..……

……...*Xanthodes intersepta* Guenee

ANALETIA CALORA

Calora, 1966, Noctuidae Lepid. Cat.,1966: 709

Type species: *Analetia micacea* Hampson

Analetia unicorna Berio

Plate 4

Forewing venation: Forewing narrow, slightly crenulate, Cu_1 hump-like; discal cell closed, more than half length of total wing; vein 3A slight; not anastomosing with 2A; 2A reaching up to tornus; 1A absent; Cu_2 arising from one-fourth from lower angle of cell; Cu_1, M_3, M_2 arising from near lower angle of discal cell, showing trifine venation; M_1 from upper angle of cell; R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole; R_1 from nearly middle of discal cell, not reaching up to tornus; Sc from base of wing more close to R_1, not reaching up to apex.

Hindwing venation: Hindwing slightly crenulated; discal cell closed, less than half length of total wing; 3A present, not reaching up to tornus; 2A reaching up to tornus; 1A absent; Cu_2 arising from well below middle of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 from just below middle of discocellulars, thin; M_1 and Rs from upper angle of discal cell; $Sc+R_1$ anastomosing with discal cell before middle of discal cell.

ATHETIS HÜBNER

Hübner, 1816, Verz. Bekannter Schmett., 1816: 209

Type species: *Noctua dasychira* Hübner.

Remarks: Han and Kononenko (2011) described 12 new species viz., *hoengshana* sp.n., *simplex* sp.n., *orthosioides* sp.n., *eupsilioides* sp.n., *tridentate* sp.n. , *linzhisp.n*., *flavicolor* sp.n., *biserrata* sp.n., *minivalva* sp.n., *longiharpe* sp.n., *bicornuta* sp.n., *furcatula* sp.n. under this genus from China with male and female genitalic attributes by ignoring wing venation. At present, this genus was known by fifteen species.

Athetis flavicolor Han and Kononeko

Plate 5

Forewing venation: Forewing narrow, slightly crenulated; discal cell almost half length of total wing; vein 3A absent; 2A reaching up to tornus; 1A absent; Cu_2 arising from one-fourth of discal cell; Cu_1, M_3, M_2 arising from near lower angle of discal cell, showing trifine venation; M_1 from upper angle of cell; R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole; R_1 from just below middle of discal cell, not reaching up to tornus; Sc from base of wing more close to R_1, not reaching up to apex.

Hindwing venation: Hindwing slightly crenulated; discal cell closed, more than half length of total wing; 3A and 2A reaching up to tornus; 1A absent; Cu_2 arising from just below middle of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 from middle of discocellulars, thin and indistinct; M_1 and Rs from upper angle of discal cell; $Sc+R_1$ anastomosing with discal cell before middle, almost reaching up to apex.

CHRYSODEIXIS HÜBNER

Hübner, 1821; Verz. Bek. Schmett. 16: 252

Type species: *Phalaena chalcites* Esper

Chrysodexis eriosoma Doubleday

Plate 6

Forewing venation: Forewing narrow, crenulated; discal cell almost half length of total wing; vein 3A slight; not anastomosing with 2A; 2A reaching up to tornus; 1A absent; Cu_2 arising from one-fifth of discal cell; Cu_1, M_3, M_2 arising from near lower angle of discal cell, showing trifine venation; M_1 from upper angle of cell; R_4 given off from R5 and anastomosing with R_3 which is given off from R_2 to form an areole; R_1 from almost middle of discal cell, not reaching up to tornus; Sc from base of wing close to R_1, not reaching up to apex.

Hindwing venation: Hindwing crenulated; discal cell closed, less than half length of total wing; 3A and 2A reaching up to tornus; 1A absent; Cu_2 arising from just below middle of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 from middle of discocellulars, well developed; M_1 and Rs from upper angle of discal cell; $Sc+R_1$ anastomosing with discal cell well before middle, reaching up to apex.

HELICOVERPA HARDWICK

Hardwick, 1965, Mem. Ent. Soc. Can., 40: 9.

Type species: *Noctua armigera* Hübner

Remarks: The genus *Helicoverpa* was discovered by Hardwick in 1965 on type species *Noctua armigera* Hübner. Todd (1978) treated this genus as a junior synonym of *Heliothis* Ochsenheimer and considered *armigera* under genus *Heliothis* Oschenheimer. Goyal (2011) considered *armigera* under genus *Helicoverpa* and many authors followed the same nomenclature. In this manuscript, the same nomenclature has been followed.

Helicoverpa armigera Hübner

Plate 7

Forewing venation: Forewing narrow, slightly crenulated; discal cell more than half length of total wing; vein 3A absent; 2A reaching up to tornus; 1A absent; Cu_2 arising from more than one-third of discal cell; Cu_1, M_3, M_2 arising from near lower angle of discal cell, showing trifine venation; M_1 from upper angle of cell; R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole; R_1 from almost middle of discal cell, not reaching up to tornus; Sc from base of wing close to R_1, not reaching up to apex.

Hindwing venation: Hindwing slightly crenulated; discal cell closed, less than half length of total wing; 3A, 2A present, reaching up to tornus; 1A absent; Cu_2 arising from just below middle of discal cell; Cu_1, M_3 stalked from lower angle of discal cell; M_2 from middle of discocellulars, thin; M_1 and Rs stalked from upper angle of discal cell; $Sc+R_1$ not reaching up to apex.

OCHROPLEURA HUBNER

Hubner, 1816, Verz. Bekannter Schmett., 1816: 223.

Type species: *Phalaena plecta* Linnaeus.

Remarks: Genus *Ochropleura* was established by Hübner in 1821 on type species *Phalaena placta* Linnaeus. At present this genus was known by 11 species including *leucogaster* (Freyer).

Ochropleura leucogaster Freyer

Plate 8

Forewing venation: Forewing narrow, slightly crenulated; discal cell more half length of total wing; vein 3A slight; not anastomosing with 2A; 2A reaching up to tornus; 1A absent; Cu_2 arising from one-sixth of discal cell; Cu_1, M_3, M_2 arising from near lower angle of discal cell, showing trifine venation; M_1 from upper angle of cell; R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole; R_1 from well below middle of discal cell, not reaching up to apex; Sc from base of wing close to R_1, not reaching up to apex.

Hindwing venation: Hindwing slightly crenulated; discal cell closed, more than half length of total wing; 3A, 2A present, 3A not reaching up to tornus and 2A reaching up to tornus; 1A absent; Cu_2 from one-fifth portion of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 from middle of discocellulars, indistinct; M_1 and Rs stalked from beyond upper angle of discal cell; $Sc+R_1$ anastomosing middle of discal cell, reaching up to apex.

PERICYMA HERRICH-SCHAFFER

Herrich-Schaffer, 1845, Syst. Bearb. Schmett. Europe, 2: 429.

Type species: *Acidalia albidentaria* Freyer.

Remarks: Herrich-Schäffer in 1845 erected genus *Pericyma* on the type species *albidentaria* Freyer from U.S.S.R. Sekhon (2015) studies external genitalia of two species i.e. *umbrina* Guenee and *glaucinans* Guenee from India.

Pericyma umbrina Guenee

Plate 9

Forewing venation: Forewing narrow, not crenulated; discal cell slightly more than half length of total wing; vein 3A slight; not anastomosing with 2A; 2A reaching up to tornus; 1A absent; Cu_2 arising from one-fourth of discal cell; Cu_1, M_3, M_2 arising from near lower angle of discal cell, showing trifine venation; M_1 from upper angle of cell; R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole, areole minute (smallest as compared to rest of the studied Noctuid species); R_1 from just below middle of discal cell, not reaching up to apex; Sc from base of wing close to R_1, not reaching up to apex.

Hindwing venation: Hindwing slightly crenulated; discal cell closed, less than half length of total wing; 3A, 2A present, reaching up to tornus; 1A absent; Cu_2 from one-fourth portion of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 absent; M_1 and Rs stalked from upper angle of discal cell; Sc+R_1 anastomosing near base of discal cell, reaching up to apex.

SESAMIA GUENEE

Guenee, 1852, Hist. Nat. Insectes., 5: 95.

Type species: *Corsus nonagrioides* Lefebvre

Remarks: Guenee in 1852 established genus *Sesamia* on type species *nanagrioides* Lefebvre. Sekhon (2015) studied species *inferens* (Walker) from India.

Sesamia inferens Walker

Plate 10

Forewing venation: Forewing narrow, not crenulated; discal cell slightly more than half length of total wing; vein 3A absent; 2A reaching up to tornus; 1A absent; Cu_2 arising just above lower angle of discal cell; Cu_1, M_3, M_2 arising from near lower angle of discal cell, showing trifine venation, M_2 from well below middle of discocellulars; M_1 from upper angle of cell; R_4 given off

from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole; R_1 from just below middle of discal cell, not reaching up to apex; Sc from base of wing close to R_1, not reaching up to apex.

Hindwing venation: Hindwing not crenulated, highly excised below M3; discal cell closed, less than half length of total wing; 3A not reaching up to tornus; 2A present, reaching up to tornus; 1A absent; Cu_2 from just below middle of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 from middle of discocellulars; M_1 and Rs stalked just beyond upper angle of discal cell; Sc+R1 anastomosing almost from middle of discal cell, reaching up to apex.

SPODOPTERA GUENEE

Guenee, 1852, Hist Nat. Insectes, 5: 153.

Type Species: *Hadena mauritia* Boisduval

Remarks: The genus *Spodoptera* was established by Guenee in 1852. Hampson (1894) designated *Hadena mauritia* Boisduval as the type species of this genus. Muddasar and Venkateshalu (2017) studied three species viz., *S. exigua, S. litura and S. Mauritia* under genus *Spodoptera* in detail from Karnataka, India.

Spodoptera litura Fabricius

Plate 11

Forewing venation: Forewing narrow, slightly crenulated; discal cell slightly more than half length of total wing; vein 3A slight; not anastomosing with 2A; 2A reaching up to tornus; 1A absent; Cu_2 one-fourth portion of discal cell; Cu_1, M_3, M_2 arising from near lower angle of discal cell, showing trifine venation; M_1 from upper angle of cell; R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole; R_1 from well below middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing not crenulated; discal cell closed, less than half length of total wing; 3A, 2A present, reaching up to tornus; 1A absent; Cu_2 from just below middle of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 thin, arising from just below middle of discocellulars; M_1 from upper angle; Rs just above upper angle of discal cell; Sc+R_1 anastomosing just above middle of discal cell, reaching up to apex.

Trigonodes Guenee

Guenee,1852, Hist. Nat. Ins., Spec. Gen. Lepid., **7**: 281.

Type species: *Phalaena hypasia* Cramer

Trigonodes hypasia Cramer

Plate 12

Forewing venation: Forewing narrow, crenulated; discal cell more than half length of total wing; vein 3A absent; 2A reaching up to tornus; 1A absent; Cu_2 arising from one-fourth of discal cell; Cu_1, M_3, M_2 arising from near lower angle of discal cell, showing trifine venation; M_1 from upper angle of cell; R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole; R_1 from well below middle of discal cell, not reaching up to apex; Sc from base of wing, close to R_1 and not reaching up to apex.

Hindwing venation: Hindwing crenulated; discal cell closed, less than half length of total wing; 3A not reaching up to tornus, 2A present, reaching up to tornus; 1A absent; Cu_2 from one-fourth portion of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 arising near to lower angle of discocellulars; M_1 and Rs stalked from upper angle; $Sc+R_1$ anastomosing well above middle of discal cell, reaching up to apex.

HYPOCALA GUENEE

Guenee, 1852, Hist. Nat. Insectes, **7**: 73.

Type species: *Hyblaea deflorata* Fabricius.

Remarks: Genus *Hypocala* was described by Guenee in 1852 on its type species *deflorata* Fabricius. Hampson (1894) included six species under this genus from different localities of British India. At present this genus was known by 5 species including *rostrata*.

Hypocala rostrata Fabricius

Plate 13

Forewing venation: Forewing narrow, highly crenulated; discal cell almost half length of total wing; vein 3A slight; not anastomosing with 2A; 2A reaching up to tornus; 1A absent; Cu_2 arising from just below one-third of discal cell; Cu_1, M_3, M_2 arising from near lower angle of discal cell, showing trifine venation; M_1 from upper angle of cell; R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole; R_1 from almost middle of discal cell, not reaching up to apex; Sc from base of wing close to R_1, not reaching up to apex.

Hindwing venation: Hindwing highly crenulated; discal cell closed, less than half length of total wing; 3A not reaching up to tornus, 2A reaching up to tornus; 1A absent; Cu_2 arising from just below middle of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 from just above

middle of discocellulars, thin and indistinct; M_1 and Rs stalked from almost upper angle of discal cell; $Sc+R_1$ anastomosing just above middle of discal cell, reaching up to apex.

THYSANOPLUSIA ICHINOSE

Ichinose, 1973; Kontyu, 41 (2): 137

Type species: *Phytometra intermixta* Warren

Thysanoplusia orichalcea Fabricius

Plate 14

Forewing venation: Forewing narrow, crenulated; discal cell slightly almost equal to total wing; vein 3A slight; not anastomosing with 2A; 2A reaching up to tornus; 1A absent; Cu_2 almost one-third portion of discal cell; Cu_1, M_3, M_2 arising from near lower angle of discal cell, showing trifine venation; M_1 from upper angle of cell; R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole, areole smaller than *Xanthodes intersepta*; R_1 from well below middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing crenulated; discal cell closed, less than half length of total wing; 3A, 2A present, reaching up to tornus; 1A absent; Cu_2 from just above lower angle of discal cell; Cu_1 from just beyond lower angle of discal cell; M_3 arising from lower angle of discal cell; M_2 well below middle of discocellulars and more close to M_3 as compared to *Xanthodes intersepta* M_1 and Rs stalked from upper angle; $Sc+R_1$ anastomosing well above middle of discal cell, reaching up to apex.

XANTHODES GUENEE

Guenee, 1852; Hist. Nat. Ins., Spec. Gen. Lepid. 6: 209

Type species: *Xanthodes transversa* Guenee

Xanthodes intersepta Guenee

Plate 15

Forewing venation: Forewing narrow, highly crenulated; discal cell more than half length of total wing; vein 3A slight, minute; not anastomosing with 2A; 2A reaching up to tornus; 1A absent; Cu_2 nearly one-fourth of discal cell; Cu_1, M_3, M_2 arising from near lower angle of discal cell, showing trifine venation; M_1 from lower angle of cell; R_4 given off from R_5 and

anastomosing with R_3 which is given off from R_2 to form an areole; R_1 from middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing crenulated; discal cell closed, almost half length of total wing; 3A and 2A reaching up to tornus; 1A absent; Cu_2 from nearly one-fifth portion of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 arising below middle of discocellulars, thin; M_1 and Rs stalked from upper angle; $Sc+R_1$ anastomosing well above middle of discal cell, reaching up to apex.

XESTIA HÜBNER

Hübner, 1818, Zutrage Samml. Exot. Schmett. 1: 16.

Type species: *Noctua ochreago* Hübner.

Remarks: The genus *Xestia* was erected by Hübner in 1818 and Hampson in 1903 designated *Noctua ochreago* Hübner as its type species reported from London. Srivastava (2001) described three species i.e. *nigrum* Linnaeus, *renalis* Walker and *semiheribida* Walker from India.

Key to the studied species of genus *Xestia* Hübner

1.Forewing with vein R_1 beyond middle of discal cell; hindwing with vein $Sc+R_1$ anastomosing with discal cell at middle……..……*Xestia nigrum* Linnaeus

- Forewing with vein R_1 below middle of discal cell; hindwing with $Sc+R_1$ anastomosing near beyond middle of discal cell……..……...*Xestia tamsi* (Wileman and West)

Xestia nigrum Linnaeus

Plate 16

Forewing venation: Forewing narrow, slightly crenulated; discal cell more than half length of total wing; vein 3A slight; 2A reaching up to tornus; 1A absent; Cu_2 nearly one-sixth of discal cell; Cu_1, M_3, M_2 arising from nearly lower angle of discal cell, showing trifine venation; M_1 from upper angle of cell; R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole; R_1 originating from beyond middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing slightly crenulated, showing beak like structure at R_5; discal cell closed, almost half length of total wing; 3A not reaching up to tornus;, 2A present, reaching up to tornus; 1A absent; Cu_2 from nearly one-fifth portion of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 present, from middle of discal cell; M_1 and Rs stalked just beyond upper angle; $Sc+R_1$ anastomosing with discal cell at middle, reaching up to apex.

Xestia tamsi Wileman and West

Plate 17

Forewing venation: Forewing narrow, slightly crenulated; discal cell more than half length of total wing; vein 3A slight; not anastomosing with 2A; 2A reaching up to tornus; 1A absent; Cu_2 nearly one-fourth of discal cell; Cu_1, M_3, M_2 arising from nearly lower angle of discal cell, showing trifine venation; M_1 from upper angle of cell; R_4 given off from R_5 and anastomosing with R_3 which is given off from R_2 to form an areole; R_1 from below middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing slightly crenulated; discal cell closed, almost half length of total wing; 3A, 2A present, reaching up to tornus; 1A absent; Cu_2 from nearly one-fifth portion of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 arising below middle of discocellulars, thin; M_1 and Rs stalked just beyond upper angle; $Sc+R_1$ anastomosing near beyond middle of discal cell, reaching up to apex.

FAMILY SPHINGIDAE LATREILLE, 1802

(Plates 18-30)

Diagnostic features: Forewing broad or elongated, apically acute in many genera; discal cell always closed; vein 3A+2A forked at base; 1A absent; Cu_2 and Cu_1 present; M3 from lower angle of cell; M_2 from/ below/well below/above middle of discocellulars; M_1 from upper angle of cell or stalked with R_5 and R_4; $R_{(3+2)}$ are totally fused; R_1 from before upper angle of cell; Sc from base of wing very close to costa, sometimes not reaching up to apex. Hindwing with discal cell always closed; 3A present, reaching or not reaching up to tornus; vein 2A forming a forked near base; Cu_2 and Cu_1 present; M_3 from lower angle of cell; M_2 from/ below/well below/above middle of discocellulars; M_1 and Rs stalked or from upper angle of cell; $Sc+R_1$ forming a bar with discal cell.

Key to the studied species of family Sphingidae

1. Hindwing with vein Cu_2 from two-third of discal cell……...…….*Acherontia styx* Westwood
- Hindwing with vein Cu_2 not from two-third of discal cell……..2
2. Forewing with vein M_2 from middle of discocellulars……..... *Agrius convolvuli* Linnaeus
- Forewing with vein M_2 from below middle of discocellulars ……...……...……..3

3. Forewing highly crenulated; hindwing with discal cell half the length of total wing……...
……..…….……..……*Cypa decolor* Walker

- Forewing not crenulated at Cu_2 and Cu_1; hindwing with discal cell less than half the length of total wing……..……4

4. Hindwing with vein $Sc+R_1$ anastomosing with discal cell near base……
……...…….……..…*Macroglossum belis* Linnaeus

- Hindwing with vein $Sc+R_1$ anastomosing with discal cell not near base ……5

5.Forewing with veins M_1, R_5 and R_4 stalked……
……*Polyptychus trilineatus undatus* Rothschild and Jordan

- Forewing with veins M_1,R_5 and R_4 not stalked ……...6

6. Hindwing with discal cell more than half the length of total wing; M_2 just below middle of discocellulars……..…*Sataspes scotti* Jordan

- Hindwing with discal cell more than half the length of total wing; M_2 just above middle of discocellulars……..…….……...*Daphnis nerii* Linnaeus

ACHERONTIA LASPEYRES

Laspeyres, 1809, Jen, Allg, Litt. Zeit., 4: 88; Hampson, 1892, Moths India 1: 67; Bell and Scott, 1937, Fauna British India, Moths,5: 52-54.

Type species: *Acherontia atropos* Linnaeus

Remarks: This genus is represented by three species. The two widely distributed species are namely *lachesis* Fabricius and *styx* Westwood. Holloway (1987), Pittaway (1995) and Kaleka et al. (2011) and Saini (2018) studied these two species in detail.

Acherontia styx Westwood

Plate 18

Forewing venation: Forewing broad, apically acute; discal cell closed, less than half length of total wing; 3Aforming a fork with 2A, reaching up to tornus; 1A absent; Cu_2 from two-third of discal cell; Cu_1 from well above lower angle of cell; M_3 from lower angle of cell; M_2 below middle of discocellulars; M_1 from upper angle of discal cell; R_5 and R_4 stalked from well beyond upper angle of cell; $R_{(3+2)}$ just before upper angle of cell; R_1 well below from middle of discal cell; Sc from base of wing not reaching up to apex, close to costa and R_1.

Hindwing venation: Hindwing oval; discal cell closed, shorter than half length of wing; 3A present, reaching up to tornus; 2A slightly forked at base; 1A absent; Cu_2 from two-third of cell; Cu_1 from well above lower angle of cell; M_3 from lower angle of cell; M_2 below middle of discocellulars; M_1 and Rs stalked from beyond upper angle of cell; $Sc+R_1$ anastomosing with cell with middle of discal cell.

AGRIUS HÜBNER

Hübner, 1819, Verz. Bek. Schmett.,1819: 140; Holloway, 1987, Moths of Borneo,3: 31.

Type species: *Agrius cingulata* Fabricius

Remarks: Tutt (1902) designated *cingulata* Fabricius as the type species of this genus. The present genus is represented by 6 species throughout tropical and subtropical regions (Pittaway, 1995, Saini 2018).

Agrius convolvuli Linnaeus

Plate 19

Forewing venation: Forewing elongated, narrow, apically acute, slightly crenulated towards tornus; discal cell closed, almost half length of total wing; 3A forming a fork with 2A, reaching up to tornus; 1A absent; Cu_2 from just below middle of discal cell; Cu_1 from well above lower angle of cell; M_3 from lower angle of cell; M_2 from middle of discocellulars; M_1 from upper angle of discal cell; R_5 and R_4 stalked from well beyond upper angle of cell; $R_{(3+2)}$ just before upper angle of cell; R_1 well before from upper angle of discal cell; Sc from base of wing not reaching up to apex, close to costa and R_1.

Hindwing venation: Hindwing oval; discal cell closed, shorter than half length of wing; 3A present, not reaching up to tornus; 2A slightly forked at base; Cu_2 from less than two-third of cell; Cu_1 from well above lower angle of cell; M_3 from lower angle of cell; M_2 below middle of discocellulars; M_1 and Rs stalked from nearly upper angle of cell; $Sc+R_1$ anastomosing with cell before middle of discal cell.

CYPA WALKER

Walker, 1864, List specimens Lepid. Insects Colln. Br. Mus. London, 31: 41; Hampson, 1892, Moths India,1:71; Bell & Scott, 1937, Fauna British India, Moths,5: 217-218.

Type species: *Cypa decolor* (Walker)

Remarks: Walker established the genus *Cypa* with *ferruginea* as its type species in 1864. At present, this genus is represented by ten species from the Oriental and Eastern Palearctic and only two species i.e., *decolor* Walker and *pallens* Jordan are known from India.

Cypa decolor Walker

Plate 20

Forewing venation: Forewing elongated, narrow, apically acute, highly crenulated; discal cell closed, shorter than half length of total wing; 3A forming a fork with 2A, reaching up to tornus; 1A absent; Cu_2arising from just below middle of discal cell; Cu_1 from above lower angle of cell; M_3 from lower angle of cell; M_2 below middle of discocellulars; M_1 from upper angle of discal cell; R_5 and R_4 stalked from well beyond upper angle of cell; $R_{(3+2)}$ just before upper angle of cell; R_1 arising from two-third portion of discal cell; Sc from base of wing not reaching up to apex, close to costa and R_1.

Hindwing venation: Hindwing crenulated; discal cell closed, half length of total wing; 3A present, reaching up to tornus; 2A slightly forked at base; Cu_2 from just below middle of discal cell; Cu_1 from well above lower angle of cell; M_3 from lower angle of cell; M_2 below middle of discocellulars; M_1 and Rs stalked from beyond upper angle of cell; $Sc+R_1$ anastomosing with cell nearly middle of discal cell.

MACROGLOSSUM SCOPOLI

Scopoli, 1777, Intr. Hist. Nat., 1777: 414; Rothschild and Jordan, 1903, Novit. Zool., 9: 616; Bell and Scott, 1937, Fauna British India, Moths, 5: 345-348.

Type species: *Macroglossum stellatarum* Linnaeus

Macroglossum belis Linnaeus

Plate 21

Forewing venation: Forewing elongated; discal cell closed, slightly less than half length of total wing; 3A forming a fork with 2A, reaching up to tornus; 1A absent; Cu_2arising from middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 just below middle of discocellulars; M_1 from upper angle of discal cell; R_5 and R_4 stalked from well beyond upper angle of cell; $R_{(3+2)}$from just above upper angle of cell; R_1 arising from well before upper angle of discal cell; Sc from base of wing not reaching up to apex, close to costa and R_1.

Hindwing venation: Hindwing oval; discal cell closed, less than two-third length of wing; 3A present, not reaching up to tornus; 2A slightly forked at base; Cu_2 from middle of discal cell; Cu_1 and M_3 arising close to each other from lower angle of cell; M_2 middle of discocellulars; M_1 and Rs from upper angle of cell; $Sc+R_1$ anastomosing with discal cell near base.

POLYPTYCHUS HÜBNER

Hübner, 1822, Verz. Bek. Schmett.,1822: 141; Hampson, 1892, Moths India, 1: 68-69; Bell & Scott, 1937 Fauna British India 5: 160-163.

Type species: *Polyptychus dentatus* Cramer

Polyptychus trilineatus undatus Rothschild and Jordan

Plate 22

Forewing venation: Forewing broader; discal cell closed, less than half length of total wing; 3A forming a fork with 2A, reaching up to tornus; 1A absent; Cu_2 arising from nearly middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 below middle of discocellulars; M_1, R_5 and R_4 stalked from upper angle of discal cell; $R_{(3+2)}$ just above upper angle of cell; R_1 arising from more than two-third portion of discal cell; Sc from base of wing not reaching up to apex, conjoint with costa and R_1.

Hindwing venation: Hindwing serrated; discal cell closed, shorter than half the length of wing; 3A present, reaching up to tornus; 2A slightly forked at base; 1A absent; Cu_2 from just below middle of discal cell; Cu_1 from above lower angle of cell; M_3 from lower angle of cell; M_2 below middle of discocellulars; M_1 and Rs stalked from just beyond upper angle of cell; $Sc+R_1$ anastomosing with cell middle of discal cell.

SATASPES MOORE

Moore, 1858, Cabinet Orient. Ent. 1858: 61

Type species: *Sataspes infernalis* Westwood

Sataspes scotti Jordan

Plate 23

Forewing venation: Forewing elongated, narrow; discal cell closed, less than half length of total wing; 3A forming a fork with 2A, reaching up to tornus; 1A absent; Cu_2arising from middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 just below middle of discocellulars; M_1 from upper angle of discal cell; R_5 and R_4 stalked from well beyond

upper angle of cell; $R_{(3+2)}$just above upper angle of cell; R_1 arising from less than two-third portion of discal cell; Sc from base of wing not reaching up to apex, close to costa and R_1.

Hindwing venation: Hindwing oval; discal cell closed, more than half the length of wing; 3A present, not reaching up to tornus; 2A slightly forked at base; Cu_2 from just below middle of discal cell; Cu_1 from above lower angle of cell; M_3 from lower angle of cell; M_2 just below middle of discocellulars; M_1 and Rs stalked from upper angle of cell; $Sc+R_1$ anastomosing with cell nearly middle of discal cell.

DAPHNIS HÜBNER

Hübner, 1819, Verz. Bekannter Schmett., 1819: 137; Hampson, 1892, Moths India, 1: 94; Inoue et al., 1997, Sphingidae Thailand, 2: 63.

Type species: *Sphinx nerii* Linnaeus

Remarks: The genus *Daphnis* Hübner was known by nine species including *nerii* Linnaeus. Rothschild and Jordan (1903) and Bell and Scott (1937) described these species in genus *Deilephila* Laspeyres, but Holloway (1987) shifted these species to *Daphnis* Hübner, as described by Hampson (1892) followed by Pittaway (1995), Kaleka et al. (2015) and same has been followed in the thesis.

Daphnis nerii Linnaeus

Plate 24

Forewing venation: Forewing elongated, narrow, articulated, apically acute; discal cell closed, shorter than half length of total wing; 3A forming a fork with 2A, reaching up to tornus; 1A absent; Cu_2 arising from nearly middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 below middle of discocellulars; M_1 from upper angle of discal cell; R_5 and R_4 stalked from well beyond upper angle of cell; $R_{(3+2)}$ just before upper angle of cell; R_1 arising from well beyond middle of discal cell; Sc from base of wing not reaching up to apex, close to costa and R_1.

Hindwing venation: Hindwing elongated; discal cell closed, almost two-third length of wing; 3A present, reaching up to tornus; 2A slightly forked at base; 1A absent; Cu_2 from well below middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 from just above middle of discocellulars; M_1 and Rs stalked from beyond upper angle of cell; $Sc+R_1$ anastomosing just before middle of discal cell.

HIPPOTION HÜBNER

Hübner 1822, Verz. Bek. Schmett.1822: 135

Type species: *Hippotion celerio* Linnaeus

Remarks: This genus represented by twenty two species restricted to the tropics and subtropics of the old World, out of which five species i.e., *celerio* Linnaeus, *echeclus* Boisduval, *boerhaviae* Fabricius, *rafflesi* Butler and *velox* Fabricius are known from India (Saini, 2018).

Key to the studied species of genus *Hippotion* Hübner

1.Forewing with vein Cu_1 from just beyond lower angle of cell; $R_{(3+2)}$ well above upper angle of cell; hindwing with vein M_2 from middle of discocellulars……..…*Hippotion celerio* Linnaeus

- Forewing with vein Cu_1 from well beyond lower angle of cell; $R_{(3+2)}$ just above upper angle of cell; hindwing with vein M_2 from just below middle of discocellulars…… ……*Hippotion rosetta* Swinhoe

Hippotion celerio Linnaeus

Plate 25

Forewing venation: Forewing elongated, narrow, apically acute; discal cell closed, shorter than half length of total wing; 3A forming a fork with 2A, reaching up to tornus; 1A absent; Cu_2 arising from middle of discal cell; Cu_1 from just beyond lower angle of cell; M_3 from lower angle of cell; M_2 just below middle of discocellulars; M_1 from upper angle of discal cell; R_5 and R_4 stalked from well beyond upper angle of cell; $R_{(3+2)}$ well above upper angle of cell; R_1 arising from well beyond upper angle of discal cell; Sc from base of wing not reaching up to apex, close to costa and R_1.

Hindwing venation: Hindwing oval; discal cell closed, less than half length of wing; 3A present, not reaching up to tornus; 2A slightly forked at base; 1A absent; Cu_2 well above from lower angle of cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 from middle of discocellulars; M_1 and Rs stalked from upper angle of cell; $Sc+R_1$ anastomosing with cell nearly middle of discal cell.

Hippotion rosetta Swinhoe

Plate 26

Forewing venation: Forewing elongated, narrow, apically acute; discal cell closed, more than half length of total wing; 3A forming a fork with 2A, reaching up to tornus; 1A absent; Cu_2

arising from well beyond lower angle of discal cell; Cu_1 from well above lower angle of cell; M_3 from lower angle of cell; M_2 just below middle of discocellulars; M_1 from upper angle of discal cell; R_5 and R_4 stalked from well beyond upper angle of cell; $R_{(3+2)}$ just above upper angle of cell; R_1 one-fourth portion of discal cell, not reaching up to apex; Sc from base of wing not reaching up to apex, close to costa and R_1.

Hindwing venation: Hindwing oval; discal cell closed, almost half length of wing; 3A present, not reaching up to tornus; 2A slightly forked at base; Cu_2 from just below middle of discal cell; Cu_1 from above lower angle of cell; M_3 from lower angle of cell; M_2 from just below middle of discocellulars; M_1 and Rs from same point of upper angle of cell; $Sc+R_1$ anastomosing with cell nearly middle of discal cell and conjoint with Rs.

THERETRA HÜBNER

Hübner, 1881, Verz. bek. Schmett., 1881: 135; Rothschild and Jordan, 1903, Novit, Zool., 9: 762; Bell and Scott, 1937, Fauna British India, Moths, 5: 427-428.

Type species: *Theretra nessus* Drury

Remarks: The genus known by thirty species occurring in the Oriental and Australian regions. Hungfu and Linyao (1997) included six species from China in volume XI of *Fauna Sinica*. Sondhi et al. (2017) reported a new species i.e., *shendureenis* from Kerala, India.

Key to the studied species of genus *Theretra* Hübner

1.Forewing excised below R_4; Cu_2 from middle of discal cell; M_1 and Rs stalked from just beyond upper angle of cell……...…….. *Theretra nessus* Drury

- Forewing not excised below R_4; Cu_2 from beyond middle of discal cell; M_1 and Rs stalked from upper angle of cell.....……*Theretra oldenlandiae* Fabricius

Theretra nessus Drury

Plate 27

Forewing venation: Forewing elongated, narrow, apically acute, excised below R_4, beak-like; discal cell closed, shorter than half length of total wing; 3A forming a fork with 2A, reaching up to tornus; 1A absent; Cu_2 arising from middle of discal cell; Cu_1 from well beyond lower angle of cell; M_3 from lower angle of cell; M_2 just below middle of discocellulars; M_1 from upper angle of discal cell; R_5 and R_4 stalked from well beyond upper angle of cell; $R_{(3+2)}$ just before upper angle of cell; R_1 arising from two-third length of discal cell; Sc from base of wing not reaching up to apex, close to costa and R_1.

Hindwing venation: Hindwing oval; discal cell closed, two-third length of wing; 3A present, reaching up to tornus; 2A slightly forked at base; 1A absent; Cu_2 from just below middle of discal cell and excised below; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 from middle of discocellulars; M_1 and Rs stalked from just beyond upper angle of cell; $Sc+R_1$ anastomosing with cell nearly middle of discal cell.

Theretra oldenlandiae Fabricius

Plate 28

Forewing venation: Forewing elongated, narrow, apically acute, not excised; discal cell closed, shorter than half length of total wing; 3A forming a fork with 2A, reaching up to tornus; 1A absent; Cu_2 arising from beyond middle of discal cell; Cu_1 from above lower angle of cell; M_3 from lower angle of cell; M_2 just below middle of discocellulars; M_1 from upper angle of discal cell; R_5 and R_4 stalked from well beyond upper angle of cell; $R_{(3+2)}$ just before upper angle of cell; R_1 arising from beyond middle of discal cell; Sc from base of wing not reaching up to apex, close to costa and R_1.

Hindwing venation: Hindwing oval; discal cell closed, less than two-third length of wing; 3A present, reaching up to tornus; 2A slightly forked at base; 1A absent; Cu_2 from below middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 from middle of discocellulars; M_1 and Rs stalked from upper angle of cell; $Sc+R_1$ anastomosing at middle of discal cell.

NEPHELE HÜBNER

Hübner, 1822, Verz. Bek. Schmett., 1822: 133; Hampson, 1892, Moths India, 1: 108; Bell and Scott, 1937, Fauna British India, Moths, 5: 324-325

Type species: *Nephele didyma* Fabricius

Key to the studied species of genus *Nephele* Hübner

1. Forewing with vein M_2 well below middle of discocellulars; hindwing with vein 3A reaching up to tornus……..……*Nephele didyma* Fabricius

- Forewing with vein M_2 just below middle of discocellulars; hindwing with vein 3A not reaching up to tornus……...……..……*Nephele hespera* Fabricius

Nephele didyma Fabricius

Plate 29

Forewing venation: Forewing elongated, slightly broad, discal cell closed, less than half length of total wing; 3A forming a fork with 2A, reaching up to tornus; 1A absent; Cu_2 arising from nearly middle of discal cell; Cu_1 from well above middle of discal cell; M_3 from lower angle of cell; M_2 well below middle of discocellulars; M_1 from upper angle of discal cell; R_5 and R_4 stalked from well beyond upper angle of cell; $R_{(3+2)}$ from well beyond upper angle of cell; R_1 arising from one-fourth portion of discal cell; Sc from base of wing not reaching up to apex, running close to costa and R_1.

Hindwing venation: Hindwing smaller than forewing; discal cell closed, less than two-third length of wing; 3A present, reaching up to tornus; 2A slightly forked at base; 1A absent; Cu_2 from just beyond middle of discal cell; Cu_1 from above lower angle of cell; M_3 from lower angle of cell; M_2 from middle of discocellulars; M_1 and Rs stalked from upper angle of cell; $Sc+R_1$ anastomosing from just below middle of discal cell.

Nephele hespera Fabricius

Plate 30

Forewing venation: Forewing elongated, narrow, apically acute; discal cell closed, shorter than half length of total wing; 3A forming a fork with 2A, reaching up to tornus; 1A absent; Cu_2 arising from middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 just below middle of discocellulars; M_1 from upper angle of discal cell; R_5 and R_4 stalked from well beyond upper angle of cell; $R_{(3+2)}$ just before upper angle of cell; R_1 arising from well before upper angle of discal cell; Sc from base of wing not reaching up to apex, close to costa and R_1.

Hindwing venation: Hindwing oval; discal cell closed, two-third length of wing; 3A present, not reaching up to tornus; 2A slightly forked at base; 1A absent; Cu_2 from just below middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 from below middle of discocellulars; M_1 and Rs stalked from upper angle of cell; $Sc+R_1$ anastomosing with cell nearly middle of discal cell.

FAMILY GEOMETRIDAE LEACH, 1815

(Plates 31-42)

Diagnostic features: Forewing with discal cell always closed; vein 3A forming or not forming a fork with 2A, 1A absent; Cu_2 and Cu_1 present; M_3 from lower angle of cell; vein M_2 from or

from above middle of discocellulars, R_5 rising from R_4 and R_3; R_2 either present or absent; R_1 present; $Sc+R_1$ from base of wing, not reaching up to apex. Hindwing with discal cell always closed; vein 3A short, apparently absent in some forms; 2A present; 1A absent; Cu_2 and Cu_2 present; M_3 lower angle of discal cell; M_2 may or may not be present; M_1 from upper angle of discal cell; Rs present; $Sc+R_1$ with a well-developed pre-costal spur.

Key to the studied species of family Geometridae

1. Forewing with vein R_1 from upper angle of discal cell; hindwing with vein M_3 extending outwardly to form a tail……...……...……*Ourapteryx clara* Butler

- Forewing with vein R_1 originating above or just upper angle of discal cell; hindwing without tail……...…….2

2. Forewing with veins Cu_1 and M_3 almost from same point……..*Chiasmia frugaliata* Guenee

- Forewing with veins Cu_1 and M_3 almost not from same point…….……..3

3. Hindwing with veins M_1 and Rs from upper angle of cell…….……. …….*Digrammia subminiata* Packard

- Hindwing with vein 3A reaching upto less than or more than half portion of inner margin; M_1 and Rs not from upper angle of cell…….……..4

4. Forewing with discal cell more than half length of total wing; vein R_1 well beyond upper angle of cell……..…… *Rhodometra sacraria* Linnaeus

- Forewing with discal cell less than half length of total wing; vein R_1 just beyond or upper angle of cell……..……..…5

5. Hindwing with veins M_1 and Rs stalked from well beyond upper angle of discal cell…… …….…….*Spaniocentra pannosa* Moore

- Hindwing with veins M_1 from upper angle of discal cell; Rs from just above upper angle of discal cell……...…….…..*Traminda mundissima* Walker

OURAPTERYX LEACH

Leach, 1814, in Leach & Nodder, Zool. Miscell., **1**: 79.

Type species *Phalaena sambucaria* Linnaeus

Remarks: The genus *Ourapteryx* was proposed by Leach for its type species *sambucaria* (Linnaeus) from Europe in 1814. Hampson (1895) included as many as nine species from the British India localities under this genus. Prout (1915, 1928) added four species i.e. *citrinata* Prout, *leucadelpha* Prout, *nigrifimbria* Prout and *versuta* Prout from different parts of the world.

The genus was revised and recharacterized by Inoue (1985a) and Holloway (1993) by incorporating external male and female genitalic structures. At present, this genius is represented by 75 species including *clara*.

Ourapteryx clara Butler

Plate 31

Forewing venation: Forewing broad, outer margin not crenulated, apex acute; discal cell less than half length of total wing; 3A short; 2A reaching up to tornus; 1A absent; Cu_2 arising from almost middle of discal cell; Cu_1 and M_3 from lower angle of cell; M_2 arising from middle of discocellulars; M_1 arising from upper angle;R_5 arising from common vein R_4 and R_3; R_2 absent; R_1 upper angle of cell, short, not reaching up to apex; Sc from base not reaching up to apex, conjoint and anastomosing with R_1.

Hindwing venation: Hindwing with outer margin less crenulated and forming a tail at vein M_3; discal cell less than length of total wing; 3A short, one-third length of inner margin; 2A reaching up to tornus; 1A absent; Cu_2 arising from well below middle of discal cell; Cu_1, M_3 from lower angle; M_2 absent; M_1 upper angle of discal cell; Rs from just above upper angle of cell; vein Sc+R1 strongly angled at base, connected at well before middle of discal cell, with well-developed pre-costal spur.

CHIASMIA HUBNER

Hubner, 1816, Verz. bekannter Schmett., 1823: 295.

Type species: *Phalaena clathrata* Linnaeus

Remarks: The genus *Chiasmia* was defined by Hübner in 1823 on type species *Phalaena clathrata* Linnaeus. Hampson in volume three (1895) included twenty four Indian species of present genus *Chiasmia* Hübner under genus *Macaria* Curtis and never mentioned the former name. In 1986, Inoue, suggested that they should be placed in genus *Chiasmia* Hübner. Latter on Scoble (2002) considered all the Indian species under genus *Chiasmia* Hübner. At present, species *frugaliata* Guenee is under this genus and present species have been identified from the relevant literature (Hampson, 1895).

Chiasmia frugaliata Guenee

Plate 32

Forewing venation: Forewing with outer margin not crenulated, apex acute; discal cell closed, less than half length of total wing; 3A minute, reaching up to one-fourth of inner margin; 2A reaching up to tornus; 1A absent; Cu_2 just below middle of discal cell; Cu_1 just above from lower angle of cell; M_3 from lower angle, Cu_1 and M_3 almost from same point; M_2 arising from middle of discocellulars; M_1 from upper angle; R_5 arising from R_4 and R_3; R_2 absent; R_1 from just above upper angle of cell, short, not reaching up to apex; Sc from base not reaching up to apex, close to R_1.

Hindwing venation: Hindwing globular, with outer margin not crenulated, slightly extended outward of vein M_3; discal cell closed, less than total length of wing; 3A short, close to inner margin; 2A reaching up to tornus; 1A absent; Cu_2 arising from nearly middle of discal cell; Cu_1 from just above lower angle of cell of discal cell; M_3 from lower angle of cell; M_2 absent; M_1 from upper angle and Rs from just above upper angle of cell; vein Sc+R_1 strongly angled at base, almost from middle of discal cell, with well-developed pre-costal spur.

Digrammia subminiata Packard

Plate 33

Forewing venation: Forewing with outer margin not wrinkled; discal cell almost equal to total wing; 3A short reaching up to one-third of inner margin; 2A reaching up to tornus; 1A absent; Cu_2 arising from well below middle of discal cell; Cu_1 just above lower angle; M_3 from lower angle; M_2 arising from middle of discocellulars; M_1 arising from upper angle; R_5 arising from R_4 and R_3; R_2 absent; R_1 well above upper angle of cell, not reaching up to apex; Sc from base not reaching up to apex, conjoint with R_1.

Hindwing venation: Hindwing globular with outer margin not crenulate; discal cell less than half length of total wing; 3A short, reaching half of inner margin; 2A reaching up to tornus; 1A absent; Cu_2 arising from well below middle of discal cell; Cu_1, M_3 stalked from just above lower angle; M_2absent; M_1 and Rs from upper angle of discal cell; vein Sc+R_1 strongly angled at base, with a well-developed pre-costal spur and connected at well above middle of discal cell.

Rhodometra sacraria Linnaeus

Plate 34

Forewing venation: Forewing with outer margin not crenulated, apex acute, beak-like; discal cell more than half length of total wing; 3A short; 2A reaching up to tornus; 1A absent; Cu_2 just

below middle of discal cell; Cu_1 well beyond lower angle of cell; M_3 from lower angle; M_2 arising from just above middle of discocellulars; M_1 arising from upper angle;R_5 arising from common vein R_4 and R_3; R_2 from common stalk of R_3 and R_4; R_1 from well beyond from upper angle of cell, short, not reaching up to apex; Sc from base not reaching up to apex.

Hindwing venation: Hindwing with outer margin not crenulated, globular; discal cell more than total length of wing; 3A short, reaching more than total length of inner margin; 2A reaching up to tornus; 1A absent; Cu_2 arising from just below middle of discal cell; Cu_1 just above lower angle of discal cell; M_3 from lower angle; M_2 absent; M_1 from upper angle and Rs just above upper angle of discal cell; vein $Sc+R_1$ strongly angled at base, connected at well before middle of discal cell, with well-developed pre-costal spur.

SPANIOCENTRA PROUT

Prout, 1912, Genera Insectes, 129: 13-94.

Type Species: *Comibaena pannosa* Moore

Remarks: This genus *Spaniocentra* was erected by Prout in 1912 on type species *pannosa* Moore from Sri Lanka. Holloway revised the genus *Spaniocentra* Prout on the basis of external genitalic attributes in 1996. According to Scoble (1999), four species are known under this genus from India and species *pannosa* is one of them.

Spaniocentra pannosa Moore

Plate 35

Forewing venation: Forewing with outer margin not crenulated, apex acute; discal cell less than half length of total wing; 3A short; 2A reaching up to tornus; 1A absent; Cu_2 just beyond middle of discal cell; Cu_1 and M_3 stalked from lower angle of cell; M_2 arising from above middle of discocellulars; M_1 from upper angle; R_5 arising from R_4 and R_3; R_2 from common stalk of R_3 and R_4; R_1 from just above upper angle, short, not reaching up to apex; Sc from base not reaching up to apex, close to R_1.

Hindwing venation: Hindwing with outer margin not slightly crenulated from Cu_2 to M_1, globular; discal cell less than total length of wing; 3A reaching upto less than half portion of inner margin; 2A not reaching up to tornus; 1A absent; Cu_2 arising from just above lower angle; Cu_1, M_3 stalked from just beyond lower angle of cell of discal cell; M_2 just above middle of

discocellulars; $M_1$and Rs stalked from well beyond upper angle of discal cell; vein Sc+R1 strongly angled at base, almost from middle of discal cell, with well-developed pre-costal spur.

TRAMINDA SAALMULLER

Saalmüller, 1891, Lepid. Madagascar, 2: 496.

Type species: *Timandra atroviridata* Saalmuller

Remarks: The present genus was erected on its type species *atroviridata* by Saalmüller in 1891. Warren studied many new species in his publications of this genus in 1895, 1897 and 1899. Likewise, Prout (1916, 1938) also described some new species under genus *Traminda* Saalmüller from different parts of the World including India. Holloway (1997) not only recharacterized the genus by inclusion of external male and female genitalic attributes in its diagnosis but also suggested a new combination for one of the Indian species *aventiaria* Guenee. The genus is known by 22 species from the Globe and out of which only two are reported from India viz., *aventiaria* and *mundissima.*

Traminda mundissima Walker

Plate 36

Forewing venation: Forewing outer margin not crenulated, apex acute; discal cell less than half length of total wing; 3A longer than *Spaniocentra pannosa*; 2A reaching up to tornus; 1A absent; Cu_2 well below middle of discal cell; Cu_1 and M_3 from lower angle; M_2 arising from well above middle of discocellulars; M_1 from upper angle of cell; R_5 arising from common stalk of R_4 and R_3; R_2 from common stalk of R_3 and R_4; R_1 from upper angle of cell, short, not reaching up to apex; Sc from base not reaching up to apex, close to R_1.

Hindwing venation: Hindwing with outer margin slightly crenulated, globular, forming a pyramid structure at vein M_2; discal cell less than total length of wing; 3A absent; 2A reaching up to tornus; 1A absent; Cu_2 arising from just above lower angle; Cu_1, M_3 stalked from well beyond lower angle; M_2 from well above discocellulars; M_1 from upper angle of cell; vein Rs just above upper angle of cell; vein Sc+R_1 strongly angled at base, connected at well before middle of discal cell, with well-developed pre-costal spur.

HYPOMECIS HÜBNER

Hubner, 1821, Index Exot. Lepid., 1821: 7.

Type species: *Hypomecis umbrosaria* Hubner

Remarks: The genus *Hypomecis* was proposed by Hübner on type species *umbrosaria* Hübner in 1821 from North America. Holloway in 1993 gave complete synonymy and diagnosis of the genus with a special emphasis on external male and female genitalic attributes. Scoble (1999) enlisted 153 species from the globe under this genus including 27 species from India.

Key to the studied species of genus *Hypomecis* Hübner

1. Forewing with vein M_2 from middle of discocellulars; hindwing with discal cell more than half the length of total wing; Cu_1 and M_3 from same point of lower angle of cell…… ……..…….*Hypomescis* sp.
- Forewing with vein M_2 from just above middle of discocellulars; hindwing with discal cell half the length of total wing; Cu_1 from just above lower angle of cell; M_3 from lower angle of discal cell…….…..……. *Hypomecis transcissa* Walker

Hypomecis sp.

Plate 37

Forewing venation: Forewing outer margin slightly wrinkled, acute apex; discal cell slightly more half length of total wing; 3A short; 2A reaching up to tornus; 1A absent; Cu_2 arising from less than two-third of discal cell; Cu_1 just above lower angle; M_3 from lower angle; M_2 arising from middle of discocellulars; M_1 arising from upper angle; R_5 arising from R_4 and R_3;R_2 from just above upper angle of discal cell, short, not reaching up to apex; R_1 from well above , not reaching up to apex; Sc from base not reaching up to apex, conjoint with R_1.

Hindwing venation: Hindwing globular with outer margin highly crenulate; discal cell more than half length of total wing; 3A short, reaching half of inner margin; 2A reaching up to tornus; 1A absent; Cu_2 arising from almost one-fourth of discal cell; Cu_1 and M_3 originating from same point of lower angle of cell; M_2 absent; M_1 from upper angle; Rs from just above upper angle of discal cell; vein $Sc+R_1$ strongly angled at base, connected at almost middle of discal cell, with well-developed pre-costal spur.

Hypomecis transcissa Walker

Plate 38

Forewing venation: Forewing with outer margin not wrinkled; discal cell slightly more than half length of total wing; 3A forming fork with 2A reaching up to tornus; 1A absent; Cu_2 arising from well below middle of discal cell; Cu_1 just above lower angle; M_3 from lower angle; M_2

arising from just above middle of discocellulars; M_1 arising from upper angle;R_5 arising from common vein R_4 and R_3; R_2 from just above upper of discal cell, short not reaching up to apex; R_1 well above upper angle of cell, short, not reaching up to apex; Sc from base not reaching up to apex, not conjoint with R_1.

Hindwing venation: Hindwing globular with outer margin less crenulated than *Hypomecis* sp.; discal cell half than length of total wing; 3A short, reaching less than half of inner margin; 2A reaching up to tornus; 1A absent; Cu_2 arising from almost one-fourth of discal cell; Cu_1 just above lower angle of cell; M_3 from just lower angle; M_2 absent; M_1 from upper angle; Rs from just above upper angle of discal cell; vein Sc+R_1 strongly angled at base, connected at almost middle of discal cell, with well-developed pre-costal spur.

PETELIA HERRICH-SCHAFFER

Herrich-Schaffer, 1855, Syst. Bearbeitung Schmett. Eur., **6**: 109, 122.

Type species: *Petelia medardaria* Herrich-Schaffer

Remarks: The genus *Petelia* was established by Herrich-Schaffer in 1855 on its type species *medardaria* Herrich-Schaffer. Hampson synonymized genus *Petelia* Herrich-Schaffer under genus *Dilinia* Hübner in 1895 but treated it under a separate Section-I in his fauna volume. He studied six Indian species under genus *Dilinia* Hübner and out of which five were placed under Section-I (*Petelia* Herrich-Schaffer). Prout (1930, 1932) followed the same nomenclature and described three species under genus *Dilinia* Hübner. Fletcher (1979) revalidated genus *Petelia* Herrich-Schaffer as a valid genus and synonymized genus *Dilinia* Hübner under genus *Cabera* Trietschke. Holloway (1993) studied genus *Petelia* Herrich-Schaffer in detail and recharacterized by incorporating external male and female genitalic attributes in its diagnosis. He studied five species from Borneo including a new species i.e., *tuhana* under this genus. At present, 14 species are reported under this genus.

Key to the studied species of genus *Petelia* Herrich-Schaffer

1. Forewing with vein Sc reaching two-third portion of costa; hindwing with vein 3A up to middle of inner margin…….…….*Petelia immaculata* Hampson
- Forewing with vein Sc reaching up to one-third portion of costa; hindwing with vein 3A reaching almost to tornus…….……..*Petelia medardaria* Herrich-Schaffer

Petelia immaculata Hampson

Plate 39

Forewing venation: Forewing broad, outer margin not crenulated, apex acute, beak like; discal cell less than half length of total wing; 3A short; 2A reaching up to tornus; 1A absent; Cu_2 below middle of discal cell; Cu_1 just above lower angle; M_3 from lower angle; M_2 arising from middle of discocellulars; M_1 arising from upper angle of cell; R_5 arising from common vein R_4 and R_3; R_2 from common stalk of R_3 and R_4; R_1 from well above upper angle of cell, short, not reaching up to apex; Sc from base not reaching up to apex, conjoint and anastomosing with R_1; Sc reaching up to two-third portion of costa.

Hindwing venation: Hindwing with outer margin less crenulated; discal cell less than length of total wing; 3A short, reaching middle of inner margin; 2A reaching up to tornus; 1A absent; Cu_2 arising from just below middle of discal cell; Cu_1 and M_3 from lower angle; M_2 absent; M_1 from upper angle; Rs just above upper angle of discal cell; vein $Sc+R_1$ strongly angled at base, connected at before middle of discal cell, with well-developed pre-costal spur.

Petelia medardaria Herrich-Schaffer

Plate 40

Forewing venation: Forewing with outer margin not crenulated, apex acute, beak-like; discal cell less than half length of total wing; 3A short, almost reaching tornus; 2A reaching up to tornus; 1A absent; Cu_2 below middle of discal cell; Cu_1 just above lower angle; M_3 from lower angle; M_2 arising from middle of discocellulars, thin; M_1 arising from upper angle;R_5 arising from common vein R_4 and R_3; R_2 from common stalk of R_3 and R_4; R_1 from well above upper angle of cell, short, not reaching up to apex; Sc from base not reaching up to apex, conjoint and anastomosing with R_1; Sc reaching upto one-third portion of costa.

Hindwing venation: Hindwing with outer margin less crenulated; discal cell less than length of total wing; 3A reaching almost to tornus; 2A reaching up to tornus; 1A absent; Cu_2 arising from just below middle of discal cell; Cu_1 and M_3 from lower angle; M_2 absent; M_1 from upper angle; Rs just above upper angle of discal cell; vein $Sc+R_1$ strongly angled at base, connected at well before middle of discal cell with well-developed pre-costal spur.

THALASSODES GUENEE

Guenee, 1858, Hist. Nat. Insectes, 9: 359.

Type species: *Thalassodes pilaria* Guenee

Remarks: This genus i.e., *Thalassodes* was proposed on type species *pilaria* Guenee in 1858 by Guenee. Hampson in 1895 included as many as 28 species from Indian subcontinent under this

genus. Prout (1911, 1912, 1916, 1925, 1933) made extensive studies on various species of this genus. Scoble (1999) listed four species of the present genus including *quadraria* and *veraria* from India.

Key to the studied species of genus *Thalassodes* Guenee

1. Forewing with discal cell less than half the length of total wing; Cu_1 and M_3 from lower angle of cell; hindwing with discal cell less than half the length of total wing; Cu_1 and M_3 stalked from well beyond lower angle of cell…….…...….*Thalassodes quadraria* Guenee

- Forewing with discal cell more than half the length of total wing; Cu_1 from well above lower angle of discal cell; M_3 from lower angle of cell; hindwing with discal cell more than half the length of total wing; Cu_1 and M_3 not stalked……*Thalassodes veraria* Guenee

Thalassodes quadraria Guenee

Plate 41

Forewing venation: Forewing with outer margin not crenulated, apex acute; discal cell less than half length of total wing; 3A forming fork with 2A reaching up to tornus; 1A absent; Cu_2 well below middle of discal cell; Cu_1 and M_3 from lower angle of cell; M_2 arising from just above middle of discocellulars; M_1 arising from upper angle; R_5 arising from common vein R_4 and R_3; R_2 from common stalk of R_3 and R_4; R_1 from just above upper angle of cell, short, not reaching up to apex; Sc from base not reaching up to apex, close to R_1.

Hindwing venation: Hindwing with outer margin slightly crenulated, globular; discal cell less than total length of wing; 3A short; 2A reaching up to tornus; 1A absent; Cu_2 arising from just above lower angle; Cu_1, M_3 stalked from well beyond lower angle of cell; M_2 from just above discocellulars; $M_1$and Rs stalked from well beyond upper angle of cell; vein $Sc+R_1$ strongly angled at base, connected at well before middle of discal cell, with well-developed pre-costal spur.

Thalassodes veraria Guenee

Plate 42

Forewing venation: Forewing with outer margin not crenulated, apex acute; discal cell more than half length of total wing; 3A short; 2A reaching up to tornus; 1A absent; Cu_2 well just below middle of discal cell; Cu_1 well above upper angle of cell; M_3 from lower angle of cell; M_2 arising from well above middle of discocellulars; M_1 from upper angle; R_5 arising from R_4 and

R_3; R_2 from common stalk of R_3 and R_4; R_1 from just above of discal cell, short, not reaching up to apex; Sc from base not reaching up to apex.

Hindwing venation: Hindwing with outer margin slightly crenulated, globular; discal cell more than half length of total wing; 3A present; 2A reaching up to tornus; 1A absent; Cu_2 arising from nearly middle of discal cell; Cu_1 from just above lower angle of discal cell; M_3 from lower angle of cell; M_2 from well above discocellulars; $M_1$and Rs stalked from well beyond lower angle of cell; vein $Sc+R_1$ strongly angled at base, connected at well before middle of discal cell, with well-developed pre-costal spur.

FAMILY EREBIDAE LEACH, 1815

(Plates 43-64)

Diagnostic features: Forewing with discal cell closed; 3A minute/reaching up to tornus or absent; 2A present; 1A absent; veins Cu_2-M_2 appears to be four-branched and hence name as quadrifid venation (Zahiri et al. 2011); M_1 from upper angle of cell; R_5-R_4 either forming a areole or separate or branched; R_1 from discal cell; Sc from base of the wing, not reaching up to apex. Hindwing with discal cell closed; 3A, 2A and 1A may be absent or present; Cu_2-M_2 present; M_1 and Rs may or may not be stalked; $Sc+R_1$ anastomosing with discal cell.

Key to the studied species of family Erebidae

1. Forewing with vein Cu_2 originating from one-third of discal cell; M_2 sends a small bar in discal cell..... *Achaea janata* Linnaeus
- Forewing with vein Cu_2 not originating from one-third of discal cell; M_2 not sending a small bar in discal cell.....2
2. Hindwing with vein Cu_1, M_3 and M_2 arising from nearly same point of lower angle of discal cell.....*Aloa lactinea* Cramer
- Hindwing with vein Cu_1, M_3 and M_2 not arising from very close same point of lower angle of discal cell.....3
3. Forewing with vein M_3 and M_2 from same point of lower angle of discal cell..... .....*Arctornis bubalina* Chao
- Forewing with vein M_3 and M_2 not from same point of lower angle of discal cell.....4
4. Forewing with wing greatly excised below 2A.....*Calyptra parva* Banziger
- Forewing with wing not excised below 2A.....5
5. Hindwing with 1A prominent.....*Dasychira* sp.

- Hindwing with 1A absent or indistinct.....6

6. Forewing with areole larger.....*Digama hearseyana* Moore

- Forewing with areole narrower.....7

7. Hindwing crown-like; vein M_3 extended outwards.....*Episparis liturata* Fabricius

- Hindwing without M_3 extended.....8

8.Hindwing with vein M_1 and Rs stalked from just beyond upper angle of discal cell..... .....*Utetheisa pulchelloides* Hampson

- Hindwing with vein M_1 and Rs not stalked from upper angle of discal cell.....9

9. Forewing with vein 3A reaching more than half of inner margin..... .....*Leucoma salicis* Linjnaeus

- Forewing with vein 3A minute.....10

10. Hindwing with vein M_1 and Rs stalked from well beyond upper angle of cell..... .....*Somena scintillans* Walker

- Hindwing with vein M_1 and Rs stalked not from well beyond upper angle of cell.....11

11. Forewing with discal cell less than half the length of total wing; hindwing with discocellulars 'U' shaped.....*Thyas coronata* Fabricius

- Forewing with discal cell more than half the length of total wing; hindwing with discocellulars not 'U' shaped.....12

12. Hindwing with 1A present, indistinct beyond lower angle of discal cell..... .....*Lygephila craccae* Denis & Schiffermuller

- Hindwing without vein 1A.....13

13. Hindwing with vein Cu_2 from almost middle of discal cell…….....*Spilosomsa metarhoda* Walker

- Hindwing with vein Cu_2 from well beyond middle of discal cell.....14

14. Hindwing with vein $Sc+R_1$ anastomosing at middle of discal cell.....*Attatha ino* Drury

- Hindwing with vein $Sc+R_1$ anastomosing at base of discal cell.....15

15. Hindwing with vein 3A reaching up to tornus; M_2 arising from just above lower angle of discal cell.....*Grammodes geometrica* Fabricius

- Hindwing with vein 3A not reaching up to tornus; M_2 arising from lower angle of discal cell.....*Mocis frugalis* Fabricius

ACHAEA HÜBNER

Achaea Hübner, 1823, Verz. Bek. Schmett., 17: 269

Type species: *Phalaena melicerta* Drury

Remarks: This genus constitute six species worldwide namely *ablunaris* Guenee, *janata* Linnaeus, *argilla* Swinhoe, *serva* Fabricius, *mercatoria* Fabricius and *eusciasta* Hampson.

Achaea janata Linnaeus

Plate 43

Forewing venation: Forewing broad, slightly crenulated; discal closed, almost half the length of total wing; vein 3A and 1A absent; 2A reaching up to tornus; Cu_2 one-third of discal cell; Cu_1 just above lower angle of cell; M_3 from lower angle of cell; M_2 below middle of discocellulars, sending a small bar in discal cell; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from upper angle of cell; R_5, R_4 stalked well beyond upper angle of discal cell; R_3 arises from R_4, which is given off to R_2 to form an areole; R_2 not reaching up to apex; R_1 well below middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing slightly crenulated; discal cell closed, almost one-third length of total wing; 3A, 2A present, reaching up to tornus; 1A absent; Cu_2 well below middle of discal cell; Cu_1, M_3 arising from lower angle of discal cell; M_2 arising well below middle of discocellulars; M_1 and Rs from upper angle of cell; $Sc+R_1$ anastomosing with discal cell near base, reaching up to apex.

ALOA WALKER

Walker, 1855, List Spec. Lepid. Insects Colln Br. Mus., 3: 699

Type species: *Phalaena lactinea* Cramer

Aloa lactinea Cramer

Plate 44

Forewing venation: Forewing narrow, not crenulated; discal cell more than half length of total wing; vein 3A and 1A absent; 2A reaching up to tornus; Cu_2 one-fourth of discal cell; Cu_1 just above lower angle of discal cell; M_3, M_2 arising from nearly lower angle of discal cell; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from upper angle of cell; R5, R4 stalked well beyond upper angle of discal cell; R3 arises from R4, which is given off to R_2 to form an areole; R_1 from well before upper angle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex, conjoint with costa.

Hindwing venation: Hindwing slightly crenulated; discal cell closed, more than half length of total wing; 3A absent; 2A present, reaching up to tornus; 1A absent; Cu_2 from just below middle of discal cell; Cu_1, M_3 and M_2 arising from nearly same point of lower angle of discal cell, very close to each other; M_1 and Rs from upper angle of cell; $Sc+R_1$ anastomosing with discal cell near middle.

ARCTORNIS GERMAR

Germar, 1810, Diss. Sistens Bombycum Species, 1: 18

Type species: *Arctornis submarginata* Fabricius

Arctornis bubalina Chao

Plate 45

Forewing venation: Forewing with apex rounded, not crenulated; discal cell closed almost equal to half the length of total wing; 3A and 1A absent; 2A reaching up to tornus; Cu_2 from just below middle of cell; Cu_1 from just above lower angle of cell; M_3 and M_2 nearly from same point; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from upper angle; R_5 originating from common stalk of R_4 , R_3 and R_2 ; R_1 emerging from just above upper angle of cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing oval, apex rounded; discal cell closed, less than half the length of total wing; 3A and 2A present, emerging from base of wing, reaching up to tornus; 1A absent; Cu_2 from just below middle of discal cell; Cu_1 and M_3 stalked from well beyond lower angle of cell; M_2 from just above lower angle of cell, very close; M_1 and Rs stalked from well beyond upper angle of cell; $Sc+R_1$ from base, anastomosing just below middle of discal cell.

CALYPTRA GUENEE

Ochsenheimer, 1816, Eur. Schmett., 4: 78.

Type species: *Phalaena thalictri* Borkhausen.

Calyptra parva Banziger

Plate 46

Forewing venation: Forewing narrow, apex circular; discal cell closed, more than half the length of total wing; 3A, indistinct; 2A reaching up to tornus, wing greatly excised below 2A, 'S'-like; 1A absent; Cu_2 from well below middle of cell; Cu_1 from just above lower angle of cell; M_3 from lower angle; M_2 from just above lower angle of cell; Cu_2, Cu_1, M_3, M_2 showing

quadrifine venation; M_1 from just below upper angle of discal cell; R_5 originating from common stalk of R_4 and R_3; R_3 arises from R_4 which give rise to R_2 forming an areole; R_1 originating from well below middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing broad; discal cell closed, less than half the length of total wing; 3A present and 2A present, emerging from base of wing, reaching up to tornus; 1A absent; Cu_2 from well above lower angle of discal cell; Cu_1 from almost lower angle of cell; M_3 from lower angle of cell; M_2 from just above lower angle of cell, very close; M_1 and Rs stalked from upper angle of discal cell; $Sc+R_1$ from base, anastomosing just above middle of discal cell.

DASYCHIRA HÜBNER

Hübner, 1809; Samml. Exot. Schmett. 1: 178

Type species: *Dasychira tephra* Hübner

Dasychira sp.

Plate 47

Forewing venation: Forewing narrow, not crenulate; discal cell closed, more than half the length of total wing; 3A present, indistinct, thin; 2A reaching up to tornus; 1A absent; Cu_2 from one-fifth of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle ; M_2 from just above lower angle of discal cell; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from just below upper angle; R_5 originating from common stalk of R_4 and R_3; R_3 and R_2 arises from R_4 which is given off to R_1 to form an aerole; R_1 emerging from well below middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex, conjoint with R_1.

Hindwing venation: Hindwing broader, apex rounded; discal cell closed, slightly more half the length of total wing; 3A , 2A and 1A present, emerging from base of wing, reaching up to tornus; 1A thin; Cu_2 just below middle of discal cell; Cu_1 just above lower angle of cell; M_3 from lower angle of cell; M_2 from well above lower angle, reaching up to post medial area; M_1 and Rs stalked just beyond upper angle of discal cell; $Sc+R_1$ from base, anastomosing just above middle of discal cell.

DIGAMA MOORE

Moore, 1860, Cat. Lep. Ins. Mus. Nat. East India House 2: 297

Type species: *Digama hearseyana* Moore

Digama hearseyana Moore

Plate 48

Forewing venation: Forewing narrow, not crenulate; discal cell closed, more than half the length of total wing; 3A present, minute; 2A reaching up to tornus; 1A absent; Cu_2 from one-fourth of discal cell; Cu_1 from just above lower angle of cell, closer than *Dasychira* sp.; M_3 from lower angle ; M_2 from just above lower angle of discal cell; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from well below upper angle; R_5 originating from common stalk of R_4 and R_3; R_3 and R_2 arises from R_4 which is given off to R_1 to form an areole, areole larger in size as compared to rest of the species; R_1 emerging from just below middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing broader, apex rounded; discal cell closed, slightly more half the length of total wing; 3A and 1A absent, 2A emerging from base of wing, reaching up to tornus; Cu_2 well below middle of discal cell; Cu_1 and M_3 from lower angle of cell; M_2 from above lower angle of cell; M_1 and Rs stalked from upper angle of discal cell; $Sc+R_1$ from base, anastomosing just above middle of discal cell.

EPISPARIS WALKER

Walker, 1857, List Spec. Lepid. Insects Colln Br. Mus. 10: 413, 475

Type species: *Episparis penetrata* Walker

Episparis liturata Fabricius

Plate 49

Forewing venation: Forewing broad; discal cell closed, slightly less than half the length of total wing; 3A minute; 2A reaching up to tornus; 1A absent; Cu_2 from one-fourth of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle; M_2 from just above lower angle of discal cell; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from just below upper angle; R_5 originating from common stalk of R_4 and R_3; R_3 and R_2 arises from R_4 which is given off to R_1 to form an areole; R_1 emerging from just below middle of discal cell, not reaching up to apex, close to R_2; Sc from base of wing, not reaching up to apex, close to R_1.

Hindwing venation: Hindwing broader, crown-like, vein extended at M_3; discal cell closed, one-third length of total wing; 3A present, not reaching upto tornus; 2A emerging from base of wing, reaching up to tornus; 1A absent; Cu_2 just below middle of discal cell; Cu_1 and $M_1$from

lower angle of cell; M_2 from just above lower angle; M_1 and Rs from upper angle of discal cell; $Sc+R_1$ from base, anastomosing near base of discal cell.

UTETHEISA HÜBNER

Hübner, 1819; Verz. Bek. Schmett. 11: 168

Type species: *Phalaena ornatrix* Linnaeus

Utetheisa pulchelloides Hampson

Plate 50

Forewing venation: Forewing broad; discal cell closed, more than half the length of total wing; 3A minute, thin, up to half length of wing; 2A reaching up to tornus; 1A absent; Cu_2 from one-fourth of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 just above lower angle of cell, well below from discocellulars; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation ; M_1 from just below upper angle of cell; R_5 originating from common stalk of R_4 and R_3 which give rise to R_2 to form an areole; R_1 emerging from near middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing oval, undulated; discal cell closed, more than half the length of total wing; 3A present and 2A present, emerging from base of wing, reaching up to tornus; 1A absent; Cu_2 from middle of discal cell; Cu_1 from well above lower angle of cell; M_3 from lower angle of cell; M_2 from just above lower angle of cell, close to M_3; M_1 and Rs stalked from just beyond upper angle of cell; $Sc+R_1$ from base, anastomosing from middle of discal cell.

LEUCOMA HÜBNER

Hübner, 1822; Syst. Verz. 1822: 14-15

Type species: *Phalaena salicis* Linnaeus

Leucoma salicis Linnaeus

Plate 51

Forewing venation: Forewing narrow, apex almost rounded; discal cell closed, almost half the length of total wing; 3A present, thin and not reaching upto tornus; 1A absent; 2A reaching up to tornus; Cu_2 just below middle of discal cell; Cu_1 from just above lower angle of cell; M_3 and M_2 from lower angle of cell; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from just below upper angle; R_5 originating from common stalk of R_4, R_3 and R_2; R_1 emerging from well above

middle upper angle of cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing globular; discal cell closed, less than half the length of total wing; 3A present, not reaching up to tornus; 2A and 1A present, emerging from base of wing, reaching up to tornus; Cu_2 just below middle of discal cell; Cu_1 and M_3 stalked from well beyond lower angle of cell; M_2 from just above lower angle; M_1 and Rs stalked from well beyond upper angle of discal cell; $Sc+R_1$ from base, anastomosing from middle of discal cell.

SOMENA WALKER

Walker, 1856; List Spec. Lepid. Insects Colln Br. Mus. 7: 1734

Type species: *Somena scintillans* Walker

Somena scintillans Walker

Plate 52

Forewing venation: Forewing with apex rounded, not crenulated; discal cell closed, almost than half the length of total wing; 3A minute; 2A reaching up to tornus; 1A absent; Cu_2 from just below middle of discal cell; Cu_1 from just above lower angle of cell; M_3 and M_2 nearly from same point; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 arises from common stalk of R_5, R_4 and R_3; R_5 originating from common stalk of R_4, R_3 and R_2; R_1 emerging from well above upper angle of cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing oval; discal cell closed, less than half the length of total wing; 3A and 2A present, emerging from base of wing, reaching up to tornus; Cu_2 from well below middle of discal cell; Cu_1 and M_3 stalked from lower angle of cell; M_2 absent; M_1 and Rs stalked from well beyond upper angle of cell; $Sc+R_1$ from base, anastomosing at just below middle of discal cell.

THYAS HUBNER

Hübner, (1824), Samml. Exot. Schmeet. 2: 203.

Type species: *Thyas honesta* Hübner

Remarks: Genus *Thyas* was established in 1824 for its type species *Thyas honesta* Hubner from Eastern India by Hübner. Hampson (1894) synonymized it under genus *Ophiusa* Hampson and synonymised *Thyas* Hübner under *Lagoptera* Guenee. Nye (1975) gave full generic status to *Thyas* with *honesta* as its type species latter which was followed by Banziger (1982) Poole (1989) and same has been followed during the present work.

Thyas coronata Fabricius

Plate 53

Forewing venation: Forewing broad, undulated; discal cell closed, less than half the length of total wing; 3A minute; 2A reaching up to tornus; 1A absent; Cu_2 just below middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 just above lower angle of cell, well below from discocellulars; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from upper angle; R_5 originating from common stalk of R_4 and R_3 which give rise to R_2 to form an areole; R_1 emerging from just below middle of discal cell, not reaching up to apex, close to R_2; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing globular, undulated; discal cell closed, almost one-third length of total wing, discocellulars 'U' shaped; 3A present and 2A present, emerging from base of wing, reaching up to tornus; 1A absent; Cu_2 well below lower angle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 from just below middle of discocellulars; M_1 and Rs from upper angle of discal cell; $Sc+R_1$ from base, anastomosing well before middle of discal cell.

LYGEPHILA BILLBERG

Billberg, 1820, Enumeratio Insect. Mus. G.J. Billberg, 1820: 85.

Type species: *Phalaena lusoria* Linnaeus.

Lygephila craccae Denis and Schiffermuller

Plate 54

Forewing venation: Forewing narrow, apex almost acute, articulated; discal cell closed, more than half the length of total wing; 3A minute, thin; 2A reaching up to tornus; 1A present, indistinct, visible up to half length of wing; Cu_2 just below middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 just above lower angle of cell; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from upper angle; R_5 originating from upper angle of cell; R_4 originating from just above upper angle of cell which is giving rise to R_3 and R_2 arising from common stalk of R_4 and R_3; R_1 emerging from well above upper angle of cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing globular, articulated; discal cell closed, less than half the length of total wing; 3A present and 2A present, emerging from base of wing, reaching up to tornus; 1A

present, thin, indistinct from beyond upper angle of discal cell; Cu_2 just below middle of discal cell; $Cu_1$and M_3 stalked from just beyond lower angle of cell; M_2 from well above lower angle; M_1 and Rs from upper angle of discal cell; Sc+R_1 from base, anastomosing almost near base of discal cell.

SPILOSOMA CURTIS

Curtis, 1825, British Entomology 2: 92

Type species: *Bombyx menthastri* Denis and Schiffermüller

Spilosoma metarhoda Walker

Plate 55

Forewing venation: Forewing with apex almost rounded, not crenulated; discal cell closed, more than half the length of total wing; 2A reaching up to tornus; 3A and 1A absent; Cu_2 from just below middle of discal cell; Cu_1 from just above lower angle of cell; M_3 and M_2 nearly from same point; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 arises from upper angle; R_5 originating from common stalk of R_4, R_3 and R_2; R_1 emerging from well above upper angle of cell, not reaching up to apex; Sc from base of wing, not reaching up to apex, close to R_1.

Hindwing venation: Hindwing oval; discal cell closed, more than half the length of total wing; 3A and 2A present, emerging from base of wing, reaching up to tornus; 1A absent; Cu_2 from almost middle of cell; Cu_1 from just above lower of cell; M_3 from lower angle of cell; M_2 just above lower angle, well below middle of discocellulars angle; M_1 and Rs from upper angle of cell; Sc+R_1 from base, anastomosing well before middle of discal cell.

ATTATHA MOORE

Moore, 1878, Proc. Zool. Soc. Lond. 1878(4): 847

Type species: *Hypercompa regalis* Moore

Attatha ino Drury

Plate 56

Forewing venation: Forewing narrow, serrated; discal cell closed, more than half length of total wing; vein 3A minute, indistinct; 2A reaching up to tornus; 1A absent; Cu_2 just below middle of discal cell; Cu_1, M_3 and M_2 arising from near lower angle of discal cell; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from upper angle of cell; R_5 arises from common vein of R_4

and R_3 which is given off to R_2 to form an areole; R_2 not reaching up to apex; R_1 well below middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing globular, serrated; discal cell closed, less than half length of total wing; 3A and 1A absent; 2A present, reaching up to tornus; Cu_2 well beyond middle of discal cell; Cu_1, M_3 from lower angle of cell; M_2 from well below middle of discocellulars; M_1 and Rs from upper angle of cell; $Sc+R_1$ anastomosing at middle of discal cell.

GRAMMODES GUENEE

Guenee, 1852, Boisduval & Guenee, Hist. Nat. Insectes Lepid, **7**: 275.

Type species: *Noctera gometrica* Fabricius

Remarks: Genus *Grammedes* was erected by Guenee in 1852 on its type species *Noctua geometrica* Fabricius from East India. At present this genus was known by 25 species worldwide.

Grammodes geometrica Fabricius

Plate 57

Forewing venation: Forewing narrow; discal cell closed, slightly more than half the length of total wing; 3A minute, thin; 2A reaching up to tornus; 1A absent; Cu_2 just below middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle; M_2 from just above lower angle of discal cell; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from just below upper angle; R_5 originating from common stalk of R_4 and R_3; R_3 and R_2 arises from R_4 which is given off to R_1 to form an areole; R_1 emerging from well beyond upper angle of discal cell, not reaching up to apex, close to R_2; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing globular, toothed; discal cell closed, almost one-third length of total wing; 3A present and 2A present, emerging from base of wing, reaching up to tornus; 1A absent; Cu_2 well beyond middle of discal cell; Cu_1 and M_3 from lower angle of cell; M_2 from just above lower angle of cell; M_1 and Rs from upper angle of discal cell; $Sc+R_1$ anastomosing near base of discal cell.

MOCIS HÜBNER

Hubner, (1823) 1816, Verz. Bekannter Schmett. 1823: 267

Type species: *Phalaena virbia* Cramer.

Remarks: Genus *Mocis* was proposed by Hübner in 1823 on type species *Phalaena virbia* Cramer. Poole (1989) included *Remigia* Guenee, *Pelamia* Guenee, *Baratha* Walker and *Cauninda* Moore as junior synonyms of *Mocis* Hübner. Poole in the same year included 39 species in genus *Mocis*. Holloway (2005) studied two species i.e. *undata* Fabricius and *frugalis* Fabricius from Borneo. At present this genus was known by 41 species.

Mocis frugalis Fabricius

Plate 58

Forewing venation: Forewing broad, serrated; discal cell closed, almost half the length of total wing; 3A minute, thin; 2A reaching up to tornus; 1A absent; Cu_2 just below middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 just above lower angle of cell; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from upper angle; R_5 originating from common stalk of R_4 and R_3 which give rise to R_2 to form an areole; R_1 emerging from beyond upper angle of discal cell, not reaching up to apex, close to R_2; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing globular, serrated; discal cell closed, less than half the length of total wing; 3A present, not reaching up to tornus; 2A emerging from base of wing, reaching up to tornus; 1A absent; Cu_2 well beyond middle of discal cell; Cu_1 and M_3 stalked from lower angle of cell; M_2 from lower angle of discal cell; M_1 and Rs from upper angle of discal cell; $Sc+R_1$ from base, anastomosing near base of discal cell.

ANOMIS HÜBNER

Hübner (1821), 1816, Verz. Bekannter Schmett., 1816: 249

Type species: *Anomis exacta* Hübner.

Remarks: Hampson (1894) reported ten species viz., *mesogona* Walker, *sabulifera* Guenee, *trilineata* Moore, *fulvida* Guenee, *lineosa* Walker, *hossfieldii* Guenee, *sinuosa* Moore, *erosa* Hübner, *precedens* Walker and *fasciosa* from British India including Burma and Sri Lanka under genus *Cosmophila* Boisduval. Tams (1924) transferred species *fulvida*, *flava*, *lineosa*, and *figlina* to genus *Anomis* Hübner. During the present studies, the wing venation of two species namely *fulvida* Guenee and *lineosa* Walker have been studied in detail.

Key to the studied species of genus *Anomis* Hübner

1. Forewing with vein M_2 arising from below middle of discocellulars; hindwing with Cu_1 and M_3 stalked from lower angle of discal cell.....*Anomis fulvida* Guenee

- Forewing with vein M_2 arising from well below middle of discocellulars; hindwing with Cu_1 and M_3 stalked from beyond lower angle of discal cell..... *Anomis lineosa* Walker

Anomis fulvida Guenee

Plate 59

Forewing venation: Forewing narrow, slightly serrated, slightly extended at vein M3; discal cell more than half length of total wing; vein 3A minute; 2A reaching up to tornus; 1A absent; Cu_2 just below middle of discal cell; Cu_1 just above lower angle of discal cell; M_3, M_2 arising from nearly lower angle of discal cell or below middle of discocellulars; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from upper angle of cell; R_5 arises from common vein of R_4 and R_3 which is given off to R_2 to form an areole; R_2 not reaching up to apex; R_1 just below middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing slightly crenulated; discal cell closed, almost half length of total wing; 3A and 1A absent; 2A present, reaching up to tornus; Cu_2 well above from lower angle of discal cell; Cu_1, M_3 stalked from lower angle of discal cell; M_2 from well below middle of discocellulars; M_1 and Rs stalked from upper angle of discal cell; $Sc+R_1$ anastomosing discal just above middle of discal cell.

Anomis lineosa Walker

Plate 60

Forewing venation: Forewing narrow, not crenulated , vein M_2 extended; discal cell closed, almost half length of total wing; vein 3A minute, faint; 2A reaching up to tornus; 1A absent; Cu_2 well below lower angle of discal cell; Cu_1, M_3 and M_2 arising from near lower angle of discal cell or well below middle of discocellulars; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from upper angle of cell; R_5 arises from common vein of R_4 and R_3 which is given off to R_2 to form an areole; R_2 not reaching up to apex; R_1 just below middle of discal cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing globular, not crenulated; discal cell closed, less than half length of total wing; 3A and 1A absent; 2A present, reaching up to tornus; Cu_2 well above from lower angle of discal cell; Cu_1, M_3 stalked beyond lower angle of discal cell; M_2 from well below

middle of discocellulars; M_1 and Rs stalked from beyond upper angle; $Sc+R_1$ anastomosing with discal just above middle of discal cell.

CREATONOTOS HÜBNER

Hübner, 1819, Verz. Bek. Schmett. 11: 170

Type species: *Phalaena interrupta* Linnaeus

Key to the studied species of genus *Creatonotos* Linnaeus

1. Forewing with vein Cu_1 away from M_3; hindwing with vein M_2 away from M_3…….....
.....*Creatonotos gangis* Linnaeus

- Forewing with vein Cu_1 near to M_3; hindwing with vein M_2 near to M_3.....
.....*Creatonotos transiens* Walker

Creatonotos gangis Linnaeus

Plate 61

Forewing venation: Forewing narrow, apex rounded, not crenulate; discal cell closed, more than half the length of total wing; 3A absent and 1A absent; 2A reaching up to tornus; Cu_2 from well below middle of discal cell; Cu_1 from just above lower angle of cell, less close to M_3 as compared to *Creatonotos transiens*; M_3 from lower angle; M_2 from just above lower angle of cell, very close; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from upper angle of discal cell; R_5 originating from common stalk of R_4 and R_3; R_2 originating from common stalk of R_5, R_4 and R_3; R_1 from well above upper angle of cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing broad, apex rounded; discal cell closed, more than half the length of total wing,; 3A present and 2A present, emerging from base of wing, reaching up to tornus; 1A absent; Cu_2 just below middle of discal cell; $Cu_1$from just above lower angle of cell; M_3 from lower angle of cell; M_2 from near lower angle of cell, less close to M_3 as compared to *Creatonotos transiens*; M_1 and Rs from upper angle of discal cell; $Sc+R_1$ from base, anastomosing just above middle of discal cell.

Creatonotos transiens Walker

Plate 62

Forewing venation: Forewing narrow, apex rounded, not crenulate; discal cell closed, more than half the length of total wing; 3A and 1A absent; 2A reaching up to tornus; Cu_2 from well below

middle of discal cell; Cu_1 from just above lower angle of cell, closer than *gangis* (Linnaeus); M_3 from lower angle; M_2 from just above lower angle of cell, very close, closer than *gangis* (Linnaeus); Cu_2, Cu_1, M_3, M_2 showing quadrifine venation; M_1 from upper angle of discal cell; R_5 originating from common stalk of R_4 and R_3; R_2 originating from common stalk of R_5, R_4 and R_3 ; R_1 well above upper angle of cell, not reaching up to apex; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing broader than *gangis* (Linnaeus), apex rounded; discal cell closed, more than half the length of total wing,; 3A present and 2A present, emerging from base of wing, reaching up to tornus; 1A absent; Cu_2 just below middle of discal cell; Cu_1 from almost lower angle of cell; M_3 from lower angle of cell; M_2 from just above lower angle of cell; M_2 much closer than M_3 as compared to *gangis*; M_1 and Rs from upper angle of discal cell; $Sc+R_1$ from base, anastomosing well above middle of discal cell.

SPIRAMA GUENEE

Guenee, 1852, Boisduval and Guenee. Hist Nat. Insectes Lepid., **7**: 194.

Type species: *Phalaena retorata* Clerck

Remarks: Genus *Spirama* was erected by Guenee in 1852 on its type species *Phalaena retorta* Clerck. Hampson (1894) synonymised three genera under *Spirama* Guenee and included four species i.e. *retorata* Clerck, *vespertilio* Fabricius, *pudens* Walker and *unistrigata* Guenee under it. Poole (1989) included *Spiramia* Walker as a junior synonym of *Spirama* Guenee, and included 19 species in the genus *Spirama*. Srivastava (2002) studied male and female genitalia of type species from Himachal Pradesh. In the present study two species namely *heliciana* Hübner and *retorta* Clerck studied in detail from IISER Mohali, Punjab.

Key to studied species of genus *Spirama* Guenee

1. Forewing and hindwing with vein M_2 below middle of discocellulars……..……...
   .....*Spirama heliciana* Hübner
- Forewing and hindwing with vein M_2 well below middle of discocellulars……...
  .....*Spirama retorta* Clerck

Spirama heliciana Hübner

Plate 63

Forewing venation: Forewing broad, undulated; discal cell closed, less than half the length of total wing; 3A and 1A absent; 2A reaching up to tornus; Cu_2 from nearly middle of discal cell; Cu_1 and M_3 from lower angle of cell; M_2 from well below from middle of discocellulars; vein Cu_1 and M_3 much closer than *Spilosomsa metarhoda*; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation, M_2 below middle of discocellulars; M_1 from upper angle; R_5 originating from common stalk of R_4 and R_3 which give rise to R_2 to form an areole; R_1 emerging from well below middle of discal cell, not reaching up to apex, close to R_2; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing globular, undulated; discal cell closed, almost one-third length of total wing; 3A present and 2A present, emerging from base of wing, reaching up to tornus; 1A absent; Cu_2 just below middle of discal cell; Cu_1 and M_3 from lower angle of cell; M_2 just below middle of discocellulars; M_2 below middle of discocellulars; M_1 and Rs stalked from upper angle of discal cell; Sc+R_1 from base, anastomosing just before middle of discal cell.

Spirama retorta Clerck

Plate 64

Forewing venation: Forewing broad, slightly serrated; discal cell closed, less than half the length of total wing; 2A reaching up to tornus; 3A and 1A absent; Cu_2 below middle of discal cell; Cu_1 from just above lower angle of cell; M_3 from lower angle of cell; M_2 well below from middle of discocellulars , M_2 closer to M_3 than in *Spirama heliciana*; Cu_2, Cu_1, M_3, M_2 showing quadrifine venation, M_2 well below middle of discocellulars; M_1 from upper angle; R_5 originating from common stalk of R_4 and R_3 which give rise to R_2 to form an areole; R_1 emerging from well below middle of discal cell, not reaching up to apex, close to R_2; Sc from base of wing, not reaching up to apex.

Hindwing venation: Hindwing globular, serrated; discal cell closed, almost one-third length of total wing; 3A present and 2A present, emerging from base of wing, reaching up to tornus; 1A absent; Cu_2 from middle of discal cell; $Cu_1$and M_3 stalked from lower angle of cell; close to M_3; M_2 well below middle of discocellulars; M_1 and Rs stalked from just beyond upper angle of discal cell; Sc+R_1 from base, anastomosing near base of discal cell.

FAMILY CRAMBIDAE LATREILLE, 1810

(Plates 65-77)

Diagnostic features: Forewing with discal cell always closed; vein 3A and 2A present, not separate from 2A; 1A absent; Cu_2 and Cu_1 present; M_3-M_1 present, usually M_2 arising near lower angle of discal cell; R_5-R_1 present; R_4 and R_3 are stalked; Sc from base of the wing, not reaching up to apex; hindwing with discal cell closed; 3A and 2A present; 1A may or may not be present; Cu_2 and Cu_1 present; M_3-M_1present; M_2 usually more closer to lower angle of discal cell; vein Rs usually anastomosing with vein Sc+R_1.

Keys to studied species of family Crambidae

1. Forewing with vein Cu_1 and M_3 stalked from lower angle of discal cell.....
.....*Botyodes diniasalis* Walker
- Forewing with vein Cu_1 and M_3 stalked from lower angle of discal cell.....2
2. Hindwing with Cu_2 well beyond middle of discal cell…....*Cnaphalocrocis medinalis* Guenee
- Hindwing with Cu_2 not just beyond middle of discal cell.....3
3. Forewing with M_2 just above lower angle of discal cell.....*Diaphania indica* Saunders
- Forewing with vein M_2 near lower angle of cell.....4
4. Forewing with vein R_1 arising from well beyond upper angle of discal cell……
.....*Hymenia perspectalis* Hübner
- Forewing with vein R_1 arising not from well beyond upper angle of discal cell.....5
5. Forewing with M_1 originating from just below upper angle of discal cell; hindwing with 1A indistinct upto beyond discocellulars.....*Haritalodes derogata* Fabricius
- Forewing with M_1 originating from not just below upper angle of discal cell; hindwing with 1A not indistinct upto beyond discocellulars.....6
6. Hindwing with vein Sc+R_1 anastomosing with vein Rs from upper angle of discal cell.....
.....*Microthyris anormalis* Guenee
- Hindwing with vein Sc+R_1 not anastomosing with vein Rs from upper angle of discal cell...
.....7
7. Hindwing with vein 1A indistinct near middle of discal cell....*Omphisa anastomosalis* Guenee
- Hindwing with vein 1A distinct in the wing.....8
8. Hindwing with Cu_1, M_3 and M_2 arising from same point of lower angle of discal cell.....
.....*Conogethes punctiferalis* Guenee
- Hindwing with Cu_1, M_3 and M_2 arising from near lower angle of discal cell.....9

9. Forewing with vein R_2 just above upper angle of discal cell.....
.....*Parotis marginata* Hampson

- Forewing with vein R_2 not just above upper angle of discal cell.....10

10. Forewing with vein R_2 very very close to upper angle of discal cell.....
.....*Pygospila tyres* Cramer

11. Forewing with vein R_2 not very close to upper angle of discal cell.....12

- Hindwing with Rs anastomosing with vein $Sc+R_1$ well beyond upper angle of discal cell.....*Meroctena tullalis* Walker

12. Hindwing with Rs not anastomosing with $Sc+R_1$ well beyond upper angle of discal cell….13

- Forewing and Hindwing with veins Cu_1, M_3 and M_2 closer to lower angle of discal cell.....*Palpita asiaticalis* Inoue

13. Forewing and Hindwing with veins Cu_1, M_3 and M_2 not much closer to lower angle of discal cell.....*Eoophyla sejunctalis* Snellens

BOTYODES GUENEE

Guenee, 1854, Hist. Nat. Ins., Spec. Gen. Lepid., 8: 320

Type species: *Botyodes asialis* Guenee

Remarks: The genus *Botyodes* was established by Guenee in 1854, with its type species *asialis* Guenee. Currently, this genus is represented by eleven species namely, *caldusalis* Walker *andrinalis* Vieete, *asialis* Guenee, *crocopteralis* Hampson, *fraternal* Moore, *borneensis* Munroe, *brachytorna* Hampson, *fulviterminalis* Hampson, *diniasalis* (Walker), *principalis* Leech and *ufalis* Hampson (Ko et al. 2019).

Botyodes diniasalis Walker

Plate 65

Forewing venation: Forewing narrow, apex acute, discal cell closed, less than half length of total wing; 3A joined with 2A at more than one-third length of 2A, 2A reaching up to tornus; 1A absent; Cu_2 nearly one-fourth of discal cell; Cu_1 and M3 stalked from lower angle of discal cell; M_2 from well below middle of discocellulars, near to lower angle; M_1 from above middle of discocellulars; R_5 from nearly upper angle of cell; R_4 from upper angle of cell; R_4 and R_3 stalked; R_2 from just above upper angle of cell**,** not reaching up to apex; R_1 from near middle of discal cell not reaching up to apex; Sc from base of wing not reaching up to apex.

Hindwing venation: Hindwing with apex triangular, discal cell closed more than two-third length of total wing; 3A not reaching up to tornus; 2A present reaching up to tornus; 1A present, thin; Cu_2 from well beyond middle of discal cell; Cu_1 and M_3 stalked from lower angle of cell; M_2 from well below middle of discocellulars near to lower angle; M_1 from upper angle; vein Rs anastomosing with vein $Sc+R_1$ well beyond upper angle of cell.

CNAPHALOCROCIS LEDERER

Lederer, 1863, Wien. Ent. Monats., 7(11): 384

Type species: *Botys iolealis* Walker

Remarks: The genus *Cnaphalocrocis* Lederer includes ten species along with *medinalis* Guenee. Species *medinalis* was orginally described under genus *Salbia* by Guenee (1863) which was transferred to genus *Cnaphalocrocis* by Lederer (1954).

Cnaphalocrocis medinalis Guenee

Plate 66

Forewing venation: Forewing with apex triangular; discal cell closed, one-third length of total wing; 3A not separate from 2A, joining at almost more than one-third length of 2A, 2A reaching up to tornus; 1A absent; Cu_2 nearly one-third of discal cell; Cu_1 from just above lower angle of discal cell; M_3, M_2 nearly from lower angle of discal cell, almost from same point; ; M_1 from above middle of discocellulars; R_5 from nearly upper angle of cell; R_4 from upper angle of cell; R_4 and R_3 stalked; R_2 from just above upper angle of cell**,** not reaching up to apex; R_1 from near middle of discal cell not reaching up to apex; Sc from base of wing not reaching up to apex.

Hindwing venation: Hindwing with apex triangular; discal cell closed, less than half length of total wing; 3A present not reaching up to tornus; 2A present reaching up to tornus; 1A absent; Cu_2 from well beyond middle of discal cell; Cu_1 from just above lower angle of cell and M_3, M_2 arising from same point of lower angle of discal cell; M_1 from middle of discocellulars, thin; vein Rs anastomosing with vein $Sc+R_1$ middle of discal cell.

DIAPHANIA HÜBNER

Diaphania Hübner, 1818 Verz. Bek. Schmett., 2: 24

Type species: *Diaphania vitralis* Hübner

Remarks: This genus is known by eight species worldwide including *indica* Saunders.

Diaphania indica Saunders

Plate 67

Forewing venation: Forewing narrow, apex acute, discal cell closed, more than half length of total wing; 3A not separate from 2A, joining at one-third length of vein 2A; 2A reaching up to tornus; 1A absent; Cu_2 almost one-fourth of discal cell; Cu_1 from just above lower angle of discal cell and M_3 from lower angle of discal cell; M_2 from just above lower angle of discal cell; M_1 from well above middle of discocellulars, near to upper angle; R_5 from upper angle of cell; R_4 from upper angle of cell; R_4 and R_3 stalked; R_2 from just above upper angle of cell, very close to upper angle**,** not reaching up to apex; R_1 from well below middle of discal cell not reaching up to apex; Sc from base of wing not reaching up to apex.

Hindwing venation: Hindwing with apex triangular; discal cell closed more than one-third length of total wing; 3A present and 2A reaching up to tornus; 1A absent; Cu_2 from well below middle of discal cell; Cu_1 from just above lower angle of cell and M_3, M_2 from nearly same point of lower angle of cell; M_1 from upper angle; vein Rs anastomosing with vein $Sc+R_1$ well beyond from upper angle of cell.

HYMENIA HÜBNER

Hübner, 1825, Verz, bek, Sehemett., 1825: 360; Hampson, Moths India, 2: 262; Shibuya, 1928, J. Fao. Agr. Hokkaido Imp. Univ. Sapporo, 1928: 170.

Type species: *Hymenia perspectalis* Hübner

Remarks: This genus was erected by Hübner with its type species *perspectalis* in 1825 and was represented by 3 species worldwide viz., *lophoceralis* Hampson, *nigerrimalis* Hampson and *perspectalis* Hübner.

Hymenia perspectalis Hübner

Plate 68

Forewing venation: Forewing narrow, apex circular; discal cell closed, almost half length of total wing; excised below M_1; 3A joining with 2A at more than one-third portion of vein 2A, 2A reaching up to tornus; 1A absent; Cu_2 nearly one-third of discal cell; Cu_1 just above lower angle of cell, M_3 from lower angle of cell, M_2 from near lower angle of discal cell; M_1 from just above middle of discocellulars; R_5 from upper angle of cell; R_4 and R_3 stalked; R_2 arising from common stalk of R_4 and R_3, and conjoint with R_4 and not reaching up to apex; R_1 from well

beyond from upper angle of discal cell, not reaching up to apex; Sc from base of wing not reaching up to apex.

Hindwing venation: Hindwing with apex acute, globular; discal cell closed almost one-third length of total wing; 3A present reaching up to tornus; 2A present reaching up to tornus; 1A present; Cu_2 from two-third of discal cell; Cu_1, M_3 almost stalked from lower angle of cell; M_2 arises near to lower angle; M_1 from beyond upper angle of cell; vein Rs anastomosing with vein $Sc+R_1$ well beyond upper angle of cell.

HARITALODES WARREN

Warren, 1890, Ann. Mag. Nat. Hist., 6(6): 476.

Type species*: Botys multilinealis* Guenee

Remarks: This genus was having two species viz., *H. basipunctalis* Bremer and *H. derogate* Fabricius (Tabesh et al. 2015).

Haritalodes derogata Fabricius

Plate 69

Forewing venation: Forewing narrow, apex flattened, discal cell closed, more than half length of total wing; 3A joining 2A nearly two-third length of 2A, 2A reaching up to tornus; 1A absent; Cu_2 nearly one-third of discal cell; Cu_1 from just above lower angle of discal cell and M_3, M_2 from nearly same point of lower angle of discal cell; M_1 from just below upper angle of discal cell; R_5 from upper angle of cell; R_4 and R_3 stalked; R_2 arising from common vein of R_4 and R_3; R_1 from well below middle of discal cell not reaching up to apex; Sc from base of wing not reaching up to apex.

Hindwing venation: Hindwing with apex flattened; discal cell closed less than half length of total wing; 3A present reaching up to tornus; 2A present reaching up to tornus; 1A present, obsolete up to beyond discocellulars; Cu_2 from nearly one- fourth middle of discal cell; Cu_1 from just above lower angle of cell and M_3, M_2 from nearly same point of lower angle of cell; M_1 from upper angle; vein Rs anastomosing with vein $Sc+R_1$ at just beyond upper angle of cell.

MICROTHYRIS LEDERER

Lederer, 1863, Wien. Ent. Monats., 7(12): 432

Type species: *Botys prolongalis* Guenee

Remarks: *Microthyris* was a genus of subfamily Spilomelinae of grass moth family Crambidae and was first described by Julius Lederer in 1863.

Microthyris anormalis Guenee

Plate 70

Forewing venation: Forewing narrow, apex acute, triangular, discal cell closed, less than half length of total wing; 3A joining with 2A at more than one-third of length of vein 2A, 2A reaching up to tornus; 1A absent; Cu_2 nearly one-fourth of discal cell; Cu_1, M_3, M_2 nearly from same point of lower angle; M_1 from just above middle of discocellulars; R_5 and R_4 from upper angle of cell; R_3 and R_2 stalked; R_2 from same point of R_4, and conjoint with R_4 and not reaching up to apex; R_1 from almost middle of discal cell not reaching up to apex; Sc from base of wing not reaching up to apex.

Hindwing venation: Hindwing with apex acute, globular; discal cell closed, less than half the length of total wing; 3A present not reaching up to tornus; 2A present reaching up to tornus; 1A present; Cu_2 from nearly middle of discal cell; Cu_1, M_3, M_2 arising from same point of lower angle of cell; M_1 from upper angle; vein Rs anastomosing with $Sc+R_1$ from upper angle of cell; M_1, Rs and $Sc+R_1$ conjoint with each other.

OMPHISA MOORE

Moore, 1886, Lepid. Ceylon 3(3): 317

Type species: *Botys illisalis* Walker

Omphisa anastomosalis Guenee

Plate 71

Forewing venation: Forewing narrow, discal cell closed, more than half length of total wing; 3A joining 2A at more than one-third portion of vein 2A, 2A reaching up to tornus; 1A absent; Cu_2nearly one-fifth of discal cell; Cu_1 just above lower angle of cell, M_3 from lower angle of cell, M_2 from near lower angle of discal cell, close to M_3; M_1 from just above middle of discocellulars; R_5 from upper angle of cell; R_4 and R_3 stalked; R_2 nearly from upper angle of cell not reaching up to apex, and conjoint with R_4; R_1 nearly one-fourth of discal cell not reaching up to apex; Sc from base of wing not reaching up to apex, closed to R_1.

Hindwing venation: Hindwing with apex rounded; discal cell closed less than half length of total wing; 3A present not reaching up to tornus; 2A present reaching up to tornus; 1A present,

indistinct near middle of discal cell; Cu_2 from well above lower angle; Cu_1 just above upper angle of cell; M_3, M_2 stalked from beyond lower angle of discal cell; M_1 from upper angle of cell; vein Rs anastomosing with vein $Sc+R_1$ just beyond M_1, running close to discal margin.

CONOGETHES MEYRICK

Conogethes Meyrick, 1884, Trans. Ent. Soc. London, 1884(3): 314

Type species: *Astura punctiferalis* Guenee

Remarks: This genus was known by five species worldwide namely *tharsalea* Meyrick, *pluto* Butler, *ersealis* Walker, *haemactalis* Snellen, *semifascialis* Walker and *punctiferalis* Guenee.

Conogethes punctiferalis Guenee

Plate 72

Forewing venation: Forewing slightly broad, apex flattened, discal cell closed, less than half length of total wing; 3A not separate from 2A, joining at more than one-third length of vein 2A, 2A reaching up to tornus; 1A absent; Cu_2 nearly one-fifth of discal cell; Cu_1 from just above lower angle of discal cell and M_3 from lower angle of discal cell; M_2 near to lower angle; M_1 from above middle of discocellulars; R_5 from just below upper angle of cell; R_4 from upper angle of cell; R_4 and R_3 stalked; R_2 arising from very close to upper angle of cell, not reaching up to apex; R_1 from well below middle of discal cell, not reaching up to apex; Sc from base of wing not reaching up to apex.

Hindwing venation: Hindwing broader, apex flattened, beak-like, slightly excised below M_1; discal cell closed one-third length of total wing; 3A present not reaching up to tornus; 2A present reaching up to tornus; 1A present; Cu_2 from beyond middle of discal cell; Cu_1, M_3, M_2 from same point of lower angle of cell; M_1 from upper angle; vein Rs anastomosing with vein $Sc+R_1$ well beyond from upper angle of cell.

PAROTIS HÜBNER

Hübner, 1878, Proc. Zool. Soc. London, 1878: 701

Type species: *Parotis psittacalis* Hübner

Remarks: This genus is represented by three species namely, *marginata, pomonalis, psittacalis* (Irungbam et al. 2016)

Parotis marginata Hampson

Plate 73

Forewing venation: Forewing narrow, discal cell closed, nearly equal to total length of wing; 3A joining with vein 2A at more than one-third length of 2A, 2A reaching up to tornus; 1A absent; Cu_2 nearly one-fifth of discal cell; Cu_1 just above lower angle of cell, M_3 from lower angle of cell, M_2 from near lower angle; M_1 from just above middle of discocellulars; R_5 just below upper angle of cell; R_4 and R_3 stalked; closed to R_5; R_2 from just above upper angle of cell not reaching up to apex, and conjoint with R_4; $R_1$from nearly middle of discal cell not reaching up to apex; Sc from base of wing not reaching up to apex, closed to R_1 and costa.

Hindwing venation: Hindwing with apex rounded; discal cell closed less than half length of total wing; 3A present reaching up to tornus; 2A present reaching up to tornus, 2A thicker than 3A and 1A; 1A fainted than 2A and 3A; Cu_2 from slightly more than one-fifth portion; Cu_1, M_3 and M_2 nearly stalked from lower angle of cell; M_1 from upper angle of cell; vein Rs anastomosing with vein $Sc+R_1$.

PYGOSPILA GUENEE

Pygospila Guenee, 1854, Hist. Nat. Ins., Spec. Gen. Lepid., 8: 312.

Type species: *Phalaena tyres* Cramer

Remarks: This genus was represented worldwide by ten species including *tyres* (Cramer).

Pygospila tyres Cramer

Plate 74

Forewing venation: Forewing narrow, discal cell closed, slightly less than half length of total wing; 3A attached with vein 2A, joining at more than one-third portion of 2A, 2A reaching up to tornus; 1A absent; Cu_2 nearly one-third of discal cell; Cu_1 just above lower angle of cell, M_3 from lower angle of cell, M_2 from near lower angle of discal cell; M_1 from well above middle of discocellulars; R_5 from upper angle of cell; R_4 and R_3 stalked; R_2 very-very close to upper angle of cell not reaching up to apex, and conjoint with R_4; R_1 from middle discal cell not reaching up to ape, close to R_2; Sc from base of wing not reaching up to apex.

Hindwing venation: Hindwing with apex acute, triangular; discal cell closed less than half length of total wing; 3A present reaching up to tornus; 2A present reaching up to tornus; 1A absent; Cu_2 from above lower angle of discal cell; Cu_1, just above upper angle of cell; M_3, M_2 nearly stalked from lower angle of discal cell; M_1 from upper angle of cell; vein Rs anastomosing with vein $Sc+R_1$ beyond M_1.

MEROCTENA LEDERER

Lederer, 1863, Wien. Ent. Monats., 7(11): 392

Type species: *Meroctena staintonii* Lederer

Remarks: The species *tullalis* Walker was still under the above mentioned genus. At present, this genus is known by three species.

Meroctena tullalis Walker

Plate 75

Forewing venation: Forewing narrow, apex triangular, discal cell closed, more than half length of total wing; 3A joining at middle of 2A, 2A reaching up to tornus; 1A absent; Cu_2 nearly one-third of discal cell; $Cu_1$from above lower angle of discal cell and M_3, M_2 from nearly same point of lower angle; M_1 from just above middle of discocellulars; R_5 from upper angle of cell; R_4 and R_3 stalked; R_2 from almost of same point of R_4, not reaching up to apex; R_1 from middle of discal cell not reaching up to apex; Sc from base of wing not reaching up to apex.

Hindwing venation: Hindwing with apex acute, discal cell closed less than half length of total wing; 3A present reaching up to tornus; 2A present reaching up to tornus; 1A present; Cu_2 from nearly middle of discal cell; Cu_1 from above lower angle of cell and M_3, M_2stalked from lower angle of cell; M_1 from upper angle; vein Rs anastomosing with vein $Sc+R_1$ well beyond upper angle of cell.

PALPITA HÜBNER

Hübner, 1808, Verz. Bek. Schmett., 1: 209

Type species: *Pyralis unionalis* Hübner

Remarks: On the basis of morphological description, the two species i.e., *annulifer* Inoue and *asiaticalis* Inoue can be distinguished from each other on the basis of the costal margin which is darker in case of *annulifer* (Irungbam et al. 2016).

Palpita asiaticalis Inoue

Plate 76

Forewing venation: Forewing narrow, discal cell closed, slightly more than half length of wing; 3A joining with vein 2A at more than one-third portion of vein 2A, 2A reaching up to tornus; 1A absent; Cu_2 nearly one-fourth portion of discal cell; Cu_1, M_3 and M_2 originating from almost from same point of lower angle of cell, more closer than *Eoophyla sejumctalis*; M_1 from above middle of discocellulars; R_5 just below upper angle of cell; R_4 and R_3 stalked; R_2 from well

above upper angle of cell not reaching up to apex and conjoint with R_4; R_1 from below middle of discal cell, not reaching up to apex; Sc from base of wing not reaching up to apex.

Hindwing venation: Hindwing with discal cell closed, less than half the length of total wing; 3A present nearly reaching up to tornus; 2A present reaching up to tornus, 2A thicker; 1A present; Cu_2 from slightly more than one-fifth portion of discal cell; Cu_1, M_3 and M_2 originate from near lower angle of cell, more closer than *Eoophyla sejumctali*, M_1 from upper angle of cell; vein Rs anastomosing with vein $Sc+R_1$ well beyond upper angle of cell; close to M_1.

EOOPHYLA SWINHOE

Swinhoe, 1900, Cat. Het. Mus. Oxford, 2:442.

Type species: *Eoophyla peribocalis* Walker

Remarks: The genus *Eoophyla* was proposed by Swinhoe in 1900 with *peribocalis* Walker as its type species. Recently, the genus was revised and so far, this genus has about 166 species reported all over the world (Nuss et al. 2016).

Eoophyla sejunctalis Snellens

Plate 77

Forewing venation: Forewing narrow, discal cell closed, less than half length of total wing; 3A separate joining at more than one-third portion of 2A, 2A reaching up to tornus; 1A absent; Cu_2 nearly one-fourth of discal cell; Cu_1 just above lower angle of cell, M_3 from lower angle of cell, M_2 from near lower angle of discal cell; M_1 from just above middle of discocellulars; R_5 from upper angle of cell; R_4 and R_3 stalked; R_2 well above upper angle of cell not reaching up to apex and conjoint with R_4; R_1 from nearly one-fourth of discal cell not reaching up to apex; Sc from base of wing not reaching up to apex.

Hindwing venation: Hindwing with apex rounded, globular, inner margin excised near base; discal cell closed nearly one-third of total wing; 3A present not reaching up to tornus; 2A present reaching up to tornus; 1A present; Cu_2 from well above lower angle; Cu_1 just above upper angle of cell; M_3, M_2 nearly stalked from lower angle; M_1 from upper angle of cell; vein Rs anastomosing with vein $Sc+R_1$ just near M_1.

3.2 Bibliography

1. Banziger H (1982) Fruit-piercing moths (Lepidoptera:Noctuidae) in Thailand: A general survey and some new perspectives. Mitt. Schweiz. Ento. Ges. 53(34): 213-240.
2. Bell, TRD, Scottand FB (1937*)*The Fauna of British India, including Ceylon and Burma. Moths- Sphingidae, 5: 1-537.
3. Goyal T (2011), Taxonomic studies on family Geometridae (Lepidoptera) from Western Ghats of India, Punjabi University Patiala, 279pp.
4. Grote, AR (1862) Additions to the catalogue of U.S. Lepidoptera. Proc. Entomol. Soc. Phila., 1: 218-219.
5. Hampson GF (1892) Fauna of British India including Ceylon and Burma, Moths, 1: 1-527. Taylor and Francis Ltd., London.
6. Hampson GF (1894) Fauna of British India including Ceylon and Burma. Moths. Vols. I & II, London. Taylor and Francis Ltd., 1-107, 160-609.
7. Han, HL Kononenko, VS (2011). Twelve new species of *Athetis* Hübner, (1821) 1816 from China (Lepidoptera: Noctuidae). Zootaxa, 3068: 49-68.
8. Holloway JD (1987) Moths of Borneo, 3: 1-199. South dene, Kuala Lumpur, Malaysia.
9. Holloway JD (2005) Moths of Borneo (part 15 & 16): family Noctuidae, subfamily Catocalinae, Malayan Nature Journal, 58:1-529
10. Hampson GF (1894) Fauna of British India including Ceylon and Burma. Moths. Vols. I & II, London. Taylor and Francis Ltd., 1-107, 160-609.
11. Irungbam J, Chib MS, Wangdi K (2011) Taxonomic review of the superfamily Pyraloidea in Bhutan (Lepidoptera). J. Asia Pacific Biodiversity 9 (2016): 355-382.
12. Kaleka AS, Singh D, Kaur P (2011) Studies on external genitalia of Indian species of genus *Acherontia Laspeyres* (Sphinginae: Sphingidae: Lepidoptera). Ann. Ent., **29**(1): 3-8. Kaleka, AS, Singh D, Kaur, P (2015) Genitalic studies of two species of genus *Daphnis* Hübner (Sphingidae: Lepidoptera) from India. J. Chem. Biol. Phy. Sci., 5(2): 1531-1537.
13. Ko JH, Lee TG, Na SM, Park, BS, Bae YS (2019) Review of the genus *Botyodes* Guenee (Lepidoptera: Crambidae: Spilomelinae) from Laos, with three newly recorded species. J Asia Pacific Biodiversity, 12:278-283.
14. Nuss M, Landry B, Mally R, et al. (2016) Global Information System on Pyraloidea. Available at:www.pyraloidea.org [Date accessed: 16 March 2016].

15. Nye IWB (1975)The generic names of moths of the world. (Part 1): Noctuidae, Agaristidae, and Nolidae. London. The Gresham Press, Unwin Brothers Ltd., 568 pp.
16. Pittaway AR (1995) Sphingidae of the western Palaearctic: their ecology and biogeography. PhD Thesis, Imperial College, university of London, UK. 244pp.
17. Poole, RW(1989) Lepidopterorum Catalogue (New Series), Fascicle 118 Noctuidae, Parts 1-3, New York, E. J. Brill, 1314pp.
18. Rothschild W, Jordan K (1903) A revision of the Lepidopterous family Sphingidae. Novit. Zool, 9: 1-972.
19. Sekhon CK (2011) Taxonomic significance of external male and female genitalic structures in family Noctuidae, Punjabi university Patiala, 144pp.
20. Sondhi Y, Kitching, IJ, Basu, DN, Kunte K (2017) A new species of *Theretra* Hübner (Lepidoptera: Sphingidae) from the southern Western Ghats, India. Zootaxa, 4323(2):185-196.
21. Srivastava A (2002) Taxonomy of moths in India. Deheradun, India, Published by International Book Distributors, 1-334pp.
22. Tabesh HB, Alipanah H, Sahragard A (2015) First record of *Haritalodes derogata* (Fabricius) (Lepidoptera: Crambidae: Spilomelinae) from Iran. J. Crop Prot. 4(2):167-171
23. Tams WHT (1924) List of moths collected in Siam by E. J. Godfrey, B.Sc., F.E.S. with description of new species, J. Nat. Hist. Soc. Siam., 6: 229-289.
24. Todd, EL (1978) Check list of species of *Heliothis* Ochsenheimer (Lepidoptera: Noctuidae). Proc. Ent. Soc. Wash., 80(1): 1-14.
25. Tutt, JW (1902) British Moths. Nat. His. Brit. Lepid. London, 558pp.
26. Youqiao L, Chunsheng W (2006) Fauna Sinica insect volume 47 (Lepidoptera: Lasiocampidae). 422pp.
27. Zahiri R, Hollaway JD, Kitching IJ, Lofantaine JD, Mutanen M, Wahlberg N (2011) Molecular phylogenetics of Erebidae (Lepidoptera, Noctuoidea). Syst. Ent., 37(1):102-124.

4. DISCUSSIONS

4.1 General information

Insects form the most diverse group of animals on earth, comprising of more than a million described species and delineating more than half of all described living organisms. An attempt to update the existing knowledge about the beautifully patterned and economically important moths referable to order Lepidoptera in the form of an entomological research problem entitled "Examining the wing venation pattern of different species of moths (Lepidoptera) found in IISER Mohali". The majority of moth fauna in relation to wing venation had been mainly less studied by Indian workers in details. Unfortunately, after Hampson, no serious attempt had been taken by others to explore elaborated form of wing patterns in case of moths. During the present investigations, an effort has been made to examine wing venation features which will add remarkably to the taxonomy of moths. The results from our observation clearly demonstrate that how wing venation plays principal role in the segregation of groups up to species level.

The observations made during the present studies can be discussed as follows:

i. After thorough assortment, it was established that available and collected material belonged to **77** species referable to 67 genera, out of which 3 species, 14 species, 13 species, 12 species, 22 species and 13 species belong to families Lasiocampidae, Noctuidae, Sphingidae, Geometridae, Erebidae and Crambidae respectively.

ii. The diagnostic features of wing venation of the above mentioned 6 families have been given. Dichotomous keys to the studied families, genus and species have also been formulated.

iii. First reference, type species, and suitable remarks were included under genus (wherever available).

iv. For each species, detailed descriptive account of wing venation along with the coloured plates has been adequately mentioned and prepared.

v. Family Lasiocampidae was least diverse in number with only 3 species observed so far; both wings with discal cell either closed or open; forewing with all the veins were present except the one of the anal veins, 3A fused with 2A without forming a basal fork; Sc mostly conjoined with costa. Hindwing present with all the veins; where vein 3A and 2A not fused; $Sc+R_1$

anastomosing with Rs forming a humeral cell which give rise to prominent or indistinct humeral veins which was a unique characteristic as compared to the rest of the other studied families.

vi. In case of family Noctuidae, both the wings with discal cell always closed and 1A was almost absent; three veins namely Cu_1, M_3, M_2 give rise to trifine venation. Hindwing with all the veins were prominent except vein M_2 which sometimes was absent.

vii. Forewing was apically acute in many genera in case of family Sphingidae; discal cell always closed in both the wings; vein 3A+2A forked at base; 1A absent almost always absent; all the radial veins were separate except $R_{(3+2)}$ which were totally fused. Hindwing with vein 2A forming a forked near base; M_2 from/ below/well below/above middle of discocellulars and $Sc+R_1$ forming a bar with discal cell.

viii. The species studied from family Geometridae were having discal cell closed in both the wings; forewing with vein 3A sometimes forked with 2A; all the radial veins present except R_2 which was sometime not present in some species. Hindwing with vein 3A was absent in some forms and $Sc+R_1$ with a well-developed pre-costal spur which was not present in any other studied family. Species *Ourapteryx clara* Butler having unique feature when compared to its other studied Geometrid species that hindwing forming a tail at vein M_3.

ix. Family Erebidae was most diverse within the moth family with an account of 22 species. In spite of this, literature revealed that many species have been merged in this family on the basis of wing venation and external genitalia. The wings with discocellulars closed; forewing with 3A may be absent; veins Cu_2-M_2 forms quadrifid venation in appearance and all the radial veins were present. Hindwing 1A may be absent sometimes and M_1 and Rs may or may not be stalked.

x. The representatives of family Crambidae were observed to have a closed discal cell in both the wings. Forewing with 1A absent; rest all the veins were present. Hindwing 1A was sometime present; all the cubital, medial and radial veins were present; M_2 usually closer to lower angle of discal cell.

Thus, the present work discusses the trends and differences in moth wing venation in 6 family(s) viz. Lasiocampidae, Noctuidae, Sphingidae, Geometridae, Erebidae and Crambidae. These results were suggestive of significant variations in wings of collected moth specimens and also agree to the fact that additional comparative quantitative studies must be carried out. This will surely help in assessment to substantially improve our understanding of moth wing venation.

4.2 A List of presently studied species under 6 families is given below:

Lasiocampidae

1. *Trabala vishnou* Lefebvre
2. *Gastropacha leopoldi* Tams
3. *Streblote siva* Lefebvre

Noctuidae

4. *Analetia unicorna* Berio
5. *Athetis flavicolor* Han and Kononeko
6. *Chrysodexis eriosoma* Doubleday
7. *Helicoverpa armigera* Hübner
8. *Ochropleura leucogaster* Freyer
9. *Pericyma umbrina* Guenee
10. *Sesami ainferens* Walker
11. *Spodoptera litura* Fabricius
12. *Trigonodes hypasia* Cramer
13. *Hypocala rostrata* Fabricius
14. *Thysanoplusia orichalcea* Fabricius
15. *Xanthodes intersepta* Guenee
16. *Xestia nigrum* Linnaeus
17. *Xestia tamsi* Wileman and West

Sphingidae

18. *Acherontia styx* Westwood
19. *Agrius convolvuli* Linnaeus
20. *Cypa decolor* Walker
21. *Macroglossum belis* Linnaeus
22. *Polyptychus trilineatus undatus* Rothschild and Jordan
23. *Sataspes scotti* Jordan
24. *Daphnis nerii* Linnaeus
25. *Hippotion celerio* Linnaeus
26. *Hippotion rosetta* Swinhoe

27. *Theretra nessus* Drury
28. *Theretra oldenlandiae* Fabricius
29. *Nephele didyma* Fabricius
30. *Nephele hespera* Fabricius

Geometridae

31. *Ourapteryx clara* Butler
32. *Chiasmia frugaliata* Guenee
33. *Digrammia subminiata* Packard
34. *Rhodometra sacraria* Linnaeus
35. *Spaniocentra pannosa* Moore
36. *Traminda mundissima* Walker
37. *Hypomecis* sp.
38. *Hypomecis transcissa* Walker
39. *Petelia immaculate* Hampson
40. *Petelia medardaria* Herrich-Schaffer
41. *Thalassodes quadraria* Guenee
42. *Thalassodes veraria* Guenee

Erebidae

43. *Achaea janata* Linnaeus
44. *Aloa lactinea* Cramer
45. *Arctornis bubalina* Chao
46. *Calyptra parva* Banziger
47. *Dasychira* sp.
48. *Digama hearseyana* Moore
49. *Episparis liturata* Fabricius
50. *Utetheisa pulchelloides* Hampson
51. *Leucoma salicis* Linnaeus
52. *Somena scintillans* Walker
53. *Thyas coronate* Fabricius
54. *Lygephila craccae* Denis and Schiffermuller
55. *Spilosoma metarhoda* Walker

56. *Attatha ino* Drury
57. *Grammodes geometrica* Fabricius
58. *Mocis frugalis* Fabricius
59. *Anomis fulvida* Guenee
60. *Anomis lineosa* Walker
61. *Creatonotos gangis* Linnaeus
62. *Creatonoto stransiens* Walker
63. *Spirama heliciana* Hübner
64. *Spirama retorta* Clerck

Crambidae

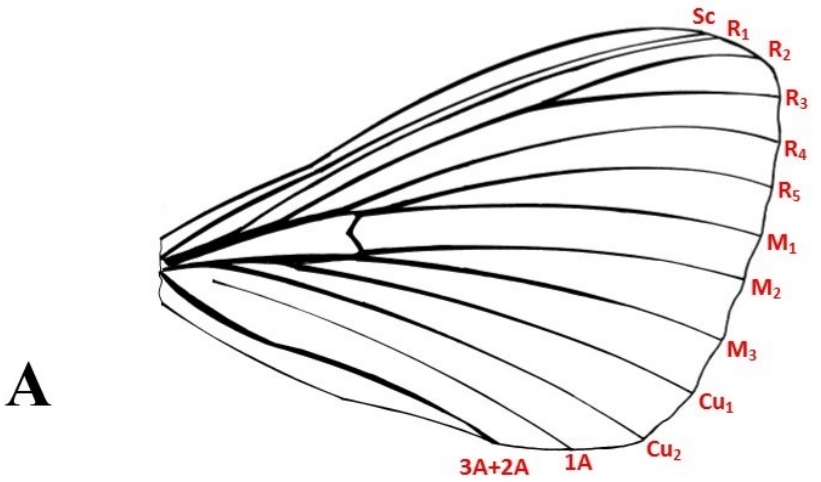
65. *Botyodes diniasalis* Walker
66. *Cnaphalocrocis medinalis* Guenee
67. *Diaphania indica* Saunders
68. *Hymenia perspectalis* Hübner
69. *Haritalodes derogata* Fabricius
70. *Microthyris anormalis* Guenee
71. *Omphisa anastomosalis* Guenee
72. *Conogethes punctiferalis* Guenee
73. *Parotis marginata* Hampson
74. *Pygospila tyres* Cramer
75. *Meroctena tullalis* Walker
76. *Palpita asiaticalis* Inoue
77. *Eoophyla sejunctalis* Snellens

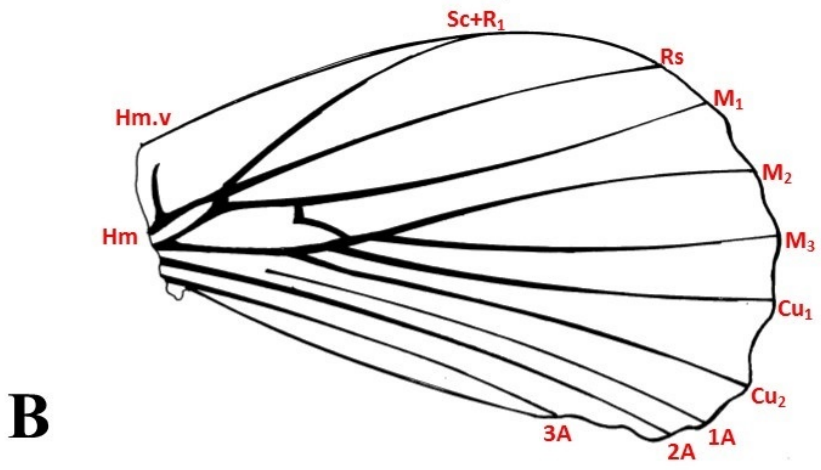
5. CONCLUSION AND SCOPE FOR FUTURE RESEARCH

Research is a continuous process and there is always enough scope for further improvement. Though this group of Indian moths is of immense importance but it has remained neglected from taxonomic and monitoring point of view and its classification is still unstable. Now a day number of manuscripts/articles focusing on external genitalia of moths and molecular studies but disregard the wing venation. Is wing venation is not significant at taxonomic point of view? However, it is observed that wings in case of insects including moths are the most striking features as it not only related with the flight behavior or fascinated towards human but also related with morphology, histology including ultra-structure of micro and macro individuals. The arrangement of veins in moth wings not only indicating the number of veins present but also help in diagnosing/segregating the moth family/sub-family/super-family from each other and hence provides a corrugated profile to the species. The following observations indicate the main role in segregating the individuals not only at the family level but also at the species degree and we assumed that wing venation in case of moths is underestimated to date. In conclusion, it can be stated that wing venation plays a same role as genital morphology and molecular studies which is now in high trends in numerous manuscripts. To add more and more wing venation studies concentrating on moths species to species would be of particularly of great importance. It is need of the hour to take up revisionary studies starting from wing venation followed by higher studies on Indian moth group especially from Punjab region which is still unexplored. The present work is a beginning in this direction and it is suggested that wing venation features should be observed and analyzed in elaborate form so that the bunch of attributes will incorporate in the characterization of different genera, families, subfamilies etc which will result in the strong taxonomic machinery of a particular group. At the end, I will close this window with the comments that there is a lot of scope to conduct taxonomic studies particularly wing venation on this group of moths from various areas of this vast country. By nature`s law, no work is absolute and perfect and there is always a room for improvement and to open window for a new goal. Thus, the present work holds some encouraging conclusions and connotes a great deal for future research in this direction.

PLATE - 1

From Book "Moths of IISER Mohali"



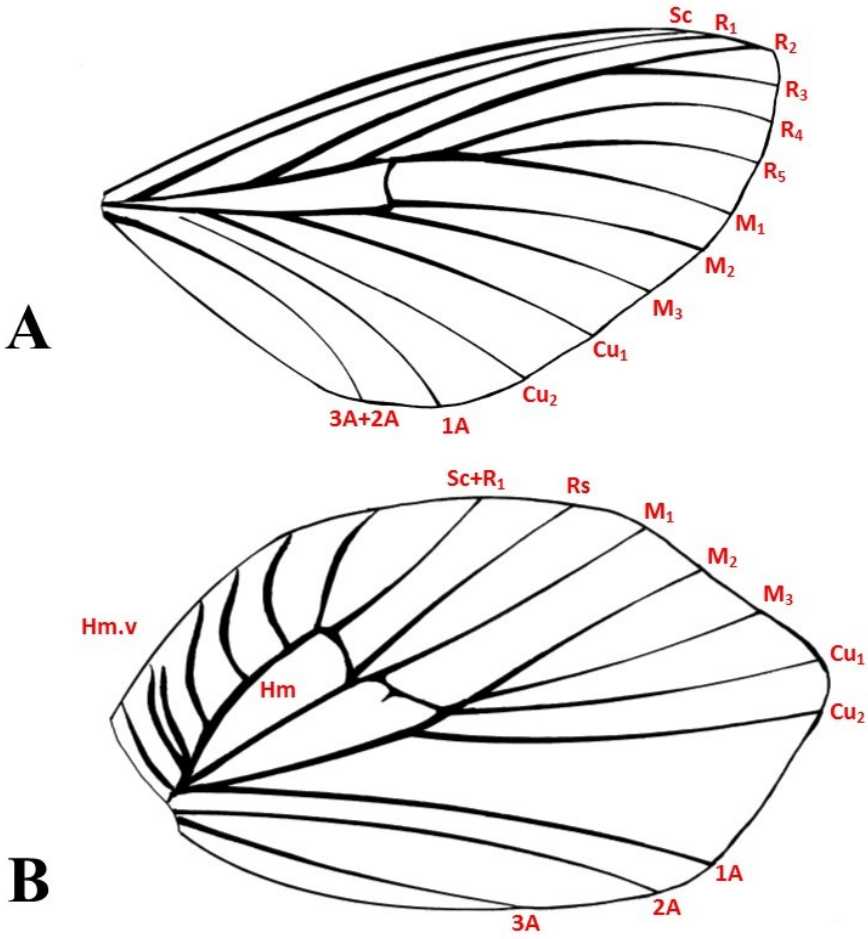


Trabala vishnou Lefebvre

A-Forewing, B-Hindwing

PLATE - 2

From Book "Moths of IISER Mohali"

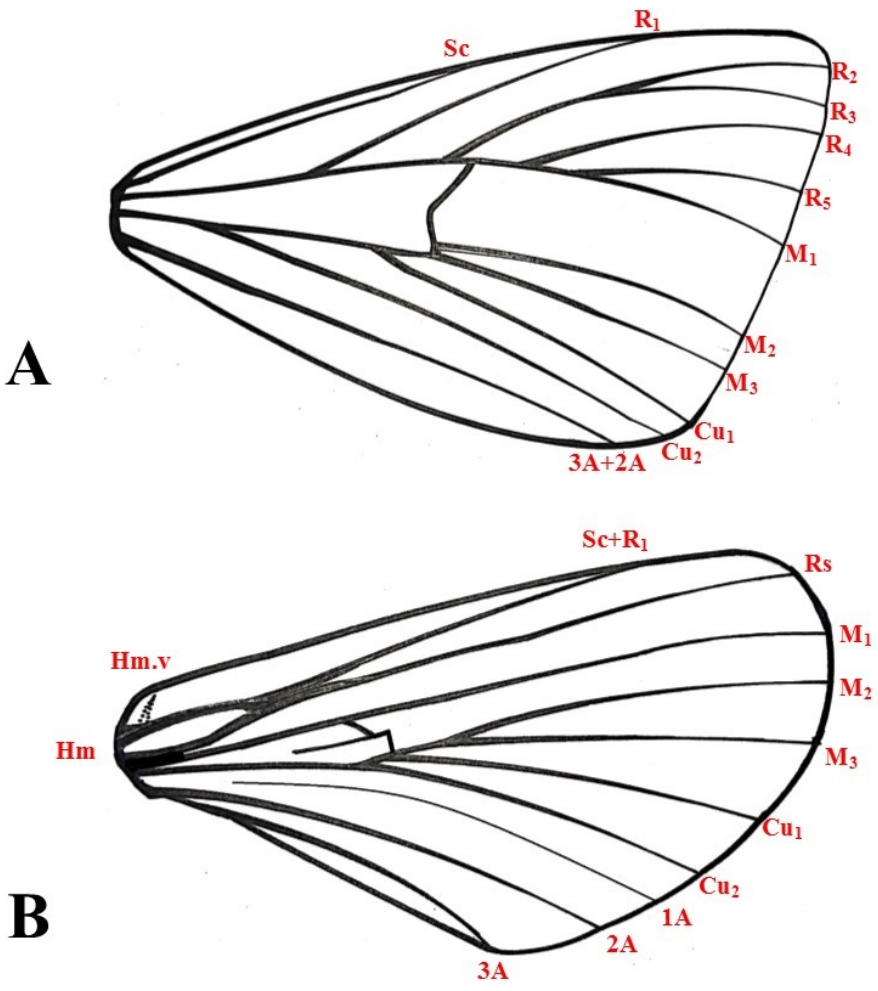


Gastropacha leopoldi Tams

A-Forewing, B-Hindwing

PLATE - 3

From Book "Moths of IISER Mohali"

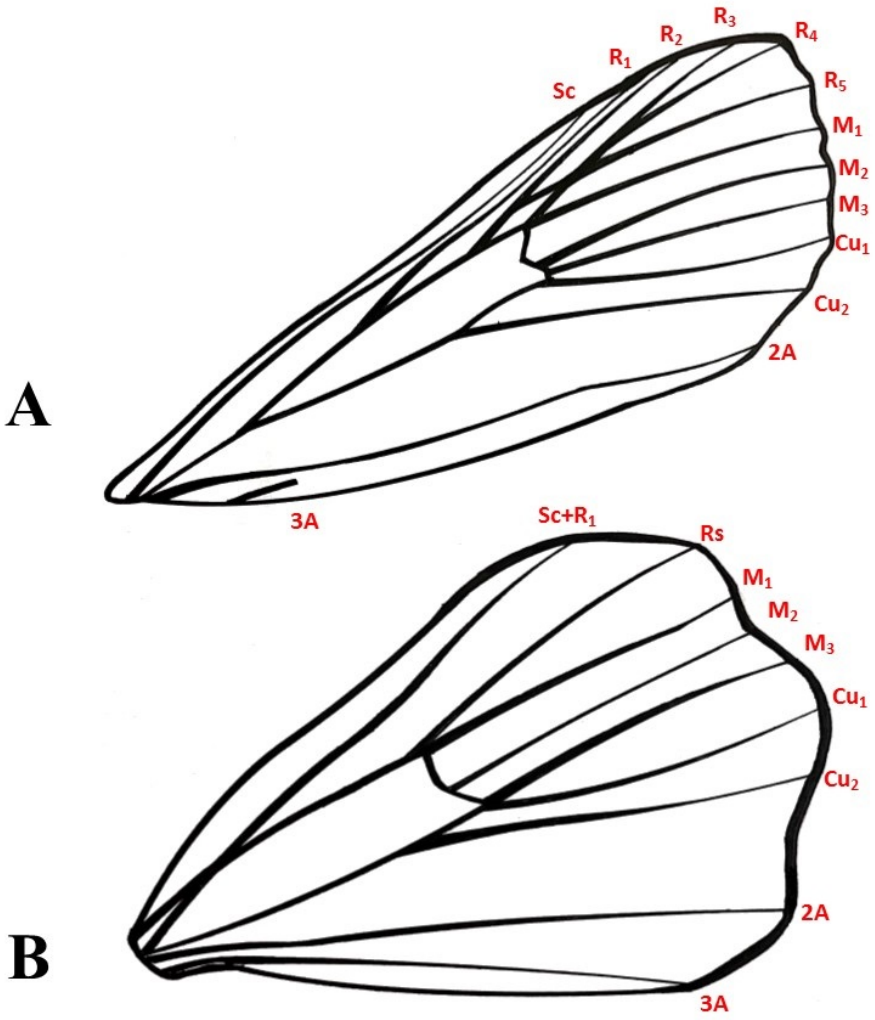


Streblote siva Lefebvre

A-Forewing, B-Hindwing

PLATE - 4

From Book "Moths of IISER Mohali"

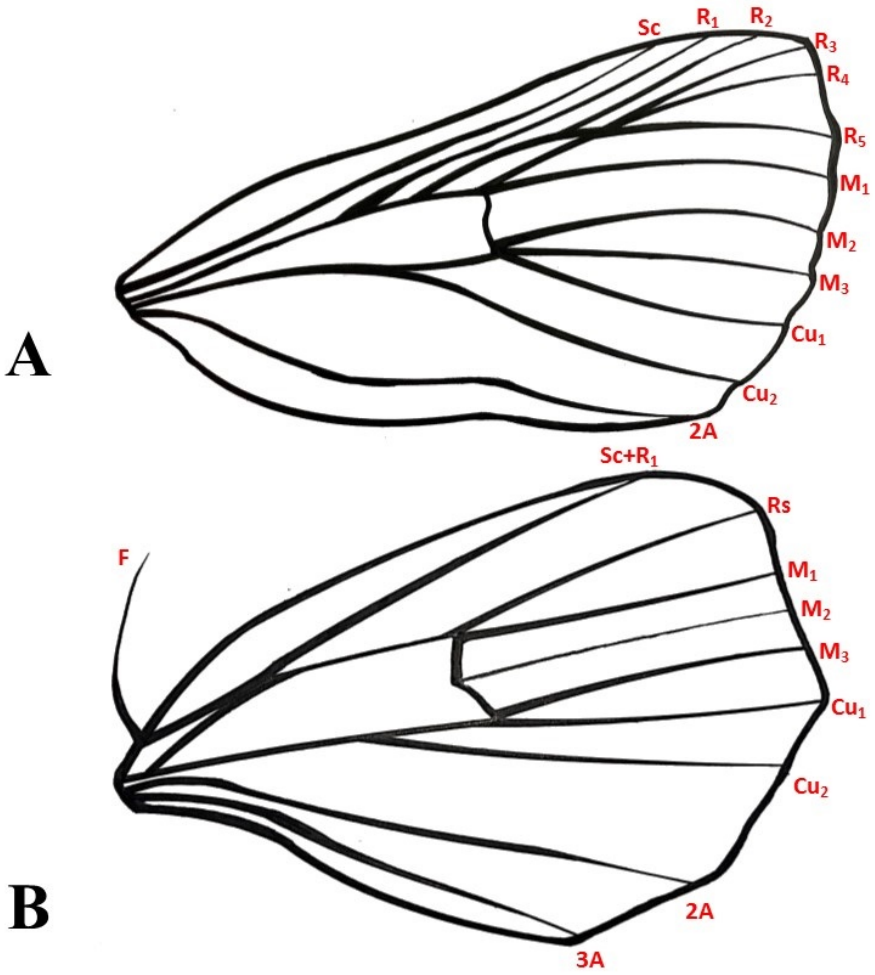


Analetia unicorna Berio

A-Forewing, B-Hindwing

PLATE - 5

From Book "Moths of IISER Mohali"

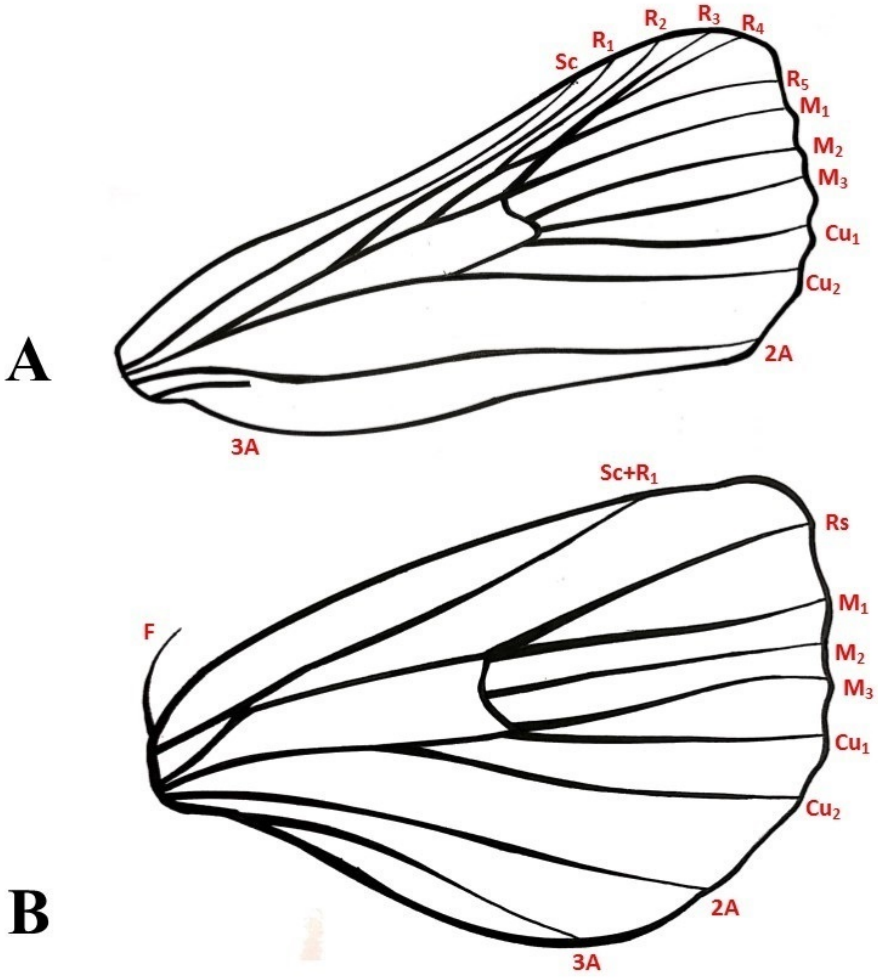


Athetis flavicolor Han and Kononeko

A-Forewing, B-Hindwing

PLATE - 6

From Book "Moths of IISER Mohali"

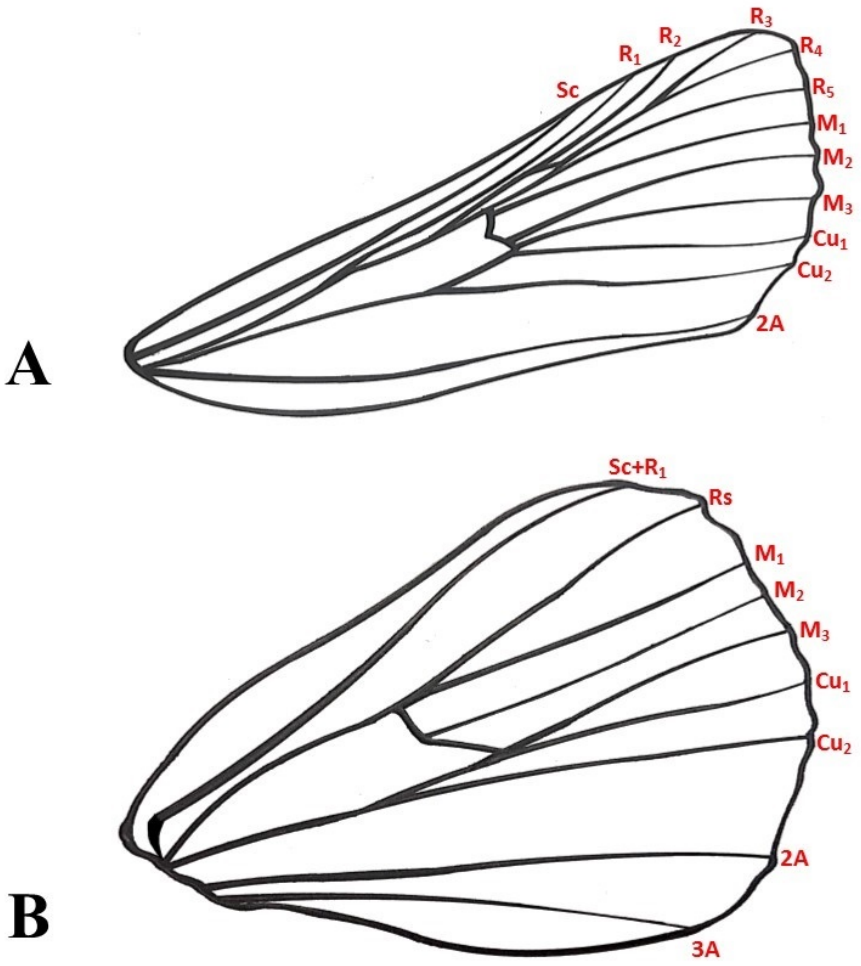


***Chrysodexis eriosoma* Doubleday**

A-Forewing, B-Hindwing

PLATE - 7

From Book "Moths of IISER Mohali"

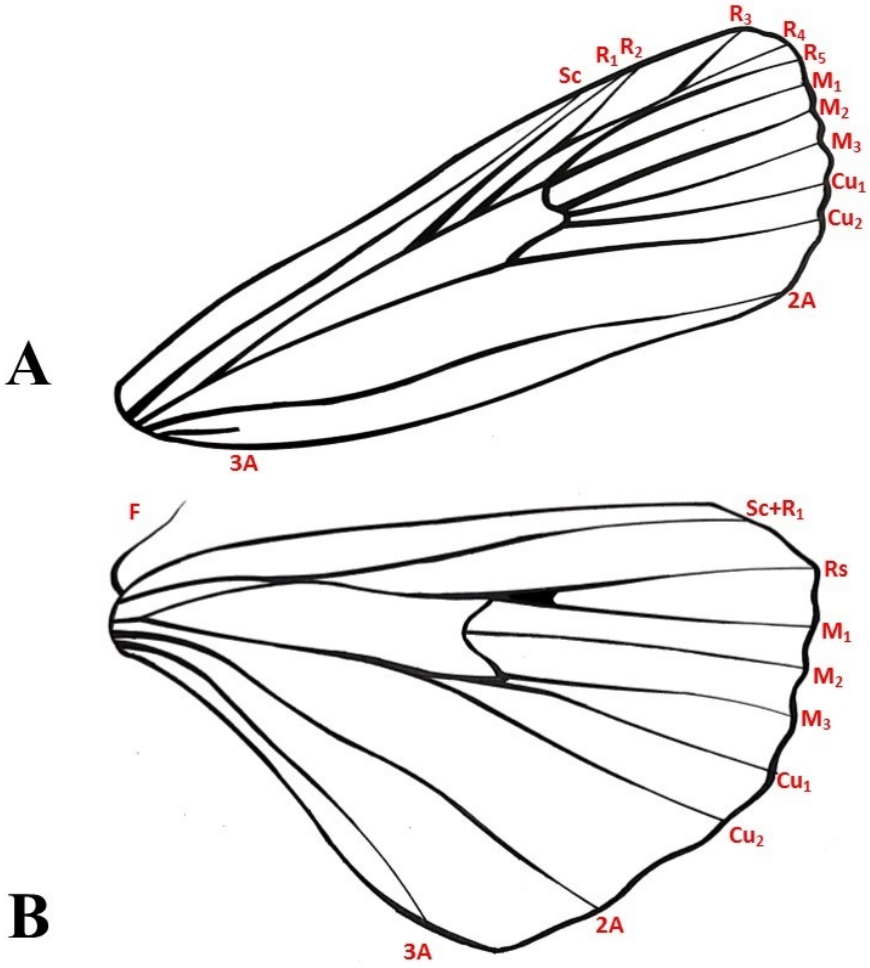


Helicoverpa armigera Hübner

A-Forewing, B-Hindwing

PLATE - 8

From Book "Moths of IISER Mohali"

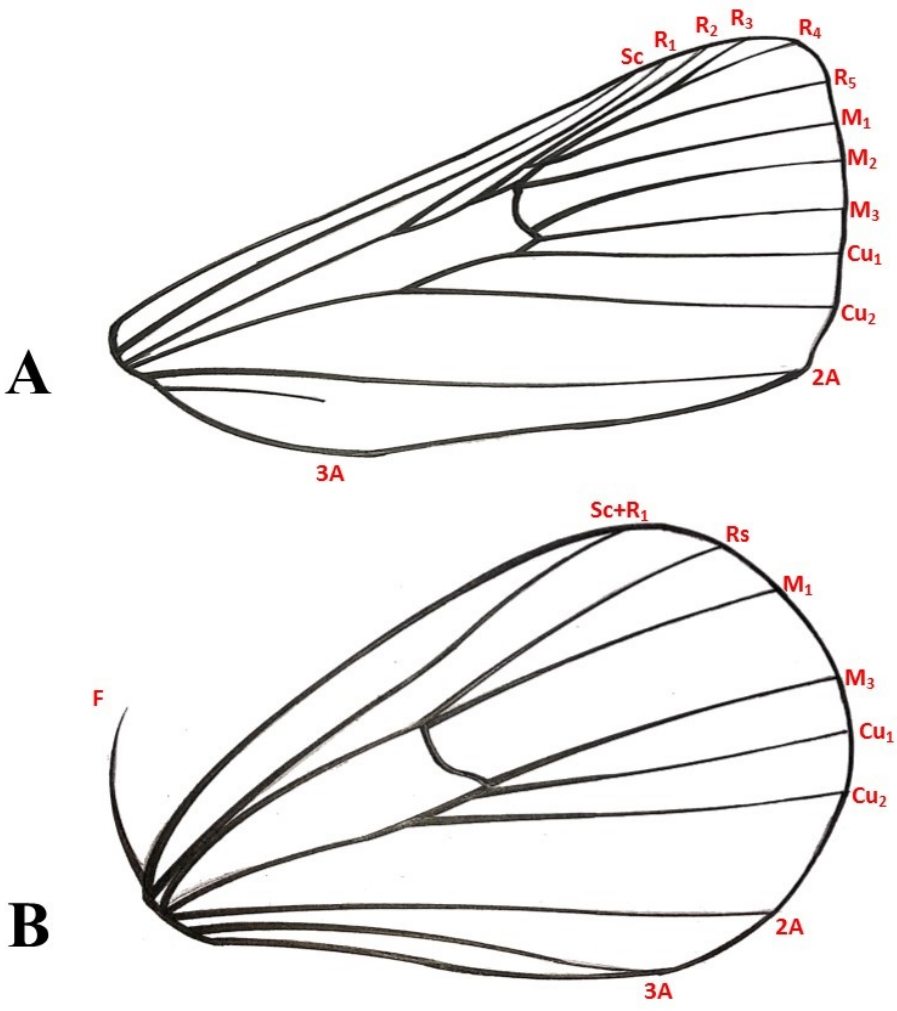


***Ochropleura leucogaster* Freyer**

A-Forewing, B-Hindwing

PLATE - 9

From Book "Moths of IISER Mohali"

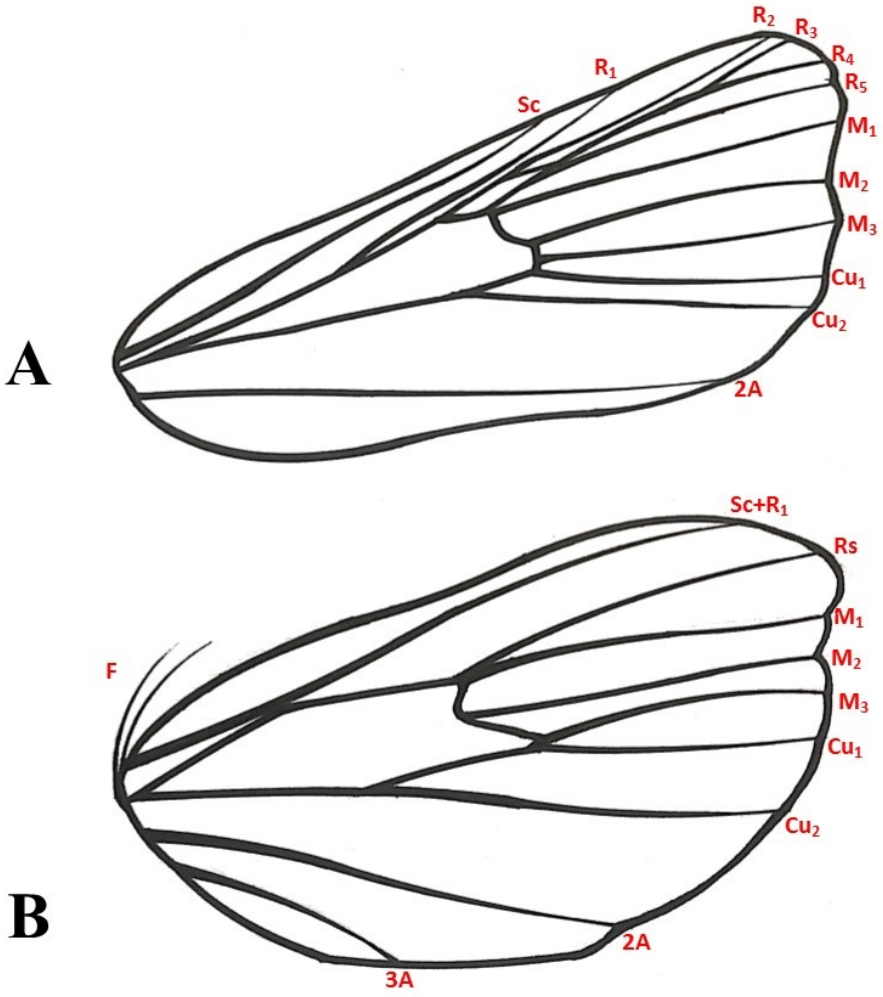


Pericyma umbrina Guenee

A-Forewing, B-Hindwing

PLATE - 10

From Book "Moths of IISER Mohali"

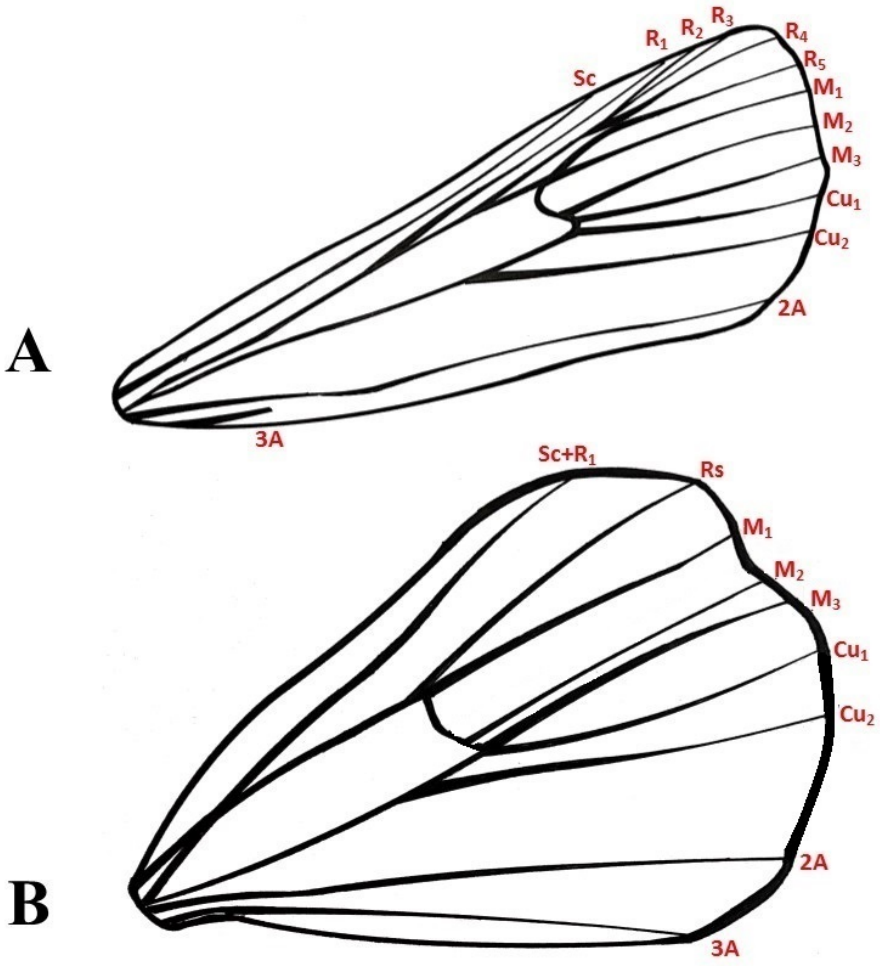


***Sesamia inferens* Walker**

A-Forewing, B-Hindwing

PLATE - 11

From Book "Moths of IISER Mohali"

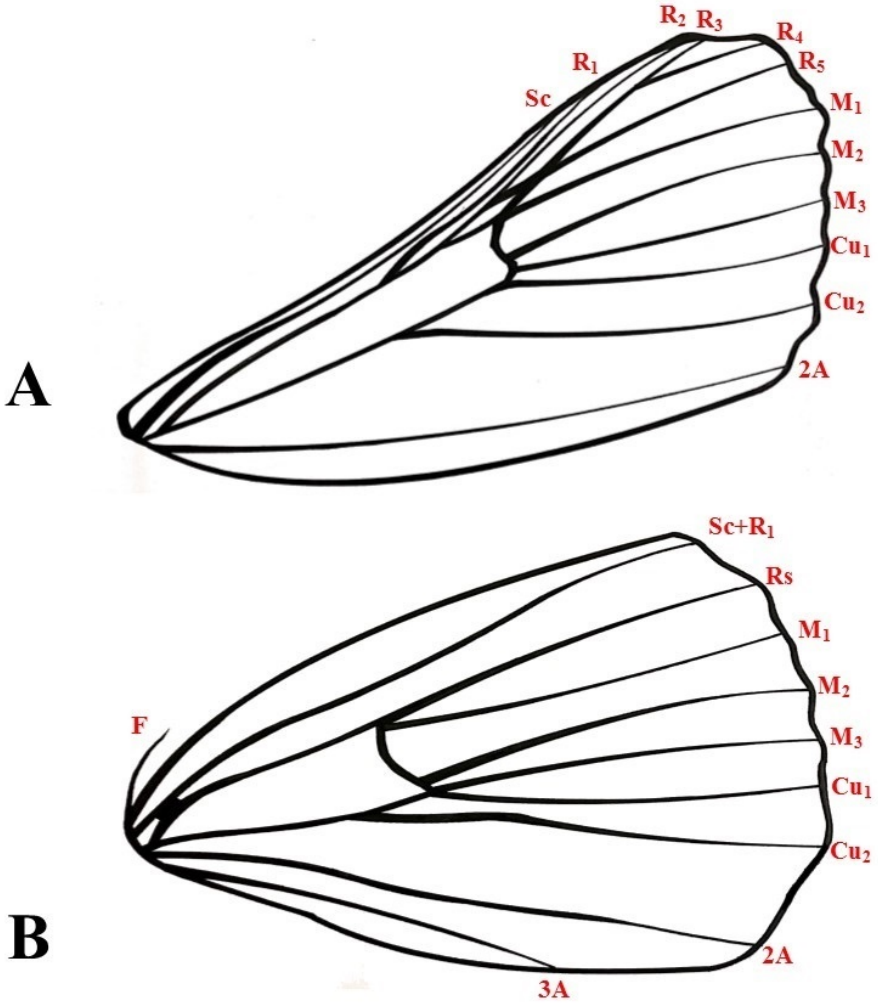


Spodoptera litura Fabricius

A-Forewing, B-Hindwing

PLATE - 12

From Book "Moths of IISER Mohali"

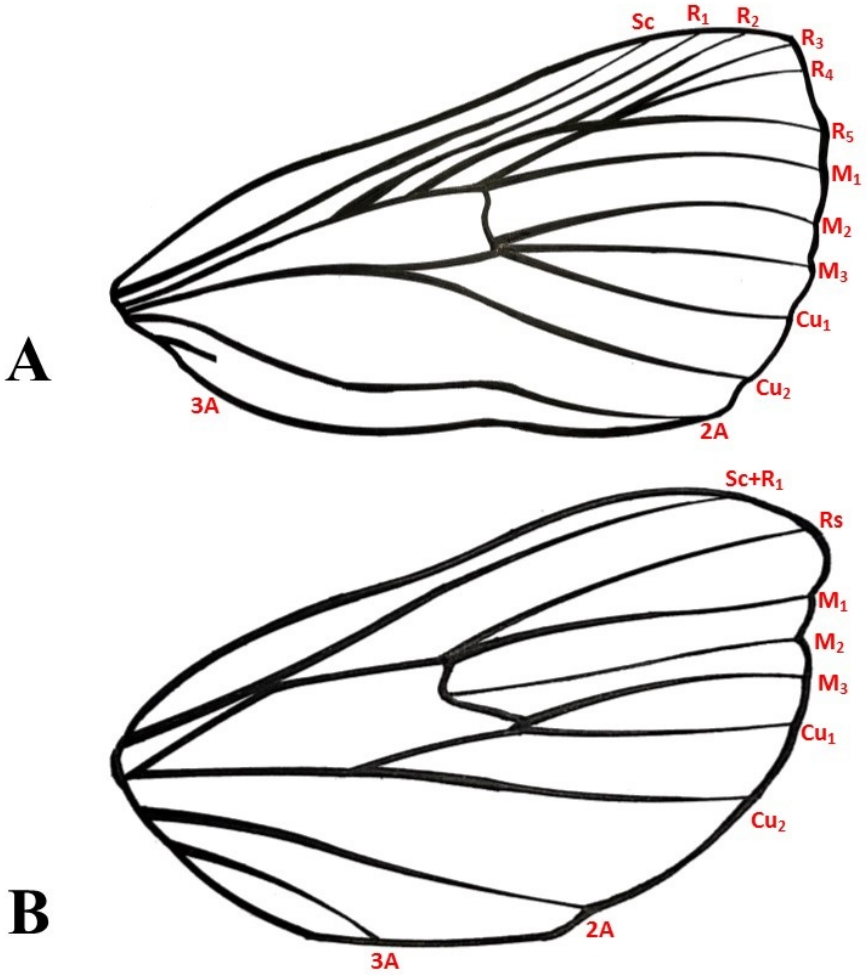


Trigonodes hypasia Cramer

A-Forewing, B-Hindwing

PLATE - 13

From Book "Moths of IISER Mohali"

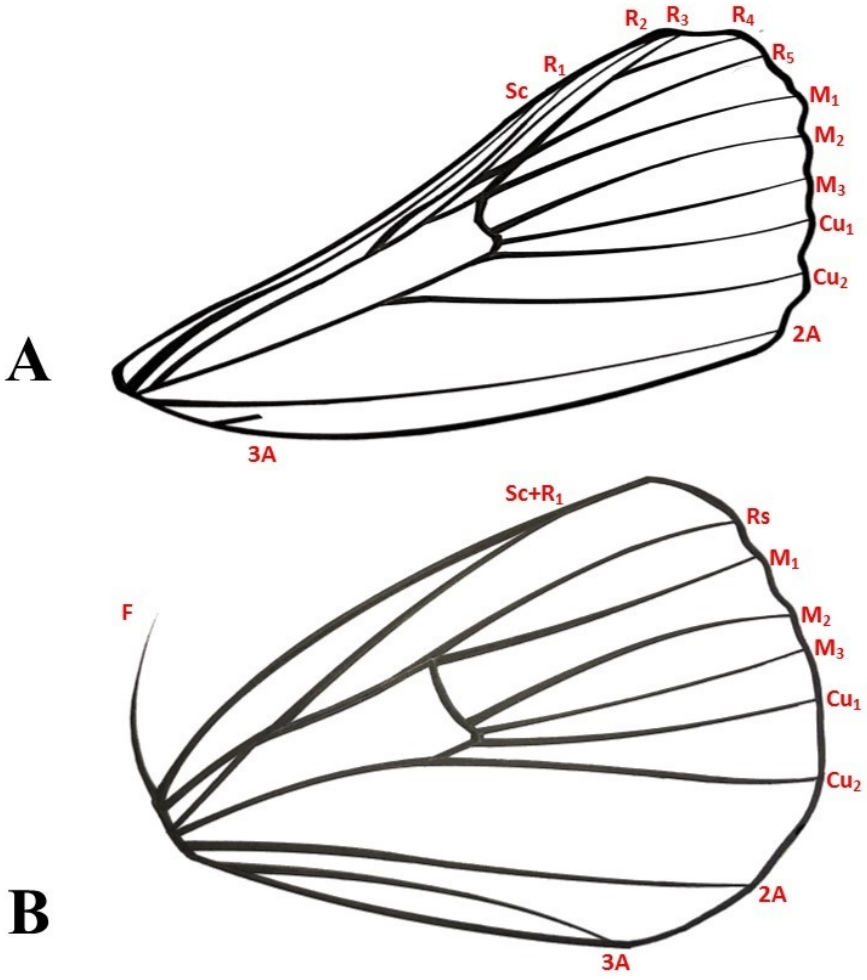


Hypocala rostrata Fabricius

A-Forewing, B-Hindwing

PLATE - 14

From Book "Moths of IISER Mohali"

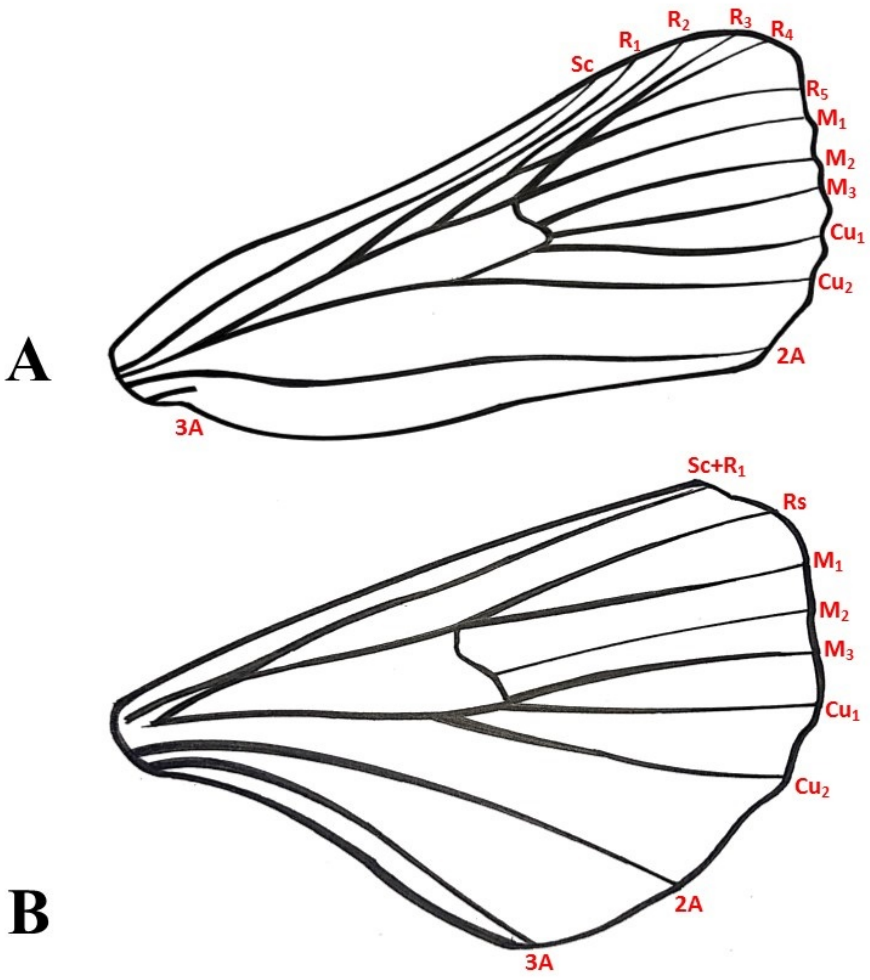


***Thysanoplusia orichalcea* Fabricius**

A-Forewing, B-Hindwing

PLATE - 15

From Book "Moths of IISER Mohali"

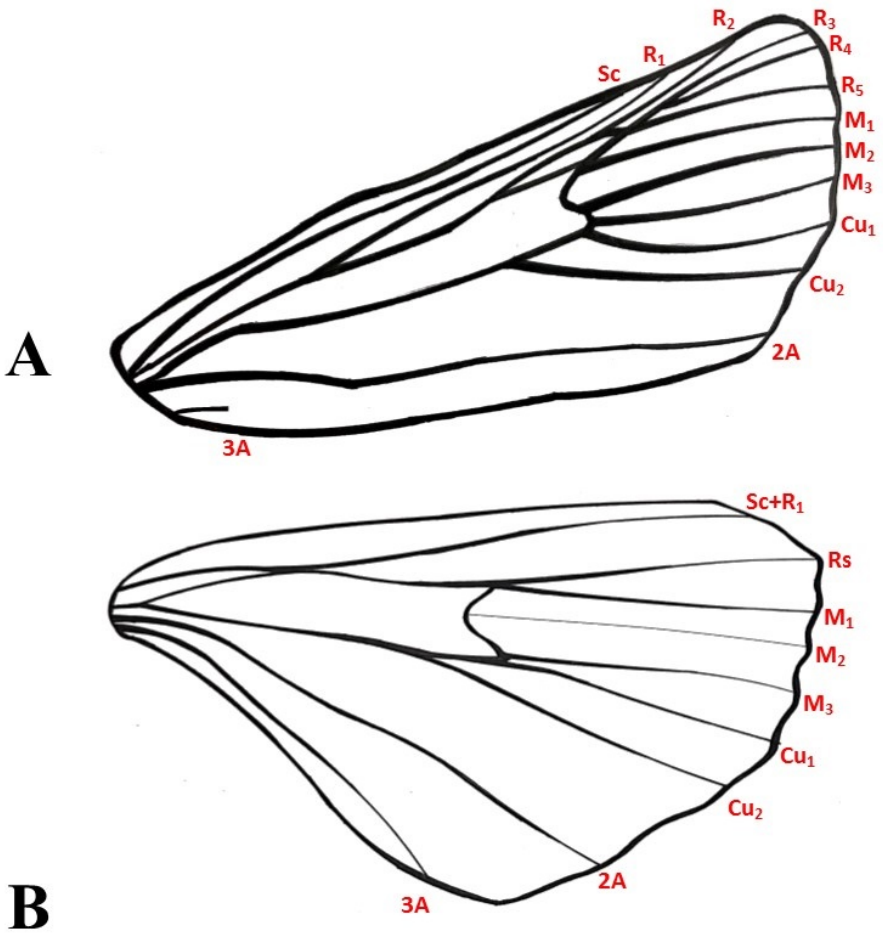


Xanthodes intersepta Guenee

A-Forewing, B-Hindwing

PLATE - 16

From Book "Moths of IISER Mohali"

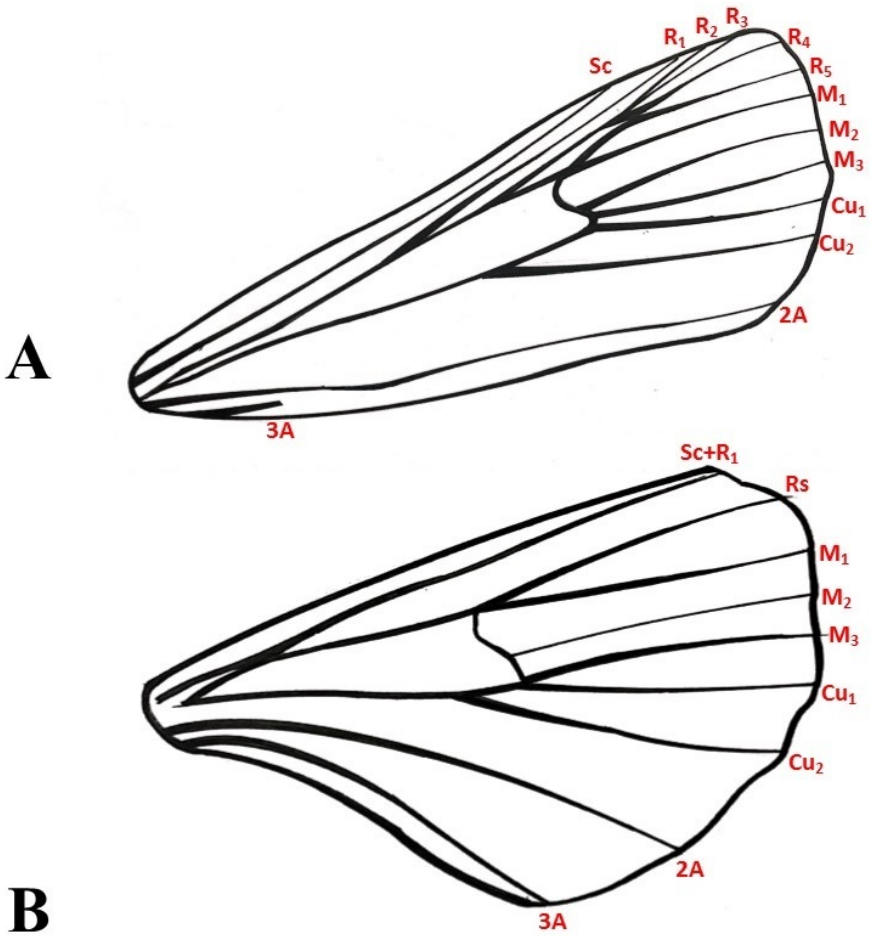


Xestia nigrum Linnaeus

A- Forewing , B– Hindwing

PLATE - 17

From Book "Moths of IISER Mohali"

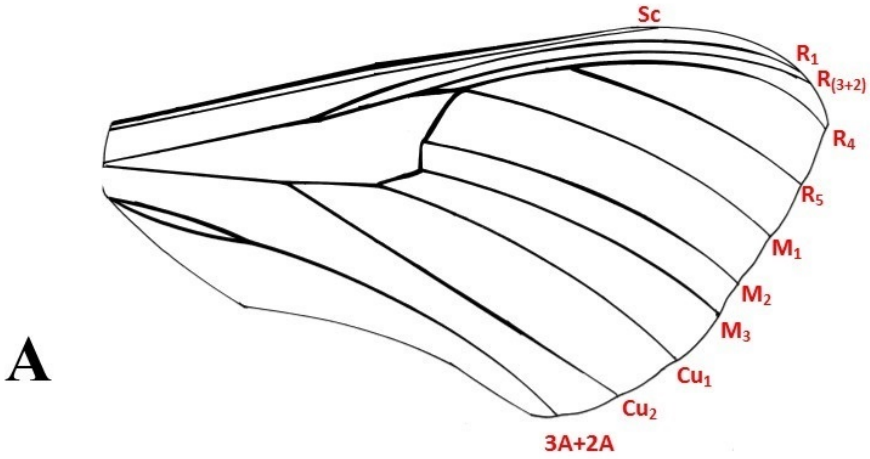


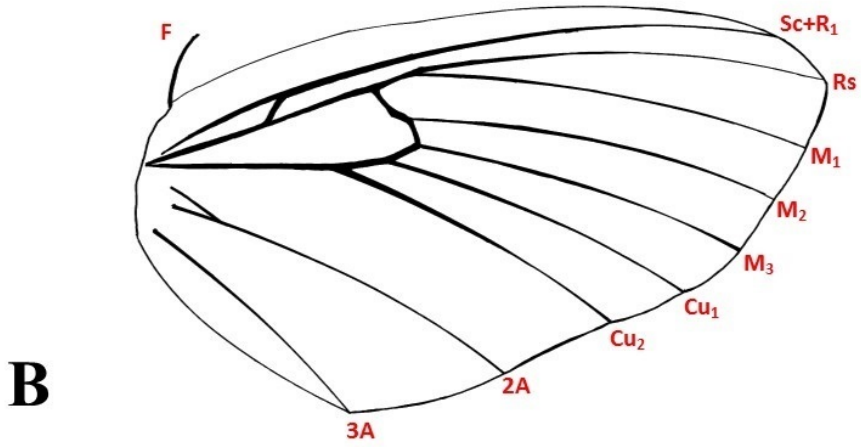
Xestia tamsi Wileman and West

A-Forewing, B-Hindwing

PLATE - 18

From Book "Moths of IISER Mohali"



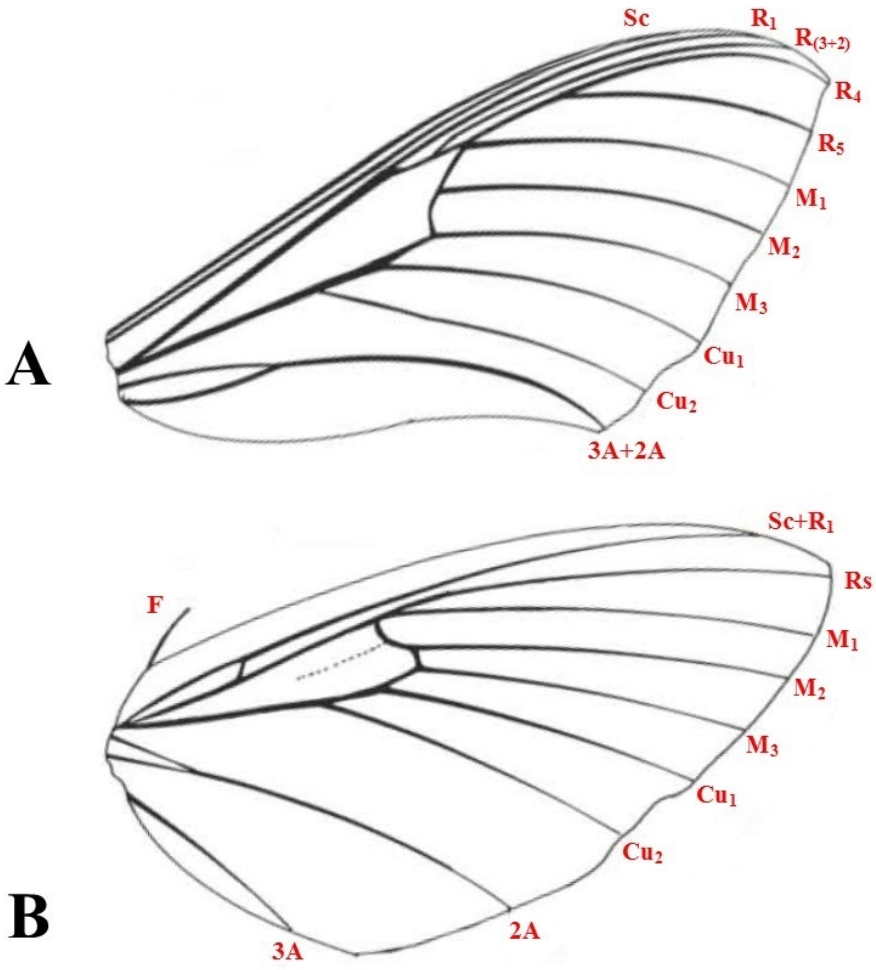


Acherontia styx Westwood

A-Forewing, B-Hindwing

PLATE - 19

From Book "Moths of IISER Mohali"

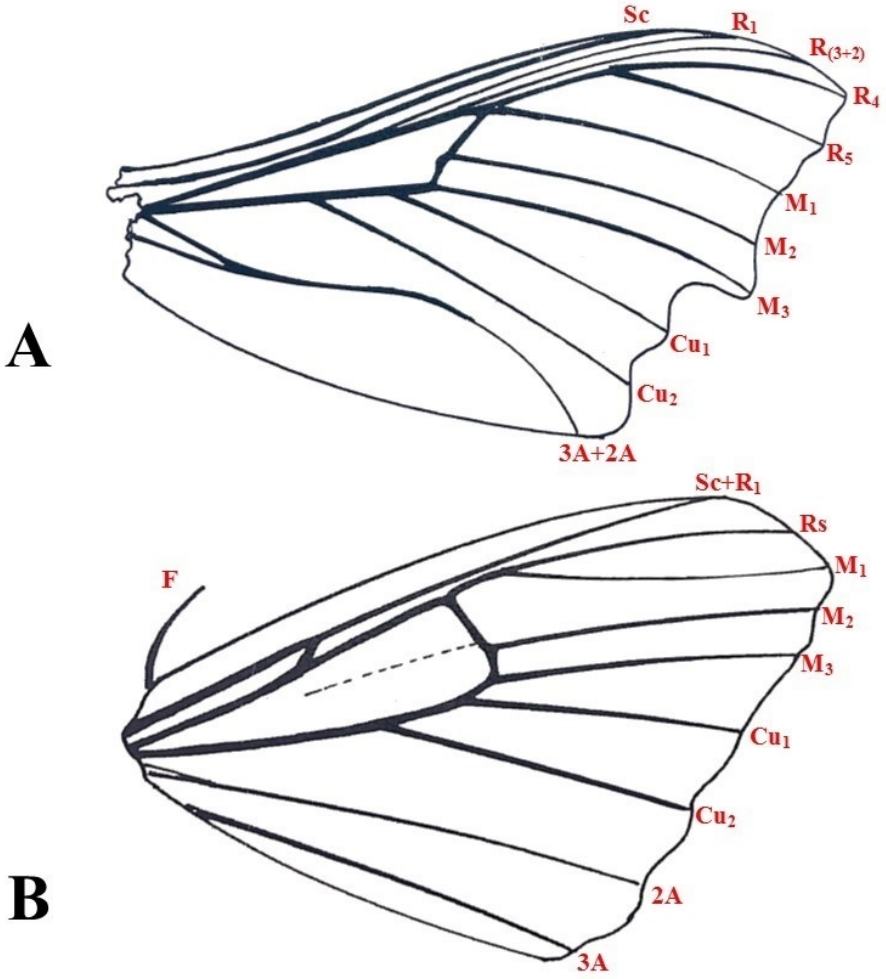


Agrius convolvuli Linnaeus

A-Forewing, B-Hindwing

PLATE - 20

From Book "Moths of IISER Mohali"

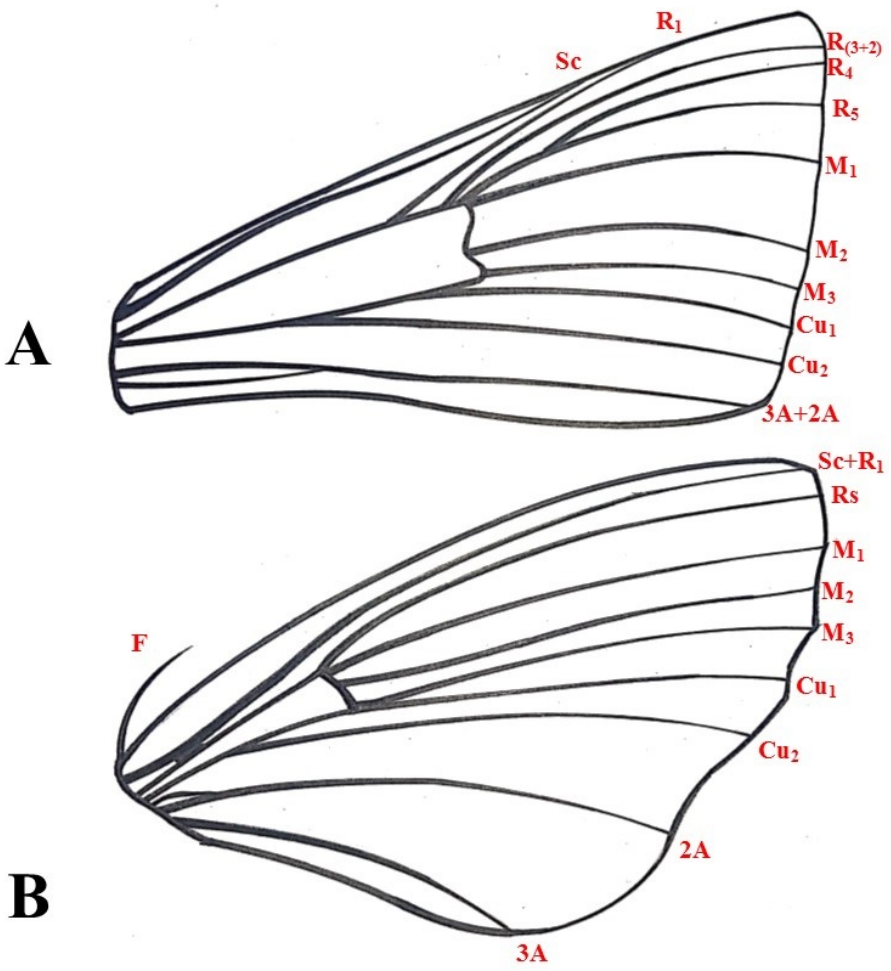


Cypa decolor Walker

A-Forewing, B-Hindwing

PLATE - 21

From Book "Moths of IISER Mohali"

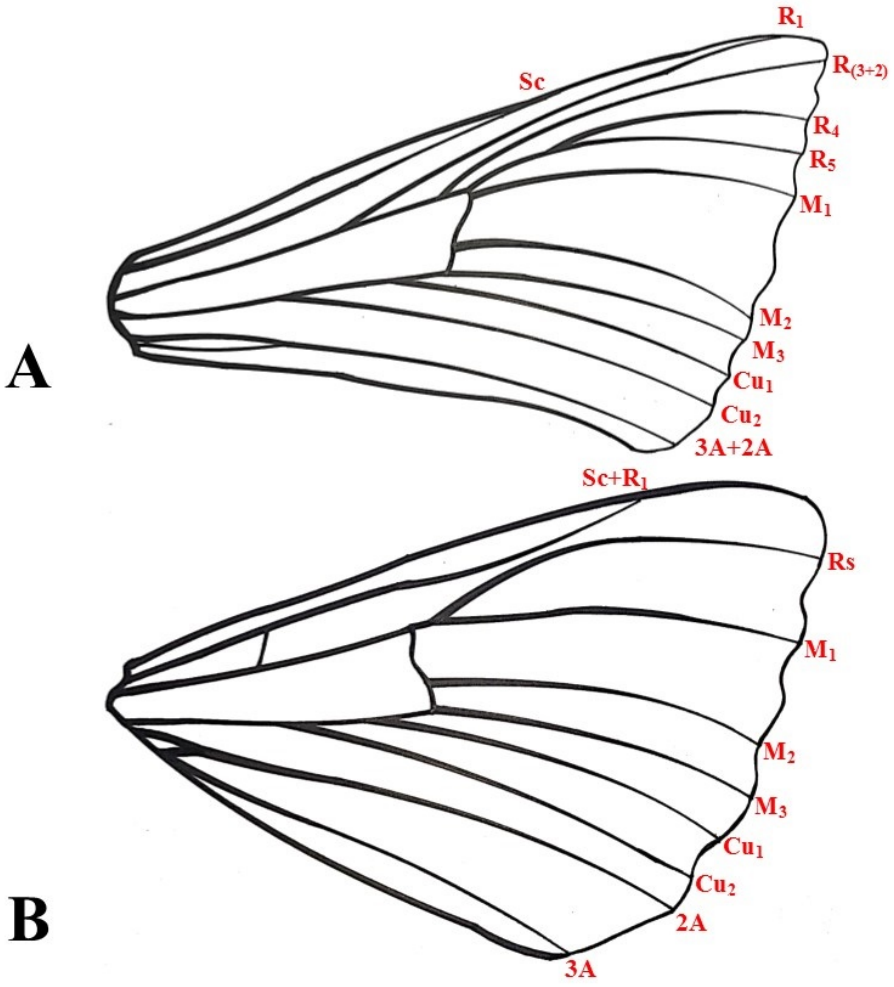


Macroglossum belis Linnaeus

A-Forewing, B-Hindwing

PLATE - 22

From Book "Moths of IISER Mohali"

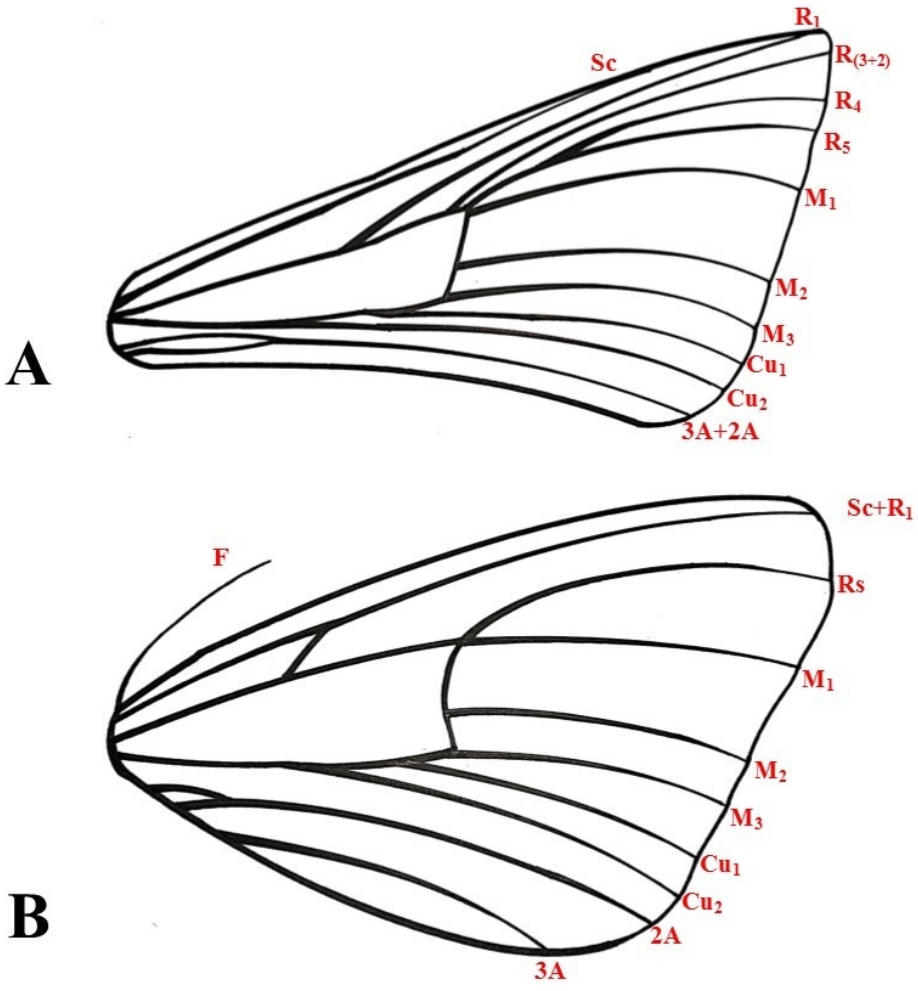


Polyptychus trilineatus undatus Rothschild & Jordan

A-Forewing, B-Hindwing

PLATE - 23

From Book "Moths of IISER Mohali"

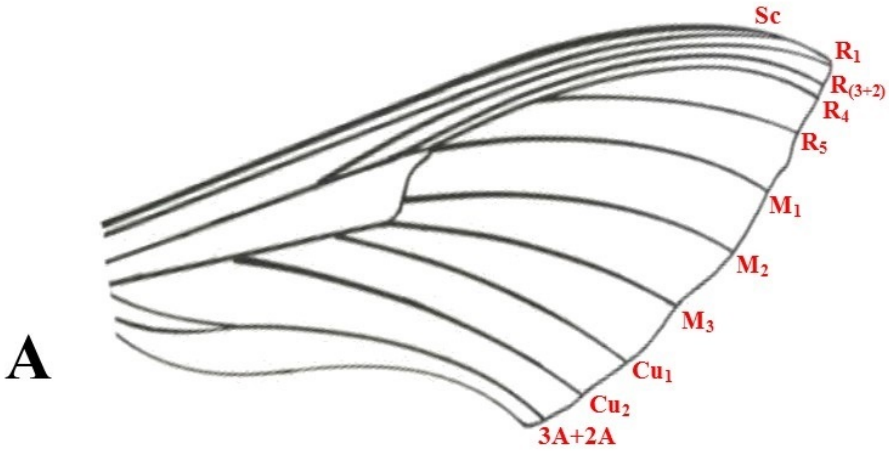


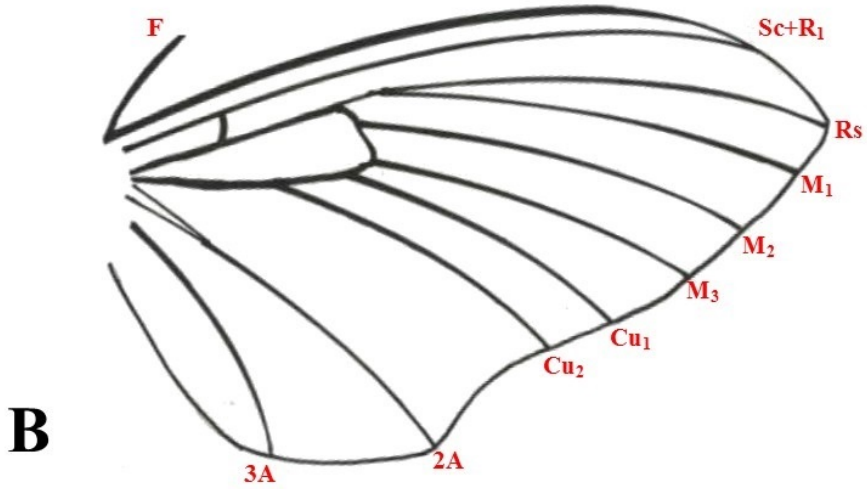
Sataspes scotti Boisduval

A-Forewing, B-Hindwing

PLATE - 24

From Book "Moths of IISER Mohali"





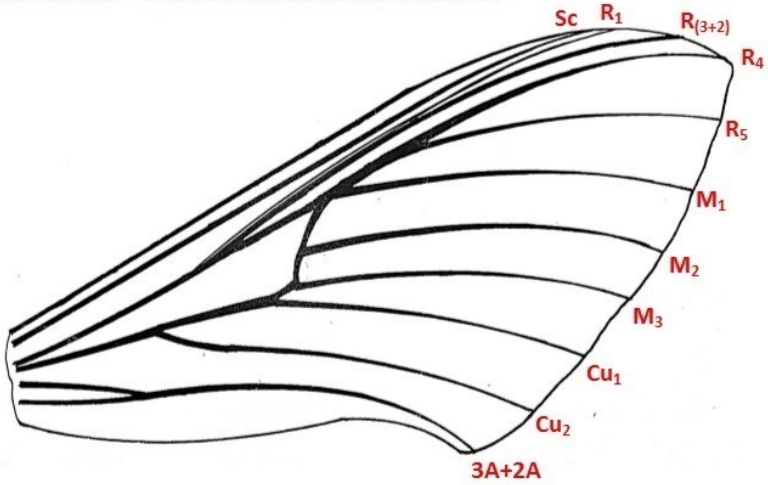
Daphnis nerii Linnaeus

A-Forewing, B-Hindwing

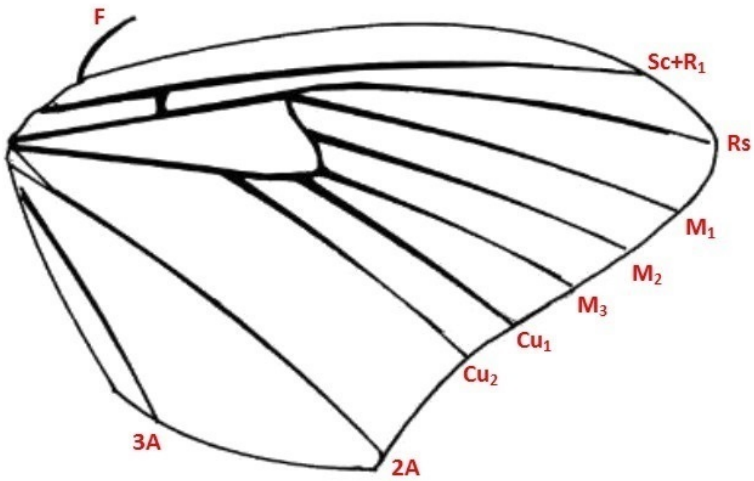
PLATE - 25

From Book "Moths of IISER Mohali"

A



B

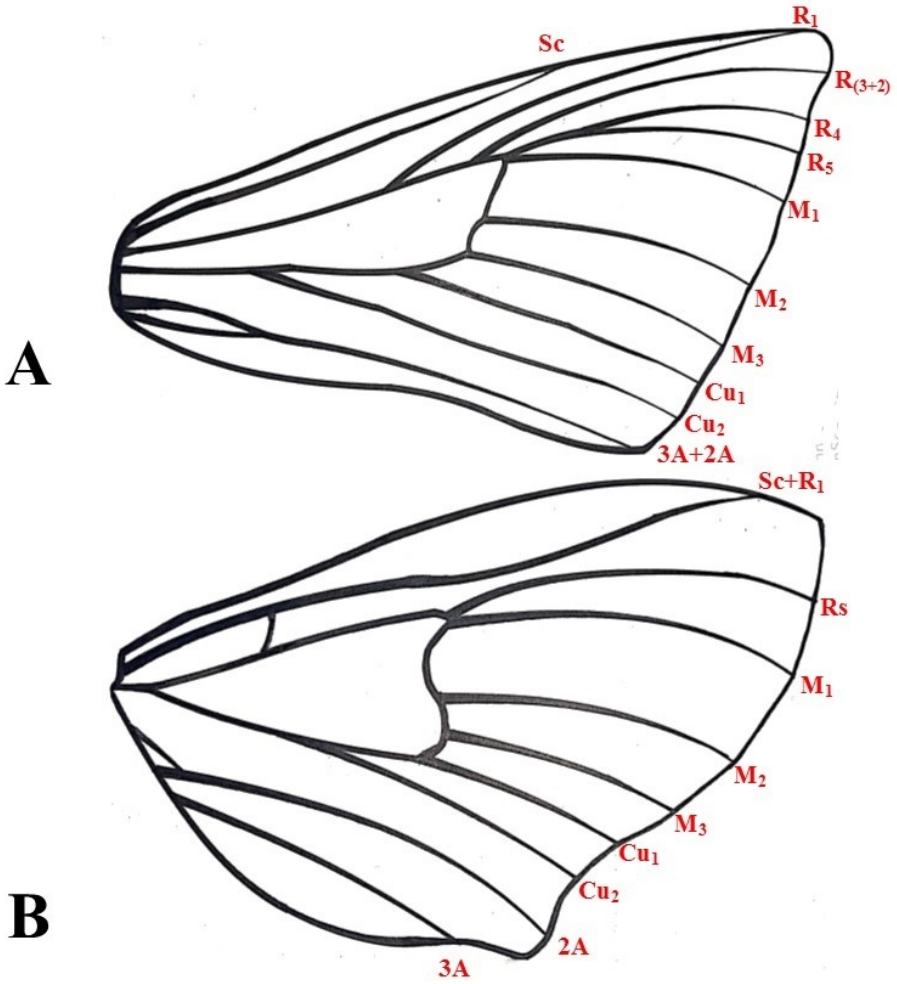


***Hippotion celerio* Linnaeus**

A-Forewing, B-Hindwing

PLATE - 26

From Book "Moths of IISER Mohali"

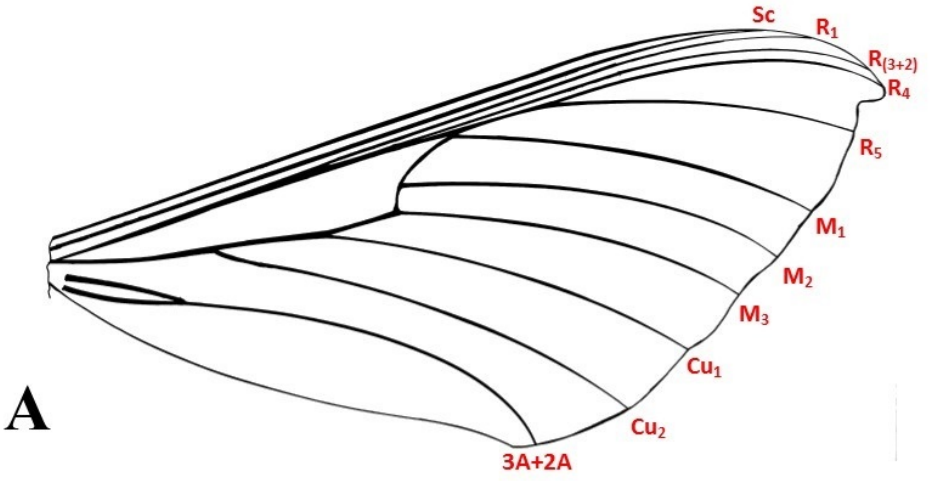


Hippotion rosetta Swinhoe

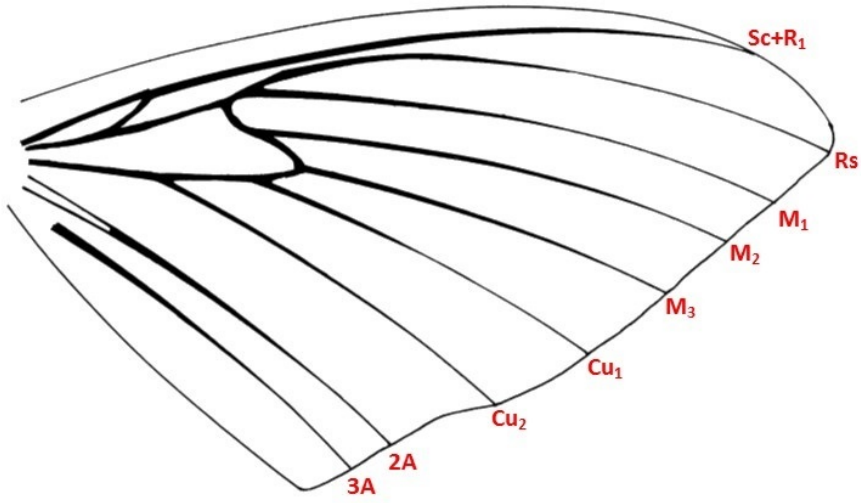
A-Forewing, B-Hindwing

PLATE - 27

From Book "Moths of IISER Mohali"



A



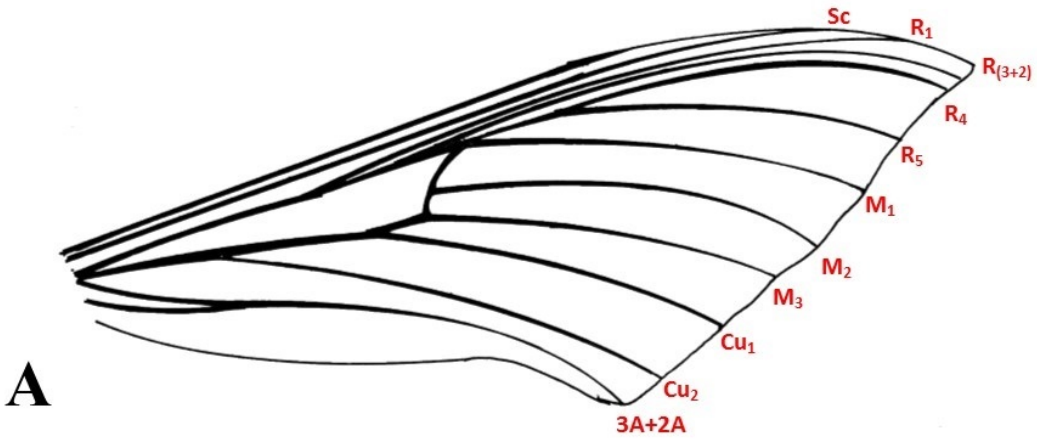
B

Theretra nessus Drury

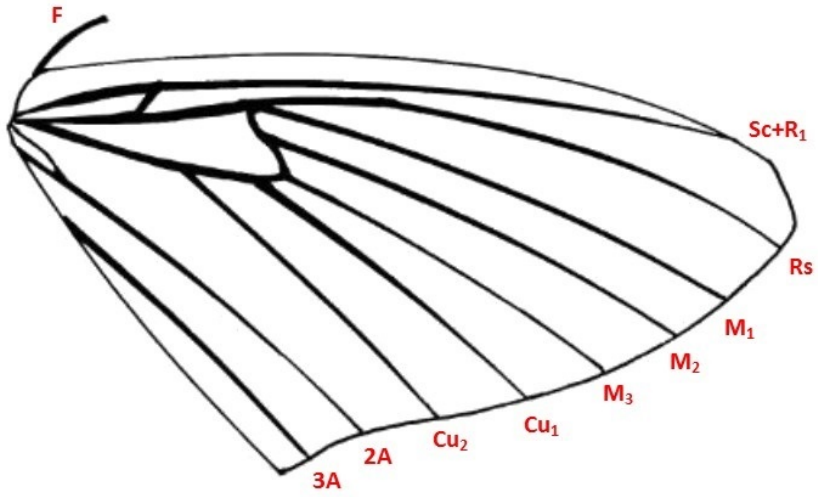
A-Forewing, B-Hindwing

PLATE - 28

From Book "Moths of IISER Mohali"



A



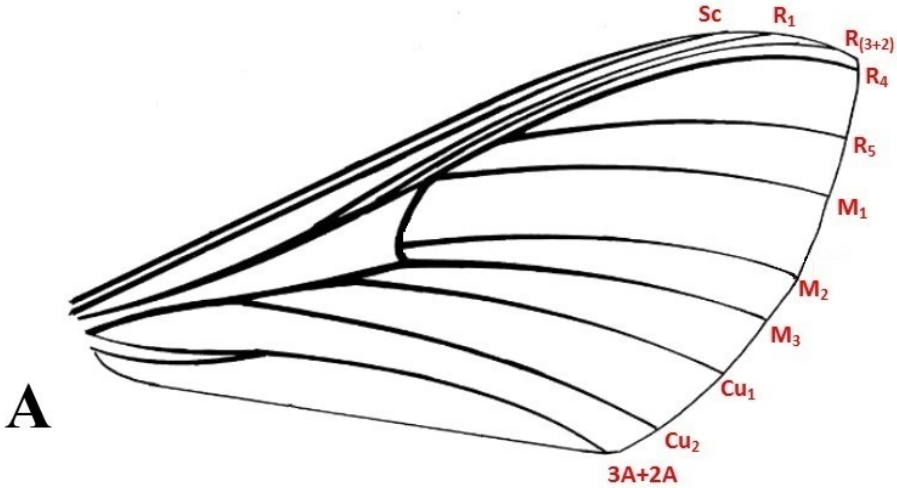
B

Theretra oldenlandia Fabricius

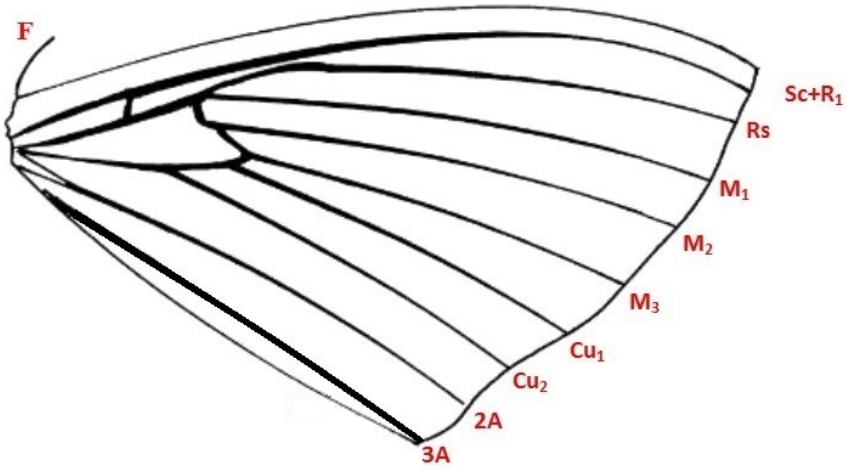
A-Forewing, B-Hindwing

PLATE - 29

From Book "Moths of IISER Mohali"



A



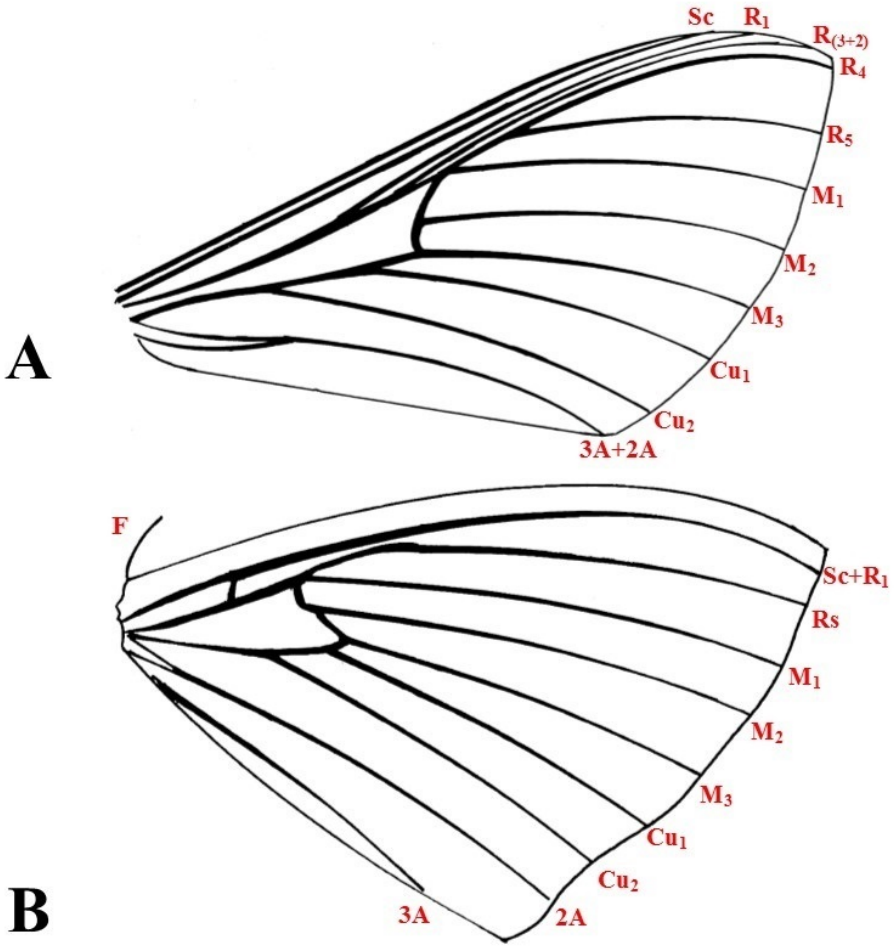
B

Nephele didyma Fabricius

A-Forewing, B-Hindwing

PLATE - 30

From Book "Moths of IISER Mohali"

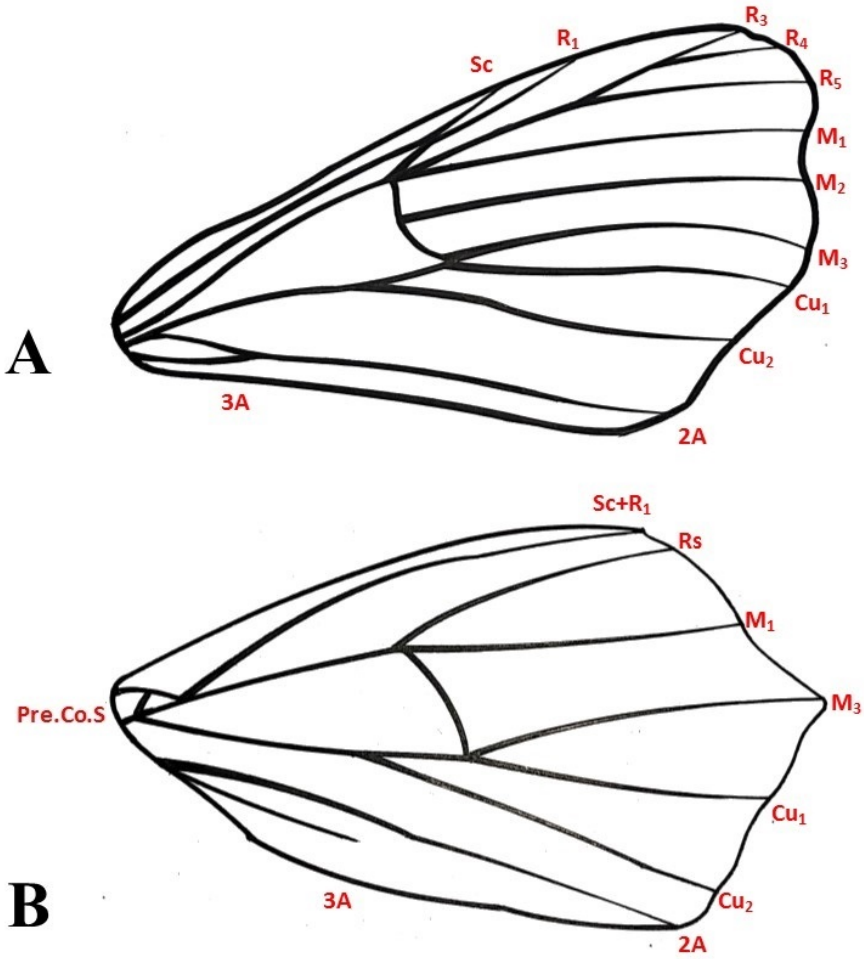


Nephele hespera Fabricius

A-Forewing, B-Hindwing

PLATE - 31

From Book "Moths of IISER Mohali"

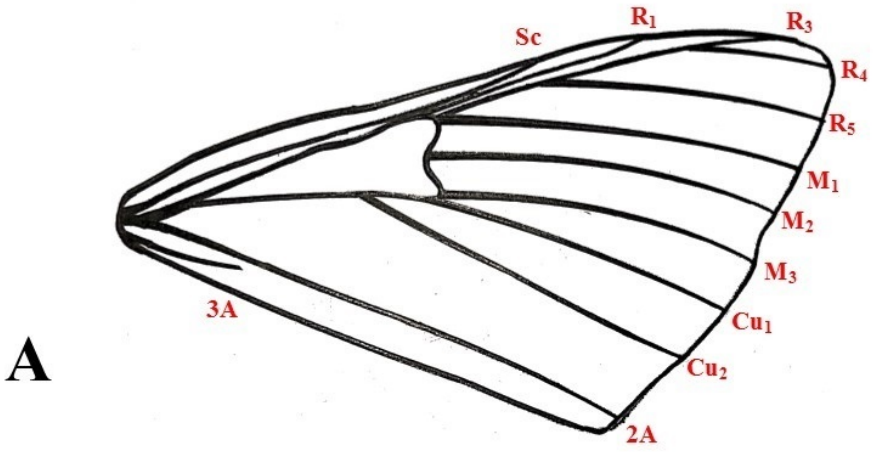


Ourapteryx clara Butler

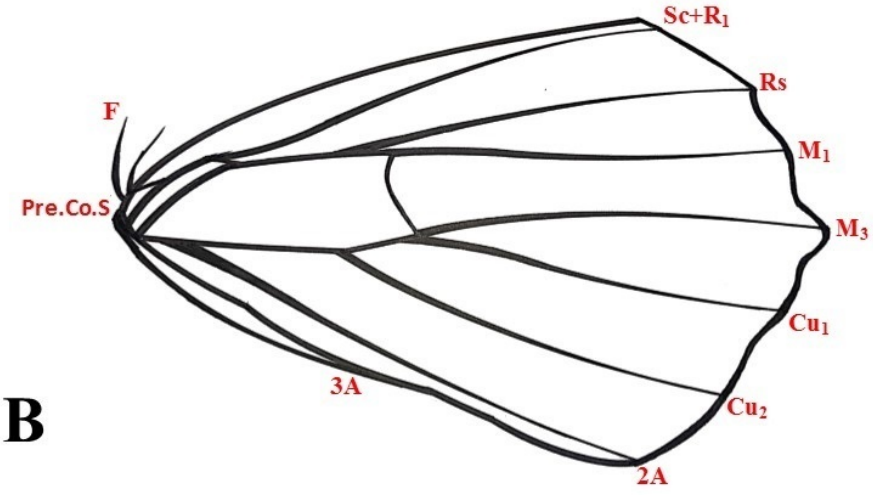
A-Forewing, B-Hindwing

PLATE - 32

From Book "Moths of IISER Mohali"



A



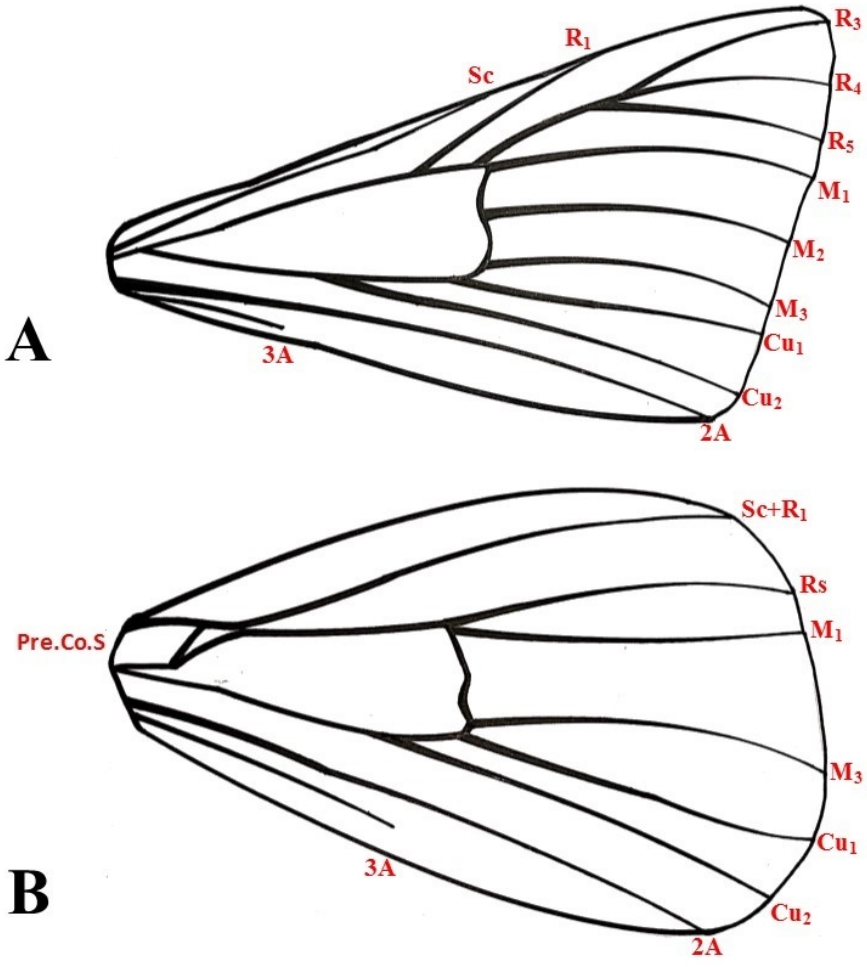
B

Chiasmia frugaliata Guenee

A-Forewing, B-Hindwing

PLATE - 33

From Book "Moths of IISER Mohali"

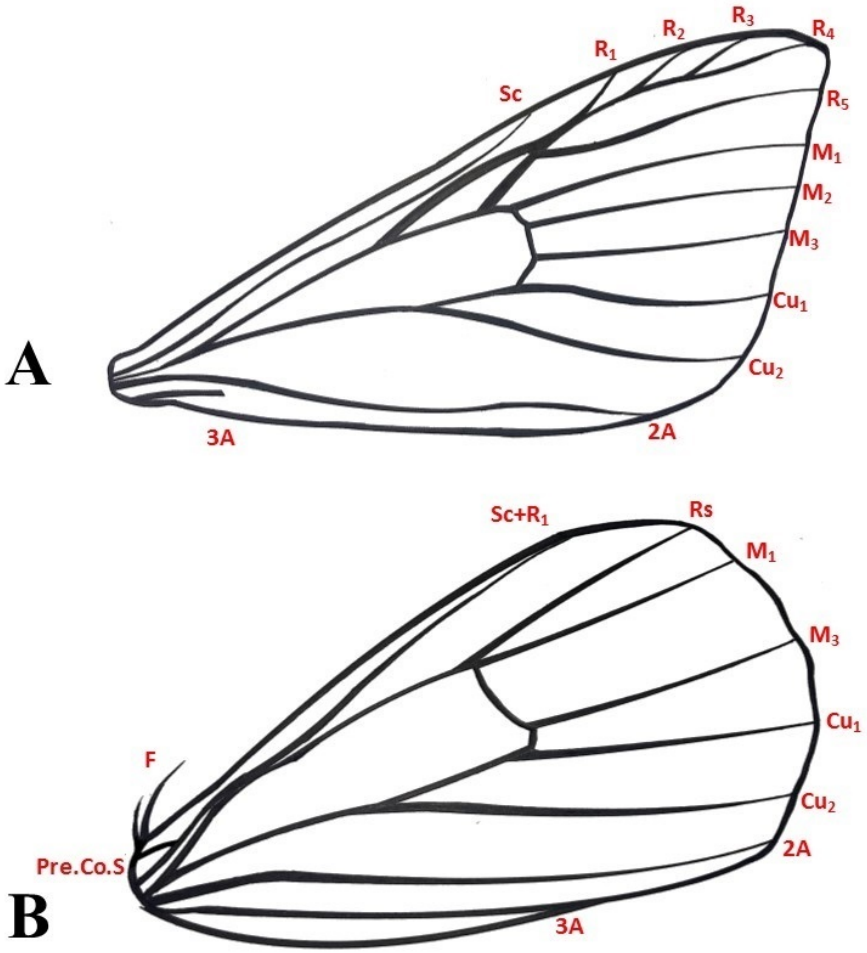


Digrammia subminiata Packard

A-Forewing, B-Hindwing

PLATE - 34

From Book "Moths of IISER Mohali"

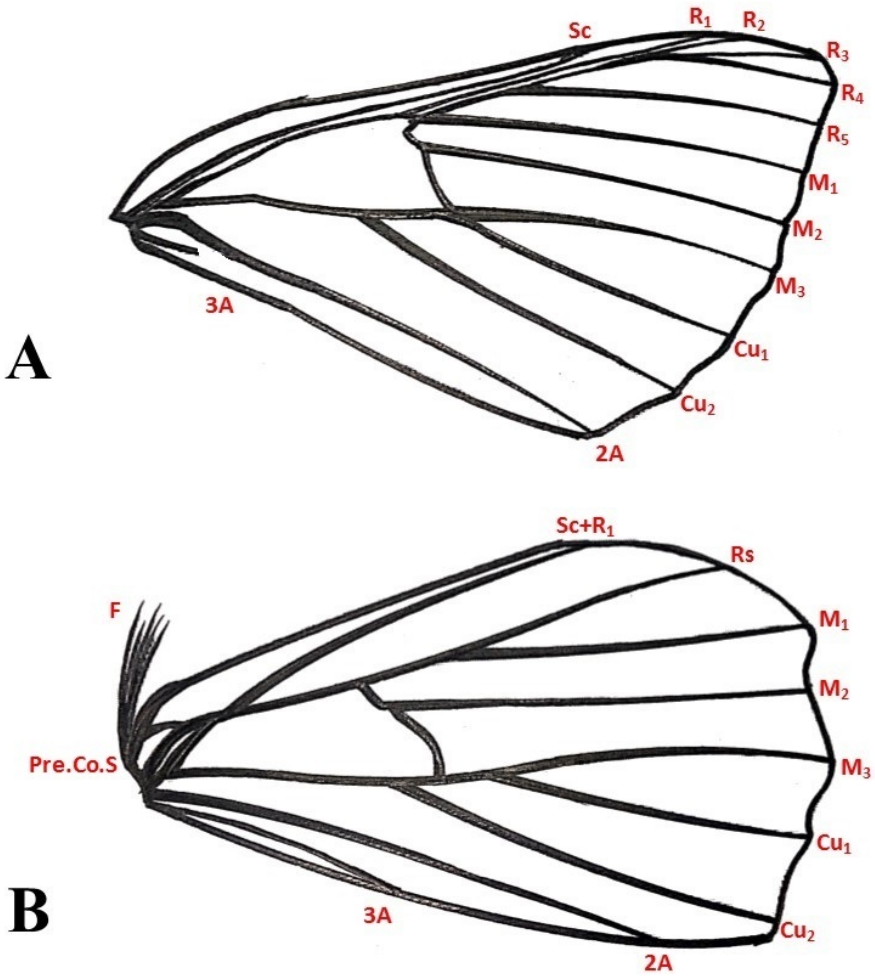


Rhodometra sacraria Linnaeus

A-Forewing, B-Hindwing

PLATE - 35

From Book "Moths of IISER Mohali"

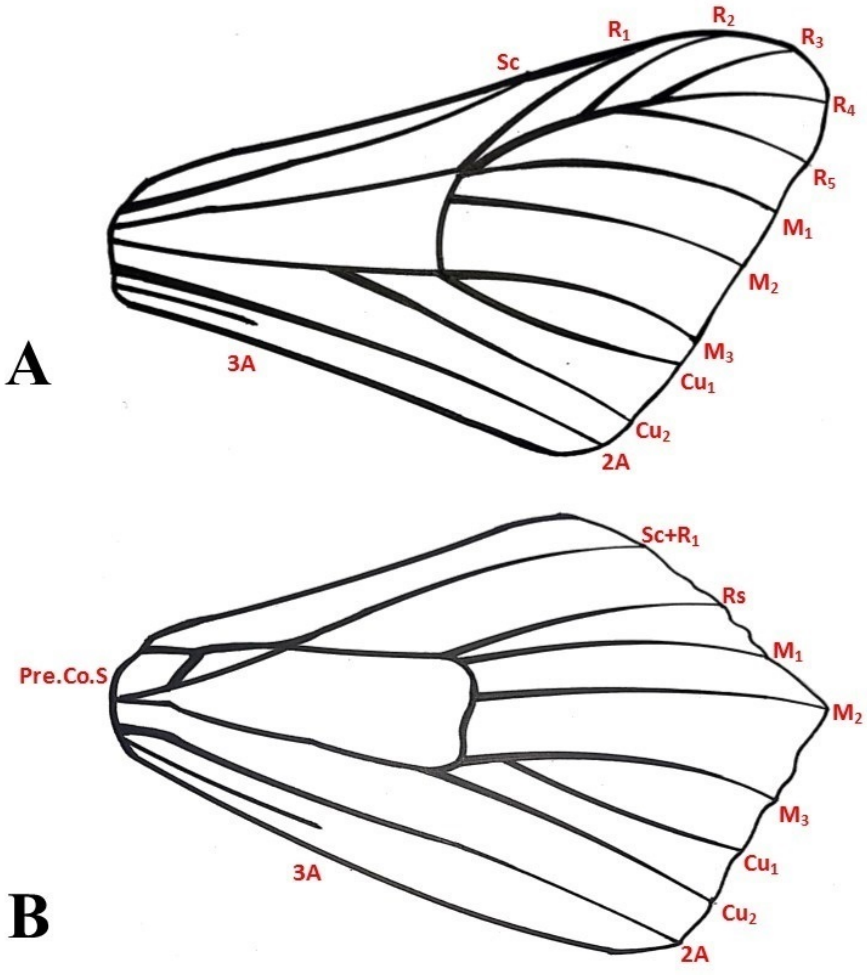


Spaniocentra pannosa Moore

A- Forewing , B– Hindwing

PLATE - 36

From Book "Moths of IISER Mohali"

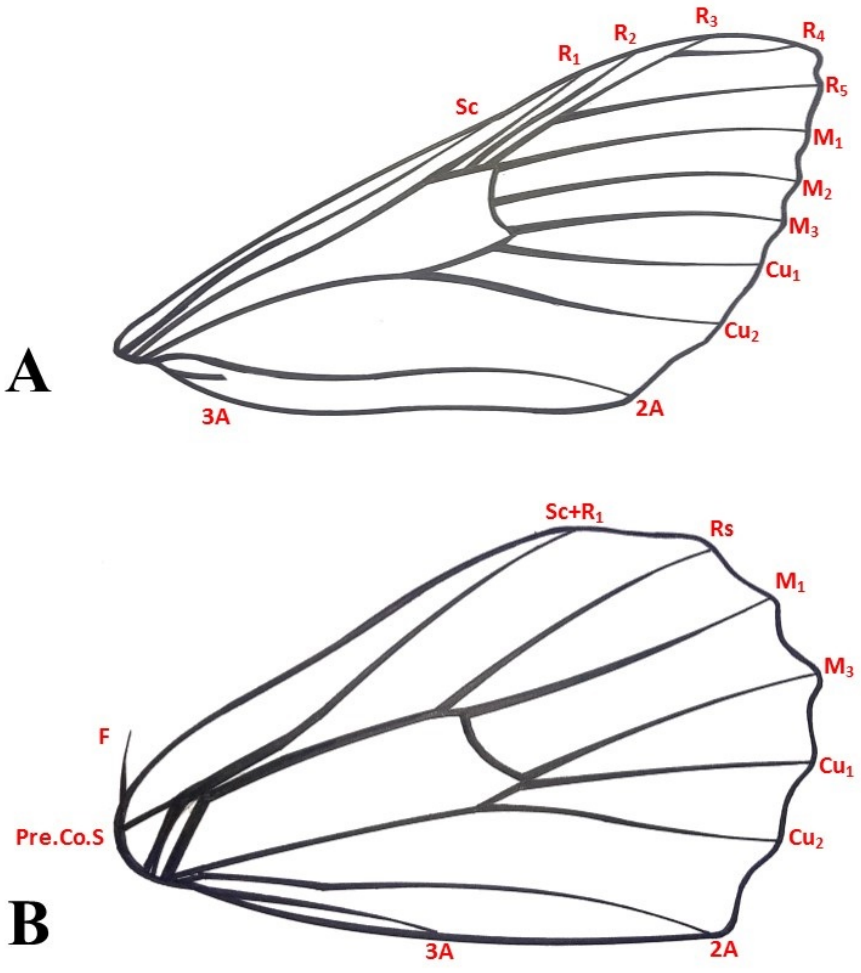


Traminda mundissima Walker

A- Forewing , B– Hindwing

PLATE - 37

From Book "Moths of IISER Mohali"

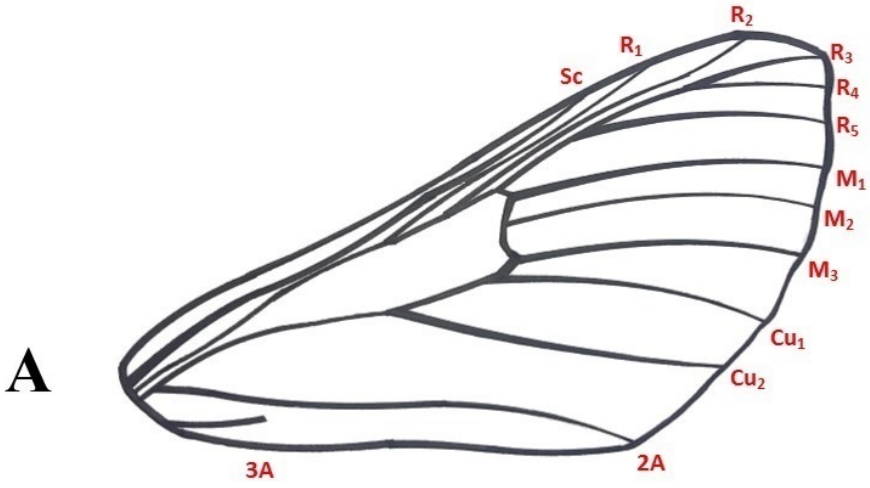


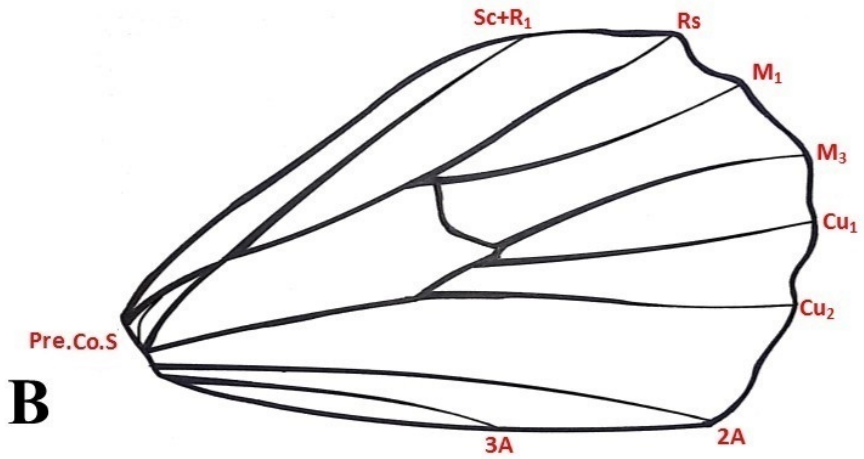
Hypomecis sp.

A-Forewing, B-Hindwing

PLATE - 38

From Book "Moths of IISER Mohali"



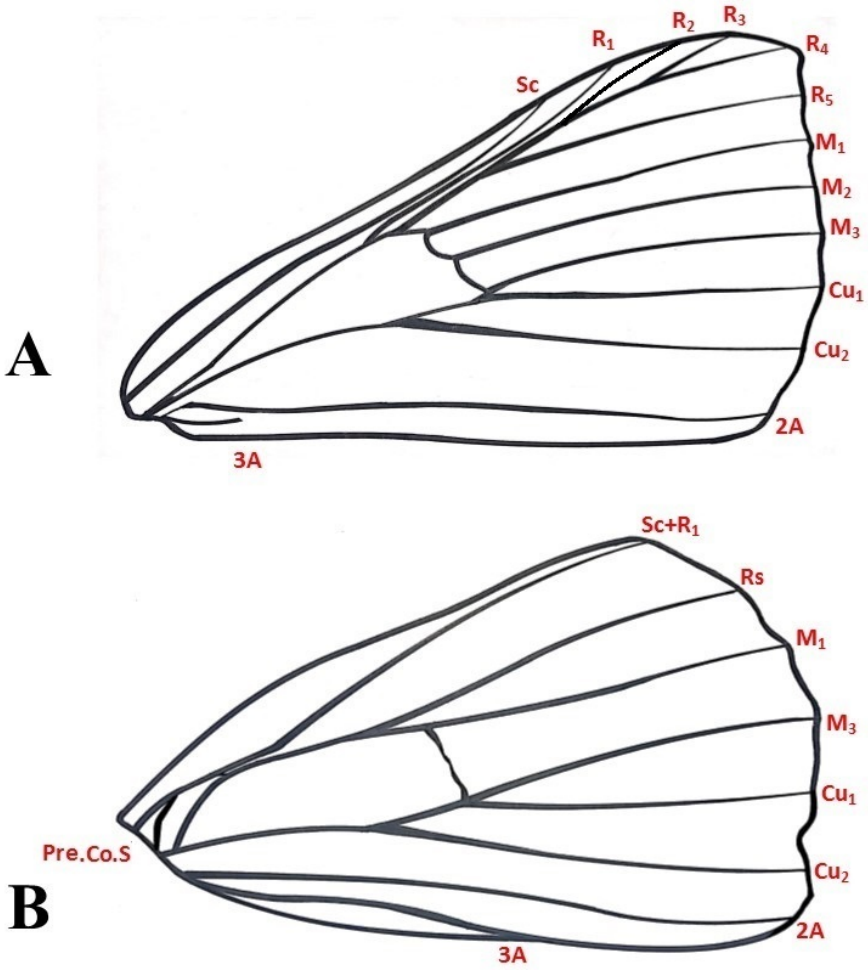


Hypomecis transcissa Walker

A-Forewing, B-Hindwing

PLATE - 39

From Book "Moths of IISER Mohali"

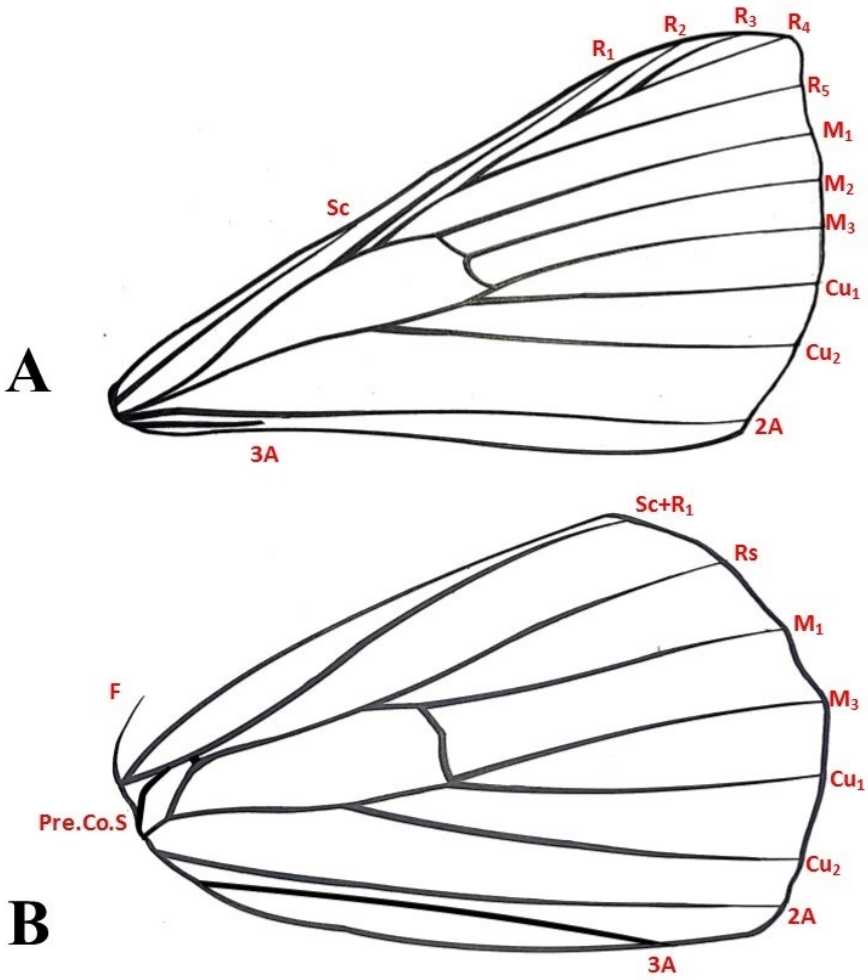


Petelia immaculata Hampson

A-Forewing, B-Hindwing

PLATE - 40

From Book "Moths of IISER Mohali"

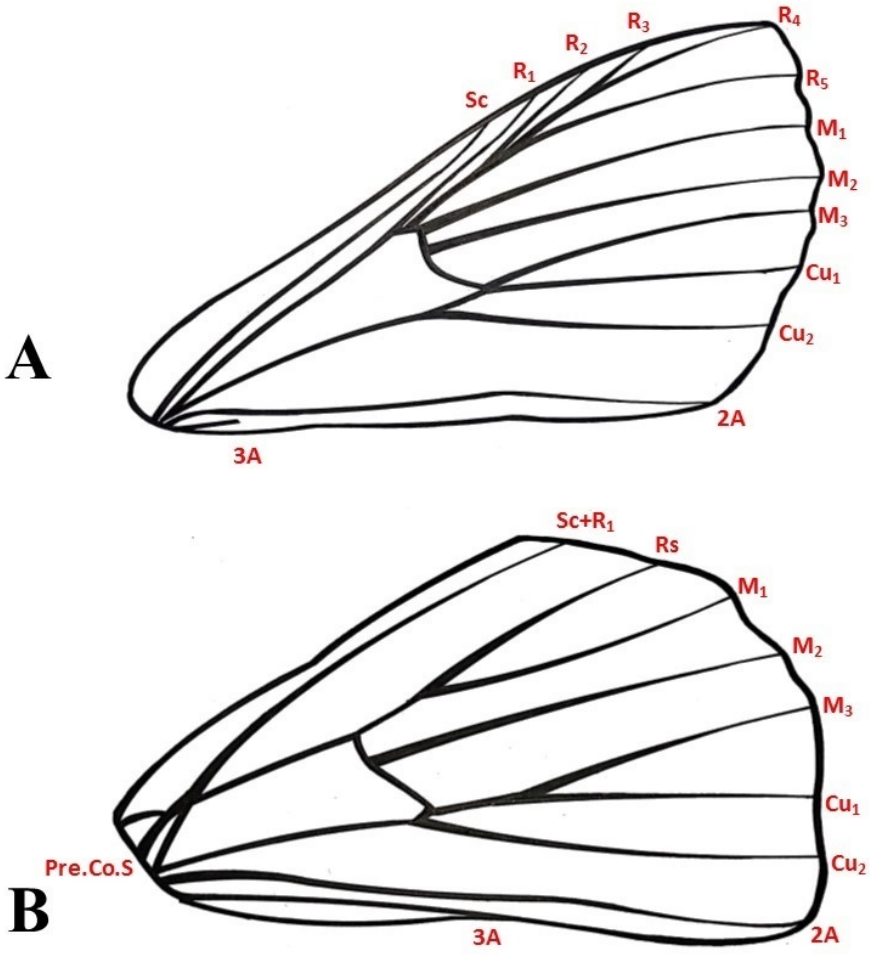


Petelia medardaria Herrich-Schaffer

A-Forewing, B-Hindwing

PLATE - 41

From Book "Moths of IISER Mohali"

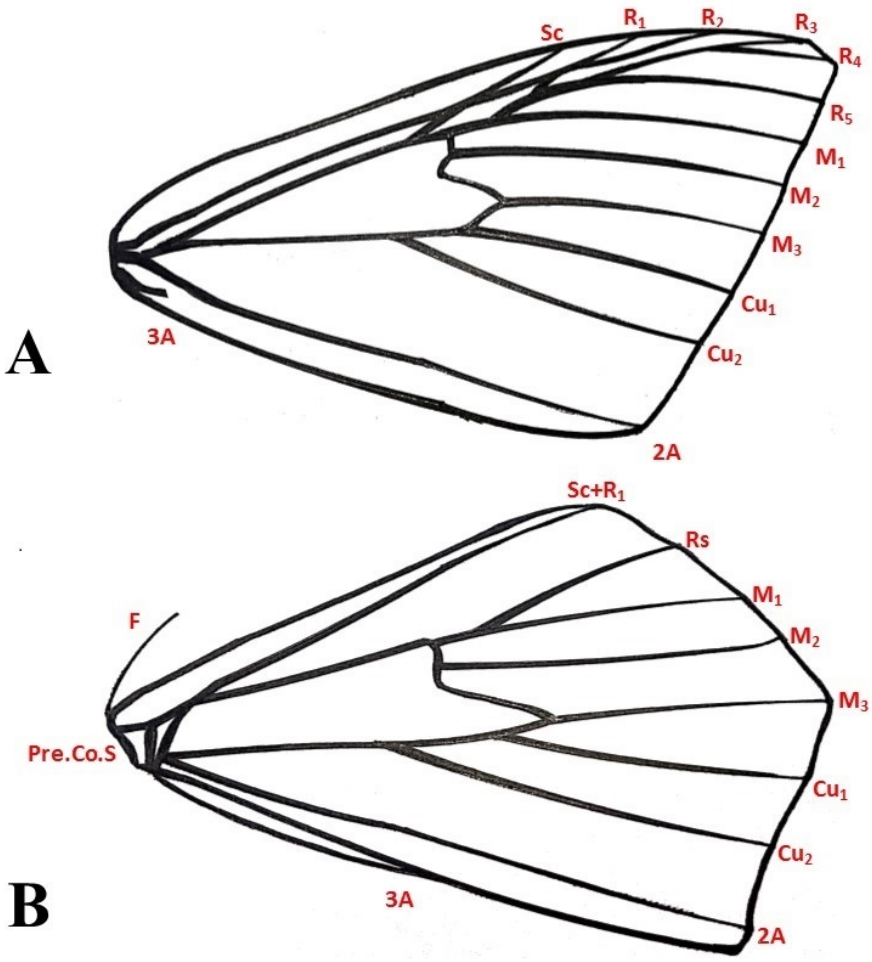


Thalassodes quadraria Guenee

A- Forewing , B– Hindwing

PLATE - 42

From Book "Moths of IISER Mohali"

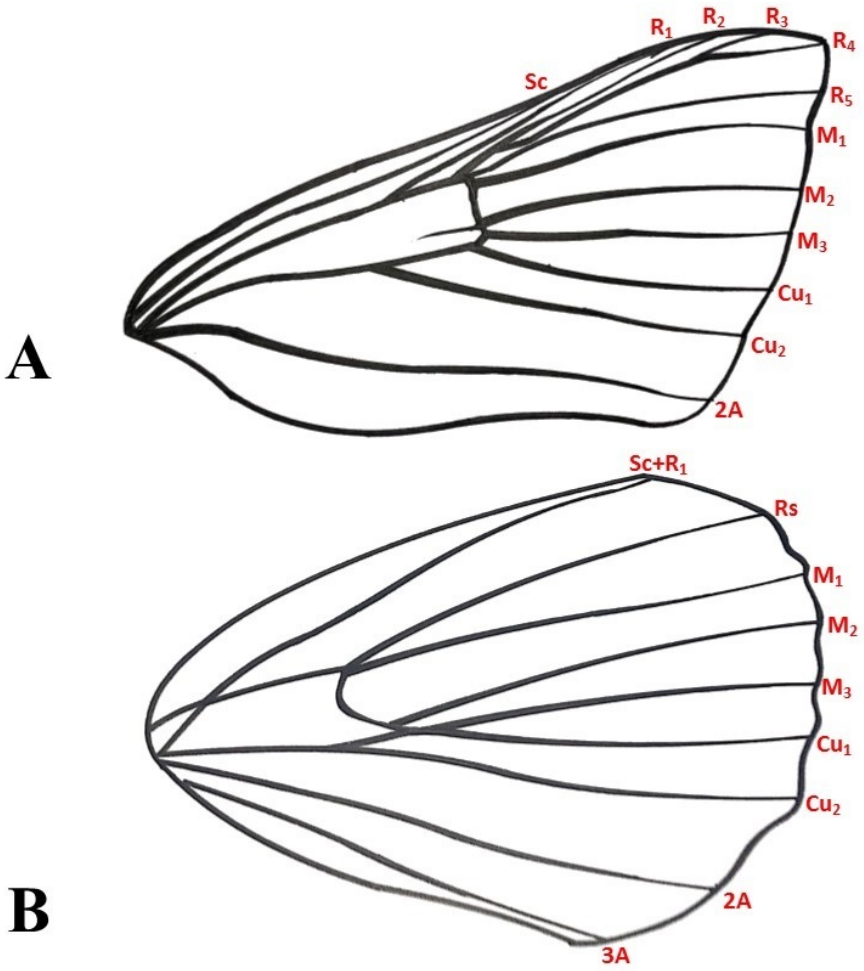


Thalassodes veraria Guenee

A- Forewing , B– Hindwing

PLATE - 43

From Book "Moths of IISER Mohali"

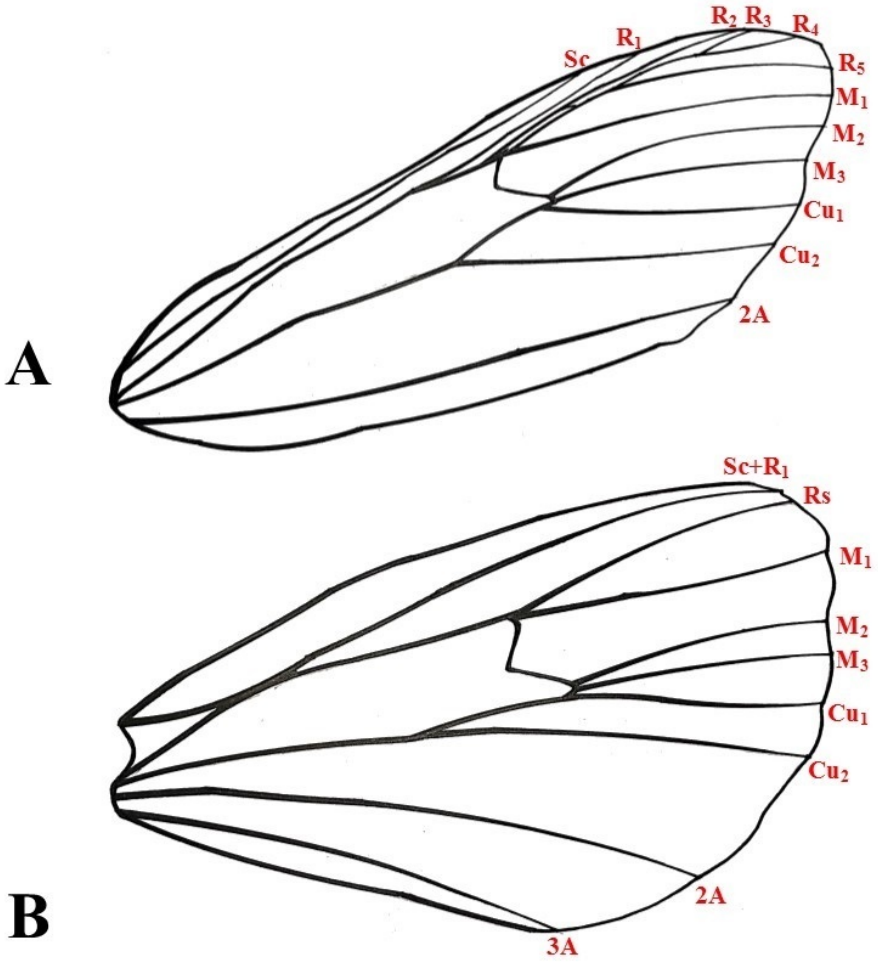


Achaea janata Linnaeus

A-Forewing, B-Hindwing

PLATE - 44

From Book "Moths of IISER Mohali"

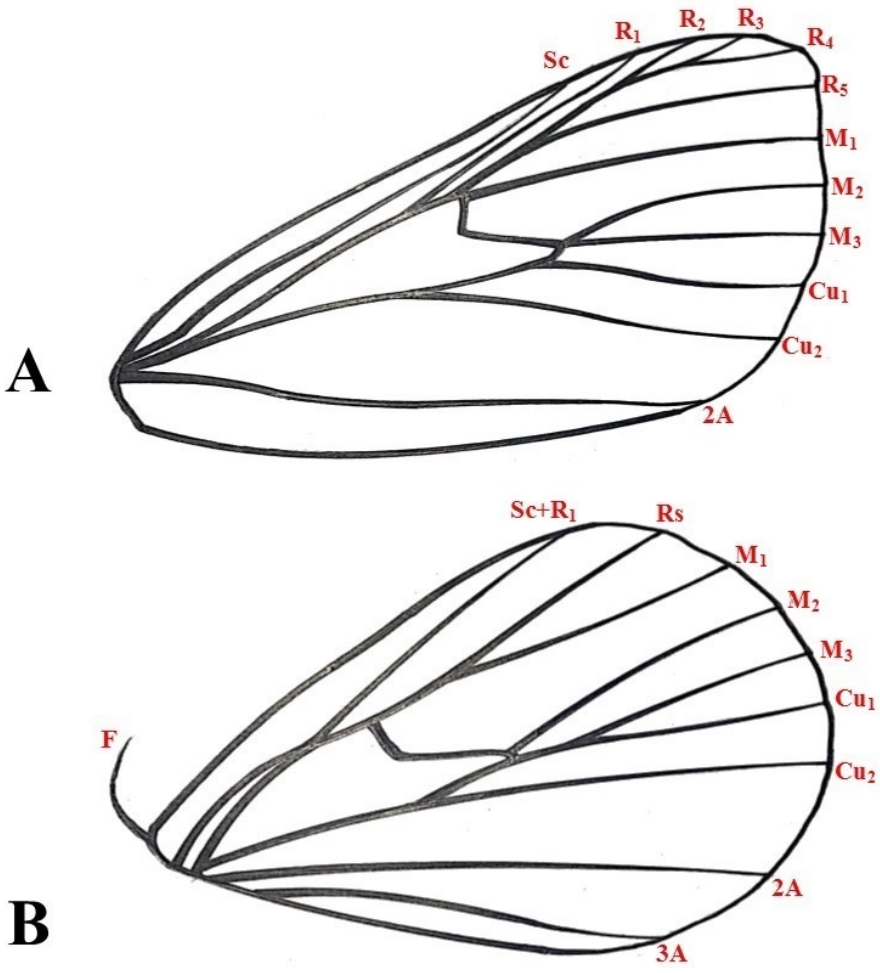


Aloa lactinea Cramer

A-Forewing, B-Hindwing

PLATE - 45

From Book "Moths of IISER Mohali"

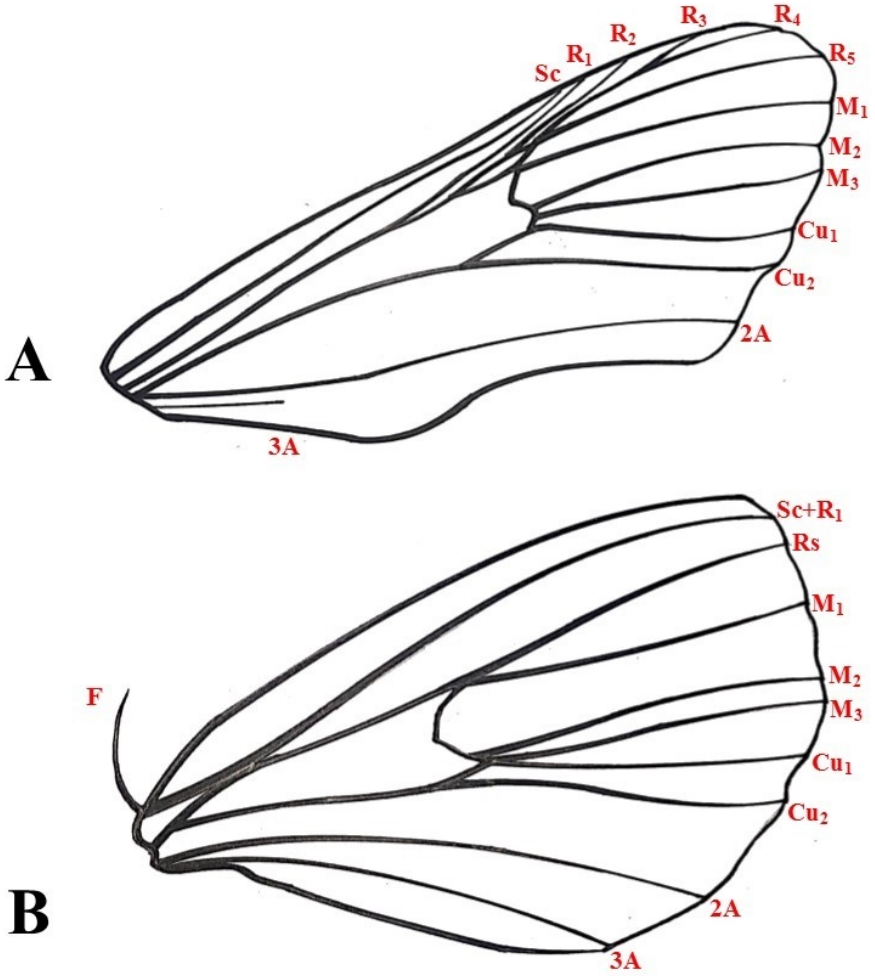


Arctornis bubalina Chao

A-Forewing, B-Hindwing

PLATE - 46

From Book "Moths of IISER Mohali"

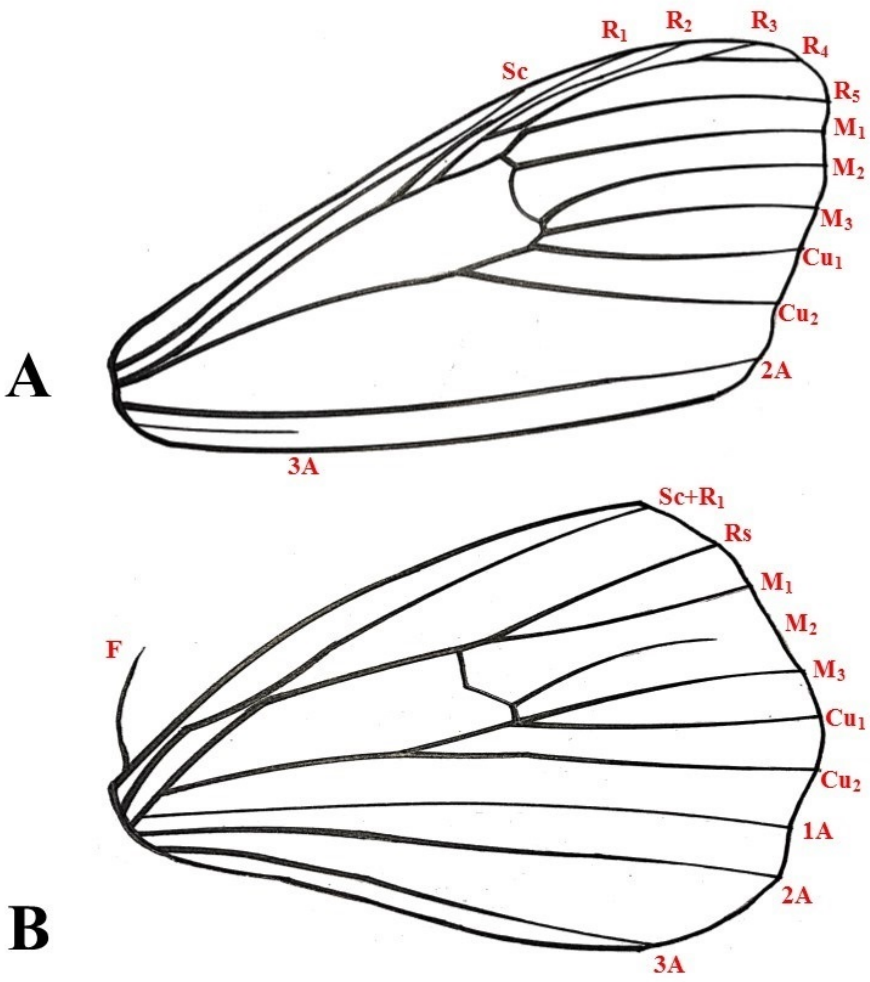


Calyptra parva Banziger

A-Forewing, B-Hindwing

PLATE - 47

From Book "Moths of IISER Mohali"

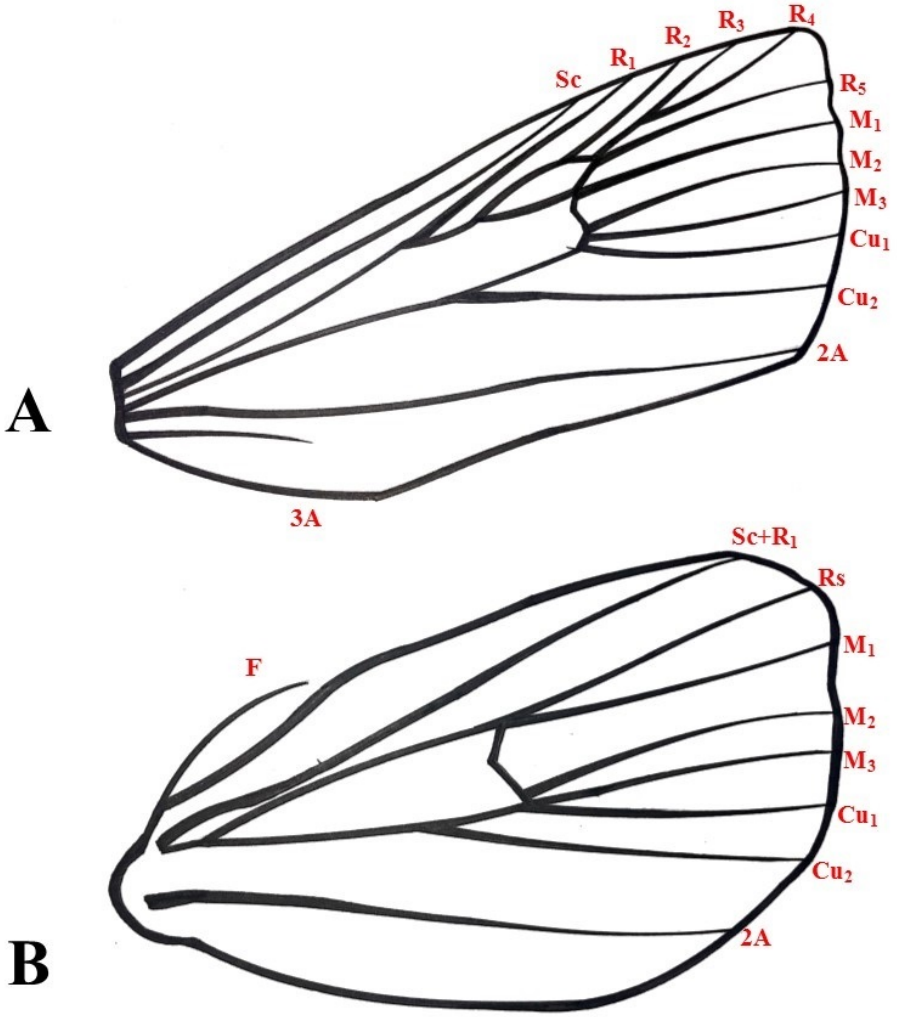


Dasychira sp.

A-Forewing, B-Hindwing

PLATE - 48

From Book "Moths of IISER Mohali"

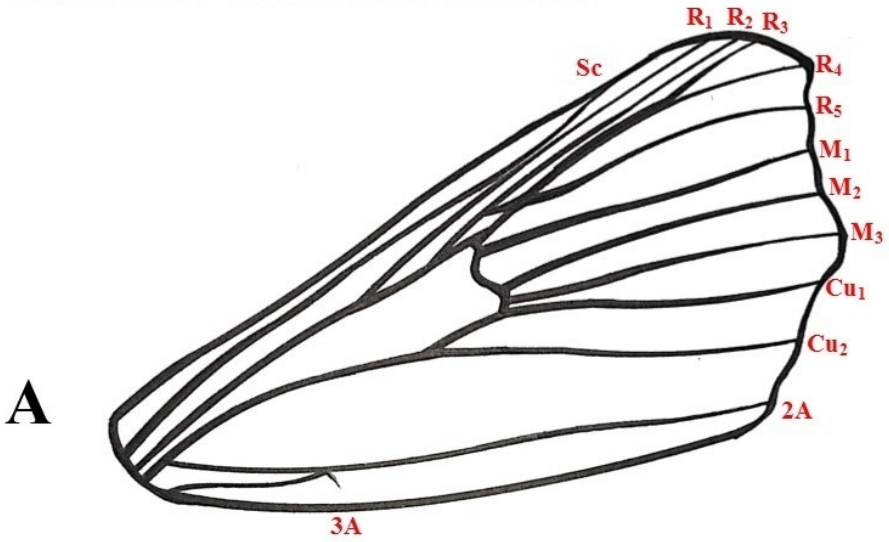


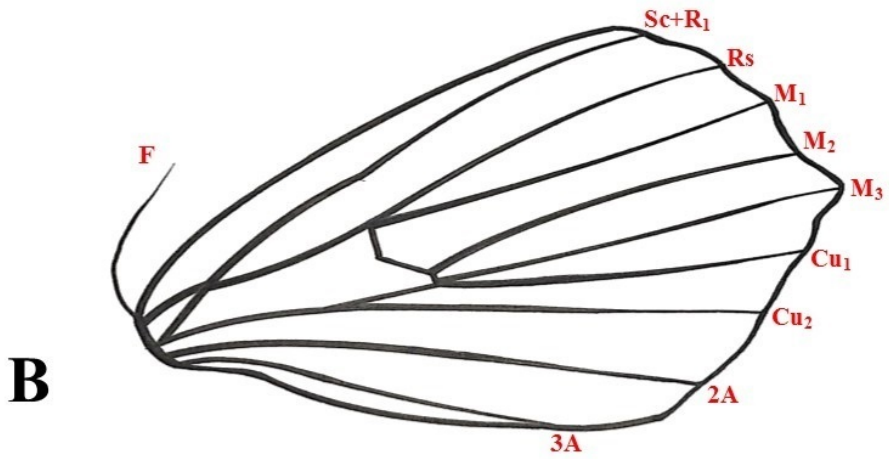
Digama hearseyana Moore

A-Forewing, B-Hindwing

PLATE - 49

From Book "Moths of IISER Mohali"



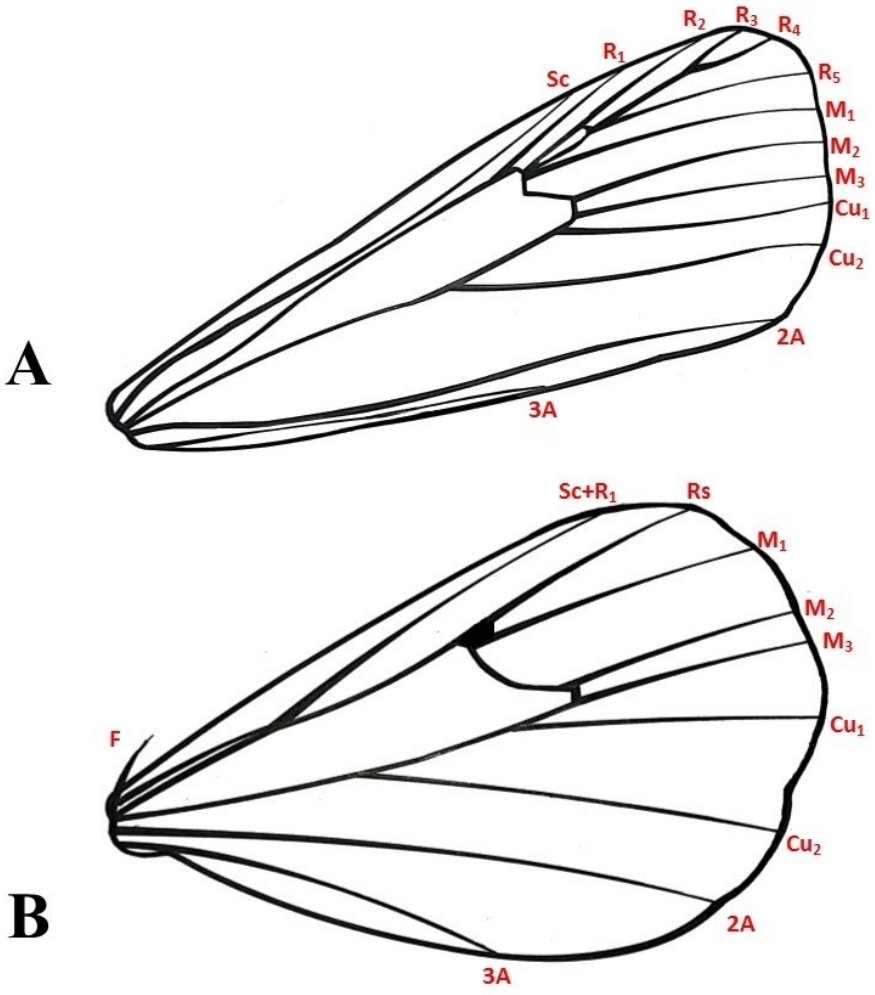


Episparis liturata Fabricius

A-Forewing, B-Hindwing

PLATE - 50

From Book "Moths of IISER Mohali"

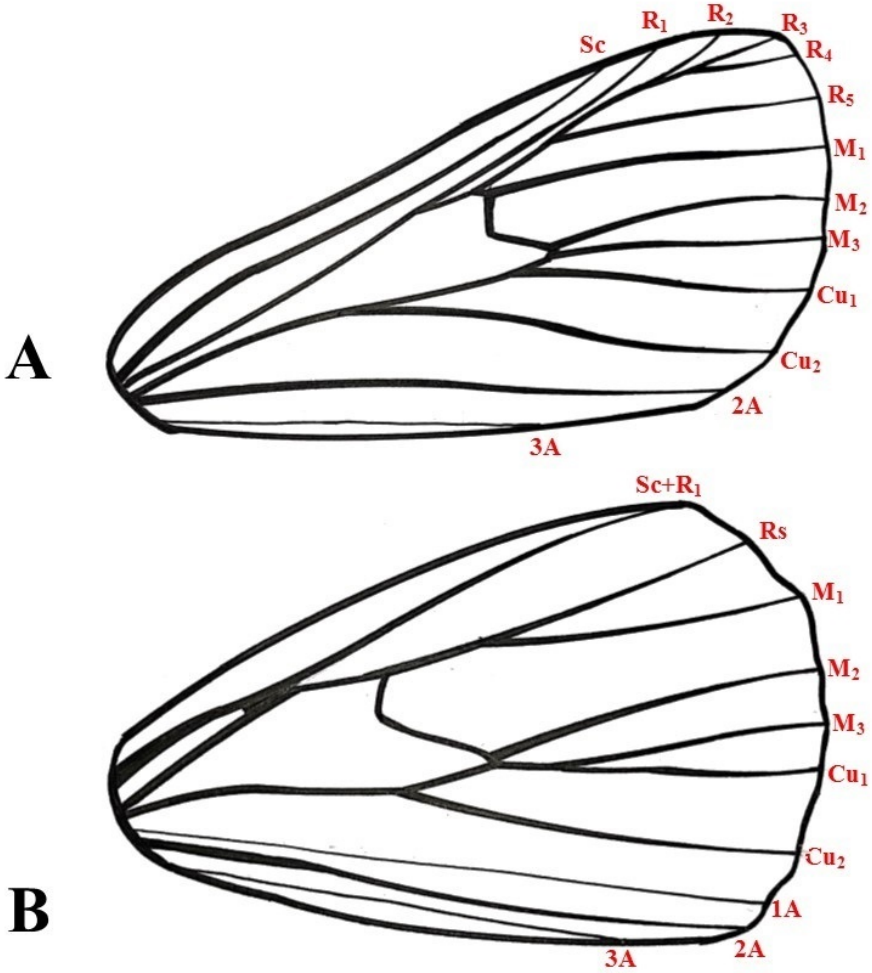


***Utetheisa pulchelloides* Hampson**

A-Forewing, B-Hindwing

PLATE - 51

From Book "Moths of IISER Mohali"

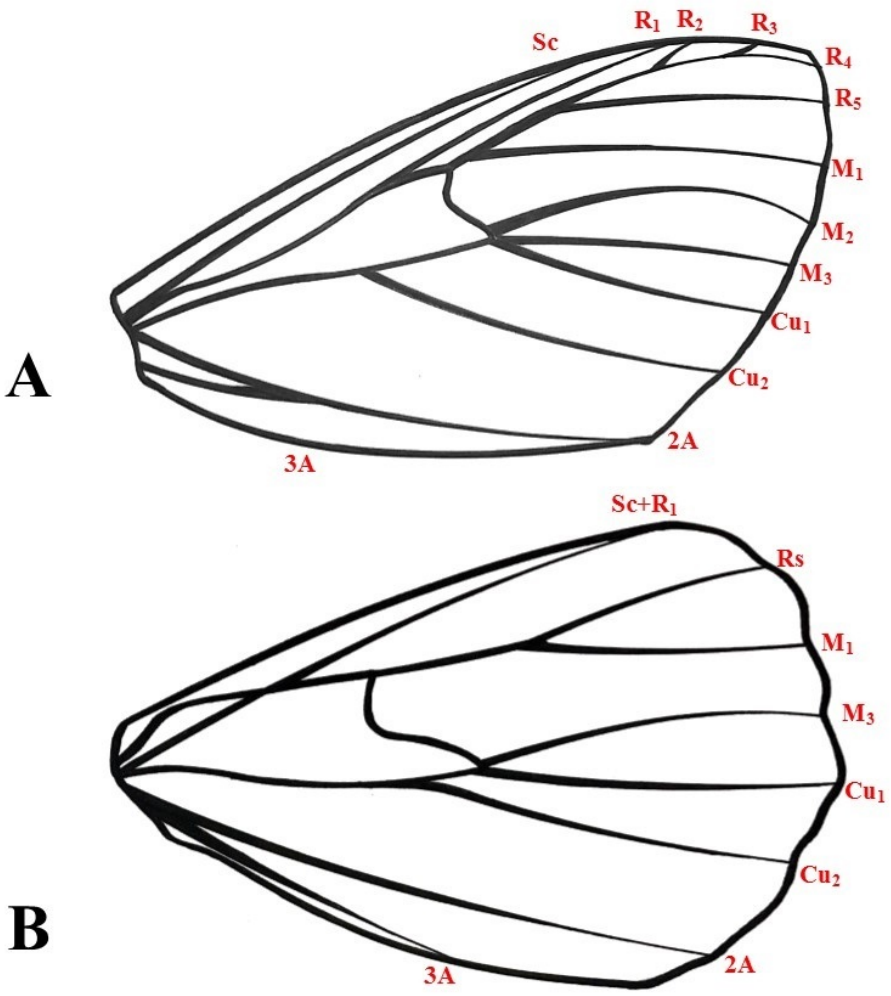


Leucoma salicis Linnaeus

A-Forewing, B-Hindwing

PLATE - 52

From Book "Moths of IISER Mohali"

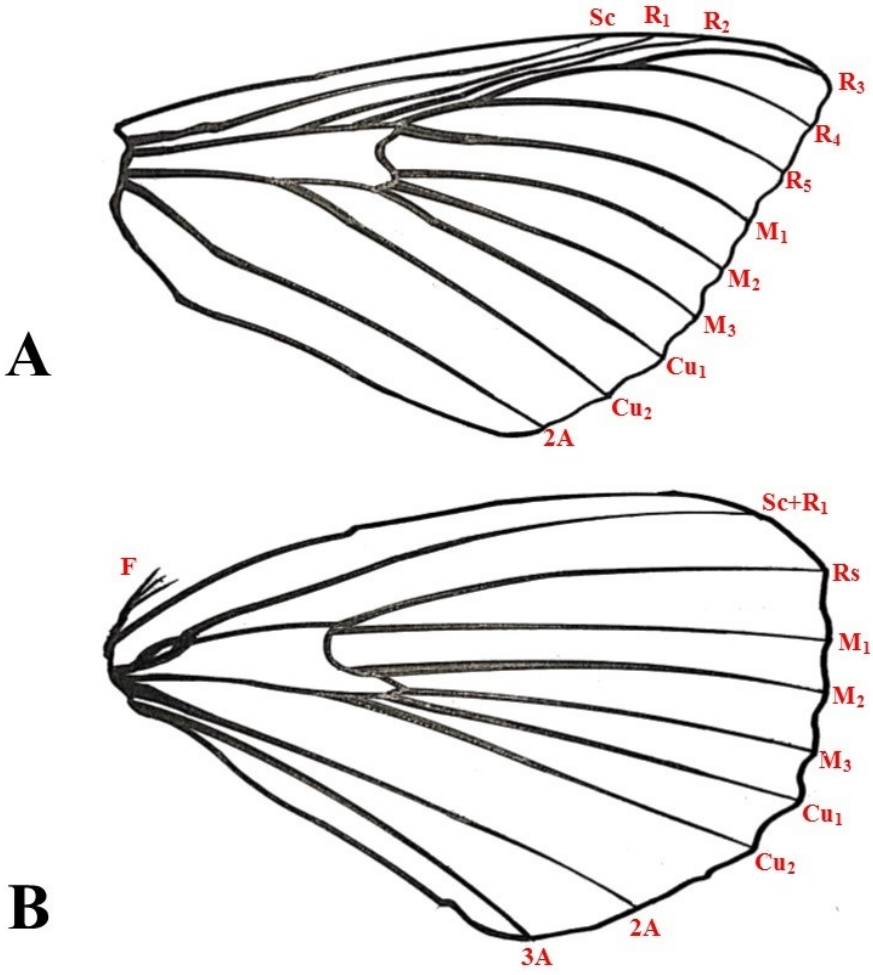


Somena scintillans Walker

A-Forewing, B-Hindwing

PLATE - 53

From Book "Moths of IISER Mohali"

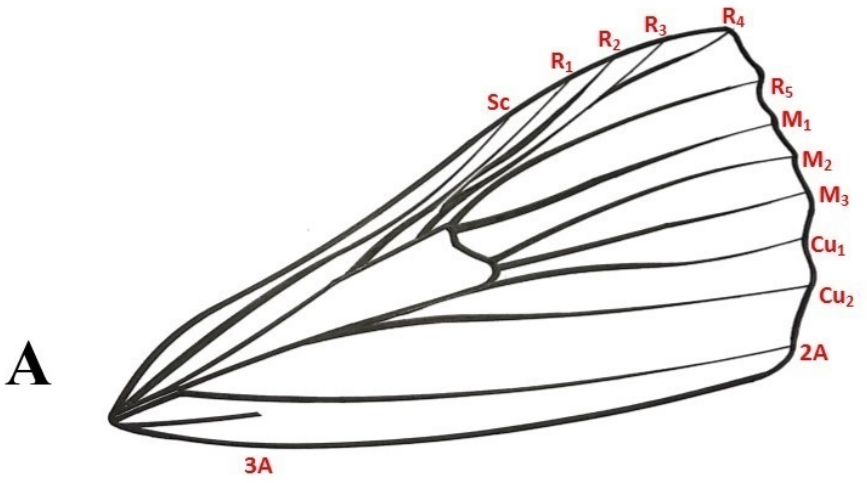


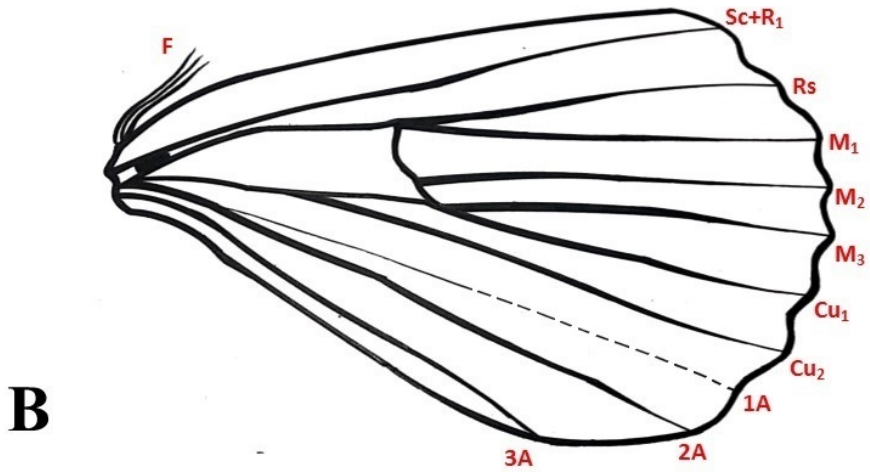
Thyas coronata Fabricius

A-Forewing, B-Hindwing

PLATE - 54

From Book "Moths of IISER Mohali"



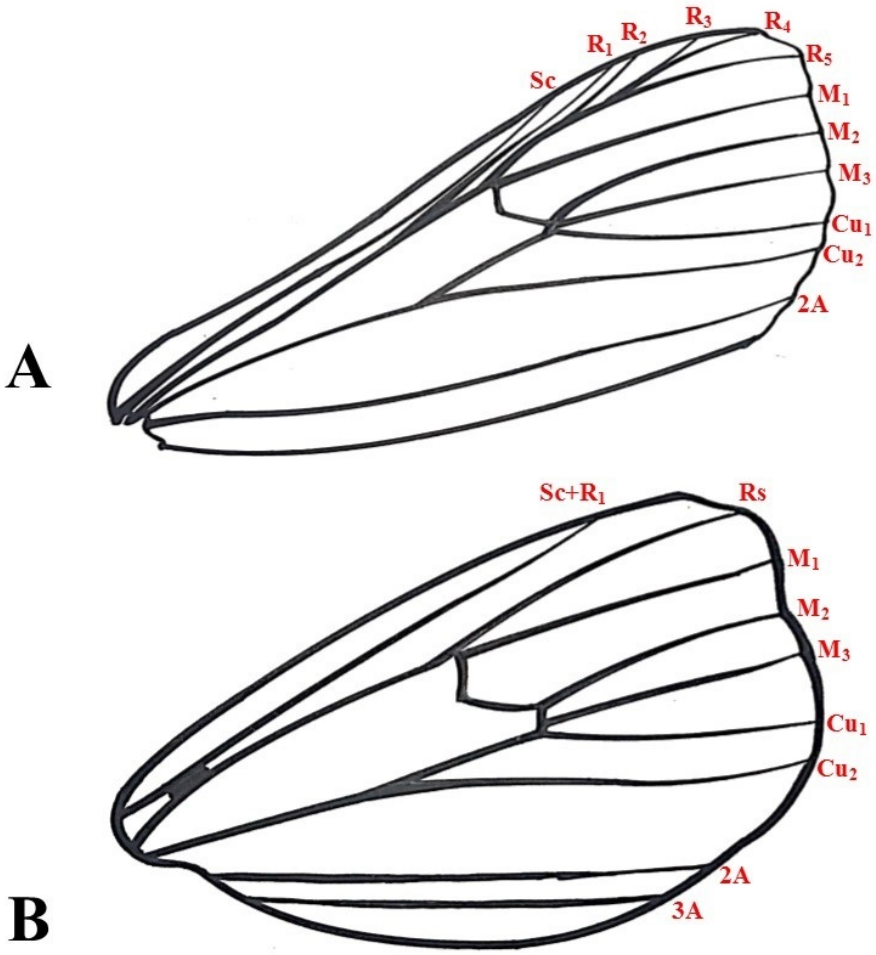


Lygephila craccae Denis and Schiffermuller

A-Forewing, B-Hindwing

PLATE - 55

From Book "Moths of IISER Mohali"

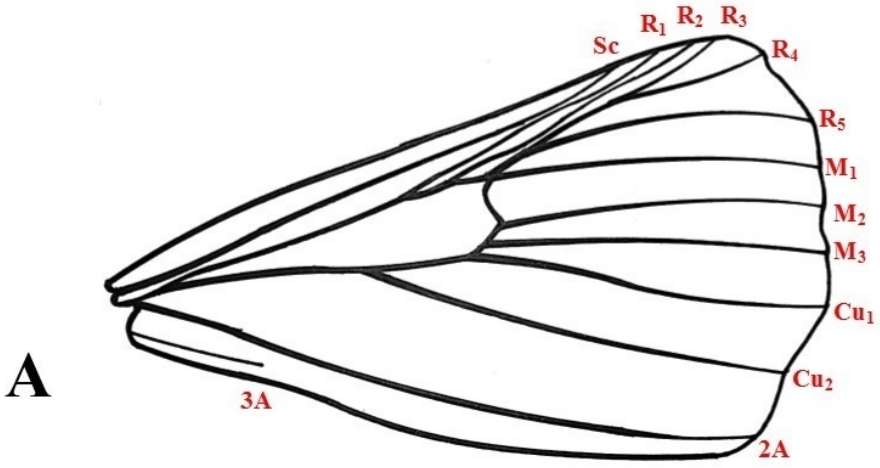


Spilosomsa metarhoda Walker

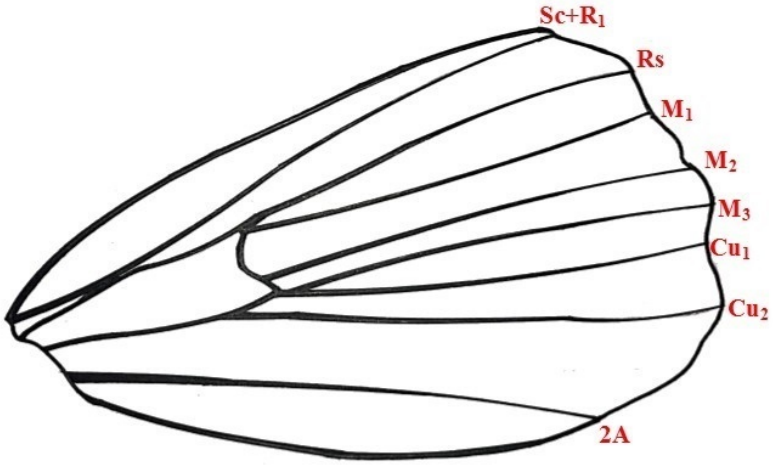
A-Forewing, B-Hindwing

PLATE - 56

From Book "Moths of IISER Mohali"



A



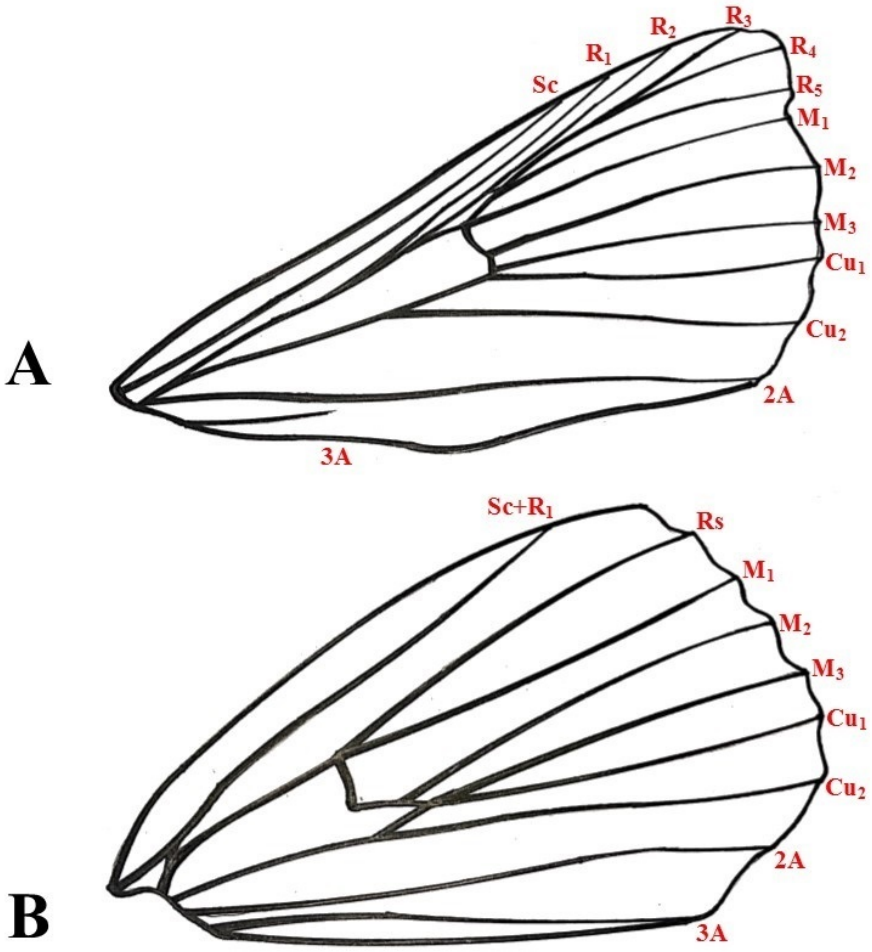
B

Attatha ino Drury

A-Forewing, B-Hindwing

PLATE - 57

From Book "Moths of IISER Mohali"

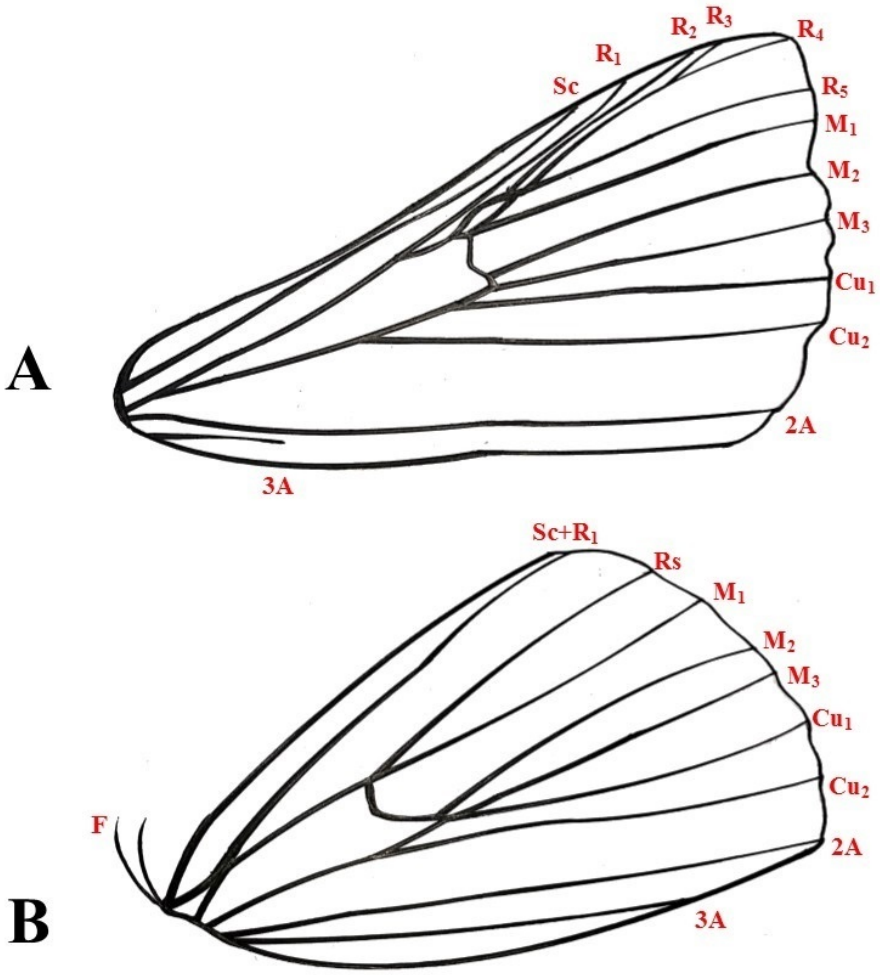


Grammodes geometrica Fabricius

A-Forewing, B-Hindwing

PLATE - 58

From Book "Moths of IISER Mohali"

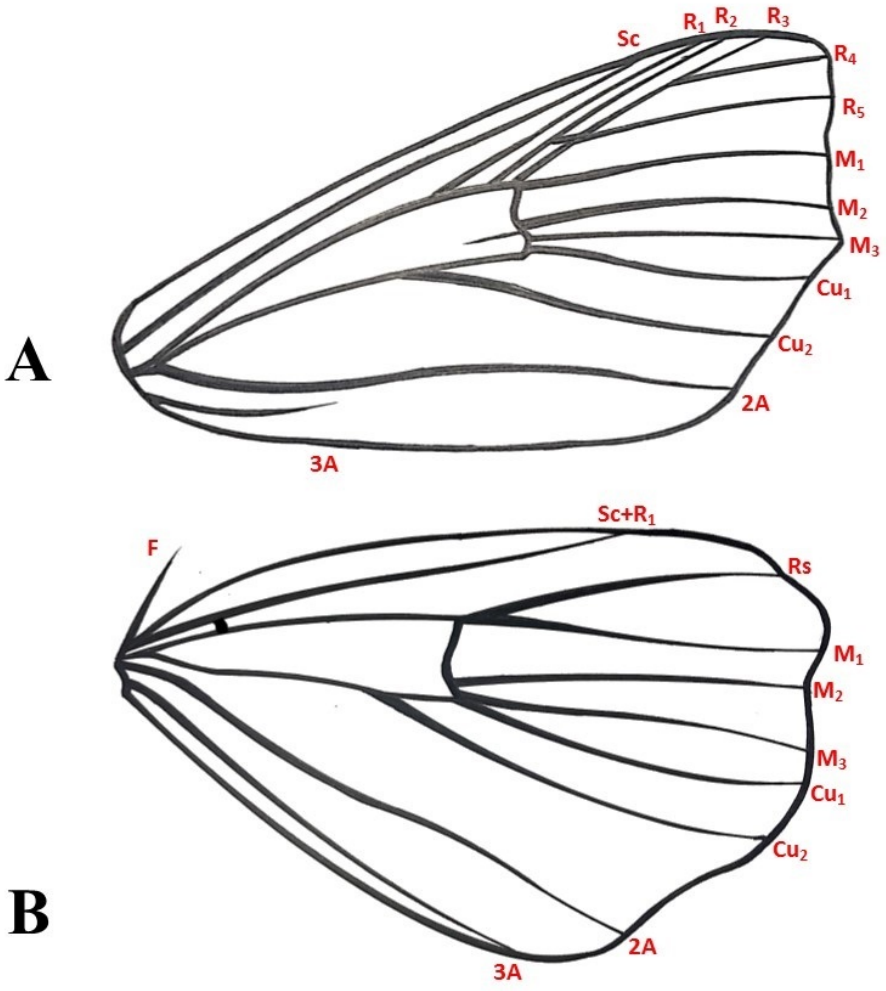


Mocis frugalis Fabricius

A-Forewing, B-Hindwing

PLATE - 59

From Book "Moths of IISER Mohali"

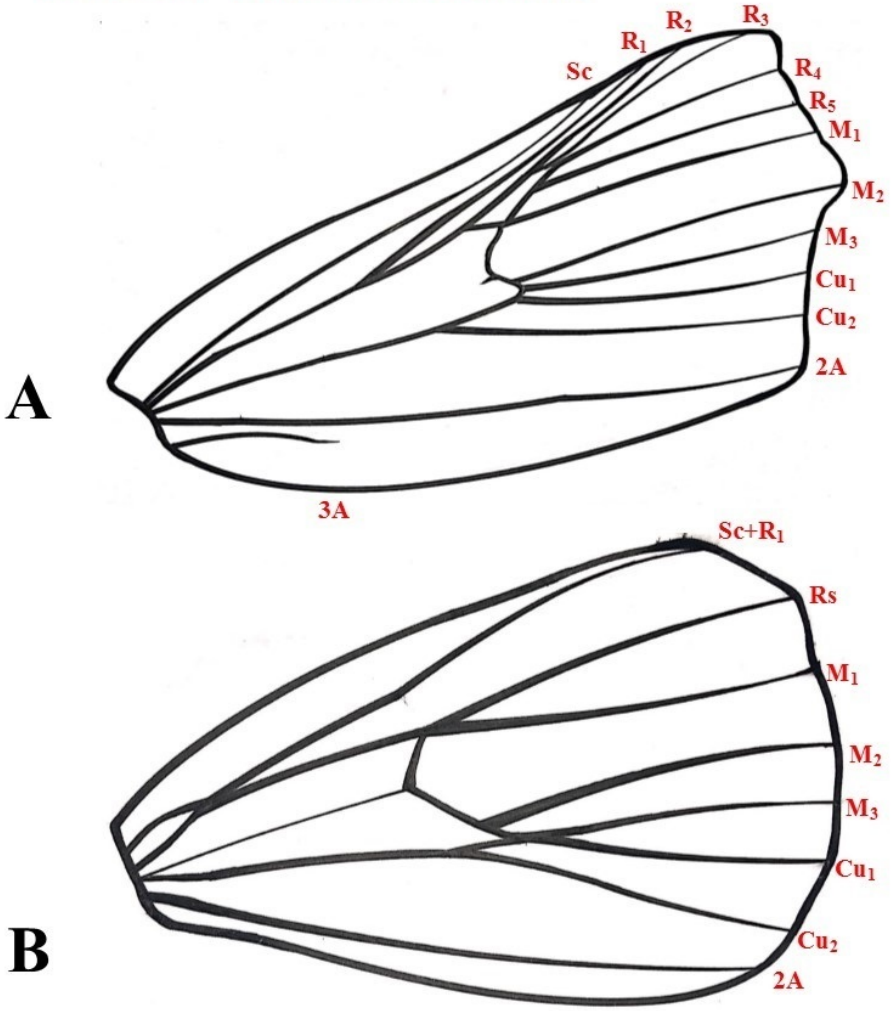


Anomis fulvida Guenee

A-Forewing, B-Hindwing

PLATE - 60

From Book "Moths of IISER Mohali"

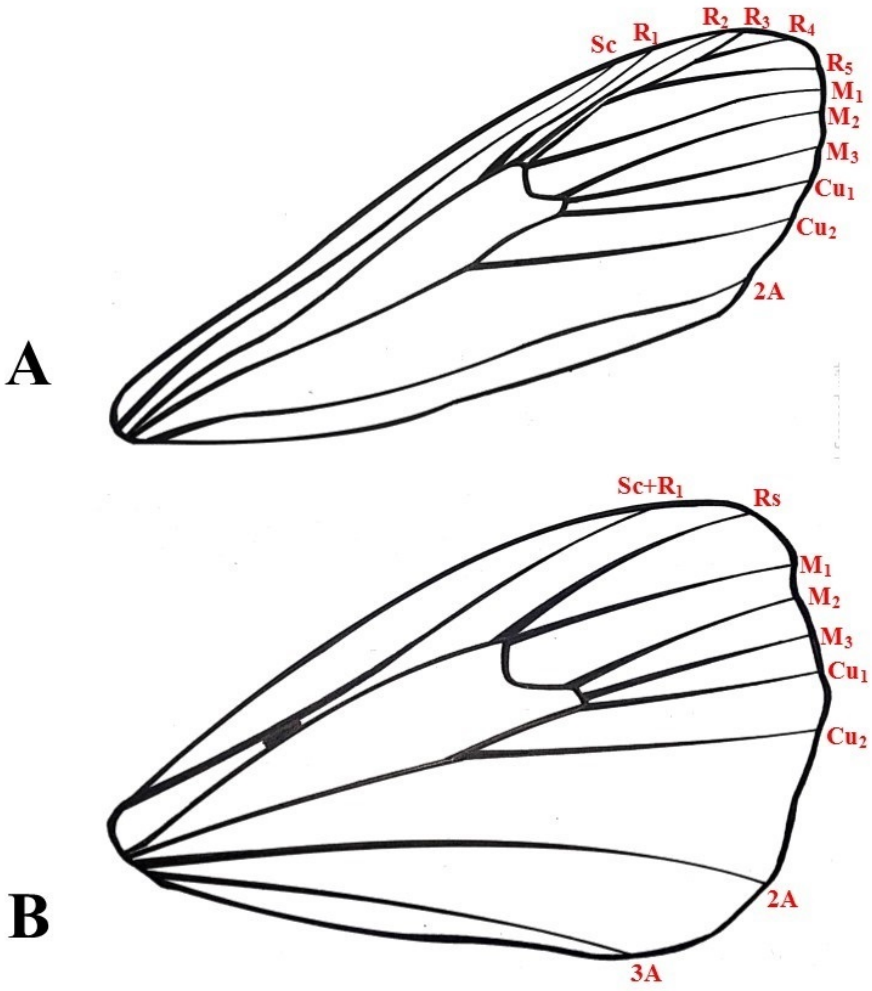


Anomis lineosa Walker

A-Forewing, B-Hindwing

PLATE - 61

From Book "Moths of IISER Mohali"

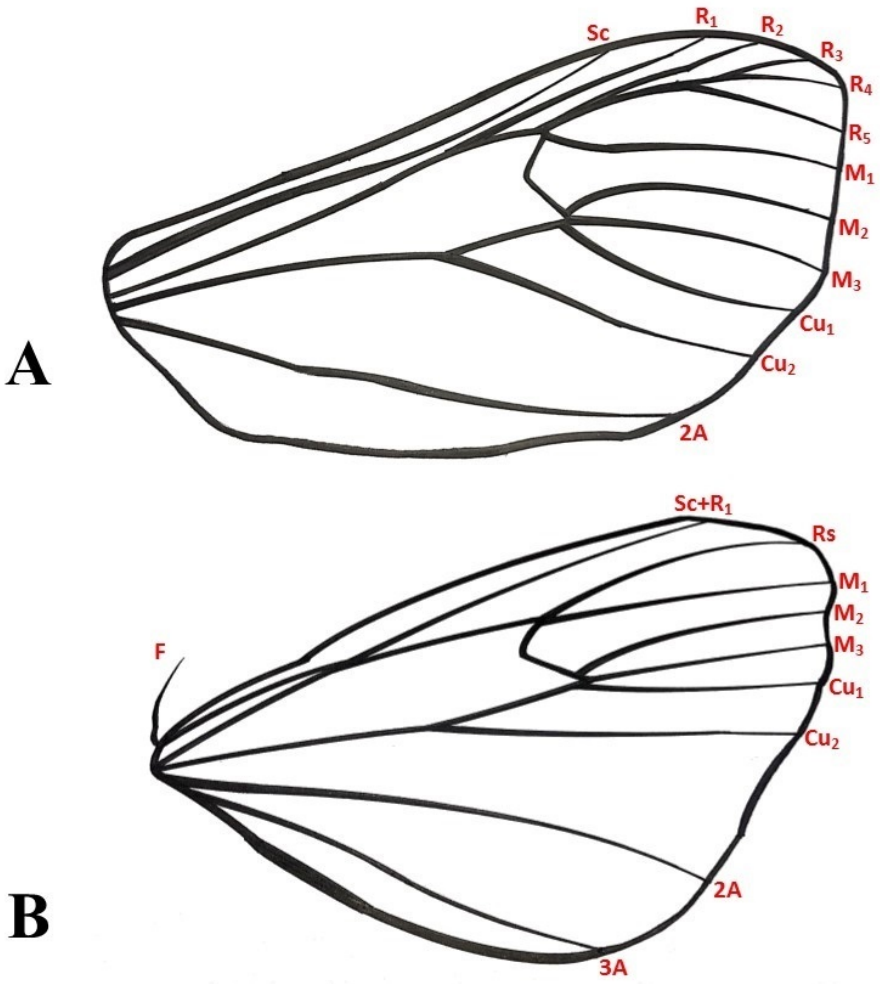


Creatonotos gangis Linnaeus

A-Forewing, B-Hindwing

PLATE - 62

From Book "Moths of IISER Mohali"

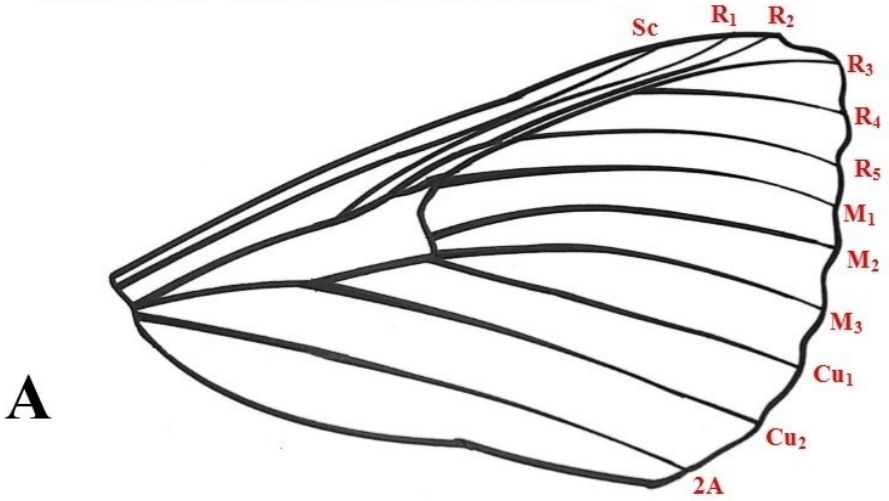


Creatonotos transiens Walker

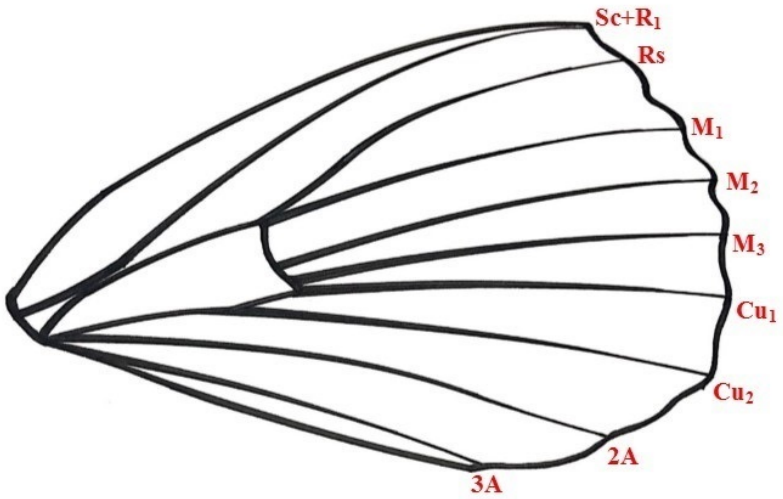
A-Forewing, B-Hindwing

PLATE - 63

From Book "Moths of IISER Mohali"



A



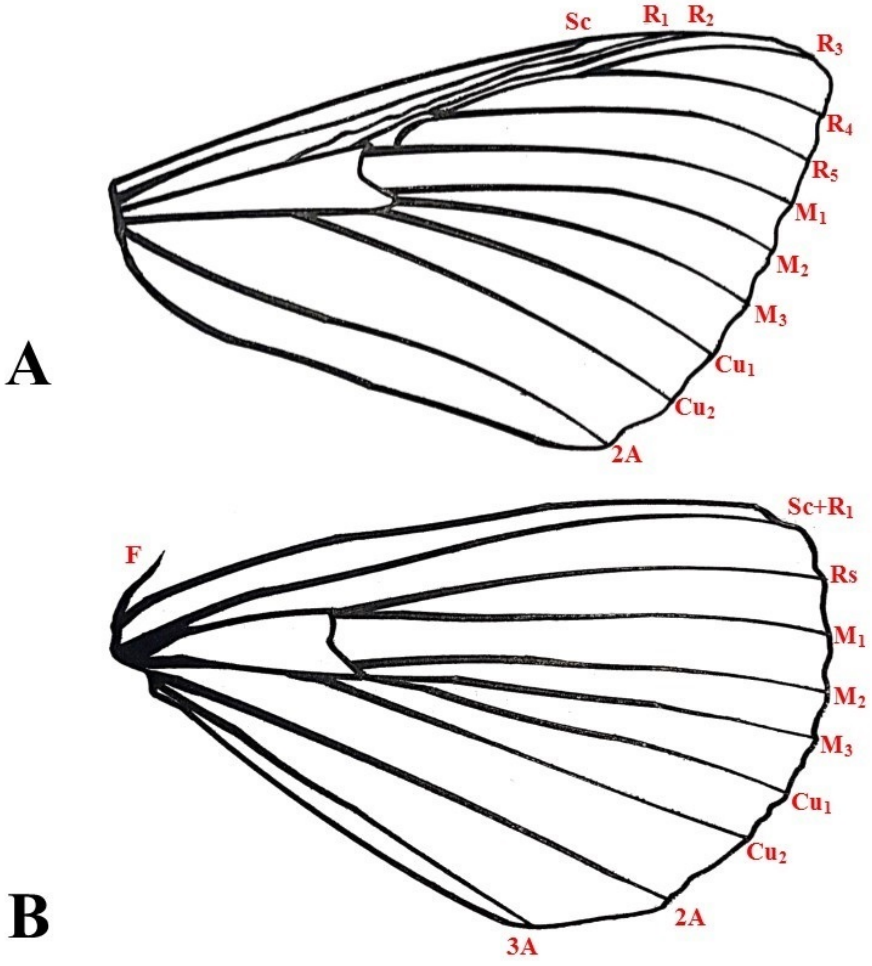
B

Spirama heliciana Hübner

A-Forewing, B-Hindwing

PLATE - 64

From Book "Moths of IISER Mohali"

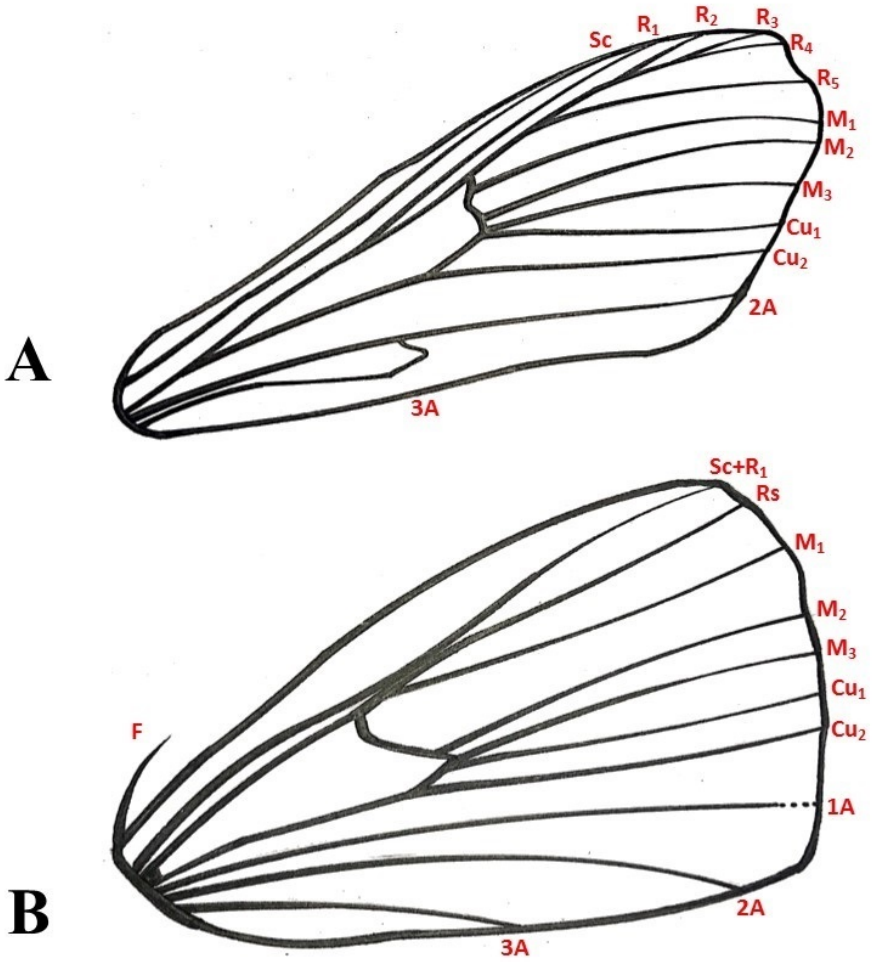


Spirama retorta Clerck

A-Forewing, B-Hindwing

PLATE - 65

From Book "Moths of IISER Mohali"

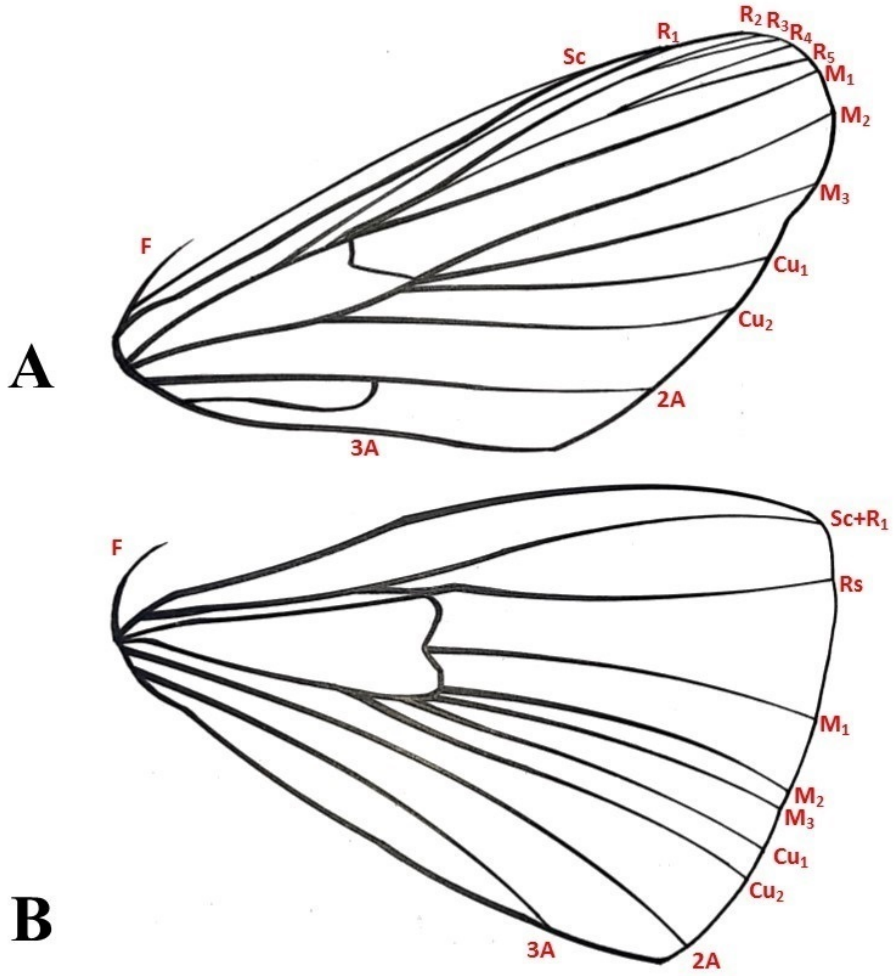


Botyodes diniasalis Walker

A-Forewing, B-Hindwing

PLATE - 66

From Book "Moths of IISER Mohali"

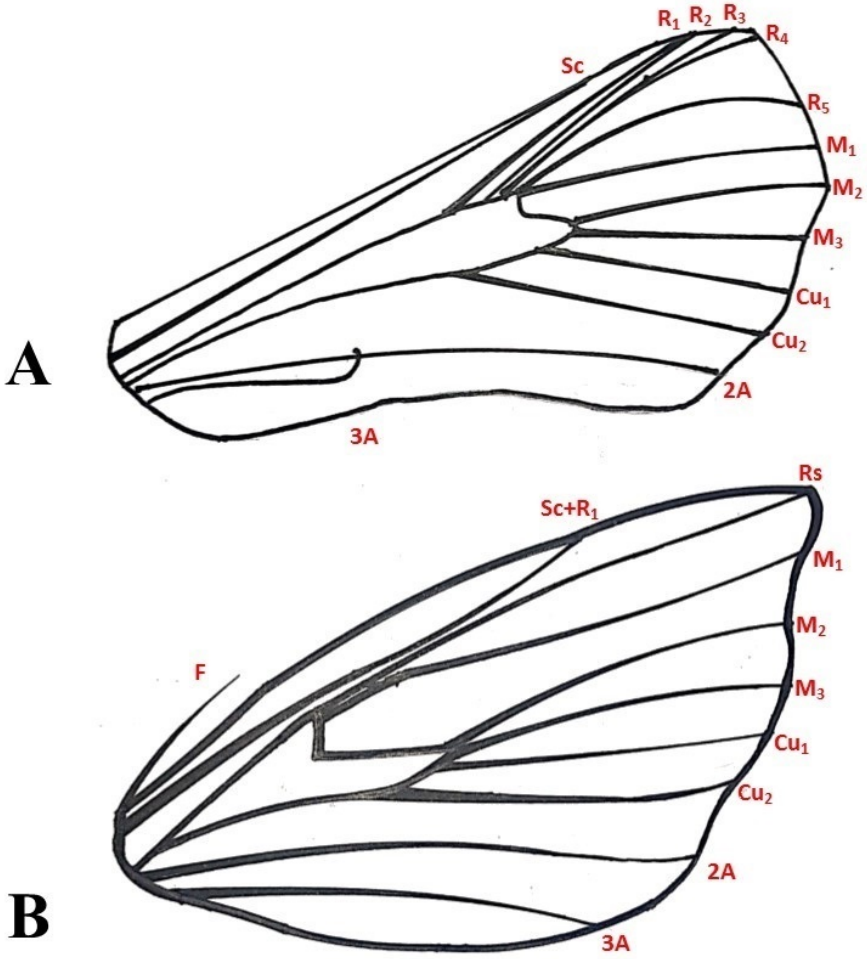


Cnaphalocrocis medinalis Guenee

A-Forewing, B-Hindwing

PLATE - 67

From Book "Moths of IISER Mohali"

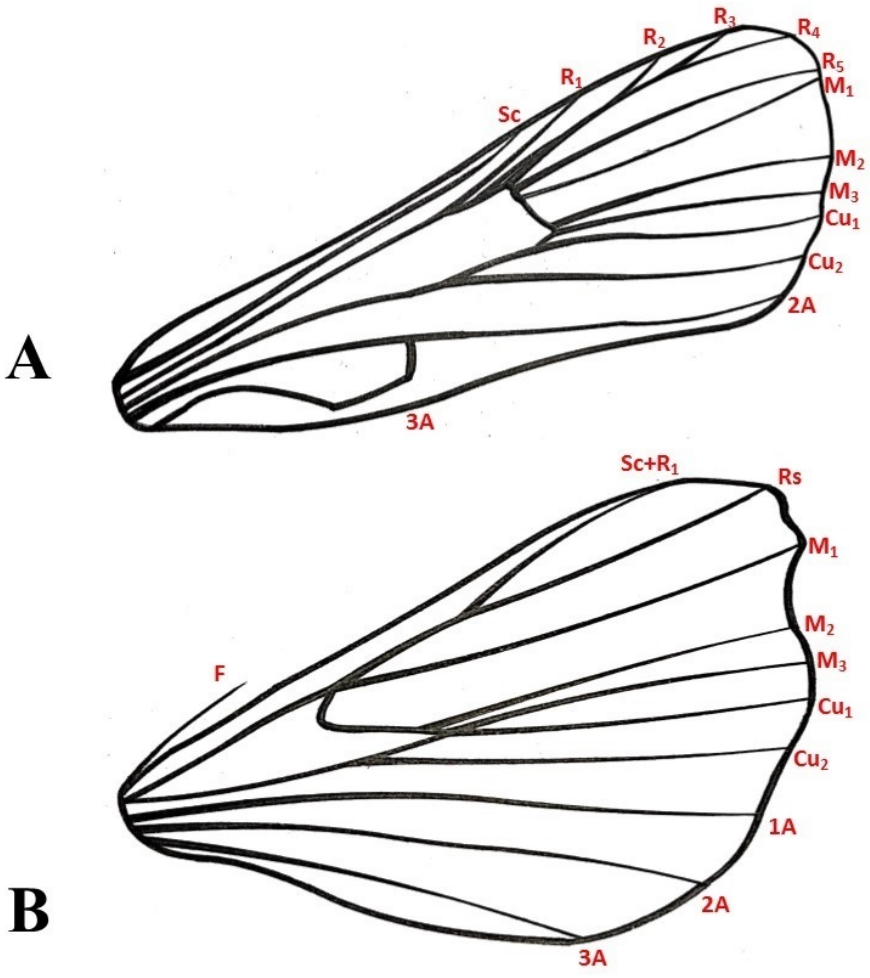


Diaphania indica Saunders

A-Forewing, B-Hindwing

PLATE - 68

From Book "Moths of IISER Mohali"

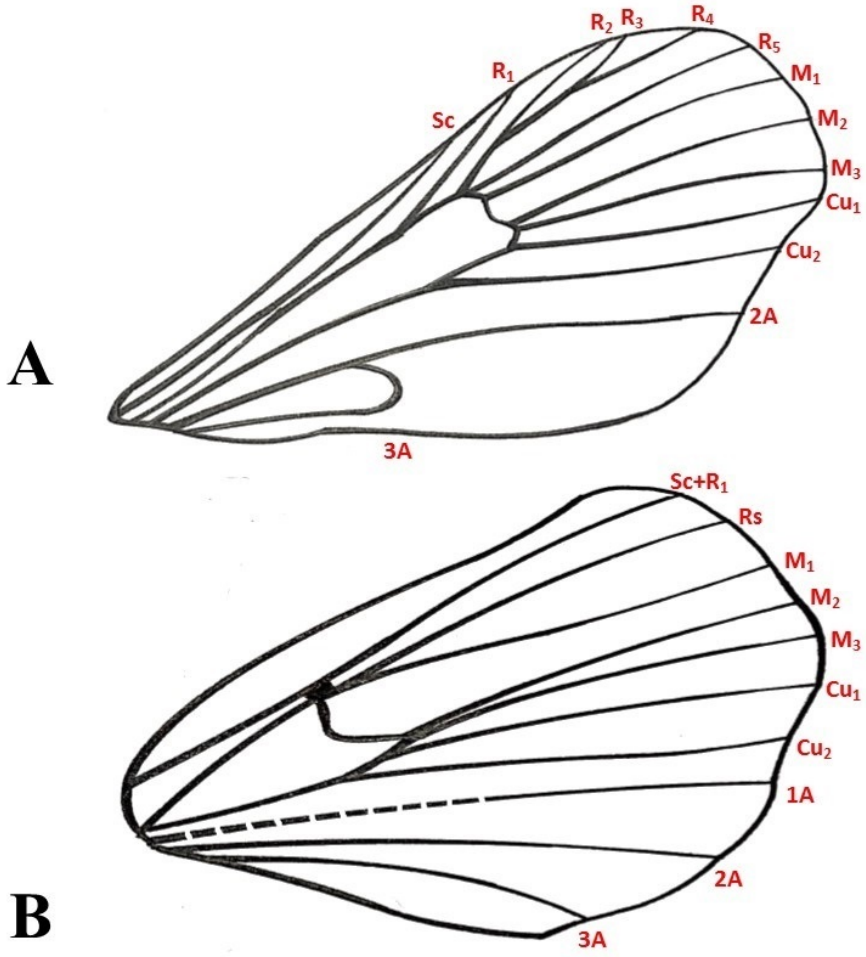


Hymenia perspectalis Hübner

A-Forewing, B-Hindwing

PLATE - 69

From Book "Moths of IISER Mohali"

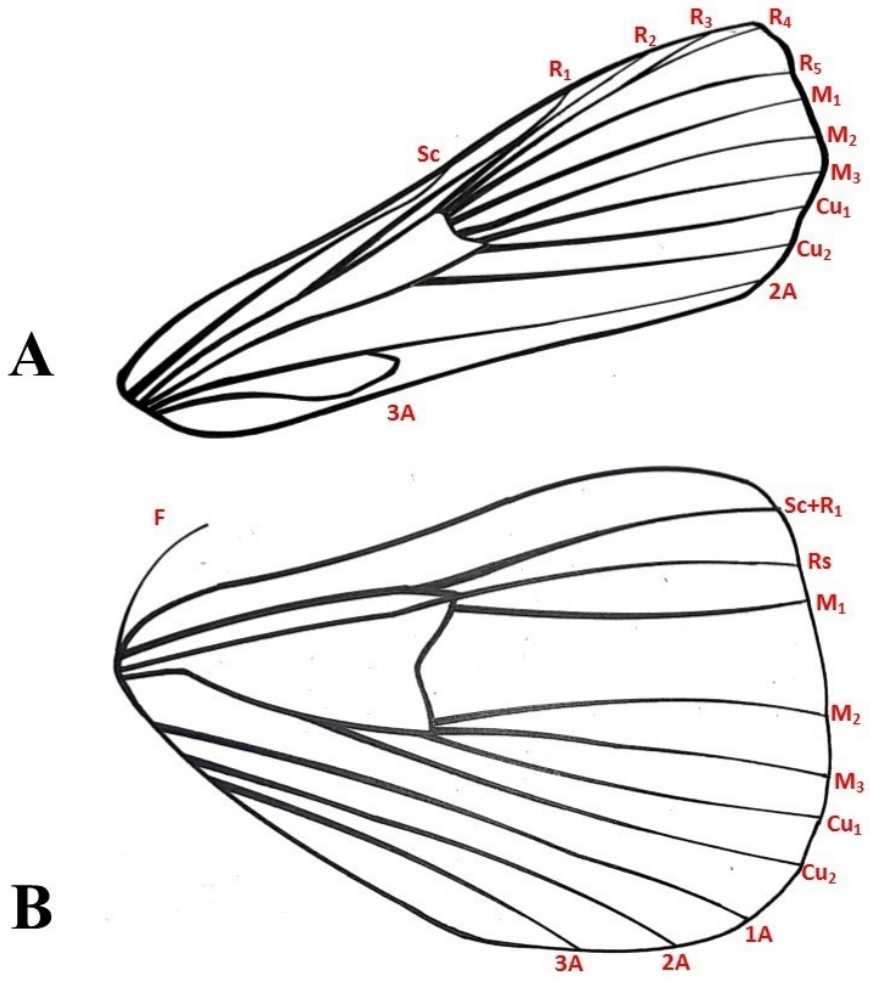


Haritalodes derogata Fabricius

A-Forewing, B-Hindwing

PLATE - 70

From Book "Moths of IISER Mohali"

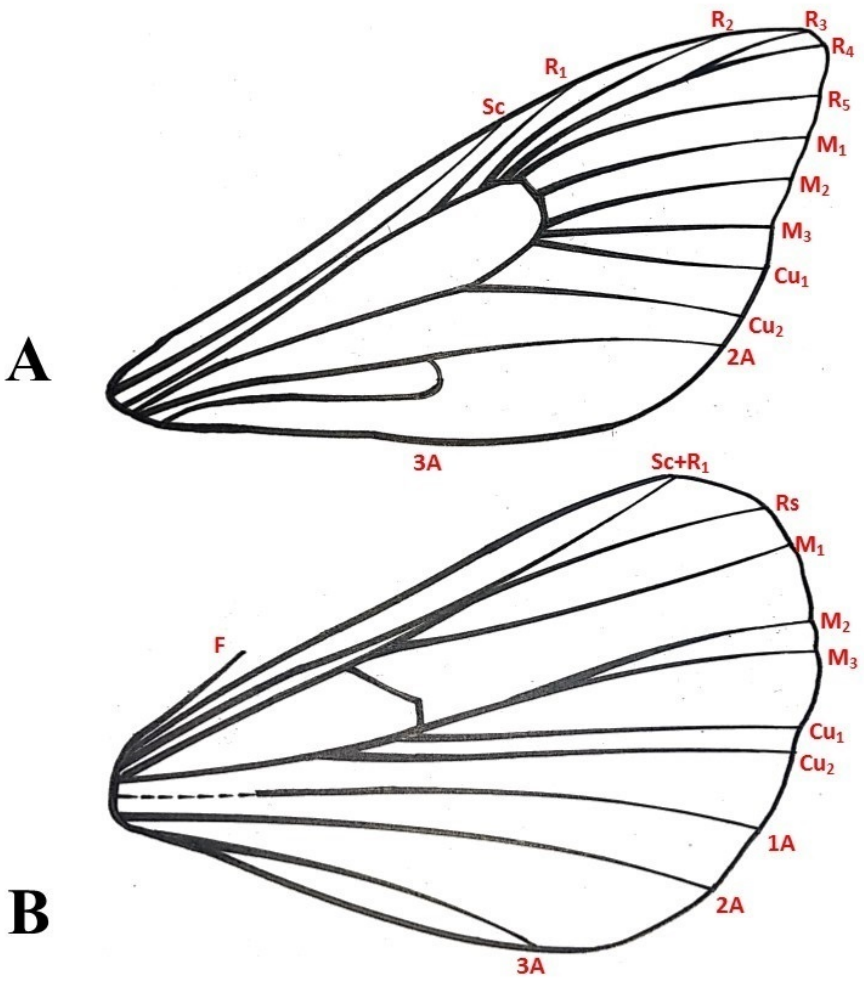


***Microthyris anormalis* Guenee**

A-Forewing, B-Hindwing

PLATE - 71

From Book "Moths of IISER Mohali"

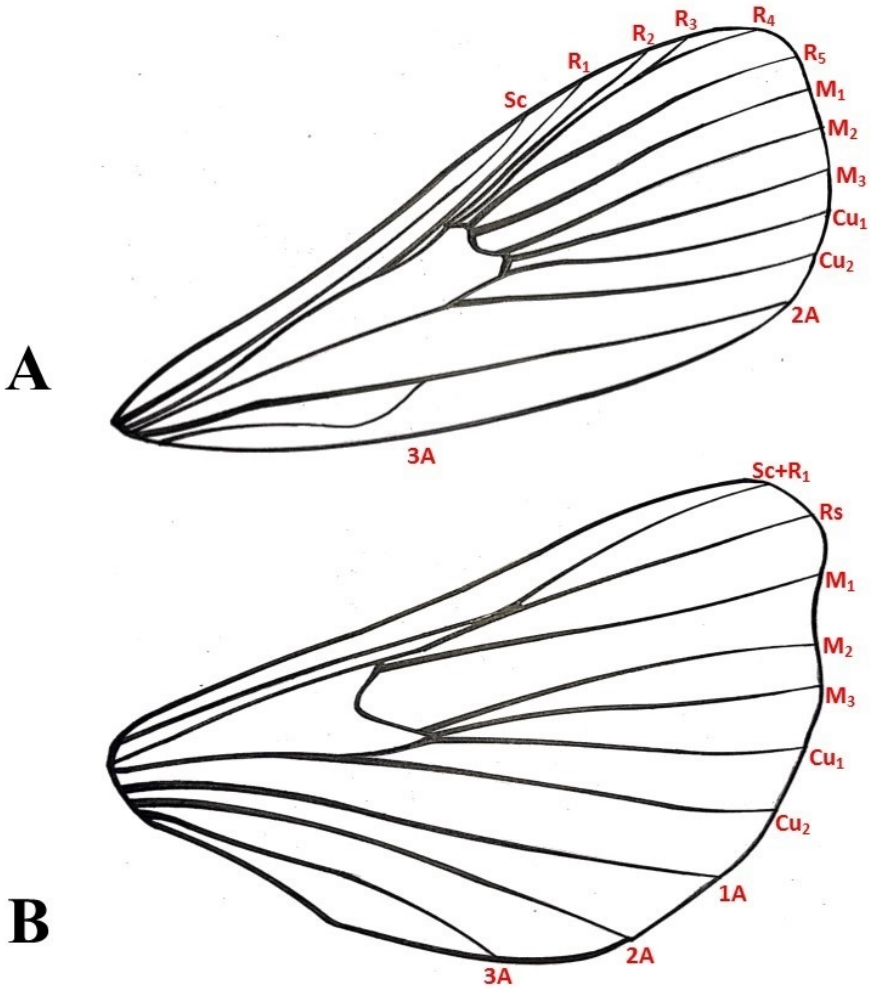


***Omphisa anastomosalis* Guenee**

A-Forewing, B-Hindwing

PLATE - 72

From Book "Moths of IISER Mohali"

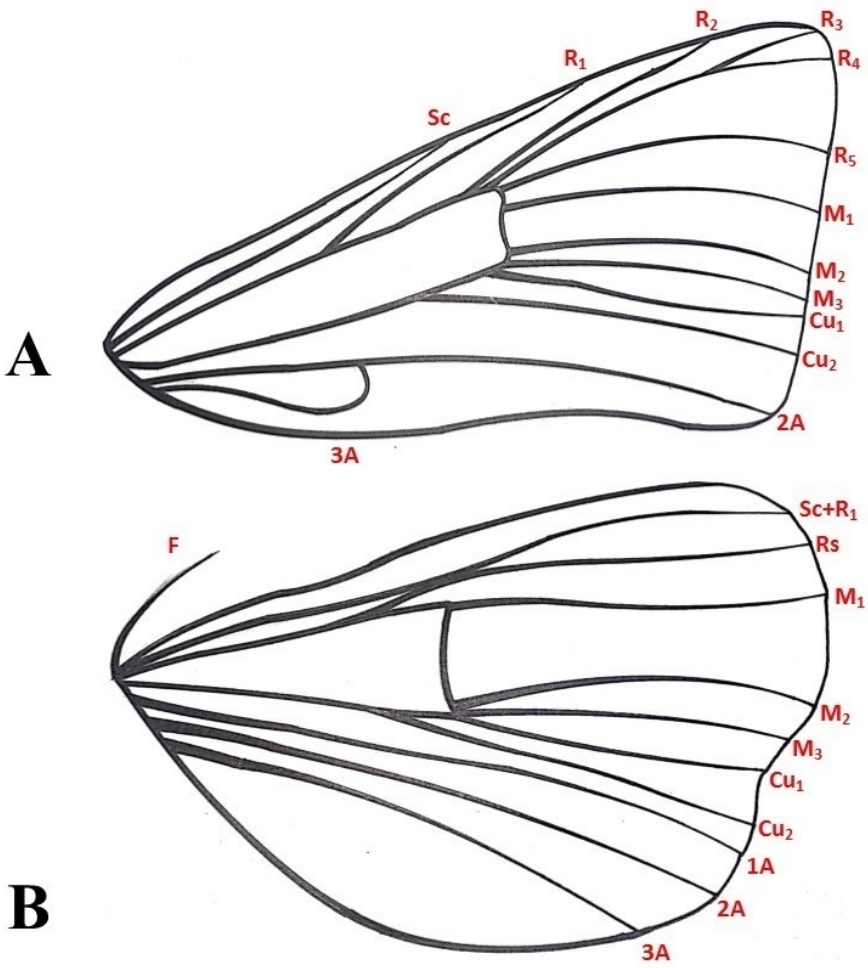


Conogethes punctiferalis Guenee

A-Forewing, B-Hindwing

PLATE - 73

From Book "Moths of IISER Mohali"

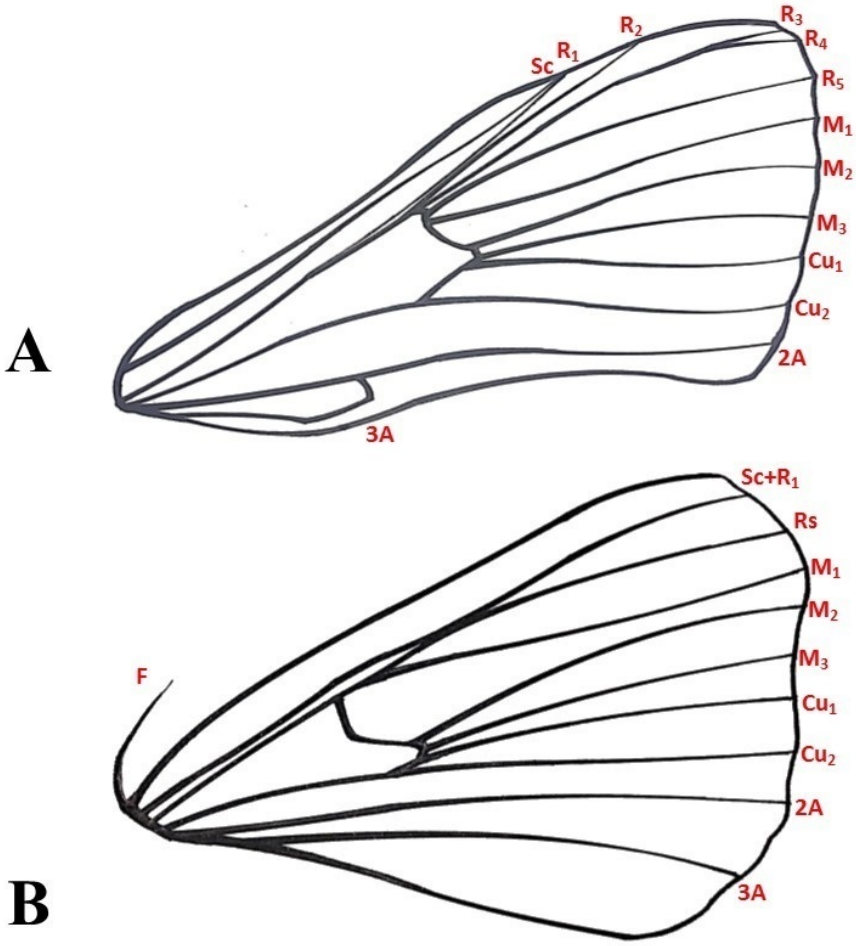


Parotis marginata Hampson

A-Forewing, B-Hindwing

PLATE - 74

From Book "Moths of IISER Mohali"

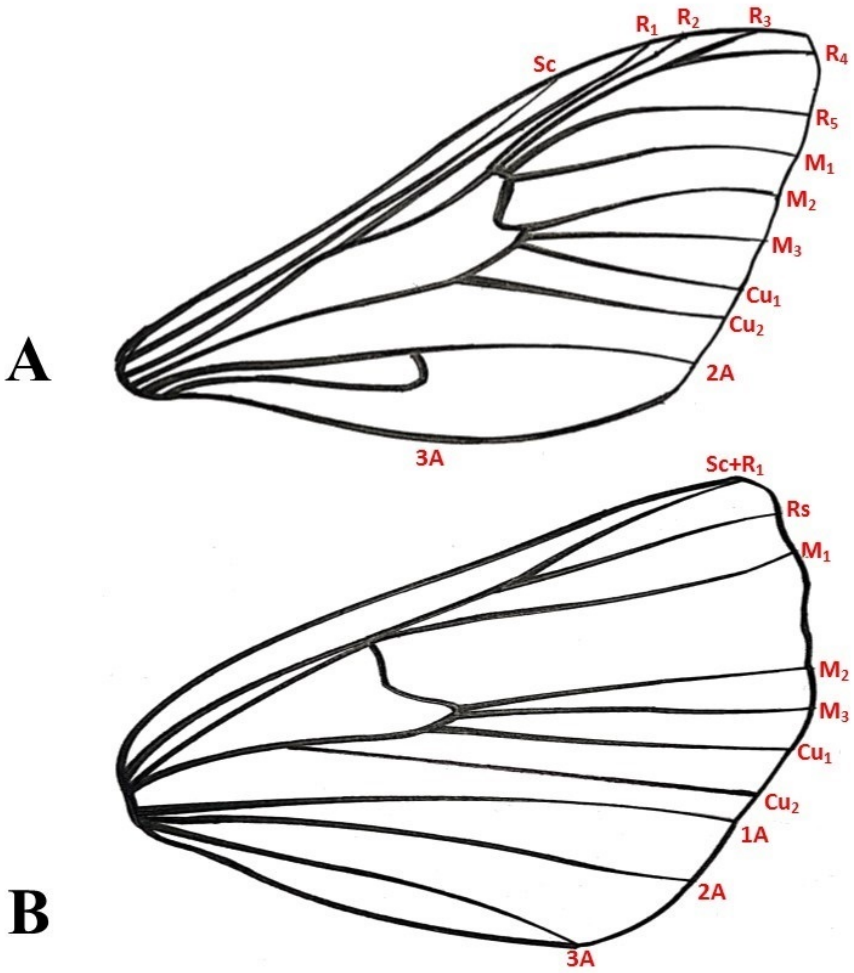


Pygospila tyres Cramer

A-Forewing, B-Hindwing

PLATE - 75

From Book "Moths of IISER Mohali"

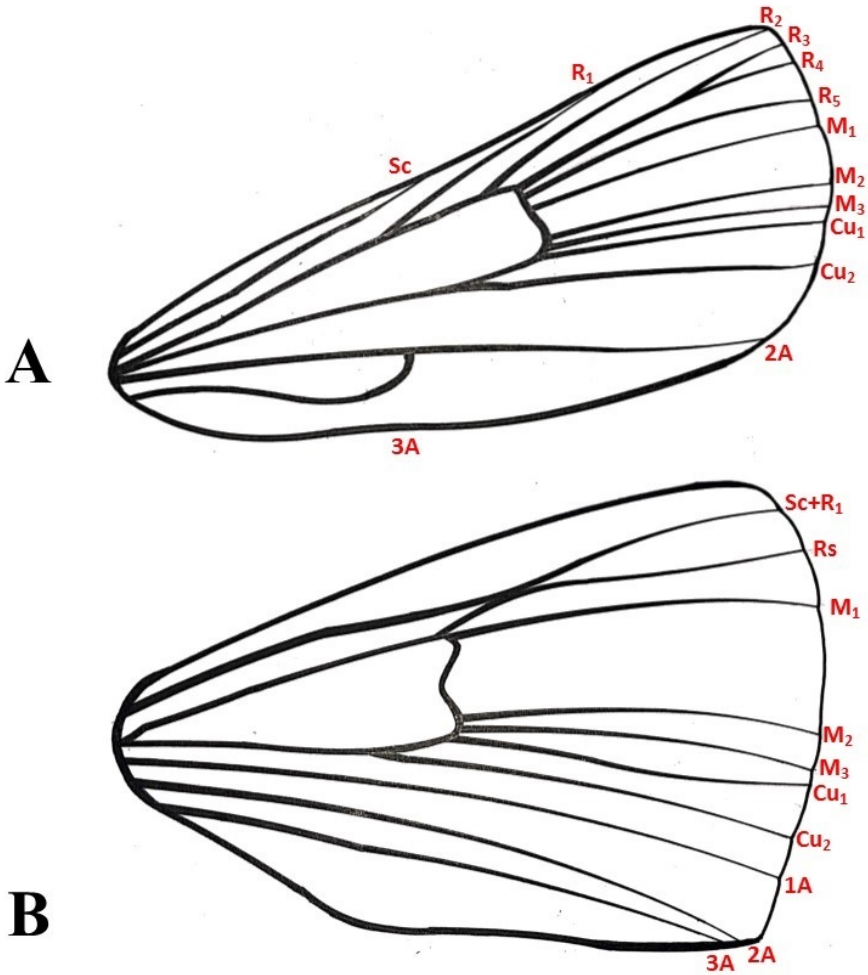


Meroctena tullalis Walker

A-Forewing, B-Hindwing

PLATE - 76

From Book "Moths of IISER Mohali"

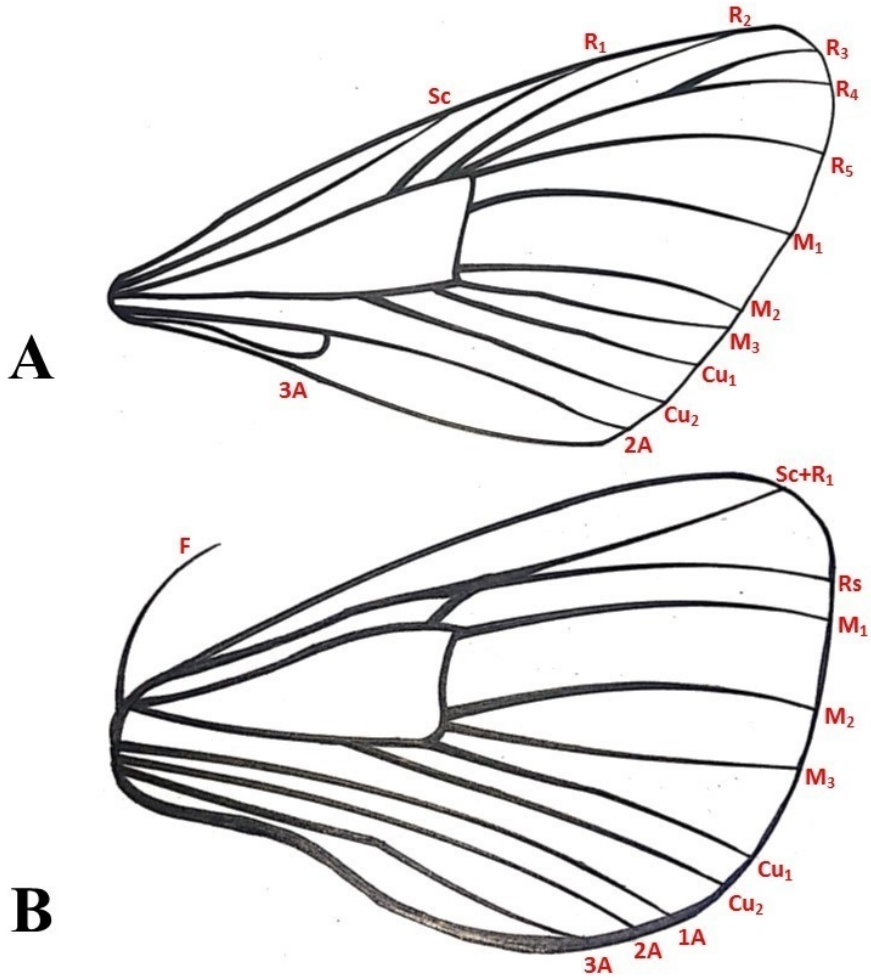


Palpita asiaticalis Inoue

A-Forewing, B-Hindwing

PLATE - 77

From Book "Moths of IISER Mohali"



Eoophyla sejunctalis Snellens

A-Forewing, B-Hindwing