Natural Resource Preservation Brief #11
The Gypsy Moth

HISTORY

The gypsy moth (Lymantria dispar) is currently the most serious insect enemy of Maryland's forests. It is a native of Europe, Asia, and North Africa and was introduced into Massachusetts from Europe in 1869 by a French scientist hoping to produce a new race of silk-producing insects. Some of the larvae (catepillars) escaped during his experiments, and in a few years the insect became well established in surrounding woodlands. By 1902, it was widespread in all of the New England states, in eastern New York, and in parts of New Jersey. Millions of dollars were spent in an effort to control it. A barrier zone was established in eastern New York in an attempt to halt the westward and southward advance. Any infestations found in this zone were treated with lead arsenate sprays. However, this effort failed to contain the insect, probably due to severe windstorms that carried larvae long distances. In general, the prevailing winds have tended to work against the insect's spread.

In 1932, infestations covering 400 square miles were discovered in Luzerne and Lackawanna counties of northeastern Pennsylvania. Two years later three other counties were found infested. These infestations were largely kept under control for 10 years with lead arsenate. Beginning in 1943, and at intervals for the next 20 years, all infestations found were treated with DDT. Spread of the moth was minimal during this period. The total area treated in the state of Pennsylvania with DDT amounted to 1,200,000 acres, 60% of this occurring in 1957-58.

Since 1963, when DDT was abandoned in favor of more environmentally acceptable but less effective insecticides, the insect began its march across Pennsylvania. In 1969, it was found for the first time west of the Susquehanna River. Other states to the south and west are rapidly being infiltrated, and it is expected that the insect will eventually occupy all of the oak regions of the country. Its dispersal is now being greatly aided by the rapidly increasing use of camping trailers and mobile homes. Vehicles that are present in infested areas during June and July frequently carry larvae, pupae, and egg masses to distant states. Federal quarantine regulations are in effect to retard spread to uninfested states.

The new era of serious gypsy moth buildups began in 1969 when 830 acres were found defoliated in Monroe County in the Poconos. The peak year of 1977 marked the first time that gypsy moth defoliation exceeding 1 million acres was recorded by a single state.

Serious tree defoliation will continue to move southward and westward, wherever oak forests predominate. In addition, there will be periodic rebuildups behind this "defoliation front." The extent of the problem area in any year will largely be determined by the effectiveness of biological and other natural controls.

The gypsy moth problem is complex. In order to thoroughly understand it, one must have a knowledge of biological interactions that occur in a forest. Programs that are undertaken must be weighed carefully, since one effort might well be counter productive to another. In any event, resolution of the problem will require years of effort and research. There is no panacea on the horizon which will cause the gypsy moth to disappear.

HOSTS

The gypsy moth catepillar is the stage that does tree damage, and it is a general feeder on many kinds of trees and shrubs. In heavy infestations, very few species of trees are ignored, especially by the older larvae. After devouring tree foilage, they have been known to feed on many other plants, including grass, vines, flowers, garden and field crops. The caterpillars also swarm over and enter buildings, creating a public nuisance. The large number of host plants, over 500, is one reason why the moth is considered such a serious pest. The gypsy moth is also the only important insect in Maryland that will feed on both hardwoods (broadleaf trees) and confiers (evergreens).

There are distinct differences in the food preferences of the very young and older larvae. Some trees are highly favored by all stages, and some are seldom fed upon. The most commonly favored and unfavored hosts in the forest are listed below.

Category 1. Food Plants Favored by All Larval Stages: alder, apple, aspen or polar, basswood, gray, white and river birches, boxelder, red gum, hawthorn, larch, mountainash, all species of oak, especially white oak and chestnut oak, blue spruce, sumac, willows, and witch hazel.

Category 2. Food Plants Favored Only by the Older Larvae (Cateorgy 1 trees must be present for younger larvae to initially feed on): beech, chestnut, hemlock, and all species of pine and spruce.

Category 3. Food Plants Moderately Favored to Unfavored (these trees are frequently defoliated when a heavy buildup has occurred on associated Category 1 trees, however, serious tree damage or mortality occurs much less often): black and yellow birch, butternut, cherry, cottonwood, elms, black gum, hackberry, hickories hornbeam, maples, pear, sassafras, sweetgum, and walnut.

Category 4. Food Plants Not Favored by Any Larval Stage (larvae must be in a starving condition to cause noticeable feeding injury and this is usually minor): arborvitae, ash, balsam fir, catalpa, cedars, dogwood, grape, holly, honeylocust, honeysuckle, horsechestnut, huckleberry, junipers, black locust, mountainlaurel, mulberry, persimmon, poison ivy, sycamore, and tulip poplar.

TREE INJURY

The gypsy moth, like many other forest defoliators, is capable of killing. The greatest impact from this insect is felt in oak forests and primarily on the ridge and plateau areas that support vast stands of chestnut oak and white oak. These species and locations are the favorite breeding grounds of the gypsy moth, and explosive populations have developed within 5 years after a few insects became established.

The Pennsylvania Department of Environmental Resources has conducted damage appraisals in all areas where heavy gypsy moth defoliation (over 60% of the tree foliage removed) has occurred for 2 or more consecutives years. The timber loss through 1979 has been 474 million board feet of sawtimber and 436 million cubic feet of pulpwood. This represents an average loss of 20% of these forest stands with a stumpage valuation of $32 million. Mortality rates

are frequently higher or lower (5% to 60%) after two years of stripping, and the killed trees often occur in pockets. Defoliation that persisted for 3 years on 10,000 acres produced oak mortality rates of 84% and an average loss for all trees of 79%. A 20% tree loss is generally considered as a tolerable rate for most forest areas that are uninhabited and undeveloped, considering the costs of control and other adverse ramifications of continual spraying in large forested areas. It almost goes without saying, however, that it would be extremely unproductive to allow high mortality rates that would decimate the forests. The current 20% loss rate is not acceptable in forested residential or other high-use, high-value areas.

Fortunately, most dense gypsy moth populations normally collapse after 2 years of heavy defoliation, due primarily to starvation, stress-induced diseases, and parasitism. Some of the surviving trees may continue to decline or die in ensuing years. Hemlocks completely stripped of their foilage will die in one year, as will be the case with many of the pines and spruces. Larch will withstand repeated defoliation for a dozen years or more. Mortality of hardwood trees other than oak is insignificant. The losses to date have been 94% oak species and the remaining 6% mostly conifers.

Defoliated hardwoods will produce a second crop of foilage within a few weeks after being stripped, and few, if any, should die from one year's damage. The refoliation produces a less dense crop and smaller leaves, and some of the twigs and branches may die. After two years of defoliation, food reserves in the tree become critical. The amount of tree mortality is also influenced by many uncontrollable environmental factors, such as the growing site and the amount of rainfall received during critical periods.

A principal reason for the severe impact on oak is a secondary insect called the two-lined chestnut borer (Agrilus bilineatus). This borer invades weakened oaks, constructing tunnels under the bark that stop the flow of nutrients and water in the tree. By late summer the borer has girdled the tree thereby causing it abrupt death. Shoestring root rot (Amillaria mellea) also invades and kills the weakened trees.

The gypsy moth, like a great many other insects has the potential to go from insignificant numbers causing very light defoliation to massive numbers causing complete defoliation in one year. This will happen when populations are on the upswing as denoted by large-sized egg masses, little parasitism, and a very high survival rate of young larvae. It is possible to get heavy defoliation with as few as 500 egg masses per acre if favored hosts predominate. When populations are declining or collapsing, and denoted by egg clusters greatly reduced in size and heavy parasitism, there may be only light defoliation with several thousand egg masses per acre.

Whether a tree ends up as a cutoff stump or a functional living tree after defoliation depends on how badly the tree was affected by defoliation, and this depends on:

-How much foliage was eaten
-If the tree refoliated
-How many years in succession the tree was defoliated
-When during the year defoliation occurred
-What the weather conditions were after defoliation
-If disease organisms and other insects attacked the tree
-How healthy or vigorous the tree was before defoliation.

LIFE CYCLE

The female gypsy moth lays one egg mass in June or July and then dies shortly thereafter. The eggs are deposited in a well-formed egg mass on trees as well as on rocks, stumps, ground foilage, houses, yard equipment, wood piles stone walls, and camping trailers. The eggs do not hatch until the following spring.

The egg masses are buff colored when first laid but many bleach out over the winter months when exposed to direct sunlight and weathering. Small pinholes evident on egg masses are emergence holes of a parasite that can destroy up to 40 percent of the eggs within a mass.

Egg masses contain from 75 to 1,000 eggs. Each egg is encased in a secretion produced by the female moth, along with scales and hairs from the underside of her body. The mixture provides the eggs excellent protection from desiccation and from winter temperatures as low as -20° F (-29°C).

In late April or early May, first-stage larve (caterpillars) emerge from individual egg masses in 3 to 5 days. Egg hatching may continue over a period of 2 to 3 weeks in any one locality, depending on the placement of egg masses and exposure to sunlight. Newly hatched larvae are buff colored but turn black within 4 hours after hatching. They may rest on or around the egg mass for hours if temperatures are below 40°F (4° C). If it is raining, larvae may remain in this position for 24 to 48 hours.

When conditions are favorable, larvae climb trees in response to light and trail silk continually as they move. When they reach the outer branches or tops of the trees, they drop on silken threads, reclimbing the strands until carried by the wind to a new location. Both the silk and long lateral hairs provide buoyancy to the windborne caterpillars.

Larvae begin feeding on acceptable host plants (of which there are many) and usually chew small holes within the perimeter of the leaf. In later stages, larvae usually feed on the leaf margins. There are two or three feeding periods during the day. First-stage larvae usually produce a mat of silk on the underside of the leaf where they rest when not feeding.

Male larvae molt (shed their outer skin) through five stages, females through six. The number of days spent in each stage varies from 4 to 10 days, depending on the stage and temperature. Second- and third-stage larvae characteristically stay in the tree crowns but may migrate to the undersides of branches and twigs.

When larvae molt to the fourth stage, their behavior changes dramatically. They feed during the night then descend the trees at dawn in search of protective locations, where they rest for the remainder of the day. At dusk, larvae climb the trees again to feed. The movement up and down the tree is triggered by low light. Larvae prefer to rest under bark flaps or other structures on the tree. If none is present, the insects will descend to the ground and rest beneath leaf litter or other nearby objects, where they are susceptible to attack by small vertebrate predators such as mice and shrews.

Larvae usually complete their development in late June or early July and begin to pupate (transform into the adult, or moth, stage), usually in the

same location where they rested as fifth- or sixth-stage larvae. During this process the larvae attach themselves to the surface with strands of silk and eventually transform into mahogany-colored pupae. The pupae, which are immobile and defenseless, are vulnerable to predators such as the ground beetle and parasites like wasps.

Female pupae are characteristically much larger than male pupae because they pass through an additional larval stage. The pupal stage of both sexes usually lasts about 2 weeks. Male moths usually emerge first because they pass through one less life stage and usually pupate earlier than the females.

Male moths are strong fliers and are usually most active during the daytime within the forest canopy. They fly in zigzag patterns and can be seen searching up and down tree trunks for female moths. The female has well-developed wings but does not fly. She compensates for this by releasing a strong sex attractant that lures male moths from the surrounding area. Mating occurs and shortly thereafter the female deposits her egg mass.

NATURAL CONTROL AGENTS

Overseas, the gypsy moth is largely controlled by over 100 known insect parasites and predators. However, outbreaks do occur periodically much like native pests do in this country. During the period 1905-34, over 40 species of parasites and predators were imported to New England, since the most effective natural enemies were lacking in North America. Nine of these are considered to be established to a noteworthy degree and are listed below.

Name	Type	Gypsy Moth Stage Attacked	No. of Generations Per Year	Fecundity (Eggs/ (Female)	Parasitism Rates to Expect *
Ooencyrtus kuvanae	Wasp	Egg	5-6	150-200	20-50%
Parasetigena silvestris	Fly	Older Larvae	1	200+	20-80%
Blepharipa pratensis	Fly	Older Larvae	1	5,000	10-25%
Compsilura concinnata	Fly	Older Larvae	3-4	90-120	2-20%
Apanteles melanoscelus	Wasp	Younger Larvae	2	50-130	10-30%
Phobocampe unicincta	Wasp	Younger Larvae	1	100+	2-25%
Brachymeria intermedia	Wasp	Pupae	1-2	3000	2-50%
Theronia atalantae	Wasp	Pupae	2-3	Unknown	Unknown
Calosoma sycophanta	Beetle	Predator on Larvae & Pupae	1	100	Unknown

*These are approximations to show relative effectiveness. The higher figure indicates the highest parasitism rate recorded, while the lower figure indicates what one may generally expect to find in typical moderate or heavy infestations. Whey gypsy moth populations are rising to outbreak levels, and in newly infested areas, the parasitism rates may be close to zero. In 1978, parasitism rates were at their highest levels for most larval parasites, resulting in about a 95% larval reduction and collapsing many of the gypsy moth infestations. Of the egg and larval parasites, only Compsilura will attack hosts other than the gysy moth, as will the last three insects listed.

In addition, there are at least 13 native American insect parasites and predators known to prey on the gypsy moth, but collectively they normally account for only 5% of the total parasitism rate.

The introduced parasites are frequently very effective control agents. Collectively, they can cause a complete collapse of heavy gypsy moth infestations or prevent light numbers from reaching outbreak levels.

OTHER CONTROL TECHNIQUES

In residential areas, homeowners can use several methods besides spraying to combat the insect. From August to April, egg masses can be scraped off of trees or other objects and then destroyed. New egg masses are firm to the touch, while the previous year's hatched egg masses, which may still be evident, are soft and spongy. Each mass destroyed prevents about 500 caterpillars from hatching. The effort will be fruitless, however, if enough eggs are left in an area to result in heavy defoliation. Be sure to look under rocks, logs, loose bark, branches, picnic tables, behind shutters, and other objects. A great number of eggs also occur high in the trees, consequently, the method is completely impractical in the average forest. In reality this method is only feasible on small trees which are isolated from nearby infested woodlands.

Many caterpillars can be easily trapped, removed and then killed by tying a band of burlap or other thick material around tree trunks. Caterpillars, after they are about half-grown, descend the tree to rest during the daytime and will find the burlap an ideal resting location. The burlap strip should be 8 inches to 1 foot wide, held in place by a cord tied in the center about shoulder high, and the upper half of the band folded down over the lower. The caterpillars will congregate under the folded portion. Bands should be on the trees from late May through mid-July, inspected daily, and the caterpillars destroyed. This method is effective in preventing heavy defoliation of valuable shade trees, but again it is impractical where large numbers of trees occur and in those cases where populations are so dense that larvae are active around the clock without seeking shelter. Larvae may also be found in bark crevices, under loose bark, and in loose ground litter. The use of sticky materials around tree trunks to trap caterpillars is not recommended since the tree bark may be damaged. Later on, from late June to late July, the pupae may be be collected and destroyed wherever found. Killing the white female moths just after they emerge from the pupal stage, but before they lay eggs, may also be effective if done on a daily basis from early July to mid-August. Since they do not fly they are easily destroyed.

Traps are used by government agencies as a survey tool to detect sparse populations of male moths. These traps have not been proven effective as a

control measure, even though they are marketed. It is nearly impossible to catch enough males to prevent successful mating. The attractant material in those traps is called disparlure, a chemical which duplicates the female sex attractant. Experimental-minded homeowners may wish to saturate their property with traps to see if infestation reductions will occur. Disparlure impregnated in small plastic strips and confetti is also marketed. When applied in a sufficient amount over an area, it reportedly will confuse male moths to an extent that mating is prevented. It is known that neither the traps nor strips will provide control in heavy infestations.

Tree survival is enhanced by keeping them in good health. Damage to the root system can result from many activities, such as construction, changing grades, altering the natural forest ground litter, and weed-killing chemicals. High-value shade trees should have an ample supply of water all summer and lightly fertilized in the fall to maximize their chances of survival after being defoliated. Miscellaneous junk in yards, loose bark flaps and dead trees should be removed since they provide shelter and enhance survival of larvae and pupae. Diversification of tree species to those less favored by the gypsy moth is strongly encouraged.

ACTIVITIES AT THE BATTLEFIELD

The current attitude of the Service toward the gypsy moth is essentially to do nothing unless specimen or historically significant trees are involved. In those cases action may be taken to control the insect. The fundamental reasons for this approach are lack of sufficient funding to support a massive control program, and uncontrolled expansion of the population appears inevitable.

Here at Antietam, we have worked cooperatively with the U.S. Forest Service to monitor the progress of the gypsy moth. All of the following survey techniques have been employed at the park:

> The various types of survey provide information on the occurrence, abundance, and extent of gypsy moth populations.
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> Sex attractant or pheromone traps operated during the summer months are the most effective and economical method available for the detection of light infestations; to delimit infested areas; to check the results of control or eradication treatments; to determine the need for or intensisty of egg mass survey; and to determine population trends.
>
> Visual scouting techniques for egg masses are used to determine if an infestation has become established, or to determine population trends. This scouting is usually done after leaf-fall and in winter for best results.
>
> Aerial defoliation surveys are conducted in the early summer, timed to coincide with pupation. This activity is recommended to determine the presence and extent of high population levels of gypsy moth.

Some control work has been done in the National Cemetery in hopes of protecting the specimen trees. To date, egg masses have been removed by hand during winter months and mass trapping has been done during the summer.

If gypsy moth activity continues to increase in the cemetery, other control

techniques will probably be employed.

At this point, however, keeping a close watch on the situation appears to be the best strategy.

The Natural Resources Management Staff

Text adapted from:

ANON. 1979. Gypsy Moth and Browntail Moth Program Manual. Animal and Plant Health Inspection Service, Department of Agriculture. Washington, D.C., 39p.

McManus, M.L. and R.T. Zerillo. 1978. The Gypsy Moth: An Illustrated Biography. U.S. Forest Service, Department of Agriculture. Washington, D.C. 15p.

Nichols, J.O. 1980. The Gypsy Moth. Bureau of Forestry, Department of Environmental Resources, Commonwealth of Pennsylvania. Harrisburg, Pa. 34p.

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