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FACT SHEET

The Gypsy Moth

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Introduction:

The gypsy moth, *Lymantria dispar*, was introduced into the US (Medford, MA) around 1869 by Etienne Leopold Trouvelot. Some larvae escaped and small outbreaks became evident in the area around 1882. Populations increased rapidly and by 1889, the Massachusetts State Board of Agriculture began a campaign to eradicate the moth. It was first detected in Connecticut in Stonington in 1905 and had spread to all 169 towns by 1952. In 1981, 1.5 million acres were defoliated in Connecticut (Fig. 1). During an outbreak in 1989, CAES scientists discovered that the entomopathogenic fungus *Entomophaga maimaiga* was killing the caterpillars. Since then, the fungus has been the most important agent suppressing gypsy moth activity.

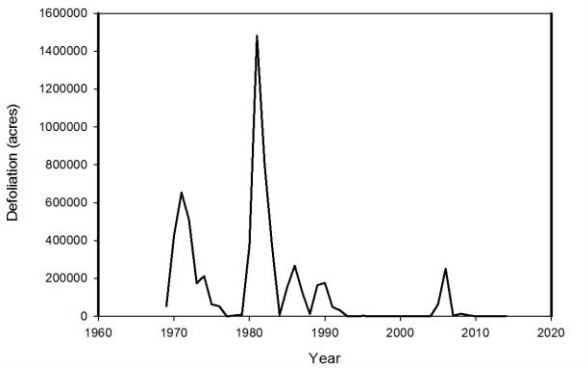

Figure 1. Number of acres defoliated by the gypsy moth in Connecticut, 1969-2014.

However, the fungus cannot prevent all outbreaks and hot spots in some areas continue to be reported. There was an outbreak in 2005-2006 and again in 2015.

Life Cycle:

There is one generation of the gypsy moth each year. Caterpillars hatch from buff-colored egg masses in late April to early May. An egg mass may contain 100 to more than 1000 eggs and are laid in several layers.

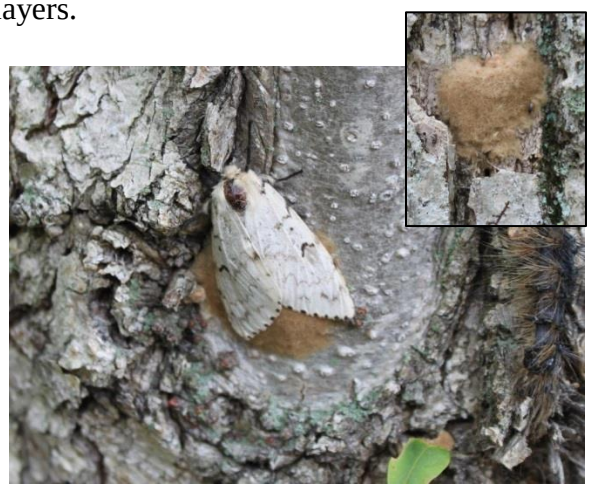

Figure 2. Female gypsy moth laying an egg mass and an egg mass (inset).

A few days after hatching, the ¼ inch long, buff to black-colored caterpillars (larvae) ascend the host trees and begin to feed on new leaves. These young caterpillars lay down silk safety lines as they crawl and, as they drop from branches on these threads,

may be picked up on the wind and distributed.

Figures 3-5. Gypsy moth caterpillars (top, middle) and pupae (bottom).

There are four or five larval stages (instars) each lasting 4-10 days (total ~ 40-days). Instars 1-3 remain in the trees, but the fourth instar caterpillars, with their distinctive double rows of blue and red spots, generally crawl up and down the tree trunks feeding mainly at night. They seek cool, shaded protective sites during the day, often on the ground. However, under outbreak conditions with dense populations of caterpillars, they may feed continuously and crawl at any time. The caterpillars complete their feeding sometime during late June to early July and often seek a protected place to pupate and transform into a moth in about 10 to 14 days. Male moths are brown and can fly. The female moths are white and, while they have wings, cannot fly. They do not feed and live for only around 6-10 days. After mating, the female will lay a single egg mass and die. Egg masses can be laid on anything; e.g., anywhere on trees, fence posts, brick walls, on outdoor furniture, cars, recreational vehicles, rock walls, firewood, and are often placed in more protected locations. Egg masses are hard. The eggs will pass through the winter and larvae hatch the following spring during late April through early May.

Figure 6-7. Mating female and male moths (top) and a female moth (bottom).

Impact of Gypsy Moth:

While gypsy moth caterpillars will feed on a wide diversity of trees and shrubs, oaks are their preferred food plant. Feeding can cause extensive defoliation. Other favored tree species include apple, birch, poplar, and willow. During heavy infestations, the caterpillars may also attack certain conifers and other less favored species.

Figure 8-9. Defoliation caused by the gypsy moth, Lyme, CT in 2006 (top) and Totoket Mountain in 2015 (bottom).

Healthy trees can generally withstand one or two partial to one complete defoliation (>50%). Trees will regrow leaves before the end of the summer, but there can be some thinning or dieback of branches. However, some older trees may be more vulnerable to defoliation, which may cause stress. Weakened trees can also be attacked by other organisms, or lack the energy reserves for winter dormancy and growth during the following spring. Three years of heavy defoliation may result in high oak mortality. Trees along ridges with thinner soils and less moisture are particularly vulnerable.

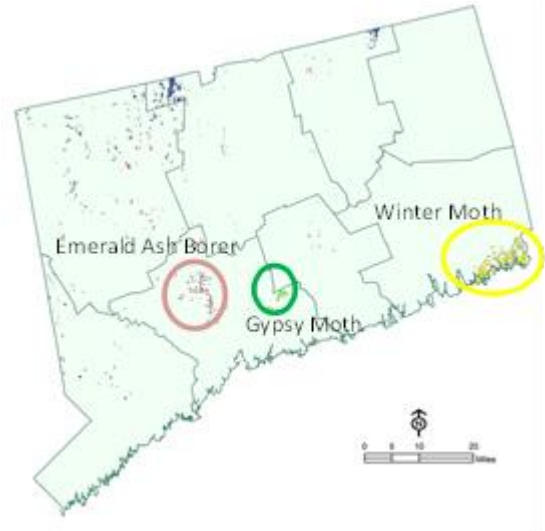

Figure 10. The 2014 aerial survey map for Connecticut showing defoliation; 1,337 acres impacted by gypsy moth, 2,456 acres by emerald ash borer, and 7,440 acres by winter moth. The state aerial survey is supported by the US Forest Service.

The gypsy moth caterpillars can also be a problem because they drop leaf fragments and frass (droppings) while feeding, and onto decks, patios, outdoor furniture, cars, and driveways, leaving a mess. Crawling caterpillar can also be a nuisance and their hairs can be irritating. The egg masses, which may be difficult to detect, can often be transported on vehicles to areas where the moth is not yet established. A national program in the states along the leading edge of the established gypsy moth range from North Carolina to upper Michigan, which helps slow the progress of the insect into new areas. Under state quarantine laws, the CAES inspects certain plant shipments destined to areas free of the gypsy moth, particularly for egg masses.

Gypsy Moth Management:

Given the potential impact of the gypsy moth caterpillar feeding on shade trees and human activities around homes and businesses, some property owners may elect to treat for gypsy moth, rather than wait and

see what control the fungus *E. maimaiga* and other natural enemies of the gypsy moth may have on caterpillar abundance. The activity of the fungus is highly weather dependent (see below). Control efforts generally target either the eggs or caterpillars and may be physical, biological, or chemical.

Physical Control

One option is to scrape, remove and destroy any egg masses. However, many egg masses may be located in inaccessible areas (such as high in the trees) and during the spring young caterpillars may be blown in from adjacent infested properties. Removed egg masses can be drowned in a container of soapy water and deposed of. Another method is the use of burlap refuge/barrier bands wrapped around tree trunks to take advantage of the behavior of late-stage migrating caterpillars who descend the trees during the day to seek protective niches and climb back up to feed at night.

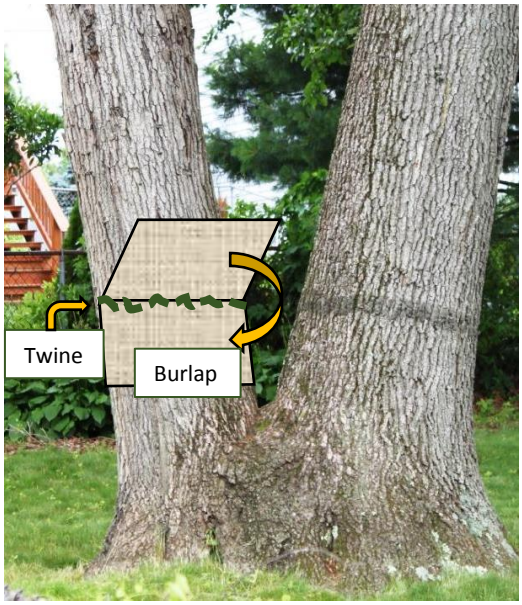

Figure 11. Tree showing remnant of sticky banding for gypsy moth from the 1980s (right) and diagram of burlap refuge band (left).

The larvae will crawl into or under the folded burlap or be trapped by a sticky band and can be killed. Some trees may still show signs of earlier bands from the 1980s (Fig. 11).

Biological Control

The major gypsy moth control agent has been the entomopathogenic fungus *Entomophaga maimaiga*, (Fig. 12). This pathogen was released in the Boston area in 1910-1911 and no evidence of infection was found. It was recognized as active during a moth outbreak in 1989. Resting spores of the fungus can survive for more than 10 years. The fungus can provide complete control of the gypsy moth, but early season moisture from rains in May and early June are important to achieve effective infection rates and propagation of the fungus to other caterpillars. The dry spring in 2015 resulted in little or no apparent fungal inoculation or spread until it killed late-stage caterpillars in some areas of the state, subsequent to most defoliation. Infected caterpillars typically hang vertically from the tree trunk, head

Figure 12-13. Spores of the fungus *E. maimaiga* (top) (CAES) and caterpillars killed by the fungus (bottom - photo Gale Ridge, CAES).

down from the tree trunks or other surfaces, but many also die in an upside down "V" position (Fig. 13), generally a characteristic of caterpillars killed by the less common gypsy moth nucleopolyhedrosis virus (NPV). No evidence of NPV was detected in caterpillars examined in 2015.

The biological insecticide *Bacillus thuringiensis* var. kurstaki (Btk) (Dipel, Biotrol, Biobit, Others – Table 1) is a bacterium that occurs naturally and only affects caterpillars of moths and butterflies. It must be ingested by feeding caterpillars for the endotoxin to work; Btk is not effective against the pupa and adult of the gypsy moth. It may be applied by air for control in areas where there are active suppression programs, but no aerial applications have been conducted in Connecticut, because *E. maimaiga* has generally kept the gypsy moth under control (Fig. 14). Btk may also be applied by commercial applicators and/or homeowners. It is most effective when applied to young caterpillars; i.e., larval instars 1 and 2 (prior to the second week of June or full leaf expansion). Generally, two applications are made, one during late April into early May on caterpillars less than a week old, followed by second treatment about 2 weeks later.

Figure 14. Aerial spraying of *Bacillus thuringiensis* in Ledyard, 1985.

Chemical Control

There are a number of crop protection chemicals labeled for the control of gypsy moth on ornamental trees and shrubs. Those labeled for gypsy moth control on ornamental trees and shrubs are provided in Table 1. There are many individual brands or trade names for the insecticides; not all may be registered for gypsy moth. Some products are classified as a Restricted Use Pesticide (RUP), formulated for use only by a licensed applicator, often due to toxicity to aquatic invertebrate animals. Other products are available to homeowners.

Treatment of Egg Masses – An alternative to the removal of gypsy moth egg masses is the treatment with insecticidal soap, mineral oil, or a soybean oil product (Table 1). The destruction of each egg mass prevents the hatching of up to 1000 caterpillars. Completely soak each egg mass with the oil or insecticidal soap. Egg masses are present from mid-summer through the next spring, which provides plenty of opportunity for removal or treatment.

Treatment for Larvae - Timing of application for the control of gypsy moth caterpillars is important and thorough coverage of individual trees is necessary for good control. Correct treatment of trees > 15 feet in height will require the services and spray equipment of a licensed arborist. An arborist is someone who is qualified to perform arboriculture (tree services) and is licensed by the Department of Energy and Environmental Protection (DEEP). The best results for most products will be obtained after the larvae have hatched, generally between mid-May and mid-June. A single application is generally sufficient to protect trees, but another application may be necessary if the entire tree was not treated or if a property is adjacent to heavily infested woodlands. In the case of insect growth regulators (IGRs) like diflubenzuron or

tebufenozide (commercial use only) and *Bacillus thuringiensis*, they are most effective when applied to the early stage caterpillars. Most of the other products for gypsy moth control are pyrethroids, some of which are only for commercial use, while other brands or formulations are available to homeowners (Table 1). Four materials are listed by the Organic Materials Research Institute (OMRI) for organic use: Btk mentioned previously, the insect growth regulator azadirachtin, spinosad, and a few pyrethrin or insecticidal soap products. Azadirachtin is the active naturally occurring insecticidal compound in the neem tree. Neem products need to be ingested to be effective and are relatively safe for pollinators and beneficial predators and parasitoids. Spinosad is a natural insecticide consisting of two compounds; spinosyn A & spinosyn D, derived from the fermentation of the bacterium *Saccharopolyspora spinosa* (discovered in sugar cane fields of the Caribbean). It works primarily through ingestion on most targeted pests, but it also can kill on contact. While generally safe for most beneficial insects, spinosad is toxic to bees up to three hours after application.

Control of Pupae – There is no chemical specifically labeled for the control of gypsy moth pupae. Similar to egg masses, the tear-dropped shaped pupae can be removed and destroyed. The pupal stage is present for only 10-14 days.

Treatment of Adult Moths – While several insecticides are labeled for the control of adult moths, applications against the adult stage are much less effective than targeting the eggs or caterpillars. Individual adult moths live between 6 to 10 days. Similarly, pheromone traps for male moths, which are meant for monitoring purposes, are not an effective control method.

Toxicological and other information for a particular chemical is available online from the U.S. Environmental Protection Agency (EPA) (www.epa.gov), the National Pesticide Information Center (NPIC) (http://npic.orst.edu/), and the Extension Toxicology Network (EXTOXNET) (http://ace.orst.edu/info/extoxnet/). The Pesticide Management Division, Connecticut Department of Environmental Protection, can provide information on laws and regulations governing the application of insecticides, certification of pesticide applicators and arborists, and which products are registered for use in the state (online -Kelly Registration Systems).

August 2015

Photographs were provided by Chief Plant Inspector Peter Trenchard except as noted, and Mr. Trenchard contributed to this fact sheet. Aerial surveys are conducted by CAES plant inspectors Peter Trenchard and Tia Blevins. Sources include CAES publications The Gypsy Moth by John F. Anderson [2-82] and The Fungus and the Gypsy Moth by Ronald M. Weseloh; Frontiers of Plant Science; 54(2) Spring 2002; Andreadis & Weseloh. 1990. PNAS. 87:2461-2465, and McManus et al. 1979. The Homeowner and the Gypsy Moth: Guidelines for Control. USDA Home & Garden Bull. No. 227.

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Table 1. Chemical and biological insecticide compounds labeled for the control of the gypsy moth on ornamental trees and shrubs by general or restricted use. Chemicals or formulations listed as restricted use may only be used by a licensed applicator. There are 4 products registered for eggs (E), 246 for larvae (L), and 78 for adults (A) of the gypsy moth in Connecticut. Many products may contain the same active ingredient and some products contain more than one active ingredient.

Chemical (active ingredient)	Representative Trade Names	Chemical class or type	Stage	Comments
General use				
Acephate	Orthene®	Organophosphate	L	
Azadirachtin	Azatrol®, Azatin®, Azamax®, Ornazin®, Neemix® 4.5, Safer Bioneem®	Insect growth regulator (IGR)	L	Neem-based Insecticide Organic, OMRI listed
Bacillus thuringiensis var. *kurstaki*	DiPel® DF, Biobit® HP, Foray®48BA, Safer® Tree, Shrub Conc. Thuricide® BT, Javelin®	Biological	L	A bacterium that kills when ingested, OMRI listed
Carbaryl	Sevin® SL and others	Carbamate	L, A	
Methoxyfenozide	Entrepid® 2F	Diacylhydrazine (IGR)	L	Molting hormone agonist, relatively non-toxic honey bees
Pyrethrins plus piperonyl butoxide (PBO) sulfur, or insecticidal soap, etc.	Pyrenone®, Garden Safe	Pyrethrin	L, A	Natural insecticide compounds from chrysanthemum flower. Most products other uses.
Insecticidal Soap	M-Pede®, Safer® Bayer Advanced Natria®	Potassium salts of fatty acids	E, L	Products with synergist PBO are not considered organic
Spinosad	Entrust® SC, Conserve® SC Bull's-Eye™ Bioinsecticide	New chemical class spinosyn A & spinosyn D	L	Bacterial fermentation product, OMRI listed
Canola oil	Bayer Natria® Ortho® Elementals™ (with pyrethrin)	Oil	L, A	Combined with pyrethrin in many homeowner products
Mineral (petroleum oil)	Ortho® Volck® Oil Spray	Oil	E	
Soybean oil	Golden Pest Spray Oil™	Oil	E	or 50% solution oil and water
General or restricted use depending on product				
Cyfluthrin	Tempo®, Bayer Lawn & Garden	Pyrethroid	L	Some products restricted use; some general use
Bifenthrin	Onyx™, Talstar®, Mence™ Ortho® Bug-B-Gon®	Pyrethroid	L	Many products restricted use; some general use
Permethrin	Astro®, Evercide®, Permanone® Bee Gone® Insecticide	Pyrethroid	L, A	Some products restricted use; most general use
Fluvalinate; tau-fluvalinate	Mavrik®, Bayer Advanced	Pyrethroid	L	Some products restricted use; some general use

Restricted (Commercial) use				
Chlorantraniliprol	Acelepryn®	Anthranilic diamide	L	Commerical use only
Cypermethrin	Cyper TC	Pyrethroid	L, A	Trunk, structural use
Deltamethrin	Deltagard® T&O, Suspend SC	Pyrethroid	L	Commercial use only
Diflubenzuron	Dimilin™ 25W	Benzophenyl urea (an IGR)	L	Certified applicators only
Lamda-cyhalothrin	Demon® Max, Simitar® CS	Pyrethroid	L, A	Commercial use only, General use products not labeled for GM
Tebufenozide	Mimic®2LV, Confirm®2 F	Insect growth regulator (IGR)	L	Specific to Lepidoptera

The list of active ingredients in products labeled for the control of gypsy moth is for informational use only and is based on searches of registry databases (e.g., kellysolutions.com/CT) and other sources. Active ingredients and products may change over time. Not all trade names (252 products registered in Connecticut alone) can be mentioned. A list of specific products acceptable by OMRI for organic use is available at https://www.omri.org/. Mention of an insecticide does not constitute a claim of effectiveness or an endorsement by The Connecticut Agricultural Experiment Station. The product label is the legal document for use and homeowners and others applying an insecticide should read and follow the label directions.