

STUDIES IN THE BIOLOGY OF THE BOLL WEEVIL IN THE MISSISSIPPI DELTA REGION OF LOUISIANA¹

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The information contained in the following pages was obtained in a series of studies in the life history and biology of the boll weevil, carried on by the writer at the Delta Boll Weevil Laboratory at Tallulah, La. Owing to the fact that what work was accomplished along these lines was done in what time could be spared from other investigations, the methods employed were more or less crude and the results obtained somewhat meager. However, the data obtained are of considerable interest and very suggestive of opportunities for future investigation along similar lines.

The experiments were started with the idea of determining the maximum and minimum number of generations during a season, but as the work progressed new lines of investigation presented themselves, and several of these were studied to some extent.

As no provision had been made to have cotton in the proper stage at an early date and since the season was very backward, the beginning of the work was unavoidably delayed until June 21, when squares began to appear in the field. On account of the lack of time necessary for carrying on the work in plant cages, it was necessary to utilize picked squares and cages of various sorts. This introduced the first unnatural condition. In nature, an infested square stays on the plant six or seven days after being punctured, during which time it grows and retains its moisture to a large extent. Under the conditions as imposed in the experiments the squares began drying before being infested. This had the effect of limiting the food supply of the developing larvæ, and caused a large percentage of the weevils reared to be small, poorly developed individuals. This was not particularly noticeable during the hotter weather, when the developmental period was of short duration; but late in the season, when the developmental period was some days longer, it became such a serious matter that very few weevils were reared, and the work had to be concluded before breeding in the field had ceased. This difficulty was increased by the necessity of importing squares from Texas during September and October, owing to the practically total infestation at Tallulah. The failure to determine the point originally intended was due to this factor.

Throughout the work the squares either dried or rotted badly, according as they were placed after infestation in well ventilated or

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close breeding cages. Nevertheless, eight hundred and sixty-eight weevils, having developmental periods ranging from eleven to nineteen days in duration were reared, and on these the data and conclusions in the following pages are based.

Methods

In starting the work eleven hibernated female weevils and as many males taken in the field were used. The females were captured as follows: five on June 21, two on June 22, and four on June 23. These were paired and each pair placed in a tumbler, closed by a square of cheese cloth, with cotton squares from which the involucres had been stripped. The squares were renewed daily and examined for egg punctures, the infested ones being placed in breeding jars, each jar containing the squares infested by all the weevils during one day. Throughout the oviposition period careful daily record was kept of the number of eggs deposited and the number of squares infested by each weevil. The female weevils were numbered H. 1 to H. 11 (meaning hibernated weevil No. 1, etc.). The males were removed as soon as oviposition was well under way. H. 1 was discarded from the series on June 27, as it had, up to that time, not oviposited, and H. 4 was thrown out on June 30, having deposited only two eggs. No weevils were reared from the eggs of this individual.

It was originally planned to use the earliest ten female weevils and the latest ten of each generation throughout the season. The number of generations reared from the earliest females would be the maximum and the number reared from the latest females the minimum number of generations possible during the season. This was carried out to the fourth generation with the earliest females, but of the latest females only those of the first generation were reared. At the time when the last eggs of the latest first generation weevils were being deposited, about the middle of September, the squares from Texas were being used, and very few adults were reared. Moreover, no squares except those from Texas were obtainable, and no attempt was made to carry the work beyond the first week of October.

Each of the female weevils which were kept for breeding the next generation was labeled with the number of the generation to which it belonged together with a letter, indicating whether it was one of the earliest or one of the latest of its generation. Thus weevil No. 4.c was the third earliest female weevil of the fourth generation and No. 1.y was the next to the last of the first generation. Each female was placed with a male in a tumbler, given fresh squares daily, and otherwise treated exactly as were the hibernated weevils.

The male weevils used were obtained sometimes from the field and sometimes from the breeding cages.

The squares infested by each series of weevils were kept in separate lots, but all those infested by the weevils of a given series during one day were placed in a common breeding cage. Thus each lot of infested squares represented one day's work of all the weevils of one series.

In order to equalize as far as possible the humidity surrounding the various lots of squares, small lots were placed in tumblers or even in large tubes with cheese cloth covers, while larger lots were placed in lantern chimneys with a square of cheese cloth over each end. The last were placed on their sides to admit of a free circulation of air about the squares. In spite of these precautions many of the squares dried too rapidly, while others became sodden and decayed badly. The greatest difficulty was experienced with the earliest infested squares of each generation, always small in number, which dried so rapidly that few of them produced adult weevils.

The methods employed in the more minute studies of the various stages and in obtaining data on other points will be described under the several topics.

Oviposition

In depositing an egg within a square, the female weevil first tests the square minutely, running over it excitedly and feeling it with the antennæ. Finally selecting a suitable place, usually on the surface of the calyx toward the base of the square, she begins drilling a hole by pulling off a little flake of the outer epidermis. Then, with her feet strongly braced and by gnawing and pushing with an augur-like motion, she thrusts her beak into the tender portion of the square. At the bottom of the puncture she makes a small cavity by gnawing, at the same time moving about the hole with the beak as a pivot. Withdrawing her beak she turns about with the center of her body as a pivot. This places the tip of her abdomen directly over the puncture, into which she thrusts her ovipositor, depositing a single egg in the chamber at the extreme end of the puncture. As she withdraws her ovipositor she plugs the puncture with a particle of excrement, pressing it down with the tip of her abdomen.¹

Sometimes the weevil fails to locate the puncture immediately with her ovipositor. In this event she searches excitedly, moving the tip of the abdomen about, feeling carefully over the surface of the square. In this search, however, she never moves her front feet, evidently

¹ In the progress of the work many egg punctures were observed which were not plugged with excrement. These could, with a lens, be distinguished from the feeding punctures by a thin film of moisture closing the puncture just below the surface of the square, and due to the moisture from the ovipositor.

using the position of these as a guide to the distance through which she should search. Failing to locate the puncture in this way, she again turns around and searches for it with her beak and antennæ. If still unsuccessful she abandons the search and makes a new puncture.

Several weevils were watched during the act of oviposition and the various portions of the process carefully timed. The time required for making the puncture varied from 1 min. 20 secs. to 8 mins. 27 secs., with an average of 3 mins. 36 secs. In but two cases did the weevil fail to locate the puncture with the ovipositor immediately. In one case the weevil found it after 1 min. 15 secs., and in the other after several minutes search the weevil abandoned it and started a new puncture. For the deposition of the egg and the sealing of the puncture the time required varied from 35 secs. to 1 min. 40 secs., with an average of 59 secs. The total time for the whole process varied from 2 min. 45 secs. to 9 mins. 30 secs., with an average of 4 mins. 41 secs. Exclusive of the time lost in hunting for the puncture, one of the weevils accomplished the act in 1 min. 55 secs.

Periodic Division of Daily Oviposition

For observations on this point the day was divided into five periods as follows: early morning, from daylight to 9.00 a. m.; late morning, 9.00 a. m. to 1.00 p. m.; early afternoon, 1.00 p. m. to 5.00 p. m.; late afternoon, 5.00 p. m. to dark; and night, dark to daylight. At the time the observations were made, from 5.00 p. m. July 20 to 5.00 p. m. July 22, daylight occurred at about 4.00 a. m. and dark at about 7.30 p. m. The two days were partly cloudy but bright and the two nights clear and moonlight. During the entire time the weevils were kept in large tubes on covered porches, during the day at the laboratory and during the night at the observer's home. At the end of each period all of the squares were removed and fresh ones supplied. All infested squares were opened to verify the fact of oviposition. The first generation weevils, 1. a-k (exclusive of 1. h), ten in number, were used. Weevil 1. b was eliminated from the results, as it deposited only one egg during the two days.

The figures obtained show that of the nine weevils six deposited eggs during the night period. On the first day the four daylight periods ranked in hourly oviposition as follows: late afternoon, early afternoon, early morning, and late morning, the weevils being much more active in the latter half of the day. On the second day the preference for the afternoon is again shown, but these two periods are reversed in order, as are also the two morning periods. The total results, obtained by adding the two days oviposition, are given in Table I. This table shows that, although there was a decidedly

larger percentage of eggs deposited in the early afternoon, the rate of oviposition is faster in the later period. There is apparently little preference on the part of the weevils between the two morning periods. The record of weevil 1. c is omitted from this table, as it died during the second day, and its record is therefore incomplete.

TABLE I
SUMMARY OF PERIODIC DIVISION OF OVIPOSITION

Period	Total eggs laid	Time in two days	Average No. eggs per hour	Per cent total oviposition in each period	Average eggs per weevil per hour.
5 p. m.-7.30 p. m.	25	5 hours	5.00	23.15	0.63
7.30 p. m.-4 a. m.	10	17 "	.59	9.26	0.07
4 a. m.-9 a. m.	21	10 "	2.10	19.44	0.26
9 a. m.-1 p. m.	17	8 "	2.13	15.74	0.27
1 p. m.-5 p. m.	35	8 "	4.38	32.41	0.55

Total, Daily, and Maximum Oviposition and Oviposition Period

Since only enough eggs from the first weevils of each generation were needed to insure a supply of female weevils for the subsequent generations, these weevils were not fed beyond a few days. No data were therefore obtained on their total oviposition. Data of this sort were obtained only for the hibernated weevils and the latest weevils of the first generation.

Oviposition of hibernated weevils.—After the discarding of weevils H. 1 and H. 4 nine hibernated weevils were left for carrying on the observations. These began ovipositing within from one to six days after being placed in the cages. The oviposition period lasted from fourteen to fifty-three days, during which time the weevils deposited from 51 to 304 eggs. The average oviposition was 203.33 eggs and the average period 34.44 days. The average daily individual oviposition varied from 3.4 to 7.66 eggs, with a total average of 5.9 eggs per day. The maximum number of eggs deposited by any weevil during one day was twenty. In all probability, had these weevils been at large, the oviposition period would have been longer and the average daily and maximum oviposition smaller, as the great abundance of squares and the elimination of the search for them undoubtedly conduced to rapid oviposition. Probably also the inability of the confined weevils to remate had some effect on the oviposition. The life of the weevils after the completion of oviposition varied from death on the last day of oviposition to ten days after the last egg, although only two of the nine lived more than three days.

The results of these observations are summarized in Table II.

TABLE II

SUMMARY OF OVIPOSITION OF HIBERNATED WEEVILS

Weevil No.	Date placed in cage	Date first egg	Date last egg	Date of death	Oviposition period, Days	Total number eggs	Average daily oviposition	Maximum No. of eggs one day
H. 2.....	June 21	June 23	July 29	July 30	37	248	6.70	16
H. 3.....	" 21	" 27	" 10	" 16	14	66	4.71	8
H. 5.....	" 21	" 22	" 13	" 14	22	115	5.23	14
H. 6.....	" 22	" 25	" 9	" 10	15	51	3.40	9
H. 7.....	" 22	" 24	Aug. 15	Aug. 25	53	229	4.32	16
H. 8.....	" 23	" 24	" 11	" 14	49	282	5.75	16
H. 9.....	" 23	" 24	" 3	" 6	41	242	5.90	17
H. 10.....	" 23	" 24	July 31	" 2	38	201	7.66	18
H. 11.....	" 23	" 24	Aug. 3	" 3	41	304	7.41	20
Totals.....						1,530		
Averages.....					34.44	203.33	5.90	14.9

Oviposition of latest first generation weevils.—The work was concluded while the latest of the first generation weevils were still ovipositing, but somewhat desultorily. The work with these weevils was, however, carried on over a period of 49 days and some data of interest were obtained. Of the nine weevils, of which the lot originally consisted, four died without producing any eggs and one was lost after five days of ovipositing. Of the four remaining, one was ovipositing throughout the 49 days, one for 44 days, and one for 43 days, while the fourth had apparently ceased ovipositing after 47 days. During the above periods the weevils deposited the following numbers of eggs: 295, 211, 183 and 198. The average total oviposition for the four weevils was 221.75 eggs. The average daily oviposition was 4.78 eggs, and the maximum number of eggs deposited by any one weevil during one day was twelve. These results are summarized in Table III.

TABLE III

SUMMARY OF OVIPOSITION OF LAST WEEVILS OF FIRST GENERATION

Weevil No.	Date first egg	Date last egg	Oviposition period, Days	Total number eggs	Average daily oviposition	Maximum number of eggs one day
1. r.....	Aug. 21	Oct. 6	47	198	4.04	9
1. s.....	" 21	" 8	49	295	6.02	11
1. x.....	" 26	" 8	44	211	4.79	12
1. s.....	" 27	" 8	43	183	4.26	9
Totals.....				887		
Averages.....			45.75	221.75	4.78	10.25

The Life Cycle

The life cycle of the weevil may properly be divided into three periods: the developmental, preoviposition (the time between emergence and the beginning of oviposition), and oviposition periods. The last has already been discussed. The developmental period may be divided into the egg or incubation, larval, pupal and postpupal or teneral adult periods. The last is the time after the casting of the pupal skin, during which the weevil remains in the pupal cell.

Preoviposition Period

Data on this period in the life of the weevil was obtained from 43 weevils, representing the earliest individuals of generations one to four and the latest of generation one. As far as possible the date of copulation was obtained. This date is, however, very liable to error, since this act may be repeated between the same two weevils a number of times and even after oviposition has commenced. The time observed to have elapsed between emergence of the female and copulation varied in thirteen cases from two to seven days. In one of the two cases, in which seven days had elapsed, the original male weevil died on the sixth day and a new one was substituted. On the seventh day the pair were in copula and two eggs had been deposited. In the other seven day case copulation was also observed on the date of first oviposition. Copulation must, therefore, have taken place sometime before observed, in all probability by the third day. These observations, therefore, mean little except as they show the minimum time required for the proper maturing of the sexes for copulation.

As mentioned above, the minimum time from emergence of the females to copulation was two days. The male in this pair was, however, one day older than the female, and copulation in this case may have been due entirely to the extreme amour of the male, and does not necessarily mean that the ovaries of the female were ripe for fertilization. In two cases the time elapsed between emergence and copulation was three days. In one of these pairs the male was four days old at the time of copulation, and in the other both sexes were of the same age. These three cases would seem to indicate that the normal time necessary for the ripening of the sexual organs in both sexes is about three days.

The total period from emergence to oviposition varied from five to twenty-three days. The seven longest periods occurred in the weevils taken as the earliest of the fourth generation. Three of these were reared from squares infested by the latest weevils of the first generation and the rest, from those infested by the early third generation weevils. The long time required by these weevils is probably partly due

TABLE IV
SUMMARY OF PERIOD FROM EMERGENCE TO OVIPOSITION

Weevil groups	Date of emergence	Date of copulation	Number of individuals	Days emergence to copulation			Date of first egg	Number of individuals	Days emergence to oviposition		
				Min.	Max.	Mean			Min.	Max.	Mean.
Earliest weevils of first generation.....	July 8-11	July 13-15	9	2.00	7.00	4.33	July 14-19	11	5.00	8.00	6.00
Earliest weevils of second generation.....	July 29-31	.....	.....	.....	.....	.....	Aug. 5-7	7	5.00	8.00	6.29
Latest weevils of first generation.....	Aug. 14-22	Aug. 19	1	5.00	5.00	5.00	Aug. 21-27	7	5.00	7.00	6.29
Earliest weevils of third generation.....	Aug. 19-21	Aug. 22-26	3	3.00	7.00	5.33	Aug. 26-28	9	6.00	9.00	6.89
Earliest weevils of fourth generation.....	Sept. 10-20	.....	.....	.....	.....	.....	Sept. 18-Oct. 8	9	8.00	23.00	12.89
Totals and averages.....	.....	.....	13	2.00	7.00	4.46	.....	.....	5.00	23.00	7.72

to the fact that they were reared at the time when the larval food was insufficient, on account of the long period required for development and the poor condition of the squares supplied. They do not, therefore, probably represent the normal time required by weevils at that season, but exceed this time by several days. The average time of 7.72 days is also probably somewhat in excess of the normal average.

The number of eggs produced on the first day of oviposition shows remarkable variation, from one to seven. Of the forty-three weevils, sixteen produced one egg and thirteen two eggs; in other words more than 67 per cent of the weevils deposited, on the first day of oviposition, less than three eggs. Some of the others responded more readily to the incentive furnished by the abundance of squares and probably exceeded their normal habit.

A summary, by groups, of the results of these observations are shown in Table IV.

Developmental Period

Incubation period.—Data on the incubation period were obtained from six lots of eggs. Of these, four lots, deposited June 27 to July 4, showed a period of about three days, and two lots, deposited July 8–10, gave a period of about two and a half days. A study of the average temperatures during the incubation periods of these six lots of eggs shows that the average maximums for the eggs having the shortest incubation periods were much higher than for those requiring the longer period, the means slightly higher, and the minimum slightly lower. This indicates that the maximum temperature is the determining factor in the duration of the incubation period. This is shown very clearly in Table V.

TABLE V

TABLE SHOWING RELATION BETWEEN INCUBATION PERIOD OF ROLL WEEVIL AND TEMPERATURE

Date of oviposition	Date of examination	Days elapsed oviposition to examination	Number of individuals	Number unhatched	Number hatched	Estimated duration incubation period	Average temperature during incubation period		
							Max.	Min.	Mean
June 27–28	July 1	3.5	6	1	5	3.0	86.4	69.7	78.1
" 28	" 1	3.0	4	3	1	3.0	86.3	69.2	77.8
" 29	" 2	3.0	10	4	6	3.0	86.8	69.2	77.8
July 3–4	" 7	3.5	several	0	all	3.0	86.6	71.8	79.3
" 8–9	" 11	2.5	12	1	11	2.5	91.0	68.8	70.0
" 9–10	" 12	2.5	10	2	8	2.5	91.7	69.3	80.5

For determining the duration of the several stages of the developmental period beyond the egg, a start was made with 107 eggs of known date. The date of hatching was estimated on the basis of the incubation period as previously determined. Of the eggs used nine were deposited June 27-28, five June 29-30, thirteen June 30-July 1, forty July 1-2, twelve July 3-4, and twenty-eight July 6-7. The incubation period for the last of these lots was placed at two and one half days and for the others at three days. The squares containing these eggs were opened a short time before pupation was expected to take place. Thereafter they were examined daily and the dates of pupation, formation of the teneral adult, and emergence recorded. By these means the actual progress of the weevils from the egg to emergence was ascertained with considerable accuracy. Of the original 107 individuals, the larval period of 98, the pupal period of 50, and the postpupal or teneral adult and total periods of 58 were determined.

The results obtained indicate that the larval period occupies slightly less than one half of the total developmental period, and approximately equals the incubation and pupal periods combined. The larval period showed somewhat greater variation than the inactive periods, the excess being probably due to the drying of the opened squares, while the egg and pupal periods were influenced largely by the temperature. The variation of one to three days in the postpupal period can be explained only by the peculiarities of the individual weevils.

The average mean total developmental period of the weevils under observation was somewhat higher than of weevils from undisturbed squares infested during the same period, due to the more rapid drying of the opened squares. The average developmental period of the 92 weevils bred from unopened squares was 13.4 days, 0.4 of a day less than for those in the opened squares. The average mean developmental period as determined above taken together with the average preoviposition period, shown in Table IV, gives an average total life cycle, exclusive of the oviposition period of about twenty days. The minimum, however, as shown by the figures of these two sets of observations, may be as low as sixteen days.

The data on the total developmental period and its several divisions are shown in Table VI.

The developmental period for individual weevils throughout the season was taken as the time between the average date of oviposition and the average date of emergence. Since examinations were made only once in twenty-four hours, this gives a possible variation of two days, and, when one observation was omitted, of three days. Obtained

TABLE VI
SUMMARY OF TOTAL DEVELOPMENTAL PERIOD

Date of deposition of eggs	Number of individuals	Incubation period, Days	Date of hatching	Date of pupation	Number of individuals	Larval period.			Date of teneral adult	Number of individuals	Pupal period.			Date of emergence	Number of individuals	Teneral adult period, Days	Total period oviposition to emergence.		
						Max.	Min.	Mean			Max.	Min.	Mean				Max.	Min.	Mean
6.27-28	9	3	6.30-7.1	7.7-8	9	8	6	7											
6.29-30	5	3	7.2-3	7.8-9	5	7	5	6											
6.30-7.1	13	3	7.3-4	7.8-9	1	6	4	5	7.12	1	4	3	3.5	7.14	1	2	14	13	13.5
				7.9-11	9	8	5	6.5	7.13	5	4	2	3	7.15	4	1	14	13	13.5
7.1-2	40	3	7.4-5	7.10-11	18	7	5	6	7.14	4	4	3	3.5	7.15	3	1	14	13	13.5
7.3-4	12	3	7.6-7	7.12-13	11	7	5	6	7.15	3	3	2	2.5	7.17	3	2	14	13	13.5
7.6-7	28	2.5	7.9-10	7.13-14	2	5.5	3.5	4.5	7.17	2	4	3	3.5	7.19	2	2	13	12	12.5
				7.14-15	15	6.5	4.5	5.5	7.18	15	4	3	3.5	7.20	10	1	13	12	12.5
				7.15-16	4	7.5	5.5	6.5	7.18	1	3	2	2.5	7.21	1	3	14	13	13.5
Totals and averages	107	2.8		7.16-17	1	8.5	6.5	7.5	7.22	1	6	5	5.5	7.21	2	2	15	14	14.5
					98	7.3	5.2	6.3		50	3.9	2.8	3.3		58	1.6	14.3	13.3	13.8

in this manner, the total period varied from eleven to nineteen days. The former is probably a somewhat shorter time than actually elapsed in any case, but the error was counterbalanced by the later weevils in the same lot of squares. In all probability, the earliest weevils from a lot of eggs deposited within twenty-four hours came from the earliest eggs and the latest from the latest eggs, so that, other things being equal, the developmental period of all the weevils from these eggs would be equal.

One of the principal factors in causing variation in the length of the developmental period within a given lot of squares and between different lots of squares during the progress of the work was the condition of the food supply. This factor was most troublesome and most difficult of control, especially in small lots of squares and late in the season.

The following table shows the variation in the length of the developmental period and the number of weevils requiring the different periods for development:

TABLE VII

Developmental period. Days	Number of weevils
11.0	6
12.0	118
12.5	16
13.0	342
13.5	14
14.0	178
14.5	10
15.0	79
15.5	2
16.0	62
16.5	1
17.0	29
18.0	8
18.5	1
19.0	1

Another factor which largely affected the development of the weevils was the temperature. In order to indicate as nearly as possible the effect of temperature on the length of the developmental period, the weighted average daily and periodic developmental periods were calculated for all of the weevils bred. The average daily period varied in duration from twelve to nineteen days, but, as each of these extremes include data on only one weevil each, the variation is more accurately shown by the thirty-three weevils emerged on August 7, which averaged 12.45 days, and the twenty emerged September 22 which averaged 16.67 days. The average period for the 868 weevils reared was 13.68 days.

For convenience in showing the effect of the temperature on the duration of the developmental period, the dates of emergence were divided as far as possible, into groups of ten days each and the weighted average

period determined for all weevils emerging between the extreme dates. For the first period, ten days ending July 17, the average period was 14.25 days; second period, ten days ending July 27, 13.9 days; third period, ten days ending August 6, 13.54 days; fourth period, ten days ending August 16, 12.92 days; fifth period, six days ending August 22, 13.48 days; sixth period, ten days ending September 11, 14.0 days; seventh period, ten days ending September 21, 15.31 days; and eighth period, eight days ending September 29, 15.97 days.

The weighted average daily, periodic, and seasonal developmental periods are shown in Table VIII.

TABLE VIII
WEIGHTED AVERAGE DAILY, PERIODIC, AND SEASONAL DEVELOPMENTAL PERIODS

Date of emergence	Number of weevils	Average developmental period	Average for period	Date of emergence	Number of weevils	Average developmental period	Average for period
July 8	6	14.17	14.25	Aug. 13	19	13.05	12.92
" 9	8	14.50		" 14	8	12.88	
" 10	7	14.29		" 15	6	13.17	
" 11	11	15.14		" 16	3	13.00	
" 14	7	13.29		" 17	1	15.00	
" 15	5	13.40		" 18	3	13.00	13.48
" 16	21	14.38		" 19	9	13.22	
" 17	7	13.86		" 20	12	13.50	
" 18	16	12.88	13.90	" 21	16	13.56	
" 19	12	12.50		" 22	5	13.60	
" 20	17	13.18		Sept. 2	1	12.00	14.00
" 21	54	12.94		" 5	2	13.50	
" 22	47	12.96		" 6	6	13.50	
" 23	25	12.48		" 7	9	13.44	
" 24	25	13.16		" 8	4	13.75	
" 25	18	13.33		" 9	5	14.80	15.31
" 26	15	13.27		" 10	6	14.00	
" 27	26	13.35		" 11	8	13.75	
" 28	29	13.58	13.54	" 12	7	14.14	15.97
" 29	14	14.00		" 13	8	14.13	
" 30	18	13.78		" 14	1	14.50	
" 31	29	14.69		" 15	8	14.75	
Aug. 1	8	13.25		" 16	2	15.75	
" 2	13	12.92		" 17	7	14.86	19.00
" 3	23	13.17		" 18	11	15.41	
" 4	18	12.94		" 20	17	16.09	
" 5	22	13.14		" 21	10	16.40	
" 6	13	13.00		" 22	20	16.67	15.00
" 7	33	12.45	13.00	" 23	15	15.00	
" 8	13	13.15		" 25	12	16.08	
" 9	10	13.00		" 26	5	16.20	
" 10	11	12.82		" 27	5	15.60	
" 11	20	13.00		" 29	1	17.00	
" 12	14	13.43					
Total weevils and average for season.....					868	13.68	

The method of obtaining the average temperatures used to show the effect of this factor on the duration of the developmental period was as follows: all recorded maximum, minimum, and mean temperatures from the average date of oviposition to the average date of emergence

were added and the average struck. These average temperatures, together with the average developmental periods of the weevils reared during the different periods, and the number of weevils representing each period, are shown in Table IX. The relation between the temperature and the developmental period is shown in graphic form on the chart. This chart shows that the relation between the average periods and any of the temperature curves is most intimate with that of the minimum, the developmental curve going down as a rule when the minimum curve goes higher. The only exceptions to this rule are found in the first and fifth periods. These two periods were repre-

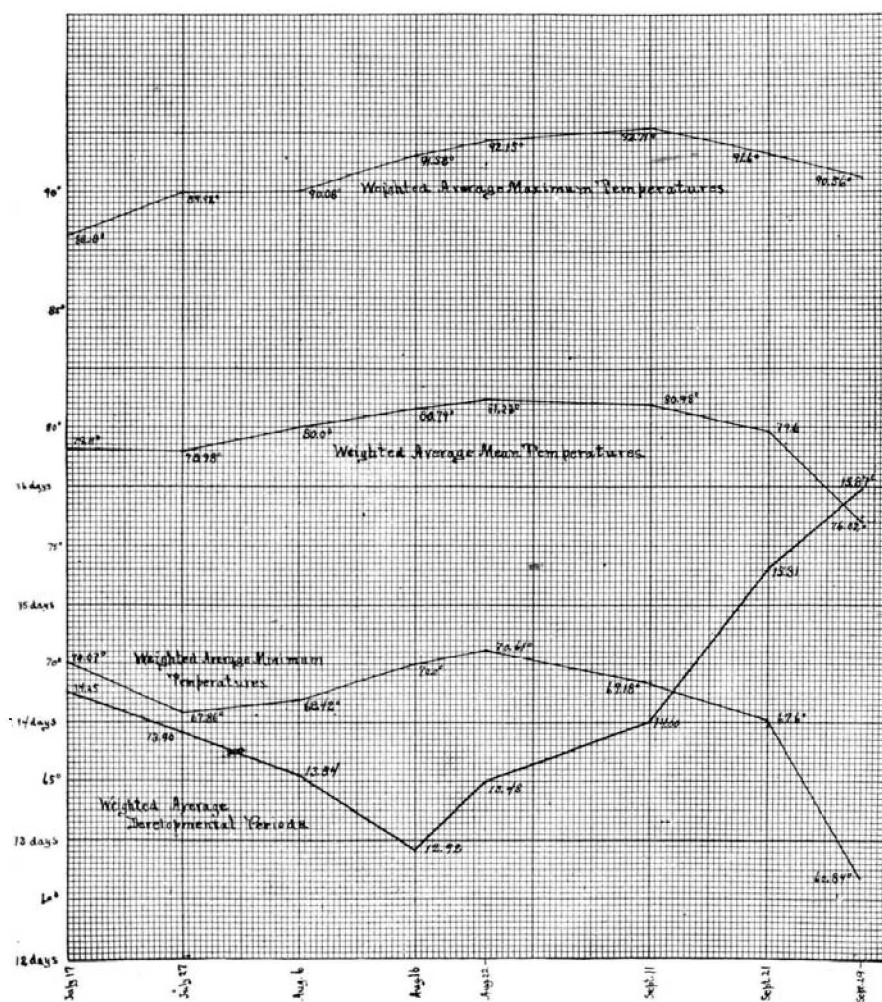


Chart showing relation between temperature and developmental period of cotton boll weevil

sented by seventy-two and forty-six weevils respectively, bred from the earliest and latest eggs of the original hibernating weevils. The lots of squares from which they were reared were small and the factor of food condition had a large effect in retarding the development. In addition, the earliest period is represented by weevils reared before the best methods of keeping infested squares were found, and these weevils were therefore further retarded by this extra deleterious effect on their supply of food. The average developmental periods in the last three periods were also considerably increased from the normal by the poor condition of the squares used late in the season. These three periods were also represented by rather small numbers of weevils. Also, the sixth period is represented only by weevils reared from the earliest eggs of two lots of weevils and hence from small lots of squares.

TABLE IX
RELATION BETWEEN LENGTH OF DEVELOPMENT AND TEMPERATURE

Number of period	Number of weevils	Average developmental period	Average date of oviposition	Average date of emergence	Average temperatures		
					Min.	Mean	Max.
1	72	14.25	June 29	July 12	70.07	79.11	88.18
2	255	13.90	July 9	July 22	67.86	78.98	89.92
3	187	13.54	" 20	Aug. 1	68.42	80.00	90.08
4	137	12.92	" 30	" 11	70.00	80.79	91.58
5	46	13.48	Aug. 6	" 19	70.61	81.23	92.15
6	41	14.00	" 24	Sept. 6	69.18	80.98	92.71
7	71	15.31	Sept. 1	" 16	67.60	79.60	91.60
8	58	15.97	" 10	" 25	60.84	76.02	90.66

Comparative Duration of Developmental Period in Males and Females

Before the work had progressed very far it was noticed that, in general, a relative majority of the earliest weevils reared from the different lots of squares were females and that the percentage of males increased as time passed. A summary of the records in this respect shows the following: of the 86 lots of squares, the females had the shortest average development in forty, the males in twenty-two, from ten lots only females were reared, from seven lots only males, and in seven cases the developmental period for both sexes was the same. The weighted average developmental period for the 475 males reared was 13.88 and for the 393 females 13.49 days, a difference of 0.39 days.

A summary of the figures based on oviposition days is given in Table X.

TABLE X

COMPARATIVE LENGTH OF DEVELOPMENTAL PERIOD OF MALE AND FEMALE BOLL WEEVILS

(In last column the signs indicate the sex showing shorter period.)

Total number of weevils	Number of males	Average period. Days	Number of females	Average period. Days	Difference
49	22	13.27	27	13.15	♀ 0.12
43	21	13.29	22	12.59	♀ 0.70
38	24	13.67	14	13.43	♀ 0.24
35	17	12.41	18	12.28	♀ 0.13
33	16	12.94	17	12.69	♀ 0.25
32	19	14.05	13	14.38	♂ 0.33
27	15	13.00	12	12.33	♂ 0.67
24	15	12.73	9	13.22	♂ 0.49
23	14	13.79	9	14.00	♂ 0.21
22	10	13.20	12	13.33	♂ 0.13
21	11	13.45	10	12.80	♂ 0.65
21	14	16.14	7	15.71	♀ 0.43
20	11	14.27	19	13.29	♀ 0.96
19	9	13.89	10	13.80	♀ 0.09
19	9	12.33	10	13.10	♂ 0.77
19	10	13.20	9	13.00	♂ 0.20
18	9	12.72	9	13.17	♂ 0.45
17	9	14.67	8	13.25	♀ 1.42
17	5	13.80	12	12.83	♀ 0.97
13	13	13.38	3	13.33	♀ 0.05
16	7	13.43	9	13.00	♀ 0.43
16	10	13.70	6	12.83	♀ 0.87
16	9	13.55	7	13.43	♀ 0.12
15	9	12.79	6	13.00	♂ 0.21
15	10	16.50	5	16.60	♂ 0.10
14	10	15.10	4	14.00	♂ 1.10
14	9	16.11	5	16.00	♂ 0.11
13	8	13.88	5	13.90	♂ 0.02
13	7	13.86	6	13.83	♂ 0.03
13	8	15.12	5	13.10	♂ 2.02
12	9	13.33	3	13.67	♂ 0.34
11	7	15.29	4	15.25	♀ 0.04
11	3	14.33	8	14.00	♀ 0.33
11	8	12.62	3	12.00	♀ 0.62
11	6	13.67	5	13.40	♀ 0.27
11	9	13.33	2	13.50	♂ 0.17
11	8	15.50	3	15.67	♂ 0.17
11	7	15.43	4	15.75	♂ 0.32
9	5	13.40	4	13.50	♂ 0.10
9	6	16.50	3	16.00	♂ 0.50
7	4	14.75	3	14.67	♂ 0.08
6	5	15.20	1	16.00	♂ 0.80
6	4	13.50	2	13.50	
6	5	12.80	1	12.00	♀ 0.80
6	3	13.33	3	13.67	♂ 0.34
6	1	14.00	5	13.20	♀ 0.80
5	1	16.00	4	15.00	♀ 1.00
5	3	13.33	2	12.50	♀ 0.83
5	2	15.00	3	15.00	
5	2	17.00	3	17.33	♂ 0.33
4	2	12.50	2	13.00	♂ 0.50
4	2	14.00	2	14.00	
4	3	15.33	1	16.00	♂ 0.67
3	1	14.00	2	14.00	
3	3	14.00			
3			3	13.33	
3	3	15.67			
2			2	14.50	
2	1	17.00	1	15.00	♀ 2.00
1			1	17.00	
1			1	15.00	
1			1	13.00	
1			1	11.00	
1	1	12.00	1	12.00	
1	1	12.00			
1	1	19.00	1	14.00	
868	475	13.88	393	13.49	♀ 0.39

Reference to this table shows that the shorter period for females occurred in squares infested on twenty-five out of the thirty-eight days when the lots of infested squares were large and more than ten weevils were reared, and the ratio for smaller lots was only seven out of thirteen in which the females showed the shorter period. Other things being equal, the larger the lot of squares, the better the condition for food and the shorter the developmental period of the weevils reared. It was in these larger lots that the predominance of females among the earliest weevils from a given day's squares was most noticeable.

THE COCCIDÆ OF LOUISIANA¹

Second Paper

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The following list of Coccidæ is the result of a rather extended search among the flora of Audubon Park, New Orleans, La., commenced more than a year ago, to ascertain what species of scale insects were the main source of food supply for the Argentine Ant, *Iridomyrmex humilis* Mayr. A preliminary list of the "Coccidæ of Audubon Park" was published in this JOURNAL last year (Vol. III, No. 5, p. 420-425, 1910) and included 34 species, with the host plants upon which they were collected. Since this list appeared, a considerable number of additional species have been collected, and the writer concluded to add to his own collections all species previously collected in Louisiana of which he could find reliable record, with the intention of commencing a check list of the Coccidæ of the state.

That this list is not nearly complete is proven by the number of newly-recorded species which have been added to it within the past year. Close search through our scanty available literature has resulted in finding records of 35 species previous to 1910. The present list almost doubles this number, as it includes 65 species, all but 20 of which are represented in Audubon Park. However, it is obviously more complete than the records which were available previously.

In order to insure accuracy, all determinations of material collected by the writer have been made by the Bureau of Entomology at Washington, D. C., through the courtesy of Dr. L. O. Howard. The writer herewith expresses his deep indebtedness to Messrs. J. G.

¹Published by permission of the Chief of the Bureau of Entomology.