FURTHER BIOLOGICAL NOTES ON THE COLORADO POTATO BEETLE, LEPTINOTARSA 10-LINEATA* (SAY), INCLUDING OBSERVATIONS ON THE NUMBER OF GENERATIONS AND LENGTH OF THE PERIOD OF OVIPOSITION. II, ILLINOIS.

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In presenting for publication the results of a third successive year's observations on the biology of this insect made in the latitude of Urbana, Illinois and supplementing those made in Georgia in 1906 (Girault and Rosenfeld, 1907) and in Ohio in 1907 (Girault, 1908), it becomes necessary to state that little or no progress has been made in regard to the continuity of observation and experiment, so that they should still be classed as desultory. The observations were made in the open or east insectary of this office at Urbana under as normal conditions as possible, but during odd hours and without previous forethought or planning and subject to much neglect at a critical time toward the last.

They are presented, therefore, mainly to add to the sum of biological data on this insect, which in the end may lead to the discovery of important laws. At present, however, they form but a small beginning and cover but one or two biological factors; as they supplement to a large degree the observations made in Ohio (Girault, 1908), they are presented in the same general manner.

Those who gather data of this kind cannot help being impressed by our poverty in this respect and by the urgent necessity of accuracy in observation, to the minute as regards time and to the fraction of a degree as regards temperature, though it is true that such errors as occur should be chance errors, hence negligible. And most decidedly other factors should be taken into consideration, for in matters of this kind,

* This may seem a trivial matter but consistency demands that the specific name of this insect be written as it was originally by Say; I see no necessity for change or reason therefor and certainly stability in nomenclature is not aided by making one. See articles 15 and 19, The International Code of Zoological Nomenclature as Applied to Medicine (Stiles, 1905). If a change was necessary the form x-*lineata* would seem preferable to the other, being less radical. A. A. G.

we cannot foresee of what great importance the most trivial observations may become in the future and there is, doubtless, more than one cause for variability in periods of development.

SUMMARY.

The following paper merely contains additional biological data along the same lines as those presented previously, obtained during the season of 1908, together with an account of the breeding of adults in confinement which resulted in reproduction by the second generation of adults under adverse conditions. This reproduction by the second generation of adults apparently, was further hindered by actual starvation and was scanty, but the behavior of the beetles would lead to the belief that they were both willing and eager to reproduce. The fact is clearly shown that reproduction occurred with a pair of normal adults of the second generation, a result contrary to what we understand to be the meaning brought out by Tower (1906), discussed previously (Girault, 1908). We do not, however, make any claims, but the evidence is sufficient to establish the fact that *exceptionally* the adults of the second generation in normal beetles do develop the germ-cells before a period of hibernation.

THE EGG.

1. *Length of Stadium.**

The duration of embryonic development was determined for about nine hundred cases during the breeding season and the results are tabulated in Table I. The separate lots were confined as previously, in darkness. In every case recorded the time is actual, unless noted to the contrary. By comparing these records with those given by Girault (1908, Table I, p. 156), differences are noticeable in regard to the duration of the stage at the same approximate dates for the two latitudes; witness Lot I of the two tables. We should expect to find here a corresponding difference in the temperatures.

* This term is used in preference to *instar* which was originally proposed to designate the insect itself at any stage or period of development, as the egg instar, third larval instar and so on, just as we say the larva, caterpillar, pupa or imago.

TABLE I.

Duration of the Egg Stadium, Urbana, Ill., Season 1908.

Remarks.	Lot No.	No. eggs	Deposited			Hatched			Duration		Effective Temp Daily Averages, Degrees Fahr.
			Month	Day	Time	Month	Day	Time	Days	Hours	
Pair No. 3 Hib. adults ..	1	58	May	29	11:45 a. m.	June	5	9:45 a. m.	6	22	24.47°
" " 3 " ..	2	49	"	30	1:30 p. m.	"	6	11:30 a. m.	6	22	25.41°
" " 1 " ..	3	18	June	4	7:00 p. m.	"	9	7:00 p. m.	5	..	34.24°
" " 1 " ..	4	48	"	8	10:45 a. m.	"	14	6:30 p. m.	6	7¾	26.9°
" " 1 " ..	5	43	"	9	3:00 p. m.	"	16	12:00 m.	7	9	24 4°
" " 3 " ..	6	33	"	12	1:00 p. m.	"	18	5:45 p. m.	6	4¾	26.25°
" " 1 Gen. 1	7b	60	July	6	1:15 p. m.	July	11	7:00 p. m.	5	5¾	32.40°
" " 1 "	8c	58	"	8	3:00 p. m.	"	13	5:00 p. m.	5	2	37.67°
" " 1 "	9d	43	"	8	4:30 p. m.	"	13	1:00 p. m.	4	21½	37.81°
" " 1 "	10e	56	"	10	1:00 p. m.	"	14	9:00 p. m.	4	8	40.22°
" " 3 Hib. adults ..	11	40	"	10	1:45 p. m.	"	15	11:30. a. m.	4	21¾	39.54°
" " 1 Gen. 1	12f	32	"	11	4:00 p. m.	"	16	9:00 p. m.	5	5	38.46°
" " 3 Hib. adults ..	13	28	"	14	2:30 p. m.	"	19	7:00 p. m.	5	4½	37.74°
" " 1 Gen. 1	14	80	"	14	2:30 p. m.	"	19	6:00 a. m.	4	15½	35.64°
" " 1 "	15	83	"	18	3:15 p. m.	"	24	8:00 a. m.	5	16¾	33.07°
" " 3 Hib. adults ..	16	11	"	19	3:30 p. m.	"	25	6:00 a. m.	5	14½	34.05°
" " 1 Gen. 1	17	53	"	19	12:30 p. m.	"	24	5:00 p. m.	5	4½	33.41°
" " 3 Hib. adults ..	18	51	"	23	11:30 a. m.	"	27	12:00 m.	4	12½	38.43°
" " 2 " ..	19	38	Aug.	4	10:00 a. m.	Aug.	9	9:00 a. m.	4	21	34.78°
" " 2 " ..	20	26	"	5	10:30 a. m.	"	10	2:00 p. m.	5	3½	33.24°
" " 3 " ..	21	41	"	5	10:30 a. m.	"	10	3:00 p. m.	5	4½	33.50°

But first attention should be drawn to the fact that there exists variation in the duration of embryonic development for batches of eggs deposited at the same time, hence subject to the same environmental factors including temperatures. Thus in lots 13 and 14 (Table I), from different parents, deposited at the same time on June 14 hatched at different times on June 19, lot 14 hatching 13 hours earlier than lot 13. And in lots 8 and 9; although there is a difference of an hour and a half between the times of deposition, the times of hatching diverge still more being separated by four hours and the lot deposited last hatched first. These lots were from the same parent. But contrary to this, in lots 10 and 11 deposited by different parents within 45 minutes of each other, the lot deposited first hatched first, the times of hatching being 14½ hours apart. However, lots 20 and 21 deposited by different parents at the same time hatched within an hour of each other. The data are insufficient but parentage apparently does not account for the variation between batches of eggs deposited simultaneously and we must state tentatively that it is inherent and hence subject to the laws of chance or else there are factors involved which have escaped detection. We think this variation is inherent and

hence limited or continuous and with sufficient data could be plotted in the same way as other continuous variations. It is of the same nature, apparently, as individual variations in the duration of postembryonic stadia, a matter of common observation and which are not controlled by temperature within certain time limits, nor by food.

As found previously, the daily average effective temperature increases as the period of embryonic development decreases and conversely. But for equal periods of development as shown in foregoing, equal amounts of temperature were not necessary, as witness lots 1 and 2, 7 and 12 and lots 13 and 21; also lots 9, 11 and 19. For a degree of temperature (effective) there appears to be a variable amount of growth or development, which as yet remains unpredictable; it is a specific, or maybe generic, characteristic.

2. *Number of Eggs Deposited.*

The data obtained on this point but serve to confirm what is stated by Girault (1908, p. 157 ff.) in a previous paper and also to increase the maximum number observed to be deposited by several hundred. The data were derived mainly by keeping in confinement three pairs of hibernated beetles captured early in the season while mating in a potato field and one or two pairs of the succeeding generations. The total number of eggs deposited, the rate of deposition and other related points for the pairs of the several generations are brought out in Table II presented herewith. The records fall short of what actually would have been the totals for the generations, as toward the second week in August the adult beetles were much neglected and finally died of starvation. The effect of this lack of nourishment on the second generation (or parents of the third generation) was especially noticeable, for although mating occurred freely throughout the different lots, oviposition occurred but once and most of the beetles disappeared into the soil for hibernation nearly as soon as their food was discontinued. The results indicate, however, that the first generation of adults are capable of as large an amount of reproduction as are the hibernated beetles and that the second generation of adults (or parents of the third generation) were willing or able to reproduce.

The three pairs of the hibernated beetles were obtained from a potato field in Urbana captured while mating at 11

TABLE II. Number of Eggs Deposited in Confinement by Pairs of Different Generations, 1908.

Mass No.	Hibernated Adults. 1st Mating observed: May 23, 11 a. m. Pair No. 1. Date	No. Eggs	Pair No. 2. Date	No. Eggs	May 27, 7:30 p. m. Pair No. 3. Date	No. Eggs	Generation I. Parents 2d Gen. First mating observed June 23, 9 a. m. Pair No. 1 Date	No. Eggs	Generation II. Parents 3d Gen. First mating observed Aug. 11, 3 p. m. Pair No. 2 Date	No. Eggs
1	May 23, 7:00 p. m.	73	May 23–27	8	May 28, 1:30 p. m.	77	July 8, —:— a. m.	52	Aug. 11, 10:00 a. m.	3
2	" 30, 7:00 p. m.	27	" 30, 11:00 a. m.	25	" 29, 11:45 a. m.	58	" 8, 3:00 p. m.	58	" 12, —:— p. m.	9
3	June 1, 2:00 p. m.	50	" 30, 5:00 p. m.	22	" 29, 3:00 p. m.	11	" 8, 4:30 p. m.	43		
4	" 3, —:— a. m.	38	June 1, 1:00 p. m.	48	" 30, 1:30 p. m.	49	" 9, 2:00 p. m.	53		
5	" 4, —:— a. m.	62	" 2, 2:00 p. m.	46	June 1, 1:30 p. m.	64	" 10, 1:00 p. m.	56		
6	" 4, 7:00 p. m.	18	" 4, 12:00 M.	53	" 2, 2:30 p. m.	38	" 10, —:— p. m.	30		
7	" 5, 12:00 M.	29	" 5, 10:30 a. m.	43	" 4, 2:00 p. m.	47	" 11, 10:00 a. m.	44		
8	" 6, —:— a. m.	46	" 6, —:— a. m.	8	" 5, 10:00 a. m.	27	" 11, 4:00 p. m.	32		
9	" 7, 11:00 a. m.	49	" 6, —:— a. m.	23	" 6, 11:00 a. m.	36	" 12, —:— a. m.	41		
10	" 8, 10:45 a. m.	48	" 7, 11:30 a. m.	42	" 6, —:— p. m.	9	" 13, 1:00 p. m.	14		
11	" 9, 3:00 p. m.	43	" 8, 12 M.	57	" 7, 11:30 a. m.	45	" 14, 2:30 p. m.	80		
12	" 11, 3:30 p. m.	24	" 9, 3:30 p. m.	52	" 7, 7:30 p. m.	23	" 15, 12:30 p. m.	58		
13	" 13, 2:00 p. m.	35	" 10, 3:00 p. m.	23	" 8, 12:30 p. m.	39	" 16, 8:00 p. m.	80		
14	" 14, 4-6 p. m.	34	" 12, 1:00 p. m.	51	" 9,2:30-4:30 p.m.	56	" 17, 12:00 M.	64		
15	" 17, 3:00 p. m.	1	" 13, 3:00 p. m.	32	" 10, 4:00 a. m.	48	" 18, 3:15 p. m.	83		
16	" 22, 1:30 p. m.	37	" 14, 10:00 a. m.	6	" 11, 3:45 p. m.	21	" 19, 12:30 p. m.	53		
17	" 23, 9:00 p. m.	39	" 20, 3:00 p. m.	13	" 12, 1:00 p. m.	33	" 21, 11:30 a. m.	88		
18	" 24, 2:30 p. m.	21	" 21, 1:20 p. m.	40	" 13, 2:45 p. m.	45	" 21-22, a. m.	40		
19	" 26, 1:00 p. m.	36	" 22, 1:30 p. m.	49	" 14, 4-6 p. m.	31	" 24, 2:00 p. m.	6		
20	" 26, 4:00 p. m.	32	" 23, 9:10 a. m.	36	" 16, 1:30 p. m.	33	" 25, 10:30 a. m.	9		
21	" 28, 3:00 p. m.	26	" 24, 1:30 p. m.	29	" 17,	1	" 26, 12:00 M.	30		
22	" 30, 10:00 a. m.	30	" 28, 2:20 p. m.	14	" 21, 1:30 p. m.	36	" 27, 10:00 a. m.	26		
23	July 1, 1:30 p. m.	42	" 29, 3:00 p. m.	24	" 22, 1:30 p. m.	21				
24	" 3, 2:45 p. m.	31	July 1, 10:00 a. m.	10	" 23, 1:10 p. m.	41				
25	" 4, 2:50 p. m.	31	" 2, —:— p. m.	30	" 26, 5:30 p. m.	8				
26			" 3, 2:40 p. m.	25	July 4, 3:30 p. m.	28				
27			" 6, 1:20 p. m.	44	" 6, 1:30 p. m.	33				
28			" 7, 3:00 p. m.	42	" 8, 2:00 p. m.	46				
29			" 9, 11:45 a. m.	41	" 9, 1:30 p. m.	34				
30			" 10, 1:00 p. m.	14	" 10, 1:45 p. m.	40				
31			" 12, 9:30 a. m.	14	" 11, 2:00 p. m.	29				
32			" 12, 1:00 p. m.	8	" 12, 9:00 a. m.	10				
33			" 14, 2:30 p. m.	28	" 14, 2:30 p. m.	28				
34			" 15, 12:00 M.	37	" 14, 5:00 p. m.	33				
35			" 17, 11:45 a. m.	45	" 15, 3:00 p. m.	32				
36			" 18, 10:30 a. m.	49	" 18, 10:00 a. m.	27				
37			" 19, 1:30 p. m.	24	" 19, 3:30 p. m.	11				
38			" 21, 1:00 p. m.	31	" 23, 11:30 a. m.	51				
39			" 25, 10:00 a. m.	10	" 25, —:— p. m.	70				
40			" 25, 10:30 a. m.	21	" 26, 4:00 p. m.	17				
41			Aug. 2,	19	" 29, —:— p. m.	34				
42			" 3,	16	" 30, 10:00 a. m.	10				
43			" 4, 10:00 a. m.	38	Aug. 2,	10				
44			" 5, 10:30 a. m.	26	" 3, —:— p. m.	17				
45			" 6, —:— p. m.	22	" 4, —:— p. m.	19				
46			" 7, 11:00 a. m.	19	" 5, 10:30 a. m.	41				
47			" 11, 10:00 a. m.	1	" 6, —:— p. m.	21				
48			" 16, —:— p. m.	4	" 8, —:— p. m.	12				
49					" 10, —:— p. m.	19				
50					" 12, —:— p. m.	9				
	Total	902	Total	1362	Total	1578	Total	1040	Total	12
			Average, 1280.6							
	No. of batches 25		No. of batches 48		No. of batches 50		No. of batches 22		No. of batches 2	
	Av. per batch 36.08		Av. per batch 28.37		Av. per batch 31.6		Av. per batch 47.2		Av. per batch 6	
	Daily av. 21.47		Daily av. 16.40		Daily av 20.76		Daily Av. 52.		Daily av. 6	

A. M., May 23 (pairs No. 1 and 2) and at 7:30 P. M., May 27, 1908 (pair No. 3) and confined with food immediately after capture. The single pair of the first generation resulted from a mass of 60 eggs deposited by hibernated beetles and taken from the field on May 23, 1908 and the single reproducing pair of the second generation are direct descendants of the pair of the first generation.

In the case of an extra cage containing a large number of adults collected in the field during the latter part of July, a female was observed to deposit a mass of 103 eggs, the largest single mass of eggs yet recorded. In another case, the rate of oviposition was timed; a female deposited in succession in a single mass in the usual manner 64 eggs in a period of time occupying 3200 seconds or 53 1-3 minutes. The rate of deposition was regular, each single deposit requiring 50 seconds—40 seconds to pass the egg and to fasten it and about 10 seconds to obtain position for the next deposit.

Attention is called to the rapid deposition of the single pair of the first generation, having a daily rate of deposition of 52 eggs and on a single day (July 8) depositing as many as 153 eggs in three separate batches, averaging 51 eggs each.

THE LARVA.

1. *Duration of Larval Stadia.*

We were able to make more observations concerning this phase of the beetle's life during 1908 than at previous times. The records for the first fifteen lots in the annexed table (Table III) comprise single larvae of the same age and parentage, that is, they are all from the same batch of eggs, hatching at the same average time but confined separately each individual ecdysis being recorded.

Lot No. 16, comprising 45 larvae, was from the same mass of 60 eggs as the larvae of lots No. 1-15, but upon hatching were confined together on their food. With them, the first ecdysis became general at 4 P. M., May 29; the second ecdysis began at 7 P. M., May 31, but was not general until 2:30 P. M., June 1, and was completed at 6 P. M., June 1, occupying a period of 23 hours. On June 3, the larvae were large, plump and healthy, eating voraciously, but only 30 in number, 15 having died. The third ecdysis began at 5 P. M., June 4,

TABLE III.

Duration of Larval Stadia for Different Generations, 1908.

Lot. No.	No. Larvae	Hatched	Source	1st Ecdysis Stadium I	Duration of Stadium Days	Duration of Stadium Hours	2d Ecdysis Stadium II	Duration of Stadium Days	Duration of Stadium Hours	3d Ecdysis Stadium III	Duration of Stadium Days	Duration of Stadium Hours	Entered soil Stadium IV	Duration of Stadium Days	Duration of Stadium Hours	Sums Days	Sums Hours	Total effective Temp. Degrees Fahr.	Average daily Effective temp Degrees Fahr.
1	1	May 27, 11:00 a. m.	Hib. adults (nature)	May 29, 12:00 M.	2	1	May 31, 6:00 p. m.	2	6	June 4, 9:30 a. m.	3	15½	June 7, 4:30 a. m.	2	19	10	17½	285.8°	26.80°
2	1	"		" 29, 11:30 a. m.	2	½	" 31, 4:30 p. m.	2	5	Died	..	..	.....	..	..	..	..	.....	.....
3	1	"		" 29, 12:30 p. m.	2	1½	" 31, 11:00 p. m.	2	10½	Died 10 a.m. June 2	..	..	.....	..	..	..	..	.....	.....
4	1	"		" 29, 7:00 a. m.	1	20	" 31, 2:00 p. m.	2	7	"	..	..	.....	..	..	..	..	.....	.....
5	1	"		" 29, 7:00 a. m.	1	20	" 31, 1:30 p. m.	2	6½	June 4, 9:30 a. m.	3	19	Died	..	..	..	..	.....	.....
6	1	"		" 29, 11:00 a. m.	2	..	" 31, 7:00 p. m.	2	8	" 4, 12:00 M.	3	17	June 8, 7:00 p. m.	3	19	11	20	345.9°	28.05°
7	1	"		" 29, 8:00 a. m.	1	21	" 31, 1:30 p. m.	2	5½	" 4, 9:30 a. m.	3	19	" 7, 4:30 a. m.	2	19	10	17½	285.8°	26.80°
8	1	"		" 29, 1:00 p. m.	2	2	" 31, 6:00 p. m.	2	5	" 4, 11:00 a. m.	3	17	" 7, 4:30 a. m.	2	17½	10	17½	285.8°	26.80°
9	1	"		" 29, 11:00 a. m.	2	..	" 31, 11:00 p. m.	2	12	Died June 6	..	..	.....	..	..	..	..	.....	.....
10	1	"		" 29, 8:00 a. m.	1	21	" 31, 11:30 a. m.	2	3½	June 4, 6:00 a. m.	3	16½	Died	..	..	..	..	.....	.....
11	1	"		" 29, 2:00 p. m.	2	3	June 1, 9:00 a. m.	2	19	" 4, 12:00 M.	3	3	June 8, 7:00 p. m.	3	19	11	20	345.9°	28.05°
12	1	"		" 29, 10:00 a. m.	1	23	May 31, 2:30 p. m.	2	4½	" 4, 7:00 a. m.	3	16½	" 7, 4:30 a. m.	2	21	10	17½	285.8°	26 80°
13	1	"		" 29, 1:00 p. m.	2	2	June 1, 2:00 p. m.	3	1	Died 6 p. m., June 3	..	..	.....	..	..	..	..	.....	.....
14	1	"		" 29, 3:00 p. m.	2	5	" 1, 1:00 p. m.	2	22	June 5, 11:00 a. m.	3	22	Died	..	..	..	..	.....	.....
15	1	"		" 29, 12:30 p. m.	2	1½	" 1, 7:00 a. m.	2	16½	" 4, 6:00 p. m.	3	11	Died	..	..	..	..	.....	.....
..	..	1-15 Average.			2	½		2	14½		3	12½		3	6¼	11	9½		
16	45	May 27, 11:00 a. m.		May 29, 4:00 p. m.	2	5	June 1, 2:30 p. m.	2	22½	June 5, 8:00 a. m.	3	17½	June 7, Noon	2	4	11	1	298.2°	27.10°
17a	..	July 7, 6:30 a. m.		July 10, 2:00 p. m.	3	7½	July 13, 6:00 a. m.	2	16	July 15, 12:30 p. m.	2	6½	July 19, 7:00 a. m.	3	18½	12	½	425.5°	35.45°
18b	..	" 11, 7:00 p. m.	Gen. I—mixed	" 14, 6:00 a. m.	2	11	" 16, 1:00 p. m.	2	7	" 19, 7:00 p. m.	3	6	" 24, 8:00 a. m.	4	13	12	13	453.56°	35.82°
19c	58	" 13, 5:00 p. m.	Gen. I—Pair No 1	" 15, 6:00 p. m.	2	1	" 18, 11:00 a. m.	2	17	" 22, —:— p. m.	..	..	" 25, 9:00 p. m.	..	..	12	4	433.13°	35.12°
20d	43	" 13, 1:00 p. m.		" 16, 6:00 p. m.	3	5	" 18, 12:00 M.	2	6	" 20, 9:00 p. m.	2	9	" 24, 8:00 p. m.	4	1½	11	21½	409.26°	35.09°
21e	56	" 14, 9:00 p. m.		" 17, 12:00 M.	2	15	" 19, 1:00 p. m.	2	1	" 22, —:— p. m.	..	..	" 25, 11:00 p. m.	..	..	11	2	385.40°	35.03°
22f	32	" 16, 9:00 p. m.		" 18, 6:00 p. m.	2	21	" 21, 9:00 p. m.	3	3	" 23, —:— p. m.	..	..	" 27, 6.00 a. m.	..	..	10	9	362.00°	35 04°
		a to f Average			2	16¼		2	14		2	18¼		3	3¾	11	11		

and was general at 8 A. M., June 5, concluding at 2 P. M., June 5, occupying a period of 21 hours. But 18 larvae successfully survived the ecdysis. Entering the soil for pupation began on June 7, at 4:30 A. M. and all larvae had entered by June 8, 7 P. M. Table III summarizes.

2. *Number of Ecdyses.*

There can be no doubt but that the normal number of larval ecdyses, excluding pupation, is three and as additional evidence we have observed this number in two hundred and the fifty cases during the season without a single exception for whole number. The question may be considered as settled.

3. *Duration of the Larval Stage.*

There being no data concerning this point other than what are already included in Table III, it is unnecessary to repeat them here, but reference should be made to the column of sums of that table.

THE PUPA.

1. *Duration of Pupal Stage.*

Table IV summarizes sufficiently well all of our data for 1908 concerning this phase of the beetle's life cycle.

TABLE IV.

DURATION OF PUPAL STAGE, ACTUAL TIME IN SOIL, SEASON 1908.

Lot No.	No. Pupae	Entered Soil.	Adults Emerged	Length Time in Soil. Days.	Hours.	Sum of Effective Temp. Degrees Fahr.
1	1	June 7, 4:30 a. m.	June 21, 1:30 p. m.	14	9	418.4°
6	1	" 8, 7:00 p. m.	" 22, 6:00 a. m.	13	11	383.2°
7	1	" 7, 4:30 a. m.	" 19, 4:00 p. m.	12	11½	307.5°
8	1	" 7, 4:30 a. m.	" 21, 1:30 p. m.	14	9	418.4°
11	1	" 8, 7:00 p. m.	" 22, 1:00 p. m.	13	18	396.6°
12†	1	" 7, 4:30 a. m.	" 21, 1:30 p. m.	14	9	418.4°
16	45	" 7, noon	" 22, noon	15		444.2°
17a	..	July 19, 7:00 a. m.	July 30, 6:00 p. m.	11	9	425.9°
18b	..	" 24, 8:00 a. m.	Aug. 4, 7:00 p. m.	11	11	450.6°
19c	58	" 25, 9:00 p. m.	" 6, 7:00 a. m.	11	10	404.5°
20d	43	" 24, 11:00 p. m.	" 4, 8:30 a. m.	10	9½	396.4°
21e	56	" 25, 11:00 p. m.	" 5, 12:15 p. m.	10	13¼	397.4°
22f	32	" 27, 6:00 a. m.	" 6, 6:00 p. m.	10	12	410.6°

* These numbers correspond with the lots in Table III.

† Average of Lots No. 1 to 12, 13 days, 19½ hours.

THE ADULT.

1. *Length of Life in Confinement.*

a. In Pairs Normally Reproducing.

The data obtained on this point are scanty and much vitiated by the fact that the lots were neglected too soon to obtain normal results, but they supplement to some extent the data obtained in 1907 tending to support the theory that the average duration of life of normally reproducing adults is two months or more. The average here is 1.8+ months, the data however being insufficient.

TABLE V.

LENGTH OF ADULT LIFE IN CONFINEMENT, NORMALLY REPRODUCING.

Lot No.	No. Individuals.		Source.	Date Confined, 1908 (Emergence.)	Date of Death, 1908.		Length of Life, Months	
	Male	Female			Male	Female	Male	Female
I. Hibernated								
1	1	1	.....	11 a. m., May 23	June 4*	July 7	0.4	1 5
2	1	1	Potato field, mating.	11 a. m., May 23	Aug. 16†	Aug. 16†	2.8+	2.8+
3	1	1		7:30 p.m., May 27	July 26	Aug. 16†	1.96	2.66+
II. Gen. I								
1	1	1	Hibernated adults (nature)	June 23	Aug. 16‡	Aug. 16‡	1.8+	1.8+
III. Gen. II	Many	Many	Pair No. 1, Gen I.	July 30—Aug. 8	August‡	August‡	0.5+	0.5+

* Escaped. † Liberated. ‡ Starved and entered hibernation.

2. *Length of the Period of Oviposition.*

As with the previous section, the results here are abnormally short in point of duration for the reasons given. They are merely tabulated therefore, without further comment.

TABLE VI.

LENGTH OF THE PERIOD OF OVIPOSITION. DIFFERENT GENERATIONS, 1908.

Generation No.	First Mated.	First Eggs Deposited.	Last Eggs Deposited.	Length of Period of Oviposition, Days.
Hibernated—				
Pair No. 1.....	11 a. m., May 23	7 p. m., May 23	2:50 p.m., July 4	42+
Pair No. 2.....	11 a. m., May 23	May 25*	August 16, p. m.	83
Pair No. 3.....	7:30 p.m., May 27	1:30 p. m., May 28	August 12, p. m.	76
I—Pair No. 1.....	9 a. m., June 23	July 8, a. m.	10 a. m., July 27	20+
II.—Pair No. 1c.....	Aug. 11, 3 p. m.	Aug. 11, 10 a. m.	Aug. 12, p. m.	1+

* Average time of a period of 4 days.

3. *Mating.*

The observations on this habit are also limited, but those matings actually observed are summarized in Table VII. In a single case, the time actually involved from beginning to end of the act was obtained, being three and one-half hours (10:30 A. M. to 2 P. M., June 18, Pair No. 3, hibernated adults.)

TABLE VII.

Frequency of Mating in Reproducing Pairs. Different Generations, 1908.

Generation No.	Pair No.	First Mating	Subsequent Matings	Last Matings	No. of Matings	Observed Period of Mating, Days	Period of Oviposition, Days	No. Eggs, Masses Deposited
Hibernated	1	11 a. m., May 23	May 28, 30, 31..... June 1.....	June 4*	6	12	42+	25
	2	11 a. m., May 23	May 27, 30..... June 2, 4, 21..... July 1, 23, 26, 28.... Aug. 3, 4, 5, 5, ... 7, 7.....	August 11	17	80	83	48
	3	7:30 p. m., May 27	May 30..... June 3, 4, 10, 13, 18, 18, 20, 24, 24.... July 1, 9, 15, 17, 17 .	July 18	17‡	52	76	50
I	1	9 a. m., June 23	.....	July 8	2	15	20+	22
II	1a 1c 1d 2d 3d	Aug. 3, 3 p. m. Aug. 9, 4 p. m. Aug. 9, 10 a. m.° Aug. 9, 10 a. m.° Aug. 9, 6:30 a. m.°	Aug. 4, 5, 6..... Aug. 11, 12.....	Aug. 7, 9 a. m.‡ Aug. 13, 3 p. m.	5 4	3½ 4	.. 1+	.. 2
	1e 1f	Aug. 11° Aug. 11	Aug. 13.....	Aug. 14	3	3	..	..

* Male escaped. † Male died July 26. ‡ Male entered soil for hibernation.
° Only observed mating; hibernation followed within 10 days.

Mating was observed during the following hours of the day: Practically at any hour between 7 A. M. and 11 P. M., more commonly at 9, 10 and 11 A. M. and 1, 2, 3, 4 and 6 P. M. or at fractions of those hours. The function was observed most commonly at 9 and 10 A. M., over 31 per cent of the 58 times the act was observed being either at or between those two hours. Fifty per cent of the observed matings occurred in the morning and fifty per cent. in the afternoon or evening. Observations were continued throughout most of the night, up at least until midnight, commencing again at six o'clock in the morning.

4. *Potency of Fertilization.*

As concerns this point, it was noticed in the case of the hibernated pairs, and with these pairs only was opportunity presented to gather any data bearing on the question, that the female of Pair No. 1 continued to deposit fertile ova for one month after the absence of the male (June 4, 7 P. M., to July 4, 2:50 P. M.); and that the female of Pair No. 3 deposited fertile ova for seventeen days after the death of her mate. No other data were obtained.

5. *Number and History of Generations Reared in the Laboratory.*

Our data here are also meagre, but they certainly do tend to uphold the opinion that the adults of the second generation (or parents of the third generation) are at least able, if not willing, to reproduce and hence the observations of last year (Girault 1908) are upheld and Tower's (1906) dictum that "The second generation does not develop the germ-cells nor show any reproductive activity until after it has passed through a period of hibernation or aestivation" becomes in our minds less and less authoritative. These beetles of the second generation with us certainly showed reproductive activity, if repeated matings can be called such, and one pair, even under very adverse conditions—starvation—deposited fertile eggs, which surely must be conceded to be reproduction which cannot of course take place without development of the germ-cells. The beetles with us this year plainly showed symptoms of what we would call eagerness and ability to reproduce. These beetles were those of the second generation, as will be shown in the following brief historical sketch, and were normal in every way, that is to say, did not represent any special race of the species.

On May 23, 1908, or at the earliest possible date, 60 eggs of the species were collected from a potato plant in a small plot of potatoes at Urbana, Illinois and brought to the laboratory to comprise the first generation or descendants of the hibernated adults. The larvae came to maturity early in June and pupated and eleven adults emerged between June 21 and June 23. They were confined together with food. On the latter date a pair were found mating and were at once isolated as the parents of the second generation.* From this pair of adults of the first generation, there were taken for the special

*The others were accidentally poisoned with arsenate of lead.

purpose of rearing a sufficient quantity of the second generation, six lots or batches of eggs numbered from *a* to *f*. In all 49 adults were obtained from the six batches. For clearness, the batches are treated in detail: (1) Batch *a*, consisting of about 20 (number unknown) eggs hatched at 6:30 A. M., July 7, the resulting larvae entering the soil for pupation at the average time of 7 A. M., July 19 and on July 30 and 31, 4 adults were obtained. These were at once fed and at 3 P. M., August 3, a pair were observed mating and were isolated. This pair continued to mate until 9 A. M., August 7, the ♂ entering the soil shortly afterward; with them mating was observed five times, but no oviposition occurred. In the meantime, the two remaining beetles had hibernated (August 8), the mated female following a week later. Hibernation induced by starvation due to lack of time in which to feed the beetles. (2) Batch *b*, consisting of 60 eggs came to larval maturity at 8 A. M., July 24, and on August 4 and 5, two adults were obtained comprising the whole survival. These were males and hibernated on August 22. (3) Batch *c*, 58 eggs, came to larval maturity at 9 P. M., July 25, and gave from August 5 to 7, 4 adults which were placed on food as they emerged. A male died on August 8 and a pair were mating at 4 P. M., August 9; this pair was then isolated. On August 11 at 10 A. M., 3 eggs were deposited which proved to be fertile; mating was again observed at 3 P. M. the same day and at the same hour on August 12; later the same day (12) 9 eggs were deposited on a leaf, which also proved to be fertile; another mating was observed at 9 A. M., August 13, but thereafter no other matings were observed and further reproduction did not occur. The remaining adult died on August 22, but the mated pair remained alive without food until August 25, when the cage was broken up. Oviposition and mating in spite of insufficient food. (4) Batch *d*, 43 eggs, came to larval maturity at 10 P. M., July 24, and on August 4 from 7 to 10 A. M., 11 adults were obtained, the total survival. On August 9, 3 pairs observed mating were isolated but other matings did not occur with them nor oviposition, caused as we have reason to believe, by the neglect to supply food. Thus, on August 13 the third pair had entered the soil for hibernation and two days later the second pair had done likewise; the first pair remained on top of the soil until August 25,

when they were killed and removed. Of the remaining five adults, two had died by August 11 and the three others hibernated on August 22. (5) Batch *e*, 56 eggs, came to larval maturity at the average time of 11 P. M., July 25, and gave 24 adults from August 4 to August 6, which were confined together with food. But a single pair was isolated, observed mating on August 11, though previously, mating had occurred promiscuously. This pair was neglected after isolation and no further reproductive activity occurred; on August 13 at 9 A. M., the male entered the soil for hibernation and on August 25 the pair were removed still alive. Of the remaining 22 beetles, 4 hibernated on August 11 at 9 A. M. and by August 22, all had disappeared beneath the soil, two having died there. No reproduction, but during the period of feeding, after several days, mating was frequent and promiscuous and there is good reason for believing that reproduction was prevented by actual starvation at a critical period. (6) Batch *f*, 32 eggs, arrived at larval maturity at the average time of 6 A. M., July 27, and gave 4 adults August 7 and 8; on August 11, a mating pair of this lot were isolated and the remaining two also paired. The first pair mated again on August 13 and August 14 but no oviposition followed and they were removed on August 25, after days of starvation. The second pair had hibernated by August 22, without depositing eggs and with no further observed matings.

In general it may be stated that the adults of the second generation just after emergence fed voraciously for several days and then began to mate as though eager to reproduce and one pair acutally deposited fertile eggs, insuring at least a portion of a third generation. It was at this time in their lives, just following the period of heavy feeding and the beginning of mating that stress of other work caused the food to be neglected and after August 8, the beetles were starving and were forced to hibernate. Incidentally, it was also true that their food-plant in nature was also very scarce at this time, so even if at large, it is not unreasonable to suppose that these beetles of the second generation would have been forced into hibernation before reproduction could begin, though willing and able to reproduce. What little evidence we have gathered this year forces us to conclude that the second generation of adults *exceptionally* are both willing and able to reproduce, merely

supplementing what was previously indicated to be true in 1907. The evidence of course is gross in nature, for we did not actually examine the mated females in any case for spermatozoa, so that in the majority of cases, actual mating is open to question. It is needless to say that this should have been done. But in at least one case we are sure that both mating and reproduction occurred as fertile ova were deposited.

In regard to the seasonal history in 1908, the second generation was obtained nearly a month earlier than that obtained in 1907, so that there was ample time for a third generation. The following table summarizes the generations reared in confinement.

TABLE VIII.

Generations Reared in the Laboratory, Urbana, Illinois, 1908.

Generation No.	Eggs Deposited.	Adults Out.	Length of Cycle.		Effective Temp Sums, Degrees F.
			Days	Hours	
I.	May 21*	June 22	32	..	948.2°*
II. Lot a	July 2†	July 30, 11 p. m.	28	12	..
b.	July 6, 1:15 p. m.	August 4, 7 p. m.	29	5¾	1062.3°
c.	July 8, 3 p. m.	August 6, 7 a. m.	28	16	1056.6°
d.	July 8, 4:30 p. m.	August 4, 8:30 a. m.	26	16	979.6°
e.	July 10, 1 p. m.	August 5, noon.	25	23	976.9°
f.	July 11, 4 p. m.	August 7, 6 p. m.	27	2	1009.9°
III.	August 11 and 12.	Not reared to maturity	..	..	..

* Approximated; hatched 11 a. m., May 27. † Approximated; hatched 6:30 a. m., July 7.

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