Introduction

Moths—History, Folklore, Importance, Conservation, Observation

I've been a longtime lecturer on the garden club circuit, always to advocate for native flora. Many times over the years, a more traditional fellow conference speaker has made a comment to the effect of "Grow what makes *you* feel good" or "Your garden is all about *you*" or, perhaps, "Gardens are all about shape, color, and layers." Comments like the first two always make me think, "Why? Why is it always all about us?" People have destroyed enormous swaths of habitat and have directly caused the imperilment or extinction of scores of species. Our homes, farms, suburbs, and cities have displaced rich biodiversity with dead zones of turfgrass and other non-native plants. Comments like the third remind me that we've got a long way to go regarding education about ecosystems and the tangled web of plant and animal interactions. To think of gardens only in terms of botanical architecture and color is to think of a one-dimensional landscape dictated solely by aesthetics. Better, in my view, that the plant and animal twain purposefully connect in a garden. To successfully produce a gardenscape that truly interacts with the world around it, it's necessary to use indigenous plant species. That way, a multidimensional garden that fosters valuable native animals, from insects to birds, may be crafted. In doing so the landowner can create a miniature ecosystem that is infinitely more intellectually *and* aesthetically stimulating than a garden based only on superficialities of color and shape. Furthermore, such a garden can help with the production of animals that form the underpinnings of food webs. Not only do native-centric landscapes contribute to the health of our natural resources; they provide endless fascination courtesy of the zoological inhabitants. And perhaps foremost among these inhabitants are the moths.

—Jim McCormac

One summer day I was lackadaisically watering a flower bed and glimpsed a whir of motion at the butterfly bush beside me. A hummingbird! No, it had six legs . . . more like a giant bee! This was by far the weirdest animal I had ever seen. After it darted off, I excitedly raced into my house to do a quick internet search. When I discovered that the mystery flyer was a species of the aptly named Hummingbird Clearwing moth, I was dumbfounded. How could this creature be a *moth?* I revisited that flower bed throughout the summer in hopes of encountering

Chelsea Gottfried's son Will holds the Carolina Sphinx Moth (*Manduca sexta*) discovered in their garden.

it again, to no avail. Moth encounters have an exceptional ability to connect people with nature. They can foster a desire to protect and expand native habitats, simultaneously benefiting moths and numerous other organisms.

For years, I have planted a large vegetable garden and have loathed the destruction of my tomatoes, peppers, and eggplants by dreaded Tobacco Hornworms. I even paid my sharp-eyed youngest son to hunt and feed them to our chickens, which justified their removal in my mind. While weeding one evening, I discovered a Carolina Sphinx Moth (the adult hornworm) resting in my garden. Shamefully, my first thought was to destroy her since doing so would prevent a future generation of hornworms from terrorizing my garden. She was just too beautiful, though, and my oldest son and I quickly became enamored with her. Eventually, we returned her to the garden, and I realized that sacrificing a few of my dozens of plants is worth it to support such an amazing creature. Since that revelation, I have observed that the hornworms' parasitoid enemy *Cotesia congregata,* a Braconid wasp, seems to naturally keep their numbers in check. Before, I had simply been stealing the wasps' food to give to my chickens! This exemplifies the intrinsic value of moths. They have evolved extraordinary life cycles and unbelievable adaptations in association with numerous other organisms, and each species deserves a chance to thrive regardless of its appeal to us. While we cannot reverse all the harm that has been done to ecosystems, our yards are an opportunity for us to increase moths' odds of survival by choosing to grow the native plants they have adapted to eating.

I've been a typical landscaper for most of my life, choosing nonnatives from local garden centers based solely on aesthetics. I filled flower beds with roses, hydrangeas, lavender, and butterfly bushes, wasting time and money and becoming increasingly frustrated when these plants became diseased or died. A few years ago, I planted an "experimental" bed with only native plants and have since vowed never to use nonnatives again. Not only did this native bed require less effort, but it was also much more environmentally friendly—no watering, spraying, or fertilizing and only minimal weeding. What's more, it has attracted far more moths and other pollinators than my other beds ever have. I realized how selfish I had been regarding what I'd planted in my yard, not thinking about how it is part of a much larger ecosystem. As my property is surrounded by agricultural fields, I am currently transforming my backyard (and front yard!) into a sanctuary garden. I've chosen a variety of beautiful, moth-productive perennials,

shrubs, and trees to incorporate into my landscaping, with the added benefit of shrinking the lawn area. It has been over ten years since my memorable Hummingbird Clearwing moth encounter, and I'm hoping my evolving moth-scape will attract many more!

—Chelsea Gottfried

WHY MOTHS?

A sharp looker but generally unwelcome, the Meal Moth is one of very few moths considered a pest.

Why in the world would anyone want to encourage moths, let alone intentionally garden for them? Don't moths chew holes in our clothes, raid our dried goods, and defoliate oak trees? Well, yes to those three issues, courtesy of the Common Clothes Moth (*Tineola bisselliella*), Indian Meal Moth (*Plodia interpunctella*), Meal Moth (*Pyralis farinalis*), and Spongy (formerly Gypsy) Moth (*Lymantria dispar*). However, these four species (three of which are nonnative imports from the Old World) are very much the exception when it comes to moths. Only a vanishingly small fraction of a percent of our thousands of moth species cause any sort of issue to humans, and virtually all those that do are not indigenous to the region in which they cause issues. Contrarily, moths are essential to the mechanics of healthy ecosystems. Without them, ecological communities would eventually collapse. The ensuing chaos would have far-reaching impacts to humans in ways far worse than some holes chewed in clothes, a smattering of caterpillars in the cereal box, or even localized oak defoliation. Any richly speciose group of organisms is certain to be of great ecological importance. About 150,000 moth species have been described worldwide so far, and roughly 13,000 of them occur in North America north of Mexico. Perhaps no group of organisms provides such important ecological services as do moths yet receives so little credit. Throughout the course of this book, we hope to press the case for conservation of this amazing group of insects by promoting a new paradigm for gardeners and gardening.

MOTHING HISTORY

While people have been interested in moths for a long time, serious students of this branch of the Lepidoptera have been scarce until fairly recently. In eastern North America, several books have been especially notable for spiking interest in this group of insects. The first, and a truly pioneering work, was *The Moth Book* by W. J. Holland, published in 1916. This 698-page tome is rich in its descriptions of moth species and their natural history. Four reprints have been

issued, the last in 2010. In 1984, *A Field Guide to Moths of Eastern North America* by Charles V. Covell emerged. Now interested parties had a more efficient way to tag names to moths that they saw, as this book is strictly an identification manual. Covell also included common names for all moths. Entomologist David Wagner released his epic *Caterpillars of Eastern North America* in 2005. It features nearly 700 species of caterpillars, the overwhelming majority of which are moths. This guide triggered enormous interest in moths from a larval perspective. The year 2012 saw the release of the *Peterson Field Guide to Moths of Northeastern North America* by David Beadle and Seabrooke Leckie. This modern moth guide has helped win scores of converts to the darker side of butterflies. University of Delaware researcher Doug Tallamy opened eyes far and wide to the importance of moths and their critical roles in ecology with his first book, *Bringing Nature Home: How Native Plants Sustain Wildlife in Our Gardens* (2007). Subsequent writings by Tallamy have strengthened his message of native flora and its role in animal conservation and have created widespread awareness of the importance of "going native." Finally, the proliferation of digital photography has exposed legions of photographers to moths and their beauty. Sharing imagery on social media platforms has spawned scores of moth-based groups, in addition to the appearance of accurate and well-run websites such as BugGuide and the Moth Photographers Group. The ever-increasing utility of smart phone–based identification apps like iNaturalist, Leps, and Google Lens has made it easier for anyone to put names to mystery moths, further spiking interest in this marvelous group of animals.

MOTH MYTHS AND REPUTATION

> Every association of moths is with night and mystery and death.
>
> —D. C. Peattie, *An Almanac for Moderns,* 193

When it comes to the Lepidopterans, moths have long gotten the short end of the stick. Numbers have certainly not worked in their favor. Even though there are overwhelmingly more moths (perhaps 90 percent of *all* Lepidopterans worldwide) than butterflies, the latter

The Black Witch is steeped in dark legend. An alternate name is *Mariposa de la Muerte* (Butterfly of Death).

are indisputably more popular and better known. The mismatched ratio of books on butterflies to books on moths is ample evidence that people see better in light than dark. Hollywood and Japanese sci-fi flicks give more evidence of moth typecasting. The poster for *Silence of the Lambs,* presenting the cannibalistic Hannibal Lecter, features the image of a Death's-head Hawkmoth. That's not the first movie to use moths in the genus *Acherontia* with a grim connotation. The Black Witch (*Ascalapha odorata*), a huge tropical moth, is steeped in ominous superstition. Its Spanish name is even more foreboding than its English one: *Mariposa de la Muerte,* or "Butterfly of Death." A common piece of folklore has it that the appearance of the Black Witch foreshadows an impending death. Mothra, a giant ferocious moth-beast, wages battle against Godzilla in the Japanese sci-fi flick *Mothra vs. Godzilla.* The mythical Mothman was allegedly spotted repeatedly in the mid-1960s in the Point Pleasant, West Virginia, area. Mothman's presence was implicated in the catastrophic collapse of the Silver Bridge, which spanned the Ohio River, on December 15, 1967. And we could go on and on regarding ominous moth lore.

Contrarily, butterflies are all light and goodness, and one will be hard pressed to find them associated with evildoing. Butterfly-filled plant conservancies and butterfly houses are popular, people release butterflies at weddings, many species—especially the Monarch—are icons for conservation, and butterflies are abundantly depicted in art. The following excerpt from the poem "Butterfly" by Charlie Birkett sums up a popular sentiment:

> butterflies, butterflies,
> beautiful butterflies
> wings spread out
> for everyone to see
> . . . . . .
> the wings of faith
> fluttering across the sky
> the wings of hope
> helping with every hand.

Spicebush Swallowtails (*Papilio troilus*) at a native Pinxter-flower Azalea (*Rhododendron periclymenoides*). Butterflies play important pollinator roles, but not on the epic scale of moths.

Contrast that with this passage from Charles Dickens's novel *Great Expectations:* "Moths, and all sorts of ugly creatures" replied Estella, with a glance toward him, "hover about a lighted candle. Can the candle help it?" Similar sentiments abound in writings dating back to the Bible: "Do not store up for yourselves treasures on earth, where moths and vermin destroy, and where thieves break in and steal. But store up for yourselves treasures in heaven, where moths and vermin do not destroy" (Matthew 6:19–21). This passage refers to the Clothes Moth (*Tineola bisselliella*).

We feel it is time to go to bat for our (mostly) nocturnal butterflies, the vital role that they play in the world, and how we can help them.

Extraordinary detail in a Polyphemus Moth's (*Antheraea polyphemus*) wings. The color and patterning are created by myriad protective scales. Lepidoptera means "scaled wing" (*lepis* = scale, *pteron* = wing).

WHAT IS A MOTH?

Moths, like their better-known brethren the butterflies, are members of the Order Lepidoptera. The word "lepidoptera" stems from ancient Greek and means *scaled* (lepis) *wings* (pteron). Most moth (or butterfly) external features are covered with tiny, tightly appressed scales. These scales are like shingles on a house, providing protection, insulation from the elements, and—most obvious to observers—coloration and patterning. Many moths have showy coloration, ornate designs, or both. Coloration is caused by pigments, photonic crystals, or in some cases light diffraction through a phenomenon known as *thin-film interference.* The extremely thin scales serve to enhance reflected light and to amplify colors.

The Order Lepidoptera is massive, containing around 10 percent of *all* living organisms thus far described. Nearly 170,000 species have been identified to date. Of that total, butterflies comprise about 17,500 species, and moths are around 150,000 species. Moth diversity is nine times that of butterflies. The evolution of moths far predates that of butterflies. Fossilized moth remnants date back to the onset of the Jurassic Period, some 190 million years ago. Butterflies are young whippersnappers by comparison, having arisen in the Paleocene, about 56 million years ago.

As noted in the book's epigraph—"The bottom line is all butterflies are moths, and there's no such thing as butterflies"—moths and butterflies are essentially the same. However, there are some consistent differences. But, as almost always in nature, exceptions abound!

MOTHS	BUTTERFLIES
Nocturnal (many exceptions)	Diurnal
Antennae threadlike or broad and fernlike	Antennae club-tipped or knob-tipped
Plump and hairy bodies	Slender and smooth bodies
Cocoon (spun by larva, soft, using silk, plant parts, setae)	Chrysalis (smooth, hardened case of exposed pupa)

A second instar Tobacco Hornworm (*Manduca sexta*) atop a final (fifth) instar caterpillar. Few animals increase as much in size as caterpillars. At the end of their growth cycle, caterpillars may be hundreds or even thousands of times larger than when they hatched.

The four-part moth life cycle, in which the organism undergoes striking changes between phases, is an example of complete metamorphosis. Life begins as an egg, from which the larva (caterpillar) hatches. Caterpillars grow through molts—four or five in most of our species—and the caterpillar emerges from each molt larger in size. After the larval stage concludes, the caterpillar forms a cocoon, in which the transformation to an adult occurs. The transformative phase between caterpillar and adult is the pupa, which is housed within the cocoon. Some moth species pupate in wood, soil, or other sites. Rather than making cocoons, these species, including the sphinx moths and the imperial and royal moths, pupate in a "naked" manner and resemble a chrysalis. Finally, the winged reproductive adult emerges to commence the cycle anew (female moths of a very few species lack wings; see the inset box on Evergreen Bagworm Moth on page 42).

THE IMPORTANCE OF MOTHS

It's impossible to be sure of the number of moth species within the region covered by this book. It could be 4,000? 5,000? Even 6,000? One thing is certain. The moth total absolutely dwarfs their diurnal counterparts, the butterflies, probably by a factor of 30 or more. Any group of organisms as prolific as moths is sure to play an outsized role in natural food webs. And moths surely do. Many species are incredibly fecund, with

A "wall of fame" composed of notable moths plucked from a nearby mothing sheet and temporarily posed. An array of this sort is indicative of high-quality habitat with diverse native flora.

A pair of Salt Marsh Moths (*Estigmene acrea*), female on left, with hundreds of freshly deposited eggs.

some females capable of producing hundreds or even thousands of eggs. When an organism engages in such a "carpet-bombing" reproductive strategy, mortality rates are assuredly sky-high. Some experts put larval mortality of many moth species at about 99 percent. And some never even make it out of the egg—they fall victim to certain parasitoid wasps. But all those caterpillars perishing are not for naught. They are nature's tube steaks, protein-rich sausages on legs, lusted after by birds, other insects, and even mammals. Moth larvae make the songbird world go round and fuel countless less conspicuous organisms. Adult moths are an important food source for numerous other insects, spiders, and birds. Of the latter group, moths are a primary food group for the goatsuckers, or nightjars, in the Family Caprimulgidae, such as Chuck-will's-widow and Eastern Whip-poor-will. Finally, in this region moths are probably the principal prey for bats. Bats and moths are intertwined in a fascinating evolutionary arms race, with both groups evolving ever more sophisticated hardware for capturing prey or eluding hunters. The bat-moth relationship is detailed on page 16.

MOTHS AS POLLINATORS

As we've noted elsewhere, butterflies are just moths, only more conspicuous and far less diverse. Even the most casual observer notices that many butterfly species love to visit flowers. So do legions of moths—most of them just do it under the cloak of darkness. Go into the yard after nightfall, turn your flashlight on flowering plants, and you may be surprised at how many moths are tapping nectar. Indeed, far more moths—both individuals and species—are probably visiting your flowers than are butterflies. It may even be that moths are more efficient pollinators than butterflies. While most butterflies have smooth, largely hairless bodies, moth bodies and wings are often clad in thick layers of scales, so much so that they look furry. Because of this, pollen adheres well to moths, and many species serve as efficient vectors for transporting pollen and effecting cross-pollination.

Common Milkweed (*Asclepias syriaca*)—or any other milkweed—can attract many moth pollinators such as this Spotted Grass Moth (*Rivula propinqualis*).

A Variegated Cutworm moth (*Peridroma saucia*) visits the flowers of Wild Bergamot (*Monarda fistulosa*).

The evolution of flowering plants (angiosperms) from more primitive ancestors began about the same time that moths appear in the fossil record. *Archaeolepis mane* is the oldest known moth, dating back to the Early Jurassic, about 190 million years ago. The latter two periods of the Mesozoic Era, the Jurassic and Cretaceous, saw an explosion in flowering plant diversity and likely an attendant increase in moth diversity. Moths and plants have had a long time in which to coevolve specialized relationships with one another. Plants with white flowers—especially those with long corolla tubes—seem especially attractive to moths. Light flower colors are probably more visible to night-flying moths, and hence a greater lure. The nectaries—which contain the nectar reward that stimulates pollinators to plumb the depths of the flower—are typically at the base of the elongate corolla. Many species of moths have very long proboscises (tongues), allowing them access to the nectaries. Other plants, including many orchids, evening-primrose, four-o-clocks (in the genus *Mirabilis*), phlox, and wisteria, produce scents at dusk or throughout the night that lure moths. In a strategy that certainly evolved to select for moth pollinators, some plants bloom only or primarily at night. Some primroses in the genus *Oenothera* are an excellent regional example.

The Orchidaceae (orchids) are the second-largest flowering plant family in the world, eclipsed only by the Asteraceae (Sunflower Family). There are about 28,000 species worldwide, and many of them have highly specialized relationships with moth pollinators. A famous example involves Morgan's Sphinx (*Xanthopan morganii*) of Madagascar. This big moth with an extremely long proboscis was discovered in 1882 in Africa. However, its existence was predicted two decades prior by Charles Darwin. He received some orchid specimens from botanist James Bateman in 1862, including *Angraecum sesquipedale* from Madagascar. This orchid, often now known as Darwin's Orchid, features a foot-long nectar spur. Darwin postulated that there must be a moth with an extremely long proboscis capable of accessing the nectar at the base of the spur, and in the process it would pollinate the plant. In 1903, a subspecies of Morgan's Sphinx was discovered in Madagascar that had the requisite nearly foot-long proboscis. It was named *Xanthopan morganii* subspecies *praedicta,* the trinomial in reference to Darwin's Lepidopteran prediction. Still, observations of the moth pollinating the orchid were required to verify the hypothesis. In 1991, Ohio entomologist Gene Kritsky wrote a captivating account in the journal *American Entomologist* about the tale of Darwin, the moth, and the orchid, noting that nearly nine decades after the discovery of Morgan's Sphinx in Madagascar, no one had yet caught the moth in the act of pollination. The following year, a team led by biologist Lutz Wasserthal would capture the first photos of the moth visiting the orchid. In 2004, Philip DeVries captured

(*left*) A Morgan's Sphinx, with its foot-long proboscis unfurled. It uses this extremely long tongue to reach the nectar deep within the nectar spurs of Darwin's Orchid.

(*right)* Darwin's Orchid, with its foot-long nectar spur, can be pollinated only by Morgan's Sphinx.

video footage of the moth feeding on the orchid. It took nearly a century and a half to validate Darwin's prediction, one he could make based on his knowledge of plant anatomy and orchid pollinators and his advanced understanding of evolution and coevolutionary partnerships.

Our region has its own "Darwin's Orchids." While orchids are not nearly so plentiful here as in tropical haunts, about five dozen species occur in the area covered by this book. Many, if not most of them, depend upon moths for pollination. A notable example is the Eastern Prairie Fringed Orchid (*Platanthera leucophaea*), which is listed as threatened by the federal government. A denizen of prairies, it has suffered greatly due to habitat loss. Within the range covered by this book, small populations persist in Illinois, Indiana, Michigan, Ohio, and Wisconsin. It is

A Carolina Sphinx (*Manduca sexta*) pollinates the federally threatened Eastern Prairie Fringed Orchid (*Platanthera leucophaea*). The larval stage of this moth is the Tobacco Hornworm, best known for eating tomato plants. Consider sacrificing some plants to grow this valuable native moth.

(*right*) The spindly flowers of a Cranefly Orchid, with their elongate nectar spurs. A small suite of moth species provides pollination services.

(*far right*) A tiny Grape Plume Moth probes the nectar spur of a Tubercled Rein Orchid. A greenish pollen sac (pollinium) is stuck to the moth's proboscis.

pollinated exclusively by large sphinx moths, relatives of the aforementioned Morgan's Sphinx. The ivory-white flowers emit a strong fragrance in the early evening, serving to lure moths. At least two sphinx moths in this book, Carolina and Pandorus Sphinx moths, are documented pollinators of the orchid.

Much smaller and less showy orchids also have moth-pollinator relationships. The authors documented dozens of Grape Plume Moths (*Geina periscelidactylus,* page 147) pollinating a colony of Tubercled Rein Orchids (*Platanthera flava*). These moths are diurnally active, which suggests the orchid flowers may emit a subtle fragrance (none was detectable to our noses) during the day. Ohio botanist Warren Stoutamire unraveled the mystery of Cranefly Orchid (*Tipularia discolor*) pollination. This wispy species of the woodland understory produces an aroma at night to lure moth pollinators. Five species—four are Noctuid moths and one is a Geometrid moth—are documented pollinators, and all are common. Two of these species, the Common Looper (*Autographa precationis*) and the Brown-hooded Owlet (*Cucullia convexipennis*), have species accounts on pages 223 and 229, respectively. The asymmetrical shape of the flower forces the moth's eye into contact with a sticky pollinium (pollen sac) as the insect plunges its proboscis deep into the nectary. Pollen is then transported to other flowers.

Not all plants have such specialized pollinator relationships, and a diversity of moths visit many of our flowering plants. Members of the Sunflower Family (Asteraceae) seem to be especially heavily visited. Blazing-star, boneset, goldenrod, Joe-pye, and coneflowers are moth magnets within that huge family of plants. Just as they are for butterflies, milkweeds are irresistible to many moths. White flowers in general are good places to search for moths after dark. Plants that are attractive to butterflies will probably be heavily visited by moths—most just come after dark, so you'll have to make a bit more of an effort to admire them. See our plant profiles for scores of suggestions for valuable sources of nectar for moths.

Yellow-collared Scape Moths and many other generalist pollinators frequent members of the Sunflower Family (Asteraceae), such as this Mistflower (*Conoclinium coelistinum*).