UNIVERSITY OF TENNESSEE

33

Upon the request of the Committee on Graduate Study the under-signed have examined the thesis entitled

Studies in the Life History of Melittia Satyriniformis in Tennessee

presented by Oscar E. Couch

candidate for the degree of Master of Science in Agriculture, and hereby certify that it is worthy of acceptance.

J. M. Bentley

Edwin B. Powers

Examiners.

THESIS

# STUDIES IN THE LIFE HISTORY OF THE MELITTIA SATRINIFORMIS IN TENNESSEE

A Part of the Requirement for the Degree of
Master of Science in Agriculture



UNIVERSITY OF TENNESSEE
KNOXVILLE, TENNESSEE

OSCAR EARL COUCH

1929

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Plate 1.

Adult female, oil colored by C.M.Wheeler,
(after Beutenmuller).



# Introduction

This thesis was chosen for the purpose of making a detail study of Melittia satriniformis Hübn. in Tennessee, and to clear up a slight confusion over the number of generations that the species passes through each year.

There has been much literature written on the history, classification, and injury of the species, but very little has been written on the life history.

Franklin Sherman, Chief: Division Entomology and Zoology of the South Carolina Experiment Station said the following along with his answer to the questionaire sent him: "Perhaps one reason why this problem was suggested to you for work on Master's thesis is because very little(or no) exact work on it has been published from the southern states, and the opportunity seems to be wide open for you to dig out a lot of facts which, while not entirely unknown, have at least never been definitely proven for this section of the country."

The experiments are not as scientific as they should be due to the fact that I had no way of finding the humidity, and recording the accurate temperature in the room, where the experiments were carried on. The temperatures for the incubation period were taken at the laboratory, but those for the starvation test were secured from the U.S. Weather Bureau.

My success in getting results in the life history experiments was due to the hearty cooperation of the truck farmers, Entomologists of the different Agricultural Experiment Stations, and the supervision of Professor Bentley.

# HISTORY

Chittenden (1), gives the following historical statement of the squash-vine borer:

"As far as is known the squash-vine borer is a native of the Western Hemisphere and is widely distributed in the United States, practically wherever squashes are cultivated. Available records and examination of material in the collection of the U. S. National Museum show that it has a range embracing territory from the New England States and Canada in the North to the Gulf States Southward and Westward to the region beyond the Missouri River, which comprises the major portion of the Carniolian and Austroporion areas of the upper and lower Austrial life zones and a portion also of the Transition zone. It is evidently of tropical origin and occurs in Mexico, where it is also widely distributed, and in Guatemala, Panama, Venezuela, Argentina, and the Lower Amazon.

"In 1825 Hübner (2), described the squash-vine borer under its present name (Melittia satriniformis). T. Wm. Harris redescribed it in 1828 as AEgeria cucurbitae, and later J. O. Westwood named it Trochilium ceto, but for

(1) U. S. D. A. Bureau of Ent. Bul. 668, p. 1.

(2) Beutenmuller's Monograph of Sesiidae, of America, North of Mexico, p. 234.

some reason it has been referred in literature and collections under the name of Melittia ceto.

"In 1828 Flint described this insect under the name of AEgeria cucurbitae. My Edwards redescribed the species as Melittia amoenia."

When T. Wm. Harris redescribed the species in 1828, he was apparently not aware of Hubner's work, because Henry Doubleday (3) called his attention to Hubner's figure in the following note, dated Feb. 27, 1841:

"Have you ever seen Hubner's Exotic Lepidoptera? Your AEgeria cucurbitae is his Melittia satriniformis."

For some cause the names AEgeria or Melittia cucurbitae or ceto were used in literature and collections until 1897 when attention was given to Hubner's name (2).

The earliest record found on the occurrence of the squash-vine borer in the United States was recorded in an article entitled, "Insects" by T. Wm. Harris (4), Milton, Massachusetts, Aug. 11, 1828, the year that he redescribed the insect. The following record is given in this article on the squash-vine borer:

"You may have observed that the squash and other cucurbitaceous vines frequently die during this month,

(2) Beutenmuller's Monograph of Sesiidae, of America, North of Mexico, p. 234.

(3) Entomological Correspondence, p. 161.

(4) New England Farmer, Vol. 7, No. 5, p. 33-34 - 1828.

down to the root. On examining the stalk, near the root you may discover a small whitish grub, which lives in the centre, and is the cause of this premature decay. The grub, when it has attained its full size, is about one inch long; it then enters the ground, forms a cocoon of coarse silky substance, covered with grains of earth, and becomes a chrysalis. Thus survives the winter, and about the last of June or first of July the perfect insect was disclosed. It is closely related to the peach tree borer insect, and belongs to the same genus. It does not appear to have been described by Linnaeus nor Fabricius. Still, as I have not access, to many of the works containing descriptions of American insects I can not confidently pronounce it to be a nondescript and therefore give it a specific name provisionally, only till it shall prove to be entitled to an older one."

Plate 11.

Photostat, after Hubner, Jacob. Zutrage
Zur Sammlung Exotischer Schmetterlinge
Drittens Hundert.

227.

# Melittia Satyriniformis.

(Sphinx hymenopteroides, sesia gracilis.)

Fig. 453. 454.

Herr Escher ist der Einsender dieser merkwürdigen Gattung, welche der getreuen Abbildung ungeachtet, noch eine genauere Beschreibung verdient.

Der ziemlich gemeinförmige Leib ist schwarz, grünlich schimmernd und mit hellbegränzten Leibringen geziert; die Streichler sind rostgelb mit schwarzen Spitzen, und die keulenförmig gefiederten Ohren an den krummgebogenen Enden mit zarten Häckchen versehen. Oben sind die Vorderflügel braun und bis auf ein kurzes, von der Basis derselben gegen die Mitte hingezogenes, helles Glasstreifchen, ganz undurchsichtig; die Hinterflügel gläsern mit braunem Franzenrand. Die Unterfläche, den grünlichen Schimmer der Vorderflügel ausgenommen, kommt fast ganz mit der obern überein.

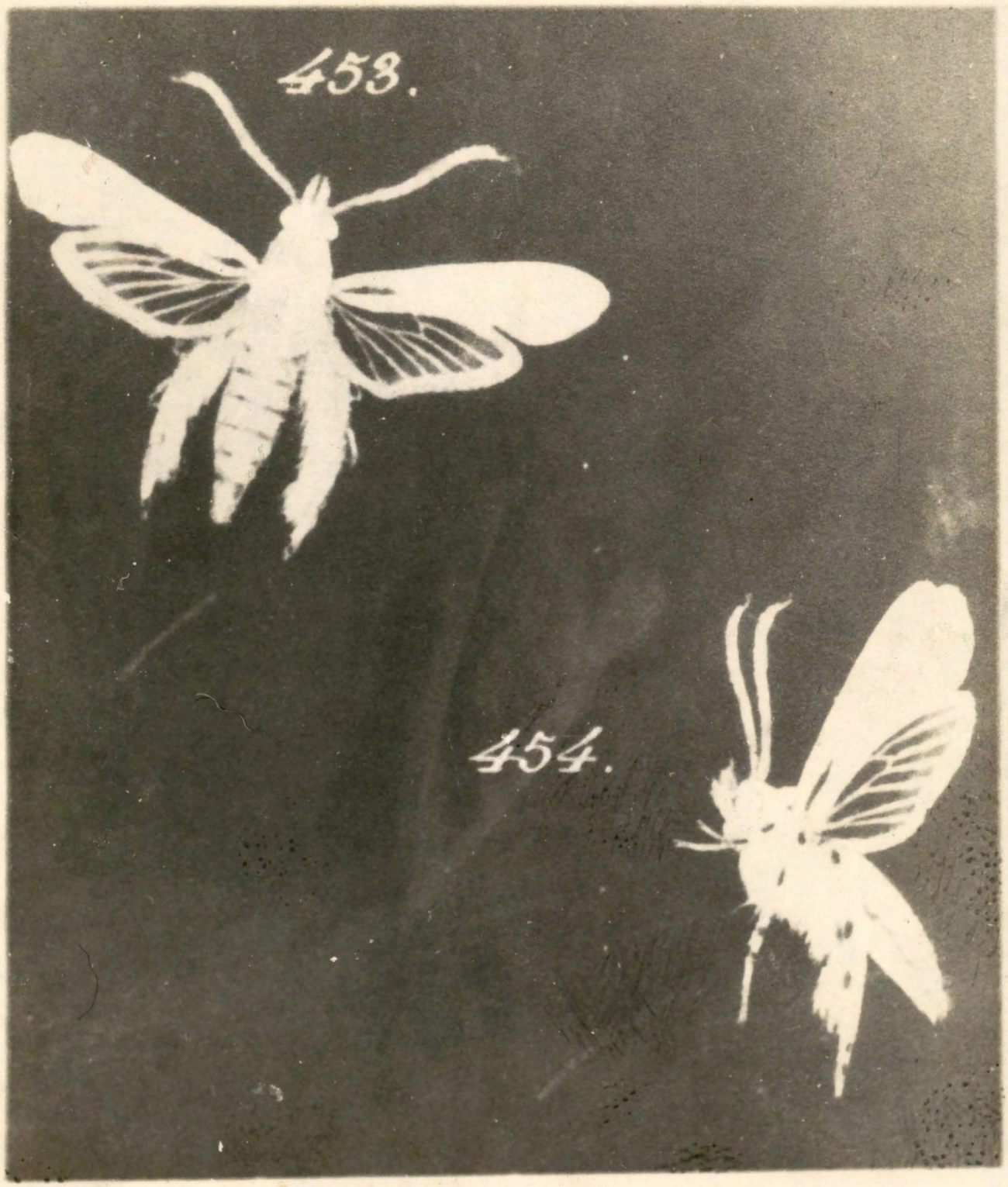
Vorzüglich bewundernswürdig sind aber die Füße, und besonders deren letztes Paar, welches zwar wie die andern schwarz, weiß geringelt und orange gelb und schwarz behaart, aber eben von diesen zweifarbigen Haarbüscheln so sehr überladen ist, daß das ganze Geschöpf dadurch ein monströses Ansehen erhält. Auch sind auf dieser dichten Fußbekleidung noch weiße federähnliche Bürstchen wahrzunehmen, von welchen immer eines an der Einlenkung jeder Schiene steht.

Als eine auffallend ähnliche Gattung die sich aber in der Größe und in der Anlage der Oberflügel dennoch sehr unterscheidet, merke ich hier Bombiliformis Cramers * an, welcher als die Heimath seiner Art, Coromandel angiebt, während das Vaterland des von mir gelieferten männlichen Exemplars, nach Angabe Herrn Eschers, Georgien ist.

*) Cram. vitl. Kap. 400. C.

Plate 111.

Figures of Melittia satriniformis, after Hubner, Jacob. Zutrage Zur Sammlung Exotischer Schmetterlinge, (figs. 453-454)


453.
454.

English Translation of Plate III, by Henry Johnston Darnall, Professor of Germanic Languages of the University of Tennessee.

Melittia Satriniformis

(Sphinx hymenopteroides, sesia gracilis.)

Fig. 453. 454.

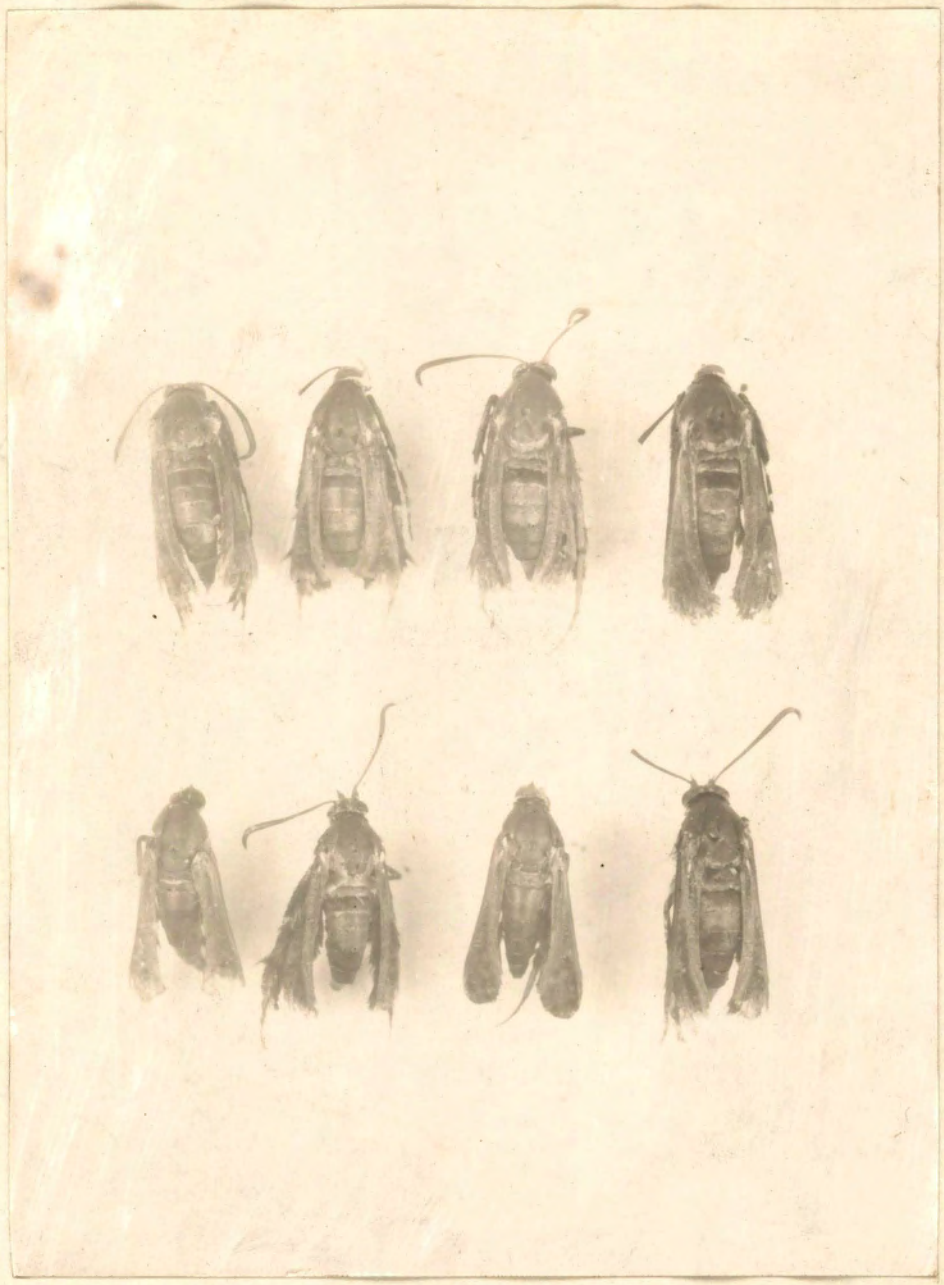
Mr. Eschmer is the sender of this strange kind, which in spite of the formation, deserves an exact description.

The striking form is black, shining greenish, divided with brightly shining body rings, with dark spots and the expressive, and like oars on the curved dark spots, with tender hooks at the ends. Towards the end of a bright glass ring stripe, entirely unseen is a brown stripe. The lower convex, with the exception of the greenish front wings comes in entirely in conflict with the upper ones.

Specially, however, are the feet and especially the last pair, which like the others are ringed black and orange yellow, but are covered with black and gold, but are colored with these two colored hairs. But the whole creation can be noted like feathers, which can be seen at the front of each figure. A special kind which can be distinguished in the position of the upper wing. I notice here the Ecombiliformis of Cramer. Direct is the home of its kind, given the Coromandel sample of the male, according to the saying of Mr. Escher, as a, "Georgian."

Plate IV.

Adult females, variation in size.



## DESCRIPTION OF THE SPECIES

The adult female moth is from 5/8 of an inch to an inch in length with a wing expanse of from one to one and one half inches. The antenna is cylindrical, filiform, with a recurved hook; thorax olive green; palpi pale orange to white and upturned. The front wings are opaque, or olive green in color; the hind wings are clear, with scales on the veins and outer margins. The hind legs are long, clustered with tufts of red and white hairs on the outside; the inside is clothed with black and white. The abdomen is pointed toward the posterior end; segments on the dorsal side of the abdomen separated by velvet gray lines. The dorsal side of the abdomen is orange to red with a row of black dots, and the ventral side is light orange in color. The females may be seen flying from plant to plant very freely in the heat of the day and may often be mistaken for wasps. They become less active as night approaches and may be easily caught resting on the leaves of squash plants.

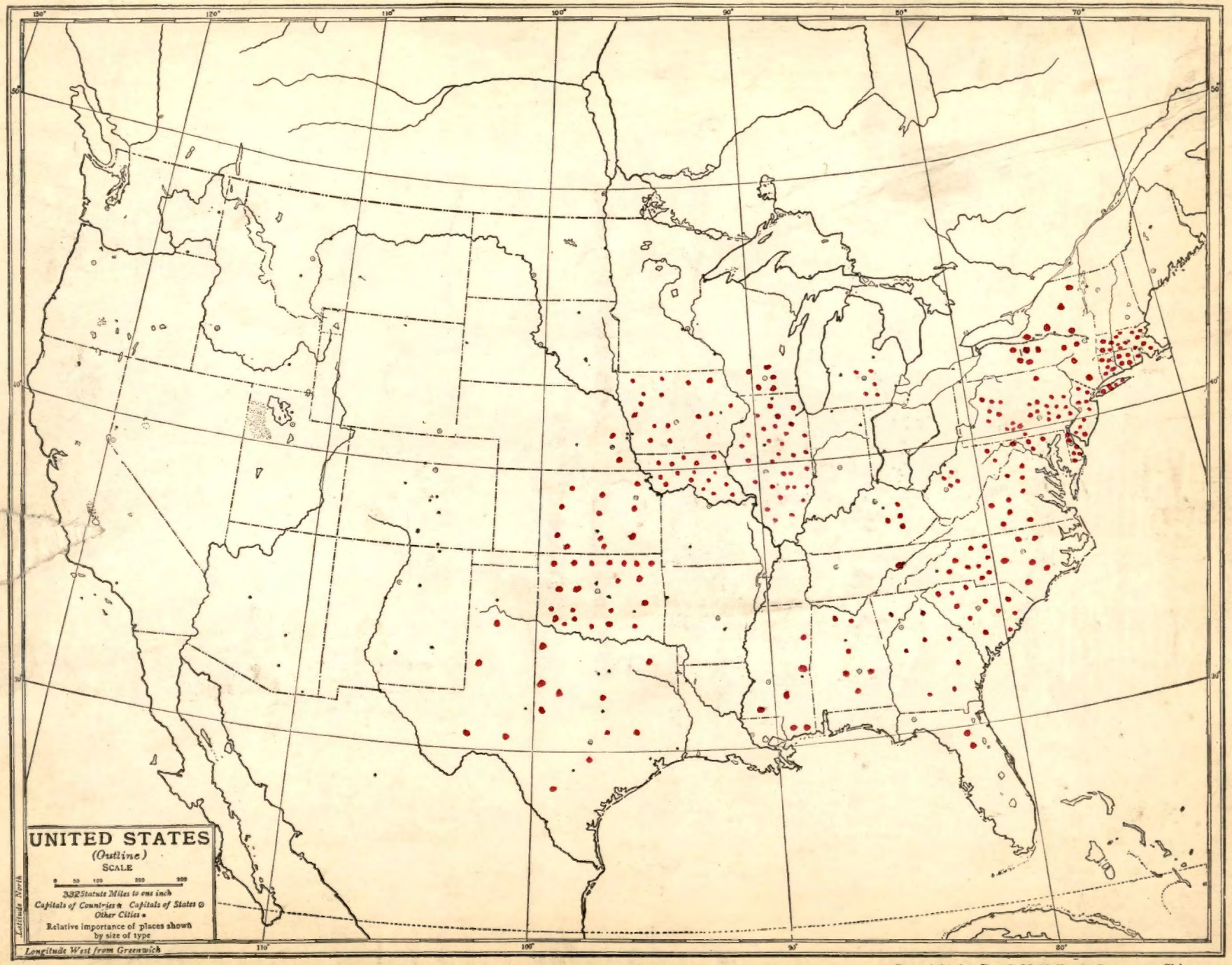
### The Male Moth

The male moth is usually a little smaller in size and a little darker in color than the females. These characteristics can not always be relied on to determine the sexes because the female varies so much in size, color and shape. The following statement proves that the females vary in color:

> "A few females, among many specimens of both sexes, are to be found having the abdomen brownish black above, thus corresponding more nearly to Hubner's satriniformis; therefore Hubner may have had this variety before him, when he wrote his description." (1)

Plate V.

Distribution of Melittis melissophyllum
in the United States.




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About the only characteristic that will easily distinguish the sexes of the moths is the difference in the types of antennae. As mentioned above the female has a cylindrical, filiform antenna with a recurved hook, while the male has a combination of the cylindrical, filiform, recurved hook, and pectinate type of antenna.

According to Spencer and Henderson (2) there are more males than females seen flying around in the field, because the females are underneath the foliage in search for places to deposit eggs.

In Tennessee my observations have been that there are more females than males flying around in the field and resting on top of the squash leaves. During my observations, beginning in June and lasting until the first of August only one male was found.

(1) Entomological Correspondence, p. 235.

(2) Virginia Agri. Exp. Sta. Bul. 52, p. 402.

## DISTRIBUTION

According to Boutenmuller (1) the squash-vine borer is found in Mexico, Guatemala, Panama, Argentina, and the lower Amazon. The distribution of the species in the United States

(1) Boutenmuller's Monograph of the Sesiidae of America, North of Mexico, p. 234.

was determined by sending questionaires to each of the state experiment stations. The following states reported the occurrence of the squash-vine borer:

Alabama, California, Connecticut, Delaware, Florida, Georgia, Illinois, Iowa, Indiana, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Mississippi, Missouri, North Carolina, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Dakota, South Carolina, Tennessee, Texas, Virginia, West Virginia and Wisconsin.

The distribution within the states is shown on a distribution map, Plate V.

## CLASSIFICATION

Melittia satriniformis Hübn. is a borer and belongs to the order Lepidoptera. The name of the order comes from the Greek, "Lepo," meaning scaley, and "Pteron," a wing. Melittia satriniformis Hubn. belongs to the clear wing family known as AEgeriidae.

Beutenmuller gives the following history of the family in his "Monograph of the Sesiidae of America, North of Mexico", p. 219:

"This family of moths was left in peace for over a century at the head of the Heterocera, but has received a varied treatment of late years, having been shifted from place to place by various authors, and it has not as yet found a definite systematic position.

"Linne (1758) placed the species in the Sphingidae, in

which position they were left undisturbed for many years. Newman in 1832 called attention to the relationship of the Sesiidae to the Cossidae and Hepialidae, and in 1878 Butler attempted to prove their affinity to the Colechidae, in which group they were also placed by Meyrick in 1895."

Fracker(2) gives the following statement:

"Sesiidae the name used in Dyar's list for the family is one which is best known, but as it has been described in all the more recent systematic work, there seems to be no reason for continuing the error. It appears to be clearly established that Sesia belongs in the Sphingidae family and that AEgeria is the oldest genus in the family." (1)

"The squash-vine borer was first named as Melittia satriniformis by Hübner, in 1825. Three years afterward Harris redescribed it as AEgeria cucurbitae. This species was named Trochilium ceto by Westwood in 1848. In 1842 Hy. Edwards redescribed the species as Melittia ameena. The names Aegeria or Melittia cucurbitae or ceto were used in American literature until 1897 when attention was given to Hübner's name."

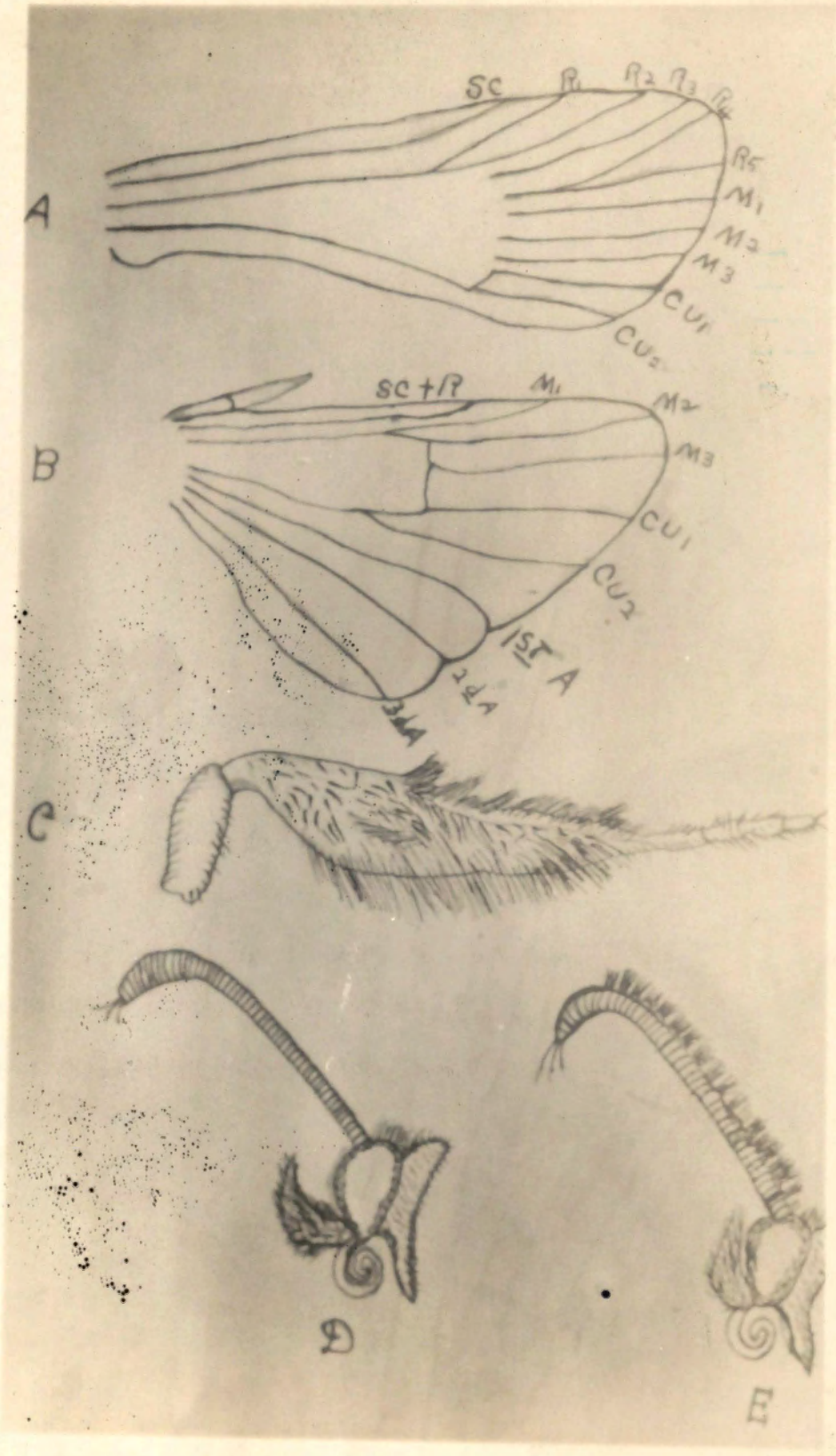
The following characters distinguish Melittia from any of the other members of the family:

(1) Illinois Biological Monograph, Vol. II, No. 1, p. 75.

(2) Beutenmuller's Monograph of Sesiidae of America, North of Mexico, p. 234.

Plate VI.

A. Fore wing of Matrbia subnitidiroella.
(enlarged).
B. Hind wing. (enlarged).
C. Vena ion. (enlarged).
D. Head and antenna of female. (enlarged).
A, B, C, and D are after Beutenmüller.
E. Head and antenna of male. (enlarged).


A
Sc
R1
R2
R3
R4
R5
M1
M2
M3
CU1
CU2
B
Sc+R
M1
M2
M3
CU1
CU2
1ST A
VR
C
D
E

"Palpi upturned, clothed with short hairs above and below. Antennae with fascicles of cilia in the male, clavate, pointed at the tip, simple in the female. Hind tibia and tarsi thickly clothed with very long hairs. Fore wings with 12 veins, R4 and R5 on a stalk, 2dA very short. Hind wings with 9 veins; M3 from middle of cell; Cu, from end of cell. Abdomen cylindrical, tapering toward the apex. Anal tuft very slight, similar in both sexes." Melittia Hubner, Verz. Bek. 1816, p. 128. (After Beutenmuller's Monograph of America, North of Mexico, p. 231).

"Small species (24-34 mm.). Abdomen red with black spots along the back; fore wings metallic green. M. satriniformis." (3)

(3) Beutenmuller's Monograph of Sesiidae of America, North of Mexico, p. 234.

## COMMON NAMES

As far as I have been able to determine there is only one common name referring to Melittia satriniformis Hubn. and that is the squash vine borer. A number of scientific names have been given this species. Hubner first named it Melittia satriniformis in 1825, and in 1828 Harris redescribed it as AEgeria cucurbitae. Westwood gave it the name Trochilium ceto, and recorded it wrongly from China in 1848. Hy. Edwards redescribed the species again as Melittia amoena. There was much confusion over the scientific name until 1839 when

attention was given to Hubner's name. (1)

(1) Beutenmuller's Monograph of the Sesiidae of American, North of Mexico, p. 234.

## ECONOMIC IMPORTANCE

The squash-vine borer damages Cucurbitaceous plants from a small percent to total destruction. Professor Peacock said that the late crop of Bush squash at the University of Tennessee Horticultural garden was almost totally destroyed by this insect. Early squashes are not injured as much as late squashes, because they are usually larger than late ones when injury occurs, and can usually outgrow the injury without very much damage. On the afternoon of July 18, I examined a squash patch of 760 hills and every hill was infested with from one to six squash-vine borers.

In 1920 Mr. John Tillery said that he examined 560 hills of squash containing from one to three vines at Ebenezar, Tennessee, and found 108 vines infested with the squash vine borer.

Metcalf and Flint (1) said that, "this pernicious borer is in many localities a very destructive pest of squashes and

(1) Destructive and Useful Insects, p. 466.

pumpkins, sometimes destroying 25% or more of the crop. Attention will often be first called to it by the sudden wilting of a long runner or an entire plant. Examination of the wilted vine will reveal masses of coarse greenish yellow excrement which the borer has pushed out of the vine through the hole in the side. If such a vine is split open it will be found hollowed out and partly filled with moist slimy frass similar to that cast out on the ground. Plants injured to the point of wilting usually contain a number of borers. Infested vines are often completely girdled, and die beyond the point of attack."

C. R. Cleaveland (2) said that, "Attempts in 1922 and 23 in the entomological experimental garden at Lafayette, Indiana to grow a small patch of Hubbard squash were complete failures, due to complete destruction of the plants by this borer."

Carl J. Drake of the Iowa State College of Agriculture said, "the squash-vine borer is very common in Iowa. The vines are frequently badly infested or even entirely destroyed by the borer in the vicinity of Ames." Franklin Sherman of Clemson College, South Carolina, said, "at Raleigh, North Carolina, it is a nuisance in garden plantings of squash, and undoubtedly shortens the lives of plants, or reduces their bearing in market gardens."

(2) Journal of Economic Entomology, Vol. 20, No. 1. 1927.

Plate VIII.

A. Squash plant pollinated by squash-vine borers.

B. Squash plant ill-used by the squash-vine borers.





W. P. Flint, Chief Entomologist of the State of Illinois said, "the squash-vine borer is very destructive to squash vines throughout all Central and Southern Illinois where squashes are grown."

The three reports above were taken from replies to questionaires sent out to several experiment stations.

## HOST PLANTS

In my observations in the field the squash and pumpkin seemed to be the preferred host plants of the squash-vine borer, but when these two host plants were absent it would attack the gourd, melon and cucumber. The latter were never noticed to be injured when squashes were planted in adjoining rows. According to my observations in the field injury is greatest to the following varieties of squash: Hubbard, Marrow Cymlings, Bush, Ford Hook, White Summer Crookneck, Golden Summer Crookneck, and other late varieties.

D. S. Kellicot (1) said, "the larvae will feed in the stems and roots of wild balsam apple (Echinocystis lobata)."

Professor H. Garman (2) said, "the moths may be frequently seen in July in gardens and fields about Lexington, Kentucky, and appear to have a fondness for the flowers of

(1) Insect Life, Vol. V, No. 1, p. 81.

(2) Ky. Agri. Exp. Sta. Bul. 91, p. 37-38.

Plate VIII.

Top. Screen cage used in experiments.

Bottom. Potted plants used in experiments.



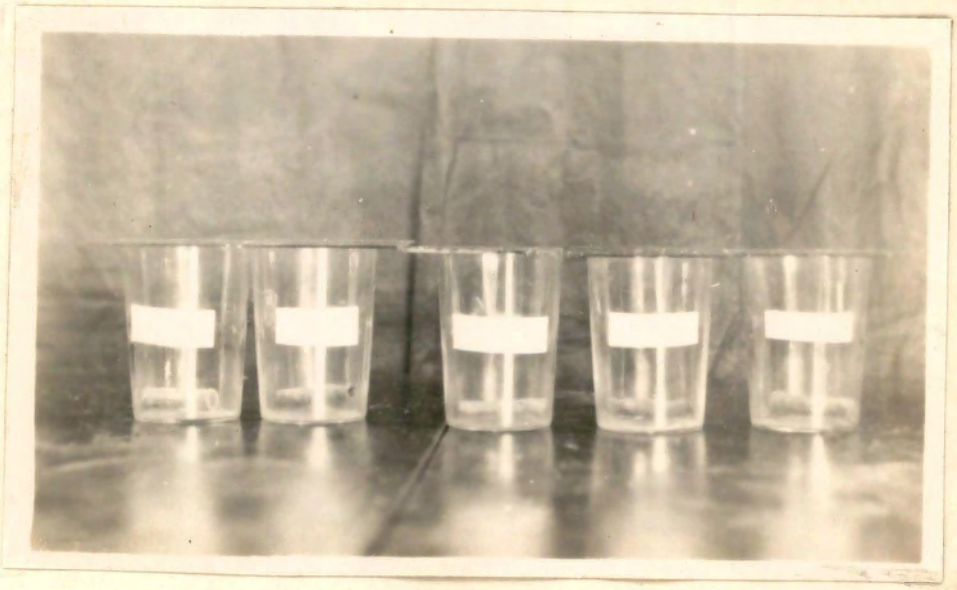


Plate IX.

Top. Cages used in experiments.

Bottom. Glass tumblers, used in experiments.





the Bokhara Clover (Melotus Alba)."

## METHOD OF STUDY

For the purpose of studying the pupal stage some cocoons were found at the University of Tennessee Horticultural garden in March and were brought into the laboratory for further observation. These cocoons were placed in 5x7x5 inch glass cages and about 2 inches of dirt was placed over the cocoons. Every other day a little water was sprinkled over the dirt in the cages to add moisture.

Early in June several trips were made to near by truck farms to look for emerging adults. On June 11th some females depositing eggs on squash plants near Island Home were found. These adults were brought into the laboratory and caged in 3 different sizes of cages, one 5x7x5 inch glass cage with a wire screen top, one wire screen cage 25x13x13 inches, one cone shaped screen fly trap, 18 inches in circumference at the bottom, 13 inches in circumference at the top, and 9 inches high. The three different sizes of cages were used to determine which one was better for rearing purposes.

For observing the egg laying habits each female was placed in a separate cage. These females were fed overripe bananas and sweetened water. As soon as the eggs were laid they were transferred to squash plants, bearing the number of the cage, and the date the eggs were laid. The eggs laid each day by each female were placed on separate squash plants to determine the length of the hatching period, and also to determine the fertility of each female. Eggs were placed in the laboratory

and under outside conditions to determine the difference in the hatching periods. After the eggs hatched the young larvae were placed separately in ordinary one pint glass tumblers with glass covers. The larvae were fed small bits of squash vine cut into lengths of one or two inches. Each day the old pieces of squash vine were slit in order to find the cast larval skins, and new pieces of squash vine were replaced.

Under natural conditions the larvae cocoon about two inches under ground, and for that reason dirt was placed in the bottom of the glass tumblers. In order to determine the duration of the cocoon stage some grown larvae were placed in glass tumblers without dirt. These larvae would cocoon along the sides of the glass and the change from the cocoon to the pupal stage could be observed from day to day.

The distribution map was obtained by getting the distribution from several experiment stations. The following is a form of the questionnire which was sent to the different experiment stations:

SQUASH-VINE BORER
Melittia satriniformis

1. (a) Does the squash-vine borer (Melittia satriniformis) occur in your state? _____

   (b) Does it do very much damage? _____

2. Does it have any other food plant other than the squash, cucumber, pumpkin and gourd? _____

3. (a) What time does the moth occur in the spring in your state? _____

   (b) How long after the moth seems to occur until you notice damage to the cucurbit vines? _____

4. How many broods do you have a year? _____

5. How many molts have you observed? _____

6. (a) What time does the squash vine borer begin to hibernate? _____

(b) Does it hibernate in the larval or pupal stage, or both, in your state? _____

7. (a) What is the relation of the climatical conditions to the feeding habits of the squash vine borer? _____

(b) What does the adult moth feed upon in the spring? _____

8. What is the number of individuals per acre based upon field counts? _____

9. What is the mortality occurring at the time of entrance into hibernation in your state? _____

10. Have you been able to determine whether temperature has any influence upon sex determination or not? _____

11. What is the number of generations in your state? _____

a. Minimum number in season _____

b. Maximum " " " _____

c. Average " " " _____

12. Did you ever carry on cage experiments with squash vine borers? _____
If so what was your method of supplying them with food? _____
Will they live by transferring them from one squash stem to another? _____

13. Does your state have a bulletin or circular on the squash vine borer? If so, please send me copy if available. If not, give number of bulletin or circular.

## LIFE HISTORY

### The Egg

The egg is oval in form, convex above, red in color, flattened on the side of attachment and has an impressed area on the upper side. The size is about one twenty fifth of an inch in length, one thirtieth of an inch in width, and about one

Plate X.

Insect in All Stages

A. Egg on Squash-vine.

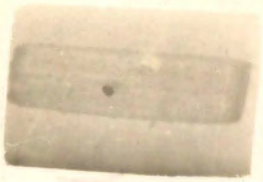
B. Larva.

C. Cocoon.

D. Pupa.

E. Male Moth.

F. Female Moth.



A



B



C



D



E



F

sixtieth of an inch thick.

Under the high powered microscope the egg shows a finely shagreened surface, with slightly raised lines forming hexagonal figures.

## Eggs Hatching

Near the hatching period the eggs become darker and slightly larger. However, those that are infertile become smaller and are slightly depressed along the sides. When the egg hatches the larva makes a small hole in one end of the shell about the size of a pin hole, and wiggles out to the surface. Within a few minutes after hatching the larvae begin to feed on the squash plants. The incubation period for eggs placed in the laboratory was 1.2 days more than those placed outside to hatch. The difference in the hatching period was probably due to the difference in temperature. Table II and III shows the results of these experiments.

TABLE I. SHOWING FERTILITY AND % OF EGGS THAT HATCH

| CAGE | OVIPOSITION PERIOD | DAYS | NUMBER EGGS LAID | PERCENT THAT HATCH |
|---|---|---|---|---|
| 1 | June 12-14 | 2 | 10 | 60 |
| 2 | June 11-15 | 4 | 21 | 76 |
| 3 | June 14-16 | 3 | 8 | 50 |
| 4 | June 15-18 | 3 | 6 | 33.3 |
| 5 | June 14-17 | 2 | 12 | 66.6 |
| 6 | June 18-21 | 3 | 6 | 83 |
| 6 | TOTAL | 17 | 63 | 368.9 |
| | AVERAGE | 2.83 | 10.5 | 61.48 |

TABLE II. EGGS PLACED OUTSIDE TO HATCH

| DATE | TEMPERATURE | | | DATE LAID | NUMBER LAID | DATE HATCHED | NUMBER HATCHED | PERCENT HATCHED | PERIOD DAYS |
|---|---|---|---|---|---|---|---|---|---|
| | MAX. | MIN. | MEAN | | | | | | |
| July 10 | 90° | 70° | 80° | July 10 | 10 | July 15 | 4 | 60% | 5 |
| 11 | 88 | 80 | 84 | | | July 16 | 2 | | |
| 12 | 90 | 82 | 86 | | | | | | |
| 13 | 93 | 80 | 86.5 | | | | | | |
| 14 | 86 | 78 | 82 | | | | | | |
| 15 | 84 | 82 | 83 | | | | | | |
| 16 | 86 | 78 | 84 | | | | | | |

AVERAGE LENGTH OF INCUBATION PERIOD 5.5 DAYS

TABLE III. EGGS PLACED INSIDE TO HATCH

| DATE | TEMPERATURE MAX. | TEMPERATURE MIN. | TEMPERATURE MEAN | DATE LAID. | NUMBER LAID | DATE HATCHED | NUMBER HATCHED | PERCENT HATCHED | PERIOD DAYS |
|---|---|---|---|---|---|---|---|---|---|
| July 1 | 87° | 63° | 75° | July 1 | 30 | | | | |
| 2 | 85 | 68 | 71.5 | | | | | | |
| 3 | 83 | 56 | 69.5 | | | | | | |
| 4 | 80 | 67 | 73.5 | | | | | | |
| 5 | 72 | 60 | 66 | | | | | | |
| 6 | 78 | 60 | 69 | | | July 6 | 5 | | 5 |
| 7 | 83 | 62 | 72.5 | | | July 7 | 11 | 70.3 | 6 |
| 8 | 84 | 66 | 75 | | | | | | |
| 9 | 89 | 82 | 85.5 | | | July 9 | 9 | | 8 |
| | | | | AVERAGE INCUBATION PERIOD INSIDE | | | | | 6.3 DAYS |

## NUMBER OF MOLTS

From my observations Melittia satriniformis Hübn., the number of molts was always the same, three in number. On account of the larvae boring into cucurbit stems the small pieces of squash stems in the cages had to be torn apart each day to observe the larval changes. Each molt the dark dorsal skin of the head was cast and the dorsum of the head became lighter as maturity approached. Several experiments were started, but only 5 larvae were reared to the pupal stage, and only one of thememerged during this period. The record for the instars is shown in Table IV.

TABLE IV. LENGTH OF INSTARS.

| Hatched | 1st Molt | 2nd Molt | 3rd Molt | Period Days |
|---|---|---|---|---|
| June 20 | June 24 | July 3 | July 13 | 23 |
| June 21 | June 25 | July 2 | July 14 | 23 |
| June 23 | June 29 | July 3 | July 12 | 19 |
| June 23 | June 26 | July 3 | July 9 | 16 |
| June 24 | June 27 | July 4 | July 13 | 20 |

The Average Period from Hatching to the 3rd Molt is 20.1 Days.

### First Larval Stage

The newly hatched larva is about one-eighth of an inch long, white in color with a dark brown head. According to Herbert Spencer (1) the head varies in transverse diameter from 0.39 to 0.43 mm. The young larva differs from the later larval stages in having the head larger in proportion to the body, in being more hairy, and in having the body tapering

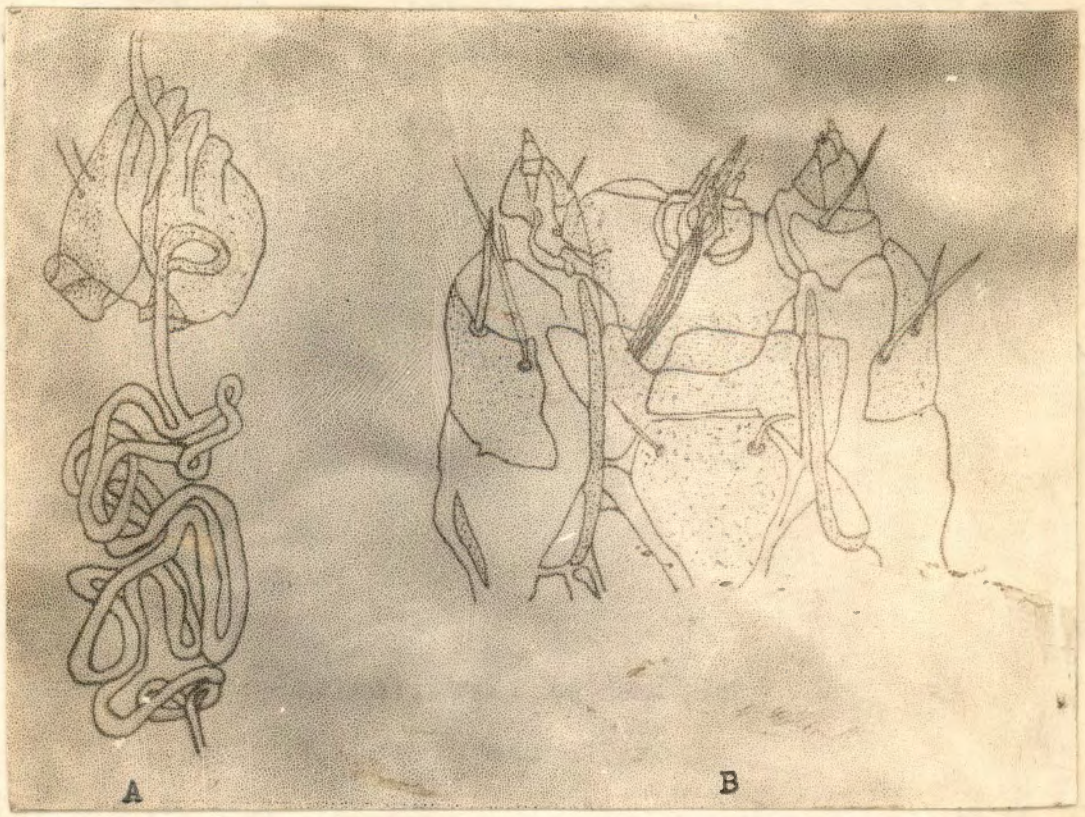
Plate XI.

A. Spinneret of squash-vine borer larva.

B. Head of larva,(enlarged).

A and B are after J.B.Smith

C. All four stages of larvae,(original).



A B



C

from the head to the posterior end. Each segment on the lateral side of the larva has two rows of setae below and one row above the row of spiracles. On the dorsal side of the larva there are two rows of setae running lengthwide, and on the ventral side there are no setae present, but on the prolegs there are two transverse bands of uniordinal crochets.

Second Larval Stage

In the second larval stage the color of the body is whiter and the head becomes darker than the first stage. According to Herbert Spencer (1) the head capsule varies from 0.64 mm. to 0.85 mm. in transverse diameter. There is an area just back of the head similar to the small letter "w".

Third Larval Stage

In the third larval stage the body is white in color, the head is light brown, and the prothorax begins to become light brown. According to Herbert Spencer (1) the head capsule varies from 1.29 to 1.57 mm. in transverse diameter. The small "w" mark behind the head becomes larger and more distinct than in the two preceding instars.

The Last Larval Stage

The larvae of the last stage are about an inch in length, fleshy, soft, and tapering at each end. The head is brown with the small figure similar to the letter "w" on the dorsum larger, and more distinct than the preceding larval stages.

(1) Va. Truck Exp. Sta. Bul. 52, p. 403-405.

The prothorax is marked dorsally by two curved oblique, brown bands which diverge toward the anterior end, forming a figure similar to an inverted "v". There are 10 abdomial segments; the 10th is less distinct with a light brown mark across the dorsal side. In the last larval stage there is more damage noticed to squash and other cucurbit vines than in the preceding stages. There is so much variation in the size of larvae found in the field that there was much confusion in the earlier days as to whether all these larvae belonged to the same family. F. H. Chittenden (2) said, "In the summer of 1897 it was noticed that the larvae of an apparently second species were also at work within the stems of squash. These were much smaller, and more slender than those of what were known to be Melittia satriniformis, but as they were not known to be different species, no effort was made to preserve specimens, or to rear them at that time.

"The following year the same larvae were observed. Those who saw them believed them to be a distinct species, but the writer was extremely doubtful as to the possibility of two species being present on cucurbit vines as no other adult Sesiid had been found on cucurbits by those who have studied this class of insects. This opinion was strengthened by rearing at about the same time the young larvae from the eggs. To verify the writer's belief in the molts, a number of young

(2) U. S. D. A. Bureau of Ent. Bul. 19, p. 34-40.

larvae that appeared to be ready to molt were separated, and July 25, two molted, and upon the next molt the ordinary form of satriniformis was obtained. The species was not carried through all of its molts, but enough was learned to show that the larva differs greatly from the time it hatches from the egg until it is ready for pupation."

TABLE V. STARVATION TEST -- LARVAL STAGES

1st larval Stage

| DATE COLLECTED | HOUR COLLECTED | NUMBER DIED | DAY DIED | HOUR DIED | TEMPERATURE MAX. | TEMPERATURE MIN. | TEMPERATURE MEAN | TOTAL HOURS |
|---|---|---|---|---|---|---|---|---|
| | A.M. P.M. | | | A.M. P.M. | | | | |
| July 8 | 4 | 1 | July 10 | 7 | 83° | 80° | 81.5° | 27 |
| 8 | 4 | 1 | 10 | 4 | 83 | 80 | 81.5 | 24 |
| 8 | 4 | 1 | 9 | 10 | 83 | 80 | 81.5 | 17 |
| 8 | 4 | 1 | 10 | 8 | 83 | 80 | 81.5 | 20 |
| | TOTAL | 4 | | | 332 | 320 | 32.60 | 88 |
| | AVERAGE | | | | 83 | 80 | 80.15 | 22 |

Larvae of the first instar grow very quickly and if their food supply is shut off their life is very short. Table V. will show the average length of life of the first instar larvae in the starvation test.

TABLE VI. STARVATION TEST -- LARVAL STAGES

2nd larval Stage

| DATE COLLECTED | HOUR COLLECTED | NUMBER DIED | DAY DIED | HOUR DIED | TEMPERATURE | | | TOTAL HOURS |
|---|---|---|---|---|---|---|---|---|
| | A.M P.M. | | | A.M. P.M. | MAX. | MIN. | MEAN | |
| July 8 | 4 | 1 | July 9 | 6 | 89° | 82° | 85.5° | 14 |
| July 8 | 4 | 1 | July 10 | 3 | 83 | 80 | 81.5 | 47 |
| July 8 | 4 | 1 | July 11 | 5 | 88 | 82 | 85 | 73 |
| | 4 | 1 | July 11 | 6 | 88 | 82 | 85 | 74 |
| | TOTAL | 4 | | | | | | 208 |
| | | | AVERAGE LIFE | | | | | 52 HOURS |

Larvae of the second instar live more than twice as long as first instar larvae because they have been feeding and have gained more strength than the former instar. Table VI. will show the results of this test.

TABLE VII. STARVATION TEST -- LARVAL STAGES

3rd larval Stage

| DATE COLLECTED | HOUR COLLECTED A.M. | HOUR COLLECTED P.M. | NUMBER DIED | DAY DIED | HOUR DIED A.M. | HOUR DIED P.M. | TEMPERATURE MAX. | TEMPERATURE MIN. | TEMPERATURE MEAN | TOTAL HOURS |
|---|---|---|---|---|---|---|---|---|---|---|
| July 8 | | 4 | 1 | July 9 | | 10 | 89° | 82° | 85.5° | 30 |
| July 8 | | | 1 | July 10 | 8 | | 83 | 80 | 81.5 | 40 |
| July 8 | | | 1 | July 10 | | 2 | 83 | 80 | 81.5 | 46 |
| July 8 | | | 1 | July 10 | | 3 | 83 | 80 | 81.5 | 47 |
| July 8 | | | 1 | July 10 | | 11 | 83 | 80 | 81.5 | 55 |
| July 8 | | | 1 | July 12 | 10 | | 82 | 80 | 81 | 90 |
| July 8 | | | 1 | July 12 | | 1 | 82 | 80 | 81 | 93 |
| July 8 | | | 1 | July 13 | 9 | | 86 | 84 | 86 | 113 |
| July 8 | | | 1 | July 13 | | 11 | 88 | 84 | 86 | 127 |
| | TOTAL | | 9 | | | | | | | 641 |
| | | | | AVERAGE LIFE | | | | | | 71.22 |

The length of life in the starvation test increased as the larvae became older. The third and fourth instars are almost ready to go into the Cocoon Stage, where food is not required, and consequently are able to live longer under the starvation test. Table VII and VIII will show the results of the starvation test on 3rd and 4th instar larvae.

TABLE VIII. STARVATION TEST -- LARVAL STAGES

Last Larval Stage

| DATE COLLECTED | HOUR COLLECTED A.M. | HOUR COLLECTED P.M. | NUMBER DIED | DAY DIED | HOUR DIED A.M. | HOUR DIED P.M. | TEMPERATURE MAX. | TEMPERATURE MIN. | TEMPERATURE MEAN | TOTAL HOURS |
|---|---|---|---|---|---|---|---|---|---|---|
| July 8 | | 4 | 1 | July 13 | 5 | | 88° | 84° | 86° | 109 |
| | | | 1 | July 14 | 6 | | 88 | 78 | 83 | 134 |
| | | | 1 | July 16 | | 8 | 90 | 82 | 86 | 196 |
| | | | 1 | July 17 | 10 | | 90 | 80 | 85 | 210 |
| | TOTAL | | 4 | | | | | | | 640 |
| | | | | AVERAGE LIFE | | | | | | 160 |

## COCOON STAGE

When the larvae have reached their growth they begin to spin silken cocoons. Some of the larvae go down into the ground to a depth of two inches and spin a cocoon of silk with particles of dirt and squash vine, while others remain in the stem and change to the cocoon stage. Plate XI, Fig. B will show the fat mouth parts, except the mandibles, which are gorge like structures, shown in Plate XI, Fig. A.

Dr. J. B. Smith (1) said the following in regard to the spinning of the cocoons:

> "The most interesting feature is the spinneret, seen in the center of the mouth structures. The larva when it goes under ground, spins a silken cocoon, in which it rests until ready to change to a pupa. The silk is secreted in two long glands, situated one on each side of the body, coiled irregularly, as shown in Plate XI, Fig A, which represents that of the right side. The two glands unite into a common duct just inside the mouth structures, and a chitinous tube shown dark in the center of Plate XI, Fig. A carries the secretion to the opening of the spinneret."

Larvae cocooning in midsummer will remain in this stage for about 5 days, while those cocooning in the fall will remain in the cocoon stage all winter, and change to the pupa in the spring, or early summer. Table IX shows the duration of the

(1) N. J. Agri. Exp. Sta. Bul. 94, p. 37.

cocoon stage in midsummer.

The cocoons found in March never emerged and those for life history work had to be reared from eggs laid June 11th.

TABLE IX. DURATION OF COCOON STAGE

| DATE COCOONED | NUMBER COCOONED | DATE PUPATED | NUMBER PUPATED | PERIOD DAYS |
|---|---|---|---|---|
| July 6 | 1 | July 12 | 1 | 6 |
| July 7 | 2 | July 13 | 2 | 6 |
| | | July 14 | 1 | 7 |
| July 10 | 1 | July 16 | 1 | 6 |
| July 19 | 5 | July 23 | 5 | 4 |
| TOTAL | 10 | | 10 | 29 |
| | | AVERAGE DURATION FROM COCOON TO PUPA | | 5.8 DAYS |

Plate XII.

A. Pupal case, after adult has emerged.

B. Cocoon slit along side to show pupa within.

C. Cocoon in squash stem cut along side to show larva in first pupal stage.



A



B



C

## PUPAL STAGE

The larva changes from the cocoon into the pupal stage within the silken cocoon. In order to watch the change take place a small slit was made down the side of the cocoon. When the pupa is in its first stage it is white, and as it becomes older the color changes to dark brown. When the pupa is in its last stage it is about 5/8 of an inch in length and 16 mm. in width.

The duration of the pupal stage is about 7 days or more in midsummer. One larva pupated July 15, and July 22 a female moth emerged.

## EMERGENCE

When the pupa transforms to the adult, it breaks through one end of the cocoon, wriggles out and up to the surface of the ground, splits the skin, down the back and side and squirms out. Within two hours after emergence the adult begins to be active.

## PERIOD BETWEEN EMERGENCE AND EGG LAYING

The period between emergence and egg laying for one female was two days. The female emerged July 22 and began egg laying July 24. According to Professor James Walker the females begin laying 3 days after emergence. N. J. Agri. Exp. Sta. Bul. 94, p. 27-40.

TABLE X. LENGTH OF LIFE OF ADULTS CAPTURED IN FIELD AND CAGED

| NUMBER CAPTURED | | DATE CAPTURED | DATE DIED | NUMBER DIED | PERIOD DAYS | |
|---|---|---|---|---|---|---|
| Male | Female | | | | Male | Female |
| | 9 | June 11 | June 13 | 8 | | 2 |
| | | | June 14 | 1 | | 3 |
| | | | June 15 | 1 | | 4 |
| | 2 | June 12 | June 13 | 2 | | 1 |
| | 4 | June 13 | June 15 | 2 | | 2 |
| | | | June 16 | 2 | | 3 |
| | 2 | June 14 | June 16 | 1 | | 2 |
| | | | June 17 | 1 | | 3 |
| | 2 | June 18 | June 21 | 1 | | 3 |
| 1 | | June 19 | June 21 | 1 | 2 | |
| | 1 | June 19 | June 23 | | | 4 |

AVERAGE FEMALE LIFE 2 DAYS -- AVERAGE MALE LIFE 2 DAYS

Adults captured in the field and caged in the laboratory do not live very long. The average life for 21 females and one male was only two days. However, one female lived in captivity for five days. Their short life in captivity is almost accounted for by their nervous and delicate make up. As soon as they are caged they begin to fly from side to side until they are completely exhausted, or until they have injured themselves in some way.

Since only one male could be captured for this test the difference between the life of the male and female could not be determined accurately.

TABLE XI. STARVATION TEST

Adults

| NUMBER CAGED | DATE CAGED | TEMPERATURE MAX. | MIN. | MEAN | OBSERVED DAY | HOUR A.M. | P.M. | NUMBER DIED | PERIOD HOURS |
|---|---|---|---|---|---|---|---|---|---|
| 9 | July 1, 4 P.M. | 88° | 75° | 79° | July 1 | | 10 | 1 | 6 |
| | July 1 | 92 | 70 | 81 | July 2 | 5 | | 1 | 13 |
| | July 1 | 92 | 70 | 81 | July 2 | 10:30 | | 1 | 18½ |
| | July 1 | 92 | 70 | 81 | July 2 | | 2 | 1 | 22 |
| | July 1 | 92 | 70 | 81 | July 2 | | 3:30 | 1 | 23½ |
| | July 1 | 92 | 70 | 81 | July 2 | | 5 | 1 | 25 |
| | July 1 | 92 | 70 | 81 | July 2 | | 11 | 1 | 31 |
| | July 1 | 92 | 70 | 81 | July 3 | 8 | | 1 | 40 |
| | July 1 | 92 | 70 | 81 | July 3 | | 5 | 1 | 49 |
| | July 3, 4:30 P.M. | 80 | 68 | 71 | July 4 | | 4 | 1 | 58 |
| | | | | | | | | 10 | 326 |
| | | | | | AVERAGE LENGTH OF LIFE IN HOURS | | | | 32.6 |

The adults for the starvation test in Table XI were captured in the field, placed in ordinary screen fly trap cages, without food or water. The length of life under these conditions is very short, due partly to the lack of food, a nd their nervous make up.

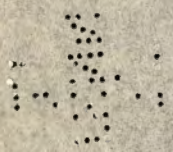


Plate X111.

Male and female copulating,(enlarged).

## REPRODUCTION

### Copulation

One pair of squash-vine borer adults was captured copulating June 19th. They were flying in the air with the posterior ends of their abdomen tied together, and it seemed as if the female was trying to get loose from the male. The couple soon lighted on the ground near a lower leaf of a squash plant, where they were captured. The pair was brought into the laboratory and put into a screened cage for further observation. They were never found tied again and the male died June 21.

### Period Between Copulation And Egg Laying

According to Professor James Walker (1) the moths do not copulate on the day they emerge from the pupa, and do not begin to lay eggs until the third day. He based his statement on observations of specimens in confinement, and also on field notes. (1)

Since only one adult emerged in the laboratory during my experiments, I was unable to get the period between the first copulation and the first eggs laid.

### Oviposition

The female squash-vine-borer deposits her eggs singly on the sten of the host plant. When the moths first begin to lay

(1) N. J. Agri. Exp. Sta. Bul. 94, p. 27-40.

Plate XIV.

Female depositing eggs.



eggs in the early part of June, and while the squashes are small they lay most of their eggs on the main stem near the ground. As the plants begin to grow and run the moths lay their eggs under, and on the sides of the vines. Some few females were noticed laying eggs on leaf stems, leaves, buds, and even on the ground. Observations in the field show that the moths prefer large squash plants to small ones, or other members of the cucurbitaceae family for oviposition. The female has been noticed laying eggs on cucumber vines in only a few instances. She flies from plant to plant in a zigzag manner and either lights at the base of the stem, on a leaf and crawls down near the ground. Then the abdomen is placed almost perpendicular to the stem; the ovipositor is worked back and forth until a reddish brown egg is laid, and securely glued to the plant. After the egg is laid the female flies on to another plant. According to my observations in the field and laboratory the whole process of egg laying requires only 10 seconds.

## Number of Broods

There seems to be much confusion over the number of broods of Melittia satriniformis Hubn. in the different states. Professor J. B. Smith's (1) quotation from the manuscript drawings by Abbot clearly proves that in Georgia it has two annual broods. Professor Kellicot (2) said that in New Jersey

(1) Insect Life, Vol.V, No. 1, p. 81

(2) Insect Life, Vol.V, No. 1, p. 85 and 86.

there was two broods and possibly a second brood in Central Ohio. Professor. H. Garman (3) & (4), said that the species was single brooded in Kentucky and Connecticut, but in Washington, D. C. there was a second brood. Herbert Spencer (5) proves in his seasonal history chart that there are two generations a year in Virginia. Glenn W. Herrick (6) said there was one generation a year in Maryland.

According to my observations in the field and laboratory there are two and possibly a third brood of Melittia satriniformis in Tennessee.

(3) Ky. Agri. Exp. Sta. Bul. 91, p. 37.

(4) Conn. Agri. Exp. Sta. Report for 1907-1908, p. 806-807.

(5) Va. Truck Exp. Sta. Bul. 52, p. 400.

(6) G. W. Herrick's Injurious Insects, p. 261.

## SEASONAL HISTORY

The squash-vine borer adults appear about the first of June in Tennessee. The numbers increase until the last of June, and then there is a rapid decrease until the last of July, when the second brood appears. Since the first crop is planted the first of May and squashes begin to mature on these vines the latter part of June, the first crop is not usually damaged very severely by the pest. The vines at that time are large and are not injured to a great extent by the tiny larvae which hatch from the eggs laid by the spring brood of moths.

The larvae become noticeably destructive in the fields of

Tennessee about the first of July and according to the truck growers around Knoxville they continue to be present until the vines are killed by frosts. The first cocoon is spun the first week in July and adults of the summer generation appear about July 20th. As a rule there are not as many larvae in this generation as there are in the first. According to truck growers near Knoxville the last cocoons are spun the latter part of October. The larvae hibernate in the cocoon stage, pupate and do not emerge until June of the next year.

## NATURAL ENEMIES

According to H. H. Worthley (1), no parasitic enemies of the adult moth have yet been recorded. It is the chance prey, however, of certain large robber flies (Asilidae) which have been observed to pounce upon the moths in the fields. The larvae in their tunnels in the squash stem appear to have escaped parasites, but are sometimes attacked by the larvae and adults of ground beetles (Carabidae). These agencies are of little economic importance.

The eggs of the squash-vine borer are subject to a high degree of parasitism by a tiny wasp of the family Scelionidae, the members of which are exclusively egg parasites. The species has been identified by Mr. A. B. Cohan, of the United States

(1) Massachusetts Agri. Exp. Sta. Bul. 218, p. 4.

Plate XV.

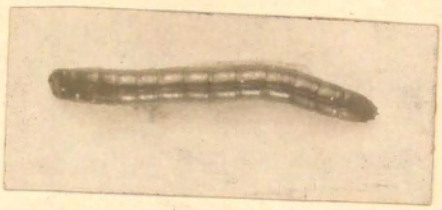
A. Cocoon of squash-vine borer, showing cavity, eaten by wireworm.

B. Wireworm, a natural enemy of squash-vine borer cocoons.

C. A mite belonging to the Arachnida family, a parasite of squash vine-borer adults.



A



B



C

National Museum, as Telenomus (Prophanurus) SP.

In 1890, Dr. J. B. Smith (2) said, "in looking over Mr. Mitchell's field where last season's squashes were raised, I found that every hill had been visited by moles, undoubtedly searching for the pupa of the borer. They had worked very thoroughly, for I did not succeed in finding a single cocoon. Moles are great destroyers of insects, and I do not believe they missed many hills in the entire field. Last winter was very mild, however, and they probably had much better opportunity for work than usual."

Some squash-vine borer cocoons were found in the horticultural garden at the University of Tennessee Experiment Station, and were accidentally placed in a small box with a wireworm. The next morning the cocoons were examined and the wireworm had almost eaten his way through one of them. Plate XV, Fig. B. will show a picture of the cocoon with the hole eaten in the side.

One of the female moths captured June 11th, 1929, was noticed to have a large cluster of mites (belonging to the Arachnida family) on the under side of her body, and on June 13th the moth died. Plate XV, Fig. C. will show a picture of the mite, natural size.

(2) N. J. Agri. Exp. Sta. Bul. 75, p. 32-34.

## SUMMARY


1. Melittia satriniformis Hübn. is probably of tropical origin.
2. The first recorded occurrence of the species in the United States was at Milton, Massachusetts, in 1828.
3. The first adult was found in the field June 11th.
4. Average length of incubation period of eggs placed outside to hatch was 5.5 days.
5. Average length of incubation period of eggs placed in the laboratory was 6.3 days.
6. Average number of eggs laid by females confined in cages was 10.5.
7. The largest number of eggs laid by females confined in cages was 21.
8. The highest percent of eggs to hatch was 70.3.
9. The larvae molt 3 times during their life.
10. Average period from hatching to 3rd molt was 20 days.
11. The period from the egg to the adult moth for one moth was 31 days.
12. Larvae of the first stage lived an average of 22 hours under starvation conditions.
13. Larvae of the second stage lived an average of 52 hours under starvation conditions.
14. Larvae of the third stage lived an average of 71.22 hours under starvation test.
15. Larvae of the last stage lived an average of 160 hours under starvation test.
16. Average duration of cocoon stage for five cocoons in mid-summer was 5.8 days.

17. Duration for one pupa in midsummer was 7 days.

18. Period between emergence and egg laying was 2 days.

19. Average life of adults captured in the field and caged in the laboratory was 2 days.

20. Average length of life of adults under starvation test was 32.6 hours.

21. There are two and possibly a third brood of Melittia satriniformis in Tennessee.

22. Hibernation takes place in the cocoon and pupal stage.

23. Wireworms, robber flies, ground beetles, certain mites of the Arachisida family, and moles are natural enemies of the squash-vine borer.

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