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DESCRIPTION:

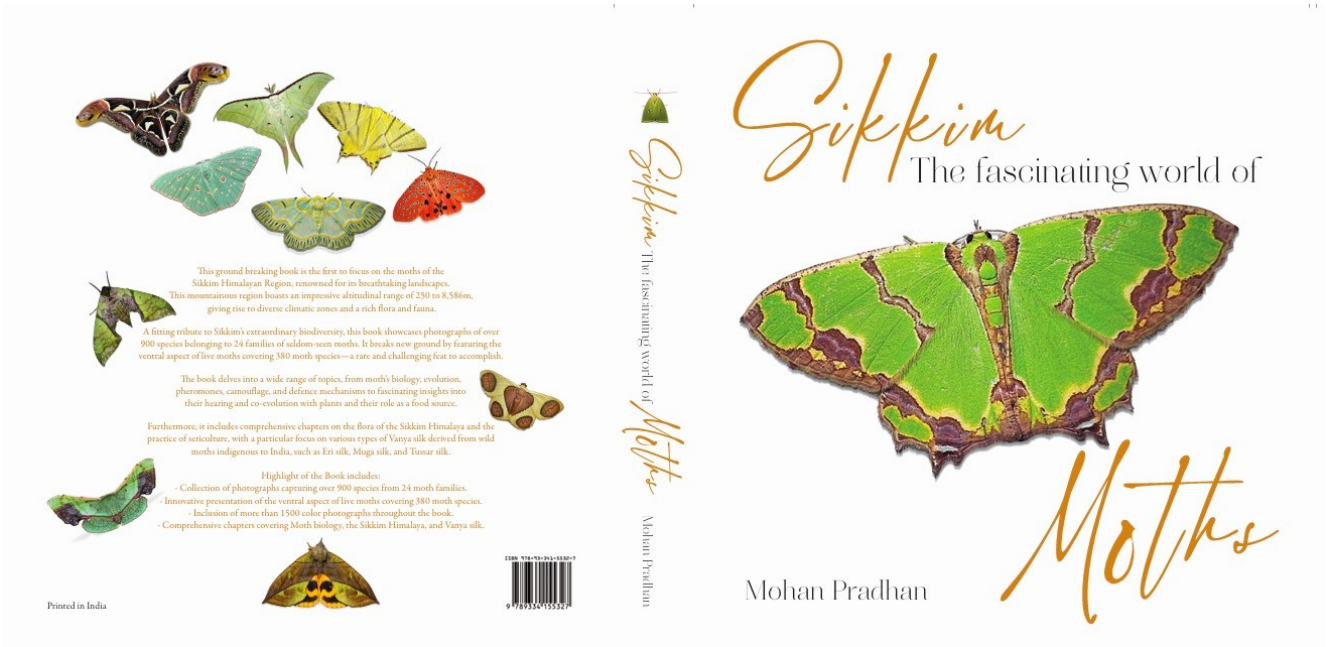
Moths, some of Earth's most ancient residents, evolved long before dinosaurs roamed the planet. With a stunning diversity of over 160,000 species around the globe, they along with butterflies make up one in ten known non-microbial species on Earth, reflecting a richness of life that deserves our attention.

This delightful book takes you on a journey into the mesmerizing world of moths in the Sikkim Himalayas, showcasing the captivating variety of these often-underappreciated creatures. While butterflies often steal the limelight, it's fascinating to note that moths have been around for over 150 million years longer! These remarkable insects play essential roles in our ecosystem, serving as crucial pollinators and as sustenance for countless animal species, including humans.

This pioneering book is the first of its kind to focus on the moths of the breathtaking Sikkim Himalayan area, which is celebrated for its natural beauty. Sikkim is home to the third highest mountain in the world, including that of an UNESCO World Heritage site that harmoniously blends nature and culture. Despite being the second smallest state in Indian, Sikkim is a bio-diversity hotspot, showcases one of the highest concentrations of plant and animal life. As the only Organic State in India, it provides an exceptional environment for studying both flora and fauna.

Readers will explore a range of captivating subjects, including moth biology, evolution, pheromone signaling, camouflage strategies, and amazing adaptations in hearing, co-evolution with plants and the production of silk like Eri, Muga, and Tussar, stemming from wild moth's native to this vibrant region.

The book features over 900 seldom-seen moth species, with more than 390 vividly showcasing the ventral aspects of live moths—a truly remarkable achievement! Notably, over 90% of the stunning 1,500 color photographs were taken using a smartphone, illustrating the power of accessible technology. The author passionately advocates for citizen science and community involvement in conservation. This initiative celebrates the accessibility of nature documentation through smartphone photography, inviting everyone to engage with and appreciate the wonders of the natural world!



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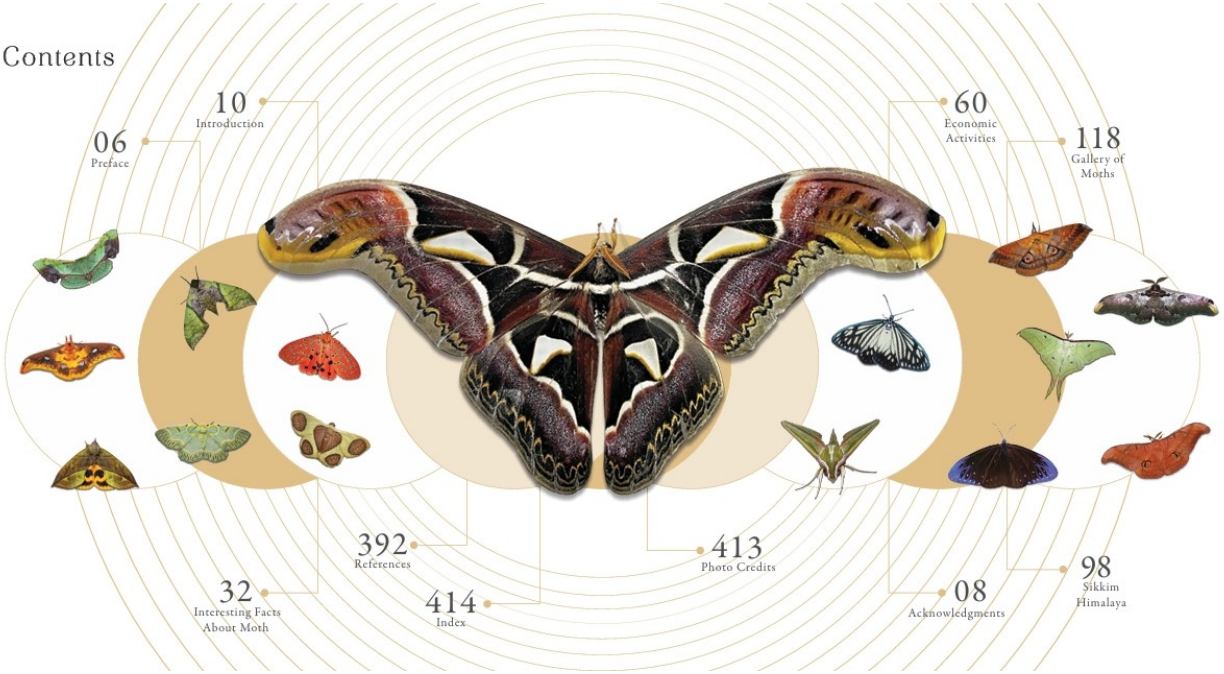


Muga Silk

Antheraea assamensis Helfer, 1837

Muga silk is produced from the cocoons of the moth *Antheraea assamensis*. The word "Muga" is derived from the Assamese word "Muga," meaning golden amber, as the yarn has a bright golden hue. At Rs.30-35 ,000.00 per kilogram of raw silk yarn, this is the most expensive silk in the world. The production is confined to the northeastern states of India, namely Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, and West Bengal. Assam accounts for about 95% of the Muga silk production in India. The Muga is reared outdoors on trees and is semi-domesticated as pre- and post-rearing is done indoors. They are multivoltine, producing six broods in a year. Muga caterpillars are polyphagous, consuming a wide range of plants. The host plants play an essential role in Muga production, as they are necessary for the health of the caterpillars. The leaves of the plants are the source of foliage proteins that are converted into silk proteins. Factors such as survival rate, quality of silk and fecundity depend on the access and availability of host plants to the caterpillars of the Muga moths.

Som (*Persea bombycina Kost.*) and Soalu *(Litsea monopetala Roxb.)* are the primary and preferred host plants

Previous page: Tasar yarn (hand reeled ghicha, machine reeled ghicha, ballkal yarn from the pinduncle of cocoon and machine reeled yarn)

Tropical Tussar Silk

Antheraea paphia (Linnaeus,1758)

Male and femel Tussar moth

Tussar silk is produced from the cocoons of the moth Antheraea paphia. It is semi-domesticated. Unlike Mulberry sericulture, cultivating and rearing Tussar caterpillars involves utilizing host plants found in natural forests. Its rearing and cultivation are primarily confined to the Indian States of Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, and to a smaller extent to the Indian States of Andhra Pradesh, Maharashtra, Uttar Pradesh and West Bengal in India. India is the largest producer of tropical Tussar silk. Tussar is derived from the Sanskrit "Trasara,' a weaver's shuttle, reel, or pool of thread, as they are traditionally woven on a shuttle-pit loom made from ropes, wooden beams, and poles. The shuttle is thrown from side to side during the process of weaving. Tussar silk is deeply intertwined with the identity of an Indian woman, as it is said that a bride's trousseau is incomplete without at least one saree made of Tussar silk.

Chemical Defence

Moths have found novel ways of protecting themselves against predators, using an arsenal of chemicals, both produced by themselves or sequestered from their diet. As plants developed toxins to ward off hungry caterpillars, the caterpillars in turn evolved ways of tolerating them. These toxins from the plants are sequestered by the now toxin tolerant caterpillars to chemically defend themselves from predators. In most cases the toxins acquired at this stage are passed onto not only the pupa but also onto the adult moth.

These chemically defended caterpillars or moths are usually brightly coloured, the aposematic signalling to its predators of its bitter taste and toxicity. Some moths and caterpillars also emit foul smelling odours like pyrazine as a defence mechanism against predators. Some caterpillars regurgitate their gut content containing furanocoumarins, which are photo-active compounds. These compounds can blister the skin upon contact, when activated by sunlight.

Members of the Family Zygaenidae are brightly coloured and are mainly active during the day. Their bright colours warn predators that they are poisonous. Their bodies synthesise hydrogen cyanide in levels that are lethal to small birds. In the case of *Miliona basilis*, the larvae bear an orange head and final segment, aposematically signalling to its predators of its toxicity which it acquires from the Podocarpus leaves. This is retained throughout pupation onto adulthood.

Some species in the Family Noctuidae, subfamily Condicinae, feed on plants of *Asteraceae*, particularly those containing pyrrolizidine compounds.

In the members of Tribe Lithosiini, they feed on Lichens which produce the chemical compound of usnic acid. This serves as a repellent agent against predators besides its well-established function of ultraviolet protection and antimicrobial properties.

It is hypothesized that when defensive chemicals persist onto the adult stage, their protection against predators and the availability of nectar as a new source of food from flowering plants, may have enabled some moth species to switch to diurnal lifestyle rather than relying on the protection of darkness for flight.

Miliona basilis

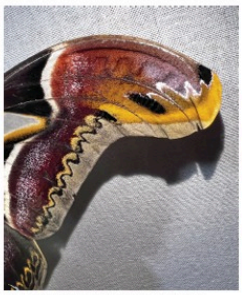
As the caterpillars feed on plants some of them become chemically defended as they sequester toxins and or come with inbuilt armour of spiky hairs and spines. The hairs often have detachable tips, that will irritate would be predators by lodging in the skin.

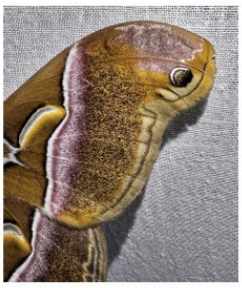
Mimesis and Mimicry

In mimesis, moths have evolved cryptic coloration and modifications to imitate various natural objects in their environment. This allows them to blend in seamlessly into their habitat or even to startle their predators when required or by directing the predators attack to a part of the body that is less important, enabling it to escape.

There can be modifications to parts of their body or parts of their wings to resemble bird droppings, eye spots, snake heads or spiders to startle their predator. Modifications can also help them to resemble a leaf or a twig to blend into their surroundings. Some of the larger emperor silk moths being large, slow and defenceless against predators have developed large eye spots and markings that resemble a snakehead on their wing tips which when flashed startle and scare off the predators.

A caterpillar mimicing a twig



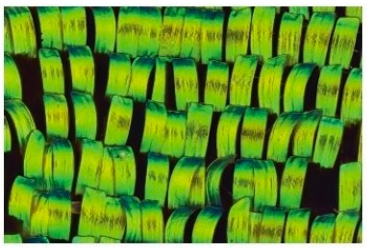


Wingtips of *Archaeoattacus edwardsii* and *Samia canningi*

Scales:

The name of the insect order of Lepidoptera to which moths belong is derived from the Greek word 'lepis' and 'pteron' for "scale winged". Thousands of overlapping scales cover the wings and body of the moth. Most scales are lamellar, or blade-like and attached with a pedicel, while other forms may be hair-like or specialized as secondary sexual characteristics. A typical scale consists of a lightweight, almost hollow, ridged chitinous plate with an upper and lower lamina. The surface of the upper lamina is structured whereas the surface of the lower lamina is smooth. Scales covering the wings are arranged in a roof tile like manner and attached to it by a stalk or pedicel. Scales help in the draining of water, thermoregulation and enable the development of patterns that help in the visual displays for mating. They also help the moth to defend itself aposematically or to conceal itself. Additionally, the scales assist in dampening sound which reduces its footprint against predators. The arrangement of different coloured and shaped scales and their ability to absorb or reflect light create an unlimited spectrum of colours and patterns.

Physical colours and colour pigments embedded in the scale create a colour effect by absorbing light components or partly reflecting them. The shape of the scale plays an important part in the colour effect. Iridescent and metallic coloration occurs at a nano level. The extremely microscopic wrinkles or grooves built into the scales help in the repeated interference, diffraction and scattering of light to create iridescent and brilliant colour effects.



The iridescent wings of the sunset moth Chrysiridia rhipheus are covered by thousands of scales, placed in a roof-tile like manner. Some of the moths not only contain pigmentation in the scales, but the physical colours can also arise from the actual structure of the scales. The iridescence is created by the process of diffraction of light at the microscopic, nano-structure level of the scales.

Moth wing scales. Color enhanced scanning electron micrograph (SEM) of a section through a scale from the wing of a silk moth (*Bombyx mori*). All butterflies and moths have these transparent scales on their wings, which have tiny ridges on them. The ridges break up and reflect light, giving the wings their shimmering iridescent appearance. (Magnification x26,500 when printed at 10 centimetres wide).

Sikkim Himalayas

Sikkim Himalayas.

Physical

Some of the largest and most spectacular moths are found in the Sikkim Himalayas. Both experts and enthusiasts continue to be amazed by their sheer volume and staggering diversity. The reason lies in the climate, location and topography of the region coming together to create a unique habitat where moths flourish. The Himalayan Mountain chain which runs from West to East abruptly changes direction when it reaches Sikkim. To the West of Sikkim, it runs North to South dominated by the world's third highest mountain, Khanchendzonga (8,586 m).

The summer temperatures vary between 18°-21°C by day and 10°-15°C by night and during the winter reach 10°-12°C by day, while it is often below freezing at night. The higher regions experience snow during the winter months and is often characterised by mist and fog at all times of the year. Rainfall is at a peak from the month of June to September thereafter decreasing rapidly.

The secondary vegetation comprises of ferns, terrestrial orchids, *Aristolochia*, *Arisaema*, *Berberis*, *Daphne*, *Enkianthus deflexus* (Griff.) C.K. Schneid, *Hydrangea heteromala* D. Don, *Impatiens*, *Viburnum grandiflorum* DC., *Hypericum*, *Lilium*, *Luculia*, *Lyonia villosa* (Hook.f. ex C.B. Clarke), *Lonicera*, *Mahonia*, *Pieris formosana* (Wall.) D.Don, *Rosa*, *Rubus*, *Vaccinium*, etc. Cultivated crops consists of Oats, Cardamom, Barley, Millet, Potato, Peas, Tea, Cabbage, Cauliflower, Kiwi fruit, etc.

Rhododendron arboreum

Some of the plants found in this zone are *Abies densa* Griff., *Acer pectinatum* Wall. Ex Pax., *Betula utilis* D. Don, *Gamblea ciliata* C.B. Clarke, *Juniperus pseudosabina* Fish. & Meyer, *Juniperus squamata* D. Don, *Larix griffithiana* Carriere, *Litsea sikkimensis* (Meisn.) D.G. Long, *Prunus rufa* Hook.f., *Rhododendron anthopogon* D. Don, *Rhododendron campanulatum* D. Don,

Rhododendron niveum the State Tree of Sikkim pg 13

Rhododendron cinnabarinum Hook.f., *Rhododendron falconeri* Hook.f., *Rhododendron hodgsonii* Hook.f., *Rhododendron lepidotum* Wall. Ex G. Don, *Rhododendron niveum* Hook.f., *Rhododendron nivale* Hook.f., *Rhododendron setosum* D. Don, *Salix myrtillacea* Anderson, *Sorbus arachnoides* Koehne, *Sorbus microphylla* Wenz., *Tsuga distichum* (L.) Rich, etc. Some of the plants growing in the alpine meadows are *Primula capitata* Hook., *Primula sikkimensis* Hook., *Saxifraga*, *Corydalis*, *Bistorta*, *Gentian*, *Aconitum*, *Polygonatum*, *Fritillaria*, *Iris*, *Euphorbia*, *Meconopsis*, *Rheum*, *Pedicularis*, *Saussurea*, *Bergenia*, terrestrial orchids and numerous species of grasses.

Primula sikkimensis

Cypripedium himalaicum

Alpine valley

Meconopsis horridula

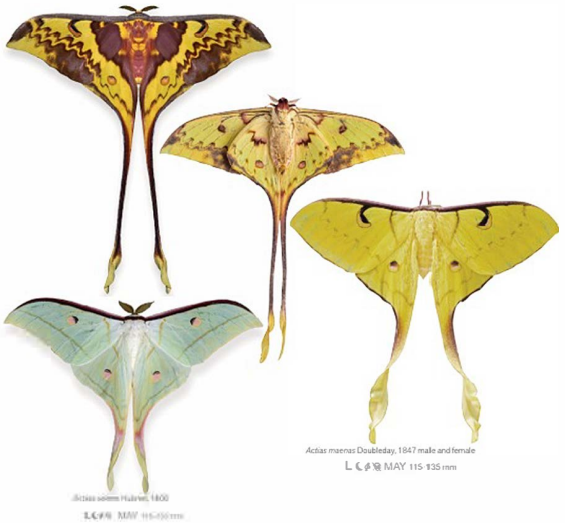
SATURNIIDAE (Emperor, Silk moths)

The name is derived from Latin; Saturnia, daughter of the god Saturn. This is a family of some of the largest moths in the world. They are slow flying, heavy bodied moths with large wings that are brightly coloured with a woolly appearance. The adult male has broadly branched antennae. The wings are usually held outspread while resting with some of the species having a window or an eye spot on both their forewings and hindwings or the likeness of a snake's head at the tip of the forewing. In some species the hindwing is extended into a long tail. The largest moth of India, Attacus atlas, with a wingspan of up to 250 mm across is found in this family. They have a very short lifespan in their adult stage. The proboscis is absent or vestigial and they are unable to feed. They are mostly nocturnal. Caterpillar is mostly large to very large and fleshy, often with brightly coloured knobs and spines. Most species spin cocoons.

Caterpillars feed on *Acer, Salix, Betula, Moringa, Prunus, Terminalia, Quercus, Magnolia, Cinnamomum, Rosabuxus, Shorea, Tectona, Capparis, Ailanthus, Litsea, Berberis, Cassella, Ricinus, Zanthoxylum*, etc.

Subfamily Rhodinia

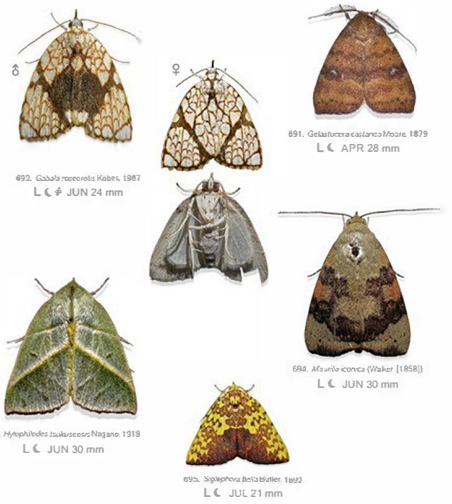
Rhodinia newara Moore, 1872 female and male
L ♂♀ MAY 115-136 mm



Actias maenas Doubleday, 1847 male and female
L ♂♀ MAY 115-135 mm

Actias selene Hübner, 1806
L ♂♀ MAY 115-150 mm

Gallery of Moths



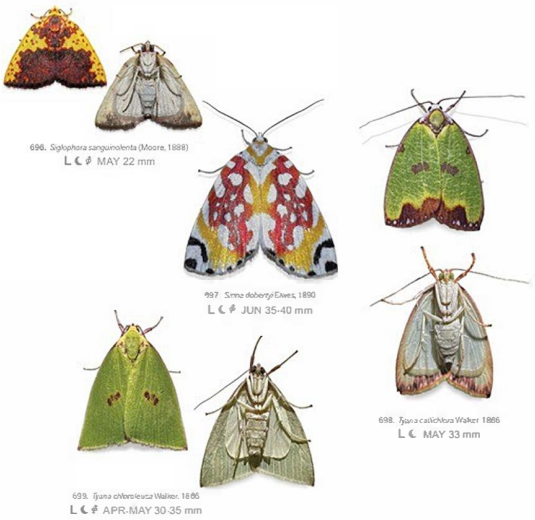
692. *Gabala rosearata* Kobes, 1987
L ♂♀ JUN 24 mm

691. *Gelastocera castanea* Moore, 1879
L ♂ APR 28 mm

693. *Mytophiodes tsukusaensis* Nagano, 1918
L ♂ JUN 30 mm

694. *Masuda iconica* (Walker, [1858]) L ♂ JUN 30 mm

695. *Siglephora bellatrix* Butler, 1882
L ♂ JUL 21 mm



696. *Siglephora sanguinolenta* (Moore, 1888)
L ♂♀ MAY 22 mm

697. *Sinna dohertyi* Elwes, 1890
L ♂♀ JUN 35-40 mm

698. *Tyana calichlora* Walker 1866
L ♂ MAY 33 mm

699. *Tyana chloroleuca* Walker, 1866
L ♂♀ APR-MAY 30-35 mm

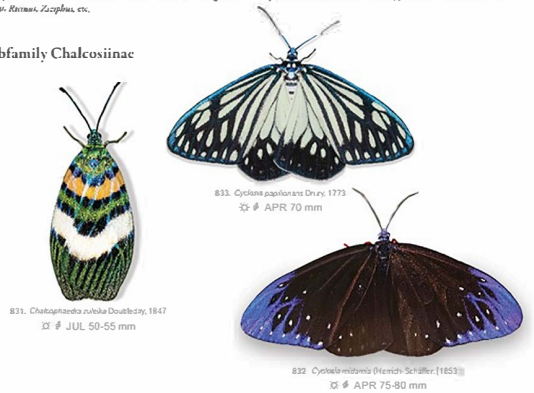
Gallery of Moths

Family Zygaenidae (Burnet moths)

The name "Burnet" for these moths has an interesting origin. It is derived from the medieval Latin word "burneta", which referred to a dark brown cloth. The moths were named after this fabric due to their rich, dark colouration. The association with the cloth likely reflects the deep hues of their wings. They are small to medium-sized moths that are mostly brightly coloured. Sometimes the hindwings are extended into a long tail. Proboscees are present. Antennae are clubbed, thread like or mostly feathery and they do not taper to the tip. They are chemically defended as they synthesize hydrogen cyanide in levels that are lethal to small birds. They are mostly diurnal flower visitors and are known to mud-puddle.

Caterpill are aretleaf skeletonizers and feed on *Rhododendron, Quercus, Buddleja, Hibiscus, Camellia, Litsea, Polygonum, Rosa, Melastoma, Malus, Rubus, Ricinus, Ziziphus*, etc.

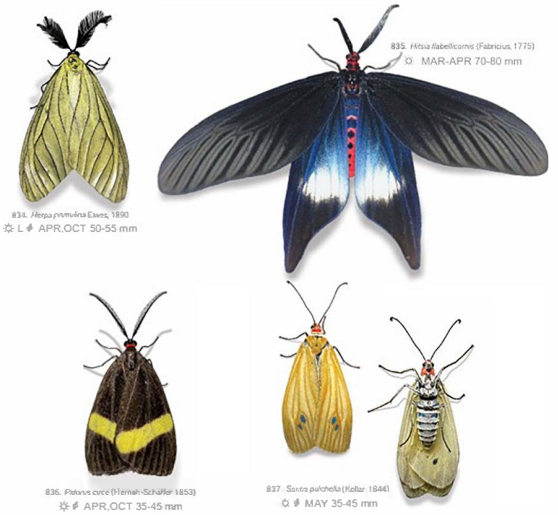
Subfamily Chalcosiinae



831. *Chalcoprasedia zuleika* Doubleday, 1847
☼ ♂ JUL 50-55 mm

833. *Cyclosia papilionaris* Drury, 1773
☼ ♂ APR 70 mm

832. *Cyclosia midamia* (Hemich-Schäffer, [1853])
☼ ♂ APR 75-80 mm



834. *Herpa pyrrhina* Elwes, 1890
☼ L ♂ APR,OCT 50-55 mm

835. *Histia flabellicornis* (Fabricius, 1775)
☼ MAR-APR 70-80 mm

836. *Pidorus cana* (Hemich-Schäffer 1853)
☼ ♂ APR,OCT 35-45 mm

837. *Sorita pulchella* (Kollar, 1844)
☼ ♂ MAY 35-45 mm