NANTUCKET PINE TIP MOTH CAUSED FLOWER AND CONELET MORTALITY

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The seed orchard program in the South is of particular interest to me historically. My first assignment as an entomologist with the U. S. Forest Service in 1958 was to work with the Georgia Forestry Commissions' Arrowhead and Horseshoe Bend seed orchards at Cochran and Glenwood, Georgia. At that time these orchards were in their infancy and work was concentrated with establishing stock trees and grafting of superior scions. Today these orchards, and many others throughout the South, are producing annual crops of seed.

Certainly few insect pests have generated such universal concern in seed orchards as tip moths. In the past this concern in some cases was difficult to justify. There is no doubt that tip moth damage can appear to be devastating when every shoot on a young seed orchard tree is dead and brown, however there is still some question as to the real impact that tip moths have on seed production.

The first published concern about the impact of tip moths on seed orchard trees appeared in a paper by Zak in 1956. His immediate concern was with the effect tip moths have on initial survival of outplanted grafted stock. While tip moths can seriously injure young trees, it is doubtful that any tree mortality can be directly related to this insect.

Zak further contended that tip moth damage on productive trees may destroy terminal buds containing embryonic flower buds and thus reduce seed yields. This is a valid concern. If tip moths attack and kill the shoots and associated overwintering buds, then the primordia are lost and no conelets are produced the following spring.

In 1966 we conducted a study on loblolly pine, *Pinus taeda* L., at the Arrowhead Seed Orchard and on shortleaf pine, *P. echinata* Mill., at a seed orchard at Athens. The shoots of these producing seed orchard trees were artifically pruned to simulate tip moth attack. These artificial attacks were repeated throughout the spring and summer to generally coincide with the three or four tip moth generations. The terminal one-inch of all shoots on selected branches was pruned with shears and each branch tagged. An adjacent branch of the same size was similarly tagged but the shoots were not pruned. During the spring of the following year (1967) counts were made of the number of flowers developing on the unpruned branches (checks) and the adjacent pruned branches (treatments). A ratio was obtained by dividing the number of flowers developing on the pruned branches into the number of flowers developing on the unpruned branches. The higher this ratio the greater the effect the treatment had on flower production. These data show that the influence simulated tip moth damage has on flower production increases as the season progresses (Figure 1).

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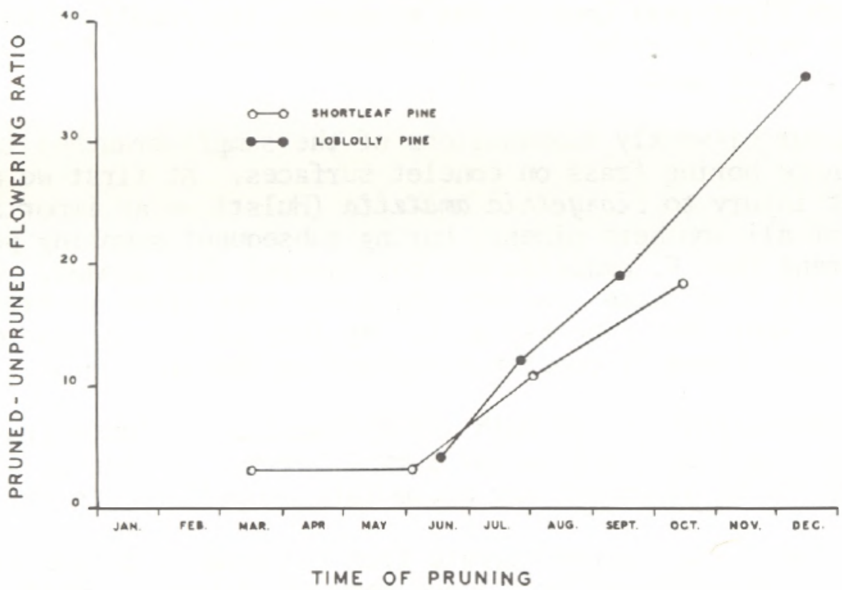

Figure 1.--Unpruned-pruned flowering ratio shows the increasing effect artificial tip moth damage (pruning) has on flower production *as* the growing season progresses.

More recently we have found in studies with both loblolly and shortleaf pines that this simulated tip moth injury is not necessarily a true measure of the actual effect tip moth can have on flower production. We have observed fall tip moth damage to shoots in the tops of trees which are similar in size and fruiting ability to producing seed orchard trees. Based on our clipping study this would be the most hazardous time to have tip moth attack. However, this late season attack generally is comparatively mild. In most cases only the terminal bud is hollowed out leaving lateral dormant buds uninjured. The uninjured lateral buds on these tip moth attacked shoots will successfully flower the following spring if they contain flower primordia.

Thus, tip moth shoot attack in the fall of the year does not always limit flower production the following spring. It depends largely on whether or not all the overwintering buds on the attacked shoot are killed.

In 1968 we started a 2-year study to determine the impact of various mortality factors on shortleaf pine seed production in the Georgia Piedmont. Five open grown shortleaf pines (25-30 ft.tall), similar in shape and cone production to trees growing in a seed orchard, were selected for study. Branches were selected and examined at 2-4 week intervals during the growing season. Each first-year conelet was examined, its condition noted, and causes of injury or death recorded. This provided observations for two years of first-year conelet mortality factors.

During our bi-weekly examinations of the sample branches in 1968, we observed minute boring frass on conelet surfaces. At first we attributed this conelet injury to *Dioryctria amatella* (Hulst) -- an important cone destroying insect of all southern pines. During subsequent sampling periods, it became apparent that D. *amatella* was not causing this damage. In May we reared an adult from these conelets which was identified as *Rhyacionia* frustrana (Comst.), the Nantucket pine tip moth. By July IS it was apparent that tip moth was a major cause of conelet mortality on shortleaf pine.

First indications of tip moth injury consist of minute frass on the conelet surface resulting from first instar larval boring. *As* larval feeding progresses, a small quantity of oleoresin may accumulate around or over the lesion.

The second instar larvae migrate from the conelet to the supporting shoot. This migration is evidenced by a loose network of webbing which is laid down on the tip of the shoot and the adjacent injured conelet. A tent of webbing is constructed generally in the angle formed by the shoot and the conelet stalk. Once this tent is completed feeding within the conelet renews. Most commonly boring begins in the conelet stalk and extends up into the conelet thereby causing its death. The tip moth larva then migrates either to the shoot tip or to a healthy conelet to continue feeding and development. This results in the death of additional conelets or the tip of the shoot. Pupation occurs in these dead structures. The webbing and oleoresin-covered tent keep the dead conelet from dropping off the shoot immediately thus permitting damage evaluation for a longer period of time.

Larval feeding during the first tip moth generation commenced during the 3rd week of April in both 1968 and 1969. A majority (98.3%) of all tip moth-caused conelet mortality occurred during the first tip moth generation. However, in September 1968 and 1969, during the third generation, slight tip moth-caused conelet mortality was observed.

The impact of tip moths on conelet mortality is graphically illustrated in Figure 2. The two inserts at the bottom of this graph show the incidence of conelet mortality caused by tip moths. These inserts agree in time with the horizontal axis of the graph and the vertical axes are drawn to the same scale as the vertical axis of the parent graph.

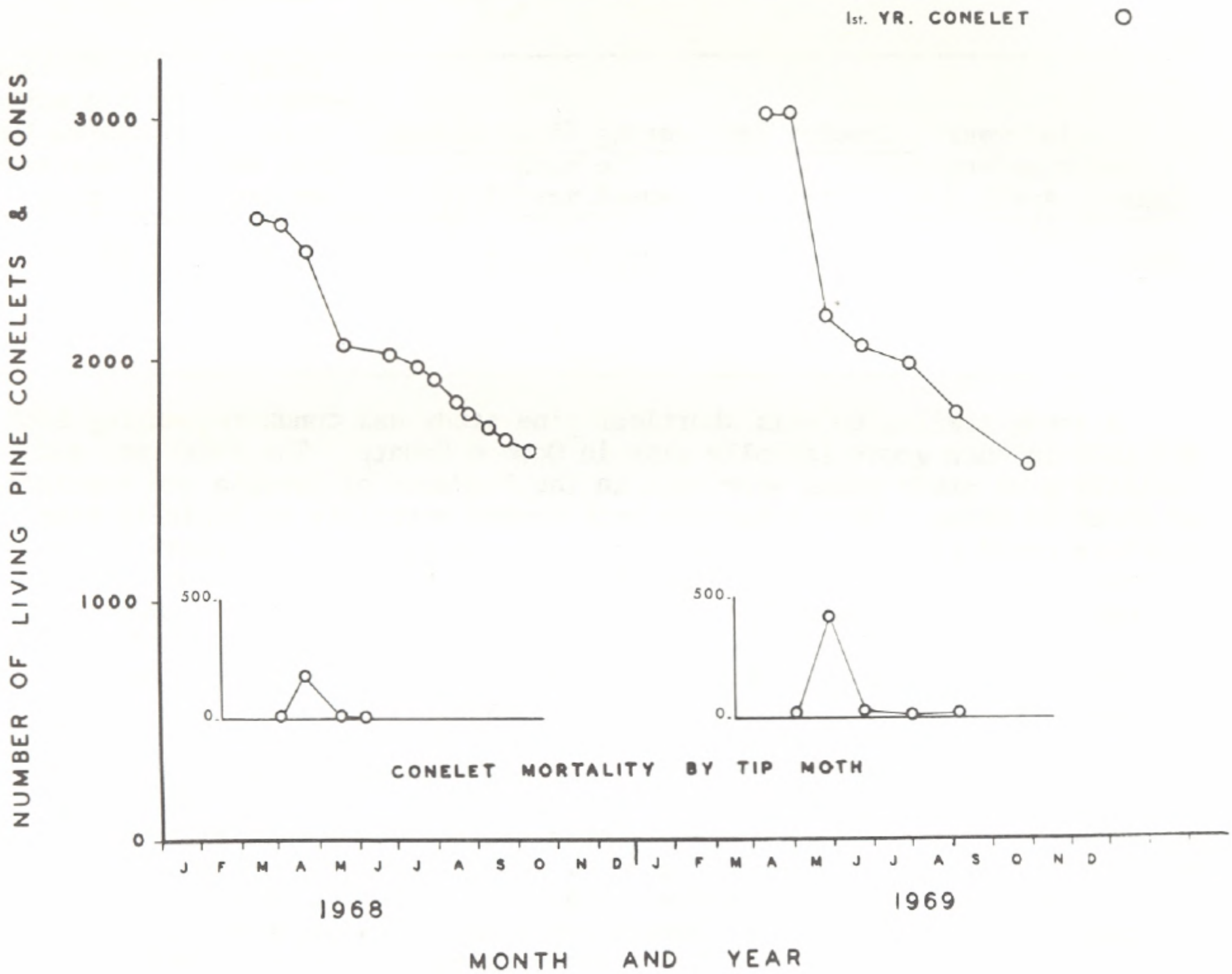

Figure 2.--Survival of first-year conelets during two seasons. Inserts indicate time and incidence of tip moth-caused first-year conelet mortality.

During both years of the study the most dramatic mortality to first-year conelets occurred in the spring. From April 21 to June 26, 1968, 569 of the first-year conelets died. Of these dead conelets 212 (37.3%) were killed by tip moth larvae. Similarly during this same period in 1969, 981 conelets died of which 445 (45.4%) were attributed to tip moth infestation. Expressed on the basis of total first-year conelet loss during each of the two study years these losses were 21.9% in 1968 and 31.3% in 1969 (Table 1).

During October of 1969 the second-year cone crop was harvested (a product of the spring 1968 conelet crop). At that time only 1208 sound cones were collected from the original 2591 conelets. This represented only a 46.6% harvest. Of this two year loss, 15.3% could be attributed to tip moth feeding on conelets, and was the largest single insect-caused mortality factor observed on shortleaf pine cones (Table 1).

Table 1.--Shortleaf pine conelet losses due to tip moth during 1968 and 1969

Year	1st year conelets April 3	Conelet loss during first season Total	Tip moth-caused mortality	Total conelet/cone loss to harvest	Percentage tip moth-caused loss of harvested crop
1968	2591	970	212 (21.9%)	1383	15.3 2/
1969	3031	1482	464 (31.3%)	--	

A study similar to this shortleaf pine study was conducted during 1969 and 1970 in open grown loblolly pine in Oconee County. The shortleaf and loblolly pine study areas were both in the Piedmont of Georgia and separated by about 15 miles. Only minor tip moth-caused mortality to loblolly pine conelets could be found (less than 1%). Observations of shortleaf pine adjacent to these loblolly pine trees established that tip moth was active in this area and was causing considerable conelet mortality. No comparative counts were made between these two pine species but incidental observations indicated that tip moths were as abundant on these adjacent shortleaf pines as they were on the shortleaf pine study trees in Clarke County.

On shortleaf pine the Nantucket pine tip moth was the greatest single identifiable factor causing mortality of first-year conelets. During two years of observation, two other conelet mortality categories **exceeded or** approximated the importance of tip moth. These included conelets aborted or missin . The abortion category (25.6% **in** 1968 and 28.9% in 1969) represents allcone ets that died without damage symptoms. This death was assumed to be due to physiological factors. The missing category (36.7% in 1968 and 28.2% in 1969) accounted for the most conelet loss during the **two years. These conelets were missing an subsequent** sample branch observations, and thus no cause for conelet disappearance could be established. However, this does not preclude their death by tip moths.

The fact that nearly all of tip moth-caused mortality occurred during the two month period April to June 26 should provide a fairly good opportunity for the application of effective controls. Control using either contact or systemic insecticides directed to be effective during the second or third week of April should significantly reduce tip moth-caused conelet mortality. Since conelet mortality by tip moths did not occur during the second tip moth generation, only one insecticide application per season would be necessary.

Let's **review** the past and present tip moth controls that have been used and are now **open to** the seed orchard manager. Periodic sprays of **organo-** chlorine compounds, which were so successfully employed in the **past, are no**

2/ Crop harvested in 1969.

longer registered for tip moth control. The much used and very successful systemic insecticide phorate (Thimet®) enjoyed a brief history of registration until April of this year when the American Cyanamid Company withdrew all registrations of Thimet for forest use. The reasons for this action were "Thimet's extreme toxicity and the lack of safe methods with which to apply it." This leaves us with only one registered pesticide for control of tip moths in seed orchards. This compound is dimethoate or Cygon®. The recommended control is to drench the terminals with a 0.12 percent water emulsion of dimethoate. While this material is systemic it may be necessary to repeat sprays each generation to obtain control for the complete season.

In the past tip moths were generally regarded as insects that indirectly affect flower production in seed orchards. However in view of our recent studies we find they cause conelet mortality by direct feeding. Tip moths should therefore be viewed with greater respect as a potential seed orchard pest. This is particularly true of shortleaf pine seed orchards.

In certain instances the importance of tip moths during the summer and fall can now be minimized. Their major impact occurs in the spring of the year when direct conelet feeding can cause significant mortality.

LITERATURE CITED

Yates III, H. 0., and B. H. Ebel. 1971. Shortleaf pine conelet loss due to the Nantucket pine tip moth *Rhyacionia frustrana* (Comstock) (Lepidoptera: Olethreutidae). Submitted for publication in the Ann. Entomol. Soc. Amer.

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