LIFE HISTORY AND CONTROL OF THE PEAR BORER IN VIRGINIA

AEGERIA PYRI HARRIS (LEPIDOPTERA: AEGERIIDAE)

by

Marvin L. Bobb

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in
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Approved:

W. D. Richardson
Course Adviser

H. G. Wilson
Head of Department

H. H. Zinn
Dean of Agriculture

Virginia Polytechnic Institute
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INTRODUCTION

The name pear borer is not at all suggestive of the habits of this insect in Virginia; although in some states it may cause considerable injury to pear trees. Probably apple crotch-borer, as suggested by Brooks (1), would be more appropriate, since the main injury, especially in Virginia, is done to apple trees. The pear borer is not generally considered of economic importance in Virginia, but in some instances it has caused considerable injury to apple trees.

In the Andrews orchard at Hollins, Virginia, the borers were very abundant in the trunks and larger limbs of the apple trees; and though the trees look to be in a healthy condition, they are gradually becoming weaker and some means of borer control is needed. This insect may never cause the death of many trees directly, but the borers weaken the trees to such an extent that other injurious borers and diseases that ordinarily do not attack healthy trees are able to gain entrance into the tree.

The data contained in the following pages were secured during 1933 and 1934, but the life history studies were largely made during 1934 in the Andrews orchard.

HISTORICAL

Origin and Distribution

Brooks (1) states that the pear borer is a native American insect and was first described by Dr. Thaddeus W. Harris in 1830. It is widely distributed in the eastern part of this country and has been recorded from the following states: Maine, New York, New Jersey, Pennsylvania, Michigan, Maryland, West Virginia, Virginia, North Carolina, South Carolina, Georgia, Mississippi, Alabama, Missouri, and Texas. The species, no doubt, occurs in several states not included in the foregoing list.

Figure 1 shows the states in which the pear borer has been recorded, and Figure 2 shows the counties and localities in Virginia from which it was collected while these studies were being made. Figure 2, therefore, is by no means complete for Virginia.

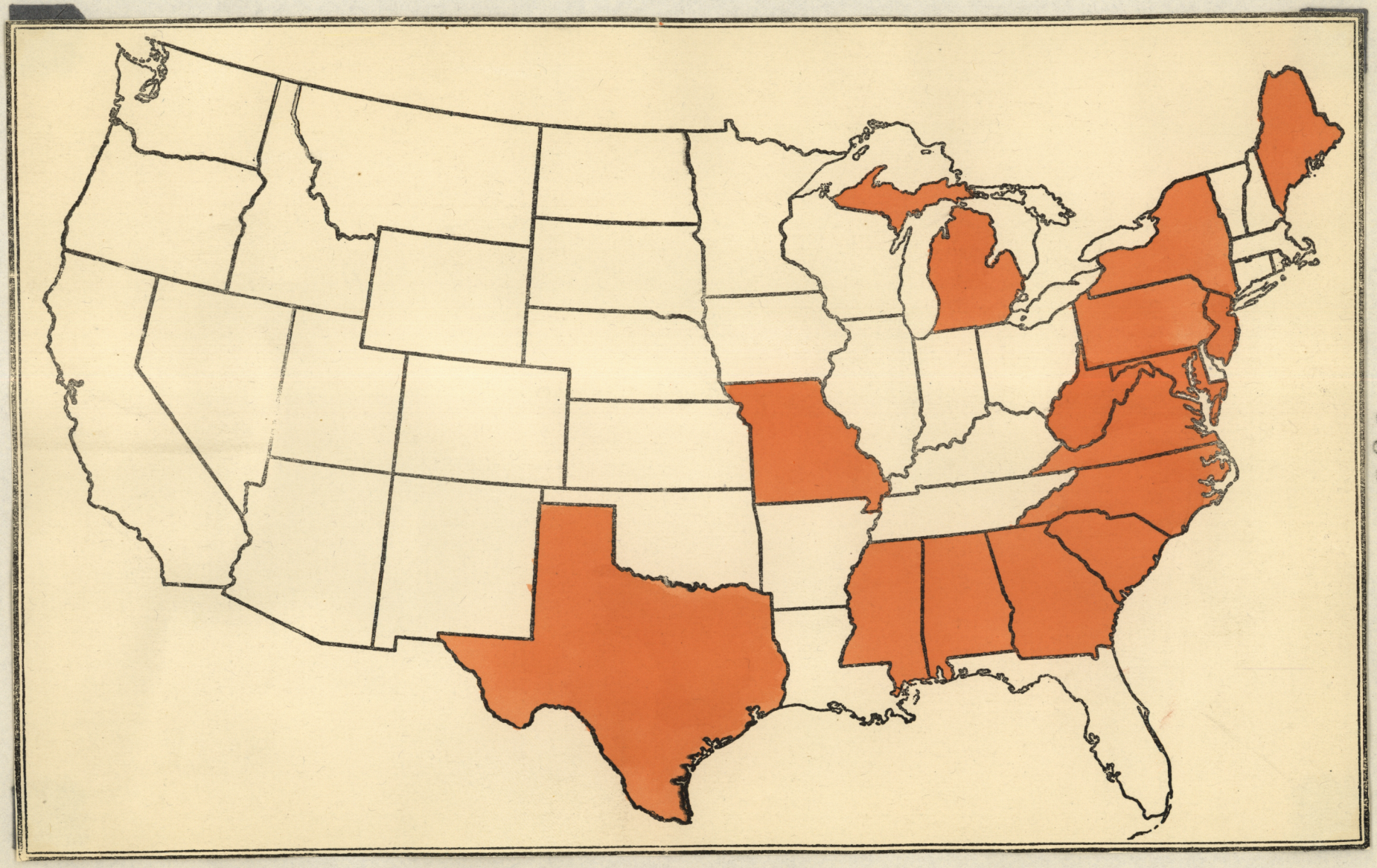


Figure 1.—Map showing the known distribution of the pear borer in the United States

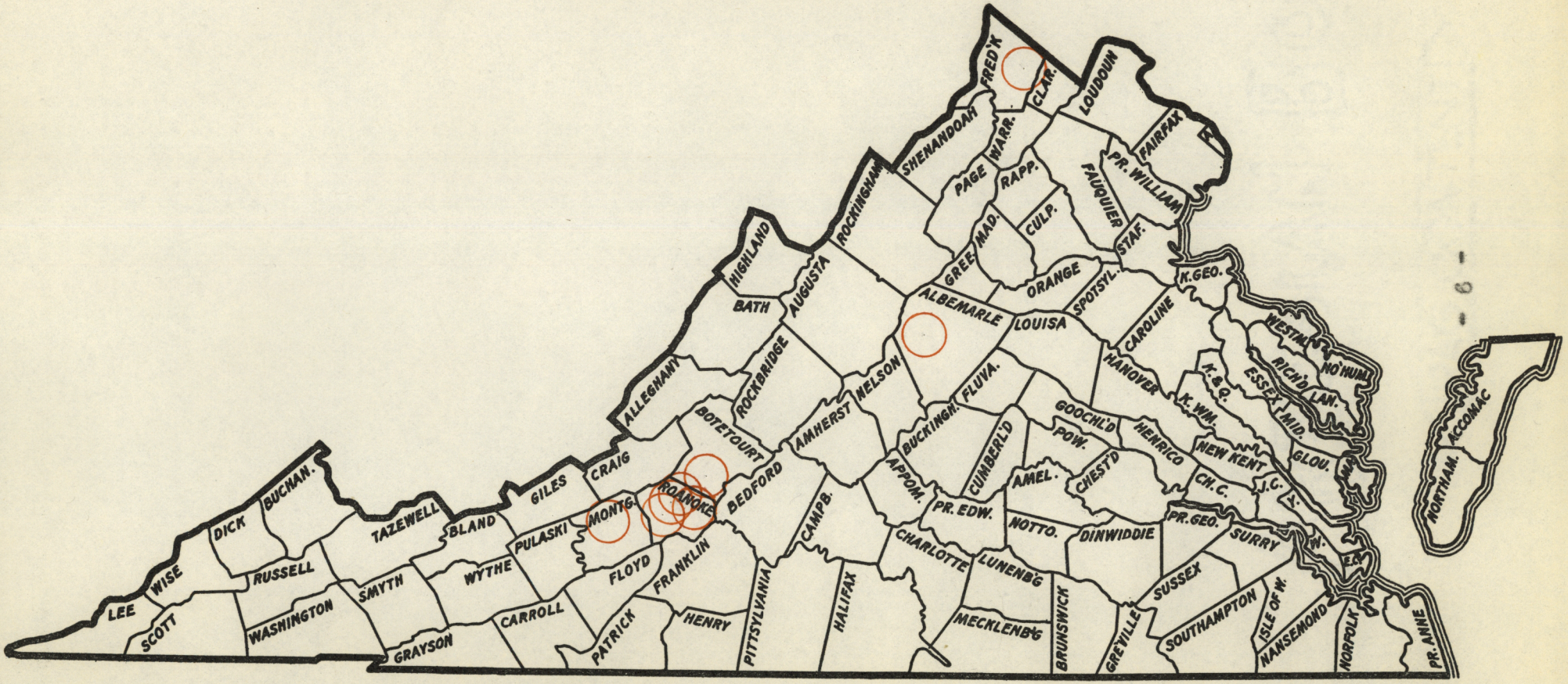


Figure 2.—Map showing the counties and localities in Virginia where the pear borer was taken in 1933 and 1934 (Not complete)

METHODS AND MATERIALS

Studying the larval stages of the borer was difficult because the larvae remain hidden in the bark of the tree from the time the eggs hatch until the moths emerge. Many methods were tried in order to watch the development of the larvae throughout the year but none of these were successful. One method was satisfactory, however, in obtaining the length of the pupal period. Nearly mature larvae were embedded between the bark and sapwood of thin strips of apple wood. Two strips with a piece of cotton between them to hold moisture were put between glass plates and a rubber band was put around them to hold the plates in contact with the wood. The strips were just thick enough to allow the borer to work between the glass and always be in sight. The container was then slipped into a black paper envelope to exclude the light and to make it resemble the natural surroundings of the borer. Each day the plates were examined and the date of pupation and the date of moth emergence were recorded. Figure 3 is a picture of this apparatus.

Larvae were embedded in the trunks of apple trees throughout the year at Blacksburg in order to obtain the length of the life cycle but this was not entirely satisfactory. The main data relied upon for this information were obtained in the orchard at Hollins, Many borers were cut out of the trees

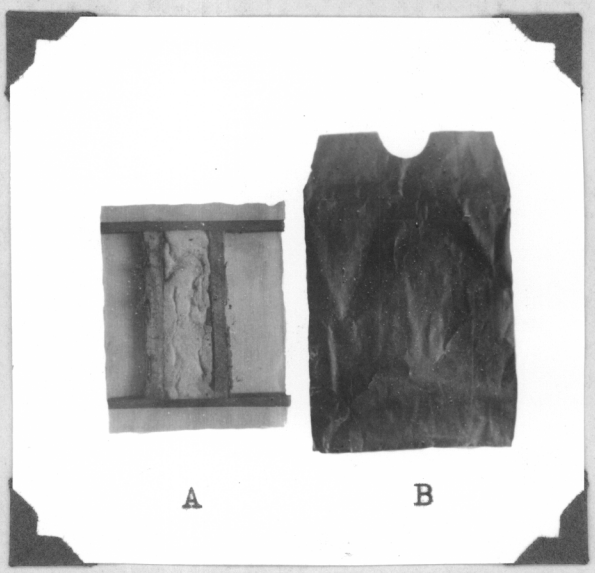


Figure 3.--Apparatus used in obtaining the length of the pupal period of the pear borer. A, glass plates containing thin strips of apple wood with cotton between them; B, black paper envelope

each week during 1934. Approximately 80 percent of the borers which were in the tree in the spring emerged as moths during May and June, and about 5 percent emerged during the remainder of the year. This would mean that only 15 percent remained in the tree over two winters, thus having a two-year life cycle.

Bait-pails were used in obtaining records on moth emergence. These pails consisted of quart fruit jars suspended from the limbs of apple trees, usually in the upper third of the tree. The jars were filled with sorghum molasses diluted with water at the rate of one part to twenty parts of water.

The pails were examined twice each week, usually on Tuesday and Friday, and the number of moths was recorded.

Studies on the control of this insect by spraying trees containing larvae were made. The number of borers in each tree were counted and then the trees were sprayed. On examining the trees several weeks later more live borers were present than at the time of the treatment. This was due to eggs being laid on the trees after the spray was applied. These records, therefore, had to be disregarded. It was then decided to mark the location of each borer present in the tree before it was sprayed. A small nail with a large paper head was driven about two inches above each borer so that they could be located easily. This method was used in all control experiments during 1934 and proved very satisfactory.

LIFE HISTORY

The pear borer passes through four stages of development; namely, egg, larva or borer, pupa, and adult. The egg is laid in cracks and under loose scales of bark by the female. The egg hatches into a minute, dirty-white borer, which feeds on the inner bark and cambium of the trees. The insect passes the winter in a hibernaculum. On completing its growth in the spring or summer, it becomes sluggish and transforms into the inactive pupal stage. In this stage no food is eaten and a wonderful change in appearance takes place. From the pupa emerges the active adult moth.

The Egg

Description.—The eggs are light brown in color when first deposited, but gradually change to a chestnut brown before hatching. After the egg hatches, the shell remains a light tan or approximately the same color as when the egg was first deposited. The egg shell is very hard and it is difficult to puncture it with a needle. The eggs are oval, slightly flattened on one end, glossy, and finely sculptured. The average size of each egg is 0.59 mm. long, 0.38 mm. wide, and 0.21 mm. thick. Figure 4.

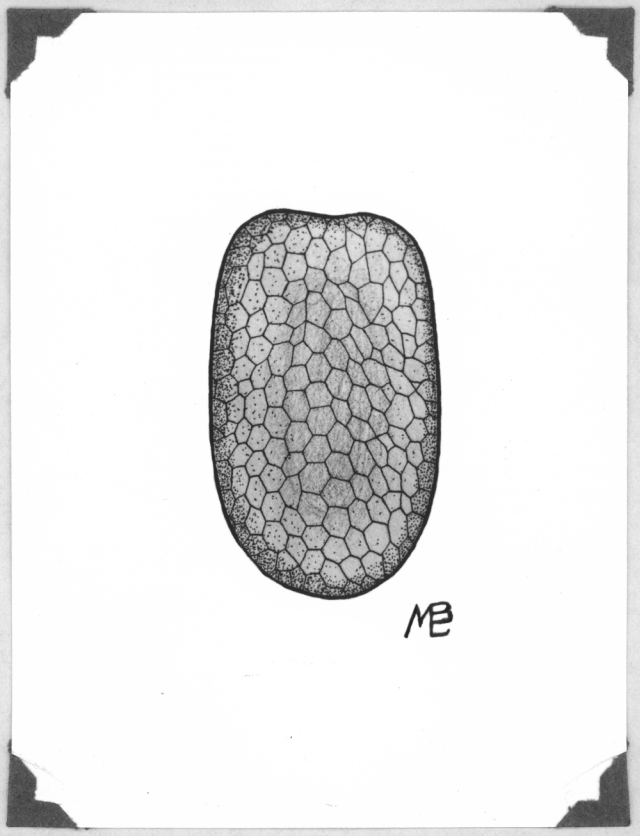


Figure 4.—Egg of the pear borer enlarged

Hundreds of female pear borers were cut open and the unlaid eggs were examined. All sizes of eggs were found. Some were very small, round, white, and soft; a few were the same size as mature eggs but were pearly white; and the others had turned brown and could not be told from the deposited eggs. The abdomen was filled with eggs.

Incubation period.—Many attempts were made to induce females to deposit eggs in the laboratory, but only one egg was secured and this one did not hatch. Several eggs, how-

ever, were collected in the orchard and brought back to the laboratory to await hatching. The incubation period ranged from 4 to 7 days with an average of 5.6 days at an average temperature of 76.2 degrees F., as may be seen in Table 1. No definite conclusions can be drawn from so few eggs, but it will at least show the approximate duration of the egg stage.

Table 1.—Incubation period of pear borer eggs collected in the orchard

Date deposited	Date hatched	Incubation period	Average temperature
June 19	June 23	7 days	74.1
June 19	June 25	6 days	74.9
June 22	June 28	6 days	77.2
June 23	June 28	4 days	77.6
June 28	July 5	5 days	77.3
Average		5.6 days	76.2 F.

The Larva

Description.—The body of the larva is dirty-white in color. The food in the intestine can be seen and this causes the larva to appear to have a dark brown stripe down the center of the back. The head is brown but shades into black at the tips of the mandibles. Segments 1 to 10 are

of a uniform width, but segments 11 to 13 taper to a blunt point. The body is clothed with numerous setae. Several setae are located on the head and eight setae are on the anal plate. There are nine pair of oval, brownish spiracles which are located on the first thoracic segment and on the first eight abdominal segments. The larva has three pair of true legs on the three thoracic segments, and five pair of sucker feet, or prolegs, on abdominal segments three, four, five, six, and thirteen. There is a double row of hooks on the first four pair of prolegs, but on the anal pair there is only one row. The hooks are variable in number on the five pair of sucker feet. There are more hooks present in the anterior row than in the posterior row of each proleg, and the total number of hooks on the pairs of prolegs decrease in number from the anterior pair to the posterior pair. The larva is shown in Figure 5.

The larvae feed mainly on the inner bark and cambium, but in young trees where the bark is thin they will burrow slightly into the sapwood. The burrows are usually several inches long and have a central chamber with lateral tunnels leading off in several directions as shown in Figure 6.

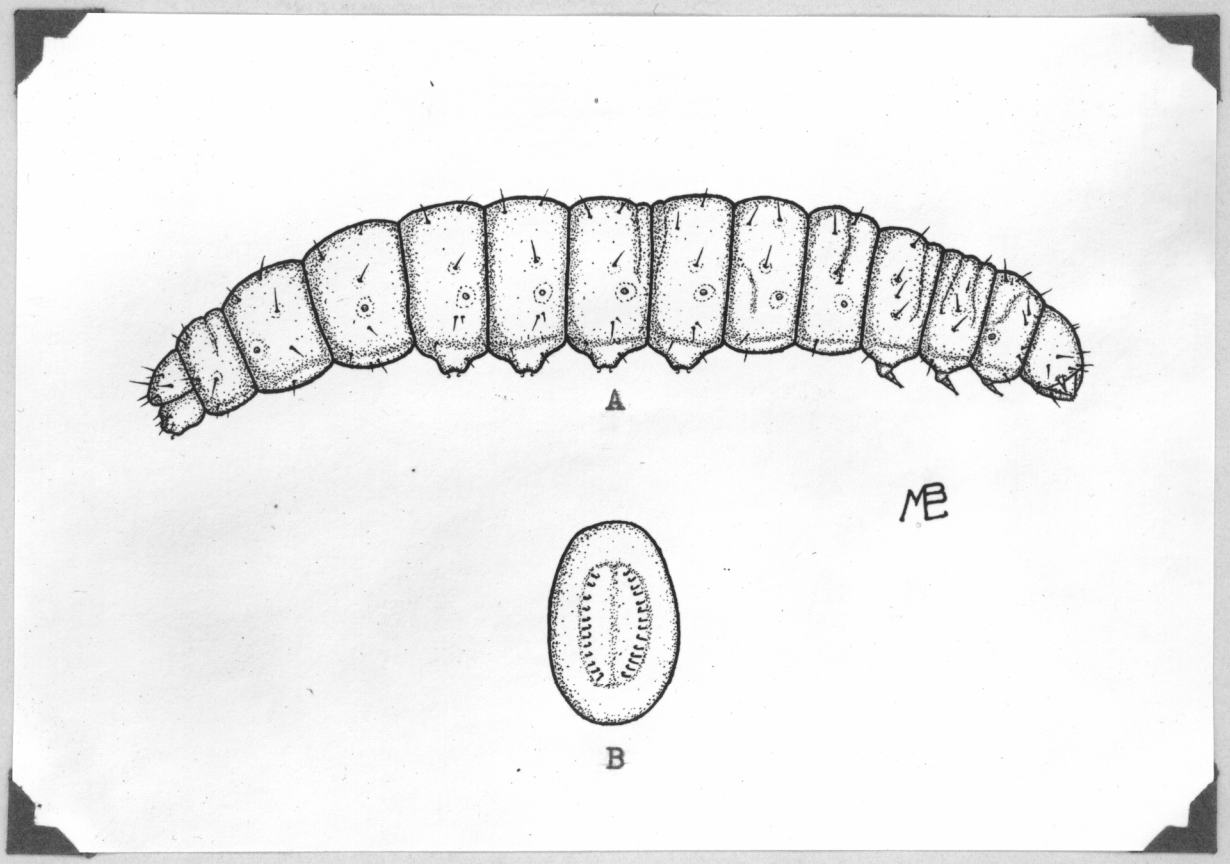


Figure 5.—The larva enlarged. A, lateral view of the larva; B, ventral view of a proleg showing the hooks

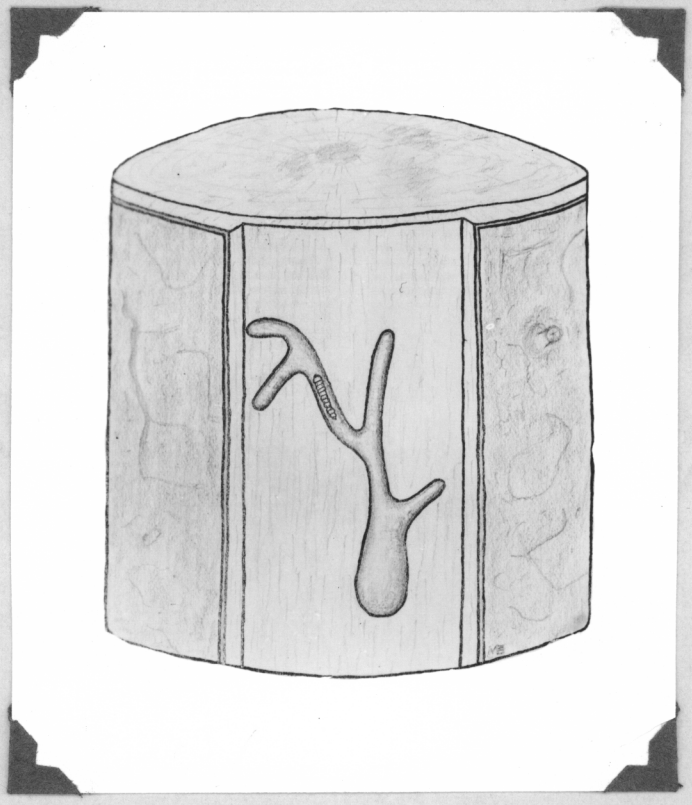


Figure 6.—Typical tunnel showing central chamber with lateral branches running off in several directions. The tunnel is made in the cambium

Larval stages.—The growth of an insect occurs exclusively during the larval period, and the molts occurring during the growing period divide the larval stage into a number of sharply separated sizes. The cuticle is hard and growth inside this inexpansible shell cannot be regular and continuous. In order to make any appreciable increase in size the shell must be cast off.

There are six larval stages as shown by measurements of the head capsule in Table 2.

Table 2.—Measurements of larval stages of the pear borer

Stage	Average width	Average length	Average width of head capsule	Number of measurements
1	--------	1.0 mm.	0.27 mm.	1
2	0.69 mm.	3.5 mm.	0.62 mm.	3
3	1.14 mm.	6.0 mm.	0.97 mm.	2
4	1.72 mm.	8.7 mm.	1.31 mm.	10
5	2.25 mm.	10.0 mm.	1.66 mm.	50
6	2.96 mm.	13.4 mm.	2.00 mm.	26

Habits and cannibalistic tendencies.—On June 19, 1933, many larvae of all sizes were collected in the orchard and were put in one large container with bark. On examining the larvae several days later only about half of them could be found. The larger larvae had devoured the smaller larvae leaving only the head capsules. This cannibalistic tendency also exists in the orchard.

Length of larval stage.—The borers may have either a one-year or a two-year life cycle, but in Virginia about 85 percent of them seem to have a one-year life cycle. Allowing 4 to 7 days in the egg stage, 3 to 4 days in the prepupa stage, and 14 to 21 days in the pupa stage, one can see that most of the life cycle is spent in the larval stage.

For those larvae which have a one-year life cycle the larval stage extends over a period of from 11 to 13 months. This period lasts from 20 to 24 months for the larvae having a two-year life cycle.

The larvae stop feeding in the fall when the weather turns cold and spend the winter in a silken hibernaculum. They resume feeding in April and those having a one-year life cycle start pupating about the first of May, although pupae are not plentiful until after the middle of May. Those larvae having a two-year life cycle feed through the summer and pupate the following spring. There are some variations and not all larvae followed this cycle. A few of the eggs that are laid during mid-summer develop into moths by late summer of the following year. Thus, these moths also have a one-year life cycle. The larvae spend the winter in various stages of larval growth.

The Pupa

Prepupal period.—After the larva completes its growth, it constructs a cell of silk and particles of woody material in the old feeding chamber. It then becomes sluggish and robust, and turns pearly-white or cream in color. The abdomen tapers to a blunt point which is quite different from the

true larval stage. The prolegs can hardly be seen. The length is 10.0 mm., and the width is 2.5 mm. at the widest part.

Pupation.--Pupation takes place within an oblong-ovate cocoon formed of and woven together with tough fibers of silk, small particles of frass or woody material. When the larva is ready to pupate the head capsule splits along the top and the newly formed pupa wriggles its way out of the old larval skin. The skin shrivels up behind the head capsule. Figure 7 shows the cocoon of the pear borer.

Description.—The pupa is light brown in color when first formed, but gradually turns to a dark brown or black banded with yellow. It is strongly chitinized, which enables it to resist unfavorable weather and predatory insects. There are seven pair of spiracles located on the sides of the last seven segments of the abdomen, omitting the anal segment. Each segment of the abdomen, except the last, bears two rows of transverse spines on the dorsal side. The spines of the anterior row are much larger than those of the posterior row, except on the next to the last segment, where those of the two rows are the same size. In some specimens, the anal segment contains only one row of eight large spines, which encircles the segment. The two most ventral spines are caudad of the other six. In other specimens, there are many

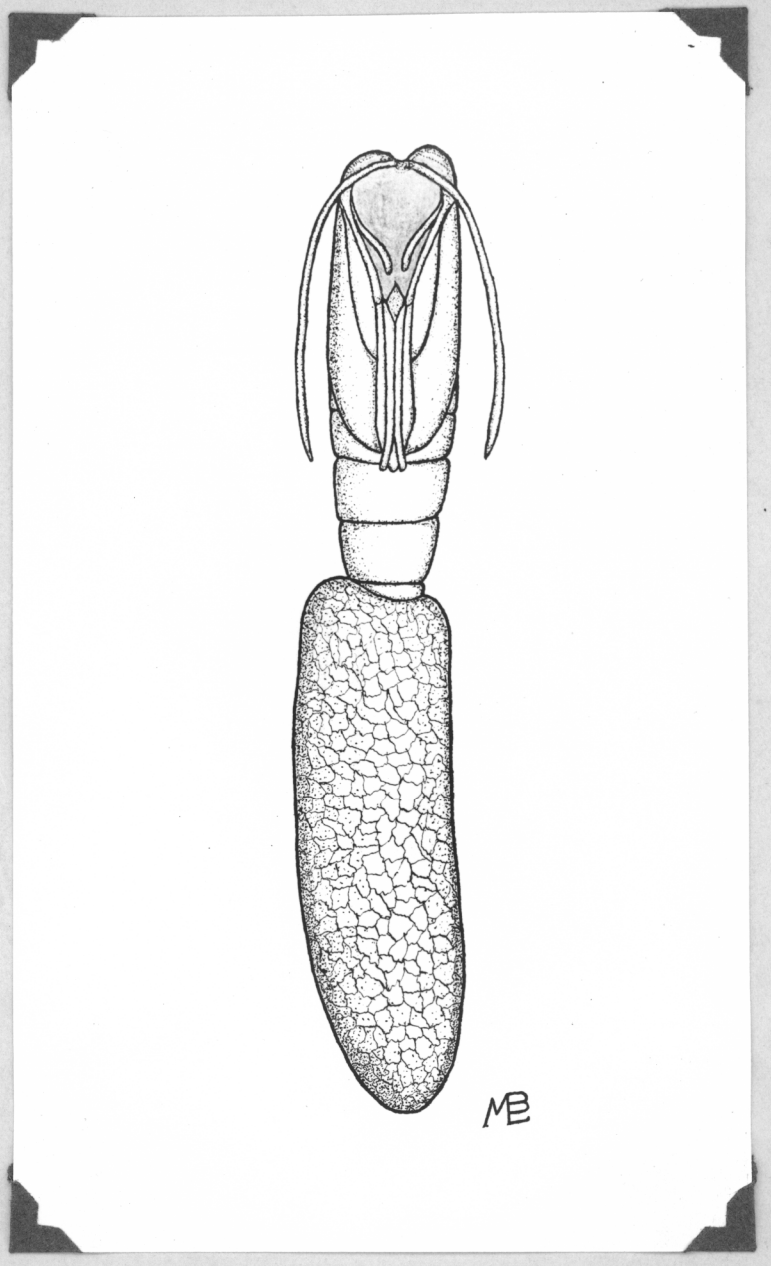
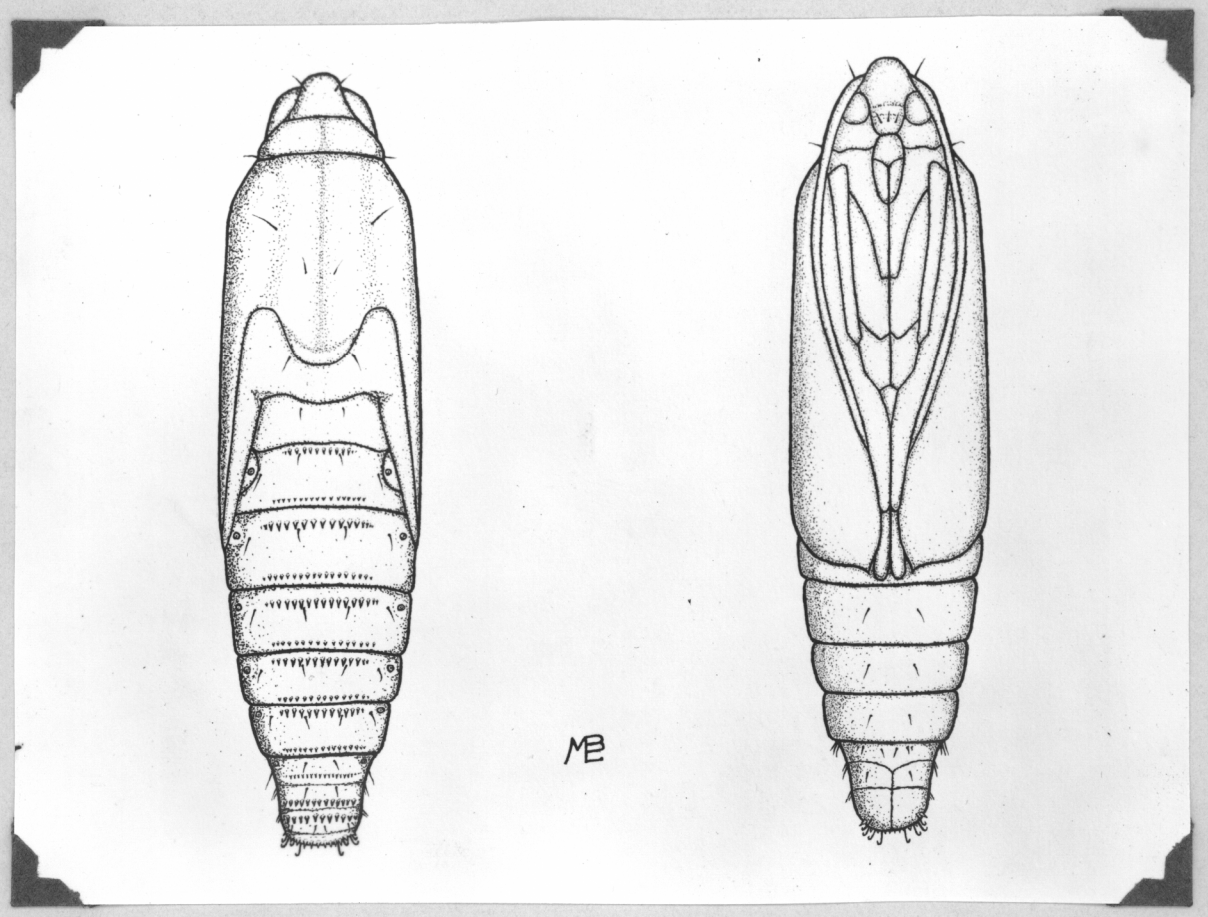


Figure 7.—Cocoon of the pear borer with the empty pupa case projecting

spines on the dorsum of the last segment. Eight long setae, which have a hook at the tip of each, also project from this segment.

All of the appendages are firmly glued down to the body and the abdomen is the only part capable of movement. The pupa is shown in Figure 8. The length is 8.25 mm. and the width is 2.0 mm.



A B

Figure 8.--The pupa enlarged. A, dorsal view; B, ventral view

Length of pupal stage.—The length of the pupal period was approximately the same for specimens of the same sex, but was different for those of the two sexes. The pupal period for the males averaged 23.0 days, and for the females 17.44 days. Table 3.

Table 3.—Length of the pupal stage of the pear borer at Blacksburg, Virginia, 1934

Date pupated	Date emerged	Days in pupal stage	Sex	Mean temperature
May 19	June 11	23	male	66.9
May 19	June 11	23	male	66.9
May 28	June 16	19	female	68.6
May 29	June 17	19	female	69.5
May 30	June 17	18	female	69.7
May 31	June 18	18	female	70.2
June 1	June 18	17	female	70.4
June 1	June 19	18	female	70.4
June 2	June 19	17	female	70.7
June 3	June 21	18	female	71.2
June 4	June 17	13	female	71.0

Summary

Average pupal period for female ..... 17.44 days

Average pupal period for male ..... 23.0 days

The Adult

A short time before the moth was ready to emerge the pupa wriggled its way out of an exit hole in the bark by means of the spines on the body until only the tip of the abdomen remained in the bark. The pupa skin then cracked along the head and thorax and the moth crawled out on the bark of the tree and remained quiet until the wings had expanded and the body of the moth had hardened. Figure 9 is a picture of the cast skins projecting from the bark after the moths had emerged.

Figure 9.—Cast pupa skins projecting from the bark of an apple tree

Description.—The pear borer is a small, clear-winged moth measuring 7 to 11 mm. in length and 12 to 17 mm. across the wings. The general color is purplish-black with a metallic luster. There are three bands of yellow scales around the abdomen which merge into a solid yellow strip on the ventral side. In some specimens, the middle band of yellow scales is absent. The abdomen terminates in an anal tuft, which is black in the male and black with yellow on each side in the female. The eyes are jet black and are surrounded by white scales. There are two ocelli located on the front between the compound eyes. The palpi are pale yellow below and blue-black, sprinkled with yellow scales, above. The antennae are filiform and slightly thickened towards the tips. In the male, they are black, but in the female they are black with yellow at the tips. The first pair of legs has the femur yellow and the tibia and tarsi black, and the second and third pair of legs have the femur black and the tibia and tarsi yellow. The second pair of legs has one pair of tibial spurs, and the third pair of legs has two pairs of tibial spurs. The tarsi are five-jointed, and are armed with many small spines. Two claws are located at the tip of the last joint of each tarsus. The wings are long and narrow, and fringed with long, black hairs. The margins and veins are covered with blue-black scales. The hind wings have a long hair-like frenulum.

The moths bear a remarkable resemblance to bees and wasps, owing to the transparency of their wings and to their close resemblance in color patterns. The moths are active on wing and fly by day, preferring the hottest sunshine. They are inconspicuous and are not often observed. Figure 10.

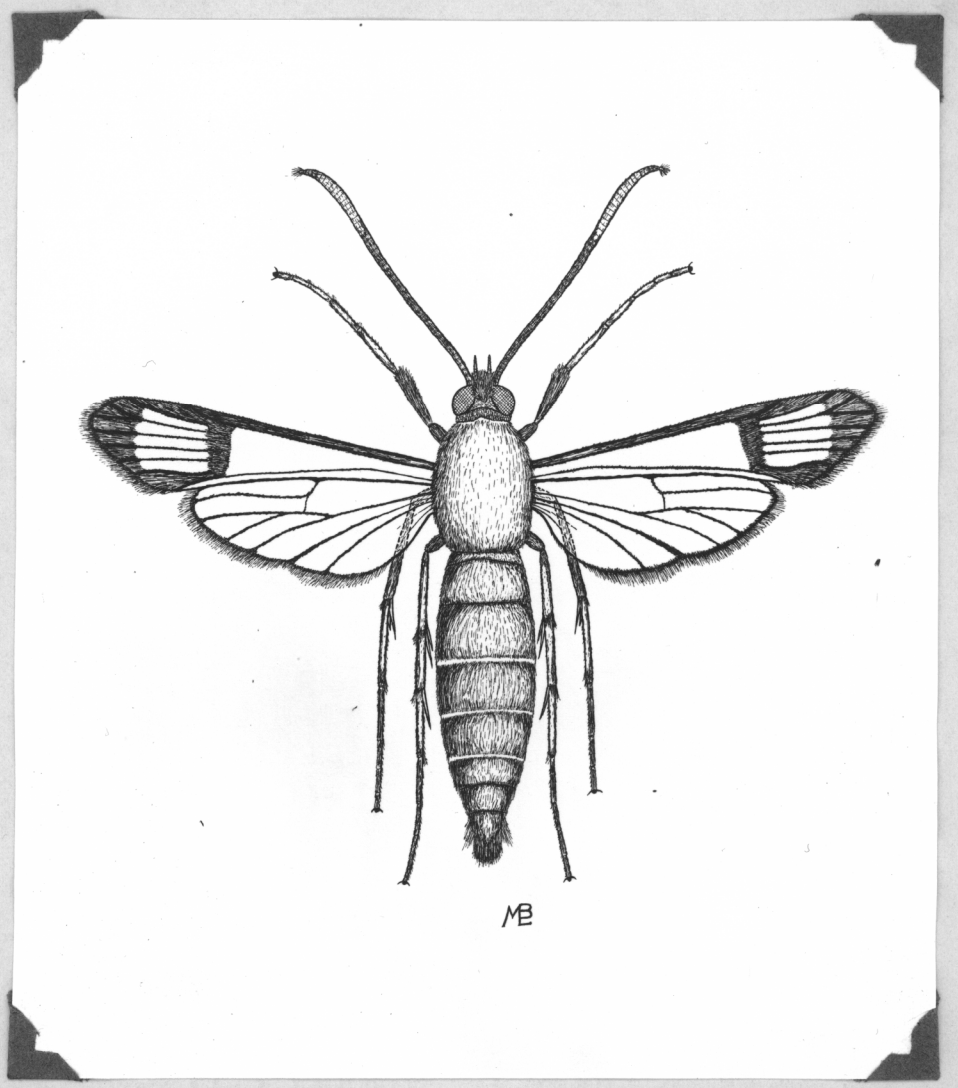


Figure 10.—Female moth enlarged

Oviposition

Method.—If the observer is careful, he will be able to get within several inches of the ovipositing female, but any sharp or quick movement frightens the moth and it will dart out of sight. They are able to move very rapidly and it is useless to try to follow them. The writer has been able to get close enough to the moth to observe her through a hand lens while ovipositing.

On approaching a tree the female moth flies around the trunk or larger branches of the tree with the antennae brushing the bark until a favorable spot for ovipositing is found. This spot is not necessarily the roughest, for most of the moths select a slightly roughened area with small cracks and crevices. They seldom deposit their eggs on loose hanging bark. As soon as the female moth alights, she extends her rear legs straight backwards and moves the abdomen back and forth as she walks along over the bark. The ovipositor is inserted in many cracks and under scales of bark before the egg is deposited. When a suitable crevice is located the ovipositor is inserted, and the female remains very still for a few seconds while the egg is being deposited.

After laying an egg, the female usually takes to the wing, but frequently returns to the same location after fly-

ing around the tree. Only one egg is deposited at a time, but frequent visits to the same area accounts for the eggs being bunched together. After several eggs are deposited, the female seems to become tired and may alight on a leaf or on the bark and remain there for five or ten minutes before ovipositing again.

Time of day.—The moths were active from 10:00 a. m. to 5:00 p. m. on warm days, but were most active between 2:00 and 4:00 p. m. during which time most of the eggs were deposited. Few or no moths were seen flying around the trees on cool or rainy days.

Distinguishing the Sexes

The female had a much larger abdomen than the male; the upper half of the antennae were yellow at the tip; and there was more yellow under the abdomen, a yellow band covering one complete segment. One stripe on the abdomen of the female emerged into a wide band of yellow on the ventral side and continued to the anal tuft. The anal tuft had a bunch of yellow hairs on each side.

The antennae of the male were wholly black, and the abdomen was long and slender.

Length of Life

Cotton saturated in sugar water was added to the cages containing the moths to provide food. The length of the life of the males was from two to ten days and averaged 4.46 days. Table 4.

The length of the life of the females was from one to twelve days and averaged 4.96 days. Table 5.

Table 4.—Length of life of male pear borers kept in cages in laboratory at Blacksburg, Virginia, 1934

Number moths	Date emerged	Date died	Number days	Mean temperature
1	May 30	June 9	10	69.1
2	June 11	June 16	5	69.8
1	June 12	June 16	4	69.0
1	June 13	June 16	3	68.4
1	June 14	June 18	4	70.5
1	June 14	June 19	5	70.6
1	June 14	June 17	3	70.1
2	June 16	June 19	3	72.5
2	June 16	June 22	6	73.1
1	June 18	June 22	4	73.0
1	June 22	June 24	2	76.5
13	Average		4.46 days	71.1 F.

Table 5.—Length of life of female pear borers kept in cages in laboratory at Blacksburg, Virginia, 1934

Number moths	Date emerged	Date died	Number days	Mean temperature
3	May 26	June 7	12	60.3
1	June 10	June 16	6	70.1
2	June 13	June 16	3	68.4
2	June 14	June 17	3	70.1
1	June 14	June 21	7	71.3
2	June 15	June 19	4	72.0
1	June 16	June 21	5	72.8
2	June 16	June 22	6	73.1
1	June 17	June 22	5	73.1
1	June 17	June 21	4	72.8
1	June 18	June 19	1	71.5
1	June 18	June 22	4	73.0
2	June 19	June 23	4	74.1
1	June 20	June 24	4	75.2
2	June 21	June 24	3	75.5
1	June 21	June 25	4	75.9
1	June 22	June 24	2	76.3
25	Average		4.96 days	72.1 F.

Injury

Observations of injury were made on several different varieties of apples but mainly on the York variety at the Andrews orchard. The trees were 40 years old, and were very large. The descriptions and the degrees of injury contained in the following pages were confined to these large trees.

The larvae were found feeding everywhere in the bark of the tree except in the smaller limbs. Their work was

marked by the exuding of frass and by the oozing of reddish-brown drops of liquid from the wounds.

Certain areas in the orchard were badly infested while few borers were found in other sections of the orchard. This was partly due to the fact that the continuous working of the larvae year after year in the same trees caused the bark to become roughened furnishing an ideal place for the moths to deposit their eggs and for the larvae to work. The majority of the borers were located in the crotches and on the trunks of the trees, but a few were found in and around pruning scars and injured areas on the larger limbs. Trees that were badly infested had rough bark and looked as though they had been neglected. In the Andrews orchard at Hollins it was not unusual to find 50 to 100 or more borers in a single tree. The injury caused by a few borers would be negligible, but with 100 borers per tree treatment of some kind is necessary in order to keep the trees in a vigorous and healthy condition.

Young trees are not generally attacked by the pear borer, but old trees are often so severely injured that their vitality is lowered and their resistance to other insects and diseases is reduced to such an extent that some secondary pest completes the destruction of the tree.

The injury to the trees was caused by the larvae feeding in the cambium of the trunks and larger limbs and in and

around pruning scars. The latter was the more important type of injury as the borers working around the scars kept the wounds from healing and left them in such a condition that disease could easily get started. Figure 11 is a picture of the larva feeding in the cambium of an apple tree.

Figure 11.--Burrow opened to show larva feeding in the cambium of the trunk of an apple tree

The larvae made tunnels in the cambium, and where the bark was thin these tunnels sometimes extended into the sapwood. The tunnels were usually 1.5 to 4 inches long with branch tunnels running off in several directions. The burrows were provided with an outlet, which was used for throwing out frass or waste material and also as an exit hole for the pupa just before the moth emerged.

The moths often deposited eggs around the burrows of other species of borers and in trees damaged by winter injury. The borers were not able to live in dead trees; and when the tree died, the larvae present in it perished. In Figure 12 are pictures of injured apple trees which show the roughened bark and unhealed pruning scars.

Food Plants

The most important food plants of the pear borer are the pear and apple, but the apple is by far the most important in Virginia. Brooks (1) reports the pear borer attacking Juneberry (Amelanchier canadensis) and thorn (Crataegus sp.) and has observed it in black knots caused by Plowrightia morbosa on wild and cultivated cherry (Prunus sp.). Smith (3) records mountain ash (Sorbus americana) also as a host plant.

A B

Figure 12.—Trees showing the work of the pear borer larvae. Note the work of the larva around the pruning scars in B

BAIT-PAIL STUDIES

The bait-pail studies provided a valuable source of information as to the emergence of moths, the percentage of eggs deposited before the moths were captured, and the proportion of sexes. The bait-pails which were suspended from the limbs of the trees by means of a wire hook consisted of quart fruit jars containing sorghum syrup diluted with water at the rate of one part of the syrup to twenty parts of water. A wire screen with quarter-inch mesh was placed over the top of the jar to keep out large insects. Figure 13 shows a pail suspended in the top of a large apple tree.

In 1933, bi-weekly records were kept on the capture of pear borer adults in bait-pails used in connection with codling moth (Carpocapsa pomonella L.) and oriental fruit moth (Grapholitha molesta Busck) studies in the Crumpacker orchard at Bonsack and in the Nininger orchard at Cloverdale.

Bait-pails were put up in five orchards in 1934, the Markley orchard at Salem, the Crumpacker orchard at Bonsack, the Layman and the Nininger orchards at Cloverdale, and the Andrews orchard at Hollins; and bi-weekly records kept on the emergence of moths. The records for these orchards during 1933 and 1934 are shown in Figures 14 and 15.

Figure 13.—Bait-pail in the top of an apple tree in the Andrews orchard

Five of the bait-pails in the Andrews orchard were arranged in three series as follows: one pail in the extreme top of the tree (24 feet from the ground), two pails in the middle of the tree (12 feet from the ground), and two pails on the lowest limbs of the tree (4 feet from the ground). This was done in order to obtain some information as to the height of the flight of the moths. Table 6 gives the catch

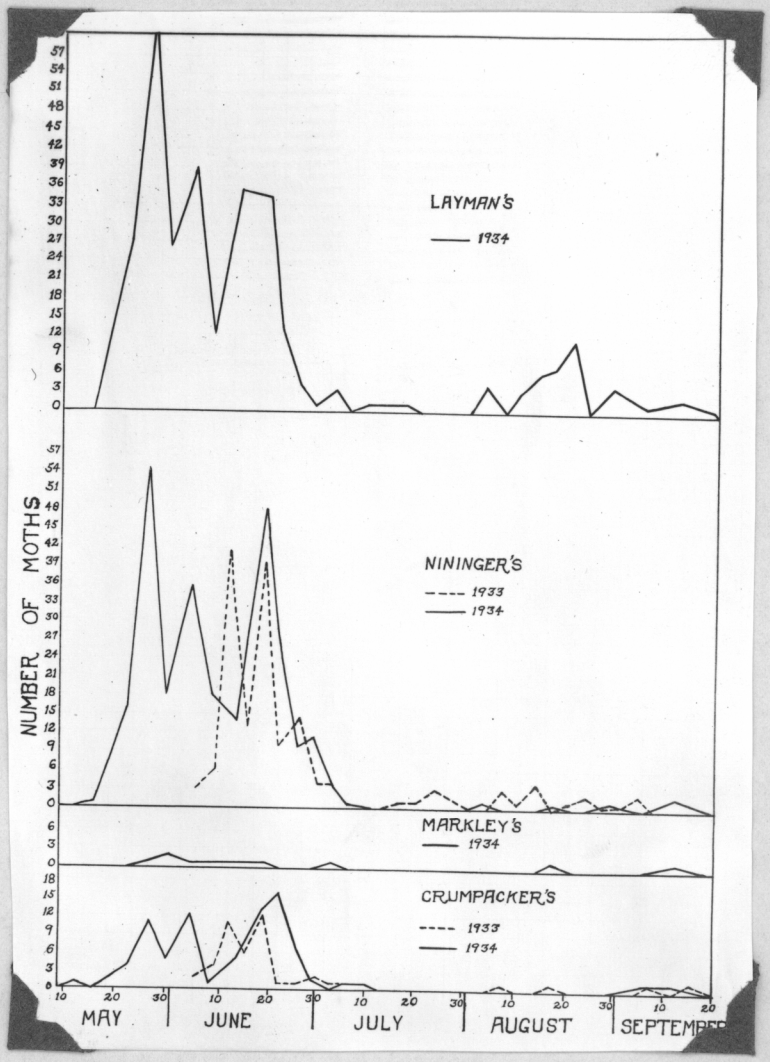


Figure 14.—Emergence of pear borer moths during 1933 and 1934 as shown by bait-pail catches

of moths for each series of bait-pails. Almost twice as many moths were caught in the pails that were placed from 12 to 24 feet above the ground as in those 4 feet above the ground.

Total moth emergence, temperature, and precipitation for the Andrews orchard are shown by graph in Figure 15.

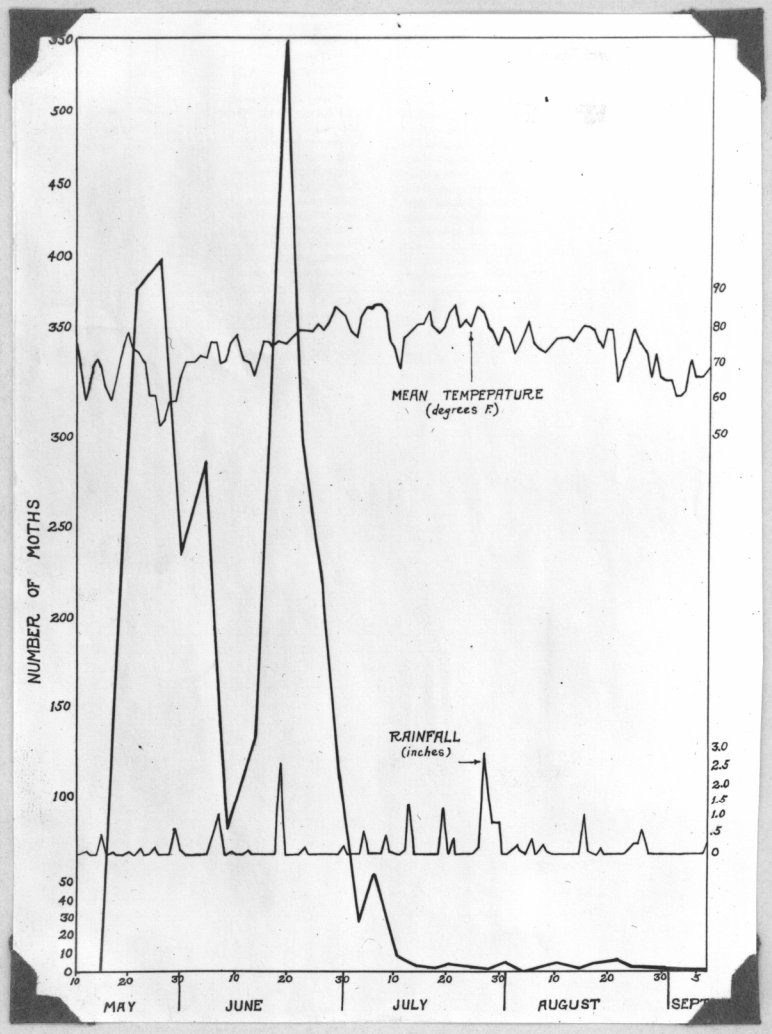


Figure 15.--Total catch of pear borer moths trapped in bait-pails in the Andrews orchard, Hollins, Virginia, 1934

This shows that 99 percent of the moths emerged between May 15 and July 10. Only 5 percent of the moths that emerged after June 21, however, produced offspring that had a one-year life cycle. The 80 percent which emerged before June 21 and the 5 percent for the remainder of the year gave a total of 85 percent which had a one-year life cycle.

Table 6.—Bait-pail catch in pails in three series at Hollins, Virginia, 1934

Date	Location in tree above ground		
	Series A	Series B	Series C
	Top (24 feet)	Middle (12 feet)	Lowest limbs (4 feet)
May 22	37	63	25
26	45	42	33
30	30	42	16
June 4	76	47	26
8	8	22	2
13	23	24	6
19	75	49	43
22	35	30	15
26	25	30	17
29	14	18	13
July 3	3	4	2
6	5	13	5
10	1	2	1
13	0	0	1
17	0	0	0
20	0	0	0
24	0	0	0
27	0	0	0
31	1	0	1
Aug. 3	0	0	0
7	0	0	0
10	0	1	0
14	1	0	0
17	0	0	0
21	0	0	0
24	0	0	0
29	0	0	0
Sept. 5	0	0	0
12	0	0	0
Total	375	407	206

The first decrease in moth emergence was due to a considerable drop in temperature and partly to a three-day rainy period which prevented the flight of the moths. The other decline in the bait-pail catch was probably due to another three-day rain which amounted to 1.51 inches. On June 19, 2.5 inches of rain fell, but the majority of the moths had emerged and one rainy day did not affect the emergence curve to any great extent.

Proportion of Sexes Taken in Bait-Pails

The moths caught in bait-pails were collected at intervals during each month. Table 7 gives the number and the percent of male and of female pear borers caught when each collection was made. It is very interesting to note that only males were caught in the first collection. No moths were seen in copulation, but evidently they mate very soon after the emergence of the female.

Table 7.—Percentage of male and female pear borers caught during each month in the Andrews orchard at Hollins, Virginia, 1934

Date	Number specimens	Number males	Number females	Percent males	Percent females
May 22	86	86	0	100.00	0.00
May 25	103	97	6	94.18	5.82
May 30	92	85	7	92.39	7.61
June 4	252	165	87	65.48	34.52
June 8	89	55	34	60.66	39.34
June 22	121	105	16	86.78	13.22
July 3	27	12	15	44.45	55.55
July 6	46	22	24	47.83	52.17
Aug. 21	13	9	4	69.24	30.76
Total and average percent	829	636	193	76.72	23.28

Percentage of Eggs Deposited by Females Before Caught

This part of the bait-pail studies was carried out in order to determine what percentage of the eggs were deposited before the moths were trapped in the pails. Specimens taken from the bait-pails were cut open and the number of eggs counted. The number of eggs in the females varied from 16 to 87 with an average of 47.7 eggs per female.

Pear borers reared in the laboratory, which had deposited no eggs, were used to determine the number of eggs the female usually contained. These laboratory specimens

showed a variation from 54 to 93 eggs with an average of 71.2 eggs per female. This shows that the moths had deposited approximately 33.0 percent of their eggs before being caught in the bait-pails.

CONTROL

Natural Enemies

Woodpeckers sometimes open the burrows and eat the larvae, but in the Andrews orchard at Hollins not a single instance was noted during 1933 and 1934. Many of the borers, however, have been removed from the trees in the Markley orchard at Salem by a species of this bird.

A fungus disease has been noted to kill a small number of borers in the Andrews orchard each year. A few of them were drowned in the sap after a rainy period.

Parasites and Predators

A cadelle beetle and larva (Tenebroides corticalis Melsh.) were often found feeding on the pupae and the larvae of the pear borer. A beetle or a larva was frequently found in the cell with a half devoured larva or pupa.

Brooks (1) states that the larvae and the pupae of the pear borer are rather extensively attacked by hymenopterous

parasites. He has reared the following from this host: Microbracon sp., Phaeogenes ater Cress, Lissonota sp., Itoplectis annulipes (Brulle'), Macrocentrus sp., Ephialtes (Prov.), and Tetrastichus sp. In addition to these Stilbopoides seseavora Roh. has been reared from the pear borer.

Cutting out Borers

The borers may be located in the trees by the frass oozing from the tunnel and they may be removed with a sharp hawk-bill knife in the fall or early spring. They work just under the bark and if care is taken in cutting them out, little injury is done to the tree by the operation. In worming the trees the incisions should always be made vertically, if possible, and care should be exercised not to injure or cut any more of the sound wood than is actually necessary in removing or crushing the borers in their burrows.

The writer has noted several times that where nails have been driven in the trees the borers may penetrate the solid wood beside the nail half an inch or more. In such cases it is not advisable to cut out the borer as this would cause considerable injury to the tree.

Tanglefoot

It was thought that with a large emergence of moths, as occurred during the spring of 1934, many of them could be caught by coating the trunks of the trees with tanglefoot. This was done on several trees, but very few moths were caught. The tanglefoot seemed to act as a repellent, as few moths were seen flying about the trees on which the material had been applied. The borers which were in the trees at the time the tanglefoot was applied were not affected in any way and continued to feed. The frass was pushed out through the material.

Bait-Pails

In an orchard heavily infested with pear borers bait-pails would be an economical method of reducing the numbers of this insect. A large percentage of the moths present in the orchard are captured, and laboratory records show that only 33 percent of the eggs have been deposited at the time of their capture. It would be necessary to clean the pails of moths and add syrup once a week during May and June in order to get the maximum catch.

Sprays

The minute borers began feeding on the bark soon after they were hatched. Several insecticides were applied as sprays to the trunks of the trees in an effort to kill the small borers before they penetrated the bark. Table 8 gives the results of these experiments. The trees were examined four weeks after the applications were made. All the arsenicals used gave practically the same results, except calcium arsenate which was the most effective of all arsenicals tried. The percentage killed, however, was not sufficient in any of the cases to warrant the cost of labor and materials used.

Perhaps, more larvae were killed than were recorded as it was practically impossible to locate the minute borers when they were first hatched. Sprays applied in June may prove more effective, but it would be difficult to obtain accurate data on the results.

Washes

Snapp (4) has reported good results from paradichlorobenzene dissolved in crude cottonseed oil for the control of the lesser peach borer (Synanthedon pictipes G. and R.); so experiments with paradichlorobenzene-oil washes applied

Table 8.—Results of experiments with insecticides on pear borer larvae, Hollins, Virginia, 1934

Material	Strength	Applied with	Date applied	Number trees	Number borers	Number dead	Percent dead
Nicotine plus Soap	1-800 ½ lb. to 100 gals.	Sprayer	July 24	3	35	2	5.71
Sodium Arsenate	1 lb. to 50 gals. water	Sprayer	July 27	4	171	6	3.51
Sodium Arsenite	1 lb. to 50 gals. water	Sprayer	July 27	4	116	6	5.17
Calcium Arsenate	1 lb. to 50 gals. water	Sprayer	July 27	4	44	6	13.63
Lead Arsenate	1 lb. to 50 gals. water	Sprayer	July 27	4	90	4	4.44
Sodium Arsenite plus Calcium Arsenate	1 lb. to 50 gals. water	Sprayer	July 27	4	103	2	1.94
Sodium Arsenate plus Calcium Arsenate	1 lb. to 50 gals. water	Sprayer	July 27	4	151	3	1.99
Kerosene emulsion	1 part to 5 parts water	Sprayer	July 27	4	72	4	5.55
Check				4	250	2*	0.80

* - One emerged and one was killed by fungus.

to the trunks and larger limbs of the trees with a paint brush were conducted during 1934. Table 9 gives the results of tests with several washes.

A wash composed of paradichlorobenzene and cottonseed oil gave excellent results, but an emulsion of the two gave only 63 percent kill and was not as effective as cottonseed oil used alone.

Pine tar oil used alone, in combination with paradichlorobenzene, and with paradichlorobenzene and water gave good results, and was equally as good as cottonseed oil.

White mineral oil and paradichlorobenzene gave good results. White mineral oil alone was only 57 percent effective at the end of one week, but was 96 percent effective after three weeks. Red mineral oil was less effective in combination with paradichlorobenzene than white mineral oil.

Paradichlorobenzene dissolved in kerosene oil was quite effective on the larvae, but the outer tissues of the tree were slightly injured. This was not serious enough, however, to injure the growth of the tree.

Some of the trees on which these washes were applied had been scraped while others had not. The percentage of kill was approximately the same for scraped trees as for unscraped trees, and it would not be advisable to spend the time scraping the trees before the materials are applied. The washes were much easier to apply and less material was used, however, on the scraped trees.

Table 9.—Results of experiments with paradichlorobenzene dissolved in various oils, and with oils used alone for the control of the pear borer, Hollins, Virginia, 1934

Materials	Strength	Applied with	Date applied	Number trees	1 week		2 weeks		3 weeks		4 weeks		8 weeks	
					Total larvae	Percent dead	Total larvae	Percent dead	Total larvae	Percent dead	Total larvae	Percent dead	Total larvae	Percent dead
Pine tar oil	Straight	Paint brush	April 21	2	--	-----	--	-----	--	-----	--	-----	28	82.14
Pine tar oil Paradichlorobenzene	2 quarts 1 pound	Paint brush	April 21	1	--	-----	--	-----	--	-----	--	-----	10	90.00
Pine tar oil Paradichlorobenzene Water	2 quarts 1 pound 1 quart	Paint brush	April 21	2	--	-----	--	-----	--	-----	--	-----	22	95.45
Red mineral oil Paradichlorobenzene	2 quarts 1 pound	Paint brush	April 22	2	--	-----	--	-----	--	-----	--	-----	8	75.00
Cottonseed oil Paradichlorobenzene	2 quarts 1 pound	Paint brush	June 22	2	--	-----	--	-----	--	-----	--	-----	31	96.77
Cottonseed oil Paradichlorobenzene	2 quarts 1 pound	Paint brush	July 20	7	--	-----	--	-----	--	-----	21	95.24	--	-----
Cottonseed oil Paradichlorobenzene	2 quarts 1 pound	Paint brush	August 29	2	--	-----	14	92.86	10	90.00	--	-----	--	-----
Cottonseed oil Paradichlorobenzene Water	2 quarts 1 pound 7 gallons	Sprayer	July 24	4	--	-----	--	-----	--	-----	30	83.33	--	-----
Cottonseed oil	Straight	Paint brush	July 20	3	--	-----	--	-----	--	-----	17	76.47	--	-----
Cottonseed oil	Straight	Paint brush	August 29	2	--	-----	17	70.59	18	55.55	--	-----	--	-----
Kerosene Paradichlorobenzene	2 quarts 1 pound	Paint brush	August 29	2	--	-----	28	89.29	--	-----	--	-----	--	-----
White oil Paradichlorobenzene	2 quarts 1 pound	Paint brush	September 12	2	13	84.61	--	-----	69	92.75	--	-----	--	-----
White oil	Straight	Paint brush	September 12	2	7	57.14	--	-----	27	96.29	--	-----	--	-----

Recommendations

The following recommendations are suggested as a result of work on the control of the pear borer:

In late August or September, apply a wash of paradichlorobenzene and cottonseed oil to the borer infested areas on the trunks and larger limbs of the trees using a paint brush. It is not essential to remove the frass and loose bark before the application is made, but the practice will save much time and materials. The following proportions should be used:-

Cottonseed oil ..... 2 quarts

Paradichlorobenzene ..... 1 pound

If desired, the material may be applied between May 1 and May 15; but usually the orchardists are busy at this time of the year, and, for this reason, it would be better to make the application in the fall of the year.

White mineral oil or pine tar oil may be substituted for the cottonseed oil with practically as good results. The material to use depends upon the price and the availability of the material.

Use bait-pails from May 15 to July 15 as a supplementary control measure to the paradichlorobenzene and cottonseed oil treatment in the fall. Hang the pails in the upper third of the trees.

DISCUSSION

Borers that had just hatched could not be located in the tree; and, as a result, no accurate measurements were made of the head capsule during the first stadium. The method used by Dyar (2) in calculating head capsule measurements during a stadium was used in obtaining the width of the head capsule during the first stadium.

The writer has not been able to determine the difference between the male and the female pear borer pupa. It is known, however, that some difference exists between them. One difference occurs in the arrangement of the spines and setae on the last segment of the abdomen. This difference has been noted in many specimens, but it has not been possible to determine definitely which group of characters belongs to the male and which group belongs to the female pupa.

SUMMARY

1. The pear borer is widely distributed in the eastern part of this country.
2. The abdominal cavity of the female was filled with eggs.
3. The incubation period of the eggs averaged 5.6 days at a mean temperature of 76.2 degrees F.
4. The larvae fed mainly on the inner bark and cambium of the trees, but occasionally burrowed slightly into the sapwood.
5. There were six larval stages.
6. Larger larvae devoured smaller larvae on contact with them.
7. Around 85 percent of the borers have a one-year life cycle.
8. The winter was passed by the larva in a silken hibernaculum constructed in the burrow.
9. The pupa was strongly chitinized, and the abdomen was armed with large spines.
10. The pupal stage averaged 23.0 days for the males and 17.44 days for the females.
11. The moths were most active and most of the eggs were deposited between 2:00 and 4:00 p. m.
12. On the female moth there was more yellow than on the male.

13. The average length of life for the males was 4.46 days and for the females 4.96 days.

14. In the Andrews orchard 50 to 100 borers per tree were not unusual.

15. The apple is the main host plant of the larvae in Virginia.

16. About 99 percent of the moths emerged between May 15 and July 10.

17. The male moths emerged several days before the female.

18. The females had deposited 33 percent of their eggs when they were captured in the bait-pails.

19. The pear borer is sometimes rather extensively attacked by hymenopterous parasites.

20. The borers may be removed with a sharp hawk-bill knife in the fall or early spring.

21. In heavily infested orchards, bait-pails would be economical and quite effective in reducing the number of moths present in the orchard during May and June.

22. The common insecticidal sprays are not effective in killing the larvae.

23. Paradichlorobenzene dissolved in cottonseed oil, white mineral oil, and pine tar oil and applied to the trunks and larger limbs of the trees with a paint brush gave excellent results without injury to the tree.

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