= Chrysiridia rhipheus =

Chrysiridia rhipheus (Madagascan sunset moth) is a day @-@ flying moth of the family Uraniidae . It is considered one of the most impressive and appealing @-@ looking lepidopterans . Famous worldwide , it is featured in most coffee table books on Lepidoptera and is much sought after by collectors . It is very colourful , though the iridescent parts of the wings do not have pigment ; rather the colours originate from optical interference . Adults have a wingspan of 7 ? 9 cm (2 @.@ 8 ? 3 @.@ 5 in) .

Dru Drury , who described the moth in 1773 , placed it in the genus Papilio , considering it a butterfly . Jacob Hübner placed it in the moth genus Chrysiridia in 1823 . Later redescriptions led to junior synonyms such as Chrysiridia madagascariensis (Lesson , 1831) .

At first the moth was thought to be from China or Bengal , but was later found to be endemic to Madagascar . It is found throughout the year in most parts of the island , with peak populations between March and August , and smallest numbers between October and December . Females lay about 80 eggs under the leaves of Omphalea spp . The caterpillars are whitish @-@ yellow with black spots and red feet and are covered in club @-@ ended black setae . Silk spun from the mouth helps the caterpillars hold on to smooth leaves and climb back to the plant when they fall . After completing four instars , the caterpillars spin an open network cocoon . The pupal stage lasts from 17 to 23 days . Chrysiridia rhipheus is the sole specialist herbivore of the four species of Omphalea in Madagascar . Omphalea is toxic : the toxins are sequestered by the feeding caterpillar and retained in the pupal and adult stages . Thousands of these moths migrate between the eastern and western ranges of their host plants .

= = Taxonomy = =

The Madagascan sunset moth was first described by the British entomologist Dru Drury in 1773 from a specimen obtained from a Captain May of Hammersmith . Because of its resemblance to swallowtail butterflies , Drury described the species as Papilio rhipheus.1 The specimen Drury received had the head of a different species attached , probably that of a butterfly , which had clubbed antennae ? this trait is frequently used to differentiate moths from butterflies . Once the inaccuracy in Drury 's specimen was found , the moth was placed in the genus Urania , until 1823 when the German entomologist Jacob Hübner placed it in a new genus , Chrysiridia . The moth has also been described under other names . Because Drury described his specimen as having clubbed antennae and being tailless , William Swainson thought it was a different species than the complete specimen described by Cramer . In 1833 , Swainson named the butterfly Rhipheus dasycephalus and the moth Leilus orientalis . Other synonyms include U. crameri by Maassen in 1879 and U. ripheus var. madagascariensis by Lesson in 1831 .

Native Malagasy people call it Adriandolo or Lolonandriana , from lolo for " spirit " or " butterfly " and andriana for " noble " or " king " , therefore meaning " noble butterfly " , " noble spirit " , " king butterfly " or " king spirit " .

The genus Chrysiridia is entirely African and the only other species in the genus is the East African C. croesus . Chrysiridia is one of three diurnal uraniine genera . The other two genera are Urania , its sister taxon , and Alcides , the most basal . In the group , the use of Endospermum is an ancestral state (a plesiomorphy) . The more basal Alcides feed on Endospermum and Omphalea , while Urania and Chrysiridia feed only on Omphalea .

= = Description = =

Chrysiridia rhipheus has a wingspan of 7 ? 9 centimetres (2 @.@ 8 ? 3 @.@ 5 in) , and sometimes up to 11 centimetres (4 @.@ 3 in) . Moths from the highlands , 900 ? 1 @,@ 080 metres (2 @,@ 950 ? 3 @,@ 540 ft) , have a median wingspan of 7 cm (2 @.@ 8 in) ; moths from lower altitudes , 600 m (2 @,@ 000 ft) , have a median wingspan of 9 cm (3 @.@ 5 in) . Like many other uraniine moths , the sunset moth has an uncanny resemblance to swallowtail butterflies

, especially in its tails and colourful wings , and can easily be mistaken for a butterfly .

The sunset moth is black with iridescent red , blue and green markings . There is a fringe of white scales on the wing edges , wider on the hindwings . The moth has six tails , very often lost or damaged during its life . Pattern variations are common , and the moth is often partly asymmetrical ; one of the factors causing this is temperature shock during the pupal stage .

= = = Wing microstructure = = =

Unlike in many other moths , the colour of C. rhipheus 's wings does not come from pigments . The colour originates from coherent scattering and interference of light by the microstructure of the ribbon @-@ like scales covering the moth 's wings . These structural characteristics make this species and its Neotropical relative Urania common subjects of research in optical science .

The colours on the Madagascan sunset moth 's wings are produced by the conjunction of two optical phenomena :

An air @-@ cuticle multilayer in the scales creates optical interference . Each scale contains cuticle layers with randomly located blocks of cuticle that hold them in place and maintain an air gap between them . The layers and air gaps are narrower than the wavelength of visible light . The structure varies from one layer at the proximal end of each scale , to about six layers at the distal end . This multilayer structure strongly reflects certain wavelengths of light , which are determined by the thicknesses of the layers and the angle at which the light hits the scale .

The scales are highly curved , which creates inter @-@ scale reflection . This mechanism is unusual among Lepidoptera . The proximal part of each scale is almost flat ; the scale then gradually curves up and then steeply bends down at the distal end , covering the proximal part of the next row of scales . Because of this shape , adjacent rows of scales have valley @-@ like grooves between them . This allows light to strike one scale , reflect at a roughly 90 ° angle , strike the next scale , and be reflected away from the wing . Because the angle of each reflection is far from normal incidence , the interference effect favours reflection of different colours of light than are seen when light strikes near the top of the curved part of the scale .

The colour seen in each part of the wing is the combination of the colours reflected by these two effects .

Because the cuticle layers are arranged in rows , with a cylindrical curve , the amount of the second type of reflection is dependent on the polarization of the incoming light . This makes the moth 's overall colour polarization @-@ dependent . Many insects can detect polarization of light , so it has been proposed that this feature may be used as a visual signal between moths . This has not yet been studied , however .

= = Distribution and habitat = =

Drury 's specimen was given to him by Captain May of Hammersmith and believed to have come from China . Cramer believed the specimen came from Chandernagore in Bengal , however , giving rise to the French name " page de Chadernagor " . It is now known that Chrysiridia rhipheus is endemic to Madagascar . Thousands of adult moths seasonally migrate between geographically isolated populations of their host plant Omphalea spp . They can be found almost everywhere on the island , except in the south @-@ west and the extreme subdesertic south of the Androy where their host plant is absent . They migrate from the three species in the dry deciduous forest in the west (O. ankaranensis , O. occidentalis and O. palmata) to the eastern rainforest species (O. oppositifolia) . The western species are largely in protected areas . The eastern species , on the other hand , is mostly unprotected and dispersed in widely scattered populations threatened by deforestation . Being the only evergreen species , O. oppositifolia is probably crucial for the moth 's survival . The Jamaican moth Urania sloanus , from the same subfamily (Uraniinae) , most likely became extinct after the loss of one of its host plant species .

The moths migrate in response to changes in the host plants . Chrysiridia larvae defoliate the whole plant , and even eat the flowers and fruit , and thus have a considerable negative impact on the

reproduction and survival of seedlings . The plants probably react by changing their nutrient and secondary compound levels , becoming toxic to the larvae and causing high mortality . Omphalea populations that are not damaged by moths for long periods of time have lower toxicity . These factors cause mass increases in local population , followed by sudden crashes . The population crashes might result from increased larval mortality , but are more likely caused by the emigration of the adult moths . Through semiochemicals , the plant may recruit hymenopteran parasitoids as a protection , hence playing a role in the population dynamics of the moth .

= = = Host plants = = =

Like C. croesus and species of the genus Urania , C. rhipheus is a specialist species whose caterpillars feed strictly on species of the pantropical genus Omphalea (Euphorbiaceae) . Four species of the genus Omphalea are endemic to Madagascar :

O. ankaranensis , a shrub from the limestone karst of northern Madagascar
O. palmata , a dry forest shrub , closely related to O. ankaranensis , but from western Madagascar
O. occidentalis , also a dry forest species of western Madagascar
O. oppositifolia , a tree from the east coast rainforest of Madagascar

Omphalea , like many other members of the Euphorbiaceae , possesses leaf nectaries that attract polistine wasps , which are predators of early instar caterpillars . The leaf nectaries also attract ants . The ants usually protect their host plant , eating both the nectar and plant @-@ eating insects on it . However , they generally completely ignore Chrysiridia caterpillars , making it likely that the caterpillars possess a chemical deterrent as a primary defence . This chemical deterrent comes from the host plants . Omphalea species contain polyhydroxy alkaloids potentially sequestered or excreted by the caterpillar , the pupa and the adult moth .

= = Behaviour = =

Unlike most moths , the sunset moth is day flying and the bright aposematic colours warn predators of its toxicity , a strategy seen in many diurnal moths . Another habit the moth has in common with many butterflies is the night resting posture ? the wings are held vertically over the back . During their migrations they roost in a group for the night . The moth flies over the crown of trees and in clearings . Sometimes because of high winds it is carried about 100 m (300 ft) , it then falls , inert and wings closed , to the ground .

= = = Life cycle = = =

Continuous generations of the moth are present all year . The highest populations are found from March to August (fall and winter) , while the lowest are from October to December (spring) . The females lay their eggs late in the afternoon or at nightfall , and locate potential oviposition sites visually . Like the eggs of other Uraniidae , the sunset moth 's eggs are domed with projecting ribs . A single egg weighs about 1 milligram (3 @.@ 5 × 10 ? 5 oz) and usually has 17 ribs , but sometimes 18 or less often 16 . The eggs are usually laid on the lower surface of Omphalea leaves , but occasionally on the upper surface . Eggs are laid in groups of 60 to 110 , usually about 80 .

After they hatch , the small caterpillars only eat the tissue (parenchyma) between the veins of the leaves . They do this to avoid the sticky and toxic latex produced by the plant 's laticifers and transported in the veins . After 3 ? 4 days , the caterpillars also eat flowers , fruit , tendrils , petioles and young stems (as well as continuing to eat leaves) , defoliating the entire plant . They are particularly fond of the glands at the base of the leaf , near the petiole . They can deal with the chemical defences in the latex , which does not cause the problem of mouthpart coagulation . The caterpillars spin silk from their mouth with an ' ? ' motion of the head as they walk , this keeps them from falling from the smooth surface of the leaves . The silk also permits them to climb back to the plant should they fall . Strong rain makes them fall despite the silk . There are four instars , and the caterpillar stage lasts from two months in the warm season to two and a half to three months in the

cold season . The caterpillar is whitish @-@ yellow with black spots and red feet and is covered in club @-@ ended black setae . It has five pairs of prolegs on segments 3 to 6 and 10 , and six true legs attached to the thorax .

After completing all but its last moult , the caterpillar spins a cocoon out of silk . The cocoon can be in the tree crown or between two leaves , but is most often near the ground , between moss and bark . It is an open network cocoon with large and irregular mesh . In the warm season , the cocoon takes about 10 hours to spin , the metamorphosis takes place about 29 hours later and lasts about 6 minutes . These durations are slightly longer in the cold season . The chrysalis stage lasts 17 days in November , the warmest month , and 23 days in July , the coldest month . Five to six days before eclosion , the motifs of the wings start to become visible . The moth emerges during the night or in low light , by splitting the pupal case from the top . Once out of the pupal exuvia (the pupal exoskeleton) , the moth finds a horizontal surface , from which it suspends itself by its four anterior legs . The wings are deployed in about 10 minutes , by pumping haemolymph into the wing veins . The moth then beats them a few times , waits 45 minutes to let them harden , then beats them lightly again . The moth finally takes flight between one and a half to two hours later .

= = = Nectar sources = = =

Adult moths prefer white or whitish @-@ yellow flowers as a nectar source , which indicates that visual cues play a large role in their selection . Most flowers visited are inflorescences of small flowers or have dense filaments , giving them the appearance of a bottle brush , often because of the conspicuous projecting stamens as in many Leguminosae (Mimosoideae , Myrtaceae and Combretaceae) . However , not all white flowers elicit a response : the white and showy flowers of Omphalea oppositifolia are not visited by the adult moths . Nectar sources include the flowers of :

Terminalia catappa (Indian almond)
Camellia sinensis (tea plant)
Eriobotrya japonica (loquat)
Eucalyptus spp . , especially E. saligna
Cussonia vantsilana
Mangifera indica (common mango tree)

All these flowers are white , with the exception of Camellia sinensis which has a yellow centre , and all either have dense filaments or are formed of tight clusters of small flowers .

= = In culture = =

This spectacular moth is considered one of the most impressive and beautiful Lepidoptera , rivalling almost any of the butterflies in brilliance of colouring and form . It is featured in most coffee table books on the Lepidoptera , and is much sought after by collectors . It is collected in the wild , and raised commercially for the international butterfly trade ; its wings were used to make jewellery in the Victorian era . The Madagascan sunset moth appeared on a 6 maloti postage stamp in the Lesotho Postal Services Butterflies of Africa issue of 20 August 2007 . Only one of the four species of host plants , Omphalea oppositifolia , is used to raise the moth commercially , mainly using plants collected in the wild , but also some cultivated for the purpose .

In Malagasy , lolo is polysemous for " butterfly " or " moth " and " soul " , there is little doubt that this is because a pupa resembles a covered corpse and that the adult emerges from it ? like the soul from body of the dead . The Malagasy people believe the soul of the dead or of ancestors appears in the form of a Lepidopteran , and thus to attack it is to attack the ancestors .