TB 854 (1948) USDA TECHNICAL BULLETINS UPDATA

LIFE HISTORY AND HABITS OF THE PEACHTREE BORER IN THE SOUTHEASTERN STATES

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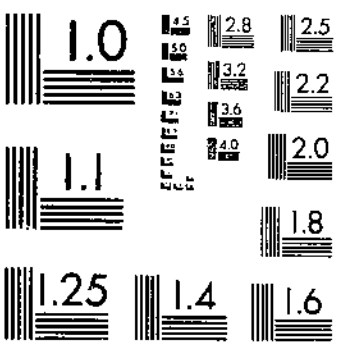

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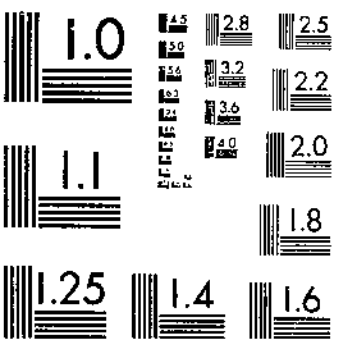

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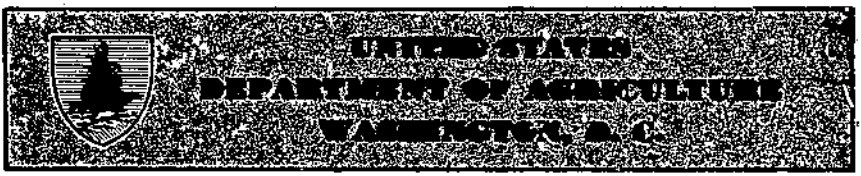
Technical Bulletin No. 854 • November 1943



Life History and Habits of the Peachtree Borer in the Southeastern States[1]

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SUMMARY

Investigations of the life history and habits of the peachtree borer in the Georgia peach belt were conducted during the years 1930 to 1938, inclusive, as an aid in timing applications for control. The methods followed and the data obtained are presented in this bulletin.

The peachtree borer is a native American pest of peach trees, occurring chiefly from the Rocky Mountains eastward and from New England to the Gulf of Mexico. The injury is done by the larvae as they feed on the cambium and inner bark of the tree. This borer is chiefly a pest of peach trees, although other related trees are subject to attack.

The construction of 128 cocoons was observed, and in every case the cocoon was completed by the larva within 24 hours.

The prepupal and pupal periods of females averaged 4.4 and 19.0 days, respectively, in 1933. From none to 2 percent of the larvae entered the prepupal stage in June, from 8 to 37 percent in July, from 55 to 80 percent in August, and from 6 to 12 percent in September. Pupation under orchard conditions in central Georgia began as early as April 19.

The period of moth emergence under peach-orchard conditions in central Georgia may begin as early as May 9 and extend to as late as

[1] Submitted for publication Feb. 20, 1943.

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November 8. Most of the moths appear in August and September, the peak of emergence usually occurring about the middle of September.

Of 1,325 moths that emerged during 3 seasons, 53.1 percent were females. The first moths to emerge are usually males, and early in the season the emergence of males is greater than that of females. More females than males emerge during the peak and last of the season.

The moths are diurnal. There is a marked tendency for female moths to begin and do considerable ovipositing on the tree from which they emerged. Their flight is a rambling one with a tendency to fly in circles. Female moths do not travel great distances, their daily flight being confined to a few hundred feet when flying from tree to tree to oviposit. The males are swift, active flyers, and disperse more quickly and over a larger area than do females.

Most of the female moths begin to lay eggs on the day they emerge. Oviposition is not confined entirely to peach trees, and some eggs are placed on grass, weeds, stumps, sticks, and leaves of various plants and on the soil.

The females kept in the insectary deposited an average of one-third of their eggs during the first day after mating, over one-half by the end of the second day, and over three-fourths by the end of the fourth day. The females kept under orchard conditions deposited two-fifths of their eggs during the first day after mating, two-thirds by the end of the second day, and over three-fourths by the end of the third day. The maximum number of eggs deposited by a single female was 1,257. The average numbers of eggs deposited per female during 4 years were 579 in the insectary and 515 in the orchard. The earliest oviposition was recorded on May 19 and the latest on November 8.

In the insectary the average longevity of the female moth ranged from 7.0 to 10.3 days, and the maximum number of days between emergence and death was 24. In cages in the orchard, the average longevity of the female moth ranged from 3.8 to 8.4 days, and the maximum number of days between emergence and death was 20. The average longevity of the male moth in the insectary ranged from 5.0 to 11.2 days, and the maximum number of days between emergence and death was 23.

The incubation period in the insectary ranged from 7 to 48 days, with averages from 9.4 to 13.2 days. The incubation period in the orchard ranged from 8 to 44 days, with averages from 10.4 to 13.2 days. The maximum incubation records were taken in December. Eggs hatched as early as May 30 and as late as December 15.

The over-winter larval feeding period during four seasons ranged from 264 to 383 days. The average duration of the over-winter larval feeding period for the individuals that hatched in the several months of the four seasons was as follows: August 335 days, September 326 days, October 318 days, and November 288 days. There is a retardation or cessation of growth of larvae under natural conditions between the last of October and the middle of March.

The peachtree borer normally has one generation a year in Georgia. There are no records to indicate that any individuals require 2 years to complete their life cycle.

Common parasites of the peachtree borer in central Georgia are *Telenomus quaintancei* Girault, *Microbracon sanninoideae* Gahan, and *Anthrax lateralis* Say. The last-named parasite has been known to

parasitize as many as 4.48 percent of peachtree borer pupae. Field mice and rats are the most important predators of the peachtree borer in central Georgia. Other predators are ants, chrysopid larvae, spiders, pigs, moles, and skunks.

INTRODUCTION

The peachtree borer (*Sanninoidea exitiosa* (Say)[2]) is one of the most serious insect pests that attack the peach, since every year, directly or indirectly, it causes the death of many trees. Its importance has been recognized ever since the early settlers introduced the peach into this country. Since an understanding of the seasonal history of this insect is essential to the timing of control measures, and as no comprehensive study of the life history and habits of this insect under southern conditions had been made, the Bureau of Entomology of the United States Department of Agriculture in 1930 undertook investigations of the biology of the borer at its Fort Valley, Ga., laboratory. This bulletin, which contributes to such an understanding, is a report on the results of studies carried on intensively from 1930 to 1933, supplemented by observations made by the present Bureau of Entomology and Plant Quarantine as opportunity offered from 1934 to 1938.

HISTORY

The peachtree borer is a native of the United States and has been written about for nearly two centuries. Peter Kalm,[3] the Swedish naturalist, made the earliest statement regarding this insect that has been noted. In 1749, in his Travels into North America, he said:

> Peach-trees have often been planted here, and never would succeed well. This was attributed to a worm which lives in the ground, and eats through the root, so that the tree dies. Perhaps the severity of the winter contributes much to it.

A paper entitled "On The Nature of the Worms so Prejudicial to the Peach-Trees for Some Years Past, and a Method for Preventing the Damage in Future," by J. Cooper, printed in 1771 in the Pennsylvania Gazette and Journal,[4] leaves no doubt as to the ravages of the peachtree borer during the eighteenth century. Some time before 1800 John Ellis submitted to the American Philosophical Society a prize essay[5] which gave a brief and fairly correct account of the peachtree borer. The original description of the insect was published by Thomas Say in 1823,[6] after which there was a noticeable increase in the number of references to the peachtree borer, and a further increase occurred after the establishment of the agricultural experiment stations. Nearly five hundred papers on the peachtree borer had been published by the close of 1933.

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[2] Order Lepidoptera, family Aegeriidae.

[3] KALM, PEHR. TRAVELS INTO NORTH AMERICA. [1749.] Translated by J. R. Forster. V. 2, p. 244. Warrington [England]. 1770.

[4] Not seen as the files of the early issues of this paper are not available for the duration of the war.

[5] ELLIS, J. ACCOUNT OF A METHOD OF PREVENTING THE PREMATURE DECAY OF PEACH TREES. Amer. Phil. Soc. Trans. 5: [325]–326. 1802.

[6] SAY, T. AMERICAN ENTOMOLOGY. V. 1, pp. 36–41. *In* LeConte, J. L., ed., The Complete Writings of Thomas Say on the Entomology of North America. 2 v. New York. 1859.

NATURE OF INJURY

The injury is done by the larvae as they feed on the cambium and inner bark of the tree trunk, usually just below but sometimes just above the soil level (fig. 1). The larger roots are also sometimes subject to borer attack. Peach trees of all ages from nursery stock to the oldest trees are injured. Young trees are sometimes completely girdled by the insect, and though this is less likely to occur to older trees, these are often so severely injured that their vitality is lowered and they are rendered especially susceptible to attack by other insects or by diseases. The presence of the insect in a peach tree is usually

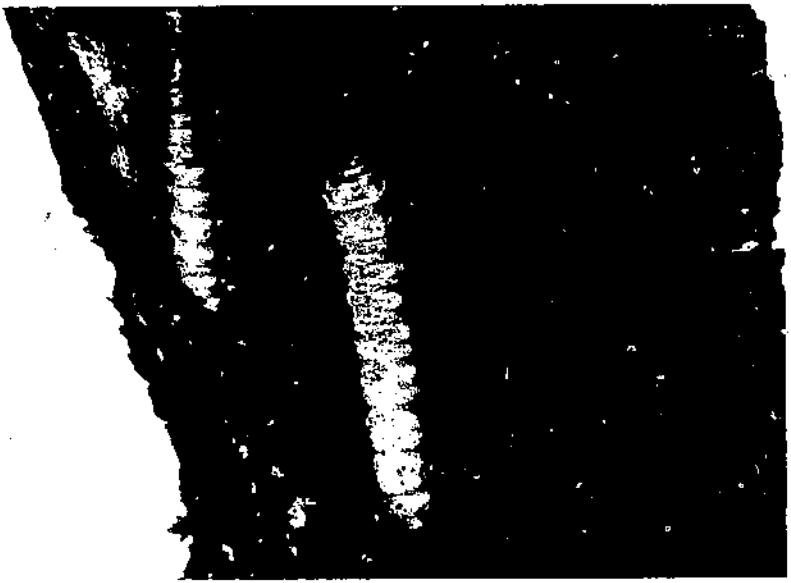

FIGURE 1.—Base of young peach tree, with bark cut away to show two larvae of the peachtree borer. About twice natural size.

indicated by gum, particles of bark, and frass at the base of the tree. The masses of gum and other material are especially conspicuous in wet weather during the growing season.

HOST PLANTS AND DISTRIBUTION

The original host plants of this native American insect are thought to have been wild cherry and wild plum. The female moth has been observed ovipositing on small wild cherry trees in a commercial peach orchard near Fort Valley, Ga. The insect is now chiefly a pest of peach trees, although other trees belonging to the genus *Prunus* are subject to attack. It has been reared at Fort Valley a number of times from *Prunus hortulana* Bailey, a species claimed to be resistant to borer attack, and also from *Prunus serrulata sachalinensis* Makino. Other stone-fruit trees attacked are nectarine, plum, prune, cherry, apricot, and almond.

This insect is found in most of the peach-growing localities of North America but occurs chiefly east of the Rocky Mountains and from New England to the Gulf of Mexico. It is present in Canada, and

has been reported from several Rocky Mountain and Pacific Coast States, but it appears to be of less economic importance in these States, where it is largely replaced by the western peach borer (*Sanninoidea opalescens* (Hy. Edw.)).

NOMENCLATURE

In describing the borer in 1823, Say placed it in the genus *Aegeria* and gave it the specific name *exitiosa*. The insect has been known by a number of scientific names and is now placed in the genus *Sanninoidea*.

The American Association of Economic Entomologists has adopted for this species the common name "peachtree borer," but the insect has also been known as the peach borer, the major or greater peach borer (to distinguish it from the lesser peach borer (*Sanninoidea pictipes* G. and R.)), and the eastern peach borer (to distinguish it from the western peach borer (*Sanninoidea opalescens*)).

METHODS, TECHNIQUE, AND EQUIPMENT

Records and observations on each stage of the life history of the peachtree borer, except the larval feeding period, were made both in

FIGURE 2.—The insectary at Fort Valley, Ga., used for the studies of the peachtree borer under insectary conditions.

peach orchards and in an insectary of the usual type, located in the laboratory yard (fig. 2) at Fort Valley. On account of the long larval feeding period, it was not practicable to obtain records on that stage in the insectary, and all data on the duration of the larval feeding period were obtained in orchard trees. A peach orchard on the laboratory grounds and several near the city limits provided convenient locations for the studies of the life history of the peachtree borer under orchard conditions.

In connection with the work, records were made of temperature, humidity, rainfall, and other factors, by use of standard weather instruments.

For Studies of the Cocooning, Prepupal, and Pupal Periods

Records on the cocooning, prepupal, and pupal periods were made from large larvae, removed from orchard peach trees just before and, at times, during the pupation season. These were placed on celluloid

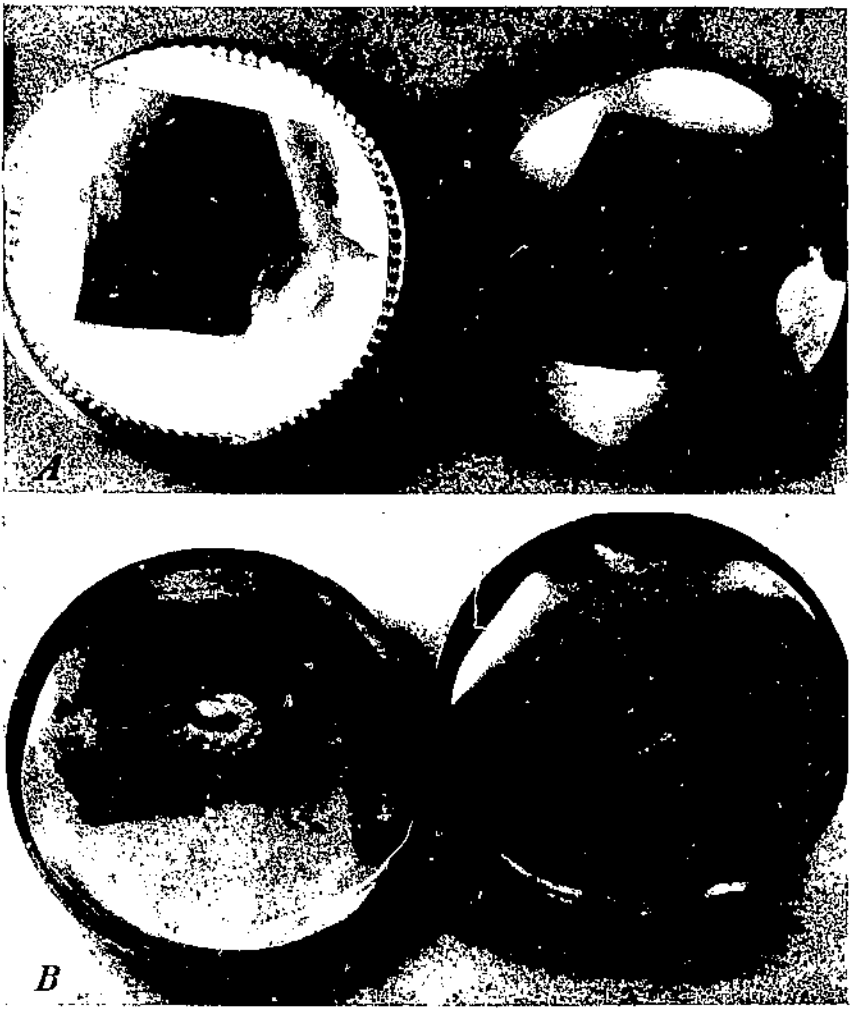

FIGURE 3.—Special ventilated tin boxes used for studies of cocooning, prepupal, and pupal periods of the peachtree borer: *A*, Peach bark on loose celluloid disk in bottom of box; *B*, celluloid disks turned upside down on top of boxes to show larvae at work on peach bark under the celluloid.

disks in round, specially constructed, ventilated tin boxes, and each was supplied with a piece of fresh peach bark. The bark, which was renewed at intervals, contained sufficient moisture for the development of the insect, and the loose celluloid disks in the bottom of the box permitted observations on the stages (fig. 3). The termination of the prepupal stage and the beginning of the pupal stage were deter-

mined by making a very small opening in the side of the cocoon with a dissecting needle and using either a hand lens or a binocular if those stages could not be observed through the celluloid disks. The duration of the pupal stage was then determined through daily observations for moth emergence from the pupation boxes.

Records on the first and last prepupa, the peak of the prepupal occurrence, and the prepupal and pupal stages combined for individuals that completed their larval feeding period in peach trees in commercial orchards were obtained by regularly removing the cocoons from the same trees throughout the season and observing them daily for the dates of adult emergence.

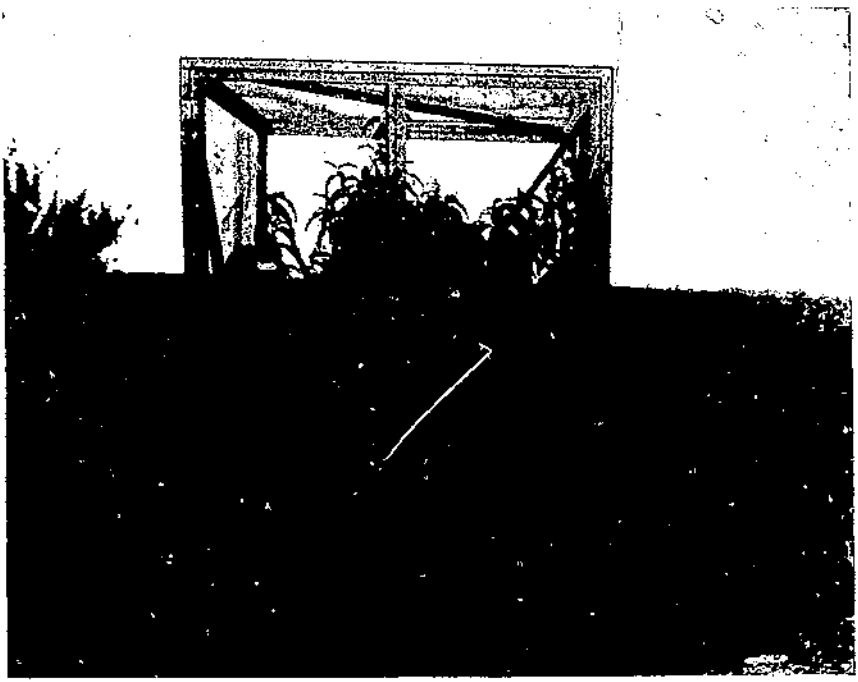

FIGURE 4.—Large screen cage built over a peach tree and used for various phases of the study of the peachtree borer.

FOR STUDIES OF THE ADULTS

Records of the emergence of moths in the orchard throughout the season were obtained by placing wire-screen cages around the lower trunks of a number of infested trees and regularly removing and recording the cast pupal skins from each tree. Records of moth emergence throughout the season under insectary conditions were obtained from the tin pupation boxes and from cocoons collected from trees used for studies of the larval feeding period and from trees examined regularly for records on the combined prepupal and pupal stages.

The moths mated readily in a large screen cage built over a peach tree (fig. 4). The studies of the flight and movement of females in

the orchard were made by marking the moths with alcohol-soluble dyes (fig. 5) and then following them after they were liberated, or by recovering them on other days after their liberation.

FIGURE 5.—Adults of the peachtree borer placed in small wire cages for marking with alcohol soluble dyes from a hand atomizer for use in flight studies.

Records on the longevity of all ovipositing females in the insectary and orchard were obtained from females confined in cages (fig. 6, *A* and *B*) in connection with the oviposition records. Longevity records were also obtained for males confined in special containers which would not permit flight. In larger cages that permit more or less flight, the insects often injure themselves in attempting to escape.

FOR STUDIES OF OVIPOSITION

The fertilized females were confined in individual oviposition cages immediately after they had been mated to determine the number of eggs deposited by each insect during each 24-hour period of its life. These cages were of two types, one for records under conditions in the insectary and the other for use in the field. Those used in the insectary were made entirely of wire screen and fastened to the shelves with rubber bands (fig. 6, *A*). A card of blotting paper on which the eggs were deposited was fitted under the cage, and at the end of each 24-hour period this was removed, the eggs counted, and a new card inserted. Each cage was provided with peach foliage, a sponge wick in a vial containing sugar solution for food, and water in a sponge on a celluloid disk to provide moisture. These cages provided adequate ventilation and light, and seemed to give conditions fairly comparable with those existing in the field. There was very little difference between the oviposition records obtained under insectary conditions and those obtained in the peach orchard.

The cages used in the field were constructed of celluloid with a band of screen wire at each end to permit circulation of air. The bottoms of these cages were covered with cheesecloth and on the top

was a sleeve made of the same material through which a peach twig was inserted into the cage (fig. 6, *B*), the sleeve being then fastened around the supporting limb. The cage was removed at the end of

FIGURE 6.—Cages used for oviposition records of moths of peachtree borer: *A*, Insectary cages; *B*, field type oviposition cages fastened about twigs of a peach tree. Note cloth sleeves fastened around the limbs from which the twigs are growing.

each 24-hour period, the eggs on the peach leaves and in the cage were counted, and the cage was then placed on another limb.

FOR STUDIES OF INCUBATION

For records on the incubation period under insectary conditions, the blotting-paper cards bearing eggs were tacked to shelves in the insectary. Below each card was placed a glass jar to catch the newly hatched larvae for use in other studies. Records on the incubation period under field conditions were obtained by hanging the cards containing eggs in a peach tree. The destruction of the eggs by ants was prevented by the use of a ring of sticky banding material on the trunk of the tree. At the end of each 24-hour period all eggs on the cards were examined under a binocular microscope for records on the incubation period.

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For Studies of the Larval Period

The larval feeding period, which in some cases lasts about 12 months, was studied in peach trees in a commercial orchard. The trees for these studies were protected from natural infestation by the use of tar-paper protectors, which were put in place before the adults began to emerge in the field (fig. 7). The cone-shaped protector was cut from a roll of 2-ply tar roofing paper. It was sunk 8 to 10 inches in the soil and tied tightly at the top to the tree trunk with cord. To prevent the entrance of larvae from outside, the seam where the flap overlapped and the top of the protector where it came into contact with the tree were covered with sticky tree-banding material. As soon as they were available, newly hatched larvae were taken to the orchard on moist blotting paper, the pro-

FIGURE 7. Protector used to prevent contamination of study material of the peachtree borer with other larvae.

tector was removed, and the larvae were placed on the tree trunk at the ground line with a camel's-hair brush, after which the protector was replaced. Better larval entrance was effected when the larvae were placed on a little gummy frass taken from another peach tree and placed at points where entrance was desired. The protectors were removed from the trees at the close of the normal hatching period. The trees containing these insectary-hatched larvae were examined regularly the following year from early summer until fall, to remove the matured larvae when they had left the trees to pupate.

DESCRIPTIONS

The Egg

The egg (fig. 8, *A*) is usually a rich chestnut brown, although some are lighter, almost straw colored, especially when the female moth

has just about completed her oviposition. The egg is distinctly flattened, depressed or concave on one side, and one end is slightly broader than the other. The normal egg measures about 0.7 mm. long, 0.5 mm. wide, and 0.3 mm. thick. Those deposited near the close of a female's oviposition period are somewhat smaller.

The Larva

A newly hatched larva (fig. 8, *B*) is grayish white with brown head, whereas older mature larvae (fig. 8, *C*) are white or cream-colored, and in addition to a brown head have a yellow sclerotized area on the dorsal aspect of the prothorax and another on the caudal segment of the abdomen. Newly hatched larvae range in length from 1.5 to 1.7 mm. and have a head width of 0.25 mm. Normal, mature larvae range in length from 1¼ to 1½ inches (32 to 38 mm.).

The Pupa

When the pupa is first formed it is white, but it soon turns to a medium shiny brown. Both male and female pupae remain thus until the later stages of development, when the formation of adult body scales causes the female pupae (fig. 8, *E*) to become shiny black with a dull reddish band around the middle, and the male pupae (fig. 8, *D*) to become black, although not so decidedly so as female pupae, and without any visible band. The abdominal segments of both male and female pupae possess sharp chitinous projections on the top. The male pupa has two such rows of projections on the seventh abdominal segment, but the female has only one row on that segment. Female pupae range in length from 14/16 to 16/16 inch (22 to 24 mm.) and are more robust than male pupae, which range in length from 12/16 to 13/16 inch (19 to 21 mm.).

The Adult

Adults of the peachtree borer are very active, clear-winged moths. They are trim and slender in body and capable, especially the males, of swift flight. The body scales of the male are bright steel blue together with pale yellow to white. The pale-yellow stripes on the abdomen fringe the margins of the segments, and because of the varying intensity of these stripes the abdomens of different males appear to vary in the number of stripes from two to six. Scales covering the legs and face are predominantly pale yellow. Both front and rear wings of the male are clear (fig. 9, *A*). Dark steel-blue scales cover the front wings, legs, and entire body of the female, except that a band of bright orange to reddish scales covers the fourth abdominal segment. In certain northern localities the fifth abdominal segment of the female is often also covered with orange scales, and a moth of this type is shown in figure 9, *B*. The rear wings are clear (fig. 9, *B*). The wing spread of female moths ranges from 1 6/16 to 1 8/16 inches (35 to 38 mm.), and of male moths from 1 1/16 to 1 3/16 inches (27 to 30 mm.). Body length (measured from cephalic margin of head to caudal tip of tuft of scales on caudal end of abdomen) of females ranges from 12/16 to 15/16 inch (19 to 24 mm.), and of males from 11/16 to 13/16 inch (17 to 21 mm.).

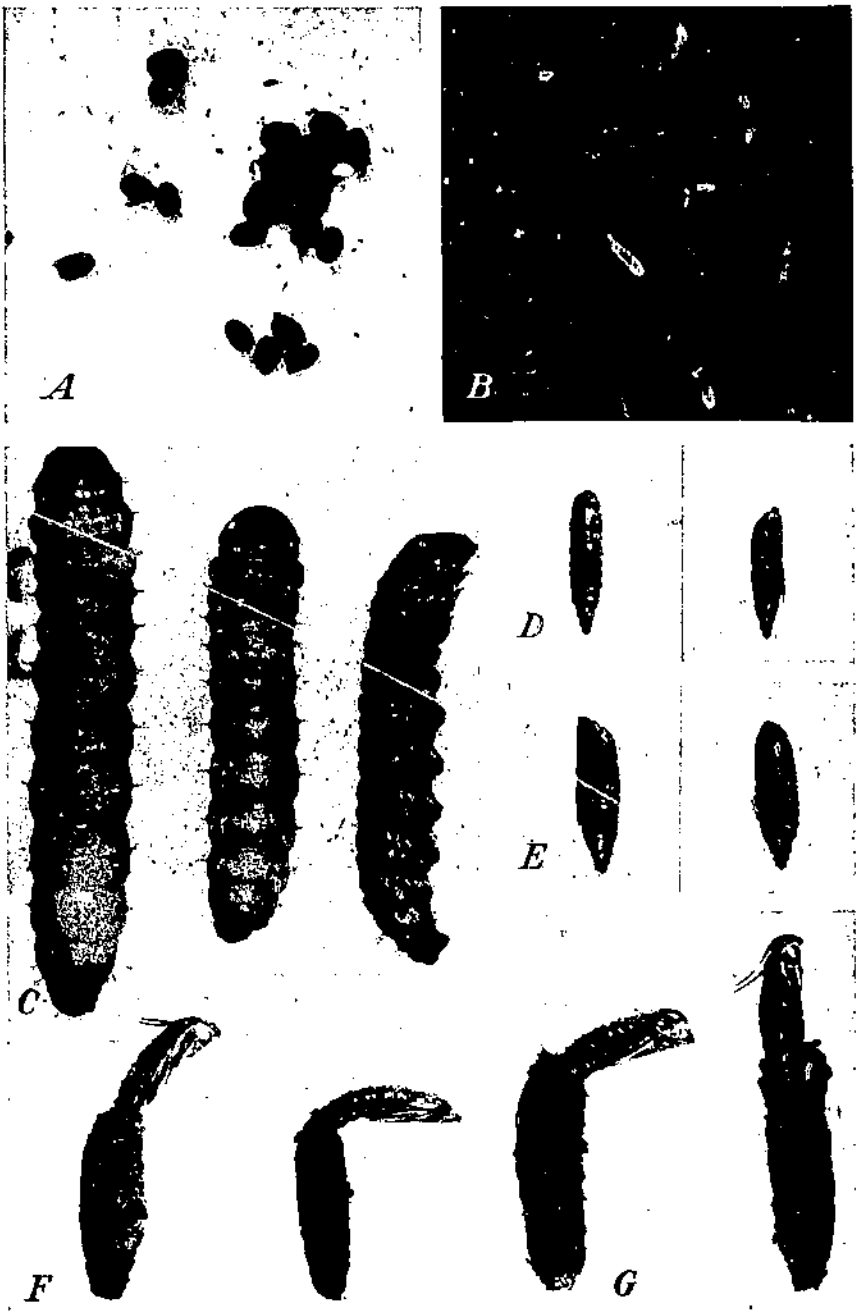

FIGURE 8.—Developmental stages of the peachtree borer: *A*, Eggs (most of these have hatched), × 10; *B*, larvae just out of the eggshells, × 7; *C*, full-grown larvae, about twice natural size; *D*, male pupae; *E*, female pupae; *F*, empty pupal skins of males protruding from cocoons; *G*, same of females; *D*, *E*, *F*, *G*, natural size.

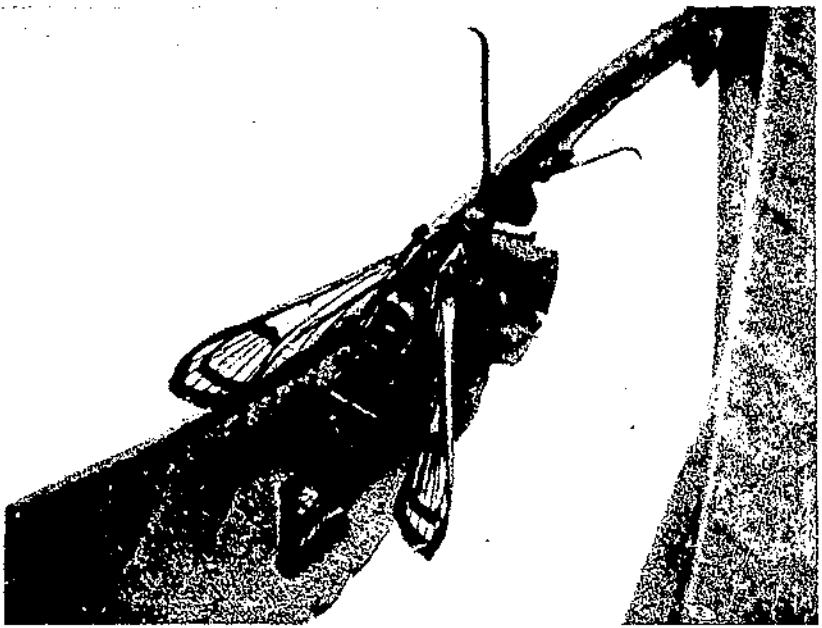

FIGURE 9.—Adults of the peachtree borer (*Sanninoidea exitiosa*): *A*, Male, × 2½; *B*, Female (northern type, with orange scales on both fourth and fifth segments), × 2½.

LIFE HISTORY AND HABITS OF THE PEACHTREE BORER

The peachtree borer hibernates as a partly grown larva in its burrow underneath the bark of the tree. In the spring, feeding is resumed and the larval period is completed.

Cocooning Period

Upon reaching maturity, the larvae that are working below ground bore through the bark of the tree beneath the soil level and make channels in the soil up to within an inch or less of the surface. As soon as these channels are completed, the larvae force to the top particles of chewed-up bark, or frass, and then proceed to construct their cocoons by webbing these particles together (fig. 8, *F* and *G*). If the larvae are feeding above ground, especially in old trees where there are large feeding channels, some larvae construct their cocoons above the level of the soil at an opening which they cut through the bark.

The construction of 128 cocoons was observed during 4 seasons, 1930–1933. The construction of the cocoon proceeds more slowly in dry weather than in wet weather, but in every case the cocoon was completed by the larva within 24 hours.

The Prepupal Period

After completing the cocoon, the larva changes to the prepupal condition, during which it is inactive and its body shortens. The color of the full-grown, feeding larva is maintained until the latter part of the prepupal stage, when it becomes lighter.

The earliest date recorded in the insectary for the change to prepupa was in 1936, when one individual completed its larval feeding period and entered the prepupal stage on April 29. In the different years not more than 2 percent of the larvae under observation entered the prepupal stage in June, from 8 to 37 percent became prepupae in July, from 55 to 80 percent in August, and from 6 to 12 percent in September. The prepupal period, as determined for a few individuals beginning their pupation in the insectary in August and September, 1930, averaged 5.3 and 5.0 days, respectively, in the two months. In 1933 the prepupal period for 97 individuals ranged from 3 to 7 days, with averages of 4.2 and 4.4 days for males and females, respectively.

The Pupa

On completion of the prepupal stage, the insect molts and transforms to the pupa within the cocoon. The pupa, when first formed, is white, but it soon turns brown and then black. It is inactive under normal conditions, but if disturbed it reacts with circular movements of the abdomen.

Records on the pupal period were obtained by making daily observations for moth emergence from the cocoons which had been used for the prepupation records in the insectary. Many records were also obtained on the combined prepupal and pupal stages of larvae that constructed their cocoons in the insectary and in peach orchards. Table 1 presents a summary of the records on the pupal stage and

the combined prepupal and pupal stages during the 4 years 1930 to 1933, inclusive.

TABLE 1.—*Summary of records of the pupal stage and the combined prepupal and pupal stages of the peachtree borer at Fort Valley, Ga., seasons of 1930–1933*

PUPAL PERIOD

Where cocoons were constructed	Year	Individuals observed	Duration of period					
			Maximum	Minimum	Average period in—			
					June	July	August	September
		Number	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*
Insectary	1932	11	25	16	------	------	17.4	24.5
Do	1933	82	21	17	21	18.6	18.6	18.9

PREPUPAL AND PUPAL PERIODS COMBINED

Insectary	1931	43	26	20	------	22.2	23.3	------
Do	1932	3	33	22	------	------	22.0	32.5
Orchard trees	1930	53	27	19	------	22.5	22.7	------
Do	1931	89	34	20	------	22.3	23.1	29.0
Do	1932	125	43	19	------	21.5	24.1	30.7
Do	1933	40	27	19	20.0	21.5	22.8	23.0

June 28 was the earliest pupation date recorded in the insectary during the years 1930–33. In 1935, however, pupation began in the insectary on May 20, and in 1936 it began as early as April 19 in the field and on May 4 in the insectary. In 1933, males required an average of 17.7 days and females 19 days to complete the pupal period. During the 4 years 1930 to 1933, males required an average of 22.8 days and females 23.6 days to complete the combined prepupal and pupal stages.

THE ADULT

EMERGENCE AND PROPORTION OF SEXES

A pupa preparing for emergence begins to wriggle round and round in the cocoon and at the same time exerts pressure on the front end. Finally an opening is made through the cocoon, after which the pupa continues to wriggle until it has worked up through the surface of the soil or through the opening previously made in the bark. The many projecting spines on the pupa aid it in pushing its way out of the cocoon and into the open. As soon as the pupa breaks through to the open it begins to expand by repeated movements until there is a break in the dorso-cephalic end of the pupal skin, and through this the adult moth (fig. 8) emerges. When the adult has freed itself from the pupal skin it usually crawls up the tree trunk or a nearby weed stem or grass blade, where it unfolds its wings to dry.

Emergence of moths takes place between 7:00 a. m. and 1:30 p. m. More moths emerge on clear days than on cloudy days.

Table 2 gives the dates of first and last adult emergence, the peak of emergence, and the percentage of moths emerging in each month of the several years in which records were made throughout the season.

TABLE 2.—*Emergence of peachtree borer moths at Fort Valley, Ga., 1930–33*

Year	Date of emergence			Percentage of moths emerging in—			
	First	Peak	Last	July	August	September	October
1930	July 22	Sept. 15	Oct. 24	6.4	16.7	69.2	7.7
1931	Aug. 6	...do...	Oct. 27	0	22.5	76.5	1.0
1932	July 2	...do...	Nov. 8	1.6	23.7	69.7	5.0
1933	June 26	Sept. 9	Oct. 2	2.4	19.3	78.3	0

The emergence records for 1932, taken from 25 selected peach trees in a commercial orchard at Fort Valley, are shown in graphic form in Figure 10. They are typical for central Georgia.

Although systematic records were not kept later than 1933, early-season observations from 1934 to 1938, inclusive, indicated that moths

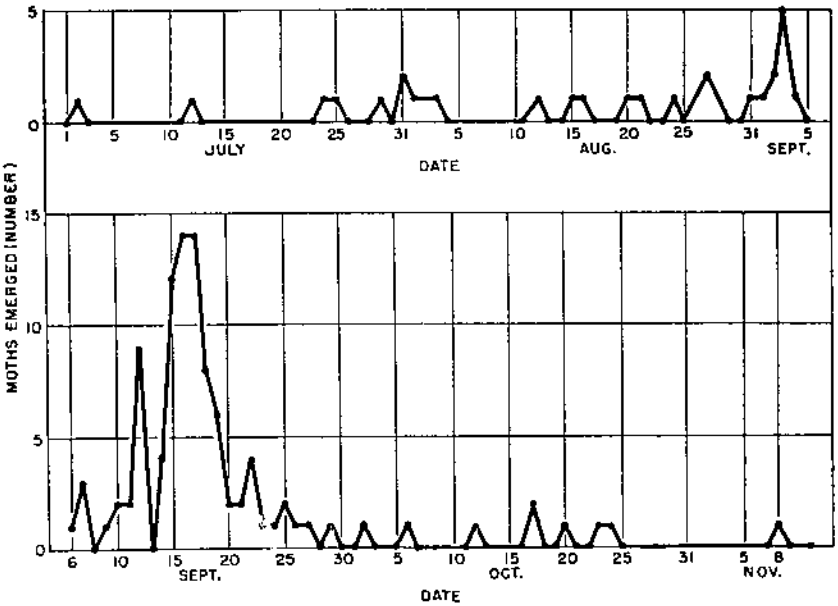

FIGURE 10.—Emergence of peachtree borer moths from 25 selected peach trees in a commercial peach orchard near Fort Valley, Ga., during the season of 1932.

may begin to emerge as early as May. The earliest evidence of emergence was the finding of a fresh male pupal shell on May 9, 1936. During that season a number of fresh cast pupal skins were observed in orchards during May, and female moths emerged and began depositing fertile eggs as early as May 19. In most seasons in central Georgia, however, the greater part of the moths emerge in August and September. This is later than the main part of the emergence of moths in northern localities, and is just the opposite of what might be expected. No reason for this has been determined.

Of the total emergence of 1,325 moths during the seasons of 1931, 1932, and 1933 the percentage of females was 53.1. The first moths to emerge are usually males, and early in the season the males predomi-

nate, but more females than males emerge during the peak and latter part of the season.

HABITS AND ACTIVITY OF MOTHS

The moths are diurnal and are most active in clear weather. During the night they rest on the trunk, limbs, or foliage of peach trees, on nearby weeds, or on the ground. They also rest during rainy periods of daylight, and are mostly inactive on cloudy days.

Moths have been observed drinking water and taking sweetened water from a sponge in oviposition cages, but during the 9 years of these studies moths have not been seen to take any kind of food in the field.

The flight habits of a number of moths were observed in the orchard, in many cases by means of moths marked with violet dye (fig. 5). Female moths whose flight was followed until they were lost—periods varying in duration from a few minutes to 3 days—traveled distances ranging up to 1,070 feet. In most cases the distances were much shorter, and many of the moths followed a more or less circular course, returning to a point close to the tree near which they had been liberated. None of them flew out of the orchard in which liberated, except to an adjacent orchard across a road. In several instances marked moths that were lost to view returned later to the starting point. One female moth liberated in an open field made circular flights and returned several times to the starting point, instead of flying to a peach orchard a few hundred yards away. Her instinct appeared to lead her to expect to find a peach tree at the point where she was liberated. Although the female moths are strong fliers, they seem to have a tendency to remain fairly close to the tree from which they emerge, and to deposit most of their eggs on or close to that tree or nearby trees.

The male moths are seldom seen in the field. They are strong fliers, seem to be readily attracted to the females, and apparently travel considerable distances. In two cases marked males flew distances of about 0.6 mile to female moths, one male making the flight in 20 minutes.

OVIPOSITION

It is the usual habit for the female moths to mate and to begin depositing their eggs on the day on which they emerge, although in some cases oviposition may not begin until the next day. The hours of greatest egg-laying activity are from 9 a. m. to about 4 p. m. No eggs are deposited during the night. More eggs are deposited on bright, sunny days than on cloudy days, although extremely hot and dry weather retards oviposition somewhat, and oviposition ceases entirely during rain. As indicated in the discussion of flight habits, most of the eggs are laid on or near a small group of trees surrounding the tree from which the female emerged.

The eggs are usually deposited singly, but occasionally in small groups (fig. 8, *A*). Sometimes the eggs are grouped by females returning several times to the same place to oviposit. The eggs are placed with the flat side next to the surface on which they are deposited, and are held in place by an adhesive fluid. Before placing the egg, the female usually moves her ovipositor about over the surface, apparently searching for a suitable spot for each egg or a place against which to rest the end of her ovipositor.

All parts of a peach tree—trunk, limbs, twigs, and leaves—are visited and oviposited on by the female. Eggs are also placed on weeds, grass, cotton stalks and bolls, fallen twigs and sticks, and leaves of various plants, and on bare soil around the tree trunk. A few eggs may be deposited on weeds and grass as far as 10 feet from the base of the tree. The majority, however, are deposited on the lower 6 inches of the trunk and on the soil immediately adjacent to the trunk. Aside from ovipositing on and around normal, growing peach trees, females have been observed depositing eggs on the stumps and wilted or dead tops of peach trees that had been cut down.

OVIPOSITION RECORDS

Table 3 brings together the combined egg-laying records of all peachtree borer females under observation in the insectary and in peach orchards during the 4 years 1930 to 1933, inclusive. During that period oviposition records covered 159,253 eggs.

TABLE 3.—*Summary of records of egg laying by 284 peachtree borer females under insectary and field conditions at Fort Valley, Ga., 1930–33*

INSECTARY

Year	Females ovipositing	Date of oviposition		Egg record					
		First	Last	Total deposited	Average per individual	Maximum laid by 1 individual	Maximum deposited by 1 individual in a 24-hour period	Minimum laid by 1 individual	Average eggs in body after death
	Number			*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
1930	2	Aug. 12	Sept. 3	1,623	811.5	979	394	644	143.0
1931	54	Aug. 11	Nov. 8	34,009	629.8	1,257	834	42	----
1932	91	July 29	Nov. 2	53,216	584.8	1,125	600	9	204.3
1933	54	July 10	Sept. 30	27,600	511.1	965	619	55	245.2
Total or extreme	201	July 10	Nov. 8	116,448	579.3	1,257	834	9	218.5
ORCHARD									
1931	32	Aug. 12	Sept. 25	14,370	449.3	977	500	36	----
1932	34	Aug. 23	Oct. 28	19,075	561.0	1,026	537	107	170.2
1933	17	Aug. 1	Oct. 2	9,351	550.1	985	556	218	198.5
Total or extreme	83	Aug. 1	Oct. 28	42,808	515.7	1,026	556	36	179.6

The supplementary observations made from 1934 to 1938 added records of earlier ovipositions than those shown in table 3, as eggs were laid on May 19, 1936, by a female that emerged from a cocoon collected in a peach orchard several days earlier. In 1935 eggs were laid as early as June 4 by a female that emerged on June 3 from a cocoon collected in a peach orchard on May 22.

The oviposition period in the insectary was a little more extended than in the orchard. The females kept in the insectary deposited an average of one-third of their eggs during the first day, over one-half by the end of the second day, and over three-fourths by the end of the fourth day. The females in orchard cages deposited two-fifths of their eggs during the first day, two-thirds by the end of the second day, and over three-fourths by the end of the third day.

One hundred and twenty-one well-developed eggs were taken from the body of an apparently uninjured field female found dead in a peach orchard in 1932. Two fresh-looking females captured in commercial peach orchards in 1933 were dissected after death, and in their bodies were found 47 and 137 undeveloped eggs. Therefore, as in the cages in the insectary or orchard, field-reared free females under natural conditions in a peach orchard do not always deposit all the eggs that form within their bodies.

LONGEVITY OF MOTHS

The duration of the adult stage was determined for each female used for oviposition records in cages in the insectary and in the field and for a number of males confined each season in cages sufficiently small to prevent injury by flight against the sides. Table 4 gives a summary of the longevity records of 471 peachtree borer moths during the seasons of 1930 to 1933, inclusive.

TABLE 4.—*Longevity of peachtree borer moths at Fort Valley, Ga., 1930–33*

Year	Sex	Location of cage	Moths under observation	Maximum period between emergence and death	Average period between emergence and death					
					July	August	September	October	November	Season
			Number	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*
1930	Females	Insectary	29	17	.....	7.6	9.4	6.0	------	8.7
1930	Males	do	33	8	4.0	5.7	5.3	------	------	5.4
1931	Ovipositing females	do	55	17	------	5.8	7.4	10.8	[1] 13.0	7.3
1931	do	Orchard	36	7	------	3.9	3.8	------	------	3.8
1931	Males	Insectary	33	14	------	------	5.0	------	------	5.0
1932	Ovipositing females	do	90	24	[1] 4.0	7.0	8.4	15.1	[1] 16.0	10.3
1932	do	Orchard	31	20	------	4.6	6.6	14.0	------	8.4
1932	Males	Insectary	18	23	------	6.0	8.8	16.8	------	11.2
1932	do	Orchard	2	6	------	------	6.0	------	------	6.0
1933	Ovipositing females	Insectary	56	16	7.6	6.2	7.5	6.0	------	7.0
1933	do	Orchard	16	10	------	4.9	4.8	7.0	------	5.0
1933	Males	Insectary	72	22	7.0	7.9	6.1	11.0	------	7.2

[1] 1 female.

The shorter life of ovipositing females in the field is attributed to the greater effort on the part of the moths to escape from the field cages, which received more light than the insectary cages. Males confined in cages under orchard conditions soon beat themselves to death in efforts to escape, and longevity records obtained under such conditions are not reliable. The longevity of males caught in the orchards, however, was judged to be about the same as of those reared in the insectary.

The moths appear to live much longer when the weather is cool, and the duration of the adult stage is shortened by very hot summer weather.

INCUBATION OF EGGS

Table 5 presents a summary of the incubation records on 58,824 peachtree borer eggs in the insectary and in peach orchards, taken in the 4 years 1930 to 1933, inclusive. These records do not include eggs that were lost or eggs that were parasitized during their exposure in the field.

TABLE 5.—*Summary of the incubation records of eggs of the peachtree borer at Fort Valley, Ga., seasons of 1930 to 1933, inclusive*

Year	Date of hatching		Eggs under observation	Eggs hatching	Incubation period		
	First	Last			Maximum	Minimum	Average
			Number	*Percent*	*Days*	*Days*	*Days*
INSECTARY							
1930	Aug. 21	Oct. 25	1,750		17	9	9.8
1931	do	Oct. 17	14,251	93.7	14	8	9.5
1932	Aug. 6	Dec. 15	17,677	93.9	48	7	13.2
1933	July 20	Oct. 15	8,203	96.8	15	7	9.4
ORCHARD							
1931	Aug. 29	Dec. 1	4,719	[1] 63.5	28	9	10.8
1932	Aug. 26	Dec. 9	9,639	94.1	44	8	13.2
1933	July 26	Oct. 14	2,585	95.9	15	8	10.4

[1] Many eggs were killed by some material in the blotting paper on which they were laid.

In 1930 no record was made of the number of eggs lost during the studies of incubation in the insectary; the actual proportion of eggs hatching was therefore not determined.

In 1931 some dye or other substance in the blotting paper on which the eggs were deposited caused a considerable number of them to fail to hatch. This occurred only in the orchard; no such effect was observed in the insectary. The chilling effect of rains, dews, and fogs in the field is believed to be responsible for the longer average incubation period under peach-orchard conditions as compared with that in the insectary in 1931 and 1933.

The incubation period of the eggs was greatly influenced by temperature. At daily mean temperature averages of about 80° F. the period was 7 to 9 days; at temperatures of about 70° the period averaged 12 to 13 days; at 65° the eggs hatched in about 13 to 18 days; at temperatures averaging below 60°, 25 to 45 days were required. There appeared to be no correlation between humidity and the incubation period.

HATCHING

For 2 or 3 days before the egg hatches, the head capsule of the larva can be seen through the eggshell. When time for hatching arrives, the larva chews out an opening in the blunt (micropyle) end of the egg and crawls out. The pieces of eggshell chewed out by the larva are not consumed.

Hatching takes place usually at night or in the early morning hours, although eggs have been observed hatching hourly from 8 a. m. to 5 p. m.

The earliest hatching recorded in the course of these studies occurred on May 30, 1936, from eggs laid by a moth that began to oviposit on May 19. In 1935 eggs began to hatch as early as July 15. These had been deposited by a female that emerged on July 6.

THE LARVA

HABITS OF NEWLY HATCHED LARVAE

The newly hatched larvae (fig. 8, *B*) are negatively heliotropic and positively geotropic. When placed on the tree trunk they begin im-

mediately to descend. Some individuals require a half hour to reach the base of a tree from a point on the trunk 16 or 18 inches above the soil level. When placed on limbs they begin immediately to crawl down, although in most cases they fall off before they get to the trunk. When liberated in the sparse shade of a peach tree they went away from the tree toward the denser shade of nearby pecan trees. When liberated in the sun away from any shade except that offered by a peach tree, they went toward the tree, even though the trunk was in the sun. When placed in the shade on the ground a few inches from the base of a peach tree, the larvae bored into the soil in a crack or between loose particles of earth.

Although many are able to stick on during windy weather, even though at times they hold on with only a thread of web, some are blown off the trees. On arrival at the base of a peach tree the active newly hatched larvae immediately seek entrance into the bark layers at or below the ground line, and begin to feed. Observations have indicated that not more than 15 percent of the newly hatched larvae are successful in gaining a foothold and beginning their development in the tree.

CANNIBALISM

Large numbers of newly hatched larvae confined in glass jars showed no signs of cannibalism. No evidence of cannibalistic traits has been noted in groups of large larvae confined together in close quarters with fresh peach bark for food. Full-grown or nearly matured larvae (fig. 8, *C*) will kill one another when several are placed together in close quarters without food, but they have not been observed actually to eat the dead ones under such conditions, as occurs with some lepidopterous larvae.

GROWTH OF LARVAE IN NURSERY STOCK AND ORCHARD TREES

Table 6 gives the length and head width of larvae of different ages from newly hatched to full grown, reared in peach nursery stock and orchard peach trees.

TABLE 6.—*Length and head width of peachtree borer larvae reared in peach nursery stock and orchard trees at Fort Valley, Ga., 1934–35*

Date of observation	Age of larvae	Larvae in peach nursery stock (in insectary first six weeks)		Larvae in 4-year-old orchard peach trees	
		Length	Width of head	Length	Width of head
1934	*Weeks*	*Millimeter*	*Millimeter*	*Millimeter*	*Millimeter*
Sept. 17	(1)	1.5–1.7	0.25	1.5–1.7	0.25
23	1	3			
Oct. 1	2	5–6	.6–0.7	5–6	[2].6–0.7
9	3	9–11	1.0–1.3		
15	4	8–11	.7–1.3	11	1.3
22	5	10–13	1.3–1.8		
29	6	9–16	1.0–2.0	11–18	1.2–2.0
Nov. 5	7	10–16	1.5–2.0		
Dec. 1	11	11–16	1.5–2.0	13–20	1.7–2.0
1935					
Jan. 2	15	12–15	1.7–2.0	13–18	1.7–2.0
Mar. 16	26	12–20	1.7–2.0	12–23	1.5–2.5
Apr. 13	30	15–20	1.8–2.0	18–26	2.0–2.5
May 13	34	28	2.5–3.0	21–25	2.2–2.75
27	36	28	2.5–3.0	25	2.75

[1] Newly hatched.

[2] 0.7 for larvae just molted.

It will be noted that growth is very much retarded or ceases entirely during the late fall and winter months, a period during which comparatively low temperatures prevail.

LARVAL FEEDING PERIOD

Information on the duration of the larval feeding period was obtained in peach trees in commercial orchards during the seasons of 1930–31, 1931–32, 1932–33, and 1933–34. From a few to 200 newly hatched larvae were placed on each tree used for these studies. Table 7 presents a summary of the records of the larval feeding period taken during the 4 seasons.

TABLE 7.—*Summary of records on the larval feeding period of the peachtree borer in peach trees at Fort Valley, Ga., during the seasons of 1930 to 1934, inclusive*

Season	Total trees infested	Total larvae placed on trees	Total larvae that completed their feeding period	Larval feeding period		Average duration of feeding period of larvae that hatched in—			
				Maximum	Minimum	August	September	October	November
	Number	*Number*	*Number*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*
1930–31	11	927	21	364	307	357	338	310	----
1931–32	27	2,195	60	383	272	340	336	323	284
1932–33	25	3,173	140	341	285	327	318	311	289
1933–34	11	990	17	353	325	352	337	320	----
Total, all seasons	74	7,285	238	383	272	335	326	310	288

The larvae hatching in successive months required progressively less time to complete their feeding periods. Very dry weather during the summer is believed to retard the growth of the young larvae in peach trees, possibly because of a toughening effect on the bark, and this may be responsible for the longer feeding period for larvae hatching during the summer. As a result of this condition, the later-hatching larvae tend to catch up with the earlier ones in their development. The shortest overwinter larval feeding period noted, however, was that of a larva hatching on August 21, 1935. This was placed on a potted nursery tree, and completed its feeding on May 11, a period of 264 days.

NUMBER OF GENERATIONS PER YEAR

Although it has been generally believed that in this country the peachtree borer has only one generation annually, observations at Fort Valley in 1935 showed that two generations in one year are possible under certain conditions. Peach nursery stock was artificially infested with the season's first newly hatched borers on July 15 and 17, and on September 30 females, smaller than normal, emerged from these trees, having completed their larval feeding, cocooning, prepupal, and pupal periods in 75 days. It is believed that some individuals completed these periods in 65 days, as males, smaller than normal, were taken near these nursery trees on September 20. The female moths mated with normal males on the day they emerged and immediately began to deposit second-generation eggs, which proved to be fertile. The

second-brood larvae had every appearance of being normal, healthy individuals. All the second-generation adults reared in 1935 were undersized, however, indicating some abnormal condition in their environment or stamina.

In 1936 all overwintered larvae were removed from twelve 4-year-old orchard peach trees. Sixty larvae from eggs that began to hatch on May 30 were then placed on each of these trees at each of six different times during the period May 30 to June 14. These trees were examined every 2 weeks from September 14 to October 30 for second-generation pupae or adults, but none were found. The very dry weather in the summer of 1936 is believed to have prevented rapid growth of the larvae after they were placed on the trees. Three individuals of a second generation were reared in normal peach trees in each of the seasons of 1937 and 1938. It is evident that the proportion of peachtree borer larvae completing their development and emerging as moths the same season is an insignificant fraction of the total population.

No records or observations made during the 9 years' study of this insect indicate that in Georgia more than 1 year is required for some individuals to complete their life cycle. Screen cages were constructed over orchard peach trees in which fertile females were kept during the entire oviposition period of 1934. These trees were kept caged again during the oviposition period of 1935, and during that season all cocoons were removed before the moths emerged. Careful examinations in 1936 showed that these trees contained no borers, which is evidence that none of the larvae entering the trees in 1934 required 2 years to complete its life cycle.

PARASITES AND PREDATORS

Three parasites of the peachtree borer are common in central Georgia. These are the hymenopterous egg parasite *Telenomus quaintancei* Girault,[7] the hymenopterous larval parasite *Microbracon sanninoideae* Gahan,[7] and the dipterous pupal parasite *Anthrax lateralis* Say.[8]

The egg parasite *Telenomus quaintancei* required from 30 to 35 days in the fall and more than 2 months in the early winter to complete its life cycle at Fort Valley. This parasite was rather abundant from September to December 1932, and parasitized 1.3 percent of the eggs exposed in the orchard on blotting paper cards during that period.

The larval parasite *Microbracon sanninoideae* (fig. 11) was fairly abundant throughout the season of 1932. It was determined the following year that these parasites pass the winter as pupae. Thirty-two of them, about two-thirds of them females, emerged from one peachtree borer cocoon on September 3, 1933. More females than males have always been reared from single borer cocoons, and of those that emerge late in the season practically all are females.

The pupal parasite *Anthrax lateralis* (fig. 12) is an abundant parasite of the peachtree borer in some years. Of 782 peachtree borer pupae collected in August 1933, 35, or 4.48 percent, were parasitized by that species. In 1933 most of the parasite adults emerged in Septem-

[7] Identified by C. F. W. Muesebeck.
[8] Identified by C. T. Greene.

ber, although they have emerged as late as October 12. From 40 to 45 days are probably required for this parasite to complete its life cycle during the fall in central Georgia.

Field mice and rats are the most important predators of the peachtree borer in central Georgia. They destroyed hundreds of pupae in practically every commercial peach orchard there in 1932, and in many orchards they destroyed about two-thirds of the individuals that pupated in August 1933. These predators dig the peachtree borer cocoons from around the trees and eat out the contents.

FIGURE 11.—Adult female of *Microbracon sanninoideae*, a hymenopterous parasite of peachtree borer larvae, × about 5.

FIGURE 12.—Adult female of *Anthrax lateralis*, a dipterous parasite of peachtree borer pupae, × about 3½.

Ants are important predators of the peachtree borer in Georgia. *Dorymyrmex pyramicus* (Roger)[8] and *Pheidole* sp.[8] were found preying on newly hatched peachtree borer larvae in 1932 and 1933, and no doubt ants kill large numbers of newly hatched larvae during their journey from the egg to the point of entrance into the peach tree. *D. pyramicus* were also found carrying off peachtree borer eggs from a peach tree in August 1933. *Solenopsis xyloni* MacCook[9] destroys peachtree borer larvae and pupae in cocoons. These ants have been observed crawling in and out of small holes which they made for entrance into the cocoons to feed on the contents.

One of the jumping spiders of the family Attidae has been observed preying on newly hatched peachtree borer larvae as they crawled around the lower part of the trunk of a peach tree. Peachtree borers are also killed by chrysopid larvae, pigs, moles, and skunks.

[8] Identified by William Mann.

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