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# Biology and control of Euzophera ostricolrella Hulst on yellow-poplar, Liriodendron tulipfera L. in Tennessee

Joe H. Hope

To the Graduate Council:

I am submitting herewith a thesis written by Joe H. Hope entitled "Biology and control of Euzophera ostricolrella Hulst on yellow-poplar, Liriodendron tulipfera L. in Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Biology.

Charles D. Pless, Major Professor

We have read this thesis and recommend its acceptance:

E. Thor, J. W. Hilty, D. Williams

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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# BIOLOGY AND CONTROL OF *EUZOPHERA OSTRICOLORELLA* HULST ON YELLOW-POPLAR, *LIRIODENDRON TULIPIFERA* L. IN TENNESSEE

A Thesis

Presented for the

Master of Science

Degree

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Joe H. Hope, III

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## ABSTRACT

Euzophera ostricolorella Hulst (Lepidoptera: Pyralidae) was first described as a serious pest in 1954 when it caused heavy losses in yellow-poplar, Liriodendron tulipifera L., woodlots in Kentucky and Tennessee. The borer now damages shade trees and seed orchards in Tennessee. In 1977 the borer was bivoltine in East Tennessee. Adults of the overwintering brood emerged from April 27 to June 8 and adults of the summer brood emerged from August 27 to October 10. The average incubation period of the eggs was 9 days and the pupal period was 18 days. The major larval parasites of the borer were Venturia nigricoxalis Vier. and Macrocentrus delicatus Cress. The parasitism rate was 18% and 36% respectively, for the overwintering and summer broods. The two most effective borer control treatments were:(1) paradichlorobenzene placed around the base of the tree and covered with a six inch mound of sawdust, and (2) lindane-oil solution sprayed into a six inch mound of sawdust placed around the base of the tree.

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# CHAPTER I

## INTRODUCTION

The root-collar borer, *Euzophera ostricolorella* Hulst (Figure 1), has become a serious pest in yellow-poplar, *Liriodendron tulipifera* L., seed orchards and shade trees in Tennessee. Yellow-poplar has been planted extensively as a lumber tree throughout the southeast. Yellow-poplar seed orchards have been established with a large number of clones derived from selected trees from different parts of Tennessee and adjacent states.

The study was conducted primarily in two adjacent yellow-poplar seed orchards at the Plant Science Farm near Knoxville, Tennessee. In the study area, tree mortality attributable to root-collar borers has been extensive in recent years. Although the root-collar borer has been recognized to be economically important since 1958, its life cycle has not been thoroughly studied. The major objective of the research reported here was to learn more about its life history, habits, and ecological relationships. Another objective was to develop and evaluate control methods for the borer.


Figure 1. (A) Larva and (B) larval gallery of E. ostricolorella revealed when bark is removed.

## CHAPTER II

## LITERATURE REVIEW

Euzophera ostricolorella Hulst (Lepidoptera: Pyralidae), a root-collar borer of yellow-poplar, Liriodendron tulipifera L., was originally described by Hulst (1890). Forbes (1923) and Heinrich (1921), also made descriptions of the adult. Heinrich (1921) first described the larvae and pupa. According to Heinrich," this distinct species apparently has only one host, the tulip tree, and is probably distributed throughout the range of the host."

The larvae of the lepidopterous borer were first reported as a serious pest in 1954 when it caused heavy losses in yellow-poplar woodlots in western Kentucky and Tennessee (Hay 1958). Schuder and Giese (1962) observed considerable dieback and mortality caused by the borer in a yellow-poplar woodlot in northern Indiana and at least one shade tree in West Lafayette, Indiana. They also noted that "tunneling by the larvae provides avenues of entrance for various pathogens and the latter probably account for the demise of infested trees."

In nothern climes, the borer apparently has only one annual generation (Schuder and Giese, 1962). Hay (1958) found evidence of a partial second generation in Kentucky. Observations in yellow-poplar seed orchards in East Tennessee over the five years before this study provided evidence that there were two distinct annual broods of the insect there.

Prior to the present study, no natural enemies of Euzophera ostricolorella Hulst had been identified. Hay (1958) reported evidence of woodpeckers feeding on borer infested trees. He also found empty pupal cases of hymenopterous and dipterous insects in borer tunnels; however, he did not collect any parasites from host material reared in the laboratory.

Only small-scale control tests with insecticides have been made for this insect (Burns, 1970). Hay (1958) found that an oil solution of 0.5% BHC and 2% DDT was more effective than the water emulsion formulation. Schuder and Giese (1962), claimed satisfactory control with an oil solution of dieldrin, but supplied no data to support it.

# CHAPTER III

## METHODS AND MATERIALS

### I. BIOLOGY OF EUZOPHERA OSTRICOLORELLA HULST

Life history studies of Euzophera ostricolorella were begun in the fall of 1976. The two study-site orchards, planted in 1963, were the first yellow-poplar seed orchards to be established in this country. They occupied approximately 1.2 hectares combined area; originally they contained 346 grafted trees.

#### Field Cages

Emergence data for the field population of borers and their parasites were collected by caging the lower 75 centimeters (cm) of the tree boles. The cages (Figure 2) were constructed of nylon window screening supported by an inner frame of poultry wire. Duct tape sealed the top of the cage against the tree and sawdust sealed the bottom against the soil. The nylon window screening was secured by stapling its sides to a 2.5 x 2.5 x 70 cm piece of wood. In March, 1977, 21 trees ranging in size from 7.5 cm to 30 cm in diameter breast height (dbh) were selected at random to be caged. Euzophera ostricolorella moths and its parasites were collected from cages by removing one side and reaching an arm under the cage to capture them in vials. These insects were counted and removed daily until the end of the emergence period. The plants and soil around the base of the cages were sprayed with Paraquat® to eliminate weeds that would hamper the collection of the insects. In July, 1977, 20 additional

Figure 2. Field emergence cage used to trap adults of E. ostricolorella and its larval parasites.

trees were caged to aid in identification of the fall emergence period.

Ultraviolet (UV) Light Traps

An UV light trap powered by a 12 volt battery was operated in the seed orchard to survey the uncaged population. Another light trap was maintained in Blount Co., Tn., throughout the study to monitor a population in an area isolated from the seed orchard. These light traps were checked daily and insects caught were removed.

Insectary and Laboratory Rearing

Adults were caged reared in an insectary to augment field studies. In spring 1977, adults were transferred from caged trees in the seed orchard to rearing cages (Figure 3) whose dimensions were 25 x 39.5 x 30 cm in size. Fresh cut sections of yellow-poplar stems 40 cm long and 4 cm in diameter were placed in each cage to serve as oviposition sites. Mechanical injuries were thought to be attractive to the insects. Three sawcuts approximately 1 mm x 5 mm were made on each section. Burns (1970) notes that "egg laying has not been observed but that eggs are probably laid in crevices of the bark." The sections were sealed with paraffin at the top end and the bottom was placed in water to prevent dessication. Sugar water and fresh yellow-poplar flowers were placed in each cage to serve as food sources. This procedure was repeated in September with adults emerging in the fall. The duration of the egg stage and the number of eggs laid were determined by observation in both the insectary and the field. An artificial infestation was established in May on an uninfested yellow-poplar tree of 9 cm dbh in the seed orchard. Eight first-stage larvae were

Figure 3. Rearing cage used in the insectary.

transferred to small knife cuts made in the bark. The larvae were carefully placed in the cuts and covered with a small piece of duct tape to protect them from predators. The purpose of the artificial infestation was to determine if larvae could mature to adults by the fall emergence period.

## Head Capsule Measurements

The number of larval instars of the borer was determined by Dyar's Rule (Dyar, 1890). According to Dyar, "the sclerotized parts of an insect do not change in area during a stadium and the increase in area of these parts during larval development occurs only at ecdysis." One hundred larvae were collected and preserved during the study period and the widths of the head capsules were measured. The head capsules were measured with the aid of a binocular microscope equipped with an ocular micrometer.

## Isolation of Fungus Associated with the Borer

Isolations of a fungus associated with borer tunnels were made in August, 1977. Samples of tree tissue were taken from margins of active borer galleries in trees free of disease symptoms. Phloem and wood samples were surface sterilized with 70% ethyl alcohol followed by brief flaming. The samples were then plunged into sterile potato dextrose agar in petri plates. According to Tuite (1969), potato dextrose agar will increase fungi that attack living trees. The plates were incubated at 25°C for six days. Transfers were made to achieve pure cultures for identification.

Survey of Yellow-Poplar Seed Orchards in West Tennessee

In March, 1977, six orchards in West Tennessee owned by the Tennessee Division of Forestry, were surveyed for borer damage and disease symptoms. Three of the orchards were located at the State Division of Forestry Nursery, Madison County; three other orchards were in Chickasaw State Forest, Chester, and Hardeman Counties. A survey of borer damage was also made in an orchard at the Ames Plantation, Fayette County. The diameters of a sample of trees in each seed orchard were measured at breast height diameter to determine their range and average size. Yellow-poplar trees located near the seed orchards in mixed hardwood stands were visited to survey borer attacks and disease symptoms.

## II. DEVELOPMENT AND APPLICATION OF BORER CONTROL TREATMENTS

Sticky-Trap Treatments

(1) In August, 1974, prior to initiation of the present study, Stikem®, a sticky trap material, was applied to 39 yellow-poplar trees in the seed orchard. The application was made to the bottom 14 cm of the tree boles (Figure 4). (2) In April, 1976, Stikem was applied to 72 additional trees with a paper wrap placed in between it and the bark (Figure 5). In March, 1977, the Stikem and paper treatment was removed from the trees. Larvae of the overwintering generation were counted from both groups of Stikem treated trees by the coarse frass which could be detected on the bark exterior.

Figure 4. Sticky trap material applied to yellow-poplar in August, 1974.

Figure 5. Sticky trap material applied to paper tree wrap.

Figure 4

Figure 5

Topical Applications of Chemical Insecticides

In September, 1976, three chemical treatments were applied to 20 trees in the seed orchards. Each treatment was applied to 20 trees. (1) A diesel oil solution containing Lindane EC(1%) was sprayed on a paper tree wrap (Figure 6) to the point of runoff. The spray was applied with a compressed air hand sprayer to the basal 14 cm of the trunk. (2) A diesel oil solution containing Lindane EC (1%) was sprayed on a 14 cm mound of sawdust surrounding these trees (Figure 7). The sawdust mound was used as a barrier to the borers and to maintain the insecticide activity of the spray for a longer period of time. The sawdust mound was sprayed with approximately 300 milliliters. (3) Paradichlorobenzene (PDB) crystals were applied in a band around the base of the tree with a mound of sawdust placed over it (Figure 8). The PDB crystals were applied at a rate of 95 grams per tree.

The applications were made to coincide with the beginning of the fall emergence period of the E. ostricolorella adults. In March, 1977, the paper tree wraps and sawdust mounds were removed from the treatments. Four trees of each treatment were selected at random and caged to determine the survival of the overwintering generation of borers. Four of the trees which were caged for the life history study also served as check trees for the treatments. Uncaged treated trees were examined for borer activity as indicated by frass being pushed out of emergence holes by surviving larvae.

Injections of Systemic Chemicals Into Trees

In July, 1977, two different insecticides were injected into

Figure 6. Paper tree wrap sprayed with Lindane-oil solution.

Figure 7. Mounds of sawdust were sprayed with Lindane-oil solution. Two trees in the background have emergence cages on them.

Figure 8. Mound of sawdust covering a ring of Paradichloro-benzene crystals.

13 trees each. The systemics were injected (Figure 9) with hand pressurized capsules containing either two milliliters of 86% Bidrin®, a carbamate, or three milliliters of 50% Metasystox-R®, an organophosphate, into the phloem tissue. The injections were spaced every 10 cm around the tree and 30 cm above the soil line. It took approximately three hours for the pressurized capsules to empty.

Applications were made to kill borers of the summer generation feeding in the phloem tissue. In August, 1977, all of the treated trees were caged to determine the survival of the summer generation of borers. Thirteen of the trees which were caged for the life history study served as check trees for the treatments.

Figure 9. Pressurized capsule containing systemic insecticide being driven on feeder tube.

## CHAPTER IV

## RESULTS AND DISCUSSION

### I. BIOLOGY OF *EUZOPHERA OSTRICOLORELLA* HULST

#### The Adult

Male and female *E. ostricolorella* (Figure 10) are identical in color markings and size with variations in size among individuals in the population. The sexes can be distinguished by examination of the genitalia. The newly emerged female has a larger abdomen than the male. The female abdomen has a swollen appearence because it is filled with eggs. Heinrich (1956) described the forewing as purplish brown in color with a dark grayish color along the costa and some grayish dusting in the apical area. The transverse lines are whitish and not darkly bordered. The hind wing has a pale smokey color with a fine dark line along the terminal margin. He described the wing span of *E. ostricolorella* as being 29 to 40 mm. Measurements of both male and female spread specimens collected in Tennessee ranged from 28 to 38 mm. The length of the moths, not including the antennae, ranged from 15 to 17 mm.

Adults were rarely observed in the field except in caged trees. Adults were easily collected from the caged trees during the emergence periods. They were inactive during daylight hours and always found on the side of the cage away from the sun. Adults were active at night and were attracted to ultraviolet light traps. The light trap in the seed orchard collected 23 moths during the fall emergence period. The light trap in the natural stand of yellow-poplar in Blount Co., Tn. yielded three moths during the spring and four moths during the fall emergence

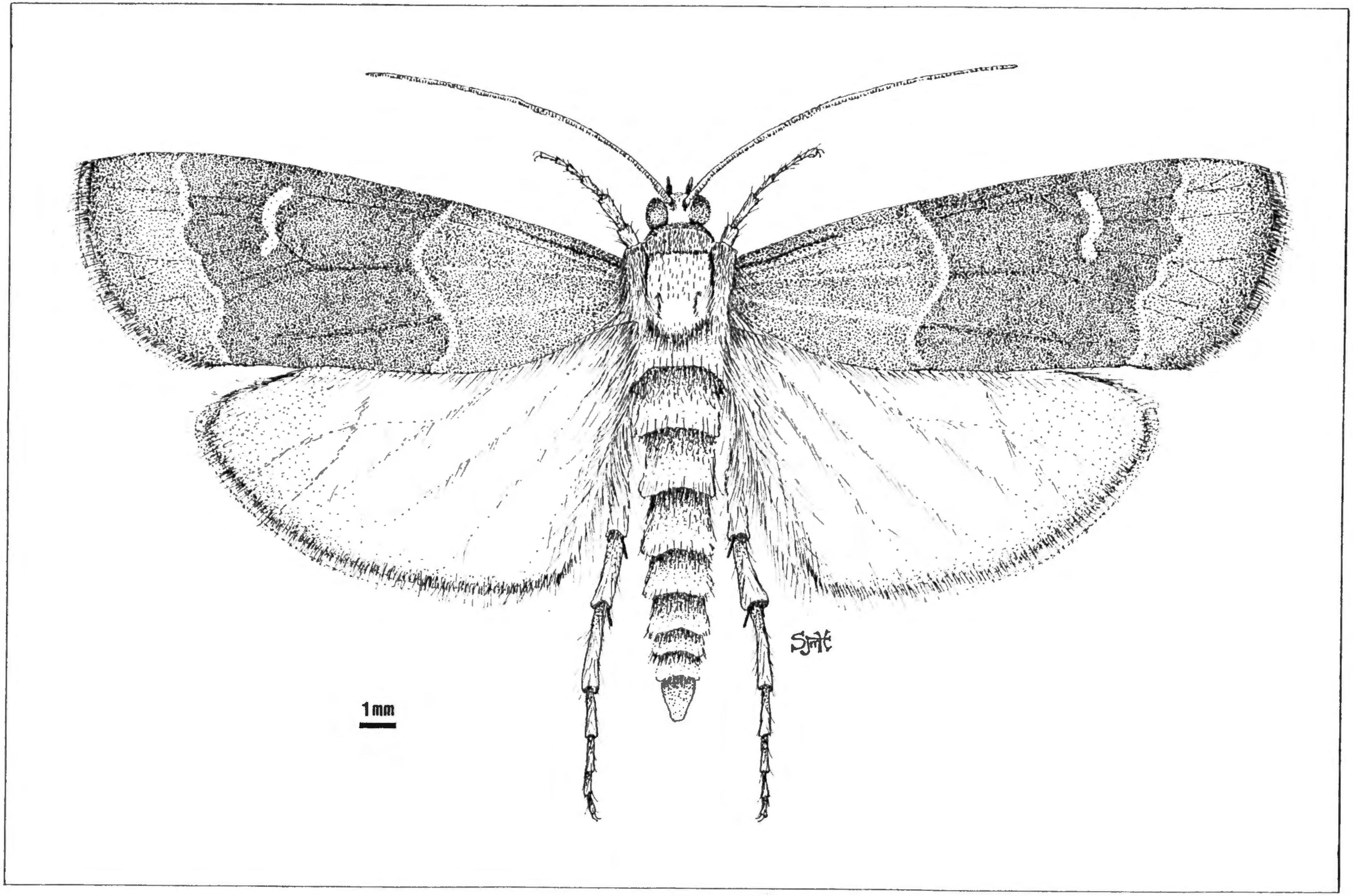


Figure 10. Euzophera ostricolorella: Adult.

period, an indication of low numbers of the borer in natural mixed hardwood stands. Mating was never observed, but it occurred at night among the moths placed in the insectary. Ovipositing occurred at night in the insectary. Adults were never observed feeding on sugar water and fresh yellow-poplar flowers in the insectary. The moths may have fed at night because they lived for eight days in the insectary. Frequent visits were made to the insectary and the moths were totally inactive during the daylight hours.

E. ostricolorella was completely bivoltine (Figure 11) in 1977. Adults and parasites of the overwintering generation emerged from April 27 to June 8, with peak emergence in mid-May (Figure 12). The summer generation emerged from August 27 to October 10, with peak emergence in mid-September (Figure 13). Fifteen cages from the spring emergence period were left on the trees and checked during the fall emergence period along with the newly caged trees. There were no emergences from any of the 15 caged trees indicating that all of the overwintering generation had emerged during the spring. In the artificial infestation only one out of the original eight larvae survived to emerge. The length of time from egg to adult was May 16 to October 2, indicating a complete summer generation. There was no larval activity in caged trees after the fall emergence period, indicating that there were two complete generations.

## The Egg

The egg (Figure 14) was dull red in color, oblong, measuring approximately 0.9 mm x 0.5 mm. When first laid it was light red but

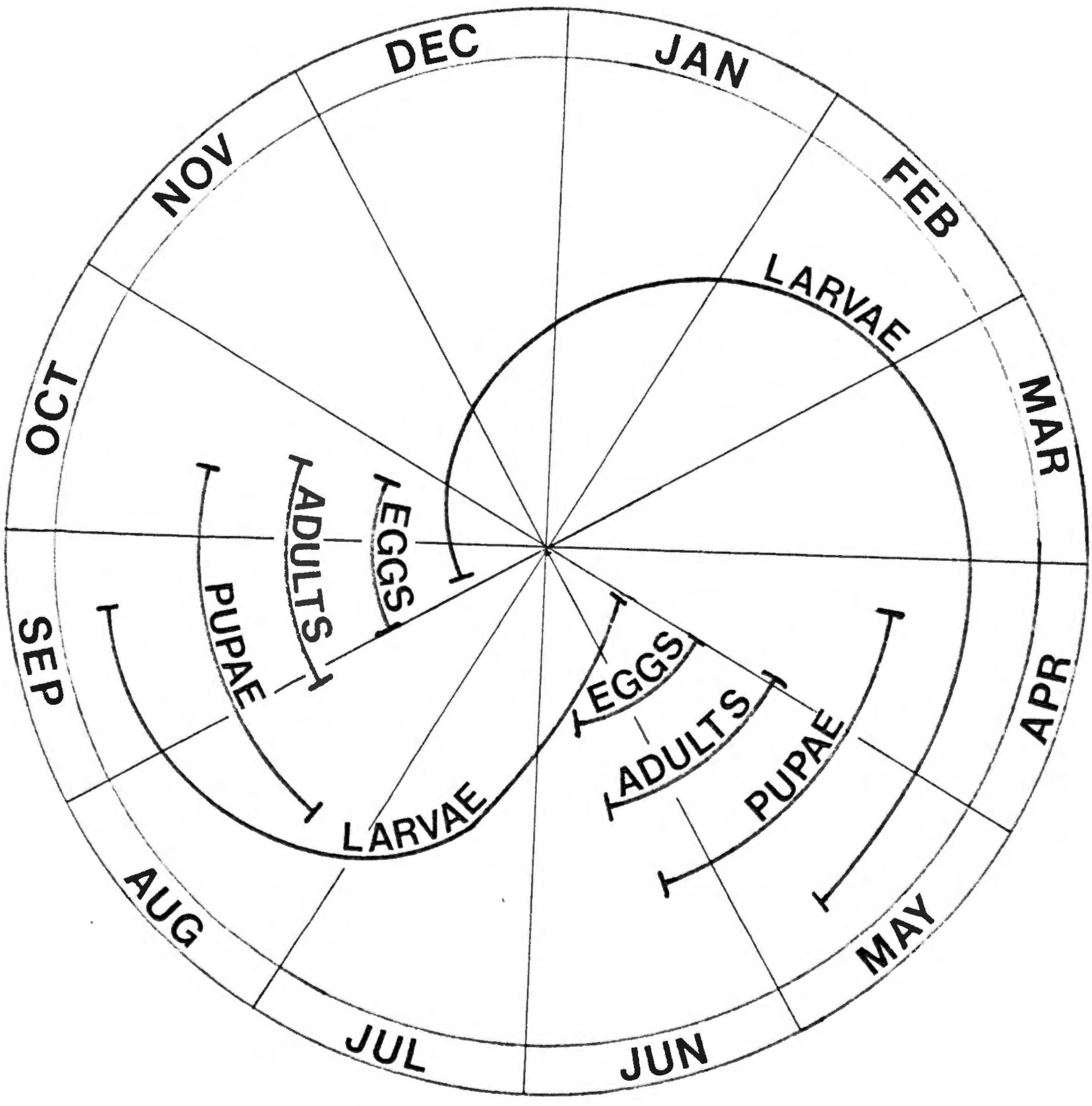


Figure 11. Seasonal life history of _E. ostricolorella_ during 1977 in Tennessee.

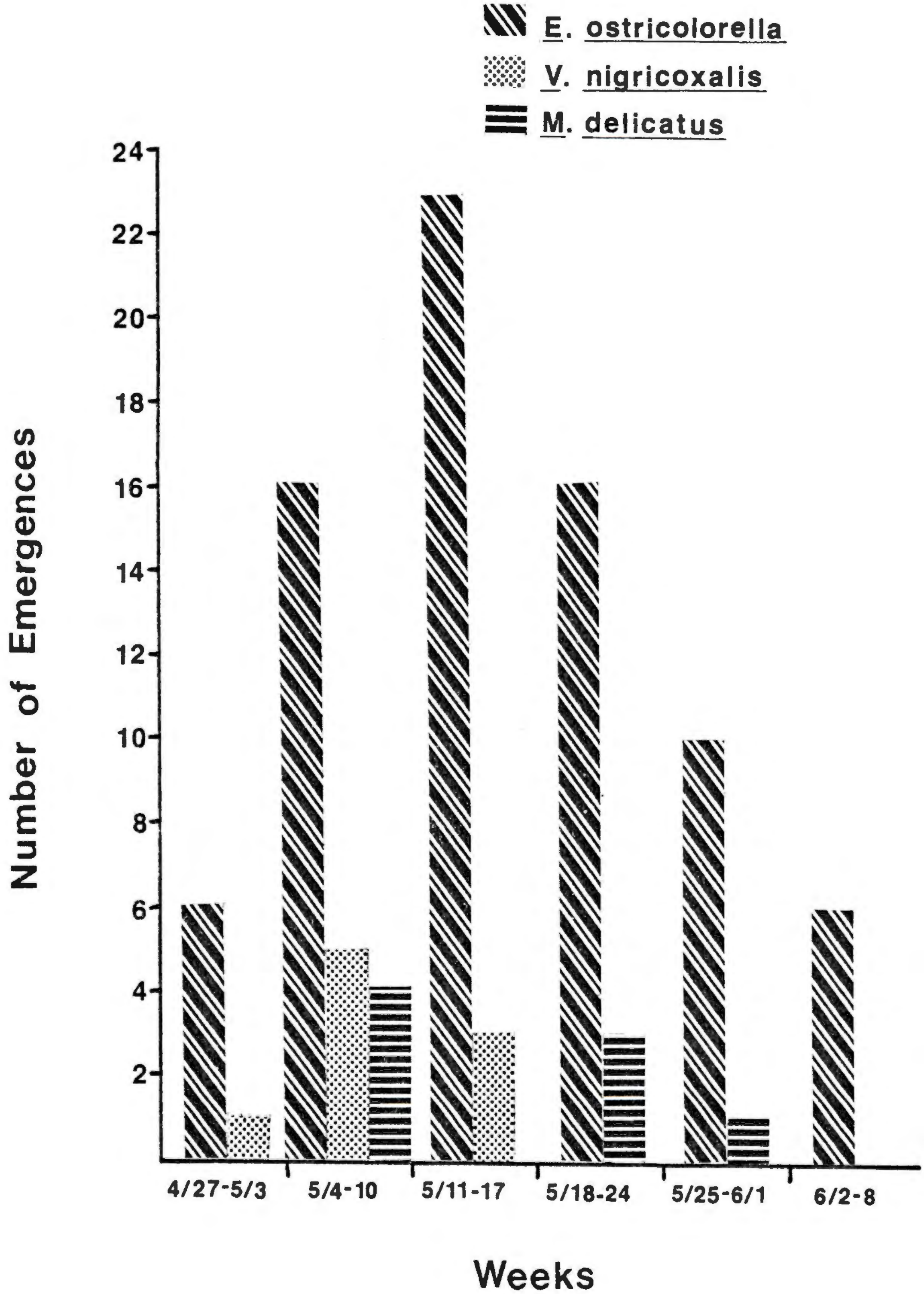


Figure 12. Field emergence of E. ostricolorella, V. nigricoxalis, and M. delicatus during 1977 in Tennessee of the overwintering generation.

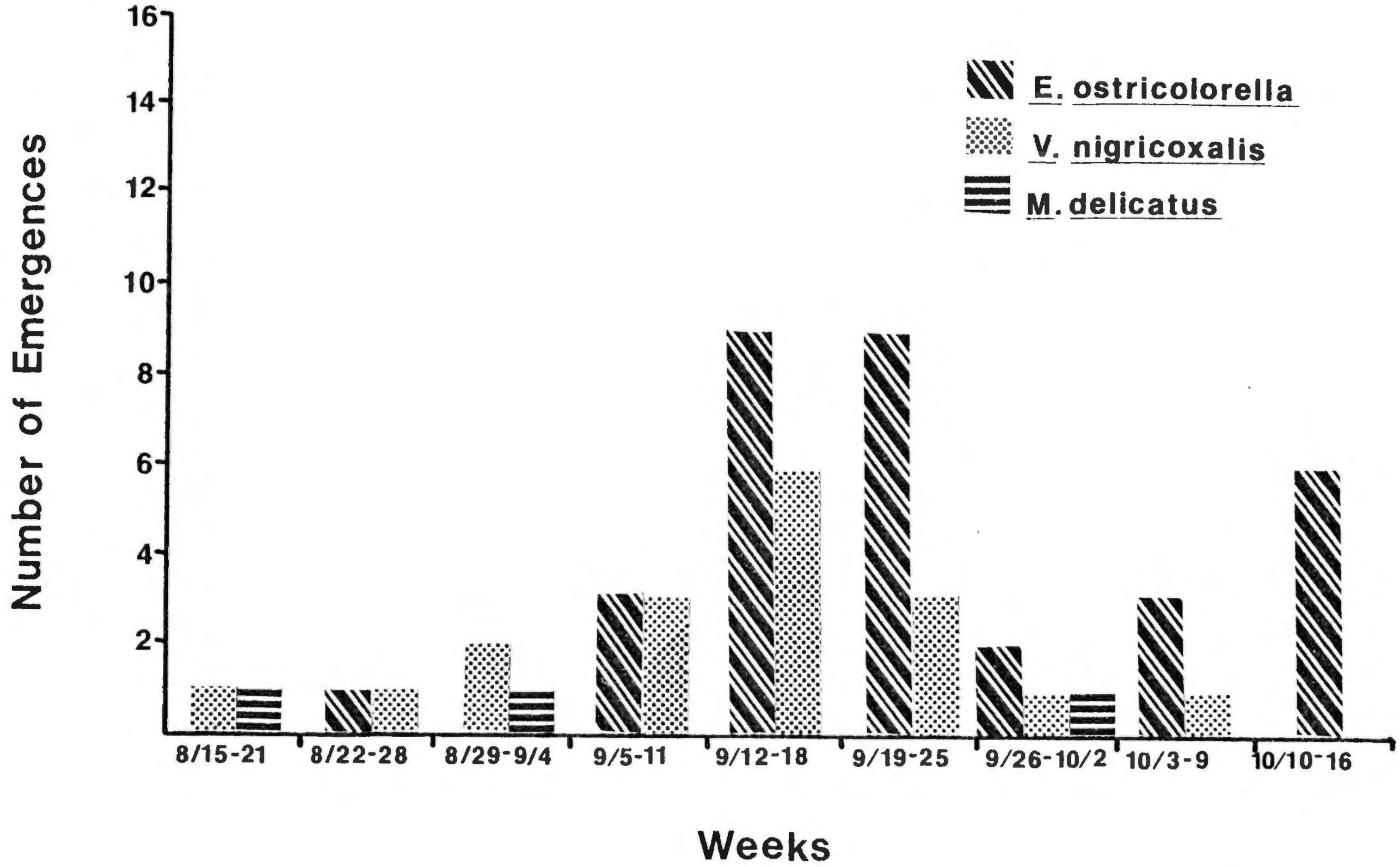


Figure 13. Field emergence of E. ostricolorella, V. nigricoxalis, and M. delicatus during 1977 in Tennessee of the summer generation.

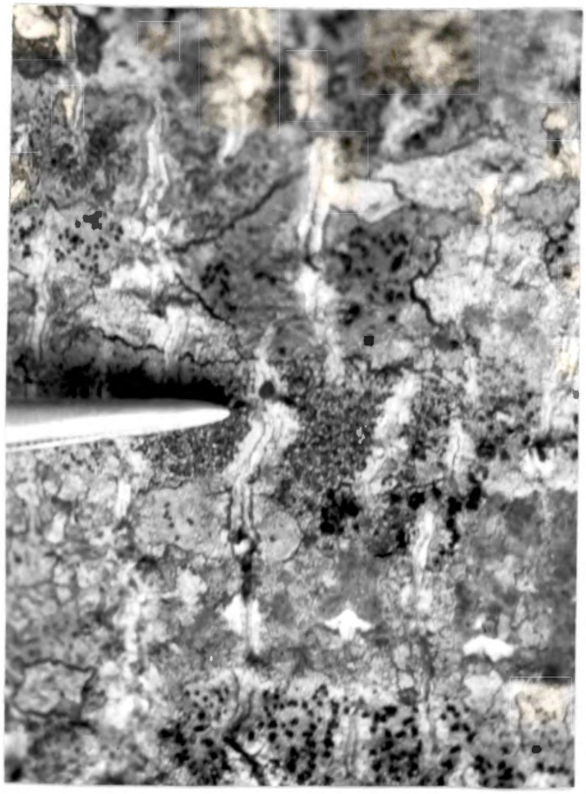

Figure 14. Egg of Euzophera ostricolorella.

becomes darker before hatching.

The virgin adults, placed in cages in the insectary during the fall and spring emergence periods, mated and oviposited in artificial cuts and natural crevices in the bark of the stem sections. The two groups, each containing 6 moths, in the spring rearing, laid 43 eggs and 41 eggs. Only the latter group produced any fertile eggs. The infertile eggs were pale yellow in color. The incubation period of the fertile eggs was 9 days. The two groups in the fall laid 39 eggs and 34 eggs. None of the eggs hatched but were red in color. An early frost during the incubation period could have attributed to their mortality.

In the field, females oviposited at night in crevices in the bark. As many as 38 eggs were found on a single tree. The eggs were scattered over an area up to 14 cm above the ground level. Eggs were observed in the seed orchard during both adult emergence periods.

In September, 1977, a stem section from the insectary containing 34 eggs was cut in half. It was taken to the seed orchard to expose the eggs to suspected egg parasites observed there. The stem left in the seed orchard for two days was hung by a string from a branch to prevent egg predation. After two days, there were only three of the original 15 eggs left and 6 phalangids were on the section. The phalangids might have preyed on the eggs. No egg parasites were reared in the laboratory from the remaining eggs.

<u>The Larva</u>

The white to cream colored larvae with redish-brown head capsules are the destructive stages of E. ostricolorella. Larvae (Figure 15) ranged in length from 0.3 cm in the first instar to 3.3 cm in the sixth instar. First-stage larvae were observed in May, 1977, after hatching on a stem section in the insectary. Upon hatching, larvae consumed the egg shells. All larvae migrated downward on the stem section and started boring. The larvae produced silk threads which were observed only with the aid of a microscope. Fine piles of boring dust were produced around the holes made by the first-stage larvae. The first through third-stage larvae were observed to tunnel as deeply into the bark as the latter stage larvae. Larvae were very susceptible to dessication when exposed directly to the atmosphere, and the tunnels apparently provided the necessary moist environment.

Head capsule measurements of larvae indicated six instars (Figure 16). Males and females were equal in rate of development and number of instars. As shown in Figure 16, head capsule measurements did fall into six discontinuous groups, and peaks appeared in their frequency distributions. The average larval period was 210 days for the overwintering generation and 91 days for the summer generation. E. ostricolorella overwinters in Tennessee, in the larval stages. Winter mortality of the borers was not observed. Heinrich reported the range of the borer to extend as far north as New York State, so it is obviously a cold hardy species. In December, 1977, 6 fifth-stage larvae of the overwintering generation were collected that had spun a thin layer of silk around their bodies. This silk insulation acted as a hibernaculum for these immature larvae. Sixth-stage larvae made emergence tunnels to the outside of the bark after excavation of

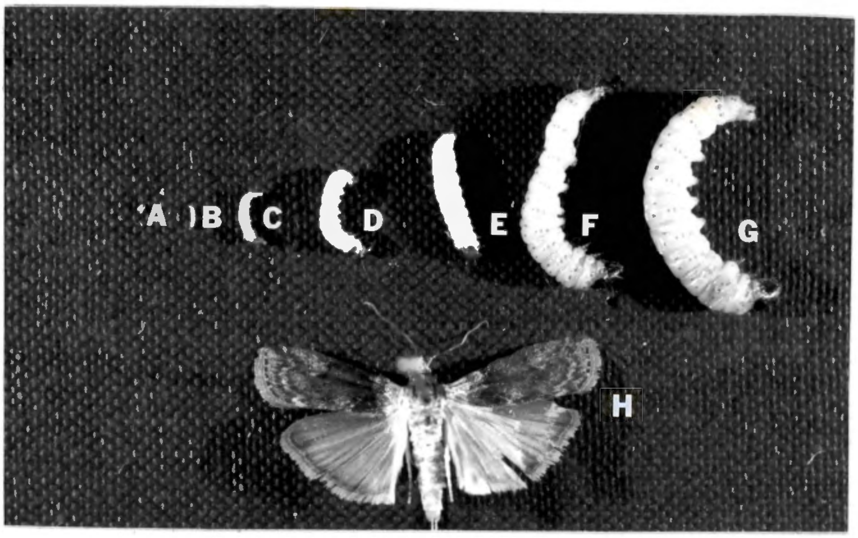


Figure 15. (A) Egg; (B-G) first through sixth-stage larvae; (H) adult of Euzophera ostricolorella.

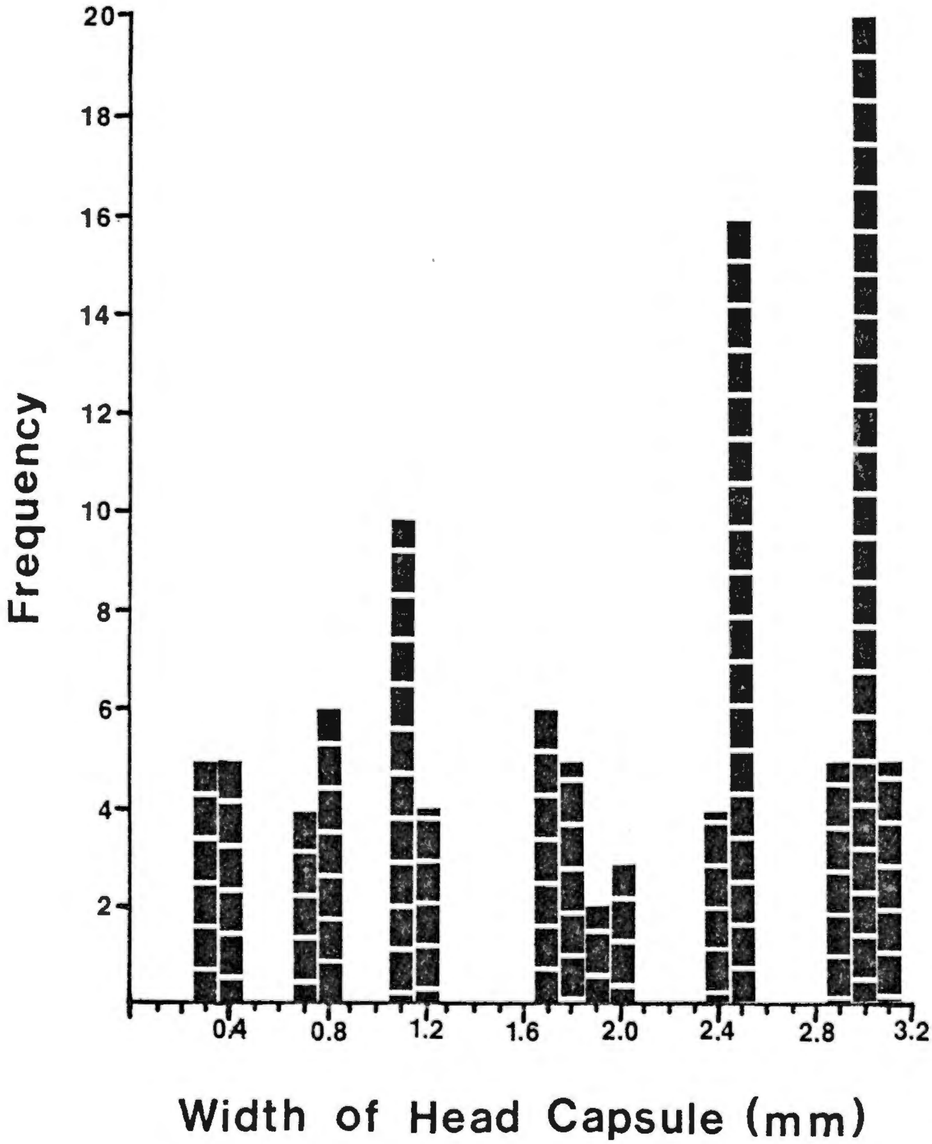


Figure 16. Frequency distributions of head capsule measurements of *E. ostricolorella*.

pupal chambers. Emergence holes were sealed by emergence caps (Figure 17) of a wood-silk composition. These emergence caps kept the tunnels sealed until the adults were ready to emerge to the outside. The larvae, upon completion of the emergence caps, returned to their pupal chambers, spun cocoons (Figure 18), and pupated.

Damage by the larvae was usually restricted to within 12 cm above the soil line and 7 cm under the soil line. Rarely were attacks found higher in the trees. The size range of borer-attacked trees in the seed orchards near Knoxville, was 5 cm to 35 cm dbh; the average was 25 cm dbh. Larval galleries were primarily vertical and confined to the cambium-phloem tissue. Average gallery dimensions were 10 cm by 0.65 cm. Pupal chambers averaged 2.8 cm by 0.65 cm and were partially excavated into the xylem tissue. As many as 30 mature larvae and pupae were collected at one time from a single tree 10 cm dbh. Caged trees contained an average of four larvae per tree of the overwintering generation. For the summer generation, caged trees averaged 2.25 larvae per tree. Caging data indicated that the overwintering generation was larger than the summer generation in Tennessee.

## The Pupa

The pupal period was passed within a cocoon made of silk, as seen in Figure 19B. Sixth-stage larvae spun a cocoon in a pupal chamber. The cocoon had a small hole at the end facing the emergence tunnel. Larvae pupated with their heads in the direction of the emergence holes. All sixth-stage larvae reared under laboratory conditions had a pupal period of 18 days. Adults emerged through the dorsal side of the head

Figure 17. Emergence cap made by sixth-stage larva of E. ostricolorella prior to pupation.

Figure 18. Cocoon of E. ostricolorella removed from its pupal chamber.

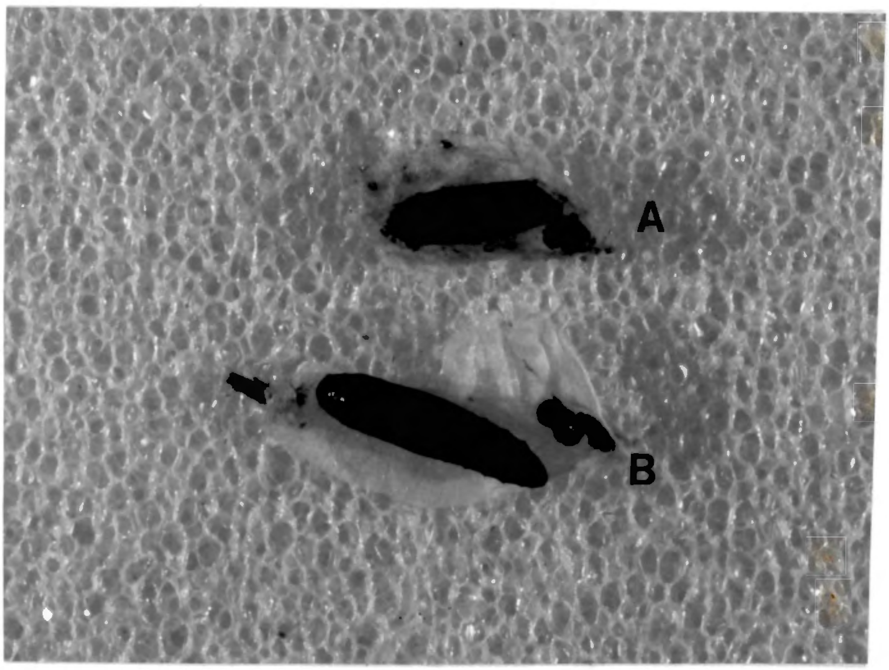


Figure 19. Pupae of (A) V. nigricoxalis and (B) E. ostricolorella.

and thoracic regions of the pupal case. The adults crawled out of the emergence tunnel leaving their pupal case in the cocoon and pushed through the emergence cap to the outside of the bark. Empty pupal cases were found by cutting away bark at emergence holes and following emergence tunnels approximately 3 cm down the trunk.

Larval Parasites

Two species of larval parasites were reared in field cages, the most abundant one being *Venturia nigricoxalis* Viereck (Figure 20), (Hymenoptera:Ichneumonidae). This small wasp has a black head and thorax and a red abdomen. The legs have a mixture of red and black mottled areas. The females averaged 11 mm in length, excluding their antennae and ovipositor. The average length of their ovipositor was 8 mm. The males averaged 9 mm in length, excluding their antennae. Emergence of *V. nigricoxalis* began the same day as that of *E. ostricolorella* during the spring emergence period, as shown in Figure 12, page 23. No *V. nigricoxalis* were collected in field cages after mid-May, but were frequently observed searching on other trees until June 2. The emergences of this parasite during the fall emergence period preceded that of *E. ostricolorella* by one week as illustrated in Figure 13, page 24. Female parasites which were observed searching were attracted to borer frass on the trees. The parasite would insert its ovipositor many times per second in the immediate area of the frass. One tree which was caged immediately after parasite oviposition was observed and had one emergence from it of *V. nigricoxalis*. The emergence hole was in an area where the parasite of the previous generation was observed ovipositioning. The

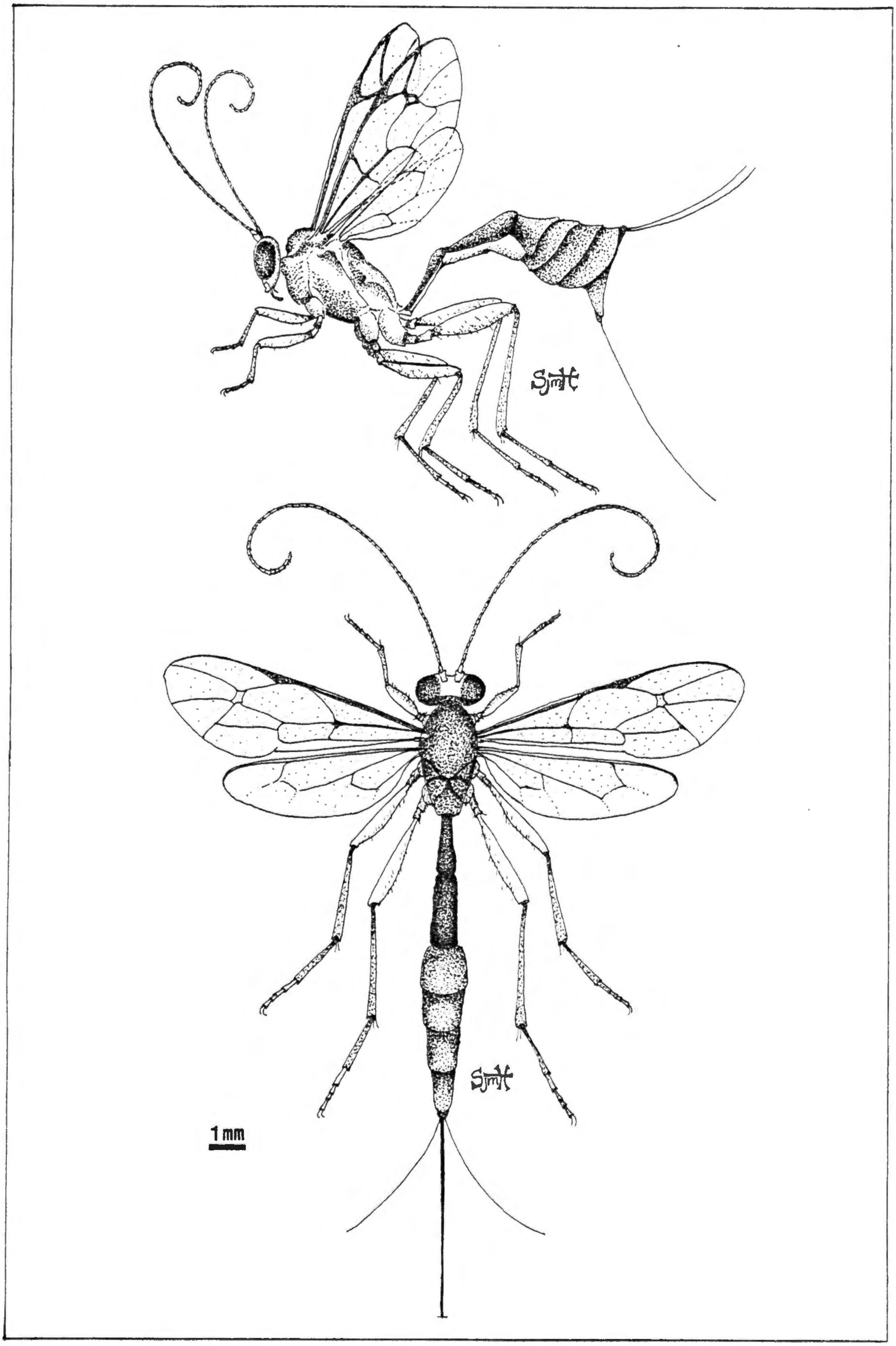


Figure 20. Larval parasite, Venturia nigricoxalis Vier., female.

length of parasite development from egg to adult was 19 days. V. nigricoxalis was reared many times from sixth-stage larvae collected in the field. Based on adult rearing records, parasitism was 10% in overwintering larvae and 30% in summer larvae. The female to male ratio for V. nigricoxalis was 2:1 during the spring emergence and 4:3 during the fall emergence. The author believes that this parasite oviposits in third through sixth-stage borer larvae and development time of the parasite is dependent on the development time of E. ostricolorella larvae. Parasitized borer larvae do not pupate; however, borer larvae must not die before preparing an exit hole or the parasite would have no exit to the outside of the bark. All parasites reared in the laboratory had E. ostricolorella cocoons around their hymenopteran pupal cases. Figure 19, on page 33 shows the pupal cases of the parasite and the borer.

A second major parasite was Macrocentrus delicatus Cresson (Figure 21), (Hymenoptera:Braconidae). It is gold with a black tint on the dorsal surface of the body. Females averaged 8 mm in length, excluding antennae and ovipositor. The average length of the ovipositor was 11 mm. The males averaged 7 mm in length, excluding antennae. The emergence of M. delicatus in Figure 12, page 23 occurred during the latter half of the spring emergence of E. ostricolorella. During the fall emergence period it was collected in low numbers, but still coincided with E. ostricolorella emergence. Dissection of fifty preserved borers yielded one M. delicatus larvae in a fourth-stage larva.

Since the larval parasite did not kill the borers until the damage was done to the tree, I have some reservations about the true

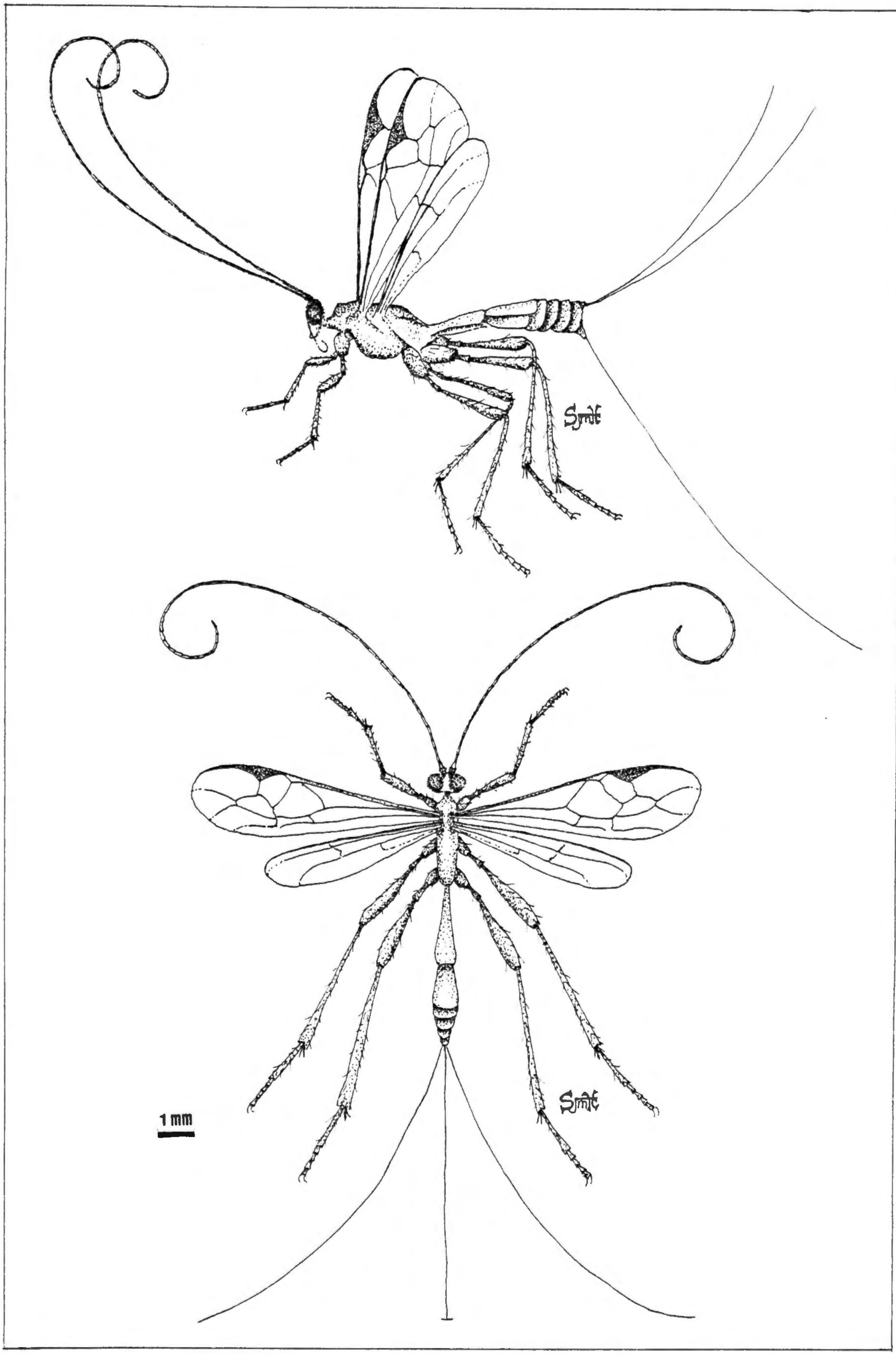


Figure 21. Larval parasite, Macrocentrus delicatus Cress., female.

potential of the parasites as a short term control agent. The parasites could be very effective over a long range in reducing borer populations. The parasites had a combined rate of parasitism of 18% in the overwintering larvae and 36% in the summer larvae.

Fungus Association

In addition to damaging or killing the tree by girdling, the borer apparently predisposes trees to invasion by the fungus *Fusarium solani* (Martins, (Appel and Wollenweber)). This fungus was isolated from samples of phloem tissue adjacent to larval galleries. The same fungus was also isolated from the gut of the borer larvae.

The disease symptoms observed in the seed orchard at Knoxville were the same as those described by Dochinger and Seliskar (1962). The disease symptoms (Figure 22) were confined to the tree trunks arising from areas of previous borer attacks. The first observable symptoms of the disease were vertical cracks in the bark. When the outer bark around these cracks was removed, elliptical cankers were found. Foliar symptoms did not appear in early stages of the disease, but when cankers enlarged, the crown defoliated on the damaged side of the tree. Some diseased trees were observed to form callus tissue around cankers where borers had not reinfested. Dochinger and Seliskar (1962) believed that establishment of *Fusarium solani* was dependent upon the time of the year it was inoculated. They found that September inoculations would stay active and spread for more than two years. The summer generation of borers would be more important in the establishment of the disease. Dochinger and Seliskar (1962) also showed that *Fusarium solani* could

Figure 22. Fusarium canker arising from area of borer attacks.

not successfully invade yellow-poplar unless the bark was injured. *Fusarium solani* apparently contributed significantly to the mortality of borer-damaged trees in this study. Many of those trees were only partially girdled by insects, but disease symptoms were evident. Many surviving trees showing symptoms of decline had been attacked by both borers and fungus pathogen.

## Survey of Yellow-Poplar Seed Orchards in West Tennessee

The combined number of trees in the orchards surveyed in West Tennessee was 1,395. The range and average size is shown in Table 1. All trees greater than 5 cm dbh were either infested by borers or contained feeding scars and emergence holes caused by the insects. Trees less than 10 cm dbh usually contained few scars or emergence holes. Larger trees often had emergence holes too numerous to count accurately. The largest tree in the survey, 36.8 cm dbh, contained 134 evident emergence holes. Exposed roots of the older trees also had been attacked heavily by the borers. Yellow-poplar trees sampled in woods near the orchards had been attacked by borers, but in much lower numbers.

Disease symptoms were evident in only 10 % of the yellow-poplar trees examined outside the orchards. Fusarium canker disease symptoms were widespread in West Tennessee orchards (Table 1), especially among younger trees. An earlier survey (Churchwell, 1977) indicated that *Fusarium solani* had infected or killed 19%, 22%, and 50% of the trees in the three orchards at the State Nursery, respectively. It was observed that trees infected with the fungus had also been attacked by *E. ostricolorella* larvae at the points where the cankers originated.

TABLE I. Incidence of *Fusarium* Canker in Eight Yellow-Poplar Seed Orchards in Tennessee

| Orchard | No. Trees | Size Range (dbh in cm) | Average Size (dbh in cm) | Fusarium Canker Incidence* |
|---|---|---|---|---|
| Pinson 1 (Madison Co.) | 72 | 12.9-36.8 | 25.3 | 1 |
| Pinson 2 (Madison Co.) | 60 | 17.7-37.6 | 24.6 | 5 |
| Pinson 3 (Madison Co.) | 268 | 3.8-11.6 | 8.1 | 2 |
| Chickasaw 1 (Chester Co.) | 180 | 3.9-21.3 | 11.9 | 4 |
| Chickasaw 2 (Chester Co.) | 68 | 6.8-21.5 | 12.7 | 4 |
| Chickasaw 3 (Hardeman Co.) | 209 | 5.0-20.5 | 13.7 | 3 |
| Ames (Fayette Co.) | 548 | 4.0-17.0 | 9.9 | 3 |
| Knoxville (Knox Co.) | 346 | 5.0-35.5 | 25.0 | 3 |

* 0 = 0-10%, 1 = 10-20%, 2 = 20-30%, 3 = 30-40%, 4 = 40-50%, 5 = more than 50%.

The same association was also noted for the trees at the Chickasaw and Ames Plantation orchards.

Trees with primary symptoms arising from borer attacks at the root collar, sprouted profusely from just below the dead tissue. Such sprouts were reliable secondary symptoms of the Fusarium canker disease since borer attacks alone did not initiate such sprouting. _Fusarium solani_ has severely damaged trees in both East and West Tennessee seed orchards.

## II. EVALUATION OF CONTROL TREATMENTS

### Sticky-Trap Treatments

The treatments with Stikem were ineffective in reducing _E. ostricolorella_ populations. The trees with the three year old treatment averaged 3.6 larvae per tree. The one year old Stikem and paper tree wrap treatment averaged 2 larvae per tree. The larvae tunneled less deeply into the phloem tissue in these trees compared to check trees.

### Topical Applications of Chemical Insecticides

Table II presents a summary of the results of the three topical treatments. The data here show the mean number of surviving insects per tree for each chemical insecticide.

Paradichlorobenzene under a sawdust mound proved to be the most effective treatment. PDB controlled 100 percent of the overwintering larvae. The uncaged trees of this treatment did not show activity when examined for surviving larvae. The oil solution containing Lindane EC (1%) sprayed on a sawdust mound averaged 0.25 larvae per tree. These

TABLE II. Effectiveness of Chemical Insecticides Applied Topically

| Treatment | Mean No. of Surviving Insects/Tree* | | |
|---|---|---|---|
| | E. ostricolorella | V. nigricoxalis | M. delicatus |
| Paradichlorobenzene and sawdust | 0a | 0a | 0a |
| Lindane, oil, and sawdust | 0.25a | 0a | 0a |
| Lindane, oil, and paper | 1.5 b | 0a | 0.25a |
| Check | 3.5 c | 0.5a | 0.5 a |

* Any two means followed by the same letter are not significantly different ($P < .05$, Duncan's New Multiple Range Test).

uncaged trees had no signs of frass when examined for surviving larvae. The oil solution containing Lindane EC (1%) sprayed on a paper tree wrap did not give effective control compared to the previous two topical applications. It averaged 1.5 larvae per tree. Some of the paper tree wraps were not removed until the end of the spring emergence period. The paper tree wraps were riddled with emergence holes (Figure 23).

## Injections of Systemic Chemicals Into Trees

Table III presents a summary of the results of the injections of the systemic insecticides, giving the mean number of surviving insects per tree for each systemic chemical.

Bidrin averaged 0.15 larvae per tree compared to 0.23 larvae per tree of the Metasystox-R. Both systemic insecticides reduced populations significantly when compared to the check trees. The check trees averaged 1.38 larvae per tree. The larvae that survived the treatments were found to have been tunneling directly between injection points on the trees, indicating that horizontal movement of the chemicals is very limited.

Figure 23. Numerous emergence holes from the overwintering generation through paper tree wrap treated with Lindane-oil solution.

TABLE III. Effectiveness of Injected Systemic Insecticides

| | Mean No. of Surviving Insects/Tree* | | |
|---|---|---|---|
| Treatment | E. ostricolorella | V. nigricoxalis | M. delicatus |
| Bidrin® | 0.15a | 0a | 0a |
| Metasystox-R® | 0.23a | 0.15a | 0a |
| Check | 1.39b | 0.69b | 0.15a |

* Any two means followed by the same letter are not significantly different ($P < .05$, Duncan's New Multiple Range Test).

## CHAPTER V

## SUMMARY AND CONCLUSIONS

In mixed hardwood forests in Tennessee, root collar borers have caused little damage to yellow-poplar trees; however, occasional emergence holes have been observed. In less natural habitats (lawns, woodlots, seed orchards) dieback and mortality of trees is common. Monoculture of yellow-poplar may account for increases in *E. ostricolorella* populations in woodlots and seed orchards. On the basis of the study done by Dochinger and Seliskar (1962) it would appear that *Fusarium solani* is not a virulent pathogen and "damages yellow-poplar only when the host is weakened because of unfavorable environment." Numerous attacks by *E. ostricolorella* weakened yellow-poplar to the point that *Fusarium solani* can successfully establish in wounds. As yellow-poplar becomes more extensively planted, and as the area planted in seed orchards increases, it seems likely that losses resulting directly or indirectly from borer activity may increase.

Effective methods of controlling the borer are necessary to ensure longevity of seed orchards. Results of one year's data indicate that conventional chemical sprays applied to the bark have been largely unsuccessful. Physical barriers, including paper tree wraps, sticky coatings, and cages were unsuccessful. Promising treatments include sawdust barriers containing insecticides and systemic insecticides injected into trees. All treatments should coincide with the beginning of spring and fall emergence periods. The two most effective topical applications of chemical insecticides are being evaluated during spring, 1978.

There is a need for further research on the nature of the association between *Euzophera ostricolorella* and *Fusarium solani*. *Euzophera ostricolorella* is only suspected of being a vector of the fungus. The exact mechanism of transmission should be studied.

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