THE BIOLOGY OF *STEGASTA BOSQUEELLA* (CHAMBERS)

(LEPIDOPTERA, GELECHIIDAE)

By

CURTIS V. MANLEY JR.

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THE BIOLOGY OF STEGASTA BOSQUEELLA (CHAMBERS)

(LEPIDOPTERA, GELECHIIDAE)

Thesis Approved:

R R Walton
Thesis Adviser

W. B. Drew

Astonwell

J. E. Webelder

Dean of the Graduate School

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PREFACE

While employed by the Oklahoma State University Entomology Department, the author became interested in Stegasta bosqueella (Chambers), a small lepidopteran. The larva infests peanuts or ground nuts, alfalfa, partridge peas, and possibly other legumes.

A research program designed to elucidate the biology of Stegasta bosqueella in Oklahoma was planned and initiated under the supervision of Dr. R. R. Walton, Professor of Entomology, Oklahoma State University.

The author wishes to express his appreciation to his major advisor, Dr. R. R. Walton, for patient advice and helpful assistance in planning and collecting data in this study; special thanks to Dr. W. A. Drew, Assistant Professor of Entomology for assistance in taxonomic studies. Appreciation is given also to other members of the author's committee: Dr. D. E. Howell, Professor and Head of the Department of Entomology; Dr. James E. Webster, Professor of Biochemistry; and Mr. G. A. Bieberdorf, Assistant Professor of Entomology.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

Peanut production is an important industry in certain areas of Oklahoma. The nature of the soil type needed, soft sandy land, creates problems in keeping the soil moist and fertile for good production. Leaching of water and plant minerals is an ever present problem. However, less predictable but very important is the damage done by insects and disease. Some of the more important pest problems include stunted, malformed or weakened plants caused by thrips, lepidopteran larvae and leafhoppers; defoliation by leaf spot (Cercospora arachidicola Hori), caterpillars and grasshoppers; and minor damage to nuts by soil insects.

During the period 1957-60, inclusive, most growers were concerned over damage to peanut plants by the red-necked peanutworm, Stegasta bosqueella (Chambers), a small moth of the family Gelechiidae.

Growers and peanut breeders in the state had paid little or no attention to the red-necked peanutworm and no collection of the species was recorded for the state by entomologists. The pest was observed by Dr. R. S. Matlock, Department of Agronomy, Oklahoma State University, feeding on peanuts in Payne County, Oklahoma in 1955, but no official record was made at this time. During the summer of 1957, extremely heavy and widespread infestations developed throughout the state. Infestations in 1958, 1959 and 1960, in most peanut production areas of the state were generally lower than populations in 1957 but continued at economic levels.

The results presented in this paper concerning Stegasta bosqueella include seasonal development, host plants, life stage descriptions, oviposition and incubation, duration of larval instars and pupal stage, pupation sites, adult activity and longevity, and parasitism. Data for this study were collected during 1957, 1958, 1959, and 1960; primarily from Caddo County in southwestern Oklahoma and Payne County in northern Oklahoma.

REVIEW OF LITERATURE

Information pertaining to the biology of S. bosqueella (Chambers), is limited. Most author's only mention it's presence.

Meyrick (1904) placed 15 species in the genus Stegasta. The adults are small moths that are conspicuously marked; with whitish palpi, whitish-yellow heads, brownish fuscous antennae with whitish annulations, whitish-yellow to bronze thorax, brownish forewings, cilia generally whitish-grey to yellowish, and hindwings usually grey.

The species bosqueella was described by Chambers (1875) as follows:

> Palpi dark brown, with a yellow white annulus around the middle and tip of the second and third joints. Head yellowish white; antennae dark brown, with the extreme tip of the basal joint white. Thorax above, and base of the forewings brown; dorsal margin of the forewings, from the base to the ciliae, pale orange yellow, with a broad fascia of the same hue at about the basal fourth, passing across the wing and gradually narrowing to the costa. Behind this fascia to the apex the wing is brown, containing an irregular yellowish spot at about the middle of the costal margin, and a white one immediately before the ciliae. The brown color has a rich maroon tint, and not a dead lustreless hue. Legs and tarsi brown, annulate with pale yellowish. Venter brown, with two yellowish bands before the apex.

Chambers described the species in the genus Oecophora by mistake but rectified his error almost immediately. His original description was published in May 1875, this placed bosqueella in the family Tineida, genus Oechophora. In July 1875, he changed this to Gelechia, family Gelechiidae.

Chambers had this to say about the error:

By some unaccountable error, this species is described as an Oecophora, while a true Oecophora, which I intended to publish as Oecophora australisella, does not appear at all.

Walsingham (1882) had this to say about Chambers original description:

> This is certainly a Gelechia, not an Oecophora as suggested by Chambers (Bull. U.S.G.&G. Surv. iv. p. 87, and "Index"): the palpi and the form of the hind wings at once distinguish it. The description should be amended as follows: -Head maroon-brown; the upper or costal protion of the pale orange fascia is tinged with white; the costal spots are both white, the outer one being by far the largest and most conspicuous; there is also a small white spot on the margin below the apex, with some few white scales below it. In the specimens before me the tip of the basal joint of the antennae is scarcely to be called white.

Meyrick included the species G. bosqueella in his original description of the genus Stegasta, stating at this time that the home of the genus is America.

Dyar (1903) made this original larval description (Busck 1903):

> Head rounded, bilobed, full, oblique and retracted, mouth projecting; the labium and spinneret prominent; clypeus high, triangular, antennae small; shining black, labium and epistomal pale; width, 0.6 mm. Body cylindrical, normal; joints 2 to 3 and 12 to 13 tapering; thorasic feet distinct, the joints black ringed; abdominal feet slender, rather small, normal, the crotchets in a complete ring about the small, circular planta; cervical shield large, transverse, rounded on the posterior corners, shining black, cut by a fine, faint, pale dorsal line; joints two and three entirely dark vinous except the neck in front of the cervical shield; joint 4 in the incisure in front and in a broad band on the posterior third of the same dark vinous, extending even on the venter. The white area thus formed on the anterior part of joint 4 on the otherwise uniformly red thorax appears irregularly edged and lumpy. Rest of the body whitish, immaculate, greenish from the blood, tubercles small, round, black but distinct, bearing short, stiff setae. On the thorax tubercles ia and ib are separate, iia and iib, iv and v united in pairs. On joint 3 the tubercle plates are large of ib, iia plus iib and iv plus v, but on joint 3 they are small, and the paired tubercles stand separate through contiguous; on the prothorax the prespiracular and subventral tubercles are large. On the abdomen tubercle i is dorsad and cephalad to ii, iii is near the spiracle, above it iv and v contiguous, in line, vi subventral posteriorley, vii of three contiguous tubercles on the anterior side of the leg base, viii on the inner side of the leg base. Spiracles small, black ringed;

anal shield pale brown distinct; anal feet with brownish outer shields.

Gelechia costipunctella (Mschl.) is a synonym of Gelechia bosqueella (Chambers) according to Walsingham (1887) and Meyrick (1904).

Bissell (1942), recorded a light infestation of ground nuts in a locality in Georgia by larvae of Stegasta bosqueella (Chambers), which tunnel the ends of the shoots and feed on the unfolding leaves, but have not caused appreciable damage there. The larvae were also collected on Chamaecrista in the same and other localities in the state. Pupation took place in the tunneled shoots. Larvae collected on ground-nuts in October 1935 and September 1941 and on Chamaecrista in August 1941 transformed to adults in December 1935 and October and September 1941, respectively.

Busck (1903) mentioned that specimens from Texas and Kansas were in the United States National Museum.

Heinrich (1921) listed it as one of the larva that might be confused with the pink bollworm.

Walton (1957) made the first official report on it's occurance in Oklahoma.

METHODS AND MATERIALS

S. bosqueella was studied in the field, in the laboratory, and under conditions that combined both field and laboratory materials. Seasonal development and host records were based on field observations. Life stage descriptions were made primarily from spceimens reared on peanut plants in the laboratory or under combination field-laboratory conditions. Oviposition, pupation sites, feeding damage, and moth activity were studied in the field and in the laboratory. The duration of larval and pupal periods, and moth longevity were determined from specimens in the laboratory. Specimens of all stages were frequently collected from field grown peanuts during the growing seasons, and these served as check specimens against laboratory reared materials. Potted plants were located in the laboratory near windows to obtain sunlight, but were moved from this position when light and temperature conditions became unsatisfactory. If temperatures became excessive in cages, the pots were moved to a location that received less direct sunlight. When sunlight in the laboratory was inadequate, the potted plants were moved out of the laboratory for varying periods of time.

Seasonal Development

Records on seasonal development were based on observations in peanut fields made at intervals of approximately one week, in 1957 and 1958, to longer periods in the other years. Observations were begun in

mid-June in 1957 and in May in the last three seasons. Field sampling continued until infestations declined markedly due to the plants approaching maturity. A minimum of two fields were surveyed in each of Payne and Caddo Counties during each season. The number and size of larvae and the number of pupae were recorded from an examination of a minimum of 50 plant terminals per field per observation. Notes were recorded on the relative abundance of moths and, occasionally the soil beneath damaged plants was examined for the presence of pupae.

Hosts

Host records were based on examinations of aerial portions of plants, particularly the shoot terminals and immature pods. The plant species examined included peanut (Arachis hypogaea L.), partridge pea (Cassia fasiculata Michx.), alfalfa (Medicago sativa L.), prairie acacia (Acacia angustissima Mill.), blue wild indigo (Baptisia australis L.), field pea (Pisum arvense L.), hairy vetch (Vicia villosa Roth), cowpea (Vigna sinensis L.), soybean (Glycine max L.), and kudzu (Pueraria thumbergiana Benth.).

Samples, 100 terminal shoots and/or pods, were collected for these various legumes during the growing seasons of 1957 through 1960. The domesticated legume samples were taken from fields near Stillwater, Perkins, and Poteau, Oklahoma. The samples of wild legumes, from range land and road side, were collected near Perry, Stillwater, Coyle, Perkins, Fort Supply and Poteau, Oklahoma. With the exception of peanuts, partridge peas, and alfalfa; 300 sample shoots and/or pods were collected for examination. Alfalfa and partridge pea samples ran

to approximately 1,000 each. Peanut, the primary host, samples ran as high as 5,000 a season.

Eggs

Information on the site and pattern of oviposition was obtained by examination of peanut shoots from plants grown in the field and in pots, and from egg records taken from oviposition cages. Two types of cages were used in the laboratory to study and facilitate mating and oviposition. Half-gallon ice cream cartons, open at one end and closed at the other with nylon mesh, were placed over potted plants to serve as copulating cages. From 6 to 10 moths, including both sexes, were placed in one cage and left for a two-day period. They were then transferred to pint cartons, closed at one end and covered at the other with nylon mesh. Eggs were collected daily from the mesh.

An incubation chamber consisted of a petri dish, with cover in place, containing a piece of moist absorbent paper near saturation level. Eggs were placed on the bottom of the dish but not in contact with the paper. Incubation of eggs was also tried in dishes without moisture. The incubation temperature was approximately 80 degrees F.

Larvae

Larvae collected from eggs in the laboratory, were reared through to the pupal stage. First instar larvae were removed from the incubation site and placed on terminal tips of growing potted plants. Polyethylene tubing, four inches in length and one and one-half inch in diameter, was sealed on one end and taped tightly around the plant shoot below the terminal area. Approximately ten larvae were placed

in each terminal cage. All larval instars were checked every three hours during 12 hours in the daytime. The second instar larvae received the same treatment as did the first.

Third, fourth, and fifth instar larvae were reared on two food sources. Some were reared under the conditions described for the early instars but others were fed on terminals pulled from plants and placed in half-pint ice cream cartons that were sealed on both ends. These tips were wrapped, on the stem end, with damp absorbent paper.

Records were taken to determine the instar duration of these larvae. During each successive ecdysis the cast skins were removed to eliminate confusion. The date of each molt was recorded and this information was tabulated.

Pupae

To determine pupation sites, infested peanut plants from the field and in pots, and the soil beneath them, were inspected. Plants were examined externally and dissected, with the majority of attention directed to the terminal buds, foliar structures and stems of plant shoots. Soil was removed to a depth of 3 to 4 inches from the area covered by the plant. The soil was then sifted and washed through a series of wire mesh sieves that ranged from 1/4- to 1/16-inch mesh size. When larvae approached maturity in the laboratory, they were usually placed in 15 by 55 mm vials that contained only soil. A limited number of mature larvae were left in cartons which contained pulled shoot tips of growing plants on which they had fed. Larval entries into soil, the progress of pupation, and adult emergence were

recorded from daily observations made on specimens in vials containing soil.

Adults

Information concerning the activity of moths was based on observations made in peanut fields and with adults caged on plants in the laboratory. Laboratory specimens were under conditions similar to those in copulating cages.

Longevity was determined by using laboratory emerged adults. They were placed in half-gallon ice cream cartons covered with nylon mesh on one end and placed over a growing peanut plant. Morning and evening examinations were taken to determine the approximate length of life.

Overwintering

A search for overwintering forms was made during the spring of 1960 and the fall, winter, and spring of 1960-61. Soil, to a depth of four inches was collected from the rows of the 1959 and 1960 crops in three peanut fields where plants had sustained red-necked peanutworm damage. In one of these fields, the plants and plant debris were not disturbed until soil sampling was begun for overwintering forms. In the other two fields, the crop had been harvested by a conventional peanut digger. The soil was sieved and debris scanned as described for pupation site samples. Soil beneath partridge pea plants, that showed peanutworm damage, was also examined. Mature plants and plant debris of peanuts and partridge peas were examined and dissected.

Parasitism

Larvae collected from the field were used to study possible parasitism. Unusually sluggish or sickly appearing larvae were isolated. As the parasite larvae finished feeding and emerged from the peanutworms, they were placed in 15 by 55 mm shell vials and allowed to pupate and emerge. These adult parasites were sent to the Insect Identification and Parasite Introduction Research Branch, United States Department of Agriculture, for identification.

Sex Determination

Sex determination was accomplished by isolating single adults in pint cartons. After separating many specimens, these were studied to determine morphological differences.

RESULTS

Seasonal Development

Four, and perhaps more, generations of Stegasta bosqueella developed on peanuts during the growing season in the years 1957 to 1960. Since this pest attacks alfalfa and partridge pea (Cassia fasciculata), it is likely that one or more generations develop on these early plants before peanut plants are available. The earliest larval infestation records for peanuts were on volunteer plants before the planted crops had emerged. If weather permits, a very high per cent of the state's crop is planted between May 25 and June 10. In the event of frequent rains during this period, seeding may be delayed from one to three weeks.

The earliest collection record for Stegasta bosqueella during this study was for moths taken in light traps at Stillwater May 16, 1959 and May 24, 1960. Light traps were not operated during May in 1957 and 1958. Some of the larval and pupal records obtained on peanuts are arranged to indicate seasonal development (Table 1). In 1957, inspection of fields was started July 17 following reports from growers that peanuts were showing insect damage. The great majority of larvae collected on this date were in the later instars and a few pupae were collected. From a study of succeeding collections in 1957 and later years, it is estimated that the brood collected July 17 began in early July or late June.

Table 1. Records on seasonal development of the red-necked peanutworm, Stegasta bosqueella (Chambers) on peanuts, Caddo County, Oklahoma.

Brood	Year	First Larva	Last Larva	First Pupa	Estimated Duration of Brood
First	1957	--	--	--	--
	1958	June 6	July 2	June 22	4 Weeks
Second	1957	Early July	July 23	July 15	4 Weeks
	1958	July 7	Aug. 3	July 21	4 Weeks
Third	1957	July 21	Aug. 14	Aug. 2	3 to 4 Weeks
	1958	July 29	Aug. 20	Aug. 15	3 to 4 Weeks
Fourth	1957	Aug. 12	Sept.17	Sept. 1	3 to 4 Weeks
	1958	Aug. 19	--	Sept.12	5 Weeks
Fifth	1957	Sept.12	Nov. 1	Oct. 20	8 Weeks
	1958	--	--	--	--

Collections made in the next three years indicate that an earlier brood of peanutworms was in this field during June. Collections made in October (1957, 1958, and 1960) showed light larval infestations present on peanut plants that were making terminal growth but not on those that had completed growth. Extensive sampling during August in fields where plants had ceased terminal growth because of drought stress uncovered no larvae.

Population levels in peanuts, as measured by larval counts, varied during the growing season, between fields in the same community and between years. Seasonal population peaks occurred in the period from late July to early September. Seasonal peaks by years were as follows: 1957 and 1958, late July (3rd brood), and late August (4th brood); 1959, early August (4th brood); 1960, early September (4th brood). The average populations (for all collections) and the seasonal peak populations, expressed as number of larvae per 100 shoots, were as follows:

1957, 71 and 130; 1958, 35 and 114; 1959, 21 and 30; 1960, 56 and 106.

The per cent of shoots damaged by peanutworms was recorded in nearly all cases when larval counts were made. Since the number of larvae found was influenced greatly by the date of collection, in relation to the life cycle of the insect, the level of damage is a more accurate index of seasonal population levels. The average per cent of shoots damaged by years was: 1957, 94.6; 1958, 78.7; 1959, 47.8, and 1960, 61.2.

In consideration of collection records for all years and information obtained on the length of the life cycle from studies on the duration of life stages, the following points concerning seasonal development are indicated: (a) infestations of S. bosqueella developed on other host plants before peanuts were available; (b) larval infestations almost immediately developed on peanut plants when they emerged in June; (c) larval infestations persisted in peanut fields as long as plants made terminal growth of shoots; (d) seasonal peak populations occurred during the period from late July to early September.

Hosts

A limited number of samples from several domesticated and wild legumes were examined for infestation by S. bosqueella. These included alfalfa, partridge pea, prairie acacia, blue wild indigo, field pea, cowpea, soybean, hairy vetch, and kudzu. Only two of the plant species, alfalfa and partridge pea, were found to be infested. From a total of 5,000 shoots examined from 14 fields during the years 1957 through 1960, a total of 286 larvae were recovered. Larvae were collected from nine fields of alfalfa in 1958 and 1959.

The highest number of larvae recovered from alfalfa per 100 shoots, was six. Larvae displayed essentially the same type of feeding on alfalfa as on peanuts. Apparently initial feeding of the early instars occurs within the terminal buds. The buds may be destroyed or if not the leaves developing therefrom show epidermal abrasion, mining, small chewed holes or, less frequently, marked structural distortions. No larval measurements were made from these specimens but they appeared to be normal.

Partridge pea, a wild legume, was collected from Payne and Woodward Counties in 1958, 1959, and 1960. Incidence on these plants ran as high as 25 per 100 shoots examined. Damage to partridge pea was again on the bud area of the plants. General bud and leaf destruction, mining, and general structural distortion was apparent on the infested plants. The larvae taken from these plants were reared on peanuts; the resulting adults were normal in appearance.

Information on the biology of S. bosqueella is presented under the four life stages. In tests to determine the length of the life stages, observations were made at least daily and in certain instances more than one time during the day. Multiple observations were not made of all specimens however, and the life stage durations are expressed as the number of whole days (24 hrs.) involved. It is recognized that a day is a gross unit for measuring the short duration of some of the stages.

Eggs

The eggs are small, ovoid-elongate in shape, and are white to pale yellow or cream colored (Figure 1). They appear to be circular in cross section and show no sculpturing or reticulations. The eggs measure

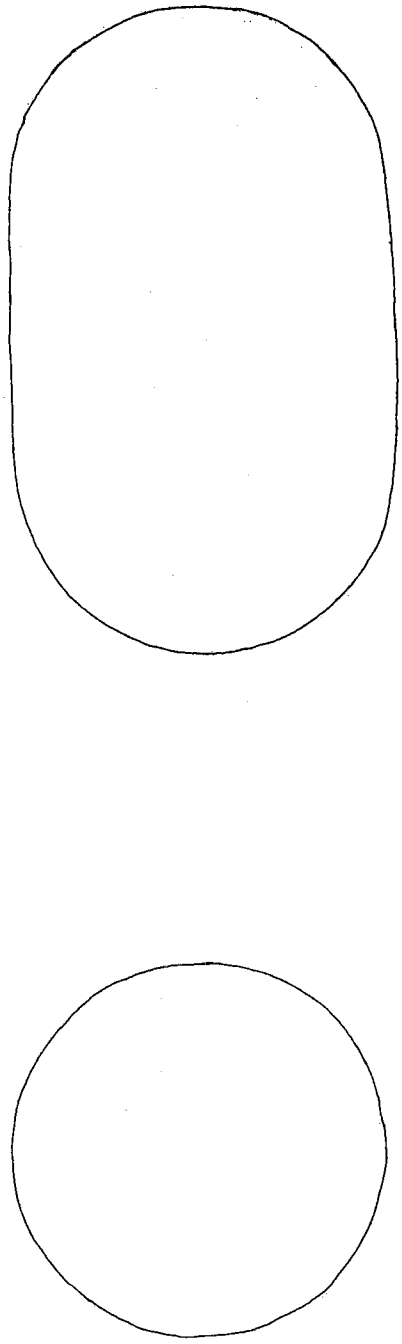

Fig. 1. Stegasta bosqueella (Chambers) egg, long axis and cross section.

approximately 0.32 mm long and 0.23 mm in diameter.

Because of their small size and inconspicuous color, the eggs may be easily over-looked when deposited on green plants. Eggs found on peanut plants in the field and in pots were deposited singly and on their sides. They did not show flattening at the point of contact. The degree of adherence to foliage and nylon mesh of cages was limited so that they were easily dislodged. All eggs observed on plants were located beneath the scales of buds, enclosed in the cluster of unopened developing leaves, or in the recesses of leaf axils. Because of these observed sites and the susceptibility to dislodgment, it appears doubtful that eggs are placed in exposed positions.

Females in pint carton cages laid eggs singly on the comparatively rough, porous surface of nylon mesh but did not deposit on the smooth walls of the carton. All eggs were deposited at night.

Incubation records were obtained for 448 eggs during the period August 4 to September 3, 1958. These eggs were deposited by females on nylon mesh in carton cages. Upon removal from the oviposition cage, eggs were maintained at approximately 80 degrees F. The results are given in Table 2. The period of incubation for all eggs was three days. During the first day of incubation no noticeable change occurred in the appearance of the eggs. By the second day embryonic development was discernible through the egg shell and during the third day a fairly definite outline of the larva could be seen. Larvae emerged from the eggs by chewing their way out of the end. After hatching, egg shells were clear or transparent in appearance.

Table 2. Incubation period for the eggs of Stegasta bosqueella (Chambers), Stillwater, 1958.

No. Eggs	Date Deposited	Date Hatched	Number of Days
63	Aug. 4	Aug. 7	3
29	Aug. 5	Aug. 8	3
34	Aug. 17	Aug. 20	3
52	Aug. 18	Aug. 21	3
20	Aug. 29	Sept. 1	3
200	Aug. 30	Sept. 2	3
50	Aug. 31	Sept. 3	3

Table 3. Duration of larval instars of Stegasta bosqueella (Chambers), Stillwater, 1958.

Group	Instar	No. Larvae	Per Cent Survival	Beginning Date	Molt Date	Days in Instar	Mean Temp. °F.
A	1st	20	50	Sept. 1	Sept. 3	2	84.3
	2nd	10	50	Sept. 3	Sept. 6	3	83.0
	3rd	5	40	Sept. 6	Sept. 9	3	78.6
	4th	2	100	Sept. 9	Sept. 12	3	77.7
	5th	2	100	Sept. 12	Sept. 16*	4	73.4
B	1st	200	25	Sept. 2	Sept. 4	2	83.3
	2nd	50	30	Sept. 4	Sept. 7	3	82.0
	3rd	15	67	Sept. 7	Sept. 10	3	78.3
	4th	10	80	Sept. 10	Sept. 13	3	75.0
	5th	8	100	Sept. 13	Sept. 17*	4	74.2
C	1st	50	60	Sept. 3	Sept. 5	2	82.3
	2nd	30	70	Sept. 5	Sept. 8	3	80.8
	3rd	21	52	Sept. 8	Sept. 11	3	77.5
	4th	11	73	Sept. 11	Sept. 14	3	73.3
	5th	8	100	Sept. 14	Sept. 18*	4	72.4

*Entered the soil to pupate.

Larvae

The red-necked peanutworm developed through five larval instars. Early fifth instar larvae are 8 to 10 mm in length, the head capsule is brownish (Figure 2), the pro- and mesothorax a striking red or wine color, the remainder of the body is white to cream color (Figure 3). Upon being disturbed in the field, they move very rapidly seeking concealment within foliar recesses of the plants.

First instar larvae differ from the fifth in size and coloring. The first instar larvae range from 0.8 to 1.0 mm in length at the time of molt. The pro-and mesothorax do not have the wine coloration of the fifth instar (Figure 4). This conspicuous coloration does not appear in the early second instar larvae but is fully shown by the third or last day of this instar.

The third and fourth instar larvae exhibit all of the characteristics of the fifth, being only somewhat smaller in size.

A determination of larval instar duration was made during this study (Table 3). First instar larvae, taken directly from the incubator, were reared on the shoot tips of growing potted plants. These were checked frequently to determine as accurately as possible the time of ecdysis. After molting to the second instar they were changed to fresh plants and again checked frequently. The third, fourth, and fifth instars were again handled in a like manner, except that, in many instances the later instars were fed on pulled terminals in closed containers rather than on the potted plants.

Just prior to each molt the larvae became sluggish in movement and disinterested in food. Peristaltic movements, starting from the anterior end and moving to the posterior, could be observed. A

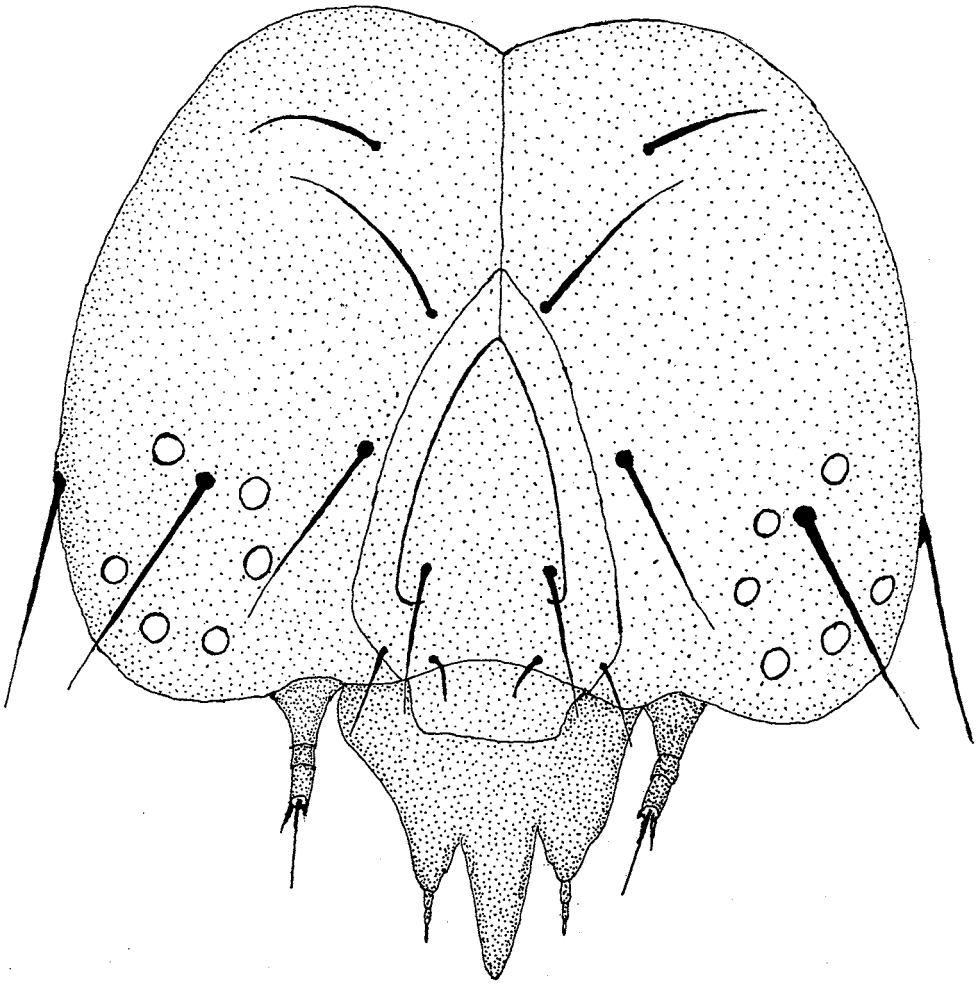

Fig. 2. Stegasta bosqueella (Chambers) head capsule.

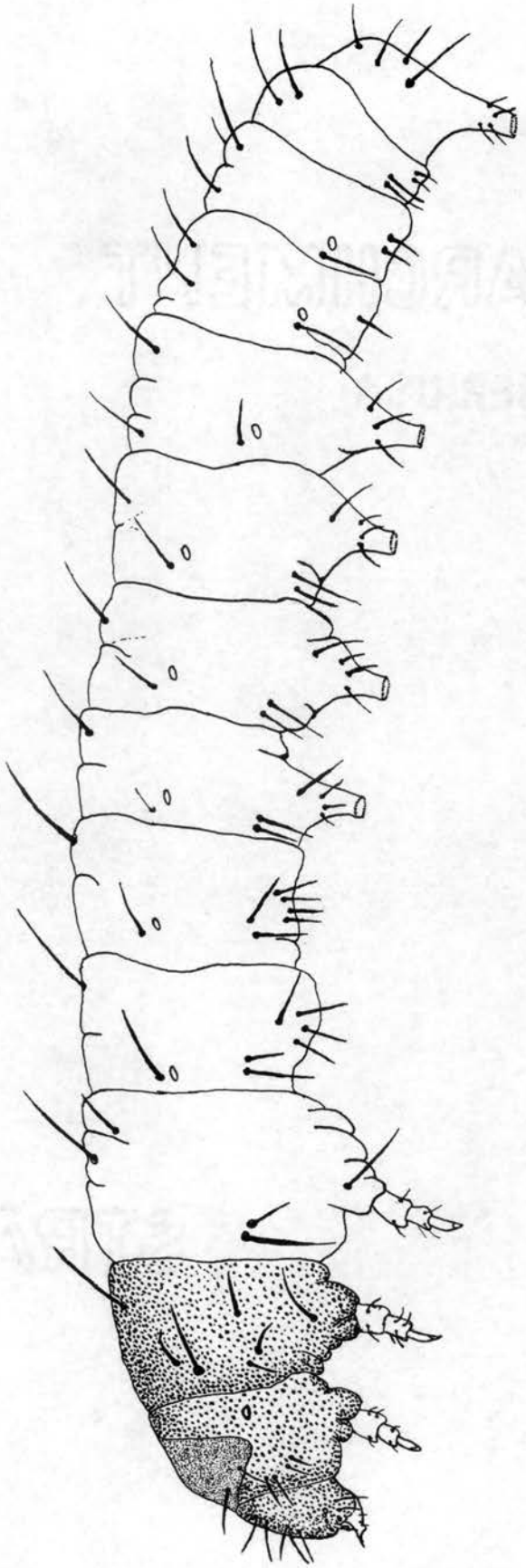

Fig. 3. Stegasta bosqueella (Chambers) fifth instar larva.

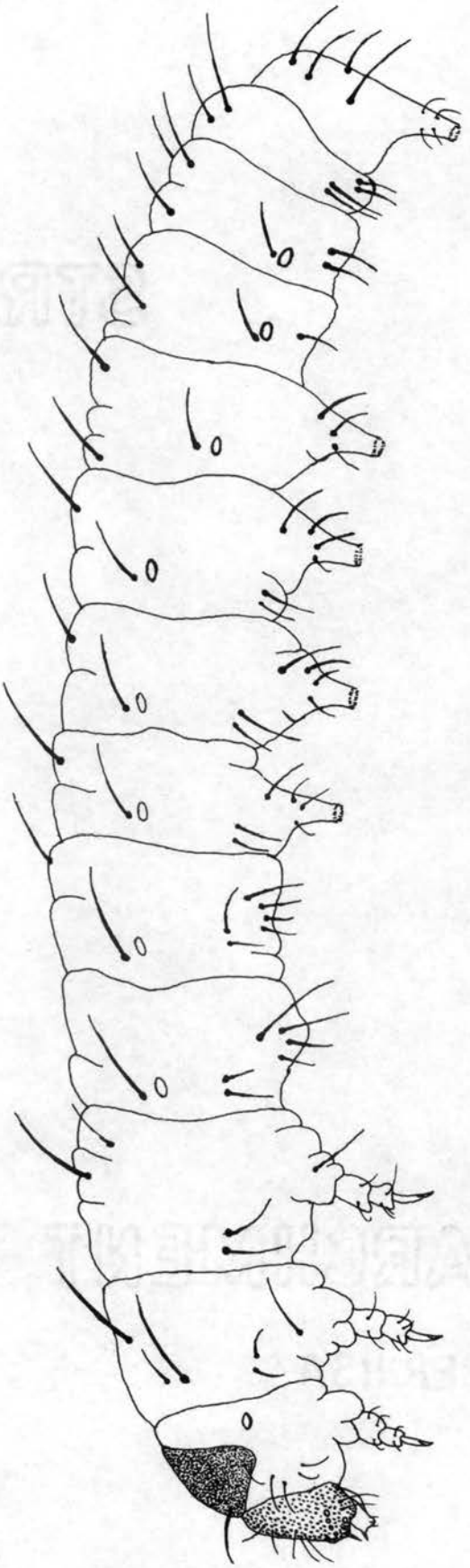

Fig. 4. Stegasta bosqueella (Chambers) first instar larva.

secretion could be seen, and a slow, but definite, change could be followed in this transition. The process required three to four hours for completion. Approximately 24 hours prior to the final change into the pupal form, the fifth instar larvae acquired a faint red coloring throughout the body. Feeding was sporadic and larvae became restless, crawling aimlessly about on plant or soil surfaces.

The larvae fed primarily on the growing tips of all plant species that they attacked. The leaves, between the epidermal layers, were mined by the first and second instar larvae. The later larvae fed between the folded leaves, generally chewed small holes in them, and mined into the plant stem in some instances. Occasionally larvae could be found feeding in the secondary bud areas of the plant. As the terminal leaves opened in their natural growth the larvae would migrate to the young developing terminal, again entering and feeding between the tightly closed leaves. Upon completion of feeding, the fifth instar larvae moved down the plant and wandered around on the soil at the plant base, burrowed into the soil and spun silken cocoons in which they pupated. In a few instances, larvae pupated in plant recesses or in tunnels within the plant shoots.

Cannibalism was induced in the larvae by placing several on an inadequate food supply. The author observed peanutworms feeding on others, under this reduced food supply situation, in the laboratory.

Pupae

The mature larva spins a thin silken cocoon, 8 to 10 mm long, which serves to enclose the pupa. The pupae are obtect and from 6 to 8 mm long. Soon after the larval skin is shed, the color becomes tan

which gradually deepens to a dark brown and then to black. The posterior is sparcely covered with bristles and the posterior margin of the last abdominal segment is lined with hair fringe (Figure 5).

Out of approximately 2,500 pupae collected from the field and obtained from larvae in the laboratory, only two pupae were located in a site other than soil. One was in a sample of terminal shoots collected at Paradise, Oklahoma; the other on a plant in the laboratory, this being an instance in which the larvae could not reach the soil due to the polyethylene cage around the shoot. In both cases the pupae were located in the top leaf axil.

A total of 111 pupae were observed in the laboratory during 1957 and 1958. In 1957, mature larvae were placed in 15 by 55 mm vials which were closed with screen wire lids. When pupation was complete within the cocoon, the lids were replaced by moist cotton stoppers. This point was recorded as the beginning of the pupal period. The duration of the pupal period for 57 specimens, as measured by this method, is presented in Table 4.

Since only 17 per cent of 370 specimens processed by this method survived to emergence, a different rearing technique was employed in 1958. Soil of moderate moisture content was placed in a vial to a depth of approximately 3/4 inch, after which a mature larva was put in the vial and confined by a screen wire stopper. The beginning of the pupal period was recorded when the larva entered the soil. By this method, approximately 95 per cent of the larvae survived to emergence. The results are given in Table 5. The pupal period in both years' tests is expressed in terms of the nearest whole day.

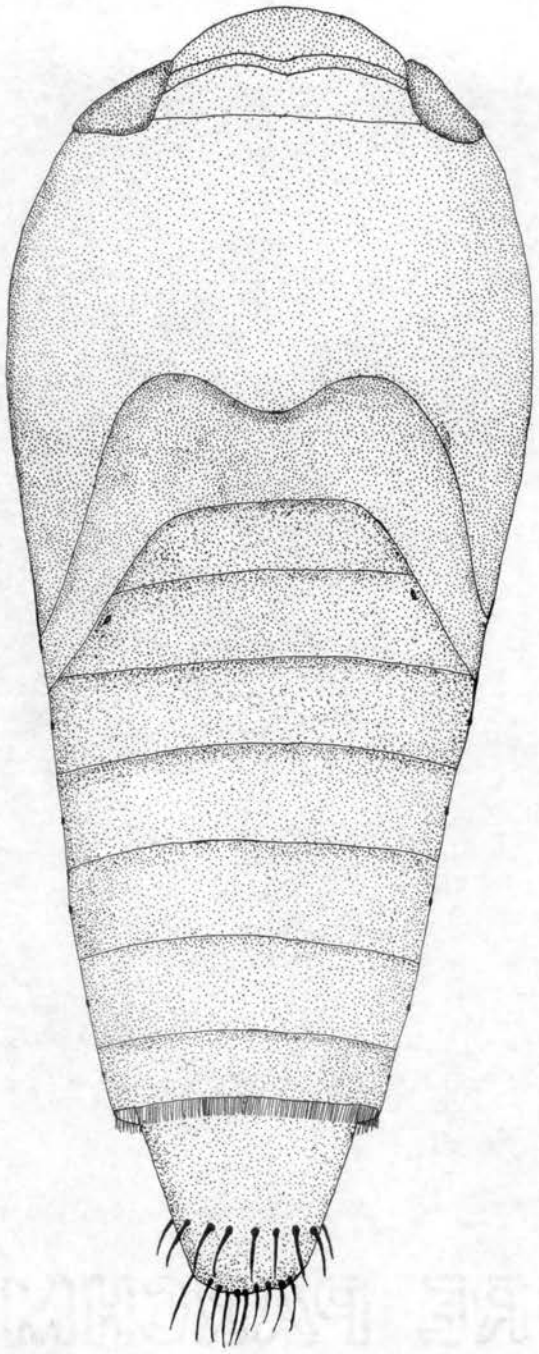

Fig. 5. Stegasta bosqueella (Chambers) pupa.

Table 4. The period from pupation to moth emergence by Stegasta bosqueella, Stillwater, August, 1957.

Number of Specimens	Period in Days	Mean Air Temperature Degrees F.
9	5	85.3
45	6	81.6
3	7	82.7

Table 5. Days elapsed from the entrance of mature larvae into soil until moth emergence by Stegasta bosqueella, Stillwater, August, 1958.

Number of Specimens	Period in Days	Mean Air Temperature Degrees F.
9	7	82.1
33	8	80.0
12	9	78.5

The length of the pupal period, as measured by the earlier method (Table 4), ranged from 5 to 7 days; by the 1958 method it varied from 7 to 9 days (Table 5). Because of the difference in methods, the results are not directly comparable. The time required for the larva to enter the soil, spin the cocoon, and molt is included in the 1958 pupal period, but not by the earlier method. The latter method is logical since the duration of the 5th larval instar was recorded as complete when the insects entered the soil. Thus, to determine the length of the entire life cycle, the prepupal period must be measured.

Furthermore, the latter method is preferred because it simulates to some extent the natural pupation media of the insect, resulting in a very high percentage of survival.

Whole-day units are great in magnitude to measure such short periods and would tend to obscure the effects of small variables in the experiment. However, the data reflect to some degree the influence of temperature on the length of the period. In the 1957 test, specimens that emerged in 5 days were observed during the periods when the mean air temperature was 85.3 degrees as compared to those that emerged in 6 and 7 days which had been under temperatures of 81.6 and 82.7 degrees, respectively (Table 4). In the 1958 test (Table 5), specimens that emerged in 7, 8 and 9 days were held in the laboratory during periods when the mean temperatures were 82.1, 80.0, and 78.5 degrees F., respectively.

Adults

The adults of S. bosqueella range from 10 to 12 mm in length. The antennae, head, and thorax are brown. The forewings are dark but there is a very conspicuous yellowish-white figuration visible on these wings while they are folded at rest. It gives the distinct appearance of the outline of a bowling pin, the top of the pin posterior, the bottom of the pin anterior. This very striking figure, in contrast with the darker background color of the forewings, is visible for some distance, and facilitates locating the adults when they are at rest in exposed positions.

Adults collected from pupae, lived from 6 to 16 days in the laboratory. They were placed in the cages over potted peanut plants.

Ample moisture and growing plants for food were available.

During periods of bright daylight or bright light in the laboratory, the adults may be found beneath the plants resting on lower leaves or the soil. During early morning, late evening, or heavily overcast days, these moths may be observed in large numbers. If disturbed under these conditions, these moths make short flights and come to rest in the open, usually on the soil surface.

Overwintering

Attempts were made to determine the overwintering stage or stages and site for S. bosqueella. The investigation included processed inspections of field materials made during the dormant seasons to recover larvae, pupae or adults from potential overwintering sites. A total of 350 soil samples collected from three peanut fields, were examined during the dormant seasons of 1959-60 and 1960-61. During the same time, a large volume of plants and plant debris were examined from these fields and from partridge pea plants. The information uncovered to date includes many pupal cases and one living pupa. The living specimen, taken from a soil sample at Stillwater, March 7, 1961, was normal in appearance. Unfortunately, the specimen was mechanically injured during processing, eliminating the possibility of adult emergence.

The small number of forms recovered is not surprising even though soil and plant debris constituted the common overwintering sites. Only a small per cent of the growing season population of insects overwinter, and considering the efficiency limitations of the processing method,

the number expected to be recovered would be extremely low. The depth of soil samples may have been inadequate, but it was believed that samples of moderate depth and greater area would be more productive than samples of reduced area and greater depth. The great weight of soil severely restricted the amount that could be collected, transported and processed by available personnel and facilities.

Data, to be presented later, show that the soil is the natural and common site of pupation during the growing season. These facts and the presence of living pupa in soil during early March, are strong evidence that soil serves as an overwintering site of S. bosqueella in peanut fields.

Parasitism

Four species of internal hymenopterous parasites were collected from larvae of S. bosqueella. Three belong to the family Braconidae, one to Ichneumonidae.

Braconidae

Apanteles epinatiae Vier. Det. C. F. W. Muesebeck

Orgilus n. sp. Det. C. F. W. Muesebeck

Chelonus (Microchelonus) n. sp. Det. C. F. W. Muesebeck

Ichneumonidae

Pristomerus sp. nr. appalachianus Vier.
Det. L. M. Walkley

All of these parasites finished feeding internally and emerged just prior to the normal pupation times of the worm. As they ruptured the body wall and emerged, they continued feeding until only the head capsule and part of the body wall, of the larva, remained. This period

of external feeding lasted between three and four hours. Upon completion of feeding, the larvae spun a cocoon in which they pupated. Many times the parasite cocoon was stuck to the remains of the larvae (Figure 6). From one to four parasites per parasitized worm were collected during this study.

Sex Determination

The only apparent external sex difference of the adults is median dorsal tuft of scales on the apex of the abdomen of the males. This tuft is lacking on females.

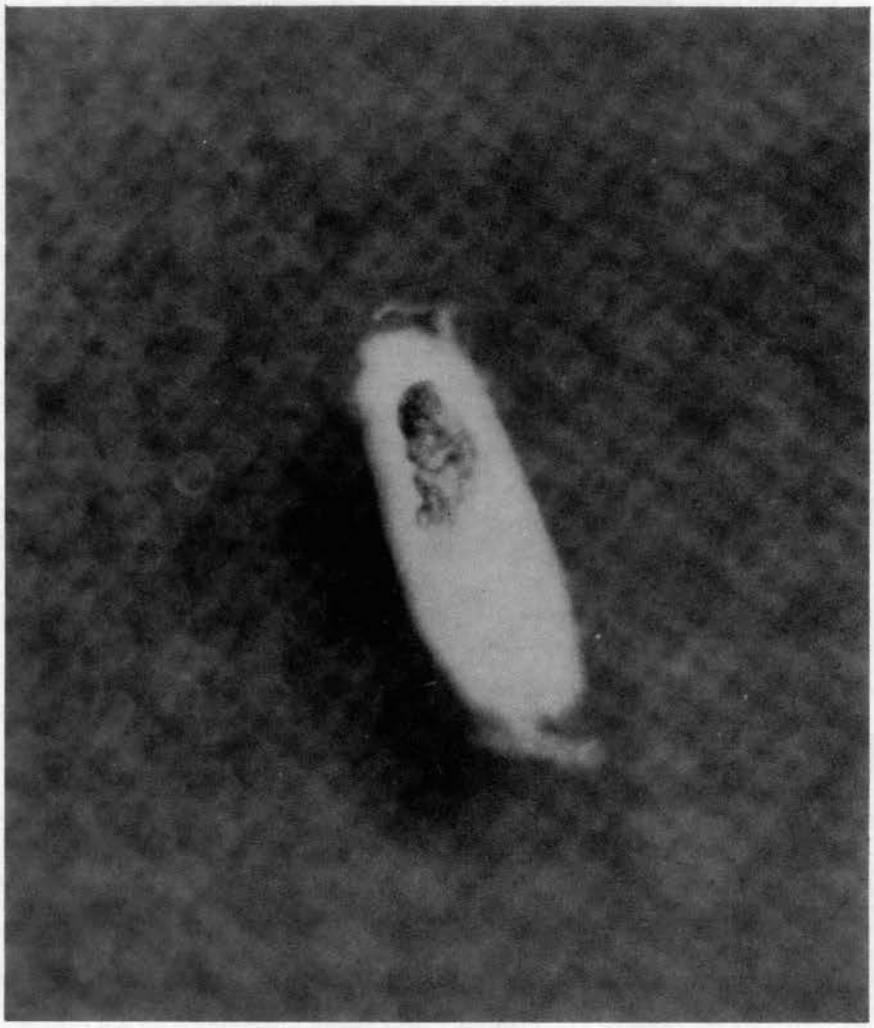

Fig. 6. The remains of Stegasta bosqueella (Chambers) larva, attached to the cocoon of an internal parasite.

SUMMARY AND CONCLUSIONS

This study of Stegasta bosqueella (Chambers), the red-necked peanutworm, included seasonal development, host plants, life cycle, and feeding. The investigation was made during four growing seasons (1957-1960) and two winters (1959-60 and 1960-61). Research was conducted in the laboratory at Stillwater, Oklahoma and under field conditions in five counties located in north central, central, southeastern, and western sections of the state. Approximately 30,000 plants and plant shoots, and 5,000 insect specimens were involved in the study.

At least four generations of Stegasta bosqueella developed per year on peanuts: the collection date extremes were mid-May and late October for adults, and early June and early November for larvae. Seasonal population peaks of larvae occurred from late July to early September. Alfalfa and partridge pea were additional plants found to be infested from nine species of domesticated and wild legumes examined. Infestations may occur on these host prior to the emergence of peanut plants.

The eggs of S. bosqueella are small, white to pale yellow, generally inconspicuous. They are deposited singly between the closed leaves of developing terminal shoots. The incubation time for eggs, in the laboratory, was three days.

In the laboratory larvae of red-necked peanutworm developed through five instars, and completed the larval period in about 15 days. The late second, third, fourth, and fifth instar larvae possess a striking red color on the pro- and mesothorax.

Primary feeding occured on the terminal shoots of peanuts, alfalfa, and partridge pea. These developing leaves were mined or chewed and occasionally stems were mined. Cannibalism was induced by placing large numbers of larvae on a limited food supply.

The pupation site, under normal conditions, was nearly always the soil beneath the growing plants. The pupal period extended from 5 to 9 days. Temperature and soil moisture probably affected the per cent of survival and time to adult emergence.

Adults are small, dark colored moths, that have a whitish-yellow figuration apparent when the wings are folded at rest. They lived a maximum period of 16 days in the laboratory.

The study indicates that S. bosqueella overwinters as a pupa in the soil.

Four species of internal parasites were collected from larvae of the red-necked peanutworm during this study. Three were from the family Braconidae and one from the family Ichneumonidae; three of these four were undescribed.

SELECTED BIBLIOGRAPHY

Bissell, T. L. 1942. A micro leaf worm on peanuts. Jour. Econ. Ent. 35:104.

Busck, August. 1903. A revision of the American moths of the family Gelechiidae, with descriptions of new species. Proc. U. S. Nat. Mus. 25:864-65.

Dietz, W. G. 1910. Revision of the genera and species of the Tineid sub-families Amydriinae and Tineinae inhabiting North America. Trans. Amer. Ent. Soc. 31:1-96.

Dyar, Harrison G. 1903. Descriptions of the larvae of some moths from Colorado. Proc. U. S. Nat. Mus. 25:405-08.

Chambers, V. T. 1875. Tineina from Texas. Can. Ent. 7:92, 124.

Chambers, V. T. 1878. Description of new Tineina from Texas, and others from northern localities. Bull. U. S. G. & G. Surv. 4:87.

Forbes, W. T. M. 1903. Stegasta key. N. Y. Acad. Sci., Sci. Surv. P. R. 12:128.

Heinrich, Carl. 1921. Some Lepidoptera likely to be confused with the pink bollworm. Jour. Agr. Res. 20:807-36.

Lower, Oswald. 1899. Descriptions of New Australian Lepidoptera. Proc. Linn. Soc. N. S. Wales. 24:83-116.

Meyrick, E. 1904. Descriptions of Australian micro-lepidoptera. Proc. Linn. Soc. N. S. Wales. 29:314.

Meyrick, E. 1925. Lepidoptera; Heterocera; Gelechiidae. Genera Insectorum 184:87.

Peterson, A. 1948. The larvae of insects. Edwards Brothers, Inc. Ann Arbor, Michigan. Part I. p. 104.

Walsingham, T. G. 1882. Notes on Tineidae of North America. Trans. Amer. Ent. Soc. 10:178.

Walsingham, T. G. 1887. Revision of the West-Indian micro-lepidoptera, with descriptions of new species. Proc. Zool. Soc. London. 67: 54-182.

Walsingham, T. G. 1909. Lepidoptera; Heterocera. Biol. Centr. -Amer. 4:60.

Walton, [R. R.] 1957. U. S. Dept. Agric., Plant Pest Control Branch, Agric. Res. Serv., Coop. Econ. Insect Rept. 7(34):682.

Walton, R. R. and F. Gifford. 1957. Preliminary studies on the biology and control of the red-necked peanutworm, Stegasta bosqueella (Chambers), on peanuts in Oklahoma. (Abstract) Bull. Ent. Soc. Amer. 3(3):32.

Walton, R. R. and R. S. Matlock. 1959. A progress report of studies of the red-necked peanutworm in Oklahoma. Okla. Agric. Exp. Sta. Proc. Series P-320.

VITA

Curtis V. Manley Jr.

Candidate for the Degree of

Master of Science

Thesis: THE BIOLOGY OF STEGASTA BOSQUEELLA (CHAMBERS), LEPIDOPTERA GELECHIIDAE.

Major Field: Entomology

Biographical:

Personal Data: Born in Amarillo, Texas, April 5, 1933, the son of Curtis Veldon and Olive Ferris Manley.

Education: Graduated in 1951 from Big Spring High School, Big Spring, Texas; received the Associate of Science from Eastern Oklahoma A. & M. College, Wilburton, Oklahoma, May 1958; received the Bachelor of Science degree from Oklahoma State University with a major in Entomology in May, 1960; completed the requirements for the Master of Science degree in May, 1961.

Experiences: United States Army, Artillery Officer, Continental Defense Command, Korean Theatre of Operations Korean War, 1953-56; U. S. Forest Service, Talihina, Oklahoma, fall 1956 and summer 1957; Research Assistant, Entomology Department, Oklahoma State University, summers 1958, 1959, 1960; National Science Foundation Undergraduate Research Assistant academic year 1959-60; Graduate Teaching Assistant academic year 1960-61.

Organizations: Sigma Xi, Phi Kappa Phi, Alpha Zeta, Phi Sigma, Entomological Society of America, Sanborn Entomology Club.