THE HEMLOCK BORER

THE EUROPEAN PINE SHOOT MOTH AND ITS RELATION TO PINES IN WISCONSIN

TECHNICAL BULLETIN NUMBER 19
WISCONSIN CONSERVATION DEPARTMENT
Madison 1, Wisconsin
1959

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Ali Hussain and R. D. Shenefelt
Department of Entomology, University of Wisconsin

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Daniel M. Benjamin
Department of Entomology, University of Wisconsin

Philip W. Smith
Wisconsin Department of Agriculture

Ronald L. Bachman
Department of Entomology, University of Wisconsin

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CONTENTS

(Edited by Ruth L. Hine)

THE HEMLOCK BORER*

by

Ali Hussain and R. D. Shenefelt

Department of Entomology, University of Wisconsin

The hemlock borer (*Melanophila fulvoguttata* Harr.), an insect associated with dying hemlock, has attracted considerable attention in Wisconsin. It was abundant and caused damage in the Menominee Indian Reservation during the latter half of the 1930's, and has recently occurred in large numbers in the Flambeau River State Forest in the stand of mature trees.

In 1949 there were about 11 million board feet of hemlock in the Flambeau River State Forest, but blowdowns occurring in 1951 and 1952 reduced the amount standing to about 6½ million board feet. Up to 1955 about 900 to 1,000 trees had died each year, the majority of these being single trees scattered among apparently healthy ones. The annual loss has been about 250,000 board feet. The dying trees are usually heavily infested by the hemlock borer and more lightly by another flat-headed borer, *Chrysobothris scabripennis* C. & G.

The adult hemlock borer is a black beetle with brassy reflections below and on the wing covers. It varies from about ¼ to ½ inch in length and is a little less than half as wide as long. Each wing cover usually shows three yellowish or orange-colored spots.

The females glue their white, elongate oval eggs to the bark under scales or in crevices, from the middle of June into late August. The eggs may be deposited singly or in clusters of from 2 to 22, and are laid especially in places exposed to the sun. One female produces about 150 eggs. In the forest, the incubation period is from 8 to 12 days, with most of the eggs hatching at about 10 days. The newly hatched borer, or larva, makes a slit along the narrow end of the egg, emerges, and soon starts boring into the bark, making an oblique channel. After it reaches the cambium, the mine is gradually enlarged.

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A mature hemlock borer larva in its pupal cell in the bark, ready for winter.

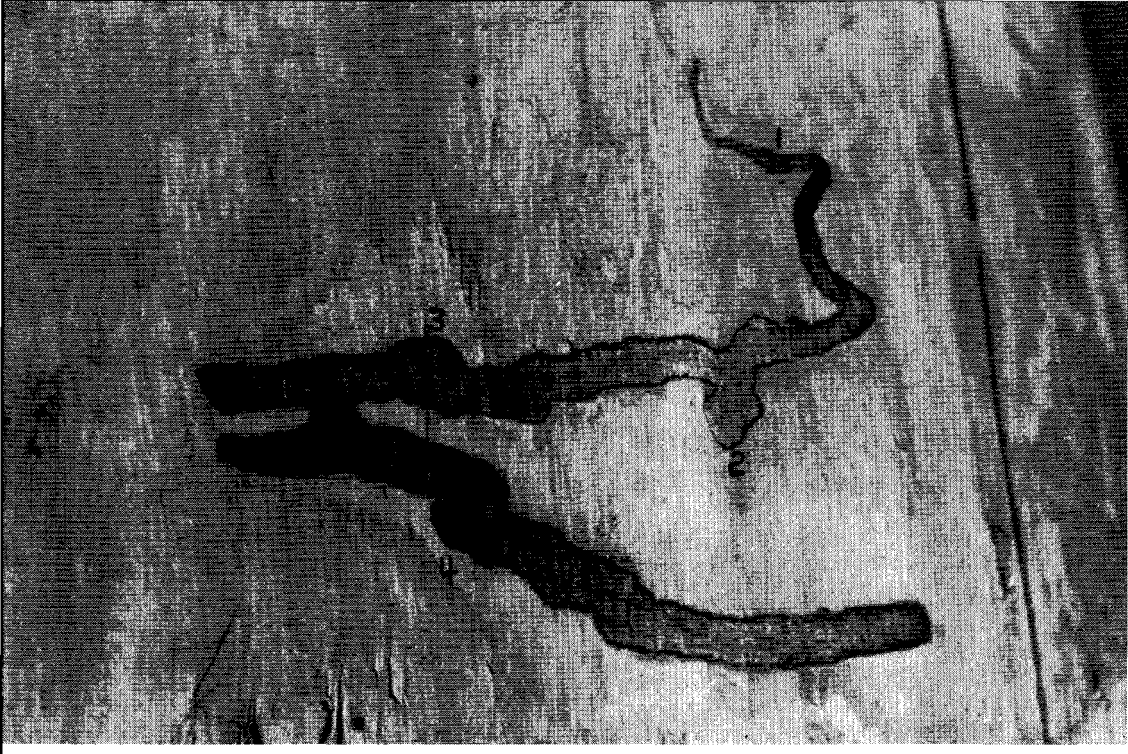
The larvae travel in many directions, and their paths may criss-cross. When the insects are numerous, such boring girdles the tree. After molting four times, the larva re-enters the bark and constructs a pupal cell. Here, doubled upon itself, it passes the winter.

The mature larva is from ½ to 1 inch long, white, with brown mouth parts, and has the characteristic flattened enlargement of the thorax which was responsible for the adoption of the name "flat-headed borers" On the upper plate of the enlarged thorax a narrow inverted V is found.

In the early spring, the insect changes to a prepupa. The abdomen swells, becomes straight and shorter and the body turns yellowish. This stage lasts about four weeks and then the pupa appears. During the pupal stage the insect is transformed from a larva to the adult beetle.

Pupae were found in the Flambeau River State Forest from the middle of May until the last of July and the adults emerged from the first week in June to the second week in August.

The adult beetle chews its way to the outside, requiring about three days of continuous effort to cut the slightly-curved, oval-shaped emergence tunnel. After emerging, the beetle feeds on the needles of hemlock, ragging them slightly, or on the moss which grows commonly on the trunks of the trees. It is a sun-loving and very active form.



A mine made by the larva of the hemlock borer in the cambium. The numbers show the points at which molting of the larva occurred.

The life cycle may require either one or two years, depending upon the time the eggs are laid. Those insects developing from eggs laid in June or July complete their development in one year. Young larvae emerging from eggs laid in August spend the first winter in the cambium region and the second in the pupal cell, thus requiring nearly two years for completion of the cycle.

While the main host of the beetle is hemlock, it is also known to attack white pine, tamarack, balsam fir, and black, white, and red spruce. The insect must be regarded as belonging to the secondary-primary group, i.e., it usually attacks trees dying from other causes. When favorable material is present for breeding, however, it builds up rapidly in numbers. The eggs of the borer are laid on healthy as well as decadent trees. Usually the healthy trees are able to overcome the effects of being invaded by a few larvae. In the Flambeau, small pockets containing remnants of dead larvae can often be found under the bark in "healthy" trees. When a tree declines somewhat in vigor it is not so able to withstand such attack. And, when numbers of the beetle are high, trees may be invaded and overwhelmed very rapidly. Thus, the beetle kills many trees which would otherwise survive. In areas like the Flambeau River State Forest, one of the few remaining places in Wisconsin where such

big hemlock timber occurs and where everything possible is being done to preserve the stand, the hemlock borer must be regarded as a definite menace.

After the blowdown occurred, the borer built up a very large population in the windthrown timber. Since then, it has killed many trees. The first external evidence of heavy attack is a slight thinning and a slight paling of the needles. Trees showing these symptoms will be dead a year or two later. When the cambium of these slightly off-color trees is examined, it is usually found to be literally honeycombed by the borer larvae. Such trees cannot be saved.

Numerous biological agents attack the insect. For example, egg parasites and ants destroy the eggs, and parasitic wasps kill a portion of the larvae. Woodpeckers strip the bark from large areas in attacked trees and drill numerous holes while searching for the worms. Since the insect epidemic started, however, these natural enemies have not succeeded in overcoming the beetle population.

Control of the hemlock borer lies in keeping the forest in as healthy a condition as possible. Windthrown or "brood" trees should be removed from the area as rapidly as possible and utilized. Because most of the larvae have completed development and left before the trees are "dead", light sanitation-salvage cuts must be made almost continuously. Such cutting avoids making openings in the stand and thus does not encourage further windthrow. It forces the natural enemies to concentrate their efforts toward searching out the individual borers instead of having a "feast" at a full table.

THE EUROPEAN PINE SHOOT MOTH AND ITS RELATION TO PINES IN WISCONSIN*

by

Daniel M. Benjamin
Department of Entomology
University of Wisconsin

Philip W. Smith
Wisconsin Department
of Agriculture

Ronald L. Bachman
Department of Entomology
University of Wisconsin

The European pine shoot moth, *Rhyacionia buoliana* (Schiff.), is an insect that stunts and distorts red (Norway) pine and other hard pine species. In some cases, larval mining and tunnelling in buds and shoots may kill trees. Although it has been known in Wisconsin since 1951, it has already caused serious damage and threatens hard pines in the southern and eastern sections of the state.

The shoot moth was discovered on Long Island, New York in 1914 (Busck, 1915) and has since spread over northeastern United States to include most of the area from Maine to Virginia and from the Atlantic coast to Wisconsin and Illinois. It also has been recorded in Colorado, Nebraska, Florida, Tennessee and in Canada from Ontario eastward. In Wisconsin, the insect was reported initially in Milwaukee, Sheboygan and Waukesha Counties and became abundant in Milwaukee County in 1954 (Wis. Conservation Dept., 1953; Wilkinson, 1957). Infestations have been found in the following 24 southern and eastern counties (Fig. 1): Brown, Calumet, Columbia, Dane, Dodge, Door, Fond du Lac, Green, Green Lake, Jefferson, Kenosha, Manitowoc, Milwaukee, Oconto, Outagamie, Ozaukee, Racine, Rock, Sheboygan, Walworth, Washington, Waukesha, Winnebago and Wood.

Life History and Biology

The European pine shoot moth is a member of the family Olethreutidae in the order Lepidoptera. As is characteristic of species in this order, it has four distinct developmental stages: adult, egg, larva (this stage causes the damage to pines), and pupa.

The adult moth has a wingspread of about three-quarters of an inch and the forewings are rusty-orange with silvery markings. Emergence

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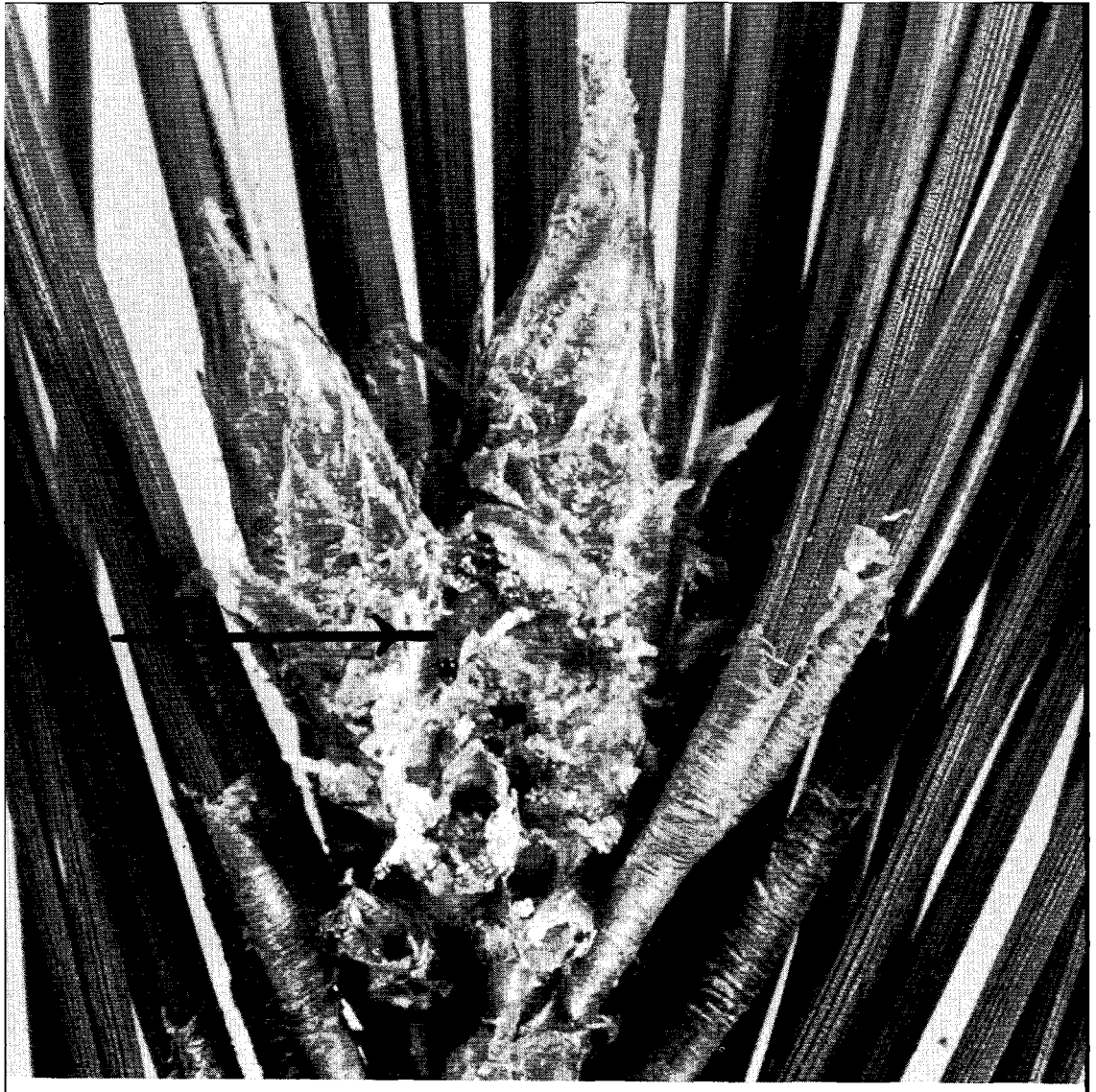

European pine shoot moth larvae emerging from mined-out red pine bud.

occurs in late June and early July and mating takes place soon after. Moths generally fly after dark during periods of calm or light wind. Flights of a few hundred feet are common, but females rarely migrate far afield. Unless infested nursery stock is involved, natural spread is slow. Since the shoot moth has but a single generation per year, population build-up is slow.

Shoot moth eggs are small, being about two-thirds the width of a pine needle in diameter. They are flat and yellowish and are laid singly or in patches in overlapping masses on needles toward the tips of branches. Hatching requires about 10 days.

Newly emerged larvae move about for a short time, then settle in the axil of a needle where they spin a small tent-like structure. Next, they mine the bases of needles and cause one or two needles near the ends of the twigs to die and turn brown. These discolored needles are the first indication of attack and furnish the most obvious evidence of infestation during the latter part of the growing season. The larvae soon leave the needles and bore into the buds. This feeding causes a flow of pitch which forms the characteristic bubble-like structures at the base of a bud or between two or more buds. No additional signs of attack are evident until the next season.

The partially grown shoot moth larvae overwinter beneath the blister-like bubble of hardened pitch or within a mined lateral or terminal bud. At this time they are about 3/16 inch long, brown and have black heads.

With the onset of warm weather in the spring, the larvae resume their tunnelling in the developing buds. It is during this period that the buds are destroyed and serious damage occurs. Early symptoms of infestation are the bending over of buds and a copious flow of pitch. Buds surviving the infestation will continue to elongate, but the terminal may be badly distorted and result in the typical "posthorn". Lateral shoots are often badly gnarled or twisted.

Feeding is completed by early June and the mature larvae, which are about 5/8 inch long, transform to the pupal stage beneath a pitch mass or in a mined bud. By mid-June or early July transformation to the adult is completed and the moths emerge.

Hosts

The shoot moth attacks native Wisconsin pines and many others that have been introduced. Red and mugho are most commonly damaged and Scotch pine also suffers severely. Eastern white pine may become infested, but apparently suffers little if any damage. Among pines grown in Wisconsin in either the forest or as ornamentals, the following are subject to infestation (Wilkinson, 1957): jack pine *(Pinus banksiana)*, lodgepole pine *(P. contorta)*, Swiss mountain or mugho pine *(P. mugo)*, Austrian pine *(P. nigra)*, ponderosa pine *(P. ponderosa)*, red or Norway pine *(P. resinosa)*, Digger pine *(P. sabiniana)*, eastern white pine *(P. strobus)*, Scotch pine *(P. sylvestris)*, Japanese black pine *(P. thunbergii)*.

European pine shoot moth larvae seldom kill trees but often cause serious injury to both lateral and terminal buds. As a result, trees may be so stunted and deformed as to be worthless for Christmas trees,

pulp, lumber or ornamentals. In some instances infested trees may grow only a few inches in height during several years and never rise above 10 to 15 feet. Infestations may occur in forest nurseries, or soon after planting in the forest and continue until tree crowns grow together. Usually, little damage occurs after trees exceed 15 feet in height.

Predicted Distribution and Potential Danger Zones

The European pine shoot moth appears to be extending its range in Wisconsin. For those who wish to grow pines, it is more important to understand which areas may expect trouble rather than to speculate on the eventual distribution of this pest.

Cold weather appears to restrict spread of the insect and —18° F. is generally considered fatal to overwintering larvae (Batzer and Benjamin, 1954; Rudolph, 1951; West, 1936) Seldom does the shoot moth become epidemic where —18° F. occurs frequently, but where this low temperature is recorded rarely, large, damaging populations may build up over several seasons. Minimum temperatures and their frequency in Wisconsin vary greatly from southeast to northwest. For instance, lows of —18° F. are recurrent in the northwestern part of the state and —30° F. to —50° F. are common. In the southeast, even —18° F. occurs infrequently and lower temperatures are rare. Winter survival of the shoot moth may be expected to vary accordingly.

From 30-year temperature records for Wisconsin, the state has been divided into three zones based upon the frequency with which the —18° F. lethal temperature occurs (Fig. 1). Potential danger zones for the shoot moth are predicted on the basis of minimum temperatures as follows:

Zone 1. Lethal temperatures occur 0 to 2 times in an average five-year period. The shoot moth can build up severe infestations. Planting of hard pines is hazardous and inadvisable without planned control measures.

Zone 2. Lethal temperatures occur 2 to 4 times every five years. Infestations will be very localized and controls should be necessary only occasionally.

Zone 3. Lethal temperatures occur 4 to 5 times every five years. The shoot moth should have little opportunity to become established.

Shoot moth larvae in buds protected by a heavy snow cover readily survive sublethal air temperatures. However, there are several reasons

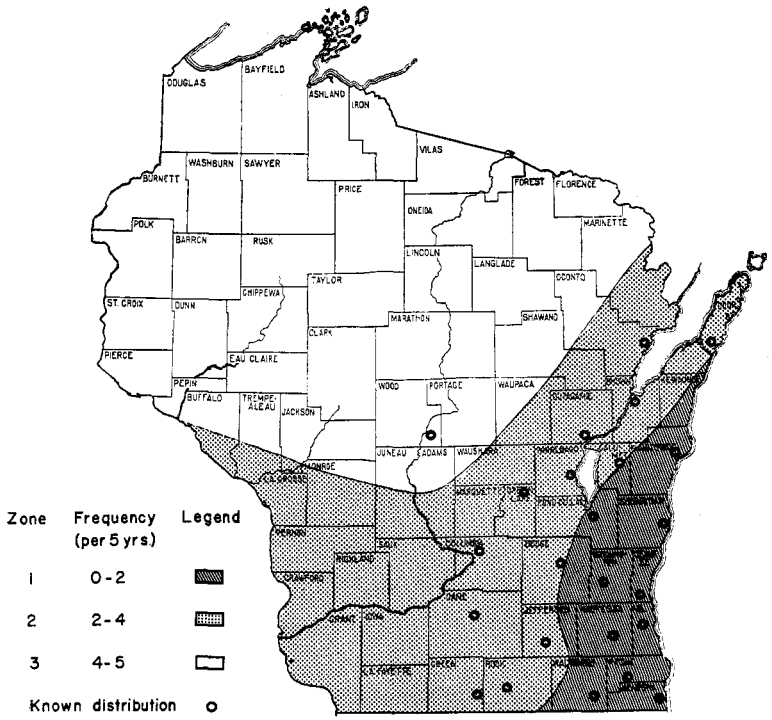

Figure 1. Potential danger zones based on the frequency with which the lethal temperature of —18° F. occurs.

why this surviving population is expected to be of little significance. The form or shape of infested trees would not be seriously altered if larvae above the snow were killed during winter by lethal temperatures. Overwintering larvae do not move far in spring, and generally leave the bud they were in to enter an adjacent shoot. Thus, larvae that infested lateral buds and survived would continue to infest lateral shoots. Yet, they create a problem as a reinfestation reservoir for the following year. In years and areas where lethal temperatures do not occur, larvae in terminal buds may survive and seriously deform the tree.

Yearly snowfall sufficient to protect larvae from lethal temperatures in Wisconsin is limited to the extreme northern part of the state. Fortunately, this area experiences —18° F. and below almost every year. Therefore, snow cover should be of limited significance in determining potential shoot moth danger zones in Wisconsin.

Control of the Shoot Moth

Spread of the shoot moth in nature is generally slow as the adult moths move about very little. Most frequently adults remain in or near the immediate infestation area. Widespread distribution may take place during the dissemination of infested nursery stock. In areas where the shoot moth is not established, this means of spread is considered the most important.

As with many other insects, biological, cultural and insecticidal controls all play an important part in learning to live with the shoot moth. Several native insects prey upon this pest and other species have been introduced from abroad to help combat it. These parasites and predators have been helpful, but they have not prevented populations from reaching outbreak proportions. Epidemics still may require emergency measures in some areas of the infested regions of the country. Very little is known of the complex of beneficial insects associated with this pest in Wisconsin and to date none have been introduced from abroad.

Cultural Control

Removing infested tips by pruning or shearing in early May and late July is practiced by some Christmas tree growers. The economy and success of this method is dependent upon the pine species involved, thoroughness of effort, potential reinfestation reservoir in nearby plantings, timing, and purpose for which the trees are being grown. Scotch and mugho pine produce an abundance of buds and recover more rapidly from shearing than red (Norway) pine. If a planting is heavily infested, pruning will be of little help unless all the infested tips are removed and even this is of questionable value if a nearby planting is heavily infested. The expense of shearing may be justified for Christmas tree or ornamental plantings, but it would be a questionable control practice in pulp or timber plantings. Infested tips removed just prior to moth emergence in June must be destroyed to prevent reinfestation, or caged to contain moths but allow parasites to escape. Shearing just following moth emergence does not destroy the insect, but such trees may escape serious reinfestation because of retarded bud development. Infested tips may be removed during late summer or fall. These tips need not be destroyed as it is questionable whether the larvae could complete their life cycle in buds that had been detached. Since most pines do not respond best to shearing in late fall or winter, removal of infested tips at this time is not recommended.

Distorted red pine buds injured by European pine shoot moth feeding in early June.

Tree nurseries are inspected annually by Department of Agriculture personnel in order to restrict the spread of noxious insects in Wisconsin. This yearly survey, required by Wisconsin Statute 94.60, is made during the growing season. All species of pines are examined and if larvae of the shoot moth are detected, the nursery stock is quarantined and withdrawn from sale. Pines are re-examined in late summer since larvae may not be present or detected during midsummer inspections. Nurserymen are given recommendations for proper treatments and stock is released for sale thereafter if found to be free of infestation.

If the infestation is light, i.e., if less than one per cent of the trees harbor shoot moth larvae, pruning or hand roguing (weeding) is recommended. All trees are examined and infested buds removed or the trees destroyed. Most infested trees will be detected and the larvae destroyed by this method. However, studies in Michigan revealed that some infested trees are missed even after a third examination (Flink, 1958b). Consequently, it is generally necessary to turn to other means. Costs of hand roguing in 2–2 transplant beds run approximately $0.50 per thousand trees examined (based upon a $1.86 per hour labor cost).

Insecticidal Control

Control of the shoot moth with insecticides requires accurate timing and complete coverage of the infested buds. For effective timing, it is necessary to observe infested trees frequently and to be able to recognize the onset of larval activities in early spring and adult emergence later in the season. Larval feeding in late April and early May is evidenced by the appearance of glistening resin exudates around the buds. Empty pupal cases within gnarled buds and the presence of rusty-orange colored moths with silver-marked wings foretell the laying of shoot moth eggs.

As little experimental spraying for shoot moth control has been conducted in Wisconsin, the findings of researchers in neighboring states must be relied upon. In Michigan, knapsack sprayer applications of 2 pounds actual DDT per 100 gallons of water applied between 2 weeks prior to and 2 weeks after larvae resume feeding in the spring gave good control (Miller and Haynes, 1958b). The foliage was sprayed until well moistened. If no observations of larval activity are made, spraying should begin around mid-April in latitudes of lower Michigan. Unseasonably warm or cool weather would, of course, advance or delay the spray dates.

DDT sprays applied with hydraulic equipment about the time shoot moth eggs hatch in late June gave good control in Ohio (Miller and

"Posthorn" caused by European pine shoot moth.

Neiswander, 1955). In Wisconsin, spraying to control newly emerged larvae should begin when empty pupal cases are evident or when adults are observed among the pines. This would occur when new red pine needles are approximately one-half the length of previous years'

needles (Wilkinson, 1957). A second application should be made 10 days later. The formulation recommended contains 4 pounds of 50 per cent wettable DDT per 100 gallons of water.

Knapsack sprayers may be used on small areas (25 acres or less), but on larger areas mobile hydraulic, orchard-type sprayers are required. Care should be taken to apply enough spray to lateral and terminal twigs so that the insecticide runs down the needles and accumulates where the needles join the twigs. Spraying should begin when shoot moth populations are low rather than after epidemics cause widespread damage.

In Michigan forest nurseries, infested red pine transplant beds were sprayed with DDT when hand roguing failed to give satisfactory control (Flink, 1958b). The author hoped that this late June application would eliminate the need for methyl bromide fumigation the following year when trees are shipped.

Mist blowers have been employed successfully in the control of the shoot moth in Michigan (Miller and Haynes, 1958a). DDT sprays are recommended at the following rates: (a) for trees 4 to 6 feet in height, 50 gallons per acre of a spray containing 1 gallon of 25 per cent emulsifiable DDT per 9 gallons of water; (b) for trees less than 4 feet in height, 35 gallons per acre of the foregoing mixture. Application should be made in April or June as for other control applications. No mist blower applications should be made when wind velocities exceed 7 miles per hour.

Fumigation of Nursery Stock

Fumigation with methyl bromide for shoot moth control was developed by H. A. U. Monro in Ontario, Canada and field tested by Flink (1958b) in Michigan. Because no experimental work on this means of control has been conducted in Wisconsin, and it is essential to make available to the public this latest information, these findings will be presented in some detail:[1]

> "Fumigation may be carried out on fall or spring tree shipments, but at present the treatment is recommended only for seedlings which are dormant. Dormant pines are those which show no visible growth of the shoots at the time of treatment. If the plants are dormant they will tolerate dosages considerably in excess of those stipulated. However, if growth has begun some degree of injury is almost certain to be sustained.

[1] The writers express their most sincere appreciation for the information on fumigation supplied by H.A.U. Monro, Can. Dept. Agriculture, London, Ont. and P. R. Flink, Mich. Conservation Dept., Lansing, Mich., and for their permission to quote directly from this correspondence.

Fumigation chambers for treatment of nursery stock at atmospheric pressure may be constructed in different ways and with different materials. Under some circumstances existing rooms in buildings may be modified for this purpose. The two basic requirements are, first, that the chamber will hold the required concentration of fumigant satisfactorily throughout the treatment and, second, that it is located so that there is no danger to any person either during treatment or during the post-fumigation aeration process.

An efficient and economical plywood chamber, suitable for fumigating pine seedlings, may be constructed for about $150.[2] If it is not much over 500-cubic-foot capacity it may readily be moved around in the nursery, or transported by truck from one nursery to another. The most convenient method of applying methyl bromide is by one-pound cans, using the "jiffy" applicator. Therefore, it is suggested that the cubic capacity of fumigation chambers be kept close to 500 or 1000 cubic feet. These two sizes facilitate calculations for dosage which can then be based on numbers of whole cans.

The seedlings are fumigated after they are packed into the normal types of shipping bales, which may each contain several thousand trees. Actually, it is advantageous to treat them this way as the fumigant penetrates only to a very limited extent into the damp moss packed around the roots, and the roots are protected from excessive concentrations of fumigant. Yet, on the other hand, the fumigant readily diffuses into the foliage to reach the larvae in the shoots.

The chamber should not be overloaded. It is recommended that the lowest tier of bales be placed on parallel 2- x 4-inch scantlings, to permit the fumigant to diffuse under the load. A one-foot space should be allowed between the bales and walls, and two or three feet between the top tier of bales and the ceiling. With such an arrangment one 600-cubic-foot fumigation chamber held 65,000 red pine seedlings made up of 13 bales of 2–0 stock (50,000 trees) and 28 bundles of 2–2 stock (15,000 trees).

Only *pure* methyl bromide is to be used for fumigating nursery stock. Other preparations may contain warning gases such as chloropicrin, which is very injurious to living plants. Using pure methyl bromide without a warning agent requires strict safety precautions to prevent workers from accidently entering the fumigation chamber immediately after it is opened.

The temperature from which a given dosage is chosen is based on the lowest temperature in the system. Readings accurate to the

[2] Detailed plans and material lists for a chamber of 600-cubic-foot capacity are available from the Forestry Division, Michigan Conservation Department, Lansing 26, Michigan.

Small portable plywood fumigation chamber for methyl bromide treatment of pine seedlings. (Courtesy Michigan Conservation Dept.)

nearest degree F. should be taken in two places (top and bottom) of the chamber free space, and also in at least six bales (among the pine foliage) in different parts of the load.

Methyl bromide (CH_3Br) fumigation of dormant pine seedlings

Schedule for two-hour exposure

Lowest temperature reading (°F.)	Dosage CH_3Br per 1000 cubic feet of chamber space	Dosage CH_3Br per 500 cubic feet of chamber space
60° and above	4 pounds	2 pounds
50° to 59°	6 pounds	3 pounds
40° to 49°	8 pounds	4 pounds

Schedule for longer exposures

This is suggested especially for lower temperatures so that, if there is time for longer exposures, less weight of fumigant will be

used. It is also designed to make full use of the one-pound cans. Note the variation in exposure times.

Lowest temperature reading (°F.)	Dosage CH_3Br per 1000 cubic feet of chamber space	Dosage CH_3Br per 500 cubic feet of chamber space	Exposure period in hours
60° and above	2 pounds	1 pound	4
50° to 59° --	4 pounds	2 pounds	3
40° to 49° --	4 pounds	2 pounds	4

After the chamber is loaded and all doors and openings closed the fumigant is discharged into the fumigation space. Full instructions for application and information on precautions are supplied with each carton of cans purchased and these are also printed on the cans. While the fumigant is being discharged the circulating fan is turned on and left running for 15 minutes. It should also be turned on for 10 minutes once every half hour during the fumigation period.

At the end of the required period, which is counted from the time the last of the fumigant is discharged, the exhaust ports are opened and the exhaust and circulation fans operated for 15 minutes. After this time the door may be opened slightly for a further 5 minutes, and then opened wide for another ten. Next, a test may be made with a halide gas leak detector lamp, and if the operator is satisfied that there is no detectable fumigant left in the free air of the chamber, workers may enter to unload. The exhaust fan should be running during the entire unloading process.

It is important that the bundles of seedlings be kept in the open air for at least 12 hours after the fumigation, preferably away from direct sunlight. Fumigants absorbed by the foliage and packing material is slowly released, and if the trees are kept in a closed room or confined space, high concentrations of fumigant may build up. This aeration is needed for the protection of the workers and the trees. At low temperatures absorption of fumigant on the foliage is greatly increased and proper aeration is especially important.

The tree shipments also may be loaded immediately into trucks, but the carrying space must be well ventilated in transit. Under some conditions direct sunlight may cause the residual vapours to injure the freshly fumigated trees and they should be kept in the shade during the remaining daylight of the day of treatment."

Methyl bromide (chloropicrin-free) costs about $0.70 per pound in one-pound pressure cans. At 60° F. the approximate cost for fumigating 2–0 seedlings in Michigan in 1958 was $0.0133 per 1000 trees or about $0.04 per 1000 2–2 transplants.

Nine year old red pine plantation stunted by European pine shoot moth attack.

Surveying for Shoot Moth Infestations

Early detection of shoot moth infestation is of paramount importance in combatting this pest. To systematize the search for the insect in forest areas a survey procedure was developed and is being tested by the Lake States Forest Insect Survey Committee (Flink, 1958a). The following is a direct quotation of the recommended procedure:

"A series of plots, spaced at 10 pace intervals, should be located along two lines across the plantation. The four trees nearest to the plot center are considered the plot. The survey lines should be such as to divide the plantation into approximate thirds. The total number of infested leaders, non-infested leaders, infested tips in top whorl and non-infested tips in top whorl should be tallied.

"The survey can be made from early August until early June when the larvae are in the buds, indicated by dead needles and pitch globules. The larvae are found either in the bud or under

the pitch globule. An alternate method of survey is to consider the injury alone. This can be made at any time of the year, looking for dead needles from late July to late May and dead shoots the remainder of the year."

In nurseries, inspection may be conducted at any time, although infestations are most apparent between early August and late May.

Recommended Procedures to Reduce Damage

Hard pines can be grown sucessfully in Wisconsin in spite of depredations of the European pine shoot moth. In order to do so, however, certain changes in planting procedures may be required. Also, proper consideration will have to be given the use of shearing, weeding, fumigation and spraying. Recommended procedures to reduce damage by the shoot moth in Wisconsin pine plantations are as follows (See Fig. 1 for zone locations):

Zone 1

a. Restrict planting of hard pines especially mugho, Scotch and red pines.

b. Inspect pine plantings annually between early August and late May.

c. Control shoot moth by shearing and pruning when population is low.

d. Employ chemical means if shearing and pruning give inadequate control.

Zone 2

a. Inspect pine plantings annually between early August and late May.

b. Control shoot moth by shearing and pruning when population is low.

c. Control shoot moth by chemical means in localized areas if shearing and pruning fail to do so.

Zone 3

a. Inspect pine plantings at 2- or 3-year intervals between early August and late May.

b. Control shoot moth by shearing and pruning.

c. Chemical control of shoot moth should be restricted to localized areas of severe infestation.

Nurseries

a. Inspect pine seedlings and transplants annually between early August and late May.

b. Control shoot moth by shearing, pruning and roguing whenever encountered.

c. Control shoot moth in field beds by hydraulic chemical sprays if the infestation is severe.

d. Control shoot moth in shipping stock by fumigation.

Summary

The European pine shoot moth is a serious threat to the growing of hard pines in southeastern Wisconsin. This insect has spread from New York westward and now infests 24 southern and eastern counties of Wisconsin. The life cycle of the shoot moth is briefly discussed and its habits outlined. Among the 10 hard pines grown in this state, red, Scotch and mugho are most seriously damaged.

Cold weather inhibits the spread of the shoot moth and —18° F. has been determined to be the critical level for its survival. Three potential danger zones in Wisconsin have been delimited based upon 30-year weather records. Severe infestations are predicted only for the southeastern section.

Control of the moth through cultural practices, spraying and fumigation is discussed. DDT is recommended for spraying and methyl bromide for fumigation. A survey method is given and practices to reduce damage from the moth in pine plantations are given.

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