



# CONTENTS

**6**  
.....  
INTRODUCTION

**10**  
.....  
WHAT IS A MOTH?

**12**  
.....  
MOTH CLASSIFICATION

**14**  
.....  
LIFE CYCLE

**48**  
.....  
INTERACTIONS

**84**  
.....  
MOTHS OF TROPICAL RAINFORESTS

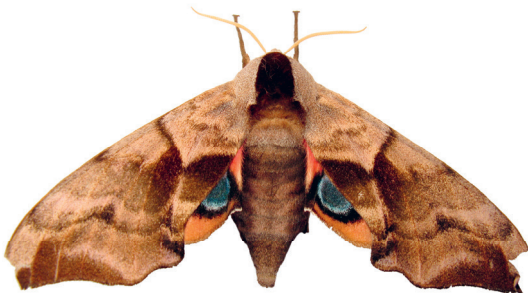
**116**  
.....  
MOTHS OF GRASSLANDS  
& MEADOWS

**156**  
.....  
MOTHS OF DESERTS & TUNDRA

**190**  
.....  
MOTHS OF TEMPERATE DECIDUOUS  
FORESTS

**224**  
.....  
MOTHS ON CONIFEROUS  
& WETLANDS PLANTS

**262**  
.....  
MOTHS IN AGROECOSYSTEMS  
& AROUND HOMES



**280** Glossary

**281** Moth Families

**282** Resources

**284** Index

**288** Acknowledgments





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# INTRODUCTION

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# The world of moths

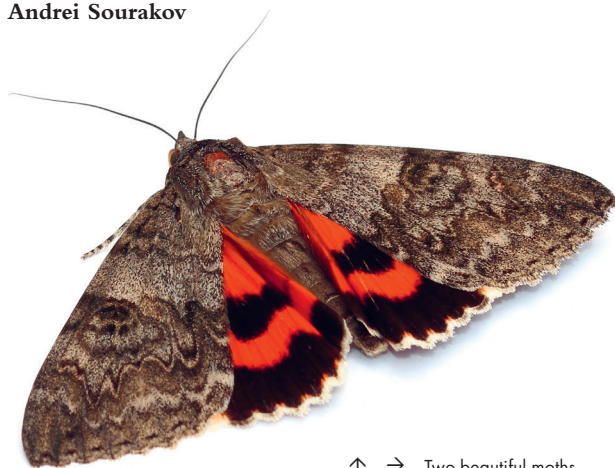
It's the 1970s, and I am walking from school past a high-rise apartment building. I suddenly stop in my tracks, while my heart begins to race. On the brick wall, I detect the unmistakable triangular shape of the Red Underwing moth. Slowly, not to startle it, I approach; even more slowly, I extend my 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.

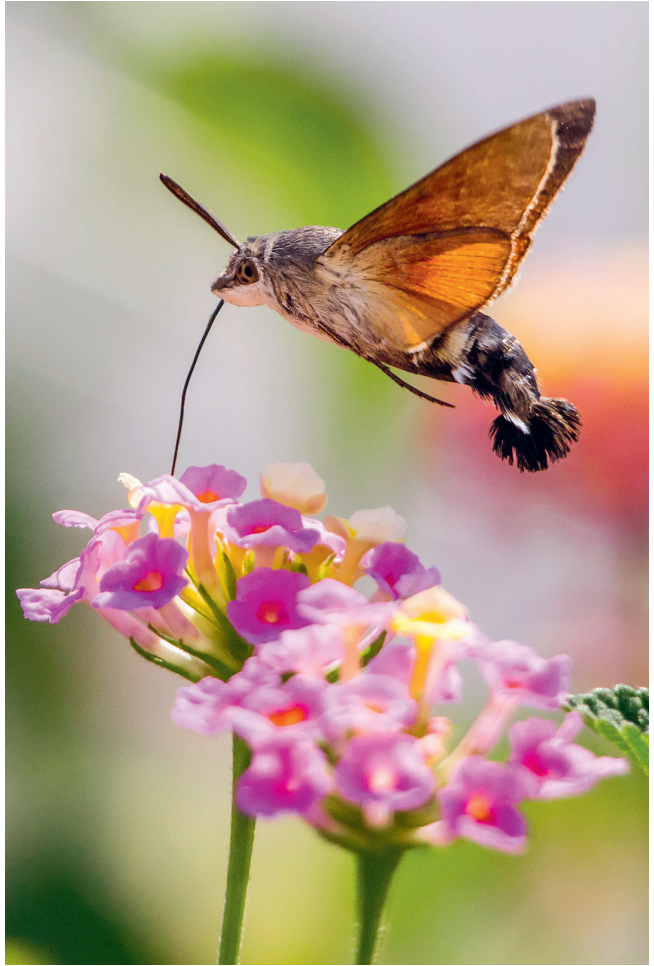
## MOTH OR CADDISFLY?

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.

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## 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 (antheleids)

### 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)

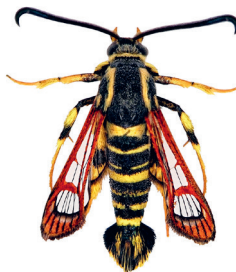


**SCYTHRIDIDAE**

Flower moths (scythrroids)

**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 (ypnomeutids)

**ZYGAENIDAE** ↓

(zygaenids)





# INDEX

## A

abdomen 45  
Abstruse False Looper 239  
*Acrolophus pholeter* 131  
Adult Oak Beauty Moth 200  
African savanna 124–7  
agriculture 53, 119, 122, 262–79  
Agrippina Moth 65, 88, 93, 102  
alpine tundra 178  
American Lappet Moth 178, 186–7  
Andes 131  
Angoumois Grain Moth 270–1  
antennae 52  
ants 20, 61, 82, 94, 209  
aposematism 35, 72, 92, 100, 106, 114, 142, 258  
*Apotomis frigidana* 177  
Apple Ermine 204–5  
*Araucaria* trees 26, 227, 228, 233  
*Araucarivora gentilii* 233  
Arch Drab 127  
Arctic Tiger Moth 175  
Arctic Woolly Bear Moth 174–5  
Army Cutworm 132  
armyworms 35, 78, 162  
Artemis Moth 206  
Asian Atlas Moth 21  
Asian Corn Borer Moth 79, 80–1  
Asimina Webworm Moth 30  
Atlas Moth 40, 65, 88  
Australian Pond Moth 227, 242, 245  
Australian Processionary  
Caterpillar Moth 21  
Australian savanna 128–9*ic*

## B

bacteria 78–9, 269  
Baldcypress Leaf Roller 227

ballooning 27, 202  
Banded Euproctis 127  
Banded Woolly Bear 198–9  
Batesian mimicry 71, 92  
bats 18, 72, 80, 83, 87, 90, 91, 112, 159, 205, 206  
Beautiful Tiger Moth 125  
bee hawk moths 138  
biodiversity 88–9, 92, 99, 229  
Cerrado 122  
deserts 160  
grasslands 140  
oak trees 196  
biological control 163, 171, 266  
Bird-cherry Ermine 204, 205  
biting midges 78  
Black Witch Moth 62  
Black-tipped Heliolonche 184–5  
Blinded Sphinx 214–15  
Blue Underwing 218–19  
Bogong Moth 132–3  
Bordered White 256–7  
*Bostra pyroxantha* 127  
*Bradypodicola hahneli* 95  
Brindled Pug 201  
Bristly Cutworm Moth 53  
bromeliads 91  
Brown China Mark 17, 250–1  
buck moths 53, 172–3  
burnet moths 92, 136, 152–3  
Burnished Brass Moth 135  
Burns' Buck Moth 172  
bursa copulatrix 54

## C

Cabbage Looper 26, 77, 264  
Cabbage Palm Moth 166  
cacti 159, 160, 162–3  
Cactus Moth 163  
caddisflies 10  
camouflage 66–7, 70, 74, 110, 138, 200–1  
Canadian Sphinx 246

carpenter moths 168–9, 230  
Casebearing Clothes Moth 271  
castanets 80  
castniid moths 51, 55, 91, 128  
Catalpa Sphinx 209  
caterpillars 22–32, 45, 64–5, 72, 74–9  
African savanna 126–7  
aquatic 242–3  
biodiversity 89  
camouflage 66  
feeding 18–19  
as food 127, 236  
frass 30  
hearing 82  
legs 26–7  
metamorphosis 38–9  
mimicry 68–71  
molt 31, 77  
overwintering 21  
warning calls 82–3  
*see also* silk  
*Catocala* 197  
Cecropia Moth 22, 34, 37, 198  
*Cenatonyx satanaria* 200  
*Ceratophaga vicinella* 131  
Cerrado 120–3  
Cheetah Moth 125  
*Chingizid* 168  
clearwing moths 18, 42, 71, 230  
climate change 87, 98–9, 158  
Clouded August Thorn 197  
*Cocciphila silvatica* 229  
cocoon 32–7, 41, 65, 203  
Codling Moth 51, 266  
coevolution 92–3  
color 42, 88  
camouflage 66–7  
dimorphism 55  
eggs 20, 21  
metallic 134–5  
toxic species 70  
*see also* aposematism  
Columbia Silk Moth 234  
Comet Moth 88, 112–13

Common Clothes Moth 177, 270, 271  
Common Fruit-piercing Moth 62  
compound eyes 39, 46  
Comstock, John Henry 180  
coniferous forests 224–61  
Copitarsia Worm Moth 58  
coremata 51  
Corn Earworm 266, 278–9  
cornuti 54  
courtship 50–5, 80–1  
crambid moths 34, 51, 58, 146, 176, 200, 211, 250  
Cream-striped Owl Moth 124  
*Cretonotus* 51  
cremaster 32  
Creosote Moth 161  
Crimson-speckled Flunkey 125  
CRISPR 269  
crochets 26, 65, 244  
Crocus Geometer 198–9  
*Cryptoses choleopi* 95  
Curve-lined Owllet Moth 26  
cutworms 26, 53, 132, 162, 170, 178, 179, 227, 239  
cycad moths 240  
*Cydia duplicana* 230

## D

Dali, Salvador 93  
Darwin, Charles 92–3  
Darwin's Moth 97  
day-flying 10  
de Grey, Thomas 94  
Death's-head Hawk Moth 62  
Death's-head Sphinx Moth 82  
deforestation 98–9, 119  
desert moths 156–89  
Dew Moth 106  
Diamondback Moth 34, 264  
diapause 21, 37, 250  
*Dirphia araucariae* 233  
Dogbane Tiger Moth 72  
Dyar, Harrison Gray Jr. 95

## E

Eastern Tent Caterpillar 19, 20  
Echo Moth 240  
eclosion 32, 40, 61, 94, 102, 146, 192–3, 231, 244  
Edwards Wasp Moth 59  
eggars 140–1, 186, 204  
  *see also* lappet moths  
eggs 16–21, 25, 31, 54, 58, 204  
  incubation time 21  
  parasitoids 74–5  
  poisonous 21  
  shape 17  
Elm Spanworm 199  
*Endoxyla leucomochla* 169  
Endromidae 12  
Enigma Moth 232  
*Entephria lagganata* 178  
erebid moths 12, 34, 58, 62, 65, 81, 136, 170, 174, 240  
*Erebus ephesperis* 102–3  
*Eremocossus vaulogeri* 168  
ermine moths 204–5  
Erythrina Borer 34, 272–3  
Erythrina Leaf Miner 21  
Erythrina Leaf Roller 34, 37  
Esther Moth 238  
*Eucosma* 141  
Eurasian steppes 140–1  
European Buff-tip Moth 66  
European Sundew Moth 148–9  
Evergreen Bagworm 37, 231  
eyes 24, 39, 46–7  
eyespots 70, 92, 102, 112, 142, 144, 182, 206, 208, 212, 214

## F

Faggot Case Moth 231  
Fall Armyworms 78  
Fall Webworm 19, 75, 274–5  
fat body 57  
fern moths 240  
fertility 57, 58, 61  
fertilization 16, 54

Fir Tussock Moth 203  
Five-spotted Hawk Moth 159  
flannel moths 34, 93  
flight 72  
  ballooning 27, 202  
  hovering 59, 61, 138–9, 142, 220  
  tails 72, 88, 112, 206  
  *see also* wings  
Florida Fern Moth 240  
food 31, 46, 56–63, 94–5  
  inchworms 201  
  moths as 127, 133, 154, 169, 236  
  *see also* host plants;  
  polyphagy  
fossilized moths 10  
Fred the Thread 247  
Frisly Grass Tubeworm Moth 66, 70  
fungi 78–9, 125

## G

galeae 10  
gender  
  molt 31  
  sex ratio 79  
  sexual dimorphism 112  
  *see also* courtship  
genome editing 269  
geometrid moths 26, 58, 63, 66, 131, 138, 146, 160, 176, 178, 199–201, 227, 228, 238  
  *see also* inchworms  
Ghost Moths 51, 55, 128–9  
Giant Sphinx Moth 93  
gills 250  
Glover's Silk Moth 234  
Goat Moth 220–1  
Golden Sun Moth 128  
granulosis virus 269  
grassland moths 116–55  
Green Longhorn 55  
Green Page Moth 96, 110–11  
Gypsy Moth 20–1, 27, 76, 202

## H

hair-pencils 51, 108  
Hampson, George Francis 123  
hawk moths 32, 35, 44, 46, 59, 60, 62, 65, 71, 72, 82, 83, 91, 142–3, 179, 188–9, 214, 254–5  
  conifer forests 234  
  eggs 18  
  grasslands 138–9  
  pollination 120–1, 159, 188, 247, 254  
  seasonal diversity 97  
  temperate forests 208–9  
  wetlands 227  
  *see also* sphinx moths  
hearing 82  
helicoids 16  
hemimetabolous insects 38  
hemocytes 76  
hemolymph 39, 57, 75, 76, 78  
the Herald 222–3  
Hercules Moth 88  
hibernation 132, 179, 222  
*Holocercus holosericeus* 168  
holometabolous insects 38  
*Homaledra* 166  
Horned Spanworm 26  
host plants 50–1, 59, 90  
  aquatic 244–5  
  conifers 226–39  
  deserts 162–71  
  moth migration 96–7  
  temperate forests 194–9  
Hubbard's Silk Moth 182–3  
Hübner's Wasp Moth 137  
Hummingbird Clearwing 71  
Hummingbird Hawk Moth 138–9  
*Hypocrita reedia* 100–1  
*Hypomocoma* 227, 243

## I

ichneumonid wasps 74, 75  
Imperial Moth 65, 206–7

inchworms 26, 197, 198–9, 200–1, 216, 227, 228, 238  
  *see also* geometrid moths  
Indian Meal Moth 269, 270–1  
Indigo Stem Borer 141  
instars 31, 32, 37, 67  
integrated pest management (IPM) 266, 271  
Io Moth 19, 21, 31, 37, 66, 70, 195, 212–13  
*Iridopsis cypressaria* 238  
*Isoceras knuegeri* 168

## J

Japanese Silk Moth 34  
Jersey Tiger 150–1  
Jonasi Silk Moth 206  
Joshua tree 165  
Juniper Budworm 230

## K

Kentish Glory 208  
*Kerzhnerocossus* 168  
Knudson, Edward 166

## L

labial palps 27, 30, 46  
Labrador Tiger Moth 175  
labrum 24, 30  
lappet moths 129, 178, 186–7, 204, 237  
  *see also* eggars  
Larch Bud Moth 177, 230  
Larch Casebearer 232  
Larch Silkworm 234  
Larch Tolyte 237  
Laurelcherry Smoky Moth 27, 202  
leaf miners 32, 40, 86, 88, 131, 247  
leaf rollers 32  
leaf-tying moth 171  
legs 26–7, 44  
lekking 50, 55

- lianas 90  
lichen moths 106, 240  
Linden Looper 201  
Linnaeus, Carl 123  
Lobster Moth 211  
longevity 40, 58  
Louisiana-eyed Silk Moth 21, 246  
Luna Moth 39, 206
- M**
- Madagascan Sunset Moth 96  
Maggie Moth 146, 201  
Maid Alice 136  
mandibles 30, 31, 46, 82  
Maple Spanworm Moth 216–17  
maple trees 198–9  
March Moth 201  
Marion Flightless Moth 177  
mating 50–5  
maxilla 10, 24, 30, 46  
maxillary palps 30, 46, 164  
meconium 37  
melanism 67, 199, 200  
Merian, Maria Sibylla 93  
mesquite 170–1, 182  
Mesquite Cutworm 170  
Mesquite Webworm Moth 170–1  
metalmark moths 71  
metamorphosis 37, 38–9, 93  
*Meyrickella torquesauria* 232  
micromoths 126, 131, 148, 160, 178, 204, 227, 229  
micropyles 16  
migration 96–7, 179  
    Arctic 177  
    grasslands 132–3  
    Green Page Moth 110  
*Milionia basalis* 227, 258–9  
mimicry 44, 66, 68–72, 92–3, 100, 138, 146, 200, 216  
monkey puzzle trees (*Araucaria*) 26, 227, 228, 233
- Mopane Worm 126  
Morrison's Pero Moth 238  
Mottled Prominent 195  
Mottled Umber 201  
Mountain Burnet 136  
mountain grasslands 130–3  
mouthparts 10, 24, 30–1, 39, 43, 46–7  
    *see also* proboscis  
Mulberry Silkworm 33  
Müllerian mimicry 72, 92  
Mustard Ghost Moth 154–5
- N**
- Neaxestis piperitella* 127  
nectar 56, 57, 58–62, 91, 97, 132, 138, 159, 179, 228, 247  
    extrafloral 61  
    rainforest 91  
nematodes 78  
Nenets tundra 176–7  
Nessus Sphinx 82  
nests 204  
Nine-spotted Moth 136–7  
noctuid moths 26, 58, 65, 76, 91, 138, 162, 178, 232, 238, 239  
North American prairies 141
- O**
- Oak Besma 201  
Oak Hook-tip 197  
Oak Leaf Roller 195  
Oak Leaf-tier 195  
Oak Processionary 197  
oak trees 194–7, 209  
oak worm moths 53, 195  
ocelli 46  
Oleander Hawk Moth 124, 142–3  
Olive Moth 264  
ommatidia 46  
orchids 60–1, 91, 97, 247  
Oriental Barsine Lichen Moth 106–7
- Ornate Bella Moth 19, 21, 24, 31, 57, 123, 125  
ovaries 39, 45  
oviposition 16–19, 25  
    *see also* eggs  
owl moths 82  
owlet moths *see* noctuid moths
- P**
- Painted Lichen Moth 106  
Pale Beauty Moth 198–9, 201  
Pale Tiger Moth 198–9  
Pallid Emperor Moth 126–7  
Palm Moth 51, 55  
palms 166–7  
Pandora Pine Moth 227, 236  
*Papaipema* 141  
páramo 131  
parasitoids 18, 20, 64, 74–8  
*Paropta paradoxa* 168  
Peppered Moth 67  
pesticides 53, 74, 256, 266, 268, 276, 278  
    'natural' 269  
pharate pupa 37  
phenotypic plasticity 66  
pheromone traps 220, 252, 268, 272, 276  
pheromones 50–3, 55, 205  
*Phiaris* 177  
Pine Beauty 239, 252–3  
Pine Carpenterworm 230  
Pine Devil 234  
Pine Hawk Moth 226–7, 254–5  
Pine Processionary 239  
Pine Tube Moth 230  
Pine-tree Lappet 237  
Pink Bollworm 161  
Pitch Mass Borer 230  
Pitcher Plant Moth 227, 245  
*Platyptilia calodactyla* 177  
plume moths 10, 126, 148, 177  
Polar Tiger Moth 175  
Police-car Moth 59  
Polka-dot Wasp Moth 35, 72, 81
- pollination 60–1, 120, 159, 188, 247, 254  
Polymorphic Pondweed Moth 243  
polyphagy 25, 37, 104, 144, 186, 188, 203, 231, 238  
Polyphemus Moth 34, 82, 195  
polyphenism 66  
Ponderosa Pine Seedworm Moth 260–1  
Prchal's Pine Moth 236  
predators of moths 64–73, 87, 229  
    *see also* bats; spiders  
prepupa 37  
proboscis 10, 39, 43, 46, 60–1, 62–3, 82, 97  
processionary moths 21, 197, 239  
prolegs 26–7  
prominent moths 26–7, 195  
puddling 63  
pupae 32–7, 38–9  
Purplish-brown Loopers 200  
Puss Moth 26–7, 71  
pyrrolizidine alkaloids (PAs) 59
- Q**
- Queensland Pink Bollworm 161
- R**
- rainforests 84–115  
Red-fringed Emerald 200  
Rigid Sunflower Borer 141  
Riley, Charles Valentine 165  
Ringed China-mark 243  
Ross, John 175  
Rosy Maple Moth 198  
*Rothschildia erycina* 114–15  
Royal Walnut Moth 25, 234  
Rustic Sphinx 24

## S

Salt and Pepper Looper 239  
*Saurita cassandra* 123  
Scheer, Joseph 93  
*Schinia* 138  
Senita Moth 162  
sensilla 44, 46, 52, 53  
sericulture 33  
silk 202–5  
    Austrian monks 204–5  
    cocoon 32–7, 41, 65, 203  
    production 27  
    sericulture 33  
silk moths 21, 32, 34, 52, 56,  
    65, 82, 114–15, 126–7,  
    182–3, 195, 198, 206–7, 214  
    Cerrado 122  
    on conifers 233–5  
    mesquite 170  
SilverY Moth 134  
Six-spot Burnet 136, 152–3  
sloths 95  
slug moths 27, 65, 210–11  
Small Eggar 140–1  
Small Emperor Moth 141,  
    144–5  
Small Magpie 146–7  
Smoky Tetanolita Moth 53  
snout moths 95, 162  
Sooty-winged Chalcoela 211  
sound production 50, 55, 80–3  
Southern Flannel Moth 37, 65,  
    210  
Soybean Looper Moth 61  
Spanish Moon Moth 248–9  
speciation 10, 165, 229, 234  
sperm 16, 38, 50, 54, 58  
spermatophores 54  
sphinx moths 24, 82, 93, 179,  
    208, 209, 214–15, 234, 246  
    *see also* hawk moths  
spiders as predators 53  
Spindle Ermine 205  
spines 65, 72  
spinneret 27, 202

Spiny Hook-tip 197  
spiracles 45, 82  
Spruce Bud Moth 57, 58  
Spruce Budworm 229  
Spuler, Arnold 95  
spurs 44, 65  
Staghorn Cholla Moth 162  
stem borers 32, 141  
stemma 24  
stridulation 44, 83  
Striped Hawk Moth 179, 188–9  
sub-Antarctic region 177  
Subflexus Straw Moth 74, 267  
subtropical desert moths 160–1  
Sugar Cane Borer Moth 91  
sunset moths 63, 96  
Swallow-tailed Moth 201

## T

tachinid flies 77  
tanning 37  
tear-drinking moths 51, 62–3  
*Tegeticula* 164–5  
temperate deciduous forest  
    moths 190–223  
Temperate Tussock Moth 33  
temperature  
    development time 31  
    grasslands 118, 119  
    metabolism 57  
    phenotypic plasticity 66  
    prepupal stage 37  
tent caterpillars 204  
territory 50, 80  
testes 37, 38, 45  
thorax 41, 42, 44  
tiger moths 34, 51, 55, 59, 72,  
    83, 90–1, 92, 99, 100–1, 125,  
    150–1, 174–5, 198–9  
Tindale, Norman 169  
*Titulcia meterythra* 108–9  
Tobacco Budworm 74  
Tobacco Hornworm 25, 82,  
    264  
tortoise burrows 131

Tortoise Commensal Noctuid  
    Moth 131  
tortracid moths 21, 125, 131,  
    141, 176, 177, 195, 229, 230,  
    232  
toxins 65, 70, 72, 74, 100, 125  
    burnet moths 152  
    conifers 228  
    as defense 24  
    eggs 21  
    grassland moths 136–7  
    Green Page Moth 110  
    nectar 59  
    pupae 34, 35  
    rainforest plants 90–1  
    silk moths 114  
*Triabala pallida* 104–5  
*Triacholena sulfurosa* 232  
Trichogrammatidae wasps  
    74–5  
Tropical Sod Webworm Moth  
    61  
Tropical Swallowtail Moth  
    78, 96–7  
tubeworm moth 94  
tuft moth 91  
tundra moths 156–89  
tussock moths 34  
Two-striped Cordgrass Moth  
    246  
tympanum 82

## U

ultrasound signals 50, 55,  
    80–1, 83, 205  
underwing moths 21, 62, 70,  
    197, 218–19

## V

vampire moths 63  
viruses 78–9, 269

## W

Walnut Sphinx 82  
warning calls 82–3  
Wasp Parasitizer Moth 211  
WaterVeneer 242, 244  
Waterlily Borer Moth 227,  
    244  
Waterlily Leafcutter Moth  
    244–5  
Western Avocado Leaf Roller  
    Moth 58  
Western Sheep Moth 172  
wetlands 17, 224–61  
whistling moths 80  
White-lined Sphinx 179  
White-marked Tussock Moth  
    203  
wings 38, 39, 40–3, 55  
    color 42  
    largest 88  
    metamorphosis 38, 39  
    scales 41, 42, 43, 66, 83  
    spots 71  
    tails 72, 88, 112, 206  
witchetty grubs 169  
*Wolbachia* 79  
wood borers 168–9, 230  
Wood Leopard Moth 276–7  
Wood Tiger Moth 55  
woolly bears 65, 136, 174–5,  
    198–9

## X

*Xanthothrix ranunculi* 180–1

## Y

Yellow Woolly Bear 198–9  
yucca moths 18, 160, 164–5