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THE FIELD CRICKET IN RELATION TO THE COTTON PLANT IN LOUISIANA[1]

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CONTENTS

INTRODUCTION

The field cricket (*Gryllus assimilis* F.[4]) is a widely distributed insect that feeds on many kinds of plants. Crickets are found in so many places that their importance as crop pests is not always recognized, and very little has been published on their biology and habits.

There is considerable confusion as to the specific determinations and the numerous varietal forms of the genus *Gryllus*. Rehn and Hebard (*9*)[5] list 45 synonyms of *G. assimilis*, and Blatchley (*2*) recognizes trinomial names for 6 varieties, but says in conclusion that the student can use these names or call all field crickets *G. assimilis*. Specimens of the form studied in Louisiana were all determined by the late A. N. Caudell as *G. assimilis* var. *pennsylvanicus* Burm.

[1] Submitted for publication June 27, 1938.
[2] Deceased September 24, 1936.
[3] In conducting the present studies the writers were assisted at one time or another by the following workers: G. W. Davis, P. M. Gilmer, P. A. Glick, H. B. Mills, C. F. Rainwater, E. E. Rogers, F. D. Smith, and L. H. Stubblefield. The airplane dusting was done by J. F. Payne, and the late A. N. Caudell furnished taxonomic assistance.
[4] Order Orthoptera, family Gryllidae.
[5] Italic numbers in parentheses refer to Literature Cited, p. 27.

CRICKET DAMAGE IN GENERAL

INJURY TO MISCELLANEOUS CROPS

There are a number of references in the economic literature to cricket damage in various crops. Severin (*11*, *15*) reports *Gryllus assimilis* in South Dakota as a major alfalfa pest that sometimes destroys fields of seed alfalfa within a few days. It is also well known along the Atlantic seaboard from New York to Mississippi as a pest of strawberries. According to Thomas and Reed (*17*) the crickets gnaw away the epidermis of the runners and prevent the setting of new strawberry plants. The most serious damage to strawberries, however, is the destruction of the buds and blooms, the dwarfing of unripe fruit, and the eating of holes in ripe fruit Quaintance (*8*), Watson (*18*), and Harrison (*5*) have each recorded *G. assimilis* as a pest of strawberries. Damage has also been reported to wheat and other small grains, corn, tomatoes, and other crops (*4, p. 14*; *19*). Field crickets sometimes enter houses in large numbers, according to Dean (*3*), causing damage to fabrics and rubber goods similar to that caused by the house cricket (*G. domesticus* L.). They are also attracted to animal food, and McColloch (*6*) observed a cricket feeding on termites as they emerged from the ground. In fact this cosmopolitan insect feeds on almost any plant or animal matter available.

RECORDS OF INJURY TO COTTON

A note by Riley (*10*) refers to a species of *Gryllus* as doing irreparable damage to cotton, sweetpotatoes, potatoes, peas, and tobacco in Jena, Catahoula Parish, La., in May 1887. It is not certain that this damage was caused by *G. assimilis*. Snapp and Stafford (*16*), at Deeson, Miss., in September 1918, found *G. assimilis* var. *luctuosus* Serv.[6] (unusually abundant that year) damaging cotton during the night by "combing away the lint from the upper seeds in the newly opened bolls, cutting away the seed hull, and eating out the contents." McGregor (*7*) gave an excellent account of this species as a cotton pest in the Imperial Valley of California. Large fields of seedling cotton were devastated, and replanting was frequently necessary. Ballou (*1*) and Wolcott (*20*) record this species as damaging cotton in the West Indies. There are also unpublished reports that *G. assimilis* frequently caused considerable damage to the stand of seedling cotton in the Laguna district of Mexico.

Several other species of *Gryllus* have been reported as cotton pests from different parts of the world. In fact, wherever cotton is grown, damage to it by some species probably occurs, and crickets are among its minor pests. Severe damage is usually local and confined to seedling cotton planted on or adjacent to favorable breeding places of the crickets. Often the stand is only partly reduced, but in some cases whole fields are completely destroyed and replanting one or more times becomes necessary. Feeding on the plants or seeds in the open bolls may continue, however, until harvest. The extent of the damage and the fact that it is caused by crickets is often not recognized by the grower, and control measures could be profitably used much more frequently than they are.

[6] Synonymous with var. *pennsylvanicus* Burm.

OUTBREAK AT QUEBEC, LA.

An unusually serious and locally destructive outbreak of *Gryllus assimilis* at Quebec, Madison Parish, La., in 1930 gave the writers an opportunity to study the life history and habits of the cricket in relation to the cotton plant. The most important results of these studies, which were finished in 1933, are given herein.

Plants showing unusual insect damage were brought by a planter to the Tallulah, La., laboratory on July 17. Men provided with flashlights, who were sent to the fields that night, found great numbers of crickets feeding on the cotton plants. No rain had fallen for more than 2 months; the soil, of the kind known as "buckshot," was baked and cracked and the plants were growing only slowly. Had it not been for the drought, the plants could have put out new leaves and outgrown the damage by crickets. Rain came, however, on August 15—the first since early in May—and a heavy rain occurred on August 18, after which the plants grew rapidly. On September 29 the plants bore no evidence of injury, but the yield of cotton had been reduced. By November 19 uninfested land had made three-eighths of a bale per acre, similar but moderately infested land two-eighths of a bale, and the most heavily infested areas only one-eighth of a bale.

Incidentally, "millions" of these crickets invaded the village of Tallulah on several successive nights, particularly on September 28 and 29. They swarmed under street lights and entered stores by thousands, causing alarm but doing no damage so far as could be ascertained.

CHARACTERISTIC INJURY TO COTTON

This cricket habitually cuts off fragments of cotton leaves and lets them drop to the ground, where they dry out, or the leaves partly eaten by the crickets during the night dry out in the hot sunshine and at length are shed. The visible result, when the crickets are numerous, is an irregular row (fig. 1) of dried leaf fragments on the ground, under the plants on each side of the row, with an occasional square or flower. These rows of pale yellow pieces of leaves, conspicuous against the dark soil, indicate damage by crickets.

The crickets have a pronounced habit of making holes along the courses of the main veins (fig. 2), which is also characteristic. Another evidence of cricket feeding is that the blades of leaves are cut from their petioles, leaving the latter on the plants (fig. 3).

Crickets also gnaw into stems (fig. 4, *A*) and squares and often eat out large holes in bolls (fig. 4, *B*). They eat the foliage in an irregular, haphazard manner, much as do grasshoppers and May beetles. Many small plants 6 or 8 inches high were observed defoliated or with the main stems severed so that they died outright (fig. 4, *C* and *D*). On larger plants (1 or 2 feet high) only a comparatively small number of leaves had been eaten, and these were usually lower leaves.

All these kinds of injury observed in the field were also found to be produced by crickets feeding on caged cotton plants in the field and in the insectary. Damage to seedling cotton is shown in figure 5.

FIGURE 1.—Damage to cotton by crickets. A row of leaf fragments along a row of cotton plants.

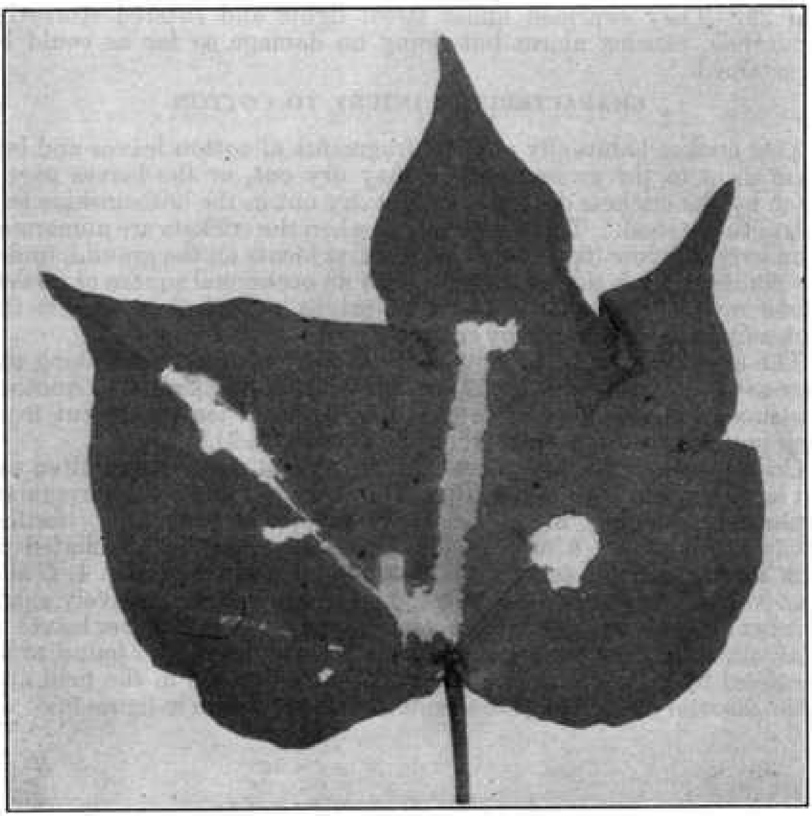

FIGURE 2.—A cotton leaf showing holes eaten along the course of the veins. This is a characteristic type of cricket feeding.

FIGURE 3.—Cotton plant 1 foot in height damaged by crickets.

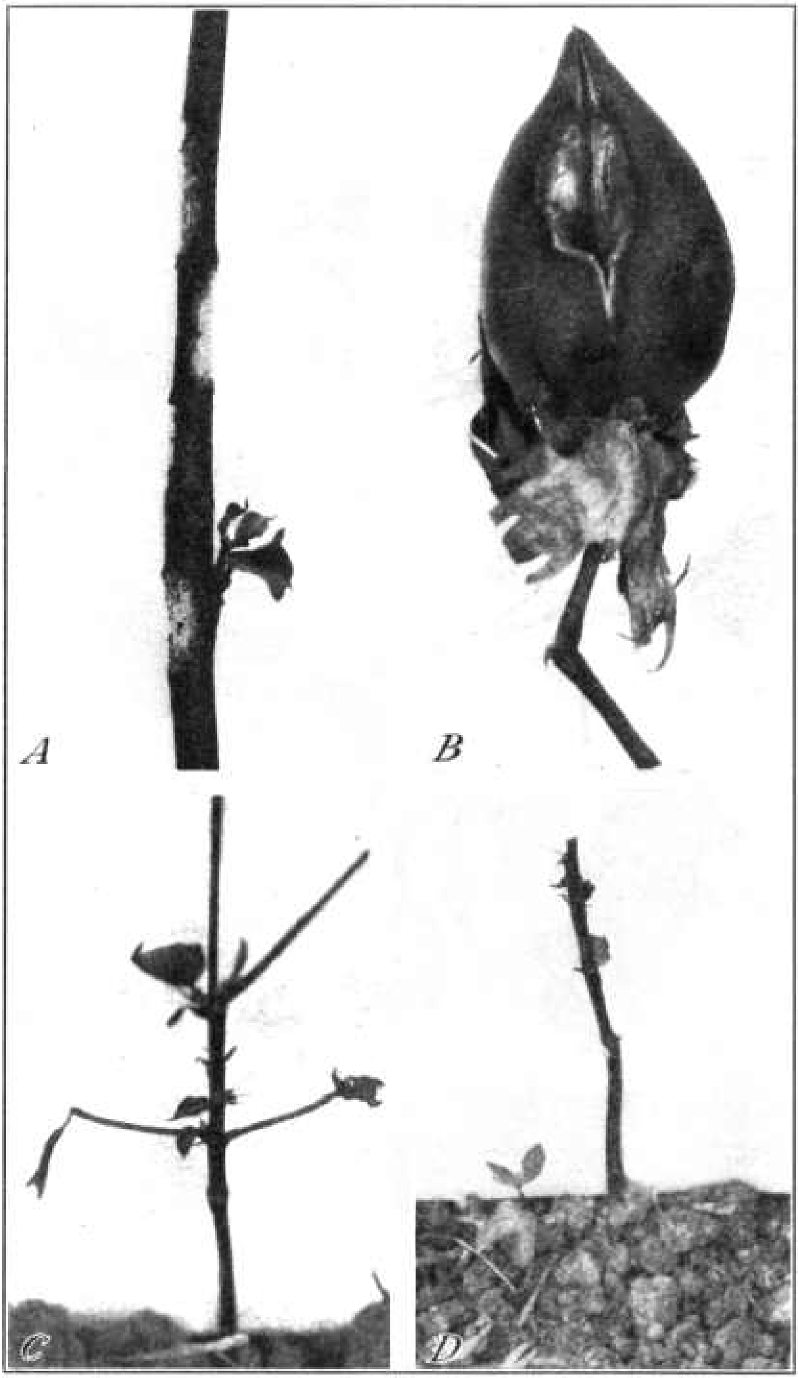

FIGURE 4.—*A*, Stem of a cotton plant gnawed by crickets; *B*, cricket damage to a cotton boll; *C*, cotton plant 8 inches high showing cricket damage; *D*, remains of a cotton plant ruined by crickets.

HABITS OF THE CRICKETS

Owing to a drought at the time of these studies in 1930 the soil in cottonfields was baked and cracked. The crickets stayed down in the cracks during the daytime. By digging they could often be found only 2 or 3 inches from the surface, but when exposed they at once followed the cracks downward to depths of a foot or more. At dusk they began to emerge, and when it was dark they issued in constantly increasing numbers. They walked about on the ground, running or hopping away or dodging under clods when disturbed, meeting one another, chirping, courting, and feeding on the fallen fragments of cotton plants.

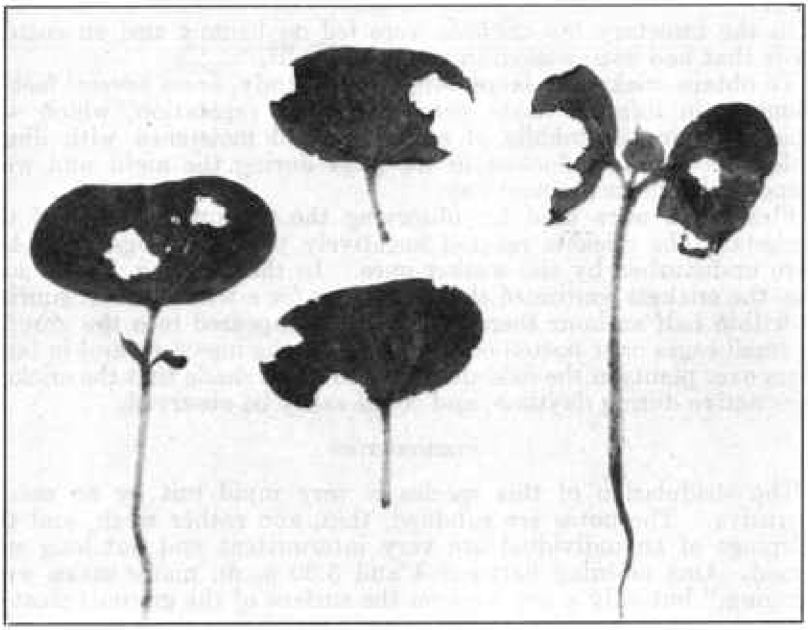

FIGURE 5.—Characteristic damage to seedling cotton by the field cricket.

FEEDING HABITS

When the crickets came out of the ground after sunset they paid no attention to the cotton plants for 2 or 3 hours, but stayed on the ground feeding on the dried fragments they had cut from cotton plants the night before or earlier. They gnawed the edges or veins of these fragments and tasted fallen dried squares or flowers. Finally a few crickets could be found on the plants, and their numbers slowly increased. On green plants the crickets often gnawed the bracts of squares, ate round holes in squares, and nibbled blossoms. Their chewing was audible.

It was several times observed that a cricket working on a green leaf would perch on the upper surface of the leaf with head toward the petiole and move backward as it ate out the leaf along the course of a vein.

These crickets showed omnivorous habits. In the cottonfield they fed to some extent on volunteer cowpeas, a pod of which often showed a row of holes where the cricket had eaten through the pod and hollowed out the seeds. In a mass of decaying bananas and oranges dumped in a cottonfield, several crickets were observed feeding on the bananas, which they eventually consumed, although the oranges were not eaten.

One cricket was seen under a street light, eating a moth. Crickets were observed eating dead or dying individuals of their own species, and the dead bodies of cockroaches and tiger beetles. A female cricket was seen feeding upon a still living cricket of the same sex, and had eaten a hole in the last three abdominal segments of her prey.

In the insectary the crickets were fed on banana and on cottonseeds that had been soaked in water and split.

To obtain crickets in large numbers for study, areas several feet in diameter in infested fields were cleared of vegetation, which was piled back in the middle of each area and moistened with dilute molasses. Crickets flocked to the piles during the night and were found under them the next day.

Flashlights were used for observing the nocturnal habits of the crickets. The crickets reacted negatively to the stronger rays but were undisturbed by the weaker ones. In the morning, before sunrise, the crickets continued their activities for a while, but at sunrise, or within half an hour thereafter, they disappeared into the ground. In small cages over potted cotton plants in the insectary and in large cages over plants in the field there was so much shade that the crickets were active during daytime, and could easily be observed.

STRIDULATION

The stridulation of this species is very rapid but by no means obtrusive. The notes are subdued, thin, and rather weak, and the chirpings of an individual are very intermittent and not long sustained. One morning between 4 and 5:30 a. m. many males were "singing," but only a few were on the surface of the ground; most of them seemed to be chirping from cover, just below the surface. Undoubtedly the stridulation is affected by several factors, particularly temperature and humidity, the effects of which have not been worked out.

LIFE HISTORY

GENERATIONS

Two generations are represented during the calendar year in Louisiana, one of them incomplete. Eggs are deposited in the latter part of April and early part of May by adults that have overwintered as nymphs. The adults developing from these eggs appear in the latter part of July and during August. They deposit eggs, and the resulting nymphs continue their development until cold weather, usually reaching about the sixth instar or a later one. These nymphs overwinter and become adults early in the following spring.

MATING

The details of mating were often observed, and the following is taken from notes [7] made by H. B. Mills on August 7:

> Specimens of this species kept in the office were observed several times throughout the act of mating. The male has a special, rapid, mating song which is rather wiry and high-pitched, with a continuous undertone to which at regular intervals (three or four times a second) are added strong clicking sounds. The whole body of the male vibrates during this song. As many as four females were seen approaching a male during this mating song and dance. During mating the male's cerci vibrate rapidly, and he turns his head quickly to one side and then the other.

The process of mating has been fully described by Severin (*15*).

OVIPOSITION

The eggs are not laid in a mass but are scattered a little in the soil, though sometimes two or three eggs stick together. H. B. Mills [7] describes the process of oviposition as follows:

> The female inserted her ovipositor its full length into the soil, then withdrew it slightly and deposited an egg. Without withdrawing the ovipositor entirely she pulled it up and reinserted it at a slightly different angle and deposited another egg. This operation was repeated several times. A swelling of the ovipositor, passing from the base outward, showed the rapid passage of an egg.

To this description, G. W. Davis adds:

> The female pushes the ovipositor into the ground at an angle of about 35° from the horizontal. She then retracts the ovipositor about one-half its length, changes the angle slightly, and reinserts it. After repeating this from four to eight times she moves to a new place and repeats the process.

THE EGG

The egg (fig. 6) is at first translucent lemon yellow, subcylindrical, rounded at both ends, straight or slightly curving, and smooth, averaging in length 2.16 mm and in width 0.47 mm. Two days after being laid the egg is dull whitish yellow. Three or four days before hatching the eye spots become visible through the chorion, and later on the antennae and body segments, and the egg becomes darker.

EGG PRODUCTION

The breeding cages used were lantern globes covered with screen wire and set in 6-inch flowerpot saucers containing damp soil. A male and a female that had overwintered as nymphs in the insectary were placed in each cage.

Every day, at a regular time, the soil of each cage was examined for eggs. To remove the crickets temporarily, a cylindrical screen-wire catching cage, 6 inches long, 2 inches in diameter, and open at one end, was used. When this was placed over a cricket, the insect readily climbed up into it and could then be removed. The soil from the breeding cage was then spread on a sheet of glass with a black background, against which the eggs were easily seen.

Each day all the eggs laid that day were removed with a moistened brush to a Petri dish containing slightly damp soil. Excessive moisture, and especially mold, were detrimental to the eggs.

[7] Unpublished notes.

Five females produced a total of 1,416 eggs. Oviposition began as early as 9 days and as late as 26 days after the first observed mating and continued throughout life.

The number of eggs per individual ranged from 45 to 808, with an average production of 283. The number laid per female per day varied greatly. The maximum number recorded was 150.

In April and early in May the great majority of the eggs were laid at a mean daily temperature of 69° F., the range of temperature being from 66° to 78°, inclusive. Late in May most of the eggs were laid at a mean daily temperature of 78°, the range being 75° to 80°.

INCUBATION PERIOD

Eggs that were deposited and that hatched between April 19 and May 31 required 17 to 31 days for the incubation period. Fifty-seven

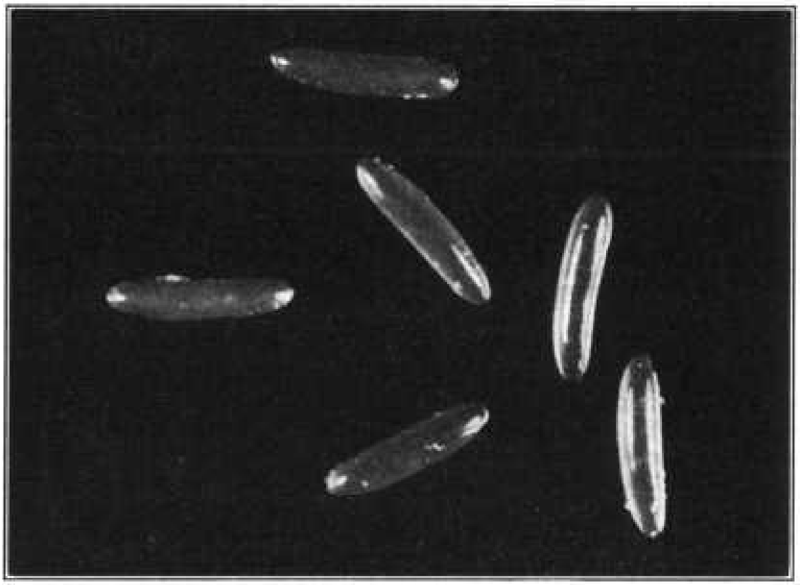

FIGURE 6.—Eggs of the field cricket, × 11.

percent, however, hatched on the eighteenth day, during a period of a few days when the daily mean temperature was around 80° F. The daily mean temperature during the entire incubation period of most of the eggs was about 73°, but during the earlier part of this period it was around 69°.

Between May 1 and June 4 from 12 to 21 days' incubation was required. Sixty-one percent hatched on the thirteenth and fourteenth days. The daily mean temperature during this time was about 76° F. Between May 18 and June 11 from 11 to 18 days' incubation was required. Eighty-four percent hatched on the fifteenth and sixteenth days, as the daily mean temperature during this time was about 75°.

The length of the egg period depended primarily, but not exclusively, upon temperature. Eggs laid by one female over a 24-hour period and kept under practically the same conditions varied in their incubation periods up to 14 days. The variation was less at higher temperatures.

The foregoing discussion applies to the eggs of the first generation. Of the eggs deposited for the second generation on August 15, 36 percent hatched in 16 days, at a daily mean temperature of 79° F; 2 percent in 17 days, at 79°; 11 percent in 21 days, at 79.5°; and 51 percent in 23 days, at 79.4°.

HATCHING

G. W. Davis observed eggs that were kept free in Petri dishes and describes[8] the process of hatching as follows:

> At hatching, the nymph begins to move in the eggshell, and in a few minutes the chorion splits at the anterior end of the egg, the split running longitudinally from the top of the head to the abdomen. The nymph emerges by a series of wavelike movements, beginning in the last segments of the abdomen and moving forward. After the head and front pair of legs are free the insect pulls itself out by means of the front legs. The young nymph rests from 1 to 10 minutes and then begins to move about. In several instances observed, the split of the chorion was too short to free the head of the nymph. The nymph managed to free its body but was unable to disengage its head from the chorion, and in almost every case died without being able to free itself.

Severin (*15*) has described the hatching of eggs imbedded in the soil.

MOLTING

In molting, the old skin splits along the median dorsal line of the head, thorax, and base of the abdomen. The abdomen, thorax, and hind legs are forced out of the skin by convulsive movements of the abdomen. Then the skin breaks away from the head, beginning at the top, and the forelegs and middle legs are used to crawl out of the old skin. The antennae are freed last.

The determination of the exact number of molts was difficult at first; in fact, impracticable by direct observation, for (1) molting occurs at all times of day and night, (2) it requires only a few minutes, and (3) the cast skin is usually eaten immediately after the molt. The junior author devised a method of marking the nymphs with a minute spot of aluminum paint placed on the pronotum in order to ascertain when they molted. It was afterwards found that a similar method had been previously used by Severin (*13*), who marked each nymph with white ink. The daily inspection of the nymphs could be made rapidly by this method, as the absence of the spot of paint meant, of course, that the nymph had molted since the previous day. This molt was recorded and the nymph was marked again.

For marking the nymphs, a little aluminum dust was mixed with amyl acetate to the proper consistency. This paint was applied on the point of a fine needle, under a binocular microscope, in the case of the very small nymphs; for larger nymphs, larger needles were used and, if necessary, a dissecting microscope.

The nymph to be marked was removed from its cage to a shell vial, which was then stoppered and numbered. This vial was placed on crushed ice. As soon as the nymph became quiet, it was marked. The nymph quickly revived and was returned to its cage, apparently none the worse for having been chilled. There was no indication that this process of marking affected the activity or the normal development of the nymph.

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[8] Unpublished notes.

THE NYMPHAL INSTARS

NUMBER OF INSTARS

In the season of 1933, 131 crickets were reared from egg to adult, and the total number of molts of each individual was accurately ascertained. The number of instars proved to be surprisingly large. Thus, 102 nymphs had 10 instars before becoming adults, 14 had 9, 13 had 11, and 2 had 12 instars. The total number of instars, then, ranged from 9 to 12, with 10 as the normal number.

FIRST INSTAR

(Fig. 7, *A*)

Soon after hatching, the general color is gray dorsally and white ventrally. The head is pale brown and the eyes dark brown. The antennae are gray with white articulations. The palpi are white; the pronotum pale gray on anterior three-fourths, bordered with pale yellow posteriorly and laterally, with four to seven black setae along the posterior border, on each side of the median line. The mesonotum is pale yellow, with setae the same color. The metanotum is pale gray. The coxae and trochanters are white, and the femora are white with gray basally and along the under side; the tibiae and tarsi are gray. The abdomen is pale gray dorsally, the posterior segments being bordered behind and laterally with ferruginous. The cerci are pale ferruginous, yellow basally, and white apically. The setae of the head, body, and legs are black.

In the course of a few hours most of the gray parts become dark brown to black. The yellow of the pronotum and mesonotum is darker. The epicranial suture is evident as a pale Y-shaped mark. The median dorsal line, which may extend almost to the end of the abdomen, is pale yellow. The coxae, trochanters, and tarsi are white. The cerci are black apically.

Two pairs of spurs are present at the extremity of each hind tibia. Hind tibial spines are absent in the first instar, though there are two series of strong, black, outstanding setae (usually three outer and two inner) that might be mistaken for the spines.

SECOND INSTAR

(Fig. 7, *B*)

Immediately after the first molt the nymph is pale reddish brown, which changes to shiny black in about an hour. The pronotum is brown to black throughout, or with a trace of the marginal yellow border. The mesonotum is dull yellow to pale brown. The median dorsal line is pale yellow. The posterior border of the pronotum and of the mesonotum each have a row of four to seven round black spots on each side of the median line, each spot bearing a black bristle. The tarsi are blackish; the cerci ferruginous, yellow basally and black apically, the segments ringed with brown.

Hind tibial spines are present, but are small. Typically there are two outer and three inner ones, though one or more may be rudimentary or absent, and occasionally there are three outer spines. Just above each spine is one of the strong black setae found in the first instar.

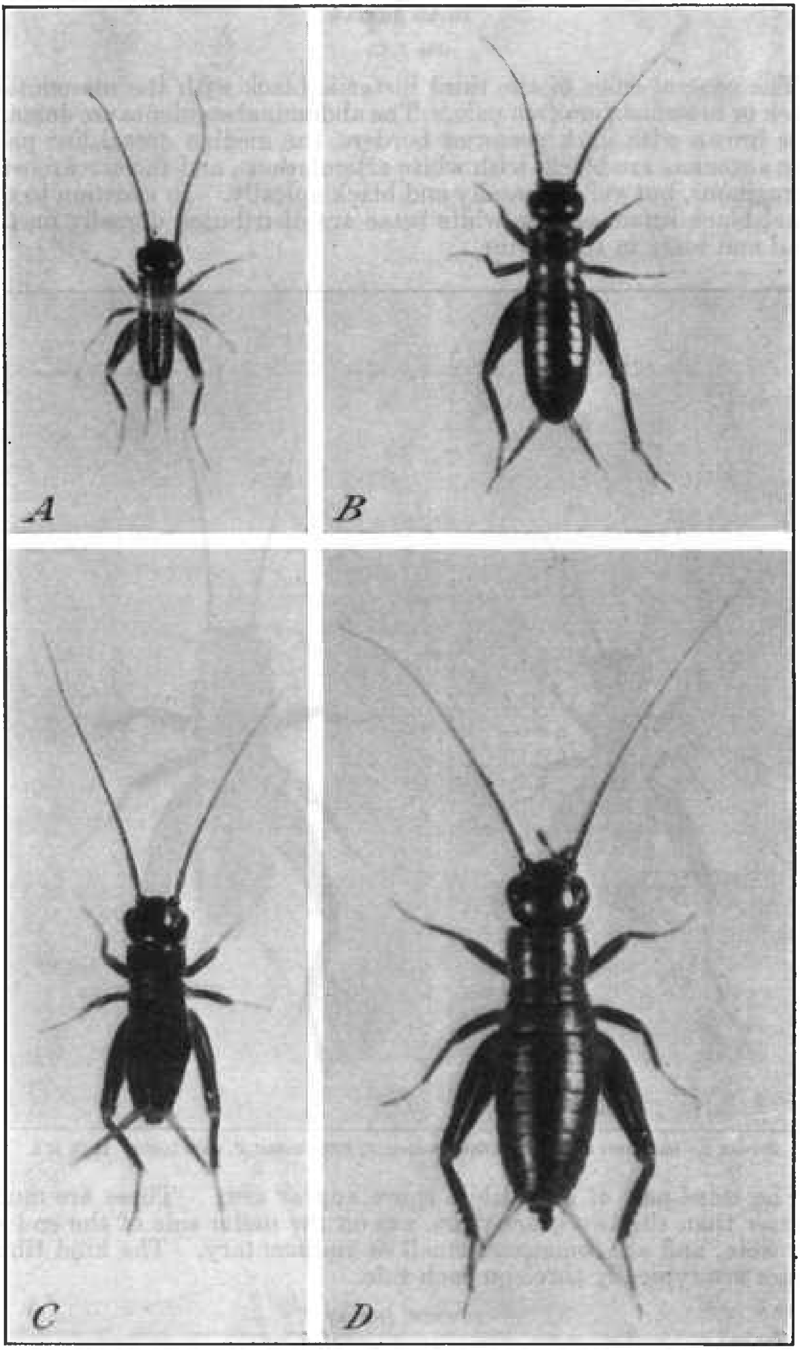

FIGURE 7.—Immature stages of the field cricket: *A*, First instar; *B*, second instar; *C*, third instar; *D*, fourth instar. All × 8.

THIRD INSTAR

(Fig. 7, *C*)

The general color of the third instar is black with the mesonotum black or brownish, or often pale. The abdominal segments are dorsally pale brown with dark posterior borders, the median dorsal line pale. The antennae are black, with white articulations, and the cerci mostly ferruginous, but yellow basally and black apically. In addition to the usual black setae, minute white setae are distributed dorsally on the head and body in this instar.

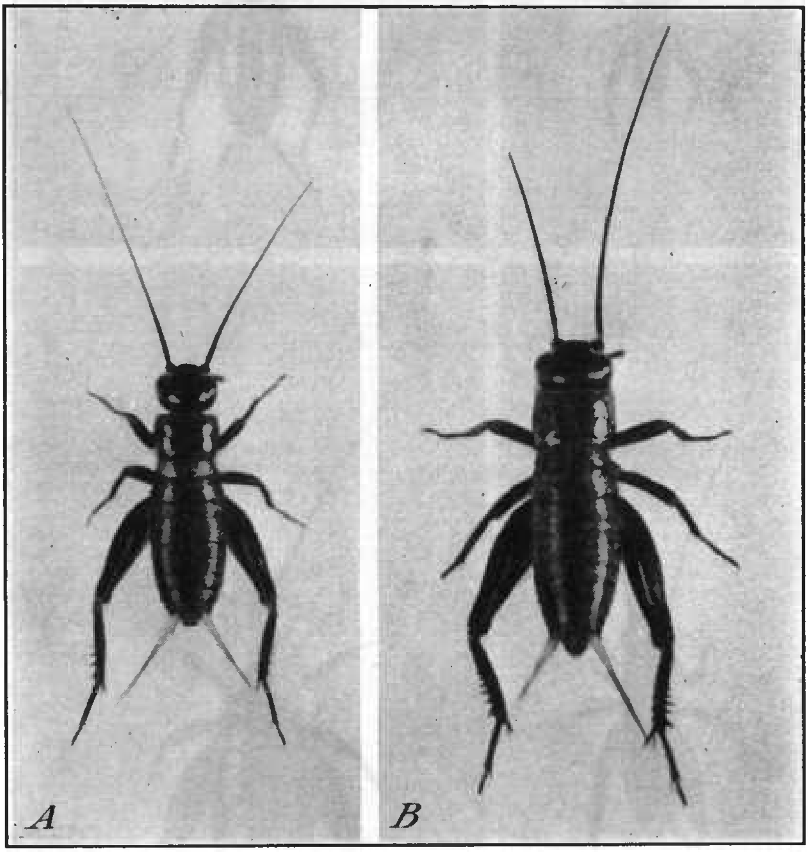

FIGURE 8.—Immature stages of the field cricket: *A*, Fifth instar; *B*, sixth instar. Both × 5.

The third pair of hind tibial spurs appear also. These are much shorter than the two other pairs, are on the under side of the end of the tibia, and are sometimes small or rudimentary. The hind tibial spines are typically three on each side.

FOURTH INSTAR

(Fig. 7, *D*)

The minute white setae of the head and body are more numerous in the fourth than in the third instar. The third pair of hind tibial spurs are well developed. There are typically five hind tibial spines in the outer row and four in the inner row. A rudimentary proximal fifth spine may be present in the inner series.

FIFTH INSTAR

(Fig. 8, *A*)

In the fifth instar the white setae of the head and body are even more numerous than in the fourth, and the hind tibial spurs and spines are better developed. Typically there are six outer and five inner spines,

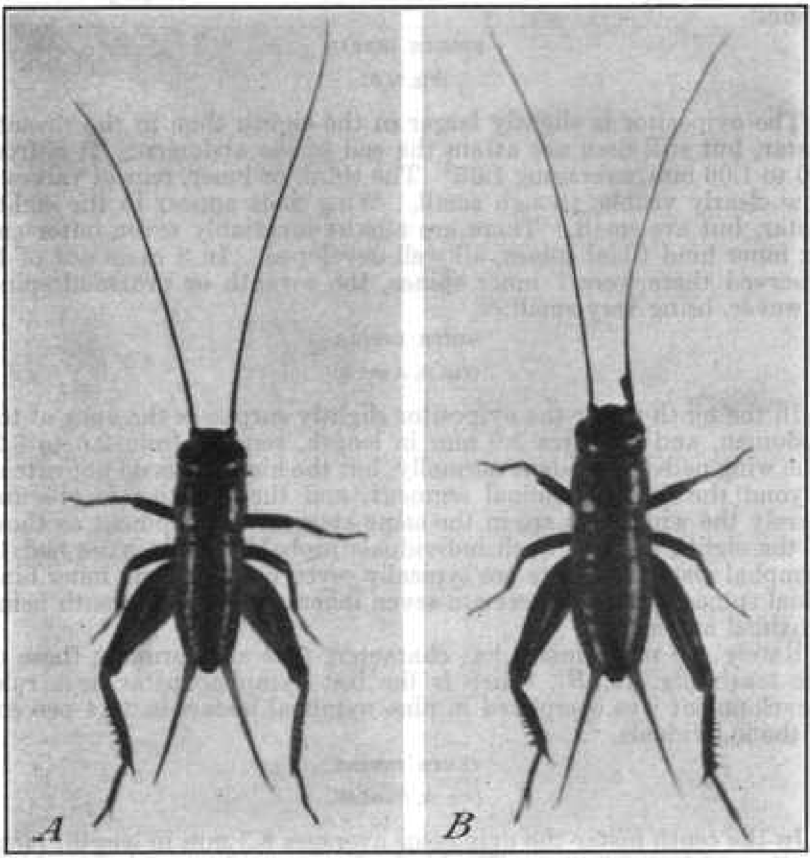

FIGURE 9.—Immature stages of the field cricket: *A*, Seventh instar; *B*, eighth instar. Both × 4.

but the outer spines are occasionally either five or seven, and the inner rarely six.

SIXTH INSTAR

(Fig. 8, *B*)

The number of hind tibial spines is typically the same in the sixth as in the fifth instar, that is, six outer and five inner, but as variations there may be only five outer and four inner spines.

SEVENTH INSTAR

(Fig. 9, *A*)

The ovipositor appears in the seventh instar as two evident pairs of short fingerlike appendages which do not extend to the extremity of the abdomen. The ovipositor is from 0.5 to 0.6 mm long. Wing pads are not yet present in this instar.

The hind tibial spines usually number seven outer and six inner, the proximal, or seventh, outer spine being small. These numbers are typical of adults also. In some instances there were only six outer spines.

EIGHTH INSTAR

(Fig. 9, *B*)

The ovipositor is slightly larger in the eighth than in the seventh instar, but still does not attain the end of the abdomen. It is from 1.0 to 1.06 mm, averaging 1.05. The third, or inner, pair of valves is now clearly visible, though small. Wing pads appear in the eighth instar, but are small. There are almost invariably seven outer and six inner hind tibial spines, all well developed. In 3 cases out of 35 observed there were 7 inner spines, the seventh or proximal spine, however, being very small.

NINTH INSTAR

(Fig. 10, *A* and *B*)

In the ninth instar the ovipositor slightly surpasses the apex of the abdomen, and averages 2.9 mm in length, ranging from 2.6 to 3.2. The wing pads are evident normally, but the hind wings do not extend beyond the first abdominal segment, and the venation is obscure. Rarely the wing pads are in the same stage of development as those of the eighth instar. Such individuals probably would have had 11 nymphal instars. There are typically seven outer and six inner hind tibial spines. Rarely there are seven inner spines, the seventh being proximal and small.

Rarely the ninth instar has characters that are normally those of the tenth (fig. 10, *B*), which is the last nymphal instar as a rule. Development was completed in nine nymphal instars in 10.4 percent of the individuals.

TENTH INSTAR

(Fig. 10, *C* and *D*)

In the tenth instar the ovipositor averages 6.3 mm in length, ranging from 6.2 to 6.5 mm. The hind wings extend beyond the middle of the third abdominal segment, and their venation is evident. There are seven outer hind tibial spines and six inner. In rare cases there may be seven inner spines owing to the presence of an additional small proximal spine.

In a few abnormal individuals, the tenth instar shows the characters of the ninth (fig. 10, *C*). Such individuals would probably have 11 nymphal instars.

Development was completed in 10 nymphal instars in 77.8 percent of the crickets.

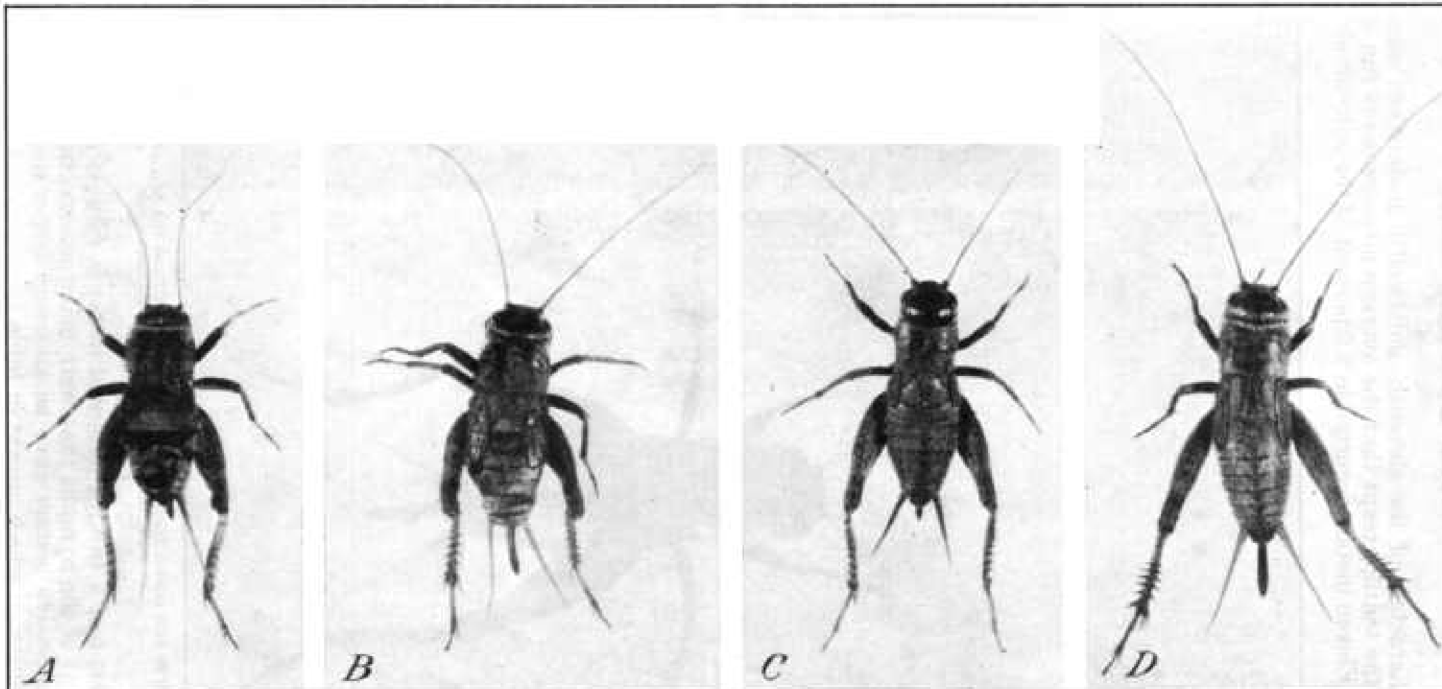

FIGURE 10.—Immature stages of the field cricket: *A*, Ninth and next to last nymphal instar; *B*, ninth and last nymphal instar; *C*, tenth and next to last nymphal instar; *D*, tenth and last nymphal instar. All × 2.

ELEVENTH AND TWELFTH INSTARS

(Fig. 11, *A*)

The characters of the eleventh and twelfth instars are essentially those of the tenth, except that the average measurements run slightly larger. Eleven instars occurred in 9.9 percent of the individuals. The

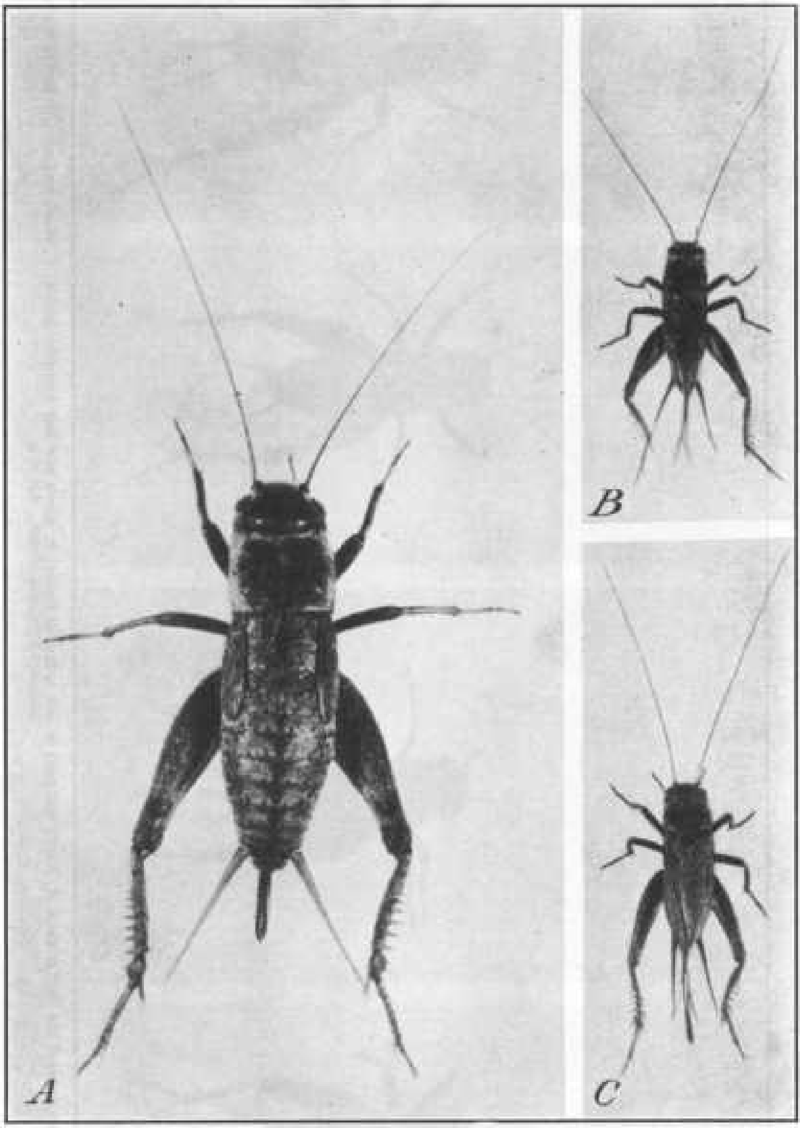

FIGURE 11.—The field cricket (*Gryllus assimilis*): *A*, Eleventh and last nymphal instar, × 3; *B*, adult male, natural size; *C*, adult female, natural size.

development of a twelfth nymphal instar is rare; it occurred in only 1.5 percent of the nymphs that were under observation.

The successive instars gave successively larger measurements, the more essential of which appear in table 1.

TABLE 1.—*Measurements of the nymphal instars of Gryllus assimilis var. pennsylvanicus, Tallulah, La.*

Instar	Total length		Head				Pronotum				Antennae				Cerci, length	
			Length		Width		Length		Width		Length		Segments			
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
	Millimeters	*Millimeters*	*Millimeters*	*Millimeters*	*Millimeters*	*Millimeters*	*Millimeters*	*Millimeters*	*Millimeters*	*Millimeters*	*Millimeters*	*Millimeters*	*Number*	*Number*	*Millimeters*	*Millimeters*
First	2.0- 2.5	2.2	0.76-0.86	0.81	0.7 -0.76	0.73	0.3 -0.37	0.34	0.6-0.7	0.64	2.5- 2.9	2.7	33- 35	34	0.83-1.10	0.98
Second	2.4- 3.4	3.05	.88-1.0	.93	.83-1.0	.94	.46- .55	.50	.7- .9	.78	3.5- 4.3	3.9	46- 49	47	1.0 -1.3	1.4
Third	2.4- 4.0	3.16	1.0 -1.1	1.05	1.0 -1.1	1.05	.4 - .68	.56	.8-1.0	.9	3.7- 4.6	4.3	53- 59	56	1.5 -1.8	1.6
Fourth	4.2- 4.4	4.3	1.3 -1.7	1.5	1.3 -1.6	1.45	.8 - .83	.84	1.4-1.6	1.46	5.0- 6.0	5.4	54- 78	71	2.0 -2.6	2.3
Fifth	4.6- 6.5	5.6	1.5 -2.5	1.9	1.6 -2.5	1.9	1.0 -1.5	1.22	1.6-2.1	1.9	7.0- 9.0	8.3	79-102	90	2.3 -3.0	2.7
Sixth	7.8- 9.0	8.1	2.3 -2.4	2.3	2.2 -2.4	2.3	.86-1.6	1.1	2.3-2.4	2.3	10.0-11.0	10.7	98-113	102	3.7 -4.0	3.9
Seventh	9.3-12.4	10.6	2.8 -3.0	2.9	2.6 -3.0	2.8	1.8 -2.1	2.0	2.8-3.0	2.9	14.0-16.0	15.4	135-149	140	4.6 -5.2	4.9
Eighth	11.0-13.0	12.0	3.2 -3.7	3.4	3.1 -3.7	3.4	2.3 -2.7	2.4	3.5-3.8	3.6	17.0-19.0	18.0	148-177	156	6.4 -7.0	6.7
Ninth	12.0-17.5	13.6	3.5 -4.5	3.9	3.5 -4.5	3.9	2.5 -3.5	2.9	4.0-4.8	4.3	20.0-29.0	23.5	153-193	174	7.0 -7.6	7.1
Tenth	16.0-19.0	18.0	4.8 -5.7	5.2	5.0 -6.0	5.6	3.5- 4.0	3.8	5.0-6.0	5.6	28.0-28.5	28.2	164-213	188	8.0 -9.0	8.3
Eleventh	18.0-22.0	20.0	5.5 -5.6	5.5	5.3 -5.5	5.4	4.0 -4.5	4.2	5.5-6.0	5.7	21.0-31.0	25.0	197-209	203	8.0 -9.0	8.5
Twelfth (1 specimen)	19.0	19.0	6.2	6.2	5.8	5.8	4.0	4.0	6.0	6.0	Broken	-------	Broken	-------	9.0	9.0

LENGTH OF STADIA OF FIRST GENERATION

In the first generation, in 1933, 131 individuals were carried from egg to adult. The smallest nymphs were reared in shell vials 75 mm long and 35 mm in diameter containing 20 mm of damp soil in the bottom. Moisture was essential, especially at molting, and in dry weather the tops of the vials were covered with damp paper. Ordinarily no covers were necessary, as the nymphs were unable to climb the sides of the vials as long as they were kept clean.

After the third molt nymphs were placed in larger cages, of the lantern-globe type already described. In these cages moist sand was used instead of soil, as the latter favored the development of mold. These cages were covered with screen wire when the nymphs became large enough to jump out.

The length of the stadia of the first 11 instars of the first generation are given in table 2. Only 2 crickets had 12 nymphal stadia. One of these was a twelfth instar from July 29 until August 8, or 10 days, at a daily mean temperature of 80.8° F., the other from August 11 until August 29, or 18 days, at 78.9°.

The first adult of the first generation appeared on July 12, and three more on July 15. After that adults came in increasing numbers, the great majority appearing during the last week of July and the first week of August. The last two adults in the insectary came on August 25.

These first-generation adults, which produce the eggs for the second generation, had mostly died off by October 15.

THE ADULT

(Fig. 11, *B* and *C*)

Mostly shining black. Tegmina black to brown, yellowish brown along the humeral angle; tibiae black; hind femora reddish brown basally; cerci black or brownish; ovipositor black. Head and pronotum subequal in width; basal antennal segment not projecting beyond front of head; pronotum with posterior margin feebly sinuate, with a median impressed line that seldom attains the posterior margin; width of pronotum 5–6 mm in male, 6–7 mm in female, length 4–5 mm in the male, 5 mm in the female. Tegmina with inner edges straight and overlapping, in the male attaining the tip of the abdomen, in the short-winged female slightly exceeding the tip, a little longer in the long-winged female. Wings shorter than tegmina, or projecting beyond the tegminalike tails. Length of tegmina: Male, 11–12.5 mm; short-winged female, 10–12 mm; long-winged female, 12–15 mm. Hind femora short and stout, slightly longer than ovipositor; hind tibial spines, seven outer and six inner, rarely varying in number. Ovipositor 13.5–15 mm in the short-winged form, 14–16 mm in the long-winged form. Fresh individuals often have a minute gray pubescence on pronotum, sternum and legs. Total length of male 18 mm (range, 16–19 mm), of female 17.4 mm (range 17–18 mm).

The measurements of Louisiana specimens run a little larger than those given by Blatchley (*2*) for specimens from Indiana.

TABLE 2.—*Percentage of individuals of Gryllus assimilis var. pennsylvanicus in the first 11 instars for the periods indicated, with the daily mean temperature (°F.) for the outstanding groups in parentheses, Tallulah, La.*

Time spent in instar (days)	First instar (May 9-June 4)	Second instar (May 14-June 4)	Third instar (May 21-June 10)	Fourth instar (May 27-June 19)	Fifth instar (June 4-25)	Sixth instar (June 11-30)	Seventh instar (June 20-July 7)	Eighth instar (June 26-July 13)	Ninth instar (July 2-21)	Tenth instar (July 10-Aug. 2)	Eleventh instar (July 18-Aug. 11)
4	----	2.2	----	----	----	0.8	----	----	----	----	----
5	6.8	11.4	13.2	2.5	6.3	29.3	13.8	4.0	----	----	----
6	38 (80.6°)	48 (77.1°)	32.0 (72.8°)	15.0	9.4	56.9 (75.0°)	66.6 (81.6°)	42.5 (84.0°)	3.1	----	----
7	37 (77.4°)	22.9	28.3	21.6	15.7	4.2	17.0	37.0	29.9	0.9	----
8	11.4	12.2	22.6	38.3 (73.7°)	34.6 (73.3°)	6.9	2.4	15.0	36.2 (82.0°)	1.8	----
9	3.8	3	3.7	17.5	29.1	1.7	----	1.5	18.9	3.6	----
10	1.5	----	----	4.1	3.1	----	----	----	5.5	8.1	23.0
11	.8	----	----	----	1.5	----	----	----	3.9	19.8	30.0 (80.7°)
12	----	----	----	----	----	----	----	----	1.5	36.0 (78.0°)	15.0
13	----	----	----	----	----	----	----	----	.8	23.4	7.0
14	----	----	----	----	----	----	----	----	----	6.3	15.0
16	----	----	----	----	----	----	----	----	----	----	7.0

PROPORTION OF SEXES AND OF SHORT- AND LONG-WINGED FORMS

Of the first-generation crickets reared in the insectary approximately 60 percent were males and 40 percent females. Seventy percent of the total number were short-winged forms. The ratio of short-winged to long-winged forms, however, varied somewhat for the sexes, being 2 to 1 for the males and 3 to 1 for the females. The average developmental period was slightly less for the males than for the females and was less for the short-winged than for the long-winged forms of both sexes. The number of days from hatching to maturity for both the males and females increased with the number of nymphal instars.

The developmental period ranged from a minimum of 63 days for several individuals with nine molts to a maximum of 108 days for a single individual that died in the twelfth instar. The average period for all the records was 74.6 days. These data are summarized in table 3.

Table 3.—*Nymphal development of short- and long-winged forms of the field cricket according to sex for the first generation, Tallulah, La., 1933*

Nymphal instars (number)	Males				Females				All forms	
	Short-winged		Long-winged		Short-winged		Long-winged			
	Individuals	Developmental period	Individuals	Developmental period	Individuals	Developmental period	Individuals	Developmental period	Individuals	Developmental period
	Number	*Days*	*Number*	*Days*	*Number*	*Days*	*Number*	*Days*	*Number*	*Days*
9	8	65.2	3	66.6	1	63.0	2	64.5	14	65.2
10	41	74.4	20	73.7	33	74.4	8	74.7	102	74.3
11	3	85.6	3	89.0	4	84.2	3	84.0	13	85.6
12	[1] 1	88.0	0	0	0	0	0	0	1	88.0
Total or average	53	73.9	26	74.6	38	75.1	13	75.3	130	74.6

[1] One other male died.

SECOND GENERATION

The second generation in the insectary in 1933 began with eggs laid on August 15 by crickets of the first generation that had been reared from the egg.

The second generation continued to develop in the field until the first killing frost on November 10. In the shelter of the insectary, however, the crickets continued their development for awhile longer.

Data on this partial second generation are shown in table 4, and table 5 shows that, as is usually the case, the length of a stadium increases as the mean daily temperature decreases.

TABLE 4.—*Duration of stadia of the partial second generation of the field cricket developing from eggs laid on August 15, 1933, Tallulah, La.*

First stadium (Aug. 31–Sept. 16)		Second stadium (Sept. 4–27)		Third stadium Sept. 10–Oct. 17)		Fourth stadium (Sept. 16–Nov. 5)		Fifth stadium (Sept. 22–Nov. 19)		Sixth stadium (Sept. 29–Dec. 19)	
Individuals	Time in stadium	Individuals	Time in stadium	Individuals	Time in stadium	Individuals	Time in stadium	Individuals	Time in stadium	Individuals	Time in stadium
Number	*Days*	*Number*	*Days*	*Number*	*Days*	*Number*	*Days*	*Number*	*Days*	*Number*	*Days*
2	4	1	4	1	4	3	6	1	5	1	15
12	5	10	5	8	5	9	7	2	7	1	16
13	6	14	6	9	6	4	8	4	8	1	19
15	7	4	7	7	7	1	15	1	15	1	20
3	8	1	8	1	8	1	16	1	16	1	21
6	9	2	9	1	9	1	17	1	17	1	26
------	------	2	10	1	16	3	18	2	18	1	32
------	------	2	11	2	17	1	19	1	19	1	33
------	------	3	12	1	22	2	20	4	20	------	------
------	------	------	------	------	------	2	22	1	29	------	------
------	------	------	------	------	------	------	------	1	32	------	------
51	------	39	------	31	------	27	------	19	------	8	------

TABLE 5.—*Length of stadia of the field cricket in relation to temperature*

Instar	Individuals	Average length of stadium	Mean daily temperature	Instar	Individuals	Average length of stadium	Mean daily temperature
	Number	*Days*	°*F.*		*Number*	*Days*	°*F.*
First	51	6.5	80.2	Fourth	27	11.8	73.7
Second	39	6.9	79.3	Fifth	19	15.5	70.7
Third	31	7.6	76.3	Sixth	8	22.7	68.0

OVERWINTERING

The development and activities of the second generation of crickets are interrupted in the fall by low temperature and are almost stopped by the first killing frost. The nymphs find protection under piles of grass, straw, or weeds, or under boards or loose clods of earth, and in cracks or holes in the ground. They also burrow into the soil in cold weather. Their burrows, from 1 to 3 inches deep, were abundant in the furrows in cottonfields in the latter part of November, and often a burrow contained a nymph. Plowing early in February 1931, at a depth of about 3 inches, turned up young crickets in abundance. On warm days in winter the crickets resume their activity, and feed and molt.

In 1933 the first killing frost at Tallulah came on November 10. On that date the nymphs in the insectary consisted of five fifth instars, eight sixth instars, and six seventh instars. These nymphs were in large lantern globes resting on sand. The air temperature in the insectary was practically that out of doors. Early on any morning after a heavy frost the crickets would be standing motionless on the surface of the sand or resting in burrows that they had made. As the temperature rose during the day they became active, fed, and occasionally molted. The mortality during winter is high, however, as can be inferred from the small number of crickets found in spring as compared with the large number present the preceding fall, and is corroborated by the results of tests.

In one test a thick layer of hay in the bottom of an outdoor cage 4 feet square served as shelter for 271 nymphs that were put into the cage in November 1931. The nymphs were of various instars and ranged in length from 5 to 18 mm. Twenty-six of them were of the last nymphal instar, and 50 were of the next to the last. On April 8, 1932, 76 of these crickets were alive, of which 37 were adults, 23 were of the last nymphal instar, and the remainder were of other instars. Of the adults, 15 were males and 22 were females.

In a second test a tub was used with 4 inches of earth in the bottom and hay and Spanish moss on top as protection. Fifty nymphs from 5 to 18 mm in length were put into the tub on October 29, 1931. The tub was covered with wire screen and left over winter in an unheated insectary with screened sides. On April 8, 1932, only three of the crickets were alive; two of these were of the last nymphal instar, and one was of the next to the last.

On October 29 and 30, 1931, 51 crickets, 2 of which were adult females, were put in 4 large lantern globes, each of which was set in a pot of loose earth and filled with Spanish moss. On April 8, 1932, only seven were alive, of which one was an adult female and three were nymphs in the last instar.

Thus the mortality was lowest in the large outdoor cage, in which 28 percent of the crickets survived the winter.

Nymphs that have successfully overwintered become adults late in April and during May. These adults produce the eggs for the first generation and then do not survive long, most of them dying off by June 15.

LIFE HISTORY IN OTHER SECTIONS OF THE UNITED STATES

The life history of the field cricket has been determined in two other sections of the United States. Severin (*13*, *15*) studied the life history of *Gryllus assimilis* in South Dakota and found only one generation a year. The majority of the crickets overwintered in the egg stage, while probably less than 5 percent passed the winter as nymphs, usually as fifth or sixth instars. He suggests that there may be two biological races, as those that pass the winter as nymphs became adults early in the season and there was little overlapping of adults. Severin (*15*) found 8, 9, or 10 nymphal instars distributed as follows: Twenty-nine male crickets with 8 instars, 29 with 9, and 1 with 10; 13 female crickets with 8 instars, 41 with 9, and none with 10.

McGregor (*7*), working in the Imperial Valley of California, found two complete generations and a partial third. The short, mild winters of that section are passed both in the egg stage, hatching being from April 20 to May 15, and as nymphs and adults. Adult crickets were recorded from the fields for every month of the year except December and "overwintering individuals assume merely a partially quiescent condition."

CONTROL

ESTIMATION OF INFESTATION

After it was found that all the crickets, upon emerging from the ground after sunset, remained on the ground for perhaps 2 hours or more, it became the practice to count them on three adjoining rows for a distance of 250 feet. As the rows were 3 feet 4 inches wide, this gave the number for 2,500 square feet, from which the number per acre was computed. The counts were begun at about 9 o'clock each night, by which time the numbers of crickets had become fairly constant.

PLOWING

At first an entire field of cotton was plowed, but without any permanent reduction in the number of crickets. Shallow cultivation in the fall or early in the spring has been recommended by Severin (*13*, *15*) as a means of killing eggs, as it exposes them to the drying effects of the air. A surface cultivation on July 26, 1930, for the purpose of filling cracks in the soil, delayed the reappearance of the crickets for a time, but by August 1 they were as abundant as before.

An experiment on the effects of plowing was made in a field of 5 or 6 acres, where on the night of August 1 there were 2,444 crickets per acre. On August 2 the field was plowed. On August 3, at night, there were 2,600 crickets per acre—an apparent increase in numbers.

DUSTING

Early in the morning of July 19 one of the fields was dusted by airplane with calcium arsenate at the rate of 8 pounds per acre. The dusting was done before sunrise, because the air was then calm and there was dew on the plants. The logical time for dusting for crickets is just before dark, but at that time there is usually a breeze and there is no dew. No benefit from the dusting was apparent on July 20, but by July 22 the numbers of crickets were noticeably less; dead crickets were seen on the ground, and ants were carrying them off. No numerical check on the effect of this dusting was obtained because at that time there was no accurate means of calculating the number of crickets per acre.

On July 29 a check count made in a heavily infested field of 100 acres showed 2,600 crickets per acre. On the middle of this field dusting by airplane was attempted after sunset on July 29, but the wind was too strong and carried the dust up from the cotton plants and in among trees. This dusting was a failure as only a little dust reached the plants. On the following morning, however, the north and the south sides of this field were dusted, calcium arsenate being used on the north side and a mixture of 75 percent of calcium arsenate with 25 percent of paris green on the south side, each at the rate of 8 pounds per acre. A second application was made on August 7 from 5:30 to 6 a. m., at which time there was a dead calm, and the dust settled on the plants. As shown in table 6, the numbers of the crickets were reduced immediately after the dusting and, in general, continued to decrease.

TABLE 6.—*Number of live crickets per acre before and after dusting, Tallulah, La., 1930*

Insecticide	Before dusting, July 29	After dusting				
		Aug. 1	Aug. 5	Aug. 9	Aug. 11	Aug. 13
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Calcium arsenate	2, 600	832	687	274	753	361
Calcium arsenate and paris green, 3:1	2, 600	1, 560	1, 394	1, 524	853	723

Cage tests were made with adult crickets on cotton plants dusted on August 6. Fifteen crickets were put in each of two cages. In the cage dusted with calcium arsenate the mortality was greatest on the third and fourth days after dusting. In the cage dusted with calcium arsenate and paris green (3:1) most crickets died on the fourth day after dusting. All died within 8 days, but a check cage showed no mortality.

POISONED-BRAN MASH

The infestation in the field dusted on July 29 and 30 offered a good opportunity to test poisoned-bran mash as a means of control. The formula used was bran, 50 pounds; paris green, 2 pounds; molasses, 1 gallon; and water, about 6 gallons. This mixture was broadcast at dusk on 12 rows, each 45 feet long and 3 feet 4 inches wide—an area of 1,800 square feet. An adjoining untreated area was used as a check. The counts were made for a distance of 40 feet on three adjoining rows in the middle of each area, or on 400 square feet.

The applications of poisoned-bran mash were made at dusk on 7 successive nights in August. The check counts were made each night from about 7 to 9 p. m. Then the crickets in the poisoned rows were counted and the number per acre calculated. The counting was not difficult with the aid of flashlights, since the crickets were all on the ground at the time. The results are shown in table 7.

TABLE 7.—*Tests in controlling the field cricket with poisoned-bran mash, Tallulah, La., 1930*

Plot	Live crickets [1] per acre on—						
	Aug. 22	Aug. 23	Aug. 24	Aug. 25	Aug. 26	Aug. 27	Aug. 28
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Poisoned	16,008	7,841	3,920	1,960	1,089	1,416	762
Check	2,614	8,059	4,247	4,465	5,118	3,811	2,504

[1] The counts were made each night after the poisoned mash had been distributed.

There was a great reduction in the numbers of crickets on the poisoned plot for 6 days. The number of crickets to begin with on the poisoned plot was remarkably large as compared with that on the check plot. The main reason for this was that the crickets flocked to the bran mash from adjacent untreated rows. Furthermore, the odor of the mash may have drawn more crickets from the cracks in the ground. Many crickets were seen feeding on the mash, and early in the morning there were many dead crickets on the ground.

For the control of the field cricket in South Dakota, Severin (*13, 14, 15*) recommended the destruction of the eggs by shallow cultivation or by deep plowing, and the destruction of the nymphs and adults by a poisoned bait. He found that a very effective poisoned bait was a bran mash prepared with sodium fluosilicate as the killing agent.

Thomas[9] obtained satisfactory control of crickets attacking strawberries by a poisoned bait made of calcium arsenate, 1 pound; corn

[9] THOMAS, W. A. CONTROL OF FIELD CRICKETS IN STRAWBERRY FIELDS. Mimeographed information sheet from the Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine, 1935.

meal, 20 pounds; and molasses solution (1 part to 9 parts water), sufficient to moisten.

Poisoned-bran mash has also been recommended by Riley (*10*), Dean (*3*), and others.

SUMMARY

The field cricket does severe but sporadic damage in cottonfields, especially during periods of drought when the plants are unable to replace the ruined leaves. In feeding, the crickets cut out large pieces from the leaves, eat out the main veins, and sometimes strip small plants entirely. They gnaw into stems and squares and often eat large holes in bolls.

One complete generation is developed during the season and a second generation overwinters as partly-grown nymphs, but with considerable mortality.

The eggs are deposited in the soil and hatch in the early part of the season in from 17 to 31 days, but in May and June this is reduced to from 11 to 18 days. An average of 283 eggs per female was recorded.

The number of nymphal instars ranged from 9 to 12, with 10 as the usual number. The average developmental period of the nymphs was found to be about 75 days.

The sex ratio as determined from the insectary rearings of the first generation was 60 percent males to 40 percent females. Seventy percent of the crickets reared were of the short-winged form.

Plowing to destroy the adults hiding in soil crevices in cottonfields proved ineffective.

Dusting with calcium arsenate or with calcium arsenate and paris green (3:1) was followed by some reduction in the number of crickets.

Poisoned-bran mash apparently gave good control.

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