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TEXAS AGRICULTURAL EXPERIMENT STATION

B. YOUNGBLOOD, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 347 APRIL, 1927

DIVISION OF ENTOMOLOGY

STUDIES ON THE BIOLOGY OF THE PECAN NUT CASE BEARER

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
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†As of April 1, 1927.
*On Leave.
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****In cooperation with the School of Agriculture.

SYNOPSIS

This Bulletin summarizes six years of observations on the life history of the pecan nut case bearer and also contains a study of the anatomical characters which differentiate it from other closely related insects, dealing more particularly with the biology of the insect than does Bulletin No. 328 of this Station.

There were four generations of this insect in 1919, 1921, and 1923. In 1918, 1920, and 1922 there were but two generations.

The winter is passed in a tough silken hibernaculum attached to buds on the trees. At the approach of spring the larvae begin feeding on the buds to which these hibernacula are attached. Later they desert the hibernacula and enter the new tender growth at the juncture of leaf stems and make burrows, in which they pupate after attaining their growth. The duration of the pupal period and the time the spring-brood moths emerge is dependent largely on the temperature. When the mean temperature was low during the month of March, the larvae did not leave their hibernacula until early in April, but in years when the mean temperature was high enough to start tree growth before the 20th. of March they began feeding prior to that time. If a period of high temperature was followed by a period of lower temperatures, larval and pupal development was retarded and the average duration of the pupal stage was greatly lengthened. This had an effect on the number of the insects in the succeeding generations. When low temperatures in March were followed by high temperatures in April, the pupal stage was shortened and there were a considerable number of moths emerging daily during the period over which emergence occurred. The moths emerged at night and, on the fourth or fifth night after they emerged, began to deposit eggs on the nuts when the latter were about the size of English peas.

These eggs hatch in about five days, and after feeding on the buds immediately below the nut clusters for about two days the larvae enter the nuts at their bases by cutting circular holes. The pupal stage is passed within the larval burrow and lasts about nine days. The first generation moths emerge during the latter part of May and the early part of June. Oviposition begins on the third or fourth night after emergence.

The eggs hatch in four days and the larvae enter the nuts as in the preceding generation.

After completing their development they pupate within the larval burrow. The moths of the second generation emerge betwen July 22 and September 7, depositing their eggs in grooves at the tips and bases of the nuts or on buds below the nut clusters.

It requires about four days for the eggs of the third generation to hatch. The larvae feed within the nuts as in the two preceding generations, or on the interior of the shucks, or on the shucks where two or three nuts touch at their bases. The moths of the third generation emerge principally during the month of September, but emergence continues sometimes as late as the 25th. of October, oviposition occurring from four to nine days after emergence.

The eggs of the fourth generation hatch in from five to nine days, after which the young larvae feed on shucks or at the bases of the leaf petioles and later spin their overwintering hibernacula.

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BULLETIN NO. 347 APRIL, 1927

STUDIES ON THE BIOLOGY OF THE PECAN NUT CASE BEARER

(*Acrobasis caryae, Grote*)

S. W. BILSING

There is some confusion as to the scientific name of the pecan nut case bearer, due to the fact that there are several species of the genus *Acrobasis* which have nut feeding habits. Gill, of the U. S. Department of Agriculture in 1925 (6) published an account of the pecan nut case bearer (*Acrobasis hebescella*), stating that "in 1902 E. P. Stiles gave an account of injury in west central Texas caused by what he called the pecan husk worm but doubtless due to *Acrobasis hebescella* and a closely related species *A. caryivorella,* Rag." The same author referred to *A. caryivorella* in a former publication of the U. S. Department of Agriculture (4). Hulst (8) in 1890 first described *Acrobasis hebescella,* and Ragonot (11) in 1890 described *Acrobasis caryivorella.* Grote (7) described *A. caryae* in 1881 from material collected by Coquillet in Illinois. An examination of the literature indicates that more study needs to be given to the anatomical characters of all of these species to separate them correctly.

The scientific name *A. caryae* Grote, is here given because according to the information at hand, the pecan nut case bearer seems to conform more nearly to *A. caryae* than to either *A. hebescella* or *A. caryivorella.* Though Dr. Harrison Dyar has identified specimens which have been sent him as *A. caryivorella,* McDunnough, in 1913 (9) examined Ragonot's type specimens in the National Museum at Paris and studied Grote's type in the British Museum at London, concluding from these studies that the "true caryae" is the species Dyar identified as *"caryivorella."*

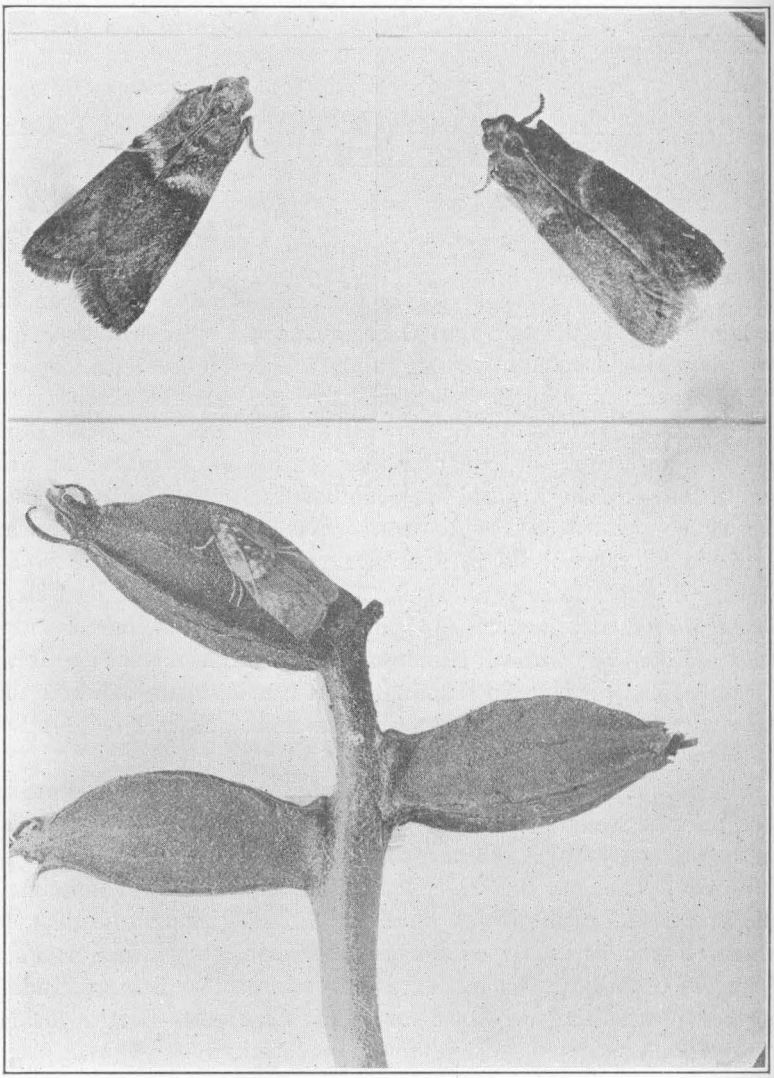

Fig. 1. Adult moths, male and female.

DESCRIPTION OF THE INSECT

Adult

Size: Small. Wing expanse 20 to 22 mm. Length to tip of abdomen 7 to 9 mm. Width of thorax 2 mm. Width at extremity of wings when moth is at rest 5 to 6 mm. Ground color pale gray. Maculation mainly defined by black scales which shade the primaries.

Head: Blackish-gray. Proboscis yellow. Eyes black and very shiny on living specimens when examined in the dark. Labial palps long, grayish-black. Antennae gray, pectinate in male.

Fore Wings: Most distinctive character is the scale ridge which extends across the wings transversely, one-third of the distance from the head to tip of wings, the scales being blackish and feathery in appearance and always pronounced in well preserved specimens. Fore wings about three times as long as wide and widest at the outer margin. Under side of fore wing of male with a small black dash at base of costa and a blackish subcostal streak from base to beyond middle. Region posterior to the scale ridge may be purplish or black. A dorsal elevation extends longitudinally from about the middle of the scale ridge almost or quite to the extremity of the wing near the inner side of the outer margin, making a decided bend about half way from the scale ridge to the outer margin. There are two obliquely transverse lines extending from the costal border, near its distal extremity, forward and inward. The anterior is indistinct and in many specimens is entirely lacking. It can seldom be determined beyond the dorsal elevation which it reaches at the anterior part of the bend. The second line begins near the first on the costal border and extends to the inner margin, near which it is deeply notched. The discal mark usually shows as two black points but is obscured by the ground color and sometimes is entirely lacking. The area between the second transverse line and the outer margin is darker than the median part of the wing. The outer margin is fringed and has a dark line at the base of the fringe.

Back Wings: Uniformly grayish with a dark line at the base of the fringe as in the fore wings, and without secondary sexual maculation.

Thorax: Front coxae black. Entire front legs dark or nearly black. Second pair of legs with two tibial spurs, the outer about three times as long as the inner. Distal end of tibia ash gray. Tarsi five jointed, nearly black on outer surface and ashy on inner surface. Distal end of tarsal joints with a fringe of yellow scales. Tibia of third leg with four spurs in two pairs, one pair being at the distal extremity of the tibia and the other one-third the distance from the

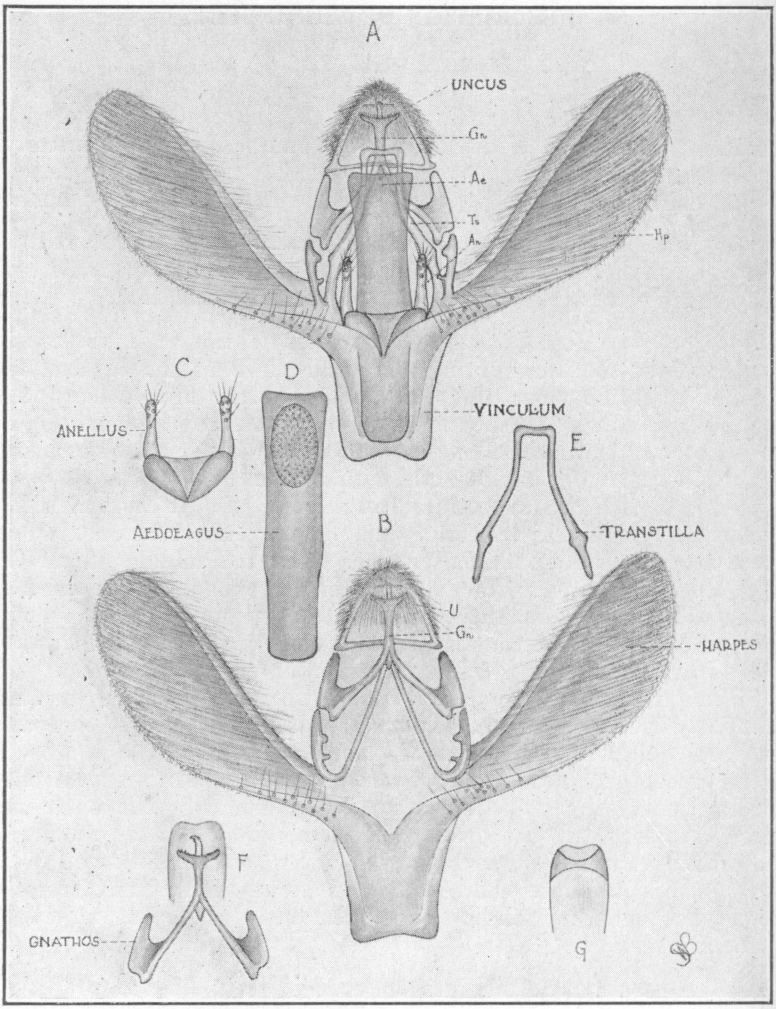

Fig. 2. Ventral view of male genitalia.

Explanation of Figure 2.

A—Ventral view of male genitalia.
B—Ventral view of male genitalia (same view as A with anellus, aedoeagus, and transtilla removed).
C—An, Anellus (chitinous support of aedoeagus).
D—Ae, Aedoeagus (outer chitinous sheath of penis).
E—Ts, Transtilla (a costal bridge connecting the harpes).
F—Gn. Gnathos (paired organ ventral to the anus).
Hp—Harpes (clasping organs).
U—Uncus (armature of the anus).

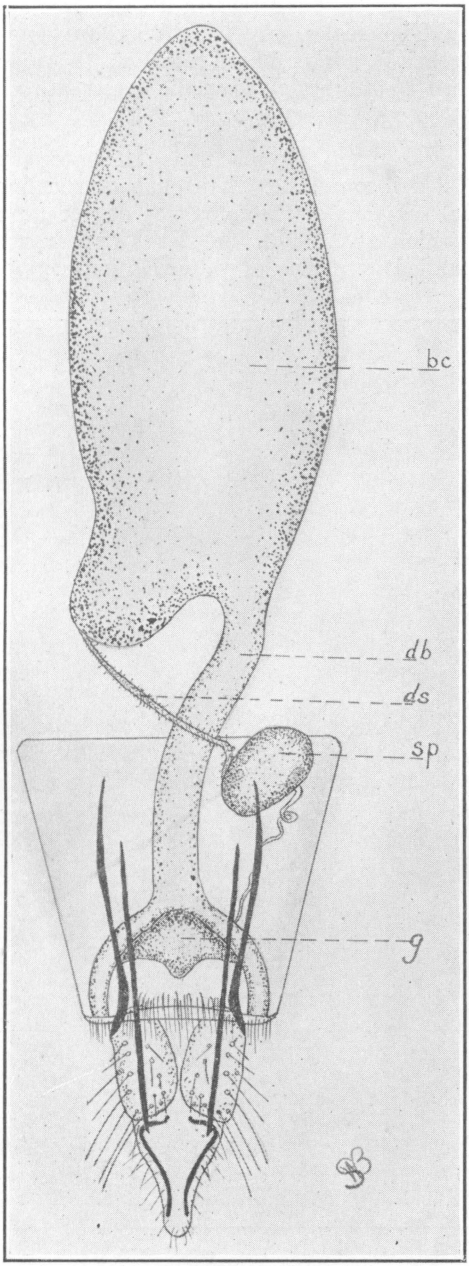

Fig. 3. Female genitalia.

Explanation of Fig. 3.

Bc—Bursa copulatrix.
Db—Ductus bursae.
Sp—Spermatheca.
Ds—Ductus seminalis.
G—Genital plate.

distal extremity. The scales on the thorax are long and feathery, those on the prothorax darker than those on the mesothorax. Halfway from the head to the scale ridge the scales are almost black, the intervening space being bluish-gray.

Abdomen: The abdomen of the male is more slender and of a more uniform blackish-gray color than that of the female. The base of each abdominal segment of the female is darker than the remainder of the segment, which gives it an annulated appearance. The vaginal opening is surrounded by a ring of yellowish hairs.

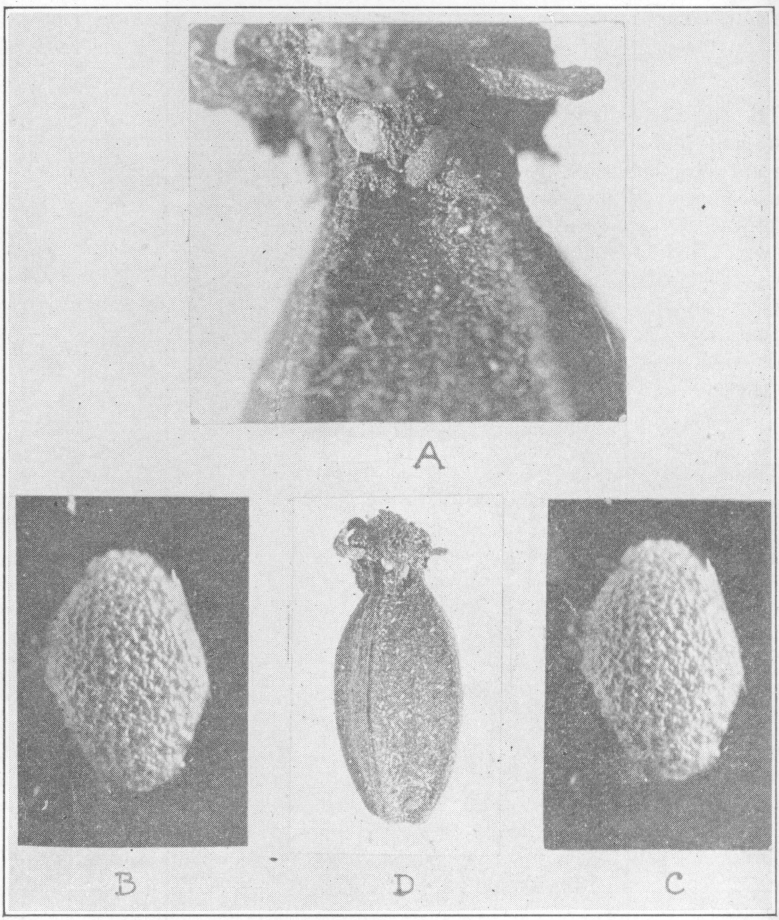

Fig. 4. Eggs of the pecan nut case bearer, showing their position on the nuts.
A—Position of egg when deposited below calyx.
B—C—A single egg much enlarged.
D—Position of egg both below calyx and at base of nut.

Genitalia (Male): The harpes or clasping organs are paddle-shaped and are large enough to be easily seen on the male when alive. The aedoeagus or tube which contains and protects the penis is elongate and is nearly as long as the entire genitalia. The anellus has two projecting lobes. The transtilla or bridge which connects the harpes is well developed. The gnathos has three hooks arising a short distance from the distal end; proximal to the median hook is a sack-like part (G) which fits down over it like a flap.

Genitalia (Female): The bursa copulatrix is large and balloon-shaped. The spermatheca is nearly spherical and is connected with the bursa copulatrix by a tube, the ductus seminalis.

Egg

The eggs are elliptical in shape and are finely reticulated. They are just large enough (.65 mm. long x .36 mm. wide) to be seen without the aid of a lens. When first laid they are bluish-white, but in a few hours small red spots appear which later increase in size and the egg is pinkish to reddish in color up to the time of hatching. The eggs, convex above and flattened below, are firmly fastened to the nut by means of a sticky substance. Upon hatching, the larva cuts its way out of the end of the egg, after which the shell has a snowy white appearance. After hatching, the egg shell may be seen for several days and sometimes for weeks if the eggs have been deposited in grooves on the sides of the nuts.

Larva

The larva when full grown is 11 to 13 mm. in length, occasional specimens measuring 15 mm. It is cylindrical and tapers slightly near the posterior end. When first hatched the larva is white or pinkish-white, later turning to an olive-gray and just before pupating changing to a jade green color. The head, mouth-parts and thoracic and anal shields are yellowish-brown. The surface of the body is much wrinkled and sparsely covered with white hairs. There are four pairs of abdominal prolegs and one pair of anal prolegs.

Head nearly quadrate, broader than long when viewed from above. Yellowish-brown, epicranium rugose. Margin rounded,—not deeply incised at rear. Greatest width at middle. Incision of dorsal hind margin not more than one-fourth the longitudinal distance across the head. Front nearly triangular, not reaching the hind margin. Adfrontal sutures sinuate, extending less than half way from adfrontal ridge to hind margin. Longitudinal ridge long, nearly half the length of head. Ocelli six; numbers 3 and 4 closer together than 3 is to 2 or 4 is to 5; numbers 4, 5, and 6 form a triangle. Distance between frontal seta F_1 and adfrontal seta Adf_1 less than the distance between adfrontal seta Adf_1 and Adf_2. Adfrontal seta Adf_2 small. Epistomal setae E_1 and E_2 well developed. Anterior setae A_1, A_2, and A_3 form

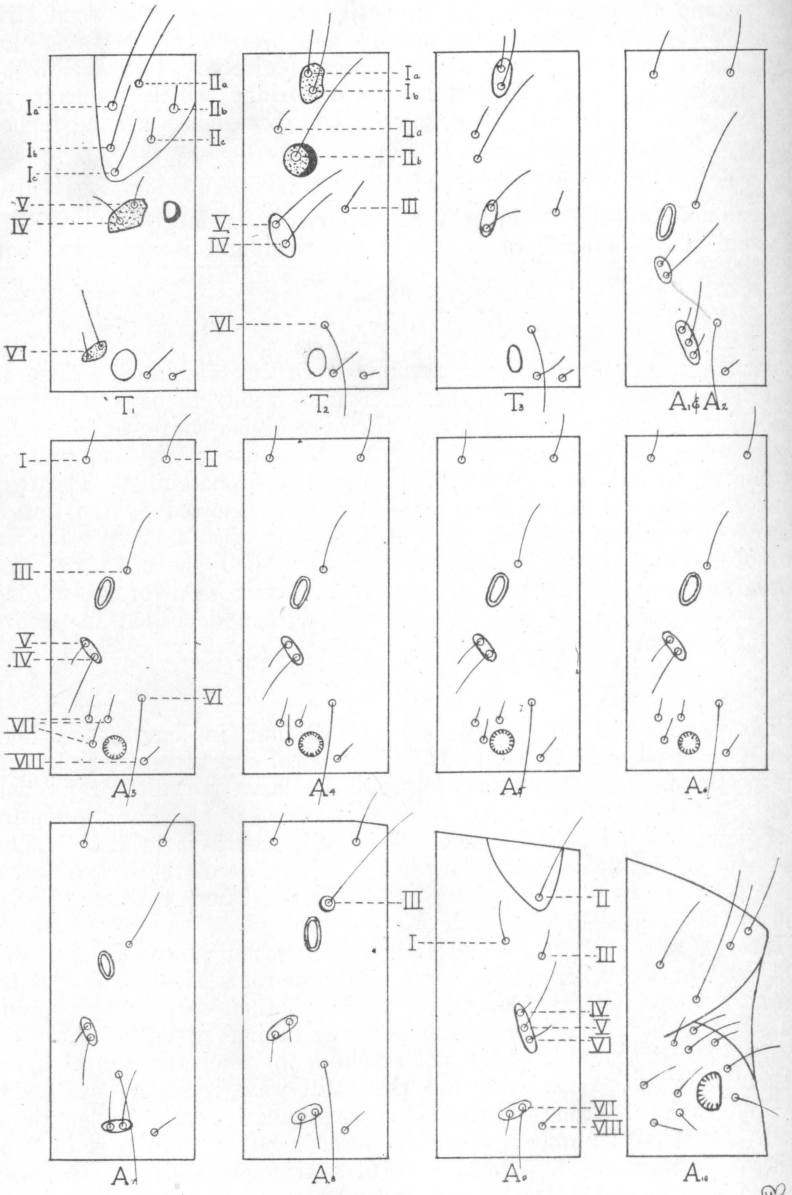

Fig. 5. Map of the arrangement of the setae of the larvae.

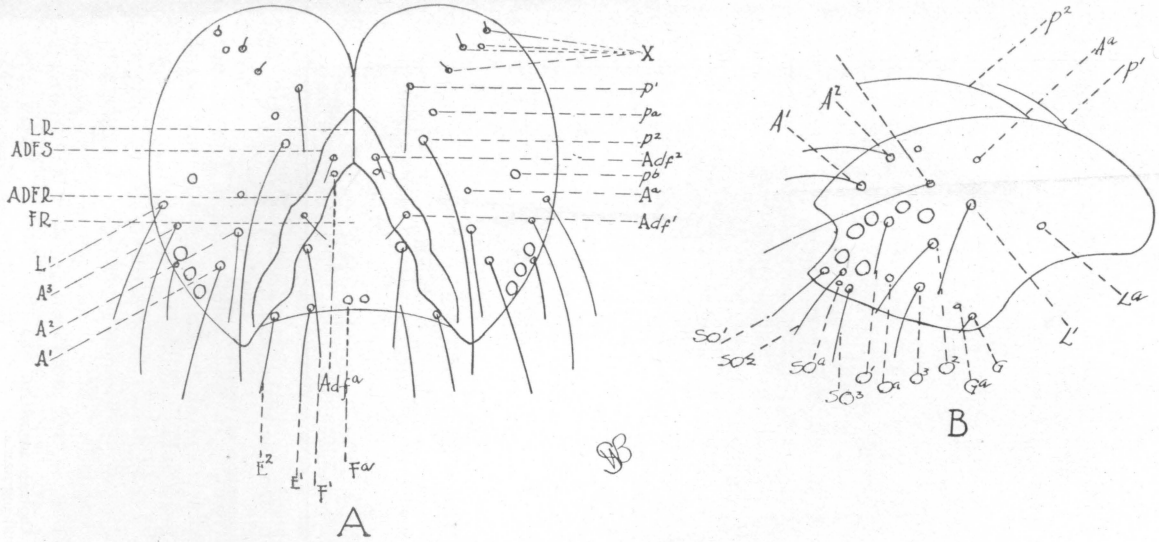

Fig. 6. Head capsule and arrangement of the setae on the head.

Explanation of Figure 6.

A—Head capsule, dorsal view.
B—Head capsule, lateral view.
LR =Longitudinal ridge of frons.
ADFR =Adfrontal ridge of frons.
ADFS =Adfrontal suture.
A_1, A_2, A_3 =Anterior setae of epicranium.
Aa =Anterior puncture of epicranium.
Adf_1, Adf_2 =Adfrontal setae of epicranium.
Adfa =Adfrontal puncture of epicranium.
X =Ultraposterior setae and puncture.
L_1, La =Lateral seta and puncture of epicranium.
F_1, Fa =Frontal seta and puncture.
P_1, P_2, Pa =Posterior setae and puncture of epicranium.
O_1, O_2, O_3, Oa =Ocellar setae and puncture of epicranium.
SO_1, SO_2, SO_3, SOa =Subocellar setae and puncture of epicranium.
G_1, Ga =genal seta and puncture of epicranium.
E_1, E_2 =Epistomal setae.

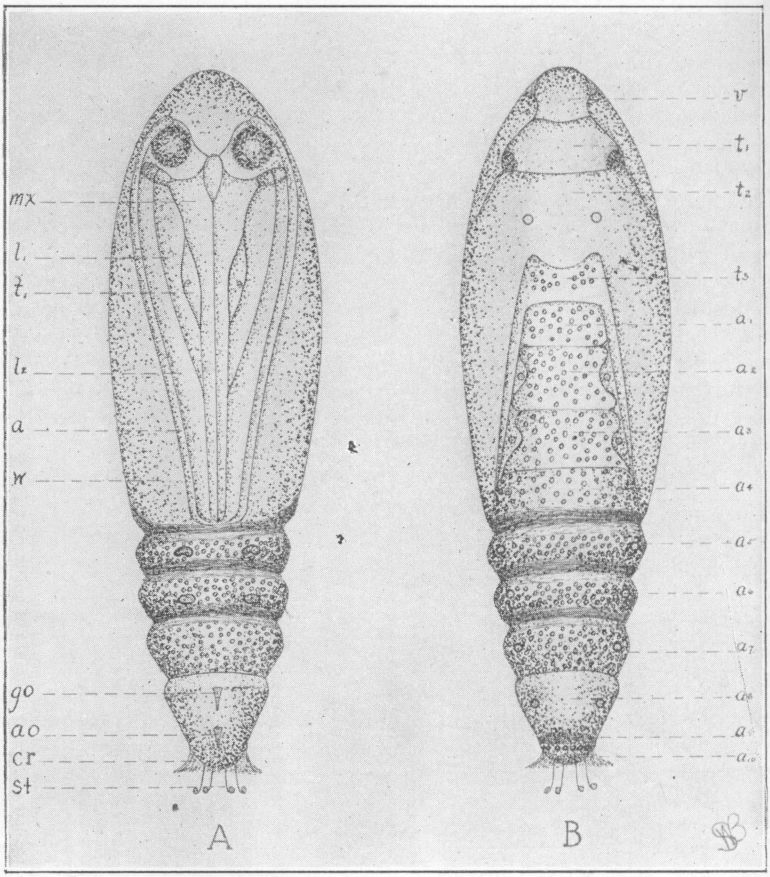

Fig. 7. Drawing of the pupa.

Explanation of Figure 7.

A—Ventral view of pupa.
B—Dorsal view of pupa.
mx = Maxilla.
l_1 = First thoracic leg.
l_2 = Second thoracic leg.
f_1 = Femora of prothoracic leg.
a = Antennae.
w = Wing.
go = Genital opening.
cr = Cremaster.
st = Stylets.
v = Vertex.
t_1, t_2, t_3 = First, second and third thoracic segments.
a_1 to a_{10} = First to tenth abdominal segments.

an obtuse angle. Seta A_2 is closer to A_1 than to A_3. Posterior setae P_1 and P_2, a little nearer to the longitudinal ridge than the margin. Seta P_1 is slightly posterior to Adf_1. Lateral seta L_1 is closer to A_3 than A_3 is to A_2. Ocellar seta O_1 is between and below ocelli 2 and 3 and about equidistant from them. Seta O_2 large and about the same distance from ocellus 1 as A_3. Seta O_3 is below O_2; A_3 and O_2 are situated in nearly a straight line. Subocellar seta SO_2 between and below ocelli 5 and 6; subocellar seta SO_3 below and posterior to subocellar seta SO_2.

Thoracic feet normal. Four pairs of abdominal prolegs with biordinal crochets arranged in a circle. Anal prolegs with a transverse line of biordinal crochets. Arrangement of body setae as shown in Fig. 5.

Labrum with median incision rounded, rather deep. Median setae small, M_1 and M_2 close to the margin. Mandibles longer than broad, three teeth, sharply pointed. Antennae two jointed; first joint longer.

Before pupating, the larva spins a flimsy cocoon composed of silk and excrement, from which is derived the name "Pecan Nut Case Bearer."

Pupa

The pupa (Fig. 7) is similar to that of many other small moths. It is 8 to 10 mm. in length. When it is first formed it is jade green in color but a few hours after pupation it turns to a brownish-yellow and later to a blackish-brown color. The two most distinctive characters are four setae, resembling golf clubs, and the cremasters or hooks,—both located at the posterior end, the latter at right angles to the longitudinal axis.

ORIGINAL DESCRIPTION

The following is the original description given by A. R. Grote, and is taken from Papilio, Vol. 1, No. 2, pp. 13-14, February 19, 1881:

"*Acrobasis caryae.* The maxillary palpi untufted, the antennae ciliate, with a sub-basal flexure and a scale-tooth on the thickly scaled basal joint. Shining grayish fuscous; the head and thorax concolorous. Smaller than *Angusella,* without the carneous shadings and reddish thorax and head. Outer line of primaries pale, narrow and faint. Inner line a ridge of raised darker scales narrowly edged outwardly by a pale, flesh-colored shade. The wing is paler, more grayish, at base. The color shifts with the light. Discal points faint. In ornamentation this species is inconspicuous. Hind wings as usual blackish; fringes interlined, concolorous. Length of primary wing, 9 mil. Reared by Mr. Coquillett from larvae on *Carya porcina;* the larva has been found "boring into the twigs." Mr. Coquillett describes the larva and chrysalis as follows:

" 'Body subcylindrical, smooth, pale greenish ash; a pale brown subdorsal dot on each side of segment 2; a wavy-fold below the spiracles;

the latter are encircled with a dark brown ring, and there is a brown piliferous dot above each; a few whitish hairs on each side of the body; top of segment 1 polished, yellowish-green; head narrower than segment 1, heart shaped, dark brown; venter pale green, unmarked; 16 legs; length, 14 mm. Found May 21, burrowing in the branches of the Pignut Hickory (*Carya porcina*) usually selecting the lower branches; imagoes about June 22. *Chrysalis*—Of the usual form, pale brown, rounded at the posterior end, at which place there is a cluster of about four slender hooked spines; length, from 7-8 mm. The larva spins a thin web around the footstalks of the leaves which grow near the terminal end of the branch, and then burrows into the terminal bud and the wood of the present year's growth. It webs its castings together and forms a short tube which projects outward from the mouth of its burrow, and is closed at the outer end. The larva probably assumes the chrysalis form in its burrow, but those which I reared deserted their burrows and spun tough cocoons beneath the litter in the bottom of the breeding-cage. These larvae are very subject to the attacks of parasites; from a small number which I collected I obtained three moths and two Hymenopterous parasites which Mr. E. T. Cresson determined to be the *Phanerotoma tibialis* of Haldeman. One of these parasites issued June 21, and the other June 26.'"

LIFE HISTORY STUDIES

The study of the life history of the pecan nut case bearer was carried on from 1918 to 1923, inclusive. Observations were continued in 1924 and 1925, but no detailed records were made for those years.

Pupation and emergence records, and length of life studies were obtained for all generations and for the entire period. The tables on egg deposition and the summaries on the oviposition records are tabulated from the records obtained from cage work. The conditions were made as nearly as possible like those of the moths under natural conditions.

As the egg deposition records were obtained on the trees in the orchard, the eggs remaining on the nuts where they were deposited, the incubation period may be considered as approximating that under natural conditions. In addition to the incubation records obtained from reared moths, records were also obtained from free flying moths. This was done by labelling certain limbs and careful daily inspection of the nuts on those limbs. When eggs were deposited, the position of the egg and the date of oviposition were recorded and a tag with the record was attached to the nut cluster containing the egg. In this way a check was obtained on the eggs obtained from reared moths. In 1923, the larvae were reared entirely on the trees, other larvae being prevented from gaining access to the nut clusters by means of a piece of muslin cloth tied below the cluster and a ring of tanglefoot applied to this. The larvae were confined to the cluster in a press-

board cylinder which was closed at one end with a cork stopper and at the other with a piece of cotton wrapped in tissue paper.

All the pupal and emergence records given for Clarksville, Corsicana, and Winona were obtained from nearly grown larvae and pupae which were collected at those places in connection with experiments on control and brought to College Station, where the life history was carried through.

Temperature Records

All the temperature records given are those taken by the Division of Entomology of the Experiment Station in co-operation with the U. S. Weather Bureau. The hygrothermograph of the Division of Entomology is located about 400 feet from the laboratory where part of the life history work was carried on.

The average mean temperatures were obtained by adding together the daily mean temperatures of the period under observation and then dividing the sum by the length of the pupal, egg or larval period.

Temperature has a very decided influence on the life history. It is thought from this study that the minimum temperature exerts the greater influence on the developing stages, especially in retarding emergence and in lengthening the pupal period. Humidity also has some influence but its exact relationship with the life history has not been determined.

Spring Brood

The spring brood consists of the larvae which have passed the winter, the pupae resulting from these larvae, and the resulting moths. The size of this brood during the period of observations was variable. After a year when a small or moderate crop of pecans matured, the spring brood was small. In 1923 it was difficult to find many spring brood larvae, except on trees which set nuts the previous year. After a year when there was a heavy crop of nuts the spring brood was usually large. In 1919 a heavy crop of nuts was harvested and the spring brood of 1920 was so large that most of the nuts which were set in the spring of 1920 were destroyed.

The length of the pupal period is more variable in the spring brood than in the three succeeding generations because low temperatures have the effect of lengthening the pupal period.

Larvae of the Spring Brood

The overwintering larvae consist of the non-transforming larvae of the third generation and all of the larvae of the fourth generation, when four generations occur.

At the approach of winter, or when there is a scarcity of food, the larvae spin tough silken cocoons, saucer shaped and from one to three millimeters in diameter, which are attached to the sides of buds, usually between the buds and the branches. They are about the same color as the bud itself and are much smaller than the cocoons which the larvae

spin to protect the pupae. The overwintering hibernacula are tough and difficult to open.

When the first warm days of spring arrive, the larva begins activity within this hibernaculum. It first feeds by cutting an opening at the point where it is attached to the bud. A small opening is also cut through the hibernaculum to the exterior, through which the larva pushes excrement and frass.

After the bud to which the hibernaculum was attached has been consumed the larva attacks other buds and soon enters the new growth at the axils of the leaves and main branches and then hollows out the interior. Some larvae feed on tender leaflets and occasionally some are found in the catkins. The time at which the larvae desert the overwintering cocoons or hibernacula, to feed on the new growth, varies with the season and the latitude. If the weather is warm they begin to come from their winter quarters about the middle of March and all of them have usually emerged by the middle of April. The point at which a larva enters a branch may be easily detected by the excrement which it pushes out. When the larva is full grown it stops up the opening through which it entered the branch and spins a flimsy cocoon made of silk and excrement. Then it pupates within this cocoon.

Pupae of the Spring Brood

The time at which the overwintering larvae begin to pupate depends to a great extent on temperature. Sudden changes in temperature and continued windy cool weather retard pupation. Humidity has some effect, the exact extent of which has not been determined. There is a correlation between the activity of the larvae and the condition of the buds, which in turn is dependent on soil temperatures. Under normal climatic conditions pupation begins about the 15th of April. In 1918 and 1921, because of high mean temperatures, some larvae began to feed during the middle of March and pupation began about April 1. In 1921 for a period of 10 days during the middle of March, the daily minimum temperature ranged from 65° F. to 70° F. Two pupal records were obtained on the 27th. of March, but on the 28th. the minimum temperature dropped to 37° F., and although it rose to 65° F. on April 5th., it again dropped to 41° F. on April 11th. and remained below 65° F. until April 24. On the 25th. of April the minimum temperature rose to 74° F. and on that day maximum pupation occurred. There were only six days from March 21 to April 25 in 1921 when the daily minimum temperature was above 65° F.; there was not a clear day during the month of April, and most of the days were windy. Fluctuations in temperature and low temperatures in April in both these years had the effect of greatly lengthening the period over which larvae were pupating and the duration of the pupal stage. In 1921 pupation extended over a period of 41 days and the period over which the larger number of individuals pupated was not as well defined as

in other years. The pupation curve for 1921 indicates that if the temperature is low, pupation will finally occur even if there is no decided rise in the temperature. The time of emergence of the adults will be delayed for a few days—sometimes as much as a week when the mean temperatures are low. From a comparison of the mean temperatures of 1918 and 1921 with those of 1919, 1920, 1922, and 1923, it will be seen that a difference of from 4° F. to 6° F. in the average mean temperatures resulted in delaying 6 to 7 days, the period over which pupation occurred and the period over which the larger number of larvae pupated. The average duration of the pupal period for 1918 was 17.5 days; that of 1921 was 18.5 days. The average duration of the pupal period for 1920, when the average mean temperature was 73.4° F., or 7° higher than in 1918, was but 12.1 days. In 1920 and 1922 when the average mean temperatures for the duration of pupal periods were 73.4° F. and 74.7° F., respectively, a large number of larvae were pupating daily during the entire time that pupation was taking place; and the period during which pupation occurred began on April 16 and continued until about May 8 or about 23 days. Maximum pupation took place on April 24 in 1920 and on April 25 in 1922.

In 1919 the temperatures fluctuated more than in 1920 or 1922. An examination of Fig. 8 shows that there were two peaks in the curve of pupation. The minimum daily temperature remained below 60° F. until April 5. From April 6 to April 8, the minimum daily temperature was 66° F., dropping to 44° F. on April 10. As soon as it began to rise again there was a daily increase in the number of larvae which pupated until the maximum number was reached.

In the spring of 1923 the spring-brood larvae were scarce. Though one person spent a month of his time collecting larvae, the number collected from day to day was so small that a continuous record could be obtained for only 123 individuals. Nearly half the larvae were collected from a single tree near the Navasota River. The reason for the paucity of spring-brood larvae in 1923 is not known, but it is believed that a lack of food and parasitism during the previous year may have been the controlling factors.

In 1922 a record was kept of the native trees which set a crop of nuts. In the spring of 1923 these were the only trees on which larvae could be found. On this account it is believed that the lack of a supply of nuts the previous year was in a great measure the cause of the scarcity of spring-brood larvae in 1923. But in 1922 it was also observed that there was a limited number of moths of the first generation, although there was a large number of first generation larvae. Hence parasitism may have also been an important factor in reducing the number of larvae.

Table 1.—Date of pupation and period over which pupation occurred. Spring brood, 1918–1923.

Date of Pupation	Number of Individuals Pupating								Total
	Year								
	1918	1919	1920	1921		1922		1923	
	College	College	College	College	Clarksville	College	Winona	College	
Mar. 27	.....	.....	.....	2	.....	.....	.....	.....	2
Mar. 29	.....	.....	.....	1	.....	.....	.....	.....	1
April 1	3	.....	.....	1	.....	.....	.....	.....	4
April 2	1	.....	.....	3	.....	.....	.....	.....	4
April 3	1	.....	.....	.....	.....	.....	.....	.....	1
April 4	3	.....	.....	3	.....	.....	.....	.....	6
April 5	2	.....	.....	11	.....	.....	.....	.....	13
April 6	1	.....	.....	7	.....	.....	.....	.....	8
April 7	2	.....	.....	2	.....	.....	.....	.....	4
April 8	8	.....	.....	10	.....	.....	.....	.....	18
April 9	.....	.....	.....	8	.....	.....	.....	.....	8
April 10	2	.....	.....	4	.....	.....	.....	.....	6
April 11	3	.....	.....	6	.....	.....	.....	.....	9
April 12	6	1	1	.....	.....	.....	.....	.....	8
April 13	3	6	.....	3	.....	.....	.....	.....	12
April 14	2	7	.....	3	.....	.....	.....	.....	12
April 15	9	28	.....	5	.....	.....	.....	.....	42
April 16	20	17	6	1	.....	1	.....	.....	45
April 17	21	6	18	5	.....	16	.....	.....	66
April 18	15	7	17	7	1	16	.....	.....	63
April 19	12	4	15	5	2	15	.....	.....	53
April 20	2	9	16	13	4	34	3	.....	81
April 21	.....	20	15	6	5	13	3	.....	62
April 22	3	44	21	3	9	16	3	.....	99
April 23	7	32	21	5	1	20	7	.....	93
April 24	2	29	64	13	10	64	6	.....	188
April 25	.....	10	49	46	17	112	30	.....	264
April 26	1	4	32	8	23	28	49	.....	145
April 27	3	6	4	6	10	31	45	3	108
April 28	.....	.....	11	25	16	34	24	35	145
April 29	.....	.....	11	1	4	12	5	18	51
April 30	.....	.....	14	8	.....	14	6	5	47
May 1	.....	3	20	1	7	24	6	7	68
May 2	.....	1	22	2	10	30	.....	4	69
May 3	.....	1	26	2	2	51	11	2	95
May 4	.....	.....	2	1	3	35	11	6	58
May 5	.....	.....	12	1	1	11	13	2	40
May 6	.....	.....	4	.....	4	45	.....	3	56
May 7	.....	.....	2	.....	2	12	4	9	29
May 8	.....	.....	2	.....	1	8	4	3	18
May 9	.....	.....	.....	.....	.....	16	.....	1	17
May 10	.....	.....	.....	.....	.....	.....	.....	6	6
May 11	.....	.....	.....	.....	.....	4	.....	3	7
May 12	.....	.....	.....	.....	1	.....	.....	7	8
May 13	.....	.....	.....	.....	.....	.....	.....	2	2
May 14	.....	.....	.....	.....	.....	1	1	3	5
May 15	.....	.....	.....	.....	.....	.....	.....	2	2
May 16	.....	.....	.....	.....	.....	.....	.....	2	2
Total...	132	235	405	228	133	663	231	123	2150

Table 2.—Relation of temperature to the duration of the pupal period. Spring brood, 1918-1923.

Length of Pupal Period, Days	Number of Individuals Pupating and Average Mean Temperatures														Total	Avg. Mean Temp.
	Year															
	1918		1919		1920		1921		1922			1923				
	College		College		College		College		Clarksville	College		Winona	College			
	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	No.	Avg. Mean Temp.	No.	No.	Avg. Mean Temp.		
8					3	78.4									3	78.3
9	1	67.0			14	77.7				12	80.0				27	78.4
10	2	65.5			32	77.2				21	79.0		1	75.0	56	77.0
11	1	66.4	2	70.5	32	76.4				63	78.4	3	2	74.1	103	77.3
12	4	66.2	31	71.7	92	72.7				53	77.7	5	5	75.4	190	73.8
13	2	67.4	74	71.2	89	72.2				52	76.3	17	9	73.9	243	72.8
14	2	68.2	30	69.8	45	71.0	3	67.5	1	120	73.6	42	24	73.5	267	72.4
15	3	66.6	25	68.3	6	72.3	2	65.0	10	113	73.5	44	43	73.4	246	72.5
16	6	67.3	19	68.2	1	71.7	11	69.3	16	66	72.0	52	11	73.8	182	71.0
17	12	66.8	4	68.5			29	69.4	25	30	70.7	15			115	69.4
18	16	66.0	1	68.3			48	69.5	35	15	69.7	2	1	73.2	118	68.9
19	21	65.5					48	68.8	19			1			89	67.8
20	9	66.3					22	67.1	2	1	70.7				34	67.0
21	2	66.5					17	66.2		1	74.5				20	66.6
22	2	67.1					3	65.7							5	66.2
23	1	67.5					2	66.9							3	67.1
24	1	68.0					1	65.7							2	66.8
Total	85	66.3	186	70.3	314	73.4	186	68.5	108	547	74.7	181	96	73.7	1703	
Average length of pupal period, days	17.5		13.6		12.1		18.5		17.3	13.8		14.9	14.4			

Table 3.—Summary of the length of the pupal period of the pecan nut case bearer. Spring brood, 1918-23.

Year	Place	Date of			Period over which pupation occurred	Number individuals observed	Length of Pupal Stage, Days		
		First Pupation	Maximum Pupation	Last Pupation			Avg.	Max.	Min.
1918	College...	April 1....	April 17...	April 27...	27	132	17.5	24	9
1919	College...	April 12...	April 22...	May 3....	22	235	13.6	18	11
1920	College...	April 12...	April 24...	May 8....	27	405	12.1	16	8
1921	College...	Mar. 27...	April 25...	May 6....	41	228	18.5	24	14
	Clarksville...	April 18...	April 26...	May 12...	25	133	17.3	20	14
1922	College...	April 16...	April 25...	May 14...	29	663	13.8	21	9
	Winona..	April 20...	April 26...	May 14...	25	231	14.9	19	11
1923	College...	April 27...	April 28...	May 16...	20	123	14.4	18	10
	Total..	.....	.....	.....	.....	2150	.....	.....	.....

Because of the relatively small number of larvae collected and the fact that the greater number were collected from one tree, it is scarcely possible to arrive at any conclusions with regard to the effect of temperature on the time of pupation. It will be seen, however, that the minimum temperature was above 60° F. most of the time from April 5 to April 14, and on April 14 dropped below 60° F., reaching 48° F. on April 17. On April 21 the minimum temperature began to rise and reached 72° F. on April 24 and 25 and maximum pupation occurred on April 28.

The period during which pupation occurred was considerably delayed in 1923, although maximum pupation took place but four days after the time of maximum pupation in 1922 and five days after maximum pupation occurred in 1920. When the mean temperature remains below 60° F. during the month of March, the larvae do not begin feeding until early in April. In such a case pupation normally begins about the 15th. of April. In years when the daily minimum temperature did not often fall below 65° F. or did not remain below 65° F. for any length of time after the larvae began to feed, pupation began about the 15th. of April and was completed in about 27 days, and a considerable number of larvae pupated each day over the period when pupation was taking place. But in years when the mean temperature was high enough to start tree growth before March 20th., the larvae came from their hibernacula and began feeding. If this period was followed by low temperatures for any considerable length of time the period during which pupation occurred was lengthened from 5 to 14 days and the average duration of the pupal stage was lengthened from 4 to 6 days.

Great fluctuations in either the mean temperature or the daily minimum temperature had the same effect as low temperature.

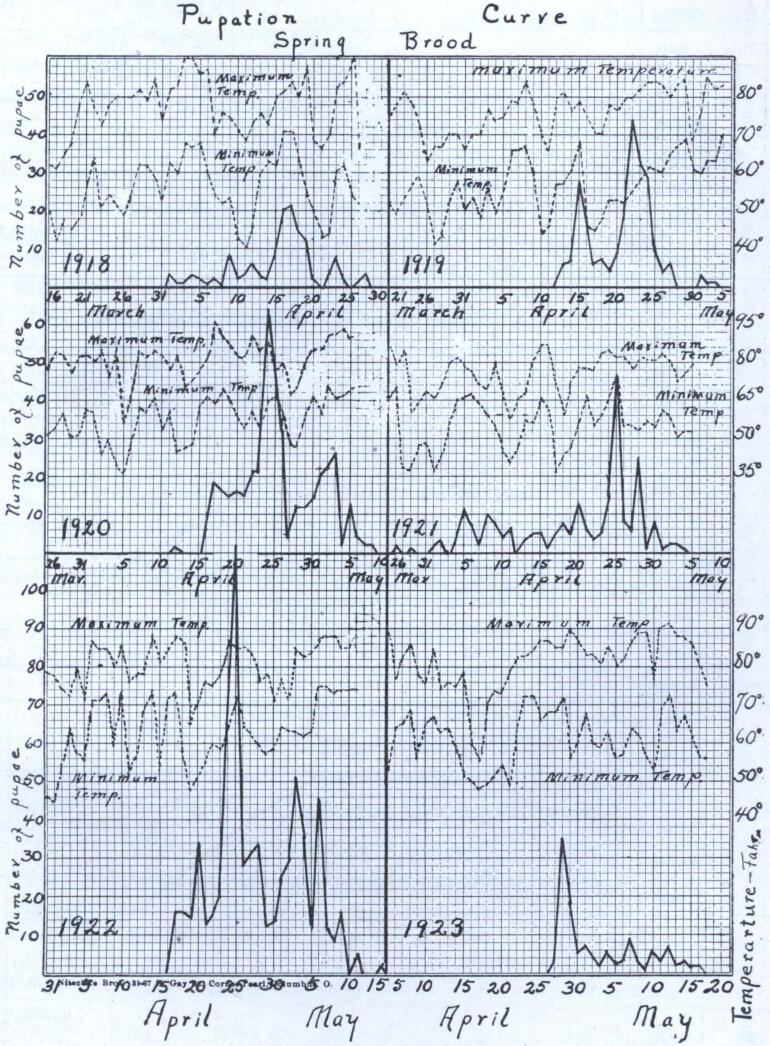

Fig. 8. Pupal records and temperatures for the spring brood. College Station, 1918–1923

Table 4.—Time of emergence of the spring-brood moths. 1918-1923.

Date of Emergence	Number of Moths Emerging																												Total
	1918			1919			1920			1921									1922			1923							
	College			College			College			College			Corsicana			Clarksville			College			Winona			College			
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	
April 15											2	2																	2
April 16	4	2	6																										6
April 19	3		3																										3
April 20										2		2																	2
April 22		1	1																										1
April 23										6		6																	6
April 24	2		2																										2
April 25										7	2	9																	9
April 26	2		2				1		1	8	3	11																	14
April 27	6		6	1		1				2	3	5																	12
April 28	2	5	7	2		2	1	1	2	5	2	7																	18
April 29	1	1	2	10	4	14	5	2	7	3	3	6																	29
April 30	6	2	8	9	8	17	2	2	4	3	3	6																	35
May 1	1	2	3	9	3	12	12	3	15	4	1	5																	35
May 2	5	1	6	8	8	16	10	5	15	2	3	5																	42
May 3	1		1	2	7	9	23	14	37	1	1	2							3	3	6								55
May 4	4	2	6	9	11	20	19	12	31		3	3							7	1	8								68
May 5	2	4	6	12	30	42	16	12	28		2	2					4	4	9	5	14								96
May 6	3	6	9	14	14	28	14	29	43	3	5	8							34	19	53								141
May 7	6	9	15	3	8	11	25	33	58	4	3	7							17	10	27	3	1	4	2		2		124
May 8	3	4	7	1	2	3	25	24	49	1	2	3		1	1		5	5	23	11	34	1	1	2	5	3	8		112
May 9	4	6	10		2	2	6	18	24	4	6	10	1		1	1	6	7	46	58	104	2	1	3	5	4	9		170
May 10		3	3		2	2	3	6	9	6	1	7	1	2	3	2	1	3	31	37	68	18	25	43	2		2		140
May 11		2	2	3		3	3	10	13	3	5	8		4	4	1	4	5	20	32	52	4	6	10	1	6	7		104
May 12					3	3	3	16	19	4	1	5		3	3	2	3	5	16	18	34	13	10	23	9	8	17		109
May 13							3	7	10	12	9	21	1		1	7	12	19	8	22	30	12	20	32	14	30	44		157
May 14	1		1				5	2	7	11	3	14	1		1	4	9	13	28	31	59	22	3	25	10	19	29		149
May 15					1	1		2	2	10	8	18	1	3	4	3	2	5	25	34	59	1	6	7	3	10	13		109
May 16				1		1				6	7	13	2	2	4	2		2	8	12	20	5	4	9	3	9	12		61
May 17										6	3	9	1		1	12	11	23	4	17	21				2	2	4		58
May 18							1	3	4	2	2	4				1	2	3	7	8	15	3	4	7	1	1	2		35
May 19								1	1	1	1	2				3	1	4	4	3	7	7	1	8	2	6	8		30
May 20											2	2				1	3	4	3	7	10	3	1	4	4	6	10		30
May 21							1		1							1	3	4		6	6	2		2	4	5	9		22
May 22																1		1	4	5	9	1	1	2	1	3	4		16
May 23																	1	1	1	1	2					5	5		8
May 24																				1	1				2	2	4		5
May 25																									1	2	3		3
May 26																										2	2		2
May 27																										1	1		1
May 28																										1	1		1
Total	56	50	106	84	103	187	178	202	380	116	86	202	8	15	23	41	67	108	298	341	639	97	84	181	71	125	196		2022

Emergence of Spring-Brood Moths

The moths emerge at night. The males begin emerging first and it is possible to determine the progress of the generation by the preponderance of males or females.

When the adult is fully formed the pupal case splits open at the larger end and the moth emerges.

The time of emergence and the length of the period over which the adults emerged is dependent on the temperature during the time the insect is in the pupal stage. If the mean temperatures are low, emergence is continued over a long period of time. In 1918 and 1921 the moths emerged over a period of 29 and 36 days, respectively, but in 1920 and 1922 when the mean temperatures were a few degrees higher emergence was completed in 26 days and 22 days, respectively. A large number of moths emerged daily over the greater part of the time during which emergence was taking place in 1920 and 1922, while in 1918 and 1921 emergence occupied a longer period.

The moths of the spring brood began to emerge as early as April 15, but emergence in large numbers occurred only from April 28 to May 6. Except in the years 1918 and 1921, when the average mean temperature of the pupal period was about 65° F., emergence was completed in from 22 to 26 days. It is a significant fact as regards control that the time of maximum emergence varied but 8 days in the six years, occurring on May 5 in 1919; on May 7 in 1918 and 1920; on May 9 in 1922; and on May 13 in each of the years 1921 and 1923.

Table 5. Summary of the emergence records of the spring-brood moths of the pecan nut case bearer. 1918-1923.

Year	Place	Date of			Number Days on which Emergence Occurred	Number moths Observed	Number Males	Number Females
		First Emergence	Maximum Emergence	Last Emergence				
1918	College....	April 16...	May 7....	May 14...	29	106	56	50
1919	College....	April 27...	May 5....	May 17...	21	187	84	103
1920	College....	April 26...	May 7....	May 21...	26	380	178	202
1921	College....	April 15...	May 13...	May 20...	36	202	116	86
	College, Corsicana, Clarksville.	April 15...	May 13...	May 23...	39	333	165	168
1922	College....	May 3....	May 9....	May 24...	22	639	298	341
	College, Winona...	May 3....	May 10...	May 24...	22	820	395	425
1923	College....	May 7....	May 13...	May 28...	22	196	71	125
	Total...	.....	.....	.....	.....	2022	949	1073

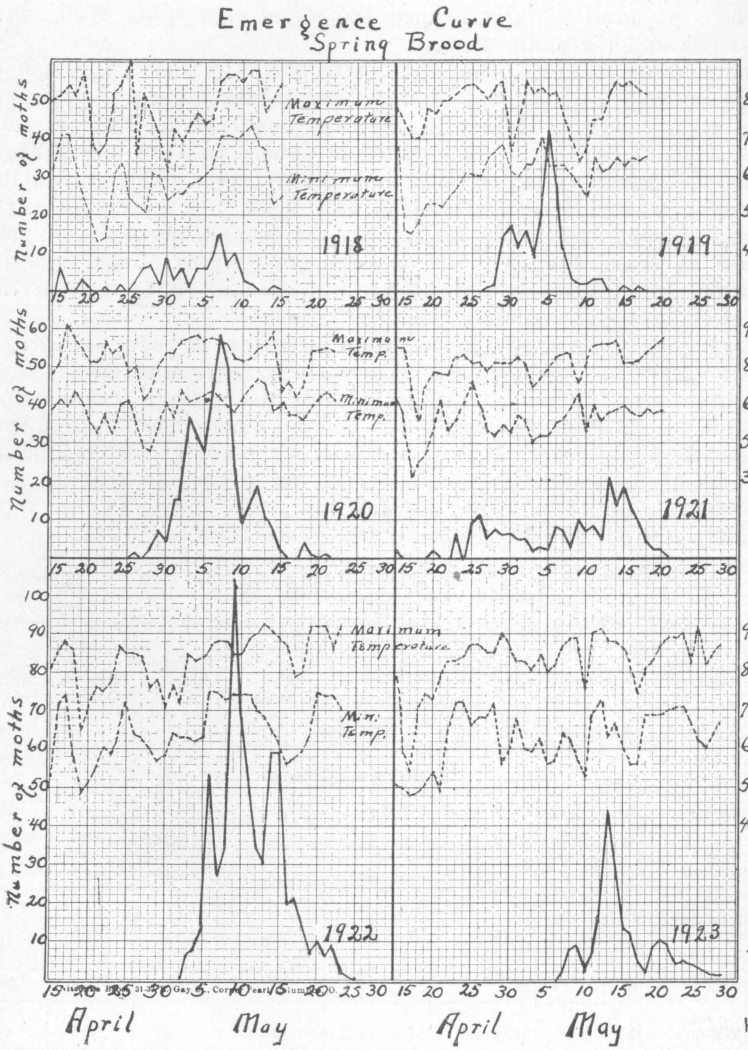

Fig. 9. Emergence records and temperatures for the spring brood. College Station, 1918-1923.

Oviposition by the Moths of the Spring Brood

The records on egg deposition were difficult to obtain, and since the moths do not behave normally in captivity, it is very probable, though field conditions were reproduced as nearly as possible, that these records are not representative of what occurs in the field. All the records were obtained in breeding cages on the trees. It is probable that the maximum number of eggs obtained in the cages would be nearly the average number deposited by any single moth under field conditions.

The eggs in this brood are usually placed in the tips of the nuts. Eggs may be deposited on the upper or lower surface of the calyx and occasionally one is deposited in the grooves at the tips and bases of the nuts. Most of them are so placed that they are difficult to find. A moth seldom deposits more than one egg in a cluster of nuts. The majority of the moths died without ovipositing.

In the cage, experiments in 1922 the first eggs deposited were laid on May 8. Observations made on nuts under field conditions showed that eggs had been deposited a few days prior to that time. Oviposition records were obtained from 64 moths. This was but a small per cent of those caged, as most of them died in the cages without ovipositing. Most of the surviving moths in the cages laid a small number of eggs. From dissections made it is thought that the maximum number laid in cages is nearly the average number under field conditions. The last eggs in the cages were obtained on May 26. The maximum number of eggs laid by one individual was 163, and this one escaped before the oviposition record was completed. The average length of life of the females that oviposited was 7.1 days. The average time from emergence to the first oviposition was 4.1 days. Oviposition occurred over an average of 1.4 days and the average time from emergence to last oviposition was 5 days. The average time from the last oviposition until the moth died was 2.1 days.

In 1923 the first eggs deposited by caged moths were laid on May 15. As it was not possible to get eggs from moths in cages until a considerable number had emerged, the first date of egg deposition in cages was a few days after that observed under field conditions.

Oviposition records were obtained from 36 females. The maximum number of eggs laid by one female was 142, deposited over a period of four nights.

The average life of the females which oviposited was 8.5 days; the average time from emergence to first oviposition was 3 days, and the average time over which oviposition occurred was 2.7 days. An average of 6.5 days elapsed from emergence to last oviposition and the average life after the last oviposition was 2 days.

Table 6.—Summary of the oviposition records of the spring-brood moths of the pecan nut case bearer. College Station Texas, 1922.

Moth Number	Date of Emergence.	Date Moth Died.	Length of Life.	Total Number of Eggs Laid.	Number Days from Emergence to First Oviposition.	Number Days on Which Oviposition Occurred.	Number Days from Emergence to Last Oviposition.	Length of Life After Last Oviposition.
1	May 3	May 8	5	1	5	1	5	0
2	May 5	May 8	3	3	3	1	3	0
3	May 5	May 10	5	31	3	2	4	1
4	May 6	May 10	4	35	3	1	3	1
5	May 6	May 15	9	8	3	1	3	6
6	May 6	May 9	3	5	3	1	3	0
7	May 6	May 10	4	8	3	1	3	1
8	May 6	May 10	4	3	3	1	3	1
9	May 7	May 15	8	5	5	2	8	0
10	May 9	May 14	5	14	2	4	5	0
11	May 9	May 22	13	8	3	4	7	6
12	May 9	May 13*	.....	163	3	.....	.....	.....
13	May 9	May 16	7	10	3	2	4	3
14	May 9	May 13	4	15	3	1	3	1
15	May 9	May 13	4	58	3	2	4	0
16	May 9	May 22	13	5	4	1	4	9
17	May 9	May 17	8	15	3	4	8	0
18	May 9	May 26	17	1	6	1	6	11
19	May 9	May 13	4	3	3	1	3	1
20	May 9	May 13	4	1	4	1	4	0
21	May 9	May 13	4	3	3	1	3	1
22	May 9	May 14	5	1	3	1	3	2
23	May 9	May 18	9	29	3	3	9	0
24	Mah 9	May 17	8	21	4	1	4	4
25	May 9	May 15	6	80	4	2	5	1
26	May 9	May 22	13	4	4	2	9	4
27	May 9	May 13*	.....	114	3	.....	.....	.....
28	May 9	May 15	6	28	3	2	4	2
29	May 9	May 14	5	7	4	2	5	0
30	May 9	May 22	13	86	4	1	4	9
31	May 9	May 20*	.....	65	4	.....	.....	.....
32	May 11	May 13	2	1	2	1	2	0
33	May 11	May 14	3	4	2	1	2	1
34	May 11	May 18	7	10	3	1	3	4
35	May 11	May 14	3	1	3	1	3	0
36	May 11	May 16	5	3	3	1	3	2
37	May 11	May 16	5	7	4	1	4	1
38	May 11	May 17	6	6	6	1	6	0
39	May 11	May 18	7	2	5	1	5	2
40	May 11	May 23	12	9	3	4	11	1
41	May 11	May 22	11	2	4	2	7	4
42	May 11	May 16	5	1	3	1	3	2
43	May 11	May 17	6	2	4	1	4	2
44	May 11	May 17	6	1	4	1	4	2
45	May 12	May 22	10	5	3	2	4	6
46	May 12	May 22	10	23	5	2	8	2
47	May 13	May 22	9	7	5	1	5	4
48	May 13	May 18	5	2	5	1	5	0
49	May 13	May 18	5	1	4	1	4	1
50	May 14	May 17*	.....	40	4	.....	.....	.....
51	May 14	May 22	8	25	7	1	7	1
52	May 14	May 18	4	1	4	1	4	0
53	May 14	May 22	8	1	4	1	4	4
54	May 14	May 25	11	20	5	3	11	0
55	May 15	May 20*	.....	38	5	.....	.....	.....
56	May 15	May 23*	.....	17	8	.....	.....	.....
57	May 15	May 24	9	1	9	1	9	0
58	May 15	May 24	9	1	3	1	3	6
59	May 16	May 24	8	4	7	1	7	1
60	May 16	May 28	12	3	7	1	7	5
61	May 17	May 28	11	12	8	1	8	3
62	May 18	May 23*	.....	10	4	.....	.....	.....
63	May 20	May 28	8	5	6	1	6	2
64	May 21	May 28	7	3	5	1	5	2

*Indicates moth escaped or was killed before record was completed.

Table 7.—Summary of the oviposition records of the spring-brood moths of the pecan nut case bearer. College Station, Texas, 1923.

Moth Number	Date of Emergence.	Date Moth Died.	Length of Life.	Total Number of Eggs Laid.	Number Days from Emergence to First Oviposition.	Number Days on which Oviposition Occurred.	Number Days from Emergence to Last Oviposition.	Length of Life After Last Oviposition.
1	May 8	May 23	15	31	7	5	13	2
2	May 9	May 15*	.....	74	4	.....	.....	.....
3	May 11	May 20	9	59	4	5	9	0
4	May 12	May 26	14	27	10	3	12	2
5	May 12	May 17	5	6	3	1	3	2
6	May 13	May 22	9	7	9	1	9	0
7	May 13	May 20	7	16	5	2	7	0
8	May 13	June 2	20	43	6	8	19	1
9	May 13	May 28	15	65	7	4	10	5
10	May 14	May 21*	.....	37	3	.....	.....	.....
11	May 14	May 20	6	2	3	2	5	1
12	May 14	May 24	10	16	4	2	6	4
13	May 14	May 24	10	43	4	6	9	1
14	May 15	May 23	8	19	4	1	5	3
15	May 15	May 20	5	32	4	1	4	1
16	May 15	May 28	13	15	5	1	5	8
17	May 18	May 20*	2	28	2	1	2	0
18	May 18	May 28	10	42	4	4	8	2
19	May 18	May 28	10	30	2	6	9	1
20	May 18	May 27	9	142	2	4	5	4
21	May 18	May 30	12	83	2	8	10	2
22	May 18	May 21	3	4	2	1	2	1
23	May 18	May 21	3	7	2	1	2	1
24	May 18	May 24	6	8	2	2	4	2
25	May 19	May 27*	.....	18	4	.....	.....	.....
26	May 19	May 30*	.....	15	3	.....	.....	.....
27	May 19	May 24	5	3	5	1	5	0
28	May 19	May 23	4	4	3	1	3	1
29	May 19	May 30	11	25	3	3	10	1
30	May 19	May 28*	.....	28	3	.....	.....	.....
31	May 19	May 28	9	4	3	3	6	3
32	May 19	May 27	8	2	4	1	4	4
33	May 21	May 26	5	1	3	1	3	2
34	May 21	May 26	5	1	3	1	3	2
35	May 21	May 26*	.....	19	3	.....	.....	.....
36	May 21	May 28	7	40	3	3	5	2

*Indicates moth escaped or was killed before record was completed.

Length of Life of the Adults of the Spring Brood

The records on the length of life were obtained entirely from moths in captivity. The length of life may be shortened in captivity by several factors. One of the most difficult of these to control was temperature. If the moths are kept in the sun or if too high a temperature existed in the mating cages the length of life was much shorter than when a lower temperature was maintained by spraying water on the cages several times a day. The fact that the moths were confined to a limited space may also have shortened the length of life. The females begin to oviposit a few nights after they emerge. The fact that they deposit their eggs in from one to twelve days is an indication that the length of life is rather short. The length of life was longer when more care was taken in feeding individual moths with a medicine dropper than when they were fed collectively with an atomizer.

Table 8.—Length of life of the adults of the spring brood, 1918-1923.

Length of Life, Days	1918		1919		1920		1921		1922		1923	
	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem
1	3	3	4	9	20	26	5	11	.....	.....	.....	.....
2	3	1	2	5	20	21	3	20	3	6	1	2
3	4	1	12	16	19	14	17	9	10	6	2	4
4	4	6	6	12	2	7	13	11	24	25	6	5
5	4	8	13	5	9	11	12	12	19	19	2	4
6	4	5	3	.....	2	5	7	4	12	17	6	7
7	4	4	7	2	.....	.....	3	1	6	7	2	6
8	8	3	3	3	.....	.....	4	.....	10	12	2	3
9	.....	2	3	1	.....	.....	.....	1	10	8	2	6
10	1	1	.....	.....	.....	.....	.....	.....	5	9	1	5
11	.....	.....	.....	1	.....	.....	.....	.....	3	2	1	2
12	.....	.....	2	1	.....	.....	.....	.....	3	4	.....	.....
13	2	2	.....	.....	.....	.....	.....	.....	1	5	1	1
14	2	1	.....	.....	.....	.....	.....	.....	1	.....	.....	1
15	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	3
16	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
19	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Average length of life	6.4	6.5	5	3.81	2.52	2.65	4.20	3.21	6.22	6.47	6.15	7.64
Maximum	19	18	12	12	6	6	8	9	15	15	13	20
Minimum	1	1	1	1	1	1	1	1	2	2	2	2

First Generation

The first generation begins with the incubation of the eggs deposited by the spring-brood moths. The first generation consists of the:

(a) Eggs of the first generation.
(b) The resulting larvae, or larvae of the first generation.
(c) The pupae of the first generation.
(d) The moths of the first generation.

From the time of the deposition of the first eggs to the death of the last moths of this generation was 66 days in 1922. The time from the deposition of the first eggs in 1923 to the death of the last moths was 70 days. Hence it may be considered that it requires about 70 days to complete the first generation.

Incubation of the Eggs of the First Generation

The incubation period was determined in the field under natural conditions. An examination of the eggs was made on the trees each day. The nuts on which eggs were deposited were not removed from the tree, in view of the fact that the nuts dry out very quickly once they are removed and often dry up entirely before the eggs hatch. When first laid the eggs are bluish-white. A few hours after, small red spots appear, which increase in size, giving the egg a reddish mottled appearance. The larva cuts its way out of the end of the egg and after hatching the shell is white and often adheres to the nut for a long time.

The incubation period was obtained from 1918-1921 by selecting certain limbs which were easily accessible from the ground, tagging them and then making daily examinations to see if any eggs were deposited by free flying moths. A large number of eggs could not be obtained in this fashion and the records for those years are more or less fragmentary. For this reason in 1922 and 1923 the egg records were made entirely from moths confined in small breeding cages. The results of this method were checked against the hatching period of the eggs deposited by free flying moths, little or no difference being found between the two.

In 1922 the minimum incubation period was 4 days, the maximum 7 days, and the average 5.6 days. A total of 860 eggs was observed.

In 1923 the minimum duration of the egg stage was 4 days, the maximum 7 days and the average 5 days. A total of 713 eggs was observed.

Table 9.—Length of incubation of the eggs of the first generation. 1922-1923.

Date of Oviposition	Number of Eggs Recorded		Incubation Period—Days															
			Year															
			1922		1923		1922		1923		1922		1923		1922		1923	
			Four Days				Five Days				Six Days				Seven Days			
	1922	1923	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.
May 9	35						35	77.8										
May 12	145		12	80.9			3	81.0			131	80.9						
May 13	479	59					92	80.8			387	81.1	58	72.5			1	73.0
May 14	21										21	81.6						
May 15	2	44	1	81.5			1	82.0	28	71.6			16	72.6				
May 16	6						4	82.1							2	82.3		
May 17	9	10					1	82.1	1	74.8	8	82.5	9	75.6				
May 18	44	13	3	82.6			40	82.9	13	77.7	1	83.2						
May 19		62							61	78.8			1	78.0				
May 20	53	165	15	83.1	32	79.5	38	83.4	133	78.5								
May 21	42	92			1	78.6	42	83.9	91	78.3								
May 22	8	82					8	84.3	82	76.6								
May 23	2	79					2	84.4	68	75.5			11	75.7				
May 24	13	80			26	74.2	13	83.3	54	74.8								
May 25	1	20					1	83.0	20	76.2								
May 27		1							1	79.0								
May 28		2							2	80.6								
May 29		4			4	81.5												
Total	860	713	31	82.1	63	77.4	280	81.8	554	77.0	548	81.1	95	73.2	2	82.3	1	73.0

Average length of incubation period—1922, 5.6 days.
Average length of incubation period—1923, 5 days.

Larval Period of the First Generation

It was difficult to obtain data on the length of the larval period and the records of 1923 only are included in this study. The difficulty in securing larval records was due to the fact that when larvae were allowed to feed under natural conditions a large number were destroyed by predaceous and parasitic enemies. Many were also lost because of the larval habit of crawling rapidly about as soon as they hatch. If the nuts were removed to the laboratory they dried up so quickly that the feeding of larvae was more or less irregular. The larval records given in Table 10 were obtained by rearing the larvae on the trees, where they were protected by cages made of press board.

On hatching from the eggs the majority of the larvae fed on buds for a short time, usually about two days, before they entered the nuts, although some entered the nuts a short time after hatching. The larvae of the first generation nearly always enter the nuts by cutting circular holes at the bases. Before cutting into the nut a silken web is attached to the nuts and forms a protected place for the larva while it is feeding.

Table 10.—Length of the larval stage. First generation. 1923.

Length of Larval Stage—Days	Number of Records	Average Mean Temperature
17	1	79.2
18	1	79.3
19	5	79.2
20	3	79.1
21	2	79.2
22	5	79.5
23	11	79.6
24	8	79.8
25	11	80.1
26	4	80.3
27	6	80.2
28	3	80.6
29	3	80.1
30	7	80.5
31	2	80.8
32	3	81.1
33	1	80.0
34	3	80.4
35	1	80.6
40	1	80.3
Total	81	80.0

Average length of larval stage—1923, 25.6 days.

The larva prefers to remain in dry nuts when not feeding and selects a hard dry nut in which to pupate. One can distinguish the characteristic work of this larva from that of other pecan feeding insects by its habit of pushing the excrement out of the burrow when feeding in the limbs and in the nuts. The larva is very active until a short time before it pupates when it stops up the entrance hole with pellets of excrement and silk and spins a flimsy cocoon on the inside of the nut. When first hatched the larva is white in color, later turning to

an olive gray and just before pupation changing to a jade green. Records were obtained on 81 individuals. The length of the larval period ranged from 17 days as a minimum to 40 days as the maximum. The average larval period was 25.6 days.

Pupae of the First Generation

The pupal period is passed inside the nuts and inside the cocoon spun by the larva. Temperature which is an important factor in determining the length of the pupal period in the spring brood does not operate to the same extent in controlling the length of the pupal period in this generation. This is probably due to the fact that both the mean and minimum temperatures have reached a height where temperature is not as important a controlling factor and also to the fact that there is less fluctuation in the temperature during the time in which the first generation is passed.

The duration of the pupal period ranged from 5 to 16 days, but the average length of the pupal period for the several years varied but little. In 1918 when the average mean temperature was about 83° F. for the duration of the pupal period, the average length was 8.5 days. In the succeeding five years the average duration was 9.6, 9, 9.5, 9, and 9.4 days, respectively.

There was more variation in the time pupation occurred than in the length of the pupal period. This variation was due in great measure to the time that the spring-brood moths emerged and the temperatures during the development of the larvae of this generation. In the three years, 1918, 1919, and 1921 the first larvae pupated during the last three days of May. In 1921 and 1922 the first larvae pupated on June 6. In 1923 the first larva pupated on June 12th. The spring brood was much later in 1923 than in any other year, which probably accounts for the corresponding delay in the period over which pupation occurred.

Table 11.—Date of pupation and period over which pupation occurred. First generation. 1918–1923.

Date of Pupation	Number of Individuals Pupating										Total
	Year										
	1918	1919	1920		1921		1922		1923		
	College	College	College	Corsicana	College	Winona	College	Corsicana	Winona	College	
May 29	3										3
May 31	1	1	4								6
June 1		1	2								3
June 2		1	6								7
June 3	4		10								14
June 4	7	2	12								21
June 5	5	1	31								37
June 6	2	2	17		1		24				46
June 7	5		30		5		6				46
June 8	20		20		2	11					53
June 8	15	14	23		5	4	1				62
June 10	22	3	17		3	2	6				53
June 11	22	6	27		7	10	17				89
June 12	25		14		8	9	17			1	74
June 13	5	14	13		5	15	23		1	5	81
June 14	5	9	4		3	15	6		9	5	56
June 15	7	7	1		5	8	5		8	4	45
June 16	2	29	4		6	19	10		9	9	88
June 17	7	18	5		2	20	6		8	12	78
June 18	4	12		2		11	10		7	23	69
June 19		29	2	3		7	20		18	17	96
June 20		22	2	21	5	22	5		19	11	107
June 21		17	2	15		10	14	9	14	13	94
June 22		17	1	20		18	6	12	9	9	92
June 23		7		9		15		9	6	14	60
June 24				6		11	8	15	12	13	65
June 25		4	1	8		8	4	7	35	17	84
June 26		4		2		10	6	7	36	15	80
June 27		2		1	1			8	9	12	33
June 28				2		2	2	4	9	15	34
June 29			1	4		1		2	6	4	18
June 30		1		2					6	2	11
July 1		4		1				2	10	1	18
July 2		2		1		2			3	1	9
July 3				4				2	2		8
July 4								1	2	1	4
July 5											0
July 6									1		1
July 7											0
July 8									1	2	3
Total	161	229	249	101	58	230	196	78	240	206	1748

Table 12.—Relation of temperature to the duration of the pupal period. First generation. 1918–1923.

Length of Pupal Stage, Days	Number of Individuals Pupating and Average Mean Temperatures																Total	Avg. Mean Temp.
	Year																	
	1918		1919		1920			1921			1922				1923			
	College		College		College		Corsicana	College		Winona	College		Corsicana	Winona	College			
	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	No.	Avg. Mean Temp.	No.	No.	Avg. Mean Temp.	No.	No.	No.	Avg. Mean Temp.		
5	3	83.5			2	78.1											5	81.3
6	3	83.2			5	78.0					2	79.3		1			11	79.8
7	13	82.8	7	78.4	8	78.1	2	3	79.0	1	3	78.6		2			39	80.0
8	33	83.7	6	80.7	32	78.9	5	7	78.8	3	33	81.6	4	10	16	81.5	149	81.2
9	43	83.7	55	79.8	81	79.2	12	13	78.9	11	65	81.8	16	66	92	81.5	454	80.9
10	17	83.7	82	79.4	56	78.8	34	13	79.5	54	30	82.4	28	61	55	79.8	430	80.0
11	4	83.5	18	78.0	12	78.8	11	6	78.8	69	1	81.6	10	33	11	78.4	175	78.8
12	1	83.4	1	76.9			2	5	78.9	19	6	80.0	3	3	1	79.6	41	79.6
13			1	77.2			1			4	2	79.0		1			9	78.4
14																		
15																		
16															1	80.3	1	80.3
Total	117	83.5	170	79.3	196	78.9	67	47	79.0	161	142	81.6	61	177	176	80.7	1314	
Average length of pupal period, days		8.5	9.6		9		9.8	9.5		10.6	9		9.8	9.7	9.4			

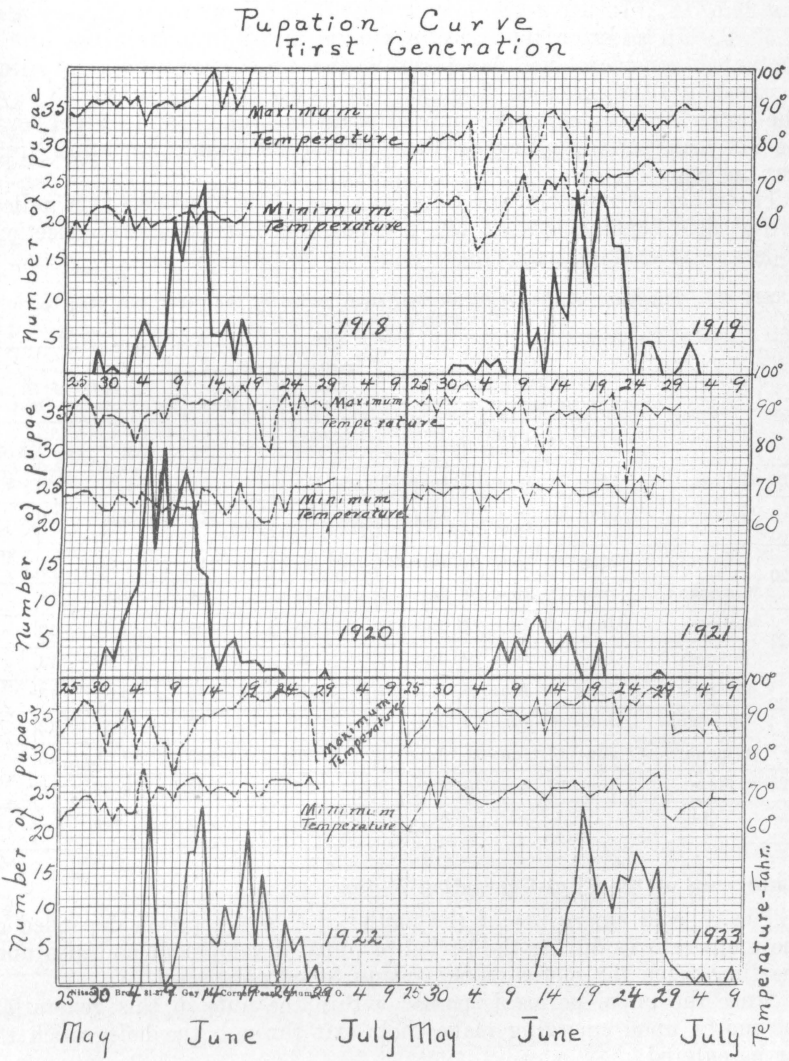

Fig. 10. Pupal records and temperatures for the first generation. College Station, 1918–1923

Although temperature does not play as important a part as in the duration of the pupal stage of the spring brood, it is still effective. In 1918 the lowest average mean temperature for any pupal period was 80.5° F. In 1919 the lowest was 73.1° F. and the highest was 81.5° F. In addition the daily maximum and minimum temperatures fluctuated considerably. As a result the time over which pupation occurred in 1919 extended from May 31 to July 2, a period of 33 days. The larger number of larvae pupated between June 3 and July 1, over the six-year period, although there was considerable variation from year to year.

The range of pupation for Corsicana cannot be considered as indicative of field conditions as it was not possible to make daily collections of larvae at that place.

Table 13.—Summary of the length of the pupal period of the pecan nut case bearer. First generation. 1918-1923.

Year	Place	Date of—			Period Over Which Pupation Occurred	Number Individuals Observed	Length of Pupal Stage—Days		
		First Pupation	Max. Pupation	Last Pupation			Avg.	Max.	Min.
1918	College.....	May 29	June 12	June 18	21	161	8.5	12	5
1919	College.....	May 31	June 16 June 19	July 2	33	229	9.6	13	7
1920	College.....	May 31	June 5	June 29	30	249	9.0	11	5
	Corsicana...	June 18	June 20	July 3	16	101	9.8	13	7
1921	College.....	June 6	June 12	June 28	23	58	9.5	12	7
	Winona.....	June 8	June 20	July 2	25	230	10.6	13	7
1922	College.....	June 6	June 6	June 28	23	196	9	13	6
	Corsicana...	June 21	June 24	July 4	14	78	9.8	12	8
	Winona.....	June 13	June 26	July 8	26	240	9.7	13	6
1923	College.....	June 12	June 18	July 8	27	206	9.4	16	8
	Total.....	.....	.....	.....	.....	1748			

Emergence of the First-Generation Moths

The time of emergence of the moths of this generation depended on the temperatures during the period of pupal development and also upon the time when the moths of the spring brood oviposited.

Since the pupal period is passed within the nuts in this generation, the moths upon emerging make their exit through the hole which the larvae entered.

Emergence of first-generation moths began between June 5 and June 15 in the several years and was completed between June 28 and July 16. During the six years the greater number of moths emerged over the period from June 9 to July 10 when the average mean temperature was approximately 80° F., for the duration of the pupal period. Maxi-

Table 14.—Time of emergence of first generation moths. 1918-1923.

Date of Emergence	Number of Moths Emerging																																	Total.
	1918			1919			1920						1921						1922									1923							
	College			College			College			Corsicana			College			Winona			College			Corsicana			Winona			College						
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total				
June 5	1	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....				1
June 6	....	1	1	....	....	....	3	....	3	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....				4
June 7	1	2	3	....	....	....	2	....	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....				5
June 8	....	2	2	....	....	....	2	....	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....				4
June 9	12	7	19	....	....	....	7	4	11	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....				30
June 10	7	9	16	....	....	....	15	6	21	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....				37
June 11	7	7	14	....	....	....	10	11	21	....	....	....	12	13	25	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....				60
June 12	8	6	14	....	....	....	13	17	30	....	....	....	6	4	10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....				54
June 13	12	11	23	....	1	1	21	21	42	....	....	....	4	11	15	....	....	....	5	....	5	....	....	....	....	....	....	....	....	....				86
June 14	19	25	44	1	....	1	23	22	45	....	....	....	9	15	24	....	....	....	2	1	3	....	....	....	....	....	....	....	....	....				117
June 15	14	14	28	1	....	1	38	24	62	....	....	....	3	9	12	....	2	2	4	5	9	....	....	....	....	....	....	....	....	....	....	2	2	116
June 16	9	27	36	1	1	2	16	9	25	....	....	....	....	11	11	2	6	8	1	2	3	....	....	....	....	....	....	....	....	....	6	2	8	93
June 17	15	18	33	....	3	3	11	11	22	....	....	....	2	....	2	3	1	4	....	....	....	....	....	....	....	....	....	....	....	....	3	7	10	74
June 18	9	11	20	2	1	3	15	12	27	....	....	....	....	1	1	3	4	7	....	....	....	....	....	....	....	....	....	....	....	....	7	4	11	69
June 19	12	11	23	5	3	8	11	6	17	....	....	....	5	11	16	10	5	15	11	16	27	....	....	....	3	3	6	19	20	39				151
June 20	4	9	13	5	5	10	7	9	16	....	....	....	2	2	4	8	4	12	9	11	20	2	2	4	3	3	6	13	13	26				111
June 21	7	9	16	1	4	5	9	4	13	....	....	....	2	4	6	6	13	19	12	6	18	3	3	6	2	1	3	22	19	41				127
June 22	3	5	8	3	7	10	3	3	6	....	1	1	....	1	1	4	7	11	5	8	13	1	5	6	6	3	9	18	27	45				110
June 23	2	2	4	4	4	8	5	4	9	2	1	3	1	4	5	23	11	34	4	7	11	7	7	14	7	8	15	14	23	37				140
June 24	1	5	6	4	4	8	1	....	1	4	4	8	....	4	4	5	3	8	10	12	22	12	4	16	22	21	43	13	19	32				148
June 25	1	3	4	11	6	17	....	....	....	1	4	5	2	1	3	5	7	12	5	6	11	5	3	8	17	23	40	10	8	18				118
June 26	....	4	4	10	8	18	2	....	2	4	3	7	5	2	7	15	11	26	5	5	10	3	5	8	21	22	43	17	23	40				165
June 27	1	....	1	7	12	19	3	2	5	8	4	12	1	....	1	7	2	9	8	19	27	6	....	6	15	16	31	17	21	38				149
June 28	....	....	....	9	13	22	1	....	1	6	5	11	....	2	2	5	11	16	7	6	13	5	8	13	17	31	48	19	15	34				160
June 29	....	....	....	5	4	9	....	2	2	4	6	10	....	1	1	16	12	28	3	7	10	5	15	20	21	29	50	8	13	21				151
June 30	....	....	....	8	12	20	1	1	2	11	5	16	1	....	1	3	12	15	4	8	12	2	2	4	31	37	68	4	10	14				152
July 1	....	....	....	7	11	18	....	....	....	4	13	17	....	....	....	8	7	15	4	5	9	6	5	11	26	29	55	5	9	14				139
July 2	....	....	....	9	7	16	....	1	1	10	10	20	....	....	....	7	6	13	2	6	8	4	10	14	26	31	57	6	4	10				139
July 3	....	....	....	3	5	8	....	....	....	6	9	15	....	....	....	9	11	20	1	2	3	7	4	11	13	16	29	4	7	11				97
July 4	....	....	....	3	4	7	....	....	....	3	5	8	....	....	....	5	6	11	3	1	4	9	6	15	4	16	20	3	5	8				73
July 5	....	....	....	....	2	2	....	....	....	2	1	3	....	....	....	5	6	11	....	2	2	3	5	8	20	30	50	6	8	14				90
July 6	....	....	....	3	1	4	....	....	....	1	2	3	....	....	....	2	4	6	....	2	2	2	7	9	14	18	32	5	9	14				70
July 7	....	....	....	....	....	....	....	....	....	1	3	4	....	....	....	....	....	....	1	1	2	....	9	9	8	16	24	3	8	11				50
July 8	....	....	....	....	....	....	....	1	1	....	1	1	1	....	1	1	....	1	....	1	1	1	3	4	2	14	16	1	5	6				31
July 9	....	....	....	....	....	....	....	....	....	2	....	2	....	....	....	....	....	....	....	....	....	2	1	3	3	6	9	3	3	6				20
July 10	....	....	....	1	1	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	3	4	1	5	6	1	3	4				16
July 11	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	5	7	1	....	1				8
July 12	....	....	....	....	....	....	....	....	....	1	....	1	....	....	....	....	....	....	....	....	....	1	....	1	....	....	....	2	....	2				4
July 13	....	....	....	....	....	....	....	....	....	....	1	1	....	....	....	....	....	....	....	....	....	....	1	1	....	....	....	....	....	....				2
July 14	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	1	....	....	....	1	....	1	....	....	....	....	....	....				2
July 15	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....				0
July 16	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1	2				2
Total	145	188	333	103	119	222	219	170	[illegible]	70	78	148	56	96	152	153	151	304	106	139	245	88	108	196	284	383	667	231	288	519				3175

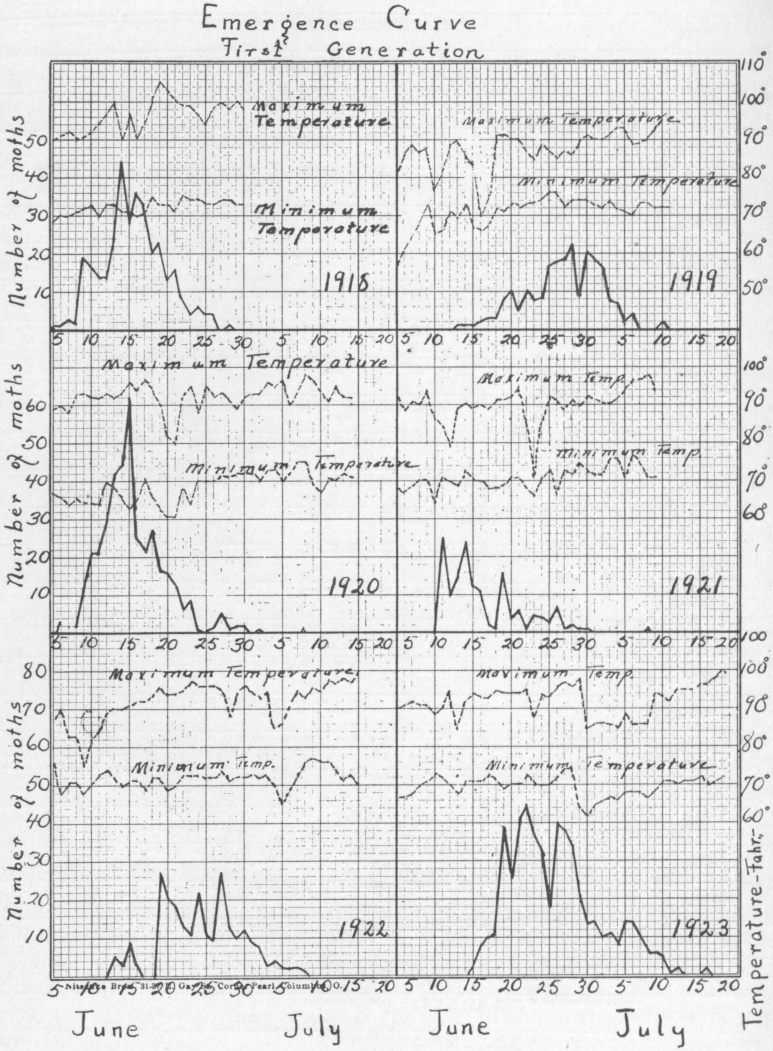

Fig. 11. Emergence records and temperatures for the first generation. College Station, Texas 1918–1923.

mum emergence took place between June 14 and June 22 in 1918, 1920, 1921, 1922 and 1923, but in 1919, when the average mean temperature during the pupal period was below 80° F., maximum emergence did not occur until June 28.

The number of moths emerging varies considerably from year to year, and this seems to be the most variable of the four generations. When there were but two annual generations there was a large number of first generation moths. In the years when there were four generations the number was also variable; in 1919 and especially in 1921 it was difficult to collect larvae and the number of moths which emerged was small; in 1923, however, it was comparatively easy to collect a large number of larvae and 519 records were obtained on emergence.

Table 15.—Summary of the emergence records of the first-generation moths of the pecan nut case bearer. 1918-1923.

Year	Place	Date of			Period Over which Emergence Occurred	Number Moths Observed	Number Males	Number Females
		First Emergence	Maximum Emergence	Last Emergence				
1918	College....	June 5...	June 14...	June 28...	24	333	145	188
1919	College....	June 13...	June 28...	July 10...	28	222	103	119
1920	College....	June 6...	June 15...	July 8...	33	389	219	170
	College and Corsicana..	June 6...	June 15...	July 13...	38	537	289	248
1921	College....	June 11...	June 11...	July 8...	28	152	56	96
	College and Winona...	June 11...	June 23...	July 14...	34	456	209	247
1922	College....	June 13...	June 19... June 27...	July 8...	25	245	106	139
	College, Corsicana and Winona	June 13...	June 30...	July 14...	32	1108	478	630
1923	College....	June 15...	June 22...	July 16...	32	519	231	288
	Total...	.....	.....	.....	.....	3175	1455	1720

Oviposition by the Moths of the First Generation

The moths of this generation begin to oviposit on the third or fourth night after emergence. At this time the calyx and pistil have become dry and hard and do not afford favorable places for egg deposition. The eggs are deposited in grooves at the tips and bases of the nuts and on buds immediately below the nut clusters. A nut cluster is usually selected which has several nuts in it, especially when the eggs are laid on the buds. All of the egg records were obtained from moths in captivity. During the first years the egg records were obtained by tagging limbs because it was not possible to obtain a continuous egg laying record in cages from many individuals, but this was finally abandoned for the cage method.

Table 16.—Summary of the oviposition records of the first-generation moths of the pecan nut case bearer. College Station, Texas. 1922.

Moth Number	Date of Emergence.	Date Moth Died.	Length of Life.	Total Number of Eggs Laid.	Number Days from Emergence to First Oviposition.	Number Days on which Oviposition Occurred.	Number Days from Emergence to Last Oviposition.	Length of Life After Last Oviposition.
1	June 19	July 2	13	1	4	1	4	9
2	June 19	July 24*	.....	11	4	.....	.....	.....
3	June 19	June 27	8	5	4	1	4	4
4	June 20	July 7	17	3	3	1	3	14
5	June 20	June 24*	.....	12	4	.....	.....	.....
6	June 22	June 28*	.....	24	5	.....	.....	.....
7	June 22	June 29	7	15	6	2	7	0
8	June 22	June 27	5	1	4	1	4	1
9	June 23	June 27*	.....	10	4	.....	.....	.....
10	June 23	July 6	13	23	4	1	4	9
11	June 23	July 1*	.....	22	6	.....	.....	.....
12	June 24	July 1	7	13	5	2	6	1
13	June 24	July 1*	.....	54	5	.....	.....	.....
14	June 24	July 2	8	14	5	2	6	2
15	June 24	June 30	6	7	4	1	4	2
16	June 24	July 3	9	2	5	1	5	4
17	June 24	July 5	11	24	4	4	8	3
18	June 24	July 3*	.....	14	9	.....	.....	.....
19	June 25	July 10	15	5	12	2	13	2
20	June 25	July 3	8	34	5	2	8	0
21	June 26	July 1*	.....	45	4	.....	.....	.....
22	June 26	July 2	6	27	4	1	4	2
23	June 26	July 5	9	4	5	1	5	4
24	June 26	June 30*	.....	31	4	.....	.....	.....
25	June 27	July 3	6	4	4	2	5	1
26	June 27	July 4	7	19	6	1	6	1
27	June 27	July 6	9	2	5	1	5	4
28	June 27	July 4	7	16	5	1	5	2
29	June 28	July 3	5	66	4	2	5	0
30	June 28	July 2*	.....	20	4	.....	.....	.....
31	June 29	July 6	7	6	6	1	6	1
32	June 29	July 10	11	4	4	2	6	5
33	June 29	July 5	6	4	4	1	4	2
34	June 29	July 5	6	7	5	1	5	1
35	June 29	July 4	5	1	4	1	4	1
36	June 29	July 6	7	13	4	2	7	0
37	June 30	July 5	5	9	5	1	5	0
38	June 30	July 6	6	14	4	2	6	0
39	June 30	July 6	6	1	5	1	5	1
40	June 30	July 10	10	5	9	1	9	1
41	June 30	July 9	9	1	8	1	8	1
42	June 30	July 10	10	6	5	1	5	5
43	June 30	July 10	10	5	9	2	10	0
44	June 30	July 9	9	1	9	1	9	0
45	June 30	July 7	7	31	6	2	7	0
46	June 30	July 5	5	36	5	1	5	0
47	June 30	July 7	7	4	7	1	7	0
48	July 1	July 8	7	74	5	2	6	1
49	July 1	July 7	6	7	5	1	5	1
50	July 1	July 13	12	9	9	2	10	2
51	July 1	July 12	11	3	5	2	8	3
52	July 1	July 11	10	20	4	3	9	1
53	July 1	July 8	7	11	5	1	5	2
54	July 1	July 8	7	16	4	2	7	0
55	July 1	July 9	8	1	4	1	4	4
56	July 1	July 8	7	11	4	2	6	1
57	July 1	July 6	5	6	5	1	5	0
58	July 1	July 6	5	36	5	1	5	0
59	July 2	July 7	5	2	5	1	5	0
60	July 2	July 8	6	12	5	1	5	1
61	July 2	July 7	5	20	4	1	4	1
62	July 2	July 10	8	11	4	3	6	2
63	July 2	July 9	7	1	4	1	4	3
64	July 2	July 11	9	1	5	1	5	4
65	July 2	July 8	6	1	5	1	5	1
66	July 3	July 9	6	18	5	1	5	1

*Indicates moth escaped or was killed before record was completed.

Table 16.—Summary of the oviposition records of the first-generation moths of the pecan nut case bearer. College Station, Texas. 1922.—Continued.

Moth Number	Date of Emergence.	Date Moth Died.	Length of Life.	Total Number of Eggs Laid.	Number Days from Emergence to First Oviposition.	Number Days on Which Oviposition Occurred.	Number Days from Emergence to Last Oviposition.	Length of Life After Last Oviposition.
67	July 3	July 10	7	12	7	1	7	0
68	July 3	July 11	8	16	6	2	7	1
69	July 3	July 10	7	25	4	3	7	0
70	July 3	July 8	5	3	5	1	5	0
71	July 4	July 10	6	3	4	2	6	0
72	July 4	July 11	7	16	7	1	7	0
73	July 4	July 15	11	47	4	5	10	1
74	July 4	July 11	7	3	6	1	6	1
75	July 4	July 11	7	1	4	1	4	3
76	July 4	July 8	4	3	4	1	4	0
77	July 4	July 18	14	1	8	1	8	6
78	July 5	July 10	5	34	5	1	5	0
79	July 5	July 11	6	32	5	1	5	1
80	July 5	July 12	7	60	4	4	7	0
81	July 6	July 12	6	56	4	3	6	0
82	July 6	July 16	10	33	4	4	7	3
83	July 6	July 11	5	15	4	1	4	1
84	July 6	July 11	5	37	4	2	5	0
85	July 6	July 13	7	3	4	2	7	0
86	July 6	July 18	12	12	4	2	11	1
87	July 7	July 11	4	35	4	1	4	0
88	July 7	July 13	6	1	4	1	4	2
89	July 11	July 15	4	16	2	1	2	2
90	July 15	July 18	3	2	3	1	3	0

In 1922 deposition records were obtained on 90 moths. The number which oviposited was a small part of the number which was caged on the trees. The length of life of the females which oviposited was 7.5 days; the number of days from emergence to first oviposition was 4.9 days. Oviposition occurred over an average period of 1.5 days for each female. From emergence to the last oviposition an average of 5.8 days elapsed and the moths lived an average period of 1.6 days after oviposition.

In 1923 oviposition records were obtained on 78 moths. The largest number of eggs laid by any individual was 143; and from dissections made of female moths it is presumed that this is nearer the average number than most of the records which were obtained in captivity.

The average length of life of the females which oviposited was 7 days; an average of 4 days elapsed from the time of emergence to first oviposition. Oviposition occurred over an average period of 2 days. From the time of emergence to the last oviposition an average of 5.7 days elapsed and the moths lived an average of 1.4 days after the last oviposition.

Table 17. Summary of the oviposition records of the first-generation moths of the pecan nut case bearer. College Station, Texas. 1923.

Moth Number	Date of Emergence.	Date Moth Died.	Length of Life.	Total Number of Eggs Laid.	Number Days from Emergence to First Oviposition.	Number Days on which Oviposition Occurred.	Number Days from Emergence to Last Oviposition.	Length of Life After Last Oviposition.
1	June 17	June 25	8	9	8	1	8	0
2	June 17	June 26*	.....	57	4	.....	.....	.....
3	June 17	June 28	11	54	4	4	9	2
4	June 17	June 25*	.....	10	3	.....	.....	.....
5	June 17	June 21*	.....	3	3	.....	.....	.....
6	June 17	June 25	8	4	3	2	7	1
7	June 18	June 22*	.....	12	3	.....	.....	.....
8	June 19	June 24	5	29	3	3	5	0
9	June 19	June 27	8	7	3	2	4	4
10	June 19	June 25	6	11	5	2	6	0
11	June 19	June 28	9	20	5	5	9	0
12	June 19	June 29*	.....	34	7	.....	.....	.....
13	June 20	July 4	14	2	4	2	13	1
14	June 20	June 28	8	10	3	2	4	4
15	June 20	June 29	9	1	6	1	6	3
16	June 20	June 24	4	11	3	2	4	0
17	June 20	June 23*	.....	5	3	.....	.....	.....
18	June 21	July 3	12	4	6	3	12	0
19	June 21	June 30	9	42	8	1	8	1
20	June 21	June 26*	.....	21	4	.....	.....	.....
21	June 21	June 25	4	1	4	1	4	0
22	June 21	June 26	5	22	4	2	5	0
23	June 22	July 2	10	4	6	3	9	1
24	June 22	June 25*	.....	5	3	.....	.....	.....
25	June 22	June 26	4	60	3	2	4	0
26	June 22	June 28*	.....	31	4	.....	.....	.....
27	June 22	June 28	6	36	3	3	5	1
28	June 22	June 26	4	8	3	1	3	1
29	June 22	July 3	11	42	4	4	9	2
30	June 22	June 30	8	14	3	1	3	5
31	June 23	June 30	7	6	3	1	3	4
32	June 23	July 6	13	13	3	2	8	5
33	June 23	June 28	5	45	3	2	4	1
34	June 23	July 8	15	5	4	1	4	11
35	June 23	June 30	7	16	4	2	5	2
36	June 23	June 28	5	23	3	2	5	0
37	June 23	June 30	7	78	3	4	6	1
38	June 24	June 30	6	143	3	4	6	0
39	June 24	June 28	4	4	3	1	3	1
40	June 24	June 30	6	12	4	1	4	2
41	June 24	June 29*	.....	39	3	.....	.....	.....
42	June 24	June 27	3	6	3	1	3	0
43	June 24	June 29*	.....	19	4	.....	.....	.....
44	June 25	July 3	8	24	3	4	7	1
45	June 26	July 1	5	28	4	2	5	0
46	June 27	July 9*	.....	102	4	.....	.....	.....
47	June 27	July 3	6	19	4	3	6	0
48	June 27	July 8*	.....	15	4	.....	.....	.....
49	June 28	July 4	6	21	4	3	6	0
50	June 28	July 3*	.....	26	4	.....	.....	.....
51	June 28	July 4	6	54	4	3	6	0
52	June 28	July 4	6	3	4	1	4	2
53	June 28	July 4	6	10	5	1	5	1
54	June 29	July 9	10	1	4	1	4	6
55	June 29	July 7	8	75	4	4	7	1
56	June 29	July 3*	.....	27	4	.....	.....	.....
57	June 29	July 8*	.....	30	5	.....	.....	.....
58	June 29	July 8	9	3	5	1	5	4
59	June 29	July 4	5	1	4	1	4	1
60	June 29	July 9	10	6	8	2	9	1
61	June 30	July 8	8	45	4	5	8	0
62	June 30	July 5	5	7	4	1	4	1
63	June 30	July 7	7	19	3	3	6	1
64	July 1	July 8	7	20	5	1	5	2
65	July 1	July 7	6	76	4	3	6	0

*Indicates moth escaped or was killed before record was completed.

Table 17. Summary of the oviposition records of the first-generation moths of the pecan nut case bearer. College Station, Texas. 1923.—Continued.

Moth Number	Date of Emergence.	Date Moth Died.	Length of Life.	Total Number of Eggs Laid.	Number Days from Emergence to First Oviposition.	Number Days on Which Oviposition Occurred.	Number Days from Emergence to Last Oviposition.	Length of Life After Last Oviposition.
66	July 1	July 6*	.....	6	4	.....	.....	.....
67	July 1	July 6	5	56	5	1	5	0
68	July 1	July 8*	.....	18	4	.....	.....	.....
69	July 2	July 10	8	5	6	2	7	1
70	July 2	July 8	6	44	4	2	5	1
71	July 5	July 9*	.....	9	3	.....	.....	.....
72	July 5	July 9*	.....	7	4	.....	.....	.....
73	July 6	July 16	10	30	5	3	9	1
74	July 6	July 11*	.....	46	4	.....	.....	.....
75	July 7	July 13	6	18	4	1	4	2
76	July 7	July 13	6	1	4	1	4	2
77	July 9	July 16	7	3	4	1	4	3
78	July 9	July 13	4	5	4	1	4	0

*Indicates moth escaped or was killed before record was completed.

Table 18.—Length of life of the adults of the first generation. 1918-1923.

Length of life—days	1918		1920		1921		1922		1923	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1	14	19	10	5	.....	.....	1	2	1	2
2	16	22	30	29	18	32	2	2	.....	1
3	28	19	32	40	4	6	4	2	5	9
4	19	21	12	11	5	9	54	64	6	10
5	13	10	8	12	4	7	42	53	13	17
6	4	5	9	6	4	2	39	56	14	19
7	.....	2	6	.....	.....	.....	19	34	12	18
8	.....	.....	.....	.....	.....	.....	10	15	7	15
9	1	.....	.....	.....	.....	.....	4	14	5	6
10	.....	.....	.....	.....	.....	.....	6	8	3	9
11	.....	.....	.....	.....	.....	.....	3	6	5	5
12	.....	.....	.....	.....	.....	.....	1	2	3	1
13	.....	.....	.....	.....	.....	.....	.....	8	1	4
14	.....	.....	.....	.....	.....	.....	1	1	1	2
15	.....	.....	.....	.....	.....	.....	.....	2	.....	1
16	.....	.....	.....	.....	.....	.....	.....	1	1	1
17	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
Average length of life	3.2	3	3.2	3.1	3.2	2.9	5.6	6.2	7	6.9
Maximum	9	7	7	7	6	6	14	17	16	16
Minimum	1	1	1	1	2	2	1	1	1	1

Length of Life of the Adults of the First Generation

The length of life records are those of the moths which were kept in cages. Many moths died on the first day after they emerged. The maximum length of life varied from 6 to 17 days in the several years and was dependent on the care exercised in feeding the adults and

regulating the temperature in the cages. The average length of life varied from 3 to 7 days. In the later years of the work methods of handling the moths and regulating temperatures were developed which account for the longer average length of life in 1922 and 1923 than in the preceding years.

Second Generation

A second generation was recorded only in the years 1919, 1920, 1921, and 1923. The reason for the absence of this generation in other years is not known, but the most plausible explanation is the lack of a supply of food.

In the years 1918, 1920 and 1922 there was an inadequate food supply at the time the larvae of this generation developed. In 1920 the second generation was very small and in that year only 20 emergence records were obtained. In 1920 the larvae almost completely destroyed the small nuts, although a heavy crop was set. In 1922 a light crop of nuts was set. The trees having the greatest promise of a crop in 1922 were the only ones on which larvae were found in the spring of 1923. This led to the supposition that food supply is the controlling factor in regulating the number of generations a year.

It is probable that parasitism also has a great deal to do with the number of generations. Parasitism is a complicated factor, since there are many primary and several secondary parasites. Further studies may prove this to be another limiting factor. It is interesting to note that four generations occurred whenever two generations were completed. The crop of nuts which matured was small in the years previous to those in which four generations occurred. In 1924, however, there were four generations following a moderate crop in 1923.

Incubation of the Eggs of the Second Generation

The incubation period was obtained from eggs on the trees. A record more nearly comparable to natural conditions could be obtained in this way because the nuts dry up in a day or two if they are removed from the trees. By the time the moths of the first generation are ovipositing the nuts are from one-third to one-half grown. On this account little opportunity is afforded the moths to oviposit in the center of the pistil and the eggs are laid either on top or under the calyx, but preferably in grooves at the tips and bases of the nuts and on the buds below the clusters.

In 1922 the incubation period was obtained on 1147 eggs. The minimum period of incubation was 3 days, the maximum 7 days, and the average 4.5 days.

In 1923 the incubation period was obtained on 1638 eggs. The minimum period of incubation was 3 days, the maximum 6 days, and the average 4.6 days.

Table 19. Length of incubation of the eggs of the second generation. 1922-1923.

Date of Oviposition	Number of Eggs Recorded		Incubation Period—Days																	
			Year																	
			1922	1923			1922	1923			1922	1923			1922	1923			1922	1923		
			Three Days				Four Days				Five Days				Six Days				Seven Days			
	1922	1923	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.
June 20	.....	3	.....	.....	.....	.....	.....	.....	3	81.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
June 21	.....	63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	63	81.7	.....	.....	.....	.....	.....	.....	.....	.....
June 22	.....	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	82.1	.....	.....	.....	.....	.....	.....	.....	.....
June 23	11	52	.....	.....	.....	.....	11	84.3	29	81.6	.....	.....	18	82.4	.....	.....	5	82.9	.....	.....	.....	.....
June 24	.....	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	83.7	.....	.....	12	83.2	.....	.....	.....	.....
June 25	.....	85	.....	.....	.....	.....	.....	.....	22	84.1	.....	.....	63	83.5	.....	.....	.....	.....	.....	.....	.....	.....
June 26	1	194	.....	.....	1	85.0	1	82.7	64	84.0	.....	.....	129	81.9	.....	.....	.....	.....	.....	.....	.....	.....
June 27	17	146	7	82.3	.....	.....	.....	.....	78	81.3	10	82.9	68	80.2	.....	.....	.....	.....	.....	.....	.....	.....
June 28	24	135	17	82.1	25	80.0	7	82.5	.....	.....	.....	.....	100	78.3	.....	.....	10	78.0	.....	.....	.....	.....
June 29	40	79	.....	.....	.....	.....	8	83.2	57	76.5	32	83.4	22	76.5	.....	.....	.....	.....	.....	.....	.....	.....
June 30	154	36	.....	.....	.....	.....	24	83.5	.....	.....	130	82.3	36	75.4	.....	.....	.....	.....	.....	.....	.....	.....
July 1	79	92	.....	.....	.....	.....	.....	.....	33	75.8	49	80.6	50	76.4	30	80.5	9	76.5	.....	.....	.....	.....
July 2	35	86	.....	.....	.....	.....	.....	.....	3	76.6	33	79.9	83	76.7	.....	.....	.....	.....	2	81.1	.....	.....
July 3	105	90	5	79.0	.....	.....	53	79.2	64	76.8	28	80.2	26	76.9	19	80.9	.....	.....	.....	.....	.....	.....
July 4	6	89	.....	.....	.....	.....	.....	.....	42	77.0	6	80.3	47	76.9	.....	.....	.....	.....	.....	.....	.....	.....
July 5	67	86	.....	.....	.....	.....	6	81.0	47	77.2	47	82.1	39	78.1	14	82.6	.....	.....	.....	.....	.....	.....
July 6	107	154	.....	.....	.....	.....	71	83.7	28	78.0	36	84.1	126	78.8	.....	.....	.....	.....	.....	.....	.....	.....
July 7	91	80	.....	.....	.....	.....	89	85.1	40	79.2	2	85.5	40	79.7	.....	.....	.....	.....	.....	.....	.....	.....
July 8	46	12	.....	.....	.....	.....	46	85.8	4	80.3	.....	.....	8	80.8	.....	.....	.....	.....	.....	.....	.....	.....
July 9	60	16	4	86.3	.....	.....	46	86.1	16	81.8	5	85.8	.....	.....	5	85.6	.....	.....	.....	.....	.....	.....
July 10	197	22	17	86.0	.....	.....	180	85.6	22	82.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
July 11	76	57	.....	.....	.....	.....	15	85.5	57	82.5	61	85.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
July 12	10	.....	.....	.....	.....	.....	1	85.0	.....	.....	9	84.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
July 13	21	19	.....	.....	.....	.....	.....	.....	19	83.2	21	83.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
July 15	.....	3	.....	.....	.....	.....	.....	.....	3	84.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	1147	1638	50	83.5	26	80.2	558	84.5	631	79.8	469	82.5	945	79.3	68	81.4	36	80.0	2	81.1	.....	.....

Average length of incubation period, 1922. 4.5 days.
Average length of incubation period, 1923 4.6 days.

Larval Period of the Second Generation

The larvae feed on the buds below the nut clusters (as in the first generation) for two or three days and then enter the nuts by cutting circular holes at their bases. Sometimes the young larvae feed on the outer surface where the nuts of a cluster nearly or quite touch each other instead of feeding on the buds.

Since the nuts are from a third to one-half grown when the larvae of this generation have hatched, one larva does not destroy as many nuts as does a larva of the first generation.

Only the larval records of 1923 are given. Records were obtained on 102 larvae. The minimum duration of the larval period was 20 days, the maximum duration was 51 days, and the average 33 days.

The average duration of the larval period was 8 days longer than in the first generation and 7 days longer than in the third generation. The average mean temperature for the larval period of the second generation was 82.5° F. or 2.5° F. higher than the average mean temperature for the larval periods of the first and third generations.

Table 20.—Length of the larval stage. Second generation, 1923.

Length of Larval Stage—Days	Number of Records	Average Mean Temperature
20	1	79.9
21	3	81.9
23	3	80.8
24	3	80.1
25	2	81.6
26	2	83.6
27	5	82.2
28	4	82.0
29	9	82.6
30	10	82.2
31	5	81.8
32	6	83.2
33	6	82.3
34	9	82.5
35	3	84.2
36	7	83.4
37	2	83.4
38	3	83.4
39	1	82.4
40	1	82.6
41	4	83.0
42	3	82.7
43	2	83.4
45	1	82.8
46	2	83.0
47	2	83.4
48	1	83.0
50	1	82.8
51	1	83.0
Total	102	82.5

Average length of larval stage, 1923, 33 days.

Pupal Period of the Second Generation

Pupal records were obtained for the second generation in the years 1919, 1920, 1921, and 1923. In 1920, however, so few larvae were

found that for all practical purposes it may be considered that a second generation was lacking.

Table 21.—Date of pupation and period over which pupation occurred. Second generation. 1919-1923.

Date of Pupation	Number of Individuals Pupating						Total
	Year						
	1919		1920	1921		1923	
	College	Corsicana	College	College	Winona	College	
July 13				2			2
July 16				3			3
July 17			3	4			7
July 18				32		1	33
July 19			2	18		5	25
July 20				38		4	42
July 21				17		6	23
July 22				11		13	24
July 23				31		23	54
July 24				10		19	29
July 25				20		28	48
July 26			2	32		51	85
July 27	1		2	29	3	38	73
July 28			1	12	4	29	46
July 29			3	13	3	29	48
July 30			1	16	1	39	57
July 31	1			12	2	46	61
Aug. 1	1		1	7	5	21	35
Aug. 2	11			14	1	22	48
Aug. 3	24			17	10	19	70
Aug. 4	1		2	25	7	28	63
Aug. 5	2		1	3	16	16	38
Aug. 6	28			1	6	21	56
Aug. 7	14				12	6	32
Aug. 8	10		1	1	16	3	31
Aug. 9	6				24	4	34
Aug. 10	3				5	2	10
Aug. 11	2		1	1	8	2	14
Aug. 12	7				2	13	22
Aug. 13					1	2	3
Aug. 14					1	5	6
Aug. 15						1	1
Aug. 16		11				1	12
Aug. 17		22					22
Aug. 18		32					32
Aug. 19		40				2	42
Aug. 20		23				2	25
Aug. 21		17				1	18
Aug. 22		8				5	13
Aug. 23		4					4
Aug. 24		6					6
Aug. 25		2					2
Aug. 27						1	1
Total.	111	165	20	369	127	508	1300

The pupal stage is passed inside the nuts as in the first generation and the larvae close the entrance holes with excrement and frass, as already described for that generation. The nuts in which the pupal period is passed are firmly fastened to other nuts or to branches or leaves to keep them from falling from the trees. The larvae of this generation begin to pupate about July 13 and continue until the latter part of August. The period over which pupation occurred varied considerably, because of climatic conditions during the spring brood and first generation. In 1919 the temperatures were irregular in both of the preceding generations and pupation was delayed. Larvae and pupae

were collected at Corsicana because of the difficulty of obtaining larvae at College, and although these records may be considered as representative of the close of the period of pupation they are not indicative of the beginning of pupation because a considerable number of larvae had pupated when the material was collected. Although it was difficult to find larvae at College in 1919 they were plentiful at Corsicana, where about 1200 were collected in two days.

Temperature had risen to the point where it had little other effect on the duration of the pupal period than to stabilize it. The duration

Table 22.—Relation of temperature to the duration of the pupal period. Second generation. 1919-1923.

Length of Pupal Stage —Days	Number of Individuals Pupating and Average Mean Temperature										Total	Avg. Mean Temp.
	Year											
	1919			1920		1921			1923			
	College		Corsicana	College		College		Winona	College			
	No.	Avg. Mean Temp.	No.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	No.	Avg. Mean Temp.		
5									2	81.0	2	81.0
6	1	83.6	1			1	81.3	2	3	80.6	8	81.3
7	3	83.1				8	82.3	4	6	94.0	21	86.5
8	21	83.6	3	2	82.5	45	82.0	3	78	86.1	152	84.4
9	30	83.7	3	10	84.1	188	82.1	45	236	85.9	512	84.2
10	15	83.3	13	3	82.9	66	82.4	26	77	85.1	200	83.8
11	8	83.2	35			3	83.5	4	17	82.7	67	82.9
12	2	83.2	41	1	81.4				5	83.2	49	82.9
13			32								32	
14			4								4	
15												
16												
17								1			1	
Total	80	83.5	132	16	83.5	311	82.2	85	424	85.7	1048	
Average length of pupal period	9		11.6	9.2		9		9.3	9			

Table 23.—Summary of the length of the pupal period of the pecan nut case bearer. Second generation. 1919-1920-1921-1923.

Year	Place	Date of—			Period During which Pupation Occurred	Number of Individuals Observed	Pupal Period—Days		
		First Pupation	Maximum Pupation	Last Pupation			Average	Maximum	Minimum
1918*									
1919	College	July 27	Aug. 6	Aug. 12	17	111	9	12	6
	Corsicana	Aug. 16	Aug. 19	Aug. 25	10	165	11.6	14	6
1920†	College	July 17	July 17 July 29	Aug. 11	26	20	9.2	12	8
1921	College	July 13	July 20	Aug. 11	30	369	9	11	6
	Winona	July 27	Aug. 9	Aug. 14	19	127	9.3	17	6
1922*									
1923	College	July 18	July 26	Aug. 27	41	508	9	12	5
	Total					1300			

*No second generation pupae. †Partial second generation.

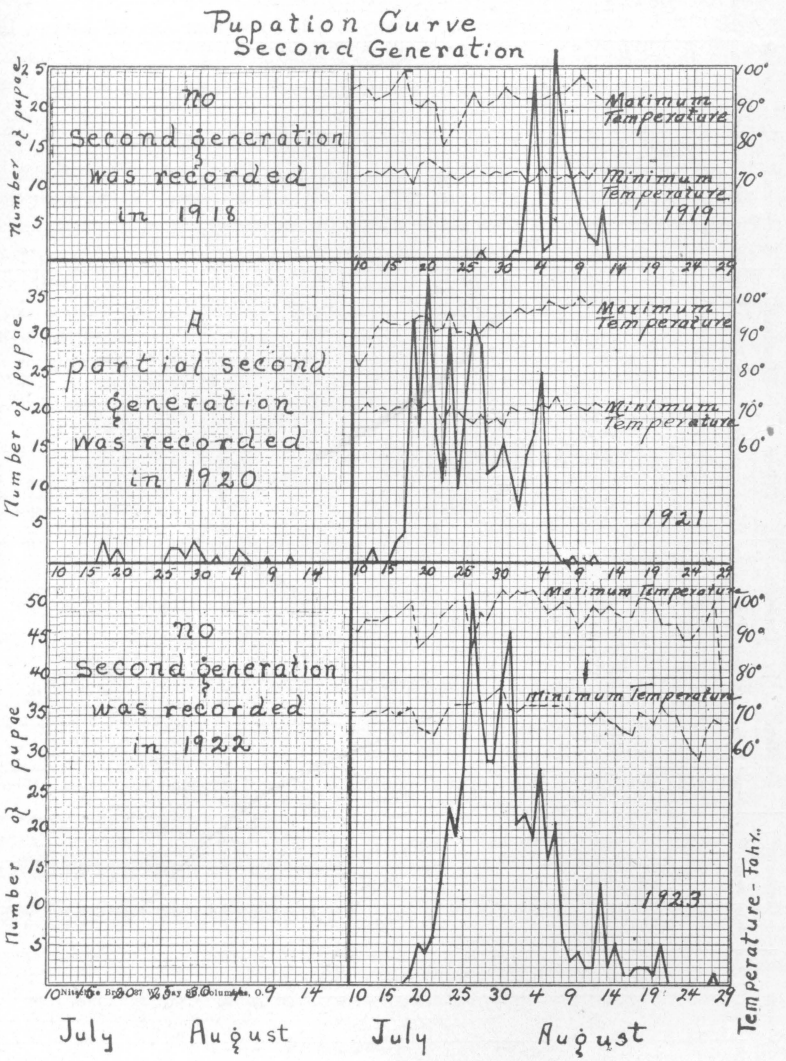

Fig. 12. Pupal records and temperatures for the second generation. College Station, Texas, 1918–1923.

Table 24.—Time of emergence of the Second Generation Moths. 1919—1920—1921—1923.

Date of Emergence	Number of Moths Emerging																								
	1919						1920						1921									1923			Total
	College			Corsicana			College			Corsicana			College			Corsicana			Winona			College			
	Male	Fem.	Total	Male	Fem.	Total	Male	Fem.	Total	Male	Fem.	Total	Male	Fem.	Total	Male	Fem.	Total	Male	Fem.	Total	Male	Fem.	Total	
July 22														1	1										1
July 23														1	1										1
July 24													5	5	10							3	1	4	14
July 25													4	6	10							4		4	14
July 26							1	2	3				12	14	26							3	3	6	35
July 27													19	13	32							4	2	6	38
July 28							1	1	2				21	26	47							12	6	18	67
July 29													19	10	29							17	15	32	61
July 30													23	24	47							15	16	31	78
July 31													18	23	41		2	2				28	18	46	89
Aug. 1													20	22	42	1		1				53	33	86	129
Aug. 2													9	10	19		1	1				44	35	79	99
Aug. 3													16	22	38	1		1	1		1	60	43	103	143
Aug. 4	1	1	2					2	2				25	50	75	1	6	7				36	32	68	154
Aug. 5													34	44	78	2	1	3				25	34	59	140
Aug. 6	2	1	3				1	1	2				42	36	78				1		1	29	38	67	151
Aug. 7								1	1				20	30	50	1	3	4	1	1	2	17	21	38	95
Aug. 8													13	15	28				5	1	6	32	17	49	83
Aug. 9								1	1				21	25	46							17	18	35	82
Aug. 10	4	5	9								1	1	10	6	16				2		2	10	30	40	68
Aug. 11	1	2	3					1	1	1		1	18	9	27				2		2	5	9	14	48
Aug. 12	5	4	9				1		1				8	9	17				5		5	7	6	13	45
Aug. 13	6	2	8					1	1				10	12	22		1	1	8	2	10	8	9	17	59
Aug. 14	9	7	16				1		1					1	1				6	9	15	6	6	12	45
Aug. 15	6	7	13										2		2				6	4	10	6	11	17	42
Aug. 16	3	1	4																	1	1	3	6	9	14
Aug. 17	10	6	16	11	5	16								1	1				4	6	10	2	3	5	48
Aug. 18				18	13	31				2	1	3							11	7	18	2	1	3	55
Aug. 19	1	2	3	23	17	40				1		1							4	7	11	3	1	4	59
Aug. 20	1		1	26	15	41		1	1	3	1	4							7	11	18	3	2	5	70
Aug. 21	1	1	2	28	25	53				1	1	2							9	6	15	1	2	3	75
Aug. 22	2		2	23	31	54													3	4	7	2	2	4	67
Aug. 24				7	26	33													7	4	11		2	2	46
Aug. 24				35	39	74													6	5	11	2	1	3	88
Aug. 25				20	17	37													4	5	9		2	2	48
Aug. 26				13	7	20													3	2	5	1		1	26
Aug. 27				15	26	41													2		2	1		1	44
Aug. 28				20	9	29													1	1	2				31
Aug. 29				17	19	36																			36
Aug. 30				30	19	49																			49
Aug. 31				12	19	31																1		1	32
Sept. 1				15	17	32																	1	1	33
Sept. 2				3	7	10																2	2	4	14
Sept. 3					3	3																			3
Sept. 4				1	1	2																			2
Sept. 5				1	1	2																			2
Sept. 7																							1	1	1
Total	52	39	91	318	316	634	5	11	16	8	4	12	369	415	784	6	14	20	98	76	174	464	429	893	2624

of the pupal period ranged from 5 to 17 days, and the duration of the pupal period of 512 individuals of the 1048 recorded for the several years was 9 days.

Emergence of the Moths of the Second Generation

The adults of the second generation begin to emerge about July 22 and emergence may continue until September 7. The males emerge first as in the preceding generations. In 1921 and 1923 the period of emergence was approximately the same, the larger number of moths emerged from July 24 to August 16. Maximum emergence occurred at College Station on August 5 and 6 in 1921 and on August 3 in 1923. In 1919, however, emergence was delayed several days at College and much longer at Corsicana, although the emergence records for Corsicana are not entirely representative of field conditions, as some moths had already emerged in the field when the larvae and pupae were collected.

Table 25.—Summary of the emergence records of the second-generation moths of the pecan nut case bearer. 1919-1920-1921-1923.

Year	Place	Date of—			Period Over which Emergence Occurred Days	Number Moths Observed	Number Males Observed	Number Females Observed
		First Emergence	Maximum Emergence	Last Emergence				
1918*								
1919	College	Aug. 4	Aug. 14... Aug. 17	Aug. 22	19	91	52	39
	College and Corsicana	Aug. 4	Aug. 24	Sept. 5	33	725	370	355
1920†	College	July 26	.....	Aug. 20	26	16	5	11
	College, Corsicana	July 26	.....	Aug. 21	27	28	13	15
1921	College	July 22	Aug. 5	Aug. 17	27	784	369	415
	College, Corsicana, Winona	July 22	Aug. 4	Aug. 28	38	978	473	505
1922*								
1923	College	July 24	Aug. 3	Sept. 7	46	893	464	429
	Total	.....	.....	.....	.....	2624	1320	1304

*No second generation moths.
†Partial second generation.

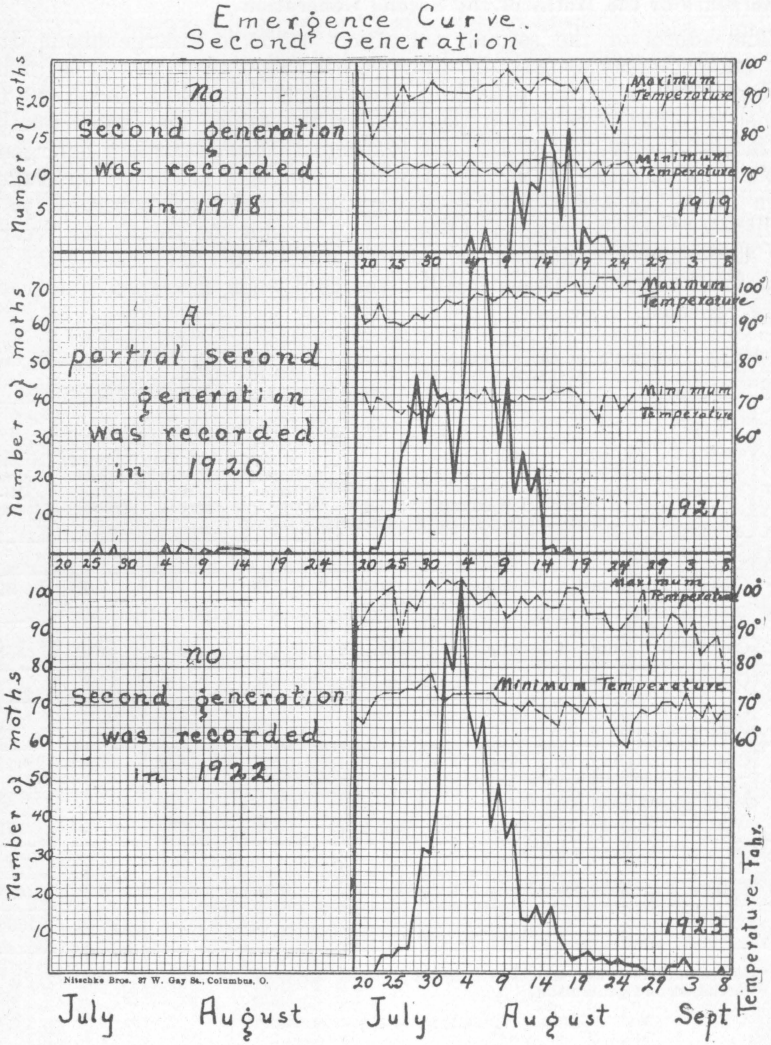

Fig. 13. Emergence records and temperatures for the second generation. College Station, Texas. 1918–1923.

Oviposition by the Moths of the Second Generation

The moths of this generation begin to oviposit on the third or fourth night after they emerge. The eggs are deposited in the grooves on the sides of the nuts near the tips and bases and also on the buds below the nut clusters. The eggs are deposited in a few nights, one moth depositing 62 eggs in a single night. An individual of this generation oviposited over a period of 12 days, which was the longest period over which oviposition occurred in any generation. Oviposition records were obtained on 64 moths; the largest number of eggs deposited by a single female was 190. The average length of life of the females which oviposited was 8 days; the average time over which oviposition occurred was 2 days. An average of 6 days elapsed from the time the adult emerged to the last egg deposition and an average of 2.2 days elapsed from the last oviposition to the death of the moth.

Table 26.—Summary of the oviposition records of the second-generation moths of the pecan nut case bearer. College Station, Texas. 1923.

Moth Number	Date of Emergence.	Date Moth Died.	Length of Life.	Total Number of Eggs Laid.	Number Days from Emergence to First Oviposition.	Number Days on Which Oviposition Occurred.	Number Days from Emergence to Last Oviposition.	Length of Life After Last Oviposition.
1	July 26	July 31	5	19	3	3	5	0
2	July 26	Aug. 4	9	99	3	3	5	4
3	July 28	Aug. 8	11	46	4	5	10	1
4	July 28	Aug. 1*	.....	74	3	.....	.....	.....
5	July 29	Aug. 4	6	17	3	2	4	2
6	July 29	Aug. 2*	.....	37	3	.....	.....	.....
7	July 29	Aug. 3	5	54	4	1	4	1
8	July 29	Aug. 3	5	48	3	2	5	0
9	July 30	Aug. 4	5	1	4	1	4	1
10	Aug. 1	Aug. 9	8	23	5	1	5	3
11	Aug. 1	Aug. 10	9	43	7	1	7	2
12	Aug. 1	Aug. 8	7	7	4	4	7	0
13	Aug. 1	Aug. 7	6	1	4	1	4	2
14	Aug. 2	Aug. 12	10	2	6	1	6	4
15	Aug. 2	Aug. 6	4	8	3	1	3	1
16	Aug. 2	Aug. 8	6	1	4	1	4	2
17	Aug. 2	Aug. 8	6	6	3	1	3	3
18	Aug. 2	Aug. 12	10	81	5	5	9	1
19	Aug. 2	Aug. 10*	.....	55	4	.....	.....	.....
20	Aug. 2	Aug. 10	8	3	6	1	6	2
21	Aug. 2	Aug. 6	4	6	3	2	4	0
22	Aug. 3	Aug. 11	8	1	6	1	6	2
23	Aug. 3	Aug. 8*	.....	88	4	.....	.....	.....
24	Aug. 3	Aug. 7*	.....	22	4	.....	.....	.....
25	Aug. 3	Aug. 20	17	66	5	11	16	1
26	Aug. 3	Aug. 7	4	11	4	1	4	0
27	Aug. 4	Aug. 13	9	9	4	2	5	4
28	Aug. 4	Aug. 13	9	4	5	1	5	4
29	Aug. 4	Aug. 10	6	72	4	2	5	1
30	Aug. 4	Aug. 11	7	2	4	2	5	2
31	Aug. 4	Aug. 12	8	49	4	3	6	2
32	Aug. 6	Aug. 15	9	44	4	1	4	5
33	Aug. 6	Aug. 18*	.....	55	4	.....	.....	.....
34	Aug. 6	Aug. 14	8	3	8	1	8	0
35	Aug. 6	Aug. 11	5	26	4	1	4	1
36	Aug. 6	Aug. 22	16	52	11	1	11	5
37	Aug. 6	Aug. 12	6	36	4	2	5	1
38	Aug. 6	Aug. 12	6	1	4	1	4	2
39	Aug. 6	Aug. 18*	.....	190	4	.....	.....	.....

*Indicates moth escaped or was killed before record was completed.

Table 26. Summary of the oviposition records of the second-generation moths of the pecan nut case bearer. College Station, Texas—Continued.

Moth Number	Date of Emergence.	Date Moth Died.	Length of Life.	Total Number of Eggs Laid.	Number Days from Emergence to First Oviposition.	Number Days on which Oviposition Occurred.	Number Days from Emergence to Last Oviposition.	Length of Life After Last Oviposition.
40	Aug. 6	Aug. 17*	.....	80	4	.....	.....	.....
41	Aug. 6	Aug. 14	8	13	4	1	4	4
42	Aug. 6	Aug. 13	7	11	4	1	4	3
43	Aug. 6	Aug. 13	7	117	4	4	7	0
44	Aug. 7	Aug. 14	7	41	5	1	5	2
45	Aug. 7	Aug. 17	10	4	5	2	6	4
46	Aug 7	Aug. 12*	.....	44	4	.....	.....	.....
47	Aug. 7	Aug. 11	4	9	4	1	4	0
48	Aug. 7	Aug. 12*	.....	28	4	.....	.....	.....
49	Aug. 7	Aug. 17	10	18	4	2	5	5
50	Aug. 7	Aug. 19	12	124	5	6	10	2
51	Aug. 8	Aug. 14	6	21	4	3	6	0
52	Aug. 8	Aug. 14	6	24	4	2	5	1
53	Aug. 8	Aug. 18	10	28	5	3	9	1
54	Aug. 9	Aug. 17	8	2	4	1	4	4
55	Aug. 9	Aug. 13*	.....	42	4	.....	.....	.....
56	Aug. 9	Aug. 17	8	83	4	4	8	0
57	Aug. 10	Aug. 26	16	1	4	1	4	12
58	Aug. 10	Aug. 21	11	30	4	2	11	0
59	Aug. 10	Aug. 15	5	58	4	1	4	1
60	Aug. 10	Aug. 15*	.....	25	5	.....	.....	.....
61	Aug. 10	Aug. 16	6	75	4	3	6	0
62	Aug. 13	Aug. 23*	.....	148	4	.....	.....	.....
63	Aug. 15	Aug. 30	15	1	8	1	8	7
64	Aug. 16	Aug. 30	14	3	11	1	11	3

*Indicates moth escaped or was killed before record was completed.

Table 27.—Length of life of the adults of the second generation. 1918-1923.

Length of Life—Days	1919		1921		1923	
	Male	Female	Male	Female	Male	Female
1	48	48	11	8	2	.....
2	41	37	37	44	3	1
3	39	33	75	74	.....	1
4	37	46	14	8	26	26
5	30	29	.....	.....	36	48
6	29	43	.....	.....	29	33
7	14	27	.....	.....	13	16
8	17	16	.....	.....	8	21
9	7	6	.....	.....	9	7
10	15	13	.....	.....	5	8
11	9	9	.....	.....	4	7
12	3	3	.....	.....	3	7
13	1	2	.....	.....	3	5
14	.....	2	.....	.....	3	1
15	.....	.....	.....	.....	2	2
16	.....	.....	.....	.....	.....	2
17	.....	.....	.....	.....	1	.....
18	.....	.....	.....	.....	1	2
21	.....	.....	.....	.....	1	.....
24	.....	.....	.....	.....	1	1
25	.....	.....	.....	.....	1	1
Average length of life	4.5	4.7	2.6	2.6	6.9	7.1
Maximum	13	14	4	4	25	25
Minimum	1	1	1	1	1	2

Length of Life of the Adults of the Second Generation

The length of life of the adults was determined from those kept in captivity in cages. On account of the usual high temperatures at the time this generation of moths appear, the life is rather short. The average length of the life of 604 moths in 1919 was 4.5 days; of 271 moths in 1921 was 2.6 days, and of 340 moths in 1923 was 7 days.

Third Generation

There was a completed third generation in 1919, 1921, and 1923, or in the same years when there was a completed second generation. There may be as many larvae in this generation as in the first and second but the number of moths was usually smaller because part of the larvae of this generation spin overwintering hibernacula. Some larvae of this generation enter the nuts to feed as in the two preceding generations but most of them either feed in protected places where two or three nuts touch at their bases or feed within the shucks.

The second and third generations overlap and each occupies a longer period of time than the first generation.

Table 28.—Length of incubation of the eggs of the third generation, pecan nut case bearer. College Station, Texas. 1923.

Date of Oviposition	Number of Eggs	Incubation Period—Days								Average Days
		3		4		5		7		
		No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	No.	Avg. Mean Temp.	
July 29	64			64	88.0					4.0
July 30	40			40	87.8					4.0
July 31	68	68	87.0							3.0
Aug. 1	71	19	87.5	47	87.2			5	86.5	4.0
Aug. 2	20			20	86.7					4.0
Aug. 3	19					19	86.3			5.0
Aug. 5	6					6	84.6			5.0
Aug. 6	23			23	84.5					4.0
Aug. 7	143			132	83.7	11	83.8			4.0
Aug. 8	160			160	83.1					4.0
Aug. 9	63			63	83.0					4.0
Aug. 10	317			317	83.6					4.0
Aug. 11	117			111	83.6	6	83.1			4.0
Aug. 12	94			85	82.8	9	82.1			4.0
Aug. 13	127			69	82.0	58	82.8			4.4
Aug. 14	94			66	82.5	28	83.1			4.3
Aug. 15	96			66	83.2	30	83.4			4.3
Aug. 16	11					11	83.8			5.0
Aug. 17	149			144	84.6	5	84.1			4.0
Aug. 18	11			11	83.6					4.0
Aug. 21	54			27	79.2	27	78.6			4.5
Aug. 22	13			13	77.7					4.0
Aug. 23	52			52	77.3					4.0
Total	1812	87	87.1	1510	83.5	210	82.9	5	86.5	4.0

Temperature which has a stabilizing effect on the various stages of the insect in the first and second generations again fluctuated as during the development of the spring brood but to a lesser extent. For that reason the duration of the different stages is not as constant in the third as in the first and second generations.

Incubation of the Eggs of the Third Generation

The incubation period in the third generation was 4 days and was determined from eggs deposited by free-flying moths and also from moths which were kept in cages. These cages were placed on the trees each evening and removed again in the morning. Records were obtained on 1812 eggs. The minimum duration of the egg stage was 3 days and the maximum 7 days. Temperatures were higher during the incubation period in this generation than in the two preceding.

Larval Period of the Third Generation

After hatching from the eggs the young larvae usually hunt a protected place and begin feeding, either where two or three nuts touch or on the buds below the nut clusters. The feeding habits of the partly grown larvae of this generation vary considerably. Some larvae enter the nuts at their bases as in the two preceding generations and hollow out the interior; others feed at the bases of nut clusters on the shucks or tunnel about in the shucks next to the nuts but do not cut through the shell.

The length of the larvel period as determined on 44 individuals varied from a minimum of 17 to a maximum of 38 days, the average being 26 days. The mean temperature for the average duration of the larval period was 80° F. and this period was 7 days shorter than in the previous generation when the mean temperature for the average duration of the larval period was 82.5° F.

Table 29.—Length of the larval stage. Third generation. 1923.

Length of Larval Stage—Days	Number of Records	Average Mean Temperature
17	1	79.8
18	2	81.4
19	1	79.5
21	4	80.3
22	4	81.8
23	2	79.9
24	5	79.3
26	5	79.9
27	6	80.1
28	2	80.0
29	2	80.3
30	2	80.2
31	2	79.9
32	1	79.9
33	1	79.3
34	1	79.0
35	1	79.6
36	1	79.6
38	1	78.9
Total	44	80.0

Average length of larval stage, 1923, 26 days.

Pupae of the Third Generation

The pupal period of the third generation is passed within the case or cocoon spun by the larva inside of the larval burrow. The cocoon may be found within the interior of the nut or in the shuck or at the bases of several nuts, depending upon where the larval development has taken place. The average length of the pupal period of the third generation is greater and more variable than in the two preceding generations but is not as great nor as variable as the pupal period of the spring brood.

Table 30.—Date of pupation and period over which pupation occurred. Third generation. 1919-1921-1923.

Date of Pupation	Number of Individuals Pupating			Total
	Year			
	1919	1921	1923	
	College	College	College	
Aug. 22	.....	.....	1	1
Aug. 24	.....	.....	1	1
Aug. 29	.....	.....	4	4
Aug. 30	.....	.....	4	4
Aug. 31	.....	.....	3	3
Sept. 1	.....	.....	11	11
Sept. 2	.....	.....	14	14
Sept. 3	.....	.....	21	21
Sept. 4	.....	.....	34	34
Sept. 5	.....	.....	18	18
Sept. 6	.....	.....	27	27
Sept. 7	.....	.....	15	15
Sept. 8	.....	.....	12	12
Sept. 9	.....	.....	20	20
Sept. 10	.....	.....	14	14
Sept. 11	.....	.....	19	19
Sept. 12	.....	24	7	31
Sept. 13	.....	37	17	54
Sept. 14	.....	25	20	45
Sept. 15	.....	14	19	33
Sept. 16	.....	14	5	19
Sept. 17	4	21	10	35
Sept 18	12	25	6	43
Sept. 19	2	32	14	48
Sept. 20	10	20	9	39
Sept. 21	7	19	12	38
Sept. 22	11	11	6	28
Sept. 23	4	9	3	16
Sept. 24	7	7	.....	14
Sept. 25	3	1	7	11
Sept. 26	6	.....	.....	6
Sept. 27	4	2	.....	6
Sept. 28	2	2	2	6
Sept. 29	5	.....	1	6
Sept. 30	11	.....	.....	11
Oct. 1	10	.....	.....	10
Oct. 2	6	.....	.....	6
Oct. 3	10	.....	.....	10
Oct. 4	10	.....	.....	10
Oct. 5	13	.....	.....	13
Oct. 6	2	.....	.....	2
Oct. 7	2	.....	.....	2
Oct. 8	4	.....	.....	4
Oct. 9	4	.....	.....	4
Oct. 10	1	.....	.....	1
Oct. 11	1	.....	.....	1
Total	151	263	356	770

Table 31.—Relation of temperature to the duration of the pupal period. Third generation. 1919–1921–1923.

Length of Pupal Stage—Days	Number of Individuals Pupating and Average Mean Temperatures						Total	Average Mean Temp.
	Year							
	1919		1921		1923			
	College		College		College			
	No.	Average Mean Temp.	No.	Average Mean Temp.	No.	Average Mean Temp.		
6	1	77.5	3	82.7	.....	.....	4	81.4
7	.....	.....	18	83.1	.....	.....	18	83.1
8	.....	.....	22	82.8	1	78.0	23	82.6
9	1	75.1	47	82.9	3	77.5	51	82.4
10	3	77.0	81	82.8	9	78.5	93	82.2
11	22	76.9	24	81.6	20	78.1	66	79.0
12	34	76.1	5	80.0	83	77.6	122	77.3
13	23	74.8	7	78.3	122	77.3	152	77.0
14	14	73.5	.....	.....	47	76.5	61	75.8
15	13	71.7	.....	.....	5	76.1	18	72.9
16	8	70.6	.....	.....	.....	.....	8	70.6
17	5	70.8	.....	.....	1	76.8	6	71.8
18	1	71.3	.....	.....	.....	.....	1	71.3
Total	125	74.6	207	82.5	291	77.3	623	
Average length of pupal period	12.9		9.5		12.6			

Table 32.—Summary of the length of the pupal period of the pecan nut case bearer. Third generation. 1918-1923.

Year	Place	Date of—			Period Over which Pupation Occurred Days	No. Individuals Observed	Length Pupal Stage —Days		
		First Pupation	Max. Pupation	Last Pupation			Avg.	Max.	Min.
1918*	College	.....	.....	.....	.....	.....	.....	.....	.....
1919	College	Sept. 17	Oct. 5	Oct. 11	25	151	12.9	18	6
1920*	College	.....	.....	.....	.....	.....	.....	.....	.....
1921	College	Sept. 12	Sept. 13	Sept. 28	17	263	9.5	13	6
1922*	College	.....	.....	.....	.....	.....	.....	.....	.....
1923	College	Aug. 22	Sept. 4	Sept. 29	39	356	12.6	17	8
	Total	.....	.....	.....	.....	770	.....	.....	.....

*No third generation.

The range of the period over which pupation occurred given in Table No. 30 is representative of field conditions for the years 1919 and 1923, but not for the year 1921. At the time the first larvae of this generation should have been collected heavy rains flooded the pecan lands in the Brazos and Navasota River Valleys and delayed the collection of larvae until after some had pupated. From general observations it is thought that the range of pupation in 1921 covered about the same period as in 1923. Pupation began on August 22 in

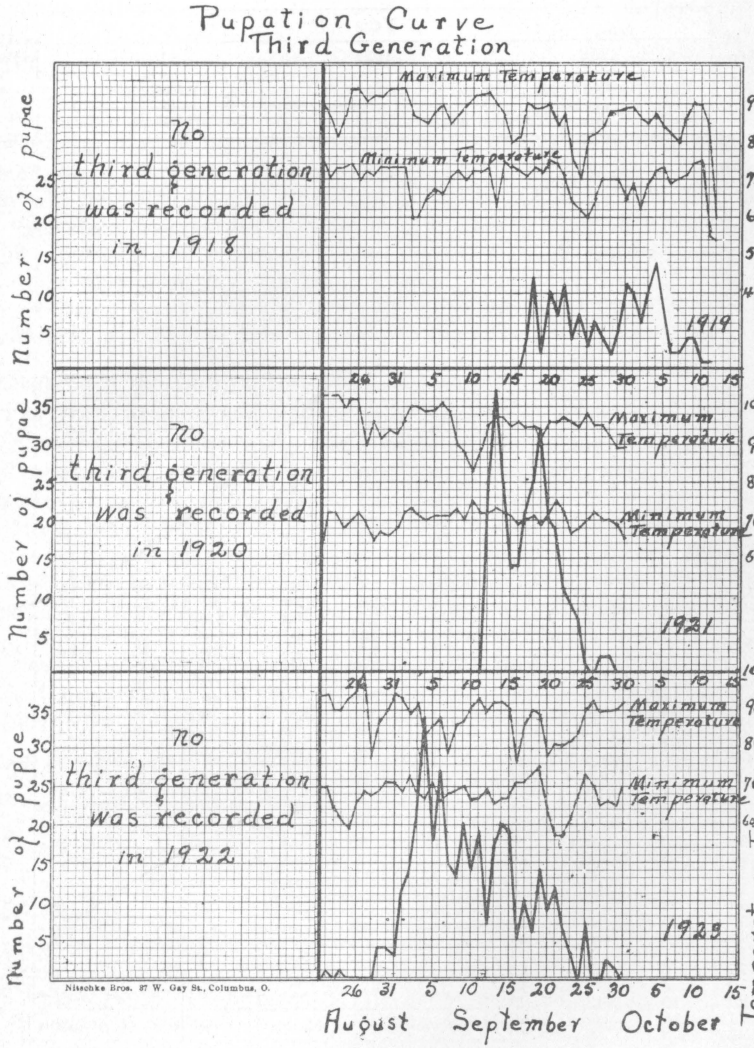

Fig. 14. Pupal records and temperatures for the third generation. College Station, Texas, 1918–1923.

Table 33.—Time of emergence of the moths of the third generation. 1919-1921-1923.

Date of Emergence	Number of Moths Emerging									Total
	Year									
	1919			1921			1923			
	College			College			College			
	Male	Fem.	Total	Male	Fem.	Total	Male	Fem.	Total	
Aug. 29	.....	.....	.....	.....	.....	.....	1	1	2	2
Aug. 30	.....	.....	.....	.....	.....	.....	.....	.....	.....	0
Aug. 31	.....	.....	.....	.....	.....	.....	.....	.....	.....	0
Sept. 1	.....	.....	.....	.....	.....	.....	1	1	2	2
Sept. 2	.....	.....	.....	.....	.....	.....	.....	.....	.....	0
Sept. 3	.....	.....	.....	.....	.....	.....	4	2	6	6
Sept. 4	.....	.....	.....	.....	.....	.....	4	4	8	8
Sept. 5	.....	.....	.....	.....	.....	.....	2	3	5	5
Sept. 6	.....	.....	.....	.....	.....	.....	3	2	5	5
Sept. 7	.....	.....	.....	.....	.....	.....	3	3	6	6
Sept. 8	.....	.....	.....	.....	.....	.....	10	4	14	14
Sept. 9	.....	.....	.....	.....	.....	.....	4	7	11	11
Sept. 10	.....	.....	.....	.....	.....	.....	7	5	12	12
Sept. 11	.....	.....	.....	.....	.....	.....	8	8	16	16
Sept. 12	.....	.....	.....	.....	.....	.....	13	6	19	19
Sept. 13	.....	.....	.....	.....	.....	.....	11	8	19	19
Sept. 14	.....	.....	.....	.....	.....	.....	9	11	20	20
Sept. 15	.....	.....	.....	.....	.....	.....	11	24	35	35
Sept. 16	.....	.....	.....	2	.....	2	16	22	38	40
Sept. 17	.....	.....	.....	10	13	23	24	26	50	73
Sept. 18	.....	.....	.....	8	12	20	11	16	27	47
Sept. 19	.....	.....	.....	15	17	32	20	21	41	73
Sept. 20	.....	.....	.....	14	13	27	13	17	30	57
Sept. 21	.....	.....	.....	22	22	44	12	15	27	71
Sept. 22	.....	.....	.....	14	22	36	4	9	13	49
Sept. 23	.....	.....	.....	14	19	33	11	6	17	50
Sept. 24	.....	.....	.....	28	24	52	6	10	16	68
Sept. 25	.....	.....	.....	13	26	39	6	12	18	57
Sept. 26	.....	.....	.....	12	20	32	11	6	17	49
Sept. 27	.....	.....	.....	18	15	33	14	20	34	67
Sept. 28	.....	.....	.....	19	26	45	16	18	34	79
Sept. 29	8	7	15	19	12	31	9	22	31	77
Sept. 30	4	2	6	2	9	11	7	20	27	44
Oct. 1	4	7	11	9	20	29	8	17	25	65
Oct. 2	7	8	15	2	19	21	6	8	14	50
Oct. 3	7	5	12	.....	9	9	1	3	4	25
Oct. 4	4	8	12	6	12	18	.....	9	9	39
Oct. 5	15	13	28	2	6	8	1	2	3	39
Oct. 6	13	15	28	2	2	4	1	.....	1	33
Oct. 7	3	10	13	.....	7	7	.....	2	2	22
Oct. 8	3	4	7	2	.....	2	1	1	2	11
Oct. 9	8	7	15	.....	.....	.....	.....	.....	.....	15
Oct. 10	10	9	19	1	2	3	1	.....	1	23
Oct. 11	9	7	16	.....	1	1	.....	.....	.....	17
Oct. 12	3	6	9	.....	.....	.....	.....	.....	.....	9
Oct. 13	4	11	15	.....	.....	.....	.....	1	1	16
Oct. 14	4	3	7	.....	.....	.....	.....	.....	.....	7
Oct. 15	5	8	13	.....	.....	.....	.....	.....	.....	13
Oct. 16	9	5	14	.....	.....	.....	.....	.....	.....	14
Oct. 17	1	3	4	.....	.....	.....	.....	.....	.....	4
Oct. 18	6	7	13	.....	.....	.....	.....	.....	.....	13
Oct. 19	4	9	13	.....	.....	.....	.....	.....	.....	13
Oct. 20	10	13	23	.....	.....	.....	.....	.....	.....	23
Oct. 21	10	7	17	.....	.....	.....	.....	.....	.....	17
Oct. 22	3	9	12	.....	.....	.....	.....	.....	.....	12
Oct. 23	1	3	4	.....	.....	.....	.....	.....	.....	4
Oct. 24	4	2	6	.....	.....	.....	.....	.....	.....	6
Oct. 25	.....	1	1	.....	.....	.....	.....	.....	.....	1
Total...	159	189	348	234	328	562	290	372	662	1572

1923 and continued until September 29. In 1919 the period of pupation was delayed. This was probably due to the delayed second generation. There was also an excessive amount of rainfall in 1919. Considering the three years, 1919, 1921, and 1923, the greater number of larvae pupated between September 1 and 26 which is probably the period over which pupation occurs for the average year.

Temperatures again become important as a factor in determining the length of the pupal period. In 1919 the average mean temperatures for the duration of the pupal period was 74.6° F. and the average duration of the pupal stage was 12.9 days. In 1923 the average mean temperature for the duration of all the pupae observed was 77.3° F. and the average duration of the pupal stage was 12.6 days. In 1919 there was considerable rainfall during this period while in 1923 there was very little. In 1921 the duration of the pupal period was 9.5 days or practically the same average length as for the first and second generations and the average mean temperature for the third generation was also nearly the same.

Emergence of the Moths of the Third Generation

The time when the moths of this generation emerge is dependent upon temperatures during the pupal period of the spring brood and of the first generation. The first moths of this generation were emerging at the same time the last moths of the second generation were emerging in 1923, hence there may be some overlapping of generations. The moths of this generation emerged over a longer period of time than in any of the preceding generations in 1923. The first moths began to emerge on August 29 in 1923. In 1919 the first moths emerged on September 29. The last moths emerged on October 13th. in 1923, but in 1919 the last ones did not emerge until October 25. In 1921 and 1923 the emergence covered about the same length of time, the larger number emerging from September 8 to October 4.

Table 34.—Summary of the emergence records of the third-generation moths of the pecan nut case bearer. 1918-1923.

Year	Place	Date of—			Number Days of Emergence	Total Number Moths	Number Males	Number Females
		First Emergence	Maximum Emergence	Last Emergence				
1918*	College.....							
1919	College.....	Sept. 29...	Oct. 5... Oct. 6	Oct. 25...	27	348	159	189
1920*	College.....							
1921	College.....	Sept. 16...	Sept. 24...	Oct. 11...	26	562	234	328
1922*	College.....							
1923	College.....	Aug. 29...	Sept. 17...	Oct. 13...	46	662	290	372
	Total.....	.....	.....	.....	.....	1572	683	889

*No third generation moths.

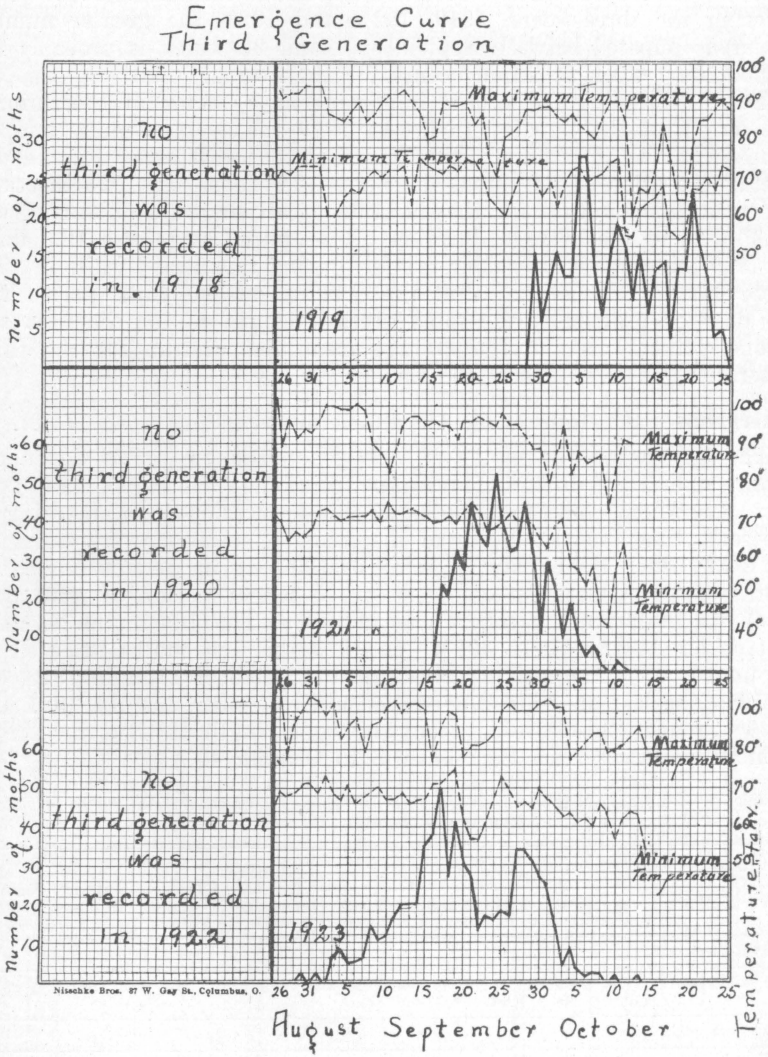

Fig. 15. Emergence records and temperatures for the third generation. College Station, Texas 1919-1923.

Oviposition by the Moths of the Third Generation

The moths of this generation deposit their eggs in grooves on the sides of nuts and on buds below the clusters as in the two preceding generations. Oviposition begins from 4 to 9 days after emergence, depending on the temperature.

It was difficult to get moths of this generation to oviposit in captivity on trees when the nights were cool, but if the moths were caged and placed in a room where a temperature of 75° F. was maintained they oviposited readily. Under such conditions a large number of eggs were deposited by single moths. In 1921 when the temperatures were high they oviposited readily. In 1923 the minimum temperatures were so low that it was necessary to remove the moths to a room where more favorable conditions prevailed.

Oviposition records were obtained from 73 females in 1923. The largest number of eggs laid by a single female was 247. The average length of life of the 73 females which laid eggs was 11.8 days. From emergence to first oviposition an average of 7 days elapsed. Oviposition occurred over an average of 2.3 days. From emergence to last oviposition an average of 8.8 days occurred and the average length of life after last oviposition was 3 days.

Table 35.—Summary of the oviposition records of the third-generation moths of the pecan nut case bearer. College Station, Texas. 1923.

Moth Number	Date of Emergence.	Date Moth Died.	Length of Life.	Total Number of Eggs Laid.	Number Days from Emergence to First Oviposition.	Number Days on which Oviposition Occurred.	Number Days from Emergence to Last Oviposition.	Length of Life After Last Oviposition.
1	Sept. 3	Sept. 20	17	139	10	3	12	5
2	Sept. 5	Sept. 21	16	54	10	6	15	1
3	Sept. 5	Sept. 25	20	68	7	5	11	9
4	Sept. 5	Sept. 19	14	247	6	5	13	1
5	Sept. 8	Sept. 23	15	208	4	9	14	1
6	Sept. 9	Sept. 30	21	17	11	2	12	9
7	Sept. 9	Sept. 21	12	1	5	1	5	7
8	Sept. 10	Sept. 15*	.....	78	4	.....	.....	.....
9	Sept. 10	Sept. 23	13	10	6	1	6	7
10	Sept. 10	Sept. 29	19	13	14	2	17	2
11	Sept. 10	Sept. 24	14	2	10	1	10	4
12	Sept. 10	Sept. 28*	.....	33	8	.....	.....	.....
13	Sept. 11	Sept. 25	14	6	12	1	12	2
14	Sept. 11	Sept. 24	13	101	4	4	9	4
15	Sept. 11	Sept. 20	9	4	8	1	8	1
16	Sept. 11	Sept. 28	17	64	16	1	16	1
17	Sept. 12	Sept. 25	13	22	4	3	7	6
18	Sept. 13	Sept. 23	10	9	4	3	7	3
19	Sept. 13	Sept. 20	7	18	4	2	5	2
20	Sept. 13	Sept. 24	11	13	8	2	10	1
21	Sept. 13	Sept. 23	10	2	3	1	3	7
22	Sept. 14	Sept. 28	14	1	5	1	5	9
23	Sept. 14	Oct. 2	18	6	17	1	17	1
24	Sept. 15	Oct. 1	16	123	4	7	12	4
25	Sept. 15	Sept. 25	10	8	4	2	8	2
26	Sept. 15	Sept. 24	9	20	7	2	9	0
27	Sept. 15	Sept. 28	13	3	10	1	10	3
28	Sept. 15	Sept. 20*	.....	20	5	.....	.....	.....
29	Sept. 15	Sept. 24	9	20	5	2	7	2

*Indicates moth escaped or was killed before record was completed.

Table 35. Summary of the oviposition records of the third-generation moths of the pecan nut case bearer. College Station, Texas. 1923—Continued.

Moth Number	Date of Emergence.	Date Moth Died.	Length of Life.	Total Number of Eggs Laid.	Number Days from Emergence to First Oviposition.	Number Days on which Oviposition Occurred.	Number Days from Emergence to Last Oviposition.	Length of Life After Last Oviposition.
30	Sept. 15	Sept. 28	13	36	6	4	9	4
31	Sept. 15	Sept. 28	13	1	7	1	7	6
32	Sept. 16	Oct. 3	17	53	10	2	11	6
33	Sept. 16	Sept. 28	12	4	6	1	6	6
34	Sept. 16	Sept. 28	12	1	6	1	6	6
35	Sept. 16	Oct. 4	18	48	14	1	14	4
36	Sept. 16	Sept. 24	8	1	6	1	6	2
37	Sept. 17	Sept. 28	11	1	10	1	10	1
38	Sept. 17	Sept. 30	13	45	5	2	10	3
39	Sept. 17	Sept. 24	7	12	5	2	6	1
40	Sept. 17	Sept. 28	11	8	5	3	9	2
41	Sept. 18	Sept. 28	10	1	8	1	8	2
42	Sept. 18	Sept. 28	10	2	6	1	6	4
43	Sept. 18	Oct. 4	16	25	9	3	11	5
44	Sept. 18	Sept. 28	10	21	6	2	9	1
45	Sept. 18	Sept. 29	11	1	10	1	10	1
46	Sept. 19	Sept. 28	9	29	5	4	8	1
47	Sept. 19	Sept. 28	9	25	5	2	6	3
48	Sept. 19	Sept. 24	5	60	5	1	5	0
49	Sept. 19	Sept. 24	5	2	5	1	5	0
50	Sept. 19	Oct. 4	15	12	5	6	14	1
51	Sept. 19	Sept. 29	10	3	6	3	10	0
52	Sept. 19	Sept. 29	10	11	5	4	8	2
53	Sept. 20	Sept. 30	10	42	7	4	10	0
54	Sept. 20	Sept. 28	8	13	5	1	5	3
55	Sept. 21	Oct. 6	15	9	9	3	12	3
56	Sept. 21	Oct. 2	11	1	10	1	10	1
57	Sept. 22	Oct. 2	10	34	6	2	7	3
58	Sept. 23	Sept. 30*	.....	25	5	.....	.....	.....
59	Sept. 23	Oct. 5	12	36	8	4	11	1
60	Sept. 23	Oct. 5	12	22	6	4	12	0
61	Sept. 23	Oct. 9	14	2	7	2	9	5
62	Sept. 24	Oct. 1	7	1	6	1	6	1
63	Sept. 24	Oct. 1	7	5	6	1	6	1
64	Sept. 28	Oct. 8	10	12	5	1	5	5
65	Sept. 28	Oct. 4	6	10	4	2	6	0
66	Sept. 29	Oct. 6	7	47	4	2	5	2
67	Sept. 30	Oct. 18	18	1	5	1	5	13
68	Sept. 30	Oct. 10	10	2	7	1	7	3
69	Sept. 30	Oct. 12	12	15	7	3	10	2
70	Sept. 30	Oct. 8	8	12	7	2	8	0
71	Oct. 2	Oct. 11	9	3	4	3	7	2
72	Oct. 4	Oct. 18	14	28	6	3	10	4
73	Oct. 4	Oct. 11	7	12	6	1	6	1

*Indicates moth escaped or was killed before record was completed.

Length of Life of the Adults of the Third Generation

The life of the adults of the third generation was longer than that of the three preceding generations. The average length of life in 1919 was 4.7 days and 8.8 days in 1923. The longer period in 1923 was due to the fact that the methods of feeding and rearing the adults had been improved over those of 1919. The adults do not thrive in captivity and are difficult both to feed and handle. The males usually die before the females.

Table 36.—Length of life of the adults of the third generation. 1919-1923.

Length of Life—Days	1919		1923	
	Male	Female	Male	Female
1	8	5	2	1
2	5	17	.....	.....
3	16	5	.....	.....
4	.....	2	7	13
5	6	4	15	23
6	14	8	19	21
7	10	12	14	19
8	.....	3	11	19
9	2	2	6	13
10	.....	1	9	19
11	1	3	5	12
12	.....	.....	5	18
13	1	.....	2	8
14	.....	.....	1	7
15	.....	.....	2	5
16	.....	.....	.....	4
17	.....	.....	1	4
18	.....	.....	.....	5
19	.....	.....	1	2
21	.....	.....	.....	1
23	.....	.....	2	.....
Average length of life	4.6	4.8	8	9.2
Maximum	13	11	23	21
Minimum	1	1	1	1

Table 37—Length of incubation of the eggs of the fourth generation pecan nut case bearer. College Station, Texas. 1923.

Date of Oviposition	No. Eggs	Incubation Period—Days								Average Days
		4		5		6		7		
		No.	Average Mean Temp.	No.	Average Mean Temp.	No.	Average Mean Temp.	No.	Average Mean Temp.	
Sept. 11	76	.....	.....	76	79.3	.....	.....	.....	.....	5
Sept. 12	49	.....	.....	49	78.1	.....	.....	.....	.....	5
Sept. 13	90	7	77.7	83	77.9	.....	.....	.....	.....	4.9
Sept. 14	93	66	77.6	27	78.4	.....	.....	.....	.....	4.2
Sept. 15	134	.....	.....	134	78.9	.....	.....	.....	.....	5
Sept. 16	165	89	79.0	76	77.3	.....	.....	.....	.....	4.4
Sept. 17	46	.....	.....	21	76.3	25	75.0	.....	.....	5.5
Sept. 18	98	.....	.....	.....	.....	78	73.9	20	74.1	6.2
Sept. 19	36	.....	.....	4	72.4	32	72.9	.....	.....	5.9
Sept. 20	103	.....	.....	.....	.....	103	72.8	.....	.....	6
Sept. 22	120	.....	.....	.....	.....	120	76.0	.....	.....	6
Sept. 23	20	.....	.....	20	77.4	.....	.....	.....	.....	5
Sept. 25	38	.....	.....	38	79.1	.....	.....	.....	.....	5
Sept. 27	36	13	78.5	.....	.....	23	78.6	.....	.....	5.2
Sept. 28	53	13	79.1	40	78.9	.....	.....	.....	.....	4.7
Sept. 29	23	.....	.....	23	78.7	.....	.....	.....	.....	5
Sept. 30	62	.....	.....	62	78.3	.....	.....	.....	.....	5
Oct. 1	11	.....	.....	11	76.2	.....	.....	.....	.....	5
Oct. 2	18	.....	.....	.....	.....	18	74.1	.....	.....	6
Oct. 3	16	.....	.....	.....	.....	16	73.6	.....	.....	6
Total...	1287	188	78.4	664	78.3	415	74.5	20	74.1	5.2

Fourth Generation

The fourth generation, which is not completed until the following spring, is represented by the egg and larval stages only. The larvae feed for a short time after hatching on the shucks if they are still on the trees. If none are available they feed at the bases of the leaf petioles and on buds, after which the larvae spin hibernacula. The latest date a larva was observed to be feeding was November 11.

Incubation of the Eggs of the Fourth Generation

The duration of the egg stage is dependent on temperature, in 1923 the minimum duration being 4 days, the maximum 7 days, and the average duration 5.2 days. The larvae which hatch from these eggs spin hibernacula in which they pass the winter. In the spring they are known as spring brood larvae.

SUMMARY

The pecan nut case bearer passes the winter in the larval stage in a tough silken hibernaculum which is made by the larva. This hibernaculum is saucer-shaped and about 3 mm. in diameter.

As soon as tree growth starts in the spring the larvae become active and begin to feed on the buds to which the hibernacula are attached. After feeding within the hibernaculum for some time the larva deserts it and enters the new growth at the axils of leaf stems. A burrow is made on the interior of the tender growth within which the larval period of the spring brood is passed. The point of entrance may be determined by the frass and excrement which the larva throws out. The larvae are feeding in these burrows during the latter part of March and the month of April. If the temperature is low or if there is a great deal of cloudy and windy weather larval development is retarded. After completing its growth the larva stops up the entrance to its burrow and spins a flimsy case or cocoon within which pupation takes place. The length of the pupal period is dependent on climatic factors, the chief of which is probably temperature. The duration of the pupal stage ranged from 9 to 24 days and the average length varied from 12 to 18 days for the several years. When the daily minimum temperature was below 65° for several days or when it fluctuated greatly or when the mean temperature was only slightly above 65° F., the period over which pupation occurred was from 4 to 6 days longer than when the minimum daily temperature was above 65° F. Emergence of spring-brood moths is dependent upon climatic factors during the time the insect is in the pupal stage. Low temperature, however, is only a delaying factor, as the natural emergence usually follows in time. The spring-brood moths emerge during the latter half of April and the first half of May, maximum emergence occurring between May 5 and May 13. The life of the adults is short, most of the moths dying within five or six days after emergence.

The eggs deposited by the spring-brood moths are the beginning of the first generation. The eggs are usually deposited in the center of the pistil or on the upper or lower surface of the calyx lobes. Oviposition begins on the third or fourth night after emergence, and is completed in a few nights. The eggs hatch in 5 days, after which the young larvae wander about until they have found a protected place and begin feeding. In most cases the larvae feed upon buds for two or three days, after which they enter the small nuts at their bases by cutting out circular holes. They feed on the interior of nuts, which at this time are a little larger than an English pea. A larva goes from one nut to another until it is full grown. Before entering a nut a larva fastens it to other nuts or a branch by means of silken threads. The length of the larval period is about 25 days. When grown the larva selects a dry nut and stops up the point of entrance with silk and excrement, after which it spins a flimsy cocoon within and pupates. Temperature at the time this generation is passed has risen to the point where its effect on the pupal stage is less marked. The average mean temperature of the pupal period of 884 individuals of the 1314 recorded for the six years was 80° F., and the average pupal period for the 1314 individuals was 9 days. The minimum length of the pupal period was 5 days and the maximum 16 days. The moths of this generation begin to emerge the latter part of May or the first part of June, and emergence is completed by the first of July. They live only a few days and begin to oviposit on the fourth or fifth night after they emerge.

There was a second generation only in 1919, 1920, 1921, and 1923; and in 1920 the number of second generation moths which emerged was negligible. It is probable that one could always find a few second generation larvae in any year if search were made over a wide enough territory. But continuous searching for several weeks in 1918 and 1922 did not result in the finding of any larvae of this generation.

The eggs hatch in from 3 to 7 days, the larger number hatching in 5 days. After hatching the larvae feed on the buds as in the preceding generation and then enter the bases of the nuts and feed on the inside. The mean temperature in this generation was a little higher than in the preceding and the larval stage was longer—the average duration being 33 days. After completing their growth the larvae close the openings through which they entered the nuts and spin flimsy cocoons within, after which pupation occurs. The period over which pupation takes place may range from July 13 to August 27. The average length of the pupal period was 9 days for each of the years 1919, 1920, 1921, and 1923. The average mean temperatures were high in each of the three years and seemed to have a stabilizing effect on the length of the pupal period.

The period over which the moths of the second generation emerged ranged from July 22 to September 7, maximum emergence occurring in two of the years between August 2 and August 6. Emergence records were made on 2624 moths.

The adults oviposit on the third or fourth night after emergence, in grooves on the sides of the nuts or on buds below the nut clusters. The largest number of eggs laid by one female was 190. Because of the hot weather the adults did not live long in the cages, the average length of life being from 2.6 to 7.1 days.

There was a third generation only in those years when a second generation was completed. The eggs of this generation hatch in 5 days, after which the larvae seek protected places where several nuts touch and begin feeding on the nuts or on buds. The larvae of this generation sometimes enter the nuts as in the two preceding generations but most of them feed in the interior of the shucks or on the shucks at the bases of a cluster of nuts. The average length of the larval period was 26 days. The average mean temperature was about the same as in the first generation and the average duration of the larval period was about the same as that of the first generation. An average mean temperature several degrees above 80° F., has the effect of lengthening the duration of the larval stage. After completing their growth the larvae spin cocoons in the larval burrows and pupate. The average duration of the pupal period varies from 9.5 to 12.5 days, the duration depending on the temperature. The time when the moths of the third generation emerge depends on the temperature during the pupal stage and also on the time when the previous generations have matured. In the several years emergence varied considerably, the period ranging from September 29 to October 25, and from August 29 to October 8. From 4 to 9 days after emergence oviposition begins and may continue for some time in cool weather.

The eggs hatch in from 5 to 9 days. The young larvae feed on the shucks when available or in the axils of leaves and on the buds, later spinning the overwintering hibernacula. Some larvae may feed as late as the 11th of November.

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