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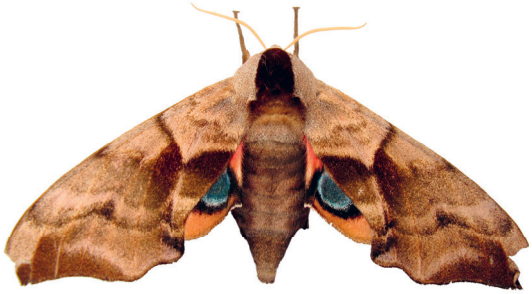


INTRODUCTION

The world of moths

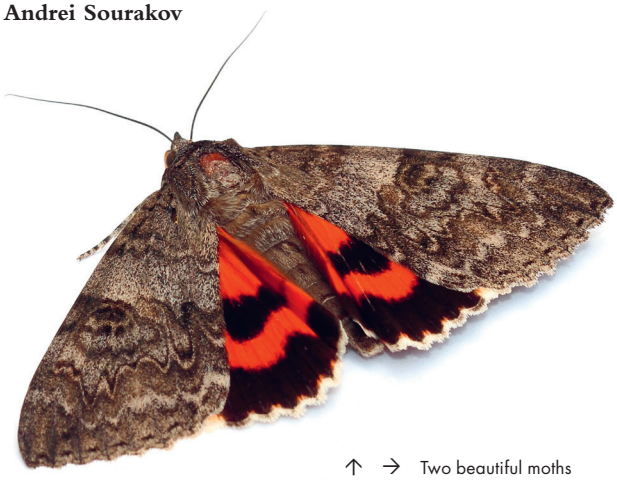
It's the 1970s, and I am walking from school past a high-rise apartment building. I suddenly stop in my tracks, while my heart begins to race. On the brick wall, I detect the unmistakable triangular shape of the Red Underwing moth. Slowly, not to startle it, I approach; even more slowly, I extend my hand and touch its hairy back. The moth flicks up its forewings, exposing a flash of red from hind wings normally hidden from view, in a desperate attempt to scare me off. When I touch it again, the moth zooms up and perches high above the ground, instantly becoming just another "scar" on the bark of the tall poplar.

The diet of their caterpillars sustains the intimate connection between moths and plants. Which plants occur where is determined by numerous factors, from geography and evolutionary history to soil composition and levels of sunlight and water. And while different continents may have different moth faunas, each moth community—whether in a rainforest or desert—bears a distinct imprint of its habitat. According to both habitat and geographic region, moths also interact with a host of other organisms—as large as grizzly bears and as tiny as viruses.

In the present volume, we first examine the moth's four stages of development, from egg to adult, and its biology and behavior in different environments, before venturing to explore examples of moths found in vast habitats of tropical forest, grasslands, deserts, and tundra. Certain moths have undergone interesting adaptations to occupy aquatic habitats, and it may come as a surprise to many that some species develop in water. There are also moths that live in sloths' fur, drink bird tears, or even, as caterpillars, predate on wasps or mollusks. The secret world of moths is truly remarkable!

Of course, moths are mobile creatures, and many of them move between habitats in search of nectar for themselves or plants to lay their eggs on. Some species even migrate seasonally and others are, like us, highly versatile, and have formed different races specifically adapted to the habitats of their geographic region. These, however, are exceptions rather than the rule, and I hope that showcasing moths as integral parts of their respective ecosystems will help in appreciating these species' roles in their environment. Today, when natural habitats are disappearing at an unprecedented rate, yielding to those created by humans, underscoring the connection between habitat type and the unique species that they harbor becomes vitally important. Only by conserving habitats can we preserve the precious species that inhabit them.

Andrei Sourakov



↑ → Two beautiful moths that the author first encountered as a child inside the city: the Red Underwing (*Catocala nupta*) that develops on poplar (top) and the Elephant Hawk Moth (*Deilephila elpenor*), whose caterpillars eat rosebay willowherb along rail tracks and in urban wasteland.

What is a moth?

The evolution of moths—insects of ancient lineage in the order Lepidoptera—is intimately entwined with that of plants. While their diversification occurred during the rise of flowering plants from around 130 million years ago, gymnosperm plants 70 million years earlier appear to have played an important role in their origins and speciation.

THE ORIGINS

It was the recent discovery of a 200 million-year-old fossilized moth in Germany that pushed back the probable date of Lepidoptera origins and prompted the hypothesis that during the Jurassic period, before there were flowers, moths developed a sucking proboscis to sip droplets of moisture from the tips of immature seeds of plants related to today's conifers. The proboscis—part of the maxilla (mouthparts) called galeae, zipped together into a straw-like organ—continued to evolve and today distinguishes most (though not all) moths and butterflies from other insects, whose classification has traditionally been based on mouthparts. Some moths have retained their chewing mouthparts, but they are in a minority.

MOTH OR CADDISFLY?

Their closest relatives are Trichoptera (caddisflies), which also developed in the early Jurassic period, and together with Lepidoptera form a group called Amphiesmenoptera. While the two share some characteristics, such as larvae that can produce silk, there are major differences; the wings of moths, for instance, are covered in scales, while those of caddisflies are hairy.

MOTHS VERSUS BUTTERFLIES

People often wonder how butterflies relate to moths and may be surprised to know there are no major differences. Butterflies, which evolved from a common ancestor about 110 million years ago, form a group of just eight families within Lepidoptera, otherwise comprised of some 130 moth families, so are simply an offshoot of the moth evolutionary tree. Based on their genetic analysis, plume moths (Pterophoridae) are probably most closely related to butterflies. Like moths, certain butterflies, including many skippers and the American moth-butterflies (Hedylidae) fly at night, while numerous moths have independently evolved day-flying habits at least 30 times during their evolution.

ECOLOGICAL IMPORTANCE

Being more ancient, moths have experienced and adapted to a far greater range of conditions and environments than butterflies and thus are more diverse in their morphology and lifestyles. And while the caterpillars of a few moth species—those that eat crops—may have given moths a bad name, most species exist in balanced relationships with their ecosystems, playing crucial roles as pollinators and food for vertebrates. Many species have developed such intimate relationships with their hosts and the flowers they pollinate that neither can exist without the other. As this book reveals, across diverse ecosystems, moths play a crucial role.

↑ Among more advanced moths are the bombycoids, such as this Hummingbird Hawk Moth (*Macroglossum stellatarum*) with a fully developed proboscis that is used to sip nectar in flight.

↖ A member of the mandibulate archaic moth family Micropterigidae, this Marsh Marigold Moth (*Micropterix calthella*) as an adult feeds on pollen grains of various plants.

Moth classification

Of the millions of animal species on Earth, two-thirds are insects. After Coleoptera (beetles), Lepidoptera (butterflies and moths) and Hymenoptera (ants, bees, wasps) are the two most numerous orders, and together these three orders are responsible for half of all insect species.

Among Lepidoptera, in terms of species, moths outnumber butterflies by more than eight to one. Taxonomists attempt to group animals so that each category, such as family or genus, is monophyletic (includes all descendants of a single ancestor and nothing else). "Moths" is not a category as such, while butterflies are. Why? Because butterflies (with their seven families) are an offshoot of moths that derived from a single ancestor, branching off moths' evolutionary tree around 100 million years ago.

The approximately 150,000 species of moths are grouped in over 120 families, which in turn are divided into subfamilies and genera. This classification changes constantly with better understanding of the evolutionary history—morphological studies of the past 250 years are now supplemented by DNA analysis. While most of the larger moths, such as Saturniidae (saturniids or giant silk moths) and Sphingidae (sphingids, sphinx moths, or hawk moths) have been described, much work remains to describe the diversity of rapidly vanishing, smaller, tropical moths.

A moth family can be tiny or numerous. For instance, the family Endromidae to which the Kentish Glory (*Endromis versicolora*) belongs, contains only about 30 species, while the family Erebidae (erebids) includes tens of thousands of species belonging to diverse subfamilies such as tiger, lichen, and wasp moths (subfamily Arctiinae), underwing moths and their relatives (Erebinae), and tussock moths (Lymantriinae). Superficially, moths belonging to the same family can look very different from each other and can lead diverse lifestyles, but they are unified by more stable morphological characters, such as wing venation.

A SELECTION OF MOTH FAMILIES

Here we list and illustrate a few representatives of the most speciose families mentioned in the book—a more complete list of families can be found on page 281.

ACROLOPHIDAE
Tubeworm moths (acrolophids)

ANTHELIDAE
Australian lappet moths (anthelids)

BATRACHEDRIDAE
(batrachedrids)

BOMBYCIDAE
Silk moths (bombycoids)

BRAHMAEIDAE
Brahmin moths (brahmaeids)

COLEOPHORIDAE
Casebearer moths (coleophorids)

COSMOPTERIGIDAE
(cosmopterigids)

COSSIDAE
Carpenter moths (cossids)

CRAMBIDAE →
Sky-pointing moths (crambids)

DREPANIDAE
Hook-tip moths and casebearers (drepanids)

ELACHISTIDAE
Grass-miner moths (elachistids)

ENDROMIDAE
(endromids)

EREBIDAE ↓
Tiger, lichen, and wasp moths, underwing moths, tussock moths, owlet moths, woolly bears (erebids)

GEOMETRIDAE ↓
Inchworms, butterfly moths (geometrids)

GRACILLARIIDAE
Leaf blotch miner moths (gracillariids)

LASIOCAMPIDAE ↓
Lappet moths or eggars (lasiocampids)

LIMACODIDAE
Slug moths (limacodids)

MEGALOPYGIDAE ↓
Flannel moths (megalopygids)

MIMALLONIDAE
Sack-bearer moths (mimallonids)

NEPTICULIDAE
Leaf miners (nepticulids)

NOCTUIDAE ↓
Owlet moths (noctuids)

NOLIDAE ↓
Tuft moths (nolids)

OECOPHORIDAE
(oecophorids)

PLUTELLIDAE
(plutellids)

NOTODONTIDAE ↓
Prominent moths (notodontids)

PRODOXIDAE
Yucca moths (prodoxids)

PSYCHIDAE
(psychids)

PTEROLONCHIDAE
(pterolonchids)

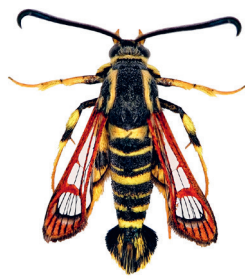
PTEROPHORIDAE
Plume moths (pterophorids)

PYRALIDAE
(pyralids)

SATURNIIDAE ↓
Silk moths, oak worm moths, buck moths (saturniids)

SCYTHRIDIDAE
Flower moths (scythridids)

SESIIDAE
Clearwing moths (sesiids)



SPHINGIDAE ↓
Hawk moths (sphingids)

STATHMOPODIDAE
(stathmopodids)

TINEIDAE
Fungus moths (tineids)

TORTRICIDAE ↓
Carpenter moths (tortricids)

URANIIDAE
Sunset moths (uraniids)

YPONOMEUTIDAE
Ermine moths (yponomeutids)

ZYGAENIDAE ↓
(zygaenids)

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