EENY608

Io Moth *Automeris io* (Fabricius) (Insecta: Lepidoptera: Saturniidae)[1]

Donald W. Hall[2]

The Featured Creatures collection provides in-depth profiles of insects, nematodes, arachnids and other organisms relevant to Florida. These profiles are intended for the use of interested laypersons with some knowledge of biology as well as academic audiences.

Introduction

The beautiful Io moth, *Automeris io* (Fabricius), is one of our most recognizable moths. It is distinctive because of its prominent hind wing eyespots. The Io moth, like many of the other saturniid moths, is less common now in parts of its range. With the exception of Cape Cod and some of the Massachusetts islands, it is now rare in New England where it was once common, and its populations have declined in the Gulf States (with the exception of Louisiana) since the 1970s (Manley 1993). The attractive Io moth caterpillar is also well-known because of its painful sting.

Automeris is a large genus with about 145 species (Heppner 1996). All *Automeris* species are characterized by large eyespots in the middle of the hind wings. Most species are found in Central and South America. There are seven species in the United States. Five of these, *Automeris zephyria* Grote (New Mexico and western Texas), *Automeris cecrops* (Boisduval), *Automeris iris* (Walker), *Automeris patagoniensis* Lemaire, and *Automeris randa* Druce (southeastern Arizona) are found only in the western U.S. (Powell & Opler 2009). *Automeris louisiana* is found only in coastal salt marshes of southwestern Mississippi, Louisiana, and eastern Texas where it feeds predominately (if not exclusively) on smooth cordgrass, *Spartina alterniflora* Loisel (Tuskes et al. 1996).

Figure 1. Male Io moth, *Automeris io* (Fabricius).
Credits: Donald W. Hall, University of Florida

Synonymy

Fabricius (1775, p.560) described the Io moth and named it *Bombyx io*. Abbott and Smith (1797, p.97) published the first account of the Io moth's life cycle under the name *Phalaena io*. Some early references used the genus name *Hyperchiria* (e.g., Eliot & Soule 1902, Lintner 1872, Stratton-Porter 1921, Strecker 1872).

Strecker (1872, p.139) described *Hyperchiria lilith* as a new species based on a series of females from Georgia with more reddish colored forewings (Figure 2). Populations

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of this color variant are common in the deep Southeast including Florida, and the name "*lilith*" is still in common usage as a subspecies of *Automeris io* to designate females with this phenotype and males that have orange-brown forewings. However, Tuskes et al. (1996) stated that the *lilith* phenotype occurs over a broad geographic range (as far north as New York) and "does not have a distribution pattern consistent with the subspecies concept." For this reason and the fact that female forewing coloration of *lilith* specimens is so inconsistent, they synonymized *lilith* with nominate *io*.

Figure 2. Image of *Hyperchiria lilith* female.
Credits: Strecker (1872, Plate XV, Fig. 17)

For a more complete list of synonyms for *Automeris io*, see Ferguson (1972) or Heppner (2003).

Less familiar common names for the Io moth include corn emperor moth (Abbott & Smith 1797) and peacock moth.

Distribution

The Io moth is found from southern Canada throughout the eastern U.S. and to eastern Mexico (Tuskes et al. 1996).

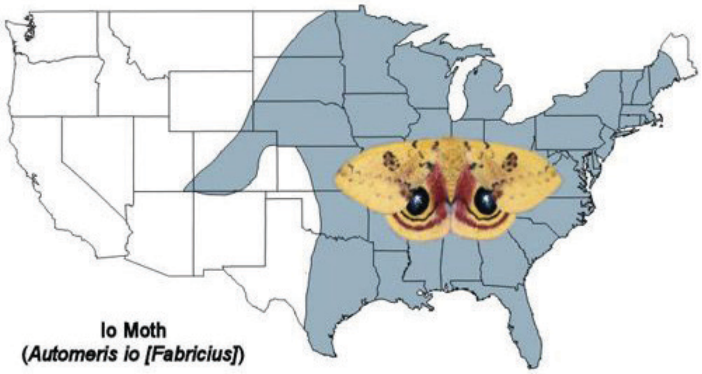

Figure 3. Io moth, *Automeris io* (Fabricius), U.S. distribution map. Map Credits: Donald W. Hall, University of Florida. (Based on map from Tuskes et al. 1996)

Description

Eggs

Eggs measure approximately 1.7 × 1.3 × 1.1 mm (Peterson 1965). They are white with yellow transverse areas on the sides and a yellow spot on the top of each egg that surrounds the micropyle (opening through which sperm enters). After three to five days, the micropyle turns black in fertilized eggs (Tuskes et al. 1996) but remains yellow in unfertilized eggs (Villiard 1975). As the eggs mature, the lateral yellow areas become orange or brown.

Figure 4. Io moth, *Automeris io* (Fabricius), approximately 36 hour old eggs.
Credits: Donald W. Hall, University of Florida

Figure 5. Io moth, *Automeris io* (Fabricius), 8 day old eggs.
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Larvae

Tuskes et al. (1996) stated that all saturniids have five larval instars. However, the number of instars may vary depending on rearing conditions. When reared on sub-optimal hosts, larvae may undergo extra molts. Sourakov (2013) found that Io moth caterpillars reared on coral bean (*Erythrina herbacea* Linnaeus) required seven instars to complete their larval development.

First instar Io moth larvae are reddish-brown with six longitudinal light lines and six longitudinal rows of spine-bearing scoli (Packard 1914; Pease 1961). Instars

2-4 become increasingly more yellowish-brown and the longitudinal lines become more distinct and lighter in color.

Full-grown (usually fifth instar) larvae are approximately 60 mm (about 2 ⅓ in.) in length (Godfrey et al. 1987). They are green with a lateral abdominal white stripe edged on the top and bottom with red stripes. Both thoracic legs and abdominal prolegs are reddish, and there are ventro-lateral reddish patches on the abdominal segments. The body is virtually surrounded with scoli bearing black-tipped venomous spines.

Figure 6. Io moth, *Automeris io* (Fabricius), newly hatched larvae.
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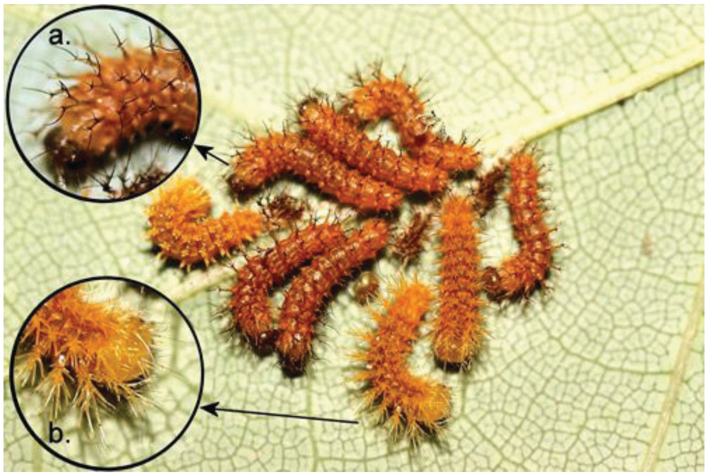

Figure 7. Io moth larvae, *Automeris io* (Fabricius), first (inset a.) to second (inset b.) instar molt.
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Figure 8. Io moth larvae, *Automeris io* (Fabricius), second instars.
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Figure 9. Io moth larvae, *Automeris io* (Fabricius), third instars.
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Cocoons

Cocoons are thin and papery.

Pupae

Pupae are dark brown. Female pupae have longitudinal notches (the developing female gonopores) on the ventral aspect of the fourth and fifth abdominal segments behind the segment that is partially covered by the developing wings (Figure 16, top).

In male pupae, the posterior margin of the fourth abdominal segment behind the segment that is partially covered by the developing wings is entire (arrow), and the notches are lacking. The fifth abdominal segment behind the segment that is partially covered by the developing wings bears two short tubercles (the developing male gonopores) (Figure 16, bottom).

Figure 10. Io moth larvae, *Automeris io* (Fabricius), third to fourth instar molt.
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Figure 11. Io moth larva, *Automeris io* (Fabricius), fourth instar.
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Figure 12. Io moth larvae, *Automeris io* (Fabricius), fourth to fifth instar molt.
Credits: Donald W. Hall, University of Florida

Figure 13. Io moth, *Automeris io* (Fabricius), full-grown larva.
Credits: Donald W. Hall, University of Florida. For detailed descriptions of the larval instars see Lintner (1872), Packard (1914) and Pease (1961).

Figure 14. Io moth cocoon, *Automeris io* (Fabricius), with dead leaf removed for photography.
Credits: Donald W. Hall, University of Florida

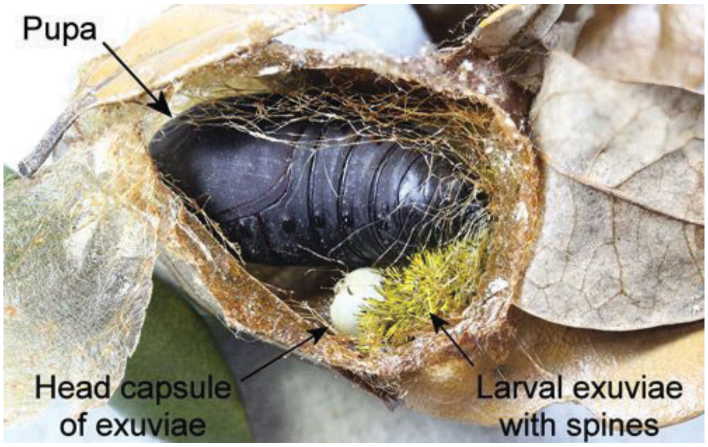

Figure 15. Io moth, *Automeris io* (Fabricius), cocoon opened to show larval exuviae and pupa.
Credits: Donald W. Hall, University of Florida

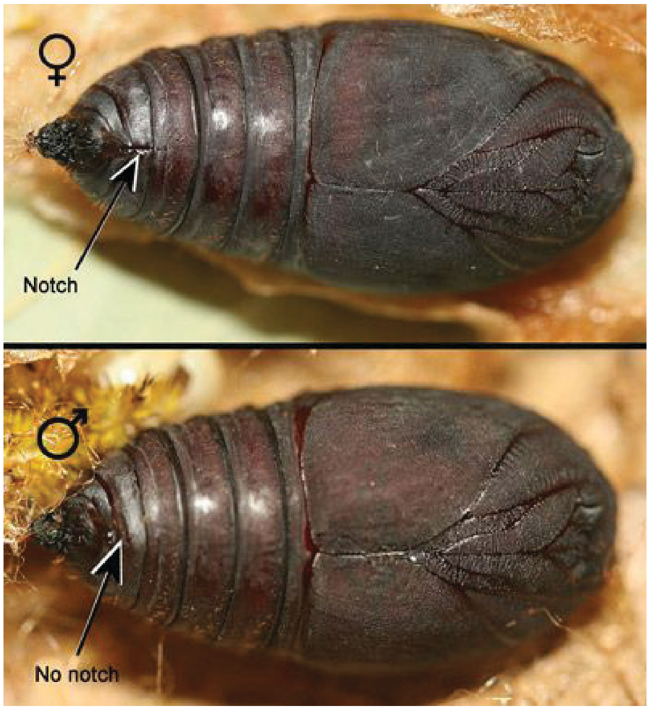

Figure 16. Io moth, *Automeris io* (Fabricius), female (top) and male (bottom) pupae.
Credits: Donald W. Hall, University of Florida. For detailed descriptions of the pupae, see Mosher (1914 & 1916)

Adults

Io moths have wingspans of 50-80 mm (approx. 2-3 in.) (Beadle & Leckie 2012; Covell 2005). Females are larger than males. Male and female Io moths can be differentiated by the antennae (Figure 17). The antennae of males are quadripectinate. Female antennae are described as bipectinate (Powell & Opler 2009) or bidentate (Ferguson 1972). Without magnification, female antennae appear almost thread-like.

Female forewings vary from red to brown (Figures 18 and 25).

Male forewings vary from yellow to tawny or orange-brown. The yellow phenotype is predominant in males from more northern areas. Darker male forewings are more common in southern populations and the darker coloration is often characteristic of males from diapausing pupae (Manley 1990[1991] & 1993; Sourakov 2014).

For photographs showing more of the color variation of adult Io moths, see Ferguson (1972) and Sourakov (2014). Manley (1990 [1991]) has conducted extensive studies on the genetics of some of the color and pattern variations in Io moths. Also, both bilateral (Hessel 1964) and mosaic (Manley 1971) gynandromorphs and an aberrant male in which the hind wings are mostly covered with black (Covell 2012) have been reported.

Figure 17. Io moth, *Automeris io* (Fabricius), female (top) and male (bottom) antennae.
Credits: Donald W. Hall, University of Florida

Figure 18. Female io moth, *Automeris io* (Fabricius), dorsal (top) and ventral (bottom) aspects.
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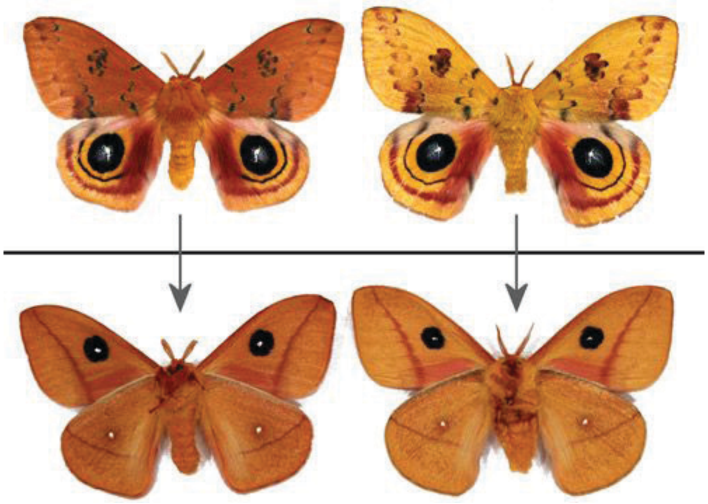

Figure 19. Male Io moths, *Automeris io* (Fabricius), showing some of the range of color variation—dorsal (top) and ventral (bottom) aspects. The male on the left was from a diapausing pupa—the one on the right from a non-diapausing pupa.
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Life Cycle

Adults usually emerge in late morning or early afternoon and remain still until evening. Collins and Weast (1961) reported that females begin to release a pheromone to call males from approximately 9:30 pm to midnight on the day of emergence. However, Manley (1993) stated that copulation rarely occurs on the night of emergence. Adults do not feed and are short-lived.

Eggs are laid in clusters on leaves or stems (usually on the undersides of leaves) over the next several nights (Peterson 1965; Tuskes et al. 1996). Eggs usually hatch within 8-11 days. Soon after hatching from the eggs, larvae eat the eggshells (chorions) (Figure 20) before beginning to feed on the host plant.

Figure 20. Io moth, *Automeris io* (Fabricius), eggs. Newly hatched larvae have eaten most of the chorions (egg shells) leaving only the bases where the eggs were glued to the substrate and the unfertilized eggs that did not hatch.
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Early instar larvae are gregarious and march in lines following silk trails as they move to new feeding areas (Soule 1891) (Figures 21 and 22).

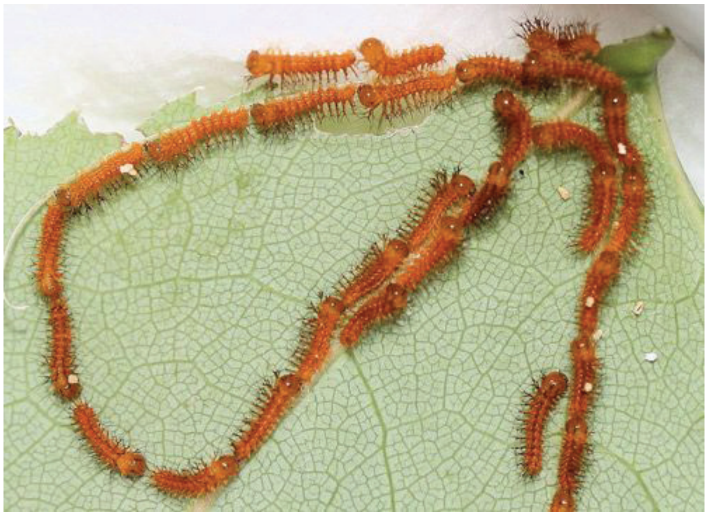

Figure 21. Io moth, *Automeris io* (Fabricius), first instar larvae in formation following silk trail to new feeding site.
Credits: Donald W. Hall, University of Florida

Figure 22. Io moth, *Automeris io* (Fabricius), first instar larvae (enlarged) in formation following silk trail to new feeding site.
Credits: Donald W. Hall, University of Florida

When ready to molt, early instar larvae queue into rosettes with the heads facing outwards (Russi et al. 1973) (see Figure 7above). After the hardening of their new exoskeletons, recently molted larvae return and eat their exuviae except for the head capsules.

When fully grown, larvae crawl down from the host plants and spin cocoons in leaf litter or in protected places like crevices in logs or rocks (Tuskes et al. 1996).

Manley (1993) conducted detailed studies of diapause and reported that northern populations are univoltine (one generation per year), those from coastal South Carolina, the Gulf States, and north Florida are probably bivoltine, those from Orlando, Florida south to a line intersecting Bradenton-Sebring-Fort Pierce probably have four generations, and more southerly Florida populations probably have four or five non-diapausing generations. Sourakov (2014) studied Io moths from the Gainesville, Florida area and suggested that there may be plasticity in voltinism based on genetics and environmental conditions.

Host Plants

Io larvae are polyphagous. The following list of genera of the most common host plants for Io moths was compiled from Beadle & Leckie (2012), Collins & Weast (1961), Covell (2005), Ferguson (1972), Tuskes et al. (1996), and Wagner (2005).

Table 1.

Genus	Common Name(s)	Family
Acer	maples, boxelder	Aceraceae
Betula	alders, birches	Betulaceae
Carya	hickories	Juglandaceae
Celtis	hackberries	Ulmaceae
Cercis	redbud	Fabaceae
Morella (=*Myrica*)	bayberries, wax myrtles	Myricaceae
Populus	aspen, poplars, cottonwood	Salicaceae
Prunus	cherries	Rosaceae
Pyrus	pear	Rosaceae
Ribes	currants, gooseberries	Grossulariaceae
Rubus	blackberries	Rosaceae
Sassafras	sassafras	Lauraceae
Salix	willows	Salicaceae
Tilia	basswoods	Tiliaceae
Ulmus	elms	Ulmaceae
Wisteria	wisteria	Fabaceae

Although Io moth larvae are polyphagous, they may have regional host preferences (Tuskes et al. 1996). For example, Collins and Weast (1961) mention that mesquite (*Prosopis* spp.) is a preferred host along the Texas Gulf Coast and Minno (personal communication) and Tuskes et al. (1996) list the following plants as common hosts in South Florida and the Florida Keys:

Table 2.

Scientific Name	Common Name(s)	Family
Piscidia piscipula (L.) Sarg.	Florida fishpoison tree	Fabaceae
Delonix regia (Bojer ex Hook.) Raf.	royal poinciana	Fabaceae
Hibiscus sp.	hibiscus	Malvaceae
Washingtonia robusta H. Wendl.	Washington fan palm	Arecaceae
Trema micrantha (L.) Blume	nettletree	Ulmaceae
Rhyzophora mangle Linnaeus	red mangrove	Rhyzophoraceae

Apparently, not all plants utilized by Io moths are equally suitable for larval development (Sourakov 2013).

For more complete lists of recorded hosts, see Heppner (2003), Robinson et al. (undated), and Tietz (1972). Scientific names, common names, family names and distribution maps for the host plants can be found in the Plants Database—USDA Natural Resources Conservation Service (2014).

Natural Enemies

Predators

The Io moth probably has a variety of predators during its life cycle including birds, mammals, spiders, and insects. Tuskes et al. (1996) reported that hornets commonly attack Io moth larvae.

Parasitoids

At least seven species of tachinid flies (Diptera: Tachinidae) (Arnaud 1978, O'Hara 2013, Peigler 1994 [1996]), two species of ichneumonids (Hymenoptera: Ichneumonidae) and two species of braconids (Hymenoptera: Braconidae) (Krombein et al. 1979, Peigler 1994 [1996]) have been reported from *Automeris io*.

Tachinid parasitoids of *Automeris io*

Compsilura concinnata (Meigen)

Chetogena (formerly *Euphorocera*) *claripennis* (Macquart)

Carcelia formosa (Aldrich & Webber)

Sisyropa eudryae (Townsend)

Nilea (formerly *Lespesia*) *dimmocki* (Webber)

Lespesia frenchii (Willliston)

Lespesia sabroskyi Beneway

Ichneumonid parasitoids of ***Automeris io***

Hyposoter fugitivus (Say)

Enicospilus americanus (Christ)

Braconid parasitoids of ***Automeris io***

Cotesia electrae (Viereck)

Cotesia hemileucae (Riley)

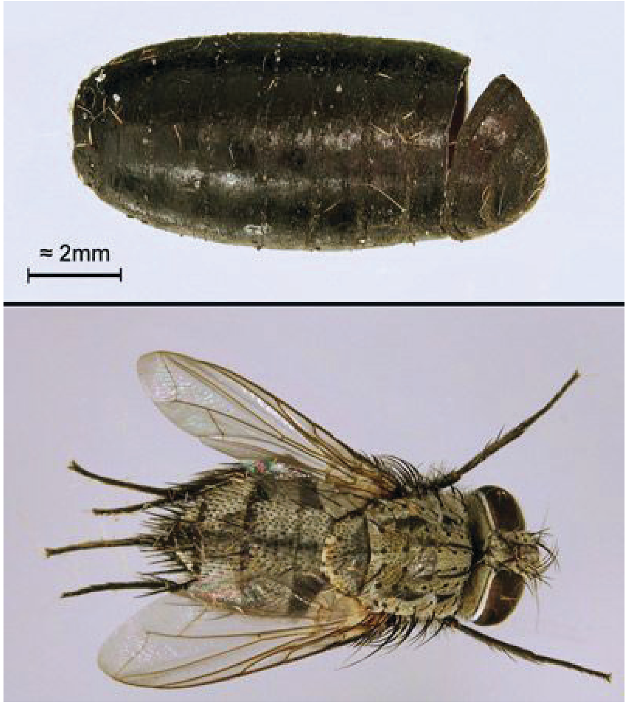

Figure 23. Tachinid fly parasitoid of *Automeris io* (Fabricius). Puparial shell (top) and adult fly that emerged from it (bottom).
Credits: Donald W. Hall, University of Florida

Defenses

Caterpillars of all instars sting (Eliot & Soule 1902) and probably gain some protection from vertebrates. The contrasting white and red lateral stripes of fifth instar larvae are likely aposematic. The spines may also repel some insect predators. Murphy et al. (2010) found that reduviid bugs and *Polistes* wasps were less likely to attack heavily spined limacodid larvae than weakly spined ones.

Adults are strictly nocturnal (Fullard & Napoleone 2001). They remain motionless during the daytime and mimic the dead brown, red, and yellow leaves that are common in forests. Dead leaves of a number of plant species exhibit a range of colors that match the color variants of male and female Io moths in their typical resting positions (Figure 24). Many of the leaves have mottled patterns that enhance the mimicry of the moths.

The relatively low density of Io moth populations (Tuskes et al. 1996) combined with the highly variable patterns in the moths' wings may prevent vertebrate predators from forming search images.

When threatened, adults flip the forewings forward exposing the large eyespots on the hind wings (Figure 24). The eyespots have white highlights resembling the glint (reflections) of vertebrate eyes. Large eyespots in butterflies have been shown to startle predatory birds (Blest 1957).

Figure 24. Io moth, *Automeris io* (Fabricius) - image of adult female digitally pasted into photo with dead Virginia creeper (*Parthenocissus quinquefolia* [Linnaeus]) leaflets (top); image of adult male digitally pasted into photo with dead flowering dogwood (*Cornus florida* Linnaeus) leaves (bottom).
Credits: Donald W. Hall, University of Florida

Figure 25. Io moth, *Automeris io* (Fabricius), adult female in startle posture.
Credits: Donald W. Hall, University of Florida

Medical Importance

Incidence and Symptoms

Stings to humans by Io moth caterpillars are not particularly common. Of 112 cases of caterpillar stings in Louisiana, 11% were attributed to Io moth caterpillars (Everson et al. 1990). However, stings are certain to be underreported.

In laboratory experiments, human volunteers varied in their sensitivity to Io caterpillar stings, and a rabbit, hamster, and mouse failed to react to the stings (Hughes & Rosen 1980).

Stings commonly result in a nearly immediate painful nettling and pruritic (itching) reaction followed by formation of a localized wheal (welt) and erythematous (reddened) flare around the wheal. The pain usually resolves within a couple of hours and the wheal and flair within 6-8 hours (Diaz 2005, Hossler 2009 & 2010, Hossler et al. 2008, Hughes & Rosen 1980, Rosen 1990). Systemic symptoms are rare.

Venomous Spines

Virtually the entire bodies of larvae are protected by venomous spines. The spines have been described in detail by Battisti et al. (2011) and Gilmer (1925). Some spines are tipped with points and others with setae (Gilmer 1925) (Figure 26). The functional difference, if any, between point-tipped and seta-tipped spines is unknown.

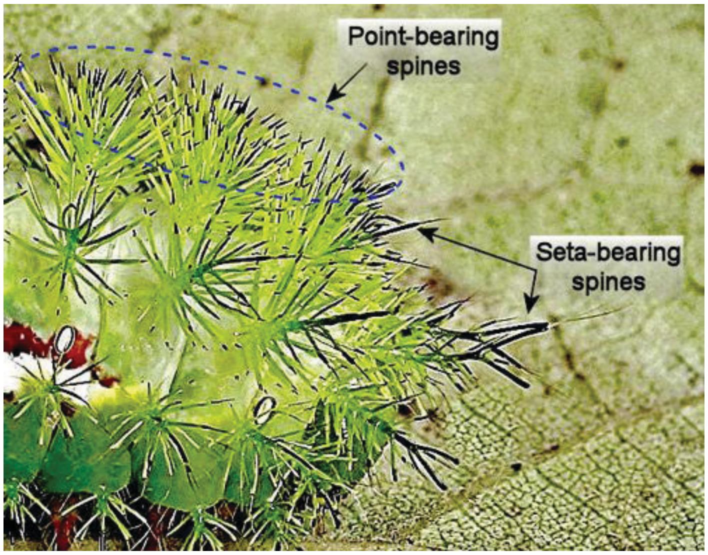

Figure 26. Io moth, *Automeris io* (Fabricius), venomous spines.
Credits: Donald W. Hall, University of Florida

When spines penetrate the skin, the tips break off and release the venom. Spine tips may remain in the skin causing further irritation (Hossler et al. 2008). Battisti et al. (2011) hypothesized that as embedded spine tips begin to break down in the skin, the chitin may invoke an inflammatory response. Chitin particles of about 10–40 µm in size are known to invoke pro-inflammatory immune responses, but smaller chitin particles may actually be anti-inflammatory (Alvarez 2014; Da Silva et al. 2009). The points on Io moth caterpillar spines that are likely to remain in the skin are roughly 12 µm in length—right at the threshold of the inflammatory size. However, their irritating effect may be merely mechanical or due to small amounts of venom remaining in the points.

Treatment

Recommended treatments include application and removal of cellophane tape to the affected area to strip embedded tips of the urticating spines from the skin. Ice packs should be applied to the affected area to minimize the inflammatory response (Diaz 2005; Hossler et al. 2008).

Venom

Io moth caterpillar venom has not been characterized (Diaz 2005), but it is unlikely to contain histamine or involve histamine-mediated reactions. Intradermal injections of the anti-histamine diphenhydramine-HCl (Benadryl®) at the site of stings in human volunteers failed to block reactions (Hughes & Rosen 1980).

Caterpillar venoms, in general, have not been well-studied. Because of the large, relatively accessible poison glands of Io moth caterpillars, Goldman et al. (1960) recommended studies with Io moth caterpillar venom as a model to determine the chemicals responsible for the pruritic symptoms of caterpillar stings. Eisner et al. (2005, p. 295) stated, "There is no reason why caterpillar venoms should not turn out to contain novel toxins of interest."

Rearing

Io moth larvae are relatively easy to rear. Although they will tolerate more crowding than most other saturniid larvae, overcrowding and high humidity may increase risk of disease (Tuskes et al. 1996). Villiard (1975) listed wild cherry as the preferred host. Tuskes et al. (1996) recommended presenting early instar larvae with a variety of food choices to determine their preference. All Io specimens pictured here were either collected as larvae on redbud (*Cercis canadensis* Linnaeus) or reared on redbud from eggs of wild-collected females.

Prepupal larvae should be removed and provided with leaf litter or tissue paper as a medium for spinning their cocoons (Tuskes et al. 1996). After the pupae have hardened (approximately 7–10 days), the cocoons can be removed and placed into emergence cages. Although the cocoons may tear when handled, successful emergence of adults will not be affected. Diapause pupae may require a chilling period prior to emergence.

Wild-caught females have often already mated. Reared adults mate readily in small cages, or females may be tethered outside to attract wild males. Worth (1980) has designed a tether for large moths that also should work with Io moths.

Mythology

The specific epithet "*io*" is from the mythological Greek woman Io, who was first priestess of Hera, wife of Zeus the god of thunder and lightning and king of both gods and men.

Even the synonym "lilith" coined by Strecker (1872) has a mythological origin. According to Jewish mythology, Adam had two wives — the first wife (unnamed) from the Old Testament scripture Genesis 1:26-27. About 800-900 B.C., this mythical first wife became known as Lilith. She and Adam supposedly had a tumultuous relationship, and Lilith left Adam and according to some legends became a night monster or evil woman who killed babies. God then created a second wife from Adam's rib (Genesis 2:22) whom Adam named Eve (Genesis 3:20). The historical origin of the character Lilith is a matter of speculation. See Pelaia (2014) for a discussion of the Lilith myth.

The well-known early twentieth century naturalist Gene Stratton-Porter (1921) called the Io moth "Hera of the Corn" (literally goddess or queen of the corn) - in reference to the Greek goddess Hera mentioned previously and the fact that corn is an occasional host plant for Io moth larvae in central Indiana where she (Stratton-Porter) lived. In fact, children (including the author) were occasionally stung by Io moth caterpillars while playing hide-and-seek in the corn fields of the Midwest.

Control

Although Io moth caterpillars have been reported from cotton (Packard 1914) and corn (Abbot & Smith 1797, Stratton-Porter 1921), they are not sufficiently abundant to require control on these crops. Control would only be required if they present a stinging hazard in landscape plants.

If control measures are required, *Bacillus thuringiensis* applications or chemical insecticides recommended for control of other caterpillars should be effective. For current control recommendations, contact your County Extension office.

Acknowledgement

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