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Profile

Biology and Management of the Buck Moth, *Hemileuca maia* (Lepidoptera: Saturniidae)

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Abstract

The genus *Hemileuca* Walker (Lepidoptera: Saturniidae) is widespread across North America, with about 20 species, including the buck moth, *Hemileuca maia* (Drury). This species is important as a periodic defoliator in oak forests of the eastern United States but is not considered to be destructive to forest resources. Buck moth populations are regulated naturally by environmental factors, particularly foliage quality, predators, parasitoids, and pathogens. The buck moth has become a species of conservation concern in northern states, where it is threatened by habitat loss, fire suppression and other anthropogenic changes in habitat conditions, and perhaps by parasitoids introduced to control invasive Lepidoptera. In the South, the buck moth caterpillars attract attention because the urticating spines of its larvae cause painful stings that often require first-aid advice. Although considered a nuisance in urban areas, this insect generally is not sufficiently abundant to warrant specific control measures. If control is warranted, several biological and insecticidal options are available.

Key words: forest management, urban forest, biological control, conservation, stinging caterpillar

The genus *Hemileuca* Walker (Lepidoptera: Saturniidae) is widespread across North America, with about 20 species (Rubinoff and Sperling 2004), several of which periodically achieve localized outbreaks and result in defoliation of grasslands, shrublands, or forests (Schowalter et al. 1977, Collins and Tuskes 1979, Drooze 1985, Peigler 1994, Wagner et al. 2003). The taxonomy of the genus is somewhat uncertain, reflecting poor discrimination of species complexes, particularly for the buck moth, *Hemileuca maia* (Drury), species complex (Scholtens and Wagner 1994, Legge et al. 1996, Rubinoff and Sperling 2004). Taxonomic issues complicate conservation efforts in northern states where subspecies of *H. maia*, and saturniids in general, have become threatened by habitat loss, fire suppression and other anthropogenic changes in habitat conditions, and perhaps by parasitoids introduced to control invasive Lepidoptera (Boettner et al. 2000, Wagner et al. 2003, Rubinoff and Sperling 2004, Gratton 2006, Hoven 2009, Elkinton and Boettner 2012).

Buck moths characterize oak-dominated forests from the Great Lakes states to New England and south to the Gulf Coast (Covell 1984, Drooze 1985, Wagner 2005). Buck moths apparently are more abundant in southern forests and oak-dominated urban landscapes than in more fragmented and altered northern forests. In the South, the buck moth attracts attention primarily because the urticating spines of its larvae cause painful stings, particularly in urban areas, where this species is commonly known as the "stinging caterpillar" (Martinat et al. 1997).

Several aspects of buck moth ecology are important for extension agents, conservation practitioners, and forest managers. First, this species can cause noticeable local defoliation of oaks but is not generally destructive to forest resources (Drooze 1985). Second, populations are regulated naturally by environmental factors, but recent changes in habitat conditions and parasitoid loads have threatened populations in northern portions of its range (Boettner et al. 2000, Wagner et al. 2003, Rubinoff and Sperling 2004, Gratton 2006, Hoven 2009, Elkinton and Boettner 2012). Third, the painful stings from larvae often require first-aid advice. Finally, although often a nuisance in urban areas, this insect generally is not sufficiently abundant to warrant specific control measures (Drooze 1985, Diaz 2005).

Description

Eggs are laid in compact spiral masses encircling twigs on oak trees in the fall (Fig. 1). Larvae hatch in March along the Gulf Coast, later in northern portions of its range, typically at the time of budburst (Drooze 1985, Foil et al. 1991). Young larvae are gregarious, becoming more solitary as they mature. Larvae are dull black with a reddish-brown head and are covered by multiple rows of branched, breakable spines that are hollow and attached to venom glands (Fig. 2 top). Mature larvae become more variable in color (Fig. 2 bottom), some being almost white, and reach lengths up to 6.5 cm (Wagner 2005).

Fig. 1. Buck moth egg mass on oak twig. Photo by Gerald J. Lenhard (LSU AgCenter); courtesy of Bugwood.org.

Fig. 2. Mature buck moth larva on oak foliage. Top: dark form; bottom: light form. Note the multiple rows of branched spines. Bottom photo by Lacy L. Hyche, Auburn University; courtesy of Bugwood.org.

Fig. 3. Processionary chain of buck moth larvae descending live oak tree.

Larvae typically complete development by mid-April–May in the South and by August in northern portions of the range (Drooze 1985, Foil et al. 1991, Hoven 2009). When mature, caterpillars descend to the ground to pupate, often forming long chains of individuals (Fig. 3). Larvae pupate under 3–5 cm of soil during late May to early June in the South and enter a summer diapause (Foil et al. 1991, Martinat et al. 1997). In New England, larvae mature and pupate in August (Hoven 2009). Pupae may overwinter for more than a single season (Wagner 2005), providing insurance against local extinction owing to adverse environmental conditions.

Adult moths (Fig. 4) emerge during late September to mid-October in northern states (Drooze 1985) and mid-December in the South (Martinat et al. 1997), to mate and lay eggs. The moths are medium-sized, dark brown to black with a white band across both forewings and hindwings (Fig. 4). Males, but not females, have a red–orange tip on their abdomens (Drooze 1985). Moths can be seen flitting erratically during mid-day, especially around oak trees during fall months and deer hunting season, perhaps giving the moths their name (Tuskes et al. 1996). Adults of *Hemileuca* spp. do not feed and must use energy stored as larvae for dispersal and reproduction (Schowalter et al. 1977, Collins and Tuskes 1979, Hoven 2009).

Ecology

The buck moth is typical of univoltine, tree-feeding saturniids. However, unlike most saturniids, the buck moth often attracts attention during localized outbreaks and in urban areas, primarily as a result of stings. Foliage quality and mortality agents are apparently the primary factors regulating buck moth populations, although abiotic variables, such as temperature and photoperiod, also are important (Foil et al. 1991, Hoven 2009). Mating and reproduction require conditions favorable to pheromone communication.

Foliage quality can vary among tree species, among conspecific individuals, and among leaf age classes. Buck moth larvae typically prefer oak foliage, particularly scrub oak, *Quercus ilicifolia* (Wangenh), and dwarf chestnut oak, *Quercus prinoides* (Willd.), in

Fig. 4. Adult buck moth, male. Photo by Gerald J. Lenhard (LSU AgCenter); courtesy of Bugwood.org.

the pine barrens of New England (Covell 1984, Wagner et al. 2003, Wagner 2005, Hoven 2009). However, Smith (1974) and Scholtens and Wagner (1994) reported that buck moths traditionally assigned to *H. maia*, in Michigan and Ohio, respectively, showed greater association with willows, *Salix* spp., and poplars, *Populus* spp.; these hosts often are associated with the New England buck moth, *H. lucina* Hy. Edwards.

In the South, forests and urban landscapes are dominated by water oak, *Quercus nigra* L., and live oak, *Quercus virginiana* Mill., which are particularly important hosts for buck moths. Martinat et al. (1997) found that larval survival was >75% on water oak, live oak, black oak, *Quercus velutina* Lam., and black cherry, *Prunus serotina* Ehrh., foliage, but <5% on all other tree species tested. Furthermore, larvae reared through fourth instar on oak foliage and then transferred to other tested species showed greatly reduced survival.

Although oaks are the preferred hosts, conspecific oaks growing next to each other and with interconnected crowns often show dramatically different degrees of defoliation, indicative of variation in foliage quality, e.g., nutritional or defensive chemistry. Foil et al. (1991) demonstrated that survival rate was significantly higher and development rate significantly shorter for larvae reared on foliage collected earlier during leaf expansion, when tannin concentrations were higher, compared with larvae reared on foliage collected later during leaf expansion. Hoven (2009) found that buck moth larvae showed significantly greater growth rates when reared on host foliage from burned plots, compared with growth rates on host foliage from unburned plots.

Elevated buck moth populations often coincide with elevated populations of white-marked tussock moth, *Orgyia leucostigma* (J.E. Smith, Lepidoptera: Erebidae), and forest tent caterpillar, *Malacosoma disstria* Hübner (Lepidoptera: Lasiocampidae). Both of these species feed on a wider variety of host plants (Drooze 1985), suggesting a common response to changes in climate, as this affects host quality.

The stinging spines of buck moth larvae likely deter vertebrate predators. However, larvae are subject to high rates of parasitism. Mitchell et al. (1985) discovered a nuclear polyhedrosis virus (NPV) that is highly virulent in buck moth larvae, but larval susceptibility appeared to decline in older larvae.

Several dipteran and hymenopteran parasitoids, especially *Leschenaultia flavipes* (Bigot) (Diptera: Tachinidae), *Hyposoter fugitivus* (Say) (Hymenoptera: Ichneumonidae), and *Meteorus autographae* (Muesebeck) (Hymenoptera: Braconidae), develop in buck moth larvae (Peigler 1994, Selfridge et al. 2007, Hoven 2009). Gratton (2006) reported that a related species or hybrid, *Hemileuca* sp., in Wisconsin suffered up to 93% parasitism by *L. flavipes* in the field. Boettner et al. (2000) and Elkinton and Boettner (2012) found that an exotic parasitoid, *Compsilura concinnata* (Meigen) (Diptera: Tachinidae), introduced in 1906 to control invasive gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Erebidae), parasitized 36% of buck moth larvae in Massachusetts, perhaps explaining the decline of buck moth populations to threatened status in that state. However, more recently, Selfridge et al. (2007) and Hoven (2009) found relatively low rates of parasitism by *C. concinnata*.

Predation of pupae has not been examined widely. Selfridge et al. (2007) reported that pupal mortality rates for *H. maia* differed significantly between caged pupae ($5.8 \pm 8.8\%$) and uncaged pupae ($38 + 22\%$) during their study on Cape Cod. These data suggest that unidentified birds, small mammals, or large invertebrate predators are responsible for additional mortality to uncaged pupae.

Abiotic factors that can impact populations include frost pockets and prescribed fire. Wagner et al. (2003) reported that buck moth abundances were higher in frost pockets (topographic depressions that trap cold air) in New England, perhaps reflecting delayed host phenology that provided more nutritious young foliage (Foil et al. 1991) later when temperatures became more suitable for young larvae. Hoven (2009) reported that parasitism by *C. concinnata* was significantly reduced in open-canopied habitats compared with closed-canopied habitat. However, Hoven (2009) and Selfridge et al. (2007) found that parasitism by *L. fulvipes* was significantly higher in more open-canopied habitats.

Like other saturniids and most insects, the buck moth depends on pheromones to attract mates and reproduce (Earle 1966, Collins and Tuskes 1979, Cardé and Baker 1984). McElfresh et al. (2001) identified the components of the female's mating pheromone, a blend consisting of a major component, (E10,Z12)-hexadeca-10,12-dienal (E10,Z12–16:Ald), and two minor components, (E10,Z12)-hexadeca-10,12-dien-1-ol (E10,Z12–16:OH) and (E10,Z12)-hexadeca-10,12-dien-1-yl acetate (E10,Z12–16:Ac), in a ratio of 100:7.4:6.3. Males were not attracted to blends consisting of different ratios of these compounds or to other compounds present in female pheromone glands.

Forest Management

Population dynamics of the buck moth are poorly known. Martinat et al. (1997) reported a regional outbreak along the Gulf Coast of southern Louisiana and Mississippi from 1980 to 1993. However, epicenters of high abundance shifted locations from year to year.

At high abundance, buck moth larvae can remove most foliage from individual oak trees or small groups of trees, leaving trees looking sparsely foliated. As with many herbivorous insects, outbreaks are likely triggered by environmental changes, especially drought and anthropogenic changes in habitat conditions (Peigler 1994, Schowalter 2016), although there are no studies of factors affecting population growth of buck moth. However, oaks are capable of replacing lost foliage after larvae have disappeared and typically show no symptoms of defoliation by mid-summer (Fig. 5). This seasonal cosmetic effect does not warrant specific management plans (see below).

In New England, buck moth populations have continued to thrive in high-quality pine barrens, where oaks are abundant codominant trees, but have declined steeply in other areas over the past several decades (Wagner et al. 2003, Rubinoff and Sperling 2004, Hoven 2009). Forest fragmentation, fire suppression, and

Fig. 5. New live oak foliage production (compensatory growth) in wake of defoliation by buck moth larvae.

Fig. 6. Buck moth stings. Note the double row of red welts on the right-hand side corresponding to the double row of spines on the larva.

perhaps the introduced *C. concinnata* have been identified as primary factors threatening buck moth populations (Boettner et al. 2000, Wagner et al. 2003, Rubinoff and Sperling 2004, Hoven 2009, Elkinton and Boettner 2012). Thinning and prescribed fire to restore pine barrens to historic conditions may benefit buck moth populations in New England by improving host nutritional quality and by reducing *C. concinnata* parasitism (Hoven 2009).

Medical Significance

People typically contact the larvae, either by stepping on them or by brushing against them on walls, shrubs, etc., during the short period when larvae are descending to the ground and before they pupate. Contact with the spines results in painful stinging that can last several hours to several days (Fig. 6). In cities such as Baton Rouge or New Orleans, where live oaks and water oaks dominate city parks, roadsides, and residential landscapes, the larvae can become a significant nuisance for humans and pets (Everson et al. 1990, Diaz 2005).

Avoiding contact with larvae is the best strategy to avoid stings (Diaz 2005). Recommendations include wearing long sleeves and pants, tucked into gloves or shoes, when pruning trees or shrubs, especially during the peak caterpillar season in April–May. If a caterpillar falls or crawls onto a person, avoid swatting or brushing, as these violent acts can embed spines in hair, clothing, or skin. Cast skins and dead caterpillars also can sting workers pruning affected branches (R. A. Goyer, personal communication). Never rub a stung area, as this can further embed spines in the skin (Diaz 2005).

Everson et al. (1990) analyzed 112 cases of caterpillar envenomation in Louisiana during 1987. Caterpillars were identified to species in 68% of the cases. Of these, the caterpillar species responsible for all but two cases were buck moth (49% of stings); puss caterpillar, *Megalopyge opercularis* (J.E. Smith) (Lepidoptera: Limacodidae) (22%); saddleback caterpillar, *Acharia stimulea* (Clemens) (Lepidoptera: Limacodidae) (16%); and io moth, *Automeris io* (F.) (Lepidoptera: Saturniidae) (11%). No patients exhibited anaphylactic responses to caterpillar stings. Clearly, buck moth inflicted the vast majority of stings, all between April 20 and June 13.

The following first-aid procedure is recommended for caterpillar stings (Diaz 2005): 1) Immediately wash off the affected area with soap and water to remove loose spines, followed by noncontact drying with a hair dryer, not a towel. 2) Gently place adhesive duct tape over the stung area and peel away to remove any remaining spine tips. 3) Swab the site with isopropyl alcohol or ammonia, then apply an ice pack to cool the site. 4) Apply topical or oral antihistamines and corticosteroids to alleviate pain and allergic reaction. Of course, if swelling or difficulty in breathing occurs, go immediately to an emergency room for treatment. A variety of pain remedies have been suggested, including aspirin, meat tenderizer marinade, calamine lotion, and aloe, to reduce the duration of pain.

Insect Management

Host plants may be inspected for buck moth larvae beginning in April and continuing through May. Avoiding areas where larvae occur, especially near schools, and/or avoiding contact with larvae are the most effective measures for preventing stings.

Management for buck moths is rarely necessary, because of the limited defoliation caused by this moth and the compensatory growth of host trees that quickly replace lost foliage. Insecticides are not recommended, because most homeowners would be unable to reach the tops of large oak trees where the caterpillars feed, nontarget effects of insecticide application outweigh benefits from reduced caterpillar abundance, and insecticides are relatively ineffective for preventing stings. Insecticide application may do more harm than good in killing other caterpillars that are endangered or that become important pollinators as adults (Boettner et al. 2000, Diaz 2005). However, if insecticide application appears to be warranted, biological larvicides, such as *Bacillus thuringiensis kurstaki* (Btk) or viruses (NPV), generally are safer and have fewer nontarget effects than organophosphates, carbamates, or pyrethroids labeled for use (Mitchell et al. 1985, Diaz 2005, Louisiana Insect Pest Management Guide 2016). Such products are most effective during early larval stages.

Pheromones have proven useful for identifying areas of high abundances but have not been explored for mass trapping or mating disruption. For example, the New Orleans Mosquito and Termite Control Board has used pheromone-baited traps since 1997 to survey parks, oak-lined boulevards, and the city zoo area. High numbers of buck moths in traps provide an early indication of potentially high larval populations the following spring (McElfresh et al. 2001).

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