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HARDWOOD DEFOLIATING CATERPILLARS IN NORTHEASTERN UNITED STATES[1]

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The vast, hardwood forests in northeastern United States provide ample habitat for a variety of leaf-eating caterpillars. Only a few, however, become abundant enough to attract the attention of the public. Thirteen such species have reached outbreak levels in this decade. Their biology, control, defoliation effects, and population declines are the subject of this paper.

These insects have one generation per year and develop through 4 different stages of growth (egg, larva, pupa, adult). Damage is caused by larvae (caterpillars) which may occur in the (1) spring (gypsy moth, *Lymantria dispar* (L.); inchworms; tent caterpils; dark tussock moth, *Dasychira basiflava* (Packard)), (2) mid-summer (saddled prominent, *Heterocampa guttivitta* (Walker)), or (3) late summer and fall (redhumped oakworm, *Symmerista canicosta* Franclemont; fall webworm, *Hyphantria cunea* (Drury)). Some species feed on a variety of trees (ie. gypsy moth; elm spanworm, *Ennomos subsignarius* (Hubner); forest tent caterpillar, *Malacosoma disstria* Hubner), while others have a more restricted host range (ie., eastern tent caterpillar, *Malacosoma americanum* (F.); cherry scallop shell moth, *Hydria prunivorata* (Ferguson)). The number of larval stages ranges to 10 or more. Eggs are usually laid in clusters (they are deposited singly by the saddled prominent). Some larvae (ie., redhumped oakworm, tent caterpillars) are gregarious; others (ie. gypsy moth, cankerworms) are solitary feeders. Overwintering occurs in the egg (gypsy moth, elm spanworm, tent caterpillars), larval (dark tussock moth), or pupal (redhumped oakworm, saddled prominent, fall webworm) stages.

Outbreaks of various species have caused nuisances, defoliation, reduction in tree growth (Kulman 1971), increased tree mortality (this may be low (Stephens 1971) or high (Kegg 1973)), alteration of previously established patterns of forest succession, and reduction in the quantity and quality of sugar maple sap.

Gypsy Moth

The most notorious and best known of the lot is the gypsy moth. This is an exotic insect accidentally introduced into the Boston, Massachusetts area in 1865. During the last 100 years it has moved out from its point of entry until today it extends from Maine southward to Delaware and westward to the western counties of Pennsylvania and New York. Infestations outside of this region have been noted in such places in Michigan, Illinois and even California. Even though the Federal government is attempting through strict regulatory efforts to prevent this insect from expanding its range further, I predict that it will eventually occupy many thousands of hectares of oak-dominated woodland to the south and west of its present range. Outbreaks tend to last no more than 2 or 3 years in any one location. However, within the boundaries of one Connecticut town defoliation was recorded for 8 consecutive years. This past year witnessed the largest acreage ever defoliated in a single state when more than 404,700 hectares were denuded, at least in part, in Pennsylvania. Interestingly enough, Connecticut was spared for the first time since 1949.

Virus epizootics, coupled with starvation, are the principle reasons for the sudden decline of an

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outbreak. A nuclear polyhedrosis virus (NPV) spreads rapidly among larvae and may remain viable for more than a year in places where large caterpillars seek shelter (Doane 1976). The behavior of the larvae that brings them into contact with the virus may explain the absence of outbreaks for several years in areas which previously have been inundated with caterpillars.

Insect parasites and predators are also important, but secondarily so. Presently, 10 exotic parasites and 2 predators are established in North America. Two of the parasites attack the eggs, two parasitize young larvae, four are parasites of late stage larvae, and two parasitize and kill pupae. Native vertebrate predators (predaceous birds and small mammals) may prevent outbreaks from occurring (Campbell and Sloan 1977).

Accelerated research has yielded few new developments in managing the gypsy moth. New, effective insecticides have been registered. There are several materials that may be used and include carbaryl, *Bacillus thuringiensis* (*Bt*), phosmet, methoxychlor, Dimilin®, acephate, mexacarbate, and a NPV. Equivocal results have been obtained with *Bt*, a bacterial insecticide. The NPV has been registered for aerial application only. All of the above mentioned materials are applied against larvae, preferably after all eggs have hatched in the spring and larvae have settled down to feed, but before they become so large that they cause extensive defoliation and are less suceptible to insecticides.

Nonchemical methods of control include (a) destruction of overwintering eggs, (b) placement of sticky bands on the boles of trees to prevent caterpillars from reaching foliage, and (c) placement of burlap skirts on boles to entice late stage caterpillars to seek shelter, thus enabling one to collect and destroy caterpillars in large numbers.

I believe that the most promising approach to the management of gypsy moth is the establishment of new natural enemies. This has not and will not be easy. This effort has been tried for several decades and only about a dozen have been established (Hoy 1977). Many others have been tried but without success. In Connecticut we are studying the biology of exotic parasites in the laboratory and in outdoor field cages, using laboratory-reared gypsy moths as hosts throughout the warmer months. Data obtained from these studies provide information on (a) the number of parasite generations per year, (b) the need for host insects other than the gypsy moth, (c) the ability of the parasite to overwinter outdoors, and (d) the synchrony of the parasite with the appearance of susceptible gypsy moth stages. We recently completed studies on a parasite obtained in India (Anderson et al. 1977) and found that it could survive Connecticut winters but is in need of another caterpillar species to serve as a host when appropriate gypsy moth stages are not present in the field. These types of studies will enable us to determine whether a particular natural enemy is likely to become established and to make decisions as to whether additional efforts are warranted for establishment of specific beneficial species.

Dark Tussock Moth

This defoliator infrequently becomes abundant in eastern oak forests. A recent outbreak occurred in Connecticut between 1973 and 1975 and caused localized defoliation. Larval parasites and a NPV were responsible, in part, for the population collapse (Kaya and Anderson 1976). Methoxychlor, carbaryl and guthion are labeled for the control of tussock moths.

Inchworms

The fall and spring cankerworms (*Alsophila pometaria* (Harris), *Paleacrita vernata* (Peck)) and lindenlooper (*Erannis tiliaria* Harr.) frequently reach outbreak levels. Outbreaks recently have been reported from Minnesota and Kansas eastward to Pennsylvania and West Virginia. Outbreaks subside possibly as a result of natural enemies, though considerably more study is needed to identify the causes. Chemical control measures are similar to those of the gypsy moth. Insecticides registered for the control of cankerworms include methoxychlor, carbaryl, acephate, *Bt*, and Diazinon. Unlike the gypsy moth, these caterpillars are highly susceptible to *Bt*. Inasmuch as females are flightless and emerge from pupal skins in the ground, sticky bands placed around the bole of isolated trees are effective in preventing adults from laying their eggs high on the tree and in keeping larvae from reaching foliage.

Another inchworm, though not as well known, is the cherry scallop shell moth which may damage stands of black cherry. Outbreaks occurred in the early 1970s in New York, Pennsylvania and southeastern Canada, and lasted about 2 years. In New York the outbreak subsided primarily because of an egg parasite belonging to the genus *Telenomus* (Schultz and Allen 1975). Few attempts have been made to control this insect.

The elm spanworm is an infrequent but important defoliator of oaks, hickories, ash, and maples (Fedde 1964). Outbreaks have occurred from southern Canada to Georgia and westward to Iowa. The most recent extensive outbreak occurred in Connecticut from 1970-1973 when 263,000 hectares were defoliated by it and the gypsy moth.

The previously mentioned insecticides for the control of cankerworms are probably effective against the elm spanworm. The placement of sticky bands on boles will prevent many caterpillars from reaching foliage.

Although there are many natural enemies of the elm spanworm, egg parasites are by far the most important in preventing and terminating outbreaks. One known as *Telenomus droozi* is significant in the southeast (Ciesla 1964) and although it is also abundant in the northeast, another egg parasite, *Ooencyrtus ennomophagous,* is the most effective here (Kaya and Anderson 1974). The superb qualities of the latter parasite are illustrated in Fig. 1. In the spring of 1971, the elm spanworm outbreak extended throughout portions of western and central Connecticut (upper left map). An egg and percent parasitism survey in the fall of 1971 revealed a distribution pattern as shown in the upper right map. Incidence of parasitism was high in southwestern Connecticut and low elsewhere. In the spring of 1972, the outbreak had collapsed in southwestern Connecticut but had spread northward and eastward (center left map). A fall egg mass survey revealed an infestation as shown in the center right map. Incidence of parasitism was high throughout the infested area. The following spring, 1973, the elm spanworm was abundant only in an area less than 20 hectares in eastern Connecticut (lower left map). Eggs laid in this area in July, 1973 were virtually all parasitized by the end of the month (lower right map). The outbreak had collapsed and larvae have been scarce ever since.

This parasite could be used as a biological control agent to prevent and terminate future outbreaks. It has been (a) reared successfully in the laboratory, (b) released and recovered in the field, and (c) shown to be able to decimate elm spanworm populations.

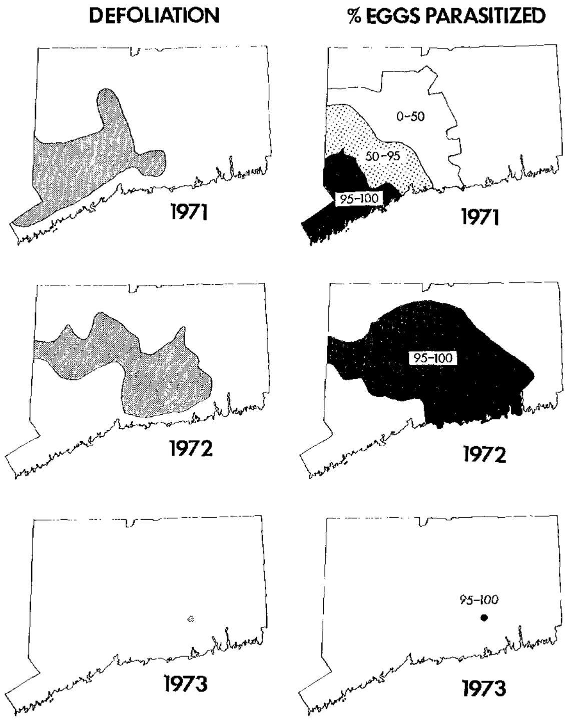

Fig. 1.—Elm spanworm distribution and incidence of parasitism of elm spanworm eggs in Connecticut, 1971-1973. (Maps redrawn from Kaya and Anderson 1974; Anderson and Gould 1974).

Tent Caterpillars

There are two kinds that occur in eastern North America, the forest tent caterpillar and the eastern tent caterpillar. The recurrent, annual, white-silken nests of the latter species on wild cherry and untreated apple trees in the spring are familiar to almost everyone. This species is not considered to be an important economic pest because it has a restricted host range though it may on occasion be important on black cherry. Wild cherry trees seem to be able to survive repeated defoliations.

The forest tent caterpillar is a much more important species and often reaches outbreak levels in poplar, maple and tupelo gum forests. Outbreaks in the 1970s were recorded from North Dakota to Vermont. The most extensive outbreaks seem to occur in the northern mid-western states and central Canadian provinces, though they also defoliate oak and gum trees in the south.

Outbreaks may last from 3 to 6 years (Witter et al. 1972). Several factors may be responsible for a decline and include (a) low winter temperatures which may kill unhatched larvae, (b) freezing weather which may kill large numbers of recently-hatched larvae, (c) lack of sufficient foliage resulting in starvation, (d) epizootics of a NPV, and (e) pupal parasitism by flies.

Early stage larvae are susceptible to a number of chemicals. Registered materials include methoxychlor, naled, carbaryl, malathion, *Bt*, diazinon, acephate and mexacarbate. Small tents and the enclosed larvae of the eastern tent caterpillar may be removed from trees and destroyed. Twigs with egg masses may be pruned and burned.

Redhumped Oakworm and Fall Webworm

Outbreaks of these two late summer and early fall defoliators have occurred from Michigan into Massachusetts. The fall webworm has been extremely numerous and is readily noticed by its tents which are often mistaken for those formed earlier in the year by the eastern tent caterpillar. The most extensive outbreaks are caused by the redhumped oakworm which defoliated more than 155,000 hectares of forest in Michigan in a single year. Outbreaks of the redhumped oakworm may last for 1-3 years (Anderson and Kaya 1977a). Those of the fall webworm usually last 3 or 4 years but may extend as long as 7 years. Reasons for their termination are not completely understood. Late summer weather has an important effect on population oscillations of the fall webworm (Morris 1964). An egg parasite is particularly important in the decline of outbreaks of the redhumped oakworm (Anderson and Kaya 1977b).

Fall webworms may be reduced on individual trees by pruning branches with small nests containing the caterpillars. Insecticides registered for its control include *Bt*, methoxychlor, diazinon, acephate and guthion.

Saddled Prominent and Greenstriped Mapleworm

The saddled prominent is the better known of these summer defoliators. Outbreaks have occurred in the northeast at about 10-year intervals and as many as 202,300 hectares of woodland were defoliated in Maine in a single year. Greenstriped mapleworm (*Dryocampa rubicunda* (F.)) outbreaks are often of a localized nature (20 ha), though outbreaks encompassing more than 11,000 hectares have been noted (Allen 1976). Outbreaks of both species may last 1-2 or possibly more years in a single location. Egg parasitism by *Telenomus* sp. plays an important part in terminating saddled prominent outbreaks (Allen 1972). Carbaryl is registered for the control of both insects.

In summary, a variety of forest defoliating caterpillars sporadically reach outbreak levels in northeastern U.S. They may be controlled by properly timed and applied insecticides. Some, such as cankerworms, may be effectively controlled on isolated trees by noninsecticidal methods. Because of the unpredictable, usually ephemeral nature of outbreaks, the arborist should not plan to rely upon the presence of these types of insects to sustain his operation, but rather should be prepared to offer other services to customers between the insects' outbreak phases.

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ABSTRACTS

Lewis, C.E. 1978. **Fastigiate trees.** American Horticulturist 57(1): 12-13.

The term and name *fastigiate* may be confusing to a few readers, but it refers to the upright habit of branching. In some cases, it implies that the side branches tend to parallel the main stem or stems, creating a more or less columnar outline. A tree of such form is a strong accent, and demands notice; often being very much alone with no compatible companions to aid it. Such trees should be used where lateral space is limited, and extra height is needed. What is the availability of fastigiate trees? How many nurseries sell trees with this type of growth habit and form? I selected fourteen catalogs that included six retail and six wholesale nurseries. I have listed the readily available fastigiate trees.

Davis, D.D. and J.B. Coppolino. 1978. **Air pollution effects on ornamental plants.** American Horticulturist 57(1): 18-19, 41.

Air pollution has existed for eons. Ancient volcanoes have spewed out noxious sulfur dioxide and dusts. Fires have swept forests, generating tons of smoke. Smelly marsh gases have long bubbled out of murky swamp waters. Conifer trees continue to produce hydrocarbons such as terpenes, the oceans emit carbon monoxide, and lightning splits oxygen molecules which reform to produce ozone. By definition, air pollution inconveniences man in some way. Although myriads of pollutants are emitted into the atmosphere, only certain ones are capable of injuring plants. Among the most important of these are ozone and sulfur dioxide. Other significant phytotoxic pollutants include ethylene, flourides, chlorides, dusts, etc. We discuss the sources of the more common pollutants and describe the effects on plants.