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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR
College Station, Brazos County, Texas

BULLETIN NO. 401 — SEPTEMBER, 1929

DIVISION OF ENTOMOLOGY

THE COTTON-SQUARE BORER

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
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†As of September 15, 1929. *Dean, School of Veterinary Medicine.
**In cooperation with U. S. Department of Agriculture.
***In cooperation with the School of Agriculture.

The cotton-square borer, *Strymon melinus* Hubner, is one of the common insect enemies of cotton in Texas. The larva or caterpillar of this insect feeds principally upon the squares. Under favorable conditions the number of squares destroyed by this species may become quite serious over limited areas, especially during the early portion of the growing season.

The insect is widely distributed within the State and is active in the field from March to November. Locally, the larvae have been recorded feeding on cotton, cowpea, bean, okra, field corn, and goatweed. In the field, oviposition begins about April 1 and extends throughout the season as long as suitable food plants remain available. Rearing records indicate that three complete generations or broods of this insect are produced during a season.

Data on the developmental stages of the cotton-square borer are presented. Under average laboratory conditions from June to August, 1928, it required 38.25 days to complete development from egg to adult. The eggs are laid singly and promiscuously upon the food plant, and during the summer months require approximately 5.5 days for incubation. Normally, the larva molts five times and requires about 23 days during warm weather to attain full growth. Pupation ordinarily occurs in the open upon the food plant, and approximately 9.5 days are required for pupal development during the summer months.

Usually multiplication of the cotton-square borer is effectively checked by natural enemies, and combative measures to reduce infestations are rarely required. When control measures appear necessary, dry applications of calcium arsenate, five to seven pounds per acre, are recommended. To be most effective the poison should be applied when the majority of the caterpillars are in the early stages of development.

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BULLETIN NO. 401 SEPTEMBER, 1929

THE COTTON-SQUARE BORER

H. J. REINHARD

The cotton-square borer, *Strymon melinus* Hubner, is one of the common insects encountered in the cotton fields of Texas. Although this species is not classed among the most economically important insect pests of cotton, nevertheless it attracts the attention of some growers practically every season by the injury it produces while feeding on the squares.

The insect is most abundant during the early part of the growing season, and usually by midsummer its numbers have been greatly reduced by natural enemies. Invariably this natural-control factor is so effective that only a small per cent of the larvæ and pupæ escape the attack of parasites during June and July. Consequently, the squares produced early in the season are most subject to attack by the cotton-square borer. Although this insect is widespread within the State, there are no cases on record where the larvæ have caused extensive injury to the crop. Sanderson (17) reports having seen 10 per cent of the stalks entirely denuded of squares in small fields in Texas where this insect was abundant. This extent of injury probably approximates the maximum and normally it is considerably less, although the extent of annual toll from the cotton crop of Texas is undoubtedly sufficient to class it as a cotton pest.

The nature of the injury done by the cotton-square borer is very similar in appearance to that done by the cotton bollworm. Both insects bore into the squares and eat the contents, after which the hollowed squares flare and are shed by the plant. For this reason the two insects oftentimes are confused by the layman. However, the two species are quite distinct. The cotton-square borer larva may be distinguished readily from the cotton bollworm by its flattened, oval-shaped body, that is densely covered with short hairs, giving it a velvety appearance. Its normal color varies from light-green to foliage-green without any contrasting color pattern. The adult or mature insect is a small, bluish-gray or slate-colored butterfly illustrated in Figure 4.

There are numerous references to this species in economic literature in which the insect is listed incidentally or mentioned in conjunction with other cotton insect pests. A few preliminary observations on its life history and habits have been published, but no details in this connection have been presented heretofore. The observations and data presented in this Bulletin have been taken at College Station as time and opportunity permitted during the past three or four years.

SYSTEMATIC HISTORY

The cotton-square borer was first described as *Strymon melinus* by Hubner (14) in 1818. The following year Godart (10) described the same species as *Polyommatus ergeus.* In 1833 Boisduval and Leconte (2) placed the species in the genus *Thecla,* describing it as new under two specific names, *hyperici* and *favonius.* Harris (11), during the same year, described it as *Thecla pan,* and again in 1841 (12) as *Thecla humili.* In 1847 Doubleday (5) described the same species new as *Thecla silenus,* but in 1852 (6) made this name a synonym of *Thecla melinus.* Henry Edwards (8) 1877 described a western variety as *Thecla pudica.* Scudder (18), in 1872, treated the species under the name *Callipareus melinus,* and in 1876 (19) erected the genus *Uranotes* with *melinus* as the type species. The combination *Uranotes melinus* obtained for many years and was used by practically all writers until 1917, when Barnes and McDunnough (1) again referred the species to the genus *Strymon.* According to Scudder (20), Dyar (7), and Barnes and McDunnough (1), the synonymy of *Strymon melinus* Hubner stands as follows:

Polyommatus ergeus Godart, 1819.
Thecla hyperici Boisduval and Leconte, 1833.
Thecla favonius Boisduval and Leconte, 1833.
Thecla pan Harris, 1833.
Thecla humili Harris, 1841.
Thecla silenus Doubleday, 1847.
Callipareus melinus Scudder, 1872.
Thecla melinus var. *pudica* Hy. Edwards, 1876.
Uranotes melinus Scudder, 1876.

COMMON NAMES

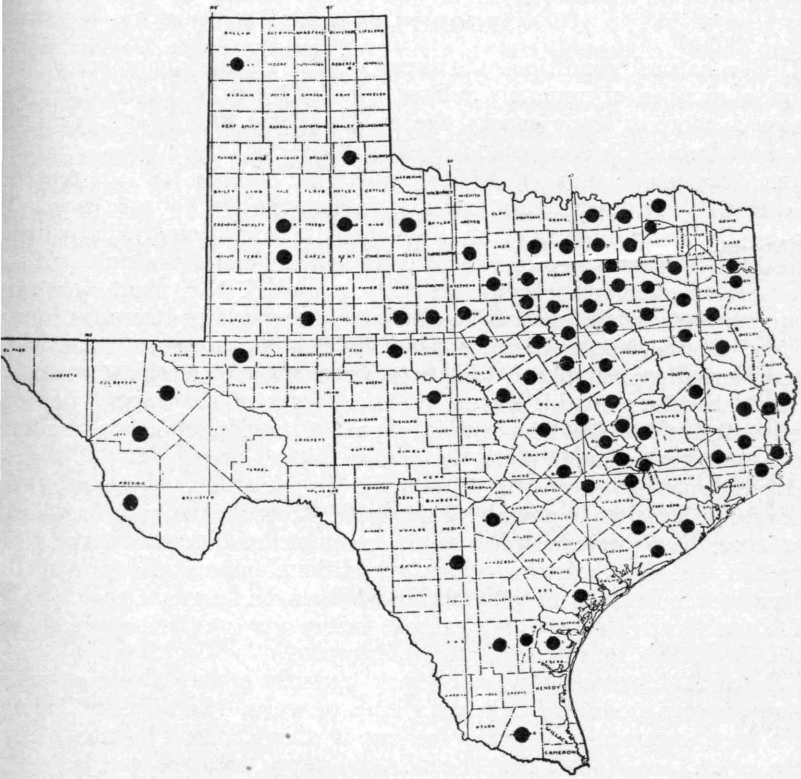
The adult stage of *Strymon melinus* has been referred to in literature by several common or popular names. The species is a member of a family of butterflies, commonly designated as the gossamer-winged or hair-streak butterflies. To differentiate it from related forms in this group, authors have called it "red spotted hair-streak butterfly," "gray hair-streak," "allied hair-streak," and "gray-streaked butterfly." When the larvæ of this species were discovered feeding upon hop vines such common names as "hop-vine Thecla," "hopeating Thecla," and "hop butterfly" were also applied to the insect. In recent literature, however, the adult insect is most frequently referred to as "the gray hair-streak."

In the Southern States where the larva of the insect attacks cotton squares the common name "cotton-square borer" has been generally used for the species. Although this common name has not been officially adopted by the American Association of Economic Entomologists, it appears to be a very suitable and descriptive name, applicable throughout

ıe section of the country where the insect may be classed as an eco-
ɔmic pest.

DISTRIBUTION

The counties within the State from which the cotton-square borer has
ɛen definitely recorded are indicated in Figure 1. The widespread
calities where the insect is known to occur indicate that its general



ɛ. 1.—Distribution of the cotton-square borer in Texas. Counties from which the insect has been recorded are indicated by dots.

nge of distribution probably includes many additional counties from
ıich it has not been reported. Its distribution in West and Northwest
ɛxas is represented by only a few authentic records; however, field
servations in Northwest Texas during August, 1928, showed that
ıare borer butterflies were rather abundant in cotton fields in the
cinity of Spur and Lubbock. In Brazos and the adjoining counties the
ecies is common practically every year, especially during the spring
d early summer months.

Holland (13) defines the general distribution of the cotton-square borer as temperate North America, ranging southward into Mexico and Central America at suitable elevations. Comstock (4) states the species occurs throughout the United States. French (9) includes the Atlantic States, Mississippi Valley, and Montana in its range of habitat. Leonard (15) lists it from New York; Britton (3) from Connecticut; Smith (21) from New Jersey; and Maynard (16) from California, Nevada, and Arizona. In addition to these states, the insect has also been reported from Oklahoma, Florida, Alabama, Mississippi, Louisiana, and New Mexico.

FOOD PLANTS

Under natural conditions the larvæ of the cotton-square borer feed upon a number of remotely related plants, which indicates that the species is more or less a general feeder. In Texas, the larvæ apparently are most frequently encountered feeding upon cotton, cowpea, bean, and okra. The insect shows a decided preference for the fruit or seedpod of each of these food plants, but also feeds upon the foliage, especially during the early instars of its development. Occasionally individuals have been observed in the field during midsummer hollowing out the seedpods of goatweed, *Croton capitatus*. Locally, this plant is a very common weed, but it does not appear to be an especially attractive source of food for the insect. During June, 1928, a cotton-square borer larva was collected on the silk of field corn, *Zea mays,* and reared to maturity in the laboratory on this source of food. Eggs of the insect have also been noted in the field on henbit, *Lamium amplexicaule,* although no larvæ were reared on this plant.

In Florida, Watson (22) reports this insect attacking loquat, *Eriobotrya,* and rearing it on this food plant. Hops, beans, and hawthorn, *Cratægus,* have been recorded as the most common food plants of the insect in the Northeastern States. Additional plants attacked by the cotton-square borer in this region include hound's tongue, *Cynoglossum;* St. John's-wort, *Hypericum;* cactus, *Echinocactus intertextus;* kidney bean, *Phaseolus;* bush clover, *Lespedeza;* and other legumes.

The adult insect or gray hair-streak butterfly apparently is attracted to any nectar-producing cultivated crop or weed. Locally, individuals have been commonly observed feeding in the blooms of cotton, bean, okra, cowpea, wild aster, pepper-vine, *Ampelopsis arborea;* trumpet weed, *Eupatorium purpureum;* mistletoe, *Phoradendron flavescens;* goatweed, *Croton capitatus,* and to a lesser extent on many other flowering plants.

ECONOMIC IMPORTANCE

Although the cotton-square borer does not rank among the most important insect enemies of cotton in Texas, yet it is capable of producing considerable injury to the crop when the optimum combination of favorable climatic conditions prevails for multiplication of the insect and repression of its natural enemies.

The squares produced by cotton plants early in the season are most subject to injury by square borer larvæ. However, there are no records available by which the extent of injury can be accurately measured. Local growers often improperly ascribe the injury done by this species to the cotton bollworm and ignore or completely overlook the potential destructive power of the larvæ of the cotton-square borer. Rearing records in the laboratory show that the larvæ of this species are voracious feeders, and each individual capable of destroying at least twenty to thirty squares during the course of its development. With this destructive capacity the insect, under favorable conditions, may become a cotton pest of considerable economic importance.

According to Sanderson (17) 10 per cent of the cotton stalks in small fields in Texas have been completely denuded of squares by this insect. This extent of injury is not a common occurrence and ordinarily it is considerably less. The destruction of three to six squares per plant over small areas has frequently been noted in local cotton fields.

METHODS OF STUDY

Detailed observations on the life history of the cotton-square borer were made in an open laboratory where the temperature and the humidity closely approximated natural conditions. Cotton was used as the food plant in rearing all individuals included in the life-history studies.

For the purpose of making observations on oviposition and securing material of known ancestry for other phases of the work, individual pairs of field-collected butterflies were placed in metal 16-mesh screen cages 6″x6″x10″ with a small branch of cotton inserted in a container of water to keep it fresh. The confined insects were fed at regular intervals in the morning and afternoon by placing small pieces of sterilized sponge soaked in a weak sugar solution on the top of the cage or by spraying the sweetened mixture directly onto the cage. At the end of each 24-hour period the insects were transferred to another thoroughly cleansed cage with a fresh cotton branch supplied for oviposition. The eggs deposited during each day were carefully removed from the plant and cage for observations on the duration of this stage. All eggs laid during the same 24-hour period were placed collectively in a glass vial (23x11 mm.) with the open end covered with one thickness of ordinary cheese-cloth. As soon as the eggs hatched the individual larva was isolated on fresh food placed in similar vials. Fresh food was supplied to each larva during the morning and afternoon of each day of its development. At the time of these semi-daily operations every individual was carefully noted for molts until the date of pupation. The pupæ were also kept isolated in individual vials and noted twice daily for emergence of adults.

In addition to the small metal screen cage used in the laboratory, two other types of larger wood frame 16-mesh screen cages measuring 2′x2′x4′ and 4′x4′x4′ were used in the field in attempting to mate the species in captivity. Apparently many of the insects reached sexual maturity; yet all efforts to secure fertile eggs from females reared in the laboratory were unsuccessful in all the types of cages used.

Throughout the warm season incidental field observations on the cotton-square borer were made locally by the writer. Other members of the Station Staff, as time and opportunity permitted, contributed general field notes on the insect in other sections of the State.

SEASONAL HISTORY

In the latitude of College Station adult cotton-square borers are active throughout the year, excepting December and January. Butterflies of the overwintering brood begin to appear during the latter part of February; the bulk of the brood appears during March and the first two weeks of April, and some belated stragglers after April 15. The available records on earliest oviposition in the field by females of the overwintering brood include the last week of March and the first week of April. It appears likely that with favorable climatic conditions eggs may be laid prior to that time. The major portion of the first generation of insects has matured by the latter part of May and the first week of June, and the adults of the cotton-square borer are usually present in maximum numbers at this time. Subsequent to this date the insect is continuously active and oviposition extends uninterruptedly throughout the warm season. The second generation, which develops during June and July, invariably is heavily parasitized. This results in a great reduction in the members of this generation which reach maturity, and adults become less noticeable in the field as the season advances.

Most writers state that this species has two generations in the North, but it appears safe to assume that three complete generations may occur in this latitude and southward, where the insect continues to breed in the fall as long as suitable food plants remain available. In the vicinity of San Antonio the butterflies are active during warm days throughout the winter months, indicating that the winter may be passed in the adult stage as well as the pupal stage. This point has not been definitely established for the species in the latitude of College Station.

In the northern limits of its distribution the insect is active in the field from May to September, and produces two broods during a season. Scudder (20) states that it probably hibernates in the pupal stage.

DESCRIPTION

Egg

In dorsal aspect the egg is circular in outline with a slight depression in the central area. The diameter is greatest about one-third the distance above the base, and from this point decreases rather sharply above and to a lesser extent below. The attached or under surface is irregularly flattened.

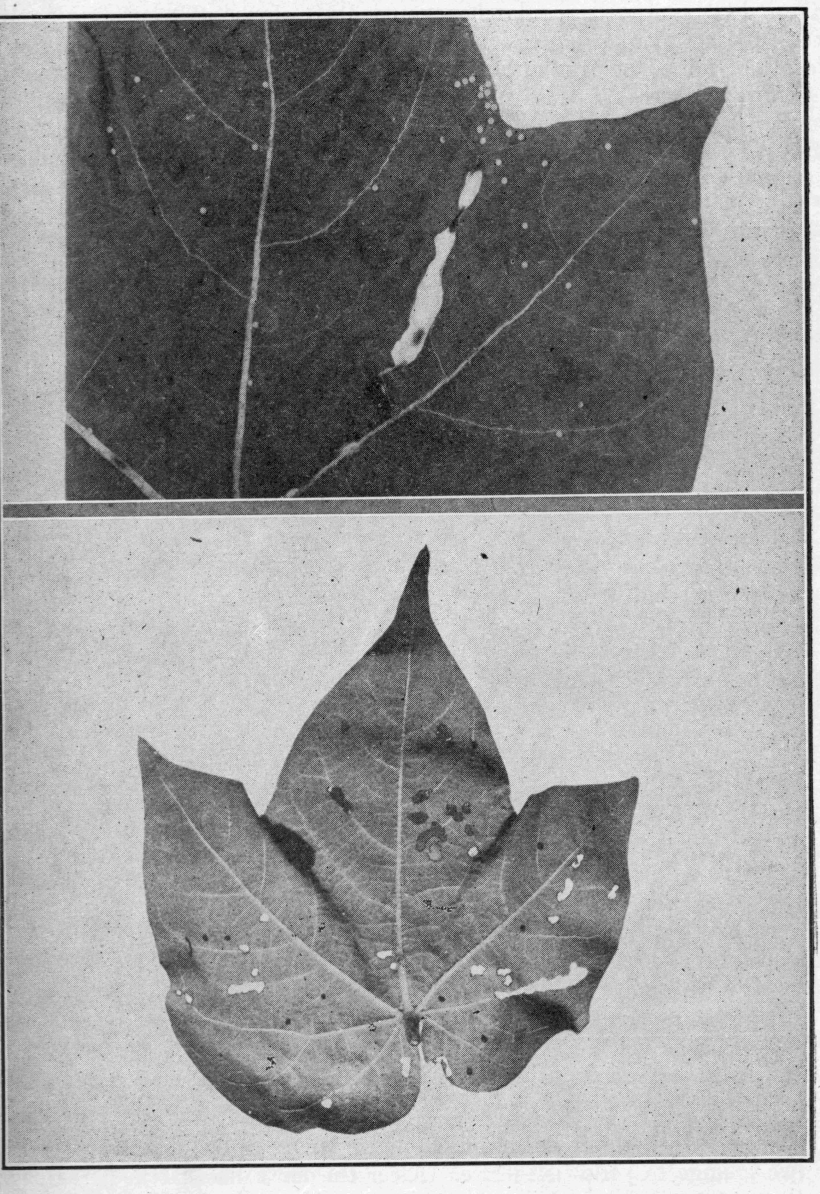


Fig. 2.—Above, eggs of the cotton-square borer laid in confinement on underside of cotton leaf; below, injury to cotton foliage by young larvae in confinement.

Under magnification the surface is conspicuously sculptured with rather deep and quite regular hexagonal depressions. The shining basal area of each pitlike depression bears a narrow, opaque, white, circular elevation, joined at brief intervals by delicate converging ridges extending inward from the sides of the depressions. These reticulations are smaller in the polar areas and are most apparent on the empty or hatched egg. The shell is opaque, thick, and rather tough, bearing more or less regularly arranged rows of short, blunt bristles.

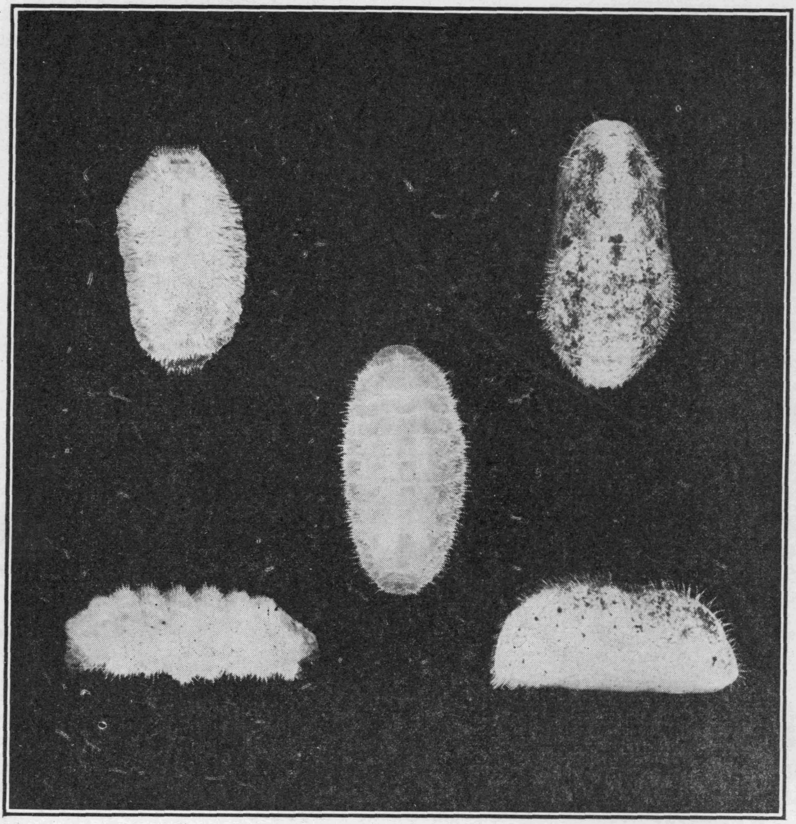


Fig. 3.—At left, mature larva of cotton-square borer; center, prepupal stage; right, pupa, all enlarged.

The eggs are pale-green or bluish-white when laid, but within a day or two change to yellowish-white. After the larva has hatched, the egg shell remains opaque and is pure white in color.

In size the eggs are slightly variable, ranging from 0.62 mm. to 0.72 mm. in diameter, and from 0.28 mm. to 0.32 mm. in height. The measurements of fifteen eggs selected at random averaged 0.679 mm. in diameter and 0.301 in height.

Larva

The caterpillar or larva, illustrated in Figure 3, is the stage in which the insect attacks and destroys cotton squares. The newly hatched larva averages about one millimeter in length and is greenish-white but turns darker in color shortly after feeding begins. The body is slender, subquadrate in cross-section, and clothed with several rows of long, pale, spiculated, bristly hairs. In dorsal aspect the head is fully exposed and but slightly narrower than the thorax. The narrow median dorsal and laterodorsal regions of the body are characteristically flattened and bounded by prominent tubercles, which bear clusters of conspicuous bristly hairs. On the dorsum the bristles curve uniformly backward and are distinctly longer than the body diameter of the larva. The lateral bristles are shorter, less curved, and directed laterally or only slightly backward. The body is paler beneath than above and sparsely clothed with short fine hairs. The legs and prolegs are short and also pale or light-greenish in color.

With each succeeding molt the larva increases proportionately faster in width than in length, and the body becomes flattened and more compact as maturity is approached. During the intermediate instars the bristly hairs become infuscated and the general color of the larva ranges from reddish-yellow to brown.

The full grown larva is short, flattened, about two and one-half times as long as wide, and tapers towards each broadly rounded extremity. The general color is variable, usually bright-green without any markings, but sometimes pale-green with faint darker stripes along the dorsum. The under side, including the legs, is uniform light-green in color. Larvæ which were reared in the laboratory for biological observations invariably were much darker in color throughout development, ranging from light-brown to almost black. The head is small, shining greenish-yellow and retracted beneath the body in front. The entire body is densely covered with bristly hairs of varying lengths, which effect a velvety appearance of the caterpillar as seen in the field. The vestiture is longer and denser at the body extremities and on the laterodorsal margins. As in the first instar, the hairs are largely pale and bear microscopic spicules.

The mature larvæ are subject to some variations in size, depending largely upon the amount and character of food consumed. Measurements of ten larvæ which were reared in the laboratory ranged from 12 mm. to 16 mm. in length and from 4.5 mm. to 6.5 mm. in width. These measurements were made with slide calipers to the nearest half millimeter.

Pupa

The pupa of the cotton-square borer varies in color from pale-yellow to brown and is covered with numerous blackish mottlings, which are variable in position, size, and intensity.

Viewed dorsally, the pupa is nearly ovate in outline with both extremities broadly rounded. A median transverse suture clearly defines the junction of the thorax and abdomen. Anterior to the suture the pupa is distinctly constricted or narrowed with the sides sloping sharply downward from a prominent rounded ridge extending along the longitudinal axis. Shortly posterior to the median transverse suture the sides bulge to the greatest width and then converge uniformly towards the posterior extremity. The abdominal segments of the insect are indicated by a series of distinct transverse sutures in the pupa case. The dorsum of the abdominal region is broadly convex and slopes abruptly downward towards the distal extremity. The entire dorsal surface of the pupa is more or less granular and sparsely covered with irregular rows of short pale or whitish bristles.

In lateral aspect the pupa appears almost straight on the ventral side and arches upward from both extremities, forming a semi-ovate outline. The constriction at the median transverse suture is noticeable above by a slight depression shortly before the middle. The rows of bristly hairs on the dorsum are most conspicuous along the median area and at the extremities. A large proportion of the central area of the pupa case is occupied by the insect's wing, the hind border of which is defined by a very definite suture that extends from the median transverse suture above diagonally downward towards the posterior, curving beneath at the distal border of the fourth abdominal segment. Under moderate magnification the wing area appears roughened, with faint traces of obscure reticulations present. The blackish mottlings usually do not extend upon the wing area, which is generally somewhat paler and is semi-translucent in appearance.

From the ventral side the pupa presents the same outline as when viewed from above, except that the posterior extremity is more prominent and less broadly rounded. The insect's eyes and head with its appendages are all clearly defined by distinct sutures. The proboscis extends along the median line to about the middle of the pupa case. At this point it is adjoined on either side by the antennal sutures, which originate near the middle of the anterior of the head. From the base they bow outwardly for a short distance and thence posteriorly inward, continuing parallel beyond the tip of the median proboscal suture and extend to the hind border of the wing areas. The latter are destitute of bristles or hairs and occupy most of the space outside of the antennal sutures, covering all but the last five abdominal segments, which are noticeably narrowed at the middle. Under magnification the wing areas appear roughened by slightly raised irregular reticulations. The abdominal segments are sparsely covered with irregular rows of pale or whitish bristles which vary in length. The distal segment is most prominent, with the bare central area bordered on each side, and to a lesser extent behind, with a group of minute modified spines. The latter are brownish and usually slightly bent below the enlarged or swollen tips. This specialized vestiture is rather inconspicuous without magnification.

The pupa is somewhat variable in size, ranging from 7.5 mm. to 10.5 mm. in length, and from 3.5 mm. to 5.0 mm. in width. The measurements of ten individuals which were reared in the laboratory averaged 9.1 mm. in length and 4.5 mm. in width. All measurements were made to the nearest half millimeter with slide calipers.

Adult

The adult cotton-square borer is a small, fragile, blue-gray butterfly, with a wing expanse ranging from 25 mm. to 32 mm.

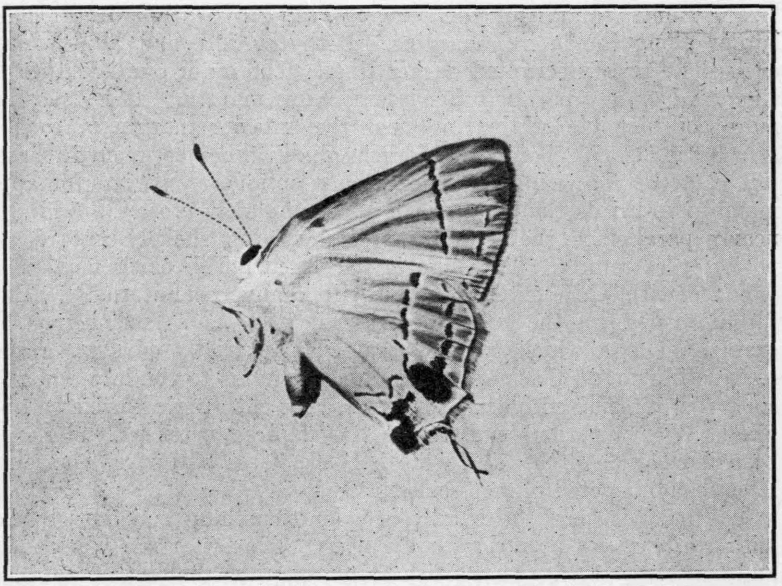


Fig 4.—Butterfly of the cotton-square borer, enlarged.

The upper surface of the wings is blackish with a faint blue-gray tinge except on the narrow posterior borders of the hind wings, where the coloration is decidedly paler. This area and anteriorly adjacent to it is rather densely covered with long, fine, gray hairs. The lateral margins of the wings are fringed with dense rows of scales, which are blackish along the basal area and grayish-white apically. The posterior lateral margins of the hind wings bear two slender tail-like prolongations. The black, briefly white-tipped anterior tail is short and rather inconspicuous in comparison with the posterior prolongation. The latter is considerably elongated, more or less twisted or coiled, black, bordered on the front edge with white, the tip bearing a dense tuft of contrasting white scales. Shortly inward between the bases of the tails a bright orange-red area superimposes a roundish black spot, which is crossed basally by a narrow bluish-white line extending distinctly towards the posterior and becomes obscured at a brief distance toward the anterior wing margin. Shortly inward from this line and parallel with it the wings are crossed by a series of irregular oblong bluish-white spots, which usually originate near the middle of the lateral margin and extend to the hind border. The outer posterior corner of the hind wing bears a rounded flaplike extension, which is deflected downward and densely fringed with long black and white scales. In the middle it bears an oblong dull orange-red spot, bordered with black on either side and white in front.

The under surface of the wings is ash-gray with a linear blackish border along the lateral margins. Both the fore and hind wings are crossed by two interrupted darker lines. The outer one is rather indistinct and closely parallels the lateral wing margin. The inner line is more conspicuous, originating near the anterior margin of each wing at a point located about three-fourths the distance between the base and tip. On the fore wing the line extends obliquely outward for approximately two-thirds the wing width and completely crosses the hind wing nearly parallel to the lateral margin, curving sharply inward at the posterior extremity. This line is tricolored. The black median stripe is edged with white externally and with orange-red internally. Extending inward from the base of each tail there is a conspicuous bright orange-red area which, at the basal edge, partially envelops a sharply contrasting round black spot. Located posterior to the latter is a larger spot with intermixed black and white scales effecting a checkered appearance. The upturned surface of the flaplike extension at the outer posterior corner of the hind wing is black, bordered in front largely with irregularly disposed orange scales.

The head is small, distinctly broader than long and densely clothed with white scales posterior to the eyes. The latter are blackish-brown and densely covered with whitish hairs except on the narrow hind border. A thick layer of white scales intermixed with moderately long white bristly hairs completely covers the face. In the middle of the frons the scales are white and orange and the lateral areas posterior to the antennæ are rather scantily clothed with short blackish hairs. The vertex is orange, bordered behind with black scales and long whitish hairs. The slender, straight, black antennæ are narrowly ringed with white scales at the base of each segment and the club is conspicuously tipped with orange.

The thorax is rather narrow, black above and thickly clothed with grayish hairs on the sides and to a lesser extent on the dorsum. The ventral side is completely covered with a dense vestiture of pure white silky hairs and scales. The legs, except the tarsal joints, are wholly clothed with white scales and concolorous long hairs on the ventral surface of the femora. On the upper side of the tarsal joints the scales are black basally and white on the narrow distal ends.

The abdomen is slender, compressed laterally, and strongly arched above along the longitudinal axis, which is more apparent in dried or preserved specimens. The dorsal surface is concolorous with the thorax, at least basally, and sometimes tinged with yellowish-orange and white apically. The venter bears a thick layer of coarse white closely appressed scales.

LIFE HISTORY

Mating and Fertility

In the field, the butterflies of the cotton-square borer have been observed frequently in the process of mating, which usually occurs late in the evening or shortly before sunset. During the act of copulation the insects remain seated on the plant faced in opposite directions with the tips of their abdomens united and the wings held in the normal upright position. They may remain united in this position for a half hour or more if not disturbed. The maximum time and the average time consumed in the act were not determined.

Although mating appears to occur sedentarily with this species, it was not observed to take place among laboratory-reared individuals within the confinement of cages placed over plants growing in the field or in the laboratory. In every case apparently sexually matured virgin females which were confined with active males failed to produce any fertile eggs.

Laboratory observations show that when fertilization has been effected in the field the eggs deposited subsequently by females placed in confinement without the further presence of any male are fertile. In other words, one mating appears sufficient to insure fertilization of at least the average number of eggs laid by each female.

Oviposition

The eggs are laid singly by the female and normally they are attached rather firmly to the foliage of the food plant. Quite often they are deposited also on the blooms, fruits, or seedpods. In the laboratory, caged females oviposited most actively after 5 o'clock in the afternoon and before 8 o'clock in the morning. Only rarely has oviposition been observed to occur in the field during that portion of the day when the insects are most active. There is some tendency for females to lay the eggs in protected situations, as along the larger leaf-veins or between the bracts of the squares and similar places. This tendency appears more pronounced among caged individuals. In confinement, field-collected females laid as many, or even more, eggs on the sides and bottoms of the cages as they did on the cotton foliage supplied for the purpose. Occasionally a few eggs were found loose on the bottoms of the cages.

Shortly after the appearance of the adults in the spring oviposition begins and is continued throughout the warm season. Since the adult insects are long-lived in nature, the period of oviposition probably extends over a considerable period of time. The data secured in the laboratory on this point are given in Table 1. In this connection it should be pointed out that the insect does not withstand confinement very readily and usually succumbs within two weeks. Moreover, the females failed to mate in the cages used and the data represent only the duration of the oviposition period of virgin females. It appears certain that the period over which eggs are laid under natural conditions is considerably longer than indicated by these data.

Table 1. Duration of oviposition period in confinement, 1928.

Pair number	First egg laid	Last egg laid	Oviposition period, days	Temperature mean
1	July 29	Aug. 6	9	83.7
3	July 30	Aug. 3	5	83.9
4	Aug. 1	Aug. 6	6	84.3
6	Aug. 2	Aug. 8	7	84.8
8	Aug. 7	Aug. 15	9	86.2
9	Aug. 8	Aug. 15	8	86.2
11	Aug. 7	Aug. 15	9	86.2
12	Aug. 9	Aug. 15	7	86.3
13	Aug. 11	Aug. 18	8	85.7
16	Aug. 15	Aug. 20	6	85.7

The figures secured on the total number of eggs laid and the daily rate of oviposition in the laboratory are given in Table 2. It should be noted that these data, for the reasons indicated in the preceding paragraph, may not be a very close approximation of either the rate at which eggs are laid or the total number produced under natural conditions. In confinement, oviposition occurred at a rapid rate over a period of four and five days, shortly after which the infertile females died. Since the insect is long-lived in nature, there is a considerable period of time during which ova may be developed within the uterus. This point, considered in conjunction with the fact that the eggs are not laid in groups or batches, but singly and generally over plants in the field, may be considered as evidence that fertile females may lay a larger number of eggs at a more uniform rate over a longer period of time than the data indicate for the caged individuals.

Incubation Period

Laboratory records on the incubation period of thirty-four individual egg lots during June and July are given in Table 3. The mean temperatures indicated are the averages of the daily extremes affecting all the eggs of each individual lot. When effective mean temperatures

Table 2. Daily oviposition records of individual pairs of cotton-square borer butterflies in confinement, 1928.

Date	Average mean temper ature	Pair number									
		1	3	4	6	8	9	11	12	13	16
July 26	79.5	E M									
July 27	81.5	0	E M								
July 28	81.5	0	0								
July 29	82.0	9	0								
July 30	82.0	20	2	E M							
July 31	84.0	16	18	0	E M						
Aug. 1	83.5	19	10	3	0						
Aug. 2	85.0	10	17	0	4						
Aug. 3	85.0	8	12	0	6						
Aug. 4	84.0	0	0	4	4	E M					
Aug. 5	83.5	0	0	7	7	0					
Aug. 6	85.0	5	0	6	14	0	E M	E M			
Aug. 7	86.0	0	.....	0	10	4	0	2	E M		
Aug. 8	85.5	0	.....	.....	11	7	4	9	0	E M	
Aug. 9	88.5	0	.....	.....	0	13	0	7	4	0	
Aug. 10	87.0	.....	.....	.....	0	10	0	6	4	0	
Aug. 11	85.5	.....	.....	.....	.....	6	7	8	3	5	
Aug. 12	86.5	.....	.....	.....	.....	12	6	1	7	4	E M
Aug. 13	87.0	.....	.....	.....	.....	4	3	0	10	14	0
Aug. 14	85.0	.....	.....	.....	.....	0	5	0	11	11	0
Aug. 15	85.0	.....	.....	.....	.....	1	1	1	13	16	2
Aug. 16	85.5	.....	.....	.....	.....	0	.....	0	0	2	14
Aug. 17	86.0	.....	.....	.....	.....	.....	.....	.....	0	4	9
Aug. 18	85.5	.....	.....	.....	.....	.....	.....	.....	.....	4	16
Aug. 19	84.5	.....	.....	.....	.....	.....	.....	.....	.....	0	2
Aug. 20	88.0	.....	.....	.....	.....	.....	.....	.....	.....	0	3
Aug. 21	88.0	.....	.....	.....	.....	.....	.....	.....	.....	0	0
Aug. 22	87.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	0

E M—Emerged, Mated.

Table 3. Duration of egg stage during summer, 1928.

Laid		Hatched		Total egg days	Weighted average incubation period days	Temperature mean
Date	Lot No.	Date	No. eggs hatched			
June 21	1	June 25-27	81	430	5.30	80.6
June 22	2	June 28	14	84	6.00	80.5
June 23	3	June 29-30	19	118	6.21	80.6
July 1	4	July 6-7	8	46	5.75	82.0
July 2	5	July 6-8	21	116	5.52	81.5
July 3	6	July 8-9	20	116	5.80	81.4
July 4	7	July 9-10	2	11	5.50	81.3
July 5	8	July 10-12	36	213	5.91	81.4
July 6	9	July 10-12	20	111	5.55	81.1
July 7	10	July 11-13	13	73	5.61	81.5
July 8	11	July 12-14	21	113	5.38	82.3
July 9	12	July 14-15	11	63	5.72	82.9
July 10	13	July 16	7	42	6.00	83.1
July 11	14	July 15-17	6	33	5.50	83.4
July 12	15	July 16-18	9	52	5.77	83.7
July 13	16	July 19	8	48	6.00	84.2
July 14	17	July 19-20	16	91	5.68	84.5
July 15	18	July 19-21	22	127	5.77	84.7
July 16	19	July 21-22	12	69	5.75	85.2
July 17	20	July 21-23	11	63	5.72	85.8
July 18	21	July 23-24	7	40	5.71	85.7
July 19	22	July 24-25	8	45	5.62	85.7
July 20	23	July 24-26	90	448	4.97	85.6
July 21	24	July 25-26	78	383	4.91	85.5
July 22	25	July 26-27	45	224	4.97	84.1
July 23	26	July 27-28	25	123	4.92	83.2
July 24	27	July 28-29	38	189	4.97	82.0
July 25	28	July 29-31	41	236	5.75	81.8
July 26	29	July 31	32	160	5.00	81.1
July 27	30	July 31-August 2	80	458	5.72	82.3
July 28	31	August 2-3	97	512	5.27	82.6
July 29	32	August 2-4	26	155	5.96	83.6
July 30	33	August 3-5	42	221	5.26	83.8
July 31	34	August 3-6	59	327	5.54	84.2

remain fairly uniform, the incubation period of the eggs is not subject to any marked fluctuations. The weighted average for the period of incubation of 1025 eggs, in mean temperatures ranging from 80.6 to 85.8 degrees F., was 5.56 days. Lower temperatures early and late in the active season probably are effective in increasing the time required for incubation of the eggs.

Some incidental field observations made in this connection during July and August, 1923, indicate that cotton-square borer eggs may hatch within a period of two or three days. However, these minimum incubation periods were not observed to occur in the laboratory during June and July, 1928, when the data presented in Table 3 were recorded.

Hatching

Soon after complete embryonic development has been attained, the larva becomes active and begins eating its way through the egg shell. The exit hole, which is eaten through the upper portion of the egg, is irregular in outline and quite variable in size, sometimes including practically the entire upper portion of the shell. Normally, however, the larva enlarges the exit just to the extent of permitting its body to pass through. When completely emerged it does not continue to feed upon the remains of the egg shell. Under favorable conditions the process of hatching may be completed within a half hour, although some individuals under observation in the laboratory required more than one hour to eat their way through the shell and emerge from the eggs. The empty egg shell remains attached and is pure white in color, which makes it a decidedly more conspicuous object than the unhatched egg on the foliage of the food plant.

Larval Development

Records on the development of 134 individuals reared in the laboratory from June 25 to August 16, 1928, are presented in Table 4. The mean temperatures given are the averages of the daily extremes obtaining during the development of each larva. Normally, five molts occur during the larval period. The first three instars are approximately of equal duration with the maximum number of individuals completing the growth for these instars in three to four and one-half days. The fourth instar comprises approximately four and one-half days and is subject to greater variations than the preceding instars. About one-third of the time required for complete larval development is spent in the fifth or final instar, which includes the prepupal period.

A summary of the detailed observations on larval development is given in Table 5. It will be noted that considerable variations in the time required for the various instars occurred, especially during the last two periods of larval development. Since all individuals were reared under similar conditions and were fed the same kind of food, viz., fresh

Table 4. Records on larval development, 1928.

Date hatched	Date of first molt	Duration of first instar days	Date of second molt	Duration of second instar days	Date of third molt	Duration of third instar days	Date of fourth molt	Duration of fourth instar days	Date of fifth molt	Duration of fifth instar days	Total duration of larval period, days	Average mean temperature
Average....	....	3.61	....	3.36	....	3.55	....	4.84	....	7.69	23.05	83.07
June 25, p.m.	June 29, a.m.	3.5	July 2, p.m.	3.5	July 6, a.m.	3.5	July 9, p.m.	3.5	July 17, p.m.	8.0	22.0	81.7
June 25, p.m.	June 29, a.m.	3.5	July 2, p.m.	3.5	July 5, p.m.	3.0	July 10, a.m.	4.5	July 16, p.m.	6.5	21.0	81.6
June 25, p.m.	June 29, a.m.	3.5	July 2, p.m.	3.5	July 5, p.m.	3.0	July 9, p.m.	4.0	July 16, p.m.	7.0	21.0	81.6
June 25, p.m.	June 29, a.m.	3.5	July 2, p.m.	3.5	July 6, a.m.	3.5	July 11, p.m.	5.5	July 19, a.m.	7.5	23.5	82.1
June 25, p.m.	June 29, p.m.	4.0	July 3, p.m.	4.0	July 6, p.m.	3.0	July 12, a.m.	5.5	July 19, a.m.	7.0	23.5	82.1
June 25, p.m.	June 29, a.m.	3.5	July 2, p.m.	3.5	July 5, p.m.	3.0	July 10, a.m.	4.5	July 16, p.m.	6.5	21.0	81.6
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 7, a.m.	4.5	July 11, a.m.	4.0	July 18, p.m.	7.5	22.5	82.0
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 7, p.m.	4.0	July 11, p.m.	4.0	July 20, a.m.	8.5	24.0	82.3
June 26, a.m.	June 29, p.m.	3.5	July 4, p.m.	5.0	July 9, a.m.	4.5	July 13, a.m.	4.0	July 19, a.m.	6.0	23.0	82.2
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 11, a.m.	5.5	July 19, a.m.	8.0	23.0	82.2
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 9, p.m.	4.0	July 17, p.m.	8.0	21.5	81.9
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 6, p.m.	3.0	Died					81.7
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 6, p.m.	3.0	July 10, p.m.	4.0	July 17, p.m.	7.0	21.5	81.9
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 6, p.m.	3.0	July 11, a.m.	4.5	July 18, p.m.	7.5	22.5	82.0
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 9, a.m.	5.5	July 13, a.m.	4.0	July 23, p.m.	10.5	27.5	82.8
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 6, p.m.	4.0	July 10, p.m.	4.0	July 18, p.m.	8.0	22.5	82.0
June 26, a.m.	June 30, p.m.	4.5	July 3, p.m.	3.0	July 8, a.m.	4.5	July 13, a.m.	5.0	July 21, p.m.	8.5	25.5	82.5
June 26, a.m.	July 1, a.m.	5.0	July 3, p.m.	2.5	July 8, a.m.	4.5	July 12, p.m.	4.5	July 21, p.m.	9.0	25.5	82.5
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 10, p.m.	5.0	July 17, p.m.	7.0	21.5	81.9
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 9, p.m.	4.0	July 16, p.m.	7.0	20.5	81.9
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 6, p.m.	4.0	July 11, p.m.	5.0	July 19, p.m.	8.0	23.5	82.2
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 10, a.m.	4.5	July 18, a.m.	8.0	22.0	82.0
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 9, p.m.	4.0	July 17, p.m.	8.0	21.5	81.9
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 6, p.m.	3.0	July 10, p.m.	4.0	July 18, p.m.	8.0	22.5	82.0
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 6, p.m.	3.0	July 10, p.m.	4.0	July 18, p.m.	8.0	22.5	82.0
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 10, a.m.	4.5	July 16, p.m.	6.5	20.5	81.9
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 10, a.m.	4.5	July 17, p.m.	7.5	21.5	81.9
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 8, a.m.	4.5	July 13, a.m.	5.0	July 20, p.m.	7.5	24.5	82.4
June 26, a m.	June 30, p.m.	4.5	July 3, p.m.	3.0	July 8, a.m.	4.5	July 18, a.m.	10.0	July 25, p.m.	7.5	29.5	82.9
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 7, a.m.	3.5	July 11, p.m.	4.5	July 18, a.m.	6.5	22.0	82.0
June 26, a.m.	June 29, p.m.	3.5	July 9, a.m.	9.5	July 13, a.m.	4.0	July 17, a.m.	4.0	July 24, p.m.	7.5	28.5	82.8
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 6, p.m.	3.0	July 10, p.m.	4.0	July 19, a.m.	8.5	23.0	82.2
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 7, a.m.	3.5	July 12, a.m.	5.0	July 19, a.m.	7.0	23.0	82.2
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 10, a.m.	4.5	July 18, p.m.	8.5	22.5	82.0
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 6, p.m.	4.0	July 10, p.m.	4.0	July 18, p.m.	8.0	22.5	82.0
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 10, a.m.	4.5	July 17, p.m.	7.5	21.5	81.9
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 6, p.m.	3.0	July 10, p.m.	4.0	July 18, p.m.	8.0	22.5	82.0

Table 4. Records on larval development, 1928.

Date hatched	Date of first molt	Duration of first instar days	Date of second molt	Duration of second instar days	Date of third molt	Duration of third instar days	Date of fourth molt	Duration of fourth instar days	Date of fifth molt	Duration of fifth instar days	Total duration of larval period, days	Average mean temperature
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 10, a.m.	4.5	July 17, p.m.	7.5	21.5	81.9
June 26, a.m.	June 30, p.m.	4.5	July 3, p.m.	3.0	July 7, a.m.	3.5	July 12, a.m.	5.0	July 19, p.m.	7.5	23.5	82.2
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 10, p.m.	5.0	July 18, p.m.	8.0	22.5	82.0
June 26, a.m.	June 29, p.m.	3.5	July 2, p.m.	3.0	July 5, p.m.	3.0	July 10, p.m.	5.0	July 20, p.m.	10.0	24.5	82.4
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 6, p.m.	3.0	July 11, p.m.	5.0	July 19, a.m.	7.5	23.0	82.2
June 26, a.m.	June 29, p.m.	3.5	July 3, p.m.	4.0	July 6, p.m.	3.0	July 10, p.m.	4.0	July 17, p.m.	7.0	21.5	81.9
June 27, a.m.	June 30, a.m.	3.0	July 3, p.m.	3.5	July 6, p.m.	3.0	July 10, p.m.	4.0	July 18, a.m.	7.5	21.0	82.3
June 27, a.m.	June 30, a.m.	3.0	July 3, p.m.	3.5	July 6, p.m.	3.0	July 11, p.m.	5.0	July 19, a.m.	7.5	22.0	82.1
June 27, a.m.	June 30, a.m.	3.0	July 3, p.m.	3.5	July 6, p.m.	3.0	July 11, p.m.	5.0	July 21, a.m.	9.5	24.0	82.8
June 27, a.m.	June 30, p.m.	3.5	July 3, p.m.	3.0	July 6, p.m.	3.0	July 10, p.m.	4.0	July 17, p.m.	7.0	20.5	82.2
June 27, a.m.	June 30, p.m.	3.5	July 3, p.m.	3.0	July 6, p.m.	3.0	July 11, a.m.	4.5	July 18, p.m.	7.5	21.5	82.3
June 28, a.m.	July 1, p.m.	3.5	July 4, p.m.	3.0	July 8, a.m.	3.5	July 12, p.m.	4.5	July 20, a.m.	7.5	22.0	82.9
June 28, a.m.	July 1, p.m.	3.5	July 4, p.m.	3.0	July 9, a.m.	4.5	July 14, p.m.	5.5	July 21, p.m.	7.0	23.5	83.0
June 30, a.m.	July 2, p.m.	2.5	July 6, p.m.	4.0	July 10, p.m.	4.0	July 15, a.m.	4.5	July 21, a.m.	6.0	21.0	83.0
June 29, p.m.	July 4, a.m.	4.5	July 7, p.m.	3.5	July 11, p.m.	4.0	July 16, a.m.	4.5	July 22, p.m.	6.5	23.0	83.1
June 30, a.m.	July 4, a.m.	4.0	July 7, p.m.	3.5	July 11, p.m.	4.0	Died					81.9
July 6, a.m.	July 10, p.m.	4.5	July 14, a.m.	3.5	July 17, p.m.	3.5	July 26, a.m.	8.5	Aug. 2, a.m.	7.0	27.0	83.1
July 6, a.m.	July 9, p.m.	3.5	July 13, p.m.	4.0	July 17, p.m.	4.0	July 23, a.m.	5.5	July 31, p.m.	8.5	25.5	83.1
July 7, a.m.	July 11, a.m.	4.0	July 13, p.m.	2.5	July 17, p.m.	4.0	July 22, a.m.	4.5	July 29, p.m.	7.5	22.5	83.2
July 7, a.m.	July 11, a.m.	4.0	July 14, p.m.	3.5	July 18, p.m.	4.0	July 23, a.m.	4.5	July 30, p.m.	7.5	23.5	83.1
July 7, a.m.	July 11, a.m.	4.0	July 13, p.m.	2.5	July 17, p.m.	4.0	July 23, a.m.	5.5	Died			83.6
July 7, a.m.	July 11, p.m.	4.5	July 14, p.m.	3.0	July 17, p.m.	3.0	July 21, p.m.	4.0	Aug. 1, p.m.	11.0	25.5	83.2
July 7, a.m.	July 11, p.m.	4.5	July 15, p.m.	4.0	July 18, a.m.	2.5	July 23, p.m.	5.5	July 31, p.m.	8.0	24.5	83.2
July 7, a.m.	July 11, p.m.	4.5	July 15, p.m.	4.0	July 18, p.m.	3.0	July 23, a.m.	4.5	July 30, p.m.	7.5	23.5	83.1
July 7, p.m.	July 11, p.m.	4.0	July 14, p.m.	3.0	July 17, p.m.	3.0	July 22, a.m.	4.5	July 30, a.m.	8.0	22.5	83.1
July 7, p.m.	July 11, p.m.	4.0	July 14, p.m.	3.0	July 17, p.m.	3.0	July 23, a.m.	5.5	July 30, p.m.	7.5	23.0	83.1
July 7, p.m.	July 11, p.m.	4.0	July 15, a.m.	3.5	July 18, p.m.	3.5	July 23, a.m.	4.5	July 31, a.m.	8.0	23.5	83.2
July 7, p.m.	July 11, p.m.	4.0	July 14, p.m.	3.0	July 18, p.m.	4.0	July 23, p.m.	5.0	Aug. 3, p.m.	11.0	27.0	83.3
July 7, p.m.	July 11, p.m.	4.0	July 14, p.m.	3.0	July 18, p.m.	4.0	July 23, a.m.	4.5	July 29, p.m.	6.5	22.0	83.2
July 7, p.m.	July 11, p.m.	4.0	July 14, p.m.	3.0	July 17, p.m.	3.0	July 22, a.m.	4.5	July 29, a.m.	7.0	21.5	83.2
July 8, a.m.	July 11, p.m.	3.5	July 14, p.m.	3.0	July 17, p.m.	3.0	July 22, a.m.	4.5	July 29, a.m.	7.0	21.0	83.4
July 8, a.m.	July 11, p.m.	3.5	July 14, p.m.	3.0	July 18, p.m.	4.0	July 23, a.m.	4.5	July 30, a.m.	7.0	22.0	83.3
July 8, a.m.	July 11, p.m.	3.5	July 15, p.m.	4.0	July 19, p.m.	4.0	July 24, a.m.	4.5	Aug. 1, p.m.	8.5	24.5	83.4
July 8, a.m.	July 11, p.m.	3.5	July 14, p.m.	3.0	July 17, p.m.	3.0	July 21, a.m.	3.5	Aug. 1, p.m.	11.5	24.5	83.4
July 8, a.m.	July 11, p.m.	3.5	July 14, p.m.	3.0	July 17, p.m.	3.0	July 23, a.m.	5.5	July 30, p.m.	7.5	22.5	83.3
July 8, a.m.	July 11, p.m.	3.5	July 14, p.m.	3.0	July 17, p.m.	3.0	July 22, a.m.	4.5	July 29, p.m.	7.5	21.5	83.4
July 8, a.m.	July 11, p.m.	3.5	July 16, p.m.	5.0	July 19, p.m.	3.0	July 23, p.m.	4.0	July 31, a.m.	7.5	23.0	83.3
July 8, a.m.	July 11, p.m.	3.5	July 14, p.m.	3.0	July 17, p.m.	3.0	July 22, a.m.	4.5	July 29, a.m.	7.0	21.0	83.4
July 8, a.m.	July 11, p.m.	3.5	July 14, p.m.	3.0	July 18, p.m.	4.0	July 23, a.m.	4.5	July 31, a.m.	8.0	23.0	83.3

July 9, p.m.	July 12, p.m.	3.0	July 15, p.m.	3.0	July 18, p.m.	3.0	July 23, a.m.	4.5	July 30, p.m.	7.5	21.0	83.5
July 9, p.m.	July 12, p.m.	3.0	July 15, p.m.	3.0	July 18, p.m.	3.0	July 23, a.m.	4.5	July 31, a.m.	8.0	21.5	83.6
July 9, p.m.	July 12, p.m.	3.0	July 15, p.m.	3.0	July 18, p.m.	3.0	July 23, a.m.	4.5	July 30, a.m.	7.0	20.5	83.5
July 9, p.m.	July 12, p.m.	3.0	July 15, p.m.	3.0	July 18, p.m.	3.0	July 23, a.m.	4.5	July 31, p.m.	8.5	22.0	83.6
July 9, p.m.	July 12, p.m.	3.0	July 15, p.m.	3.0	July 18, p.m.	3.0	July 23, a.m.	4.5	July 30, a.m.	7.0	20.5	83.5
July 9, p.m.	July 12, p.m.	3.0	July 15, p.m.	3.0	July 18, p.m.	3.0	Died					83.3
July 9, p.m.	July 12, p.m.	3.0	July 15, p.m.	3.0	July 18, p.m.	3.0	July 23, a.m.	4.5	Aug. 1, a.m.	9.0	22.5	83.6
July 9, p.m.	July 12, p.m.	3.0	July 15, p.m.	3.0	July 18, p.m.	3.0	July 23, a.m.	4.5	July 31, a.m.	8.0	21.5	83.6
July 9, p.m.	July 12, p.m.	3.0	July 15, p.m.	3.0	July 18, p.m.	3.0	July 23, a.m.	4.5	July 31, a.m.	8.0	21.5	83.6
July 9, p.m.	July 12, p.m.	3.0	July 16, p.m.	4.0	July 25, a.m.	8.5	July 29, p.m.	4.5	Aug. 3, p.m.	5.0	25.0	83.7
July 9, p.m.	July 12, p.m.	3.0	July 16, p.m.	4.0	July 19, p.m.	3.0	July 24, a.m.	4.5	July 31, p.m.	7.5	22.0	83.6
July 9, a.m.	July 12, p.m.	3.5	July 15, p.m.	3.0	July 19, p.m.	4.0	July 24, a.m.	4.5	July 31, p.m.	7.5	22.5	83.6
July 10, p.m.	July 14, p.m.	4.0	July 18, p.m.	4.0	July 21, p.m.	3.0	July 27, a.m.	5.5	Aug. 4, a.m.	8.0	24.5	83.7
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 20, p.m.	3.0	July 25, p.m.	5.0	Aug. 2, a.m.	7.5	22.0	83.8
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 21, a.m.	3.5	July 26, a.m.	5.0	Aug. 3, a.m.	8.0	23.0	83.8
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 20, p.m.	3.0	July 26, p.m.	6.0	Aug. 2, a.m.	6.5	22.0	83.8
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 21, p.m.	4.0	July 27, a.m.	5.5	Aug. 4, a.m.	8.0	24.0	83.8
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 22, a.m.	4.5	July 26, a.m.	4.0	Aug. 2, a.m.	7.0	22.0	83.8
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 20, p.m.	3.0	July 25, a.m.	4.5	Aug. 1, a.m.	7.0	21.0	83.7
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 21, p.m.	4.0	July 26, a.m.	4.5	Aug. 5, a.m.	10.0	25.0	83.8
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 21, p.m.	4.0	July 26, a.m.	4.5	Aug. 3, p.m.	8.5	23.5	83.8
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 21, p.m.	4.0	July 27, a.m.	5.5	Aug. 4, a.m.	8.0	24.0	83.8
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 20, p.m.	3.0	July 25, a.m.	4.5	Aug. 1, a.m.	7.0	21.0	83.7
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 20, p.m.	3.0	July 25, a.m.	4.5	Aug. 1, a.m.	7.0	21.0	83.7
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 20. p.m.	3.0	July 25, a.m.	4.5	Aug. 1, p.m.	7.5	21.5	83.7
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 20, p.m.	3.0	July 25, a.m.	4.5	Aug. 1, p.m.	7.5	21.5	83.7
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 20, p.m.	3.0	July 26, a.m.	5.5	Aug. 2, p.m.	7.5	22.5	83.8
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 20, p.m.	3.0	July 25, a.m.	4.5	Aug. 1, a.m.	7.0	21.0	83.7
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 20, p.m.	3.0	July 26, a.m.	5.5	Aug. 3, a.m.	8.0	23.0	83.8
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 21, p.m.	4.0	July 26, a.m.	4.5	Aug. 3, a.m.	8.0	23.0	83.8
July 11, a.m.	July 14, p.m.	3.5	July 17, p.m.	3.0	July 20, p.m.	3.0	July 25, a.m.	4.5	Aug. 1, p.m.	7.5	21.5	83.7
July 11, a.m.	July 14, p.m.	3.5	July 18, p.m.	4.0	July 22, p.m.	4.0	July 28, a.m.	5.5	Aug. 5, a.m.	8.0	25.0	83.8
July 11, a.m.	July 14, p.m.	3.5	July 18, p.m.	4.0	July 22, p.m.	4.0	July 27, a.m.	4.5	Aug. 4, a.m.	8.0	24.0	83.8
July 12, p.m.	July 15, a.m.	2.5	July 19, p.m.	4.5	July 22, p.m.	3.0	July 27, a.m.	4.5	Aug. 2, a.m.	6.0	20.5	83.8
July 12, p.m.	July 15, a.m.	2.5	July 19, p.m.	4.5	July 22, p.m.	3.0	July 27, a.m.	4.5	Aug. 4, a.m.	8.0	22.5	83.9
July 13, a.m.	July 17, p.m.	4.5	July 20, p.m.	3.0	July 24, a.m.	3.5	July 29, a.m.	5.0	Aug. 5, a.m.	7.0	23.0	83.9
July 13, a.m.	July 17, p.m.	4.5	July 20, p.m.	3.0	July 24, a.m.	3.5	July 29, a.m.	5.0	Aug. 5, a.m.	7.0	23.0	83.9
July 13, a.m.	July 17, p.m.	4.5	July 20, p.m.	3.0	July 24, a.m.	3.5	July 29, p.m.	5.5	Aug. 6, p.m.	8.0	24.5	84.0
July 13, p.m.	July 17, p.m.	4.0	July 20, p.m.	3.0	July 24, a.m.	3.5	July 29, a.m.	5.0	Aug. 5, a.m.	7.0	22.5	83.9
July 13, a.m.	July 17, p.m.	4.5	July 20, p.m.	3.0	July 25, p.m.	5.0	July 31, a.m.	5.5	Aug. 7, a.m.	7.0	25.0	84.0
July 13, p.m.	July 17, p.m.	4.0	July 20. p.m.	3.0	July 25, p.m.	5.0	July 29, p.m.	4.0	Aug. 11, a.m.	12.5	28.5	84.4
July 13, p.m.	July 17, p.m.	4.0	July 20, p.m.	3.0	July 25, p.m.	5.0	July 31, a.m.	5.5	Aug. 8, a.m.	8.0	25.5	84.1
July 13, a.m.	July 17, p.m.	4.5	July 20, p.m.	3.0	July 24, a.m.	3.5	Aug. 1, a.m.	8.0	Aug. 8, p.m.	7.5	26.5	84.1
July 14, a.m.	July 17, p.m.	3.5	July 20, p.m.	3.0	July 24, a.m.	4.5	July 29, a.m.	5.0	Aug. 5, a.m.	7.0	23.0	83.9
July 14, a.m.	July 17, p.m.	3.5	July 20, p.m.	3.0	July 24, a.m.	4.5	July 29, a.m.	5.0	Aug. 3, a.m.	5.0	21.0	83.9
July 14, a.m.	July 17, p.m.	3.5	July 20, p.m.	3.0	July 24, a.m.	4.5	July 29, a.m.	5.0	Aug. 4, a.m.	6.0	22.0	83.9
July 13, a.m.	July 17, p.m.	4.5	July 20, p.m.	3.0	July 24, a.m.	4.5	July 29, a.m.	5.0	Aug. 5, p.m.	7.5	24.5	83.9
July 17, a.m.	July 20, p.m.	3.5	July 25, a.m.	4.5	July 29, a.m.	4.0	Aug. 1, p.m.	3.5	Aug. 10, p.m.	9.0	24.5	84.4
July 14, a.m.	July 17, p.m.	3.5	July 20, p.m.	3.0	July 24, p.m.	4.0	Aug. 1, a.m.	7.5	Aug. 8, a.m.	7.0	25.0	84.1
July 14, a.m.	July 17, p.m.	3.5	July 20, p.m.	3.0	July 24, p.m.	4.0	Aug. 5, a.m.	11.5	Died			83.9

Continued on next page.

Table 4. Records on larval development, 1928. (Continued.)

Date hatched	Date of first molt	Duration of first instar days	Date of second molt	Duration of second instar days	Date of third molt	Duration of third instar days	Date of fourth molt	Duration of fourth instar days	Date of fifth molt	Duration of fifth instar days	Total duration of larval period, days	Average mean temperature
July 14, a.m.	July 17, p.m.	3.5	July 20, p.m.	3.0	July 25, a.m.	4.5	Aug. 2, a.m.	8.0	Aug. 10, a.m.	8.0	27.0	84.3
July 16, a.m.	July 20, a.m.	4.0	July 23, p.m.	3.5	July 27, a.m.	3.5	Aug. 1, a.m.	5.0	Aug. 6, p.m.	5.5	21.5	84.0
July 16, a.m.	July 20, a.m.	4.0	July 23, p.m.	3.5	July 27, a.m.	3.5	Aug. 1, a.m.	5.0	Aug. 8, a.m.	7.0	23.0	84.1
July 16, a.m.	July 20, a.m.	4.0	July 23, p.m.	3.5	July 27, a.m.	3.5	Aug. 1, a.m.	5.0	Died.			83.8
July 16, a.m.	July 20, a.m.	4.0	July 23, p.m.	3.5	July 27, a.m.	3.5	Aug. 1, a.m.	5.0	Aug. 10, a.m.	9.0	25.0	84.4
July 15, a.m.	July 18, p.m.	3.5	July 21, p.m.	3.0	July 25, a.m.	3.5	July 31, a.m.	6.0	Aug. 5, a.m.	5.0	21.0	83.8
July 15, a.m.	July 18, p.m.	3.5	July 21, p.m.	3.0	July 26, a.m.	4.5	July 31, p.m.	5.5	Aug. 7, a.m.	6.5	23.0	84.0
July 17, a.m.	July 20, p.m.	3.5	July 25, a.m.	4.5	July 30, a.m.	5.0	Aug. 2, a.m.	3.0	Aug. 16, a.m	14.0	30.0	84.7

Table 5. Summary of larval development.

Instar	Number of individuals	Number of larvae in instar for days specified.																								Weighted average days
		2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	
First	134	3	14	83	19	14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.61
Second	134	3	82	17	25	4	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3.36
Third	134	1	66	19	28	14	4	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3.55
Fourth	131	0	1	3	23	52	25	19	2	0	0	1	2	1	0	0	1	0	0	1	0	0	0	0	0	4.84
Fifth	128	0	0	0	0	0	3	1	4	8	28	32	31	8	4	1	2	1	2	1	0	1	0	0	1	7.69
Total period of larval development																										23.05

cotton squares, it may be assumed that the laboratory technic was responsible, at least, for the greatest departures from the average. In fact, it was noted that when a larva which had prepared to molt was inadvertently removed from the place of its attachment, the time required to cast the skin invariably was increased from one to several days, thus prolonging the duration of the instar. Although a number of these instances are included in the data given above, they are not sufficient to appreciably affect the average periods given for the various instars.

The newly hatched larva is active and begins feeding as soon as it has emerged from the egg. The early feeding may be characterized as mere nibbling at the surface of the food supply. In confinement, the tendency to eat into the square does not become pronounced until the third or fourth instar has been attained. As the larva grows it consumes a correspondingly larger amount of food, and during the latter part of its development shows a decided preference for the nutritious contents of the square. The larva may bore into the square from any angle. It usually eats a small circular hole less than the body diameter of the worm through the outer layers of the squares, and gradually moves inward by constricting the body and eats the contents within reach. Frequently the entire contents of large squares are consumed before the larva leaves it to attack other fruits.

Some time before the larva molts, it attaches itself to the surface of the food plant or cage, when confined, by a flimsy layer of silken threads, becomes quiescent, and does not feed. This period of inactivity ranges from twelve to twenty-four hours and usually is more protracted during the fourth and fifth molts. In the process of molting, the skin is ruptured at either side of the head and gradually splits posteriorly along the lateral margins of the body. Usually the skin is cast off entirely by faint rhythmic contractions of the body before the larva resumes feeding, although occasionally an individual may become active before it is wholly disengaged from the old skin. No larvæ were observed to feed upon the cast skins. The exact time required for the process of molting was not determined, but general observations indicate that it occurs within the limits of one to two hours.

Prepupal Period

When the larva has reached maturity it ceases to feed and attaches itself to any surface upon which it happens to be situated at the time. In this position it remains inactive for two or three days and occasionally for a longer period. During this time the larva gradually becomes distended or swollen by contracting longitudinally. Subsequently, the convolutions or wrinkles of the body surface disappear and the larva slowly assumes the general outline of the pupa. The reddish-brown color of the pupal case, which has been formed within the body wall of the larva, becomes apparent shortly before the final molt occurs.

Pupation

Normally both sexes pupate from the fifth larval instar, although a few exceptions to this rule were noted in the laboratory. Shortly after the pupal case has been formed the larval skin is ruptured in front and pushed towards the posterior by body contractions of the pupa. Usually the cast skin remains attached to the distal extremity of the pupal case. The time required for completing the final molt is brief, ordinarily occurring in fifteen to thirty minutes. Observations indicate that transformation to the pupal stage most commonly occurs during the daytime. In the field, the larva pupates upon the food plant, either fully exposed or in more or less secreted situations.

Pupal Period

From July 17 to August 26, 1928, records were made on the duration of the pupal period of 153 individuals. The data secured in this connection are given in Table 6. In each case the mean temperatures given are the averages of the daily mean temperatures affecting any individual throughout pupal development. It will be noted that the duration of the pupal period is fairly uniform, varying from nine to ten and one-half days for most individuals, when the mean temperature averages about 84 degrees F., and is not subject to marked fluctuations. Lower temperatures earlier and later in the season doubtless retard the rate of development and prolong the duration of the stage.

Table 6. Records on pupal development, 1928.

No.	Date pupated	Date emerged	Sex	Duration of pupal stage, days	Average mean temperature
1	July 17, p.m.	July 27, a.m.	Male	9.5	84.5
2	July 16, p.m.	July 25, a.m.	Female	8.5	85.3
3	July 16, p.m.	July 26, a.m.	Male	9.5	84.6
4	July 19, a.m.	July 29, a.m.	Female	10.0	84.0
5	July 19, a.m.	July 29, a.m.	Female	10.0	84.0
6	July 16, p.m.	July 25, p.m.	Male	9.0	85.3
7	July 18, p.m.	July 28, a.m.	Female	9.5	84.2
8	July 20, a.m.	July 31, a.m.	Male	11.0	83.6
9	July 19, a.m.	July 29, a.m.	Female	10.0	84.0
10	July 19, a.m.	July 29, a.m.	Female	10.0	84.0
11	July 17, p.m.	July 27, a.m.	Female	9.5	84.5
12	July 17, p.m.	July 26, a.m.	Female	8.5	84.8
13	July 18, p.m.	July 28, a.m.	Female	9.5	84.2
14	July 17, a.m.	July 27, a.m.	Female	10.0	84.5
15	July 17, a.m.	July 27, a.m.	Female	10.0	84.5
16	July 17, a.m.	July 27, a.m.	Female	10.0	84.5
17	July 17, a.m.	July 27, a.m.	Female	10.0	84.5
18	July 17, a.m.	July 27, a.m.	Male	10.0	84.5
19	July 17, a.m.	July 28, a.m.	Male	11.0	84.2
20	July 18, a.m.	July 28, a.m.	Female	10.0	84.2
21	July 18, a.m.	July 28, a.m.	Female	10.0	84.2
22	July 18, a.m.	July 29, a.m.	Male	11.0	84.0
23	July 19, a.m.	July 29, a.m.	Female	10.0	84.0
24	July 19, a.m.	July 29, a.m.	Female	10.0	84.0
25	July 19, a.m.	July 29, a.m.	Female	10.0	84.0
26	July 19, a.m.	July 29, a.m.	Male	10.0	84.0
27	July 19, a.m.	July 29, a.m.	Male	10.0	84.0
28	July 23, p.m.	Aug. 2, p.m.	Female	10.0	83.0
29	July 18, p.m.	July 29, a.m.	Female	10.5	84.0

Table 6. Records on pupal development, 1928.

No.	Date pupated	Date emerged	Sex	Duration of pupal stage, days	Average mean temperature
30	July 20, p.m.	July 31, a.m.	Male	10.5	83.6
31	July 20, p.m.	July 31, a.m.	Male	10.5	83.6
32	July 20, p.m.	July 31, a.m.	Male	10.5	83.6
33	July 20, p.m.	July 31, a.m.	Male	10.5	83.6
34	July 20, p.m.	July 31, a.m.	Male	10.5	83.6
35	July 20, a.m.	July 31, a.m.	Female	11.0	83.6
36	July 21, p.m.	Aug. 1, a.m.	Female	10.5	83.4
37	July 21, p.m.	July 31, a.m.	Male	9.5	83.4
38	July 17, p.m.	July 28, a.m.	Male	10.5	84.2
39	July 16, p.m.	July 26, a.m.	Male	9.5	84.6
40	July 19, p.m.	July 30, a.m.	Male	10.5	83.8
41	July 18, a.m.	July 27, a.m.	Female	9.0	84.5
42	July 17, p.m.	July 27, a.m.	Male	9.5	84.5
43	July 18, p.m.	July 29, a.m.	Male	10.5	84.0
44	July 18, p.m.	July 29, a.m.	Male	10.5	84.0
45	July 16, p.m.	July 25, p.m.	Female	9.0	85.3
46	July 17, p.m.	July 27, a.m.	Female	9.5	84.5
47	July 20, p.m.	July 30, a.m.	Female	9.5	83.5
48	July 22, a.m.	Aug. 1, a.m.	Female	10.0	83.1
49	July 25, p.m.	Aug. 4, a.m.	Female	9.5	82.9
50	July 18, a.m.	July 27, a.m.	Female	9.0	84.5
51	July 24, p.m.	Aug. 3, a.m.	Female	9.5	82.8
52	July 19, a.m.	July 29, a.m.	Male	10.0	84.0
53	July 19, a.m.	July 29, a.m.	Male	10.0	84.0
54	July 18, p.m.	July 28, a.m.	Female	9.5	84.2
55	July 18, p.m.	July 28, a.m.	Female	9.5	84.2
56	July 17, p.m.	July 26, a.m.	Female	8.5	84.8
57	July 18, p.m.	July 28, a.m.	Female	9.5	84.2
58	July 17, p.m.	July 27, a.m.	Male	9.5	84.5
59	July 19, p.m.	July 29, a.m.	Female	9.5	84.0
60	July 18, p.m.	July 28, a.m.	Female	9.5	84.2
61	July 19, a.m.	July 29, a.m.	Female	10.0	84.0
62	July 17, p.m.	July 27, a.m.	Male	9.5	84.5
63	July 18, a.m.	July 28, a.m.	Male	10.0	84.2
64	July 19, a.m.	July 29, a.m.	Female	10.0	84.0
65	July 17, p.m.	July 26, a.m.	Female	8.5	84.8
66	July 18, p.m.	July 28, a.m.	Female	9.5	84.2
67	July 20, a.m.	July 30, a.m.	Male	10.0	83.5
68	July 21, p.m.	July 31, a.m.	Female	9.5	83.4
69	July 21, a.m.	July 30, a.m.	Female	9.0	83.3
70	July 20, p.m.	July 31, a.m.	Male	10.5	83.6
71	July 20, p.m.	July 31, a.m.	Male	10.5	83.6
72	July 20, p.m.	July 31, a.m.	Male	10.5	83.6
73	July 20, p.m.	July 31, a.m.	Male	10.5	83.6
74	July 20, p.m.	July 31, a.m.	Male	10.5	83.6
75	July 20, p.m.	July 31, a.m.	Female	10.5	83.6
76	July 24, p.m.	Aug. 4, a.m.	Male	10.5	82.9
77	July 25, a.m.	Aug. 3, p.m.	Male	9.5	82.8
78	Aug. 2, a.m.	Aug. 11, a.m.	Female	9.0	85.5
79	July 31, p.m.	Aug. 9, a.m.	Female	8.5	85.0
80	July 29, p.m.	Aug. 7, a.m.	Female	8.5	84.0
81	July 30, p.m.	Aug. 8, a.m.	Female	8.5	84.3
82	July 31, p.m.	Aug. 10, a.m.	Male	9.5	85.1
83	July 30, p.m.	Aug. 8, a.m.	Female	8.5	84.3
84	July 30, a.m.	Aug. 8, a.m.	Male	9.0	84.3
85	July 30, p.m.	Aug. 9, a.m.	Male	9.5	84.7
86	July 31, a.m.	Aug. 10, a.m.	Male	10.0	85.1
87	Aug. 3, p.m.	Aug. 17, a.m.	Male	13.5	85.6
88	July 29, p.m.	Aug. 8, a.m.	Male	9.5	84.1
89	July 29, a.m.	Aug. 8, a.m.	Male	10.0	84.1
90	July 29, a.m.	Aug. 7, a.m.	Male	9.0	84.3
91	July 30, a.m.	Aug. 8, a.m.	Female	9.0	84.3
92	Aug. 1, a.m.	Aug. 9, a.m.	Male	8.0	85.1
93	Aug. 1, p.m.	Aug. 10, a.m.	Female	8.5	85.3
94	Aug. 1, p.m.	Aug. 11, a.m.	Male	9.5	85.3
95	July 30, p.m.	Aug. 9, a.m.	Male	9.5	84.7
96	July 29, p.m.	Aug. 7, a.m.	Female	8.5	84.0
97	July 31, a.m.	Aug. 10, a.m.	Male	10.0	85.1
98	July 29, a.m.	Aug. 7, a.m.	Female	9.0	84.0
99	July 31, a.m.	Aug. 10, a.m.	Male	10.0	85.1
100	July 30, p.m.	Aug. 9, a.m.	Male	9.5	84.7

Table 6. Records on pupal development, 1928.

No.	Date pupated	Date emerged	Sex	Duration of pupal stage, days	Average mean temperature
101	July 31, a.m.	Aug. 9, a.m.	Female	9.0	85.0
102	July 30, a.m.	Aug. 8, a.m.	Female	9.0	84.3
103	July 31, p.m.	Aug. 10, a.m.	Male	9.5	85.1
104	July 30, a.m.	Aug. 8, a.m.	Male	9.0	84.3
105	Aug. 1, a.m.	Aug. 11, a.m.	Male	10.0	85.3
106	July 31, a.m.	Aug. 10, a.m.	Female	10.0	85.1
107	July 31, a.m.	Aug. 9, a.m.	Female	9.0	85.0
108	July 31, p.m.	Aug. 10, a.m.	Male	9.5	85.1
109	July 31, p.m.	Aug. 10, a.m.	Female	9.5	85.1
110	Aug. 4, a.m.	Aug. 14, a.m.	Male	10.0	85.7
111	Aug. 2, a.m.	Aug. 12, a.m.	Female	10.0	85.5
112	Aug. 3, a.m.	Aug. 12, a.m.	Female	9.0	85.6
113	Aug. 2, a.m.	Aug. 11, a.m.	Female	9.0	85.5
114	Aug. 4, a.m.	Aug. 14, a.m.	Male	10.0	85.7
115	Aug. 2, a.m.	Aug. 12, a.m.	Female	10.0	85.5
116	Aug. 1, a.m.	Aug. 11, a.m.	Male	10.0	85.3
117	Aug. 5, a.m.	Aug. 14, a.m.	Female	9.0	85.9
118	Aug. 3, p.m.	Aug. 13, a.m.	Male	9.5	85.7
119	Aug. 4, a.m.	Aug. 14, a.m.	Male	10.0	85.7
120	Aug. 1, a.m.	Aug. 10, a.m.	Female	9.0	85.3
121	Aug. 1, a.m.	Aug. 10, a.m.	Male	9.0	85.3
122	Aug. 1, p.m.	Aug. 11, a.m.	Female	9.5	85.3
123	Aug. 1, p.m.	Aug. 11, a.m.	Female	9.5	85.3
124	Aug. 2, p.m.	Aug. 12, a.m.	Male	9.5	85.5
125	Aug. 1, a.m.	Aug. 10, a.m.	Female	9.0	85.3
126	Aug. 3, a.m.	Aug. 12, a.m.	Male	9.0	85.6
127	Aug. 3, a.m.	Aug. 12, a.m.	Male	9.0	85.6
128	Aug. 1, p.m.	Aug. 10, a.m.	Female	8.5	85.3
129	Aug. 5, a.m.	Aug. 15, a.m.	Male	10.0	85.8
130	Aug. 4, a.m.	Aug. 14, a.m.	Male	10.0	85.7
131	Aug. 2, a.m.	Aug. 12, a.m.	Male	10.0	85.5
132	Aug. 4, a.m.	Aug. 14, a.m.	Male	10.0	85.7
133	Aug. 5, a.m.	Aug. 14, a.m.	Female	9.0	85.9
134	Aug. 5, a.m.	Aug. 15, a.m.	Male	10.0	85.8
135	Aug. 6, p.m.	Aug. 16, a.m.	Male	9.5	86.0
136	Aug. 5, a.m.	Aug. 14, a.m.	Female	9.0	85.9
137	Aug. 7, a.m.	Aug. 18, a.m.	Male	11.0	86.0
138	Aug. 8, a.m.	Aug. 15, a.m.	Female	7.0	86.2
139	Aug. 11, p.m.	Aug. 24, a.m.	Male	12.5	86.1
140	Aug. 8, a.m.	Aug. 18, a.m.	Female	10.0	86.0
141	Aug. 8, p.m.	Aug. 18, a.m.	Male	9.5	86.0
142	Aug. 5, a.m.	Aug. 14, a.m.	Female	9.0	85.9
143	Aug. 3, a.m.	Aug. 12, a.m.	Female	9.0	85.6
144	Aug. 4, a.m.	Aug. 14, a.m.	Male	10.0	85.7
145	Aug. 5, p.m.	Aug. 15, a.m.	Male	9.5	85.8
146	Aug. 10, p.m.	Aug. 19, a.m.	Female	8.5	85.7
147	Aug. 8, a.m.	Aug. 17, a.m.	Female	9.0	86.1
148	Aug. 10, a.m.	Aug. 20, a.m.	Male	10.0	85.9
149	Aug. 6, p.m.	Aug. 15, a.m.	Female	8.5	86.1
150	Aug. 8, a.m.	Aug. 19, a.m.	Male	11.0	86.6
151	Aug. 10, a.m.	Aug. 20, a.m.	Male	10.0	85.9
152	Aug. 5, a.m.	Aug. 13, a.m.	Female	8.0	86.0
153	Aug. 16, a.m.	Aug. 26, a.m.	Male	10.0	85.9

The detailed records on the duration of the pupal period are summarized in Table 7. The proportion of sexes was about equal among the total number of individuals which were reared in the laboratory. According to these data, the time required by the male sex to complete pupal development averages slightly more than one-half day longer than is the case with the female individuals. The majority of males remained in the pupal stage from nine to ten and one-half days, and the females from eight and one-half to ten days. The extremes in duration of the pupal period for both sexes ranged from seven to thirteen and one-half

Table 7. Summary of pupal development.

Sex	Number of individuals	Number of pupae in stage for days specified														Weighted average days
		7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	
Male.......	76	0	0	1	0	7	21	25	15	5	0	0	1	0	1	9.98
Female.....	77	1	0	1	13	20	17	21	4	0	0	0	0	0	0	9.33

days, but the majority of individuals completed pupal development within the limits of eight and one-half and eleven days.

Summary of Developmental Periods

The data accumulated on the various developmental stages of the cotton-square borer are briefly summarized in Table 8. All stages from the egg to the pupa, inclusive, are subject to considerable variations.

Table 8. Summary of developmental periods.

	Number of individuals observed	Minimum period days	Maximum period days	Average period days
Egg	1025	4.9	6.2	5.55
First instar	134	2.5	5.0	3.61
Second instar	134	2.5	9.5	3.36
Third instar	134	2.5	8.5	3.55
Fourth instar	131	3.0	11.5	4.84
Fifth instar	128	5.0	14.0	7.69
Pupa	153	7.0	13.5	9.65

Theoretically, it appears possible for an individual to reach maturity within twenty-eight days, as is indicated by the sum of the minimum periods secured for each developmental stage. Under average laboratory conditions, however, approximately thirty-eight days are required during the summer months for complete development. The egg stage comprises about five and one-half days, the larval stage, including the prepupal period, twenty-three days, and the pupal stage about nine and one-half days.

EMERGENCE OF ADULTS

When the insect has attained maturity within the pupal case it emerges from the latter through a T-shaped split in the anterior end. The split originates at the base of the anterior extremity of the pupal case and extends posteriorly along the dorsomedian line of the thorax. Laterally, from this point of origin a secondary split extends on either side of the pupal case along the antennal sutures to the point where the latter are joined by the suture defining the hind margin of the prothorax. As the adult squeezes through the exit thus formed, the divided anterior wall of the pupal case is pushed outwardly, assuming more or less its original position after emergence has been effected. Laboratory observations made at 30-minute intervals show that the adult may emerge from the pupa and completely expand the wings within this period of time. The newly emerged individuals hang quietly to any available support, rubbing the wings together with a shearlike movement until they have attained complete expansion. At this time, although the wings are not fully hardened, the adult is capable of making at least short flights, and becomes very active, especially when confined in a cage.

In the laboratory practically all of the adults of both sexes emerged from the pupæ between 8 and 10 o'clock in the morning. In fact, only four cases of adult emergence were noted in the afternoon in a total of 153 individuals under observation. The detailed observations made in this connection are presented in Table 6.

SEXUAL DEVELOPMENT

Newly emerged females do not attain sexual maturity until a feeding period of one to three days has elapsed. After this time, in confinement, they begin to lay eggs, even though fertilization has not been effected. As has already been pointed out, mating does not occur readily with this species in captivity. In the laboratory, virgin females, confined with active field-collected males or with reared male individuals, continued to deposit only infertile eggs. Although the females attained sexual maturity within the cages, it appears likely that freedom of flight or other factors not imposed by laboratory conditions are essential for fertilization and subsequent reproduction.

LONGEVITY OF ADULTS

The normal life period of the adult cotton-square borer in nature cannot be determined accurately. Since the insect is a strong flier and is very active, individuals cannot be followed readily through their entire life period. Moreover, there is a considerable overlapping of generations in this latitude, which makes it practically impossible to decide to which generation any given individual may belong or approximate the time when it attained maturity. In the vicinity of College Station the extremes of adult activity range from February to September, but the reproductive period is confined largely to the summer months. Judging from these observations, adult longevity may comprise a period of two months or more. At least, it appears certain that the butterflies are normally long-lived under natural or field conditions.

The data secured on adult longevity under laboratory conditions are given in Table 9. Referring to these data, it will be noted that this insect does not readily withstand confinement. Although supplied with sufficient food, most of the caged individuals of both sexes died in less than two weeks. The average life period of the thirteen pairs of butterflies under observation was approximately nine days for males and ten days for females.

Table 9. Records of longevity of adults in confinement.

Number	Male			Female		
	Date *emerged*	Date *died*	Number *days*	Date *emerged*	Date *died*	Number *days*
1	July 26	Aug. 1	6	July 26	Aug. 9	14
2	July 27	Aug. 9	13	July 26	Aug. 10	15
3	July 27	Aug. 5	9	July 27	Aug. 6	10
4	July 31	Aug. 6	6	July 30	Aug. 7	8
5	July 30	Aug. 5	6	July 30	Aug. 8	9
6	July 31	Aug. 10	10	July 31	Aug. 10	10
7	Aug. 4	Aug. 14	10	Aug. 4	Aug. 16	12
8	Aug. 6	Aug. 15	9	Aug. 6	Aug. 16	10
9	Aug. 6	Aug. 19	13	Aug. 6	Aug. 16	10
10	Aug. 7	Aug. 17	10	Aug. 7	Aug. 17	10
11	Aug. 8	Aug. 16	8	Aug. 8	Aug. 21	13
12	Aug. 11	Aug. 22	11	Aug. 11	Aug. 15	4
13	Aug. 12	Aug. 20	8	Aug. 12	Aug. 22	10

NUMBER OF GENERATIONS

The available data on the seasonal history of this species indicate that three complete generations may be produced in this latitude. However, it should be stated that the generations or broods are not clearly defined. The first generation of cotton-square borers is produced from the eggs laid during March and April by adults of the overwintering brood. The bulk of the first generation reaches maturity by the latter part of May and the first week in June. The second generation develops during June and July. It is subject to very heavy parasitism, and only a small per cent of the second brood reaches maturity. The remnant of this brood continues reproduction during August and September, and rearing records show that there is ample time before the first frost occurs for the development of the third generation of insects.

In the North, where the adults of the overwintering brood emerge later in the spring, only two generations of insects are produced during a season.

HIBERNATION

The cotton-square borer does not pass through a protracted period of hibernation in this latitude. With the advent of frosts and lower temperatures, the insect disappears from the fields and is rarely seen throughout December and January. However, during brief periods of mild weather in these months, active individuals have been noted, indicating that the insect may pass through the winter in the adult stage. Although pupæ were not kept under continuous observation during the entire year, it appears more than likely that locally the species also passes through the winter in this stage as is the case in the more northern limits of its distribution.

Emergence from the dormant or semi-dormant period normally begins during the latter part of February and extends throughout March. By the middle of April the butterflies are again common in the field, and it appears safe to assume that the emergence of the major portion of the overwintering brood has been completed.

NATURAL ENEMIES

The cotton-square borer is attacked by several species of insect parasites which effectively reduce the numbers of this insect in the field. In fact, the work of the parasites limits the multiplication of the square borer to such an extent that combative measures against it rarely are necessary. During the course of these studies, four different species of parasites were reared from the larva and pupa of this insect. Two of these were Hymenoptera determined by A. B. Gahan, Bureau of Entomology, United States Department of Agriculture, as *Apanteles theclæ* Riley, and *Octosmicra* sp., of the family Braconidæ and Chalcididæ, respectively. Two of the species were Diptera, *Zenillia confinis* Fallen, and *Frontina* sp. The latter determinations were made by the writer. Data on the extent of parasitism by these species are given in Table 10.

Table 10. Rearing records of cotton-square borer parasites.

No. specimens collected	Locality collected, Texas	Stage collected	No. of square borers		Name of parasite reared
			Emerged	Parasitized	
1	College Station	5th instar larva.....	0	1	*Frontina* sp.
1	College Station	3rd instar larva.....	0	1	*Zenillia confinis* Fallen
3	Gauze........	4th instar larvae....	0	3	*Zenillia confinis* Fallen
1	College Station	Pupa............	0	1	*Octosmicra* sp.
10	College Station	1st-5th instar larvae.	1	9	*Apanteles theclae* Riley
21	College Station	2nd-5th instar larvae.	0	21	*Apanteles theclae* Riley
2	Mart........	3rd instar larvae....	0	2	*Zenillia confinis* Fallen
1	College Station	Pupa............	0	1	*Octosmicra* sp.
20	College Station	2nd-5th instar larvae.	0	20	*Apanteles theclae* Riley *Zenillia confinis* Fallen
2	Brazoria Co...	3rd instar larvae....	0	2	*Zenillia confinis* Fallen
1	Mound........	3rd instar larva.....	0	1	*Apanteles theclae* Riley
1	Rusk........	5th instar larva.....	0	1	*Apanteles theclae* Riley
5	College Station	3rd-5th instar larvae.	0	5	*Apanteles theclae* Riley
12	College Station	2nd-5th instar larvae.	0	12	*Apanteles theclae* Riley
1	Trinity.......	5th instar larva......	0	1	*Zenillia confinis* Fallen
1	Jasper Co.....	5th instar larva	0	1	*Apanteles theclae* Riley
5	College Station	2nd-3rd instar larvae.	0	5	*Apanteles theclae* Riley *Zenillia confinis* Fallen
12	College Station	3rd-5th instar larvae.	0	12	*Apanteles theclae* Riley *Zenillia confinis* Fallen
1	Balmorhea.....	3rd instar larva.....	0	1	*Apanteles theclae* Riley
1	Clarksville.....	5th instar larva......	0	1	*Zenillia confinis* Fallen
8	College Station	3rd-5th instar larvae.	0	8	*Apanteles theclae* Riley *Zenillia confinis* Fallen
1	Grand Saline...	5th instar larva	0	1	*Zenillia confinis* Fallen
1	Oletha........	3rd instar larva.....	0	1	*Zenillia confinis* Fallen
1	Lott..........	4th instar larva.....	0	1	*Zenillia confinis* Fallen
8	College Station	2nd-5th instar larvae.	0	8	*Apanteles theclae* Riley
17	College Station	4th-5th instar larvae.	6	11	*Apanteles theclae* Riley
3	College Station	Pupae............	2	1	*Octosmicra* sp.
4	College Station	5th instar larvae....	1	3	*Apanteles theclae* Riley

Rearing records show that *Apanteles theclæ* Riley is the most common and important parasite of the square borer larvæ. This species oviposits within the body of its host, where the maggots complete their development before emerging therefrom. When fully fed, the parasitic maggots emerge from the host larva and pupate in loose clusters upon its body, each individual enveloping itself in a tiny white cocoon. Seven to nine days are required for pupal development and emergence of the adult parasite. The host larva parasitized by this species does not succumb until the maggots have emerged from its body, but invariably it dies shortly thereafter and always before pupation occurs.

Four specimens of *Octosmicra* sp. were reared from the pupæ of the cotton-square borer. None of the host individuals from which this parasite was reared showed any external evidence of parasitism when collected in the field. Apparently this species also attacks the host larva in the latter instars, but does not attain maturity until some time after pupation of the host larva has occurred. In other words, the parasite passes through its entire developmental stages within the host and emerges from the pupal case of the latter in the adult stage. The available records on this species indicate that only one parasite develops to maturity within the body of each host specimen. In every instance noted the host insect was killed when attacked by this parasite. The economic importance of this parasite appears to be limited by its slow rate of multiplication.

Only one of the dipterous parasites reared from the cotton-square borer proved to be economically important. This species, *Zenillia confinis* Fallen, was commonly reared from host larvæ collected locally and in various other sections of the State. The fly deposits its eggs upon the surface of the host larva's body, usually near the anterior extremity. The tiny maggots which hatch from the ventral side of the eggs bore into the body of the caterpillar, where they feed without attacking the vital organs until practically matured. When fully fed, the maggots emerge from the host larva and normally enter the soil for pupation. In the absence of any soil the parasitic maggots pupate in the open without any protection. An average period of seven or eight days is required for pupal development and emergence of the adult fly. Invariably the host larva dies about the time when the parasitic maggots have reached maturity and emerge from its body. Usually only one or two maggots attain full development within a single host specimen. This parasite is a common species within the State and doubtless is an important factor in the natural control of the cotton-square borer.

A single specimen of a species of *Frontina* emerged from a practically matured cotton-square borer larva, which, at the time of collection in the field, showed no external indication of parasitism. The host died shortly after the maggot emerged and the latter pupated in moist sand supplied in the bottom of the cage. The fly issued from the puparium eight days after pupation occurred.

No predacious enemies of the developmental stages of this insect were noted. However, robber flies belonging to the genera *Asilus* and *Erax* were frequently observed capturing butterflies of the cotton-square borer. Aside from these observations there are no available records on any other important predacious enemy of the insect.

CONTROL MEASURES

During the time covered by these studies on the cotton-square borer no local infestation developed on cotton to the extent of making serious inroads on the crop and requiring applications of poison for controlling the insect. As has already been stated, the agencies of natural control are so effective in checking the multiplication of this species that it is rarely necessary to employ any measures for combating it.

When conditions warrant the use of control measures against this insect, applications of calcium arsenate, made at the rate of five to seven pounds per acre, are effective in destroying the younger larvæ which have not yet eaten their way into the squares. This recommendation is based upon the observations made on cotton-square borer mortality in fields of cotton which were dusted with calcium arsenate for the purpose of controlling the boll weevil.

The results secured in the laboratory from feeding square borer larvæ cotton foliage dusted with either calcium or lead arsenate indicate that the larvæ in any instar of development are susceptible to the poison. Under field conditions, however, larvæ of the later instars feed largely within the squares and consequently cannot be so effectively reached by poison applications. Thus it should be noted that applications of poison made when most of the larvæ are still small will result in the maximum degree of control.

SUMMARY

Strymon melinus is one of the "hair-streak" butterflies, the larva of which commonly feeds upon cotton squares and is popularly known as the cotton-square borer.

The distribution of the species extends over temperate North America. Although a very common species in Texas, this insect is not an especially injurious pest on cotton. Locally, the larvæ also feed commonly upon the seed pods of cowpeas, beans, okra, and to a lesser extent upon corn and goatweed, *Croton capitatus*.

The butterfly's wings expand about one inch, and are blackish-gray above and ash-gray with darker wavy streaks beneath. The hind wings bear two slender tail-like prolongations between the bases of which above and beneath are roundish black spots crowned with orange-red crescents.

Adults of the overwintering brood emerge during February and March and oviposition begins soon thereafter, extending continuously throughout the warm season. The eggs are laid singly and promiscuously upon the food plants. The incubation period during June and July, 1928, averaged about five and one-half days. The larvæ normally molt five times and require about twenty days during warm weather to attain full growth. Pupation occurs in the open, usually upon the food plant, and approximately nine and one-half days are required for pupal development during the summer months.

Rearing records indicate that three complete generations or broods of the cotton-square borer may be produced during a season. In this latitude the insect does not pass through a protracted hibernation period. It is dormant or semi-dormant throughout December and January. This period apparently is passed in both the pupal and the adult stage.

Usually the cotton-square borer is effectively held in check by natural enemies and combative measures rarely are required. When the use of the latter appear necessary, dry applications of calcium arsenate, five to seven pounds per acre, will produce a satisfactory control, especially if the poison is applied when most of the larvæ are still small.

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